Battery Simulator 1201

Manual

8700-00073 Rev. A – May 2025

WARNING

While the BS1201 does not inherently produce any high voltages, it may be used in such a way that high voltages are present on its terminals.

Exercise sound engineering principles and habits when using the BS1201 and observe best practices for dealing with high-voltage DC sources.

If the equipment is used in a manner not specified, the protection provided by the equipment may be impaired.

Revision	Date	Description	Prepared By	Reviewed By	Approver
A	5/1/2025	Initial Release	Grant Gothing	Caitlin Eaton-Robb	Paul Tortora

0 Foreword

The Bloomy Battery Simulator 1201 (BS1201) is the world's leading high-density, high-voltage battery cell simulator. It provides a safe and efficient means to simulate a broad range of battery cell and pack conditions to test battery management systems and other battery-sensitive electronics without the hazards of real batteries. The twelve cell channels provide individually-programmable cell voltages and currents to create an extremely wide variety of test conditions to comprehensively exercise the functionality of the device under test. Furthermore, the BS1201 simulates conditions that may be difficult, time consuming, unsafe, impractical or impossible using real battery cells. It is a fundamental building block of many automated test systems, including Bloomy's own family of BMS test systems.

Housed in a 19-inch, 1U (1.75") rack-mount enclosure, the BS1201 is ideal for benchtop use as well as rack mounting in a test system. Isolated cell channels from multiple units may be connected in series to simulate modules, strings or complete battery packs—up to 1,000V—while auxiliary analog and digital outputs may be used to simulate thermistors, current sensors and contactors. Remote control from a computer or CAN controller is possible via its Ethernet or high-speed CAN communications interfaces.

This manual covers the basic operation of the BS1201. The user must be knowledgeable in the application and testing of battery systems and the nature of high-voltage systems in order to use the device properly.

1 Introduction

The Bloomy Battery Simulator 1201 (BS1201) simulates twelve high voltage battery cells for testing battery management systems or other battery-centric control systems in research, integration, validation, and end-of-line test applications. With its 1,000V-rated isolation, it is capable of being used with other BS1201s to simulate battery packs of over 200 advanced-chemistry cells.

Each BS1201 unit provides twelve channels (cells) of isolated power, each channel capable of programmable voltage output of 0-5VDC and the ability to sink and source up to 500mADC. Built-in voltage and current readback for each cell provide highly accurate simulation as well as live feedback without the need for external monitoring equipment. And its onboard auxiliary analog and digital I/O can be used to simulate and monitor additional signals, including thermistors, pack current, safety, and environmental controls.

1.1 Key Features

- Cell Simulation
  - 12 independently-controlled cell channels
  - 0 to 5VDC output, sink/source up to 500mA/channel, +/-1mV, +/-1mA readback accuracy
  - 1,000VDC channel-to-earth ground isolation
  - 1,000VDC channel-to-channel basic isolation
  - 4-wire channel output for 4-wire sensing mode or local cell stacking mode
- Auxiliary I/O
  - 8x auxiliary analog inputs (0-5V)
  - 2x auxiliary analog outputs (0-5V)
  - 8x bi-directional digital interfaces (3.3V out, 3.3V/5V tolerant in)
- Safety
  - Safety compliant to IEC 61010-1 (Third Edition)
  - TTL remote shutdown
- Control
  - Up to 333Hz (200Hz nominal) cell control update rate
  - Ethernet TCP/IP, high-speed CAN
  - NI LabVIEW and Python drivers
  - CAN .dbc file
- Physical
  - 1U rackmount enclosure, 17.4"W x 1.72"H x 16.6"D, 15lbs
  - 0°C to 35°C, 20% to 80% relative humidity
  - 100-240VAC 50/60Hz input, 180W max.

1.2 Intended Uses

- Simulation of battery cell voltages, thermistors, and pack current for BMS production and design validation test
- Cell balancing current simulation up to 500mA sink/source for passive/active balancing
- Simulation of complete battery packs
- Monitoring BMS outputs (analog 0-5V and digital 3.3V)

2 General

2.1 Safety

Observe and follow all safety precautions while installing, operating, and servicing this equipment. Failure to comply with the safety precautions and warnings in this manual as well as safe engineering practices may result in injury to personnel or damage to the equipment.

2.2 Electrical

This equipment must be operated only by qualified personnel who understand these instructions, who recognize and can prevent electrical hazards, and who design and implement the necessary precautions and safeguards to prevent injury to personnel and damage to the equipment.

This instrument produces nonhazardous voltages, but the user may connect the unit in ways which may be hazardous. Appropriate precautions must be taken to protect personnel from hazardous conditions.

2.3 AC Input

Do not use an AC supply which exceeds the input voltage and frequency rating of this instrument. 100~240VAC 50/60Hz.

2.4 Grounding

This product is a Safety Class I instrument. The instrument chassis must be connected to an electrical ground to minimize shock hazard. The instrument must be connected to the AC mains through a three-conductor power cord with the ground wire firmly connected to the electrical safety ground of the AC mains.

2.5 Unit Ratings

Inputs and outputs of the equipment must not exceed the individual rating stated for each interface as specified herein or elsewhere. Exceeding these ratings will potentially damage the equipment.

2.6 System Usage

The BS1201 is intended to be used as an instrument for the simulation of series-connected cells associated with the testing of battery management systems and associated electrical components in a laboratory environment. Use the BS1201 only for its intended purpose. Observe and comply with all operating conditions stated in the data sheet, specification sheet, and user manual.

The BS1201 is to only be operated by qualified persons.

Use the BS1201 only with electrical signals for electrical measurement, control, and data. Do not connect the BS1201 outputs to mains or high transient voltages.

2.7 Environment

The BS1201 is designed for use indoors in a laboratory environment and is not for home or residential use. It is rated for a Pollution Degree 2. Air temperature, humidity, and altitude must be maintained as shown in *Specifications*.

2.8 Ventilation

The ventilation openings on the sides of the system must not be covered or obstructed. See the installation instructions (below) for clearance requirements.

2.9 Sound

Multiple units may create sound pressure levels exceeding 85dB. Wear appropriate hearing protection when using multiple units, or install the units in a sound-isolating equipment rack.

2.10 Installation

Installation of the equipment must be in accordance with these instructions. Safety for the use and incorporation of the equipment is the responsibility of the user.

Care and attention must be given to the following installation aspects of installation:

- Enclosure clearances and spacing (see 5.2)
- Earth ground provided via the AC line cord.
- High-voltage cell connections (refer to 5.4.1)
- Ensure the bottom of the unit is supported.

2.11 Connections

Make connections to the BS1201 only while the unit and any other connected equipment is unpowered. Making connections while the unit is powered may cause serious injury or damage to the unit.

Use only the cell connector specified in Section 0. Other connectors may mate properly to the unit but may not provide safe operation for voltages greater than 500VDC.

Use insulation and gage wire appropriate for the output load current and voltage.

Cables connected to the unit must be less than 30 meters in length.

2.12 Accessories

Use only accessories which meet manufacturer's specifications as defined in this manual, data sheet, and specification sheet.

2.13 Instrument Handling

Do not drop or impact the instrument. Transport the unit flat and upright in appropriate packaging.

2.14 Cleaning

Do not use water, solvents, chemicals, or other cleaning agents to clean the unit.

2.15 Service

The BS1201 is not user serviceable. Return the unit to Bloomy for maintenance or repairs. Removing the lid of the BS1201 may invalidate its isolation rating of 1,000VDC and safety rating.

2.16 Critical Component Rating

The BS1201 is not rated for use as a critical component in a nuclear control system, life support system, or safety control system.

2.17 Safety Symbols

The following symbols are present on the BS1201.

Caution is necessary when operating the device near the symbol.

This symbol is present on the rear panel of the unit.

High voltage of up to 1,000V may be present.

This symbol is present on the rear panel of the unit.

2.18 Compliance

This device complies with the essential requirements of the following applicable European Directives and carries the CE marking accordingly:

- Electromagnetic Compatibility (EMC) Directive 2014/30/EU
- Low Voltage Directive (Safety) 2014/35/EU
- RoHS Directive 2011/65/EU

Additionally, the BS1201 is compliant with the following standards:

IEC/EN 61010-1	Safety
EN 55011/FCC Part 15 Class A	Radiated Emissions
EN 55011/FCC Part 15 Class A	Conducted Emissions
EN 61000-3-2	Voltage Harmonics
EN 61000-3-3	Voltage Flicker
EN 61000-4-2	ESD Immunity
EN 61000-4-3	Radiated Immunity
EN 61000-4-4	EFT Immunity
EN 61000-4-5	Surge Immunity
EN 61000-4-6	Conducted Immunity
EN 61000-4-8	Magnetic Immunity
EN 61000-4-11	Voltage Dips and Drops

2.19 Warranty and Repairs

Bloomy Controls Inc. warrants this unit to be free of manufacturing defects for one year from the date of shipment from the factory.

Before returning the unit for service, contact Bloomy's customer support team to file an RMA request and provide a description of the problem with the unit as well as the serial number of the unit.

Estimates for non-warranty repairs will be provided for approval before repairs are performed.

2.20 Support and Feedback

For support with the BS1201 or any other Bloomy product, please submit a request through www.bloomy.com/request-support

Feedback on this manual and theBS1201 is encouraged. E-mail suggestions and feedback to: support@bloomy.com.

All technical support, including warranty and repair support will be provided by:

Bloomy Controls, Inc
68 Nutmeg Rd S.
South Windsor, CT 06074

2.21 Related Documentation

Manual (this document)

Describes installation and use of the BS1201, including detailed descriptions of unit installation, operating modes and functions, and intended use.

Specification Sheet

Provides detailed technical information on the performance characteristics of the BS1201

2.22 Related Software

BS1201 Soft Front Panel

Soft front panel for Ethernet and CAN (NI XNET-based) communications and control of one or more BS1201 units.

Drivers

Multiple driver sets are available for the BS1201 including Python and LabVIEW. In addition, CAN database (.dbc) files may also be provided.

3 Product Information

3.1 Block Diagram

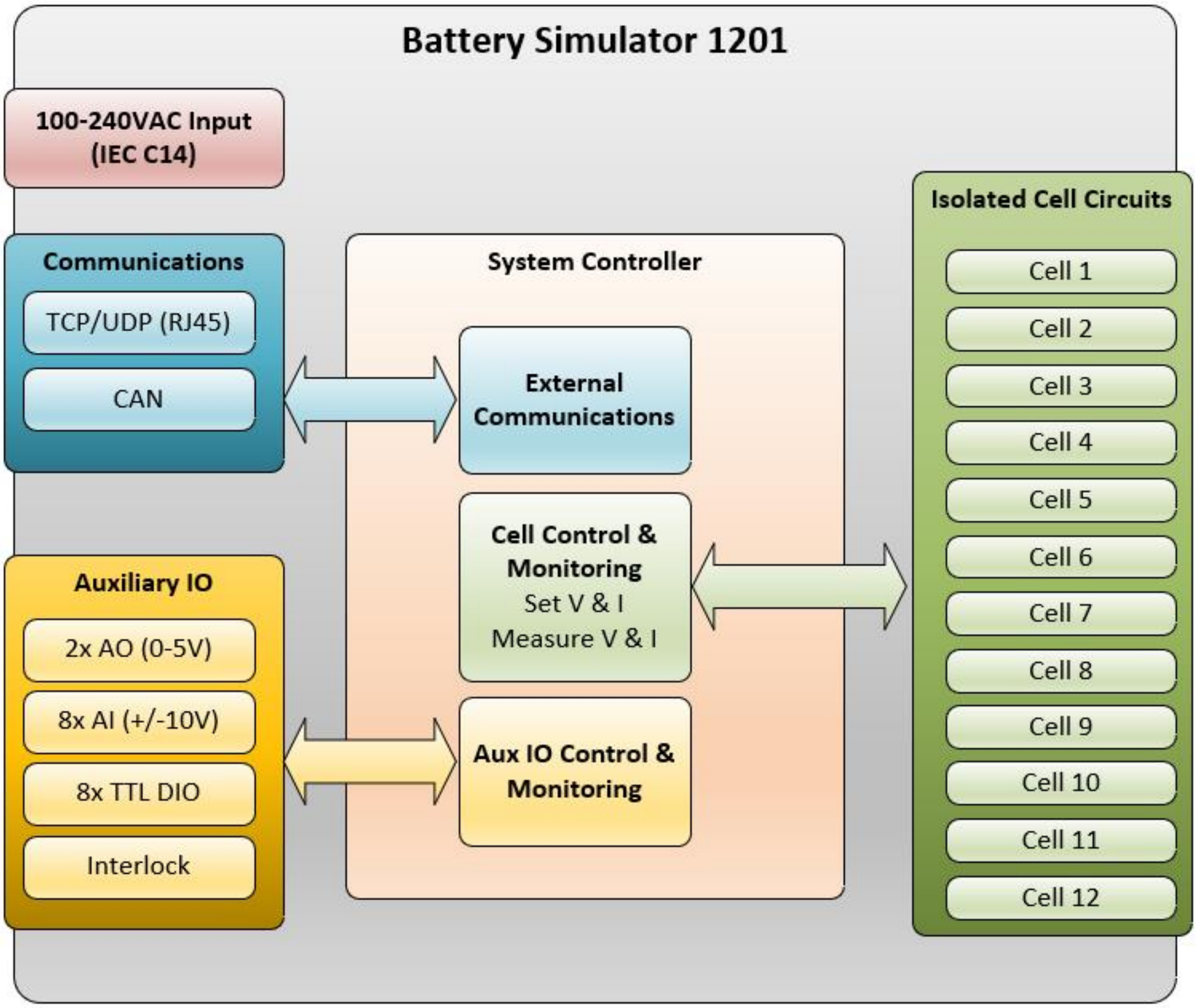


Figure 1: Block diagram of the BS1201

3.2 Equipment Ratings

3.2.1 Supply Rating

The BS1201 is designed for use with single phase AC power, 100-240VAC, 50/60 Hz and consumes 180W (max.). It is recommended to use the power supply cable that has been provided with the unit. An IEC/VDE certified replacement cable may be used.

3.2.2 Cell Connectors

Each cell is designed to output 5V at 500mA, maximum. Each cell can be controlled individually to sink or source power, up to a maximum of 2.5W. Cells can be connected in series up to 1000V.

⚠	Make cell connections **only** with the provided or recommended connectors to maintain 1,000V rating. **Use of any other connector may result in a hazardous condition.** **Do not use a different connector.**

Cell connections must be made while the unit is off. Do not touch cell connectors while voltage exceeding 500VDC is applied.

Wiring of external circuits to the cell connectors must be rated for the maximum voltage of the series-connected cells.

Component	Rated Voltage	Nominal Current
Cell Plug (Molex 39014041)	500VDC	5A

Table 1: Insulation ratings of connectors

3.3 Environmental conditions

The BS1201 is designed for indoor use in the conditions shown in the table below.

Operating Parameter	Operating Condition
Temperature	5°C – 35°C
Humidity	20% – 80 % (non-condensing)
Altitude	Up to 2000 meters
Pollution Degree	Pollution Degree II
Impact Rating	Impact resistance of 5J

Table 2: Environmental Conditions

3.4 Accessories

The table below provides a list of compatible accessories.

Accessory	P/N	Description
Fault Insertion Unit	Bloomy 1200-00047	Bloomy Battery FIU. Provides open-wire faulting and DMM connectivity to 24 cells (two BS120x's) per FIU.
Power Cord	Qualtek 312008-01	Power cord, black, NEMA 5-15P to IEC 320-C13, SJT, 7.5ft, UL and cUL listed
Cell Connector	Molex 39014041	Molex Mini-Fit Jr. 4-position plug
Cell Interface Cable Set	Bloomy 2900-00031	Set of 12 cell interface cables, 1000V, 1m. Each provides cell+, cell–, sense+, and sense – connections. Unterminated.
DB50 Cell Cable	Bloomy 2500-00671	Connects 12-cells from a BS120x to a single DB50F.
Cell Stacking Harness	Bloomy 2500-00766	Stacks 12 cells from a BS120x providing a single tap wire per cell.
CAN BS1201 Daisy-Chain Cable	Bloomy 2500-00721	3-pin male/BS1201 D25/3-pin female CAN daisy-chain cable. Connects a BS1201 to a 3-pin CAN bus.
CAN FIU Daisy-Chain Cable	Bloomy 2500-00722	3-pin male/FIU 12-pin/3-pin female CAN daisy-chain cable. Connects an FIU to a 3-pin CAN bus
CAN Adapter Cable	Bloomy 2500-00725	Adapts 3-pin CAN bus connector to standard CAN D9 connector. Use with CAN Daisy-Chain Cables as needed.

Table 3: BS1201 Accessories

4 Specifications

Refer to the BS1201 datasheet and specification sheet for detailed specifications.

5 Installation

5.1 Inspection

Before installation of the BS1201, perform a visual inspection of the unit.

> ⚠ Ensure there are no cracks or deformations to the unit and connectors. Damage may void the 1,000V isolation rating of the unit.
>
> If any cracks or visible deformations are seen, do not use the unit. Contact Bloomy Controls for support.
>
> Operating the unit with cracks or visible defects may cause injury or equipment damage.

5.2 Equipment Mounting

> ⚠ The BS1201 must be positioned horizontally and upright. Other orientations derate the isolation and capability of the unit and may be hazardous or cause damage to the unit.

> ⚠ The BS1201 must be positioned and installed so as not to obstruct access to, or prevent disconnection of, the AC input power cord.

> ⚠ Use hearing protection or a closed equipment rack when using multiple units to mitigate fan noise. When using a closed rack, ensure that ventilation is properly maintained.

When installing the unit in an EIA-standard, 19" equipment rack, observe the following precautions and design requirements:

- Provide each unit with adequate ventilation. Keep intake and exhaust vents clear of all obstructions.
- Ensure that the front panel remains user-accessible and faces the outside (front or rear) of the rack.
- Provide easy access to the power switch and ensure that the front panel indicators are visible to the user at all times.
- Ensure that bottom of unit is supported (do not rely solely on rackmount brackets).
- See Figure 1 for clearance requirements

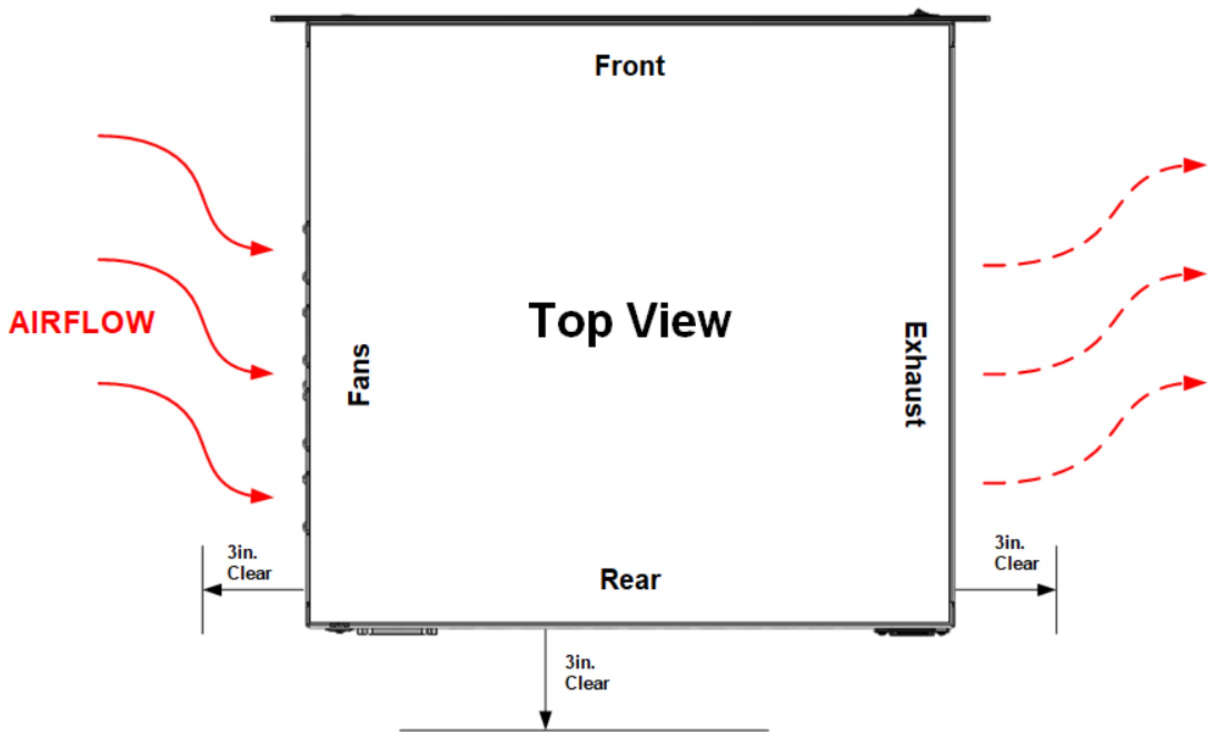


Figure 1: Unit clearances for intake and exhaust

5.3 Unit Overview

The sections below describe the key components and connectors of the unit.

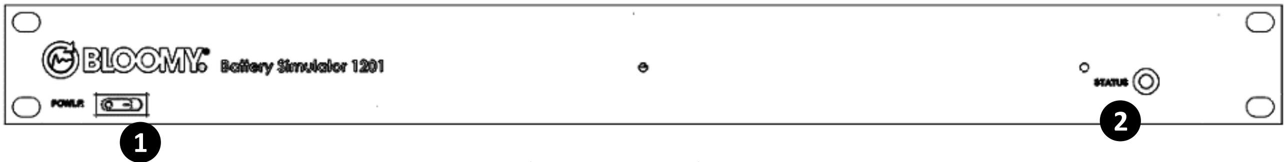


Figure 2: Front View

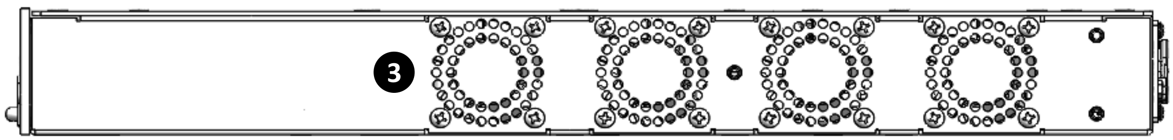


Figure 3: Right Side View

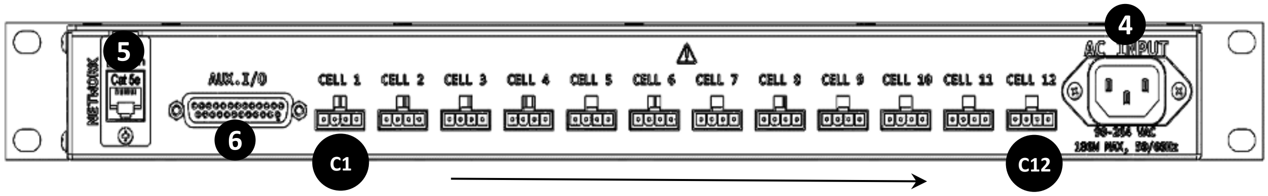


Figure 4: Rear View

Item	Name	Details	Description
1	Power Switch	Toggle Switch	Turns unit on/off
2	Status LED	Green LED	Displays unit status. Steady green indicates normal operation. Blinking indicates system error.
3	Exhaust Fans	4x exhaust fans	Provide fresh air for unit cooling.
4	AC Input Connector	IEC C14	Provides power to the unit
5	Ethernet	RJ45	Ethernet connector for device control and monitoring
6	AUX	D25, female	Auxiliary I/O connector for CAN, AIO and DIO.
C1-C12	12x cell connectors	4-pin Molex Mini-Fit Jr.	Cell connections

5.4 Connectors, Switches, Indicators

5.4.1 Cell Connectors

The twelve cell connectors provide the cell simulation outputs of the BS1201. Refer to Section 5.5 for detailed instructions on cell wiring and series cell connection.

Connector	Part Number	Details
Unit Connector	Molex 39-01-4041	4-position, 1 level, PCB mount
Mating Connector	Molex 39-00-0429	4-position, 1 level, 9A max., 18-24AWG

⚠ Use only the mating connector specified above.

Use of this connector is required for stacked (series-connected) cell outputs greater than 500V.

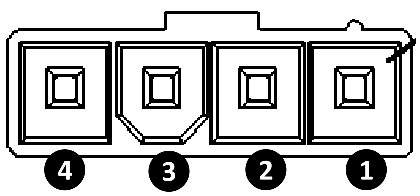


Figure 5: Molex 39-01-4041 Unit Connector, Face View

Pin	Function	Description
1	$V_{sense}+$	Positive sense
2	$V_{out}+$	Positive cell output
3	$V_{out}-$	Negative cell output
4	$V_{sense}-$	Negative sense

Table 4: Cell Connector Pinout

When $V_{sense}\pm$ are connected to the load, the BS1201 will compensate for voltage drop across the cell output load and can compensate for up to 500mV loss, total. Connection of the sense lines is not required for operation, though compensation will not occur.

5.4.2 Auxiliary I/O Connector

The Auxiliary (Aux.) I/O connector exposes the auxiliary analog and digital I/O and interlock signals of the BS1201. See Section 6.5 for detailed usage instructions for the auxiliary I/O and interlock signals. All auxiliary I/O signals are low voltage and non-isolated and cannot be used for isolated signal measurements or generation.

Connector	Part Number	Details
Unit Connector	Tyco 1658613-2	DB25 female, PCB-mount
Mating Connector*	DB25 male	DB25 male, crimp or solder

* Any commercial-quality DB25 male connector can be used with the Aux. I/O connector.

The signals on the Aux. I/O connector are described below.

Analog I/O Connection	Description
Analog Inputs 1 – 8	Single-ended inputs, referenced to GND, 0-5VDC max.
Analog Output 1 – 2	Single-ended outputs, referenced to GND, 0-5VDC
CAN+, CAN–	Controller Area Network connections
Digital I/O 1-8	3.3V digital I/Os independently configurable as inputs or outputs, 3 mA max. source/sink current
GND	Ground

Table 5: Aux. I/O Signal Descriptions

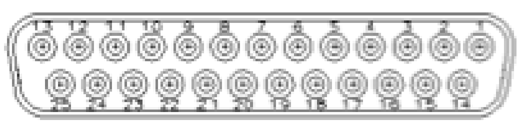


Figure 6: Aux I/O Connector Pinout, Face View

Pin	Function	Pin	Function
1	AI1	**14**	AI2
2	AI3	**15**	AI4
3	AI5	**16**	AI6
4	AI7	**17**	AI8
5	GND	**18**	GND
6	AO1	**19**	AO2
7	GND	**20**	DIO1/Interlock In
8	DIO2/Interlock Out	**21**	DIO3
9	DIO4	**22**	DIO5
10	DIO6	**23**	DIO7
11	DIO8	**24**	GND
12	GND	**25**	CAN-
13	CAN+		

Table 6: Aux. I/O Connector Pinout

5.5 Cell Wiring

Bloomy Controls Inc. may provide standard cell output cables. It is expected, as the intended use of the equipment includes research and development, that custom wiring may be necessary. The following instructions must be followed to wire the unit safely.

Refer to Section 5.4.1 for cell connector pinouts.

⚠ Battery Simulator 1201 must be mounted in an enclosure if stacked cell voltages are expected to exceed 500VDC.

⚠

The use of UL listed wire is recommended.

Wire insulation must be rated for the maximum voltage of the application.

V_{out}+ and V_{out}– wire must be sized for the full battery management system balancing current (minimum 20AWG recommended, 18AWG preferred)

V_{sense}+ and V_{sense}– wire may be 22-24AWG.

5.6 Stack Voltage Safety Requirements

The channels of the BS1201 are intended to be connected in series, or "stacked" to simulate a battery pack or module. Cell stacking is accomplished using external wiring. Safety requirements are different depending on the overall stack voltage.

⚠

When stacking multiple cells from multiple units or with external sources, hazardous voltages up to 1,000VDC may be present.

Do not touch or interact with cell connectors if the stack voltage exceeds 500VDC.

5.7 Cell Stacking

The intended purpose of the BS1201 is to simulate the series connected cells of a battery pack. The figures below show how multiple cells of a BS1201 may be connected in series to simulate the cells in a battery pack.

Mode	Description	Usage	Pros	Cons
Remote Sense, Remote Stack	4-wire connections to BMS. Voltage and Sense lines are run to BMS. Stacking is performed at the BMS.	Production Test, BMS Calibration	Line loss compensation. Higher voltage accuracy voltage at BMS during balancing/current draw	Requires connecting 4 wires into a single pin on the BMS. More difficult connectivity.
Local Sense, Remote Stack	Local sensing at the BS1201. Cells are stacked at the BMS. local to the BS1201.	HIL, Validation, mimicking "real world"	Quicker connectivity to BMS, flexibility to change stacking configuration for different BMSs	No line loss compensation at BMS Bigger voltage drop during balancing
Local Sense, Local Stack	Individual cells are stacked local to the BS1201. BMS Tap wires run from the V+ pin on each cell.	HIL, Validation, mimicking "real world"	Quickest connectivity (single wire per BMS cell)	No line loss compensation at BMS Bigger voltage drop during balancing. BMS stacking is least configurable.

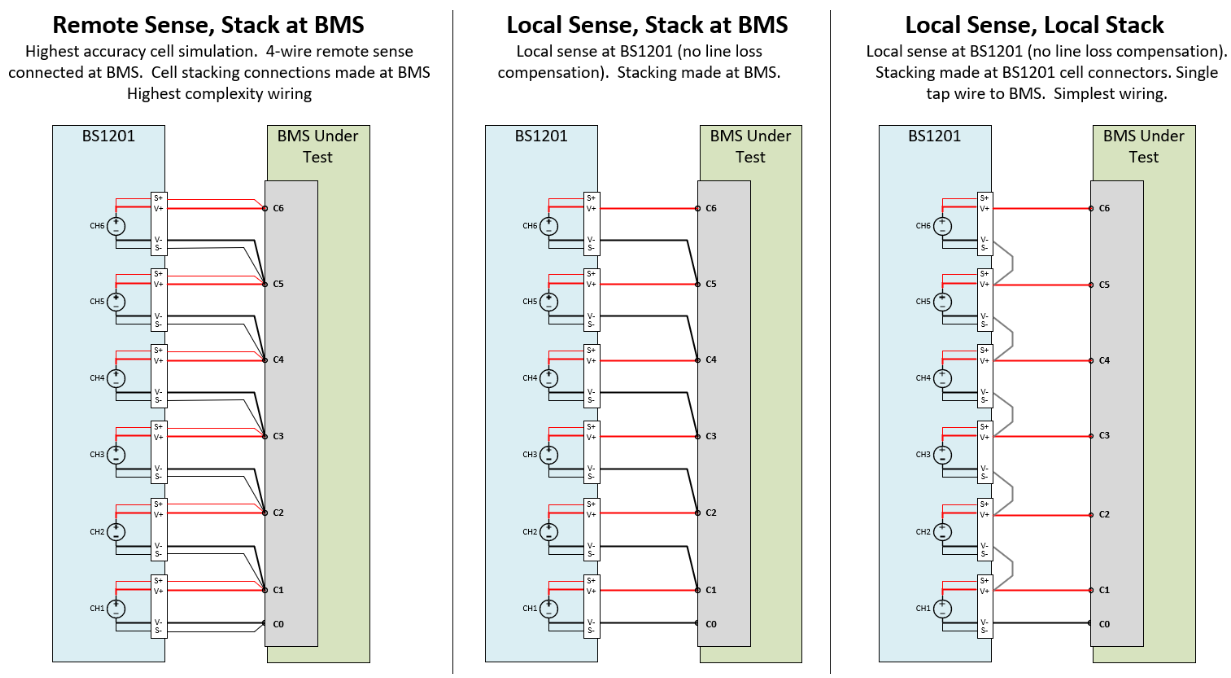


Figure 7: Cell stacking connectivity options

5.8 Stacking Multiple BS1201s

The cells from multiple BS1201 units may be stacked to create packs of greater than 12 cells. When stacking multiple BS1201s, simply stack Cell 12 of the lower BS1201 to Cell 1 of the upper BS1201 as shown in the figure below. While the figure below shows a local sense/local stack configuration, any of the three stacking modes above may be used when stacking multiple cells from multiple units.

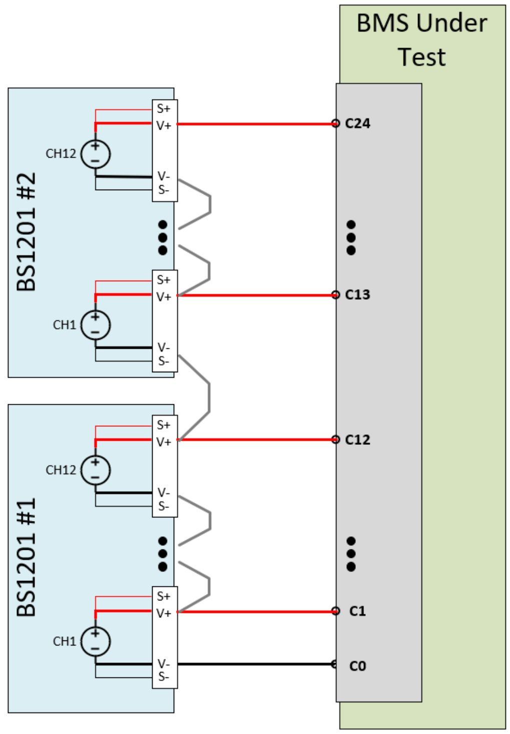


Figure 8: Stacking of multiple BS1201 units

5.9 Series Stacking with an External Voltage Source

BS1201 cells may be stacked in series with an external voltage source. When stacking with an external voltage source, the following conditions must be met:

- External source current must be limited to 500mA.
- External source must be CE marked or UL listed.
- External source + stack voltage must not exceed 1,000VDC from earth ground, including any transients.
- External source noise and ripple may affect individual cell noise. A low noise/ripple source is recommended for sensitive applications.

5.10 Parallel Connectivity

Parallel connection of cells is ***not*** supported. Do not connect cell outputs in parallel.

6 Operation

The BS1201 must be connected to a computer for external control. All control of the instrument is performed via remote communications. A Windows-based soft front panel is provided for ease of unit setup and testing, though many applications will use the command ICDs or supplied drivers for automated control of the instrument. Each aspect of the BS1201's operation is discussed further below.

6.1 Cell Output

The twelve BS1201 cell outputs act as individual isolated sink/source programmable power supplies capable of 0-5VDC and ±500mA. Each cell can operate at maximum sourcing or sinking power indefinitely. Cell setpoints may be controlled individually or in bulk by using the messaged defined for each communication protocol. Control parameters include:

- Cell Voltage – The desired output voltage of the cell
- Cell Source Current Limit – the maximum current limit of the output when sourcing
- Cell Sinking Current Limit – the maximum current limit of the output when sinking
- Enabled State – On/off state of the cell

The BS1201 can operate in one of two modes and will automatically switch between the modes based on external conditions.

6.1.1.1 Constant Voltage

Constant Voltage (CV) is the appropriate operating mode for most applications. In CV mode, the BS1201 regulates output voltage while monitoring cell voltage and current. To stay in CV mode, the programmed sourcing and sinking current limits must be greater than the current expected through the device being tested. Whether the BS1201 sources or sinks current is determined by the voltage across the device and its nature.

If the device is a resistive load or if it maintains a lower voltage than the voltage setpoint, the BS1201 will source current. If the device maintains a higher voltage than the voltage setpoint, the BS1201 will sink current. The BS1201 will automatically transition between sourcing and sinking as the external conditions change.

When regulating voltage in CV mode, the remote sense wires of each cell output can compensate for up to 500mV of conductor loss in the wiring. Remote voltage compensation is enabled when 4-wire connections are used.

6.1.1.2 Constant Current

When the current required by the device being tested exceeds the sourcing or sinking current limit setpoints, the BS1201 will transition to a constant current (CC) mode. In CC mode, the BS1201 regulates the output current while monitoring voltage and current readback. CC mode is valid for both sourcing and sinking outputs, with different limit setpoints for each. The BS1201 can source or sink as much as 500mA at 5VDC indefinitely without damage.

6.2 Cell Readback

Each cell continually measures its voltage and current. Cell voltages and currents are reported back over each of the communications interfaces (see Section 6.7).

In Ethernet mode, this data is reported via UDP frames transmitted at a user-configurable interval which defaults to 5ms intervals. In CAN mode, the BS1201 transmits data via cyclic CAN frames at a user-configurable rate which defaults to 5ms intervals. See the BS1201 Communication Specification for details on both communication methods.

6.2.1 Precision Readback Mode

The BS1201 has a specialty Operation Mode, called Precision Mode, which reduces readback noise by implementing a readback data filter. When ON, readback data may be delayed by up to 5mS vs Standard Mode. Precision Mode may be turned on via the Set Operational Mode command (see Section 8).

6.3 Cell Enable/Disable (Sleep)

Cells can be enabled or disabled either individually or all at once. Disabling the cells is equivalent to setting all current limits and voltages to zero. Internal power to the cell is maintained for rapid wakeup.

When a cell is programmatically re-enabled, the cell will automatically return to the previously-commanded voltage and current setpoints.

Cell power is only completely removed from the cell simulation circuit on failure of the hardware interlock or during alarm or fault condition.

6.4 Auxiliary I/O Control

The BS1201 includes an auxiliary I/O connector with analog and digital inputs and outputs. (See Section 5.4.2 for connector pinout.) Note that auxiliary I/O is not isolated from ground and cannot be used for isolated signal generation or measurements without an external isolator.

The BS1201 provides eight 0-5VDC analog inputs which can be used to monitor external voltages. Measured voltages are reported back over each of the communications interfaces. It also provides two 0-5VDC analog outputs which may be used to simulate thermistors, pack current, or other system-level signals. These are also commanded via the communication interfaces.

Eight bi-directional digital interfaces are provided for monitoring external digital signals or controlling external devices such as contactors or relays. When configured as inputs, logic low corresponds to a voltage of less than 1.8V. An input of greater than 1.8V is interpreted as a logic high. When configured as an output, 0V corresponds to logic low and 3.3V corresponds to logic high.

Do not exceed 3mA per channel for digital outputs and 10mA per channel for analog outputs.

6.5 Interlock

The BS1201 has a safety interlock function which will inhibit the output in the event that the interlock loop is broken. When the interlock is connected, the BS1201 will function as normal. When broken, the BS1201 outputs will be disabled, and readback will show 0V. Note that the current readback will show -500mA. This is not real current, but an artifact of the inhibit functionality, which completely disables the cell power, causing internal references to show 0V.

To set up the inhibit functionality, first enable the feature in the BS1201 configuration via the Soft Front Panel Application (this will persist after startup), then use the DIO1 and DIO2 pins for the interlock hardware signals.

The BS1201 Inhibit uses the DIO1 (Pin 20) and DIO2 (Pin 8) on the DB25 Auxiliary IO connector. Pin 20 must be pulled down to GND (pin 5 or pin 18).

To enable the BS1201 output, connect Pin 8 (source) to Pin 2 (measurement). To disable the BS1201 output, disconnect the connection. When re-enabling the BS1201 output, all cells will start up at 0V. Setpoint commands (Enable, Current, Voltage) must be re-sent.

The figures below show recommended connectivity for a single or multiple BS1201 units.

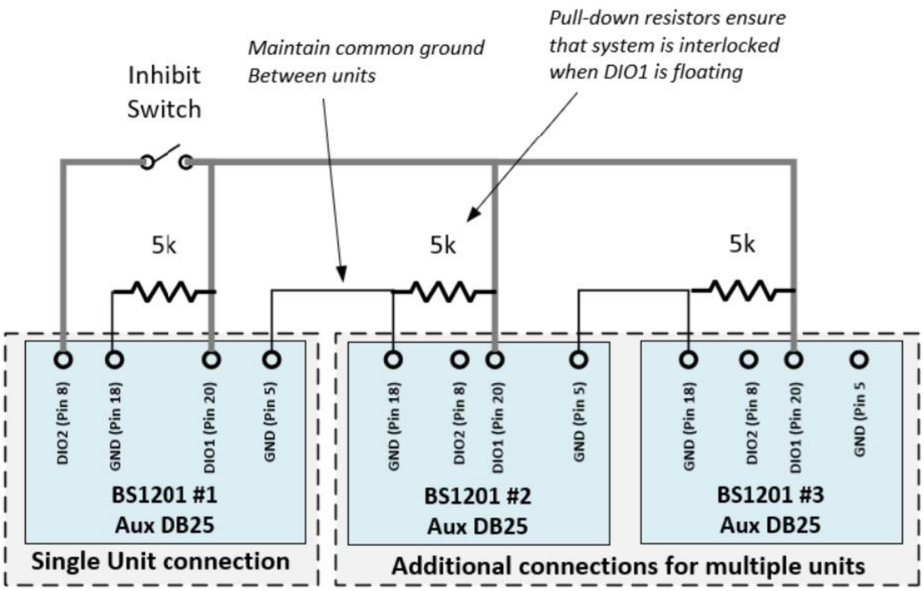


Figure 9: Interlock wiring diagram

6.6 Fan Operation

The BS1201 uses four fans to dissipate the heat generated by the instrument. On powerup, the power supply fan is set to high speed, then reduces to low after a few seconds. The fans will increase in speed based on a combination of the unit's internal temperature and cell power dissipation.

If a fan failure is detected or if the internal temperature exceeds 60C, the outputs will be disabled and the front LED will to blink continuously to. Fan status and internal temperature can be monitored via the BS1201's communications interfaces. If a fan fault occurs, return the unit for repair.

6.7 Remote Programming

The only means to control and monitor the BS1201 is via remote programming interfaces. The BS1201 can communicate over Ethernet via TCP/IP or UDP and using CAN. Refer to the *BS1201 Communication Specification* for detailed configuration and message information required to communicate with the unit.

When using multiple units controlled via Ethernet are installed on the same network, each unit must have a unique IP address and broadcast UDP port. If multiple units are used on the same CAN bus, each unit must have a unique Unit ID.

6.7.1 Modes of Operation

The Battery Simulator 1201 uses three modes: Standard Operating Mode and Hardware-in-the-Loop (HIL) Mode, and an additional Precision Mode (new for the BS1201). The Standard Operating Mode is commonly used in validation and verification systems while the HIL mode is used to maximize update rate, e.g., when running mathematical models in an HIL System, and maximizes the efficiency of CAN communication.

6.7.1.1 Standard Mode

In Standard Mode, the instrument gives equal priority to incoming CAN frames. Disabling HIL Mode or Precision Mode returns the instrument to Standard Mode.

6.7.1.2 HIL Mode

When in HIL Mode, the Battery Simulator 1201 gives priority to the incoming frames associated with cell voltage control to reduce control latency and optionally disables publishing of auxiliary analog input and digital input readback data to the CANbus. 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. While voltage and current readback for all cells is always transmitted onto the CAN bus, Analog Input and Digital I/O readback are disabled by default, though they may be enabled using a Configure frame.

Once HIL Mode is set, the Battery Simulator will execute only the commands defined as “active” in the tables defined in Sections 8.1.1.1 and 8.1.1.2.

By default, all auxiliary IO configuration channels are set to “disabled” in HIL Mode. To change this option, the Box Mode and Configure frame must be used (See Section 0).

Note: The Configure frame is ignored by the instrument in HIL Mode. Disable HIL Mode before using a Configure frame.

6.7.1.3 Precision Mode

When Precision Mode is enabled, cell voltage and current readbacks are reported as a ten-point rolling average (corresponding to 2ms of data) to reduce overall noise and improve readback precision. When Precision Mode is off, cell voltage and current readbacks are reported as instantaneous measurements. Precision Mode can be enabled while HIL Mode is enabled.

6.7.2 Ethernet Control (TCP & UDP)

The BS1201 utilizes both TCP/IP and UDP for Ethernet communication. TCP/IP is used for commands to the BS1201, and UDP is used for the BS1201 to publish periodic readback data. Refer to the Section 8 for specific details.

6.7.2.1 BS1201 default settings

Default IP Address	**192.168.1.101***
Subnet Mask	255.255.255.0
UDP Broadcast Port	**54321***
TCP Command Port	12345 (Do not modify)
UDP Broadcast Period	5mS

*Note: each BS1201 on a network must have a unique IP address and UDP Broadcast Port

6.7.2.2 PC Network Settings

The PC or Controller Network Interface Card (NIC) should be configured with the following settings*:

Mode	Static
IP	192.168.1.XXX, where XXX is unused by other instrumentation and where XXX cannot be 1 or 255.
Subnet Mask	255.255.255.0
Open Ports in firewall	54321-54350 – UDP, inbound readback data 58431 – UDP, inbound configuration info 12345 – TCP, outbound control of unit

* Refer Section 8 for detailed instructions on opening ports on a Microsoft Windows based PC.

6.7.3 CANbus

The BS1201 can communicate via CANbus. Refer to the BS101 Communication Specification for CANbus message details. CAN database (.dbc) files are available to import can frames and channels into third-party applications. The BS1201 publishing period is 5mS (200Hz) by default but can be modified as required to speed up or slow down the publishing of data. As more BS1201s are populated onto a CAN network, the publishing period must be increased to prevent overflow of the CAN bus. Note that the table below is a guideline. Additional traffic, or commands sent to the BS1201, may add traffic, requiring the publish period to be slowed down further.

6.7.3.1 CANbus bandwidth Rates

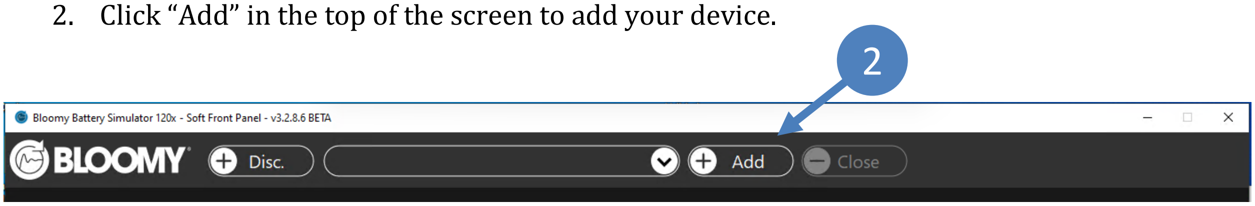
Unit Quantity	Recommended publish period
1-2	5mS
3-4	10mS
5-6	15mS
7-8	20mS

7 BS1201 Client Application

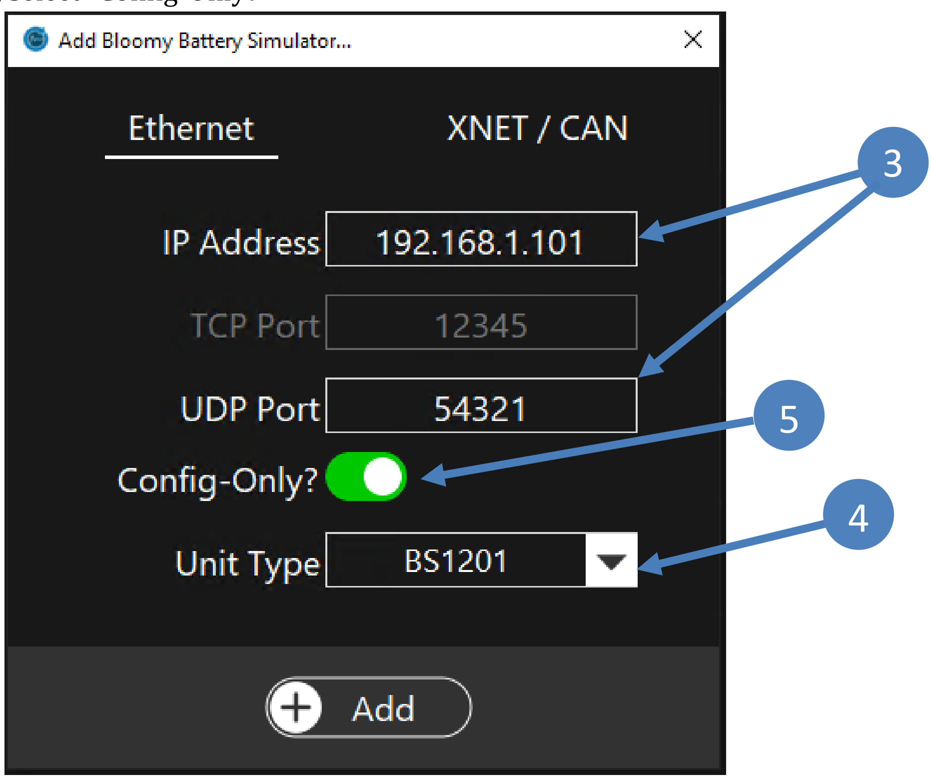
The BS1201 Client Application allows controlling and monitoring multiple BS120X devices via Ethernet or NI XNET CAN.

7.1 Adding Devices Individually

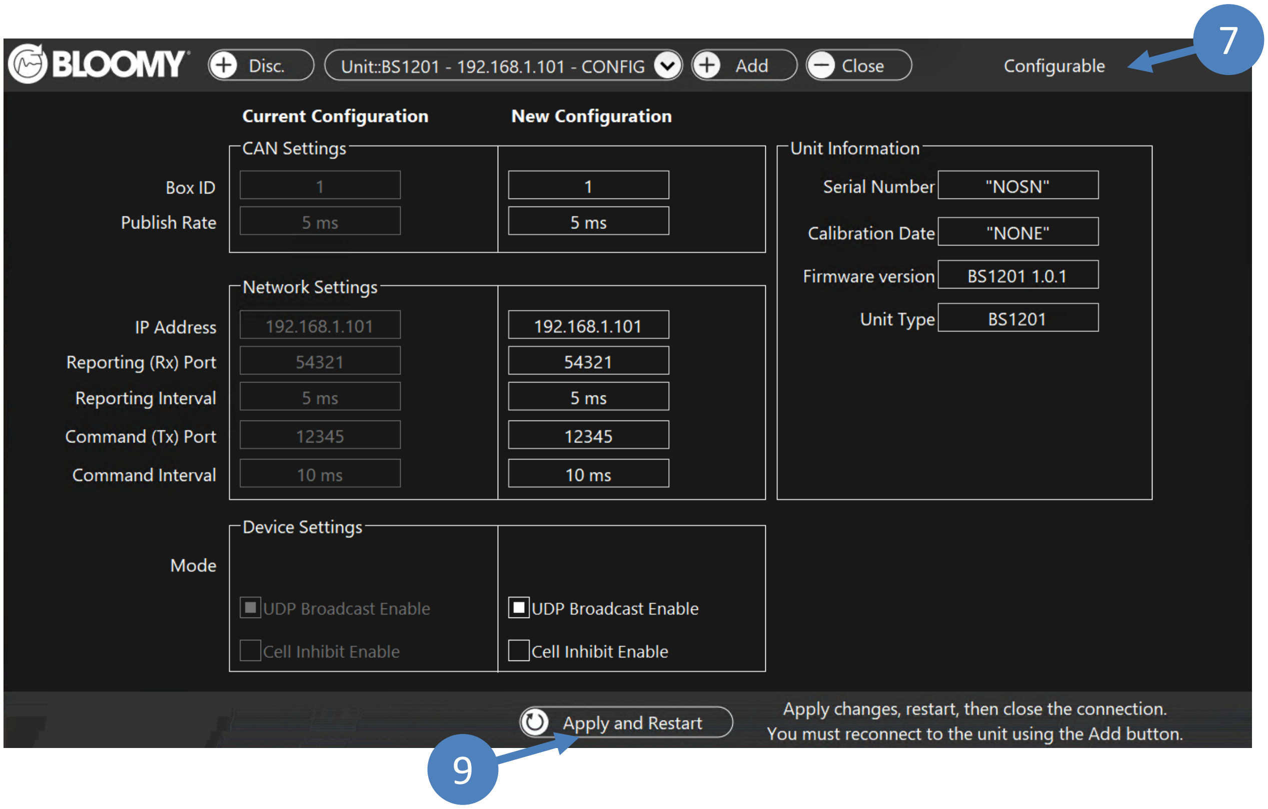
1. Open the Bloomy Battery Simulator 120X Soft Front Panel from location chosen during installation.
2. Click “Add” in the top of the screen to add your device.



3. Enter the IP address and UDP port (Default = 192.168.1.101, Port 54321
4. Select **BS1201** as the unit type.
5. To configure, select “Config-Only?”

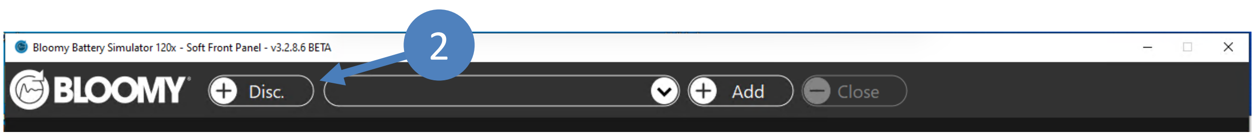


6. Click “Add” to enter the configuration screen.
7. Wait until the status in the top right corner says “CONFIGURABLE” before making any changes.
8. Update CAN Box ID, IP address, enable cell inhibit functionality, and other parameters as needed.
9. To apply changes, click “Apply and Restart”.

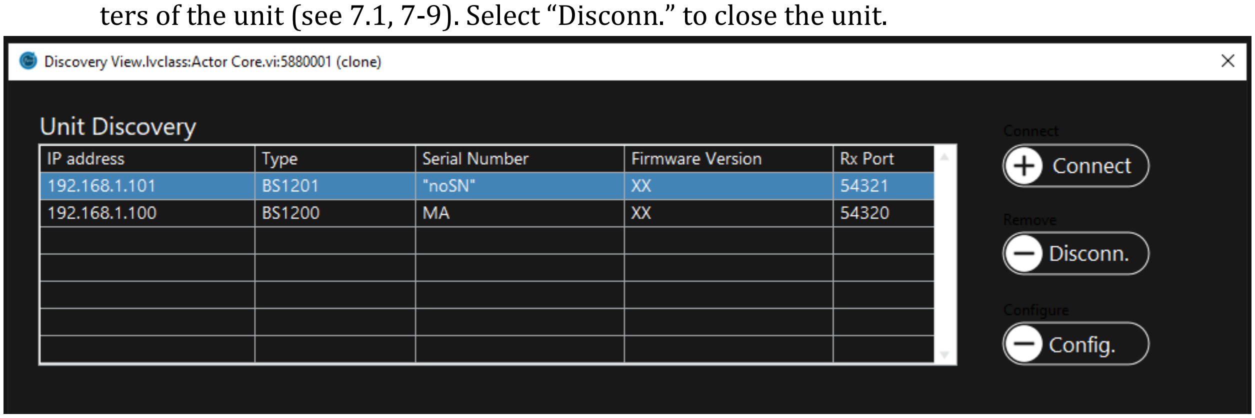


7.2 Adding Devices Automatically (Discovery)

1. Open the Bloomy Battery Simulator 120X Soft Front Panel from location chosen during installation.
2. Click “Disc.” at the top of the screen.

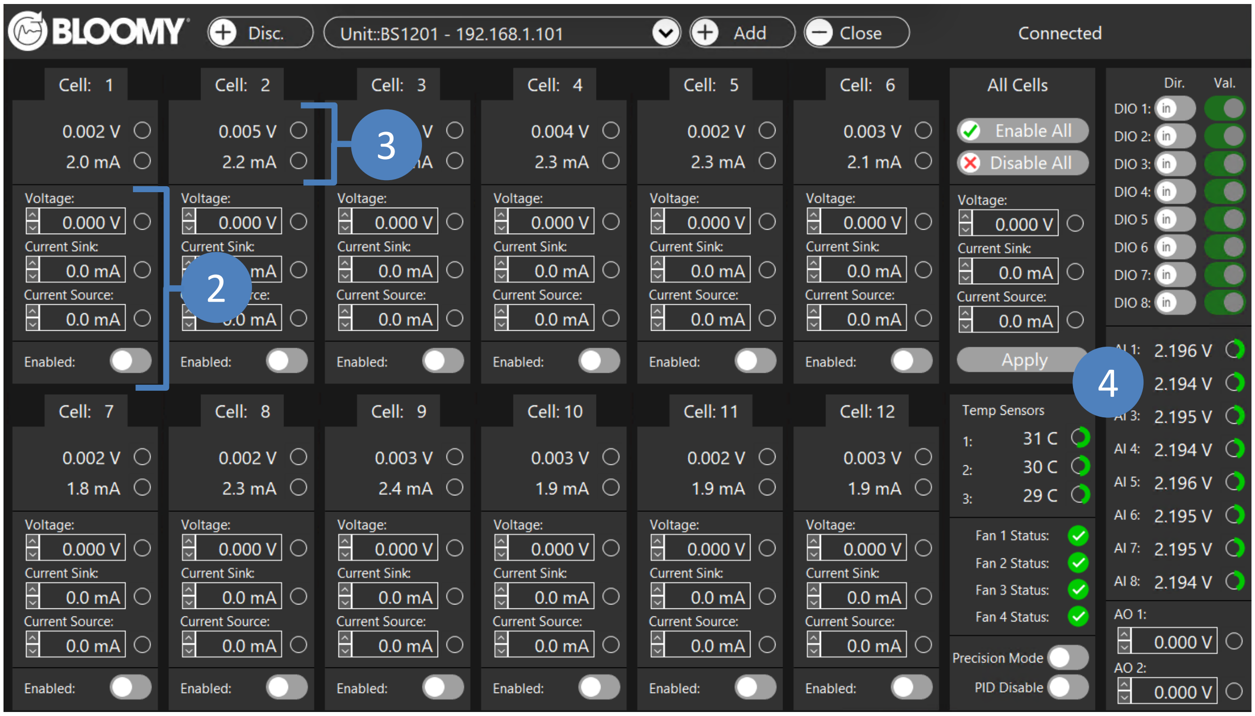


3. Select your desired unit.
4. Select “Connect” to enter the device status screen. Select “Config” to configure the parameters of the unit (see 7.1, 7-9). Select “Disconn.” to close the unit.



7.3 Navigating the BS120X Client Panel

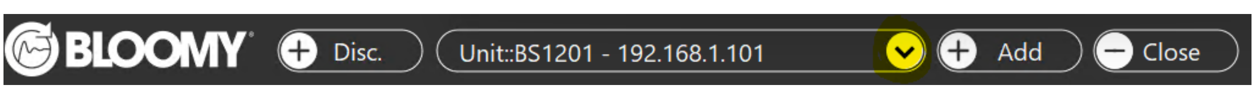
7.3.1 Using the Device Status Panel



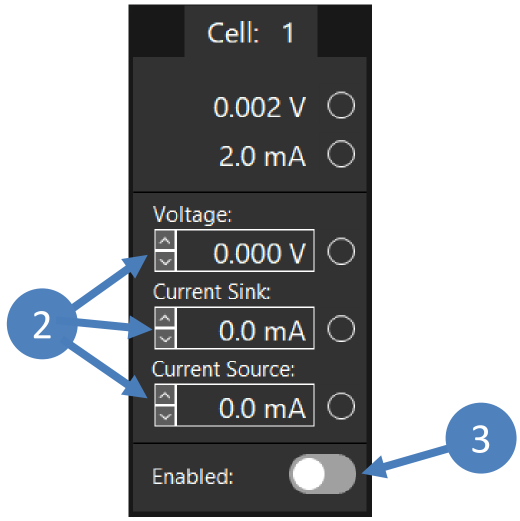
1. Click "Connect" to start interfacing with the BS120X.
2. At the bottom of each cell are the **controls.**
   a. **Current Sink** should be entered in **negative** values.
   b. Current Source should be entered in **positive** values.
3. At the top are the **readback** values.
4. Additional I/O and status information are on the right side of the screen.

7.3.2 Setting a Single Cell

1. Verify that the device you wish to use is selected in the top drop-down menu. Disconnect and click the down arrow to choose a different device.



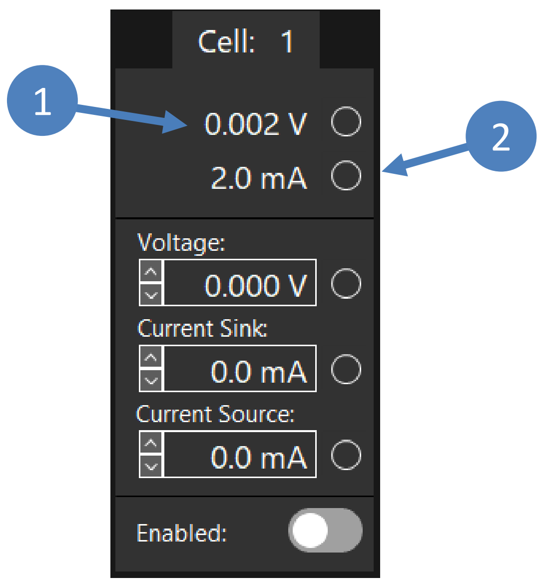
2. Use the arrows to adjust the associated Voltage, Sinking Current, and Sourcing Current set-points for each individual cell.
3. Click on the switch labelled "Enable" at the bottom of the cell to put the cell in the enabled state.



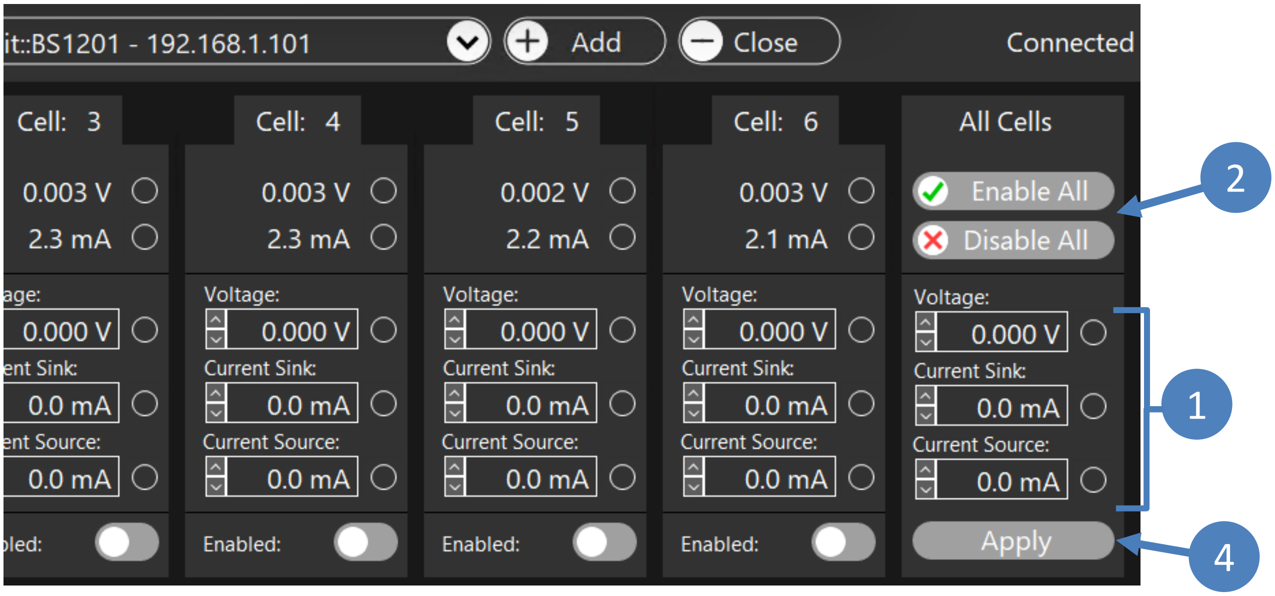
7.3.3 Monitoring Cell Readback

1. **Cell voltage readback** is located in the top of the cell.
2. **Cell current readback** is located right below voltage readback.

These display the output values of each individual cell at the given point in time.



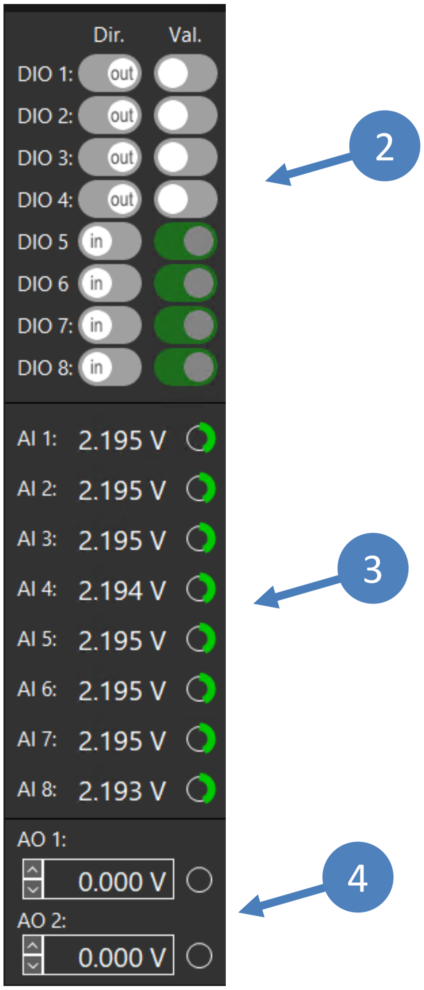
7.3.4 Setting Multiple Cells



1. The section on the far right contains controls for voltage and current for **all twelve cells**.
2. Configure enable/disable for all cells.
3. View values in individual cell readback sections.
4. Remember to click "**Apply"** after making any changes to Multi-Cell Control.

7.3.5 Using Auxiliary Analog and Digital Inputs and Outputs

1. See section 6.4 for I/O pinout information.
2. Eight **digital I/O** channels can be individually toggled as an input ("in") or output ("out"). These are located in the top right corner of the interface.
3. Eight **analog input** (0-5V) channels are in the middle right side of the interface.
4. Two **analog output** channels can be set in the bottom right corner of the interface.



Note: All analog inputs are internally protected if left externally floating. Voltages observed for floating inputs should be disregarded, as they are an artifact of the internal protection bias. These bias voltages are "weak" and will be overridden once no longer floating.

8 Communications Specifications

8.1 CAN

The BS1201 CAN bus runs at 1 MBaud (unless configured to a different value). The BS1201s should always share a CAN network separate from other devices.

8.1.1 Frames List

All messages use 11 bit arbitration IDs. The least significant 4 bits specify the BS1201 Box ID. For example, when sending a Cell Enable All frame to BS1201 Box ID #1, the arbitration ID of 0x541 must be used. Readback values being sent by the BS1201 work in a similar fashion. The default BS1201 Box ID is shown on the label located on the top cover of the BS1201.

8.1.1.1 Incoming Frames (to BS1201)

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
41	65	410	1040	Operational Mode 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

8.1.1.2 Outgoing Frames (from BS1201)

Msg ID		Base Arb ID		Description	Frame Active in HIL Mode?
[Hex]	[Dec]	[Hex]	[Dec]		
10	16	100	256	BS1201 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

8.2 Incoming Frames (to BS120x)

8.2.1 HIL Mode Start/Stop Trigger (HIL_Mode)

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

8.2.2 Cell Voltage Setpoints 1-4 (Cell_V_Set_1_4)

Signal	Start bit	# of bits	Scaling Factor	Scaling Offset	Range	Unit
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

8.2.3 Cell Voltage Setpoints 5-8 (Cell_V_Set_5_8)

Signal	Start bit	# of bits	Scaling Factor	Scaling Offset	Range	Unit
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

8.2.4 Cell Voltage Setpoints 9-12 (Cell_V_Set_9_12)

Signal	Start bit	# of bits	Scaling Factor	Scaling Offset	Range	Unit
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

8.2.5 DIO Setpoints 1-8 (Digital_IO_Set_1_8)

Signal	Start bit	# of bits	Scaling Factor	Scaling Offset	Range	Unit
DIO Output	0	8	1	0	00-FF	N/A
DIO Direction	8	8	1	0	00-FF	0: input 1: output

8.2.6 AO Setpoints 1-2 (Analog_Out_Set_1_2)

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

8.2.7 Box Mode and Message Configure (Configure)

Signal	Start bit	# of bits	Scaling Factor	Scaling Offset	Range	Unit
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

8.2.8 Operational Mode Configure

Signal	Start bit	# of bits	Scaling Factor	Scaling Offset	Range	Unit
Calibration_Enable	0	1	1	0	0 or 1	N/A
PID_Disable	1	1	1	0	0 or 1	N/A
Precision_Mode_Enable	2	1	1	0	0 or 1	N/A

8.2.9 Cell Current Set All (Cell_I_Set_All)

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

8.2.10 Cell Current Sink Setpoint (Cell_I_Sink_Set)

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

8.2.11 Cell Current Source Setpoint (Cell_I_Source_Set)

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

8.2.12 Cell Voltage Set All (Cell_V_Set_All)

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

8.2.13 Cell Voltage Setpoint (Cell_V_Set)

Signal	Start bit	# of bits	Scaling Factor	Scaling Offset	Range	Unit
Channel (0-based)	0	8	1	1	0 to 11	N/A
Cell_Voltage	8	16	0.0001	0	0 to 5	V

8.2.14 Cell Enable All

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

8.2.15 Cell Enable (Cell_Enable)

Signal	Start bit	# of bits	Scaling Factor	Scaling Offset	Range	Unit
Channel (0-based)	0	8	1	1	0 to 11	N/A
Enable	8	1	1	0	0 or 1	N/A

8.3 Outgoing Frames (from BS120x)

8.3.1 BS1201 Status (System_Status)

Signal	Start bit	# of bits	Scaling Factor	Scaling Offset	Range	Unit
Fan_Fail_1	0	1	1	0	0 = OK, 1 = Fail	N/A
Fan_Fail_2	1	1	1	0	0 = OK, 1 = Fail	N/A
Fan_Fail_3	2	1	1	0	0 = OK, 1 = Fail	N/A
Fan_Fail_4	3	1	1	0	0 = OK, 1 = Fail	N/A
Inhibit_State	4	1	1	0	0 = Disabled 1 = Enabled	N/A
Temp_Sensor_1	8	8	1	0	0 to 255	°C
Temp_Sensor_2	16	8	1	0	0 to 255	°C
Temp_Sensor_3	32	8	1	0	0 to 255	°C

8.3.2 Cell Voltages Readback 1-4 (Cell_V_Readback_1_4)

Signal	Start bit	# of bits	Scaling Factor	Scaling Offset	Range	Unit
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

8.3.3 Cell Voltages Readback 5-8 (Cell_V_Readback_5_8)

Signal	Start bit	# of bits	Scaling Factor	Scaling Offset	Range	Unit
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

8.3.4 Cell Voltages Readback 9-12 (Cell_V_Readback_9_12)

Signal	Start bit	# of bits	Scaling Factor	Scaling Offset	Range	Unit
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

8.3.5 Cell Currents Readback 1-4 (Cell_I_Readback_1_4)

Signal	Start bit	# of bits	Scaling Factor	Scaling Offset	Range	Unit
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

8.3.6 Cell Currents Readback 5-8 (Cell_I_Readback_5_8)

Signal	Start bit	# of bits	Scaling Factor	Scaling Offset	Range	Unit
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

8.3.7 Cell Currents Readback 9-12 (Cell_I_Readback_9_12)

Signal	Start bit	# of bits	Scaling Factor	Scaling Offset	Range	Unit
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

8.3.8 DIO States 1-8 (DIO_Readback_1_8)

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

8.3.9 AI Readback 1-4 (AI_Readback_1_4)

Signal	Start bit	# of bits	Scaling Factor	Scaling Off-set	Range	Unit
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

8.3.10 AI Readback 5-8 (AI_Readback_5_8)

Signal	Start bit	# of bits	Scaling Factor	Scaling Offset	Range	Unit
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

8.4 Ethernet

When the BS120x is configured to use Ethernet, commands are sent to the BS120x using TCP, while all messages sent from the BS120x are UDP broadcast.

8.4.1 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: 192.168.1.10 (or any other unused final octet other than 1 and 255)
Subnet Mask: 255.255.255.0

Firewall Port Exceptions:

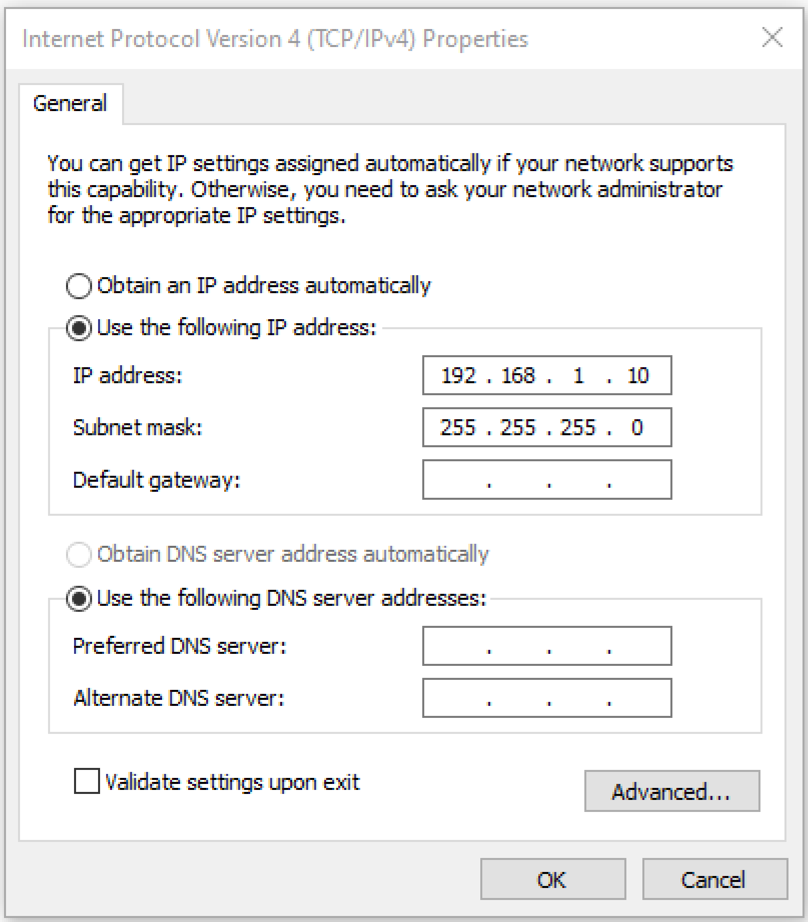
Incoming:
UDP: 54320-54350 (BS120x readback data. One unique port per BS120x unit)
UDP: 58431 (BS120x configuration broadcast, same for all units)
Outgoing:
TCP: 12345

NOTE: HOST PC'S FIREWALL PORTS MUST BE OPENED CORRECTLY TO COMMUNICATE TO THE BATTERY SIMULATOR 1201 UNITS.

8.4.2 Setup

8.4.2.1 TCP/IPv4 Configuration

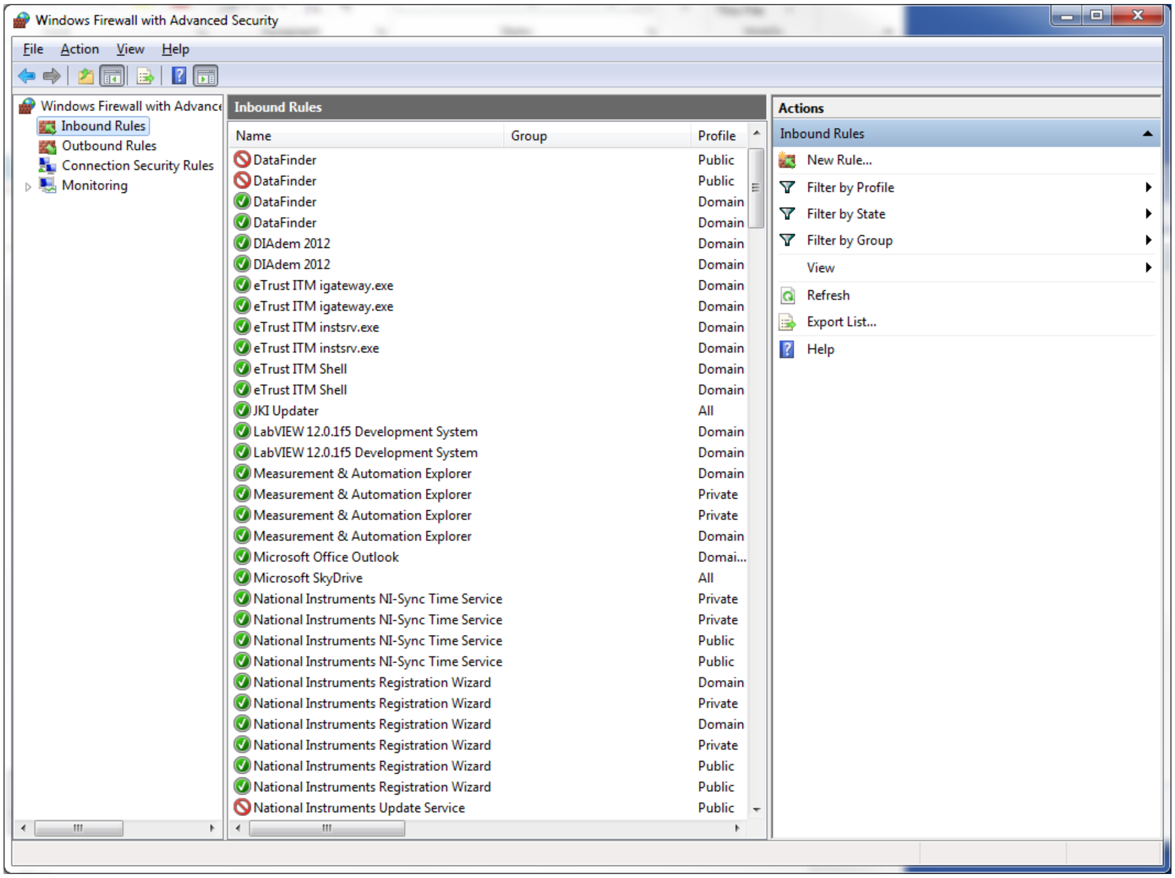
The host PC will have to be configured correctly to begin communications with the BS120x. This section will go into further detail on how to properly configure your host PC. This first involves setting the host PC's IP address to a static address. Below are the recommended IPv4 settings for the host PC.



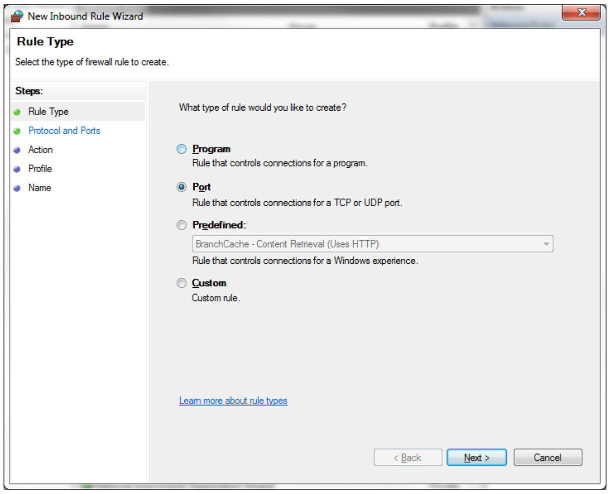
8.4.2.2 Firewall Configuration

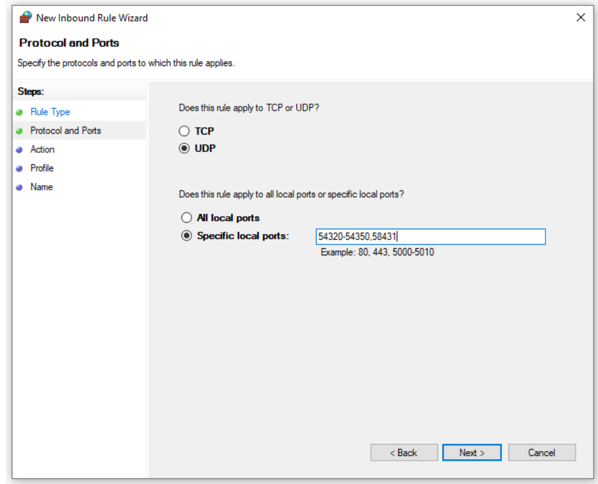
The host PC's firewall will also need to be configured to allow communications to the BS1201. This can be done in windows by taking the following steps. Open Windows Firewall with Advanced Security, found in the advanced settings of Windows Firewall under the control panel.

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

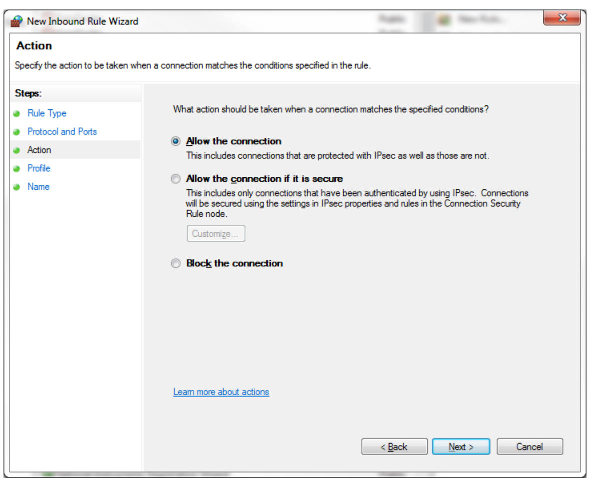


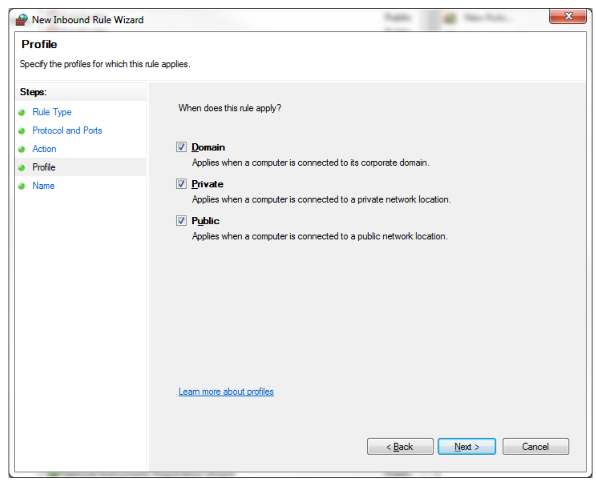
Select port and click next. Select UDP and enter the BS120x default ports of 54320-54350, 58431.



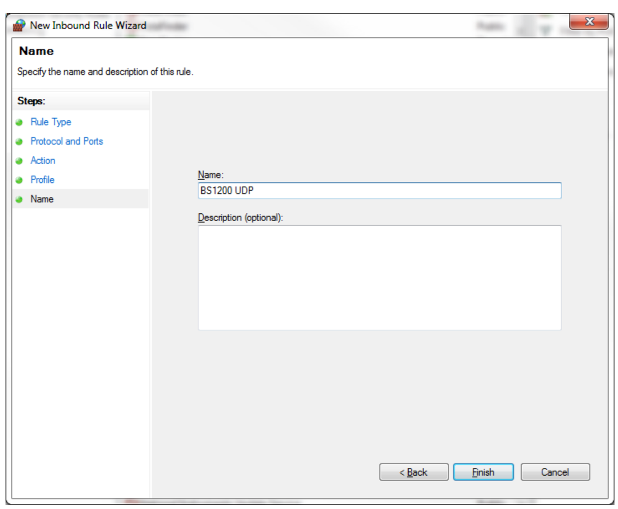


Allow the connection and click next. Apply to all domain, private, and public.

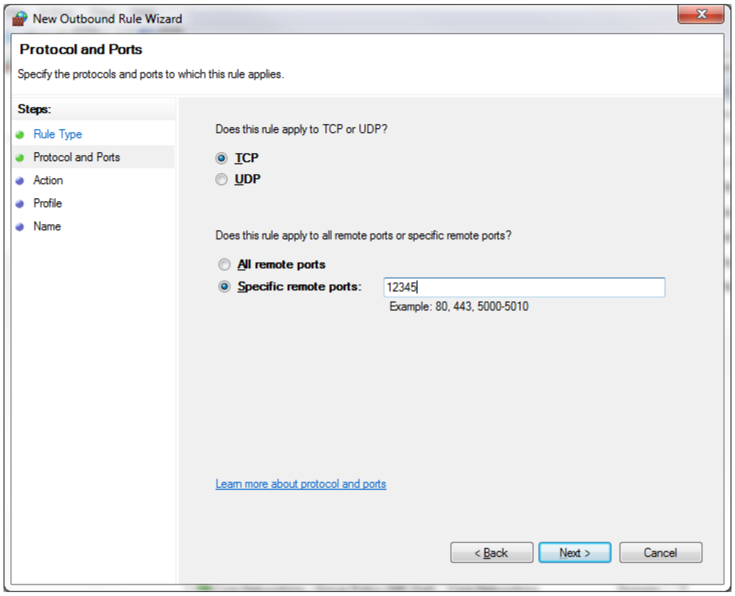




Assign a name, such as BS1201 UDP and select Finish.



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.



8.4.3 TCP

Both TCP and UDP packets are encapsulated using IPv4 and Ethernet II (DIX) frames. Payloads of TCP and UDP are in a custom format that contains several elements of the NI CAN (XNET) frame. The payload structure (Big Endian) is as a follows:

BS120x TCP/UDP payload format (Big Endian)

Arbitration ID	Extended Frame? (Normally 0)	Type {0:"CAN Data", 1:"CAN Remote"} (Normally 0)	Payload Byte Count	CAN Frame Payload
4 bytes (U32)	One Byte Boolean	1 Byte (U8)	4 Bytes (I32)	N Bytes, little-endian, tail-padded with zeroes

8.4.3.1 TCP dual packet transmission

The BS120x expects two data sets to initiate a command. The first is always 4 bytes to represent the length of the next incoming message to be received. The second frame can be one of three types.

1) **Heart beat (1 bytes)** The BS120x will time out after 2 seconds in TCP mode if it does not receive a message, so a single byte payload is required to maintain the connection. The BS120x LabVIEW driver accomplishes this with an asynchronous 10 Hz heart beat signal.
2) **Command Data (18 bytes):** contains a command to the BS120x. The payload structures of the commands can be found in Section 2.3.
3) **Configuration Command (variable length):** contains a configuration command to the BS1201 (not valid for BS1200). See Section 8.4.5 for more information.

8.4.3.2 TCP Data Examples (To BS1201) in Hex

Packet 1 (length)	**Packet 2**	**Command**
0000 0012	0000 0510 0000 0000 0008 0340 9C00 0000 0000	*Set Cell 4 to 4.0V*
0000 0012	0000 0480 0000 0000 0008 8813 E803 0000 0000	*Set all cell I limits*
0000 0012	0000 0540 0000 0000 0008 0100 0000 0000 0000	*Enable All Cells*

Data Name	ARB ID 4 bytes Box ID = 0 for TCP	Ext. frame 1 byte 00	Type 1 byte 00	Length 4bytes 00 00 00 08	Data (Little Endian)
Cell Voltage Setpoint (Cell_V_Set) **Set Cell 4 to 4.0V**	00 00 05 10	00	00	00 00 00 08	03 40 9C 00 00 00 00 00 0x03 = Cell 4 (zero-based) 0x409C = 0d40000 = 4.0000V *Note Little endian conversion
Cell Current Set All (Cell_I_Set_All) **Set all cells to 500mA sourcing, 100mA sinking**	00 00 04 80	00	00	00 00 00 08	88 13 E8 03 00 00 00 00 0x8813 = 0d5000 = 500mA 0xE803 = 0d1000 = 100mA *Note Little endian conversion
Cell Enable All **Enable All Cells**	00 00 05 40	00	00	00 00 00 08	01 00 00 00 00 00 00 00 0x01 = enabled state = True

8.4.4 UDP (From BS1201)

BS120x status messages are UDP broadcast every 5 ms (configurable). 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 8.4.3)

Note that the HIL mode used in CAN communication is irrelevant for Ethernet communication as every message is always broadcast. The data and table below details the 10x messages that are broadcast in each UDP packet.

8.4.4.1 UDP Data Examples

Raw Data Capture (hexadecimal):

```
ARB ID    EXT  Type Lng  Payload
0000 0121 0000 0000 0008 409C 3075 204E 1027
0000 0131 0000 0000 0008 409C 3075 204E 1027
0000 0141 0000 0000 0008 409C 3075 204E 1027
0000 0181 0000 0000 0008 786C 0080 E883 A08F
0000 0191 0000 0000 0008 786C 0080 E883 A08F
0000 01A1 0000 0000 0008 786C 0080 E883 A08F
0000 02A1 0000 0000 0008 0000 1027 3075 50C3
0000 02B1 0000 0000 0008 0000 1027 3075 50C3
0000 0281 0000 0000 0008 F000 0000 0000 0000
0000 0101 0000 0000 0008 101D 1C1B 0000 0000
```

Data Interpretation:

Data Name	ARB ID 4 bytes "X" = Box ID	Ext. frame 1 byte 00	Type 1 byte 00	Length 4bytes 00 00 00 08	Data (Little Endian)
Cell Voltages Readback 1-4 (Cell V Readback 1 4)	00 00 01 2X	00	00	00 00 00 08	40 9C 30 75 20 4E 10 27 4x U16 cell voltages 0x409C = 0d40000 = 4.0000V 0x3075 = 0d30000 = 3.0000V 0x204E = 0d20000 = 2.0000V 0x1027 = 0d10000 = 1.0000V *Note Little endian conversion
Cell Voltages Readback 5-8 (Cell V Readback 5 8)	00 00 01 3X	00	00	00 00 00 08	40 9C 30 75 20 4E 10 27 Same details as above
Cell Voltages Readback 9-12 (Cell V Read-back 9 12)	00 00 01 4X	00	00	00 00 00 08	40 9C 30 75 20 4E 10 27 Same details as above
Cell Currents Readback 1-4 (Cell I Readback 1 4)	00 00 01 8X	00	00	00 00 00 08	78 6C 00 80 E8 83 A0 8F 4x U16 cell currents 0x786C = 0d27768 = -500mA 0x0080 = 0d32768 = 0mA 0xE883 = 0d33768 = +100mA 0xA08F = 0d36768 = +500mA *Note Little endian conversion
See Cell Currents Read-back 5-8 (Cell I Read-back 5 8)	00 00 01 9X	00	00	00 00 00 08	78 6C 00 80 E8 83 A0 8F Same details as above
See Cell Currents Read-back 9-12 (Cell I Read-back 9 12)	00 00 01 AX	00	00	00 00 00 08	78 6C 00 80 E8 83 A0 8F Same details as above
See AI Readback 1-4 (AI Readback 1 4)	00 00 02 AX	00	00	00 00 00 08	00 00 10 27 30 75 50 C3 4x U16 AI 0x0000 = 0d00000 = 0V 0x1027 = 0d10000 = 1V 0x3075 = 0d30000 = 3V 0x50C3 = 0d50000 = 5V *Note Little endian conversion
See AI Readback 5-8 (AI Readback 5 8)	00 00 02 BX	00	00	00 00 00 08	00 00 10 27 30 75 50 C3 Same details as above
See DIO States 1-8 (DIO Readback 1 8)	00 00 02 8X	00	00	00 00 00 08	F0 00 00 00 00 00 00 00 0xF0 = T T T T F F F F
See BS1201 Status (Sys-tem Status)	00 00 01 0X	00	00	00 00 00 08	10 1D 1C 1B 00 00 00 00 0x10 = F F F F T F F F Fan 1-4 OK Output Enabled 0x1D = 0d29 = Temp 1 = 29C 0x1C = 0d28 = Temp 2 = 28C 0x1B = 0d27 = Temp 3 = 27C

8.4.5 Device Configuration (BS1201 only)

The BS1201 employs special configuration commands via the ethernet interface. These commands can be used for configuring, resetting, and obtaining the configuraiton of the unit, per the sections below.

For configuration of the BS1200, please use the supplied Soft Front Panel or use the python configuration utilities.

8.4.5.1 Reset (*RST)

Sending a *RST via the main TCP port will cause the BS1201 to perform a soft reset, as shown in the example below. Packet 1 is the 4-byte length of the next incoming packet. Packet 2 is the hex code for ASCII *RST.

Example Data

Packet 1	**Packet 2**	**ASCII Command**
0000 0004	2A52 5354	**RST*

8.4.5.2 Configure (*CFG)

Messages that are prefixed with *CFG will be flagged by the BS1201 to anticipate an incoming configuration change. Configuration changes will not take place until the unit is reset, either via the *RST command, or via power cycle. *CFG commands are formatted as follows:

*CFG <*type*> *section.key = value*

Where:

- *type* corresponds to the data type: dbl, int, bool, str
- *section.key* corresponds to the unit configuration section and key name
- *value* corresponds to the value to write to the unit configuration

Configurable Fields:

Section.Key	Data Type	Default Value	Description
UDPData.UDPDataEnable	bool	True	A value of **True** will cause the BS1201 to broadcast readback data over UDP A value of **False** will inhibit BS1201 UDP Data transmission
UDPData.UDPDataPort	int	54321	Port on the local machine that the BS1201 will broadcast readback data to. Each BS1201 should have a unique UDP Data Port
UDPData.UDPDataPeriod_mS	int	5	Broadcast period for readback data over UDP, in mS
CAN.BoxID	int	1	Box/Unit ID of the BS1201. Each BS1201 on a CAN bus must have a unique Box ID
CAN.WritePeriod_ms	int	5	Broadcast period for readback data over CAN, in mS
OperationalModes.CellInhibitEnable	bool	False	A value of **True** will cause the BS1201 to inhibit cell outputs when the inhibit lines on the Aux IO connector are opened. A value of **False** will cause the BS1201 to always enable cell outputs, regardless of the inhibit lines on the Aux IO connector.

Example Data

Packet 1	Packet 2	ASCII command
0000 0018	2A43 4647 203C 696E 743E 2043 414E 2E42 6F78 4944 203D 2031	**CFG <int> CAN.BoxID = 1*
0000 0028	2A43 4647 203C 626F 6F6C 3E20 5544 5044 6174 612E 5544 5044 6174 6145 6E61 626C 6520 3D20 5472 7565	**CFG <bool> UDPData.UDPDataEnable = True*

8.4.5.3 Query Configuration (*CFG?)

Sending *CFG? will cause the BS1201 to send its configuration information to the querying device via the main data UDP port (54321 by default). Configuration will be sent 3 times, 10mS apart. Data will sent as ASCII text in the format of an .ini file.

Example Data

Packet 1	Packet 2	ASCII Command
0000 0005	2A43 4647 3F	**CFG?*

8.4.5.4 Set IP Address (*IPA)

The *IPA message can be used for changing the IP Address of a unit. The unit will immediately reset as soon as the command is received. It will then start up using the new IP Address. *IPA commands are formatted as follows:

*IPA *AAA.BBB.CCC.DDD*

Where:

- *AAA.BBB.CCC.DDD* correspond to the new IP Address

Note: the last octet must not be a 1 or a 255

Example Data

Packet 1	Packet 2	ASCII Command
0000 0012	2A49 5041 2031 3932 2E31 3638 2E31 2E31 3235	**IPA 192.168.1.125*

9 Configuring Cell Outputs (Client or via Communications)

To configure the BS1201 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.

10 Glossary of Terms

AI – Analog In

AO – Analog Out

AUX I/O – Auxiliary Input/Output, consisting of analog and digital input/output signals of the BS1201

BS1201 – Battery Simulator 1201 (this instrument)

CC – Constant Current

Cell – a single output channel of the BS1201

CV – Constant Voltage

DI – Digital In

DO – Digital Out

HIL – Hardware in the Loop

SFP – Soft Front Panel

TTL - 5V logic level “Transistor-Transistor Logic”

Appendix A: Using the Battery Simulator 1200/1201 in High-Voltage Applications

A.1 Summary

The Battery Simulator 1200/1201 is rated for 1,000VDC of isolation, enabling the series-connection of hundreds of simulated cell channels across multiple instruments in order to simulate different configurations of battery strings, stacks or packs of up to 1,000VDC. However, any time high voltages are present in a system, proper safety precautions must be observed. This guide provides the factory-recommended safety precautions and simulated cell stack connection topologies for using the Battery Simulator 1200/1201 to simulate high voltage battery packs. Based on the BS120x cell connector creepage and clearance, “high voltage” refers to a voltage of greater than ±500V potential from earth ground per IEC61010[1].

Figure A.1: A series-connected, 192-cell simulation system using 16 Battery Simulator 1201s

A.2 Recommended Safety Precautions

The following safety precautions are recommended in applications where any of the Battery Simulator 1200/1201’s simulated cell channels are operating at greater than ±500V potential from earth ground.

A.2.1 Prevent Access to All Connectors When Voltage is Applied

Physically prevent access to the Battery Simulator 1200/1201 electronic wiring terminals, including the cell connectors, network connector, and Auxiliary I/O connector, to prevent unintended contact with system voltages. (See Figures 1 and 2.) Specifically, the following is recommended:

1) Minimum: Mount the Battery Simulator 1200/1201s in an enclosed rack to prevent operator access to the network connector, cell connectors and Auxiliary I/O connector, all of which may carry high voltages when many cells and/or other power sources are connected in series. Ensure the rack is closed during normal operation and no unintended access to the cell connectors is possible. Affix labeling to any rack doors or openings to notify operators that high voltage may be present and that the system must be powered off before servicing.

2) Preferred: In addition to enclosing the instruments, install a safety interlock which disconnects the AC power to the Battery Simulator 1200/1201 instruments and disables the outputs of other series-connected power sources in the event that the rack is opened. Install a ground-fault circuit interrupter (GFCI) which disables the system when a fault is sensed.

Figure A.2: The rear panel of the Battery Simulator 1200/1201 contains the network connector, cell connectors and the Auxiliary I/O connector. Prevent access to these connectors when high voltages are present.

Note that the Battery Simulator 1200/1201 will withstand abrupt power loss without damage, though any networked computer or controller will lose communication and may require an application reset, restart or reboot depending upon how the software is written to handle communication loss. Typically, CAN communications will restart automatically once the Battery Simulator 1200/1201 powers up.

A.2.2 Current Limit Series-Connected Devices

In the event of an internal or external fault, the Battery Simulator 1200/1201's internal ground bond is designed to protect the user and equipment from unintended high-voltage contact. Because the Battery Simulator 1200/1201 cell outputs are rated for a maximum of 500mA of current per cell, any external series-connected power sources should also be limited to 500mA if present. This limit will help to ensure that any current draw from another device will not exceed the Battery Simulator 1200/1201 cell current ratings. The current limit will also help to ensure that the Battery Simulator 1200/1201 ground bond can non-destructively shunt any current caused by a fault to ground.

A.2.3 Isolate Ground-Referenced Signals and Communications (BS1200 Only)

⚠

The Battery Simulator 1201 does not require isolation of its communications (Ethernet and CAN) or auxiliary I/O as described below.

The Battery Simulator 1200 **does** require isolation in applications where one or more cells of the Battery Simulator 1200 will be raised to ±500V potential to ground or higher.

Follow the instructions in this section when using the Battery Simulator 1200 in these applications.

When any cell of the Battery Simulator 1200 is expected to be raised to over ±500V potential to ground, the Battery Simulator 1200's ground-referenced signals and communications should be isolated from other devices. Recommended isolation techniques are described below for each type of signal.

1. Ethernet
   Use an Ethernet isolator, such as a Phoenix Contact FL ISOLATOR 1000-RJ/RJ[2], to connect each Battery Simulator 1200's Ethernet port to any non-isolated Ethernet switches or computers. (See Figure A.3.)

   When Ethernet is not used, the Battery Simulator 1200's Ethernet ports may be left disconnected and do not require an external isolator.

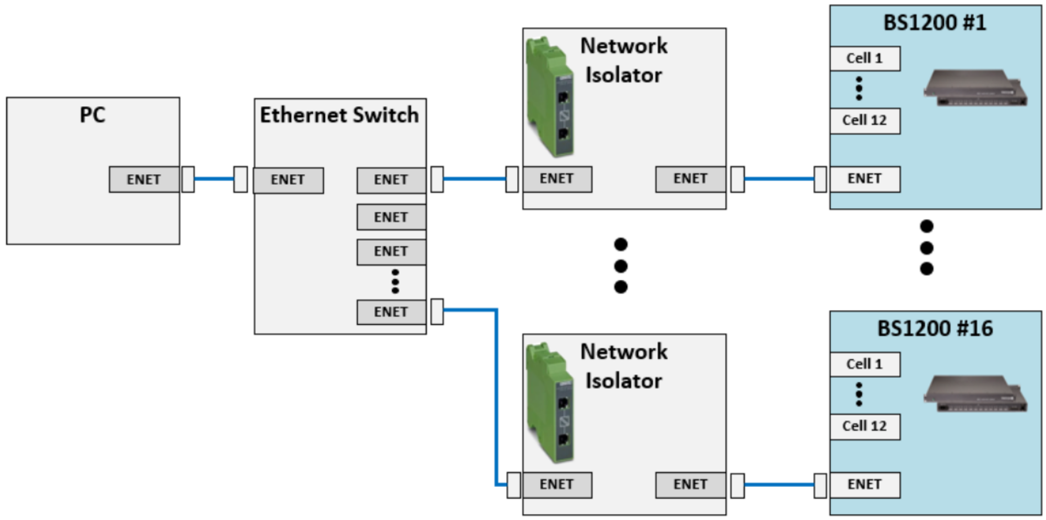


Figure A.3: Install one network isolator per Battery Simulator 1200 when the Ethernet port is used or connected.

2. CAN
   Use a CAN isolator/repeater, such as a PEAK PCAN-Repeater[3], to connect a network of Battery Simulator 1200/1201 instruments to the CAN ports of a computer and other CAN devices. For optimum performance, we recommend one CAN isolator/repeater per 2-4 Battery Simulator 1200 instruments, each connected to a separate CAN interface port on the computer or CAN controller. (See Figure A.4.)

   When CAN is not used, the Battery Simulator 1200/1201 CAN terminals on the auxiliary I/O connector may be left disconnected and do not require an external isolator.

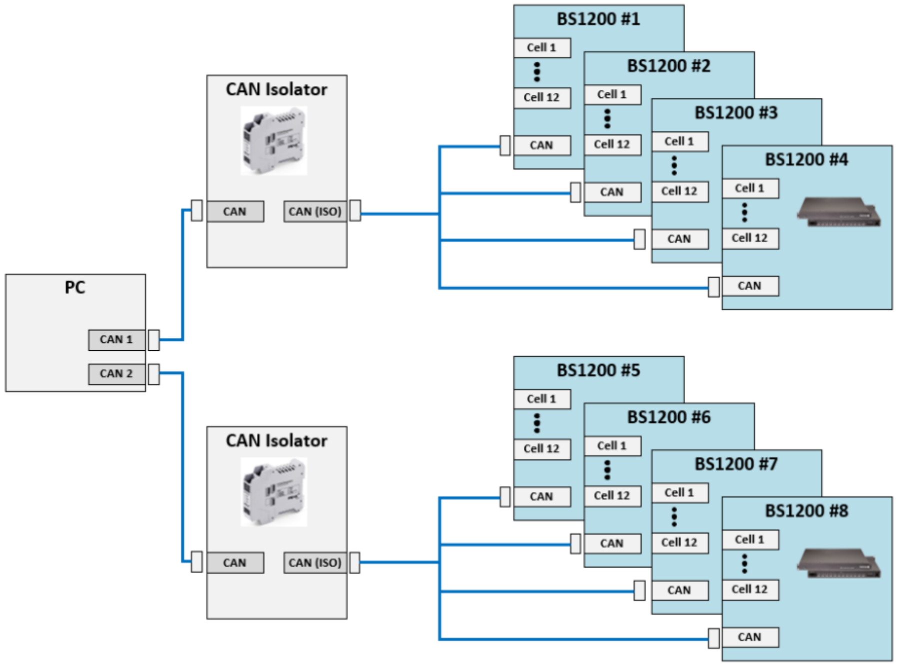


Figure A.4: Install one CAN isolator per 2-4 Battery Simulator 1200s when CAN communications are used.

3. Auxiliary I/O

   Damage to the Battery Simulator 1200 may occur if the Auxiliary I/O signals are raised beyond the limits of the I/O (3.3V digital, +5V analog) referenced to chassis ground. (This caution also applies to the Battery Simulator 1201.) Because these signals are referenced to chassis ground, care must be taken in any application to protect the inputs and outputs from voltages beyond these ranges, regardless of whether the signals are used in a high-voltage application or not.

   In high-voltage applications, the Battery Simulator 1200 chassis ground may unintentionally be raised to a high voltage thus causing the signals and signal returns also to be raised to the high voltage. Either ensure that the devices connected to the Auxiliary I/O signals are tolerant of this voltage or that appropriate isolation is installed between the Battery Simulator 1200 Auxiliary I/O and the connected devices.

   Where isolation is necessary, the following guidelines apply:

   1. Use a galvanic isolator tailored to the application for each of the analog and digital I/O signals in use. Galvanic isolation separates the inputs of the isolator from the outputs of the isolator to prevent current flow, passing the signals through an optical, capacitive, or inductive field rather than through a direct connection. Note that the CAN bus is also present on the Auxiliary I/O connector and must be isolated as described above.
   2. When the Auxiliary I/O is not used, the Battery Simulator 1200 auxiliary I/O ports may be left disconnected and do not require an external isolator.

A.2.4 Programmatic Safety Precautions

The Battery Simulator 1200/1201 powers on in a safe state with all cells at 0V and 0mA until the cell voltages and current limits are programmed from the host computer or other control device. The Battery Simulator 1200/1201 has a programmable cell current limit parameter that is individually controllable per cell. Because power dissipation in connected circuits is proportional to both voltage and current, it is a good practice to set the individual cell current limits to the lowest current necessary for the application (e.g., activating and testing the cell-balancing functionality of the battery management system). Limiting the cell power by limiting the current reduces the risk and severity of component damage as well as of electric shock.

A.3 Cell Stack Simulation Connectivity

High-voltage battery packs may be simulated using one of a number of topologies. Several of these are shown on the following pages along with their advantages and disadvantages. For illustrative purposes, a common high-voltage BMS architecture consisting of one BMS master and multiple slave cell monitoring units (CMUs) will be connected to a 192-cell stack with sixteen 12-cell CMUs. These connection topologies can be extended to other simulated battery and BMS topologies as well.

Note that all simulated cells in these examples are connected in series and not in parallel. Connecting the Battery Simulator 1200/1201 cells in parallel is not a supported control mode and not recommended because it may increase the combined current flowing through the simulated cells above the limits of the individual cells. Do do not exceed more than 500mA current per cell under any circumstances. Exceeding the 500mA current limit may damage the instrument and possibly cause other hazards.

A.3.1 Full stack simulation

In this configuration, all 192 cell voltages of the stack are simulated by 16 Battery Simulator 1200/1201 instruments, each containing 12 individually-programmable cells connected to the 16 CMUs. (See Figure A.5.) All simulated battery cells from all 16 Battery Simulator 1200/1201s are connected in series to create the full pack voltage which is then routed to the high-voltage measurement on the pack controller board. If contactors/disconnects are required, they can be simulated using real components.

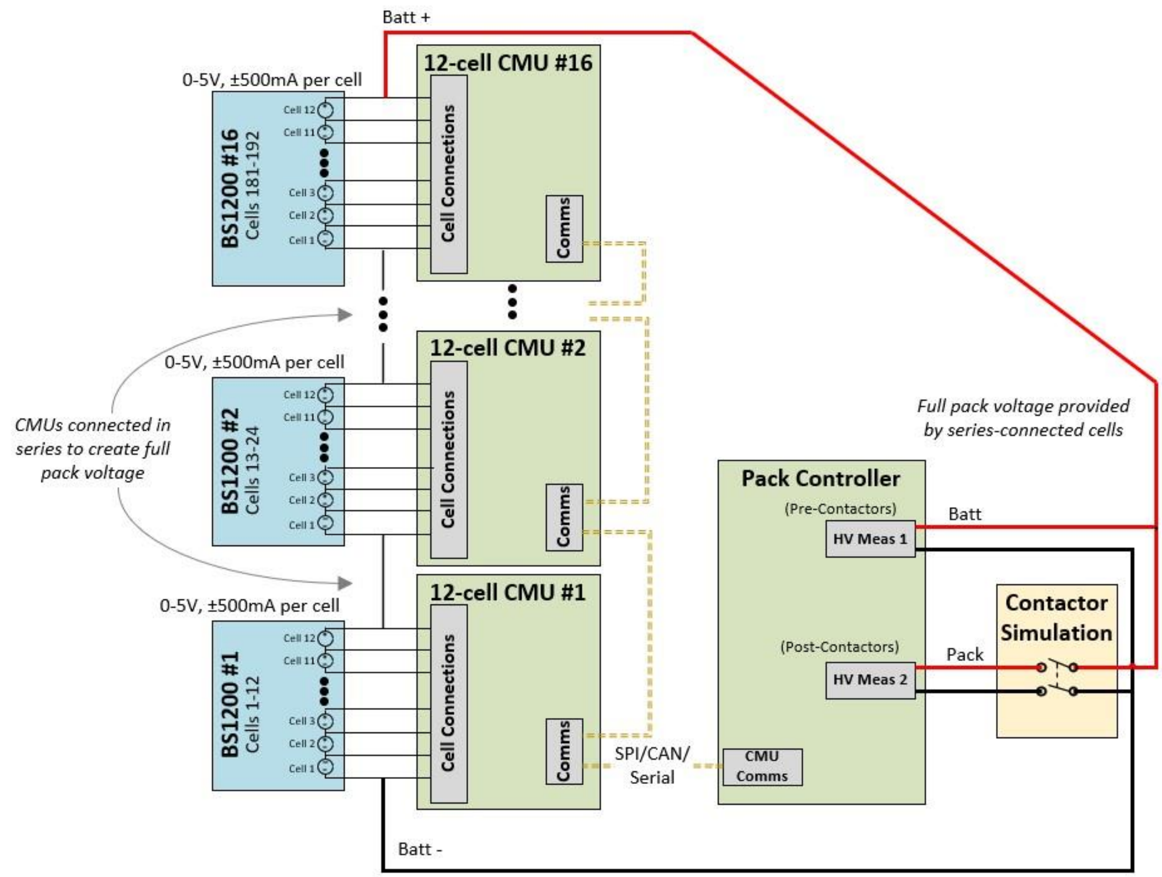


Figure A.5: Full stack simulation: all cells are individually simulated, controlled and connected in series, most similar to an actual battery stack.

Advantages	Disadvantages
Allows individual cell voltage and balancing current control and monitoring	Doesn't simulate error cases associated with pack voltage measurements, for example:
Most closely resembles the actual battery pack configuration	ΔV between sum of cell voltages and stack voltage measurement
Maximizes real-world application testing	Contactor resistance buildup
Allows CMUs to set their own addresses based on positions in stack voltage if necessary	Uses large number of high-voltage connections exceeding 500V
	Delivers substantial power at high voltage (up to 960V@500mA, or 480W, in configuration shown above)

A.3.2 Low-voltage, full-cell simulation

In this configuration, all 192 cell voltages of the stack are simulated by 16 Battery Simulator 1200/1201 instruments, each containing 12 simulated cells connected to the 16 CMUs similar to the full stack simulation above. However, instead of connecting all cells in series, each CMU's Cell 0 (lowest voltage) is referenced to ground. In this configuration, the simulated cell voltages will never exceed [5V/cell × *n* cells] per CMU. For a 12-cell CMU, the maximum possible cell voltage will be 60VDC. The high-voltage battery taps may be simulated for the pack controller measurements using external 1,000V programmable sources. Since the pack controller is not using the sources' current for balancing, the 1,000V sources can be current limited to a lower level than the simulated cells, such as < 5mA.

This configuration maximizes safety by reducing the number of high-voltage connections to two. None of the Battery Simulator 1200/1201 and CMU connections are high voltage, yet all of the cells are present and individually controlled.

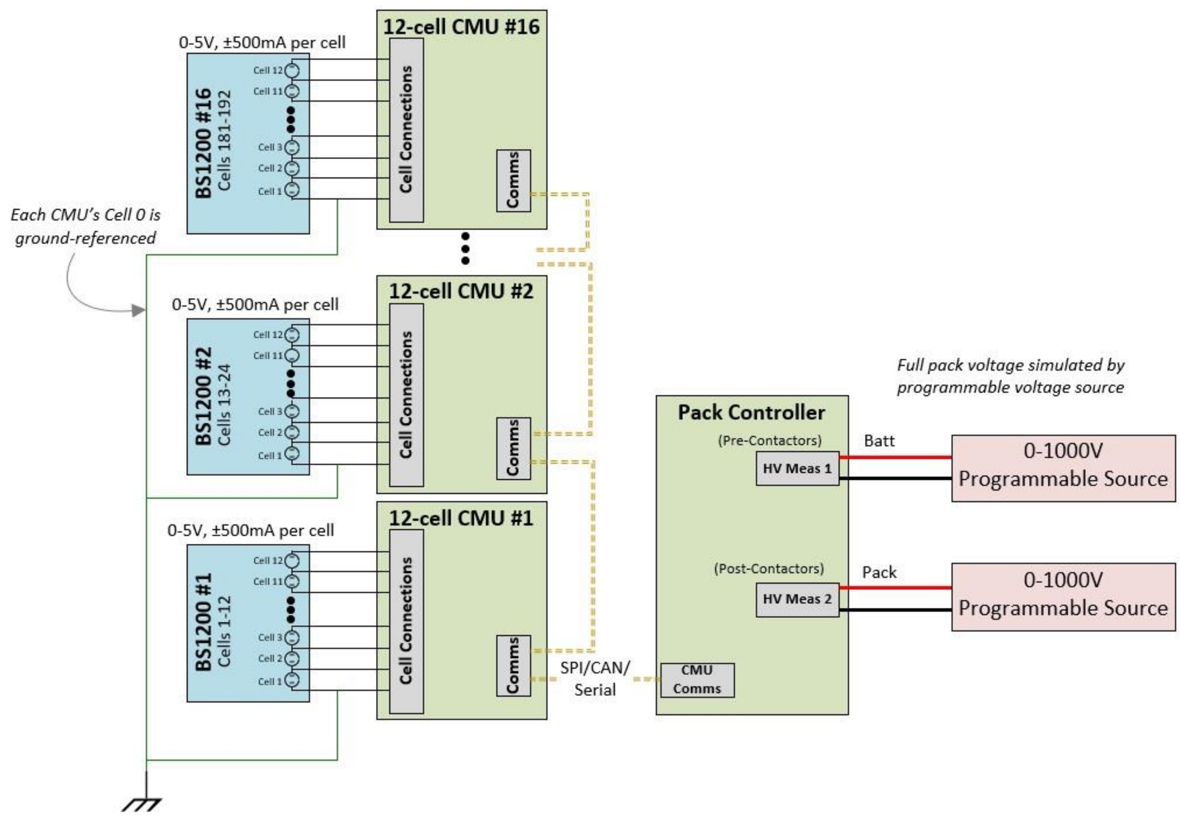


Figure A.6: Low voltage, full cell simulation: all cells are individually simulated and controlled, though each CMU is ground-referenced. High voltage is simulated by external programmable sources.

Advantages	Disadvantages
Allows individual cell voltage and balancing current control and monitoring. Does not limit the maximum number of simulated cells. Closely resembles a full pack, but without any voltages exceeding [5V/cell × n cells] per CMU. Requires only two high-voltage connections (HV Meas 1 and HV Meas 2 in Figure 5) which maximizes safety. Limits power and current (<5mA) for high-voltage connections. Simulates difference between sum of cells and pack measurement error condition. Simulates contactor faults (e.g., welded contactor) and degradation (e.g., high-resistance contacts, increased wear and delay) by directly controlling high-voltage signals.	Does not provide necessary input for CMUs which "address" themselves based on stack voltage. Requires coordinated closed-loop control of high-voltage simulations for pack and contactor voltage measurements. Requires separate high-voltage sources for pack controller's battery measurement taps if required.

A.3.3 Low voltage, shared cell simulation

This final topology minimizes the number of Battery Simulator 1200/1201s required to simulate a pack. All CMUs are ground-referenced, similar to the low-voltage/full-cell configuration. CMU voltages cannot exceed [5V/cell × n cells] per CMU. In this configuration, however, the simulated cells are shared among multiple CMUs connected in parallel. The primary limitation of this configuration is that the shared cell currents must not exceed the 500mA per cell current capacity of the Battery Simulator 1200/1201. For example, if one CMU balances with a 200mA maximum current per cell, then three CMUs connected in parallel may require as much as 600mA of combined cell current, violating the maximum current limit of the cell simulator. As with the previous configuration, the high-voltage battery taps may be simulated for the pack controller measurements using external 1,000V programmable sources.

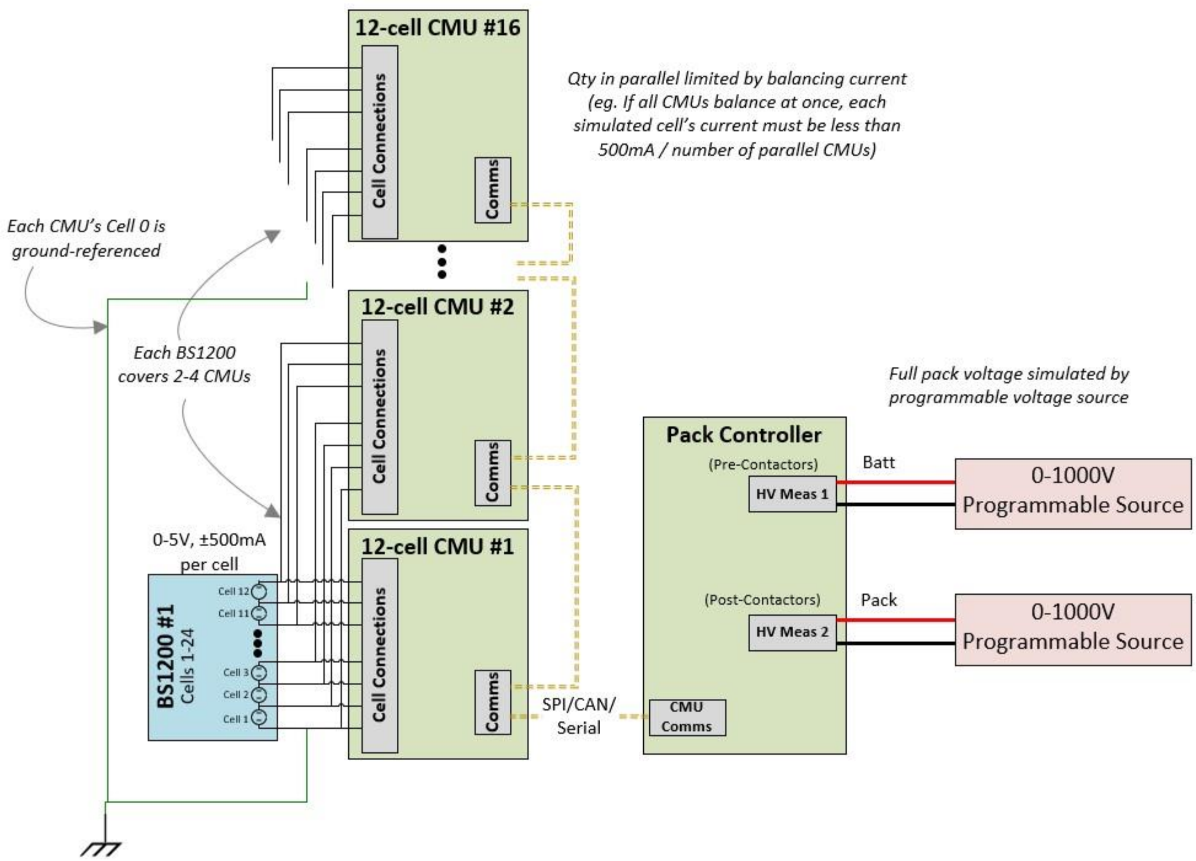


Figure A.7: Low-voltage, shared cell simulation: simulated cell channels are shared among multiple CMUs, each CMU is ground-referenced, and high voltages are simulated by programmable sources.

Advantages	Disadvantages
Reduces system cost by minimizing number of Battery Simulator 1200/1201s. Does not limit the maximum number of simulated cells. Closely resembles a full pack without any cell voltages exceeding [5V/cell × n cells] per CMU. Requires only two high-voltage connections (HV Meas 1 and HV Meas 2 in the figure above) which maximizes safety. Limits power and current (<5mA) for high-voltage connections. Simulates difference between sum of cells and pack measurement error condition. Simulates contactor faults (e.g., welded contactor) and degradation (e.g., high-resistance contacts, increased wear and delay) by directly controlling high-voltage signals.	Shares cell voltages and balancing currents among multiple CMUs making determination of which CMU is drawing balancing current using Battery Simulator 1200/1201 feedback impossible. Does not provide necessary input for CMUs which “address” themselves based on stack voltage. Requires coordinated closed-loop control of high-voltage simulations for pack and contactor voltage measurements. Requires separate high-voltage sources for pack controller’s battery measurement taps if required.

A.4 Summary and Recommendations

Simulating the cell stack of high-voltage battery packs is a critical requirement for BMS validation testing. By exercising proper safety precautions and matching the test topology to the requirements of the BMS, the test system's safety and effectiveness can be maximized. Of the topologies shown here, the optimum tradeoff between safety and performance is provided by the low voltage full cell Simulation configuration which provides the ability to simulate and monitor all cells individually, while simultaneously simulating the pack and contactor voltages through external programmable sources. The minimized number of high voltage connections and lower current limit of the external sources provides a maximally safe and effective test environment. It also provides the most flexibility to test the BMS responses to edge cases such as when the measured pack voltage differs from the CMU's reported sum of cell voltages.

If using a fully-stacked, high-voltage pack cannot be avoided through one of the alternate methodologies, mount the Battery Simulator 1200/1201 instruments in an enclosure which shuts down all AC and DC power when the door is opened or when a ground fault occurs. Additionally, always use external galvanic isolators for controlling the Battery Simulator 1200 via CAN or Ethernet, and remove the auxiliary I/O and any unused communication interface connections. These steps ensure proper system isolation from high voltages. Finally, program the Battery Simulator 1200/1201 cell current limits to exactly what the BMS requires for exercising the functions to be tested.

For more information, contact Bloomy at http://www/bloomy.com/contact-us.

A.5 Notes

1. IEC 61010 specifies safety requirements for electrical equipment for measurement, control and laboratory use. See https://www.iec.ch/homepage
2. For more information, see https://www.phoenixcontact.com/en-us/products/network-isolator-fl-isolator-1000-rjrj-2313915.
3. For more information, see https://www.peak-system.co