Statement of Work

Lucid Motors MPB EOL Production Test

Revision History

Date	Version	Author	Comment
5/21/2020	1.0	Victor Yang	First draft
5/26/2020	1.1	Mingkai Mu, Kayla Shi, Victor Yang	Add HVIL
5/30/2020	1.2	Shan Chai	Add EOL sequence.
6/10/2020	1.3	Kayla Shi, Victor Yang	Remove Hipot, and add equipment model
7/02/2020	1.4	Mingkai Mu, Victor Yang	Remove 18kW Load and add Compressor
7/06/2020	1.5	Ryan Lembitz	Change Chiller and Pressure

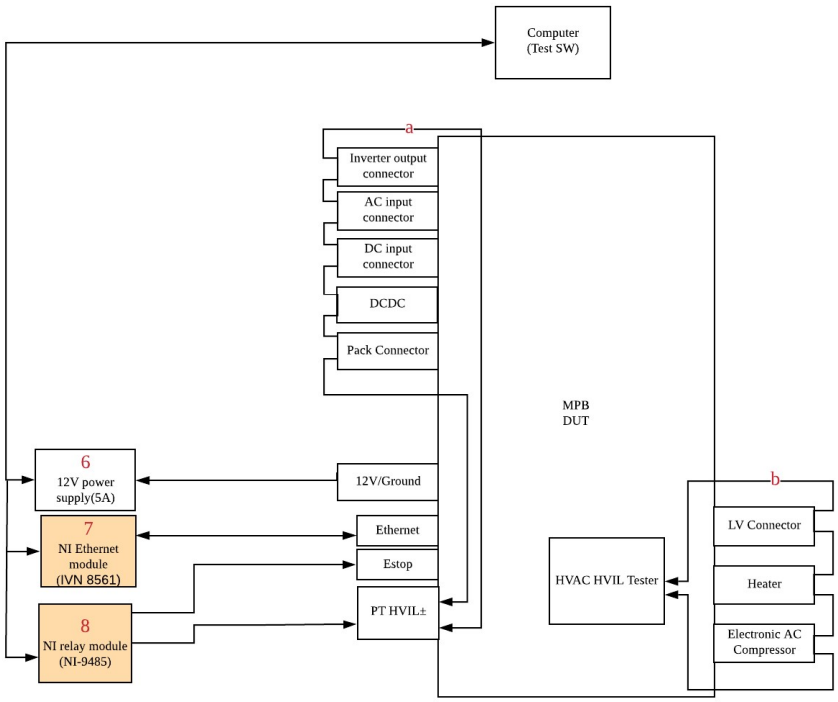
Purpose

Lucid Motors is developing and integration plan for MPB (Multifunction Power Box) production test stations. MPB will provide on-board battery charger and DC/DC power function to all electrical vehicle required power following proposal. The Lucid team wants to use LabVIEW software to control all MPB function.

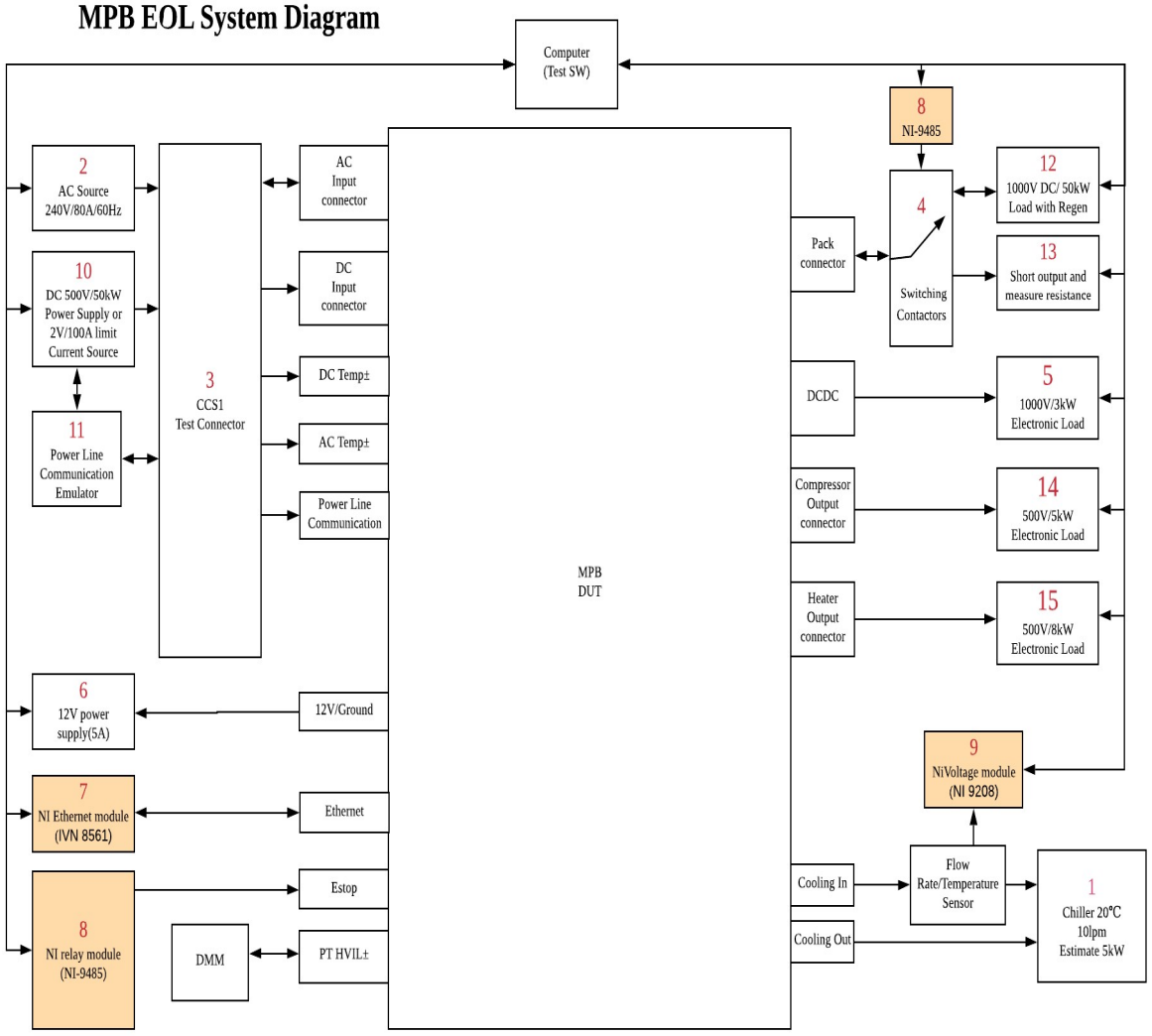
Test Station Summary

HV component	**Assembly level**	**Test station**
MPB HVIL	Assembly	HVIL Test
MPB Offset Tuning	Assembly	AC charging
MPB, AC power source, Electronic Load	Assembly	AC charging
MPB, 400V DC power source, Electronic load	Assembly	400V DC charging
MPB, 800V DC power source, Electronic load	Assembly	800V DC charging Power Line Conductivity
MPB, 1000V Power supply, Electronic load	Assembly	HAPS (Heater & AC Compressor)
MPB, 1000V Power supply, Electronic load	Assembly	DCDC

MPB HVIL
System Diagram

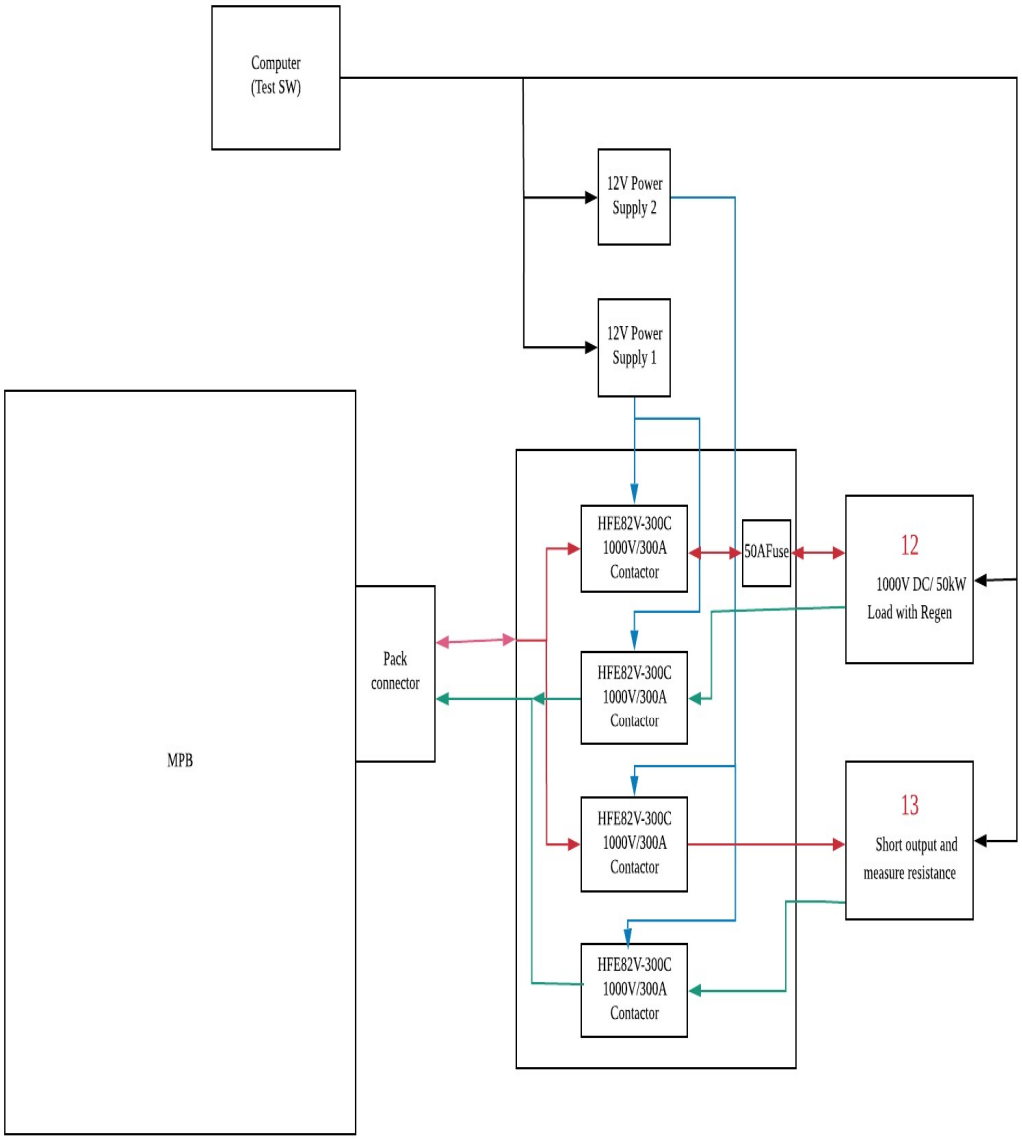


MPB EOL System Diagram



Step	Test Group	Test Description	Hardware	Equipment Item	Equipment Model	Test Time (sec)	Note
1	LV	PT HVIL Test	a, b, 6, 7, 8	12V power supply, NI Ethernet, Relay Module	1X Agilent E3633A,IVN8561, NI-9485	2	
2	HV	AC Charging	1, 2, 3, 4, 6, 7, 8, 9, 12	NI voltage meter, AC source, DC Load	NI-9208, 60kW/1000V/150A, 1ch, 1 x Model 17040-60	60	AC 80A input/DC 800V/18kW output, Ethernet communicaton
3	HV	DC charging 400V	1, 3, 4, 6, 7, 8, 9, 10, 11, 12	DC power supply, Pack load	450V/136A/60kW Source, 4 x Model 62150H-600, 60kW/1000V/150A, 1ch, 1 x Model 17040-60, Intech PLC card	30	400V input/50kW, Ethernet communication
4	HV	DC charging 800V	1, 3, 4, 6, 7, 8, 9, 10, 11, 13	DC power supply, Short pack side	450V/136A/60kW Source, 4 x Model 62150H-600	2	2V/100A limit current source to measure DC input voltage and the resistance, Ethernet communication
5	HV	HAPS-Heater output	1, 4, 6, 7, 8, 9, 12, 15	Pack DC power supply, Electronic load	1 x Model 17040-60, 600V/560A/8kW, 1 x Model 63208A-600-560	30	925V input /7kW output, Ethernet communication
6	HV	HAPS-Compressor output	1, 4, 6, 7, 8, 9, 12, 14	Pack DC power supply, Electronic load	1 x Model 17040-60, 1 x Model 63205A-600-350	30	550V input /4kW output, Ethernet communication
7	HV	DCDC output	1, 4, 5, 6, 7, 8, 9, 12	Pack DC power supply, Electronic load	1 x Model 17040-60, 1 x Model 63203A-1200-120	5	925V input /3kW output, Ethernet communication

MPB SOW Switch Contactor Schematic



Contactor

HFE82V-300C

1000V/300A

http://en.hf-relay.com/uploadfile/2019/0507/20190507032909220.pdf

ACS will need to control 5, 6, 7, 8, 9, 10, 12, 14, 15.

Equipment No.	Model	Link
5	1000V/3kw DCDC Load Chroma 62150H-600	https://www.chromausa.com/pdf/62000H%20Datasheet.pdf
6	E3633A, Agilent 12V Power supply	http://literature.cdn.keysight.com/litweb/pdf/E3634-90001.pdf
7	NI Ethernet Module IVN 8561	Need to confirm if this is controlled via DSA.
8	NI relay model NI-9485	
9	Ni Voltage Module NI 9208	
10	DC500V/50Kw Power Supply Chroma 62150H-600	https://www.chromausa.com/pdf/62000H%20Datasheet.pdf
	DMM, Chroma 12061	https://www.chromausa.com/product/digital-multimeter-12061/?gclid=EAIaIQobChMIzKzbqai-6gIVUhh9Ch1nBwpJEAAYASAAEgI62_D_BwE
12	Regenerative Battery pack, Chroma 17040	http://www.chromausa.com/pdf/17040-Regenerative%20Battery%20Pack-0519.pdf
14	AC compressor Electric Load Chroma 63205A-600-350	http://www.chromausa.com/pdf/63200A%20DC%20Load%201810.pdf
15	Heater Electric Load Chroma 63208A-600-560	http://www.chromausa.com/pdf/63200A%20DC%20Load%201810.pdf

In the EOL tests proposed below, it is required that LabVIEW will send a sequence number to MPB to setup the test mode for the corresponding test. Table below summaries communication that shall happen between LabVIEW and MPB.

Table 1: Ethernet Communication definition between MPB and LabVIEW

Sequence Number	Used in Test	Feedback to LabVIEW for display
0	Software Flashing	Done or Not.
1	HVIL Test	Result (Fail or Pass)
2	Start- Offset Tuning	N/A
3	Read Offsets – Offset Tuning	4 offset values.
4	AC Charge	Pack Output Voltage, current, fault code
5	DC 400V	Pack Output Voltage, current, fault code
6	DC 800V	N/A.
7	HAPS-Heater output	Heater Output Voltage, current, fault code
8	HAPS-Compressor output	Compressor Output Voltage, current, fault code
9	DCDC output	DCDC Output Voltage, current, fault code

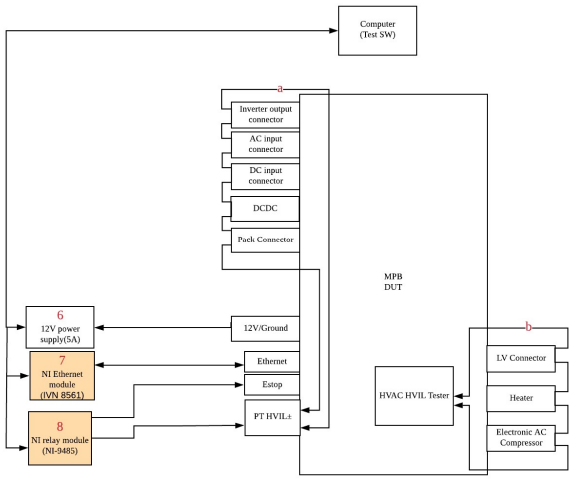
Integration Proposal

Application Flashing

1. Labview shall control the 12V power supply to achieve software upgrade.

2. Point to the right folder location to locate the binary files to be flashed on the ECU
3. Run a batch file from Labview to upgrade t application software

HVIL Test



Connection and Test sequence

4. Insert connectors for MPB Inverter output, AC input, DC input, DCDC, and Pack connectors
5. Insert connectors for LV connector, Heater, and Electronic AC compressor connectors
6. Record continuity between pin 5 and pin 6 (PT HVIL) of the LV connector, and use LabVIEW monitor resistance.
7. The LabVIEW shall send the sequence number 1 to start HVIL Tester. MPB will conduct self-test and send the result back to LabVIEW.
8. The LabVIEW shall display the result.
9. Check Pass/Fail and turn off power

MPB Automotive Ethernet Interface

All MPB communication shall be integrated to LabVIEW test program

Test Software

- LabVIEW

Test Data Requirements

Test input	
Test output	Pass/Fail
Test log	Yes

Sensor Offset Tuning

This procedure has to be conducted before any of the following high power test.

Only 12V and Ethernet connection are required for this test.

Connection and Test sequence

1. Use LabVIEW to send signal to turn on LV Harness with 12V power supply.
2. Use LabVIEW to send the EOL sequence number 2 to MPB to start the sequence.
3. Use LabVIEW to send the EOL sequence number 3 to MPB to get the offset values.
4. LabVIEW shall display and compare it with pre-defined threshold to indicate it pass or fail.

MPB Automotive Ethernet Interface

All MPB communication shall be integrated to LabVIEW test program

Test Software

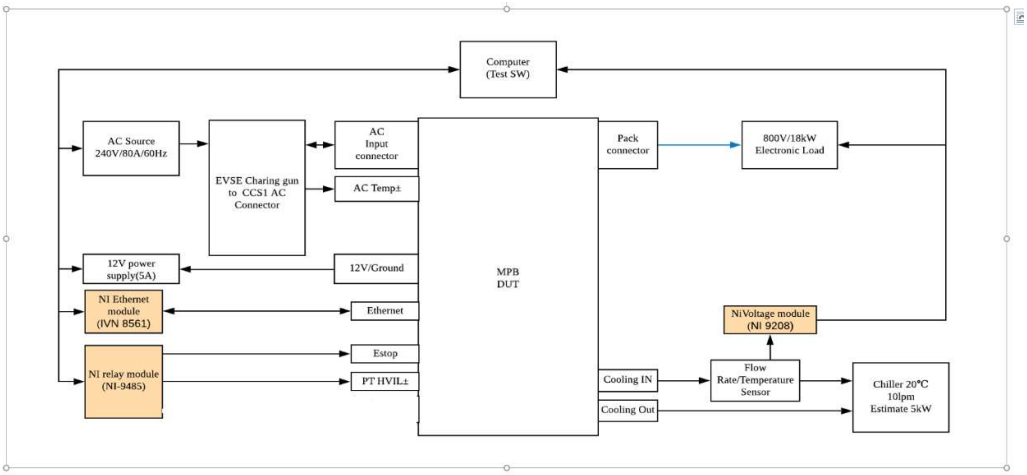
- LabVIEW

Test Data Requirements

Test input	
Test output	Pass/Fail
Test log	Yes

AC charging

Connection and Test sequence



1. Turn on AIR1000 chiller with 20psi and 20C test condition and connect coolant with MPB through water pipe during the test.
2. Set Regenerative Battery Pack (model 17040) to 800V/18kW as an Electronic Load and connect to MPB Pack connector by switching on the corresponding contactors from LabVIEW.
3. Connect AC source to EVSE, and insert charging gun to AC connector
4. Use LabVIEW to send signal to turn on LV Harness with 12V power supply and all NI sensor detectors.
5. Use LabVIEW send Ethernet signal to start the EOL sequence 4.
6. Use LabVIEW to send signal to turn on AC power to start to charge.
7. MPB will send output DC voltage, DC current and fault code to LabVIEW via Ethernet.
8. LabVIEW shall display and compare it with pre-defined threshold to indicate it pass or fail.
9. Check Pass/Fail and turn off power

MPB Automotive Ethernet Interface

All MPB communication shall be integrated to LabVIEW test program

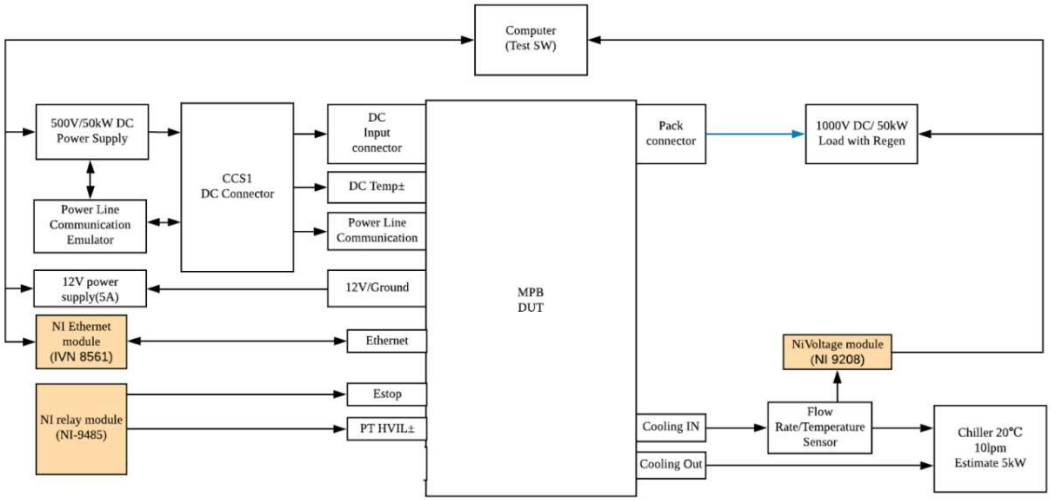
Test Software

- LabVIEW

Test Data Requirements

Test input	
Test output	Pass/Fail
Test log	Yes

DC 400V charging



Connection and Test sequence

1. Set Regenerative Battery Pack (model 17040) to 1000V/50kW as an Electronic Load and connect to MPB Pack connector by switching on the corresponding contactors from LabVIEW.
2. Use LabVIEW to send signal to turn on LV Harness with 12V power supply and all NI sensor detectors.
3. Start PLC (Power Line Communication) emulator software on PC.
4. Use LabVIEW to send the EOL sequence number 5 to MPB to start the sequence.
5. PLC emulator on PC will turn on 500V/50kW DC power to start to charge.
6. MPB will send output DC voltage, DC current and fault code to LabVIEW via Ethernet.
7. LabVIEW shall display and compare it with pre-defined threshold to indicate it pass or fail.
8. Check Pass/Fail and turn off power

MPB Automotive Ethernet Interface

All MPB communication shall be integrated to LabVIEW test program.

Test Software

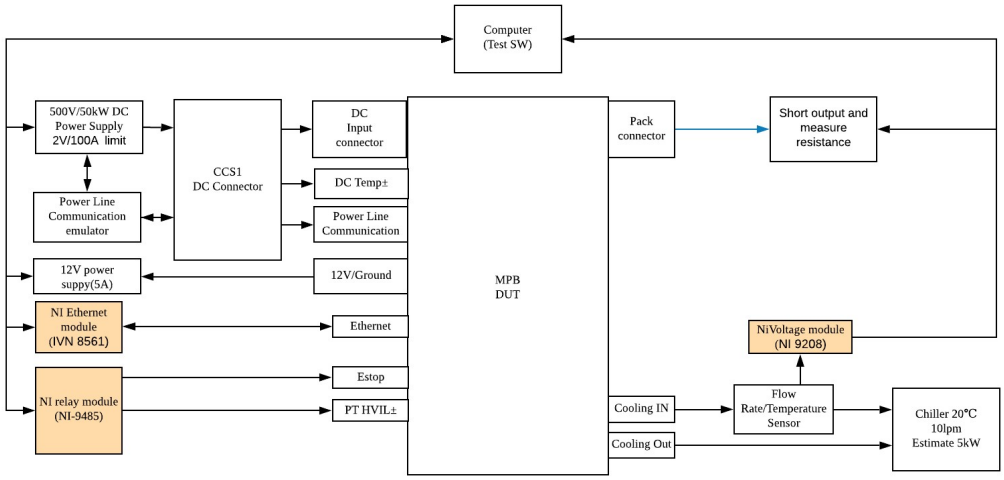
- LabVIEW

Test Data Requirements

Test input	
Test output	Pass/Fail
Test log	Yes

DC 800V Charging Power Line Conductivity

The main purpose of this test is to test the conductivity of 800V power line on MPB instead of 800V charging.



Connection and Test sequence

1. Switch to connect MPB Pack connector to short connection by switching on the corresponding contactor from LabVIEW.
2. Use LabVIEW to set 50kW DC power to 2V/100A limit
3. Use LabVIEW to send signal to turn on LV Harness with 12V power supply and NI sensor detectors.
4. Use LabVIEW to send the EOL sequence number 6 to MPB to start the sequence.
5. Use LabVIEW to send signal to turn on 50kW power to start outputting voltage.
6. LabVIEW shall measure DC input voltage and the conduction resistance and compare the conduction resistance with pre-defined threshold to indicate it pass or fail.
7. Check Pass/Fail and turn off power

MPB Automotive Ethernet Interface

All MPB communication shall be integrated to LabVIEW test program.

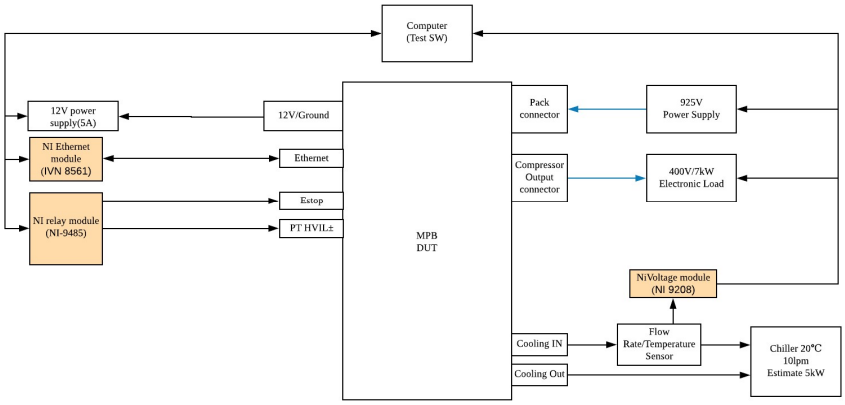
Test Software

- LabVIEW

Test Data Requirements

Test input	
Test output	Pass/Fail
Test log	Yes

HAPS-Heater output



Connection and Test sequence

1. Set Regenerative Battery Pack (model 17040) to 925V/10kW as a Power Source and connect to MPB Pack connector by switching on the corresponding contactor from the LabVIEW.
2. Connect MPB Heater output to 400V/7kW with current limit 20A Electronic Load.
3. Use LabVIEW to send signal to turn on LV Harness with 12V power supply, all NI sensor detectors.
4. Use the LabVIEW to start 925V/10kW power supply to output 925V.
5. Use LabVIEW to send the EOL sequence number 7 to MPB to start the sequence.
6. MPB will send output DC voltage, DC current and fault code to LabVIEW via Ethernet.
7. LabVIEW shall display and compare it with pre-defined threshold to indicate it pass or fail.
8. Check Pass/Fail and turn off power

MPB Automotive Ethernet Interface

All MPB communication shall be integrated to LabVIEW test program

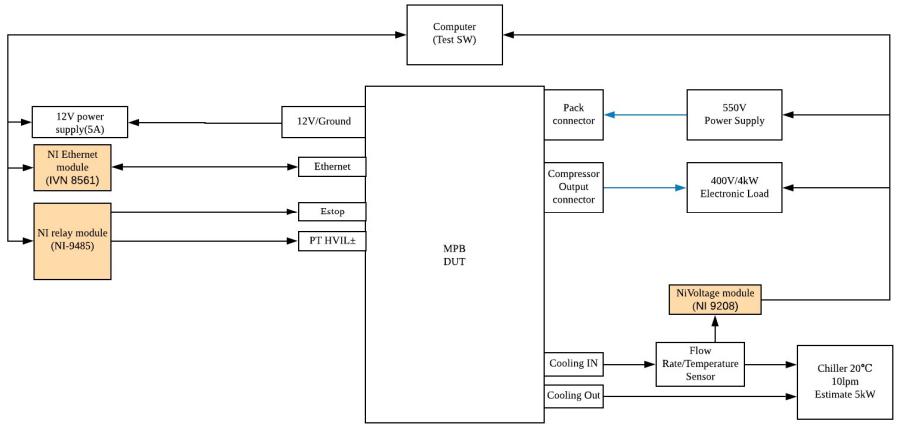
Test Software

- LabVIEW

Test Data Requirements

Test input	
Test output	Pass/Fail
Test log	Yes

HAPS-Compressor output



Connection and Test sequence

1. Set Regenerative Battery Pack (model 17040) to 550V/10kW as a Power Source and connect to MPB Pack connector by switching on the corresponding contactor from the LabVIEW.
2. Connect MPB Compressor output to 400V/4kW with current limit 20A Electronic Load.
3. Use LabVIEW to send signal to turn on LV Harness with 12V power supply, all NI sensor detectors.
4. Use the LabVIEW to start 550V/10kW power supply to output 550V.
5. Use LabVIEW to send the EOL sequence number 8 to MPB to start the sequence.
6. MPB will send output DC voltage, DC current and fault code to LabVIEW via Ethernet.
7. LabVIEW shall display and compare it with pre-defined threshold to indicate it pass or fail.
8. Check Pass/Fail and turn off power

MPB Automotive Ethernet Interface

All MPB communication shall be integrated to LabVIEW test program

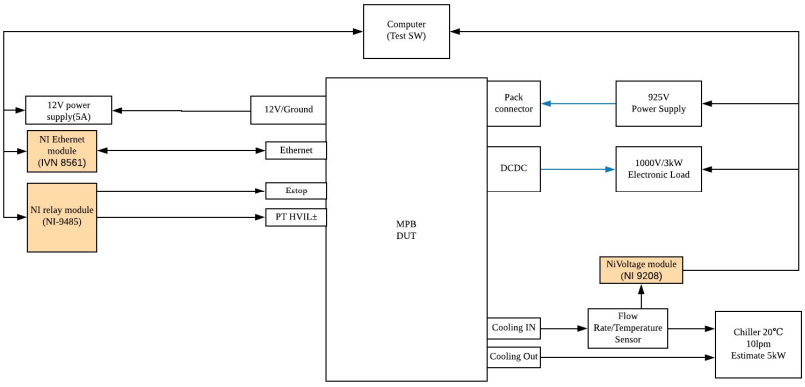
Test Software

- LabVIEW

Test Data Requirements

Test input	
Test output	Pass/Fail
Test log	Yes

DCDC output



Connection and Test sequence

1. Set Regenerative Battery Pack (model 17040) to 925V/10kW as a Power Source and connect to MPB Pack connector by switching on the corresponding contactor from the LabVIEW.
2. Set Electronic Load to 925V/3kW, and Connect MPB DCDC output.
3. Use LabVIEW to send signal to turn on LV Harness with 12V power supply, all NI sensor detectors.
4. Use the LabVIEW to start 925V/10kW power supply to output 925V.
5. Use LabVIEW to send the EOL sequence number 9 to MPB to start the sequence.
6. MPB will send output DC voltage, DC current and fault code to LabVIEW via Ethernet.
7. LabVIEW shall display and compare it with pre-defined threshold to indicate it pass or fail.
8. Check Pass/Fail and turn off power
9. Turn off the chiller to complete EOL test

MPB Automotive Ethernet Interface

All MPB communication shall be integrated to LabVIEW test program

Test Software

- LabVIEW

Test Data Requirements

Test input	
Test output	Pass/Fail
Test log	Yes