REPOINT-light full-scale track switch

Olaby, Osa; Dutta, Saikat; Harrison, Tim ; P Ward, Christopher; Dixon, Roger

REPOINT-Light Full-scale Track Switch: Experimental Results at a Railway Testing Site

Osama Olaby, Saikat Dutta**, Tim Harrison*, Christopher P Ward* and Roger Dixon****

***Birmingham Centre for Railway Research and Education, School of Engineering, University of Birmingham, Edgbaston, Birmingham, UK, B15 2TT (e-mail: o.olaby@bham.ac.uk)*
**Wolfson School of Mechanical, Electrical and Manufacturing Engineering, Loughborough University, Loughborough, UK, LE11 3TU*

Abstract: REPOINT-Light is a novel railway track switch concept which is designed to enhance the reliability of the railway network by implementing a closed loop control concept and introducing actuator redundancy in the railway switch design. After successful experiments and tests in a laboratory environment, the full-scale demonstrator of the switch is deployed in a railway testing site. This paper presents the performance of a designed controller by showing the experimental data of brushless AC motors assembly within three active bearers of the track switch. The controller is implemented in real time operation mode using NI-LabVIEW software NI hardware (CompactRIO 9035) and. The principle challenge of the controller is to synchronize the movement of six motors in three active bearers of the REPOINT-Light switch.

Keywords: REPOINT, Railway Track Switch, Actuator Redundancy, Controller Design, Cascade Control

1. INTRODUCTION

Railway track switches are safety critical assets in a railway network, which represent a single point of failure. Most of the traditional railway track switches operates with a single actuator element. These systems are very prone to failure and any failure of the switch system causes delay, and has led to derailment and catastrophic derailment. Bemment et al. (2018) showed that including redundancy into the railway system can improve the reliability of the network. A novel track switching concept, REPOINT, has been developing through the idea of incorporating fault tolerance and using feedback controller to control the motion of the switch [Bemment et al. (2013)]. The REPOINT actuation mechanism works following lift-hop-drop sequence, which lifts the switch rails from their locked position, moves in a semi-circular path and then drops in the other locked position [Bemment et al. (2013)].

REPOINT-Light is a full-scale switch development project, which aimed to develop a full-scale switch system using the REPOINT actuation mechanism and actuator redundancy whilst keeping the existing switch layout unchanged [Sarmiento-Carnevali et al. (2017) and Dutta et al. (2018a)]. The REPOINT-Light switch design includes three actuator bearers and each actuator consists of two brushless AC motors, gearhead assemblies, sensors, locking elements and cams (see Fig. 1). The closed loop control of the actuator is introduced in the switch actuators for the first time to ensure proper movement of the switch rails. A simulation model using multi-body simulation software is developed first to calculate the actuation forces required and specify the different mechanical elements. Then, the controller, which consists of three cascaded loops is developed. The challenge was to ensure proper movement of the actuators, which means synchronisation of the six motors as well as the three different actuators. The synchronisation of the movement of two electrical motors of one mechatronics actuator are tested in the laboratory to validate the modelling work [Dutta (2018b)].

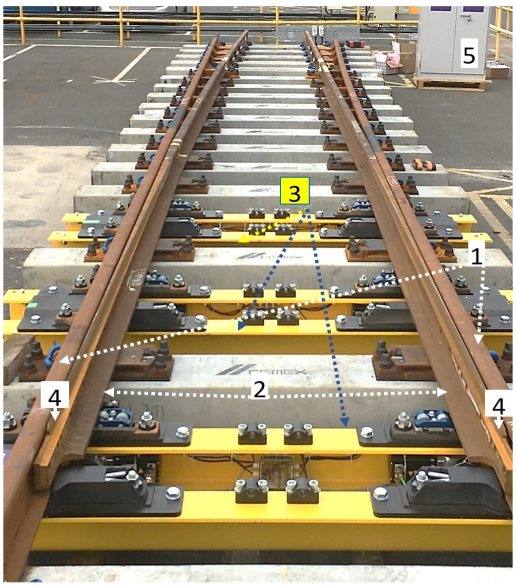

Fig. 1. REPOINT track switch: 1. Stock rails, 2. Switch rails, 3. Actuator bearer with locking elements, 4. Rail detection sensors, 5. Control unit.

2. CONTROLLER DESIGN FOR REPOINT-LIGHT

The control strategy proposed in this research is remotely operated in a railway testing site without any manual interference. The synchronization in the motion of the six motors within three mechatronics actuator bearers is achieved. The control algorithm, for each two motors within a single bearer, consists of three cascaded loops; innermost loop motor current controller, centre loop motor velocity controller and outer loop position controller. The two first loops, innermost and centre loops, are inbuilt in the motor driver. The outer loop is implemented using NI-LabVIEW software. For each active bearer, the two cam assemblies is fed with the setpoint which is a desired cam position. The feedback signal from the cam encoders is used in controlling the motion of each two AC motors. The switch rail can reach its expected position, Reverse or Normal, after moving the hopper supported by the two motors. From the front panel window of the NI-LabVIEW code, the operator can check the current state of the track switch by both, the current angles of each six cam encoders and the indication from the detection system. The operator can change the current track-switch state to either Normal or Reverse positions from an exterior electrical switch.

3. EXPERIMENTAL RESULTS

Different railway-environmental working conditions are considered during the design process of the full system of REPOINT-light project. The central processor (cRIO-9035) from NI is selected as it is suitable for use in an environment with high shock and vibration. The full signal processor with the six NI inputs/outputs modules is installed within the location cabinet next to railway track switch (see Fig. 1).

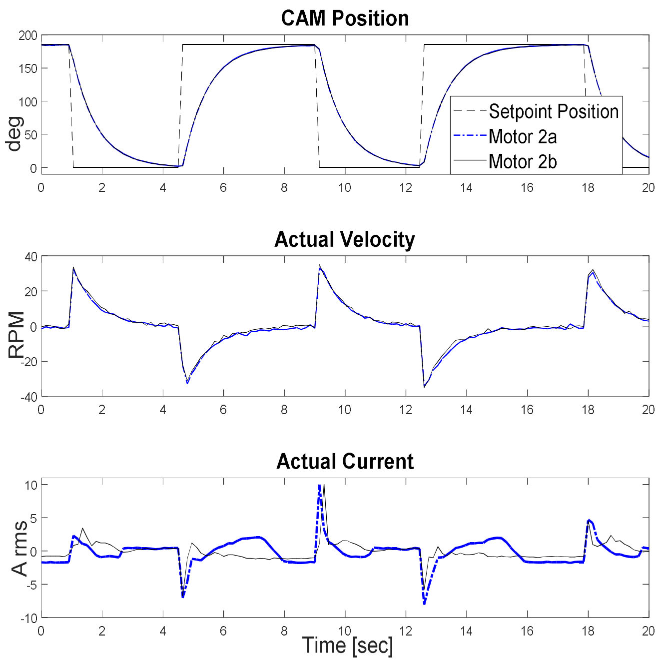

Fig. 2. Cam position, velocity and the current of the two motors of second active bearer of the novel railway track switch at a railway testing site.

Figure 2 shows a good synchronized motion of the two motors within the second actuator bearer. The cam, which is connected to each AC motor through a gearbox, is designed to move in a semi-circular path and rotates from 0° to 180°. The requirements of the performance of the REPOINT-Light switch are the switching time and the locking at Normal/Reverse positions. Figure 2 shows that the settling time for the designed controller is 3.5 seconds, which is well below the requirement (7 seconds) [Sarmiento-Carnevali et al. (2017)]. The maximum input current from the power supply for each motor doesn't exceed 13 A rms.

4. CONCLUSION

REPOINT project set out to redesign railway track switches to feature fault tolerance, primarily using redundancy of actuation, to significantly boost reliability and availability whilst minimising inspection and maintenance requirements.

This study presents the control strategy developed, and experimental results, of three mechatronic actuator bearers for a REPOINT-Light track switch. The designed controller, using NI hardware and software, is shown to perform the required operation that satisfies the control requirements of the difficult and changing railway environment.

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