Interface Control Document

ECE 492 – Spring 2014

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Abstract

The Interface Control Document (ICD) shows how the top level systems of the LFEV-ESCM system are interconnected. The interfaces of each major component within the pack are described and given a unique ID. Wiring between each system and the connectors used in each interface are also described in detail.

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Introduction

This Interface Control Document (ICD) describes the connections between each of the major subsystems in the 2014 LFEV-ESCM system. The system is designed for two configurations: Discharging and Charging. Both configurations' interfaces are fully described.

Interfaces between subsystems in the discharging configuration begin with DW while interfaces in the charging configuration begin with CW. Each subsystem is given a unique number prefaced by A, regardless of configuration. Interfaces that exist on a subsystem are prefaced by J. To refer to a particular subsystem's interface, the notation AX:JY is used where X refers to the subsystem ID, and Y to the subsystem's J interface.

Interface ID's are of the form NAME-X-Y, where NAME is the interface ID, X is the number of wires in the cable, and Y is the length of the cable in feet. X may sometimes be omitted, and alternatively, X and Y may both be omitted for some interfaces.

Top Level Subsystems

System Interface Diagram (Charging)

Charging Configuration
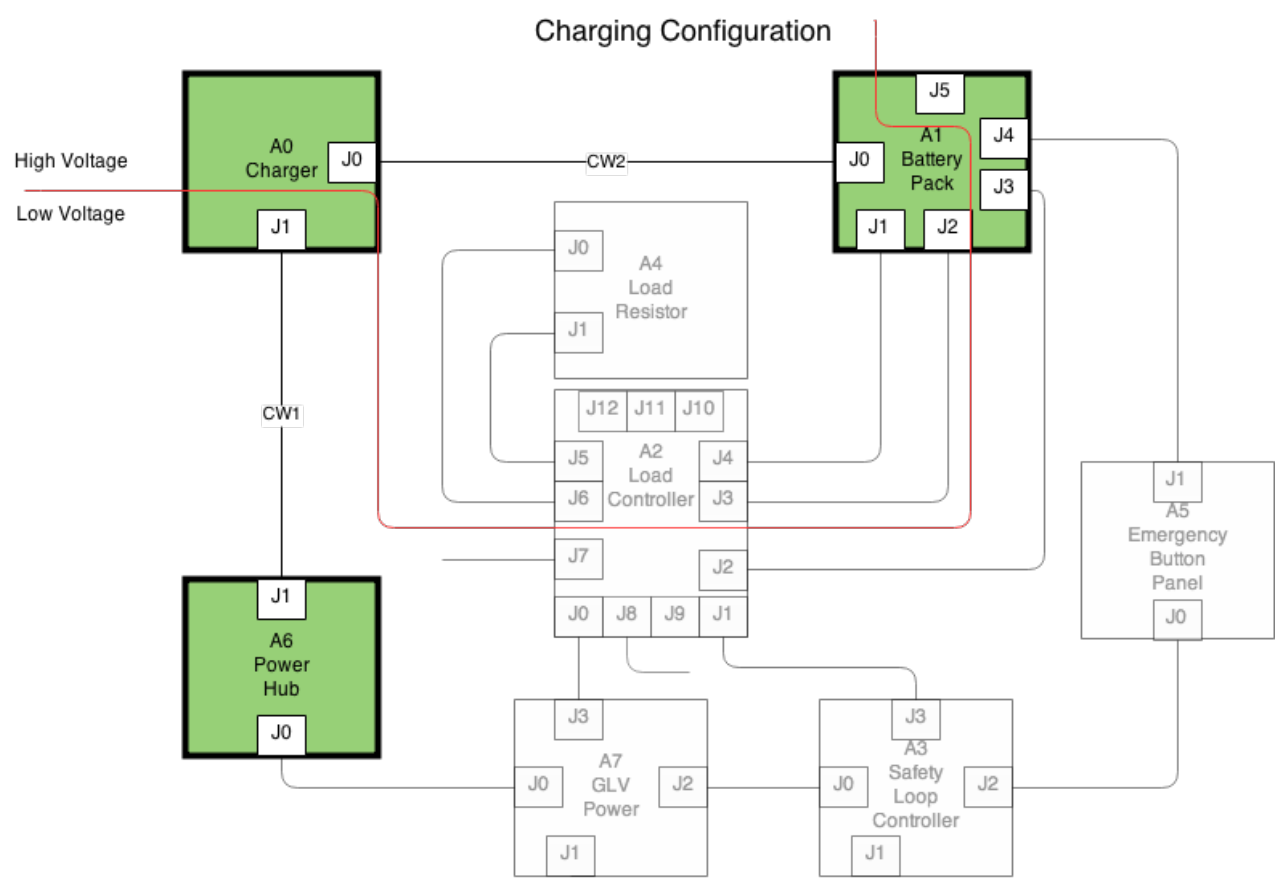
System Interface Diagram (Discharge)

Discharging Configuration

Interface List

Assembly Identification	
Component	**Name**
A0	Charger
A1	Battery Pack
A2	Load Controller
A3	Safety Loop Controller
A4	Load Resistor
A5	Emergency Button Panel
A6	Power Hub
A7	GLV Power

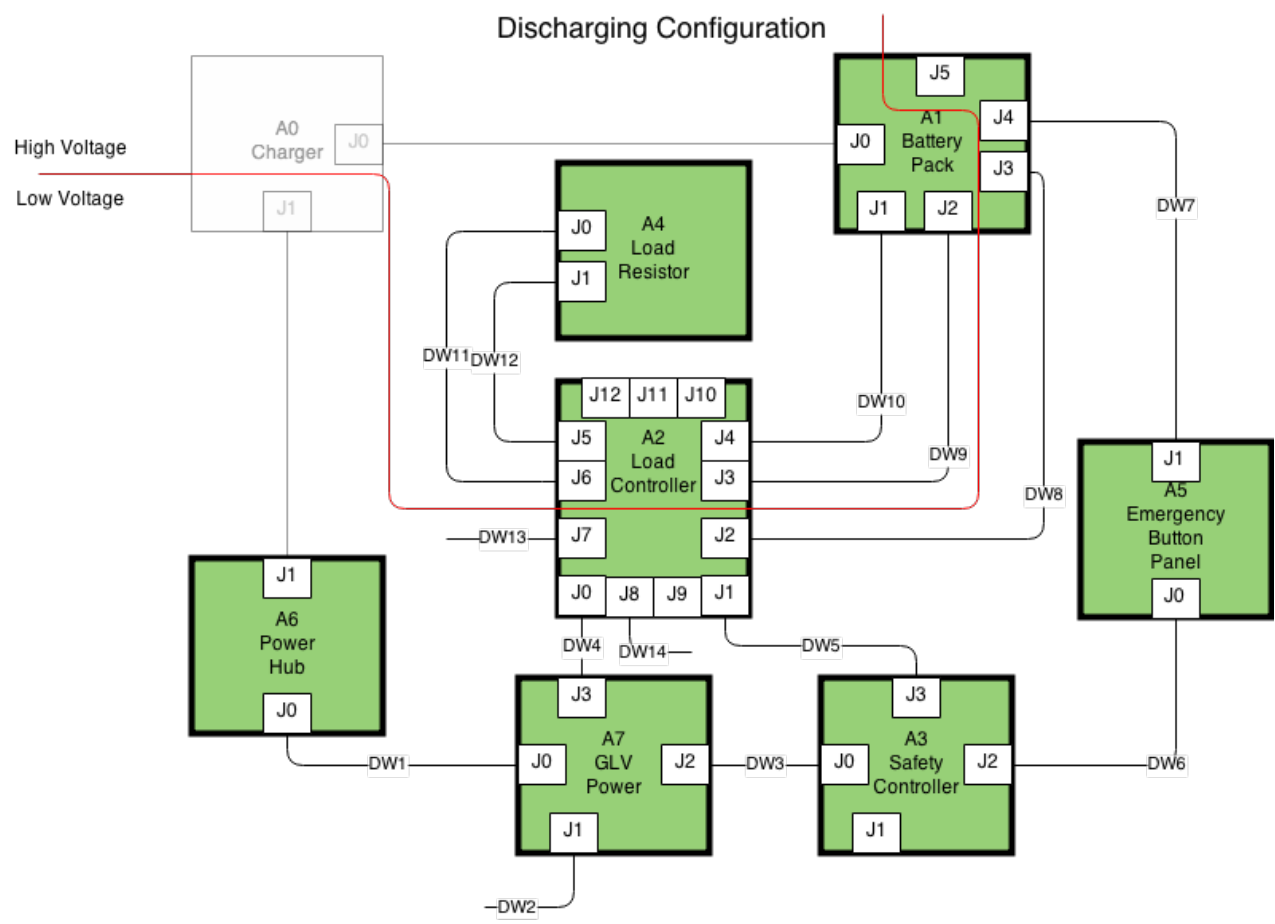| Interconnect Identification						
Wire	**ID**	**Signal**	**Color**	**Length (ft)**	**Conn. A**	**Conn. B**
CW1	SACP-6	Supply AC Power	Black	6	A6: J1	A0: J1
CW2	CC-10	Charging Cable	Black	10	A0: J0	A1: J0
CW3	CSP	Charging Safety Plug	Black	N/A	A1: J0	N/A
DW1	GLVAC-2-5	GLV Power AC Plug	Black	5	A6: J0	A7: J0
DW2	GLVCHC-1-1	GLV Chassis GND Connection	Green	1	A7: J1	N/A
DW3	TPC-2-2	Tractive Control Power	Black	2	A7: J2	A3: J0
DW4	TPC-2-8	Tractive Control Power	Black	8	A7: J3	A2: J0
DW5	SC-1-6	Safety Control	Brown	6	A2: J1	A3: J3
DW6	SLC-4-1	Safety Loop	Brown	1	A3: J2	A5: J0
DW7	SLC-4-10	Safety Loop	Brown	10	A5: J1	A1: J4
DW8	SLC-4-10	Safety Loop	Brown	10	A1: J3	A2: J2
DW9	PVPC-1-4	Pack Voltage Positive	Red	4	A1: J2	A2: J3
DW10	PVNC-1-4	Pack Voltage Negative	Black	4	A1: J1	A2: J4
DW11	THVPC	Tractive HV+	Red	3	A2: J6	A4: J0
DW12	THVNC	Tractive HV-	Black	3	A2: J5	A4: J1
DW13	SLC-E	Safety Loop End	N/A	N/A	A2: J7	N/A
DW14	LCFG-1-1	Fault Ground	Green	1	A2: J8	N/A

Charging Interconnects

CW1 – Supply AC Power

Interface	Distributor/Part No.	Manufacturer/Part No.	Type	Color
P0	McMaster-Carr/70355K85	N/A	NEMA 5-15 Plug	Black
P1	McMaster-Carr/70355K22	N/A	IEC 320	Black

P0-1   P1-1

P0   **P1**
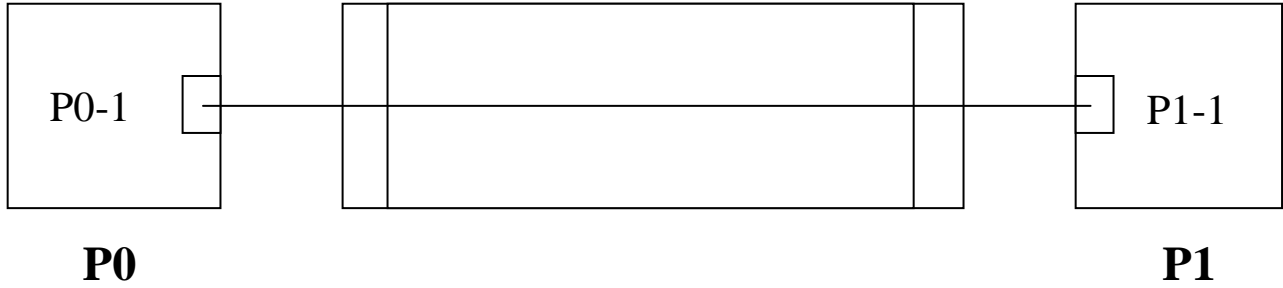
From	To	Description	Gauge	Color
P0-1	P1-1	120VAC Line Voltage	18 AWG	Black

CW2 – Charging Cable

Interface	Distributor/Part No.	Manufacturer/Part No.	Type	Color
CW2			7-Wire Cable	
P0	N/A	N/A	Anderson Config. A Male	Black
P1	N/A	N/A	Anderson Config. A Male	Black

P0   **P1**
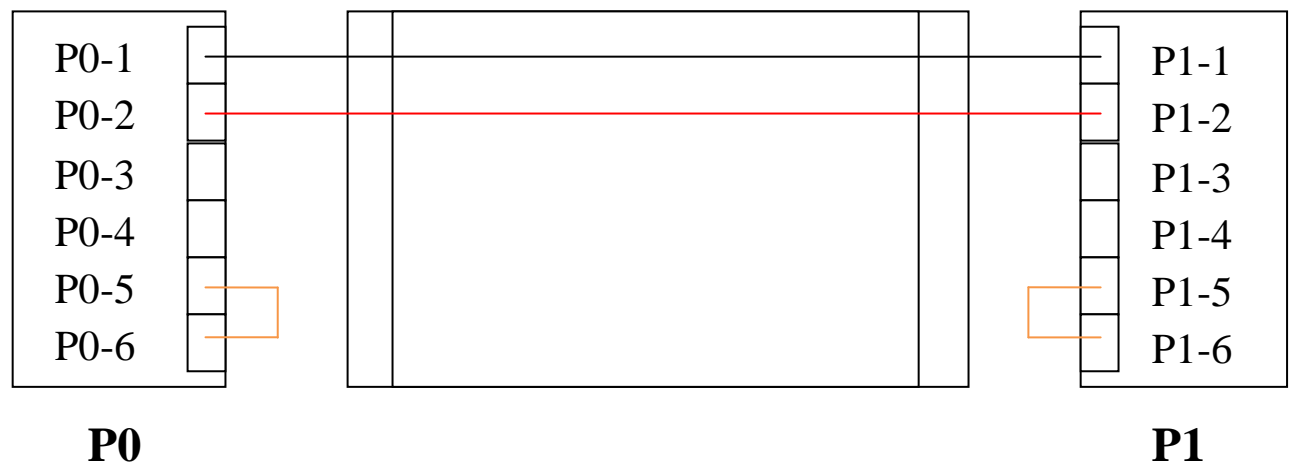
From	To	Description	Gauge	Color
P0-1	P1-1	Charger Negative	10 AWG	Black
P0-2	P1-2	Charger Positive	10 AWG	Red
P1-5	P1-6	Charger Detect	24 AWG	Orange

CW3 – Charging Safety Plug

Interface	Distributor/Part No.	Manufacturer/Part No.	Type	Color
CW2			7-Wire Cable	
P0	N/A	N/A	Anderson Config. A Male	Black

P0-1
P0-2
P0-3
P0-4
P0-5
P0-6

P0
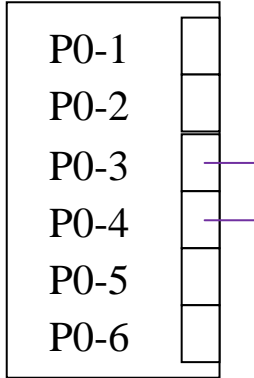
From	To	Description	Gauge	Color
P0-3	P0-4	Safety Loop	24 AWG	Purple

Discharging Interconnects

DW1 – GLV Power AC Plug

Interface	Distributor/Part No.	Manufacturer/Part No.	Type	Color
P0	McMaster-Carr/70355K85	N/A	NEMA 5-15 Plug	Black
P1	McMaster-Carr/70355K22	N/A	IEC 320	Black

P0-1   P1-1

P0   **P1**
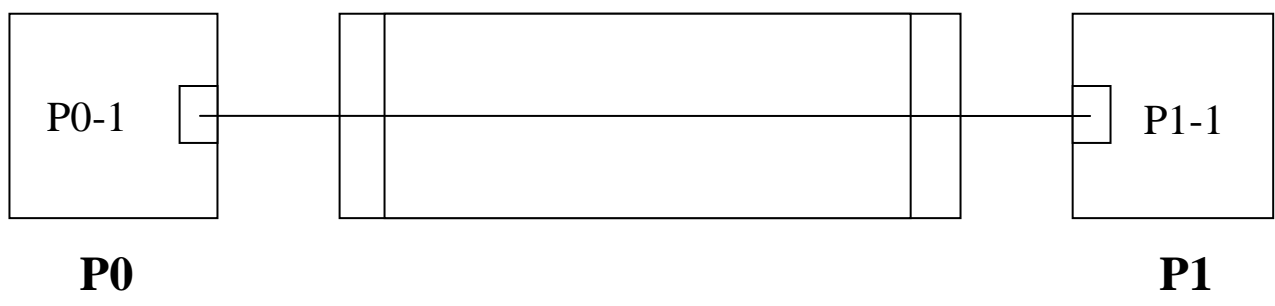
From	To	Description	Gauge	Color
P0-1	P1-1	120VAC Line Voltage	18 AWG	Black

DW2 – GLV Chassis GND Connection

Interface	Distributor/Part No.	Manufacturer/Part No.	Type	Color
P0	N/A	N/A	Anderson Config. B Male	Black
P1	McMaster-Carr/7113K221	N/A	Ring Terminal	N/A

P0-1   P1-1

P0   **P1**
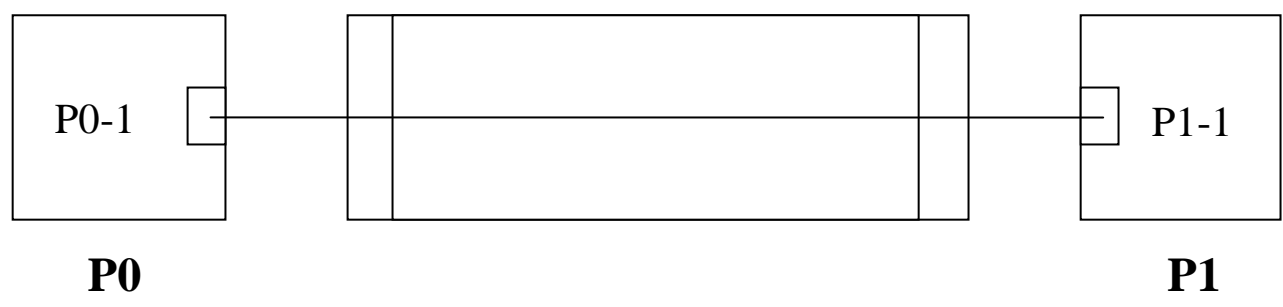
From	To	Description	Gauge	Color
P0-1	P1-1	GLV Chassis Ground	14 AWG	Black

DW3; DW4 – Tractive Control Power

Interface	Distributor/Part No.	Manufacturer/Part No.	Type	Color
DW3 DW4	McMaster-Carr/9936K16		2-Wire Cable	Gray
P0	Mouser/571-1721661	TE Connectivity/172166-1	TE 3-Pin Connector (M)	N/A
P1	Mouser/571-1721661	TE Connectivity/172166-1	TE 3-Pin Connector (M)	N/A

P0   **P1**
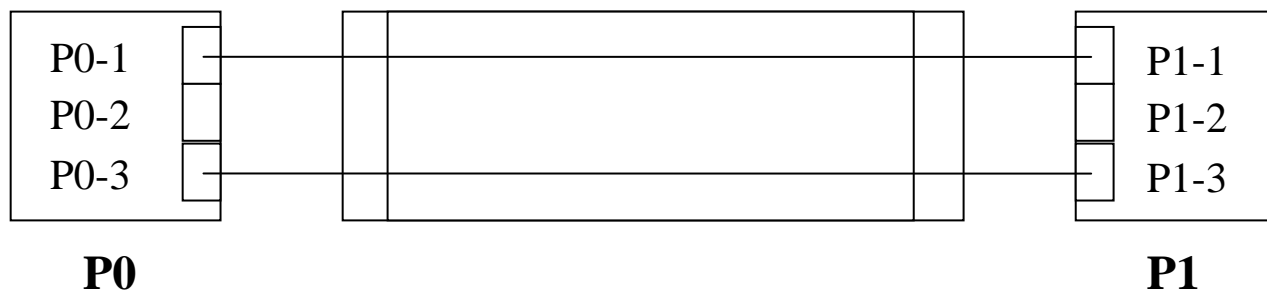
From	To	Description	Gauge	Color
P0-1	P1-1	TC 24V+	18 AWG	Black
P0-2	P1-2	Unused	N/A	N/A
P0-3	P1-3	TC 24V-	18 AWG	Black

DW5 – Safety Control

Interface	Distributor/Part No.	Manufacturer/Part No.	Type	Color
DW5	McMaster-Carr/7587K078 McMaster-Carr/7587K951	N/A	Two Wires, Not Cabled	Purple Black
P0	Mouser/538-03-06-2032	Molex/03-06-2032	Molex 3-Pin Connector (M)	White
P1	Mouser/538-03-06-2032	Molex/03-06-2032	Molex 3-Pin Connector (M)	White

P0-1   P1-1
P0-2   P1-2
P0-3   P1-3

P0   **P1**
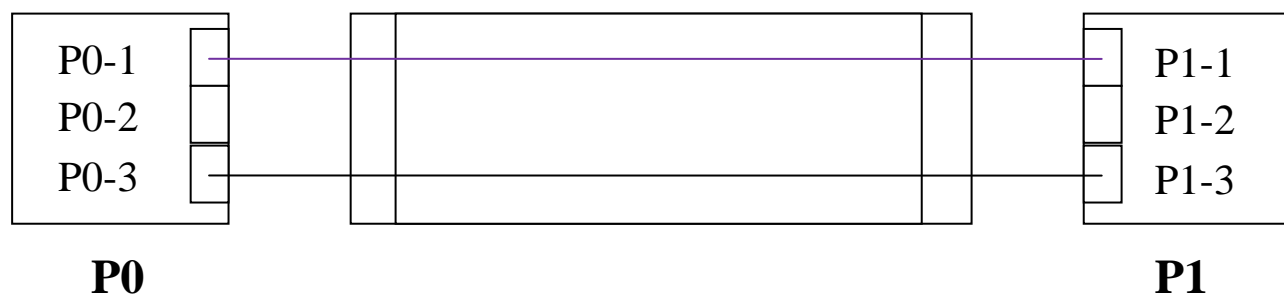
From	To	Description	Gauge	Color
P0-1	P1-1	IMD Status	18 AWG	Purple
P0-2	P1-2	Unused	N/A	N/A
P0-3	P1-3	GLV Ground	18 AWG	Black

DW6; DW7; DW8 – Safety Loop

Interface	Distributor/Part No.	Manufacturer/Part No.	Type	Color
DW6 DW7 DW8	McMaster-Carr/ 70985K73	N/A	4-Wire Cable	Brown
P0	Mouser/ 571-350779-1	TE Connectivity/ 350779-1	TE 4 Pin Connector (M)	White
P1	Mouser/ 571-350779-1	TE Connectivity/ 350779-1	TE 4 Pin Connector (M)	White

P0-1
P0-2
P0-3
P0-4

P1-1
P1-2
P1-3
P1-4
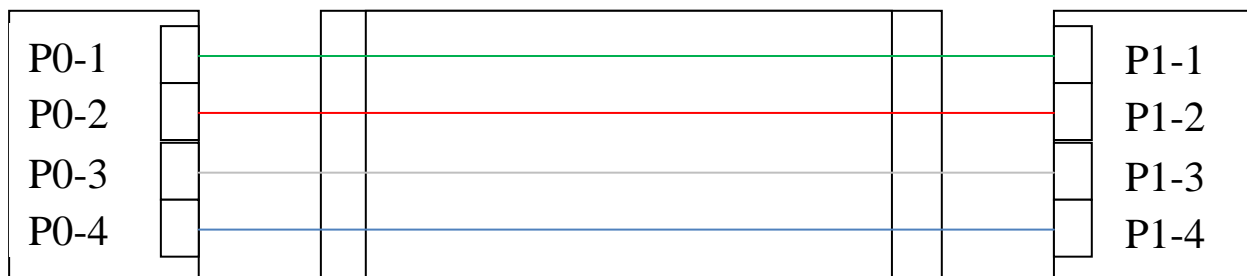
P0   **P1**

From	To	Description	Gauge	Color
P0-1	P1-1	Loop Out	20 AWG	Black
P0-2	P1-2	SL-24V+	20 AWG	Red
P0-3	P1-3	SL-24V-	20 AWG	White
P0-4	P1-4	Loop In	20 AWG	Blue

DW9 – Pack Voltage Positive

Interface	Distributor/Part No.	Manufacturer/Part No.	Type	Color
DW9	McMaster-Carr6948K962	N/A	1-Wire Cable	Red
P0	N/A	N/A	Powerlock Connector (Drain)	N/A
P1	McMaster-Carr/7113K221	N/A	Ring Terminal	N/A

P0-1   P1-1

P0   **P1**
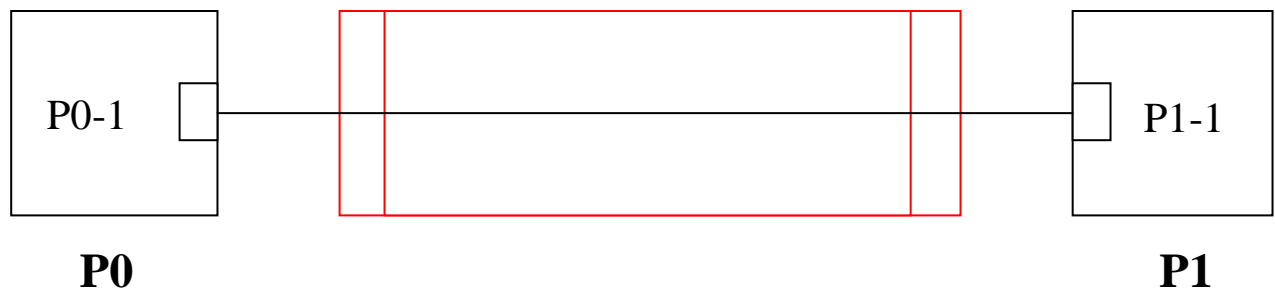
From	To	Description	Gauge	Color
P0-1	P1-1	Pack High Voltage Positive	2/0 AWG	Red

DW10 – Pack Voltage Negative

Interface	Distributor/Part No.	Manufacturer/Part No.	Type	Color
DW10	McMaster-Carr/69735K33	N/A	1-Wire Cable	Black
P0	N/A	N/A	Powerlock Connector (Source)	N/A
P1	McMaster-Carr/7113K221	N/A	Ring Terminal	N/A

P0-1   P1-1

P0   **P1**
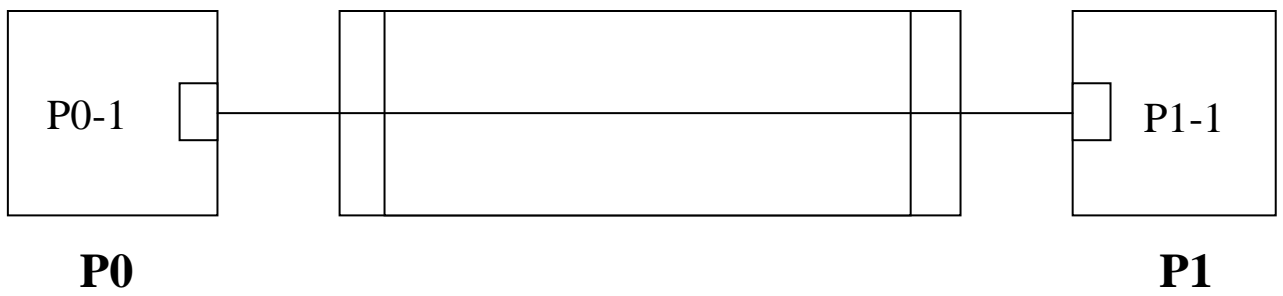
From	To	Description	Gauge	Color
P0-1	P1-1	Pack High Voltage Negative	2/0 AWG	Black

DW11 – Tractive HV+

Interface	Distributor/Part No.	Manufacturer/Part No.	Type	Color
DW11	McMaster-Carr/69735K33	N/A	1-Wire Cable	Red
P0	N/A	N/A	Ring Terminal	N/A
P1	N/A	N/A	Ring Terminal	N/A

P0-1   P1-1

P0   **P1**
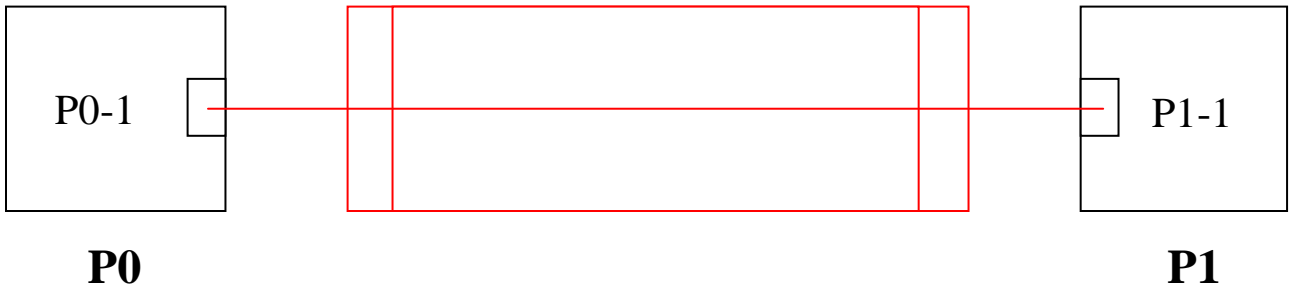
From	To	Description	Gauge	Color
P0-1	P1-1	Tractive High Voltage Positive	2/0 AWG	Red

DW12 – Tractive HV-

Interface	Distributor/Part No.	Manufacturer/Part No.	Type	Color
DW12	McMaster-Carr/69735K33	N/A	1-Wire Cable	Black
P0	N/A	N/A	Ring Terminal	N/A
P1	N/A	N/A	Ring Terminal	N/A

P0-1   P1-1

P0   **P1**

From	To	Description	Gauge	Color
P0-1	P1-1	Tractive High Voltage Negative	2/0 AWG	Black

DW13 – Safety Loop End

Interface	Distributor/Part No.	Manufacturer/Part No.	Type	Color
P0	Mouser/ 571-350779-1	TE Connectivity/350779-1	TE 4 Pin Connector (M)	White

P0-1
P0-2
P0-3
P0-4

P0
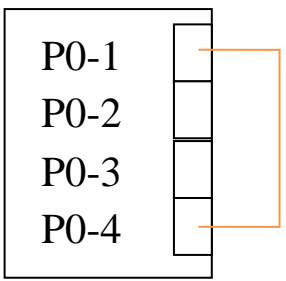
From	To	Description	Gauge	Color
P0-1	P0-4	Safety Loop Out	20 AWG	Orange

DW14 – Load Controller Fault Ground Cable

Interface	Distributor/Part No.	Manufacturer/Part No.	Type	Color
DW14	McMaster-Carr/7587K078	N/A	1-Wire Cable	Black
P0	Mouser/538-19-09-1016	Molex/19-09-1016	Molex 1-Pin Connector (M)	White
P1	McMaster-Carr/7113K221	N/A	#10 Ring Terminal	Pink

P0-1   P1-1

P0   **P1**
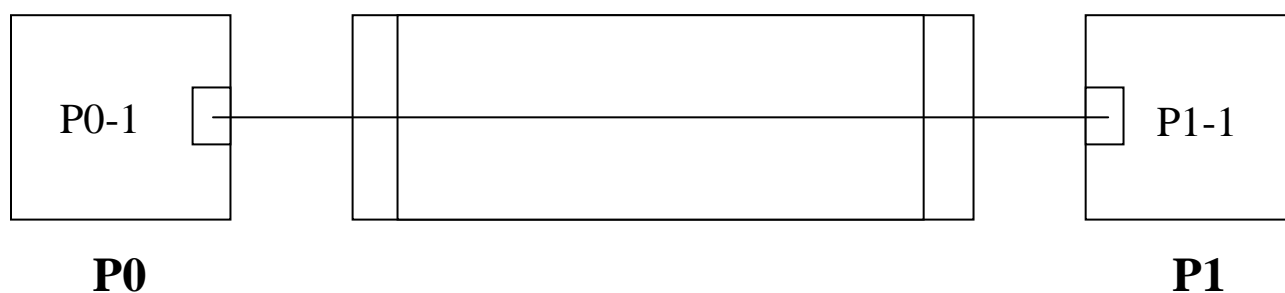
From	To	Description	Gauge	Color
P0-1	P1-1	Ground Fault	18 AWG	Black

A0 – Charger

Junction Descriptions

Junction Identification				
Junction	**Name**	**Distributor/Part No.**	**Manufacturer/Part No.**	**Interface Type**
J0	Supply Side Charging Interface	N/A	N/A	Anderson Config A (F)
J1	AC Power Cable	McMaster-Carr/7348K71	N/A	IEC 320 Power Receptacle

A1 – Battery Pack

Junction Descriptions

Junction Identification				
Junction	**Name**	**Distributor/Part No.**	**Manufacturer/Part No.**	**Interface Type**
J0	Charging Port	N/A	N/A	Anderson Config A (F)
J1	Pack HV-	N/A	N/A	Powerlock Connector (Source)
J2	Pack HV+	N/A	N/A	Powerlock Connector (Drain)
J3	Safety Loop Positive Terminal	Mouser/571-350780-1	TE Connectivity/ 350780-1	TE 4-Pin Connector (F)
J4	Safety Loop Negative Terminal	Mouser/571-350780-1	TE Connectivity/ 350780-1	TE 4-Pin Connector (F)
J5	RS-485 SCADA Communication Interface	Mouser/571-14807050	TE Connectivity/1-480705-0	TE 6-Pin Connector (F)

A2 – Load Controller

Junction Descriptions

Junction Identification				
Junction	**Name**	**Distributor/Part No.**	**Manufacturer/Part No.**	**Interface Type**
J0	Tractive Control 24	Mouser/571-1721581	TE Connectivity/172158-1	TE 3-Pin Connector (F)
J1	GLV & IMD Data	Mouser/538-03-06-1038	TE Connectivity/ 03-06-1038	Molex 3-Pin Connector (F)
J2	Safety Loop	Mouser/571-350780-1	TE Connectivity/ 350780-1	TE 4-Pin Connector (F)
J3	HV+ Pack	McMaster-Carr/ 69735K33	N/A	IR Ring Terminal Screw
J4	HV- Pack	McMaster-Carr/ 69735K33	N/A	IR Ring Terminal Screw
J5	HV- Load	McMaster-Carr/ 69735K33	N/A	IR Ring Terminal Screw
J6	HV+ Load	McMaster-Carr/ 69735K33	N/A	IR Ring Terminal Screw
J7	Safety Loop	Mouser/571-350780-1	TE Connectivity/350780-1	TE 4-Pin Connector(F)
J8	Fault Ground	Mouser/538-19-09-2018	TE Connectivity/19-09-2018	Molex 1-Pin Connector (F)
J9	Load Control Data	Mouser/538-03-06-1043	Molex/03-06-1043	Molex 4-Pin Connector (F)
J10	TSMP V+	Digikey/BU-31607-2-ND	Mueller Electric Co./BU-31607-2	4mm Banana Jack
J11	TSMP V-	Digikey/BU-31607-0-ND	Mueller Electric Co./BU-31607-0	4mm Banana Jack
J12	GLV-GMP	Digikey/BU-31607-0-ND	Mueller Electric Co./BU-31607-0	4mm Banana Jack

A3 – Safety Controller

Junction Descriptions

Junction Identification				
Junction	**Name**	**Distributor/Part No.**	**Manufacturer/Part No.**	**Interface Type**
J0	Tractive Power	Mouser/571-1721581	TE Connectivity/172158-1	TE 3-Pin Connector (F)
J1	Safety Loop	Mouser/571-350780-1	TE Connectivity/350780-1	TE 4-Pin Connector (F)
J2	Safety Loop	Mouser/571-350780-1	TE Connectivity/350780-1	TE 4-Pin Connector (F)
J3	GLV & IMD Data	Mouser/538-03-06-1038	TE Connectivity/03-06-1038	Molex 3-Pin Connector (F)

A4 – Load Resistor

Junction Descriptions

Junction Identification				
Junction	**Name**	**Distributor/Part No.**	**Manufacturer/Part No.**	**Interface Type**
J0	Load Positive	N/A	N/A	IR Ring Terminal Screw
J1	Load Negative	N/A	N/A	IR Ring Terminal Screw

A5 – Emergency Button Panel

Junction Descriptions

Junction Identification				
Junction	**Name**	**Distributor/Part No.**	**Manufacturer/Part No.**	**Interface Type**
J0	Safety Loop	Mouser/571-350780-1	TE Connectivity/350780-1	TE 4-Pin Connector (F)
J1	Safety Loop	Mouser/571-350780-1	TE Connectivity/350780-1	TE 4-Pin Connector (F)

A6 – Power Hub

Junction Descriptions

Junction Identification				
Junction	**Name**	**Distributor/Part No.**	**Manufacturer/Part No.**	**Interface Type**
J0	GLV AC Power	McMaster-Carr/ 7120K91	N/A	NEMA 5-15 Wall Outlet Socket
J1	Charger AC Power	McMaster-Carr/ 7120K91	N/A	NEMA 5-15 Wall Outlet Socket

A7 – GLV Power

Junction Descriptions

Junction Identification				
Junction	**Name**	**Distributor/Part No.**	**Manufacturer/Part No.**	**Interface Type**
J0	AC Power	McMaster-Carr/ 7348K71	N/A	NEMA 5-15 3 Prong Plug
J1	Chassis Ground Contact	N/A	N/A	Anderson Config B (F)
J2	TC 24	Mouser/571-1721581	TE Connectivity/172158-1	TE 3-Pin Connector (F)
J3	TC 24	Mouser/571-1721581	TE Connectivity/172158-1	TE 3-Pin Connector (F)

Software Interfaces

RS-485 Battery Pack⇔Central SCADA Interface

The Battery Packs on the RS-485 bus will typically operate as slave devices reacting to query commands set from the central SCADA unit in order to allow the central SCADA to obtain information from each battery pack or manage operational settings of each pack. The instruction set below contains the protocol to be used to communicate with each individual battery pack on the RS-485 bus.

1.　Data format

Serial data format is 8 bit, one start bit and one stop bit with no parity bit.

2.　End of Message

The end of message is the End Of Transmission Character (ASCII 4 or Ctrl+D in RealTerm).

3.　Acknowledge

The transmitter of the message should receive an "OK" message from the recipient of the message. If an error is detected, the recipient will return an error message instead.

4.　Protocol

The messages will be transmitted and received in ASCII for human readability. Central SCADA will act as the master and the PM board, the slave. This means that the PM board should only transmit the message if the request from Central SCADA is addressed to it.

1) The first part of the message will be the pack number. For Central SCADA, this will be the pack number that the message is addressed to and for the PM board, this will be its own pack number.
2) The second part of the message will be the command. In an acknowledgement message, this will be either "OK" or one of the error messages.
3) The third part of the message is the argument of the command. This may be omitted if the command does not require argument. For the response message from PM board, this will be the response to the command. If there is more than one response, all the responses will be listed with 'Spaces' between them.
4) The parts of the message will be separated by Space characters (ASCII 32).

An example message –

CENTRAL SCADA _____ PM BOARD
1 V? 1
(Pack number + space + command + space + argument)
This is a command to pack 1 asking for voltage of cell number 1.

<div align="right">

1 OK
(Pack number + ACK)
This is an ACK to the command.

</div>

<div align="right">

1 ??
(Pack number + response)
The response is the voltage of cell number 1. Please note that while the returned response is
'double', it will be displayed in ASCII and thus, not human readable.

</div>

1 OK
(Pack number + ACK)
This is an ACK by the Central SCADA to the response by PM Board.

5. **Command List**

Command	Description
V? n	Gets the cell voltage of 'n' cell. If 'n' is omitted, all cell voltages will be returned in the order of increasing cell numbers.
T? n	Gets the cell temperature of 'n' cell. If 'n' is omitted, all cell temperatures will be returned in the order of increasing cell numbers.
XT? n	Gets the temperature from external sensor 'n'. If 'n' is omitted all external sensor readings will be returned in order of increasing sensor numbers
C?	Gets the current in the discharge path of the battery pack
BPSS? n	Gets the bypass resistor switch state of 'n' cell. If 'n' is omitted, all bypass resistor switch states will be returned in the order of increasing cell numbers.
ADDR?	Gets the PM board address.
CELLCNT?	List the addresses of I2C devices connected to it.
TEST?	Returns '42'. (Test Command)
BPST? n	Gets the bypass time in minutes of 'n' cell. If 'n' is omitted, all times will be returned in the order of increasing cell numbers.
SAFETY?	Gets the current state of the safety loop relay on the pack manager
SOC?	Gets the current state of charge of the battery pack
Test Commands	
TESTMODE n	Turns test mode on/off. 0 - Test mode off 1 - Test mode on
TWD n	Turns the watchdog timer's input on/off. This command is only available in test mode 0 - Watchdog input off 1 - Watchdog input on
TOB n	Fakes an out-of-bounds sensor reading for test purposes. This command is only available in test mode 0 - Use normal sensor readings 1 - Emulate out-of-bound sensor reading

Note : More commands will be added as necessary.

6.   Error Message List

Error	Description
EBADFRMT	The format of the message is wrong or unknown. Usually happens when the message has missing spaces.
EBADCMD	The command is illegal or unknown.
EBADARG	The argument is in a bad format or missing.
ENOCELL	The specified cell is not connected or found. Checks with CELLCNT? command.
EERROR	This should not happen. This error message is returned when an unexpected error occurs within the PM board. This is the default error message if none of the errors fits in the above categories. Checks the log file of PM board for more information.

Note: Central SCADA should always return "OK" even if the response from the PM board is different from what is expected.

Example Error Message:
CENTRAL SCADA   PM BOARD
1 V? abcd

                                                              1 EBADARG

I2C BMS⇔Pack Manager Interface

The BMS boards on each cell act as I2C slaves while the Pack Manager serves as the master for this interface. Commands will come from the Pack Manager and will be set to the BMS boards in order to obtain sensor readings from each cell. The instruction set below contains the protocol used to communicate with each BMS board in order to modify their operation and obtain sensory data for each battery cell being monitored.

Read/Get Command Format:

Board Address	Command Number	Data Byte High	Data Byte Low
0xXX	0x1X	0xXX	0xXX

Write/Set Command Format:

Board Address	Command Number	Data Byte High	Data Byte Low
0x10	0x0X	0xXX	0xXX

Instruction Set:

Command No.	Description	Bytes Returned
0x10	Gets the Cell Voltage	2
0x11	Gets the Cell Temperature	2
0x14	Gets the bypass resistor switch state	2
0x15	Gets the slave/board address	2
0x16	Gets the Software Version	2
0x17	Gets 0x42 (Test Command)	2
0x18	Gets the bypass resistor time (in minutes)	2
0x1B	Gets the voltage and temperature of the cell	4
0x1E	Gets the time elapsed since the bypass switch has been set	6*
0x00	Sets the bypass resistor switch state	N/A
0x01	Sets the board address	N/A
0x02	Sets the bypass time in minutes	N/A
0x03	Calls the function to test the watchdog timer	N/A

*   The first two bytes represent minutes. The next two bytes refer to the seconds while the last two bytes refer to milliseconds.

Appendix A – Anderson Connectors

Parts List

Part	Name	Distributor/Part No.	Name	Color
0	Mouser/879-1470G1	Anderson/1470G1	Panel Mount Connector	Black
1	Mouser/879-1460G1	Anderson/1460G1	Cable Mount Connector	Black
2	Mouser/879-1327FP	Anderson/1327FP	Power Housing	Red
3	Mouser/879-1327G6FP	Anderson/1327G6FP	Power Housing	Black
4	Mouser/ 879-269G1-LPBK	Anderson/269G1-LPBK	Power Housing	Green
5	Mouser/879-4827G6	Anderson/4827G6	Signal Housing	Black

Configurations

Note: All configurations are shown from the front. Grey boxes indicate an absent connection. The white boxes indicate which part is the top metal part of the pin.

Configuration	Male	Female
A		
B		