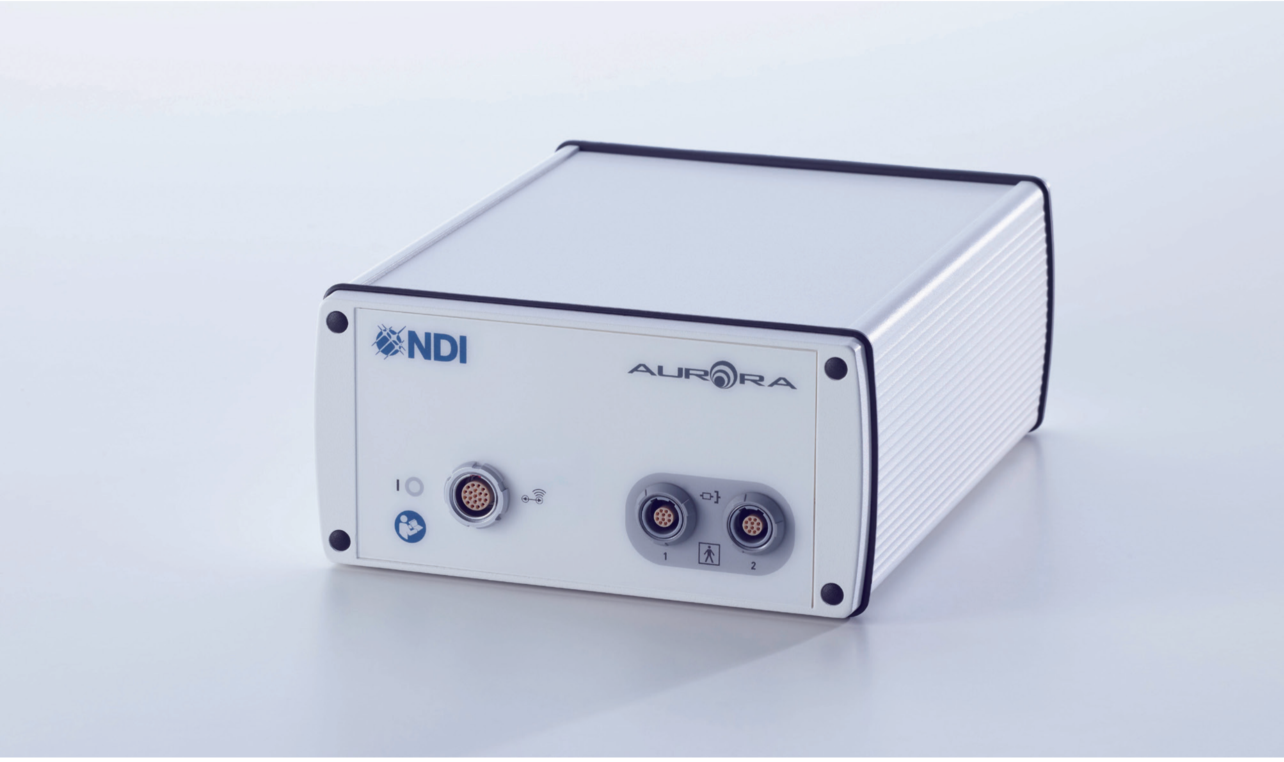
Aurora®

V3.1 USER GUIDE

This guide details information on setup, operation and troubleshooting of the Aurora® System.



NDI

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DDUG-090-024-05

Revision number	Date	Description
1	February 2014	Initial release
2	November 2014	Update to SCU information, update to PCB integration guide chapters, addition of Window Field Generator information.
3	April 2017	Update and addition of Window Field Generator information, addition of WFG II series and table of SIU boards.
4	January 2018	Addition of information related to SCU V3.1 and Planar FG 10-11 and Planar FG 10-11H
5	August 2021	Layout completely redesigned, removal of Field Generator technical specifications (see data sheets instead), expanded external synchronization port information including new trigger mode functionality

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Important: Please read this entire document before using the Aurora® System.

2 Read Me First!

Read this section before continuing with the rest of the guide.

Warning:

In all NDI documentation, warnings are marked with the word “Warning!”. Follow the information in the accompanying paragraph to avoid damage to equipment.

1. Do not use the Aurora® System if any of the hardware components or connectors are damaged. Such damage may affect system functions and contribute to inaccurate transformations and possible personal injury.

2. Do not use cables or accessories other than those listed in this guide, with the exception of those sold by NDI and NDI-authorized manufacturers. To do so may result in increased emissions and/or decreased immunity of the Aurora® System.

3. Do not operate the Field Generator within 10 m of another operating Field Generator. To do so may contribute to inaccurate transformations and possible personal injury.

4. Do not place the Field Generator cable inside the measurement volume or wrap it around the Field Generator, as it may create a magnetic interference. This interference can contribute to inaccurate transformations and possible personal injury.

5. Do not coil the Field Generator cable. The cable carries enough electric current that a magnetic field will be created when the cable is placed in a circular formation. This magnetic field may disturb the Field Generator‘s magnetic field, contributing to inaccurate transformations and possible personal injury.

6. Do not place the SCU or SIU within 1 m of the Field Generator. To do so may affect the Field Generator‘s magnetic field or introduce additional noise into the signal, contributing to inaccurate transformations and possible personal injury.

7. Do not place tool cables within 30 mm of the Field Generator cable. If placed this close - particularly if the cables are parallel to each other - the tool cable may become subject to electromagnetic interference. This interference can contribute to inaccurate transformations and possible personal injury.

8. Do not place Aurora® Sensors, Tools or Sensor Interface Units directly on the Tabletop Field Generator. Doing so will increase the risk of interference of the Tabletop Field Generator magnetic field. Such interference may produce misleading transformations which may result in possible personal injury.

9. Do not bend or kink Aurora® System cables or tool cables or use cables that are damaged. Applying transformations from a system with damaged tool cables may result in possible personal injury.

10. Ensure that the Aurora® System SCU is connected to an IEC 60950 or IEC 60601 approved workstation. If the SCU is not connected to an IEC 60950 or IEC 60601 approved workstation, leakage currents may be increased beyond safe limits and cause possible personal injury.

11. Make sure that the SCU is only connected to a main power supply that has a protective earth. Failure to do so may result in electric shock and personal injury.

12. Make sure that the SCU is positioned so that the operator cannot touch the SCU and patient simultaneously. Failure to do so may result in personal injury.

13. Ensure that the Tabletop Field Generator is placed so that the patient cannot come into direct contact with it. Failure to do so may result in personal injury.

14. Ensure that the Window Field Generator is placed so that the patient cannot come into direct contact with the connector between the Field Generator and the cable. Failure to do so may result in personal injury.

15. Do not move the Field Generator while tracking an object. The system may produce misleading transformations and result in possible personal injury.

16. Do not track in an untested application environment, as it may contain elements that affect Aurora® System functions. For example, the system can be adversely affected by electromagnetic field disturbances from other objects in the room, the close proximity of metal, and the close proximity of another Field Generator. Failure to test for such disturbances will increase the possibility of inaccurate transformations and possible personal injury.

17. Do not operate the Field Generator within 200 mm of an installed pacemaker. The magnetic field produced by the Field Generator may interfere with the operation of the pacemaker. This interference may result in personal injury.

18. The Aurora® System has not been designed or tested to be used during or following cardiac defibrillation. Cardiac defibrillation may cause inaccurate transformations and result in possible personal injury.

19. Do not expose sensors to a high magnetic field, such as a Magnetic Resonance Imaging (MRI) scanner, as they may become magnetized. Tracking with a magnetized sensor may result in incorrect transformations and result in possible personal injury.

20. Do not use the Aurora® System in the presence of other magnetic fields. To do so may lead to misleading or inaccurate transformations and possible personal injury.

21. Portable RF communications equipment (including peripherals such as antenna cables and external antennas) should be used no closer than 30 cm (12 inches) to any part of the Aurora® System, including cables specified by the manufacturer. Otherwise, degradation of the performance of this equipment could result. This may contribute to inaccurate transformations and possible personal injury.

22. Make sure that patient auxiliary leakage currents do not exceed allowable limits. Consult both IEC 60601 and applicable national differences and amendments. In addition, give special consideration to insulation materials and thicknesses to ensure the galvanic isolation of multiple tools connected to the Aurora® System. Failure to do so may lead to personal injury.

23. When using reply option 0800 with the BX or TX API command, you must take appropriate action to detect when a tool is out of volume and determine whether this situation is detrimental to your application. If a tool is out of volume reply option 0800 enables the system to return data that may lead to inaccurate conclusions and may cause personal injury.

24. Do not drop the Field Generator or subject it to impact. This may alter the Field Generator's calibration and contribute to inaccurate transformations and possible personal injury. If an impact occurs, check the accuracy or alternatively send it back to NDI for accuracy check/recalibration.

25. Do not track a tool unless you are sure that its SROM device is programmed correctly, and with the correct settings. Using an incorrectly programmed tool may produce inaccurate transformations and possible personal injury.

26. Sensors must be mounted securely within the tool body. If a sensor moves out of position, accuracy is affected. This may contribute to inaccurate transformations and possible personal injury.

27. Do not disconnect the Field Generator from the system while tracking. Disconnecting the Field Generator while in tracking mode may result in sparks being generated, and possible personal injury.

28. Do not expose or immerse the Aurora® System to liquids or allow fluid to enter the equipment in any way. Exposing the Aurora® System to liquids may result in equipment damage, produce a fire or shock hazard, and result in possible personal injury.

29. Apart from replacing the SCU fuses, there are no user serviceable parts in the Aurora® System. All servicing must be done NDI. Unauthorized servicing may result in possible personal injury.

30. Do not change either fuse without first disconnecting the SCU from its power source. Failure to disconnect the system may result in personal injury.

31. Disconnect power to the Aurora® System before cleaning it. Failure to do so may cause personal injury.

32. Do not short-circuit any of the patient isolation circuits on the SCU PCB. If a patient isolation circuit is short-circuited, there is a risk of excessive patient leakage current, which may result in personal injury.

33. After mounting the Window Field Generator, ensure that the Field Generator is not mechanically deformed. When the Window Field Generator is mechanically deformed, accuracy degrades, which may result in personal injury.

34. Use of this equipment adjacent to or stacked with other equipment should be avoided because it could result in improper operation. This may contribute to inaccurate transformations and possible personal injury. If such use is necessary, this equipment and the other equipment should be observed to verify that they are operating normally.

Caution:

In all NDI documentation, cautions are marked with the word "Caution!". Follow the information in the accompanying paragraph to avoid damage to equipment.

1. To move or ship the Aurora® System, repack in the original containers together with all protective packaging to prevent damage.

2. Do not use aerosol sprays near the equipment as these sprays can damage circuitry.

3. Do not use any solvent to clean the Aurora® System. Solvents may damage the finish and remove lettering.

4. Do not autoclave any Aurora® System component. Autoclaving may damage the system.

5. Do not put heavy objects on cable connectors. Doing so may damage the connectors.

6. Do not leave cable connectors where they can be damaged, particularly on the floor, where they can easily be stepped on and damaged.

7. Do not modify the Aurora® System equipment without authorization of the manufacturer. Unauthorized modification of the equipment may result in damage to the equipment.

When working with SCU or SIU boards as described in section 20. „PCB Integration Guide: SCU Board“ on page 69 and section 21. „PCB Integration Guide: SIU Board“ on page 76, handle the boards in an ESD-safe manner. Failure to do so can damage the boards.

3 Overview

Before using the Aurora® System, review the **Warnings**, **Cautions** and **Disclaimers** at the beginning of this guide.

Getting started?

If you are new to the Aurora® System, start here:

- Basic introduction to the Aurora® System: see section 4.1 „Introduction“ on page 10
- How the Aurora® works: see section 4.2 „Principles of Operation“ on page 11
- See section 5. „Software and Drivers Installation“ on page 18
- See section 6. „Setting up the Aurora System Hardware“ on page 28
- See section 10. „Tutorial: Learning to Use the Aurora System (NDI ToolBox)“ on page 41

Essential Information

What you need to know to get the most out of the Aurora® System:

- Tool types, sensors: see section 11.1 „Tool Components“ on page 46 and 11.2 „Aurora Tool Types“ on page 47
- Tracking data, API, error flags, measurement rate, latency, degrees of freedom (5DOF, 6DOF), coordinate systems: see section 12. „Aurora System Data“ on page 48
- How metal and other EM fields affect the Aurora® System: see section 13.2 „Interference and Distortions“ on page 55 and 13.3 „Effects of Nearby Metal on the Aurora System“ on page 56
- We also refer to the following user guides, which can be downloaded from NDI Support Site.
  DDUG-1000-2165 Aurora® Tool Design Guide
  DDUG-090-038 Aurora® Firmware Guide
  DDUG-010-466 Aurora® Application Program Interface (API) Guide

Problems with tracking?

- For problems with tracking: see section 23. „Troubleshooting“ on page 80

4 Aurora® System Overview

4.1 Introduction

This guide is applicable to the Aurora® V3.1 System. The Aurora® System is an advanced electromagnetic spatial measurement system designed to calculate the position and orientation of sensors within a defined volume and to a high degree of accuracy. The sensors are typically embedded in tools so that the system can determine the position and orientation of the tools.

The Aurora® System comprises the following components:

- Field Generator: one of Planar Field Generator (PFG), Window Field Generator (WFG) or Tabletop Field Generator (TTFG)
- System Control Unit (SCU)
- Sensor Interface Unit (SIU)
- Sensors and/or tools
- Host computer (provided by user)

The following pictures show the Aurora® System components:

System Control Unit (SCU)
(also available with black housing)

Sensor Interface Unit (SIU)
(also available with black housing)

Field Generators

Sensors

4.2 Principles of Operation

The SCU provides power to the Field Generator, which in turn produces a series of varying magnetic fields, creating a known volume of varying magnetic flux.

Sensors, typically embedded in tools, are connected to the SIU, which in turn is connected to the SCU. If these sensors are placed inside the Aurora® detection region, a voltage will be induced in them, caused by the varying magnetic fields produced by the Field Generator. The characteristics of the induced voltage depend on a combination of the sensor position and orientation, and the strength and phase of the varying magnetic fields.

The SIU converts the voltages, induced in the sensors, into digital data and sends it to the SCU. The SCU analyzes the data and calculates the position and orientation of the sensors. The resultant calculation is sent to the host computer upon request from the application software.

The characterized measurement volume is the volume where data was collected and used to characterize the Field Generator. It is a subset of the detection region. (The detection region is the total volume in which the Field Generator can detect a sensor, regardless of accuracy.) The shape of the characterized measurement volume is dependent on the Field Generator type and how it was characterized.

4.3 Field Generator

The Field Generator generates the electromagnetic field in which sensors and tools can be tracked.
For information specific to each Field Generator, please see the appropriate section:

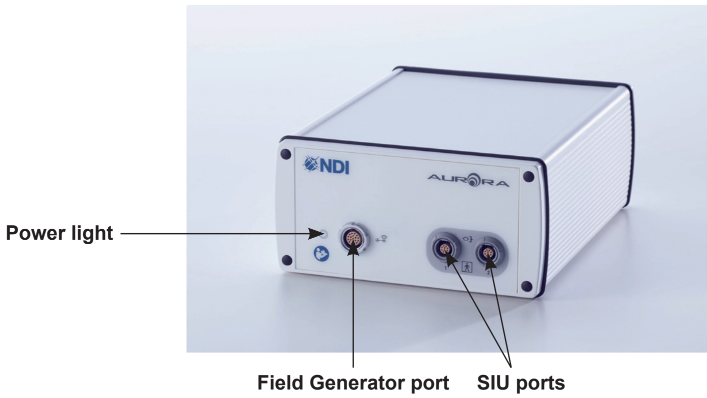
- See section 7. „Planar Field Generator“ on page 34
- See section 8. „Tabletop Field Generator“ on page 37
- See section 9. „Window Field Generator“ on page 39

4.4 System Control Unit (SCU)

The SCU controls the operation of the Aurora® System. It acts as an interface between the system components and provides visual status indications. A brief overview of the SCU functions is as follows:

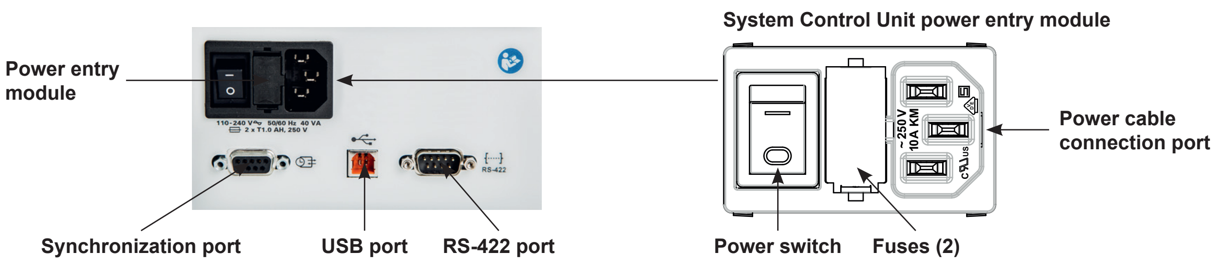
- Supplies power to the Field Generator and controls the Field Generator's electromagnetic output.
- Collects sensor data (via the SIU) and calculates sensor positions and orientations. It then sends the position and orientation data to the host computer (if requested).
- Interfaces with the host computer.

System Control Unit Front Panel



Parts	Description
Power light (green)	Lights when the SCU is powered on.
Field Generator port	Connects the SCU to the Field Generator cable.
SIU ports (2)	Connect SIU(s) to the SCU, allowing communication between the system and connected tools.

System Control Unit Back Panel

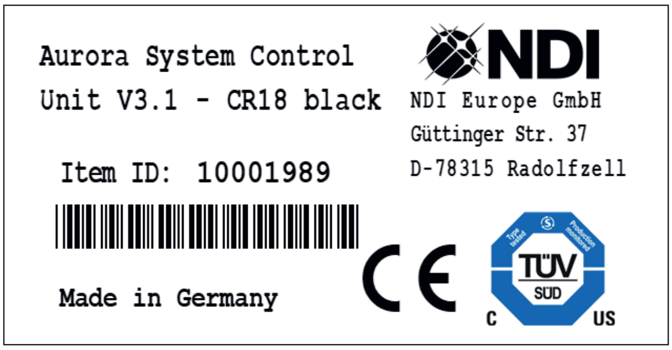


Parts	Description
Power entry module	Power switch: for turning the Aurora® System on and off Fuse holder: Fuses (2) Power cable connection port: Cable type: 3-conductor medical grade
Synchronization port	The synchronization port provides clock and trigger signals for synchronization with other devices. For details on this port, see section 14. „External Synchronization" on page 58.
USB port	A USB port used to connect the SCU to the host computer.
RS-422 port	A serial communications port used to connect the SCU to the host computer. This is an isolated port with a 9-pin D-sub male connector.

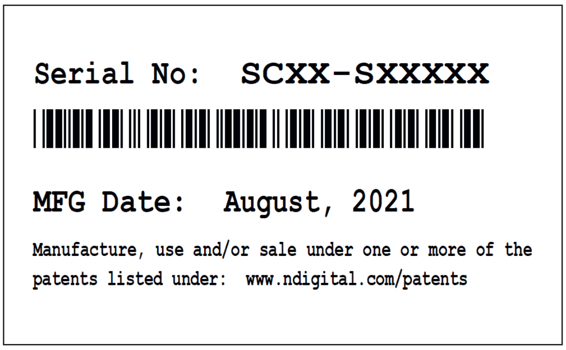
Note:
At elevations of over 2000 m above sea level, the SCU must be disconnected from the mains power supply in order to turn the Aurora® System off.

System Control Unit Labels (enclosed black)

The SCU type and serial number labels are located on the rear and bottom of the SCU, and show the item ID, model, serial number and manufacture date of the SCU.



SCU type number label



SCU serial number label

System Control Unit Specifications

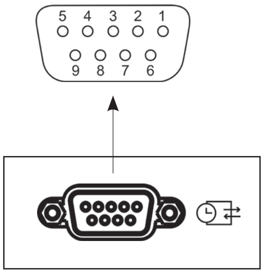
Dimensions (l, w, h):	84 mm x 172 mm x 230 mm
Weight:	2 kg
Host interface:	USB or RS-422
Input voltage:	110-240 VAC, 50/60 Hz, 0.4-0.2 A
Max. number of Sensor Interface Units (SIUs):	2

4.5 SCU Connector Pinouts

This section contains the pin definitions of the connectors on the SCU in an enclosure. For the PCB versions of the SCU, please see the SCU data sheet.

SCU Synchronization port

The synchronization port provides clock and trigger signals for synchronization with other devices.
It is populated using a female 9-pin D-type connector.

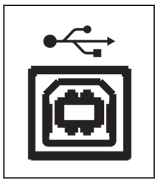


Pin	Value	Pin function
1	+3.3	SCU provides up to 200 mA, +3.3 V
2	Viso	Optocoupler anode
3	FR IN	Frame clock input (active low) Synchronization mode: falling edge triggers frame clock Trigger mode: active low trigger pulse
4	HF IN	Clock signal input
5	GND	Ground
6	HF OUT	Clock signal output
7	Reserved	Reserved
8	TR OUT	Combined firmware revision 20 and later: When asserted (active low), the Field Generator is active. Prior firmware revisions: Reserved.
9	FR OUT	Clock output at frame rate (active low)

USB Type B for host communication

There are two possible communication interfaces to the Aurora® System:

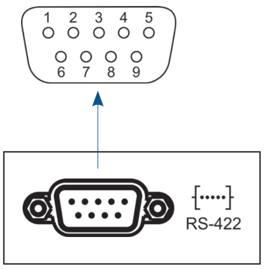
- USB
- Isolated RS-422 port



Pin	Pin function
1 to 4	Connect to a USB host using a standard USB cable

RS-422 port

A serial communications port used to connect the SCU to the host computer.
This is an isolated port with a 9-pin D-sub male connector.



Pin	Pin function
1	ISO Ground
2	CTS+
3	RTS+
4	RX+
5	RX-
6	CTS-
7	RTS-
8	TX+
9	TX-

4.6 Sensor Interface Unit (SIU)

The SIU is the interface between the sensors (usually embedded in tools) and the SCU. The main function of the SIU is to convert the analog signals, produced by the sensors, to digital signals. The digital signals are sent to the SCU for processing.

Another function of the SIU is to increase the distance between the SCU and tools, removing the requirement for a long tool cable and keeping bulky system components away from the application space. Analog signals in the tool cable (though shielded when using the NDI tool cable) are still susceptible to noise, so the shorter the tool cable, the less noise will appear on the signal from the sensors.

Each SIU can support up to eight 5DOF sensors, four 6DOF sensors, or a combination. The SIU also allows you to interface with sensorless tools, such as a footswitch. For more information about tools, see section 11. „Aurora System Tools“ on page 46.

Sensor Interface Unit Front Panel

Parts	Description
Power light (green)	Lights when the SCU is powered on.
Tool port status light (amber/green)	Lights amber when a tool is connected and green when the tool is initialized and ready for tracking.
Tool ports (4)	Connect the tools to the SIU. This tool port is a 10-pin circular plastic connector.

Sensor Interface Unit Labels (enclosed black)

The SIU type and serial number labels are located on the back of the SIU, and show the item ID, model, serial number and manufacture date of the SIU.

NDI
Aurora 4-Port Sensor Interface Unit
V3-4P FW 1.7.0
Item ID: 610511
MFG Date: Apr 2021
Made in Germany
CE

SIU type number label

Serial No: SIXX-SXXXXX
MFG Date: July, 2021
Manufacture, use and/or sale under one or more of the patents listed under: www.ndigital.com/patents

SIU serial number label

Sensor Interface Unit Specifications

Dimensions (l, w, h):	53 mm x 172 mm x 114 mm
Weight:	600 g
Max. number of sensors	8

4.7 Accessories

The following accessories are available for the Aurora® System. Please refer to the document “DDUG-1000-2236 Cables and Accessories”, which can be downloaded from the NDI Support Site.

Note:
Accessories for the Aurora® System are under continual development. For a list of current accessories and applications, contact NDI.

Mounting Arm for Planar 20-20 Field Generator

The Mounting Arm is designed to help position the Planar FG 20-20 Field Generator. This metal arm incorporates several articulated joints that enable you to position the Planar FG 20-20 Field Generator at the desired position and angle.
The Mounting Arm can be used with one clamp:

- A general purpose clamp that attaches to a table, counter edge or T-rail

Warning:
When using the mounting arm to mount the Planar 20-20 FG, ensure that FG is mounted correctly.
The mounting arm segment between the adjustment handle and the plastic segment is ferromagnetic and can adversely affect the Aurora® System. The FG must be mounted so that there is a minimum of 20 cm between the FG and this segment. Mounting the FG too close to the ferromagnetic mounting arm segment can increase the possibility of inaccurate transformations and possible personal injury.

Note:
The Mounting Arm can be used with a general purpose clamp that attaches to a table, counter edge or T-rail.

Sensors

A variety of miniature 5DOF and 6DOF sensors are available in several different configurations, allowing for many integration options.

For more information, please contact NDI or see section 12.7 „Degrees of Freedom“ on page 52.

Ready-to-Use Tools

NDI offers several ready-to-use tools, which reduce integration efforts and enable rapid application development. These tools incorporate everything required to begin tracking right out-of-the-box, including the sensor, cabling, enclosure, connection, and firmware components. Ready-to-Use Tools are not approved for medical use.

Accessories for Building Custom Tools

- **Tool Cable Assembly:** The tool cable assembly contains everything required to build an Aurora® tool. All that is required is to solder the lead wires from one 6DOF sensor (or up to two 5DOF sensors) and program the SROM device.
- **Tool Cable and Connector Components:** Tool cable, connectors and SROM devices are also available separately.
- **6D Architect:** Will be replaced by Cygna-6D.

4.8 Host Computer Requirements

A (customer-supplied) host computer is required to operate the system. The host computer must be approved to IEC 60950 or IEC 60601 standard and should meet the following minimum specifications:

- There are two possible communication interfaces to the Aurora® System: Isolated RS-422 port and USB
- 1 GHz or faster 32-bit (x86) or 64-bit (X64) processor
- 1 GHz or faster 32-bit (x86) or 64-bit (X64) processor
- 1 GB RAM (32-bit) or 2GB RAM (64 bit)
- 16 GB available hard disk space (32-bit) or 20 GB (64-bit)
- DirectX 9 graphics device with WDDM 1.0 or higher driver
- Operating system options:
  - Windows 7 (64 bit), 8 and 10
  - 64bit Linux Kernel 2.6.35 and later, and 3.0 and later
  - Mac OS X 10.10 and later
- Screen resolution 1024 x 768 (1280 x 1024 recommended)
- Gigabit network interface is recommended

4.9 Service Life / Disposal

The Aurora® System’s expected service life is approximately eight years. To ensure environmentally responsible disposal after decommissioning, please contact NDI.

5 Software and Drivers Installation

5.1 Aurora® Software

The NDI software can be downloaded from the NDI Support Site.
NDI provides the following software for use with the Aurora® System:

NDI Combined API Sample

A sample of source code to help you better understand the API commands designed specifically for NDI measurement systems. Use this application along with the “DDUG-010-466 Aurora® Application Program Interface (API) Guide” when designing your own software application.

NDI ToolBox

A collection of utilities that allow you to configure, upgrade, troubleshoot, and test the Aurora® System.

Cygna-6D

This NDI software can be downloaded from the NDI support site.

USB Drivers

The USB drivers are downloaded as part of the NDI ToolBox installation.

In addition, you can write your own software application using the Aurora® Application Program Interface (API) Guide. See the “DDUG-010-466 Aurora® Application Program Interface (API) Guide” for details.

5.2 USB Driver Installation

NDI ToolBox 5.002.022 Release Note

Read this before using the software:

- USB Driver Installation - Windows
- USB Driver Installation - Linux
- USB Driver Installation - Mac OS X
- GStreamer Installation - Windows
- GStreamer Installation - Linux

as well as other information on:

- What's new in NDI ToolBox
- Known Issues

USB Driver Installation – Windows

USB drivers are required to connect to the Polaris Spectra, Polaris Vicra, and current Aurora® Systems. The USB drivers are downloaded as part of the NDI ToolBox installation. The default download location is:

C:\Program Files\Northern Digital Inc\ToolBox\USB Driver

The drivers are also located on the Product installation media, in the USBDrivers folder.

Note:
Connect the USB Adapter before installing the drivers.

Install the drivers for Windows 7, 8.1 and 10 as follows:

When you first connect the NDI SCU or NDI Host USB Converter to the host computer, an error message may appear over the task bar. Ignore the message and complete the following steps to install the USB drivers:

1. From the Windows menu, select **Control Panel**.
2. In the top right hand corner of the Control Panel window, select **View by: Small Icons**.
3. From the Control panel, select **Device Manager**.
4. Under **Other Devices**, right click **NDI Host USB Converter**.
5. Select **Update Driver Software...** then select **Browse my computer for driver software**.
6. Select **Program Files\Northern Digital Inc\ToolBox\USB Driver**. Select **Next**.
7. In the Windows security dialog, select **Install this driver software anyway option**.
   The first set of drivers will install.
8. After the first set of drivers are installed, browse to **Other Devices** and right click **USB Serial Port**.
9. Select **Update Driver Software...** then select **Browse my computer for driver software**.
10. Select **Program Files\Northern Digital Inc\ToolBox\USB Driver**. Select **Next**.
11. In the Windows security dialog, select **Install this driver software anyway option**.
    The second set of drivers will install.

Driver installation is complete, and the system will now appear to be connected through a virtual COM port.

USB Driver Setup – Linux

The USB drivers required to connect to an NDI system that uses a Host USB Converter (Polaris Spectra/Vicra) or SCU (Aurora/Polaris Spectra) are included as part of Linux kernel versions 2.6.32 and later. Patching of these kernels is not required. If using a Linux kernel older than 2.6.32, please contact NDI support.

Note:
In order to access the system from a non-root user account, the account must be added to the „dialout“ groups.

On some older systems it may also be necessary to add it to the „lock, „tty“ or „uucp“ groups.
This can be done with the command

$ sudo usermod -aG dialout <account name>

NDI systems appear as device files „/dev/ttyUSBx“ (where x is enumerated). The driver emulates a standard serial port such that the USB device may be communicated with as a standard RS-232 or RS-422 device.

USB Driver Installation – Mac OS X

USB drivers are required to connect to the Polaris Spectra, Polaris Vicra, and some Aurora® Systems.
The driver installation package is copied to the „USB Driver“ sub-folder of the ToolBox application folder as part of the installation of ToolBox. It can also be found in the „macOS/USB Driver“ sub-folder of the installation media.

To install the USB driver after installing ToolBox:

1. Navigate to the <ToolBox Application folder>/USB Driver folder. Double click on FTDIUSBSerialDriver_Intel_NDI.pkg. The installer will launch.
2. Follow the on-screen instructions to complete the USB driver installation.
3. Restart your Mac.

GStreamer Installation – Windows

If you choose not to install GStreamer along with the ToolBox installation, or you have GStreamer already installed in C:\, your computer's existing installation of GStreamer may not be found by ToolBox's video applications, or it may not have the required plugins. To avoid these issues, you should install GStreamer using the ToolBox installer. If you do not wish to do this, you must solve these two issues manually:

- Add the following GStreamer subdirectories to your %PATH (adjust for actual install location and/or for 32-bit Windows):
  - C:\gstreamer\1.0\x86_64\bin
  - C:\gstreamer\1.0\x86_64\lib\gstreamer-1.0
- Ensure the necessary plugins are installed for NDI ToolBox Video Client. Missing element types will appear in the Console window when the Video Client attempts to set up the GStreamer pipeline.

GStreamer Installation – Windows

If you choose not to install GStreamer along with the ToolBox installation, or you have GStreamer already installed in C:\, your computer's existing installation of GStreamer may not be found by ToolBox's video applications, or it may not have the required plugins. To avoid these issues, you should install GStreamer using the ToolBox installer. If you do not wish to do this, you must solve these two issues manually:

- Add the following GStreamer subdirectories to your %PATH (adjust for actual install location and/or for 32-bit Windows):
  - C:\gstreamer\1.0\x86_64\bin
  - C:\gstreamer\1.0\x86_64\lib\gstreamer-1.0
- Ensure the necessary plugins are installed for NDI ToolBox Video Client. Missing element types will appear in the Console window when the Video Client attempts to set up the GStreamer pipeline.

If you already have GStreamer installed at C:\gstreamer, the ToolBox installer will not upgrade with necessary plugins unless it is run manually. You can run manually after ToolBox is installed using the gstreamer-1.0-x86_64-1.14.1.msi installer located in the installation directory.

GStreamer Installation – Linux

Although Windows and Mac OS X installers for ToolBox are packaged with a distribution of GStreamer, the Linux installer is not. Most, if not all, Linux distributions provide packages of GStreamer. You should find these in your distribution's package repository.

Note that some distributions split the GStreamer plugins up further than the upstream sources. Additionally, some distributions do not include the gst-plugins-bad, gst-plugins-ugly, and gst-libav packages in their main repository, for legal reasons.

For more information, visit Installing GStreamer on Linux.

What's new in NDI ToolBox 5.002

- Capture:
  - Supports image capture of color video frames for directly-connected and proxied Polaris Vega VCUs.
  - Supports image capture with Polaris Vegas using LEMO connector.
  - Snap button is disabled while images are being loaded.
- Configure:
  - Support for Polaris Vega VCUs.
  - Displays active feature keys on the main system screen for Polaris systems.
  - Recognizes the Polaris Vega Safe Mode alert flag.
  - Added Restore to Defaults option to context menu on parameters and parameter trees.
- Does not send the 0x0002 BX option by default to Aurora® in the Track utility.
- Shows warnings if connected to a Polaris Vega as a monitor connection instead of as a master.
- Introduced optional Video Client application to demonstrate the Polaris Vega VCU capabilities. Supports tracking data overlays, snapshots and recordings, and system configuration.
- Added support for Aurora® type SROM files in the SROM utility.
- IGTLink: fixed bug where the server continued to attempt to send messages to disconnected clients and stayed open.

What's new in NDI ToolBox 5.001.018

- Windows serial port support: COM ports above COM9 are supported.

What's new in NDI ToolBox 5.001

1. Support for Polaris Vega MR250.
2. Uses streaming to acquire tracking data from Polaris Vega with no missed data frames.
3. Minor improvements to FUU process for Polaris Vega.
4. Polaris Krios and Vicra volume views are drawn more accurately in Track application.
5. Fixed a number of minor defects.
6. Mac OS X package installer is code-signed by NDI.

FTDI VCP USB drivers updated for Windows and Mac OS X, fixing hot unplug issue.
- Windows driver updated to v2.12.28 (2017) from 2.8.28 (2013).
- Mac OS X driver updated to v2.4.2 (2017) from 2.2.16 (2011).

What's new in NDI ToolBox 5.000

1. Support for the Polaris Vega system
2. Support for additional Aurora® Field Generators
3. Built and deployed with 64-bit Java 8
4. Support for Windows 10
5. OS X 10.11 and signed drivers

What's new in NDI ToolBox 4.007

1. Support for the Aurora® V3 system and multiport SIU
2. Updated online help
3. Support for Mac OS 10.8
4. Support for Windows 8
5. Windows Hardware Quality Labs (WHQL) signed USB drivers

What's new in NDI ToolBox 4.005

1. Various defect fixes
2. Support for the Mac OS 10.7

What's new in NDI ToolBox 4.003

1. Support for the Aurora® Tabletop Field Generator

What's new in NDI ToolBox 4.002

1. Support for a higher baud rate (921,600) for the Aurora® System
2. Support for the new SCU for the Aurora® System

Known Issues

1. On rare occasions on some networks ToolBox may fail to reconnect to a Polaris Vega system after an FUU update is complete or after a reset initiated from the File menu. Reconnecting using the File->Connect menu resolves the issue.
2. If you are connecting to a Polaris Vega from a Mac on a statically configured network interface auto-discovery may not work unless you add a route for multicast DNS traffic (address 224.0.0.251) to the interface.
3. On Windows 7 if the CPU goes to sleep the USB driver may not wake up properly and communication will not resume unless the port is closed and re-opened.
4. Linux kernel versions 2.6.33 and 2.6.34 contain a defect that renders the FTDI usb serial driver inoperative.
   These kernel versions cannot be used with the Spectra, Vicra and Aurora® products.
   The defect is fixed in kernel 2.6.35 and later versions.
5. On some Windows machines, the GStreamer installer packaged with ToolBox has installed to another drive than C:\, but the %PATH environment variable points to the C:\ drive. To correct, find the installation of GStreamer and fix the %PATH environment variable to point to the drive where GStreamer was installed.

5.3 Installing the Software and Drivers: Linux

NDI Combined API Sample

NDI Combined API Sample: This NDI software can be downloaded from the NDI Support Site.

Note:
The NDI Combined API Sample contains an application and source code. The application is written to run on a Windows operating system; however, you can still view the source code on a Linux system.

NDI ToolBox

Install NDI ToolBox as follows:

1. Linux/ToolBox/install.bin. - This NDI software can be downloaded from the NDI Support Site.
2. Follow the on-screen instructions to complete the process.
   The default installation location is <user_account > /ToolBox.

Note:
The NDI ToolBox download includes a Java virtual machine (VM) for Windows and Linux systems. The Java VM included in the NDI ToolBox download is fully compatible with NDI ToolBox. Other versions of Java VM may cause NDI ToolBox to exhibit unusual or unpredictable behaviour.

USB Drivers

The USB drivers are included as part of the ToolBox software installation and built on Linux kernel versions 2.6.32 and later. Patching of these kernels is not required. Patches for specific older versions are downloaded as part of the ToolBox installation and are located in the ~/NDIToolbox/ usb-patch folder. The files are also located on the ToolBox installation CD, in the Linux > usbpatch folder.

Connected NDI systems appear as device files /dev/ttyUSBx (where x is enumerated). The driver emulates a standard serial port such that the USB device may be communicated with as a standard RS-232 or RS-422 device.

If you plan to access the system from a non-root user account, you will need to add the account to the “lock” and “dialout” groups. On some older systems it may also be necessary to add the account to the “tty” and “uucp” groups. You can add the account the required groups using the following command in Terminal and then restarting the machine:

sudo usermod -G lock,dialout <account name>

To install and run ToolBox on a 64-bit system, the 32-bit libraries will need to be installed first. You can do this using the following sequence of commands in Terminal (the first two commands in italics are only required on Debian systems):

sudo dpkg --add-architecture i386

sudo apt-get update

sudo apt-get install ia32-libs

On Debian systems, permissions may be required to install ToolBox. You can grant these permissions by mapping to the location of the install.sh file and using the following command in Terminal: *sudo chmod a+x install.sh*

To Install the USB Patches:

The instructions below are based on the Linux 2.6.x kernel, where 2.6.x is the kernel version number. The following changes are captured in the ftdi.patch file. The patch file is located in the *<user_account>/usb-patch/* directory after ToolBox has been installed.

Note:
These instructions and the supplied patches have been tested with specific kernel versions. If you are using a different kernel version, the patch file may not work. Only apply the patch appropriate to your kernel version. Do not apply the patch more than once. Patches are available for 2.6.8, 2.6.20, 2.6.23 and 2.6.28. (Version 2.6.28 will also work on version 2.6.30.)

The patch modifies the files *ftdi_sio.c* and *ftdi_sio.h* in the directory */usr/src/linux-2.6.x/drivers/ usb/serial*.

The modifications are:

ftdi_sio.c - added Polaris Spectra/Vicra SCU/Host USB Converter product ID to supported devices tables, added aliasing of 19.2KBd for the Polaris Spectra or Polaris Vicra System to use 1.2 MBd, and optimized transmit latency setting.

ftdi_sio.h - added the define for the USB product ID for the Polaris Spectra/Vicra SCU/Host USB Converter.

1. Apply the patch to an unmodified kernel as follows:
   a) Log on as root user.
   b) Execute the command *cd /usr/src/linux-2.6.x*
   c) Create backups of the files *./drivers/usb/serial/ftdi_sio.c* and *./drivers/usb/serial/ ftdi_sio.h*
   c) Execute the command *patch -p1 < ftdi-usb-patch-kernel-2.6.x.patch*

2. If the driver is a kernel-loadable module, apply the patch as follows:
   a) Execute the command *make modules*
   b) Execute the command *make modules_install*
   c) Restart the computer.

3. If the driver is not a kernel-loadable module, rebuild the kernel following the instructions specific to the kernel. If you are unfamiliar with kernel rebuilding, refer to the instructions usually located in the source directory or at www.kernel.org.

4. The SCU or Host USB Converter when connected will appear as /dev/ttyUSBx (where x is enumerated).

SCUs are interchangeable on the same USB port, without having to re-install drivers or losing the device file enumeration previously established, as long as all serial converters (NDI or other FTDIbased converters) are plugged in and enumerated in the same order.

5.4 Installing the Software and Drivers: Mac OS X

Additional System Requirements

The system requirements for the Mac OS X are as follows:

- Java Version: Minimum: Java 2 Platform Standard Edition 5.0 (J2SE 5.0 build 1.5.0_xx). (If you have an older version of Java you will need to download an update from the Apple Web site.) To determine which version of Java you have, launch the Terminal application and at the command prompt, enter: *java -version*.
- Account Permissions: To manage NDI software on a Mac platform you will need administrator account privileges.

NDI Combined API Sample

NDI Combined API Sample: This NDI software can be downloaded from the NDI Support Site.

Note:
The NDI Combined API Sample contains an application and source code. The application is written to run on a Windows operating system; however, you can still view the source code on a Mac platform.

Installing and Running NDI ToolBox

Install NDI ToolBox as follows:

1. NDI ToolBox: This NDI software can be downloaded from the NDI Support Site.
2. In the MacOSX folder, locate and open the ToolBox sub-folder.
3. In the ToolBox folder, locate and double-click on the **install.dmg** file. Double click on NDI ToolBox Installer and enter your administrator password.
4. Follow the on-screen instructions to complete the installation procedure.
   To run NDI ToolBox you can connect to the system using either:
   - /dev/cu.usbserial-xxxxxxxx
     or
   - /dev/tty.usbserial-xxxxxxxx

The USB driver creates two possible Virtual COM Ports (VCP) connection methods to the Aurora® System. This is for backwards compatibility with access via BSD UNIX-style device methods. The tty methods were traditionally meant to be used for call-in connections and the cu methods for callout connections. NDI ToolBox will work correctly when either of the connections is chosen.

Each NDI ToolBox Utility (Configure, Tool Tracker, Terminal Window, Console) runs in its own window. To switch between them select Command-Accent (`).

USB Drivers

Install the USB driver as follows:

1. USB driver: This NDI software can be downloaded from the NDI Support Site.
2. In the MacOSX folder, locate and open the USB Driver sub-folder.
3. Double-click on FTDIUSBSerialDriver (NDI).pkg. (This file is also placed in the ToolBox installation folder, during ToolBox installation.)

Follow the on-screen instructions to complete the installation procedure.

Note:
The driver supplied with NDI ToolBox is necessary for the creation of a VCP software interface to the Aurora® System. The driver is a Mac OS X kernel extension provided by FTDI and configured by NDI to support the Aurora® System.

Activating the VCP

Activate the VCP as follows:

1. Restart the Mac host computer. (If you have been following the previous installation procedures, the computer will have already restarted.)
2. Connect the Aurora® System to one of the Mac host computer USB ports.
3. From the Apple menu, select System Preferences..., then select the Network icon. Select OK on the resulting dialog box.
4. If necessary, “unlock” the lock icon (located in the lower left of the dialog box) and enter your password.
   a) Mac OS X 10.5 and above: Click the Apply button. (This will activate the VCP.)
      Quit the System Preferences application.
   b) Mac OS X 10.4: Proceed with steps 5 and 6 below.
5. From the Show drop-down menu, select Network Port Configurations. The newly created VCP for the Aurora® System will be shown at the top of the list.
6. Click the check box next to usbserialxxxxxxxx and click the Apply Now button. This will activate the VCP.
   Quit the System Preferences application.

Note:
A unique VCP will be assigned to each USB port to which the Aurora® System has been connected. This means that, if in the future, you connect the Aurora® System to a different USB port you will have to perform this activation procedure again.

To verify that the Aurora® System is recognized by the VCP driver, launch the System Profiler application (normally found in the Utilities sub-folder within the Applications folder). Expand the Hardware tree in the left-hand Contents pane and click on the USB branch. The USB device tree will appear in the right-hand pane. The Aurora® System should appear under the applicable USB Bus branch.

5.5 Uninstalling the Software and Drivers: Mac OS X

Uninstall NDI ToolBox as follows:

Navigate to Applications > NDI ToolBox and double click on NDI ToolBox Uninstaller application and follow the on-screen instructions. All related NDI ToolBox files and aliases to NDI ToolBox utilities will be removed from your system.

USB Drivers

Remove the USB driver as follows:

1. Launch the Terminal application (normally found in the Applications folder in the Utilities subfolder). At the command prompt, enter the following commands:

   cd /System/Library/Extensions
   sudo rm -r FTDIUSBSerialDriver.kext
   cd /Library/Receipts
   sudo rm -r "FTDIUSBSerialDriver (NDI).pkg"

2. To remove the deactivated VCPs (usbserial-xxxxxxxx) from the system:
   a) Unplug the Aurora® System from the USB port.
   b) Select Apple > System Preferences... > Network.
   c) From the Show drop down menu, select the Network Port Configurations. The menu will display a deactivated port as greyed out. Select the port and click Delete. Confirm the deletion to remove the port.

5.6 Additional Information

The following sections provide additional Mac OS X specific information.

Modified FTDI USB to Serial Driver

If you have other devices (such as a USB to serial port converter) that also use a FTDI VCP driver then installing the driver that is included on the product CD may:

1. Result in a change to the version of the driver previously installed

   and/or

2. Possibly disable access to your other devices.

The NDI configured version of the driver is based on v2.2.7 of the original FTDI VCP driver. If your device is not recognized by this version of the driver, access to your device will be disabled. Please contact NDI for assistance.

Additional Installation Files

During NDI ToolBox installation additional support files are placed outside the selected destination folder. The following files are placed in the /Library/Java/Extensions folder:

- jai_imageio.jar
- jh.jar
- libpivot.jnilib
- librxtxSerial.jnilib
- RXTXcomm.jar

Lock Files and Groups

NDI ToolBox uses lock files to manage requests to access the VCP connections to the Aurora® System. These lock files are kept in the folder /var/lock (hidden from the Finder but accessible via the Terminal application). Access to this folder is available to members of the uucp group. The user account that ran the NDI ToolBox installer was added as a member of the uucp group and the /var/lock folder was created at that time.

If an alternate user account (different from the one that was used to install NDI ToolBox) runs the NDI ToolBox utilities, then make this account a member of the uucp group as follows:

Note:
The following procedure is only applicable to Mac OS X 10.4.x. For information on Mac OS X 10.5 and higher, contact NDI for details.

1. Launch the NetInfo Manager application (normally found in the Applications folder in the Utilities sub-folder).
2. Use the hierarchical navigator to select groups > uucp.
3. Click the lock icon and authenticate (using a userid with administrator privileges).
4. Select the users property in the bottom panel.
5. Select the Directory > New Value menu. Enter the userid of the user account you wish to enter.
6. Click the lock icon and confirm that you wish the modification to become permanent.
7. Quit the NetInfo Manager application. This will allow the alternate user account to run the NDI ToolBox utilities.

Note:
Uninstalling NDI ToolBox does not remove the lock file folder or membership to the uucp group.

NDI ToolBox Preferences

When you exit NDI ToolBox, the states of each utility (window sizes, VCP last connected to, etc.) are saved to the user‘s home folder. These preference files are hidden from viewing in the Finder. They have names of the form .[*]Properties and can be viewed using the Terminal application. Launch the Terminal application (normally found in the Applications > Utilities sub-folder) and enter the following commands:

cd ~
ls -la

Moving NDI ToolBox Files

The NDI ToolBox utility applications (Configure and Tool Tracker) have to reside in a single folder (default is NDI ToolBox). (The Image Capture utility is not applicable to the Aurora® System). Within this directory is a Java file named toolbox.jar. It contains supporting code for the utilities and as such has to be located with the utilities. NDI recommends that you do not manually move the folder from where NDI ToolBox has been installed, otherwise the uninstall application will not operate correctly. If you wish to move where NDI ToolBox is installed, you should first uninstall it and then re-install.

6 Setting up the Aurora® System Hardware

6.1 Unpacking the Aurora® System

The Aurora® System is shipped with:

- Field Generator
  (Planar FG with attached cable, Window FG with separate cable, or Tabletop FG with separate cable)
- System Control Unit (SCU)
- Sensor Interface Unit (SIU)
- SCU-SIU communications cable
- Power cord
- USB cable

When you unpack the Aurora® System, be sure to handle all system components with care. Keep the packaging in good condition; you will need to use it if the system is ever transported.

Note:
See section 24. „Return, Repairs and Warranty“ on page 86 for instructions on returning your system to NDI.

6.2 Mounting the Components

Field Generator

For specific installation instructions for your Field Generator, please refer to the relevant data sheet for your Field Generator.

Warning:
Do not operate the Field Generator within 10 m of another operating Field Generator. To do so may contribute to inaccurate transformations and possible personal injury.

SCU and SIU

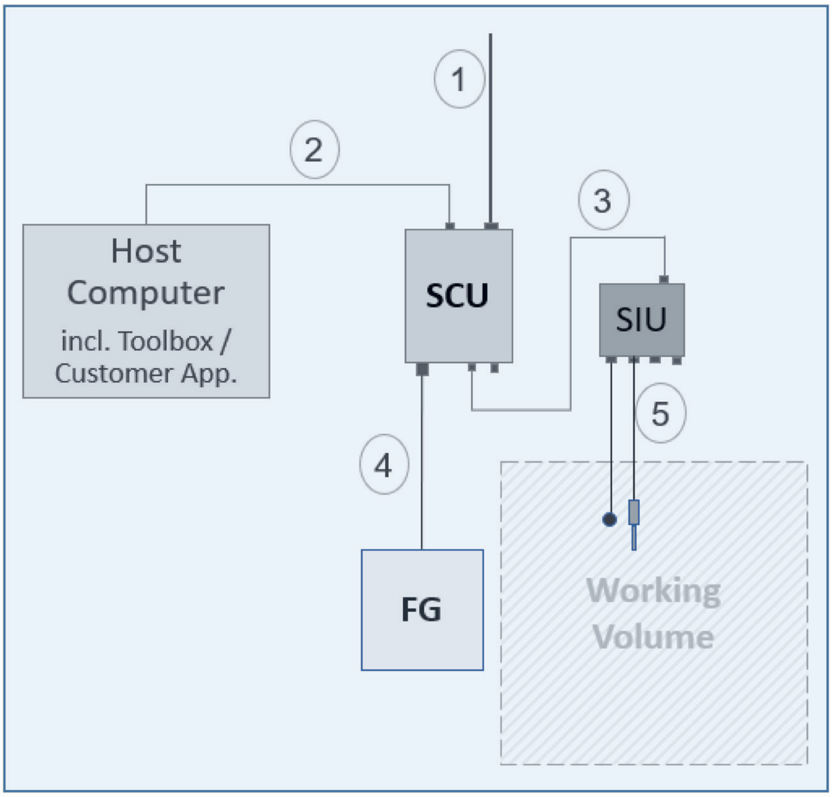
Place the SCU and the SIU on a flat surface. It is important to position the Aurora® System components and cables correctly to minimize interference and avoid inaccurate transformations. Follow these warnings when setting up the Aurora® System hardware components:

Warning:
Do not place the SCU or SIU within 1 m of the Field Generator. To do so may affect the measurement volume, contributing to inaccurate transformations and possible personal injury.

Do not place Aurora® sensors, tools or Sensor Interface Units directly on the Tabletop Field Generator. Doing so will increase the risk of interference of the Tabletop Field Generator magnetic field. Such interference may produce misleading transformations which may result in possible personal injury.

Make sure that the SCU is positioned so that the operator cannot touch the SCU and patient simultaneously.
Failure to do so may result in personal injury.

Aurora® - Wiring diagram



Part	Description
1	Power cord connected to power entry module incl. switch (SCU back side)
2	USB / RS422 cable (SCU back side)
3	SCU - SIU connection cable: 2 SIU ports (Redel, SCU front side) to SCU port (Redel, SIU back side)
4	FG cable – connected to FG and FG port (Lemo, SCU front side)
5	Sensors / Tools incl. cables connected to Tool ports (Redel, SIU front side)

6.3 Cable Management

It is important to position the Aurora® System components and cables correctly to minimize interference and avoid inaccurate transformations. Follow these warnings when setting up the Aurora® System:

Warning:

Do not place the Field Generator cable inside the measurement volume or wrap it around the Field Generator, as it may create a magnetic interference. This interference can contribute to inaccurate transformations and possible personal injury.

Do not coil the Field Generator cable. The cable carries enough electric current that a magnetic field will be created when the cable is placed in a circular formation. This magnetic field may disturb the Field Generator's magnetic field, contributing to inaccurate transformations and possible personal injury.

Do not place the SCU or SIU within 1 m of the Field Generator. To do so may affect the measurement volume, contributing to inaccurate transformations and possible personal injury.

Do not place tool cables within 30 mm of the Field Generator cable. If placed this close - particularly if the cables are parallel to each other - the tool cable may become subject to electromagnetic interference. This interference can contribute to inaccurate transformations and possible personal injury.

Make sure that the cable connecting the SCU to the host computer (USB or RS-422 cable) does not come close to other cables in the Aurora® System.

Do not bend or kink Aurora® System cables or tool cables or use cables that are damaged. Applying transformations from a system with damaged tool cables may result in possible personal injury.

6.4 Operating Environment Considerations

The Aurora® System can be affected by certain metals and by other electromagnetic field sources in the operating environment. When setting up the Aurora® System, read the following warnings, to minimize the possible sources of interference:

Warning:

Do not track in an untested application environment, as it may contain elements that affect Aurora® System functions. For example, the system can be adversely affected by electromagnetic field disturbances from other objects in the room, the close proximity of metal, and the close proximity of another Field Generator. Failure to test for such disturbances will increase the possibility of inaccurate transformations and possible personal injury.

The Aurora® System has not been designed or tested to be used during or following cardiac defibrillation. Cardiac defibrillation may cause inaccurate transformations and result in possible personal injury.

Do not expose sensors to a high magnetic field, such as a Magnetic Resonance Imaging (MRI) scanner, as they may become magnetized. Tracking with a magnetized sensor may result in incorrect transformations and result in possible personal injury.

Do not use the Aurora® System in the presence of other magnetic fields. To do so may lead to misleading or inaccurate transformations and possible personal injury.

Portable RF communications equipment (including peripherals such as antenna cables and external antennas) should be used no closer than 30 cm (12 inches) to any part of the Aurora® System, including cables specified by the manufacturer. Otherwise, degradation of the performance of this equipment could result. This may contribute to inaccurate transformations and possible personal injury.

Do not operate the Field Generator within 10 m of another operating Field Generator. To do so may contribute to inaccurate transformations and possible personal injury.

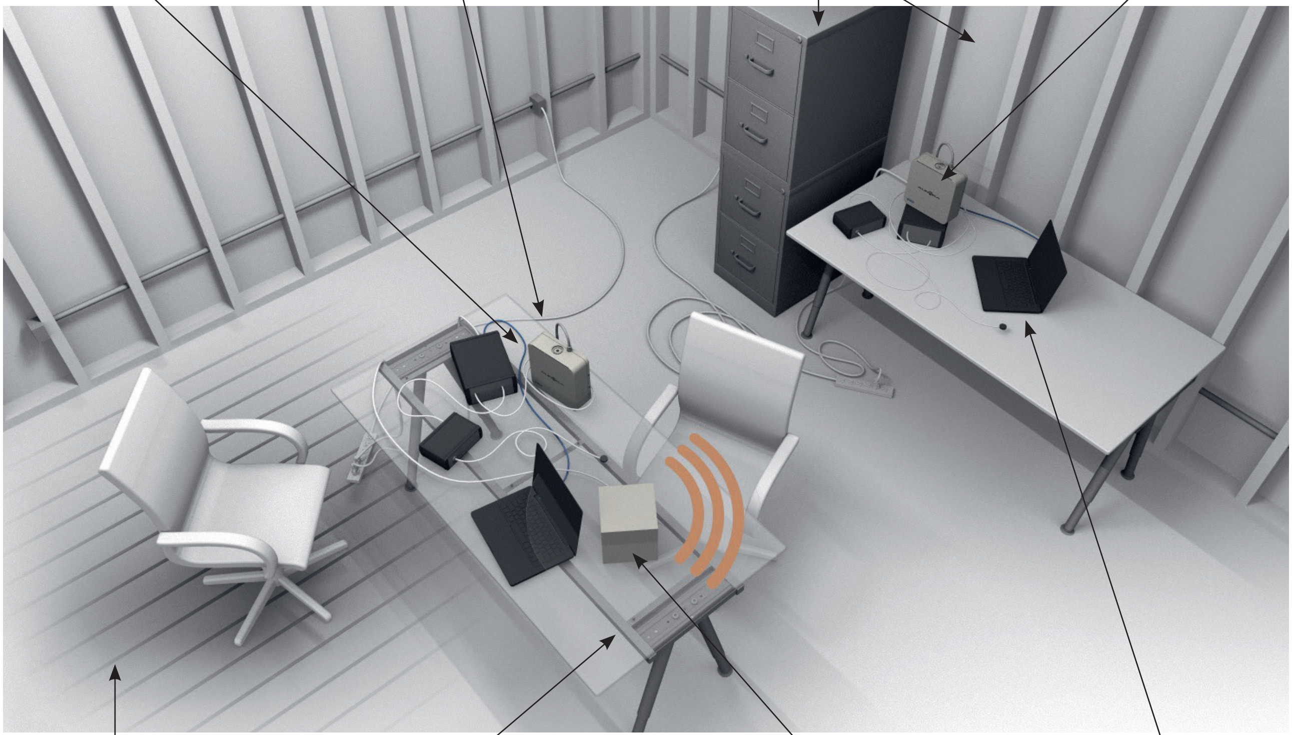
This figure shows common sources of disturbances, which you should try to avoid or minimize in your setup. For more information on how environmental factors affect the Aurora® System, see section 13.2 „Interference and Distortions“ on page 55 and 13.3 „Effects of Nearby Metal on the Aurora System“ on page 56.

The cables should not be coiled, and should not be inside the FG measurement volume.

The FG is too close to the SCU and SIU. The FG should be at least 1 m away from the SCU and SIU.

There may be metal in the walls or nearby objects. If possible do not position the Aurora® FG close to the wall or to metal objects.

The FG should be at least 10 m away from any other Aurora® FG being used simultaneously.



There may be metal in the floor. If possible do not position the Aurora® FG close to the floor.

There may be a metal frame under the table, which may cause disturbances. The metal loop formed by the frame creates eddy currents.

Other EM- and/or RFemitting devices may cause disturbances if placed too close to the FG.

Electronic devices (e.g. laptop) may cause disturbances if placed too close to the FG.

6.5 Connecting the Components

Read the following cautions and warnings before you connect the Aurora® System components.

Caution:

Do not push or pull connectors in constricted areas. Doing so may damage the connectors.

Do not put heavy objects on cable connectors. Doing so may damage the connectors.

Do not leave cable connectors where they can be damaged, particularly on the floor, where they can easily be stepped on and damaged.

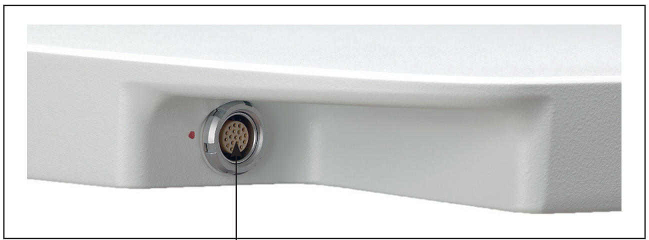
Pull connections apart by gripping the connector. Do not pull them apart by tugging on the cable as this can damage the connecting cable. Never force a connection or a disconnection.

Warning:

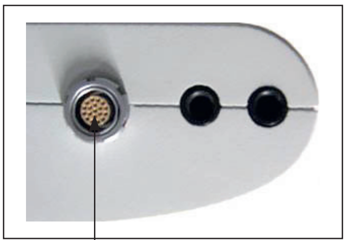
Do not use cables or accessories other than those listed in this guide, with the exception of those sold by NDI and NDI-authorized manufacturers. To do so may result in increased emissions and/or decreased immunity of the Aurora® System.

Connect the Aurora® System components as follows:

1. Insert the Field Generator cable connector into the Field Generator port (located on the front of the SCU). If your system includes a Tabletop FG or Window FG, connect the Field Generator cable to the FG, making sure that the red alignment marks on the cable and FG are aligned. See the figures.



TTFG Connector:
Field Generator connector alignment mark



WFG Connector:
Field Generator connector alignment mark

2. Connect the Field Generator cable to the FG port on the SCU.
3. Use the SCU-SIU communications cable to connect each SIU to the SCU.
4. Plug each tool into a tool port on the SIU.

Warning:

Ensure that the Aurora® System SCU is connected to an IEC 60950 or IEC 60601 approved workstation. If the SCU is not connected to an IEC 60950 or IEC 60601 approved workstation, leakage currents may be increased beyond safe limits and cause possible personal injury.

4. Use the USB cable to connect the SCU to the host computer. Alternatively, you can use the RS-422 port.
5. Plug the power cable into the power entry module on the SCU.

Warning:

Make sure that the SCU is only connected to a mains supply that has a protective earth. Failure to do so may result in electric shock and personal injury.

6. Turn on the system using the power switch on the SCU.

If the Aurora® System is operating correctly, the following occurs:

- The SCU will beep twice.
- The SCU and SIU power light LEDs will be lit green.
- The tool port status lights on the SIU will be lit amber if a tool is connected.

Note:
If the system does not operate correctly, refer to section 23. „Troubleshooting“ on page 80.

6.6 Using the Aurora® System

Read the following warnings before using the Aurora® System:

Warning:

Do not use the Aurora® System if any of the hardware components or connectors are damaged. Such damage may affect system functions and contribute to inaccurate transformations and possible personal injury.

Do not drop the Field Generator or subject it to impact. This may alter the Field Generator's calibration and contribute to inaccurate transformations and possible personal injury. If an impact occurs, check the accuracy or alternatively send it back to NDI for accuracy check/re-calibration.

Do not move the Field Generator while tracking an object. The system may produce misleading transformations and result in possible personal injury.

Do not operate the Field Generator within 200 mm of an installed pacemaker. The magnetic field produced by the Field Generator may interfere with the operation of the pacemaker. This interference may result in personal injury.

Hot-Plugging Components

Tools can be disconnected and reconnected into any SIU while the system is still running (hotplugging). SIUs can also be hotplugged into the SIU ports on the SCU.

Warning:

Do not disconnect the Field Generator from the system while tracking. Disconnecting the Field Generator while in tracking mode may result in sparks being generated, and possible personal injury.

7 Planar Field Generator

The Planar Field Generators are designed for a wide variety of clinical applications.

There are three types of Planar Field Generators:

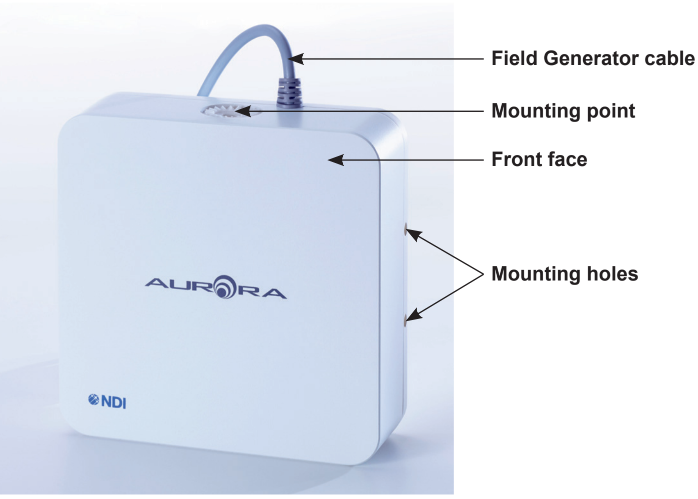
1. Planar 20-20 FG
2. Planar 10-11 FG
3. Planar 10-11H FG

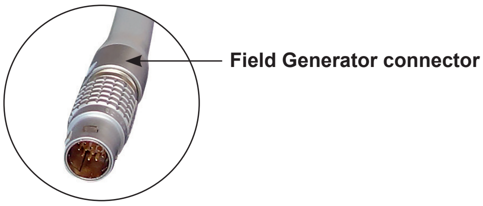
7.1 Description

Planar 20-20 FG

The Planar 20-20 FG is described in the following table and illustrated in figure.

Part	Description
Front face	The origin of the characterized measurement volume is on the front face. The characterized measurement volume (where it is possible to track) is on this side of the FG. The type label is on the back side.
Mounting point	Designed to attach the Field Generator to the NDI Aurora® Field Generator Mounting Arm, described section 4.7. „Accessories“ on page 16.
Field Generator connector	Connects the Field Generator cable to the SCU. The Field Generator connector is a 19-pin circular metal connector.
Field Generator cable	Connects the Field Generator to the SCU.
4 mounting holes, 2 per side	M8 tapped holes (thread pitch 1.25 mm, depth 13 mm). Allows the Field Generator to be attached firmly to a fixture.



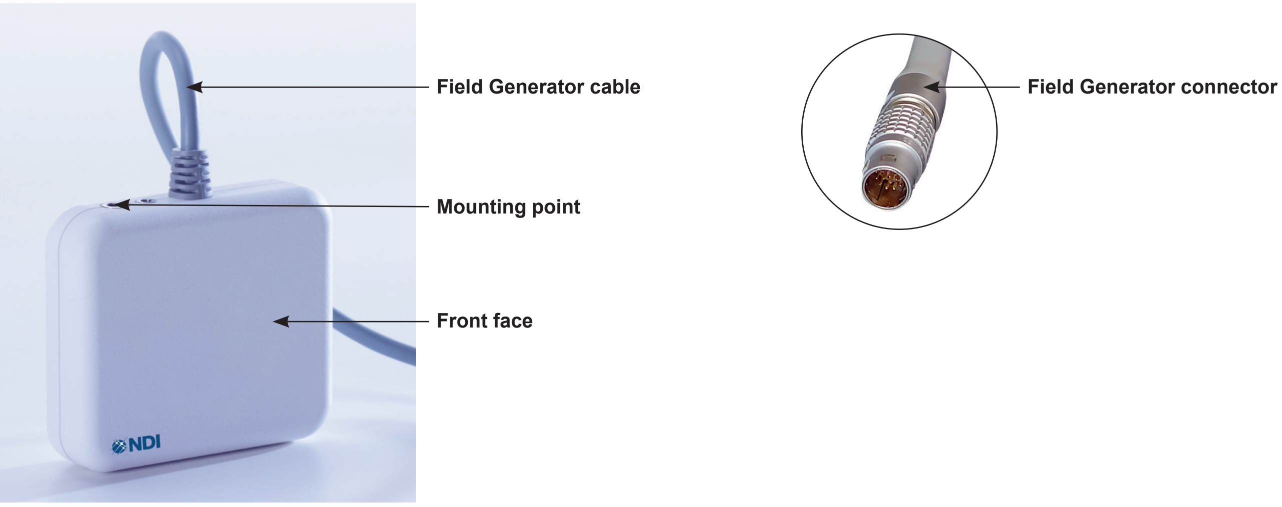


Planar 10-11 FG and Planar 10-11H FG

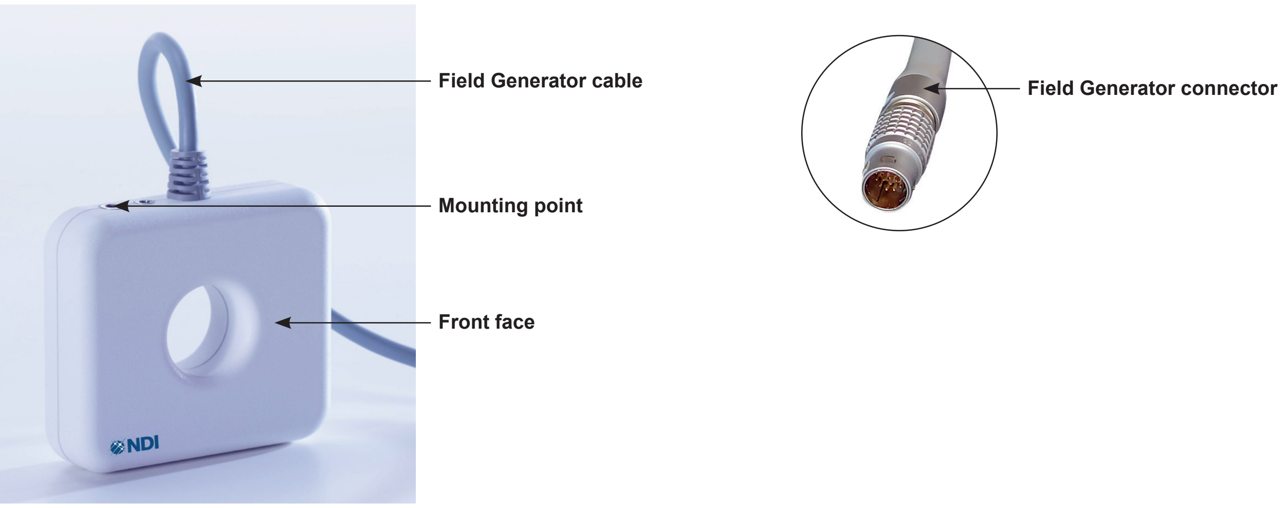
There are two variants of the Planar 10-11 FG: with or without a center hole. The dimensions and technical specifications of both variants are identical, including measurement volume and accuracy.
For details on each Field Generator, please refer to the corresponding data sheet.

The Planar 10-11 FG and Planar 10-11H FG are described and illustrated below.

Part	Description
Front face	The origin of the characterized measurement volume is on the front face. The characterized measurement volume (where it is possible to track) is on this side of the FG. The type label is on the back side.
Field Generator connector	Connects the Field Generator cable to the SCU. The Field Generator connector is a 19-pin circular metal connector.
Field Generator cable	Connects the Field Generator to the SCU.
Mounting point	Mounting interface designed to attach the Field Generator to a mounting device.



Planar 10-11 FG



Planar 10-11H FG

7.2 Planar Field Generator Measurement Volume & Technical Data

The measurement volume is the volume where data is collected and used to characterize the Field Generator. It is a subset of the detection region (the detection region is the total volume in which the Field Generator can detect a sensor, regardless of accuracy).

The technical data for the Field Generators can be found in the corresponding data sheets. Each FG's data sheet contains information including:

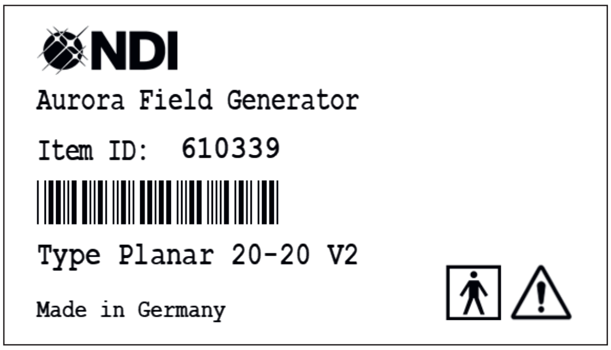
- Measurement volume description and accuracy specifications
- Mounting information
- Technical specifications
- Usage instructions and safety information

The data sheets are available on the NDI Support Site at https://support.ndigital.com

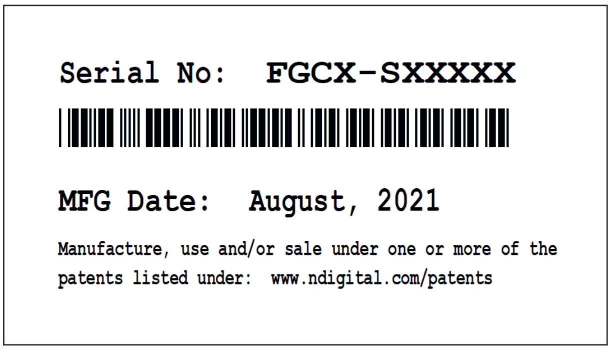
7.3 Planar Field Generator Labels

The Field Generator type and serial number labels are located on the back of the Field Generator.
They show the item ID, model and serial number of the Field Generator.

1. Planar 20-20 FG (e.g. 610339)
2. Planar 10-11 FG (e.g. 610476)
3. Planar 10-11H FG (e.g. 610477)



Planar 20-20 FG type number label



Planar 20-20 FG serial number label

Planar 10-11 FG type number label

Planar 10-11H FG type number label

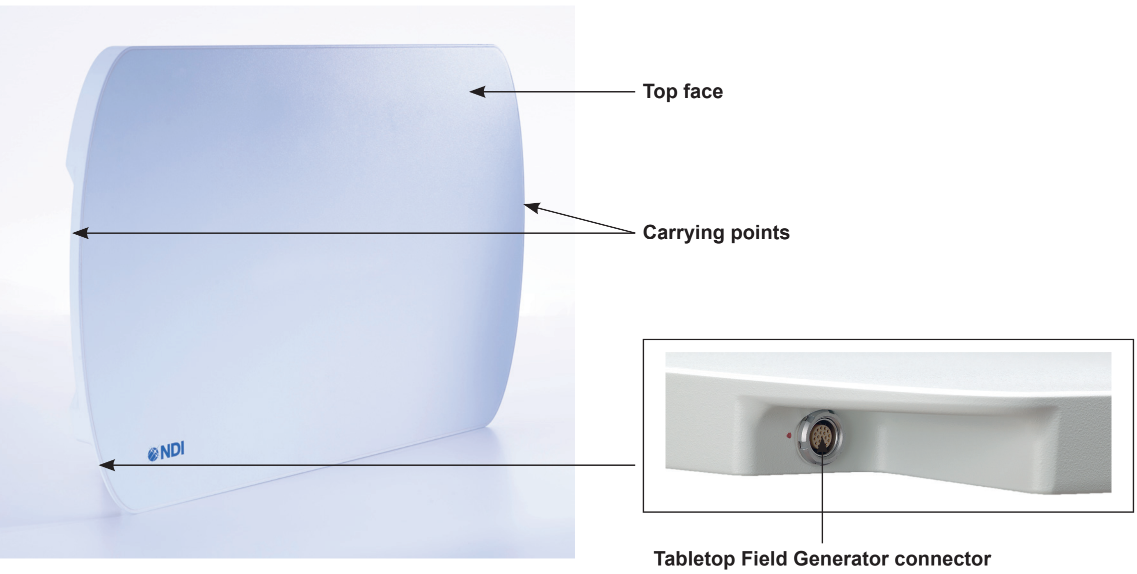
8 Tabletop Field Generator

8.1 Description

The Tabletop Field Generator (TTFG) is designed to be placed on a patient table, between the patient and the table. The Tabletop Field Generator incorporates a thin barrier that minimizes any tracking distortions caused by conductive or ferromagnetic materials located below the Tabletop Field Generator. Maximum load of the Tabletop Field Generator is 135 kg.

The following describes and illustrates the Tabletop Field Generator.

Part	Description
Top face	Origin of the characterized measurement volume.
Carrying points	Two carrying points are moulded into the Tabletop Field Generator case, as shown below.
Field Generator connector	Connects the Tabletop Field Generator cable to the SCU. The Tabletop Field Generator connector is a 19 pin circular metal connector.
Field Generator cable (not shown)	Connects the Tabletop Field Generator to the SCU, via a 19 pin, 4.5 m cable.



8.2 Tabletop Field Generator Measurement Volume & Technical Data

The measurement volume is the volume where data is collected and used to characterize the Field Generator. It is a subset of the detection region (the detection region is the total volume in which the Field Generator can detect a sensor, regardless of accuracy).

The technical data for the Field Generators can be found in the corresponding data sheets. Each FG's data sheet contains information including:

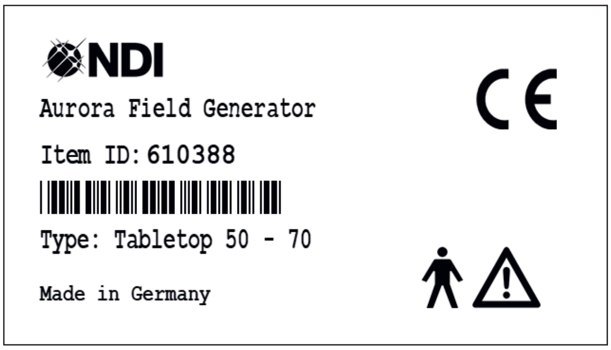
- Measurement volume description and accuracy specifications
- Mounting information
- Technical specifications
- Usage instructions and safety information

The data sheets are available on the NDI Support Site at https://support.ndigital.com

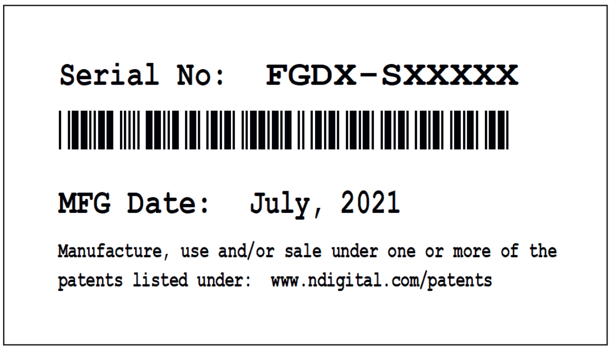
8.3 Tabletop Field Generator Labels

The Tabletop Field Generator type and serial number labels are located on the bottom side of the Tabletop Field Generator. They show the item ID, model and serial number of the Tabletop Field Generator.

- Tabletop Field Generator (e.g. 610388)



Tabletop Field Generator type number label



Tabletop Field Generator serial number label

9 Window Field Generator

9.1 Description

The Window Field Generator (WFG) is designed to be mounted under a patient table. The Window Field Generator is designed for applications in which x-ray imaging is needed.

The availability of two different operating frequencies enables the integration of the WFG into environments where motorized tools are used, to prevent interference from tools with similar frequencies.

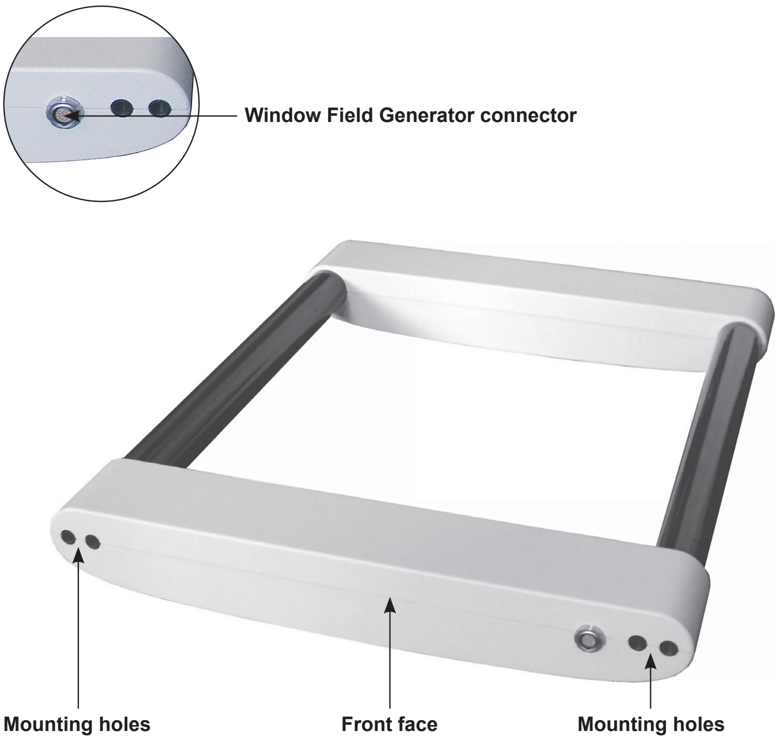
There are two types of Window Field Generators:

1. WFG II-8
   Data sheet 610445
2. WFG II-32
   Data sheet 610460

The WFG II series is also capable of supporting a wider variety of sensors, specifically those with smaller dimensions than typical sensors. The WFG II series is available in two different operating frequencies, 800 Hz (WFG II-8) and 3200 Hz (WFG II-32). The WFGs of both types are identical in size, shape, external dimensions, and with respect to mounting, but differ in weight and measurement rate.

Note:
The wires in the Window Field Generator are visible in x-ray images.

Part	Description
Window Field Generator connector	Connects the Field Generator cable to the SCU. The Window Field Generator connector is a 19 pin circular metal connector.
8 mounting holes, 4 per side	M8 tapped holes (thread pitch 1.25 mm, depth 12 mm). Allows the Window Field Generator to be attached firmly to a fixture. Use only plastic screws.



9.2 Window Field Generator Measurement Volume & Technical Data

The measurement volume is the volume where data is collected and used to characterize the Field Generator. It is a subset of the detection region (the detection region is the total volume in which the Field Generator can detect a sensor, regardless of accuracy).

The technical data for the Field Generators can be found in the corresponding data sheets. Each FG's data sheet contains information including:

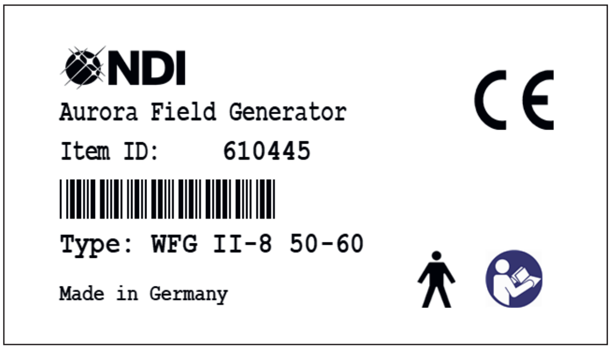
- Measurement volume description and accuracy specifications
- Mounting information
- Technical specifications
- Usage instructions and safety information

The data sheets are available on the NDI Support Site at https://support.ndigital.com

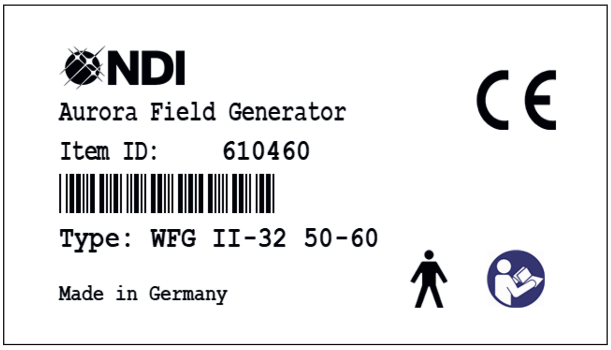
9.3 Window Field Generator Labels

The Window Field Generator type and serial number labels are located on the back of the Window Field Generator. They show the item ID, model and serial number of the Window Field Generator.

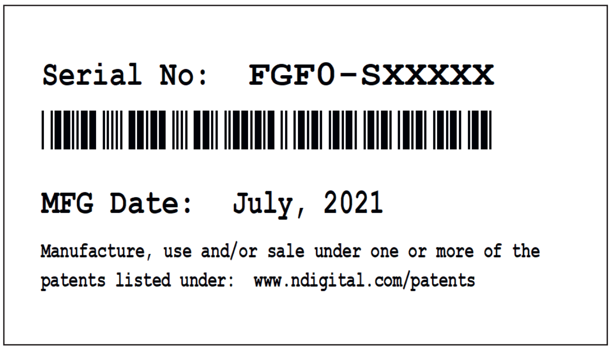
1. WFG II-8
   Data sheet 610445
2. WFG II-32
   Data sheet 610460



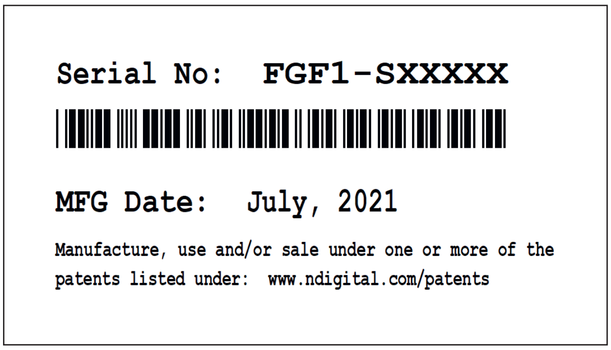
Window Field Generator II-8 (WFG) type number label



Window Field Generator II-32 (WFG) type number label



Window Field Generator II-8 (WFG) serial number label



Window Field Generator II-32 (WFG) serial number label

10 Tutorial: Learning to Use the Aurora® System (NDI ToolBox)

This chapter is intended as a tutorial to demonstrate the basic functionality of the Aurora® System using NDI ToolBox. For more detailed information on NDI ToolBox, refer to the NDI ToolBox online help. The tutorial is designed for first time users of the system to:

- set up the system to track tools,
- observe error and information flags while tracking tools,
- track using a reference tool, and
- pivot a tool to determine the tool tip offset.

10.1 Getting Started: Tracking Tools

This section describes how to set up the system to track tools.

To Set Up the System

1. Install NDI ToolBox, as described in section 5. „Software and Drivers Installation“ on page 18.
2. Set up and connect the hardware, as described in section 6.5 „Connecting the Components“ on page 32.
3. Open NDI ToolBox.
4. If NDI ToolBox does not automatically connect to the system, select either:
    - File > Connect to > (COMx) (Windows)
      or
    - File > Connect to > (/dev/ttySx) (Linux)
      or
    - File > Connect to > (/dev/cu.usbserial-xxxxxxxx) or (/dev/tty.usbserial-xxxxxxxx) (Mac)

Note:
There are two possible connection methods for Mac users. This is to allow for backwards compatibility, with access via BSD UNIX-style device methods. The tty methods were traditionally meant to be used for call-in connections and the cu methods for call-out connections. NDI ToolBox will work correctly with either connection method.

To Track Tools

1. If the tool tracking utility is not open, click  to open it.
2. Connect the tool to the SIU. The system will automatically attempt to track the tool.
3. Move the tool throughout the characterized measurement volume. As you move the tool, the symbol representing the tool in the graphical representation will move to reflect the tool's position.

10.2 Information and Error Flags

This section describes how to trigger the most common flags. Error and warning information for each connected tool is displayed in the bottom right section of the tool tracking utility.

To View Information and Error Flags

1. Set up the system to track tools, as described in section 10.1 „Getting Started: Tracking Tools“ on page 41.
2. For each tool, there is a tab in the bottom right section of the tool tracking utility. Select a tab to display tracking information for a particular tool.

Select a tab to display tracking information for a particular tool.

NDI ToolBox Tool Tracking Window

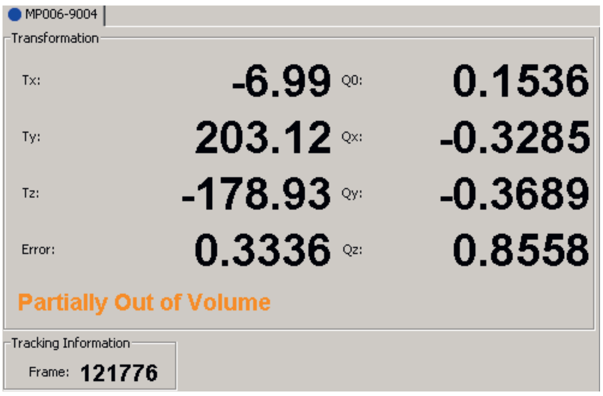
“Out of Volume” and “Bad Fit” flags:

Move the tool to the edge of the characterized measurement volume. As you move the tool to just outside the edge of the volume, NDI ToolBox will display the message “Out of Volume”. Notice that at this position, the transformation data is still displayed.

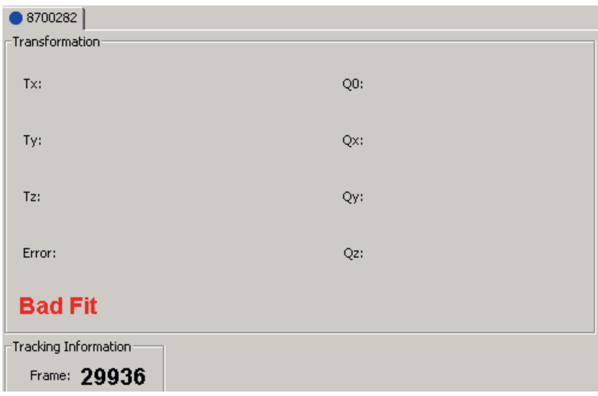
Note:
If you are using a 6DOF tool and you place the tool such that one sensor is in the volume and other is outside the volume, NDI ToolBox will display the message “Partially Out of Volume”.

Continue to move the tool outside the volume but keep it within the detection region. Notice that the transformation data goes blank.

Once the tool is completely outside of the detection region, NDI ToolBox will display the message “Bad Fit” (the transformation data remains blank).



“Partially Out of Volume” Flag



“Bad Fit” Flag

10.3 Setting a Tool as Reference

This section describes how to set a tool as reference. When you set a tool as reference, all the other tools will be tracked with respect to the reference tool.
For more information on reference tools, see section11.3 „Reference Tools“ on page 47.

To Set a Tool as Reference

1. Set up the system to track tools, as described in section 10.1 „Getting Started: Tracking Tools“ on page 41.
2. Connect at least two tools.
3. For each connected tool, there is a tab in the bottom right section of the tool tracking utility. Select the tab corresponding to the tool you want to set as reference. (The reference tool should be a 6DOF tool.)

Selecting a Reference Tool

4. Select Track > Global Reference (or right-click on the tool tab, then select Global Reference).

   The reference tool will appear as a square in the graphical display. The other tool(s) will be displayed inside a square that is the colour of the reference tool. The positions and orientations of other tools will now be reported in the local coordinate system of the reference tool.

Note:
The Aurora® System still calculates the tool transformations in the coordinate system of the Field Generator. The NDI ToolBox software then calculates and reports the tool transformations with respect to the reference tool.

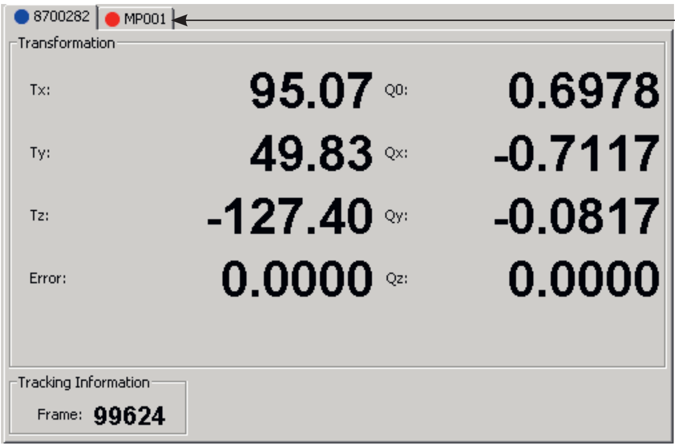
10.4 Determining the Tool Tip Offset

This section describes how to determine the tool tip offset of a probe or pointer tool by pivoting. Once NDI ToolBox has calculated the tool tip offset, it can report the position of the tip of the tool, instead of the position of the origin of the tool.

To Set Up the System to Pivot

You will need a divot in which to rest the tool tip while you pivot the tool. The size and shape of the divot must match the tool tip, to ensure that the tip does not move. For example, a probe with a 1 mm ball tip requires a hemispherical divot with a 1 mm diameter in which to pivot.

1. Set up the system to track tools, as described in section 10.1 „Getting Started: Tracking Tools“ on page 41.
2. For each connected tool there is a tab in the bottom right section of the tool tracking utility. Select the tab corresponding to the tool you want to pivot.

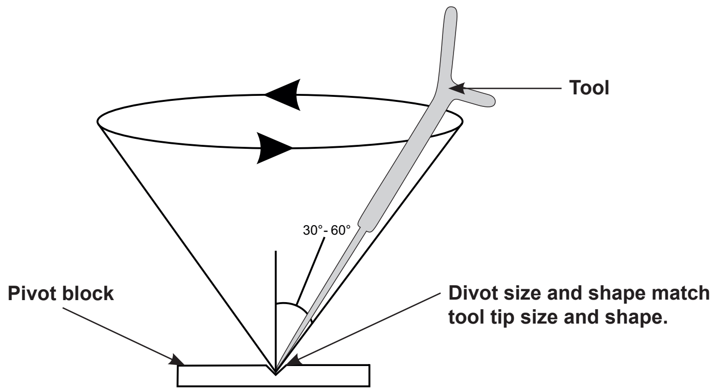


Selecting a Tool to Pivot

3. Click  to open the Pivot dialog.
4. Select an appropriate start delay (e.g. about 5 seconds) and duration, e.g. about 60 seconds.

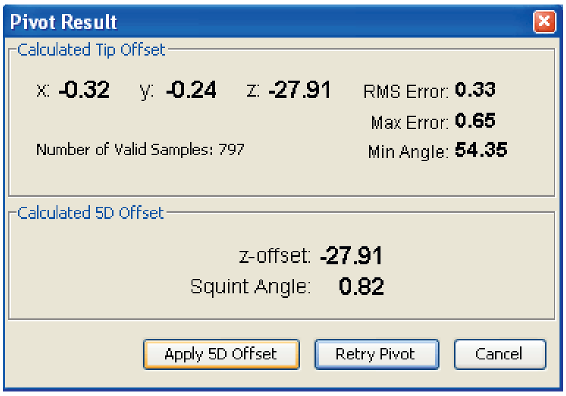
To Pivot the Tool

1. Place the tool tip in the divot.
2. Ensure that the tool is within the characterized measurement volume, and will remain within the volume throughout the pivoting procedure.
3. Click Start Collection in the Pivot tool dialog.
4. Slowly pivot the tool in a cone shape, at an angle of 30º to 60º from the vertical.
5. Keeping the tool tip stationary, slowly pivot the tool until the specified pivot duration time has elapsed.

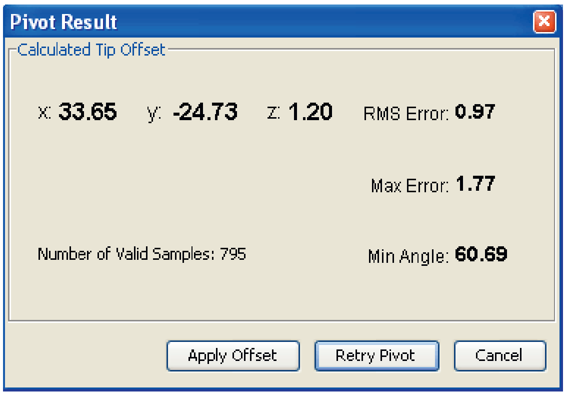


When the pivot is complete, the Pivot Result dialog appears. If the tool is a 5DOF tool, the dialog is as shown in figure. If the tool is a 6DOF tool, the dialog is as shown in figure.

Click Apply 5D Offset or Apply Offset as appropriate, to report the position of the tip of the tool.



NDI ToolBox Software: Pivot Result (5DOF) Dialog



NDI ToolBox Software: Pivot Result (6DOF) Dialog

11 Aurora® System Tools

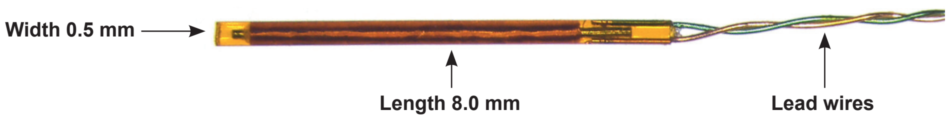
11.1 Tool Components

Aurora® System tools consist of a combination of six basic components (some of which are optional):

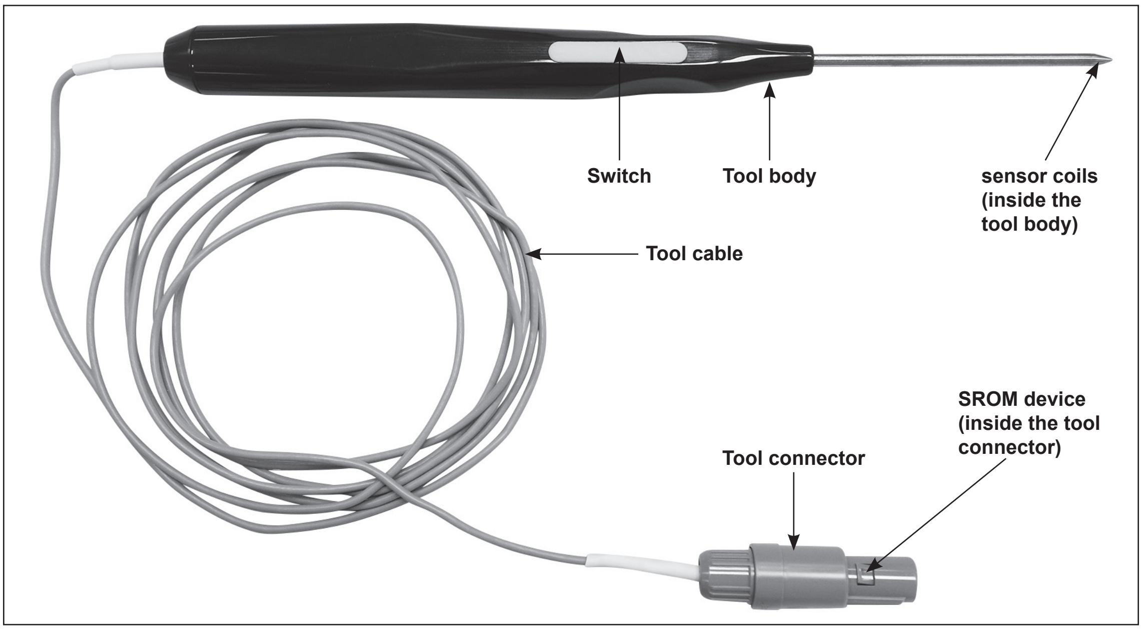
Component	Description
Sensor	The sensor coil comprises a very fine insulated wire wound around a small metal core. The sensor may be mounted on a PCB and/or connected to a pair of lead wires. A tool can contain up to two (0, 1, or 2) sensor coils.
Serial Read Only Memory (SROM) device	The SROM device stores an individual tool's specific information and (if necessary) characterization data. An SROM device is hardware that can be programmed only once. It is normally located inside the tool connector.
Tool connector	The keyed connector normally encloses the SROM device and is where all tool component wiring is terminated.
Tool cable	A shielded cable connects the sensors, switches, LEDs and other input/output devices to the tool connector.
LEDs and switches (optional)	Input/output devices indicate or initiate a tool function. Each tool can support up to three input/output devices.
Tool body	The tool body incorporates the tool's sensor coils, LEDs, switches and other input/output devices into a tool.

Note:
NDI supplies sensors specifically designed and tested for use with the Aurora® System. If you use sensors supplied by any other source, be aware that NDI does not guarantee the accuracy of measurements made with those sensors. (Other sensor designs are available, visit the NDI website at https://www.ndigital.com/products/aurora/aurora-sensors/, or contact NDI for details.)

Figure shows a typical NDI sensor:



The following diagram shows an example tool incorporating each basic tool component:



Warning:

Sensors must be mounted securely within the tool body. If a sensor moves out of position, accuracy is affected. This may contribute to inaccurate transformations and possible personal injury. Do not track a tool unless you are sure that its SROM device is programmed correctly, and with the correct settings. Using an incorrectly programmed tool may produce inaccurate transformations and possible personal injury.

11.2 Aurora® Tool Types

A tool can be categorized as one of several basic types, depending on the number of sensor coils embedded in it:

Sensor coils	Tool type	Sensor coil placement	5DOF / 6DOF
0	sensorless tool	not applicable	not applicable
1	single sensor coil tool	anywhere	5DOF
2	dual 5DOF tool	not fixed relative to each other	dual 5DOF
	6DOF tool	fixed relative to each other	6DOF
	co-linear sensor coil tool	fixed relative to each other in a co-linear fashion	5DOF
	parallel sensor coil tool	fixed relative to each other in a parallel fashion	5DOF

Note:
For more information about tool design and how to build your own tools to use with the Aurora® System, refer to the “DDUG-1000-2165 Aurora® Tool Design Guide”.

11.3 Reference Tools

A reference tool is used to allow relative measurement, rather than absolute measurement. Measuring a tool’s position and orientation is fairly straightforward as long as the following are true:

1. The Field Generator does not accidentally shift. If it does shift, the global coordinate system also shifts. This change affects the perceived location of a tool within the global coordinate system, producing misleading measurement data. Connect at least two tools.
2. The object of interest does not accidentally shift. If you are using the Aurora® System to place a tool at a specific point on the object of interest, it is very important that the object does not move with respect to the Field Generator, while you are trying to place the tool. There is no way for the system to perceive such movement, and you may end up placing the tool in the wrong location.

In many application environments, shifted objects and bumped Field Generators are not uncommon occurrences.
As such, the two above requirements are often difficult to meet.

A reference tool is designed to be fixed to an object of interest. Once fixed, if the object moves, the reference tool will also move. Other tools can be measured relative to the reference tool, in the reference tool’s local coordinate system.

The Aurora® System measures the reference tool’s movement as well as the tracking tool’s movement, producing two sets of measurements. You can design your application to interpret these measurements in the following way:

1. Calculate the reference tool’s movements to capture any (accidental or intentional) shifting.
2. Apply these movements to the tracking tool’s position and orientation data, to correct for any accidental shifting.

For a reference tool to accurately compensate movement, you should locate the reference tool close to the tracking tool’s path through the measurement volume.
For more information about reference tools, see the “DDUG-1000-2165 Aurora® Tool Design Guide”.

Note:
Reference tools are available for purchase from NDI.

12 Aurora® System Data

This chapter provides details on how the Aurora® System works. The information can help increase your technical understanding of the system, but it is not absolutely necessary in order to use the system.

12.1 Communicating with the Aurora® System

The Aurora® System is controlled using an application program interface (API). The API is a set of commands that allow you to configure and request information from the system. The Aurora® System returns information only when requested by the host computer.

NDI Combined API Sample and NDI ToolBox both allow you to view the communications stream of API commands and responses between the application and the Aurora® System.

Information Returned by the Aurora® System

When the Aurora® System is tracking tools, it returns information about those tools to the host computer (if requested). By default, the system returns:

- the position of each tool's origin, given in mm, in the coordinate system of the Field Generator. (See section 12.8 „Global and Local Coordinate Systems“ on page 52).
- the orientation of each tool, given in quaternion format. The quaternion values are rounded off, so the returned values may not be normalized.
- an indicator value, between 0 and 9.9 (where 0 is the absence of error and 9.9 is the highest indication of error). (See section 12.3 „Indicator Value“ on page 49).
- the status of each tool, indicating whether the tool is out of volume, partially out of volume, or missing. It also indicates whether the port handle corresponding to each tool is enabled and initialized. For more information on port handles, see the "DDUG-010-466 Aurora® Application Program Interface (API) Guide".
- the frame number for each tool transformation. The frame counter starts as soon as the system is powered on, and can be reset using API commands (see the "DDUG-010-466 Aurora® Application Program Interface (API) Guide" for details). The frame number returned with a transformation corresponds to the frame in which the data used to calculate that transformation was collected. (See section 12.2 „Transformations“ on page 49).
- the system status, which includes some of the system errors described in section 12.4 „Error Flags and Codes“ on page 50.

12.2 Transformations

A transformation is a combination of translation and rotation values that describes the tool's position and orientation.

Once the Aurora® System has calculated the position and orientation of a tool, it returns a transformation, representing the results. Transformations are returned in the following format:

q0 qx qy qz Tx Ty Tz indicator_value

Where:

1. *q0 qx qy qz* represents the tool's orientation (in quaternion format),
2. *Tx Ty Tz* represents the tool's position in the measurement volume (in mm) and
3. *indicator_value* represents the transformation's indicator value.

Note:
The Aurora® System calculates a tool's rotation in quaternion format (q0 qx qy qz), but Aurora® documentation explains a tool's rotation in Euler format (Rx, Ry and Rz), as it is easier to visualize. NDI ToolBox software is capable of displaying a tool's rotation using either format.

The following procedure describes how the Aurora® System produces transformations:

1. When a tool is placed in the measurement volume, its sensor(s) produce data.
2. The system receives the sensor data via the tool's SIU.
3. The system processes the sensor data and calculates a 5DOF transformation for each sensor that is producing information.
4. The system reads the tool description data previously uploaded from the tool's SROM device, or in a tool definition file previously uploaded from the host computer.
5. The following list describes the next step the system must perform, depending on the type of tool the SROM settings describe:

Single Sensor and Dual 5DOF Tools

The system does not need to perform any additional steps. The 5DOF transformation produced in step 3 is the final transformation for the entire tool. No indicator value is produced.

6DOF Tool

The system takes the two 5DOF transformations produced in step 3 and processes them using a mathematical model and the tool description data. The result is a single 6DOF transformation that reflects the position and orientation of the entire tool. Accompanying this 6DOF transformation is an indicator value.

Note:
Sensorless tools do not produce transformations.

12.3 Indicator Value

With each transformation calculated, the Aurora® System returns an indicator value. The indicator value is an estimate of how well the system calculated that particular transformation. Indicator value is formatted as a unitless value scaled to fall between 0 and 9.9 (where 0 is the absence of error and 9.9 is the highest indication of error).

For 6DOF tools, the indicator value compares sensor measurements to the tool's design (as described by its SROM device or tool definition file). The greater the difference between the calculated sensor positions and the known locations of the sensors within the tool, the higher the indicator value. Such discrepancies are often an indication that magnetic field disturbances are affecting the collected data.

For 5DOF transformations, the indicator value is always zero.

Indicator values less than 1.0 are typically considered acceptable. You should set your own thresholds, depending on the nature of your application needs.

Note:
The indicator value is not an absolute indication of overall error, but simply an indication that your measurement may be compromised, or that you have a mismatched tool definition file.

12.4 Error Flags and Codes

This section explains the error flags and codes that the Aurora® System may return. For comprehensive information on error flags and codes, refer to “DDUG-010-466 Aurora® Application Program Interface (API) Guide”.

Missing and Disabled Transformations

Normally, the Aurora® System reports a position, orientation, and indicator value for every transformation. If the system cannot return a transformation, it will report the tool as missing or disabled.

Missing Transformations

The system reports a tool as missing if it cannot calculate a transformation for the tool. The system may be unable to calculate a transformation if:

- The tool is moving too fast
- There is severe interference
- There is a system error (described below).
- The tool is not in the detection region.

By default, the system will report a tool as missing (even when it has calculated a transformation for the tool) if the tool is out of volume. The Aurora® System is specifically designed to NOT report measurements when the tool is out of volume. You can request out of volume measurements by using reply option 0800 with the BX or TX command. You enable this additional functionality at your own discretion.

Warning:

When using reply option 0800 with the BX or TX API command, you must take appropriate action to detect when a tool is out of volume, and determine whether this situation is detrimental to your application. If a tool is out of volume, reply option 0800 enables the system to return data that may lead to inaccurate conclusions and may cause personal injury.

Disabled Transformations

The system reports a tool as disabled if the port handle corresponding to the tool was not enabled, has been disabled, or is unoccupied. A port handle is unoccupied if it has been allocated, but you have not yet associated a tool definition file with that port handle. See the “DDUG-010-466 Aurora® Application Program Interface (API) Guide” for more details on port handles.

Tracking Errors and Flags

Many of the following errors and flags are displayed in NDI ToolBox. They are all returned with the TX and BX commands.

System Status Flags

System Communication Synchronization Error:
Indicates communication problems between internal sub-components of the system.

Hardware Failure:
Indicates that a system hardware failure has been detected.

Hardware Change:
Indicates that the Field Generator has been disconnected from the System Control Unit.

Configuration Change:
Indicates that an SIU has been added or removed.

Port Status Flags

Bad Fit:
The bad fit flag is set if the system is unable to determine the tool position, typically because the tool is not within the detection region.

Out of Volume:
The out of volume flag is set if a tool is completely outside the characterized measurement volume, but is still within the detection region. The flag is set regardless of whether the reply option 0800 for the TX or BX command is used. (Reply option 0800 enables the reporting of the positions of tools that are outside of the characterized measurement volume. See the “DDUG-010-466 Aurora® Application Program Interface (API) Guide” for details.)

Partially Out of Volume:
The partially out of volume flag is only applicable to 6DOF tools. The partially out of volume flag will be set if one of the tool’s sensors is inside the characterized measurement volume and the other sensor is outside the characterized measurement volume, but still within the detection region.

Broken Sensor:
Indicates that a sensor lead wire is broken, either along its length or at a connection point. (This bit may not always be set when a sensor lead wire breaks.)

Shorted Sensor:
Detects when there is a short circuit in a sensor or tool.

Signal too Large:
Detects when a sensor is too close to the FG.

12.5 Measurement Rate

Measurement rate is the rate at which the Aurora® System calculates transformations. The maximum measurement rates, or frame rates, are listed in the table below.

FG variant	Frequency [Hz]	Frame rate [Hz] Standard mode	Frame rate [Hz] Turbo mode
Planar FG 20-20, Planar FG 10-11, TTFG and WFG I	800	40	66.7
WFG II-8	800	26.7	44.4
WFG II-32	3,200	29.7	48.5

Note:
The measurement rate is internal to the Aurora® System and fixed; how fast your application receives and processes measurements from the Aurora® System is also dependent on external factors, such as serial baud rate, API command used (TX or BX), host computer performance and software application design.

When a tracking tool passes outside of the Field Generator’s measurement volume, the system may take extra time trying to find it before reporting it back as ‘missing’.

Note:
By default, the Aurora® System uses the standard frame rate. To access turbo mode, use the “faster acquisition mode” option with the TSTART API command. For details on API commands, see the “DDUG-010-466 Aurora® Application Program Interface (API) Guide”.

12.6 Latency

Latency is defined as the time between sensor movement and when a change is reported through the API (or Toolbox). The latency of the Aurora® System is not strictly defined, because there are too many variables.
It is typically 75 ms (three frames), but can be higher.

12.7 Degrees of Freedom

Aurora® tools are defined as either 5DOF or 6DOF, where DOF means degrees of freedom. The number and placement of sensors incorporated in a tool determines whether the tool is 5DOF or 6DOF and consequently the kind of measurements the Aurora® System can perform. 5DOF and 6DOF are defined as follows:

- 5DOF: Five of the six degrees of freedom. Three translation values on the x, y and z-axes and any two of the three rotation values roll, pitch and yaw. If a tool incorporates only one sensor, the rotation around the sensor's z-axis (Rz) cannot be determined. As such, only five degrees of freedom (5DOF) can be determined for single sensor tools.
- 6DOF: Six degrees of freedom. The three translation values on the x, y and z-axes; and the three rotation values roll, pitch and yaw. If a tool incorporates two sensors fixed relative to each other, the system can determine six degrees of freedom (6DOF) for the tool.

For examples of tool types, and information on how to design tools, see the "DDUG-1000-2165 Aurora® Tool Design Guide".

12.8 Global and Local Coordinate Systems

This section explains the different coordinate systems that are used by the Aurora® System to calculate the positions and orientations of tools. It is important to understand the nature of both global and local coordinate systems

Global Coordinate System

The Field Generator uses a coordinate system with the origin located approximately on the surface of the Field Generator and the axes aligned fixed relative to the Field Generator. The global coordinate system for each Field Generator is illustrated on the Field Generator data sheet. This global coordinate system is defined during manufacturing and cannot be changed. The Aurora® System will report the transformations of tools in the global coordinate system. However, if you are using a reference tool, software can calculate and report transformations in the local coordinate system of the reference tool. See section 11.3 „Reference Tools“ on page 47.

Local Coordinate System

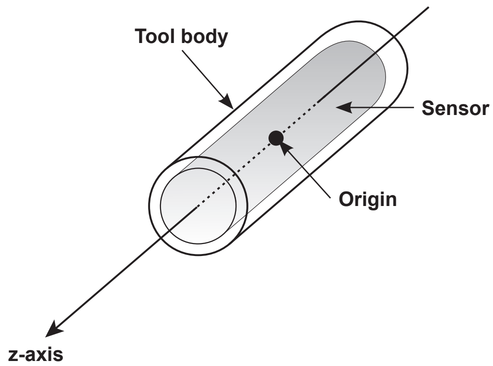
Each tool has its own local coordinate system that is defined by an origin and three axes. The tool transformation, described in section 12.2 „Transformations“ on page 49 is the transformation between the global coordinate system of the Field Generator (or reference sensor), and the tool's local coordinate system.
A 5DOF sensor tool's local coordinate system is based directly on the sensor. By default, the z-axis is along the sensor's length, with an origin at the sensor's centre. It is possible to move the origin along the z-axis. The x and y axes are not fixed, due to the inability to determine rotation about the z-axis.
A 6DOF tool's coordinate system can be defined as required for the application.

For more information about local coordinate systems and different tool designs, see the "DDUG-1000-2165 Aurora® Tool Design Guide". To see how the local coordinate systems of ready-to-use tools are defined, see the tool's data sheet.

12.9 Sensor-/ Tool Types and their Local Coordinate system

Single Sensor Tools

The single sensor tool's local coordinate system is based directly on that of its sensor. By default, the system assigns the z-axis along the sensor's length, with an origin at the sensor's centre. It is possible to move the origin along the z-axis. The x and y axes are not fixed, due to the inability to determine rotation about the z-axis.



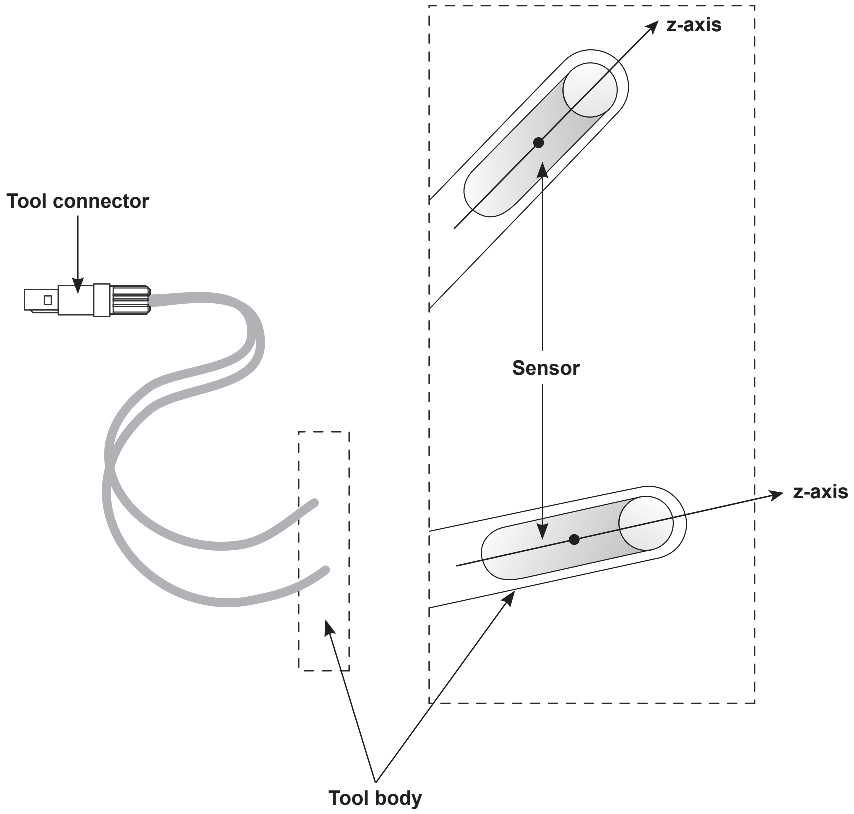
Note:
Single sensor tools do not return an indicator value. For more information about indicator values, see section 12.3 „Indicator Value“ on page 49.

Dual Sensor Tools

The single sensor tool's local coordinate system is based directly on that of its sensor. By default, the system assigns the z-axis along the sensor's length, with an origin at the sensor's centre. It is possible to move the origin along the z-axis. The x and y axes are not fixed, due to the inability to determine rotation about the z-axis.

Dual 5DOF Tools

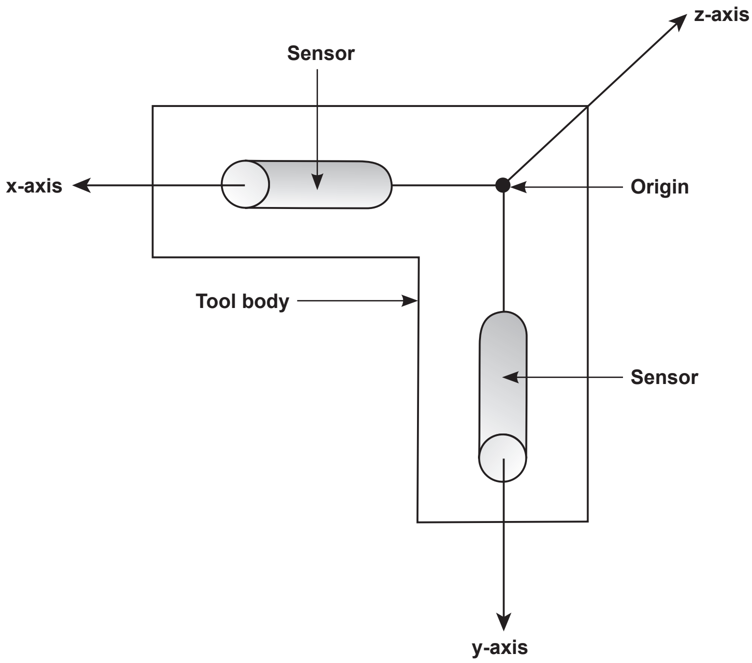
A dual 5DOF tool is essentially two single sensor tools joined to the same tool connector. As such, the tool actually has two local coordinate systems, each based on one of the sensors incorporated into its design. These local coordinate systems are determined in the same way as that of a single sensor tool.
Figure shows a sample 5DOF tool.



6DOF Tools

A 6DOF tool incorporates two sensors fixed relative to each other. 6DOF tools are assigned their own coordinate system, independent of their sensors. Each tool includes a tool definition file programmed onto the tool's SROM device. This file defines the tool's local coordinate system.

Figure shows a sample 6DOF tool with a coordinate system independent of its sensors. When the Aurora® System calculates this tool's position and orientation, it will return only one transformation and indicator value.



13 Electromagnetic Fields, Distortion and Metal

13.1 Minimum Safety Distances

The following table lists the minimum safety distances from the Aurora® Field Generators in [cm] according to various standards:

Standards	**Planar FG 20-20 800 Hz**	**Planar FG 10-11 800 Hz**	**TTFG 800 Hz**	**WFG II-8 800 Hz**	**WFG II-32 3200 Hz**
1999/519/EC	20	5	12	20	15
2013/35/EU	5	0	5	0	0
ICNIRP Guidelines 2010 Occupational Exposure	5	0	5	0	0
ICNIRP Guidelines 2010 General Public Exposure	12	5	6	12	5

13.2 Interference and Distortions

Distortion may be caused by emissions from other electrical equipment or by nearby metal. To minimize distortions to the Aurora® electromagnetic field follow the advice given in the following sections:

- 6.2 „Mounting the Components“ on page 28
- 6.3 „Cable Management“ on page 29
- 6.4 „Operating Environment Considerations“ on page 30

To determine if other equipment is causing distortion, switch the equipment on and off while monitoring the Aurora® System.

Consider factors such as the magnetic properties of adjacent materials and placement of the Field Generator when determining where the system will be used.

13.3 Effects of Nearby Metal on the Aurora® System

Most applications that require the technology made available by the Aurora® System also require metal objects: tables, tools, braces, and so forth. Although the Aurora® System's technology revolves around electromagnetic activity - activity that is affected by the presence of metal - NDI has developed ways to make the Aurora® System resistant to certain metals.

The following sections describe the metals which don't cause problems when used near the Aurora® System, as well as the problems caused by placing problematic metal near the Aurora® System.

Metals which can be used with Aurora® System

The following metal alloys work well with the Aurora® System when applied in amounts similar to that used in medical tool construction:

- cobalt-chrome alloy
- steel DIN 1.441
- titanium (TiA16V4)
- 300 series stainless steel
- more metals

Note:
Tests have also shown that the Aurora® System produces reasonable results with a steel DIN 1.4301 plate measuring 500 mm x 500 mm.

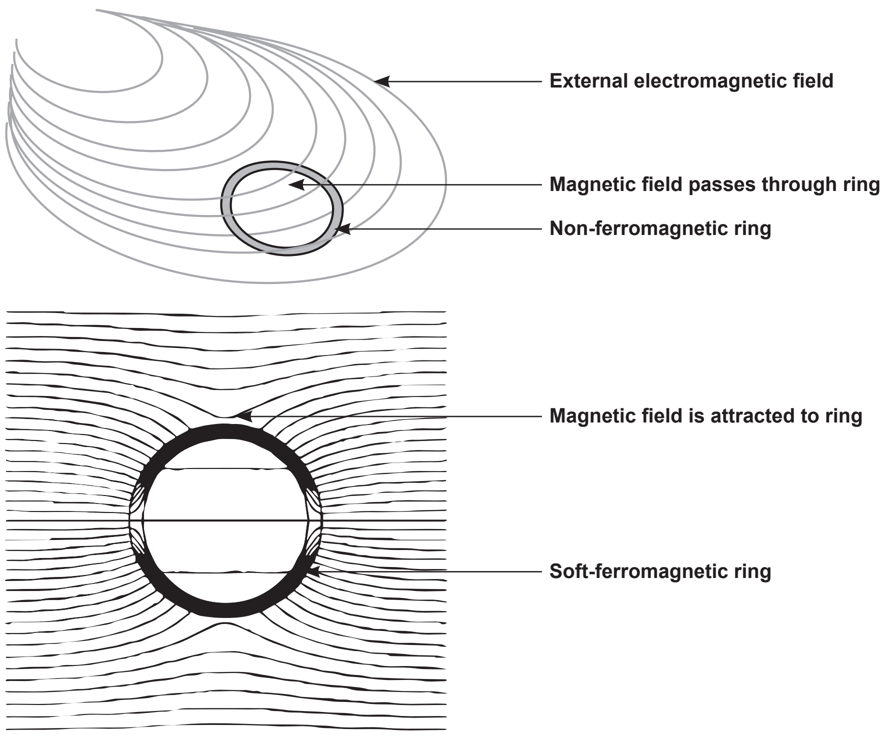
Ferromagnetic Metals

Ferromagnetic material should be avoided near the Aurora® System.

Ferromagnetic material generally has little or no net magnetic property. However, if it is placed in a magnetic field, its domains will re-orient in parallel with that field, and may even remain re-oriented when the field is turned off. Even metals with only small amounts of ferrous material in them may have these reactions.

The magnetic field produced in a ferromagnetic object attracts the external magnetic field, resulting in the external magnetic field bending towards the object itself. As such, introducing a ferromagnetic object into the Aurora® Field Generator's electromagnetic field will cause a distortion that can affect the transformation data produced. All ferrous materials will have an effect, in varying degrees, on the Aurora® System's ability to produce measurement data.

Visualizing the Effects of Ferromagnetic Material



The following metal alloys are examples of ferromagnetic metal that do not work well with the Aurora® System:

- steel DIN 1.4034
- steel DIN 1.4021

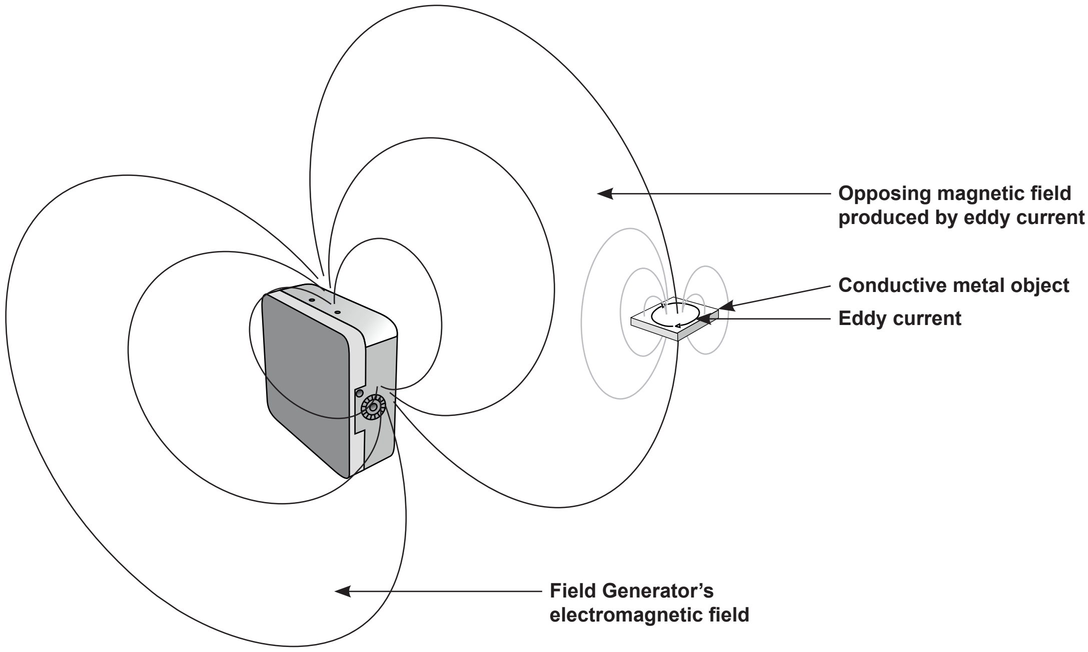
Eddy Currents

An eddy current is caused when a conductive material is exposed to a dynamic magnetic field. The changing magnetic field induces a circulating flow of electrons within the conductive material, resulting in an electric current.

These circulating currents (sometimes known as eddy currents) produce an electromagnetic effect of their own, creating magnetic fields that oppose the original, external magnetic field. The greater the electrical conductivity of the conductor, the greater the eddy current developed (and the greater the opposing magnetic field produced).

When using an Aurora® System, if a conductive metal intersects the Aurora® System's electromagnetic field, the opposing magnetic field created by resulting eddy currents disrupts that field and affects the transformation data produced.

Visualizing the Effects of Eddy Currents



One method of reducing this effect is to adjust the placement of both the tool being measured and the object producing the eddy currents. Moving the tool so that the distance between its sensors and the Field Generator is smaller than its proximity to the object creating eddy currents, may decrease the effects of the eddy currents on tool measurements.

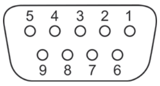
The Aurora® System uses special technology to take into account such effects as eddy currents.

Metal Loops

Another situation to consider is the effect of eddy currents in metallic loops. Loops may occur in structures like metallic table frames, or concrete reinforcement bars. Cutting the loops will reduce the effect of eddy currents. If cutting the loops is not an option, then locate the system to minimize the effects of the loops.

14 External Synchronization

The synchronization port provides clock and trigger signals for synchronization with other devices.
The SCU external synchronization port is a female 9-pin D-type connector.



Pin	Value	Pin Function
1	+3.3	SCU provides up to 200 mA, +3.3 V
2	Viso	Optocoupler anode
3	FR IN	Frame clock input (active low) Synchronization mode: falling edge triggers frame clock Trigger mode: active low trigger pulse
4	HF IN	Clock signal input
5	GND	Ground
6	HF OUT	Clock signal output
7	Reserved	Reserved
8	TR OUT	Combined firmware revision 20 and later: When asserted (active low), the Field Generator is active. Prior firmware revisions: Reserved.
9	FR OUT	Clock output at frame rate (active low)

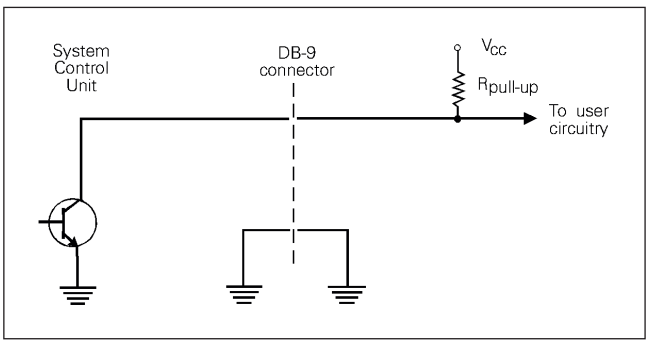
14.1 Output Signals

The output signals HF OUT, TR OUT and FR OUT are active low, open collector outputs. Each output is capable of sinking a maximum of 150 mA through an external pull-up resistor, tied to Vcc (refer to figure). V_{cc} must not exceed 15 V.

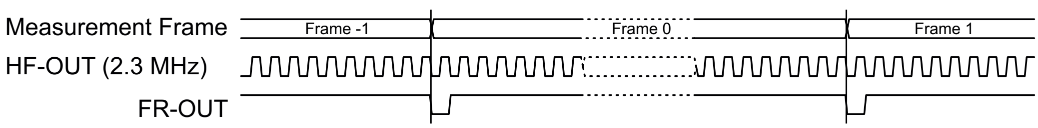
Select the pull-up resistor such that:

$$R_{pull-up} > \frac{V_{cc}}{0,15}$$

Output signal connection:



The signal goes low for 1HF OUT cycle (~430ns). TR is only active in Trigger mode, as described in section 14.3 „Trigger Mode“ on page 59.



14.2 Input Signals

The input signals FR IN and HF IN are galvanically isolated from the rest of the SCU electronics. They can be used to synchronize two Aurora® Systems. Please contact NDI technical support for details.

See section 28.1 „Contact Details“ on page 93.

14.3 Trigger Mode

The trigger mode allows an external (customer host) system to activate and deactivate the Aurora® System according to application needs, e.g. deactivation during critical treatment steps.

Aurora® hardware and firmware pre-requisites:

- SCU V3 or V3.1 with combined firmware revision 20 or higher
- Populated synchronization port on the SCU
- SIU hardware architecture 2 with firware 1.8.0 or higher

Activation and Useage

The command ‘SET Param.Tracking.Frame Sync Source=5’ enables trigger mode. This command must be sent before entering tracking mode.

The trigger signal is set on the FR IN pin of the synchronization port. An external signal of 3.3V on the FR IN line triggers a single Aurora® measurement. The Field Generator remains inactive when there is no trigger signal. The HF IN signal is not required when using trigger mode, but if it is used, it must be supplied continuously.

While in trigger mode, it is possible to check the activation status of the Field Generator via the TR OUT pin. If this pin is asserted, the Field Generator is active.

Trigger Mode Timing and Latency

The Aurora® System uses a 100 kHz clock for the trigger mode synchronization; the clocks are generated internally from a 33 MHz base clock in the following way:

Base Frequency	Divider	Frequency (Hz)	Name
33000000 Hz	/14 /23	2357143 Hz 102485 Hz	HF 100 kHz

The trigger pulse duration must be at least one complete HF cycle (~430 ns); 10 µs (a complete 100 kHz cycle) is recommended. The trigger signal is only checked during the last 100 kHz cycle of a measurement frame and is ignored in all other cycles. The maximum delay between the trigger pulse and the start of the next measurement frame is 1.5*100 kHz cycles. The exact delaz depends on when during the 100 kHz cycle the trigger pulse is asserted and sampled.

A started measurement frame is always completed. The duration of a measurement frame depends on the Field Generator timing parameter

Example:

Field Generator	Mode	Measurement frame	100 kHz cycles	HF cycles
Planar FG 20-20 V2	800 Hz normal	40.09 Hz (~25ms)	2560	58800
Planar FG 20-20 V2	800 Hz turbo	66.72 Hz (~15ms)	1536	35328

If no trigger is applied within 1 second, the commands BX and TX will time out with ERROR05. The commands can be resent immediately to continue the waiting period. BX and TX will only report the latest measured frame if new data is available; there is no duplication of measurement data.

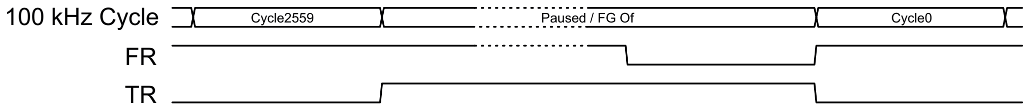
Examples:

A) Continuous operation: using a Planar FG 20-20 V2 with 800 Hz standard mode.

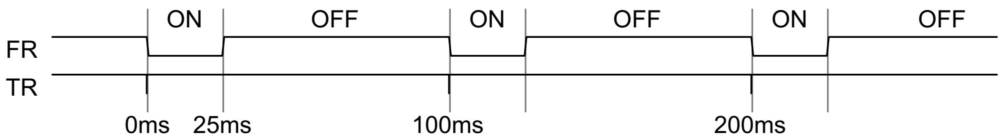
The simplest method is to keep FR IN asserted the whole time. It is also possible to assert the FR IN signal only during the last cycle of a measurement frame. Both methods result in continuous Aurora® tracking.

B) Paused operation: using a Planar FG 20-20 V2 with 800 Hz standard mode.

The pause can be arbitrarily long. During this time, the Field Generator is quiet (inactive).



C) Trigger pulse: The Field Generator is activated with a 10 Hz trigger pulse (qualitative).



15 Maintenance

User maintenance of the Aurora® System is limited to:

Recurrent Safety Tests

- cleaning
- replacing the SCU fuses – for information on replacing the SCU fuses, see the SCU data sheet.

Warning:
Apart from replacing the SCU fuses, there are no user serviceable parts in the Aurora® System. All servicing must be done NDI. Unauthorized servicing may result in possible personal injury.

15.1 Cleaning

Warning:
Disconnect power to the Aurora® System before cleaning it. Failure to do so may cause personal injury.

Do not expose or immerse the Aurora® System to liquids, or allow fluid to enter the equipment in any way. Exposing the Aurora® System to liquids may result in equipment damage, produce a fire or shock hazard, and result in possible personal injury.

Caution:
Do not use aerosol sprays near the equipment as these sprays can damage circuitry.
Do not use any solvent to clean the Aurora® System. Solvents may damage the finish and remove lettering.
Do not autoclave any Aurora® System component. Autoclaving may damage the system.

Tested cleaning agents:

- Isopropyl 70 %
- 3 % v/v hydrogen peroxide
- Opti Cide 3®
- Incidin® Plus 2 %
- Meliseptol®
- Mild soap solution

To clean the Aurora® System proceed as follows:

1. Wipe off dust with a dry, soft cloth.
2. Remove dirt or finger marks using a damp cloth and dry immediately with a clean cloth.

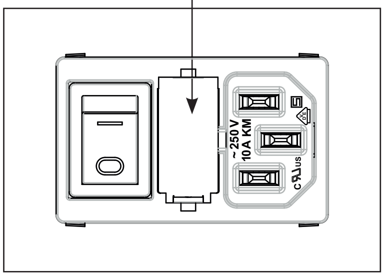
15.2 Replacing the System Control Unit Fuses

Warning:

Do not change either fuse without first disconnecting the SCU from its power source. Failure to disconnect the system may result in personal injury.

1. Disconnect the SCU from the power supply.
2. Release the two fuse holder tabs simultaneously with the aid of a tool (such as a screwdriver), and pull outwards. The tabs are marked with arrows for identification.

The figure shows the System Control Unit power entry module:



3. Remove the fuses from the fuse drawer and verify the filament is intact.
4. Replace the fuse(s) as required, with the correct type and rating (1.00 A, 250 V, Time Delay, Breaking Capacity - High, 5 mm x 20 mm).
5. Press the fuse holder inwards, ensuring that it latches correctly.

15.3 Recurrent Safety Tests

NDI recommends periodic safety tests performed at an interval of two years or less, depending on application and use. The exact test interval and test scope must be determined by the system integrator. During the safety test, the following parameters should be tested:

Test Item	Acceptance Criteria
Visual inspection	Device has no obvious damage
Protective earth resistance	< 0.20 Ohm
Isolation resistance	> 2000 MOhm
Earth leakage current NC	< 5.0 mA
Earth leakage current SFC	< 10 mA
Touch current NC	< 0.1 mA
Touch current SFC	< 0.5 mA
Patient leakage current AC NC	< 0.1 mA
Patient leakage current AC SFC	< 0.5 mA
Patient leakage current DC NC	< 10.0 µA
Patient leakage current DC SFC	< 50.0 µA

Alternatively, recurrent tests according to IEC 62353 can be performed.

16 Calibration and Verification

16.1 System Calibration

As with all measurement and testing instruments, industry practice dictates that the Aurora® System should be periodically calibrated to ensure it is operating within tolerances acceptable to the user. You must establish the system's calibration interval on the basis of your system's stability, purpose, and degree of usage.

If, at any time, any concern regarding accuracy about the Aurora® System arises, you should:

1. Calibrate the Aurora® System immediately.
2. Analyze the system's usual calibration interval and adjust it if necessary.
3. Take all other corrective measures deemed necessary by the user in the circumstances.

Note:
The Aurora® System is highly specialized instrumentation developed by NDI. It is recommended that the Aurora® Field Generator be returned to the NDI facility for calibration procedures. This practice ensures that all calibrations are conducted in accordance with procedures established specifically for the Aurora® System.

16.2 System Verification

Determining how to use the Aurora® System to best suit your specific requirements should be done carefully, with much of the testing and evaluation closely tailored to your anticipated usage.

For example, users often want to know the "maximum error" of the Aurora® System when evaluating best practices. However, the maximum error obtained from a particular data set is not a sufficiently robust measure. The spatial detail that is lost in condensed statistical summaries is often crucial, since most measurement systems have operational regions where errors tend to be considerably lower and other regions where errors tend to be substantially higher.

To learn about more valuable methods of evaluating and planning the use of the Aurora® System, refer to the research paper entitled https://www.researchgate.net/publication/10632250

16.3 Environment Verification

1. Establish a baseline for the system's performance. This may include testing in a local environment with minimal electromagnetic field disturbances.
2. Introduce each object that might disturb the characterized electromagnetic field, and objects that would be typical of the environment used in your particular application.
3. Establish an indicator value threshold reflective of your particular application requirements. For more information about what an indicator value is, see section 12.3 „Indicator Value“ on page 49.
4. Placement of the Field Generator may affect the system's performance. Consider changing the placement of the Field Generator within the environment.
5. Adjust the local environment in order to simulate your system's particular application.

16.4 Field Accuracy Verification

NDI recommends that you establish a field accuracy verification procedure, to monitor and confirm the system performance. You should establish a method and schedule that reflects the specific customer system setup.

17 Approvals and Classifications

The following approvals and classifications apply to the Aurora® V3.1 System as described in section 3.„Overview“ on page 9.

17.1 Electrical Safety Approvals

Standard	Title
IEC 60601-1:2005 +Cor.:2006 +Cor.:2007 +A1:2012	Medical Electrical Equipment, Part 1: General requirements for basic safety and essential performance
NRTL mark	Additional requirements

17.2 EMC/EMI Approvals

Standard	Title
IEC 60601-1-2:2014	Medical electrical equipment – Part 1-2: General requirements for basic safety and essential performance – Collateral Standard: Electromagnetic disturbances – Requirements and tests

17.3 Classifications

Type	Classification
Electric shock protection	Class I - protectively earthed with power from supply mains
Degree of protection from electric shock	Type BF (Tools and Sensors, Planar FG) Type B (TTFG, WFG)
Degree of protection against ingress of liquids	Ordinary equipment
Method of sterilization or disinfection	Not suitable for sterilization
Flammable atmosphere	Not suitable for use in the presence of a flammable anaesthetic mixture with air, oxygen, or nitrous oxide
Mode of operation	Continuous

17.4 EU Type Examination

Directive	Title
2014/53/EU	Radio Equipment Directive (RED)

18 Aurora® System Technical Specifications

This chapter includes technical specifications valid for the entire Aurora® System. For technical specifications for a specific Field Generator, including accuracy specifications, dimensions, and weight, see the corresponding data sheet.

18.1 Electrical Safety Approvals

The operating environmental conditions listed in table are valid for all components of the Aurora® System.

Atmospheric pressure:	70 kPa to 106 kPa
Relative humidity	30 % to 75 %
Temperature	+10 °C to +30 °C

18.2 Transportation and Storage Conditions

The transport and storage conditions listed in table are valid for all components of the Aurora® System.

Atmospheric pressure:	50 kPa to 106 kPa
Relative humidity	10 % to 90 % non-condensing
Temperature	-10 °C to +50 °C

19 Electromagnetic Compatibility

19.1 ESD Precautionary Measures

Care should be taken to mitigate the production of electrostatic charges. These measures can include, but are not limited to, air conditioning, humidification, conductive floor coverings, attire, etc.

You should discharge any built-up static before connecting or disconnecting any cables marked with the electrostatic discharge (ESD) warning symbol shown here. To discharge any built up static, touch either the SCU metal enclosure or a large metallic object.

Avoid touching accessible pins on connectors marked with the ESD symbol. You should also use an anti-static mat and bond yourself to either the SCU metal enclosure or to earth by means of an antistatic wrist strap.

All staff using the Aurora® System should receive instructions on the ESD warning symbol and training in basic ESD precautionary procedures. This training should include an introduction to the physics of ESD, the voltage levels that can occur in normal circumstances, and the damage caused to electronic components on contact with an electrostatically charged operator. In addition, users should be provided with an explanation of the methods used to prevent the build-up of electrostatic charges.

Caution:
When working with SCU or SIU boards as described in section 20. „PCB Integration Guide: SCU Board“ on page 69 and 21. „PCB Integration Guide: SIU Board“ on page 76, the system integrator must handle the boards in an ESD-safe manner. Failure to do so can damage the boards.

19.2 Cables, Transducers and Accessories

The following table shows the cables, transducers and accessories that may be used with the Aurora® System and still maintain compliance to the emissions and immunity requirements of IEC 60601-1-2:2014

Cable name	NDI P/N	Type	Shielded	Notes
USB cable	7500624.001	USB A-B cable, 5 m	Yes	--
SIU cable	610151	Communication cable between SCU and SIU, 4.5 m	No	--
Tabletop Field Generator/ Window Field Generator cable	610458	19-Conductor Lemo-Lemo cable, 4.5 m	Yes	The Tabletop Field Generator/ Window Field Generator cable is detachable.
Power Cord, AC (North America)	7500010	3- Conductor Medical Grade	No	--

Warning:
Do not use cables or accessories other than those listed in this guide, with the exception of those sold by NDI and NDI-authorized manufacturers. To do so may result in increased emissions and/or decreased immunity of the Aurora® System.

19.3 Guidance and Manufacturer's Declaration - Electromagnetic Emissions

The Aurora® System is intended for use in a professional healthcare facility environment listed in table. The customer or the user of the Aurora® System should make sure that it is used in such an environment.

Emissions test	Class	Result	Electromagnetic environment guidance
Radio frequency emissions (CISPR11) Terminal voltage (conducted) [150 kHz – 30 MHz] Radiated emission [30 MHz – 1000 MHz]	Group 1 Class A	Limits kept	The emissions characteristics of the Aurora® make it suitable for use in industrial areas and hospitals (CISPR 11 class A). If it is used in a residential environment (for which CISPR 11 class B is normally required) the Aurora® might not offer adequate protection to radio-frequency communication services. The user might need to take mitigation measures, such as relocating or re-orienting the equipment.
Harmonic current emissions (IEC 61000-3-2)	Class A	Limits not applicable	Input Power < 75 W
Flicker, voltage fluctuation (IEC 61000-3-3)	Program Mode	Limits kept	--

19.4 Guidance and Manufacturer's Declaration - Electromagnetic Immunity

The Aurora® System is intended for use in the electromagnetic environment listed below. The customer and/or the user of the Aurora® System should ensure that it is used in such an environment.

Warning:

Do not track in an untested application environment, as it may contain elements that affect Aurora® System functions. For example, the system can be adversely affected by electromagnetic field disturbances from other objects in the room, the close proximity of metal, and the close proximity of another Field Generator. Failure to test for such disturbances will increase the possibility of inaccurate transformations and possible personal injury.

The Aurora® System has not been designed or tested to be used during or following cardiac defibrillation. Cardiac defibrillation may cause inaccurate transformations and result in possible personal injury.

Do not expose sensors to a high magnetic field, such as a Magnetic Resonance Imaging (MRI) scanner, as they may become magnetized. Tracking with a magnetized sensor may result in incorrect transformations and result in possible personal injury.

Do not use the Aurora® System in the presence of other magnetic fields. To do so may lead to misleading or inaccurate transformations and possible personal injury.

Portable RF communications equipment (including peripherals such as antenna cables and external antennas) should be used no closer than 30 cm (12 inches) to any part of the Aurora® System, including cables specified by the manufacturer. Otherwise, degradation of the performance of this equipment could result. This may contribute to inaccurate transformations and possible personal injury.

Do not operate the Field Generator within 10 m of another operating Field Generator. To do so may contribute to inaccurate transformations and possible personal injury.

Portable RF communications equipment (including peripherals such as antenna cables and external antennas) should be used no closer than 30 cm (12 inches) to any part of the Aurora® System, including cables specified by the manufacturer. Otherwise, degradation of the performance of this equipment could result. This may contribute to inaccurate transformations and possible personal injury. Do not operate the Field Generator within 10 m of another operating Field Generator. To do so may contribute to inaccurate transformations and possible personal injury.

Immunity test	Test level	Result	Electromagnetic environment-guidance
Electrostatic discharge (IEC 61000-4-2) Contact discharge Air discharge	±8 kV ±2, ±4, ±8, ±15 kV	Test passed Test passed	Discharge impulses may cause the Aurora® to return MISSING instead of an incorrect reading.
Radiated RF (IEC 61000-4-3) [80 MHz – 2700 MHz] Proximity fields from RF wire-less communications equipment 385 MHz 450 MHz 710/745/780 MHz 810/870/930 MHz 1720/1845/1970 MHz 2450 MHz 5240/5500/5785 MHz	3 V/m 27 V/m 28 V/m 9 V/m 28 V/m 28 V/m 28 V/m 9 V/m	Test passed Test passed Test passed Test passed Test passed Test passed Test passed Test passed	External RF sources can distort Aurora® measurements indirectly because of imperfect filtering and demodulation effects in the amplification circuits. If the Aurora® firmware detects such a distortion, the Aurora® returns MISSING instead of an incorrect reading.
Electrical Fast Transient/Burst IEC 61000-4-4 - AC power I/O - Signal I/O lines	±2 kV ±1 kV	Test passed Test passed	Such disturbance may cause the Aurora® to return MISSING instead of an incorrect reading
Surge (IEC 61000-4-5) AC power I/O	± 0.5/1 kV L - N ± 0.5/1/2 kV L - PE ± 0.5/1/2 kV N - PE	Test passed Test passed Test passed	Such disturbance may cause the Aurora® to return MISSING instead of an incorrect reading
Conducted disturbances induced by RF fields (IEC 61000-4-6) [150 kHz to 80 MHz] ISM bands 6.779 MHz 13.56 MHz 27.030 MHz 40.68 MHz	3 V 6 V	Test passed Test passed	External RF sources can distort Aurora® measurements indirectly because of imperfect filtering and demodulation effects in the amplification circuits. If the Aurora® firmware detects such a distortion, the Aurora® returns MISSING instead of an incorrect reading.
Low frequency magnetic fields (IEC 61000-4-8)	30 A/m	Test passed	Due to the superposition of intended magnetic fields and power line magnetic fields, the tool position may show a higher position noise.
Voltage dips, short interruptions and voltage variations on power supply input (IEC 61000-4-11)	0%/0.5 periods at 0° - 315° at 45° steps 0%/1 periods 70%/25 periods 0%/250 periods	Test passed Test passed Test passed Test passed	--

20 PCB Integration Guide: SCU Board

This chapter describes the Aurora® V3.1 System Control Unit board. The board can be purchased separately for integration into a custom enclosure. When designing your own enclosure, see also: section 21. „PCB Integration Guide: SIU Board“ on page 76 and 22. „PCB Integration Guide: Design Considerations“ on page 78. There are several different PCB versions available. For technical details please review the data sheet of each board or contact NDI.

20.1 SCU Board Dimensions and Layout

Reference number: 610494

Board size: 206 mm x 135 mm x 23 mm

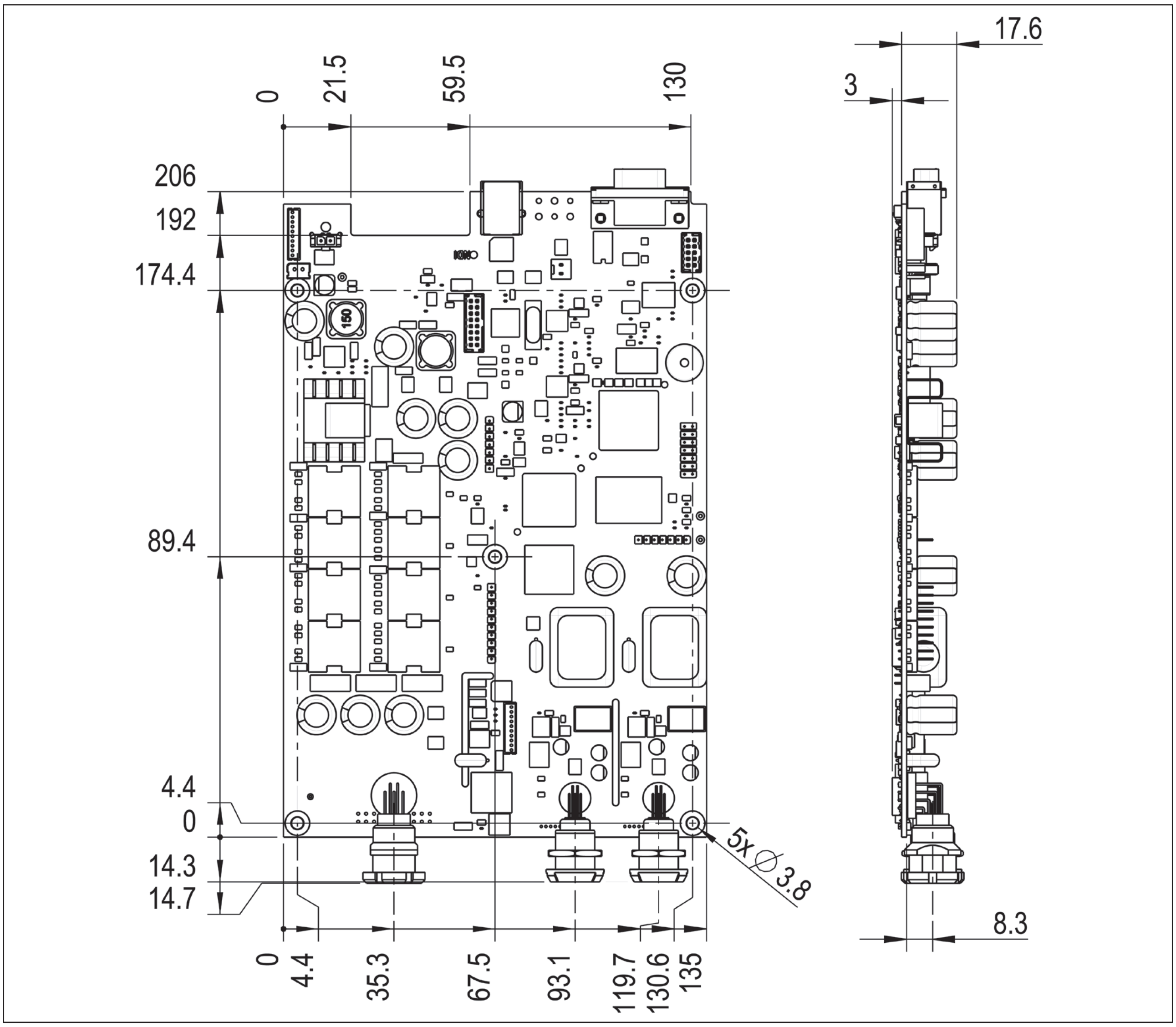
Board weight: 270 g

The following connectors extend past the end of the board:

- FG connector: 15 mm past end of board (with centre axis 8.3 mm past top of board)
- SIU Redel connector (if populated): 14.3 mm past end of board
- USB Connector: 7.1 mm past end of board
- Synchronization port: 11.2 mm past end of board

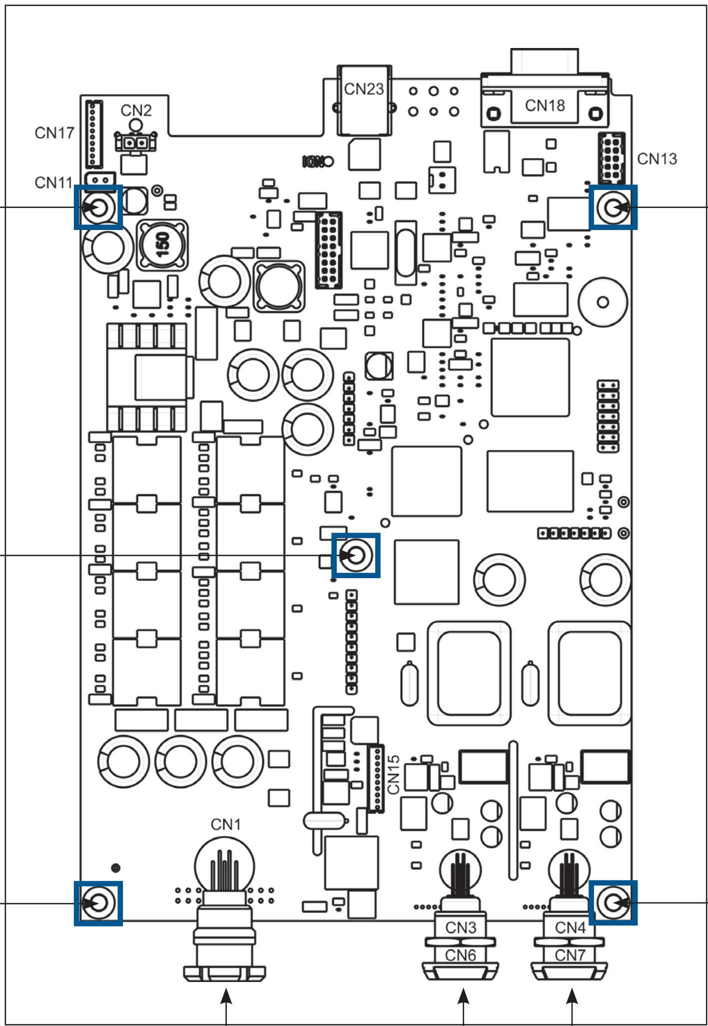
SCU Board dimensions

A 3D model of this part is available on request. Please contact NDI Product Support.
Units in mm



Reference number: 610494

SCU Board layout



Note:
See section 19.1 „ESD Precautionary Measures“ on page 66 for information on the correct handling of the SCU and SIU boards.

Mounting:

There are five mounting holes on the SCU board. Use the three mounting holes highlighted to connect the board to the earth ground of the enclosure.

Populated Connectors:

The following connectors are always populated on the SCU board:

- FG connector located at CN1 (see section 20.5 „SCU Board Connection to SIU“ on page 75 for details).
- USB type B connector located at CN23 (see section 20.4 „SCU Board Host Communication“ on page 73 for details).

Optional Connectors:

The following connection options can be specified upon ordering the SCU board from NDI:

- **SIU connector:** 10-pin Redel or 10-pin metal Lemo connectors located at CN3 and CN4, or 10-pin JST headers located at CN6 and CN7 (see section 20.5 „SCU Board Connection to SIU“ on page 75 for details).
- **Synchronization port:** female 9-pin D-type connector located at CN18 (see section 20.6 „SCU Board Synchronization Port“ on page 75 for details).
- **Power Connector:** Molex Micro-Fit 43650-0216 located at CN2 (see 20.2 „SCU Board Connection to Power“ on page 72 for details).

Headers:

The following connection options are always provided as a header on the board:

- **RS-232 port** located at CN13
- **RS-422 port** located at CN15

20.2 SCU Board Connection to Power

The SCU can be powered by either of the following two connections:

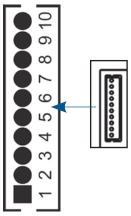
- 10-pin JST header B10B-ZR (located at CN17)
- Molex Micro-Fit 43650-0216 (located at CN2)

Only one power connector can be used at a time.

Note:
The Aurora® V3.1 boards do not provide an input protection.

Power header

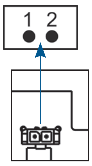
10-pin JST header B10B-ZR (located at CN17) for connection to power.
The pinouts are described as follows:



Pin	Pin Function
1	Ground
2	Ground
3	Ground
4	Ground
5	Not connected
6	Not connected
7	V in
8	V in
9	V in
10	V in

Power connector

Molex Micro-Fit 43650-0216 (located at CN2) for connection to power.
The pinouts are described as follows:



Pin	Pin Function
1	Ground
2	V in

Power supply

A medical power supply suitable to the application must be used. NDI recommends a 24 V, minimum 60 W supply with a 60601-1 approval. The power supply should offer a protection of 2 MOPP (Means of Patient Protection) input to output and 1 MOPP input to ground.

Power switch

A power switch can be added at location CN11. Connect an external power switch or short if this switch is not used. (CN11 is by default already shorted when the SCU board is purchased.) If CN11 is left open, the board cannot be powered.

Protective earth

The SCU board must be connected to protective Earth. This can be done using the three mounting holes on the board that are connected to ground. See figure „SCU Board layout“ on page 70 for details on which of the mounting holes are connected to ground.

20.3 SCU Board Connection to Field Generator

The Field Generator connector is Lemo EEG.2B.319.CLV and is located at CN1. This connector is always populated on the SCU board. To ensure the quality of the signal, it is not possible to have an FG header connection on the SCU board.

Ideally, the SCU board can be mounted such that the FG connector penetrates the enclosure. If this cannot be achieved, it is possible to extend the cable length by up to one metre by adding a bulkhead cable. This cable is available from NDI. The FG cable should not be placed in close proximity to an unshielded SIU board.

For optimal performance, the FG connector must be connected to the Earth ground of the enclosure. This connects the cable shield of the FG to ground. An ungrounded or poorly-grounded shield cable might create noise.

20.4 SCU Board Host Communication

There are three possible communication interfaces to the Aurora® System:

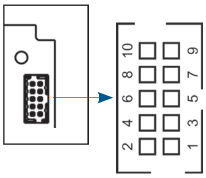
- RS-232: Molex male header, 2 mm pitch, series 87831 (header located at CN13)
- USB (located at CN23). By default, the SCU board is populated with a USB connector at CN23.
- Isolated RS-422: 10-pin JST header B10B-ZR (header located at CN15)

The communication protocol is independent of the communication interface used and is backwardscompatible with previous Aurora® Systems.

Upon power-up, the Aurora® System sends a RESET message along all interfaces. The first interface to send a valid command that is received by the Aurora® System becomes the active interface. The other interfaces are disabled until the next reset.

RS-232 Host communication

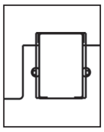
RS-232 Host communication Molex male header, 2 mm pitch, series 8783 (located at CN13)
The pinouts are described as follows:



Pin	Pin Function
1	Not connected
2	DTR
3	TX
4	CTS
5	RX
6	RTS
7	Not connected
8	Not connected
9	Ground
10	Ground

USB Host communication

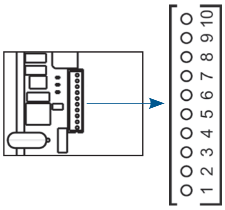
USB Type B for Host Communication (located at CN23)
The pinouts are described as follows:



Pin	Pin Function
1 to 4	Connect to a USB host using a standard USB cable

Isolated RS-422 Host communication

10-pin JST header for RS-422 Host communication 10-pin JST header B10B-ZR (located at CN15)
The pinouts are described as follows:



Pin	Pin Function
1	RX+
2	RX-
3	TX+
4	TX-
5	Reserved
6	ISO Ground
7	RTS+
8	RTS-
9	CTS+
10	CTS-

20.5 SCU Board Connection to SIU

The SCU supports connections for up to two SIUs. The SIUs can be connected the following ways:

- 10-pin JST header B10B-ZR (located at CN6 and CN7), using a 1:1 (straight through) cable to the SIU. This cable is 205 mm long and is provided by NDI.
- 10-pin Redel connector is Lemo PKB.M1.0GL.VG (located on CN3 and CN4), connecting via cable to Redel connectors on the SIU. The maximum cable length for this cable is 4.5 m.
  For more details on this option, contact NDI.

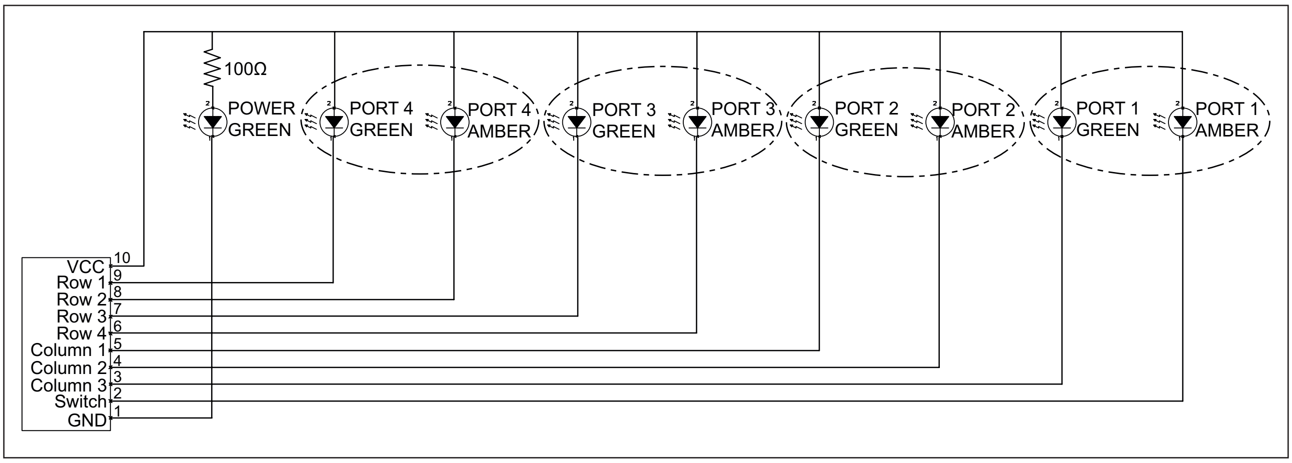
Note:
Only one of each header/connector pair can be used, i.e. one of CN3 or CN6, and one of CN4 or CN7.

20.6 SCU Board Synchronization Port

The synchronization port located at CN18 can be used to synchronize one Aurora® System with another. It can be populated using a female 9-pin D-type connector. For complete details on the synchronization port, see section 14. „External Synchronization“ on page 58.

20.7 SCU Board Power LED and Tool Port Status LEDs for the SIU

The SCU board incorporates a simple 10-pin header with 2.54 mm between the pins, located at CN16. This header provides a signal for a power LED, as well as signals for tool port status LEDs for the SIU board connected to SIU port 1 (i.e. connected to CN3 or CN6) on the SCU board.



- For other options for tool port status LEDs on the SIU, see section 21.4 „SIU Board LEDs“ on page 77.
- For details on LED behaviour, see section 4.6 „Sensor Interface Unit (SIU)“ on page 15.

20.8 SCU Board Unused Connections

CN8, CN10, CN12, CN14 and CN20 are for internal use only.

21 PCB Integration Guide: SIU Board

This chapter describes the Aurora® V3.1 Sensor Interface Unit board. The board can be purchased separately for integration into a custom enclosure. When designing your own enclosure, see also section 20. „PCB Integration Guide: SCU Board“ on page 69 and 22. „PCB Integration Guide: Design Considerations“ on page 78.

21.1 SIU Board Dimensions and Layout

The SIU board is available in several different versions: with 2, 4, 6 or 8 ports and with Redel plastic or ODU metal tool connectors or with header. The number of ports and the tool port connector type can be specified upon ordering the SIU board. For technical details please review the data sheet of each board or contact NDI.

SIU Board versions

Number of ports	Redel plastic	ODU metal	Header	Board Size in mm
2	X			90 x 66
2			X	90 x 66
4	X			135 x 89
4		X		135 x 89
4			X	135 x 89
6	X			175 x 82
8	X			90 x 247 x 12
8			X	90 x 247 x 12

Note:
Due to possible space constraints around the SIU PCB mounting holes, NDI recommends the usage of snap-on plastic posts to install the PCBs.

21.2 SIU Board Connection to SCU

SIU and SCU Boards in the Same Enclosure

The SIU can be connected to the SCU via 10-Pin JST header B10B-ZR, using a short 1:1 (straight through) cable to the SCU. This cable is provided by NDI.

SIU in a Separate Enclosure

For an external SIU in its own enclosure, a cable is needed to connect the header on the board to a Redel connector on the enclosure. A 340 mm long cable can be purchased from NDI, or you can build your own cable using the pinout described in table.

Pin on SIU board (JST B10B-ZR)	Pin on enclosure connector (Redel PKB.M1.0GL.VG)	
1	4	TXD
2	3	RXD
3	5	ADC+
4	6	ADC-
5	10	SYNC+
6	9	SYNC-
7	2	+5 V
8	1	+12 V
9	7	-12 V
10	8	GND

21.3 SIU Board Tool Port Connectors

There are three possibilities for the tool port connectors:

- Redel PKA.M1.0NL.VN
- ODU GX2LFC-P12QF00-0002
- JST B10B-ZR(LF)(SN) for 2- port SIU Samtec SMS-106-01-L-D for 4-port SIU

If the ODU connectors are used, the SIU board is considered as having a type B classification.
To provide BF type isolation when using tools with ODU connectors, care must be taken to isolate sensors and electronics in each individual tool. A tool should provide isolation of 1500 V against its connector pins, the connector enclosure, and the SCU enclosure.

Note:
For the tool connector pinout, see the “DDUG-1000-2165 Aurora® Tool Design Guide”.

21.4 SIU Board LEDs

Tool port status LEDs are available for the SIU via the following methods:

- The SCU board incorporates 10-pin header which provides the signals for the LEDs on the SIU board connected to SIU port 1 (i.e. connected to CN3 or CN6) on the SCU board. See section 20.7 „SCU Board Power LED and Tool Port Status LEDs for the SIU“ on page 75 for details.
- The LEDs are also located directly on the SIU board. These LEDs can be conveyed to another location via a light pipe.
- It is possible to use an I2C-bus for the LEDs on the SIU. This would require electronics on the patient side and would need special consideration regarding isolation. Please contact NDI for more details on this option.

22 PCB Integration Guide: Design Considerations

Note:
The approvals and classifications listed in section 17. „Approvals and Classifications“ on page 64 apply to the Aurora® V3 System as described in section 3. „Overview“ on page 9.

22.1 Patient Isolation

Since the patient isolation is implemented in the SCU board, it provides isolated power and signals to SIUs. Therefore, the SIU PCB is part of the patient side electronics. All components need to have an air clearance and creepage distance to earth ground or power sources (typically 2.5 mm air clearance and 4 mm creepage distance).

A system integrator has to consider its isolation diagram and choose a mounting option for the SIU boards.
Often, SIU PCBs are best mounted with plastic insulators, for example nylon posts.

Warning:
Do not short-circuit any of the patient isolation circuits on the SCU PCB. If a patient isolation circuit is shortcircuited, there is a risk of excessive patient leakage current, which may result in personal injury.

The following parts bridge these barriers and are considered critical components:

Port 1:

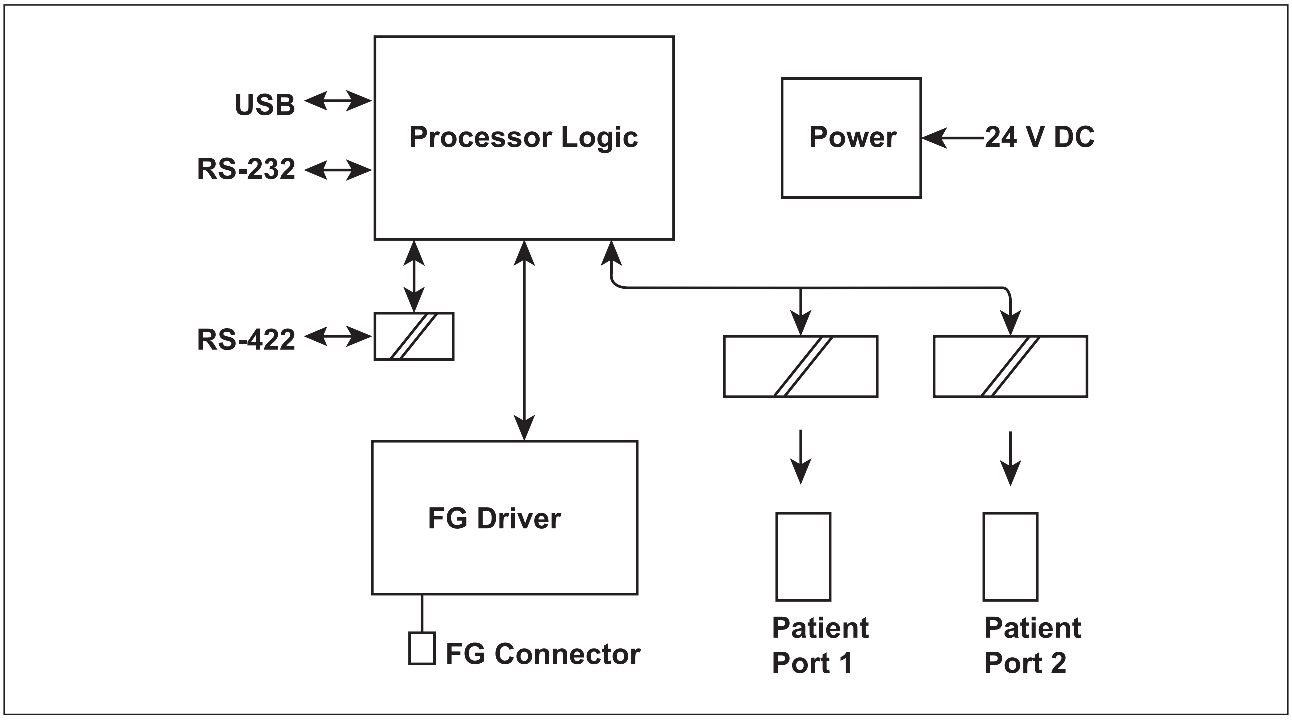
- U3 Recom REM10-2412DW/A
- U8 Analog Devices ADUM4402BRIZ
- C8 (various vendors) X1/Y1 Capacitor 100 pF

Port 2:

- U32 Recom REM10-2412DW/A
- U18 Analog Devices ADUM4402BRIZ
- C11 (various vendors) X1/Y1 Capacitor 100 pF

A block diagram illustration isolation is shown in figure.

SCU Isolation Diagram



To provide type BF isolation when using tools with ODU connectors, care must be taken to isolate sensors and electronics in each individual tool. A tool should provide isolation of 1500 V against its connector pins, the connector enclosure, and the SCU enclosure.

The capacitors on the SCU board allow leakage currents below type CF isolation level to be achieved.

Note:
The system integrator must ensure that none of the insulation barriers on the SCU board are bypassed or shorted during integration. The system integrator must test the insulation barriers in the final system.

22.2 RS-422 isolation

This section on the SCU board is constructed with the same air clearance and creepage distances of 2.5 mm and 4.0 mm respectively.

The following parts bridge these barriers and are considered critical components:

- U33 Recom R0.25S-3.33.3/H
- U20 Analog devices ADUM4402BRIZ
- C36 (various vendors) X1/Y1 Capacitor 100 pF

Note:
The system integrator must ensure that none of the insulation barriers on the SCU board are bypassed or shorted during integration.
The system integrator must test the insulation barriers in the final system.

22.3 EMC Considerations

The system integrator is responsible for adequate EMC shielding.

NDI recommends using a metal enclosure with a good connection to ground for the SCU. All metal connectors should have a low-impedance path to ground. An ungrounded or poorly-grounded FG shield cable might create a noise source visible in an EMC scan.

The SIU board is not a major source of noise and can be embedded into a plastic enclosure.

22.4 SCU-SIU Shielding

If the SCU and SIU boards are placed in the same enclosure, a high signal separation of the FG electronics on the SCU and the measurement electronics on the SIU is necessary to provide optimal performance. If the two boards are stacked on top of one another in close proximity, a ferromagnetic shield should be placed between the SCU and SIU boards. This shield should be at least as large as the SIU board and approximately 1 mm thick.

The FG cable (including a bulkhead cable inside the enclosure, as described in section 20.3 „SCU Board Connection to Field Generator“ on page 73) should not be placed in close proximity to an unshielded SIU board.

22.5 EMC Power Input

The SCU board has the following input voltage and power consumption:

Input voltage:	+12 VDC to +26 VDC
Power consumption:	Setup mode 10 W tracking mode 35 W

The SCU board’s total power consumption of 35 W splits into the FG and SIU.
The SIU power consumption is approximately 5 W.

The maximum operating ambient temperature for the SCU and SIU boards is +50 °C.

22.6 Mean Time Between Failures

Mean time between failures (MTBF) is calculated (acc. to Telcordia SR-332 Issue 4) for an environmental temperature of +50 °C. The MTBF drops by half for every +10 °C increased in environmental temperature. A fan is recommended for higher temperatures.

The MTBF are as follows:

SCU:	>250,000 hours
SIU:	>250,000 hours
All types of FG:	>1 Mio. H

Note:
The MTBF for Field Generators according to this standard does not refer to the long-term stability of the calibration. For details on calibration please refer to section 16. „Calibration and Verification“ on page 63.

23 Troubleshooting

The section highlights the most common difficulties with the Aurora® System. If you have a different problem, or if your problem persists after trying the suggestions below, please contact NDI technical support.

23.1 Data is reported as ‘Missing’

There are several possibilities why a tool or sensor may be reported as MISSING:

The tool or sensor is outside of the measurement volume.
Make sure the tools and sensors are located inside the characterized measurement volume. The various volumes are in the datasheet.

Make sure the desired measurement volume is selected. In the ToolBox Track software, you can select the volume using the menu option Track > Volumes.

The Aurora’s EM field is being disturbed by outside sources.
The Aurora® System is sensitive to disturbances in its electromagnetic field, which can be caused by other nearby electromagnetic fields or by sources of metal. If the interference is too strong, the Aurora® System will be unable to track the sensors, and the tools and sensors will be reported as missing. See section 23.5 „Reducing Interference“ on page 82 for advice on minimizing interference.

Weak spots in working volume.
In the tabletop field generator (TTFG) there can infrequently be missing points, usually close to the field generator. This is due to the TTFG's constrained geometry and shielding barrier. The position or the orientation of the sensor should be changed until it is able to be located again.

Problem with the tool definition file
If you are loading a tool definition file (.rom file) as a virtual SROM in the software, you may be using a tool definition file that is either mismatched to the tool, or one that contains a wrong setting.

- NDI provides tool definition files for all the sensors we sell. You can download the tool definition files on our support site at https://support.ndigital.com. The name of the tool definition file contains the sensor part number. If you cannot find the tool definition file for your tool, contact NDI technical support.
- If you have made or modified the .rom file using the Cygna-6D software, you may have changed a setting incorrectly so that the tool no longer tracks. Try using the default tool definition file located on the NDI support site. If the tool is able to track with the default tool definition file, contact NDI technical support for help finding the problem with your customized tool definition file.

The tool is moving too quickly
The Aurora® System may have trouble tracking the tool if it is moved too quickly.

23.2 High Indicator Value

There are several possibilities why the system is returning a high error value for the 6DOF transformations:

- If you are using a tool definition file, you may be applying one that is either mismatched to the tool, or one that contains a wrong setting. See section 23.1 „Problem with the tool definition file“ on page 80.
- Disturbances are influencing the system's calculations of how the sensors are positioned. Such disturbances include magnetic sources, metal placed too close to the system, or the system setup itself is causing interference. See section 23.5 „Reducing Interference“ on page 82.
- The tool is too far away from the Field Generator. The farther away from the Field Generator the tool is placed, the more susceptible it is to measurement noise. Try moving the tool closer to the centre of the measurement volume. In particular, if you are tracking a tool with respect to a reference tool: if the reference tool is placed too far back in the measurement volume, not only will its own transformations be affected by measurement noise, but the original tool's transformations being reported against the reference tool will also be affected.
- The tool has been dropped or changed in some way physically, so that the positions of the sensors within the tool have been shifted. In this case, the physically positions and/or orientations of the sensors within the tool no longer match the tool definition file, and the tool will not track properly.

23.3 Noisy, inaccurate or unstable data

The Aurora® System is sensitive to disturbances in its electromagnetic field, which can be caused by other nearby electromagnetic fields or by sources of metal. Disturbances to the Aurora® EM field can cause the data to be noisy, inaccurate or unstable. The distortion influence depends on the sensor orientation. For example, when two sensors are close and perpendicular to one another, it can happen that one is reported at the correct position, while the other is reported at a shifted position due to environmental disturbance. Often, the sensor pointing towards the FG is more sensitive to disturbance. See 23.5 „Reducing Interference“ on page 82 for advice on minimizing disturbances to the Aurora® EM field.

23.4 Measurement volume seems too small

If the measurement volume seems to be smaller than expected, check the following:

- The environment may have elements that are interfering with the Aurora® System's electromagnetic field. For example, metal and other electromagnetic fields can distort the measurement volume and interfere with measurements. See 23.5 „Reducing Interference“ on page 82 for advice on minimizing interference.
- Make sure the desired measurement volume is selected. In the NDI ToolBox Track software, you can select the volume using the menu option Track > Volumes.

23.5 Reducing Interference

The Aurora® System is susceptible to interference that may cause distortion of the electromagnetic field, resulting in inaccurate measurements or other tracking problems. If the Aurora® System is not tracking properly or the tracking data quality is poor, check for sources of interference:

Metal interference

The Aurora® System is sensitive to some metals, in particular ferro-magnetic metals.

- Check for metals in the setup, e.g. on the tools used, in or under the table or patient bed, or in other nearby objects. If it is not possible to completely remove the metal objects, try increasing the distance between the Field Generator and the metal, and between the sensors and the metal.
- If the Aurora® System is placed close to a wall or floor, be aware that there can be metal interference from inside the wall or under the floor. Try moving the Aurora® System to a different location.

If certain metals are placed too close to the Aurora® FG or to the sensors, the measurements will be affected, usually resulting in inaccurate data or inability to track. For more information, see section 13.3 „Effects of Nearby Metal on the Aurora System“ on page 56.

Electromagnetic interference from another Aurora® System

If using multiple Aurora® Systems in proximity to one another (including in adjacent rooms), make sure to leave at least 10 m between Aurora® Field Generators.

Electromagnetic interference from other EM-emitting devices

The Aurora® System’s electromagnetic field can be affected by nearby EM fields emitted from other electronic devices. If the Aurora® EM field is disturbed by other EM fields, the measurements will be affected, usually resulting in noisy data, high indicator values, or inability to track.

- Check for other devices emitting EM fields, including a RF emissions. To determine if other equipment is causing distortion, switch the equipment on and off while monitoring the Aurora® System.
- If the Aurora® System is placed in a small room or near a wall, check for potentially interfering devices in the adjacent room.

Interference on the sensor cables

The Aurora® System is susceptible to picking up noise along its cables. The cables between the sensors and the SIU are particularly sensitive to noise.

- Make sure the cables are not very close to other electrical or electronic equipment and are not tangled up with or lying parallel to cables from other equipment.
- To minimize the possibility of the cables picking up additional noise from the Aurora® System itself, set up the system as described in section 6.3 „Cable Management“ on page 29.

Interference caused by the Aurora® System setup

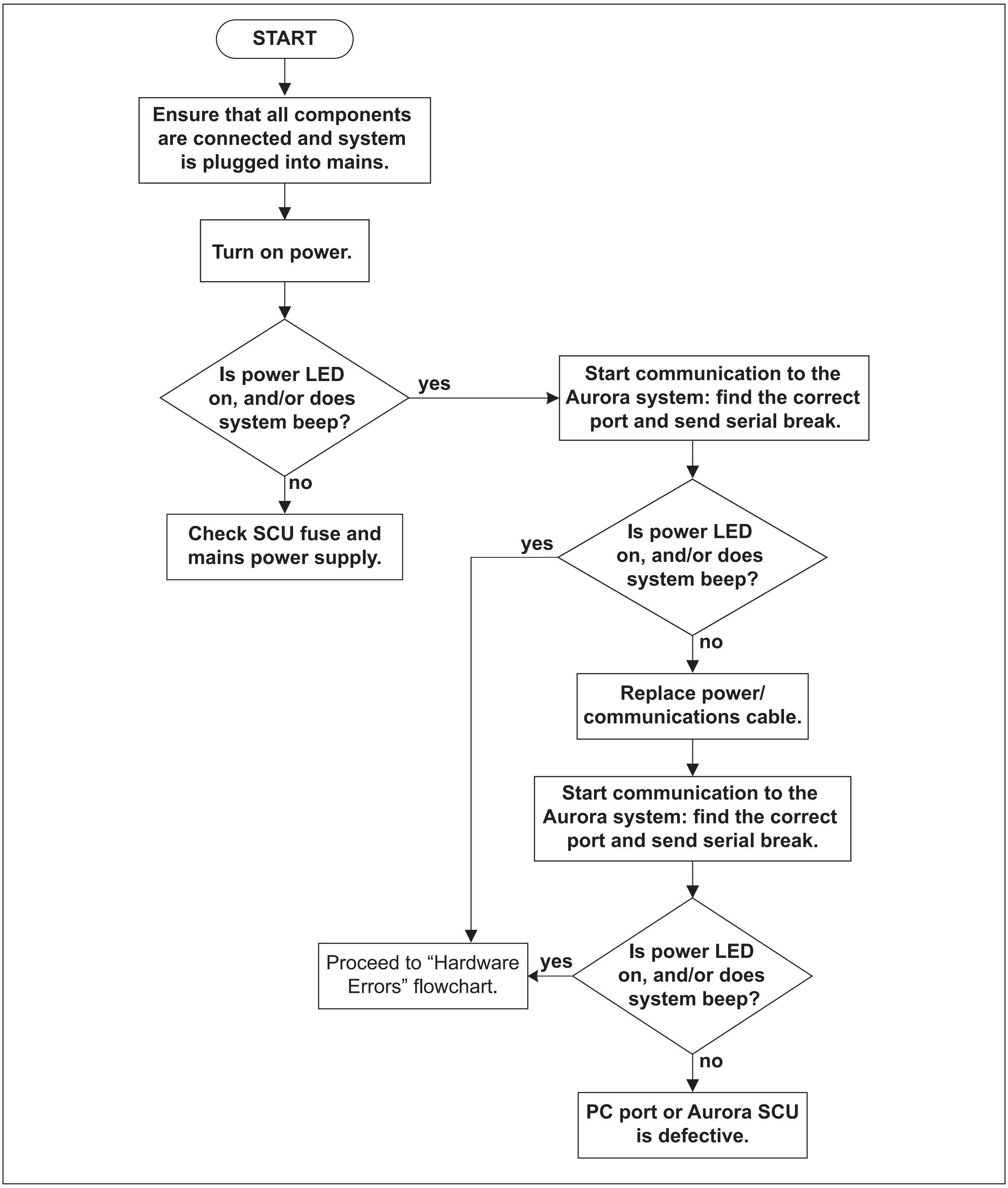
The setup of the Aurora® System may cause interference due to e.g. the proximity of the SCU to the Field Generator, or various cables to one another. To minimize the possibility of the Aurora® System components interfering with each other, set the system up as described in section 6.2 „Mounting the Components“ on page 28 and 6.3 „Cable Management“ on page 29.

23.6 Connection and Hardware problems

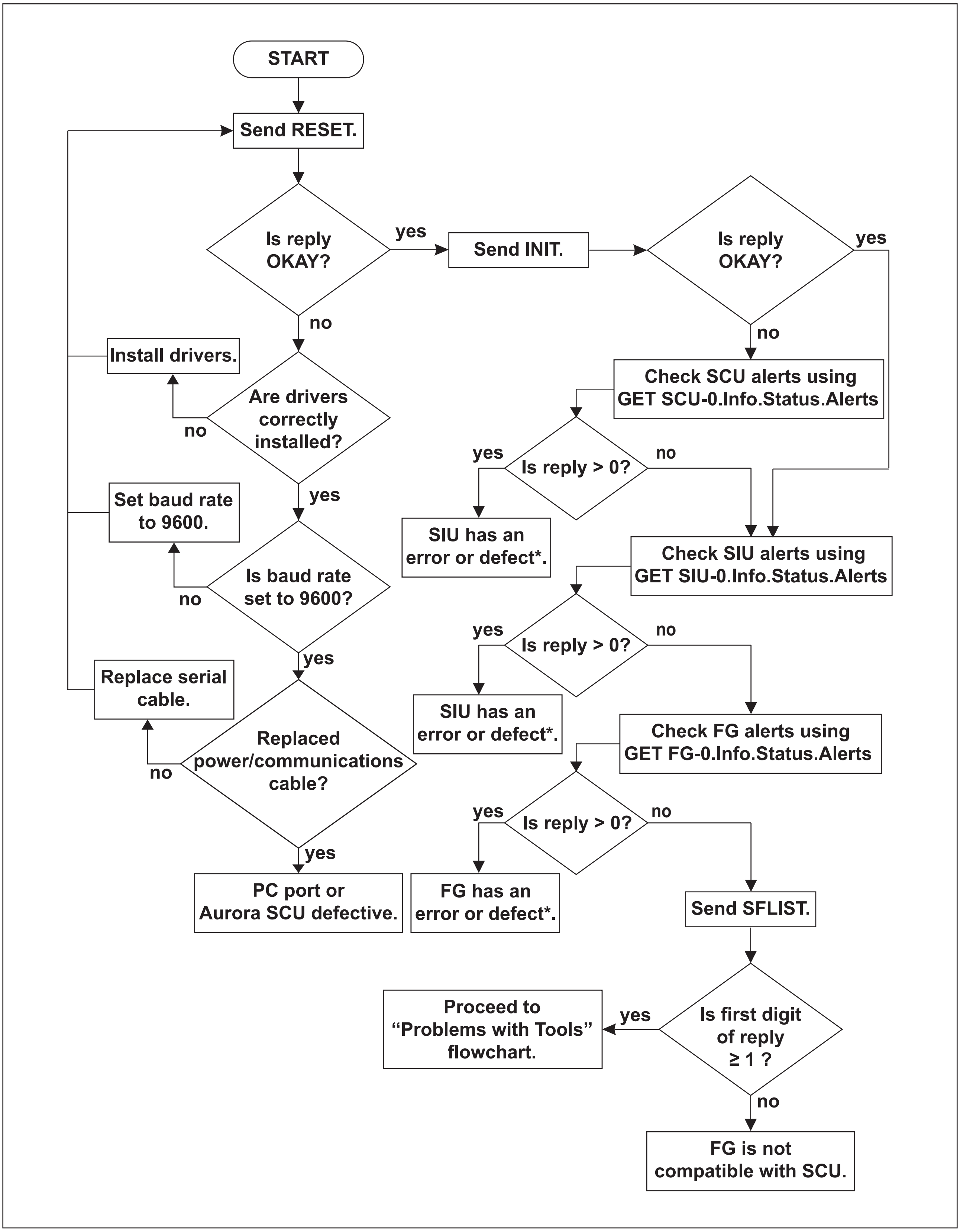
If you are unable to establish communication with the Aurora® System, check your communication settings using NDI ToolBox.

The following flowcharts detail a work flow for troubleshooting hardware problems with the Aurora® Systems. If you are not sure which flowchart applies to your problem, start with the first one and follow them in order.

Troubleshooting Flowchart: Connection problems

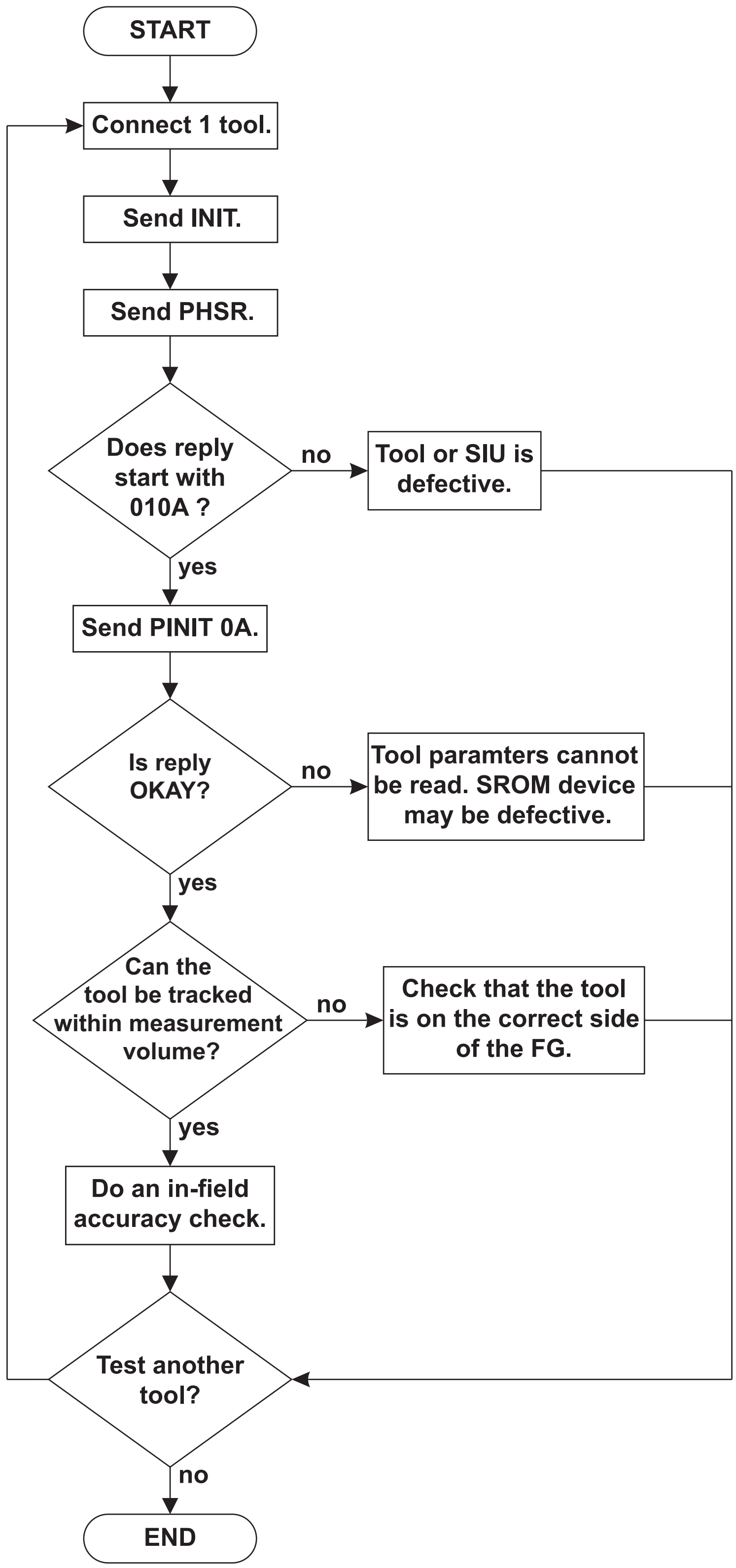


Troubleshooting Flowchart: Hardware errors



* To determine the exact defect, parse the bit field of of the Info.Status.Alerts response as described in the “DDUG-010-466 Aurora® Application Program Interface (API) Guide”, or contact NDI Technical Support for assistance.

Troubleshooting Flowchart: Problems with tools



24 Return, Repairs and Warranty

24.1 Returns and Repairs

Before returning equipment to NDI, you must either fill out a Returned Materials Authorization (RMA) request form at the NDI Support Site https://support.ndigital.com, or contact your account manager at NDI. NDI will then provide you with RMA information, shipping instructions, and the estimated repair cost.

Caution:

To move or ship the Aurora® System, repack in the original containers together with all protective packaging to prevent damage.

24.2 Warranty

Unless otherwise agreed to in writing by NDI, the warranty is as follows, and applies only to the original purchaser.

Note:
This warranty is also posted on the NDI Support Site at https://support.ndigital.com

Hardware

NDI warrants to the buyer that NDI's hardware product(s) will be free from defects in material and workmanship only for a period twelve (12) months from the date such product(s) is/are shipped from NDI to the buyer.

This warranty does not apply to product(s) normally consumed in buyer's operations or which have a normal life inherently shorter than the above-stated warranty period. Without limiting the generality of the foregoing, the following products shall have the following warranty periods:

product or components thereof which are re-chargeable batteries	90 days from shipment
magnetic sensor coils	prior to first use but no more than 90 days from shipment

Software

NDI's software product(s) is/are licensed and provided "as is, where is" without warranty of any kind. NDI makes no warranties, express or implied, that the functions contained in the software product(s) will meet the buyer's requirements or that the operation of the programs contained therein will be error free.

General Provisions Applicable to Warranty

NDI's obligations under this warranty shall be limited to repairing or replacing (at NDI's option) the product(s), EXW (Incoterms 2000) NDI's point of origin. Any original parts removed and/or replaced during any repair process shall become the property of NDI. This warranty shall apply only to the original buyer [being that legal entity which has contracted directly with NDI for the supply of the product(s)]. Repair work shall be warranted on the same terms as stated herein except such warranty shall be for a period of sixty (60) days or for the remainder of the unexpired warranty period, whichever is longer. In respect of any product(s) supplied hereunder which are manufactured by others, NDI gives no warranty whatsoever, and the warranty given by such manufacturers, if any, shall apply.

The obligations of NDI set forth in this warranty are conditional upon proper transportation, shipping, handling, storage, installation, use, maintenance and compliance with any applicable recommendations of NDI. Without limiting the generality of the foregoing, this warranty shall not apply to defects or damage resulting from: fire; misuse; abuse; accident; neglect; improper installation; improper care and/or maintenance; lack of care and/or maintenance; customer supplied software interfacing; modification or repair which is not authorized by NDI; power fluctuations; operation of hardware product(s) outside of environmental specifications; improper site preparation and maintenance; permitting any substance whatsoever to contaminate or otherwise interfere with optics; and any other cause beyond the control of NDI. The obligations set forth in this warranty are further conditional upon the buyer promptly notifying NDI of any defect and, if required, promptly making the product(s) available for correction. NDI shall be given reasonable opportunity to investigate all claims and no product(s) shall be returned to NDI without NDI first providing the buyer with a return material authorization number and shipping instructions. All product(s) returned to NDI shall be packaged in the containers originally used by NDI to ship the product(s) to the buyer.

NDI, for itself, its agents, contractors, employees, providers, and for any parent or subsidiary of NDI, expressly disclaims all warranties, express or implied, including, without limitation, of merchantability or fitness for a particular purpose.

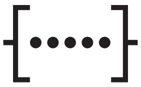
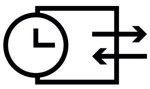
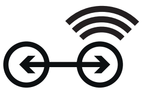
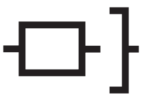
The foregoing warranty is the entire warranty of NDI. NDI neither assumes nor authorizes any person, purporting to act on its behalf, to modify or to change this warranty, or any other warranty or liability concerning the product(s).

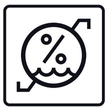
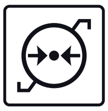
25 Abbreviations and Acronyms

Abbreviation or Acronym	Definition
5DOF	5 Degrees Of Freedom
6DOF	6 Degrees Of Freedom
AC	Alternating Current
AM	Amplitude Modulation
API	Application Program Interface
CI	Confidence Interval
DIN	Deutsches Institut für Normung (German Institute for Standardization)
EMC	Electromagnetic Compatibility
EMI	Electromagnetic Interference
ESD	Electrostatic Discharge
FCC	Federal Communications Commission
FG	Field Generator
FM	Frequency Modulation
IEEE	Institute of Electrical and Electronic Engineers
LED	Light Emitting Diode
MOPP	Means of Patient Protection
MRI	Magnetic Resonance Imaging
MTBF	Mean Time Between Failures
NC	Normal Case
NDI	Northern Digital Inc.
PFG	Planar Field Generator
RAM	Random Access Memory
RF	Radio Frequency
RMA	Returned Materials Authorization
RMS	Root Mean Square
SCU	System Control Unit
SFC	Single Fault Condition
SIU	Sensor Interface Unit
SROM	Serial Read Only Memory
TTFG	Tabletop Field Generator
UL	Underwriters Laboratories Inc.
USB	Universal Synchronous Bus
VCP	Virtual Comm Port
WFG	Window Field Generator

26 Equipment Symbols

The following table explains the symbols found on Aurora® System hardware:

Symbol	Meaning	Location
	**Warning** (To avoid personal injury, consult accompanying documentation)	Planar FG, TTFG
	Refer to instruction manual/booklet	WFG, SCU, SIU
	Possible interference to the operation of, or damage to active implanted cardiac devices	Planar FG, TTFG, WFG
	Power LED	SCU, SIU
	RS-422 serial communication port	SCU
	Synchronization port	SCU
	USB port	SCU
	Direct current	SCU
	Field Generator cable port	SCU
	Connection port between SCU and SIU	SCU, SIU
	Type BF equipment	SCU, SIU, Planar FG
	Type B equipment	WFG, TTFG

Symbol	Meaning	Location
	Fragile	Packaging
	Keep away from rain	Packaging
	Recyclable (corrugated fibre board)	Packaging
	Humidity limit	Packaging
	Atmospheric pressure limit	Packaging
	Temperature limit	Packaging
	NRTL TÜV SÜD-Mark - Nationally Recognized Testing Laboratory	SCU

27 Glossary

5DOF

Five of the six degrees of freedom needed to uniquely define the position and orientation of a rigid body in space. Three translation values on the x, y and z-axes and any two of the three rotation values, in general - roll, pitch and yaw.

6DOF

Six degrees of freedom needed to uniquely define the position and orientation of a rigid body in space. The three translation values on the x, y, and z-axes; and the three rotation values roll, pitch and yaw.

Calibration

Calibration is the process of establishing, under specified conditions, the relationship between values produced by an NDI measurement system and corresponding known values established by a device that is traceable to a national standard.

Characterization (Field Generator)

Characterizing a Field Generator is a manufacturing process used to determine and define the specific physical parameters of each Field Generator.

Characterization (tool)

Characterizing a tool is the process of creating its tool definition file (.rom).

Characterized measurement volume

The characterized measurement volume is the volume within the detection region where accuracy is within specified limits. NDI cannot guarantee measurement accuracy outside this region.

Detection region

The detection region is the total volume in which an NDI measurement system can detect a marker/ sensor, regardless of accuracy.

Dual sensor tool

A dual sensor tool contains two sensors. If the sensors are affixed relative to each other inside this tool, the system is able to measure the transformations of the tool in 6DOF.

Electromagnetic Compatibility (EMC)

Electromagnetic Compatibility (EMC) is the extent to which a piece of hardware will both interfere with other equipment and tolerate electrical interference from other equipment.

Electromagnetic Interference (EMI)

Electromagnetic Interference (EMI) are electromagnetic waves that emit from natural sources or electrical and electronic devices.

Euler rotation

An Euler rotation is a mathematical method of describing a rotation in three dimensions: the rotation of the object around each axis (Rx, Ry, and Rz), applied in a specific order.

Euler transformation

An Euler transformation is a mathematical method of describing translations and rotations in three dimensions.
Six values are reported for an Euler transformation: the three translational values in the x, y, and z-axes; and rotations around each of the axes, Rx, Ry, and Rz.

Field Generator

The Field Generator is the component of the Aurora® System that generates the electromagnetic field.

Field Generator cable

The Field Generator cable connects the Field Generator to the System Control Unit.

Field Generator port

The Field Generator port connects the System Control Unit to the Field Generator

Global coordinate system

The global coordinate system is an NDI measurement system‘s coordinate system. The global coordinate system is used by the measurement system as a frame of reference against which tool transformations are reported. By default, the global coordinate system‘s origin is set at the Field Generator.

Indicator value

The indicator value is a unitless estimate of how well the system calculated a particular transformation.

Local coordinate system

A local coordinate system is a coordinate system assigned to a specific tool.

Local frame of reference

A local frame of reference is a reference tool‘s local coordinate system.

Measurement volume

The characterized measurement volume is the volume within the detection region where accuracy is within specified limits. NDI cannot guarantee measurement accuracy outside this region.

Missing

If the system cannot determine the location of a sensor or a transformation of a rigid body/tool, that sensor or rigid body/tool is considered missing.

Quaternion transformation

A quaternion transformation is a mathematical method of describing a change in position and orientation in three dimensions. Seven values are reported for a quaternion transformation: the three translational values in the x, y, and z axes; qx, qy and qz form a vector and q0 indicates the amount of rotation about that vector.

Reference tool

A reference tool is a tool whose local coordinate system is used as a frame of reference in which other tools are reported/measured.

Rx, Ry, Rz

The terms Rx, Ry, and Rz refer to angles of rotation around the x, y and z-axes respectively.

Sensor

A sensor is a coil of wire with two lead wires whose position can be determined in 5DOF by the Aurora® System.

Sensor Interface Unit (SIU)

The SIU is the component of the Aurora® System that connects tools to the System Control Unit (SCU).

Sensorless tools

Tools that have no sensors, and cannot have their position determined. For example, a foot switch. Sensorless tools have GPIO lines that need to be recognized by the system.

Single sensor tool

A single sensor tool contains one sensor. This tool can only provide 5DOF position information.

SROM device

An SROM device is a memory device located inside a wired tool. A tool definition file can be programmed into the SROM device so that the tool can carry its own information for automatic retrieval by an NDI measurement system.

SROM image file

A tool definition file stores information about a tool. This includes information such as the placement of the tool‘s sensors, the location of its origin, and its manufacturing data. A tool definition file is formatted as a .rom file.

System Control Unit (SCU)

The System Control Unit (SCU) controls the Aurora® System. The SCU powers and directs the Field Generator‘s output, collects measurement data from tools, and calculates transformations. It also communicates with the host computer.

Tool definition file

A tool definition file stores information about a tool. This includes information such as the placement of the tool‘s sensors, the location of its origin, and its manufacturing data. A tool definition file is formatted as a .rom file.

Tool origin

The tool origin is the origin of the tool‘s local coordinate system.

Transformation

A transformation is a combination of translation and rotation values that describe the location of the tool in position and orientation. See also Euler transformation, quaternion transformation.

28 Contact Details and Updates

28.1 Contact Details

If you have any questions regarding the content of this guide or the operation of this product, please contact us:

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28.2 Updates

NDI is committed to continuous improvements in the quality and versatility of its software and hardware. To obtain the best results with your NDI system, check the NDI Support Site regularly for update information:
https://support.ndigital.com