Lafayette College | Electrical and Computer Engineering

Interconnect Maintenance Manual

ECE 492 – Spring 2020

Last Revision: 4/14/20
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Abstract

This document provides detailed information, guidelines, and purpose of the interconnect of the FSAE Electric Car Project. The interconnect is defined as the connection of all subsystems through proper cabling and connectors on each enclosure and serves the purpose of providing guidelines of how the car functions on a higher scale. Cabling and other interface systems must be rules compliant and be able to drive in certain conditions using strain relief and water proofing. This will also give insight into the progress and goals accomplished throughout the process.

Table of Contents

Electrical System Diagram

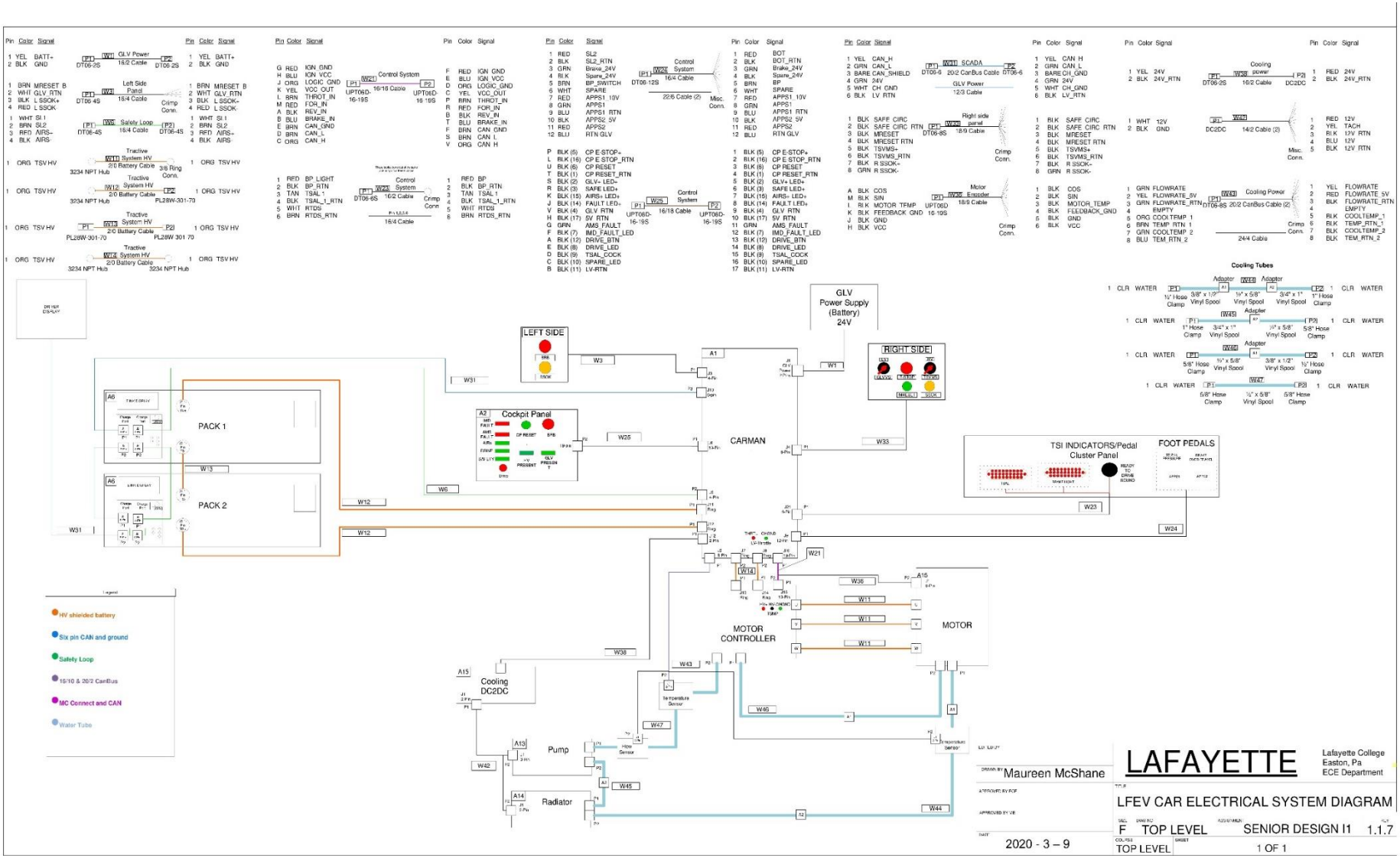

Figure 1. High Level Electrical System Diagram

Understanding the Electrical System Diagram

The Electrical System Diagram works as guidelines on how to connect the electrical subsystems in the car, the key to a functioning system.

Subsystems

Distinguished by blocks on the diagram

CarMan

This mechanical enclosure contains

- GLV (Grounded Low Voltage system)
    - Provides 24 DC power to all low voltage electrical systems
        - As well as AIRs and TSV battery packs
    - Controls safety Loop system: allows driver, surrounding people, and system components to shut down the system in case of emergency or a system failure.
    - Every conductive part that is not part of the tractive system
- TSI (Tractive System Interface)
    - Interface between motor controller and TSV
    - Provides functions for car control:
        - Controls pre-charge/discharge relay, as well as power to the motor controller
        - Throttle Plausibility
        - Receives brake signal, triggers brake light
        - Opens safety loop when IMD fault signal is received
        - High voltage and current measurement
        - Triggers TSAL (Tractive System Active Lamp) and RTDS (Ready to drive sound)
        - Determines when in drive mode

Battery Packs 1 & 2

- Deliver high voltage power to the FSAE vehicle to power it. The two packs are wired in series to provide approximately 108 V
- The packs interact with other subsystems through our SCADA (supervisory control and data acquisition) system through the vehicle's CanBus and Safety Loop.

Driver Display

- The dashboard display which provides the driver indicators to show the status of the vehicle

Side Panels

- Left Side
    - Holds the BRB (Big Red Button) and SSOK (Safety Systems OK) Lamp
    - Connected to the CarMan (GLV side)
- Right Side
    - Holds the GLVMS (Grounded Low Voltage Master Switch), the TSMS (Tractive System Master Switch), BRB, MReset (Manual Reset), and SSOK Lamp.
    - Connected to the CarMan (GLV side)

Cockpit Panel

- Holds the IMD (Insulation Monitoring Device) fault light, the AMS (Accumulator Monitoring System) fault light, AIRs (Accumulator Isolation Relay) light, Drive light, Safety light, Drive button, Cockpit Reset button, BRB, HV (high-voltage) Present light, and GLV present light.
- Connected to CarMan (Both TSI and GLV)

TSI Indicators/Pedal Cluster Panel

- TSAL, Brake Light, RTDS, Foot Pedals (Brake Pressure and Brake Over-Travel)

Motor

- EMRAX 208
- Liquid cooled

Motor Controller

- Emsiso EmDrive500 Motor Controller
- Connected to CarMan (TSI side), the motor, and CoolMan (the cooling system)
- Takes throttle signals and high voltage to input control signals to the motor

GLV Battery

- 24 V 10AH Lithium Iron Phosphate battery. Used in the LFEV (Lafayette Formula Electric Vehicle) to power the GLV system.

Cooling System

- The cooling system provides cooling for the motor controller and motor to prevent damage due to heat generated by both of them
- Components of cooling system connected to CarMan (TSI)
    - DC to DC Converter (24V to 12V)
    - Temperature Sensors
    - Flow Sensors
    - Pump
    - Radiator

Reading the Legends

Pin

- Follows the numbering on connectors (see page 10 for more information on connectors)
- DT Connectors use numbers while Amphenol Connectors use Letters

Color

- Color of conductors within cable
    - Varies between cables, based on who manufactured the cables and how they were made
- Helps for correct assignment of conductors to connector housing/signal throughout system

Signal

- Name of signal assigned to each conductor in cable

Cable Size

- First number is the AWG, second number is the # of conductors in cable
- EX:
    - (16/4) means 16 AWG, 4 conductors inside
- AWG number decreases with increased size
    - (2/0) is the battery cable, the largest cable used in the car with 2 AWG

Ports

- Labeled as P1 and P2
- Shows which kind of connector is used on the specified cable
- Crimp Connection
- DT – designates the Deutsch type of connector
- UPT – designates the Amphenol type of connector
    - More information on connectors can be found below

Wire Number

- Cable naming system used in LFEV diagram
- W followed by #

Cable Color

- assigned in order to aid in distinction of cables on diagram pertaining to a specific function

Cooling System Legend

Portion of the diagram designated by light blue water lines

- Different sized tubes used in order to have a compatible system between the motor, motor controller, pump, radiator, and different sensors.
- Adapters are shown which are used to connect the different sized tubes.
- Ports are the hose clamps and quick releases
- More information on the cooling system can be found under the subsystem tab on the site.

Length and Size

Length

While testing in the dynamometer room with cabling from previous years, it was necessary to have longer cables in order to be able to shorten and modify when transferring electrical systems to the car. The most important and expensive cables to take into consideration for length are the battery cables. The length for these are predetermined through modeling.

Size

- High voltage cables are sized based on specifications by the Formula SAE rules.
- Sizing the cables of all other subsystems is determined by a calculation to ensure the wire can handle the load without overheating.
    - Wire sizing indicated the diameter of the metal conductor of the wire which is based on the American Wire Gauge (AWG) system.
    - The gauge relates to the wire's current-carrying capacity
- Wires that are not properly matches to the amperage of the circuits they serve can create a risk of short circuit and/or fire.

The table below will help determine the appropriate wire size. A helpful wire ampacity calculators can be found online here: http://wiresizecalculator.net/calculators/wireampacity.htm

Conductor Size	Type: Copper			Aluminum/Copper-Clad Aluminum		
(AWG or kcmil)	60°C	75°C	90°C	60°C	75°C	90°C
14 AWG	15A	20A	25A—	—	—	
12 AWG	20	25	30	15A	20A	25A
10 AWG	30	35	40	25	30	35
8 AWG	40	50	55	35	40	45
6 AWG	55	65	75	40	50	60
4 AWG	70	85	95	55	65	75
3 AWG	85	100	115	65	75	85
2 AWG	95	115	130	75	90	100
1 AWG	115	130	145	85	100	115
1/0 AWG	125	150	170	100	120	135
2/0 AWG	145	175	195	115	135	150
3/0 AWG	165	200	225	130	155	170
4/0 AWG	195	230	260	150	180	205
250 kcmil	215	255	290	170	205	230
300 kcmil	240	285	320	195	230	260
350 kcmil	260	310	350	210	250	280
400 kcmil	280	335	380	225	270	305
500 kcmil	320	380	430	260	310	350
600 kcmil	350	420	475	285	340	385
700 kcmil	385	460	520	315	375	425
750 kcmil	400	475	535	320	385	435

Table 1. Wire Sizing Chart

Manufacturing

Besides a couple of the cables, most wiring is connected using the Deutsch DT series. These were chosen from the previous year and in order to save cost, we are reusing them and implementing strain relief attachments by Deutsch. We are also using Amphenol connectors for cables with more signals than the DT connectors can handle to minimize amount of cabling on the car.

TE Connectivity Deutsch Connectors

- Various sizes
- Strain relief attachment
- Connectors on diagram depict male part
    - DT06-2S (2-pin)
    - DT06-4S (4-pin)
    - DT06-6S (6-pin)
    - DT06-8S (8-pin)
    - DT06-12S (12-pin)
- Match pin size with cable size (ex. Use 16 AWG size pins for a 16 AWG cable)
    - Male sockets and female pins needed
- Backshells to be used on all Deutsch connectors outside of enclosures

A video on how to assemble and disassemble DT Connectors can be found here
A video on how to crimp contacts to wires can be found here

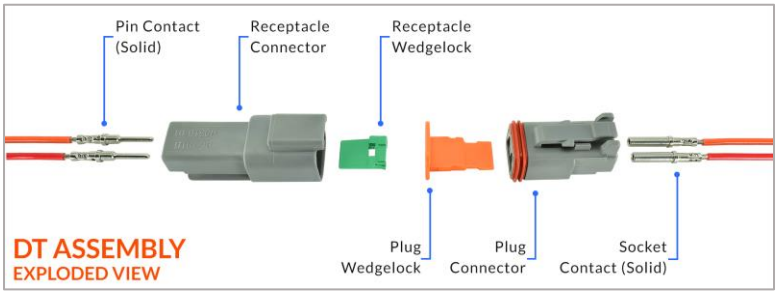

Figure 2. How to assemble DT connectors

Figure 3. DT Backshell

Amphenol

Used for cockpit cable, motor controller cable, and high voltage cable

- Cockpit and Motor Controller connector
  - UPT06D-16-19S (19-pin)
  - Using 16 AWG size pins for these connectors

- High Voltage Connector
  - PL28W-301-50
  - Used for orange high-voltage battery cables

Video on contact insertion and removal for this connector type can be found here

Figure 4. 19-pin Amphenol Connector, UPT06D-16-19S

Figure 5. Amphenol Connector, PL28W-301-50

Acknowledgements

Thank you to the previous Lafayette Formula Vehicle Teams for their previous efforts as well as the ECE department and our advisors, Prof. Chris Nadovich and Prof. Sally Sajadian, for their support throughout the project.