Battery Simulator 1200
Communication Specification

Part Number: 8800-00010

Revision History

REV	DATE	DESCRIPTION	PREPARED BY	REVIEWED BY
1.0	2013-Oct 28	Initial Release	B Hiller, R Deyo	J. Murray
1.1	2014-Jan-20	Added Ethernet	R Deyo	J. Murray
1.2	2015-Aug-31	Updated Overview config. information	B Hiller	B Hiller
1.3	2019-Feb 16	Assigned part number; added recommendation to use Soft Panel for configuration	P. Tortora	G. Gothing

Table of Contents

1. Overview

The Battery Simulator 1200 (BS1200) is configurable to communicate using Ethernet or CAN bus. To change between modes, use the Soft Front Panel application. Below are legacy instructions for making the change manually:

1. Ensure box is plugged in.
2. FTP to box IP address and navigate to /ni-rt/startup/Configuration Files.
   Default IP address is located on top of the BS1200
3. Pull the file "General Settings.xml" to a host PC and open using a text editor.
4. Find the group:
   <Name>Protocol</Name>
   <Choice>CAN</Choice>
   <Choice>TCPIP</Choice>
   <Val>0</Val>
5. Set Val to 0 for CAN, 1 for TCPIP.
6. Save and push the file back to the same location on the BS1200.
7. Restart the BS1200.

To allow multiple BS1200 boxes to be connected in parallel on the CAN bus, each box must be set to a different Box ID. The default Box ID is printed on the label located on the top of the BS1200 and is generally defaulted to 1 when shipped. When being used in an HIL system, it is recommended that no more than 2 BS1200s be connected to a CAN bus due to throughput limitations. To change the Box ID, use the Soft Front Panel application. Below are legacy instructions for making the change manually:

1. Ensure box is plugged in.
2. FTP to box IP address and navigate to /ni-rt/startup/Data.
   Default IP address is located on top of the BS1200
3. Pull the file "BS1200 Configuration.ini" to a host PC and open using a text editor.
4. Find the line with "<box_ID type='U32'>1</box_ID>":
5. Change the "1" to the desired Box ID.
6. If necessary, the CAN baudrate can also be adjusted in the same configuration file. Find the line with "<baud_rate type='U32'>1000000</baud_rate>"
7. Change "1000000" to the desired supported NI baudrate. It is recommended to leave this value at "1000000".
8. Save and push the file back to the same location on the BS1200.
9. Restart the BS1200.

2. CAN

The BS1200 CAN bus runs at 1 MBaud (unless configured to a different value). The BS1200's should always share a CAN network separate from other devices.

2.1. Frames List

All messages use 11 bit arbitration IDs. The least significant 4 bits specify the BS1200 Box ID. For example, when sending a Cell Enable All frame to BS1200 Box ID #1, the arbitration ID of 0x541 must be used. Readback values being sent by the BS1200 work in a similar fashion. The default BS1200 Box ID is shown on the label located on the top cover of the BS1200.

2.1.1. Incoming Frames (to BS1200)

Msg ID		***Base Arb ID***		***Description***	***Frame Active in HIL Mode?***
[Hex]	***[Dec]***	***[Hex]***	***[Dec]***		
8	8	80	128	HIL mode start/stop trigger	Yes
A	10	A0	160	Cell Voltage Setpoints 1-4	Yes
B	11	B0	176	Cell Voltage Setpoints 5-8	Yes
C	12	C0	192	Cell Voltage Setpoints 9-12	Yes
20	32	200	512	DIO Setpoints 1-8	Optional
22	34	220	544	AO Setpoints 1-2	Optional
40	64	400	1024	Box Mode and Message Config	No
48	72	480	1152	Cell Current Set All	No
4A	74	4A0	1184	Cell Current Sink Setpoint (Single)	No
4B	75	4B0	1200	Cell Current Source Setpoint (Single)	No
50	80	500	1280	Cell Voltage Set All	No
51	81	510	1296	Cell Voltage Setpoint (Single)	No
54	84	540	1344	Cell Enable All	No
55	85	550	1360	Cell Enable (Single)	No

2.1.2. Outgoing Frames (from BS1200)

Msg ID		Base Arb ID		Description	Frame Active in HIL Mode?
[Hex]	[Dec]	[Hex]	[Dec]		
10	16	100	256	BS1200 status	Yes
12	18	120	288	Cell Voltages Readback 1-4	Yes
13	19	130	304	Cell Voltages Readback 5-8	Yes
14	20	140	320	Cell Voltages Readback 9-12	Yes
18	24	180	384	Cell Currents Readback 1-4	Yes
19	25	190	400	Cell Currents Readback 5-8	Yes
1A	26	1A0	416	Cell Currents Readback 9-12	Yes
28	40	280	640	DIO States 1-8	Optional
2A	42	2A0	672	AI Values 1-4	Optional
2B	43	2B0	688	AI Values 5-8	Optional

2.2. Modes of Operation

The Battery Simulator 1200 contains two unique modes, standard operating mode and Hardware-in-the-Loop (HIL) mode. The standard operating mode is commonly used in validation and verification systems while the HIL mode is used to maximize the efficiency of CAN communication when running mathematical models in an HIL System.

2.2.1. HIL Mode

When in HIL mode, the Battery Simulator 1200 gives priority to the specified incoming frames to reduce latency; the instrument will attempt to pass non-HIL frames through for processing but delivery is not guaranteed.

To reduce the amount of data transmitted onto the CAN network, the Configure frame controls which messages are broadcast onto the CAN bus. Voltage and current readback for all cells will always be transmit onto the CAN bus. Analog Input and Digital I/O readback are disabled by default but may be enabled using the Configure frame.

2.2.2. Mode Settings

The HIL mode is set by the command: **HIL mode start/stop trigger**. Once set, the Battery Simulator will execute only the commands defined as active in HIL mode.

By default all auxiliary configuration channels are set to disabled during HIL mode. In order to change this option, the configuration frame must be used. Note, the Configure frame is not supported in HIL mode, so this must be sent while HIL mode is disabled.

2.3. Incoming Frames (to BS1200)

2.3.1. HIL Mode Start/Stop Trigger (HIL_Mode)

Signal	Start bit	# of bits	Scaling Factor	Scaling Offset	Range	Units
Enable	0	1	1	0	0 or 1	N/A

2.3.2. Cell Voltage Setpoints 1-4 (Cell_V_Set_1_4)

Signal	Start bit	# of bits	Scaling Factor	Scaling Offset	Range	Units
Cell_1_Voltage	0	16	0.0001	0	0 to 5	V
Cell_2_Voltage	16	16	0.0001	0	0 to 5	V
Cell_3_Voltage	32	16	0.0001	0	0 to 5	V
Cell_4_Voltage	48	16	0.0001	0	0 to 5	V

2.3.3. Cell Voltage Setpoints 5-8 (Cell_V_Set_5_8)

Signal	Start bit	# of bits	Scaling Factor	Scaling Offset	Range	Units
Cell_5_Voltage	0	16	0.0001	0	0 to 5	V
Cell_6_Voltage	16	16	0.0001	0	0 to 5	V
Cell_7_Voltage	32	16	0.0001	0	0 to 5	V
Cell_8_Voltage	48	16	0.0001	0	0 to 5	V

2.3.4. Cell Voltage Setpoints 9-12 (Cell_V_Set_9_12)

Signal	Start bit	# of bits	Scaling Factor	Scaling Offset	Range	Units
Cell_9_Voltage	0	16	0.0001	0	0 to 5	V
Cell_10_Voltage	16	16	0.0001	0	0 to 5	V
Cell_11_Voltage	32	16	0.0001	0	0 to 5	V
Cell_12_Voltage	48	16	0.0001	0	0 to 5	V

2.3.5. DIO Setpoints 1-8 (Digital_IO_Set_1_8)

Signal	Start bit	# of bits	Scaling Factor	Scaling Offset	Range	Units
DIO Output	0	8	1	0	0 to 255	N/A
DIO Direction	8	8	1	0	0 to 255	N/A

2.3.6. AO Setpoints 1-2 (Analog_Out_Set_1_2)

Signal	Start bit	# of bits	Scaling Factor	Scaling Offset	Range	Units
AO1_Voltage	0	16	0.0001	0	0 to 5	V
AO2_Voltage	16	16	0.0001	0	0 to 5	V

2.3.7. Box Mode and Message Configure (Configure)

Signal	Start bit	# of bits	Scaling Factor	Scaling Offset	Range	Units
DIO_HIL_Set_Enable	0	1	1	0	0 or 1	N/A
AO_HIL_Set_Enable	1	1	1	0	0 or 1	N/A
DIO_HIL_BCast_Enable	8	1	1	0	0 or 1	N/A
AI_1_4_HIL_BCast_Enable	9	1	1	0	0 or 1	N/A
AI_5_8_HIL_BCast_Enable	10	1	1	0	0 or 1	N/A
Calibration_Mode	16	1	1	0	0 or 1	N/A

2.3.8. Cell Current Set All (Cell_I_Set_All)

Signal	Start bit	# of bits	Scaling Factor	Scaling Offset	Range	Units
Source_I_All	0	16	0.1	0	0 to 500	mA
Sink_I_All	16	16	0.1	0	0 to 500	mA

2.3.9. Cell Current Sink Setpoint (Cell_I_Sink_Set)

Signal	Start bit	# of bits	Scaling Factor	Scaling Offset	Range	Units
Channel	0	8	1	1	1 to 12	N/A
I_Sink	8	16	0.1	0	0 to 500	mA

2.3.10. Cell Current Source Setpoint (Cell_I_Source_Set)

Signal	Start bit	# of bits	Scaling Factor	Scaling Offset	Range	Units
Channel	0	8	1	1	1 to 12	N/A
I_Source	8	16	0.1	0	0 to 500	mA

2.3.11. Cell Voltage Set All (Cell_V_Set_All)

Signal	Start bit	# of bits	Scaling Factor	Scaling Offset	Range	Units
Cell_Voltage_All	0	16	0.0001	0	0 to 5	V

2.3.12. Cell Voltage Setpoint (Cell_V_Set)

Signal	Start bit	# of bits	Scaling Factor	Scaling Offset	Range	Units
Channel	0	8	1	1	1 to 12	N/A
Cell_Voltage	8	16	0.0001	0	0 to 5	V

2.3.13. Cell Enable All

Signal	Start bit	# of bits	Scaling Factor	Scaling Offset	Range	Units
Enable	0	1	1	0	0 to 1	N/A

2.3.14. Cell Enable (Cell_Enable)

Signal	Start bit	# of bits	Scaling Factor	Scaling Offset	Range	Units
Channel	0	8	1	1	1 to 12	N/A
Enable	8	1	1	0	0 or 1	N/A

2.4. Outgoing Frames (from BS1200)

2.4.1. BS1200 Status (System_Status)

Signal	Start bit	# of bits	Scaling Factor	Scaling Offset	Range	Units
Fan_Fail_1	0	1	1	0	0 or 1	N/A
Fan_Fail_2	1	1	1	0	0 or 1	N/A
Fan_Fail_3	2	1	1	0	0 or 1	N/A
Fan_Fail_4	3	1	1	0	0 or 1	N/A
Temp_Sensor_1	8	8	1	0	0 to 255	Deg C
Temp_Sensor_2	16	8	1	0	0 to 255	Deg C
Temp_Sensor_3	32	8	1	0	0 to 255	Deg C

2.4.2. Cell Voltages Readback 1-4 (Cell_V_Readback_1_4)

Signal	Start bit	# of bits	Scaling Factor	Scaling Offset	Range	Units
Cell_V_1	0	16	0.0001	0	0 to 5	V
Cell_V_2	16	16	0.0001	0	0 to 5	V
Cell_V_3	32	16	0.0001	0	0 to 5	V
Cell_V_4	48	16	0.0001	0	0 to 5	V

2.4.3. Cell Voltages Readback 5-8 (Cell_V_Readback_5_8)

Signal	Start bit	# of bits	Scaling Factor	Scaling Offset	Range	Units
Cell_V_5	0	16	0.0001	0	0 to 5	V
Cell_V_6	16	16	0.0001	0	0 to 5	V
Cell_V_7	32	16	0.0001	0	0 to 5	V
Cell_V_8	48	16	0.0001	0	0 to 5	V

2.4.4. Cell Voltages Readback 9-12 (Cell_V_Readback_9_12)

Signal	Start bit	# of bits	Scaling Factor	Scaling Offset	Range	Units
Cell_V_9	0	16	0.0001	0	0 to 5	V
Cell_V_10	16	16	0.0001	0	0 to 5	V
Cell_V_11	32	16	0.0001	0	0 to 5	V
Cell_V_12	48	16	0.0001	0	0 to 5	V

2.4.5. Cell Currents Readback 1-4 (Cell_I_Readback_1_4)

Signal	Start bit	# of bits	Scaling Factor	Scaling Offset	Range	Units
Cell_I_1	0	16	0.1	-3276.8	-500 to 500	mA
Cell_I_2	16	16	0.1	-3276.8	-500 to 500	mA
Cell_I_3	32	16	0.1	-3276.8	-500 to 500	mA
Cell_I_4	48	16	0.1	-3276.8	-500 to 500	mA

2.4.6. Cell Currents Readback 5-8 (Cell_I_Readback_5_8)

Signal	Start bit	# of bits	Scaling Factor	Scaling Offset	Range	Units
Cell_I_5	0	16	0.1	-3276.8	-500 to 500	mA
Cell_I_6	16	16	0.1	-3276.8	-500 to 500	mA
Cell_I_7	32	16	0.1	-3276.8	-500 to 500	mA
Cell_I_8	48	16	0.1	-3276.8	-500 to 500	mA

2.4.7. Cell Currents Readback 9-12 (Cell_I_Readback_9_12)

Signal	Start bit	# of bits	Scaling Factor	Scaling Offset	Range	Units
Cell_I_9	0	16	0.1	-3276.8	-500 to 500	mA
Cell_I_10	16	16	0.1	-3276.8	-500 to 500	mA
Cell_I_11	32	16	0.1	-3276.8	-500 to 500	mA
Cell_I_12	48	16	0.1	-3276.8	-500 to 500	mA

2.4.8. DIO States 1-8 (DIO_Readback_1_8)

Signal	Start bit	# of bits	Scaling Factor	Scaling Offset	Range	Units
DIO_1_8	0	8	1	0	0 to 255	N/A

2.4.9. AI Readback 1-4 (AI_Readback_1_4)

Signal	Start bit	# of bits	Scaling Factor	Scaling Offset	Range	Units
AI_1	0	16	0.0001	0	0 to 5	V
AI_2	16	16	0.0001	0	0 to 5	V
AI_3	32	16	0.0001	0	0 to 5	V
AI_4	48	16	0.0001	0	0 to 5	V

2.4.10. AI Readback 5-8 (AI_Readback_5_8)

Signal	Start bit	# of bits	Scaling Factor	Scaling Offset	Range	Units
AI_5	0	16	0.0001	0	0 to 5	V
AI_6	16	16	0.0001	0	0 to 5	V
AI_7	32	16	0.0001	0	0 to 5	V
AI_8	48	16	0.0001	0	0 to 5	V

3. Ethernet

When the BS1200 is configured to use Ethernet, commands are sent to the BS1200 using TCP, while all messages sent from the BS1200 are UDP broadcast.

3.1. Configuration Summary

The following configurations must be set on the host computer for proper communications. The next section goes into more detail on how to set this configuration using Windows.

IPv4 :

Static IP: 192.168.1.1

Subnet Mask: 255.255.255.0

Firewall Port Exceptions:

Incoming:

UDP: 54321, 58432

Outgoing:

TCP: 12345

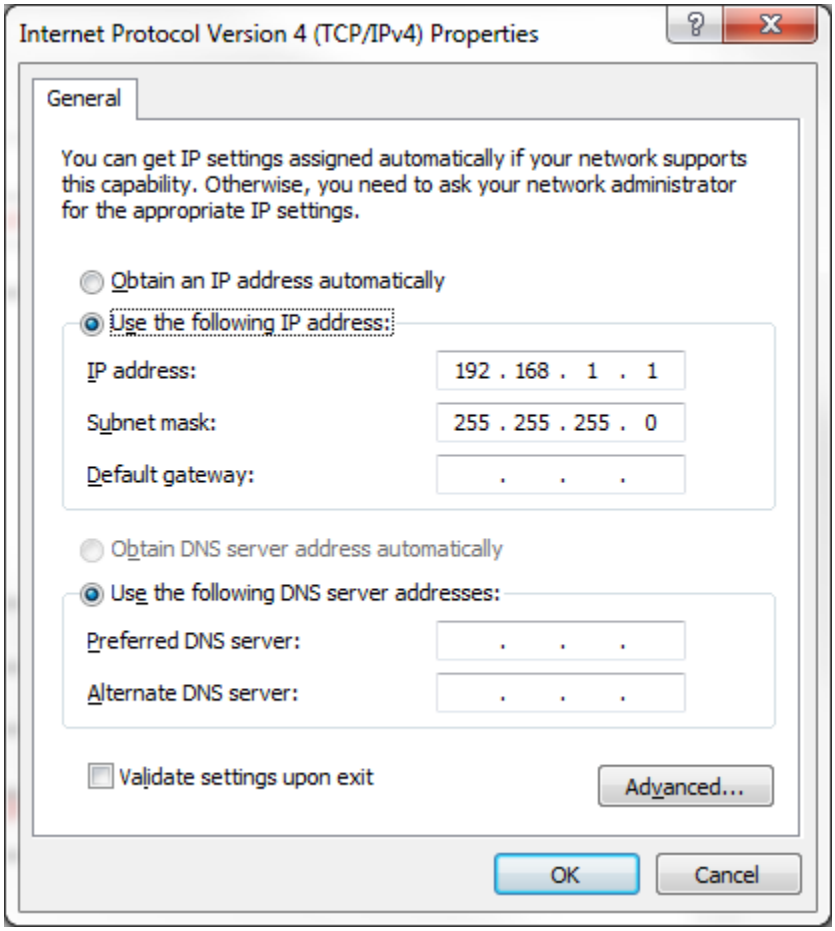
UDP: 58431

NOTE: HOST PC'S FIREWALL PORTS MUST BE OPENED CORRECTLY TO COMMUNICATE TO THE BATTERY SIMULATOR 1200 UNITS.

3.2. Setup

3.2.1. TCP/IPv4 Configuration

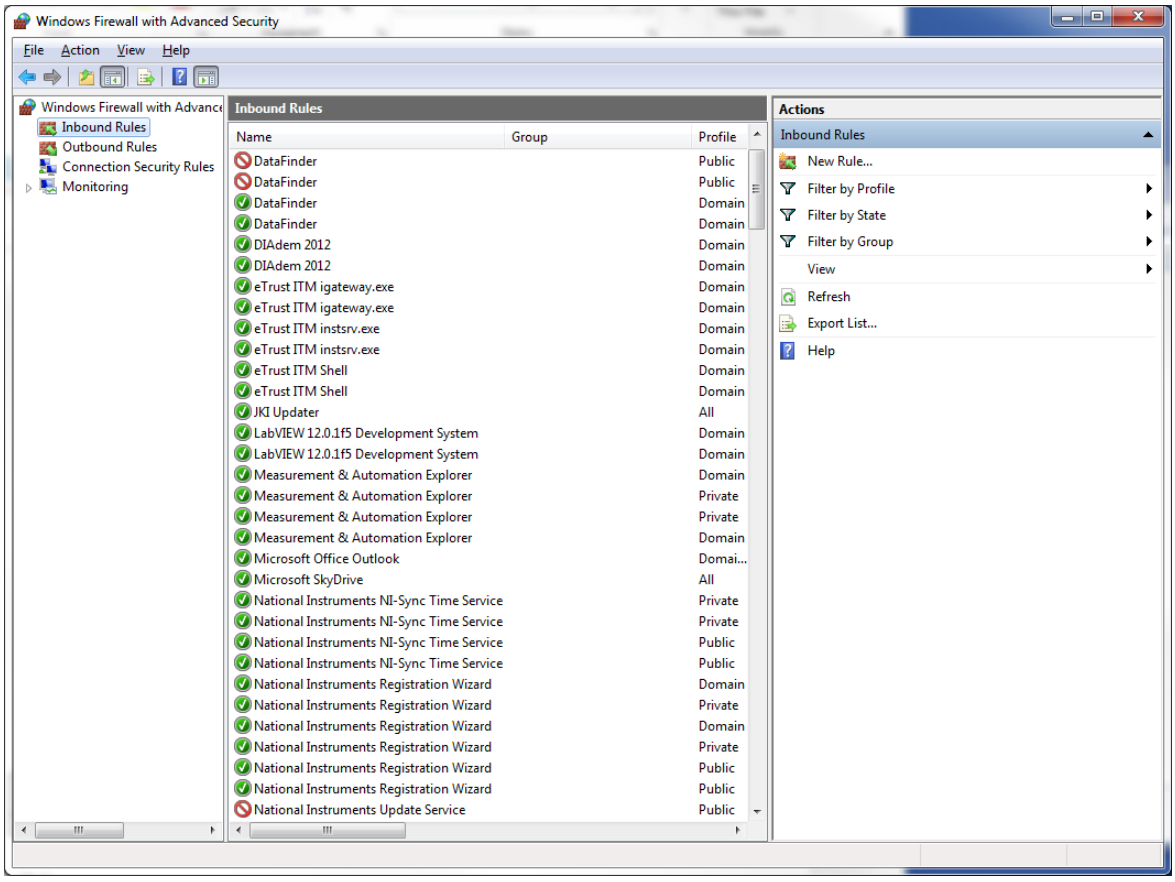
The host PC will have to be configured correctly to begin communications with the BS1200. This section will go into further detail on how to properly configure your host PC. This first involves setting the host PC's IP address to a static address. Below are the recommended IPv4 settings for the host PC.



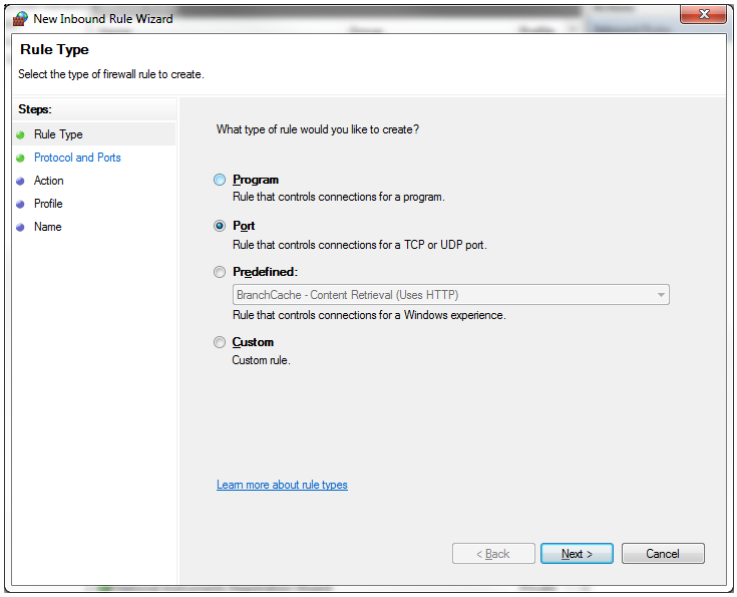
3.2.2. Firewall Configuration

The host PC's firewall will also need to be configured to allow communications to the BS1200. This can be done in windows by taking the following steps. Open Windows Firewall with Advanced Security, found in the advanced settings of Windows Firewall under the control panel.

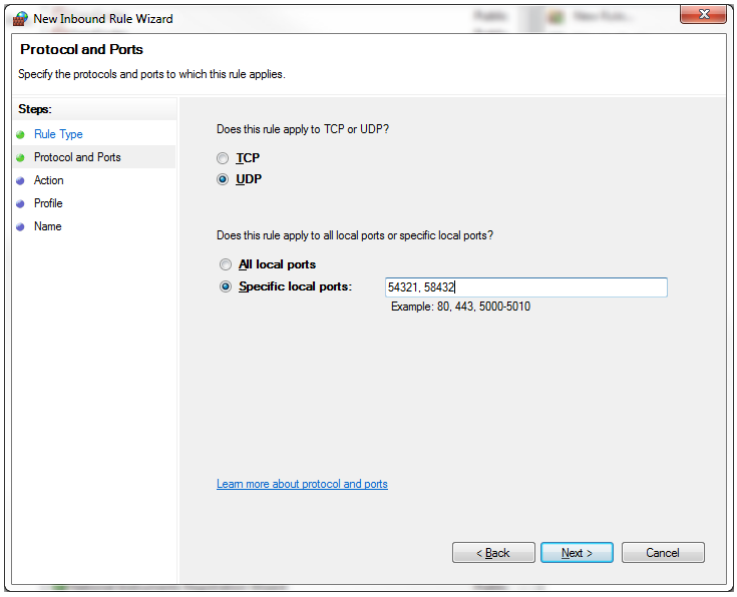
Click on "Inbound Rules" on the left hand side, then select "New Rule…" on the right hand side.



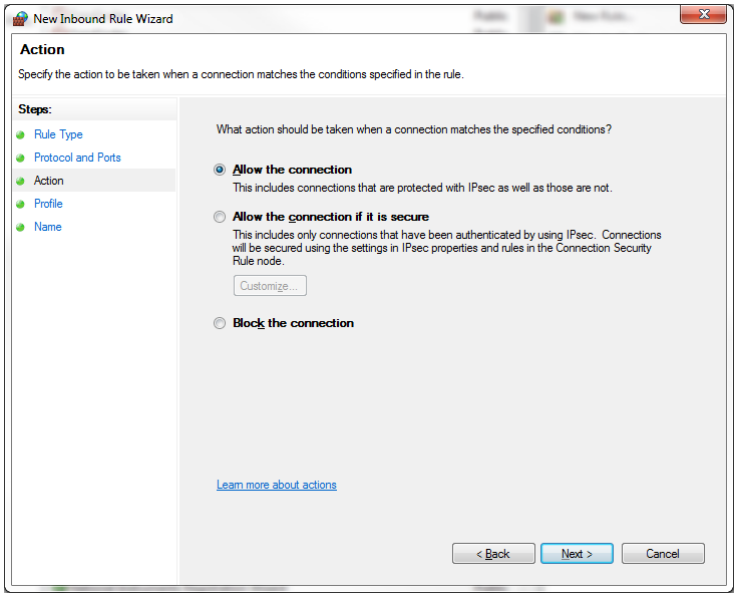
Select port and click next.



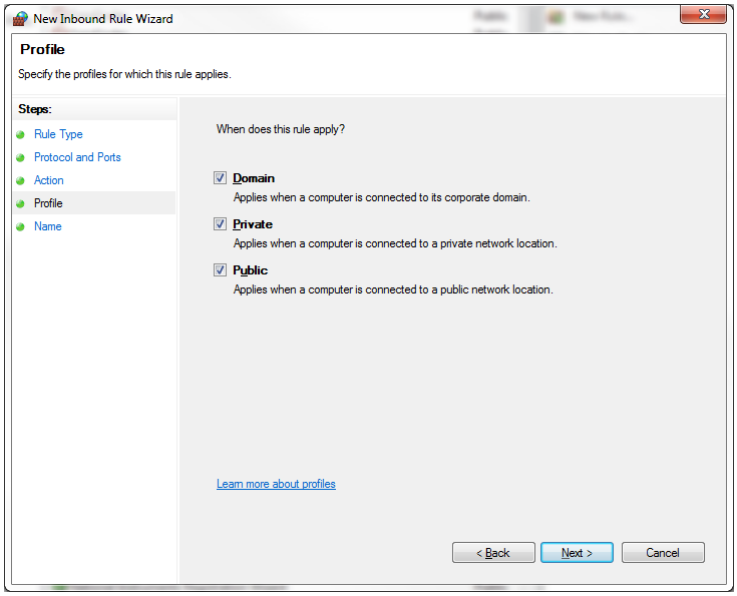
Select UDP and enter the BS1200 default ports of 54321, 58432.



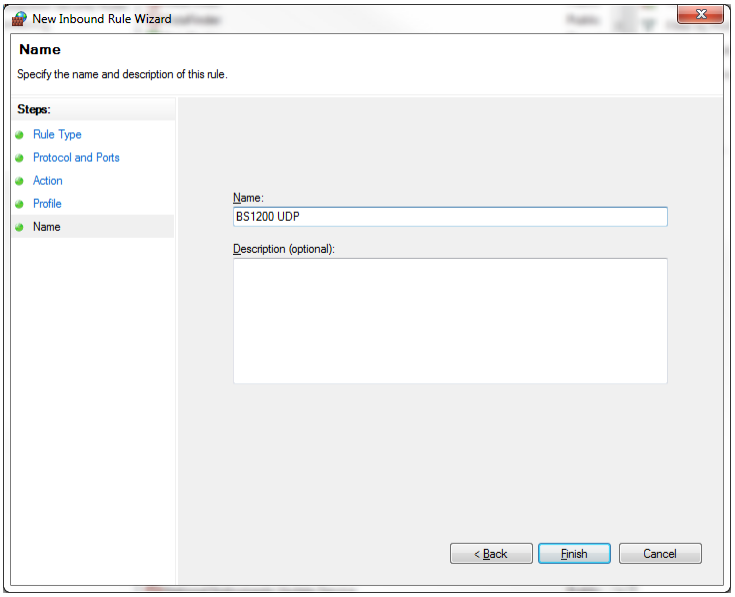
Allow the connection and click next.



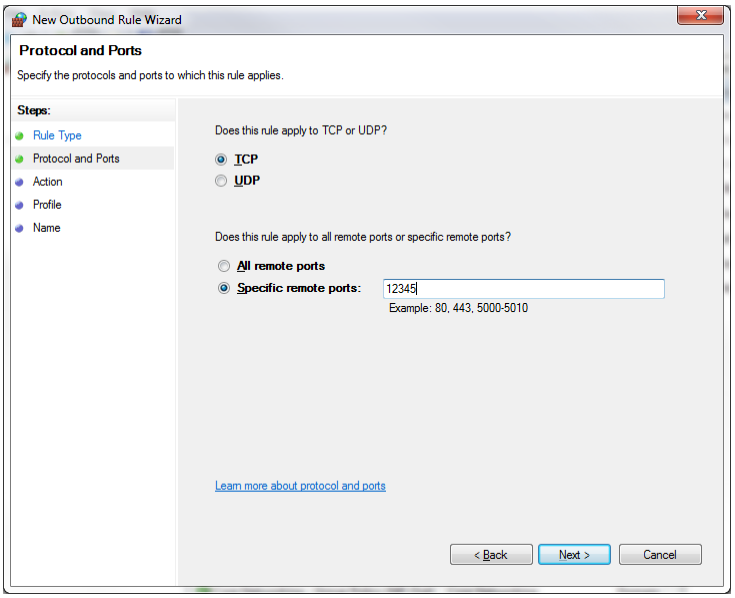
Apply to all domain, private, and public.



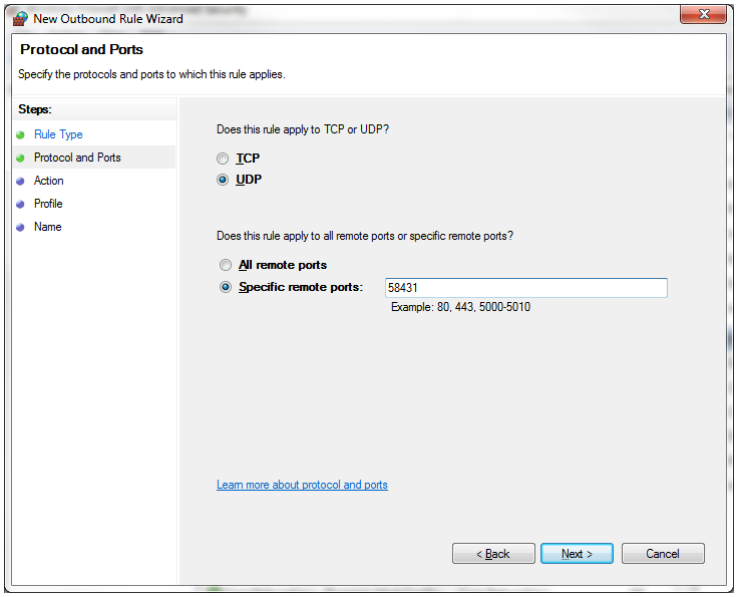
Assign a name, such as BS1200 UDP and select Finish.



On the Firewall Advanced Configuration, click on “Outbound Rules” on the left hand side, then select “New Rule…” on the right hand side. Follow the steps as before, this time selecting TCP, and specifying the default port of 12345.



Finally, create another Outbound rule, allowing UDP on the default port 58431



3.3. TCP

Both TCP and UDP packets are encapsulated using IPv4 and Ethernet II (DIX) frames. Payloads of TCP and UDP use the NI CAN frame. The payload structure (Big Endian) is as a follows.

NI CAN Frame

Total Byte Count in Message (Normally 0)	Arbitration ID	Extended Frame? (Normally 0)	Type {0:"CAN Data", 1:"CAN Remote"} (Normally 0)	Payload Byte Count	CAN Frame Payload
4 bytes (I32)	4 bytes (U32)	One Byte Boolean	1 Byte (U8)	4 Bytes (I32)	N Bytes

The BS1200 expects two data sets to initiate a command. The first is always 4 bytes to represent the length of the next NI CAN frame payload to be received. Second, is the NI CAN frame with the command to the BS1200. The payload structures of the NI CAN frames can be found in Section 2.3.

The following is an example of two TCP packets, to using the cell enable all command. The highlighted section is the TCP payload. The enable all message can be found in Section 2.1.1.

Next NI CAN frame payload length:

```
0000   00 80 2f 14 cd 7e f0 1f   af 2b 4c 5c 08 00 45 00
0010   00 2c 6a bf 40 00 80 06   0c 57 c0 a8 01 01 c0 a8
0020   01 64 56 ce 30 39 ae 0e   d3 dc 45 93 31 3e 50 18
0030   01 04 ab 38 00 00 00 00   00 12
```

NI CAN frame:

```
0000   00 80 2f 14 cd 7e f0 1f   af 2b 4c 5c 08 00 45 00
0010   00 3f 6a c0 40 00 80 06   0c 43 c0 a8 01 01 c0 a8
0020   01 64 56 ce 30 39 ae 0e   d3 e0 45 93 31 3e 50 18
0030   01 04 a3 ea 00 00 00 00   05 40 00 00 00 00 00 08
0040   01 00 00 00 00 00 00 00   00 00 00 01 01
```

3.4. UDP

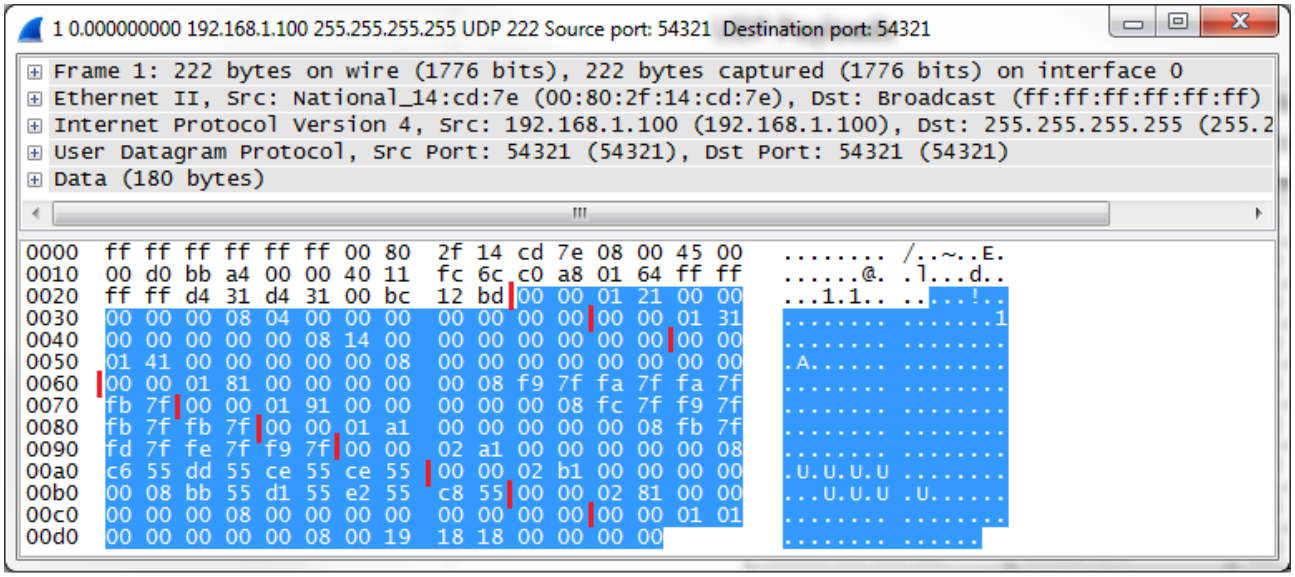
BS1200 status messages are UDP broadcast every 10 ms. The UDP payload length is always 180 bytes and is an array of NI CAN frames, following the same payload structure as TCP. (See section 2.4)

Note that the HIL mode used in CAN communication is irrelevant for Ethernet communication as every message is always broadcast.

UDP Payloads

Total Byte Count in Message 4 bytes (I32)	Arbitration ID 4 bytes (U32) "X" = Box ID	Extended Frame? One Byte Boolean	Type 1 Byte (U8)	Payload Byte Count 4 Bytes (I32)	Payload 8 Bytes
0x00 00 00 00	0x01 2X	00	00	0x00 00 00 08	See Outgoing Frames
0x00 00 00 00	0x01 3X	00	00	0x00 00 00 08	See Outgoing Frames
0x00 00 00 00	0x01 4X	00	00	0x00 00 00 08	See Outgoing Frames
0x00 00 00 00	0x01 8X	00	00	0x00 00 00 08	See Outgoing Frames
0x00 00 00 00	0x01 9X	00	00	0x00 00 00 08	See Outgoing Frames
0x00 00 00 00	0x01 AX	00	00	0x00 00 00 08	See Outgoing Frames
0x00 00 00 00	0x02 AX	00	00	0x00 00 00 08	See Outgoing Frames
0x00 00 00 00	0x02 BX	00	00	0x00 00 00 08	See Outgoing Frames
0x00 00 00 00	0x02 8X	00	00	0x00 00 00 08	See Outgoing Frames
0x00 00 00 00	0x01 0X	00	00	0x00 00 00 08	See Outgoing Frames

The following is an example of a UDP packet sent from the BS1200, box ID 1. The UDP payload is highlighted and marked with red lines to note the start of each NI CAN frame.



4. Configuring Cell Outputs

To configure the BS1200 cells for operation, the following steps should be followed. Note, it's assumed the unit is powered and communication has already been established.

1. **Configure cell source current.**
   Transmit one of the following frames:
   a. **Cell Current Source Setpoint(Single)**
      The individual cell number and current must be specified. This operation would be required for all intended active cells.
   b. **Cell Current Set All**
      Both the source and sink currents must be specified and will be applied to all cells
2. **Configure cell sink current.**
   Transmit one of the following frames:
   a. **Cell Current Sink Setpoint(Single)**
      The individual cell number and current must be specified. This operation would be required for all intended active cells.
   b. **Cell Current Set All**
      Both the source and sink currents must be specified and will be applied to all cells. This operation only needs to be performed once.
3. **Configure cell voltages.**
   Cell voltages can be set using Cell Voltage Set All, Cell Voltage Setpoint(Single), or Cell Voltage Setpoints 1-4, 5-8, or 9-12.
   a. **Cell Voltage Set All**
      Used to set all cell outputs to the same value.
   b. **Cell Voltage Setpoint(Single)**
      The individual cell number and voltage must be specified. This operation would be required for all intended active cells.
   c. **Cell Voltage Setpoints 1-4, 5-8, and 9-12**
      These frames are used to control 4 cells at a time with each having its own voltage setting and are generally used in HIL systems where high throughput is needed.
4. **Enable cell outputs.**
   Transmit one of the following frames:
   a. **Cell Enable(Single)**
      The individual cell number and state must be specified. This operation would be required for all intended active cells.
   b. **Cell Enable All**
      This frame Enables or Disables all cells at once.