

POWER LINE COMMUNICATION ON A SHUTTLE CAR

Testing conducted at Komatsu Mining workshop, Rutherford, NSW on 4 March 2021

Executive Summary

Komatsu and Nautitech® worked together to test the transmission speed of data between a shuttle car and Gate End Box (to simulate DCB). Nautitech® was able to demonstrate the transmission of Ethernet data through the Shuttle Car trailing cable and slip rings in excess of 44 Mbit/sec. This exceeds the requirements for the transmission of video and operating parameters to the DCB.

Introduction

Purpose of the test was to measure the speed and the quality of the Ethernet data communication on Komatsu shuttle cars. The test considered both the length of the trailing cable and the influence that slip rings can have on the performance of data transmission while the cable was wound/unwound. Komatsu provided resources to enable this testing to take place.

The Spitfire® broadband power line communication system from Nautitech® Mining Systems was used.

Personnel involved in testing:

- **NAUTITECH®**
Douglas Carter (Product Development and Technology Advisor)
Artur Gorski (Engineering Tech Support)
David McCloskey (NSW Business Development Manager)
- **KOMATSU**
Harshal Patwardhan – Manager Control & Automation
Glen Stolk – Team Leader
Samantha Ince –Automation Engineer

Equipment

Komatsu Equipment

Testing was performed on the surface in the workshop. The basic set up comprised the Gate End Box (GEB), the Shuttle Car (SC) and one length of the trailing cable.

1. GEB is stationary and is a part of the workshop. Although it did not represent the DCB that goes underground, it was functionally the same.
2. Shuttle Car #1290 for Aquila, was available for the test.
 - Remains stationary at the time of test.
 - Pump, traction and conveyor were activated during the time of test.
 - The cable reel was operated by hand with slow movement of the cable reel to ascertain if the slip rings would have any effect on data transfer.
3. Trailing cable, AS1802 type 275.1, mining cable with 35 mm² cross-sectional area. Total length of 55 meters.

Spitfire® equipment

1. Prior to the test, Komatsu installed one Spitfire® BPLM with remote displays in the Shuttle Car
 - a. Nautitech® part number ME1228-2-99-183 Rev.2
 - b. MAC address: 64:00:2D:09:D3:31
2. GEB, the BPLM was temporally installed for the purpose of test.
 - a. Nautitech® part number ME1228-2-99-182 Rev.2
 - b. MAC address: 00:13:C1:37:B3:5F

As a method of coupling the signal to the power cores the capacitive couplers were used. The capacitive couplers were Nautitech® part number ME1228-2-99-029, featuring insulation that is suitable for system voltages up to 3.3 kV (IEC 60071-1).

Test Instrumentation

Spitfire® Wingman was used to gather the operating statistics of the BPLMs.

Payload data was generated using JPerf. The data rate over the power line network was measured between a notebook installed to run as a server in the GEB and a notebook connected to BPLM in the SC. JPerf on both computers was set to use TCP data with default values. JPerf was set to run in dual transfer mode, in which data is transmitted in both directions at the same time.

Test equipment that required an IP address:

- DCB Notebook 197.168.1.102
- SC Notebook 197.168.1.101
- Wingman 197.168.1.100

Procedure

Three test configurations were assessed:

1. 1000 VAC power turned off. (Spitfire® BPLMs were operated from separate 240 VAC supplies.)
2. 1000 VAC power turned on, machine in idle state.
3. 1000 VAC power turned on, traction drives operating.

For each test configuration, the power line communications performance was measured for the cable reel stationary and for the cable reel being manually rotated to simulate the movement of the slip-rings that would be encountered during normal operation of the SC. (The machine SC had no wheels, so could not be driven.)

Testing Results

General operating conditions

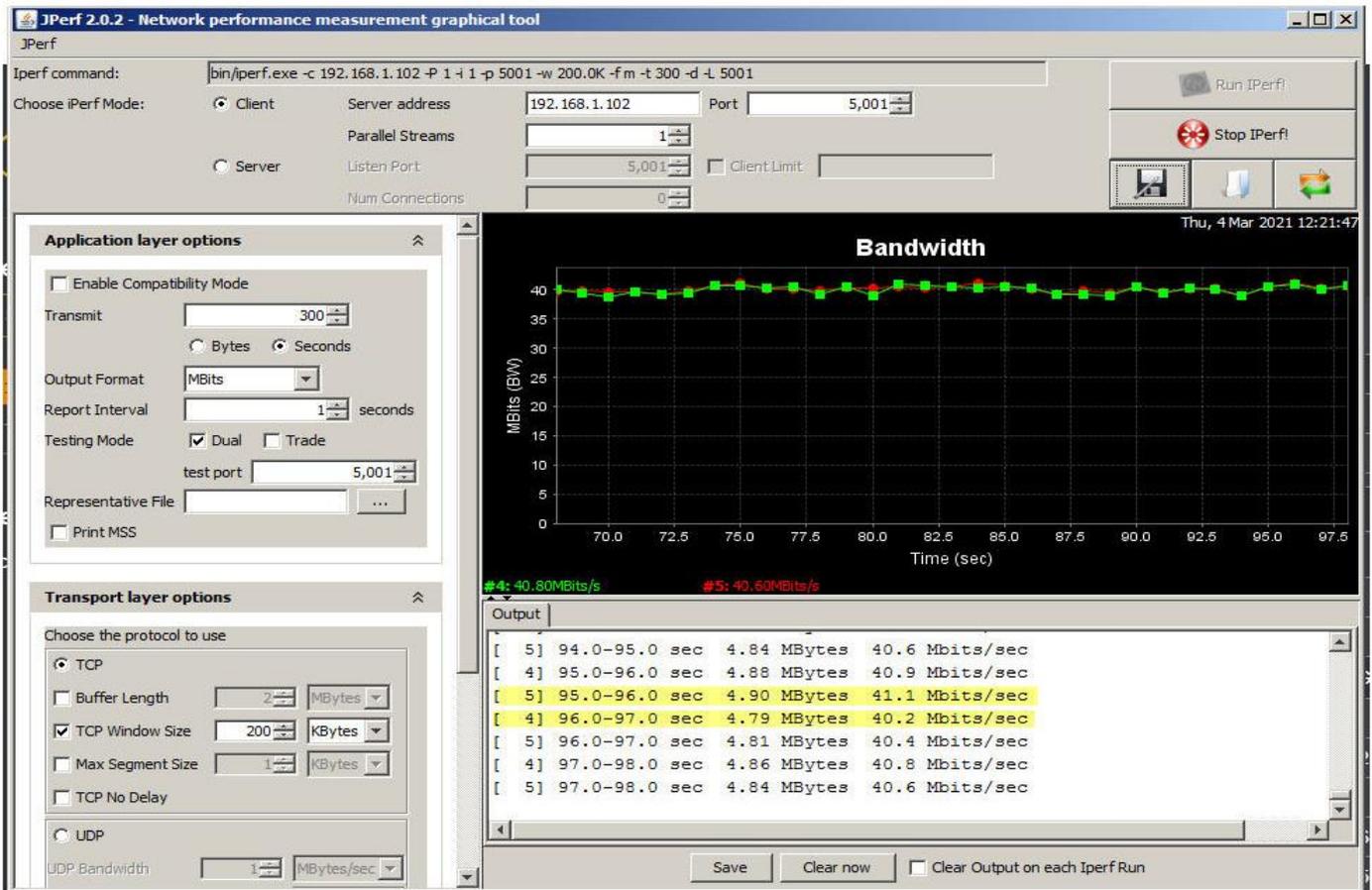
Data from Wingman shows the signal strength was between -1 to -4 dB for the various test configurations. This is a relatively strong signal, and is to be expected for a short cable.

The screenshot shows the Nautitech Web Console interface. The main content area is titled 'Spitfire Devices' and includes a 'Link Status' tab. The 'Link Status' section displays a table of peer devices and a detailed statistics table for the link between the active device and its primary peer.

Peer Devices		RX Speed [Mbps]	TX Speed [Mbps]	Primary?
MAC Address	User Description			
00:13:C1:37:B3:5F	00:13:C1:37:B3:5F	138	131	Yes

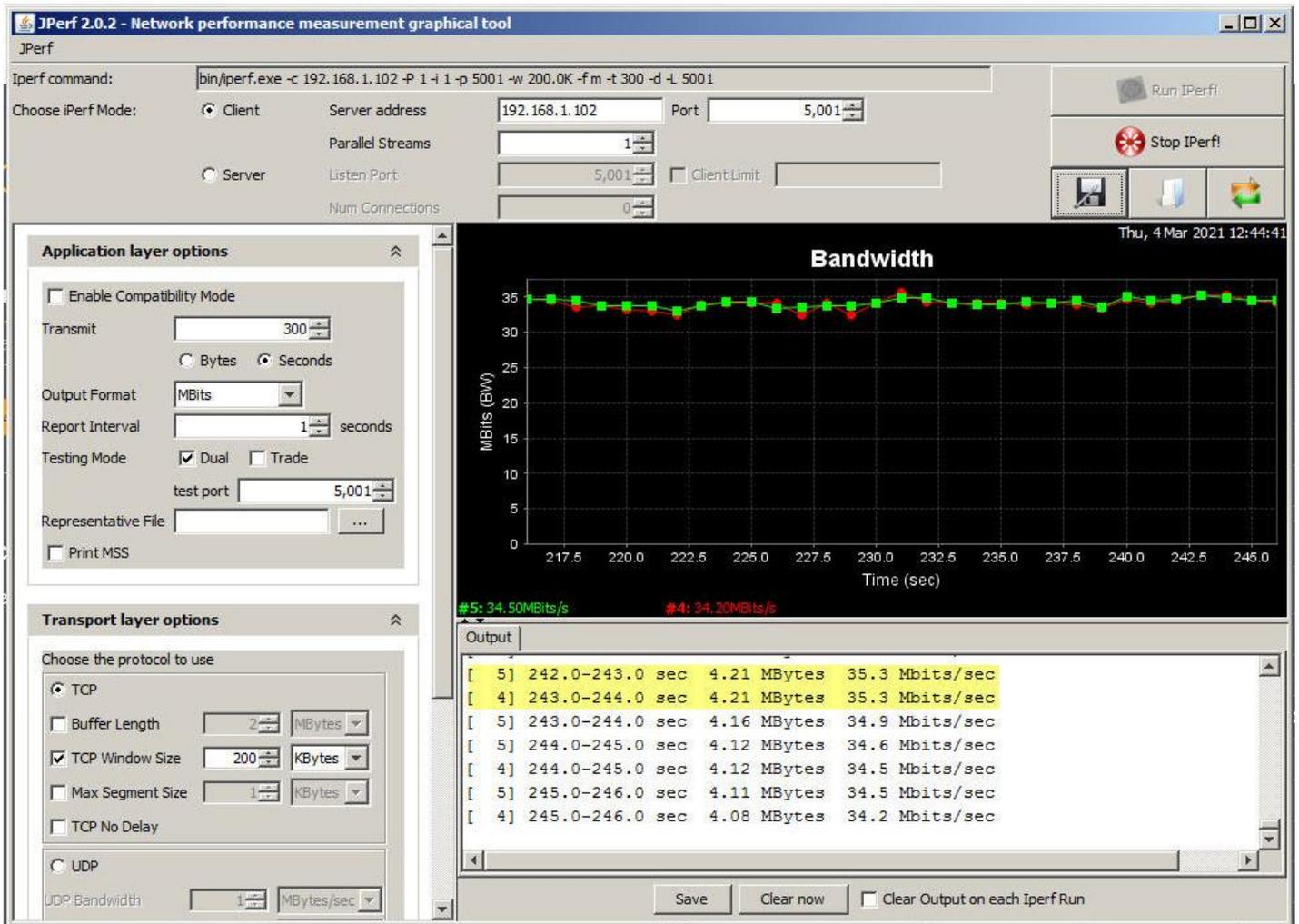
		Selected		Primary Peer	
		RX	TX	RX	TX
Physical Layer	Signal Strength [dB]	4	-	1	-
	Average Bit Loading [b/s/Hz]	9.21	8.71	8.71	9.21
Forward Error Correction	Bit Error Rate	2.79	-	1.65	-
Media Protocol Data Units	Acknowledge	62593	69687	70613	62457
	Collision	-	5704	-	321
Payload Blocks	Pass	1383262	1366520	1381737	1370745
	Fail	124230	101727	88191	133802
Cyclic Redundancy Check	Error Rate	8.24%	6.93%	6.00%	8.89%

Configuration 1



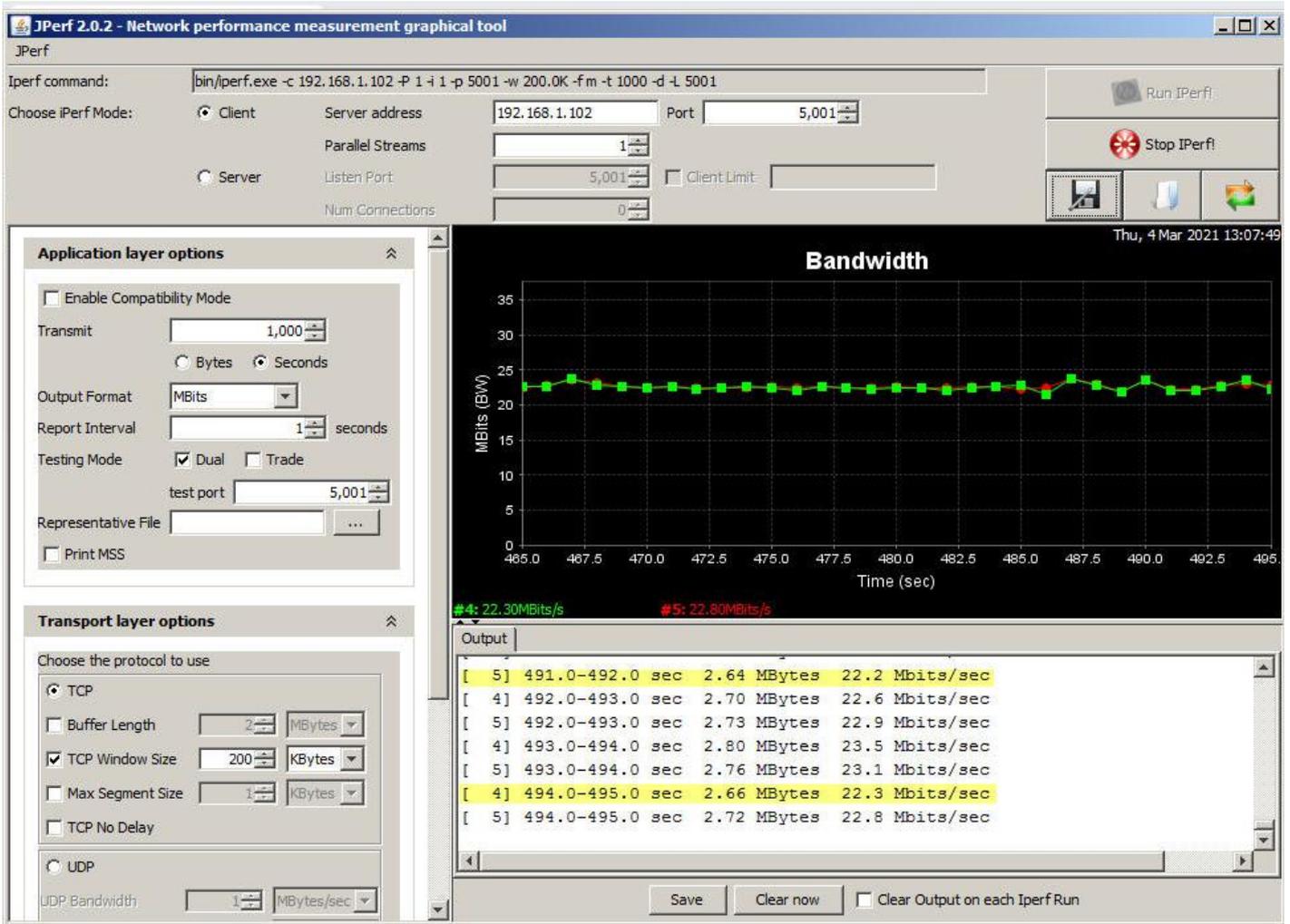
Data from JPerf indicates an aggregated data rate of 80 Mbps (40 Mbps is each direction, simultaneously). Movement of the cable reel had no effect on the data rate.

Configuration 2



Data from JPerf indicates an aggregated data rate of 70 Mbps.
Movement of the cable reel had no effect on the data rate.

Configuration 3



Data from JPerf indicates an aggregated data rate of 44 Mbps.

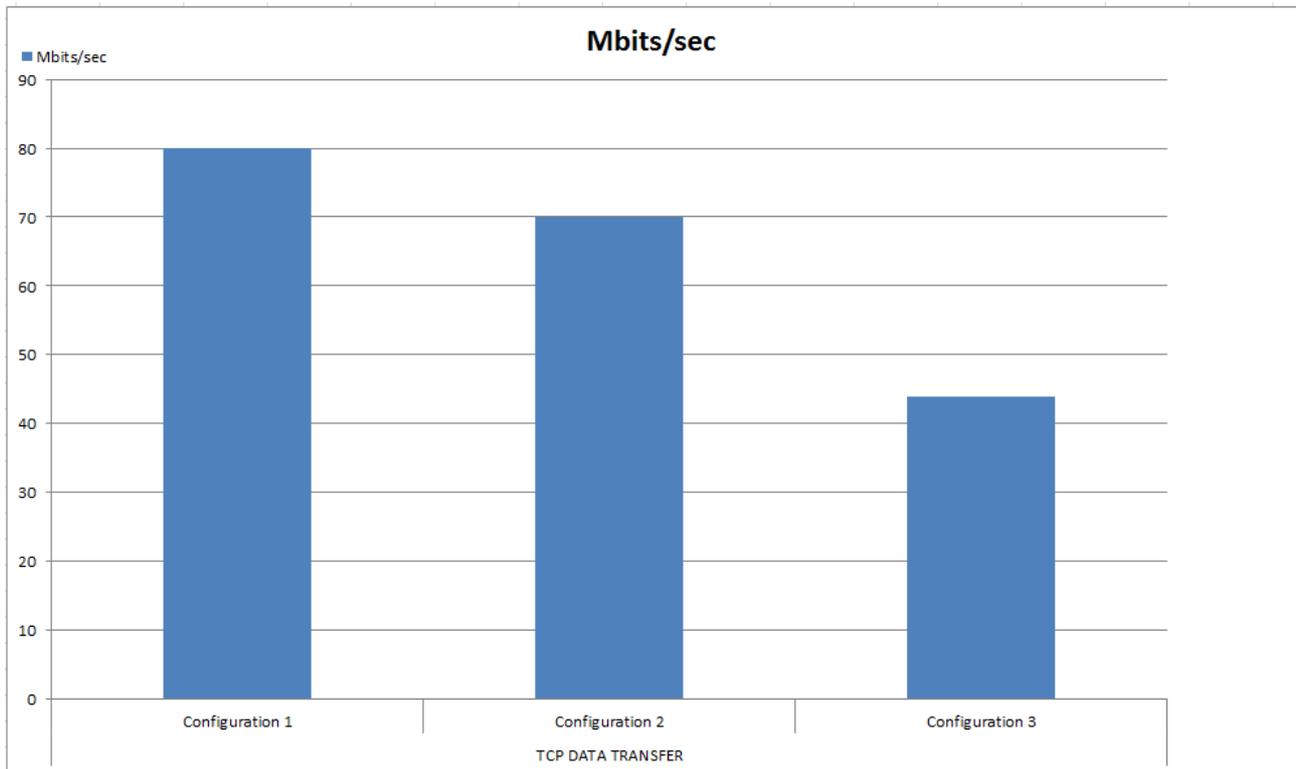
Movement of the cable reel had no effect on the data rate.

The conveyor was also operated, but had no effect on the data rate.

Comparison

The data rates from the three test configurations are shown on this combined plot.

The reduction in the data rate as more systems on the SC are energised is typical. It is caused by the adaption of the Spitfire® modems to the different conditions that exist in the three configurations. Energising of the various systems is achieved by the closing of contactors. This connects extra wiring which changes the way the high-frequency power line signals propagate.



Key results

1. An aggregated data rate of 44 Mbps was achieved under the worst case operating conditions that could be achieved in the workshop.
2. There was no indication that the slip rings affect the performance of the power line communications, whether the slip rings are stationary or moving.

Further Work

1. We recommend testing with the maximum length of trailing cable and a standard DCB fitted with Spitfire®.