Server User Manual

NOVATOR SOLUTIONS

Server User Manual

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Introduction

1 Introduction

This document contains information about the functionality of NC-Server. The document is divided into following sections:

- Introduction contains brief information about the product functionality
- Getting started gives information about system requirements, evaluation, installation and getting up and running with NC-Server and the clients as well as licensing
- Server User Manual contains detailed information about NC-Server functionality
- NC-Config User Manual contains detailed information about NC-Config functionality
- NC-Channel User Manual contains detailed information about NC-Channel functionality
- Interface Control Manual contains detailed information about the communications model of the server

1.1 What is NC-10?

The underlying software tool used in NC-Server channelization is called NC-10.

In a wideband signal source there can be many different signals of interest that must be processed further. Processing the entire wideband for every interesting signal is too CPU intensive. Instead, the signals of interest should be extracted from the wideband source to make it possible to process each signal individually.

Novator Solutions NC-10 (Novator Channelizer), powered by ChannelCoreFlex Technology from RFEL LTD. UK, is a software product that lets users leverage powerful industry-leading channelization techniques and channelize up to 1024 channels simultaneously, depending on the target.

1.2 Network Topology

The system setup with the NC-10 USRP consists of the NC-10 USRP, a server computer and optionally one or multiple client computers connected to a switch.

NC-Server is the server application running on the server computer and is used to configure the NC-10 USRP.

The NC-10 USRP has two SFP+ports for communication. The SFP+ Port 0 is used for all the configurations of both RF Front End and channelizer. This is done over Ethernet via TCP/IP commands. The SFP+ Port 0 is also used to read out raw RF data acquired in the FPGA via UDP. It is recommended to always connect the SFP+ port 0 on the USRP directly to the server computer. The SFP+ Port 1 is used to output channelized data via UDP. The SFP+ port 1 can either be connected directly to the server computer or to a switch. For other topologies please contact Novator Solutions.

Client applications can run on the server computer together with NC-Server or on separate computers. Then all computers as well as the USRP have to be connected to a common switch. An overview of the possible topologies can be seen in Figure 1.

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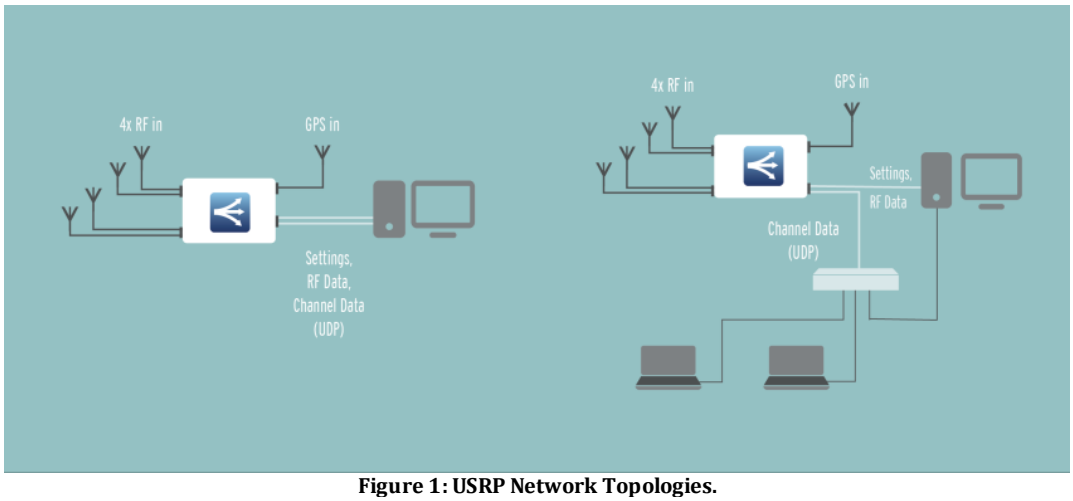

Figure 1: USRP Network Topologies.

Use of GPS is optional.

1.3 NI USRP

National Instruments USRP-2945 and USRP-2955 are software defined radios with superheterodyne RF Front End capable of receiving 4 RF inputs at the same time. Each of them has 80MHz of bandwidth. For each NC-10 channel it is possible to select which RF input it comes from. USRP is equipped with 2 SFP+ ports and a PCIe x4 connector.

In order to download a bitfile to the USRP-2945/55, it is necessary to use a PCIe x4 connector, as explained in Loading USRP Bitfile section. However, once the bitfile is loaded PCIe connection is no longer needed.

For all configurations of both the RF Front End and the channelizer, NC-10 provides the user with a capability of doing that over Ethernet, through SFP+ Port 0. Moreover, the acquired raw RF data can be streamed out through the same port.

Channel data are streamed out of the USRP via Ethernet through SFP+ Port 1. If the user prefers to multicast the channel data, the SFP+ Port 1 must be connected to a network switch. Network Topology section provides more detailed information.

The Channel data is streamed out as UDP packets in a custom format called NC Protocol or VITA49 format depending on hardware setup.

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Getting Started

2 Getting Started

This section contains information about system requirements that need to be fulfilled in order to install NC-Server.

Furthermore, it explains how to install the software.

Additional information about licensing needed in order to run the full software functionality is given.

2.1 System Requirements

Hardware

- Computer running the NC-Server software with
  - *Option A:* High-speed (10Gb/s) Ethernet interface card with 2x SFP+ connectors.
  - *Option B:* 1x 10Gb/s Ethernet interface with SFP+ connector, 1x 1Gb/s Ethernet interface, and a network switch with support for 10Gb/s and SFP+ connector.
- NI USRP-2945/55
- Two SFP+ 10Gb compatible cables. See also notes below.
- OPTIONAL: PCIe link (needed only for downloading a bitfile)

Software

- NC-Server software package containing
  - NC-Server
  - USRP Network Configurator
  - NCR Channel Editor
  - NC-10 USRP License Manager
- NC-Channel (to be run in remote clients)
- NC-Config Client software (to be run in remote clients)

Important Notes on Networking and Data Transfer

1. 1Gb/s SFP+ to RJ45 adapters will *not* transmit the 10Gb/s data sent from the USRP even if the connector form factors allow the cables to be connected.
2. Network switches with both 10Gb SFP+ ports and 1Gb RJ45 ports are usually able to convert the data flows so the client system can be connected to the USRP via a switch instead of direct cabling.
3. With higher data flows (e.g. high amounts of channels, wideband channels, and multiple wide FFT spectra enabled), the probability of package losses will increase if both the SFP0 and SFP1 data is managed by the same computer. A more robust solution is to let one computer manage the server application, another to manage channel data reads (for example with NC-Channel), and possibly a third to manage configuring and FFT display (for example with NC-Config).
4. One of the 10Gb/s network interface cards must have support for 9014 bytes Jumbo packets. If channel data protocol used is VITA49, both network interface and the network switch must support 9014 Jumbo packets.

2.2 Installing Server

The steps for installing the server is:

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1. Download NI USRP 19.1 or later driver from National Instruments web and install it.
2. Install distributed server program. Refer to Server User Manual for detailed instructions.
3. Request a bitfile by e-mailing Novator Solutions at info@novatorsolutions.se
4. Once Novator Solutions sends the information required for obtaining the bitfile, download it and place it in the default location: %Public%\Documents\Novator Solutions\NC-10\FPGA Bitfiles.
5. Update the IP address of the USRP.

Client Applications

The client application, NC-Config controls the USRP only via NC-Server by using TCP/IP commands. A network adapter and network access to the computer running NC-Server (Host computer) is required, but aside from that no hardware drivers will be needed. Refer to NC-Config user manual for client setup instructions.

2.2.1 Loading USRP Bitfile

The instructions here describe how a bitfile is upgraded in the USRP unit. With a new delivery of the USRP unit the bitfile is already upgraded to function with the latest NC-Server version and these steps are not needed. However, later on it may become necessary to update the bitfile for example when a new NC-Server version is released.

Updating the bitfile requires that you connect the PC with the USRP unit using a PCIe cable. This requires a dedicated PCIe link hardware interface which is not part of the standard NC-Server delivery.

Mojo DX to Thunderbolt 2 converter, which can be converted to USB C or Thunderbolt 3 with a cable adapter, is an alternative to plug-in PCIe interface cards. Sonnet sells this adapter that have proved to work in most cases, but no guarantees are given by Novator Solutions that they work. Contact National Instruments and computer provider when having issues with connecting to your USRP over PCIe-link.

Connection

1. Connect the USRP with a PCIe cable while the computer is turned off
2. Power the USRP on first, then the computer
3. Open MAX (Measurement and Automation Explorer)
4. Find your USRP device under “Devices and Interfaces” category
5. Click the Update firmware button in MAX
6. Browse to the NC-10 bitfile
7. After the update procedure is completed, power down the USRP unit
8. Disconnect the PCIe cable
9. Power on the USRP unit

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2.2.2 Network Configuration

Since the channelizer data is read out from the USRP through Ethernet, a correct network configuration for both the USRP and the computers that run Server or Client programs is essential before running.

A separate program called **USRP Network Configurator** is used to configure the Ethernet settings of the USRP unit. This program allows you to configure IP Address and Subnet Mask for each port and Default Gateway that applies to both ports. The program itself contains detailed help explaining how to run it.

Set new IP Addresses, Subnet Masks and Default Gateway for SFP+ ports of USRP by following the steps below:

1. Browse to the USRP Network Configurator.exe that is placed in %ProgramFiles(x86)% \Novator Solutions\ after installation of NC-Server.

2. Run the application and follow instructions inside that software.

> *NOTE: Make sure that jumbo frames are enabled and set to 9014 Bytes on the Server computer SFP interface adapters, it might also help to disable outgoing flow control on receiving network interface to increase how much data that can be received.*

Table 1 lists the network ports that NC-Server needs access to.

Port Number	Protocol	Use
2227	TCP/IP	Server↔Client communication
49152	UDP	Server↔USRP register communication
49153	UDP	USRP → Server RF data
49154	UDP	Server↔USRP register communication USRP→Server channel data
5843	UDP	Server→Client radio spectrum data from signal source 1 (marked as RF 0/RX1 in the USRP)
5843	UDP	Server→Client radio spectrum data from signal source 2 (marked as RF 0/RX2 in the USRP)
5843	UDP	Server→Client radio spectrum data from signal source 3 (marked as RF 1/RX1 in the USRP)
5843	UDP	Server→Client radio spectrum data from signal source 4 (marked as RF 1/RX2 in the USRP)

Table 1: Network Ports Accessed by NC-Server .

> *See also important notes on network connectivity under "System Requirements"*

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2.3 Licensing

To run NC-Server in fully operational mode, a license file is required. Without a valid license file, the FPGA will work for approximately 10 minutes before it stops outputting data.

Each license is tied to a specific FPGA-target, and the license file can contain licensing information for multiple boards. When NC-Server is run, it automatically searches for the serial number of the hardware resource present on the network. If the serial number is found in the license file, the corresponding license key is used to unlock the full functionality of the channelizer.

> *NOTE: If a license file is found in the default place (C:\Users\Public\Documents\Novator Solutions\NC-10\Licenses\NC-10 License.txt), but the currently addressed USRP serial number is not found in the license file, or if the license key is not valid, the Server will report an error and the hardware cannot be loaded.*

Obtaining a License Key section contains step-by-step guide for obtaining the key.

2.3.1 Obtaining a License Key

Steps required for license management are listed here:

1. Generate the license request file, either using the Server or with the standalone executable.
2. Email obtained License Request File from step 1 to info@novatorsolutions.se.
3. An email with a license file will be emailed to you within 2 business days.
4. Either use NC-10 USRP License Manager program to verify the license and place it in the default location, or move it manually to: C:\Users\Public\Documents\Novator Solutions\NC-10\Licenses\NC-10 License.txt on the Host computer. It is still possible to use other locations for license file but then make sure you configure the license file path with NC-Server.

2.3.2 NC-10 USRP License Manager

NC-10 USRP License Manager is a utility for generating a license request file for a USRP unit. It can also be used to verify a License File and place it in the correct location after it has been received from Novator Solutions. The utility is installed automatically when installing NC-Server. The program location is %ProgramFiles(x86)%\Novator Solutions\NC-Server\Addons\NC-10 USRP License Manager.exe.

Generating License Request File

1. Start the program. Verify that the PC IP Address and USRP IP Address match your system configuration (Figure 2):

    a. PC IP Address should match the IP address of your computer's network adapter that is connected to USRP port SFP0.

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b. USRP IP Address should match the IP address of the SFP0 port in the USRP

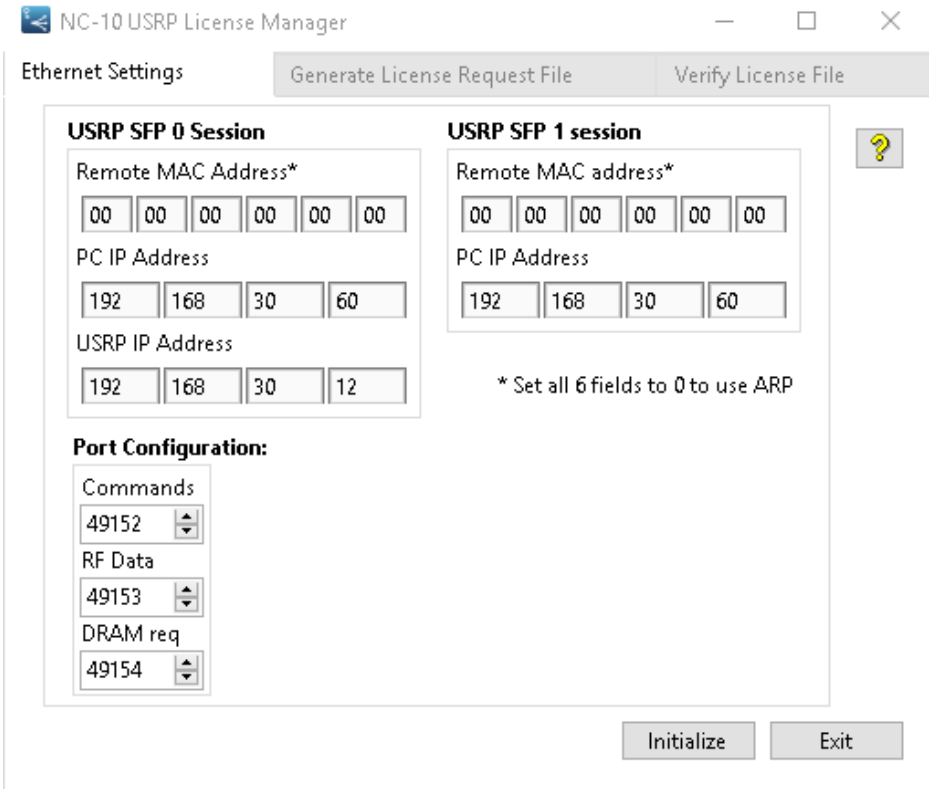

Figure 2: Initial Ethernet Settings.

> *NOTE: This utility cannot be used to change the network settings. Use USRP Network Configurator for that purpose.*

2. Press "Initialize". If the PC IP Address is correct, the program will switch to the next screen (see Figure 3 below). Make sure to enter Activation Code in case NC-10 was purchased through LabVIEW Tools Network. In License Request Folder enter a place where you want the request file to be saved, for example Desktop.

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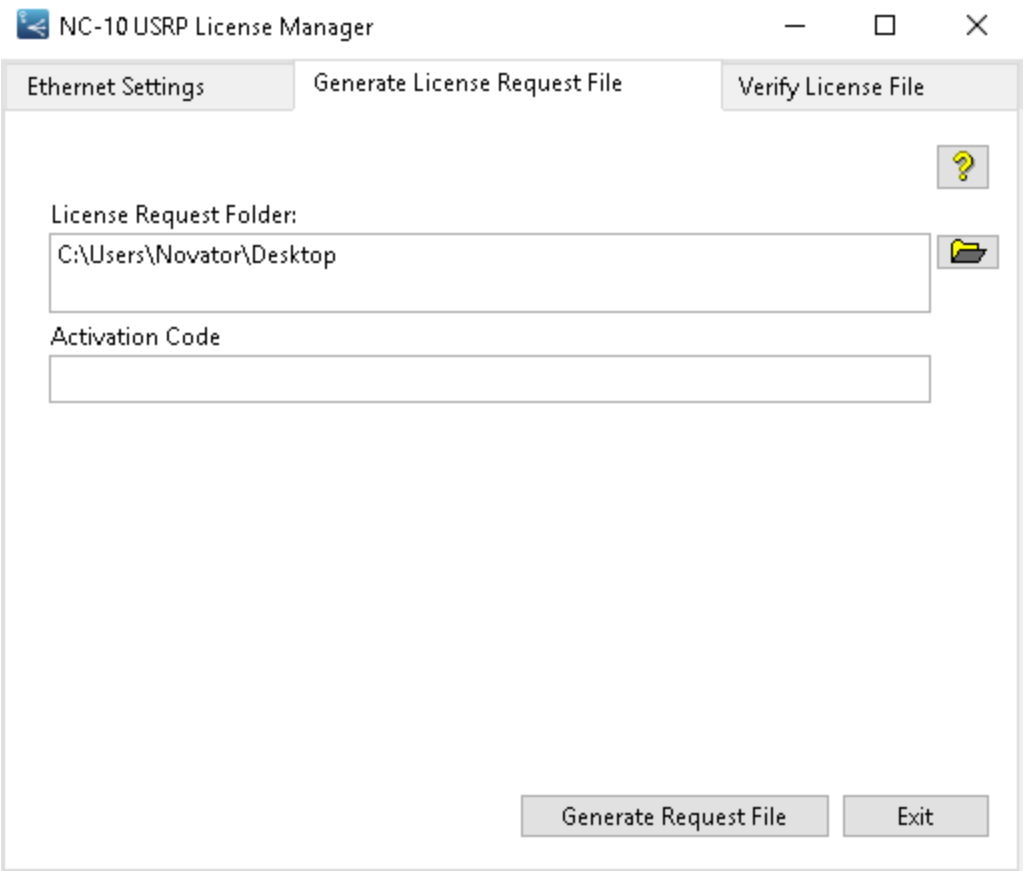

Figure 3: License Request File Generation.

3. Click "Generate Request File". If successful, a text file is going to be created in the License Request Folder, for example *20180413103444_NC-10 LicenseRequest.txt* where the initial part indicate the request file creation date and time.

4. Refer to the section on "Obtaining a License Key" for next steps.

Verifying License File

1. If you have a license file installed, you can choose the "Verify License File" tab. Fill in the path to the license file you have obtained from Novator Solutions and click "Verify License File".

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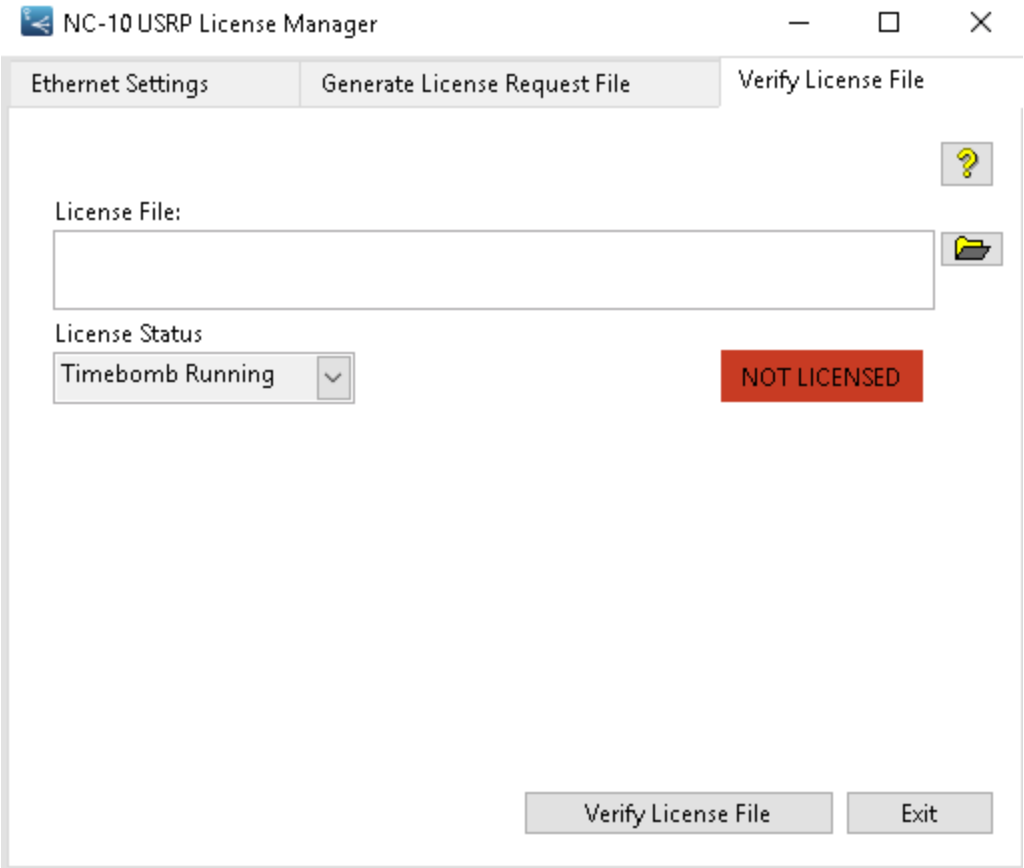

Figure 4: License File Verification.

2. If the license status is Valid as in Figure below, the program will copy the license file to the default location C:\Users\Public\Documents\Novator Solutions\NC-10\Licenses\NC-10 License.txt.

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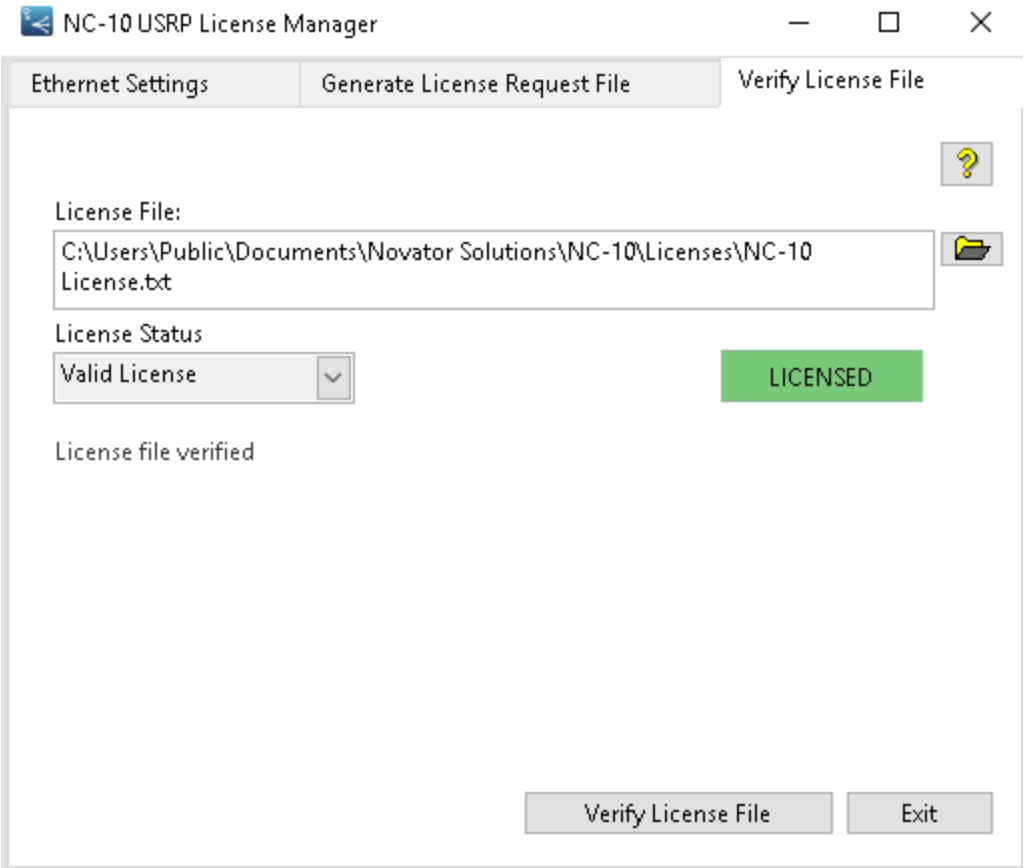

Figure 5: Valid License Identified.

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NC-10 Operation

3 NC-10 Operation

This section aims to give a more detailed view and understanding of the functionality of NC-10 that is accessible for NC-Server users.

3.1 RF Input

The NC-10 FPGA on USRP receives RF data in IQ form, where both I and Q are 16 bits wide. This data goes further to channelization process.

RF Input Rate

All four RF inputs of USRP have an input rate of 100MHz. Bandwidth of RF Data is 80MHz.

RF Input Levels

Since USRP is an uncalibrated device, levels of data are not absolute. Moreover, it is not expected that all 4 RF inputs have exactly the same frequency response and it is possible that given the same input and same settings they get different levels.

3.2 Channelizer

The Channelizer (powered by ChannelCoreFlex Technology, or CCF, from RFEL LTD., UK) operates on the input RF data and extracts the channels. Table 2 below lists the the specifications of the channelization process.

Input rate (I/Q), fin	100 MSps
Number of RF Inputs	4
Number of output channels	512 (VITA49 protocol), 256 (NCR protocol)
Data width (in and out)	16-bit I, 16-bit Q
Output channel center frequency resolution	<1Hz
Output channel sample rate	Min: 50MSps Max: 0.76kSps
Spurious-free Dynamic Range	>100 dBFS
Signal to Noise and Distortion Ratio	>90 dB
Output Channel alias-free bandwidth	80% of output sample rate
Output Channel alias filter rejection	>100 dB
Output Channel passband ripple	< ±0.1dB
Output Channel programmable gain	Coarse: 0 - 42.14dB (6.02 increment) Fine: 0 - 102.3dB (0.1 increment)
Number of filters	32
Number of filter taps per filter	31

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Table 2: CCF Specifications.

3.2.1 Channel Settings

All channels can be configured individually with parameters that depend on the currently used FPGA code. It is possible to combine wide and narrow channels, have them overlap, etc. The channels can be reconfigured during runtime without disrupting the channelization of the other channels.

The channel sample rate is the only channel setting that depends on the settings of the other channels. The total aggregate output sample rate cannot exceed 185 MHz. When configuring channels using TCP/IP commands, the aggregate output rate of all enabled channels is calculated within the Server. If the sum exceeds the limit with the new sample rate, the sample rate is not updated and the channel is disabled. Due to the internal processing on the FPGA and the sample rates of the channels, the configured sample rate for a specific channel might differ from the ones used in the calculations of the aggregate output rate. The calculated internal aggregate sample rate could thus be higher than what the aggregate sample rate would be by adding all output rates configured commands.

NC-Config documentation section describes how to configure channels.

3.2.2 Channel Gain

Two different gain settings exist for each channel, coarse and fine gain. To optimize dynamic performance the coarse gain should be as high as possible without causing any overflows. An overflow will lead to corrupted data which most likely will be unusable. Coarse gain overflow will result in wrapped data while fine gain overflow results in a clipped signal.

The fine gain can then be used to achieve the desired final gain.

Client commands section describes what commands need to be sent in order to configure Fine and Coarse Gain.

3.3 Timestamp

Channel data can be timestamped, either by using GPS time as a timebase (GPS Timestamping) or by using a computer time of the Host computer running NC-Server(Computer-based Timestamping). Only one mode of operation can be used at the time and if the user wishes to change the mode, NC-Server has to be switched to Setup Mode, where the GPS reconfiguration takes place, then to Hardware Execution Mode, as described in Server Configuration File section.

For both modes of operation, channel data will have timestamp stored in the data headers.

NOTE: USRP-2945 only supports computer based timestamping.

GPS Timestamping

It is possible to lock internal FPGA clocks to GPS and have GPS Timestamped data using the USRP GPS functionality.

If the Use GPS flag is set to true in the hardware configuration, the server will automatically try to lock to GPS upon startup. This process may take about 10 minutes. If the server manages to lock

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to GPS, the GPS time when lock occurred will be stored in the server and the internal counters in the FPGA will start counting up seconds and picoseconds after this start moment.

It is possible to read out the status of GPS locking and GPS Start Time, provided that the locking has been successful. The timestamps in both seconds and picoseconds will be forwarded further with the channel data headers as well. As mentioned, these will be counter times which means they are *relative* to the moment when GPS time was registered. Since this Start Time is stored by the Server, it is possible to fetch it and then calculate the absolute time by adding counter time and start time. Note that the Start Time inherits the accuracy from the GPS. If the GPS lock is lost due to bad signal reception or cables being disconnected, the counters will still continue to count up, but their precision will no longer be the one of the clock locked to the GPS but the one of the internal USRP clocks. If the cables are reconnected, it is possible to relock to GPS. Automatic refresh of GPS can be programmed using the refresh period of the GPS configuration. After this period has passed, the FPGA will get the signal from the Server to fetch a new GPS Start Time and to restart both counters.

Computer-Based Timestamping

If the application does not require GPS timestamping, it is still possible to have timestamped channel data. For this mode of operation "Use GPS" is not selected in the hardware configuration. A restart of Hardware Execution mode is required which will trigger the timestamp counters to restart. Accuracy of start time will depend on the time accuracy of the computer that runs the server. Accuracy of the relative time is equal to internal FPGA clock accuracy. Every time a new computer start time is written from Server, counters will be reinitialized. This process is controlled by user configurable refresh rate.

3.4 RF Output

The incoming RF data might be used for purposes other than channelization such as analysis or recording and it is, therefore, possible to forward the incoming RF data from the target device via UDP. Note that the address to which RF data is streamed can be either multicast or unicast as configured in Network Configuration Utility. However, both NC-Server and Examples expect the address to be unicast in order to work properly. Furthermore, Server performs FFT on RF IQ data and then this FFT is streamed as multicast UDP from server. It is also possible to configure number of FFT points using TCP/IP command.

3.5 Channel Output

Channel data is sent via UDP through SFP+ port 1 on USRP. Channel data from all enabled channels is combined with additional metadata and sent through the same UDP connection. There are currently two options for channel data output protocol, NCR channel data protocol and VITA49 protocol. The protocol is determined by the currently used FPGA bitfile on the USRP hardware. Contact Novator Solutions if you wish to change the channel data protocol from the current one.

The channel data protocol structures are explained in the Interface Control Manual.

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Terminology

4 Terminology

Jumbo Frame ..... Ethernet frames with more than 1500 bytes of payload. For a connection to use Jumbo Frames requires that all components (host and client computers as well as any network switches between) support them.

PCIe ..... Peripheral Control Interconnect Express, a high-speed serial computer expansion bus standard. The latest version 5 supports data transfer rates (T) of up to 32GT/s.

SFP ..... Small Form-factor Pluggable, a compact, hot-pluggable transceiver supporting data transfers of up to 1Gbit/s. SFP+ is its enhanced variant supporting data transfers of up to 10Gbit/s.

UDP ..... User Datagram Protocol, is a simple connectionless communication protocol with no handshaking dialogues. This means that the protocol has no certainty of data delivery as opposed to TCP.

Setup Mode ..... Execution mode where Server will accept incoming commands and send responses, but the commands are not passed to hardware. No frequency spectra or channel data is transmitted.

Hardware Execution Mode ..... Execution mode where Server passes the incoming commands to hardware and sends responses that are based on status returned by hardware drivers.

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5 Trademark Information

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Contact Information

6 Contact Information

For general questions on NC-Server use email sda.support@novatorsolutions.se. For support related specifically to NC-10, please email nc10support@novatorsolutions.se.

Company Name:	Novator Solutions AB
Street Address:	Hammarbacken 6A
Shipping Address:	PO BOX 744
Zip Code:	191 27
City:	Sollentuna
Country:	Sweden
Web:	http://www.novatorsolutions.com
Email:	info@novatorsolutions.se
Telephone:	+46 8 622 63 50

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Server User Manual

7 Server User Manual

NC-Server is a software tool for configuring NI USRP-2955/45 instruments to acquire, channelize and analyze radio frequency signals. It is a standalone executable that listens to commands sent by client applications over the Ethernet using TCP/IP. The executable has two optional soft front panel sections, NC-Config and NC-Channel, which are used to configure the hardware and to verify that the server data streams work, and if necessary, troubleshoot the server functions.

7.1 Installing Server

The steps to install the Server are:

1. Installing the USRP driver
2. Installing the Server software package
3. Connecting the hardware
4. Configuring the Server IP addresses
5. Testing Server Operation

Install National Instruments USRP Driver

The USRP driver can be downloaded from National Instruments website. The version supported is 19.1. Extract and run the installer as instructed on the website. Restart computer if requested after the installation has completed.

Install Server

The server installer can be downloaded from Novator Solutions. Extract the zipfile and start setup.exe.

> *Note: It is not necessary to have the USRP unit connected when installing the server application (but it is not forbidden either).*

> *Note: There is a known issue with Windows 10 update 1809 that will cause the installer to throw an error. This happens with some specific* **Regional format** *settings in Windows, for example* **English (Sweden)**. *Workaround is to temporarily change Regional format to* **English (United States)** *before running the installer. More information around the issue is available in this National Instruments Knowledge article.*

After initialisation the installer suggests destination directories, %ProgramFiles(x86)%\Novator Solutions\NC-Server for the Server, and C:\Program Files (x86)\National Instruments for the National Instruments drivers. Accept the suggested values by clicking Next. (The screen shots are from Windows 10 installation. Windows 7 and 8 are also supported, but the dialogs may look slightly different.)

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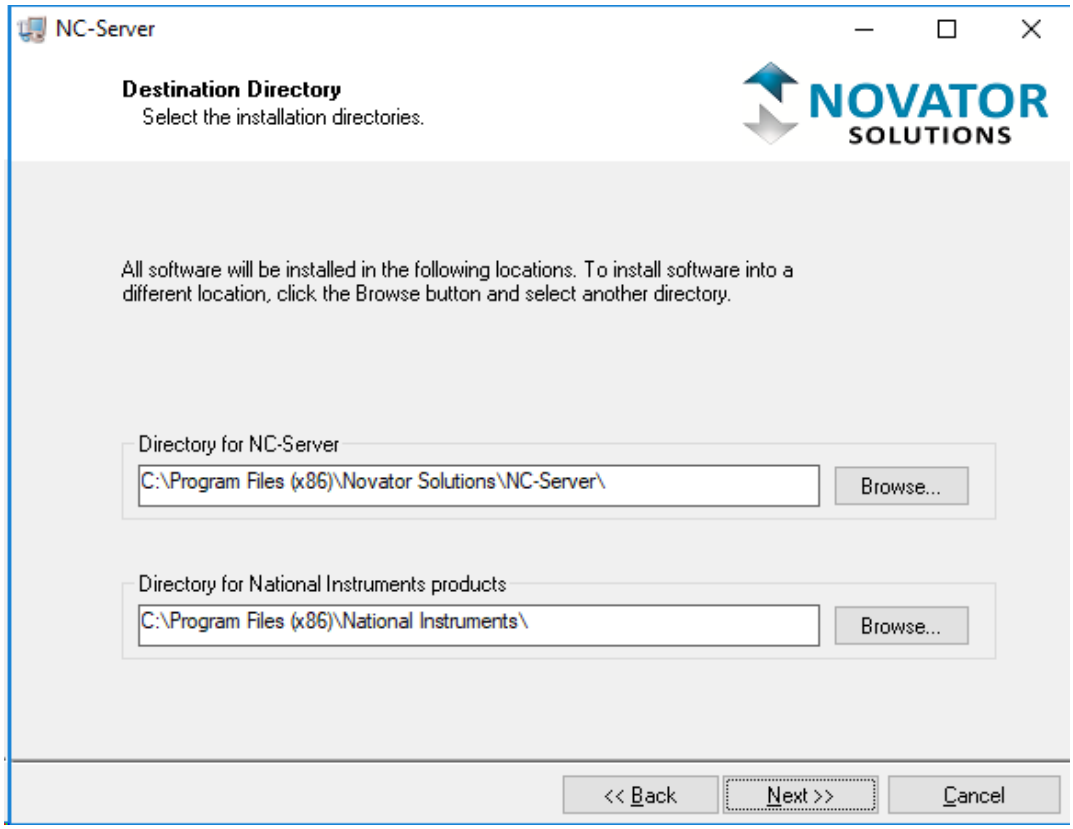

Figure 6: Installation Directories.

If your operating system is Windows 8 or Windows 10, the installer will suggest that you disable the fast startup feature. There is no need to disable it, if your only National Instruments hardware is the USRP unit and you are connecting to it only via the Ethernet. If this is the case, deselect the checkbox and press Next. More information can be found on National Instruments website, http://ni.com/info, enter code **winfaststartup**.

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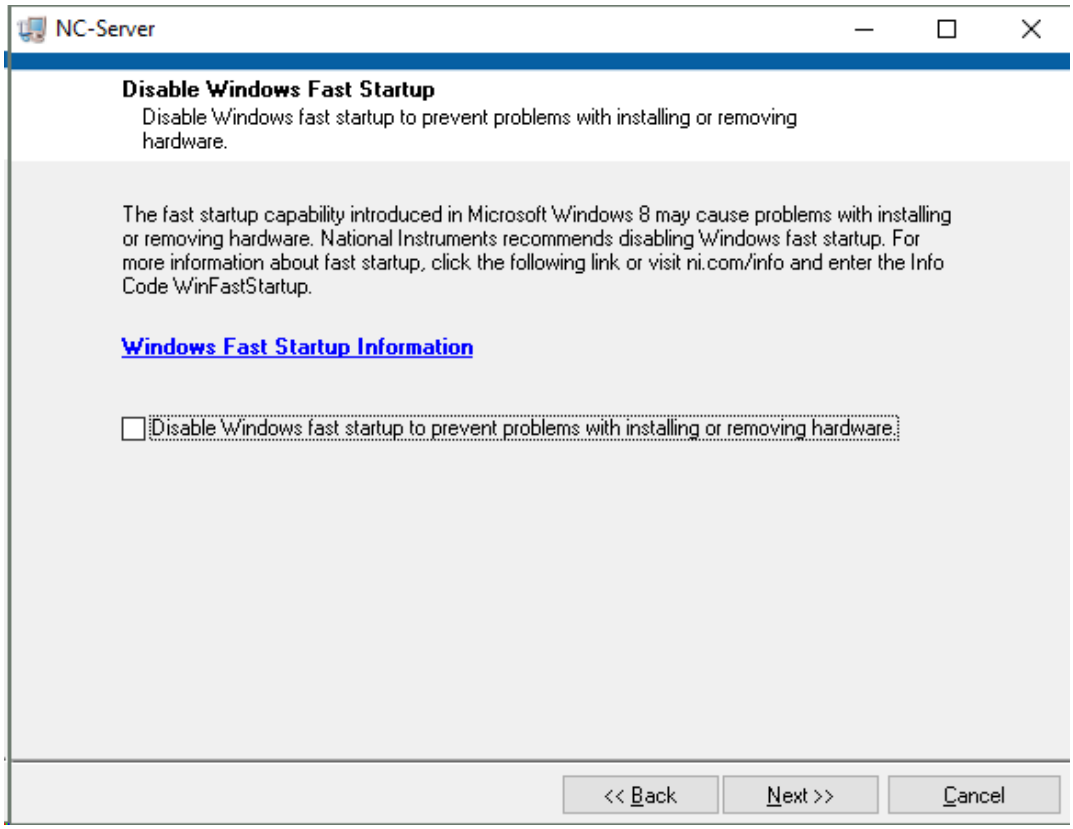

Figure 7: Note on Windows Fast Startup.

As the final step a list of changes and additions are shown in a summary screen (Figure 8). The content may differ from the one shown here depending on what needs to be updated. The server installation will begin after you click Next.

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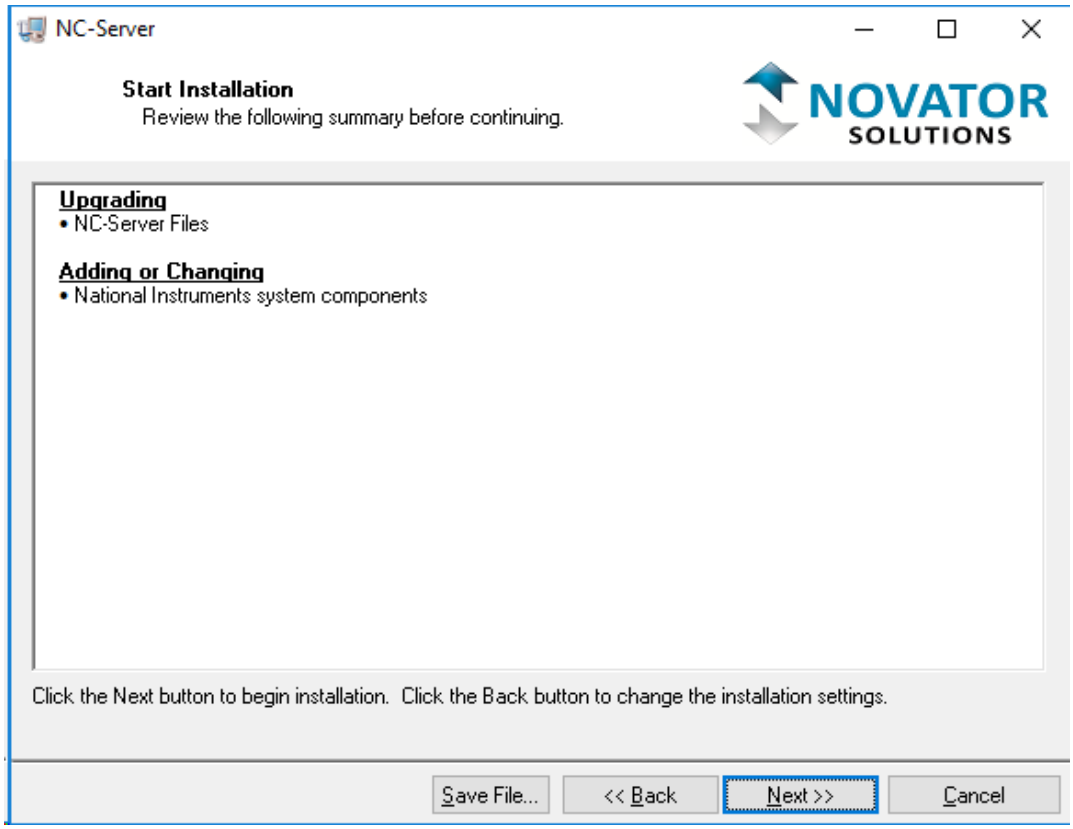

Figure 8: Installation Summary.

The installation takes a few minutes after which a confirmation screen is shown with the last-minute information on the current version.

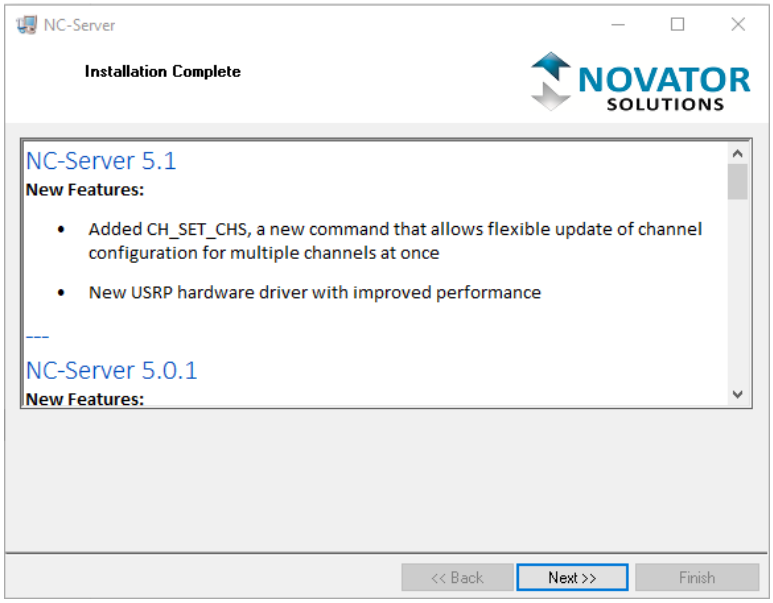

Figure 9: Completed Installation.

Clicking Next will start an update of the USRP hardware driver.

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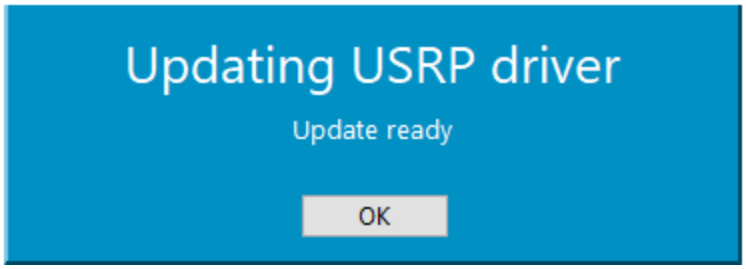

Figure 10: Update of USRP driver.

Clicking OK will finish the installation. Reboot computer after installation if prompted to do so.

Installing NC-Server as Windows Service

After rebooting the computer you will be able to install NC-Server as a Windows service. The install script is %ProgramFiles(x86)%\Novator Solutions\NC-Server\Addons\ncsetup.bat. Installing the service component is only needed if you want NC-Server to run automatically after system restarts. Before uninstalling the server software it is recommended that you uninstall the service by running %ProgramFiles(x86)%\Novator Solutions\NC-Server\Addons\ncremove.bat

The NC-Server service uses the same configurations as the interactive ("normal") Server version.

When the server is started the first time, configuration and log directories are created in public documents folders in the host computer, more precisely in:

C:\Users\Public\Documents\Novator Solutions\NC-Server\Config\
C:\Users\Public\Documents\Novator Solutions\NC-Server\Log\

The value of <Public Documents> is by default C:\Users\Public\Documents, but the location varies depending on the language of the operating system and other user-specific settings.

The server also creates entries in Windows Registry, mainly to store the window position and size between sessions. The registries are created in \HKEY_CURRENT_USER\Software\Novator Solutions\NC-Server. An additional registry entry named NCRDaemon is created in HKEY_CURRRENT_USER\Software\Microsoft\Windows\CurrentVersion\Run\ with the search path to NCDaemon executable, which is a utility for viewing the NC-Server status whether it is run interactively in Windows or as a service.

Connect the Hardware

Connect the USRP unit to the server according to your desired network topology, i.e. the SFP+ cables either directly connected from the USRP to the Ethernet adapters of the host computer, or via a switch. Make a note of the IP address of the Ethernet Adapter in the server computer that should access the USRP via its SFP0 connector.

Configure the Server IP Addresses

To begin communicating with the USRP you will have to configure its network address. Select the menu command **File >> Hardware Configuration**. The hardware settings dialog that pops up shows the default settings, see figure 11.

The fields that must be updated from the defaults are:

- Host Computer and USRP SFP Session Configurations: all fields
- FFT Configuration: IP FFT Out

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Host and USRP SFP Sessions

The SFP session IP addresses need to be filled in before the server can communicate with the USRP unit. Begin by updating the "SFP 0 Session" IP address in the *Host Computer* section to match the Ethernet adapter that is connected to the USRP Ethernet adapter marked SFP0, either directly, or via a network switch.

> *NOTE: The Ethernet adapter that is used in the host computer for SFP 0 session must have Jumbo Packets enabled and set to at least 9014 bytes. Also, if a network switch is used between the Host computer SFP 0 adapter and the USRP, the switch must also have Jumbo Packets enabled.*

> *NOTE: Host Computer SFP 0 Session must be in the same subnet as the USRP SFP 0 Session.*

The "SFP 1 Session" IP address must match the Ethernet adapter that is connected to the USRP Ethernet adapter marked as SFP1, either directly or via a network switch.

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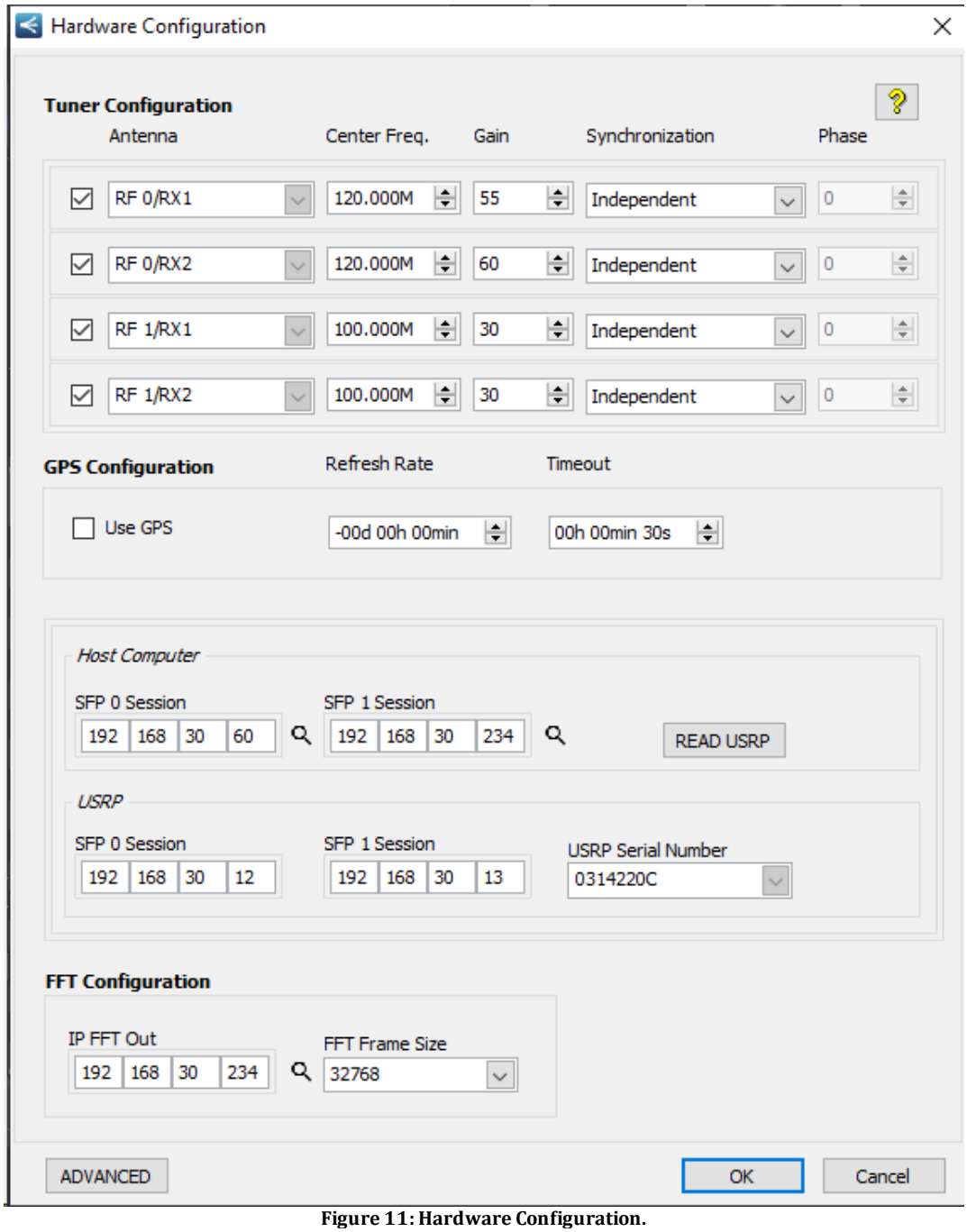

Figure 11: Hardware Configuration.

Click "READ USRP" to connect to the unit. The server will now attempt to read the USRP heartbeat, which contains the IP addresses and serial number of the unit. If successful, the fields in the *USRP* section of the Ethernet Configuration are populated with the detected values. If the Read USRP operation fails, power-cycle the USRP unit and then try again.

To change the IP addresses of the USRP unit and to see the currently configured USRP IP address, use a software tool named "USRP Network Configurator" in Program Files\Novator Solutions\Utilities. Make sure you update the changed IP address settings in the Server Hardware Configuration.

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FFT Configuration
The field "IP FFT Out" is the IP address that the clients should connect to when communicating with the server to read the tuner spectra.

For more information, refer to the hardware configuration section in this manual.

Test Server Operation

When the Server is running, select **Operate >> Run**. This will put the server in the "Hardware Execution Mode", which involves loading the hardware drivers and attempting to communicate with the USRP unit. The Event Log will show a message "Entering Hardware Execution Mode ..." and after a while, "... Hardware Execution Mode OK". Refer to the section on "Troubleshooting" if this is not the case.

When the server has entered the Hardware Execution Mode, press the "Enable FFT" button to read the frequency spectrum from the first tuner (see Figure 12 below).

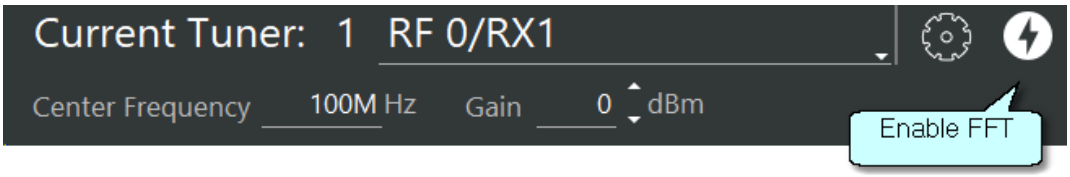

Figure 12: Enable FFT.

After a few seconds the FFT should start updating on the display indicating that the server is configured and ready to use. If the FFT is not streaming, make sure that the update rate is greater than 0 (set by pressing the Cogwheel button left to the Enable FFT button).

7.2 Server Software

NC-Server user interface consists of the following sections (see Figure 13 below):

1. Menu Bar
2. NC-Config Soft Front Panel
3. NC-Channel Soft Front Panel
4. Log views

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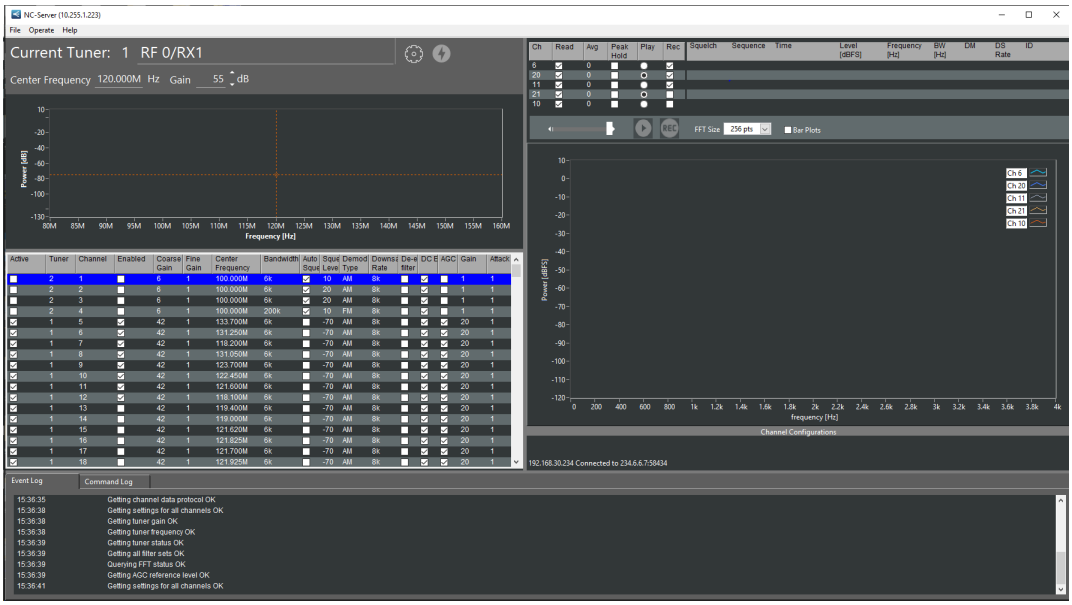

Figure 13: Server User Interface running both NC-Config and NC-Channel soft front panels.

The different sections of the server user interface can be re-sized by dragging the dividers (in lighter shade of gray in the figure above). The window size will be saved between sessions.

The following sections will explain the Menu bar contents as well as the log file views. The functionality of the NC-Config and NC-Channel sections of the user interfaces is explained in the respective software tool help documentation.

7.2.1 Server Configuration

Server Configuration is done with the help of the configuration dialogs. The configurations are stored in three different main locations depending on their usage:

1. Windows Registry
2. Configuration Files
3. Initialisation Files

Windows Registry

The general application settings are stored in Windows Registries, in section HKEY_CURRENT_USER\Software\Novator Solutions\ with subfolders created for different software tools, for example NC-Server for the server. The NC-Server application will create also subfolders for the soft front panel settings if they are used.

NC-Server subregistry data fields

- **ConfigPath**: location of the system configuration file (default C:\Users\Public\Documents\Novator Solutions\NC-Server\Config\sysconfig.json)
- **HorizontalBottomSplitter**: distance from top of the window to the splitter between the soft front panels and the log lists.
- **VerticalTopSplitter**: position from the left edge of the window to the splitter between NC-Config and NC-Channel displays
- **w.bottom, w.left, w.right, w.top**: Application window positions.

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NC-Channel and NC-Config subregistry data fields

- **chtable.***: width of the channel table column in pixels
- **chtablecolumns**: tab-separated list of channel table column names
- **chtablecolvisibility**: bitmap indicating if the column is visible or not; for details see Channel View Configuration
- **HorizontalLowerSplitter**: distance from top of the application to the splitter between the graph and the channel configuration list.
- **NWAdapter**: IP address of the local network adapter that is connected to Server.

Configuration Files

The configuration files are stored by default in the following Windows folder: C:\Users\Public\Documents\Novator Solutions\, with subfolders created for different software tools, for example NC-Server for the server. The server application creates a subfolder Config for storage of its configuration files, the same applies to NC-Config and NC-Channel client programs. The configuration files are stored as JSON coded text files with the default file identifier JSON.

The settings that are saved in configuration files are:

- System Configuration
- Hardware Configuration
- Channel Configuration
- License Configuration

Initialisation Files

The program initialisation file is stored in C:\Users\<USER>\AppData\Local\Novator Solutions\NC-Server

Initialisation files are used to store the basic program settings.

7.2.2 File Menu

File Menu contains commands for system configuration and logging.

7.2.2.1 System Configuration

This command is under "File" menu.

The system configuration dialog (see Figure 14 below) is used for setting up the general server parameters, which are explained here. Changing system parameters requires that the server is restarted. The system configuration entered here is saved in the file indicated by the "System Configuration File" setting. If the file is deleted, a new configuration file is created with default settings.

NOTE: Program restart is required for the changes to take effect.

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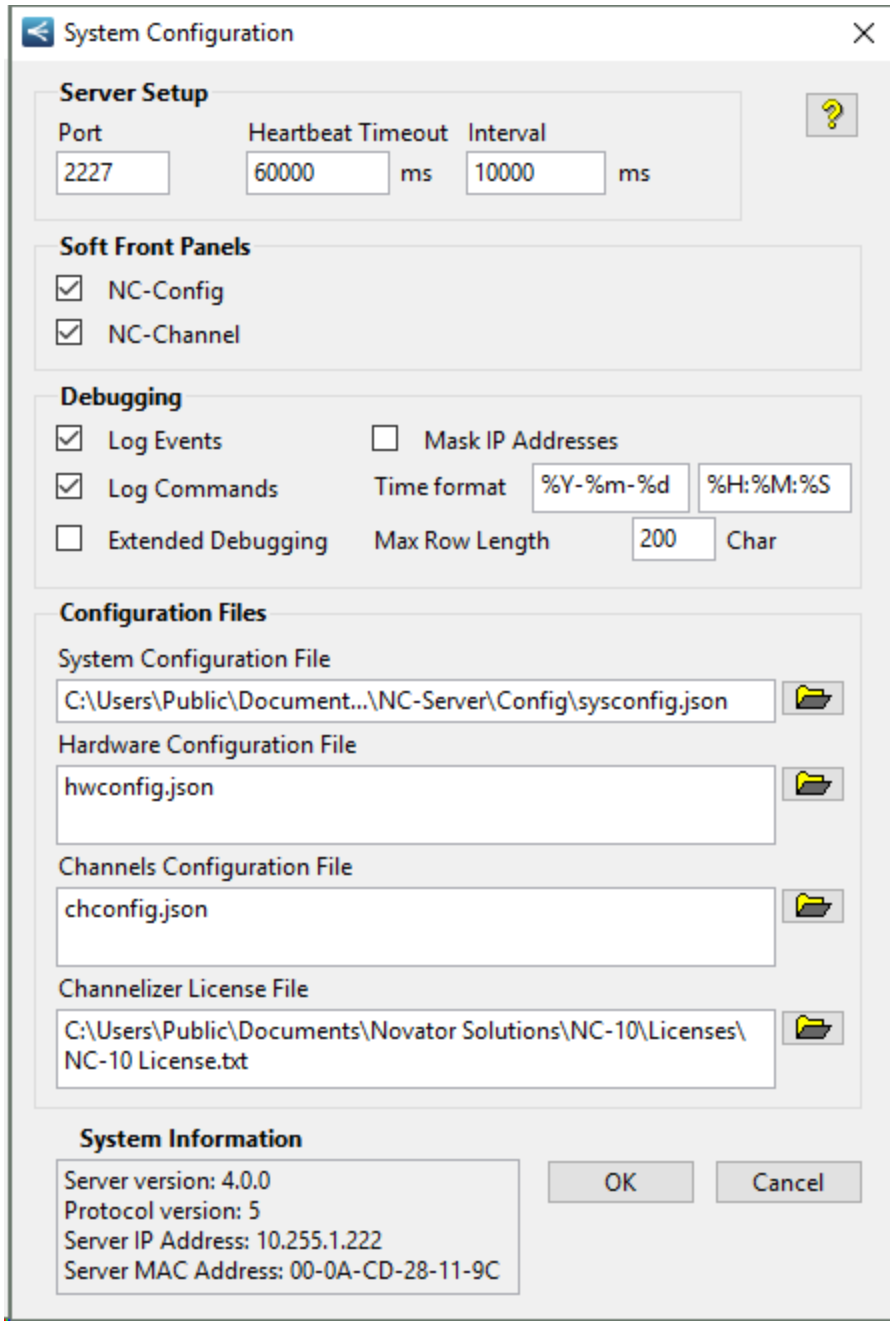

Figure 14: System Settings.

Server Setup

Parameter	Default Value	Notes
Port	2227	The port the server listens to for incoming TCP/IP connections from clients.
Heartbeat Timeout	60000 (ms)	If no communication takes place from a client application for this time, the server considers the

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		connection closed. See also Heartbeat in Communications Manual.
Heartbeat Interval	10000 (ms)	The time interval for the server to send a heartbeat token to the clients to keep the connection up.

Soft Front Panels

The soft front panels can be used to initially configure the system, and to verify that the data streams work as expected. For more information on the soft front panels, refer to the corresponding user manuals for NC-Config and NC-Channel.

By default both soft front panels are enabled.

> *NOTE: After initial configuration it is recommended that the soft front panels are disabled and further configurations are done from stand-alone client applications*

Debugging

Parameter	Default Value	Notes
Log Events	Checked	If checked, a log of the system events are shown in the server log file views and saved as a text file in C:\Users\Public\Documents\Novator Solutions\NC-Server\Log\<Date>_NC-events.txt, where <Date> is today's date. A new file is started for each calendar day. Please note that the log files are not cleaned up automatically.
Log Commands	Checked	If checked, a log of the commands from the clients and server responses are shown in the server log file views and saved as a text file in <Date>_NC-commands.txt. A new file started for each calendar day. Please note that the log files are not cleaned up automatically.
Extended Debugging	Not Checked	If checked, hardware status information can be saved in a diagnostics file when an error occurs in hardware execution mode.
Mask IP Addresses	Not Checked	If checked, the log files replaces the IP addresses in the log files with asterisks (***) for reasons of secrecy.
Time Format	%Y-%m-%d %H:%M:%S	Description of how the system date and time should be formatted in the log file names. See time formats for information on the formatting strings available.
Max Row Length	200	If greater or equal to 0, the length of the commands is restricted to a number of characters so as to keep individual

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		command lines more readable and the log files reasonably short. If Max Row Length is -1, the lines are not truncated.

NOTE: Event and Command logging may slow down the system performance slightly so they should not be used in production. Extended Debugging will slow the system down significantly, so it should only be used when a debug file is needed for troubleshooting.

Configuration Files

Parameter	Default Value	Notes
System Configuration File	C: \Users\Public\Documents\Novator Solutions NC-Server \Config\sysconfig.json	Contains the settings of this configuration dialog. If the file is deleted from the location indicated here, a new system file is created with default settings.
Hardware Configuration File	C: \Users\Public\Documents\Novator Solutions NC-Server \Config\hwconfig.json	The hardware configuration file contains the hardware capabilities file (CAP), which can be edited via **File >> Hardware Configuration** or via client commands. If only the file name is entered, the file is assumed to be in the default path. If the file is deleted, a new hardware configuration file is created with the default settings.
Channels Configuration File	C: \Users\Public\Documents\Novator Solutions NC-Server \Config\chconfig.json	The channels configuration file contains the channel parameters, which can be edited either via NC-Config either as a Soft Front Panel or as a remote client, or via client commands. If only the filename is entered, the file is assumed to be in the default path. If the file is deleted, a new channel configuration file is created with the default settings.
Channelizer License File	C: \Users\Public\Documents\Novator Solutions\NC-10\Licenses\NC-10 License.txt	A file containing the license key that enables use of the channelizer. If only the filename is entered, the file is assumed to be in the default path. If no file is entered, the system will run unlicensed, providing channelized data for 10 minutes. See Licensing for more information on how to obtain a license for your system.

System Information

Information on the server network communication parameters as well as software and protocol versions.

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Server IP address is checked at program start up and if the stored IP address does not match that of any of the existing adapters, a dialog will pop up to request the information. Since there may be several network adapters in one computer, it is important that the right adapter IP is used. Otherwise the server may receive the commands correctly from the client, but the server responses are sent to another network than the intended.

To change the IP address marked here, right-click on the System Information area and select "Refresh" from the pop-up menu.

7.2.2.2 Hardware Configuration

This command is under "File" menu.

Hardware Configuration menu allows configuration of most of the general (non-channel specific) hardware features, notably tuner settings. Many of these settings can also be configured by sending client commands. The hardware configuration functionality is provided by the NC-Config client application but it is also available in NC-Server when the NC-Config soft front panel is enabled.

> *NOTE: NC-Config reads the hardware configuration from the server, so until a connection with the server is established the command is disabled.*

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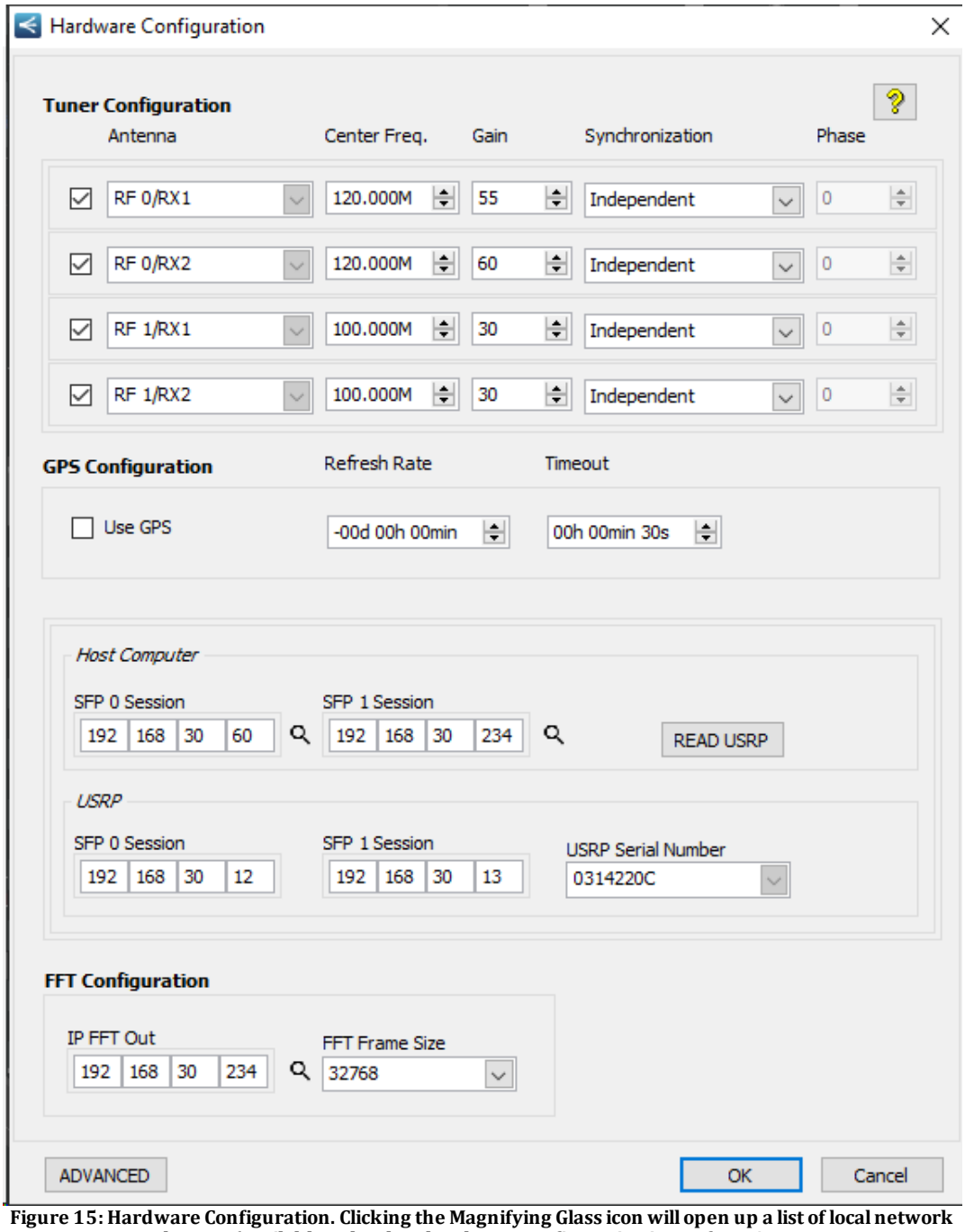

Figure 15: Hardware Configuration. Clicking the Magnifying Glass icon will open up a list of local network adapters (available only when hardware configuration is run from Server.

Tuner Configuration

The USRP consists of 4 tuners, the specifications are available on the Internet. The configurable parameters are explained in table 3 below.

Parameter	Unit	Range	Default Value	Notes

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Enabled			Checked	If disabled, the corresponding tuner will not be broadcasting RF data via SFP+0 and therefore no wideband FFT will be broadcast either.
Antenna		RF 0/RX1, RF 0/RS2, RF 1/RX1, RF1/RX2	N/A	The values are filled in automatically by the system and cannot be altered
Center freq.	Hz	50M … 5.96G	100M	Tuner center frequency f_c, adjustable also via NC-Config soft front panel. The acquired band will be ±50MHz around f_c. It is possible for the different tuners to acquire data from overlapping bands.
Gain	dB	0 … 95	0	Adjustable also via NC-Config soft front panel.
Synchronization		Independent/Import/Shared and Export	Independent	Learn more about synchronization.
Phase (not currently implemented)	degrees	0 … 360	0	The controls are disabled, phase correction is not available in this version.

Table 3: Tuner Configuration.

NOTE: Disabling a tuner will only stop the broadcasting of broadband RF data. The channels associated with the tuner will still keep receiving the RF data, and therefore all active and enabled channels will keep broadcasting. Disable a channel if you wish to stop it from broadcasting as well.

GPS Configuration

More information on timestamp can be found in the NC-10 timestamp section of the Configuration Suite Manual.

Parameter	Unit	Range	Default Value	Notes
Use GPS			Not Checked	Enables the GPS synchronization process at startup and after refresh time has elapsed. In the

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				synchronization process the USRP unit attempts to lock itself to a GPS satellite.
Refresh Rate	s		-1	Time after which the server will try to lock the USRP unit to a GPS satellite. If the value is < 0 the unit will not try to resynchronize.
Timeout	s	30 ... 86400 (=24h)	900 (=15min)	Time to let the USRP try locking to GPS satellites.

Table 4: GPS Configuration.

NOTE: Do not check "Use GPS" if the acquisition device is USRP-2945 as it only supports computer based timestamping.

Ethernet Configuration

Parameter	Notes
Host Computer: SFP 0 Session	The IP address of the host computer Ethernet adapter that is connected to the USRP SFP 0 output (radio and commands data), either directly or via a switch.
Host Computer: SFP 1 Session	The IP address of the host computer Ethernet adapter that is connected to the USRP SFP 1 output (channel data), either directly or via a switch.
USRP: SFP 0 Session	The IP address of the USRP Ethernet adapter labeled "1G/10G Eth 0".
USRP: SFP 1 Session	The IP address of the USRP Ethernet adapter labeled "1G/10G Eth 1".
Read USRP	Click this button to populate the USRP SFP 0 and SFP 1 fields. This will only be possible if the USRP device has *not* been in Hardware Execution Mode after power cycling. If the reading operation fails, power cycle the USRP and retry.
USRP Serial Number	After "Read USRP" has executed successfully, the serial number will be automatically filled in here. This field is for user reference only and will not be used by the system.

Table 5: Ethernet Configuration.

FFT Configuration

Parameter	Unit	Range	Default Value	Notes
IP FFT Out				The IP address of the Ethernet adapter that is connected to the network through which the clients will read the FFT multicast data. Enter IP address 127.0.0.1 in order to use the FFT only in the local machine. This will force the server to use UDP

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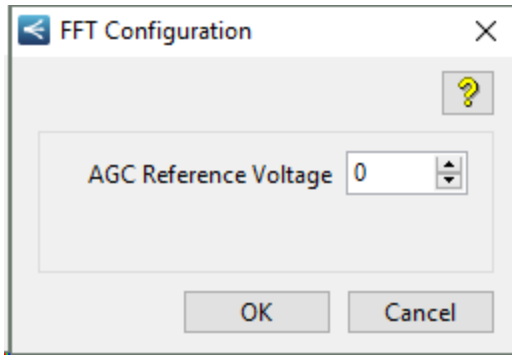
				single cast for transmit instead of multicast..
FFT Frame Size	Points	Default, 1024, 8196, 32768	Default (1024)	The number of points / broadcast FFT frame. The actual FFT buffers will be divided into frames of this size. Recommendations: **1024**: the network does not support jumbo frames and fragmented UDP frames are not acceptable **8196**: the network supports jumbo frames or fragmented UDP packets are acceptable. **32768**: fragmented UDP packets are acceptable. The lower the frame size the lower the highest possible transfer rate for FFT. If frame size 1024 is used, it is not recommended to set the FFT size to 16k or 32k.

Table 6: FFT Configuration.

Advanced

Click "Advanced" in the Hardware Configuration dialog to configure the output sound level for automatic gain control, one setting applies to all channels. The default value of 0 should usually be sufficient, but if the sound level of the demodulated channels with AGC on is too high, lower the level here; increase the value if the sound is too weak.



7.2.2.2.1 Advanced Hardware Configuration

This dialog can be opened by pressing ADVANCED, which is in the dialog that can be opened by selecting "File/Hardware Configuration..." menu command.

Advanced Hardware Configuration contains the option to select the output level for automatic gain controlled channels. The experienced sound output can vary from system to system and adjusting the value up or down may improve the experienced sound.

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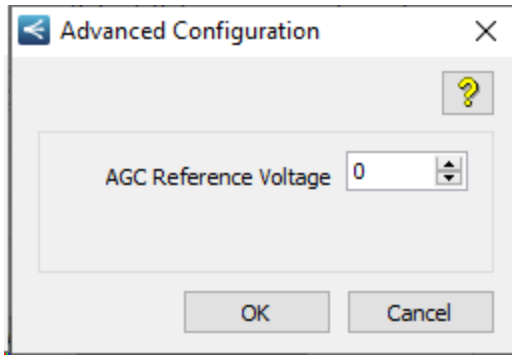

7.2.2.3 Tuner Calibration

This command is under "File" menu.

> *NOTE: Calibration here refers to correction of measurement data to correspond to physical signal levels. "Level Correction" would be a more accurate term, but for simplicity calibration is used.*

> *NOTE: This menu item is disabled if NC-Config soft front panel is not activated.*

The USRP tuner units are not calibrated to a standard source and all measurements are therefore shown as dBFS (full scale), rather than as absolute dBm levels. Internally, the IQ data is presented as *signed 16-bit* integers, and a full scale measurement in the USRP tuners corresponds therefore to a measurement value of 2^15. This value is scaled to show 10dBFS in input power.

With no calibration set up NC-Server multiplies the readings with 1/(2^15) for the spectrum display, with compensation to the tuner gain. If a more accurate readings are required a calibration coefficient can be saved so that the spectrum levels match the actual physical levels. The procedure is as follows:

1. Select the tuner to calibrate; enter a center frequency. In the example below, the center frequency is set to 120MHz. Set tuner gain to 0dB.

2. Turn on Hardware Execution Mode

3. Once the system is in Hardware Execution Mode, configure the spectrum to show 32k samples. Turn on spectrum.

4. Right-click on the spectrum display and select "Show Cursor Value".

5. Connect a known signal source to the tuner input. Set the signal source to generate a signal at the frequency of interest. In the example image below, a -10dBm signal has been generated at 110MHz.

6. Find the peak on the frequency generated. In the image below, we see that it is slightly off the generated frequency, which may be due to the frequency bin (3kHz) not exactly matching the frequency peak. Turning off spectrum update may make it easier to find the peak, and you may want to zoom in on the spectrum as in the image below.

7. Make a note of the difference between expected and read power values, Pread-Pexp, in the example -31-(-10)= -21.

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8. Continue likewise if you wish to calibrate on further center frequencies. The calibration coefficients are saved as frequency spans, and applied for any center frequency that falls inside the span. Note that you can only save one correction value / frequency, so the same correction value will be applied regardless of gain.

9. Once the calibration coefficients have been recorded, set the system to Setup Mode.

10. Open the Tuner Calibration Dialog.

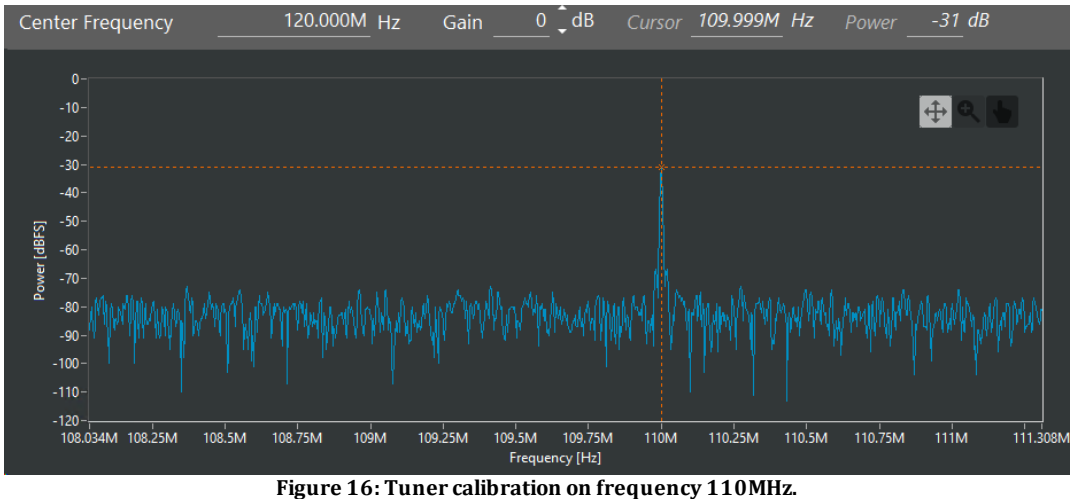

Figure 16: Tuner calibration on frequency 110MHz.

The Tuner Calibration Dialog is a simple data table management tool for entering specific calibration coefficients. By default, a gain of 1/2^15 = 3.051758*10^-5 is used on the signal on all frequency bands and on all tuners. When changing the calibration, always select the correct tuner first, then call the menu command File >> Tuner Calibration. A default calibration is shown up.

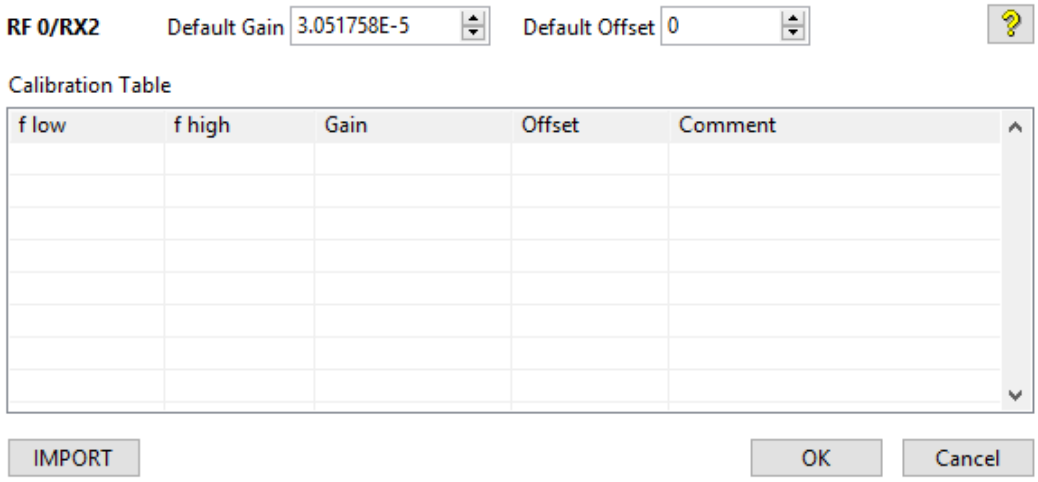

Figure 17: Tuner Calibration with default calibration on tuner 2 (RF0/RX2).

To add a calibration, right-click on the table and select "Append Row". Change the low (flow) and high (fhigh) frequency values to match the required span. Enter the recorded difference value in the Gain column.

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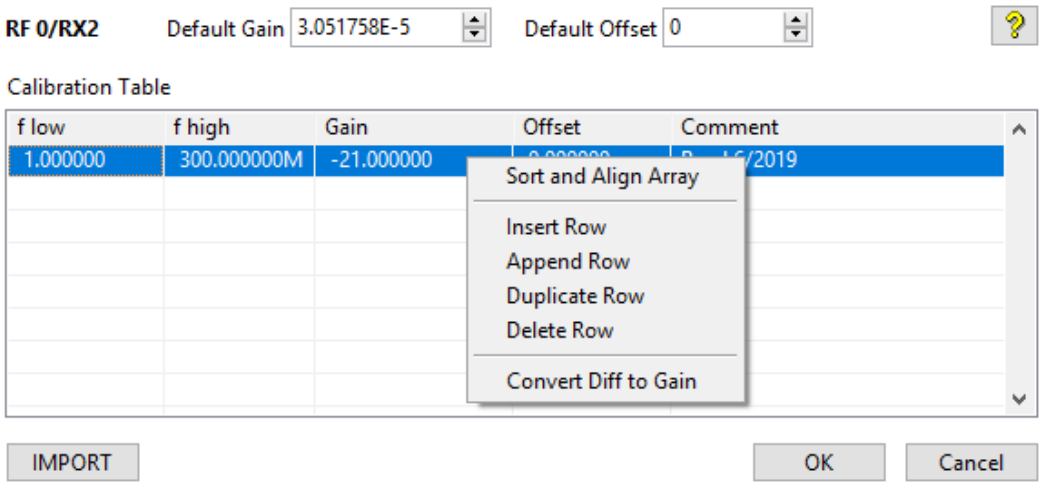

Figure 18: Entering Correction Value.

Right-click on the table, select "Convert Diff to Gain". The system will convert the Difference to actual Gain correction value.

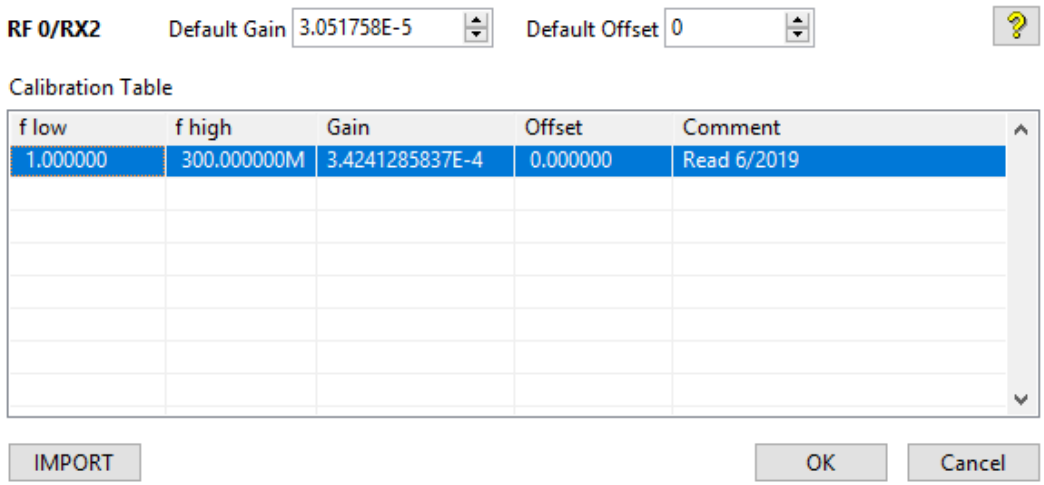

Figure 19: Difference Converted to Gain.

Observe that the values f_{low} and f_{high} stand for the lowest and highest *center frequency* that the calibration should be applied to. It is possible to enter a value of 0 for the f_{low}, which means that the calibration should be applied any time the center frequency is below f_{high}. The lowest possible center frequency is still 50 MHz. Likewise f_{high} can be set to a value above the highest possible center frequency (5.96GHz) to indicate that all values above f_{low} should use the set gain and offset values.

It is possible to import the calibration coefficients from a text file by clicking IMPORT. The file must be a text file, where each line has the values for f_{low}, f_{high}, Gain, Offset and (optionally) Comment, values must be separated by a comma.

Clicking OK will update the coefficients in a file named tncal.ini, which is stored in the system configuration folder, C:\Users\Public\Documents\Novator Solutions\NC-Server\Config\.

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Going back to Hardware Execution Mode, we can verify that the correction has been applied, see figure 20 below.

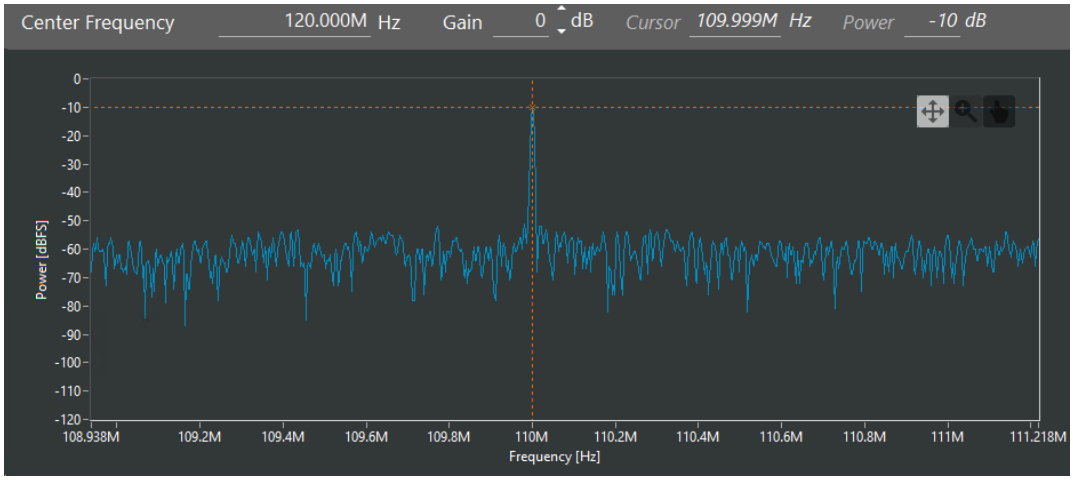

Figure 20: Tuner calibration applied.

7.2.2.4 Filter Configuration

This command is under "File" menu.

The currently used filter settings file is set in the System Configuration dialog, The Filter Editor that opens up with this menu command can be used for viewing and modifying the filter definitions in the file. The Filter Editor is also shipped as a standalone version in NC Configuration Suite, with the same functionality. Refer to the Filter Editor section for detailed instructions of use.

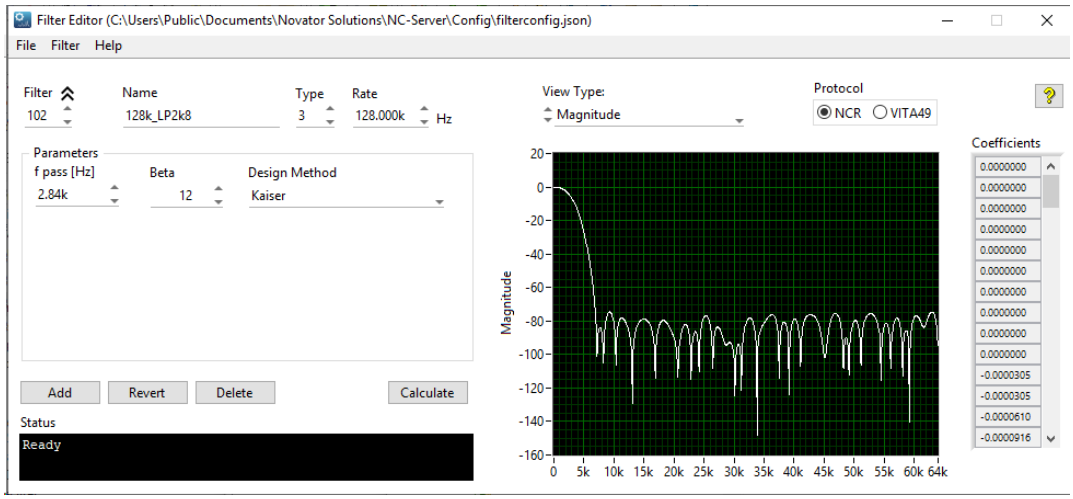

Figure 21: Filter Editing Tool.

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7.2.2.5 Channel View Configuration

This command is under "File" menu.

Use the Channel View Configurator to select the columns that are shown in the NC-Config client as well as the column widths in pixels. Initially all columns supported by the current channel data protocol are shown.

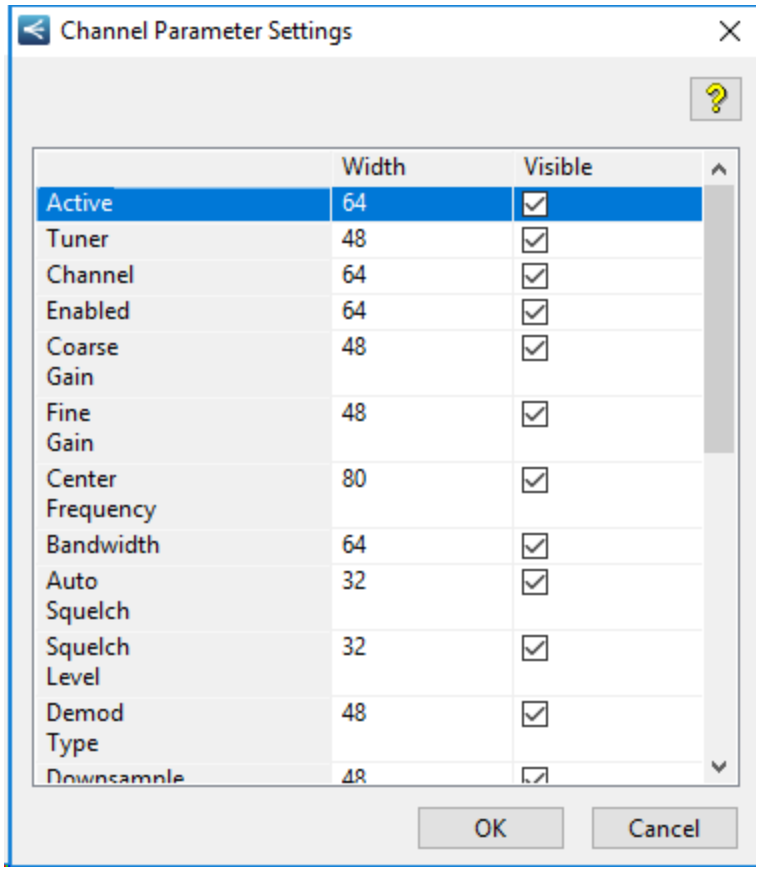

Figure 22: Channel View Configurator.

The channel view configuration setting is saved in Windows Registry value "chtablecolvisibility" as an array of column visibility bitmaps (see table 7 below).

Bit postion	Meaning
0 (least significant bit)	Visible when Channel Data Protocol = NCR
1	Visible when Channel Data Protocol = VITA49
2..7	For future use

Table 7: Column Visibility Bitmap.

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7.2.2.6 Channelizer License

This command is under "File" menu.

The Channelizer License menu has two submenus, Generate License Request and Verify License Status.

7.2.2.6.1 Generate License Request

This command is under "File" menu, submenu "Channelizer License".

Selecting this command will send a "CHZ_LICENSEREQ" command to Server. The server will respond with a license request file that can be saved in the client computer. Send the file to Novator Solutions to obtain the actual license. For details refer to "Obtaining a License Key" in this manual.

The *license request* can be generated either from the server computer, or from any connected client that runs NC-Config. However, the *actual license file* cannot be copied with the help of the client software, because access to the server file system is required.

> *NOTE: This command can only be run in Setup Mode*

7.2.2.6.2 Verify License

This command is under "File" menu, submenu "Channelizer License".

Selecting this command will send a "CHZ_LICENSE" command to the server. Server will check the license file in the configured location, and respond with information on the validity of the license. The validity can be one of the following:

- Valid license - the serial number of the currently used USRP unit is found in the license file and the license key matches the serial number
- Timebomb running - no license file is defined, the channelizer code will run for 10 minutes only
- Core locked - no license file is defined, the channelizer code has been run for more than 10 minutes, so the channelizer is locked.

For details refer to "Obtaining a License Key" in this manual.

7.2.2.7 Event Log

This command is under "File" menu.

Shows the current day's system log file in the text editor that is configured in the operating system to manage .txt files (typically Notepad.exe). The log files are saved in C:\Users\Public\Documents\Novator Solutions\NC-Server\Log\. The log will only be kept if Log Events is selected.

> *NOTE: A new log file will be started every day. Old log files will not be deleted automatically.*

More information on the Event Log

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Events are saved with a timestamp in the user defined format. The event log messages can be of five different types, the types are colour-coded in the log window. The message type is included as a tag in the message as well, see table 8 below.

Type	Text colour	Tag	Comments
General event	Black	-	Normal program execution step
Alert	Gray	Alert:	Exception in the program execution. Does not require corrective actions.
Warning	Blue	Warning:	Exception that does not prevent program execution. May indicate an invalid setting from a connected client, in which case the response status will be NOK.
General Error	Magenta	General Error:	Exception in the program execution, the program will unload the hardware drivers and go to Setup Mode.
Fatal Error	Red	Fatal Error:	Exception in the program execution, the program will be stopped.

Table 8: Server Error Levels.

Event Log will be updated only if Log Events setting is selected. However, error messages will be shown in all cases.

7.2.2.8 Command Log

This command is under "File" menu.

Shows the current day's TCP traffic log file in the text editor that is configured to manage .txt files. The log files are saved in C:\Users\Public\Documents\Novator Solutions\NC-Server\Log\ . The log will only be kept if Track Commands is selected.

> *NOTE: A new log file will be started every day after the first command has been sent or received. Old log files will not be deleted automatically.*

More Information on Command Log

All commands received from the client systems will be entered in the Command Log, as well as Server responses, timestamped in the user defined format, excluding heartbeat messages. The client commands contain also the IP address and Port of the client that has sent the command.

7.2.2.9 FFT Traffic Monitor

See NC-Config User Manual

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7.2.2.10 Exit

This command is under "File" menu. The command shortcut key is <CTRL>+Q.

Exits the application, closing the hardware and communication processes.

7.2.3 Operate Menu

Operate Menu is used to load/unload hardware drivers.

7.2.3.1 Run

This command is under "Operate" menu.

> *NOTE: This menu item is disabled if NC-Config soft front panel is not activated.*

"Run" is used to switch between Setup and Hardware Execution modes. When set, the system will go to Hardware Execution mode, which loads the hardware drivers and processes into memory. Loading the hardware drivers will take a little under one minute, during which time this menu command is disabled. When the system is configured successfully, a check mark will appear on the menu command. Additionally, the borders on the user interface will change colour from gray to blue.

To go back to Setup Mode, select the Run command again.

Possible errors during hardware load will be updated in the event logs. Refer to "Troubleshooting" section for tips on solving errors.

7.2.4 Help Menu

Help>>About... opens up a dialog with information on the current program version.

Help>>Documentation provides access to this help document.

7.2.5 Log Views

The lower part of Server user interface shows an automatically updating list of system events and commands (see Figure 23).

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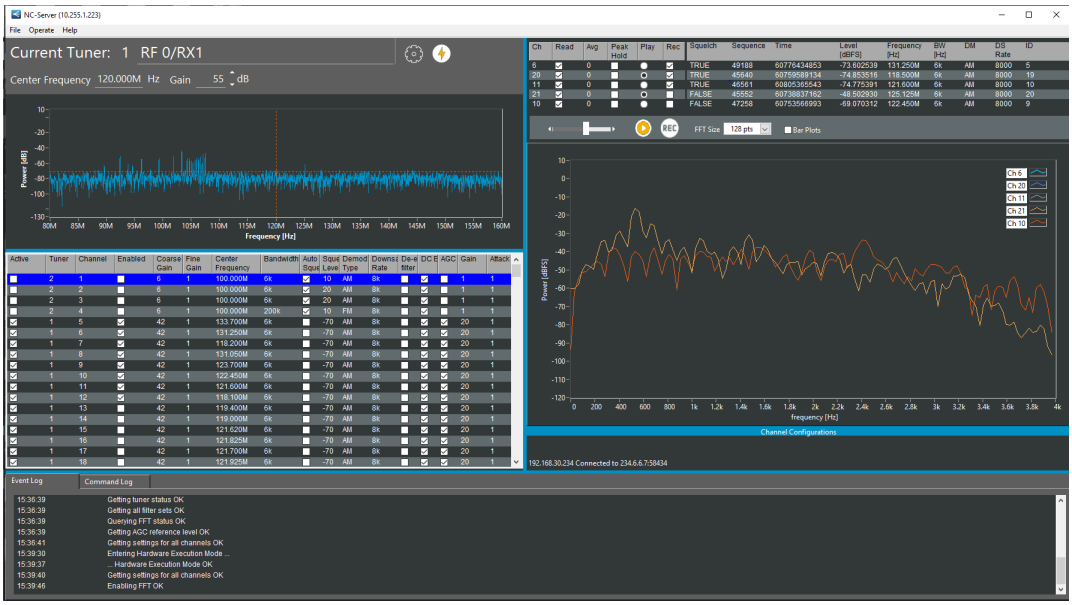

Figure 23: Server Interface, Both Soft Front Panels Enabled.

If both soft front panels are disabled, the event log section fills up the whole user interface, as in Figure 24.

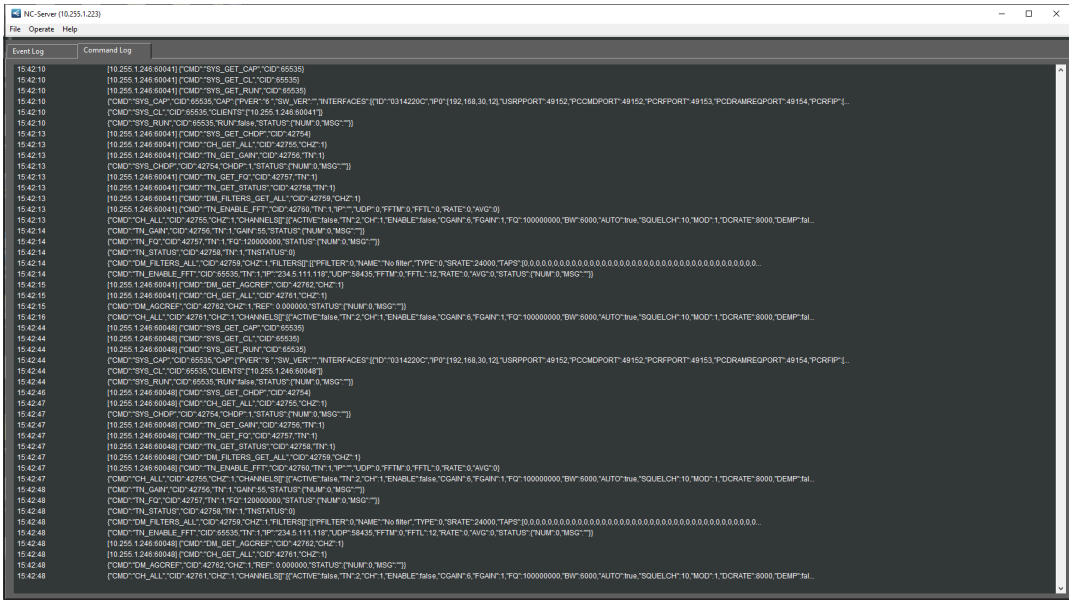

Figure 24: Server Interface, Soft Front Panels Disabled.

If logging is disabled, the log tables will be empty.

The Event Log tab shows the most current system events with timestamps. To view the complete list of events execute menu command **File >> Event Log...**

The Command Log tab shows the most current commands sent by clients (including the local soft front panels) and the server responses. To view the complete list of commands execute menu command **File >> Command Log...**

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7.2.6 Additional Information

This section contains additional information on the program features.

7.2.6.1 Startup Sequence

This section describes the initial commands and responses sent between Server and client applications at onset of a new connection. This information is important to be aware of when writing own client applications. However, if only the Novator Solutions applications, NC-Server, NC-Config and NC-Channel, are being used, the programs will handle the communication and this section can be seen as background information only, for example to help users to understand why and when possible error and warning messages appear.

When NC-Server is started for the first time, the two client applications, NC-Config and NC-Channel are started as soft front panels within NC-Server. Despite the fact that the programs are embedded into the Server interface, the clients will act as if they were running as external applications, i.e. they will receive the server initialisation strings, they will request additional configuration information, and set up their respective user interfaces according to this information.

Two sets of commands can be distinguished, Startup Strings and Configuration Strings.

Startup Strings

Server will assign a communication process to each client application when it receives a TCP/IP connection request from it. This process sends a set of commands, **Startup Strings**, to Server, which then sends the corresponding replies to the connected client. The purpose of the startup strings is to inform the client application of the server configuration. The startup strings are listed in table 9 below. Refer to "Server Interface Control Manual" for more details on the command and response syntaxes.

Command triggered by connection	Response sent to client	Details
SYS_GET_CAP	SYS_CAP	Informs the client of the available hardware resources and their current settings.
SYS_GET_CL	SYS_CL	Informs the client of other clients that are connected to the same server.
SYS_GET_RUN	SYS_RUN	Informs the client whether the server is in Setup or Hardware Execution Mode.

Table 9: Startup Strings.

Configuration Strings

Client applications are not supposed to store any configurations locally, instead, they should query the necessary server configurations to update their user interfaces and configuration dialogs. NC-Config and NC-Channel clients send configuration queries as listed in table 10 below.

NC-Config	NC-Channel	Details

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✔	✔	List of all configured channels.
✔	✔	Channel data protocol. If no hardware is connected, this command will trigger a warning on Server side and the channel protocol is not set. This may limit the functionality of the server and client applications somewhat.
✔		Demodulator filter configurations. See filter configuration for more information.

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Table 10: Configuration Strings.

7.2.6.2 Soft Front Panels

Server program consists mainly of hardware interfacing and command handling. Configuration and data display functionality is managed by add-on tools called Soft Front Panels (SFP), which are embedded software modules that can also be run as standalone executables, either in the host or in client computers.

There are two SFP programs, NC-Config and NC-Channel. The functionality of the respective executables will apply also to the SFP versions. Despite the fact that the SFP versions are part of the server executable, they will communicate with the server via TCP/IP commands the same way the standalone executables would: in the server command log the SFP commands are shown up as incoming client commands to which the server replys.

The main difference between the SFP and standalone versions is the system configuration dialog, as in the standalone executables the host IP address needs to be configured as well. Additionally, the SFP and standalone configuration and log files are saved in different folders - the SFP versions in C:\Users\Public\Documents\Novator Solutions\NC-Server\, the standalone versions in C:\Users\Public\Documents\Novator Solutions\NC-Config\ and C:\Users\Public\Documents\Novator Solutions\NC-Channel\ respectively. In Windows Registry, the SFP version configurations are in \HKEY_CURRENT_USER\Software\Novator Solutions\NC-Server, in sub-registries NCConfig and NCChannel. For the standalone executables the registry paths are \HKEY_CURRENT_USER\Software\Novator Solutions\NC-Config and \HKEY_CURRENT_USER\Software\Novator Solutions\NC-Channel.

> *NOTE: After initial configuration it is recommended that the soft front panels are disabled and further configuration are done from stand-alone client applications*

7.2.6.3 Execution Modes

NC-Server is normally started in *setup mode*. In this mode the server is available for external clients to connect, no hardware drivers are loaded, and no measurements are made. When the user selects the menu command **Operate >> Run**, or issues a command SYS_RUN with run parameter set to true from a connected client, the server will start to load hardware drivers, and attempt to make a connection to the USRP device.

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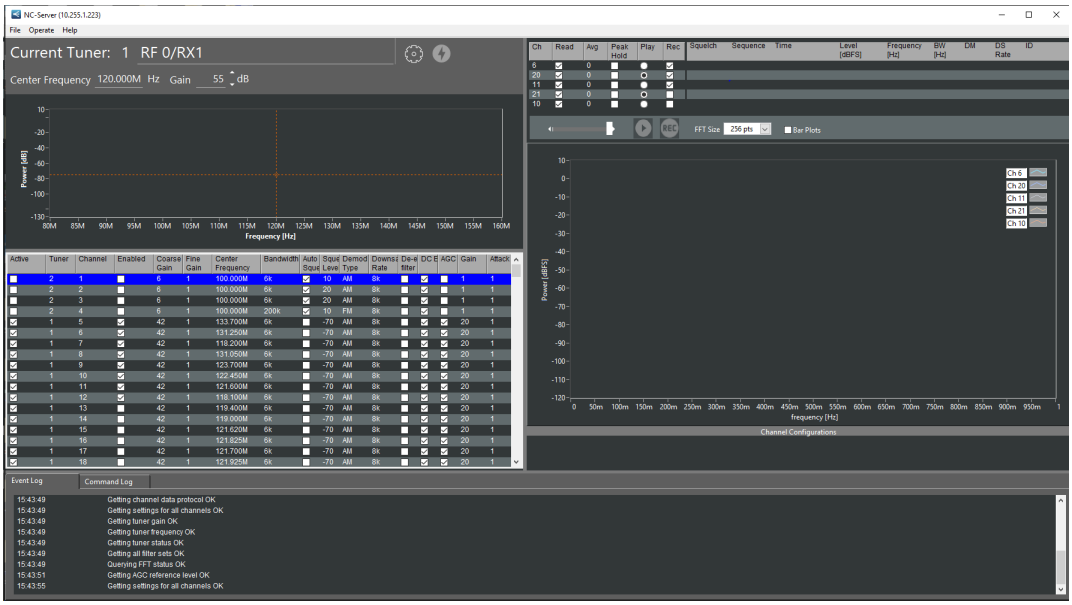

Figure 25: Configuration Mode.

When the drivers are loaded and a connection to the hardware has been established, NC-Server is in the *hardware execution mode*. To confirm this, the server will send a SYS_RUN response to the clients with the run parameter true. Furthermore, in NC-Server as well as NC-Config and NC-Channel, the hardware execution mode is indicated by the fact that the borders of the graphical user interface will turn blue (see Figure 26).

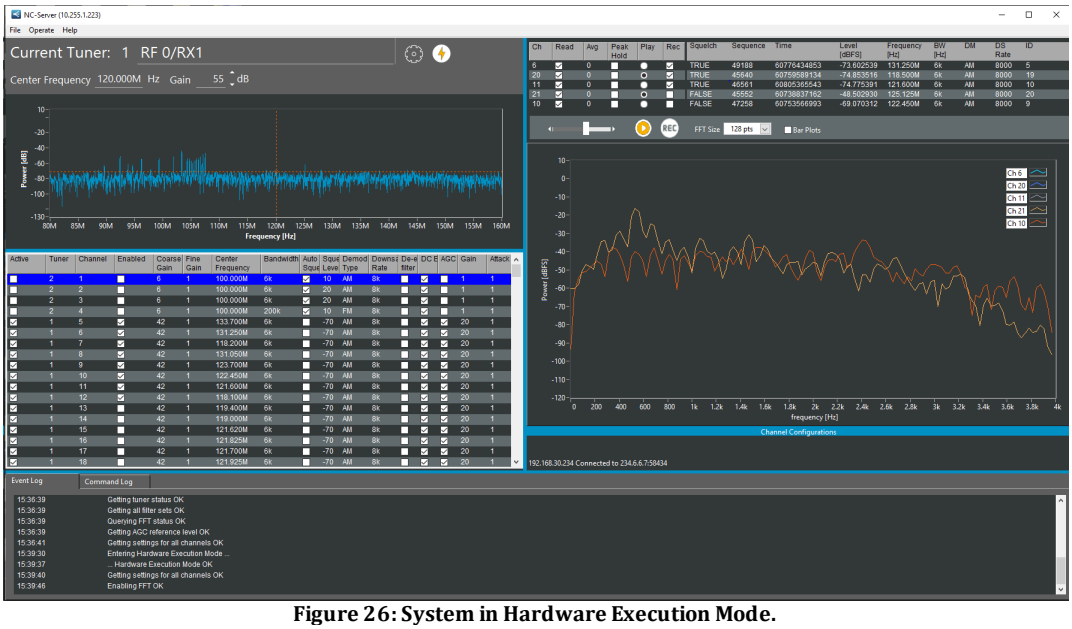

Figure 26: System in Hardware Execution Mode.

If the server was unable to load the hardware drivers the SYS_RUN will contain the "run" parameter set to false and the server goes back to setup mode.

Entering Hardware Execution Directly

It is possible to start the server executable so that it proceeds automatically to hardware execution mode. To do this the program executable has to be started with a command-line

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argument -run, either by starting the executable in Windows command prompt window, or by creating a Windows shortcut, which allows the entry of command line arguments.

> *NOTE: When entering hardware execution mode directly, the program will take longer time to react to user input since the hardware drivers are loaded immediately at startup.*

7.2.6.4 Time Formats

The time formatting can be used to tailor the way the system writes the time stamps and names the log files. See also System Configuration.

Formatting Code	Value
%a	abbreviated weekday name (for example Wed)
%A	full weekday name (for example Wednesday)
%b	abbreviated month name (for example Jun)
%B	full month name (for example June)
%c	locale-specific default date and time
%d	day of month (01–31)
%H	hour (24-hour clock) (00–23)
%I	hour (12-hour clock) (01–12)
%j	day number of the year (001–366)
%m	month number (01–12)
%M	minute (00–59)
%p	AM or PM flag
%S	second (00–59)
%U	week number of the year (00–53), with the first Sunday as the first day of week one; 00 represents the first week
%w	weekday as a decimal number (0–6), with 0 representing Sunday
%W	week number of the year (00–53), with the first Monday as the first day of week one; 00 represents the first week
%x	locale-specific date
%X	locale-specific time
%y	year within century (00–99)
%Y	year, including the century (for example, 2017)
%Z	time zone name or abbreviation, depending on the operating system locale settings

7.2.6.5 Multicast Broadcasting

NC-Server and the connected USRP unit broadcast channel and FFT data using multi-cast UDP protocol. Multi-cast UDP is a technique where the broadcasting unit sends data to a virtual IP address and port, and clients connect to the same IP and read the data. The virtual IP address

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must be selected from a particular range for multi-cast to work. In NC-Server the allowed multi-cast IP address range is from 234.0.0.0 through 239.255.255.255.

See network configuration for more information on the network topologies and configuration options.

7.2.6.6 Troubleshooting

The first step in troubleshooting is always to check the event log file for errors. Usually, if an error has occurred during hardware execution the server switches to setup mode stopping all radio and channel broadcasts. Table 11 below lists a few additional steps for solving possible issues.

Error	Possible Reasons	Solutions
No channel data. No FFT from radio.	Server is in Setup Mode.	• Switch to Hardware Execution Mode. • Check the event log for possible errors that prevent the system from going to Hardware Exeuction Mode.
	The client cannot receive the UDP broadcasts.	• Check with a soft front panel that the data is showing. • Check with a network monitoring program (for example Wireshark) in the host computer that the UDP data packets are actually being sent. • Check with a network monitoring program in the client computer that the UDP data packets are actually coming through. • If no UDP data is received, check the network connections and possible switch configuration between the server and the client. Make sure the systems are in the same subnet, and that the subnet masks match the network setup. If necessary, reconfigure the USRP to match the topology.
Going to Hardware Execution Mode fails with error -367001	Too wide channels Too many enabled channels	• This will most likely occur if you are sending all channels to the same computer that also manages the commands and RF data via its SFP+0 interface. • Preferred use case is to separate command/RF data interface from channel output, either by broadcasting the channel data via switch or directly but to another computer/network interface.
No data from one or several channels.	The channel is not broadcasting	• Use NC-Server or NC-Config to check that the following channel settings are correct (for more information on the channel settings refer to NC-Config user manual): ○ Active: selected

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		○ Tuner: the corresponding tuner must be enabled (see Hardware Configuration) ○ Enabled: selected ○ Center Frequency: must be within the corresponding tuner band (tuner center frequency ± 50 MHz) ○ Channelizer Filter: must be 1 or higher.
Channel data is scrambled	The channelizer timebomb has expired.	• Check the license status. Generate a license request if necessary. • If you expect the system to be licensed but the status received is "Timebombed", check that the system configuration has the correct path to the license file. • Check that the license file contains a row with the serial number of the USRP unit in use.

Table 11: Troubleshooting NC-Server .

7.2.6.7 Filter Editor

Filter Editor is a standalone executable that is installed with NC Configuration Suite package and can be found in Novator Solutions program group. Additionally, it can be started from NC-Server with menu command File >> Filter Configuration...

When started from NC-Server the editor will automatically adjust its settings to match the currently used USRP hardware channel data protocol with the correct filter type support, and the Protocol control is grayed out. If the editor is started as a standalone utility, it is possible to edit filters of either type. The user interface will match the currently used filter type.

Section Filter Design Tool contains detailed information on the menu commands and user interface controls.

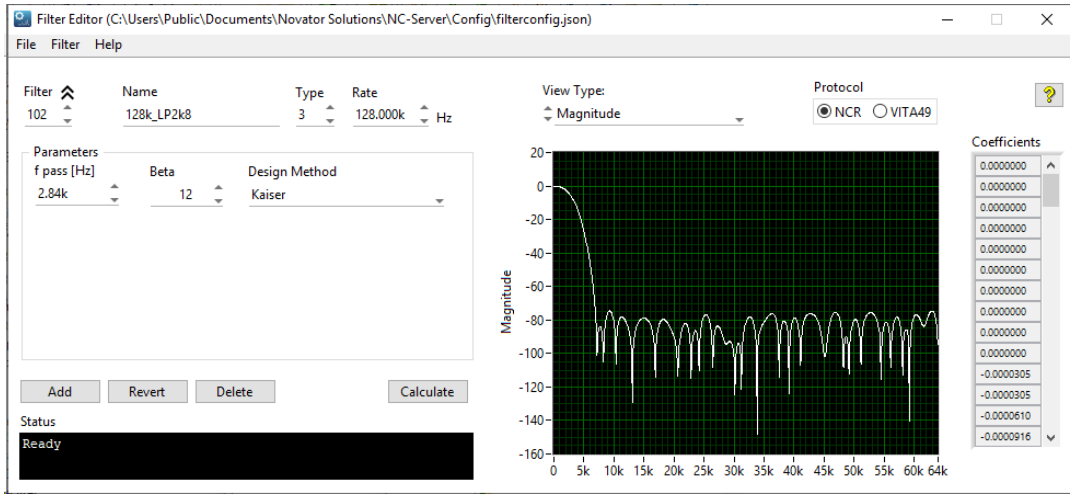

Figure 27: Filter Editing Tool with NCR Filters.

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7.2.6.7.1 Filter Types

There are two types of demodulator chain filters, system and custom. Additionally, filters are constructed in a different way for the two different protocols for channel data output data, NCR and VITA49.

System Filters

System filters are a set of predefined digital FIR filters that are applied on the channelized data prior to broadcasting the data as UDP multicast packets. The number of system filters is different for NCR and VITA49 channel data protocols.

NCR Protocol System Filters

With NCR Protocol, each of the available modulation, bandwidth and downsampling rate combinations have a set of filters that are applied on the signal. These default filter definitions are called *system filters* and they are positioned in the signal path as described in figure 28 below.

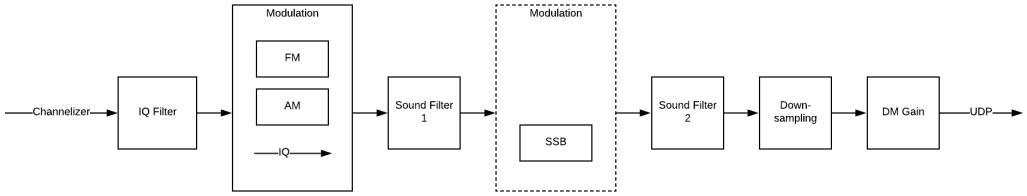

Figure 28: NCR Protocol Demodulator Chain.

The system filter configurations are read at system startup. However, it is possible for the user to bypass the system filter settings for IQ filter and Sound Filter 1, and enter their own configurations using the filter configurator.

When a channel modulation, bandwidth or downsampling rate is changed, the server selects automatically the corresponding filter settings from the system filter set. If the user has made modifications in the system filters, the modified filters will be used in all configurations from there on. To apply the new filter settings to all existing channels as well the server must be put to Setup Mode and then to Hardware Execution Mode.

Currently there are 99 system filters, although some of these are not used in the current version. Refer to the section on Demodulation Types and Filters for a table of currently used system filters for each of the channel demodulation, bandwidth and downsampling ration combination.

Vita 49 System Filters

When channel output data uses VITA49 protocol, the signal path between channelizer and UDP has only one function block, which is the IQ Filter. The only system filters defined are filters number 0 and 1, where 0 is a zero filter, and 1 is a unity (passthrough) filter.

Custom Filters

Custom Filters are additional filter configurations that can be assigned to any channel configuration and in any of the two filter positions, IQ Filter and Sound Filter 1 by setting the filter number for the channel in question. See NC-Config user manual for instructions on how to edit channel settings. Filter numbers above those used by system filters are available. In NCR Protocol, number 100 is the first custom filter position, with VITA49 it is number 2.

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Filter Construction

NCR Filters

With NCR channel data protocol the demodulator chain filters used are defined as 108 tap FIR filters, all 108 taps are listed in the filter definition, although most of the filters are symmetrical so the the first 54 taps are the mirror image of the next 54 taps.

VITA49 Filters

VITA49 channel data protocol is used with NC systems with no demodulation. Therefore all filters are used as IQ filters. The filters are defined as symmetrical 109 tap FIR filters, but only half of the taps are listed, i.e. taps 1 through 55. The other half of the filter is built using the mirror image of taps 1 through 54, leaving tap 55 as a unique middle element.

7.2.6.7.2 Demodulation Types and Filters

If channel signal is to be demodulated, the choice of bandwidths, sample rates and filters is limited to a number of combinations listed in table 12 below.

Demodulation Type†	Bandwidth [kHz]	Sampling Rate [kHz]	Output Rate [kHz]	IQ Filter Number††	Filter 1 Number
1: AM	6	24	8	1*	2
1: AM	10	24	8	4*	5
1: AM	20	24	8	7*	8
2: FM	10	24	8	10*	11
2: FM	20	24	8	13*	14
2: FM	50	64	8	16*	17
2: FM	100	128	8	19*	20
2: FM	100	192	96	22*	23
2: FM	100	384	192	25*	26
2: FM	150	192	96	28*	29
2: FM	150	384	192	31*	32
2: FM	200	248	8	34*	35
2: FM	200	384	192	37*	38
3: LSB	8	8	8	40	41*
4: USB	8	8	8	43	44*

Table 12: Demodulation Types, Filters and Sampling Rates with NCR Data Protocol.

†The numbers refer to modulation type when used in communication between server and clients.

††Filters marked with an asterisk * are passthrough (unity) filters.

Notes:

- When demodulation type and bandwidth are set to any of the combinations above, the system will automatically apply the corresponding filter numbers.
- Filter 0 is equal to not filtering the signal at all (unity filter).
- The user is at liberty to change any of the existing filters, whether they are used by the system or not. Changing the coefficients on the filters listed in the above table will affect *all* connected clients and all channels using the demodulation/bandwidth.

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7.2.6.7.3 Filter Design Tool

The filter design tool can be used to calculate response curves for existing filters, and to design new filters with different configurations. The only filter type that is supported is low-pass filters. It is possible to import filter taps for other filter types, to insert them into the filter configuration file.

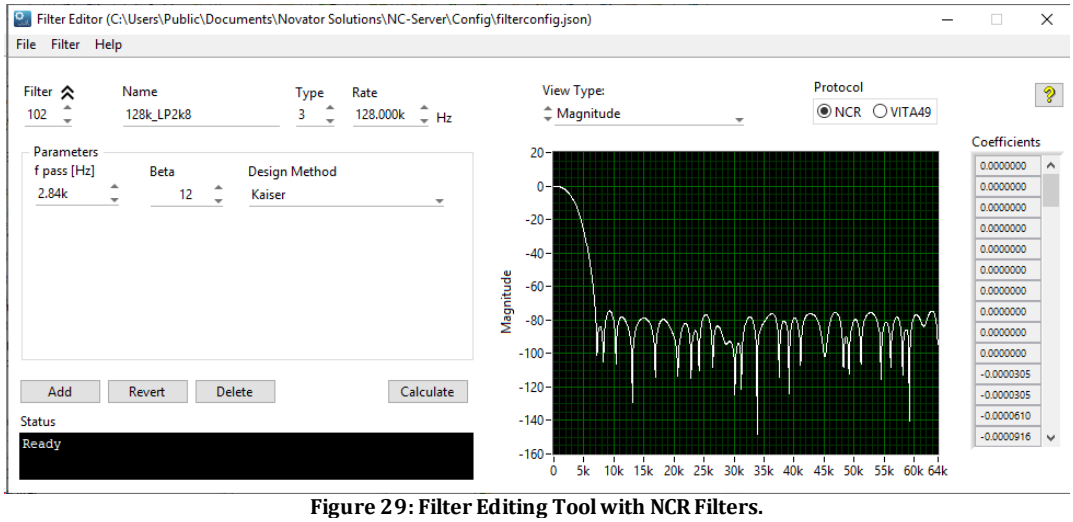

Figure 29: Filter Editing Tool with NCR Filters.

General Filter Settings

Filter

Filter number to view or edit. Pressing the double up arrow button ⏫ will jump to the highest defined filter position. When the filter number is changed the filter response curve is calculated automatically for the selected View Type. For more information on the response curve calculation, refer to **Calculate** command below.

Name

Free text describing the filter. System filters have name formats that indicate bandwidth, demodulation type, filter number and output rate, e.g. filter 1,used in filter position 1 for 6kHz AM demodulated channels where the output sample rate is 8kHz, is named `6kAM(1)@8k`.

Type

One of the following enumerations: 0 - None, 1 - IQ Filter, 2 - Filter 1. This value indicates the filter position for system filters, but for custom filters it is ignored.

Rate

Sampling rate at the filter position. For design of custom filters it is important to use correct sampling rate when calculating the filter coefficients.

Filter Design Parameters

This section is different for NCR and VITA49 filters, refer to corresponding section for more information.

Filter Management

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Add Start designing a new filter. The new filter will be assigned the next available number, and the taps will be read from the currently selected filter. Change the default filter name if needed. Filter type has no effect for custom filters.

Revert Revert filter setup to the file version.

Delete Remove the current filter and renumber the remaining filters. Available only for custom filters. Removing a filter will affect the filter numbers of the following filters, so the channel settings may need to be revised if custom filters are being used there.

Calculate Calculate the filter coefficients and draw a response curve with the used parameters. Note that there is a discrepancy between the passband that is calculated from existing filters and the filter coefficient values, i.e. if you were to re-calculate a filter whose cut-off frequency is calculated using the coefficients, you would get a different list of coefficients. This is due to the fact that different design methods yield different outcomes with regards to passband ripple, steepness, and stopband attenuation, and the system cannot reconstruct the used design method from the coefficient list alone.

Status Shows further filter information or outcome of the most recent operation.

Filter Characteristics

View Type Select between showing the filter Magnitude Response, Phase Response, Group Delay, Z-Plane graph or Impulse Response.

Coefficients Filter coefficients read from file or as resulted from the calculation. The coefficients here are displayed as normalized values between -1 and +1, limits included.

Protocol If Filter Design Tool is started from NC-Server or NC-Config, read-only setting for the channel data output protocol used by the currently connected hardware. In standalone execution the filter set the user is editing (both filter sets are saved in the same file).

Menu Commands

File > Open... Opens a new filter design file. This does not change the currently active filter in the system though, call File > System Configuration... > Filter Configuration File in NC-Server to change the currently active filters. This command is not available from a remote NC-Config client.

File > Save Saves the filter design file that is currently open for editing. This command is not available from a remote NC-Config client.

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File > Save As...	Saves a copy of the filter design under a different name, changes the actively designed file to this. This command is not available from a remote NC-Config client.
File > Allow System Filter Editing	If checked, system filters can be edited. Since editing system filters affects all future channels, this is not checked by default. This command is disabled if the filter design tool is run from a remote NC-Config client. Editing system filters should be done with caution, as system filters will affect all channels with the corresponding demodulation and bandwidth setting. It is recommended that before editing system filters, a backup of the filter configuration file is created with which the system can be reset to the default setting if necessary. Also, if the filter configuration file defined in system settings is deleted, the server will automatically recreate the default filter settings configuration.
File > Exit	Closes this application.
Filter > Open...	Reads a filter definition file (*.fds) created and inserts its coefficients into the currently active filter number. This command is available when a system filter is selected only if Allow System Filter Editing is set.
Filter > Save...	Saves the filter design in a filter definition file. This command is available only on valid filters (no error messages in Status).
Filter > Export Coefficients...	Exports the filter coefficients as a text file where each coefficient is a normalized value between -1 and +1. This command is available only if the **Coefficients** list is not empty.
Help	Open this help page.

7.2.6.7.3.1 NCR Filter Design

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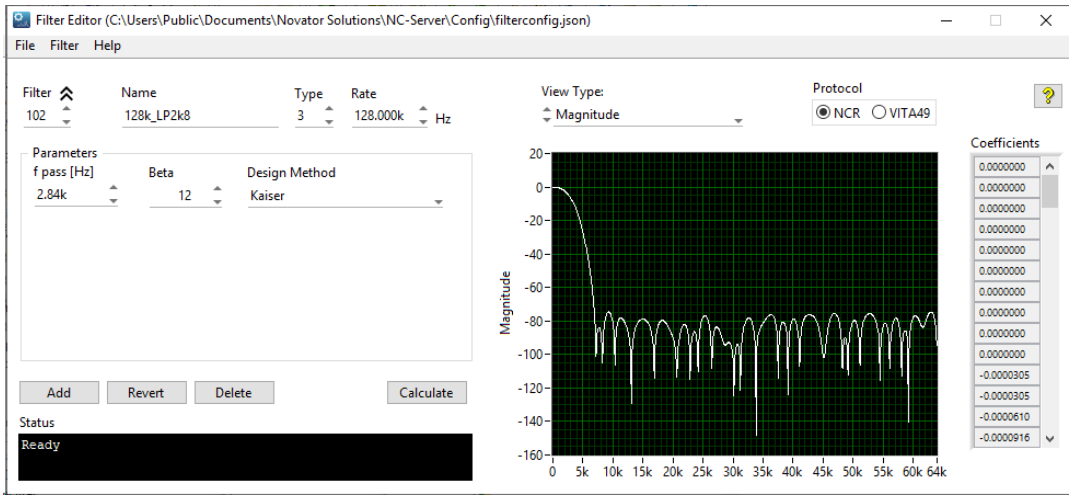
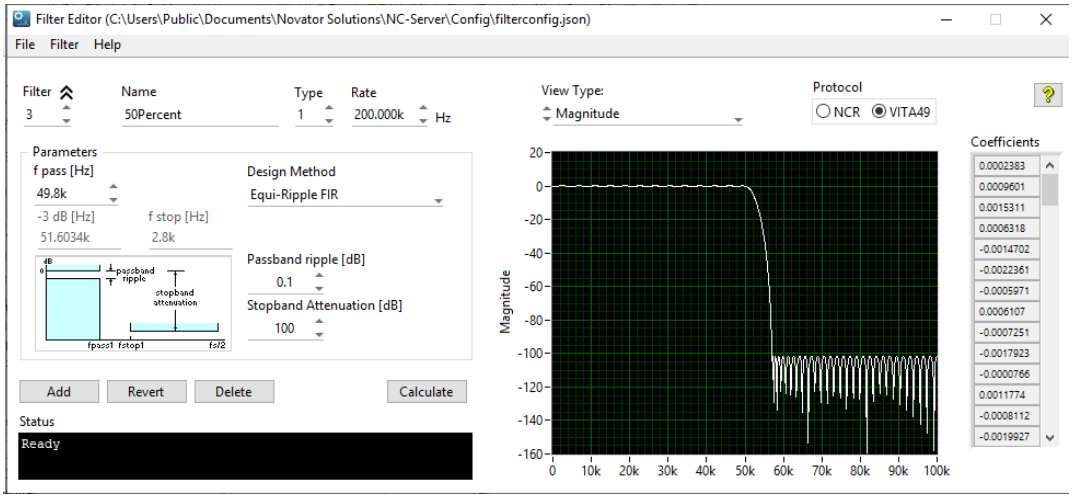


Figure 30: Filter Editing Tool with NCR Filters.

Parameters

f pass	3dB cut-off frequency for the low-pass filter in Hz. This frequency must be lower than Rate/2.
Design Method	Algorithm to use for generating the filter coefficients. For more information on the algorithms refer to National Instruments web.
Beta	Beta, an additional parameter to feed in when using Kaiser Design Method. Default value 12.
Main/Side Lobe	The ratio of the main lobe to the side lobe, an additional parameter to feed in when using Dolph-Chebyshev Design Method. Default value 60
St Dev	Standard Deviation, an additional parameter to feed in when using Gaussian Design Method. Default value 0.2

7.2.6.7.3.2 VITA49 Filter Design



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Parameters

f pass	Frequency
Beta	Additional parameter used in calculations
-3 dB	3dB cut-off frequency in Hz. This frequency is calculated during the design process.
f stop	Stop-band frequency for filter in Hz. This value is iterated during the design process until a satisfactory design is reached.
Design Method	Algorithm to use for designing the lowpas filter with the parameters f pass, Passband Ripple and Stopband Attenuation.
Passband Ripple	Allowed ripple in passband in dB.
Stopband Attenuation	Required attenuation on stopband in dB.

Pressing **Calculate** will start an iteration process where stopband frequency is increased in steps of 100 Hz from **f pass**, until a design is reached where the boundary conditions are satisfied. If this is not possible the system will return an error. You may need to adjust the **Ripple** and **Attenuation** parameters for less stringent values, or changing the design method, to reach a successful filter design.

When a filter has been designed, the **Coefficients** list is filled in, and the filter response curve is drawn.

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NC-Config User Manual

8 NC-Config User Manual

NC-Config is a software tool for configuring NC-Server. It can be run independently as a client application, either in the same computer as the server application, or in another computer that is connected to the server system via an Ethernet connection. Alternatively, it can be run as an embedded soft front panel withinNC-Server itself.

NC-Config as a Soft Front Panel

To run NC-Config as a Soft Front Panel within NC-Server, you will need to enable the corresponding setting in Server and restart. Even when NC-Config is run as a part of the server application, it will communicate with the server via the same network commands as the standalone client application would. Therefore NC-Config soft front panel can be used as a first debugging step when resolving issues with a remote client.

8.1 Installing NC-Config

The steps to install NC-Config are:

1. Installing NC-Config software package
2. Configuring the IP addresses
3. Testing client operation

> *NOTE: It is not necessary to install NC-Config in the host computer, since NC-Server already contains the same functionality.*

Before proceeding with the client install, make sure that a server is already installed and configured. Refer to Server User Manual for details.

Install NC-Config

The installer can be downloaded from https://novatorsolutions.com/spectral-data-analysis/nc10gettingstarted. Extract the zipfile and start setup.exe. You must be able to provide Administrator access to the operating system to install the software.

The program will initialize with the screen resembling figure 31. The screenshots are from a Windows 10 installation. Windows 7 and 8 are also supported, but the dialogs may look slightly different.

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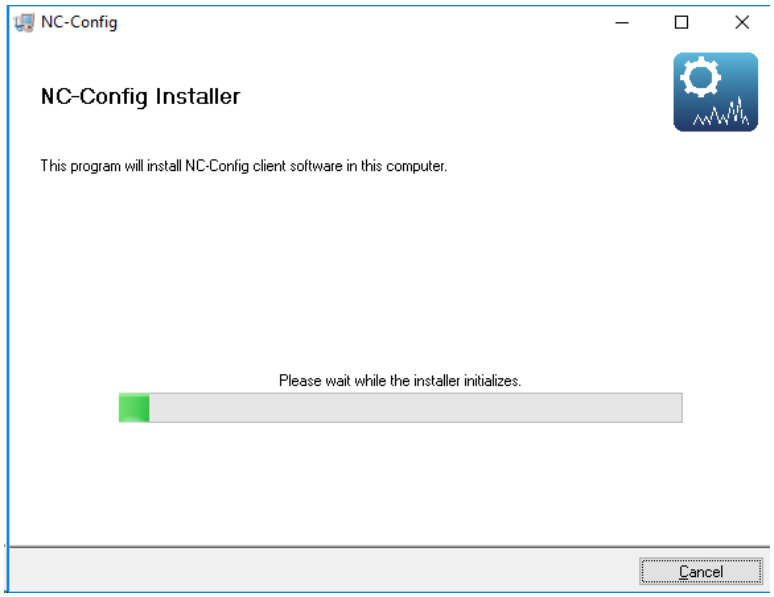

Figure 31: NC-Config Installer Initializing.

The software suggests destination directories, %ProgramFiles(x86)%\Novator Solutions\\NC-Config\ for NC-Config, and C:\Program Files (x86)\National Instruments for the National Instruments drivers. Accept the suggested values by clicking Next.

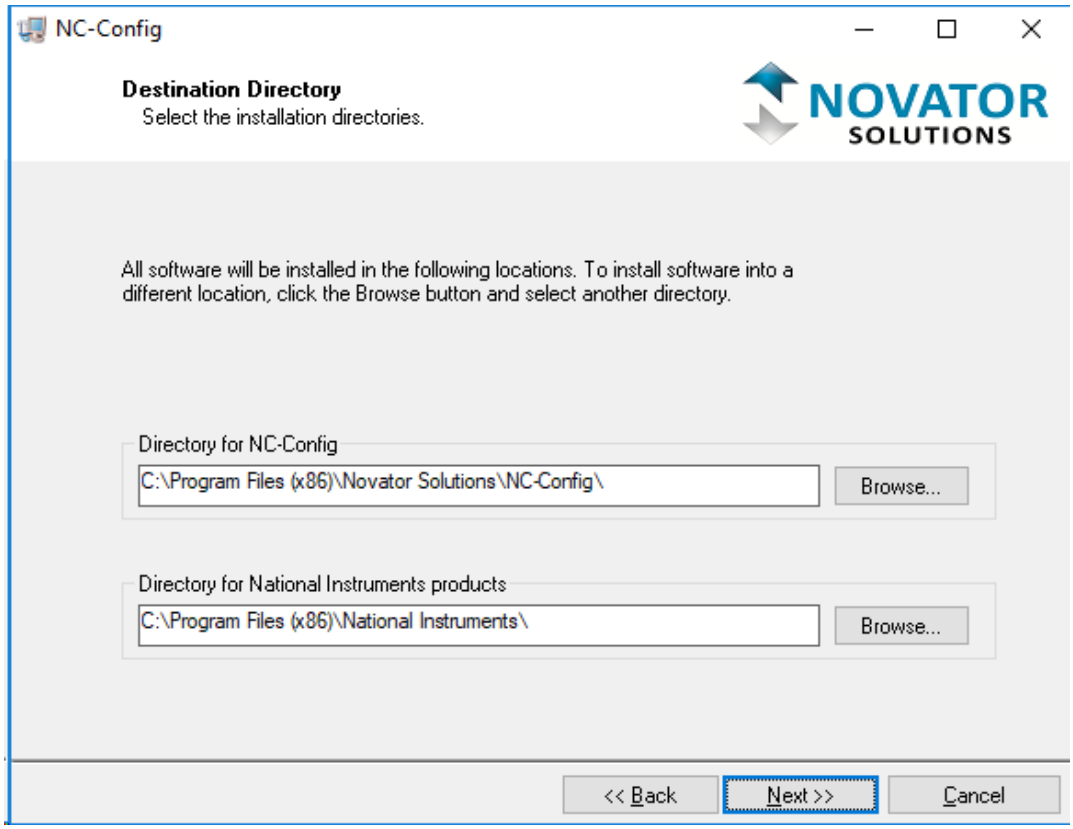

Figure 32: Installation Directories.

If your operating system is Windows 8 or Windows 10, the installer will suggest that you disable the fast startup feature. There is no need to disable it, if your only National Instruments

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hardware is the USRP unit and you are connecting to it only via the Ethernet. If this is the case, deselect the checkbox and press Next. More information can be found on National Instruments website, http://ni.com/info, enter code **winfaststartup**.

As the final step a list of changes and additions are shown in a summary screen (Figure 33). The contents may differ from the one shown here depending on what needs to be updated. NC-Config installation will begin after you click Next.

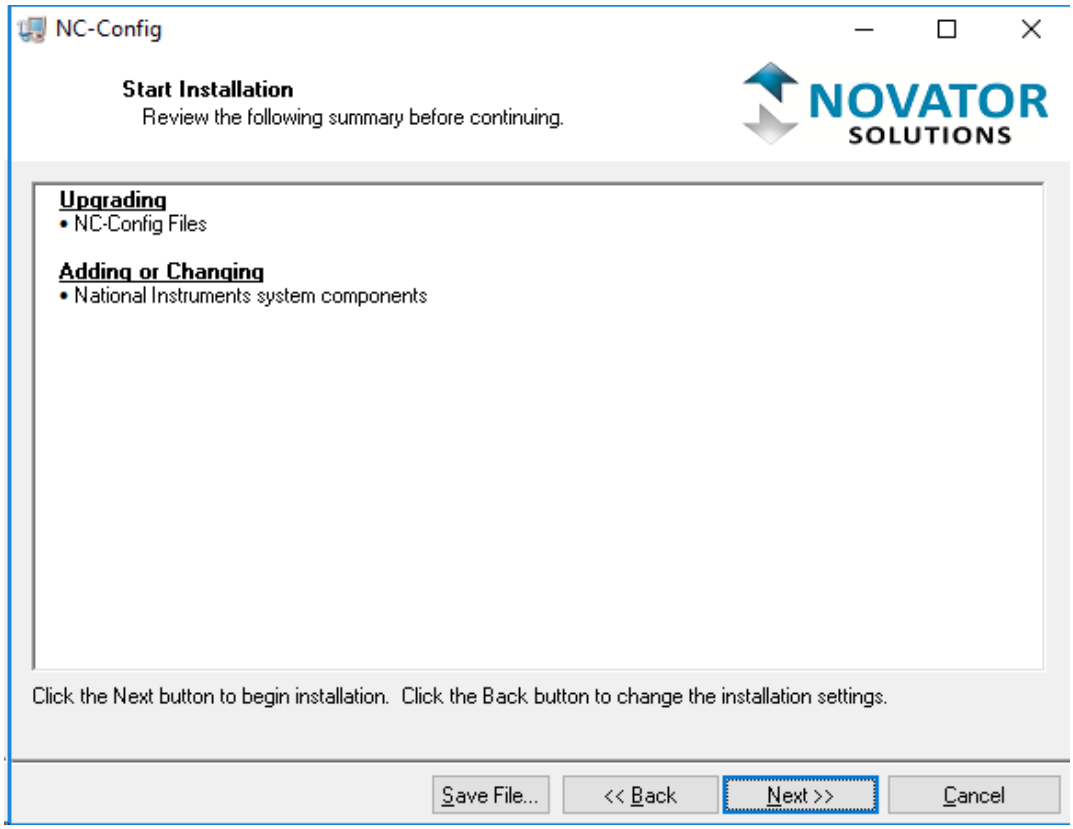

Figure 33: Installation Summary.

The installation takes a few minutes after which a confirmation screen is shown. Restart the computer if requested.

Configure the IP Addresses

Start NC-Config. To begin communicating with the Server running in a Host computer you will have to configure its network address. Select the menu command **File >> System Configuration**. Fill in the *Server IP* and *Port* fields under **Connection Setup**.

Fill in the *Local TCP* field with the IP address of the client computer (this computer). If the client computer has multiple Ethernet adapters, *Local TCP* must indicate the IP address of the adapter that will communicate with the server (as opposed to receiving tuner FFT data), see figure 34. More information on the system configuration parameters can be found in the general user instructions section.

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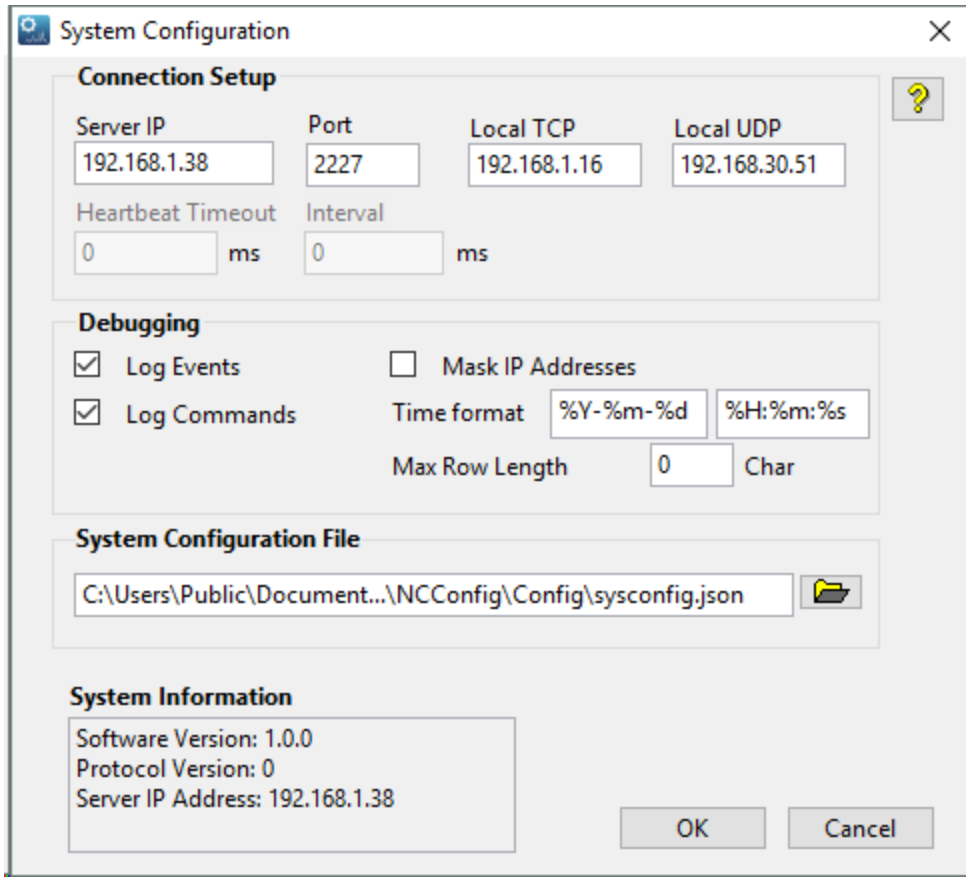

Figure 34: NC-Config System Configuration.

Restart NC-Config if you have done changes in the system configuration.

Test Client Operation

Make sure the Server is running in the host computer. Start NC-Config if it is not already running. The Server log should show in the Event Log that a client has made a connection (see Figure 35 below).

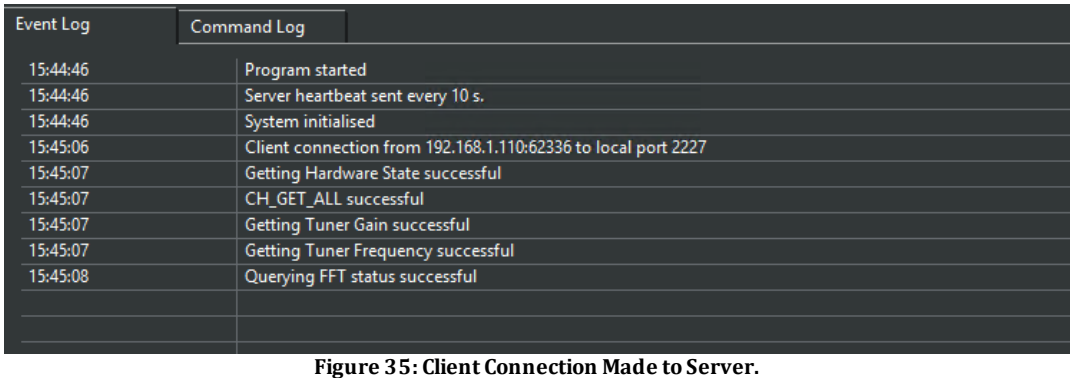

Figure 35: Client Connection Made to Server.

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8.2 File Menu

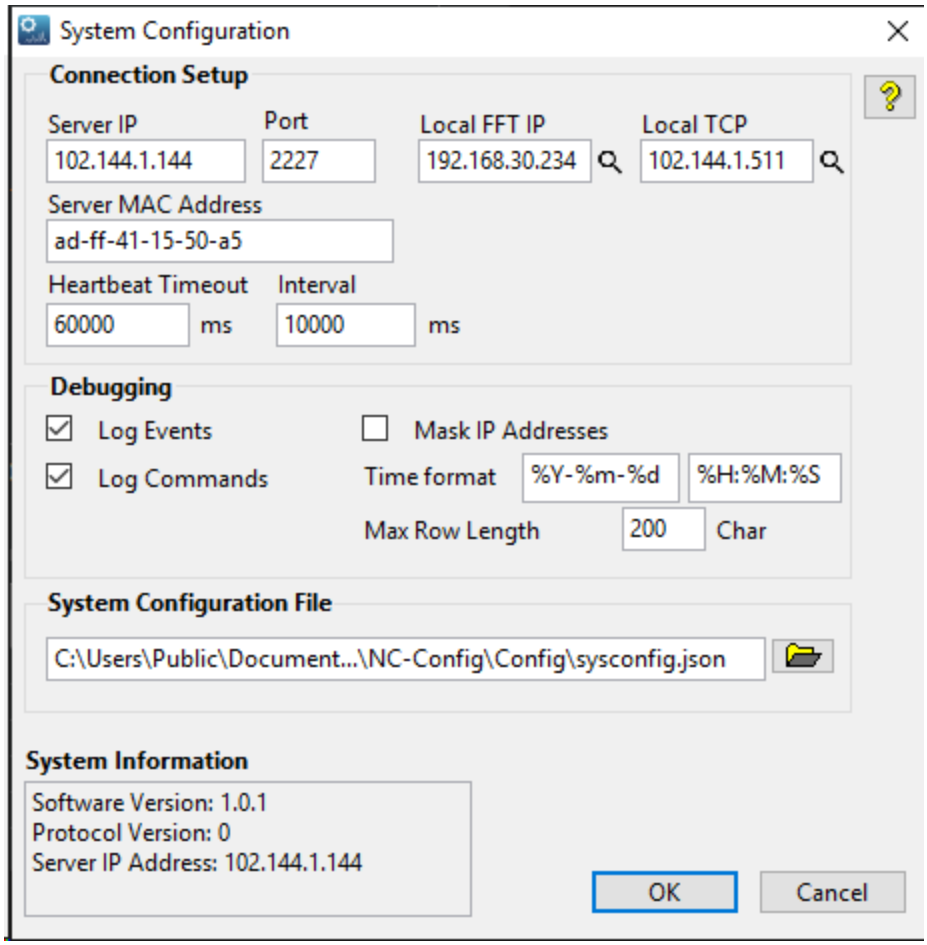
File Menu contains commands for system configuration and logging.

8.2.1 System Configuration

This command is under "File" menu.

The system configuration dialog (see Figure 36 below) is used for setting up the general server parameters, which are explained here. Changing system parameters requires that NC-Config is restarted. The configuration entered here is saved in the file indicated by the "System Configuration File" setting. If the file is deleted, a new configuration file is created with default settings.

NOTE: Program restart is required for the changes to take effect.



Connection Setup

Parameter	Default Value	Notes

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Server IP		The IP address of the server. It is also possible to have the server running in the same computer with NC-Config.
Port	2227	The port the server has been configured to listen to for incoming TCP/IP connections.
Local FFT IP		The IP address of the Ethernet adapter in this local computer that has a connection to the host Ethernet adapter that broadcasts the FFT spectra. Corresponding Server setting: IP FFT Out
Local TCP		The IP address of the Ethernet adapter in this local computer that has a connection to the host Ethernet adapter sending and receiving commands. Corresponding Server setting: Server IP Address
Heartbeat Timeout	60000 (ms)	If no communication takes place from the server for this time, this program considers the connection closed. See also Heartbeat in Communications Manual. Setting Heartbeat Timeout to 0 means that the heartbeat never times out, for example if the server does not send heartbeat.
Heartbeat Interval	10000 (ms)	The time interval for the client to send a heartbeat token to the server to keep the connection up.

Debugging

Parameter	Default Value	Notes
Log Events	Checked	If checked, a log of the system events are shown in the server log file views and saved as a text file in C:\Users\Public\Documents\Novator Solutions\NC-Config\Log\<Date>_NC-events.txt, where <Date> is today's date. A new file is started for each calendar day. Please note that the log files are not cleaned up automatically.
Log Commands	Checked	If checked, a log of the commands from the clients and server responses are shown in the server log file views and saved as a text file in C:\Users\Public\Documents\Novator Solutions\NC-Config\Log\<Date>_NC-commands.txt. A new file started for each calendar day. Please note that the log files are not cleaned up automatically.
Extended Debugging	Not Checked	If checked, hardware status information is saved by system malfunction.
Mask IP Addresses	Not Checked	If checked, the log files replaces the IP addresses in the log files with asterisks (***) for reasons of secrecy.

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Time Format	%Y-%m-%d %H:%M:%S	Description of how the system date and time should be formatted in the log file names. See time formats for information on the formatting strings available.
Max Row Length	200	If greater or equal to 0, the length of the commands is restricted to a number of characters so as to keep individual command lines more readable and the log files reasonably short. If Max Row Length is -1, the lines are not truncated.

NOTE: Event and Command logging may slow down the system performance slightly so they should not be used in production.

System Configuration File

Parameter	Default Value	Notes
System Configuration File	C:\Users\Public\Documents\Novator Solutions\NC-Config\Config\sysconfig.json	Contains the settings of this configuration dialog. If the file is deleted from the location indicated here, a new system file is created with default settings.

System Information

Information on the server network communication parameters as well as software and protocol versions.

8.2.2 Hardware Configuration

This command is under "File" menu.

For details, see Server Manual.

8.2.3 Filter Configuration

This command is under "File" menu.

For details, see Server Manual.

8.2.4 Channelizer License

This command is under "File" menu.

The Channelizer License menu has two submenus, Generate License Request and Verify License Status.

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8.2.4.1 Generate License Request

This command is under "File" menu, submenu "Channelizer License".

Selecting this command will send a "CHZ_LICENSEREQ" command to the server. The server will respond with a license request file that can be saved in the client computer. Send the file to Novator Solutions to obtain the actual license. For details refer to "Obtaining a License Key" in the Configuration Suite manual.

The *license request* can be generated either from the server computer, or from any connected client that runs NC-Config. However, the *actual license file* cannot be copied with the help of the client software, because access to the server file system is required.

> *NOTE: This command can only be run in Setup Mode*

8.2.4.2 Verify License

This command is under "File" menu, submenu "Channelizer License".

Selecting this command will send a "CHZ_LICENSE" command to the server. The server will check the license file in the configured location, and respond with information on the validity of the license. The validity can be one of the following:

- Valid license - the serial number of the currently used USRP unit is found in the license file and the license key matches the serial number
- Timebomb running - no license file is defined, the channelizer code will run for 10 minutes only
- Core locked - no license file is defined, the channelizer code has been run for more than 10 minutes, so the channelizer is locked.

For details refer to "Obtaining a License Key" in the Configuration Suite manual.

8.2.5 Event Log

This command is under "File" menu.

Shows the current day's system log file in the text editor that is configured in the operating system to manage .txt files (typically Notepad.exe). The log files are saved in the Public Documents folder, subfolder "Novator Solutions\NC-Config\Log\". The log will only be updated if Log Events is selected.

> *NOTE: A new log file will be started every day. Old log files will not be deleted automatically.*

More information on the Event Log

Events are saved with a timestamp in the user defined format. The event log messages can be of five different types, the types are colour-coded in the log window. The message type is included as a tag in the message as well, see table 13 below.

Type	Text colour	Tag	Comments
General event	Black	-	Normal program execution step

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Alert	Gray	Alert:	Exception in the program execution. Does not require corrective actions.
Warning	Blue	Warning:	Exception that does not prevent program execution. May indicate an invalid setting from a connected client, in which case the response status will be NOK.
General Error	Magenta	General Error:	Exception in the program execution, the program will unload the hardware drivers and go to Setup Mode.
Fatal Error	Red	Fatal Error:	Exception in the program execution, the program will be stopped.

Table 13: Error Levels.

Event Log will be updated only if Log Events setting is selected. However, error messages will be shown in all cases.

8.2.6 Command Log

This command is under "File" menu.

Shows the current day's TCP traffic log file in the text editor that is configured to manage .txt files. The log files are saved in the Public Documents folder, subfolder "Novator Solutions\NC-Config\Log\". The log will only be updated if Track Commands is selected.

> *NOTE: A new log file will be started every day after the first command has been sent or received. Old log files will not be deleted automatically.*

More Information on Command Log

All commands received from the client systems will be entered in the Command Log, as well as Server responses, timestamped in the user defined format, excluding heartbeat messages. The client commands contain also the IP address and Port of the client that has sent the command.

8.2.7 FFT Traffic Monitor

This command is under "File" menu.

FFT Traffic Monitor window (Figure 36) can be used to verify that the Radio Spectrum UDP packets are being received by NC-Config (either in a separate application or as a Soft Front Panel).

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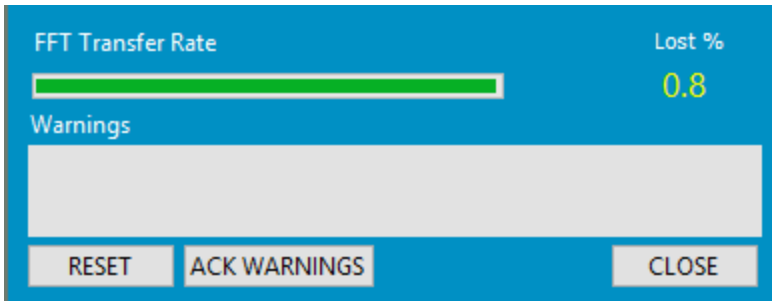

Figure 36: FFT Traffic Monitor.

The controls on this screen are used as follows:

FFT Transfer Rate ..... Shows the percentage of packets that are received. If the bar is fully green all FFT frames have been successfully received.

Reset ..... Restart calculation of FFT Transfer Rate

Ack Warnings ..... Removes any warning messages

Close ..... Closes this dialog.

Note that this tool takes all FFT streams (up to four, if all four tuners are enabled) coming from the USRP unit into account.

Example

If the transfer rate set for FFT updates is too high, some UDP packets may be lost, as in the example below (figure 37).

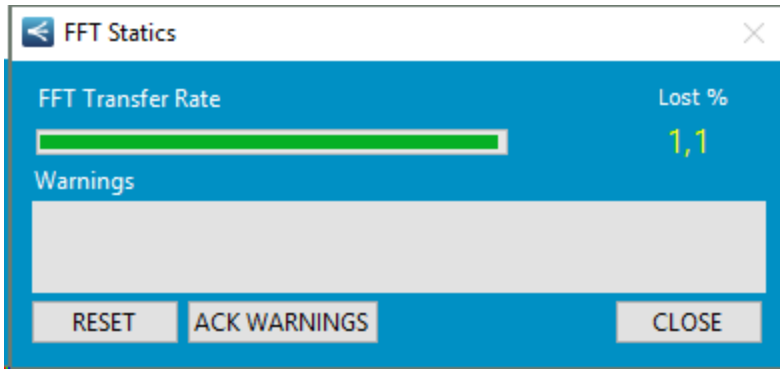

Figure 37: FFT Traffic Monitor showing data losses.

By lowering the FFT update rate we were able to receive all data packets correctly (figure 38).

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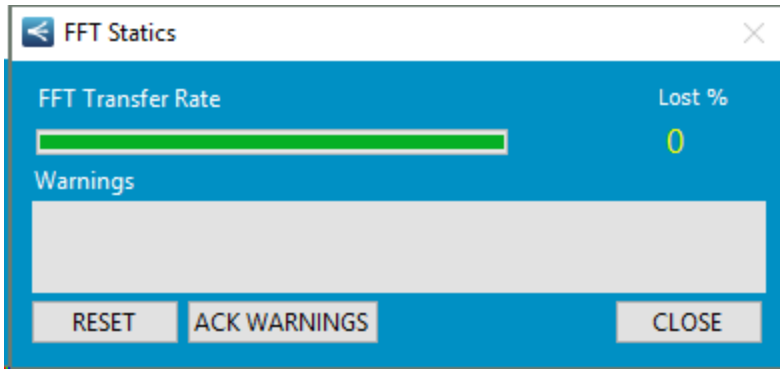

Figure 38: FFT Traffic Monitor showing lossless traffic.

It is not possible to give a rate value that would grant lossless data traffic, as it is dependent on server computer specifications as well as the overall network topology. If there are problems with high amount of dropped packets, you may also experiment with disabling the FFT for the tuners that are not used, and by decreasing the FFT size. See FFT configuration for more information.

8.2.8 Exit

This command is under "File" menu. The command shortcut key is <CTRL>+Q.

Exits the application, closing the communication processes.

8.3 Operate Menu

Operate Menu is used to load/unload hardware drivers by entering and exiting hardware execution mode.

8.3.1 Run

This command is under "Operate" menu.

"Run" is used to switch between Setup and Hardware Execution modes. When set, the system will go to Hardware Execution mode, which loads the hardware drivers and processes into memory. Loading the hardware drivers will take a little under one minute, during which time this menu command is disabled. When the system is configured successfully, a check mark will appear on the menu command. Additionally, the borders on the user interface will change colour from gray to blue.

Possible errors during hardware load will be updated in the event logs. Refer to "Troubleshooting" section for tips on solving errors.

8.4 Help Menu

Help>>About... opens up a dialog with information on the current program version.

Help>>User Manual provides access to this help document.

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8.5 User Interface

When NC-Config is started, the program will attempt to make a connection with the configured server. After a successful connection is made, NC-Config will request the hardware configuration from the server. If successful, the controls are updated in the user interface, and it will look approximately as in figure 39. The different sections are explained in the ensuing chapters.

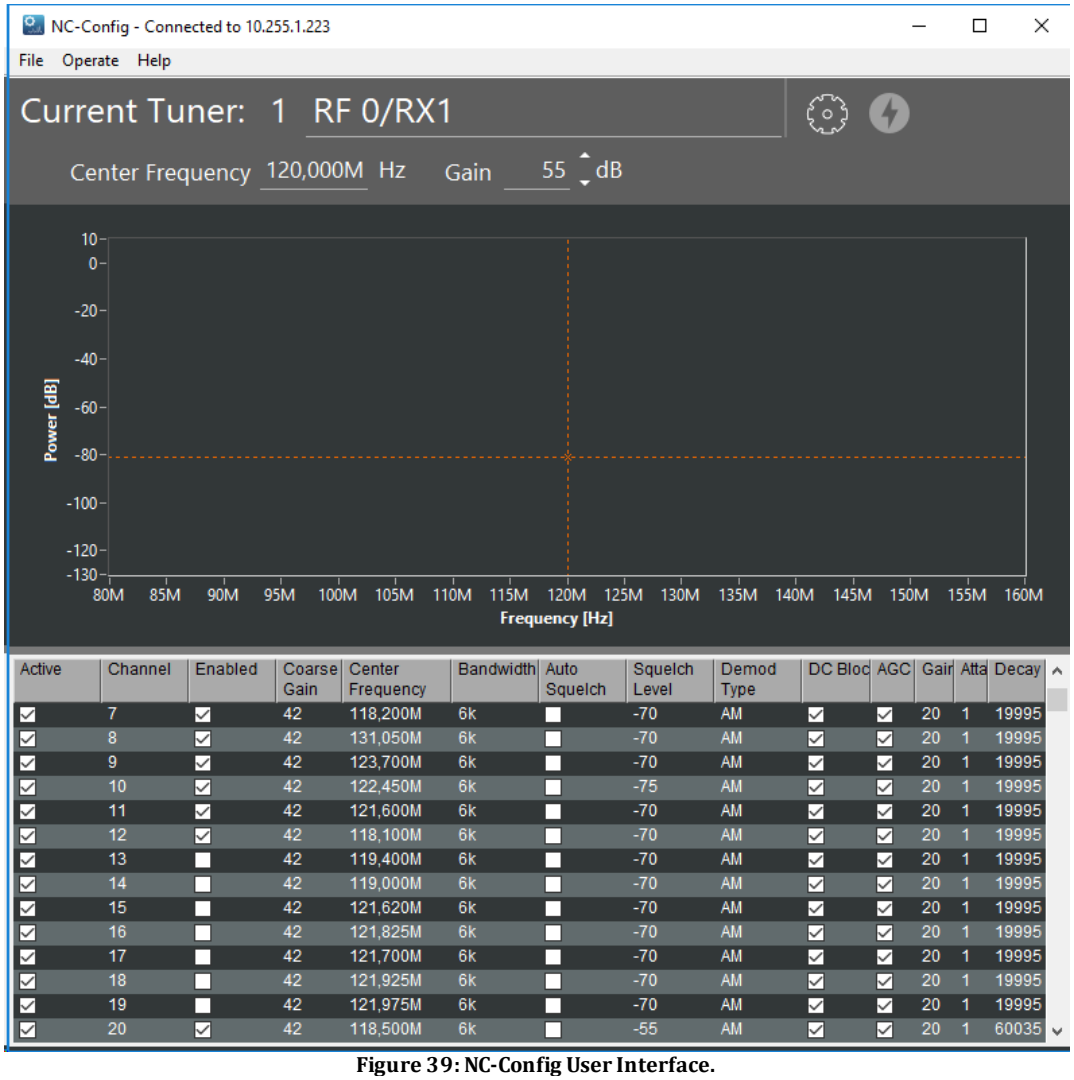

Figure 39: NC-Config User Interface.

8.5.1 Get Diagnostics Data

The "Get Diagnostics" button is visible when the server is in Extended Debugging Mode. Clicking this button will create a hardware status summary. This is useful to have as a report, especially when escalating hardware issues to Novator Solutions.

Figure 40: Get Diagnostics.

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NOTE: The Get Diagnostics button is only available when running NC-Config as a Soft Front Panel, not as a standalone.

8.5.2 Tuner Configuration

The current tuner can be selected from the Tuner Selector drop-down list, which is populated after NC-Config has made a connection to the server (figure 41).

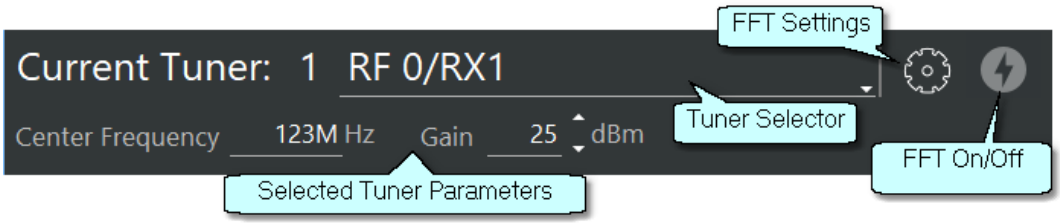

Figure 41: Tuner Controls.

When the current tuner is changed, NC-Config sends commands to the server to query the parameters for the selected tuner as well as the current FFT status. Parameters *Current Tuner*, *Center Frequency* and *Gain* are explained in the Server Manual.

8.5.3 Spectrum

Configuration

The FFT settings button is enabled after the current FFT settings have been read from the server. Clicking the FFT Settings button will open up a configuration dialog (see Figure 42).

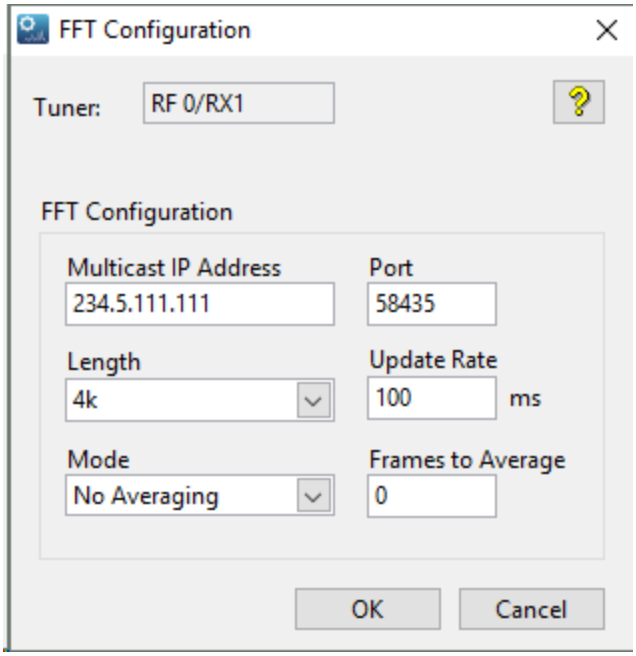

Figure 42: FFT Configuration.

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The configuration shows the currently selected tuner. However, the same settings are applied to all tuners. When a client enables the FFT it sends a command TN_ENABLE_FFT to the host with the FFT configuration parameters. The settings in this dialog are as follows:

Parameter	Range	Default Value	Notes
Multicast IP Address	Multicast IP range or localhost	234.5.111.111	Setting the IP address to "localhost" configures the server to unicast the FFT frames instead of multicasting them. This setting is recommended only if no networked clients are connected.
Length	4k (4096 Samples) 8k (8192) 16k (16384) 32k (32768)	4k	Each sample is 32 bits. The length is transferred to the server in FFTL parameter so that FFTL=$\log_2$(Length).
Mode	No Averaging (0) Vector Averaging (1) RMS Averaging (2) Peak Hold (3)	No Averaging	The mode is transferred to the server in FFTM parameter
Port	49152 ... 65535	58435	Network port for multicast traffic.
Update Rate ms	5 ...	100	Time interval between FFT frames. The actual frame rate is dependent on the host computer and network capabilities and may be lower than the setup value.
Frames to Average	0 ...	0	If Mode=1 or Mode=2, number of FFT frames to calculate the continuous average over.

Table 14: FFT Parameters.

FFT transport parameters are configured via the general hardware configuration dialog or with command SYS_SET_CAP.

FFT Display

The middle section of the NC-Config user interface consists of an FFT display, which will be updated automatically if an FFT is being sent for the channel. The display will be scaled automatically around center frequency (f_c).

Context Menu

Right-clicking the FFT Display will show the display context menu (see Figure 43 below).

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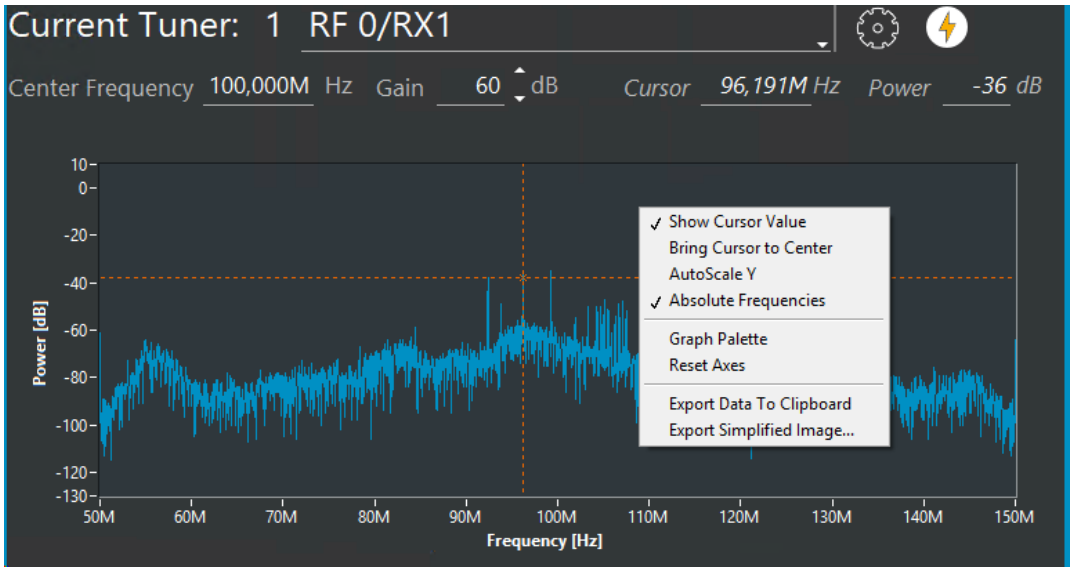

Figure 43: FFT Display Context Menu.

The menu options are:

Show Cursor Value ..... The current frequency and power on the cursor position will be shown above the FFT display.

Bring Cursor to Center ..... Bring the cursor to the middle of the display if it is no longer visible due to X axis being rescaled.

Auto Scale Y ..... Scale the Y axis to fit graph on the display

Absolute Frequencies ..... Instead of centering the FFT around 0 calculate the actual frequencies around f_c.

Graph Palette ..... Show the controls for zooming in and out and panning on the FFT display.

Zoom - click on the tool to open up a submenu with six tools (from left to right)

- Zoom area
- Zoom on x-axis
- Zoom on y-axis
- Restore full area
- Zoom in on mouse pointer while the left mouse key is down
- Zoom out on mouse pointer while the left mouse key is down

Use mouse pointer to move the cursors

Use mouse pointer to pan on the FFT area

Table 15: Graph Palette Controls.

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Reset Axes ..... Resets the axes to the full scale for example after zooming/panning.

Export Data To Clipboard ..... Copy the FFT data to clipboard for example for reporting or analyzing in a spreadsheet.

Export Simplified Image ..... Save the FFT data as a bitmap for example for reporting or analyzing in a spreadsheet.

8.5.4 Channel Configuration

The Channel List is populated automatically after NC-Config succeeds in connecting to the Server.

> *NOTE: Depending on the hardware the channel configuration may be of two kinds: VITA49 based or NCR Protocol based. VITA49 based hardware only supports IQ as channel demodulation, and has limited channel setting options. The settings not supported in the VITA49 based systems are marked with an asterisk *.*

Active	Tuner	Channel	Enabled	Coarse Gain	Fine Gain	Center Frequency	Bandwidth	Cha Filt	Multicast IP	Multicast UDP	Channel ID
☑	1	1	☑	6	2	122,450M	6k	1	234.5.6.10	58431	1
☑	1	2	☑	6	0	122,450M	6k	0	234.5.6.10	58431	0
☑	1	3	☐	6	0	110,000M	10k	0	234.5.6.10	58432	0
☑	1	4	☐	6	0	110,000M	10k	0	234.5.6.10	58432	0
☑	1	5	☑	6	0	118,100M	10k	0	234.5.6.10	58431	0
☑	1	6	☑	6	0	118,100M	10k	0	234.5.6.10	58431	0

Figure 44: Channel List.

The columns that are shown in the table is configurable, so the actual view may differ from the one in the figure. The visible channels can be configured using menu command File >> Channel View Configuration.

The channel settings are as follows:

General Channel Settings

Active ..... Selecting this checkbox will send a CH_ADD command to the server with the corresponding Multicast IP, Multicast UDP and Channel ID settings, and the channel is made active. If Enabled is checked, the channel will start to broadcast immediately. Deselecting the checkbox will send a CH_REMOVE command to the server.

Tuner ..... The tuner which is associated with the channel. The channel will only send data if its center frequency is within the band of its associated tuner.

Channel ..... The channel number - this value cannot be edited.

Enabled ..... Selecting this checkbox will start the channel streaming if the channel is active.

Coarse Gain ..... The digital gain in dB applied to the channel in the early stages of channelization. Only the following values are used: 0,6,12,18, 24,30, 36, and 42. No error is set if other values are

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used, but they will be rounded down to the nearest acceptable value.

Fine Gain ..... The digital gain in dB applied to the channel after channelization. Possible values are 0..102. To avoid overshoots and ripple effects there is a scaling of half magnitude (one bit). Configuring the gain to 6dB (in fine gain or coarse gain) will give the original signal amplitude.

Center Frequency ..... Channel center frequency in Hz. The value can be entered either as pure number, or number followed by the SI symbol, k/M/G for kilohertz/Megahertz/Gigahertz respectively.

Bandwidth ..... The desired channel bandwidth in Hz. This value can be entered either as pure number, or number followed by the SI symbol, k/M for kilohertz/Megahertz respectively.
For VITA49 based systems the *actual* channel bandwidth is the *closest possible bandwidth value,* and it will be equal or lower than the desired channel bandwidth. The value that is reported in the channel headers will be the actual bandwidth.

Squelch Settings*

Auto Squelch ..... Selected: Open channel if channel level is above the channel noise floor + the limit value in "Squelch Level"
Not selected: Close the channel if channel level is above the limit value in "Squelch Level"

Squelch Level ..... If automatic squelch is selected, how much the channel energy needs to be above the channel noise floor for the channel to open
If automatic squelch is not selected, how much the channel energy needs to be for the channel to open

Demodulation Settings*

Demodulation Type ..... 0 or IQ: Channel data is not demodulated
1 or AM: Channel data is AM-demodulated
2 or FM: Channel data is FM-demodulated
3 or LSB: Channel data is LSB-demodulated
4 or USB: Channel data is USB-demodulated

Downsample Rate ..... The downsampling ratio applied on the channel after demodulation. This field is filled in automatically if channel demodulation type or channel bandwidth is changed.

De-emphasis Filter ..... A low-pass filter that can be applied on FM-demodulated channels with 20k or 50k bandwidth prior to downsampling, to reduce the higher frequencies in a channel where pre-emphasis has been applied.

DC Block ..... A high-pass filter designed to reduce the effect of a DC-component on the demodulated channels. DC Block can only be turned on or off for FM-demodulated channels, DC Block is always on for AM and SSB (LSB and USB) channels and it is always off if channel demodulation type is IQ.

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AGC ..... Selected: Apply automatic gain controller on the demodulated signal. The output signal is limited by the Gain parameter. Not selected: Apply manual gain on the demodulated signal. The Gain parameter indicates the applied gain.

Gain ..... If AGC is selected, the upper limit for gain in the automatic gain controller algorithm. If AGC is not selected, the constant gain applied on the demodulated signal or if gain=0 no gain is applied.

Attack ..... Time within which the signal should be attenuated to the desired level when a strong signal is received.

Decay ..... Time within which the signal should be amplified to the desired level when a weak signal is received.

IQ Filter ..... A filter applied on the signal prior to demodulation. Usually a system-defined filter that will anti-alias filter the signal for the desired bandwidth

Sound Filter1 ..... A filter applied on the signal after demodulation but before downsampling.

Channel Streaming Settings

Multicast IP ..... IP number to broadcast channel stream to.

Multicast UDP ..... Port number to broadcast channel stream to.

Channel ID ..... Channel identification number.

* Configuration item is not available for VITA49 protocol based hardware.

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NC-Channel User Manual

9 NC-Channel User Manual

NC-Channel is a software tool for viewing channels that have been broadcast by NC-Server. It can be run independently as a client application, either in the same computer as the server application, or in another computer that is connected to the server system via an Ethernet connection. Alternatively, it can be run as an embedded soft front panel within NC-Server itself.

NC-Channel as a Soft Front Panel

To run NC-Channel as a Soft Front Panel within NC-Server, you will need to enable the corresponding setting in Server and restart. Even when NC-Channel is run as a part of the server application, it will communicate with the server via the same network commands as the standalone client application would. Therefore NC-Channel soft front panel can be used as a first debugging step when resolving issues with a remote client.

9.1 Installing NC-Channel

The steps to install NC-Channel are:

1. Installing NC-Channel software package
2. Configuring the IP addresses
3. Testing client operation

> *NOTE: It is not necessary to install NC-Channel in the host computer, since NC-Server already contains the same functionality.*

Before proceeding with the client install, make sure that a server is already installed and configured. Refer to Server user manual for details.

Install NC-Channel

The installer can be downloaded from https://novatorsolutions.com/spectral-data-analysis/nc10gettingstarted. Extract the zipfile and start setup.exe. You must be able to provide Administrator access to the operating system to install the software.

The program will initialize with the screen resembling figure 45. The screenshots are from a Windows 10 installation. Windows 7 and 8 are also supported, but the dialogs may look slightly different.

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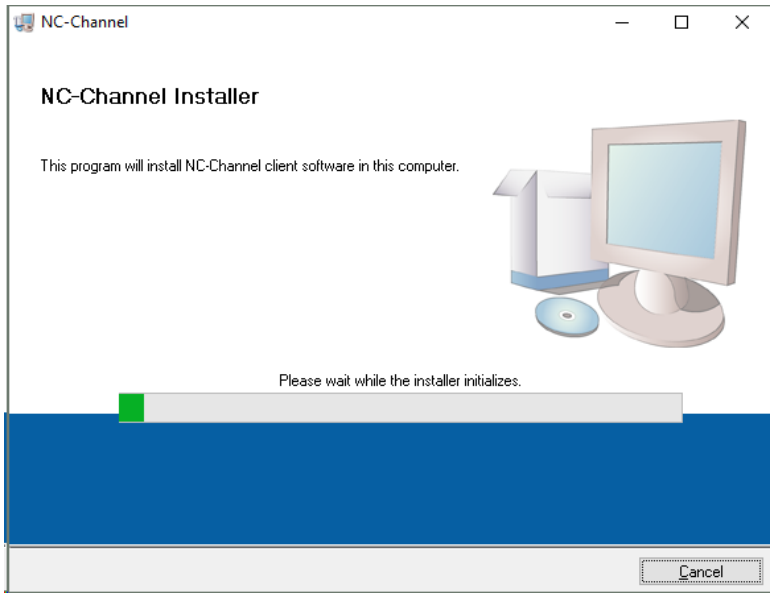

Figure 45: NC-Channel Installer Initializing.

The software suggests destination directories, %ProgramFiles(x86)%\Novator Solutions\\NC-Channel\ for NC-Channel, and C:\Program Files (x86)\National Instruments for the National Instruments drivers. Accept the suggested values by clicking Next.

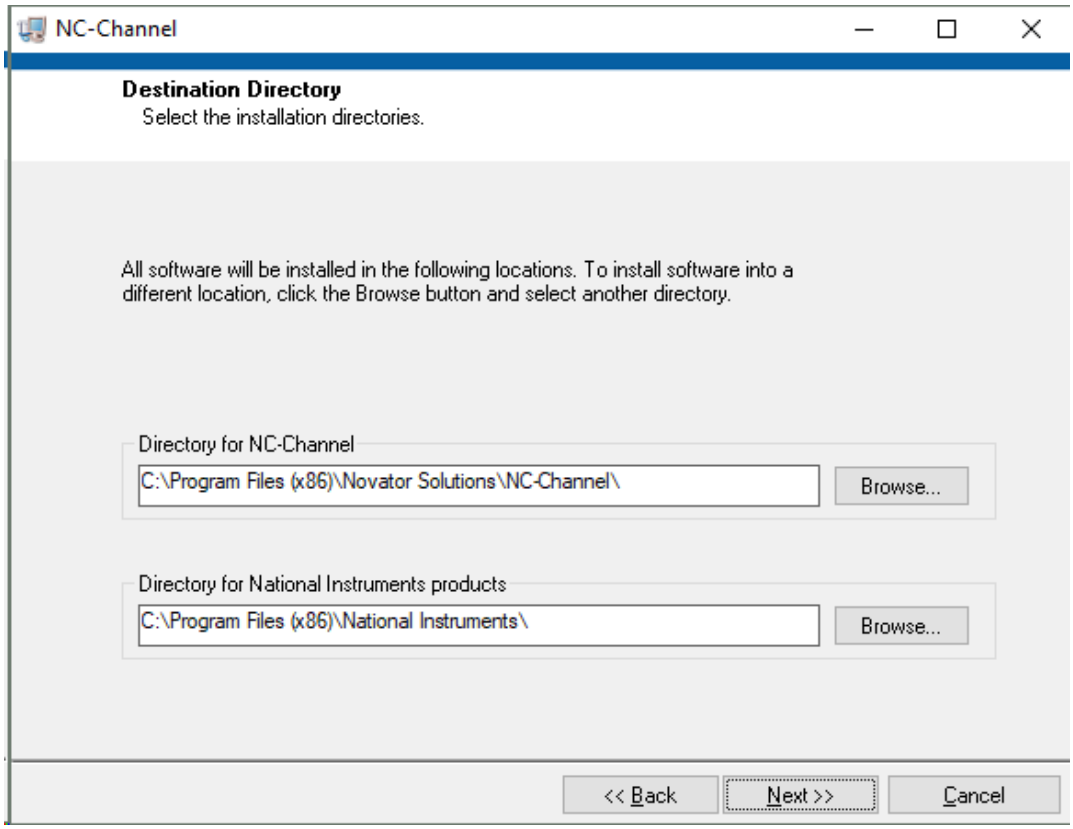

Figure 46: Installation Directories.

If your operating system is Windows 8 or Windows 10, the installer will suggest that you disable the fast startup feature. There is no need to disable it, if your only National Instruments

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hardware is the USRP unit and you are connecting to it only via the Ethernet. If this is the case, deselect the checkbox and press Next. More information can be found on National Instruments website, http://ni.com/info, enter code **winfaststartup**.

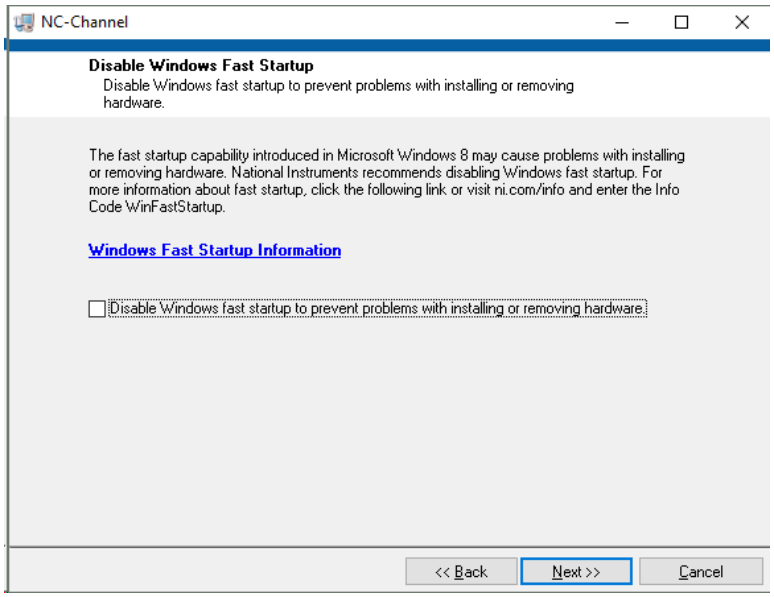

Figure 47: Note on Windows Fast Startup.

As the final step a list of changes and additions are shown in a summary screen (Figure 48). The contents may differ from the one shown here depending on what needs to be updated. NC-Config installation will begin after you click Next.

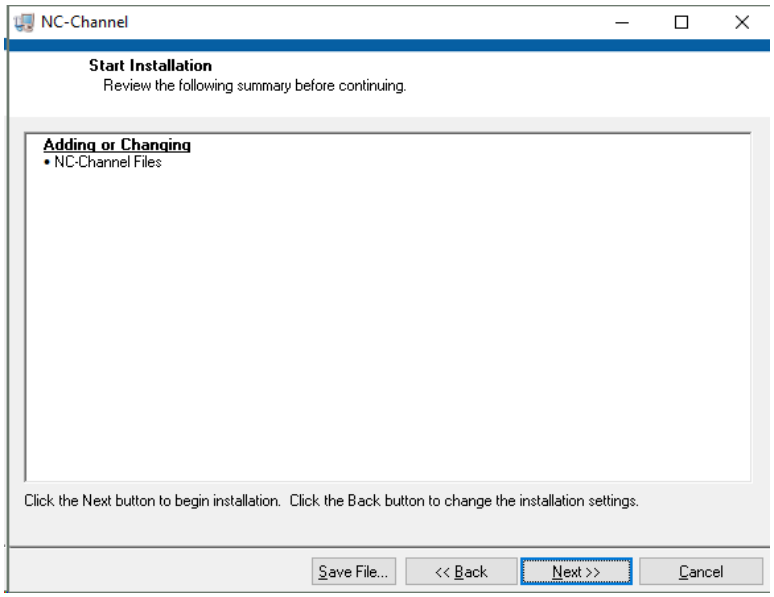

Figure 48: Installation Summary.

The installation takes a few minutes after which a confirmation screen is shown. Restart the computer if requested.

Configure the IP Addresses

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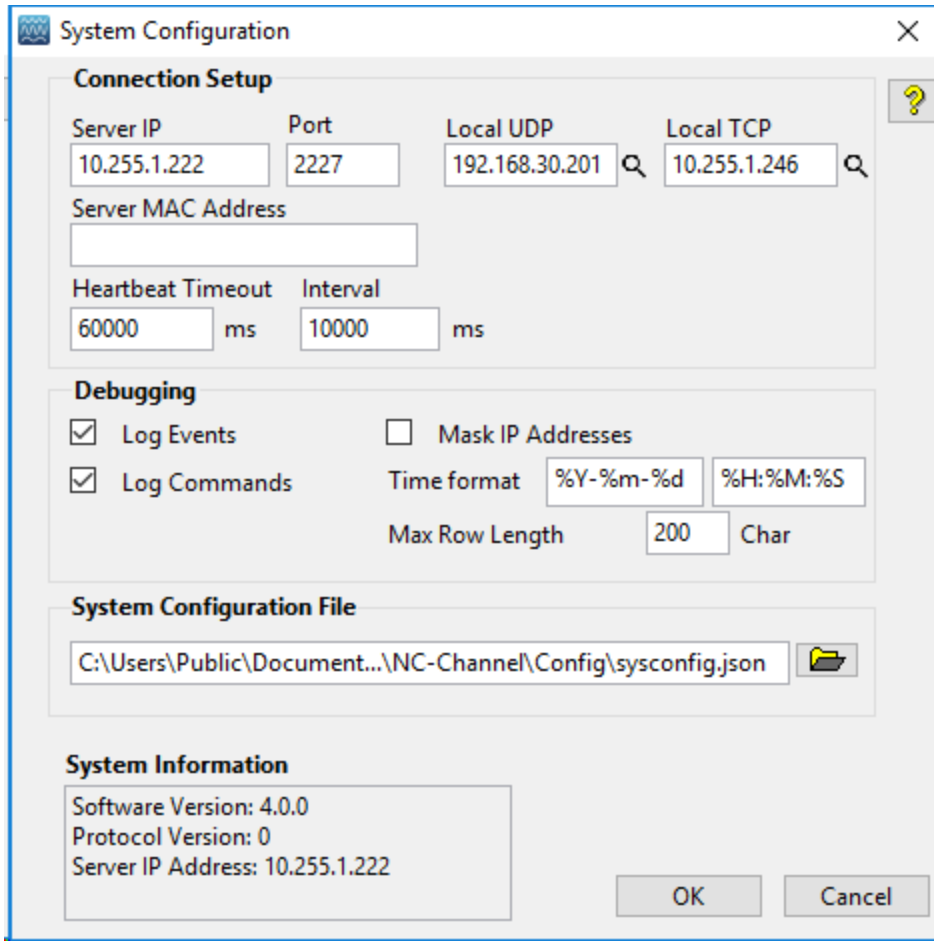
Start NC-Channel. To begin communicating with Server running in a Host computer you will have to configure its network address. Select the menu command **File >> System Configuration**. Fill in the *Server IP* and *Port* fields under **Connection Setup**.

Fill in the *Local TCP* field with the IP address of the client computer (this computer). If the client computer has multiple Ethernet adapters, *Local TCP* must indicate the IP address of the adapter that will communicate with the server (as opposed to receiving channel UDP data), see figure 49. More information on the system configuration parameters can be found in the general user instructions section.



Restart NC-Channel if you have done changes in the system configuration.

Test Client Operation

Make sure the Server is running in the host computer. Start NC-Channel if it is not already running. The Server log should show in the Event Log that a client has made a connection (see Figure 49 below).

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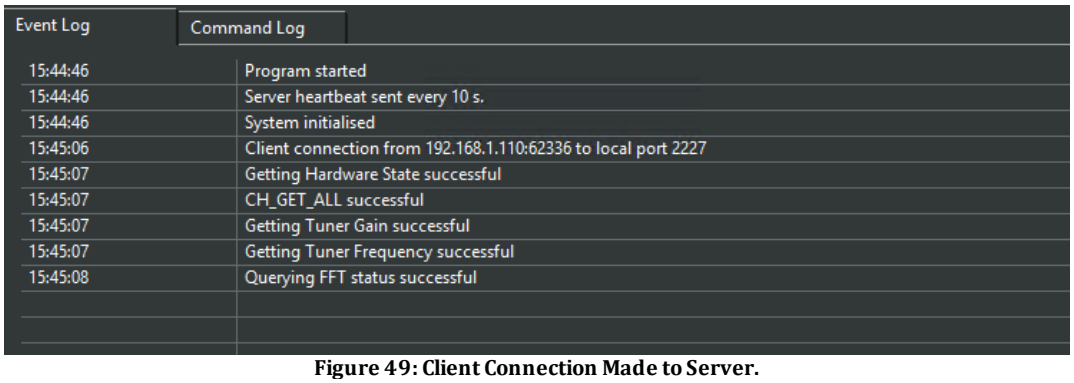

Figure 49: Client Connection Made to Server.

9.2 File Menu

File Menu contains commands for system configuration and logging.

9.2.1 System Configuration

This command is under "File" menu.

The system configuration dialog (see Figure 50 below) is used for setting up the general server parameters, which are explained here. Changing system parameters requires that NC-Channel is restarted. The configuration entered here is saved in the file indicated by the "System Configuration File" setting. If the file is deleted, a new configuration file is created with default settings.

NOTE: Program restart is required for the changes to take effect.

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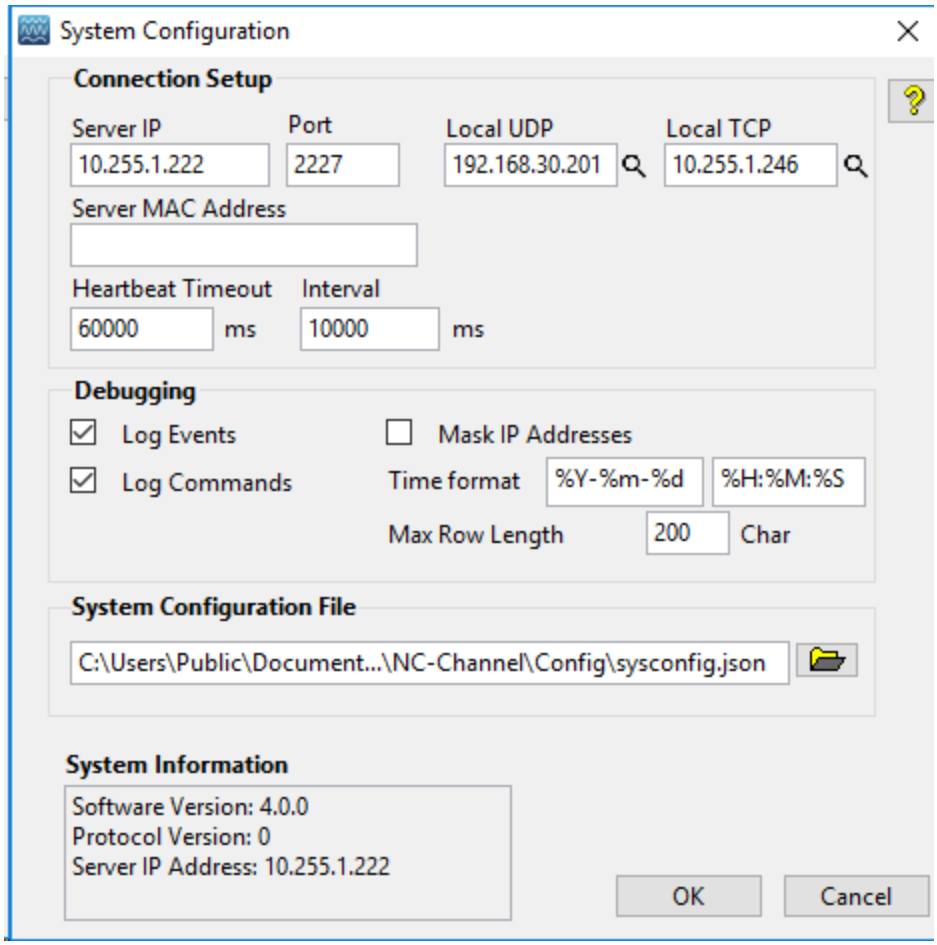

Figure 50: NC-Channel System Configuration.

Connection Setup

Parameter	Default Value	Notes
Server IP	localhost	The IP address of the server. It is also possible to have the server running in the same computer with NC-Channel.
Port	2227	The port NC-Server has been configured to listen to for incoming TCP/IP connections.
Local TCP		The IP address of the Ethernet adapter in this local computer, that has a connection to the host Ethernet adapter sending and receiving commands.
Local UDP		The IP address of the Ethernet adapter in this local computer, that has a connection to the host Ethernet adapter sending channel data.
Heartbeat Timeout	60000 (ms)	If no communication takes place from the server within this time, NC-Channel considers the connection closed. See also Heartbeat in Communications Manual.

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Heartbeat Interval	10000 (ms)	The time interval for the client to send a heartbeat token to Server to keep the connection up.

Debugging

Parameter	Default Value	Notes
Log Events	Checked	If checked, a log of the system events are saved as a text file in C:\Users\Public\Documents\Novator Solutions\NC-Channel\Log\<Date>_NC-events.txt, where <Date> is today's date. A new file is started for each calendar day. Please note that the log files are not cleaned up automatically.
Log Commands	Checked	If checked, a log of the commands from the clients and server responses are saved as a text file in C:\Users\Public\Documents\Novator Solutions\NC-Channel\Log\<Date>_NC-commands.txt. A new file started for each calendar day. Please note that the log files are not cleaned up automatically.
Mask IP Addresses	Not Checked	If checked, the log files will be written with the IP address numbers replaced with asterisks (***) for reasons of secrecy.
Time Format	%Y-%m-%d %H:%M:%S	Description of how the system date and time should be formatted in the log file names. See time formats for information on the formatting strings available.
Max Row Length	200	If greater or equal to 0, the length of the commands is restricted to a number of characters so as to keep individual command lines more readable and the log files reasonably short. If Max Row Length is -1, the lines are not truncated.

NOTE: Event and Command logging may slow down the system performance slightly so they should not be used in production.

NOTE: Channel configuration commands are long. If no concatenation is used (Max Row Length = -1) the log files will become large and opening them with Notepad.exe will be slow.

System Configuration File

Parameter	Default Value	Notes
System Configuration File	C:\Users\Public\Documents\Novator Solutions\NC-Channel\Config\sysconfig.json	Contains the settings of this configuration dialog. If the file is deleted from the location

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		indicated here, a new system file is created with default settings when the program is restarted.

System Information

Information on the server network communication parameters as well as software and protocol versions.

9.2.2 Event Log

This command is under "File" menu.

Shows the current day's system log file in the text editor that is configured in the operating system to manage .txt files (typically Notepad.exe). The log files are saved in the Public Documents folder, subfolder "Novator Solutions\NCChannel\Log\". The log will only be updated if Log Events is selected.

> *NOTE: A new log file will be started every day. Old log files will not be deleted automatically.*

More information on the Event Log

Events are saved with a timestamp in the user defined format. The event log messages can be of five different types, the types are colour-coded in the log window. The message type is included as a tag in the message as well, see table 16 below.

Type	Text colour	Tag	Comments
General event	Black	-	Normal program execution step
Alert	Gray	Alert:	Exception in the program execution. Does not require corrective actions.
Warning	Blue	Warning:	Exception that does not prevent program execution. May indicate an invalid setting from a connected client, in which case the response status will be NOK.
General Error	Magenta	General Error:	Exception in the program execution, the program will unload the hardware drivers and go to Setup Mode.
Fatal Error	Red	Fatal Error:	Exception in the program execution, the program will be stopped.

Table 16: Error Levels.

Event Log will be updated only if Log Events setting is selected. However, error messages will be shown in all cases.

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9.2.3 Command Log

This command is under "File" menu.

Shows the current day's TCP traffic log file in the text editor that is configured to manage .txt files. The log files are saved in the Public Documents folder, subfolder "Novator Solutions\NCChannel\Log\". The log will only be updated if Track Commands is selected.

> *NOTE: A new log file will be started every day after the first command has been sent or received. Old log files will not be deleted automatically.*

More Information on Command Log

All commands received from the client systems will be entered in the Command Log, as well as the NC-Server responses, timestamped in the user defined format, excluding heartbeat messages. The client commands contain also the IP address and Port of the client that has sent the command.

9.2.4 Exit

This command is under "File" menu. The command shortcut key is <CTRL>+Q.

Exits the application, closing the hardware and communication processes.

9.3 Help Menu

Help>>About... opens up a dialog with information on the current program version.

Help>>User Manual provides access to this help document.

9.4 User Interface

When NC-Channel is started, the program will attempt to make a connection with the configured server. After a successful connection is made, NC-Channel will request the channel configuration from the server. If successful, the channel list is updated, and the user interface will look approximately as in figure 51. The different sections are explained below.

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Figure 51: NC-Channel user interface sections.

Channel Selectors

It is possible to plot the spectrum of up to five channels simultaneously. The channel with the highest output rate will determine the range of the X axis. Enter the channel number in the channel selectors table, check the "Read" column to start plotting the spectrum (figure 52).

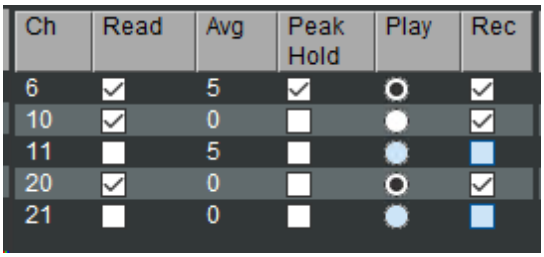

Figure 52: Channel Selectors.

Ch ..... Number of channel to plot / play back / record

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Read ..... Check to plot the channel. Data will be plotted only when the channel is not squelched.

Avg ..... Number of FFT frames to average over

Peak Hold ..... Check to select Peak Hold view of the spectrum

Play ..... Select for playback. Up to two channels can be selected. The channel number must be set and Read column must be checked for this selection to be enabled.

Rec ..... Select for recording. The channel number must be set and Read column must be checked for this selection to be enabled.

In figure 52 above, channels 6, 10, and 20 are selected for plotting.

Channel Header Data

When a channel is selected for reading, a data connection is created using the channel multicast IP and Port settings as defined in the channel configuration. Channel data is filtered to show only the data from the requested channel. However, packet header data are read for all channels that are configured with the same multicast IP and Port, and their headers are shown in the Channel Header Data table, regardless if they are selected to be read or not.

Ch	Read	Avg	Peak Hold	Play	Rec	Squelch	Sequence	Time	Level [dBFS]	Frequency [Hz]	BW [Hz]	DM	DS Rate	ID
6	☑	5	☑	○	☑	TRUE	16379	1124691531512	-74.993164	131.250M	6k	AM	8000	5
10	☑	0	☐	●	☑	FALSE	16379	1124691531512	-72.924805	122.450M	6k	AM	8000	9
11	☐	5	☐	●	☐	TRUE	16379	1124691531512	-75.016602	121.600M	6k	AM	8000	10
20	☑	0	☐	○	☑	TRUE	16379	1124691531512	-60.079102	118.500M	6k	AM	8000	19
21	☐	0	☐	●	☐	TRUE	16379	1124691531512	-75.630859	125.125M	6k	AM	8000	20

Figure 53: Channel Header Data Table.

The following channel header items are shown in table 17 below.

Name	Header field name	Comment
Squelch	Sq	True if data is squelched. Squelched channel contains only of a header packet, with no data packet, so nothing is shown in the FFT Display.
Sequence	Sequence	Sequential incrementing number for each packet, started when the USRP is powered on.
Time	TS	Nanoseconds since GPS lock or system time when going into hardware execution mode or CHZ_SET_GPSREFRESH command is sent.
Level	Level	Power level of packet in dBFS (full-scale).
Frequency	Fq	Channel center frequency in Hz
Bandwidth	Bw	Channel bandwidth
DM	Dm	Demodulation type for channel (IQ/AM/FM/LSB/USB)
DS Rate	Rate	Output rate for channel data in packet

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ID	Id	Channel identification number

Table 17: Channel Header Data Fields

Playback, Recording and Display Controls

Figure 54: Playback, Recording and Display Controls.

Playback

When the system is in hardware execution mode, it is possible to play back one or two channels via the local system loudspeakers. Select a channel to play, then click the button to start playback, click the same button again to stop playback. The playback volume can be adjusted using the slider.

Record

In hardware execution mode, it is also possible to record any of the displayed channels by clicking the REC button. Once the recording is completed, press the REC button again, and enter the folder where the recorded files are to be saved. The recordings are named in the following way: Ch_x_timestamp.wav, where x is the channel number.

NOTE: No data is saved if a channel is squelched.

During recording the data is saved in a temporary file called "ncrtemp.bin", located in the user's temporary file folder, for example "C:\Users\Operator\AppData\Local\Temp\", and renamed when the recording is completed. The recorder saves all data that comes from the selected channels, and sorts the data afterwards using the header information, so in principle it is possible to change the channel numbers and record selections while recording is going on.

FFT Size

FFT size selector can be used to adjust the frequency resolution of the spectra. One setting is applied to all channel spectra. Default value is 64 points and the value is reset when the program is started.

Bar Plots

Instead of the default chart display style it is possible to show the spectra in bars where each bar corresponds to one frequency bin. The setting is reset when the program is started. For clarity, the bar plots use a different color scheme than the default line graphs.

FFT Display with Chart Legend

The middle section of the NC-Channel user interface consists of an FFT display, which will be updated automatically when the user has enabled plot for one or more active and enabled

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channels. If the channels are demodulated, the frequency scale is 0…fs/2, where fs=channel output rate. For IQ channels the data is shown around channel center frequency ±BW/2, where BW=channel bandwidth. The display will be scaled automatically for the widest bandwidth channel.

Channel List

The channel list is populated at program startup and also whenever changes are made to channel configurations by NC-Config or other clients. It is not possible to make changes in the channel configuration in NC-Channel though. To hide the channel list drag the title bar down. To open the channel list double-click on the title bar.

Status

The status line shows recent system messages, such as connecting to server.

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Server Interface Control Manual

10 Server Interface Control Manual

This manual explains the communication strategy in an NC-Server system. The two parties in the communication system are the server and one or several clients. The server and the client can reside in the same computer or in two networked computers, but in order to maximize performance it is recommended that in production the client applications are not run in the same computer as the server. In both cases access to network is required, and use of "localhost" as a server address is not supported. All communication between the server and client takes place using TCP/IP protocol.

10.1 Introduction

The client interfaces to the host with text commands that are transferred over TCP/IP. The commands must be pure ASCII strings, coded according to the JSON standard. All commands are to be concluded with carriage return (ASCII 13) and line feed (ASCII 10) characters.

Two main communication types exist:

1. **Command + Response**: Commands initiated by the Client, to which the Server will respond. These are commands for accessing a server parameter, setting a server parameter or starting an action.

2. **Broadcast**: Both the server and the client will automatically broadcast a heartbeat signal (SYS_HB) at a set time interval to indicate that the link is alive between the two parties. The heartbeat signal sent by the server contains information of possible system failures in its STATUS field. Additionally, the server will broadcast tuner status if it changes, for example due to errors.

Command Coding

All supported commands and data types are listed in the system syntax file which is read at system startup by NC-Server, NC-Config and NC-Channel. The information in the file is used for parsing the commands and responses. All parameters in the protocol are mandatory, and they must be entered in the order indicated by the syntax file.

For clarity, the commands in the syntax file are described as pseudo-C commands, not as JSON strings. For example, a command “Get channel bandwidth” is described as CH_GET_BW(uint CID,uchar CHZ,ushort CH). In JSON coding the command would be {"CMD":"CH_GET_BW","CID":12345,"CHZ":1,"CH":1} for channelizer 1, channel 1, when CID = 12345.

Command Structure

The commands contain the following fields:

CMD	Command function name. This is an obligatory field in all commands.
CID	Command Identification. Not all commands use a command identification number.
TN/CHZ	Hardware unit number. These numbers are 1-based, that is, the first tuner and channelizer in the hardware configuration is number 1, the second, if applicable, is number 2. Not all commands use a hardware unit number.

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CH	Channel number. The channel numbers are 1-based, that is, the first channel is 1, the last is 256. Not all commands use a channel number

Additionally, commands contain fields for parameters the values of which they change. For example, command CH_SET_FQ is used to change the center frequency. Changing the frequency for channel 2 in channelizer 1 to 120MHz would be coded as:
{"CMD":"CH_SET_FQ","CHZ":1,"CH":2,"FQ":120000000}

Response Structure

The responses contain the following fields:

CMD	Response function name. This is an obligatory field in all responses.
CID	Command Identification. If a command used a CID, the response will contain the same number, unless the response is a multi-cast response.
TN/CHZ	Hardware unit number. If the command contained a hardware unit number, the response will also have it.
CH	Channel number. If the command contained a channel number, the response will also have it.
STATUS	Outcome of the command - success or failure. See Common parameters for more information.

Additionally, the response will contain values for the set or requested parameters. For example, the response to the above command, confirming that the center frequency of channel 2 in channelizer 1 has been set to 120MHz would be:
`{"CMD":"CH_FQ","CHZ":1,"CH":2,"FQ":120000000,"STATUS":`
`{"NUM":0,"MSG":""}}.`
If the client had attempted to set the channel frequency to an illegal value, the server would set the status number to 1, the frequency would not be changed, and the response would contain the original value:
`{"CMD":"CH_FQ","CHZ":1,"CH":2,"FQ":120000000,"STATUS":`
`{"NUM":1,"MSG":"An error has occurred., Code: 403208, Source: The requested channel center frequency is not within +-f_in/2."}}`

> *NOTE: The command strings and parameters are case-insensitive, except for the Boolean values true and false, which must be in all-lowercase.*

10.2 NC Channel Data Protocol

Currently there are two possible channel data output formats, NCR and VITA49 protocols. The server and client applications request the channel data format at startup, and the columns that are shown in the channel view are updated accordingly. Your client application can request the channel data output protocol with command SYS_GET_CHDP.

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NOTE: The choice of channel data protocol is coded in the FPGA bitfile that is downloaded to the USRP unit. Contact Novator Solutions if you wish to change the protocol.

10.2.1 NCR Protocol

The NCR channel protocol data consist of 48 bytes header, which is followed by 1280 bytes of channel data, or 0 bytes if channel is squelched. Tables 18 and 18 list the channel output packet formats.

Name	LSB	MSB	Data type	Full name	Comment
TS	0	63	ulong	Timestamp	Nanoseconds since GPS lock or system time when going into hardware execution mode or CHZ_SET_GPSREFRESH command is sent.
Id	64	95	uint	ID	Channel identification number
Ch	96	111	ushort	Channel	Sequential channel number 0..255
Dm	112	127	ushort	Demodulation type	Demodulation type (0-4), IQ (none), AM, FM, LSB, USB
Fq	128	191	uint	Frequency	Absolute center frequency of channel
Bw	192	223	uint	Bandwidth	Bandwidth of the active channel
Sq	224	255	bool	Squelch	Bit 224 low: data packet not squelched
Level	256	287	uint	Power level	Power level of packet
Rate	288	319	uint	Output rate	Output rate of packet
Type	320	335	ushort	Data type	Data type (0-14), N/A, bool, uchar, char, ushort, short, uint, int, float, double, ulong, long, string, array, struct
Length	336	351	ushort	Packet length	Length of the packets in bytes
Sequence	352	383	uint	Sequence number	Sequential incrementing number for each packet
	384				First Channel Data Sample
		10623			Last Channel Data Sample

Table 18: Channel Output Packet Format, Sq=false

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Name	LSB	MSB	Data type	Full name	Comment
TS	0	63	ulong	Timestamp	Nanoseconds since GPS lock or system time when going into hardware execution mode or CHZ_SET_GPSREFRESH command is sent.
Id	64	95	uint	ID	User specific value for the active channel
Ch	96	111	ushort	Channel	Sequential channel number 0..255
Dm	112	127	ushort	Demodulation type	Demodulation type (0-4), IQ (none), AM, FM, LSB, USB
Fq	128	191	uint	Frequency	Absolute center frequency of channel
Bw	192	223	uint	Bandwidth	Bandwidth of the active channel
Sq	224	255	bool	Squelch	Bit 224 low: data packet is squelched
Level	256	287	uint	Power level	Power level of packet
Rate	288	319	uint	Output rate	Output rate of packet
Type	320	335	ushort	Data type	Data type (0-14), N/A, bool, uchar, char, ushort, short, uint, int, float, double, ulong, long, string, array, struct
Length	336	351	ushort	Packet length	Length of the packets in bytes
Sequence	352	383	uint	Sequence number	Sequential incrementing number for each packet

Table 19: Channel Output Packet Format, Sq=true

NOTE: TS, time stamp, is converted from picoseconds, but due to FPGA resources optimization a division with 1024 is used. For a more precise value multiply the output timestamp with 1024 and divide with 1000 (use a large data type).

10.2.2 VITA 49 Protocol

VITA49 is a packet based protocol used commonly in Software Defined Radio applications to send digitized signal data and metadata (or context data). In NC-10 for USRP, VITA49 is used for RF data output, (referred to as IF data below).

> *NOTE: It is not possible to access the RF data when running NC-Server, which requires sole access to the RF data stream. The information below applies only to programs using NC-10 API. It is of course possible to monitor the RF data with network monitoring tools such as Wireframe, for example when verifying that the system works as expected.*

VITA49 outputs packets in such a way that first a Context Packet is sent and then IF data packet after that, see Figure 55 below. This pattern is then continuously repeated. The context packet is

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106 bytes and the IF data packet is 8258 bytes, both including all layers (Link, Internet, Transport, Application).

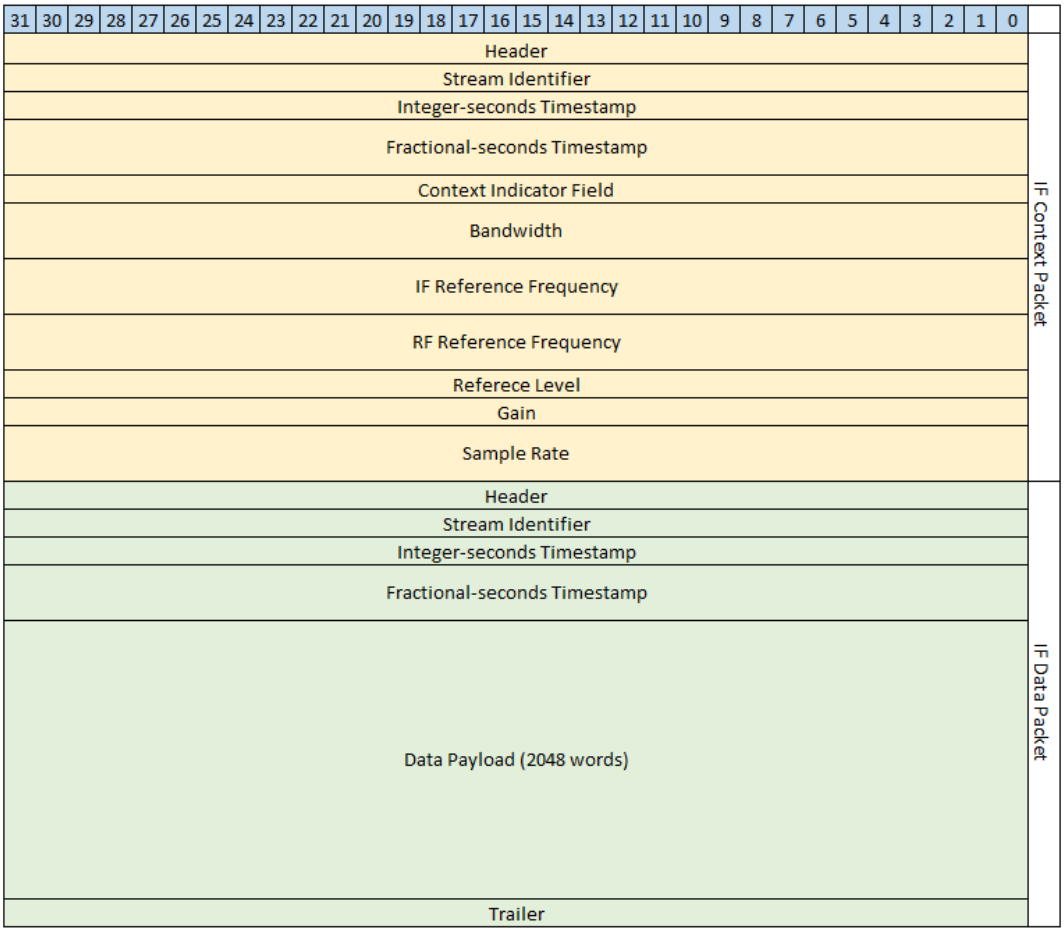

Figure 55: IF Packets.

10.2.2.1 IF Context Packet

IF Context Packet is shown in table 56 below.

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31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Header (Mandatory)																															
Stream Identifier (Mandatory)																															
Class Identifier																															
Integer-seconds Timestamp																															
Fractional-seconds Timestamp																															
Context Section (Variable, Mandatory)																															

Figure 56: VITA49 Context Packet.

Header

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Packet Type				C	Rsv		TM	TSI		TSF		Packet Count				Packet Size															

Packet Type is 4 (0100) for IF Context Packet.

Class Identifier is false (0) and not included in the IF context packet.

Bits 26 and 25 are reserved.

Timestamp Mode is false (0).

Timestamp-Integer is 3 (11) for “Other” time.

Timestamp-fractional is 2 (10) for “Real Time (picoseconds) Timestamp”.

Packet count is not used in IF context packet and will be constant 0.

Packet size is 14 (14x32bit words).

Stream Identifier

RF tuner ID.

Class Identifier

Class identifier is not used since it is disabled in the header.

Timestamp Integer

This is a time in seconds since GPS module locked to GPS signal or since computer time was written by server.

Timestamp Fractional

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This is a fractional seconds counter which will reset when Timestamp Integer changes seconds value.

Context Section

The last section of a context packet is the context section.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Context Indicator Field																															
Context Fields (Present as indicated by the Context Indicators)																															

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Bit Position	Context Indicator Field	Number of words
31	Context Field Change Indicator	0
30	Reference Point Identifier	1
29	Bandwidth	2
28	IF Reference Frequency	2
27	RF Reference Frequency	2
26	RF Reference Frequency Offset	2
25	IF Band Offset	2
24	Reference Level	1
23	Gain	1
22	Over-range Count	1
21	Sample Rate	2
20	Timestamp Adjustment	2
19	Timestamp Calibration Time	1
18	Temperature	1
17	Device Identifier	2
16	State and Event Indicators	1
15	Data Packet Payload Format	2
14	Formatted GPS Geolocation	11
13	Formatted INS Geolocation	11
12	ECEF Ephemeris	13
11	Relative Ephemeris	13
10	Ephemeris Reference Identifier	1
9	GPS ASCII	Variable
8	Context Association Lists	Variable
7	Reserved	
6		
5		
4		
3		
2		
1		
0		

The enabled context indicators are

- 29, Bandwidth
- 28, IF Reference Frequency
- 27, RF Reference Frequency
- 24, Reference Level
- 23, Gain
- 21, Sample Rate

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31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	1	1	0	0	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Bandwidth																															
IF Reference Frequency																															
RF Reference Frequency																															
Referece Level																															
Gain																															
Sample Rate																															

The size of the context section is 11x32bit words.

10.2.2.2 IF Data Packet

IF Data Packet format is shown in table 57 below.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Header (Mandatory)																															
Stream Identifier																															
Class Identifier																															
Integer-seconds Timestamp																															
Fractional-seconds Timestamp																															
Data Payload (Variable, Mandatory)																															
Trailer																															

Figure 57: VITA49 Data Packet.

Header

IF data packet header is the same as the header of the IF context packet except for the omission Timestamp Mode bit and the addition of the Trailer bit.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Packet Type				C	T	Rsv		TSI		TSF		Packet Count				Packet Size															

Packet Type is 1 (0001) for IF Data Packet with Stream Identifier.

Class Identifier is false (0) and not included in the IF data packet.

Trailer is true (1).

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Bits 25 and 24 are reserved.

Timestamp-Integer is 3 (11) for “Other” time.

Timestamp-fractional is 2 (10) for “Real Time (picoseconds) Timestamp”.

Packet count contains a modulo-16 count of IF data packets.

Packet size is 2054 (2054x32bit words).

Stream Identifier

Stream identifier is used as RF tuner id.

Class Identifier

Class identifier is not used since it is disabled in the header.

Timestamp Integer

This is a time in seconds since GPS module locked to GPS signal or since computer time was written by server.

Timestamp Fractional

This is a fractional seconds counter which will reset when Timestamp Integer changes seconds value.

Data Payload

Data Payload is always 8192 bytes (2048x32bit words).

Trailer

Trailer is enabled in the header. The trailer contains fields that indicate the validity of the data. The enabled bits are

- 31, Calibrated Time
- 30, Valid Data

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Enable Bit	Indicator Bit	Indicator Name
31	19	Calibrated Time
30	18	Valid Data
29	17	Reference Lock
28	16	AGC/MGC
27	15	Detected Signal
26	14	Spectral Inversion
25	13	Over-range
24	12	Sample Loss
23	11	User-Defined 0
22	10	User-Defined 1
21	9	User-Defined 2
20	8	User-Defined 3

Calibrated Time

The Calibrated Time Indicator, when set to one, indicates that the Timestamp in the IF Data packet is calibrated to some external reference. When set to zero it indicates that the Timestamp is free running and may be inaccurate.

Valid Data

The Valid Data Indicator, when set to one, indicates that the Data in the packet is valid. When set to zero it indicates that some condition exists that may invalidate the Data. The meaning of Valid Data Indicator is application dependent. When used in the output of an RF tuner, for example, it indicates that the Data in the packet is invalid during frequency changes.

10.3 Syntax File

The Syntax File is a text file that describes the currently used communication protocol between the instrument and the controller. It is important that the same version is used, so that the commands and responses are parsed in a correct way. The syntax file is read by NC-Server at program start-up. The file is located in "%ProgramFiles(x86)%\Novator Solutions\NC-Server\data\syntax.txt".

The first line in the syntax file must include a comment on the file version:

```
%%ver1
```

Lines that begin with %% are normally treated as comment lines this being the only exception.

All lines that are not comments are treated as **command descriptions** and they must adhere to this syntax:

1. Each line must have 5 fields, separated by a semi-colon, closed by a linebreak
2. The fields must always be entered in the same order, which is:
   a. Command
   b. Target System
   c. Multicast
   d. Response
   e. Comment

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3. A field can be left empty
4. If a command is defined multiple times only the first occurrence in the file is used. However, commands with and without the "Response" command string are treated as separate, for example CH_ADD can be sent as a command and as a server response.

10.3.1 Command

Commands are sent by the client applications to the server to

1. **Get** data values
2. **Set** data values

The server replies to both command types with a string indicating success or failure:

Success	The set/current data value(s) is returned and the STATUS parameter is set to 0 (OK). This is the usual response to all Get commands, and to Set commands if the set data value is applied by the server.
Failure	The set data value is not accepted, the original data value(s) is returned instead and the STATUS parameter is set to 1 (NOK). The MSG parameter contains information on the cause of the failure.

Command Structure

The command field in the syntax file is described as follows:

```
COMMAND(vartype1 VARNAME1, vartype VARNAME2,...)
```

This would be coded in JSON as follows:

```
{"CMD":"COMMAND","VARNAME1":val1,"VARNAME2":val 2, ... }
```

Variable types are read from the syntax file during program execution, and the values (val1, val2) are expected to match the required data type in the JSON string.

10.3.2 Target System

The target system field in the syntax file indicates which hardware unit is the recipient of the command. Currently there are three target systems that are recognized:

- System
- Tuner - there are four tuners (antenna contacts) in each USRP system
- Channelizer - there is one channelizer in each USRP system

The target system field is only read by the server application, the client applications do not use this field information in any way.

10.3.3 Multicast

This field is relevant only when the command is a "Set Data Value" command. It has two possible values, **empty string** or **M**. If the value is M, the response is considered to be a multicast response and it is sent to all connected controllers rather than just to the one sending

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the actual command. Commands that receive a multicast response are changes in hardware configuration and system status, for example power-down, which affect all connected clients.

10.3.4 Response

The response column in the syntax file indicates what the server will send as a reply when the command is issued by a client. For example the line

```
TN_SET_FQ(uint CID,uchar TN,long FQ);Tuner;M;TN_FQ
```

Indicates that when the client has sent a command "TN_SET_FQ" the server will reply with a "TN_FQ" command. The syntax file will contain a separate entry for the structure of this reply. Usually the same reply is given to both SET and GET commands, so for example "TN_GET_FQ" will also receive a "TN_FQ" reply.

It is possible also that the response is the same as the command, for example the server shutdown procedure is initiated from the clients with:

```
SYS_POFF(uint CID, bool STOP);System;M;SYS_POFF
```

The client's "SYS_POFF" will receive a confirmation "SYS_POFF" from the server. The server response has the same syntax as the command, but it is not a requirement. The server response syntax is described in the last section of the syntax.txt file.

10.3.5 Comment

The last field in a command description line is considered a comment. Currently this is for reference only and it is not used by the system itself.

10.4 Commands and Responses

Strings sent from the client application to the server are called **commands**. The server will reply to a command with a **response** message. The server does not send commands, and clients are not expected to send responses. Additionally**,** both clients and the server can send **status messages** that do not require a response, such as the heartbeat message.

The commands and responses are listed in the protocol file called syntax.txt, which is stored in %ProgramFiles(x86)%\Novator Solutions\NC-Server\data.

10.4.1 Data Types

The syntax file defines the data types for each command parameter. It is important that the client applications control the sanity of the parameter data before sending, so that the JSON strings do not attempt to write data values outside of range of the respective parameter. For some parameters even narrower limits are defined, and these additional constraints are described in the tables below. Furthermore, some parameter values are hardware dependent - these values are described in the Hardware Settings section of the User Manual.

> *NOTE: If a command is sent with a parameter value outside of its defined data range, the command outcome is unpredictable. The server will not necessarily send a NOK in the status response.*

The scalar variable types defined in the protocol are listed in table 20:

Name	Definition	Data Range (limits included)

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bool	1 bit	true, false
char	8-bit signed integer	-128 … 127
double	double-precision (64-bit) floating point number	-1.79e308 … -4.94e-324 and 4.94e-324 … 1.79e308
float	single-precision (32-bit) floating point number	-3.40e38 … -1.4e-45 and 1.4e-45 … 3.4e38
int	32-bit signed integer	–2,147,483,648 … 2,147,483,647
long	64-bit signed integer	–1e19 … 1e19
short	16-bit signed integer	-32,768 … 32,767
string	string of 8-bit characters	N/A
uchar	8-bit unsigned integer	0 … 255
uint	32-bit unsigned integer	0 … 4,294,967,295
ulong	64-bit unsigned integer	0 … 2e19
ushort	16-bit unsigned integer	0 … 65,535

Table 20: Basic Data Types

The syntax recognizes also data structures that are combinations of the basic data types, see table 21 below. The structures are recognized only if all components are included and in the right order.

Name	Variable Type	Variable Name	Use
status	uchar	NUM	Status is included in most of the system commands and it indicates if a command has been accepted (NUM=0) or not (NUM=1).
	string	MSG	Information on the reason the command is refused, such as error codes.
cap	string	PVER	Protocol version
	string	SW_VER	Server software version
	interface	INTERFACES[]	Ethernet (channel data broadcasting) interface configurations. See interface below
	tuner	TUNERS[]	Tuner configurations. See tuner below.
	channelizer	CHANNELIZERS[]	Channelizer configurations. See channelizer below.
interface	uchar	ETH	Broadcasting interface identification number, currently can only be set to 1. See also Ethernet Configuration
	uchar	TYPE	Transfer speed, 0=1Gbps, 1=10Gbps. Currently only supported value 1.
	string	NAME	Interface name
tuner	uchar	TN	Tuner interface identification number. See also Tuner Configuration. Possible values 1 and 2.
	fqrange	FQ_RANGE	Tuner frequency range. See fqrange below.

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	string	MODEL	Tuner model
	uint	SAMPLE_RATE	Data acquisition rate for the tuner
	int	FILTERS[]	Tuner filters. Empty array for USRP.
fqrange	ulong	MIN	Minimum frequency in the range
	ulong	MAX	Maximum frequency in the range
filtercfg	uchar	PFILTER	Filter configuration number.
	string	NAME	Filter name
	uchar	FILTERTYPE	Filter type: 0: None 1: IQ Filter 2: Sound Filter 1
	int	TAPS[]	Filter tap array
	uint	SRATE	Filter sampling rate
channelizer	uchar	CHZ	Channelizer interface identification number. Possible value 1.
	string	NAME	Channelizer interface name.
	filter	FILTERS[]	Channelizer filters
channels	bool	ACTIVE	Channel active status. See also Channel Configuration.
	ushort	TN	Tuner feeding the data to channel.
	ushort	CH	Channel number. Possible values 1...1024.
	bool	ENABLE	Channel enabled (broadcasting) / disabled
	uchar	CGAIN	Coarse gain. For values, see Channel Configuration
	uchar	FGAIN	Fine gain. For values, see Channel Configuration
	ulong	FQ	Channel center frequency
	uint	BW	Channel bandwidth.
	bool	AUTO	Automatic squelch on/off
	short	SQL	Squelch level
	ushort	MOD	Demodulation types. Possible values 0: IQ, 1: AM, 2:FM, 3: LSB and 4:USB.
	uint	DCRATE	Channel downconversion rate.*
	bool	DEMP	De-emphasis filter on/off*
	bool	DCBLOCK	DC block on/off
	bool	AGC	Automatic Gain Control on/off*
	uchar	GAIN	Demodulation gain or maximum applied automatic gain if AGC=true.
	ushort	ATT	Attack rate

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	ushort	DEC	Decay rate
	uchar	DMFILTER0	Filter number applied before demodulation.
	uchar	DMFILTER1	Filter number applied for demodulated signal.
	string	IP	Channel UDP multicast IP address.
	ushort	UDP	Channel UDP multicast port
	uint	ID	Channel identification number.

Table 21: Data StructureTypes

If a variable name is followed by square brackets, the data is a one-dimensional vector of the same data type.

10.4.2 Common Parameters

These repeatedly used parameters are not listed in the detailed command/response tables.

CMD

The first parameter in the JSON coded commands, before the Command ID and other command parameters, is CMD, and its value is the actual command. For example, the function for setting the channel frequency is defined as:

```
CH_SET_FQ(uint CID,uchar CHZ,ushort CH,ulong FQ)
```

The command must be the first element in the JSON string and it is coded as:

```
"CMD":"CH_SET_FQ"
```

So setting the center frequency to 110MHz for channel 9 in channelizer 1 is coded as the following JSON string:

```
{"CMD":"CH_SET_FQ","CID":12345,"CHZ":1,"CH":9,"FQ":11000000
0}
```

CID

CID, command identification, is an arbitrary number sent by the client with each command. The server will respond using the same command id. The client can then match the CID to the list of commands it has sent to verify that the command has been accepted.

However, if a command is of a multi-cast type, the corresponding reply will be sent to all connected clients. In this case the original CID is replaced by 0xFFFF by the host.

Clients should increase the CID for each sent command, and definitely not issue the same CID value multiple times until they have received the corresponding reply back from the server.

STATUS

Status message contains two fields, numeric NUM and string MSG.

NUM can have two values

0=Status OK - the setting has been updated, or the client has

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issued a get command.
1=Status Not OK - the server has not accepted the set value.

If NUM is nonzero, the MSG field will contain information on the problem. Furthermore, if the server has not accepted the value, the return string will contain the current setting for the parameter(s).

10.4.3 Client Commands

The syntax.txt file contains a complete set of commands and responses the system supports as well as descriptions on how to use them. The table below contains additional information on some of the client command parameters. Parameters uint CID and uchar CHZ that are used in all of the commands are not listed here. See protocol file for detailed description.

Command	Parameters*	Comment
TN_ENABLE_FFT	uchar TN string IP ushort UDP uchar FFTM ushort FFTL ushort RATE uchar AVG	Configure FFT streaming parameters and start streaming. This command will reconfigure the server to stream to the IP Address and port indicated by the IP and UDP parameters. If another client has already configured streaming to another address they will lose the stream. It is recommended that prior to enabling FFT client application send TN_ENABLE_FFT with RATE=0, which is considered a status request by the server, which will reply with the actual streaming parameters. See the section on FFT for more information on these parameters.
TN_SET_SYNC	uchar TN uchar SYNC	Set tuner local oscillator synchronization. Possible values: SYNC=0: Independent clocks SYNC=1: Import - the tuners on the same daughterboard will share the local oscillator (TN=1 and TN=2 are on one daughterboard, TN=3 and TN=4 are on the other) SYNC=2: Export the local oscillator from daughterboard RF1. NOTE: SYNC=1 can only be set when TN=1 or 3. SYNC=2 can only be set when TN=3.
CHZ_SET_ETH	uchar CHZ string CMDIP string USRPIP string CHZIP string USRPCHNIP	Set the USRP and server Ethernet addresses. CMDIP: Server Ethernet adapter IP address for communicating with the USRP and receiving RF data. USRPIP: USRP IP address for communicating with the server and sending RF data. CHZIP: Server Ethernet adapter IP address for receiving channel data stream. USRPCHNIP: USRP IP address for sending channel data.
CHZ_SET_GPS	uchar CHZ bool GPS long TREFRESH uint TOUT	Set the USRP GPS settings. See also GPS Configuration. GPS= true: lock to a GPS satellite to read time GPS= false: use system time TREFRESH: Refresh period in seconds, after which the system will attempt to lock itself to a GPS satellite TOUT: Timeout for attempting to lock to a satellite.
CHZ_SET_GPS REFRESH	uchar CHZ bool REFRESH	REFRESH=True: Set GPS to refresh start time REFRESH= False: Interrupt refresh
CH_ADD	ushort CH string IP ushort UDP uint ID	Activate channel number CH. Parameters: IP: multicast IP address for UDP stream, UDP: multicast port for channel stream, ID: channel identification nuber.

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CH_SET_SQL	ushort CH bool AUTO short SQUELCH	Set squelch for channel CH. AUTO=true: automatic squelch, false: squelch level is read from the SQUELCH parameter SQUELCH: AUTO=false: level in dBm to turn on squelch AUTO=true: level in dB above noise floor to turn on squelch.
CH_SET_CHS	channel CHANNELS[]	Set configuration for multiple channels. CHANNELS[]= an array of channel configurations. Each channel's configuration must include all the components in the channel structure as explained in the DataStructureTypes table in the Data Types section.
DM_SET_MOD	ushort CH ushort MOD	Set demodulation type for channel CH. MOD=modulation type, 0=IQ (no demodulation), 1=AM, 2=FM, 3=LSB, 4=USB.
DM_SET_GAIN	ushort CH uchar GAIN ushort ATT ushort DEC	Set the demodulation gain parameters for channel CH. GAIN= if AGC is off, the manual gain; if AGC is on, the maximum gain applied by AGC. ATT= attack time in ms when AGC is on. DEC = decay time in ms when AGC is on.
DM_SET_FILTER	ushort CH ushort FILTERNR string FILTERNAME uchar FILTERTYPE int TAPS[]	Configure a filter for channel CH. FILTERNR= filter position to assign the filter in. If a system filter number (0 through 99) is used, the new filter setup will affect all channels using the corresponding demodulation. If FILTERNR refers to a filter that has not been defined, the filter list will be appended with the filter. Copies of the filter will be created if necessary to fill in the missing filter positions. FILTERNAME= this value is ignored FILTERTYPE= filter type 0=no filter, 1=IQ Filter, 2=Filter1. TAPS[]= 108 taps defining the filter.

Table 22: Client Command Parameter Information.

10.4.4 Server Responses

The syntax.txt file contains a complete set of commands and responses the system supports as well as descriptions on how to use them. The table below contains additional information on some of the server response parameters. Parameters uint CID and uchar CHZ that are used in all of the commands are not listed here. See protocol file for detailed description.

Response	Parameters*	Comment
SYS_RUN	bool RUN	RUN=true: the server is in Hardware Execution Mode, RUN=false: the server is in setup mode
TN_ENABLE_FFT	uchar TN string IP ushort UDP uchar FFTM ushort FFTL ushort RATE uchar AVG	Configure FFT streaming parameters. See the section on FFT for more information on these parameters.
TN_SYNC	uchar TN uchar SYNC	Tuner local oscillator synchronization. SYNC=0: Independent clocks

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		SYNC=1: Import - the tuners on the same daughterboard will share the local oscillator (TN=1 and TN=2 are on one daughterboard, TN=3 and TN=4 are on the other) SYNC=2: Export the local oscillator from daughterboard RF1, the one with Tuners 3 and 4.
CHZ_ETH	uchar CHZ string CMDIP string USRPIP strinc CHZIP string USRPCHNIP	The USRP and server IP addresses. CMDIP: Server Ethernet adapter IP address for communicating with the USRP and receiving RF data. USRPIP: USRP IP address for communicating with the server and sending RF data. CHZIP: Server Ethernet adapter IP address for receiving channel data stream. USRPCHNIP: USRP IP address for sending channel data.
CHZ_GPS	uchar CHZ bool GPS bool LOCKED int STARTTIME long TREFRESH uint TOUT	GPS configuration status. See also GPS Configuration. GPS= true: lock to a GPS satellite to read time GPS= false: use system time LOCKED=true: the system has locked itself to a GPS satellite LOCKED=false: the system has not locked itself to a GPS satellite within TOUT. STARTTIME=if LOCKED=true, the read GPS time. The relative time in channel data starts to count from this time. If LOCKED=false, 0 if the system has never been able to lock itself to a satellite, otherwise the GPS time from the last successful locking. TREFRESH: Time (s) after which the system will make a new attempt to lock itself to a GPS satellite TOUT: How long (s) the system should try locking to a satellite before giving up.
CHZ_LICENSEREQ	uchar CHZ string LICENSEREQ	Response to a request license file. LICENSEREQ will contain the string that needs to be saved locally and then mailed to Novator Solutions for requesting license.
CH_ADD	ushort CH string IP ushort UDP uint ID	Channel number CH activated. Parameters: IP=multicast IP address for UDP stream, UDP=multicast port for channel stream, ID=channel identification nuber.
CH_SQL	ushort CH bool AUTO short SQUELCH	Squelch setting for channel CH. AUTO=true: automatic squelch, false: squelch level is read from the SQUELCH parameter SQUELCH: if AUTO=false: level in dBm to turn on squelch if AUTO=true: level in dB above noise floor to turn on squelch.
DM_MOD	ushort CH ushort MOD	Demodulation type for channel CH. MOD=modulation type, 0=IQ (no demodulation), 1=AM, 2=FM, 3=LSB, 4=USB.

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DM_GAIN	ushort CH uchar GAIN ushort ATT ushort DEC	The demodulation gain settings for channel CH. GAIN= if AGC is off, the manual gain; if AGC is on, the maximum gain applied by AGC. ATT= attack time in ms when AGC is on. DEC = decay time in ms when AGC is on.
DM_DCBLOCK	bool DCBLOCK	DCBLOCK=true: All FM demodulated channels are highpass filtered to remove DC component. DCBLOCK=false: No DC block filter is applied
DM_AGC	ushort CH bool AGC	AGC=true: Automatic gain controller is enabled, the demodulator gain value indicates the maximum gain to apply to signal AGC=false: Automatic gain controller is disabled, the demodulator gain is applied on the signal

Table 23: Server Response Parameter Information.

10.4.5 Heartbeat

The heartbeat signal is a simple token that is sent at a regular time interval from the clients to the host as well as from the host to the connected clients. The signal is defined as HB(), which in JSON coding will be {"CMD":"HB"}. The dispatch and reception of the heartbeat signal is not entered in the event or command logs.

The server heartbeat signal timing is configured with system configuration, or via a client command SYS_SET_HB.

The clients are expected to send the heartbeat signal at the time interval indicated by the TIMEOUT parameter maximum. Any client command will also be registered as a heartbeat.

Setting server heartbeat timeout to 0 will cause the client heartbeats never to time out.

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