Dynamometer Test Plan

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Abstract

This document details the acceptance test plan for the dynamometer system being developed for the LFEV design project.

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Summary

The dynamometer system being developed for the LFEV design project is intended to provide detailed characteristics of the Motor Controller System (MCS) over the entirety of it’s operating range. To verify the operation of the dynamometer system, the following features must be designed and tested:

- A sensor feedback system capable of monitoring various parameters, including: motor torque, motor speed, motor phase current, controller input voltage, and the system temperature at various points.
- A motor test stand with standardized cable labelling and cooling systems for critical components.
- Interfaces between the MCS and other critical design components, including: the VSCADA system, the GLV Power system, the TSV Load Controller, and the Safety Loop Controller.
- A power supply system that allows for switching between a commercial power supply and the TSV load controller without exposure to insulated wiring.
- An independent safety system capable of automatic shutdown in case of any of the following: ground fault, overtemperature, overspin, over-torque, or if an emergency stop button is pressed.

Further details on the acceptance test plan for each of these subsystems is provided below, as well as a complete acceptance test checklist.

Sensors

The sensors incorporated into the dynamometer test stand will be logged onto an included computer system. Verification of the following parameters will be based on data recorded by this computer, and will be included in the final testing documentation.

Torque

The torque of the motor will be measured across all RPM ranges and graphed. This torque curve will be compared to the curve provided by the manufacturer. The motor will be tested by using the Curtis controller and the safety loop to ensure that the motor cannot apply unsafe levels of torque, either through activating the safety loop or not allowing the controller to apply that much torque. The safety loop will not shut down the system if the torque values are within a safe operating range.

RPM

The motor speed will be measured across all applicable ranges. The motor speed will be shown to correlate to the throttle device for all valid ranges, and shown to idle though invalid ranges. This will be tested using the Curtis controller and the safety loop to ensure the unsafe RPMs cannot be reached. If they are reached the safety loop will activate and shut down the motor. The safety loop will not shut down the system if the RPM values are within a safe operating range.

Motor Current

The motor phase current will be measured continuously during operation. The maximum amount of current able to be applied will be limited by the Curtis controller. The safety loop will be tested to prove that it will shut down the motor if unsafe amounts of current are detected by the sensor. The safety loop will not shut down the system if the phase current values are within a safe operating range.

Controller Input Voltage

The voltage to the input of the controller will be monitored during operation. If at any point the voltage reaches unsafe levels the safety loop will be activated and cut the power to the system. The safety loop will not shut down the system if the input voltage value is within the safe operating range.

System Temperature

The temperature of the system will be monitored during operation. If unsafe temperatures are recorded the safety loop will turn off power to the system and shut the system down. The safety loop will not shut down the system if the temperature values are within a safe operating range.

Test Stand

The test stand is the physical unit that contains the sensors, sensor mounts, the motor controller, and the physical cabling between each component. Various aspects must be checked by inspection for safety, as detailed below.

Cable Management

To satisfy GPR005 (good safety and practice) we must ensure that all cables are clearly labelled, that all LEDs are colored according to what they indicate, that all wiring is properly insulated, and that all cable assemblies have a dedicated ground.

MCS Cooling System

The cooling system uses oil to absorb the excess energy produced by the spinning of the motor. Although an oil tank will not be in the final electric vehicle, this system is used to simulate a moving car. The excess energy from the car will be transferred to the wheels or the brakes in the form of kinetic energy to move the car, but here the excess energy is absorbed by the oil in the tank. A temperature sensor will be installed to measure how much energy the oil will absorb. The oil tank should heat up at a reasonable rate; basically, it should not become too hot to touch in simple a few minutes. The power dissipation rating of all parts should be at least 50% higher than the required temperature range. All components must also not exceed more than 40 degrees Celsius above ambient temperature.

Physical Design

A safe working environment must be established when working on the motor controller test stand. To ensure safe working conditions, there must be insulating covers over the motor power terminals, there must be a safety plan in place for dynamometer operation and testing. The temperature of any given part of the system must be kept at safe levels.

Interfaces

Interfaces with various systems must be designed for the dynamometer test stand and MCS. These interfaces will be developed in conjunction with the teams designing these systems, and will be included in the final acceptance test documentation given that the respective system has also been completed.

VSCADA

It must be shown that the VSCADA system can collect real-time data from the MCS test stand. Assuming that the VSCADA system has been completed, it shall be shown that it receives accurate information from the sensors specified above. The data received by the VSCADA system shall be verified by comparing the received data to data logged by the independant computer system.

GLV Power

The MCS test stand shall have inputs for a GLV power line. the voltage and current requirements of this connection will be specified in the Interface Control Document.

TSV Load Controller

The motor system will work when interfaced with the TSV Accumulator Battery Pack or commercial power supply. The power supply shall be interchangeable without exposure to insulated wiring (see power supply switching below).

Safety Loop

The safety loop system shall be interfaced with the motor system so that in the instance of an emergency the motor system shall shut down. This shall adhere to the Formula EV rules for safety concerns and scenarios.

Power Supply

The power supply system being designed is the main source of power for the MCS. This system will be switchable between a Magna-Power TS Series IV power supply and the TSV Load Controller, assuming the TSV Load Controller has been completed.

Operation

Check that the system will draw the correct amount of power and spin the motor when powered by either the commercial power supply or TSV power.

Switching

It is possible for power to be switched from the accumulator packs to the Magna-Power power supply without exposure to uninsulated TSV conductors or terminals.

Safety

The MCS will have an independent safety system to ensure safe operation of the dynamometer test stand as well as to provide redundancy for the Vehicle Safety Loop system. The following failsafes will be included in the MCS safety system:

Ground Fault

The system will automatically shut down in the event that a ground fault is detected. It will also signal that the motor must be disconnected from the drivetrain. This will be tested by forcing a ground fault and ensuring that the system behaves as expected.

Overtemperature

The system will automatically shut down when it detects that the temperature in any part of the system exceeds a given threshold. This threshold will be set based on the specifications of the parts involved. It will also signal that the motor must be disconnected from the drivetrain. This will be tested by artificially heating every relevant measurement point and ensuring that the system behaves as expected.

Overspin

The system will shut down in the event that the motor exceeds safe operating speeds. It will also signal that the motor must be disconnected from the drivetrain. This will be tested by operating the system with a lower overspin threshold. It will then be verified that the system operates as expected with an artificially lowered threshold.

Overtorque

The system will shut down if the motor is outputting an unsafe amount of torque. It will also signal that the motor must be disconnected from the drivetrain. This will be tested by operating the system with a lower overtorque threshold. It will then be verified that the system operates as expected with an artificially lowered threshold.

Emergency Stop

The system will shut down when the emergency stop button is pressed. This will be verified by pressing the emergency stop button and ensuring that the system operates as expected. The emergency stop button must be hardwired into the system.

Dynamometer ATP Checklist

Sensors	**Torque Sensor**	Torque curve corresponds with manual	☐
	RPM Sensor	Motor speed corresponds with throttle	☐
	Phase Voltage	Phase voltage is logged	☐
	Phase Current	Phase current is logged	☐
	Input Voltage	System shut down on unsafe voltage	☐
	Input Current	System shut down on unsafe current	☐
	Motor Temperature	System shut down on unsafe temperature	☐
	MCS Temperature	System shut down on unsafe temperature	☐
Test Stand	**Cable Management**	All cables/LEDs have proper labelling	☐
	Cooling System	All components below 40℃	☐
	Physical Design	No exposed high voltage terminals	☐
Interfaces	**VSCADA**	Protocol operates as expected	☐
	GLV Power	GLV supply port exists	☐
	TSV Load Controller	Interface is insulated	☐
	Safety Loop	Motor responds to shutdown command	☐
Power Supply	**Operation**	Motor runs	☐
	Switching	Power switching is insulated	☐
Safety	**Ground Fault**	System shuts down on ground fault detection	☐
	Overtemp	System shuts down on overtemp detection	☐
	Overspin	System shuts down on overspin detection	☐
	Overtorque	System shuts down on overtorque detection	☐
	Emergency Stop	System shuts down when the emergency stop button is pressed	☐