# **Success Story**

# Simplicity 🙀

# London Underground Track Circuit Condition Monitoring System



Simplicity AI provided the CompactRIO part of an award winning solution for remote condition monitoring of track circuits on the London Underground's Victoria Line



#### The Challenge

Track circuits are used to detect whether a train is present or not within a section of line, so are essential for the safe operation of service. The Victoria Line runs an intensive 33 trains per hour, carrying 89.1 million passengers per year. When track circuits fail they cause a major disruption to service, resulting in £1.5 million of passenger disbenefit since 2012.



# Key Features

• 128 Monitoring Channels

to them impacting passenger service.

- 24/7 Live Data Streaming
- Frequency and RMS Measurement

Prior to the condition monitoring solution being implemented, maintenance teams would need to

perform manual measurements of individual track

circuits by locally connecting a digital multi-meter. With

the introduction of continuous health monitoring of all

track circuits, teams can more easily detect issues prior

- System Health Monitoring
- Turnkey Automated Deployment
- Multi-Client Network Communications

#### **Technology & Implementation**

- ✓ NI CompactRIO
- ✓ LabVIEW Realtime & FPGA
- ✓ Serialised Processing Architecture

- Rapid Project Turnaround
- High Reliability Design
- Developed by Certified Experts

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## **Track Circuits**

The Victoria Line uses jointless track circuits which consist of a tuned transmitter and receiver unit. A 4-6kHz frequency shift keyed signal will be present on the track only when it is unoccupied. Maintenance teams measure the RMS and average frequency of these signals to confirm correct track circuit operation.

## **The Solution**

Simplicity AI developed custom software using LabVIEW Realtime and FPGA to RIGHT: calculate the track circuit RMS and Process Architecture on frequency, interfacing with multiple track BOTTOM LEFT: circuit monitoring clients via a custom Overview of the system component configuration for challenges faced TCP/IP protocol. The configuration of **BOTTOM RIGHT:** each CompactRIO node is handled by an National Instruments CompactRIO hardware on-board system settings file combined with automated hardware interrogation and comparison. Any issues with node health or configuration settings is reported to the control room via the Syslog protocol.



## Software

One of the main project challenges was to implement data processing from the high channel count system simultaneously within the FPGA. Performing frequency and RMS calculations for each channel in parallel was unfeasible due to the amount of FPGA resources that would be required. Simplicity

AI came up with a novel solution in the form of a serialised processing architecture, this made use of the time gap between the high speed clock of the FPGA and lower speed reporting required by the control centre. By acquiring from all channels at the same time and using the on-board memory of the FPGA the data could be reconstructed into chunks per channel, then serially processed to provide frequency and voltage RMS measurements while using the FPGA resources efficiently.



## Hardware

Overview of the Serial

the FPGA

The track monitoring system hardware nodes consist of a National Instruments CompactRIO controller, with 8 slot backplane and up to 8 C-Series modules capable of acquiring analogue data simultaneously over 128 channels. Simplicity AI effectively utilised both the FPGA and real -time aspects of the CompactRIO to develop an architecture capable of meeting London Underground's requirements.



'London Underground and Simplicity AI engineers worked in parallel as a joint team on different sections of the project'

Sam Etchell, London Underground

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### Deployment

London Underground required the deployment of 14 of these systems to the Victoria line and wished to manage this process using their own team. Simplicity AI developed a configuration and deployment process, which required only standard computer skills and not any specialised National Instruments expertise. An application was supplied which, through a one-click operation, installs both the runtime systems and software to the CompactRIO along with a configuration file. During the boot process this configuration file defines the specific system personality of each node including network settings, identification and C-Series module configuration, allowing each node to then operate independently on the network with no manual setup required.

### **Awarding Winning Project**

The project for remote monitoring of London Underground track circuits was nominated for 2 categories in the 2014 National Instruments Engineering Impact Awards, which were presented during the NIWeek conference in Austin Texas. It won the Xilinx All Programmable award, for innovative use of an FPGA.

### **About Simplicity Al**

Simplicity AI provides a range of advanced technical products and engineering services for test, measurement, control and automation, equipping customers to meet their technical and business objectives. Solutions span across a wide range of industry areas including, aerospace, defence, electronics, telecoms and medical devices. Custom software development is one of the key service offerings from Simplicity AI. Their highly qualified engineers are experts in test and measurement software technology, including National Instruments LabVIEW Real -time and FPGA.

'We used the company's enormous breath of expertise to deliver the system onto an operational railway within one year of the concept design.'

Sam Etchell, London Underground

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### References

[1] Sam Etchell, Dale Phillips, Barry Ward Remote Condition Monitoring of London Underground Track Circuits

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ABOVE: London Underground track circuit monitoring GUI

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