IFEC 2019 E-Bike Competition

Updated 28th July 2019

Test Procedures

A. **Cable Pull:**

10N of downward force is applied using a 1.015kg weight.

a. For each connector, attach the weight with a slipknot above the connector so that the wires bear all of the weight.

b. Gently lift the controller by an S-hook with handle through the controller mounting hole to lift the controller and weight off the ground.

c. Hold for 2 seconds.

d. Inspect for detached wires or connectors. No points will be awarded if any wires are pulled out.

e. Repeat test for the following connectors:

i. Battery Input (pair)

ii. Motor output (3phase together)

iii. Throttle

iv. Brake

v. Hall Sensors

B. **Insulation Resistance:** An insulation test device will be used for this procedure.

a. Select Hi-Pot insulation tester preset number 005.

b. Confirm settings: 0.250Kv, 1 second ramp, 3 second timer, mode ACW, high current 3.5mA, low current 0mA.

c. Connect ground to the controller case, connect power to the positive battery connection lead. Cover case and connectors with the insulated blanket. (See photos below)
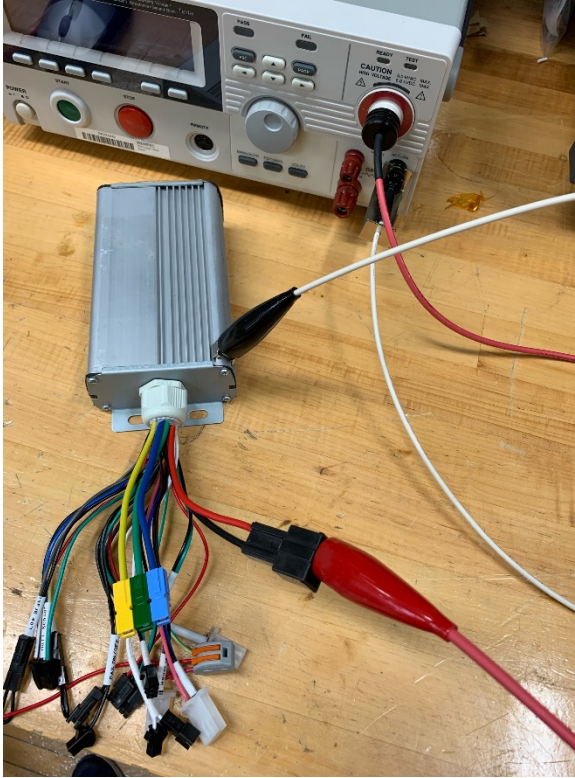
d. Press the red stop button.

e. Once ready light comes on, press the start button.

f. Record Pass/Fail

g. Repeat test for:

  a. Negative Battery Terminal

C. **Basic Operation:** This is a pass/fail test, and no points are awarded if the controller does not behave as specified below. Have the full Dynamometer circuit connected as described in the "Dynamometer" section. The Chroma DC load supply will need to be set to constant voltage (CV) of 48V, and the WT-1600 power meter reading current from the battery.

a. **Disabled State:**

    i.   E-stop ON (open contacts)

    ii.   Verify <1mA sustained average battery current

       Record current if it is >1mA

    iii.   Verify the motor shaft is free to rotate

b. **Idle State:**

    i.   E-stop OFF (closed contacts)

    ii.   Set throttle command to 0V.

    iii.   Verify <50mA average battery current

       Record current if it is >50mA

    iv.   Verify the motor shaft is free to rotate

c. **Brake State:**

    i.   E-stop OFF (closed contact)

    ii.   Brake switch is ON (closed contacts)

    iii.   Set throttle command to 2V.

    iv.   Verify <50mA average battery current

       Record current if it is >50mA

    v.   Verify the motor shaft is free to rotate

d. **E-Stop and status indication functionality**

	E-Stop	Throttle Command	Indicator LED
i.	ON (open)	0V	green
ii.	OFF (closed)	0V	flashing green @~1Hz
iii.	OFF (closed)	Disconnected	flashing red @~1Hz
iv.	ON (open)	Disconnected	flashing red @~1Hz

      e. **<u>Fault reset process:</u>**

          1. E-stop OFF (closed contact)

          2. Set throttle command to 0V.

          3. E-stop ON (closed contact)

          4. E-stop OFF (closed contact)

   5. Verify indicator light is green

D. **Free Acceleration:**

This test simulates the event of a broken chain.

    a. Set 48V constant voltage load (~3000rpm speed limit)

    b. Input 4.5V throttle command

    c. A minimum speed of 2400rpm must be achieved within 2 second

       Speed is measured using laser tachometer, and also using a separate

       oscilloscope that measures the line-line voltage waveform of the dynamometer

       motor output.

    d. Control must fault (red indicator light) if the machine speed exceeds 2500rpm

E. **Efficiency Map:** DC to DC efficiency will be measured at each operating point. See

"Dynamometer" section for configuration.

    a. Configure the Agilent waveform genereator's efficiency map throttle command

       (labeled "EFF_MAP" $1.5V$, $2V$, $3V$, $4V$). This configuration will cycle through the

       four throttle set points, holding each command for two seconds.

    b. Set the Chroma electronic load to 36V constant voltage mode.

    c. Configure the WT-1600 power meter to display, P_in, P_out, efficiency, I-line

       rms, Energy input and Energy output. Press integ, reset integ and start integ

    d. Press "output" on the waveform generator to start the test.

    e. Record results

    f. Verify battery current is <12Arms, Case Temp <48C & Speed <2500rpm

g. Repeat test at 24V and 12V.

h. Up to 2 min is allowed between each CV load test sequence

i. If the fuse blows at 12V, repeat at 16V and 20V sequentially.
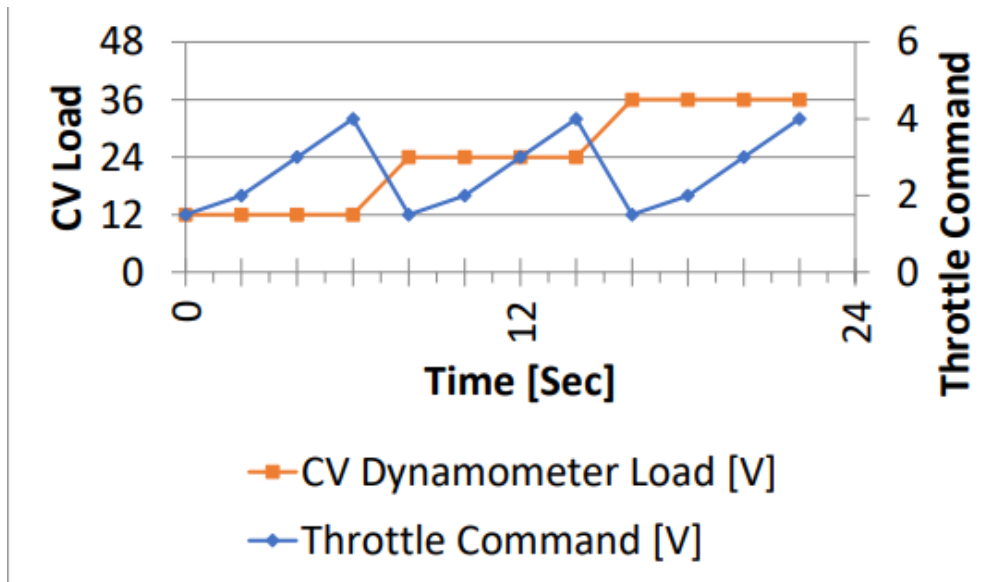
F. **Simulated Hill Climb:**

See "Dynamometer" section for configuration. Each controller will be tested for 30 seconds at full throttle (4.5V throttle command). Scores are assigned based on maximum average speed.

a. Set the Chroma load to a constant resistance (CR) of 0.1 Ohms.

b. Input 4.5V throttle command

c. Verify the WT-1800 power meter's integrator period is set to 30 seconds.

d. Press "output" on the waveform generator to begin test. This will trigger the power meter to begin recording as well.

e. Record average speed over 30 sec.

f. Verify battery current is <12Arms, Case Temp <48C

g. If the fuse blows at 0.1Ohm, repeat at 0.2 Ohm, 0.4 Ohm, and 0.8 Ohm sequentially.

G. **Field test on actual bicycle:** The top 5 teams will compete in a time-trial style relay race. Two staffers will hold stop watches, and a third will start the time trial with a buzzer or whistle. The hand off between riders must occur within a designated area after the finish line. The current rider must cross the finish line and come to a complete stop **before** the next team member may enter the track, mount, and continue riding. Additional team members may assist with mounting and dismounting. The relay must be completed by 4 different team members. If a team has less than 4 members riders must alternate. In the case where a team has a single member, the team member must dismount, walk around the bike and remount on the opposite side after each lap.
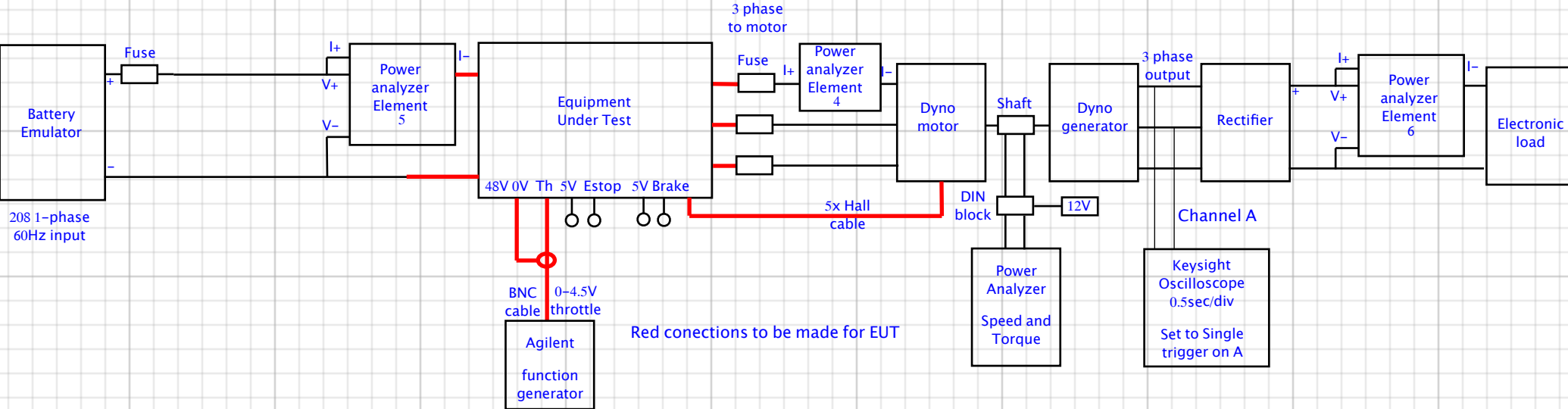
Dynamometer Circuit Setup see schematic

- ❏ Connect Battery Simulator -> 20A fuse -> Power Meter -> Controller
- ❏ Connect Hall Sensors
- ❏ Connect controller -> Fuse -> Motor
- ❏ Connect Throttle Input to Waveform generator
- ❏ Motor (load side) -> rectifier -> power meter -> Electronic load is prewired
- ❏ Brake input and E-stop input are not used. i.e. contacts are left open in their default condition.

eBike Circuit Setup see schematic

- ❏ Mount Controller
- ❏ Connect Hall Sensors
- ❏ Connect controller -> Fuse -> Motor
- ❏ Connect Throttle
- ❏ Connect Brake Input
- ❏ Connect Battery DC output -> battery protector -> Fuse -> controller

Wiring schematic for IFEC 2019
E-drive for electric bike dynamometer testing

115V ac 60Hz power for
power analyzer, electronic load, 12V power supply, Agilent function
generator

3 phase
to motor

Battery Emulator

Fuse

+

−

208 1-phase
60Hz input

I+
V+
V−

Power analyzer Element 5

I−

Equipment Under Test

48V 0V Th 5V Estop 5V Brake

Fuse

I+

Power analyzer Element 4

I−

Dyno motor

Shaft

Dyno generator

DIN block

3 phase output

Rectifier

+

I+
V+
V−

Power analyzer Element 6

I−

Electronic load

5x Hall
cable

12V

Power Analyzer

Speed and Torque

Channel A

Keysight Oscilloscope 0.5sec/div

Set to Single trigger on A

BNC cable 0-4.5V throttle

Agilent function generator

Red conections to be made for EUT

Wiring schematic for IFEC 2019
E-drive for electric bike Field testing

Push to stop

Fuse

Battery Protector

Battery Emulator

+

−

208 1-phase 60Hz input

Equipment Under Test

48V 0V Th 5V Estop   5V Brake

Display

0-4.5V

Keyswitch

Brake input

Throttle connector

3 phase to motor
Fuse

Motor

5x Hall cable