Operation Sequence of the PCU

To begin, please click or copy the URL below to your computer browser and watch the video to get a complete overview of the experimental validation of the proposed concept.

https://www.dropbox.com/s/zgi76bzdwu6bzq6/PCU10.mpv4?dl=0

A full cycle of the operation steps is outlined below in accordance with the software architecture of the PCU's controllers:

1) Move to the scanning level: Stepper1 extends the PCU from the *home* position to a predetermined level called the *scanning* level and then sends a signal to the Stepper2 controller to detect the conductor rings.

2) Scanning for conductor rings: The Stepper2 moves the brush carrier up or downwards to allow an inductive proximity sensor to detect the conductor rings. When the rings are identified, Stepper2 returns the brush carrier to the original position and then sends a signal to the Stepper1 controller to move to the contact level, referred to as the *tracking* level.

3) Move to the tracking level: The Stepper1 controller drives the PCU towards the *tracking* level until a predefined CF setpoint is reached. At this point, a CF controller is activated, signifying in the Arduino serial monitor: *"CF control in effect"*.

4) CF control: When CF control is in action, the load cell controller will be enabled to monitor and maintain the desired CF using Stepper1 and the suspension system, called an active suspension system. When the desired CF between the sliding contacts and conduction rings is reached, the controller displays: *"Power disc operation is allowed".*

5) Power disc operation: When power disc operation is allowed, the power disc is run using a variable frequency drive unit (VFD unit). Once the targeted speed is reached (2400 rpm), the power supply is switched on and the applied DC voltage is gradually increased until the operating voltage (600 V DC) is reached. At this stage, the PCU is operating at full load (30 kW) and speed (200 km/h). The Stepper2 controller indicates that "PCU is in the operation mode" in the Arduino serial monitor.

6) Swinging the sliding contacts: When the PCU is in operation, the Stepper2 controller slowly swings the sliding contacts up and down to uniformly distribute the friction across the surfaces of the

carbon brushes. This feature is considered to be analogous to the zigzagged overhead lines used in trains.

*7) Bouncing the sliding contact*s: When the PCU is in operation, the ultrasonic sensor controller is enabled to monitor wheel bounce by measuring the height of the pantograph arm from the road surface. The bouncing controller triggers the Stepper2 to compensate for any deflection caused by wheel bounce, avoiding interruptions in power transfer from the conductor rings. The stepper motor interacts with the wheel bounce at a maximum speed of 50mm/s.

8) Temperature and vibration monitoring: When the PCU is in operation, controllers of temperature and vibration are enabled to monitor the contact surface's temperature and vibration using sensors mounted on the CCU. The vibration and temperature readings are displayed on the Arduino serial monitor and the LCD2004 serial display module. In addition, an online data acquisition DAQ for the CF profile and the PCU triple-axis vibration utilises Keysight 34972A data acquisition.

9) Normal and emergency operation-stop: When this function is called, the interrupt service routine de-energises the conductor rings; stops the swinging of the contacts, and returns them to their primary position in the middle of the CCU; and deactivates the CF controller. Stepper1 then drives the PCU to the home position.