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ERL MAINTENANCE SUPPORT SDN BHD

(Company No. 498574-T)

E-MAS

Effective Railway Operations; Reliable System Maintenance

MAINTENANCE DEPARTMENT

TRAIN BRAKE SYSTEM TEST BENCH OPERATING PROCEDURE

Ref. No. G00.OMN.M01000.CA.1001.A

Release

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Amendments or additions to this procedure must be indicated with a vertical black line in the adjacent left margin.

Change Record and Configuration Control

A	18 Dec 2014	New Procedure	Dzulfaqar
Revision	**Date**	**Modification**	**Name**

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1 Purpose

The purpose of this document is to briefly describe the operation of Train Brake System Test Bench. It also explained the assembly and methodology of conducting tests using this test bench.

The goal of this test bench is to perform test on BCU, EP panels and WSP Dump valves. It shall be replicating the friction braking operation of ERL trains.

2 Scope, Distribution & Access

This document shall be accessible to all Maintenance staff. However, only competent personnel by means of education and/or experience regarding train braking system shall operate this test bench.

The scope of testing can be conducted on this test bench is limited to electrical and pneumatic function of train braking system. Several electrical and pneumatic functions have been omitted due to lack of information and equipment for performing such operation. It was described in Table 2.1.

Function	Omit Reason
Blending / Dynamic Braking	No MVB signal and test process available at the moment.
MVB Communication	The test process under development as upgrade package.
Short and Long Brake Test	No MVB signal and test process available at the moment.
Parking Brake Functions	No MVB signal and test process available at the moment.
Bogie Vibration Monitoring Functions	Inadequate information of this function for conducting the simulation.
WSP Operation interface with traction equipment	No MVB signal and test process available at the moment.
Brake Caliper Equipment	Pneumatic equipment calibrations are defined in other maintenance processes.

Table 2.1: Omitted function of train braking system

3 Abbreviations and Definitions

Abbreviation	Definitions
ADC	Ampere in Direct Current
ATP	Automatic Train Protection
BCU	Brake Control Unit

BNC	Bayonet Neill–Concelman (a kind of connector)
CRS	Commuter Rail Service
EB	Emergency Brake
E-MAS	ERL Maintenance Support Sdn. Bhd. (498574-T)
EP	Electro-pneumatic
ERL	Express Rail Link Sdn Bhd (375839-H)
MVB	Multi Vehicle Bus
PC	Personal Computer
PEB	Passenger Emergency Brake
TCN	Train Communication Network
VDC	Voltage in Direct Current
WSP	Wheel Slide Protection

Table 3.1: Abbreviation Table

4 Safety Notes

1) The test bench shall only be operated within the specification mention in Table 4.1. Any misuse or handling may cause damage and injuries.

2) The pneumatic equipment in this test bench uses high pressured compressed air. Please discharge the trapped air using appropriate method mention in Table 4.2 after the usage or assembling those pneumatic equipment.

3) The main electrical supply used by this test bench is 110VDC. Several more voltage levels are produced by BCU when it was turned ON.

Element	Parameters
Electrical Voltage Supply	110VDC +/- 10%
Electrical Current Supply	Minimum = 4ADC, Maximum 7ADC
Pressured Air Supply	Minimum = 6.5 bar, Maximum 10 bar

Table 4.1: Test Bench's Inputs Specification

Points	Position	Purpose
V1	Perpendicular to piping assembly	Isolate main pressurized air supply to entire test bench.
V2	Perpendicular to piping assembly	Isolate and discharge air in air suspension lines.
All corks on EP Panels	45^{O} diagonal to floor level	Discharge all trapped air in EP panels, dump valves and other piping.

Table 4.2: Discharging Trapped Air Points

5 Related Documentation

1) Brake Control Unit Description - Siemens Kuala Lumpur Functional Spec Issue 4
2) Bench Wiring Diagram (G00.OMN.M01000.YW.1001.*)
3) Test Bench Pneumatic Diagram (G00.OMN.M01000.XH.1001.*)
4) Brake Distance Test Routine (R00.RSE.91130.QV.1025.*)

6 Equipment and Apparatus

1) DC Power Supply 110VDC with capability to supply minimum current of 4A and electrical cabling.
2) Train Brake Control Unit.
3) A pair of EP Panels complete with variable load valve.
4) Four WSP dump valves.
5) Pressurized compressed air 10 bar supply and pneumatic piping.
6) 10 or 12 bar Manometer.
7) Service PC with pre-installed MT32.exe software.
8) Function Generator (optional – for test related to WSP function only)

Note: An Asterisk (*) used to refer to the latest version applicable for all pages in this procedure.

7 Test Bench Arrangement

7.1 Structural Assembly

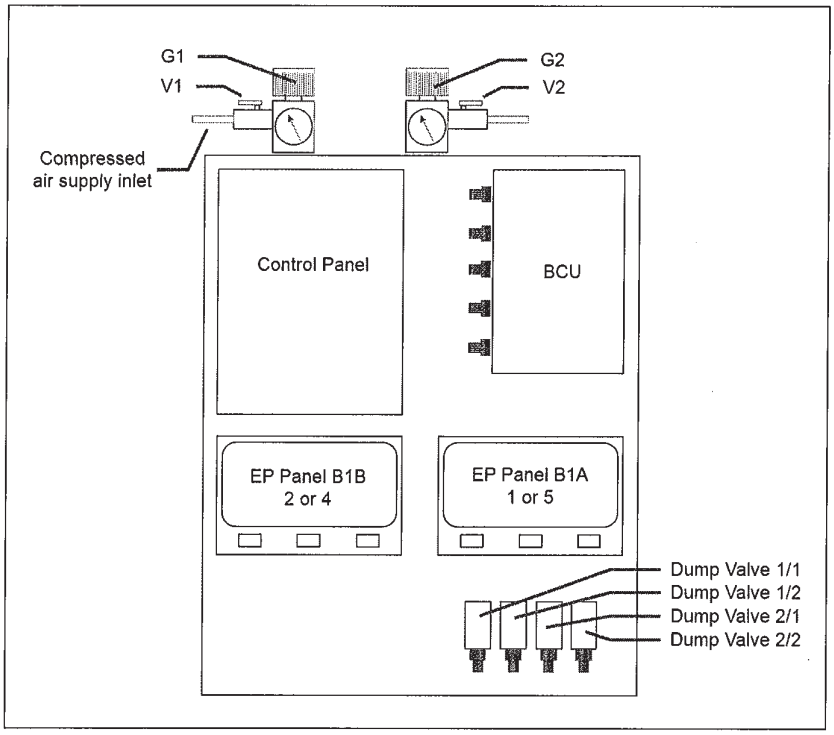


Figure 7.1: Equipment Arrangement

Note: The green elements in Figure 7.1 are the correct position of electrical connectors viewed from front of the test bench.

1) V1 is used to isolate the compressed air supply to all test bench's pneumatic equipment.

2) G1 is used to regulate the incoming compressed air supply. It was set to 10 bar. However, the test bench is still able to operate with minimum pressure of 6.5 bar. There was a pressure gauge indicating pressure of air supply.

3) V2 is used to isolate EP Panel's port #11 (air suspension inlet) from supplied compressed air. The air suspension pressure readings in maintenance software's "Live Data Display > Local BCU IO" should drop to zero if this valve is isolated.

4) G2 is used to replicate the pressure reading as in actual train's operational situation. It can be adjusted accordingly. The pressure gauge will indicate current setting value. It was used incorporated with valve V2.

5) The position of EP Panels and dump valves must be correct for proper operation of this test bench. Refer Figure 7.1 for details.

6) All pneumatic and electrical layout are installed at rear of this bench.

7.2 Control Panel

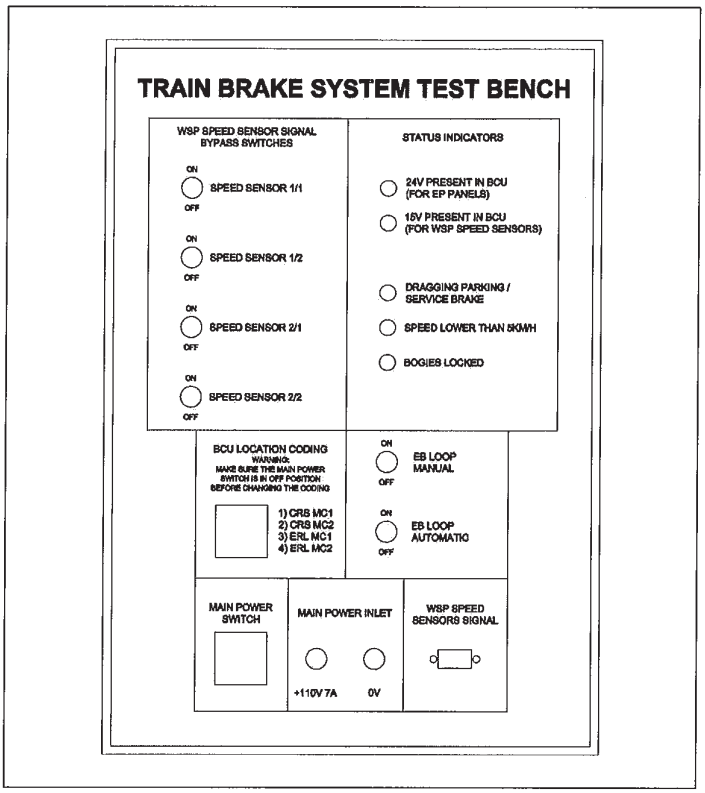


Figure 7.2: Control Panel

1) WSP Speed Sensor Signal Bypass Switches is used to cut off the generated signal to BCU to simulate sensor defective situation. This trigger can be monitored by "Live Data Display > WSP" and also recorded in event log. ON state means that the looping is closed and completed.

2) WSP Speed Sensors Signal Port is used to channel the function generator outlet to BCU's PL1 connector for simulating train speed. An opto-isolator board located between these connections is used for splitting the single source signal to four tacho signal representing each WSP speed reading. This function can be monitored by maintenance software's "Live Data Display > WSP" and also recorded in event log.

3) There were two voltage indicators representing voltage outputs from BCU. 24V is used to power up EP Panel's components while 15V is used for WSP speed signal. The test bench will not operate properly if these indicator are not illuminates.

4) Three indicators are used to represent hardwire output of brake system. Dragging Parking/ Service Brake and Speed Lower than 5km/h indicators are used to read BCU's relay outputs. Illuminated indicator means the function is in true state. Bogies Locked is used for reading the EP Panel's isolating cork looping. Illuminated indicator means the EP panel's cork in in open position. These indicators was purposely set to ON state when the test bench initial startup as to ensure all indicator bulbs are in good condition.

5) Emergency Brake (EB) Looping switches are used to replicate the hardwired emergency braking inputs into BCU and EP Panels. EB Loop Manual represent the looping from Master Controller, Emergency Brake push button and PEB. EB Loop Automatic represent the looping from ATP computer. ON state means that the looping is closed and completed.

6) Main Power Inlet is the incoming point where 110VDC supply voltage is used to power up the test bench's panel, BCU, EP Panels and Dump Valves. The maximum current allowed into the test bench system is 7A. There was no internal protection to avoid overcurrent. Red point is for +110V terminal while black point is for 0V terminal.

7) Main Power Switch is used to isolate the power inlet to all test bench's electrical components.

8) BCU Location Coding Selection Switch is used to set the coding looping for BCU. Please be advised that the test bench power must be reset after changing the coding in order to allow BCU to operate properly. Another correct way is to change the coding before switching on the system.

7.3 General Assembly Concept of Train Brake Test Bench

The assembly of test bench items must be installed according below description to avoid damages and improper functions. This test bench had been designed and built to replicate most of the train braking system operation. However, brake callipers, reservoirs and bogie vibration sensors are omitted from the simulation processes at the moment. WSP Speed sensor was also replaced by dummy signal generated by function generator.

Main purpose of this bench is for friction brake functionality testing. MVB simulation features will be added in future for enabling more test ranges.

7.3.1 Mechanical Assembly

One BCU, two EP Panels with load valve (cannot be same type) and four dump valves are required to operate the test bench. Each equipment must be secure firmly on the bench structure based on screw holes provided. No temporary jointing are allowed. Note that some installation must be carried out by two person due to heavy equipment weight. Refer Figure 7.1 for assembly layout.

7.3.2 Electrical Assembly

Each equipment mention in mechanical assembly section have electrical connections. Each connection has fool-proof arrangement to avoid wrong connection attachment. However, the MVB connections (PL7 and PL8) at BCU may be assembled in any way.

An electrical supply 110VDC 7A is required to power up whole test bench and its attachments. The power input point is available only at test bench panel. It will be distributed internally. Any 4mm banana plug test cable can be used for the electrical wiring from power supply to panel. No overcurrent protection installed internally. Main Switch located at test bench's panel is used for connecting and disconnecting main power inlet to all electrical component in the test bench.

7.3.3 Pneumatic Assembly

EP Panels and dump valves requires pneumatic connection too in order to operate properly. It was joint by flexible pneumatic tubing (diameter 12mm) with several couplings, adaptors and blank plugs. Appendix 4 shows the pneumatic circuit diagram. Refer Appendix 1 for pneumatic connection arrangement.

7.3.4 Additional Equipment

Service PC are required to check proper function of BCU and readout purposes. MT32.exe software provided by brake system manufacturer is mentioned as maintenance software throughout this document. An adaptor cable was made to link up the RS232 port of service PC to BCU.

TCN Analyser is an additional equipment which will be added in future upgrade. Two adaptor cable were made to convert typical MVB D-sub connector to BCU's circular connector.

Function generator is required when speed signal is needed. It will produce a simulated signal which replicate actual speed sensor signal in the train. The parameter must be set according to Table 7.1. The BNC – D-Sub connector (Figure 7.3) is used to linking this equipment to test bench's panel.

Parameter	Value
Waveform Shape	Square Wave
Vpp	5V
Offset	+2.5V
Frequency	5Hz

Table 7.1: Function Generator Parameters

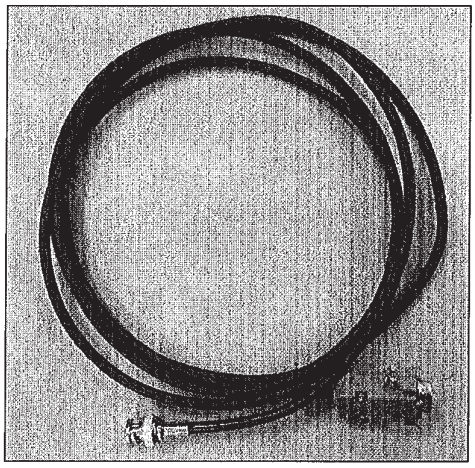


Figure 7.3: BNC – D-sub connector cable

8 Test Bench General Setup

1) Attach all braking equipment to designated places throughout the test bench as illustrated in Figure 7.1.

2) Fit all pneumatic connections according to Appendix 1.

3) Fit all electrical connections accordingly. Generally, all braking equipment had electrical connection.

4) Connect power supply to test bench using appropriate cabling. Power supply ratings must be 110VDC with current ranging from 5A to 7A. Make sure panel's Main Switch is in OFF position at this point.

5) Attach V1 inlet to workshop compressed air supply.

6) Open V1 valve to start filling the system with compressed air. Gauge 1 will show the supply pressure value.

7) Check for air leakage throughout the test bench. Correct them if necessary.

8) Ensure all toggle switches are in ON position.

9) Power up the power supply and switch ON the panel's Main Switch. Visual check for abnormalities.

10) Wait for BCU to finish the self-test once the test bench is power up.

9 Test Bench Additional Setup

1) Connect Function Generator outlet to panel's WSP Speed Sensor Signal using appropriate cabling.

2) Switch ON the Function Generator and configure it according to Table 7.1.

3) Connect Service PC directly to BCU using appropriate cabling (Figure 7.3). Then call MT32.exe software.

10 BCU Functional Description and Testing Methodology

10.1 Maintenance Link

10.1.1 Maintenance Link Description

Maintenance Link is the communication link between BCU and maintenance software's computer. A RS232 protocol connection is used for the linking. All information and function are transmitted via this link.

"Read Unit Identity" function from maintenance software is used to check this function. A good connection should indicates the values of each block except "Project Specific Block" but first the BCU must be switched ON and two voltage indicators at Train Brake Test Bench panel must illuminated.

10.1.2 Maintenance Link Test Procedure

1) General setup must be performed before proceeding.

2) Call "Read Unit Identity" function from maintenance software.

3) All block must have values except "Project Specific Block".

10.2 Emergency Brake Looping

10.2.1 Emergency and Redundant Emergency Looping Description

Emergency and Redundant Emergency Looping are hardwire connection used for triggering braking function of the BCU. These looping is connected serially to ATP computer, master controller and Passenger Emergency Brake (PEB) on the original wiring connection.

Two kind of looping simulation available to test these function. One is "Automatic Looping" mimicking the ATP computer connection while "Manual Looping" is for emergency brake triggered by master controller, PEB or Emergency Brake Push Button.

Maintenance software function "Live Data Display > Screen > Local BCU IO" will indicates the status of these emergency looping. "Automatic Looping" switch is for triggering "Emergency Input" while "Manual Looping" is for "Redundant Emerg Input".

10.2.2 Emergency and Redundant Emergency Looping Test Procedure

1) General setup must be performed before proceeding.
2) Call the "Live Data Display" function in maintenance software and select "Local BCU IO".
3) Turn ON or OFF the "EB Loop Automatic" switch and observe the changes of "Emergency Input".
4) Turn ON or OFF the "EB Loop Manual" switch and observe the changes of "Redundant Emerg Input".

10.3 Low BSR input

10.3.1 Low BSR input Description

Low BSR input signal is triggered by pressure switches B1.5 (inside EP Panels) when the supply pressure reduces below 4.75 bar. This can be monitored via maintenance software at "Live Data Display > Screen > Local BCU IO".

V1 is used to isolate the incoming supply air into the Train Brake Test Bench pneumatic circuit. Table 10.1 describes the condition of this function. Note that either one of the EB Loop switches must be in OFF state for this to happened.

Valve 1 Position	LBSR Indicator
Parallel to piping assembly	Permanent ON
Perpendicular to piping assembly	Blinking

Table 10.1: LBSR Status

10.3.2 Low BSR Input Test Procedure

1) General setup must be performed before proceeding.
2) Switch of either "EB Loop Manual" or "EB Loop Automatic" toggle switch.
3) Valve 1 is normalized and isolated accordingly based on Table 10.1.

10.4 Speed Switch Output

10.4.1 Speed Switch Output Description

Relay Output 4 (normally opened state at no power) controls the looping of Speed Switch Indicator at Control Panel. The relay will close the circuit when it detects WSP speed below than 5km/h.

It can be operated by adjusting the generated frequency for WSP according to details described in Table 10.2.

Frequency	WSP Speed	Relay 4 Status	Indicator Status
66 Hz	Above 8 km/h	Opened	OFF
107 Hz	Below 5 km/h	Closed	ON

Table 10.2: Speed Switch Status

An indicator (L2) at test bench's control is used to substitute the connections in actual train wiring.

10.4.2 Speed Switch Output Test Procedure

1) General setup must be performed before proceeding.
2) Press Function Generator's "Main Out" to transmit the generated signal.
3) Adjust the frequency according to Table 10.2 and observe the responses.

10.5 Dragging Parking / Service Brake Status

10.5.1 Dragging Parking / Service Brake Description

The Dragging Parking / Service Brake is used for wrong brake application detection which means that the brake must apply or release accordingly. Any opposite mode of operation will be declared as dragging brake status.

The correct operation simulation of this function is yet to be derive in future upgrades as it requires MVB signal to releasing the parking brake. However, at this point the simulation will assume that the parking brakes was applied to test Relay Output 2 (NC state at no power) operation.

The status of this function can be referred at two point. First at indicator panel and secondly at "Live Data Display > Screen > Local BCU IO". By manipulating the speed sensor above and below 15km/h, the Relay Output 2 shall operates.

10.5.2 Dragging Parking / Service Brake Test Procedure

1) General setup must be performed before proceeding.
2) Call the "Live Data Display" function in maintenance software and select "Local BCU IO".
3) Press Function Generator's "Main Out" to transmit the generated signal.
4) Adjust the frequency to 200Hz and panel's Dragging Parking / Service Brake indicator illuminates.
5) Adjust the frequency to 173Hz and panel's Dragging Parking / Service Brake indicator shall turned OFF.

10.6 Car (Location) Coding

10.6.1 Car (Location) Coding Description

Car coding is used to determine the location of the BCU installation. The indicator for the coding can be obtains from "Live Data Display > Screen > Local BCU IO". Table 10.3 describes the numbering location meaning.

It is a best practice to reset the BCU power after changing the coding to avoid improper function of BCU for complex test such MVB operation.

Numbering	Actual BCU Assembly Location
BCU Select 1	CRS MC1
BCU Select 2	CRS MC2
BCU Select 3	ERL MC1
BCU Select 4	ERL MC2

Table 10.3: Car Location Meaning

10.6.2 Car Coding Test Procedure

1) General setup must be performed before proceeding.
2) Call the "Live Data Display" function in maintenance software and select "Local BCU IO".
3) Rotate the Location Coding Selection Switch at panel accordingly and observe the changes in "Live Data Display". The number of selection must be same as indicated in select "Local BCU IO".

10.7 Parking Brake Status

10.7.1 Parking Brake Status Description

Parking brake is used to apply and release parking brake cylinder at brake calliper. Due to the calliper it is not installed to the test bench, the EP Panel outlet is blocked with a blank plug. Therefore this function can be operated without the need of complete assembly.

The status of these relay activation can be monitored at maintenance software's "Live Data Display > Screen > Local BCU IO". "Parking Brake Applied" B1 and B2 are the indicator for this function.

The activation of parking brake relays (B1.9 and B1.16) is done automatically by the BCU. Since this operation required MVB signal, another approach is used for simulating this function.

The parking brake relays is operated by pushing the relay's blue lever to position "1". To release the parking brake, push the Release relay lever and "Parking Brake Applied" is go inactive. Then, to apply the parking brake, push Apply relay lever and observe the "Parking Brake Applied" status re-activated.

10.7.2 Parking Brake Status Test Procedure

1) General setup must be performed before proceeding.
2) Call the "Live Data Display" function in maintenance software and select "Local BCU IO".
3) Push "Release" relay lever to position "1". The "Parking Brake Applied" status at "Local BCU IO" will inactive.
4) Push "Apply" relay lever to position "1". The "Parking Brake Applied" status at "Local BCU IO" will be re-activated.

10.8 Suspension Pressure

10.8.1 Suspension Pressure Description

Suspension pressure is used to monitor the load on train car. The information is used to compensate the braking demand based on load bear by train body.

The pressures were read by pressure transmitters B1.15 located inside EP Panels. The test point for this pressure is located at Test Point 6 internally and can be connected to 10 bar manometer.

V2 at test bench is used to supply the EP Panel's air suspension pressure. Pressure regulator G2 is used to create a pressure level mimicking the actual pressure during various condition of loads.

10.8.2 Suspension Pressure Test Procedure

1) General setup must be performed before proceeding.
2) Connect 10 bar manometer to Test Point 6 located inside the EP Panel.
3) Call the "Live Data Display" function in maintenance software and select "Local BCU IO".
4) Isolate the V2 and both "Air Suspension Bogie" 1 and 2 pressure reading will drop to zero. Same goes to manometer reading.
5) Normalize the V2 and adjust the pressure regulator G2 accordingly.
6) Pressure reading at manometer and in "Local BCU IO" must be similar.

10.9 Brake Cylinder Pressure

10.9.1 Brake Output Pressure Description

Brake Output pressures were read by pressure transmitters B1.16 located inside EP Panels. The test point for this pressure is located at Test Point 7 internally and can be connected to 10 bar manometer.

This can be monitored via maintenance software at "Live Data Display > Screen > Local BCU IO". Two gauges displayed in maintenance software in Local BCU IO are Brake Cylinder Bogie 1 and Brake Cylinder Bogie 2.

10.9.2 Brake Output Pressure Test Procedure

1) General setup must be performed before proceeding.
2) Connect 10 bar manometer to Test Point 7 located inside the EP Panel.
3) Call the "Live Data Display" function in maintenance software and select "Local BCU IO".
4) Reading from maintenance software's "Local BCU IO" must be similar to manometer readings.

10.10 Duplex Dump Valves Operation

10.10.1 Duplex Dump Valves Operation Description

WSP Dump valves are used for controlling the pressure in brake cylinder. Though no brake cylinder and caliper were installed to the test bench, the brake cylinder outlet at these dump valves are terminated with blank plug.

Maintenance software function at "Live Data Display > Screen > WSP" is used to monitor the status of these valves. Two state available for each valves which are "Hold" and "Vent".

The operation of dump valves are controlled automatically by the BCU. However, self-test can be performed to simulate the function of these valves. The self-test function can be called by the maintenance software.

10.10.2 Duplex Dump Valves Operation Test Procedure

1) General setup must be performed before proceeding.
2) Call the Self-Test function via maintenance software and click "Start Selftest".
3) Once the "Selftest Started" message appear, click "Exit" to close the Seft-Test dialog.
4) Call "Live Data Display > Screen > WSP".
5) Observe the operation of dump valve's hold and vent status.
6) A purging sound will be heard for each dump valves when "Vent" status activated.

10.11 Speed Inputs

10.11.1 Speed Inputs Test Description

Speed Inputs can be monitored via maintenance software at "Live Data Display > Screen > WSP".

The signal can be simulated using function generator instruments. Equation 9.1 describes the simulated frequency and speed reading conversion method.

$$Speed \times m = Frequency \quad \text{------ Equation 9.1}$$

Where:-

Speed is train speed in km/h
m is the calculation coefficient = 13.33 (refer Appendix 2)
Frequency is simulated frequency to obtain desired train speed

10.11.2 Speed Inputs Test Procedure

1) General setup must be performed before proceeding.
2) Press Function Generator's "Main Out" to transmit the generated signal.
3) Adjust the Function Generator's frequency accordingly based on Equation 9.1.

4) Each reading must be similar to calculated value.

5) Trigger the bypass switches accordingly and the sensor defective message is recorded in Event Log.

11 Quality Control

All BCU and EP panel, which passed the bench testing, must undergo on-board short and long brake test. It was also compulsory to execute brake distance test, thereafter all measured and calculated value must be within permissible range.

Other test deem necessary by technical executives and manufacturer requirement must also be complied. Only then the BCU is declared as fit for service for revenue services.

Appendices

List of appendices

1) Pneumatic Connection Arrangement – Appendix 1
2) Speed and Simulated Frequency Calculations – Appendix 2
3) BCU Power Supply Endurance Test Procedure – Appendix 3
4) Test Bench's Wiring Diagram (G00.OMN.M01000.YW.1001.*)
5) Test Bench's Pneumatic Diagram (G00.OMN.M01000.XH.1001.*)
6) Speed Sensor Signal Board Circuit Diagram (G00.OMN.M01000.YS.1001.*)
7) BCU internal repairing checklist (G00.OMN.M01000.CX.1001.*)

Note: An Asterisk (*) used to refer to the latest version applicable for all pages in this procedure.

Appendix 1 - Pneumatic Connection Arrangement

Note: Refer Appendix 4 for pneumatic circuit diagram details.

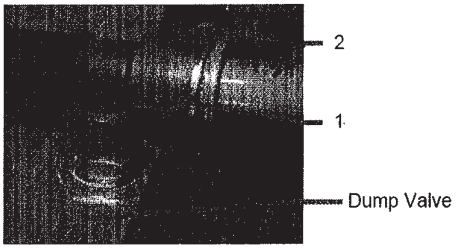


Figure A1.1: Dump Valves Inlet

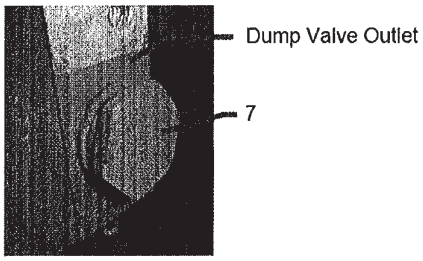


Figure A1.2: Dump Valve Outlet

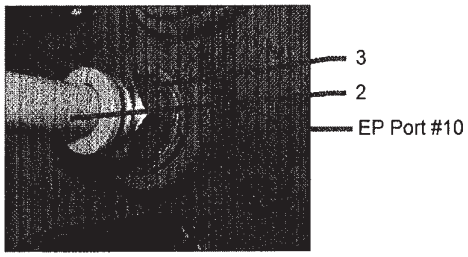


Figure A1.3: EP Port #10 – Main Air Supply Inlet

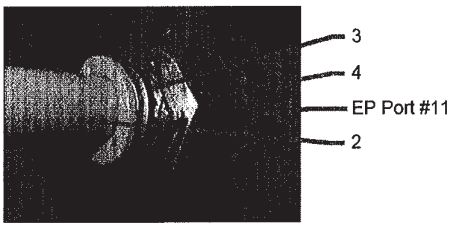


Figure A1.4: EP Port #11 – Air Suspension Inlet

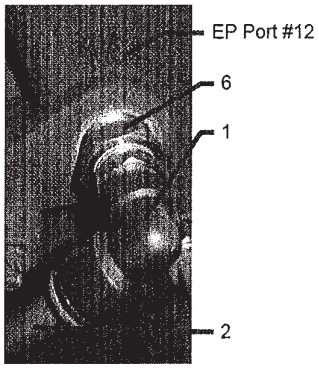


Figure A1.5: EP Port #12 – Main BSR Outlet

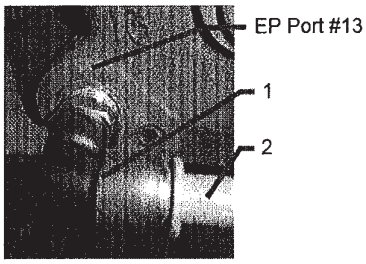


Figure A1.6: EP Port #13 – Main BSR Inlet

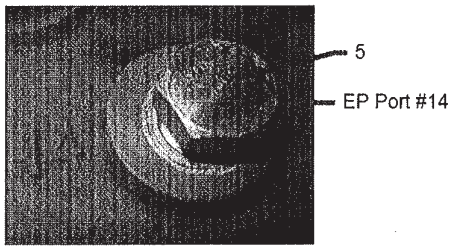


Figure A1.7: EP Port #14 – Parking Brake Outlet

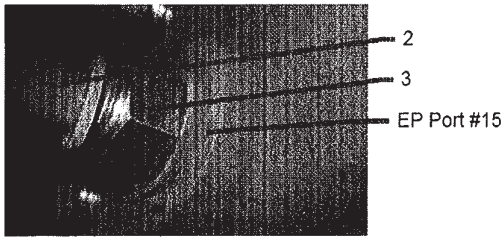


Figure A1.8: EP Port #15 – Service Brake Outlet

Point	Component Description
1	Elbow Tread - Quick Release Fitting ½" to 12mm
2	FESTO Pneumatic Tubing Dia. 12mm
3	Straight Tread – Quick Release Fitting ½" to 12mm
4	Reducer 3/8" BSPT (M) x ½" BSP (F)
5	Blank Plug 3/8"
6	Reducer ¾" BSPT (M) x ½" BSP (F)
7	Blank Plug from existing dump valves

Table A1.1: Part List

Appendix 2 – Speed and Simulated Frequency Calculations

Introduction

This document is used to determine the coefficient value for obtaining speed or frequency setting needed for BCU's WSP speed sensor reading simulation.

Method

1) BCU was attached to test bench and powered up.
2) Generated signal from function generator with square wave signal inserted into the system. Refer Table 7.1 for function generator setting.
3) Adjust the frequency accordingly and record the speed reading at WSP function in MT32.exe software.

Note: BCU used for this experiment is SN: 0141/024 and this was conducted on 27 Oct 2014 by author.

Result

Frequency (x)	Speed Value (y)			
	Axle 1	Axle 2	Axle 3	Axle 4
0Hz	0km/h	0km/h	0km/h	0km/h
100Hz	7.5km/h	7.5km/h	7.5km/h	7.5km/h
1000Hz	75km/h	75km/h	75km/h	75km/h
2000Hz	150km/h	150km/h	150km/h	150km/h

Table A2.1: Experiment Result

Conclusion

Based on the result in Table A2.1, the relationship between speed and set frequency is linear. Meaning that frequency increase proportionally linear with speed. Hence only one co-efficient needed, "M" derived from linear graph equation which been represented in Figure A2.1.

Linear Equation, $y = mx + c$ ---------- Equation A2.1

Where:-
y is speed value in km/h
x is the frequency value generated from function generator.
c is the value of Y if X is zero. In this case C = 0.
m is the linear gradient coefficient which used as speed calculation co-efficient in equation 9.1.

Any values inserted into equation A2.1 will resulting m as **13.33**.

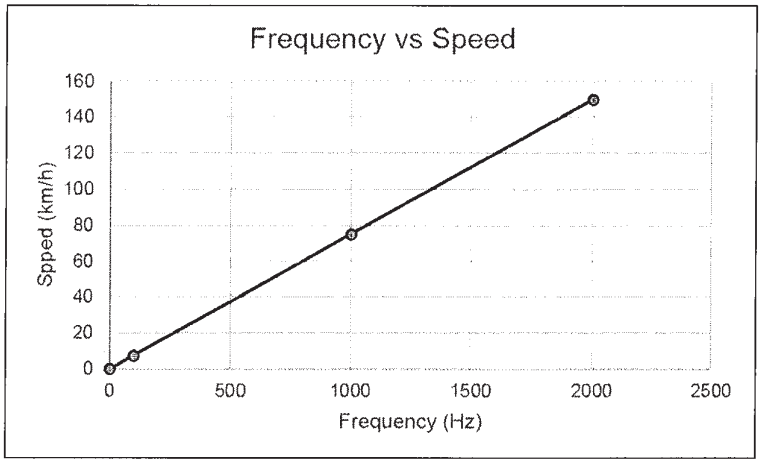


Figure A2.1: Graphical representation of Frequency and Speed relationship

Appendix 3 – BCU Power Supply Endurance Test Procedure

Introduction

This document is used as guideline for endurance test on BCU power supply circuitry.

Method

1) BCU cover is dismantled to access the internal test points.
2) A special made connector (refer Note 1) is plugged to BCU's PL3. Another end is connected to 110VDC (minimum 2 A) power source.
3) Turn ON the power source and let the BCU to start-up for several second.
4) Voltmeter was used to measure the voltages on test points according to Figure A3.1. Each reading must be observed for ten seconds and must not fluctuate more than two volts.
5) The BCU was left switched ON for three hours.
6) Step 3 was repeated for every one hour intervals together with the heat-sinks temperature recordings using infra-red temperature gun. The temperature shall not rose to more than 45°C.

Note:
1) The connector's connection must connect PL3's "p" pin to positive (+) 110VDC supply and "n" pin to common (0V) of the supply.
2) This test can only be executed in Electronic Workshop environment to ensure voltages and temperature consistency.
3) All "TP#" are located on one side of BSC board, surrounding a transformer there.
4) All "PL#" are located to the side of BCU casing.

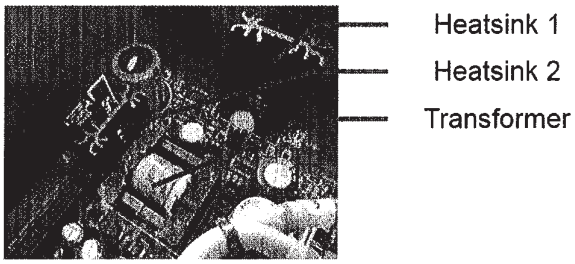


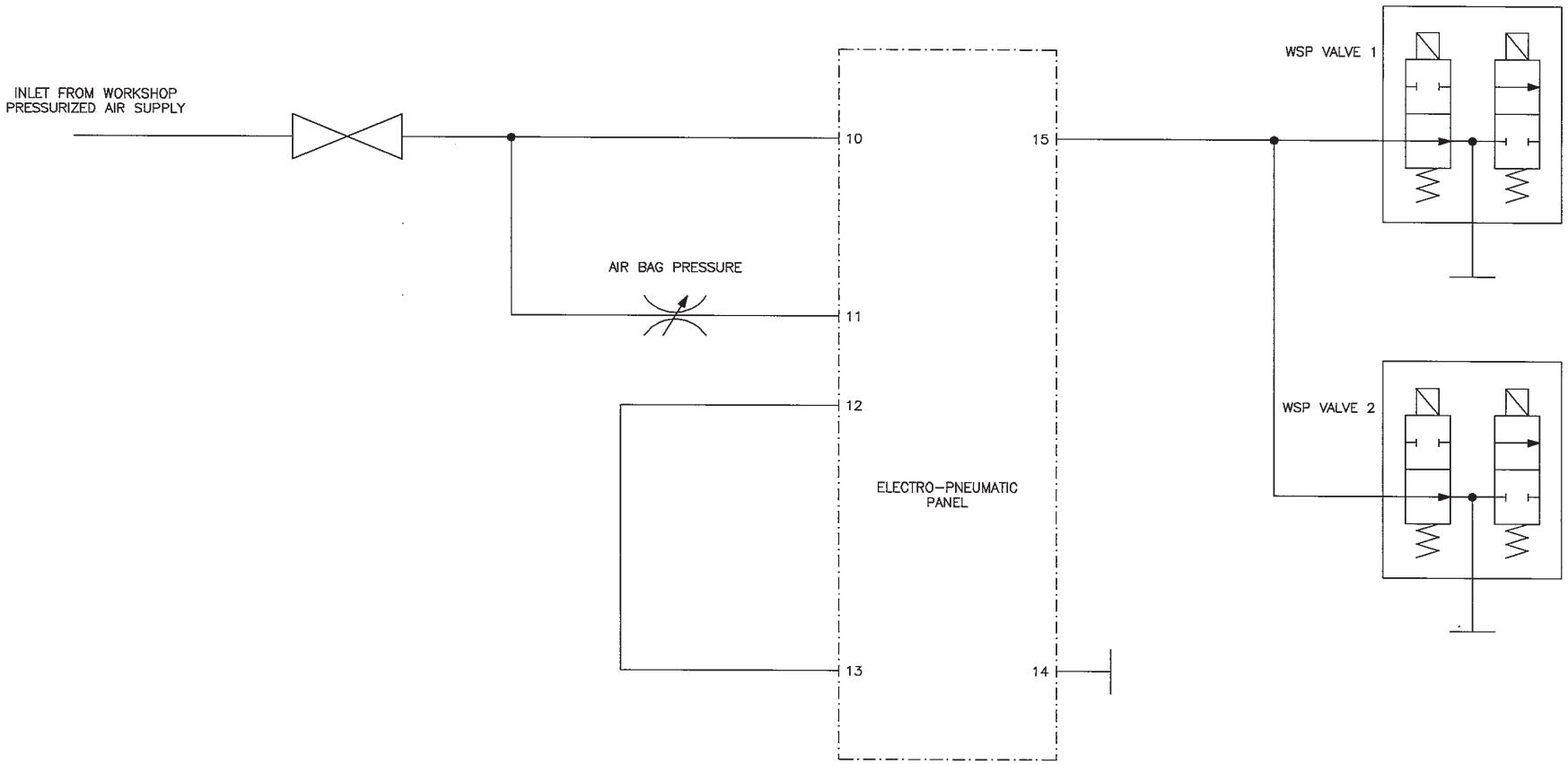
Figure A3.1: Transformer and heatsinks location

Voltmeter probe position		**Expected voltage Reading**
Red Probe	**Black Probe**	
TP10	TP9	21 to 25 VDC
TP11	TP12	28 to 32 VDC
TP13	TP14	14.5 to 18VDC
TP8	TP7	28 to 32 VDC
TP2	TP4	4.8 to 5.2 VDC
TP6	TP4	11 to 13 VDC
PL2 pin A	PL2 pin F	3.9 to 5.1 VDC
PL4 pin L	PL6 pin V	21 to 25 VDC
PL6 pin P	PL6 pin V	21 to 25 VDC
PL6 pin N	PL6 pin V	21 to 25 VDC
PL6 pin R	PL6 pin V	21 to 25 VDC
PL6 pin D	PL6 pin V	21 to 25 VDC
PL6 pin H	PL6 pin V	21 to 25 VDC
PL6 pin S	PL6 pin V	21 to 25 VDC
PL6 pin U	PL6 pin V	21 to 25 VDC
PL6 pin T	PL6 pin V	21 to 25 VDC
PL1 pin E	PL1 pin A	14.5 to 18VDC
PL1 pin M	PL1 pin G	14.5 to 18VDC
PL1 pin C	PL1 pin D	14.5 to 18VDC
PL1 pin N	PL1 pin R	14.5 to 18VDC

Table A3.1: Expected voltage reading on BCU pins and test points

1	2	3	4	5	6	7	8
	ISOLATION COCKS		T–LOADING PRESSURE REGULATOR			WSP VALVES	

EP PANEL



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				Drawn	Dzulfaqar	ERL Maintenances Support Sdn. Bhd.		EP PANEL B1A AND B1B
A	NEW RELEASE	28OCT14	DFQ			Electronics Repair Centre Dept.		CONTROL
Rev.	Remark	Date	Name					Pneumatic Diagram

Doc. No:	G00.OMN.M01000.XH.1001.A
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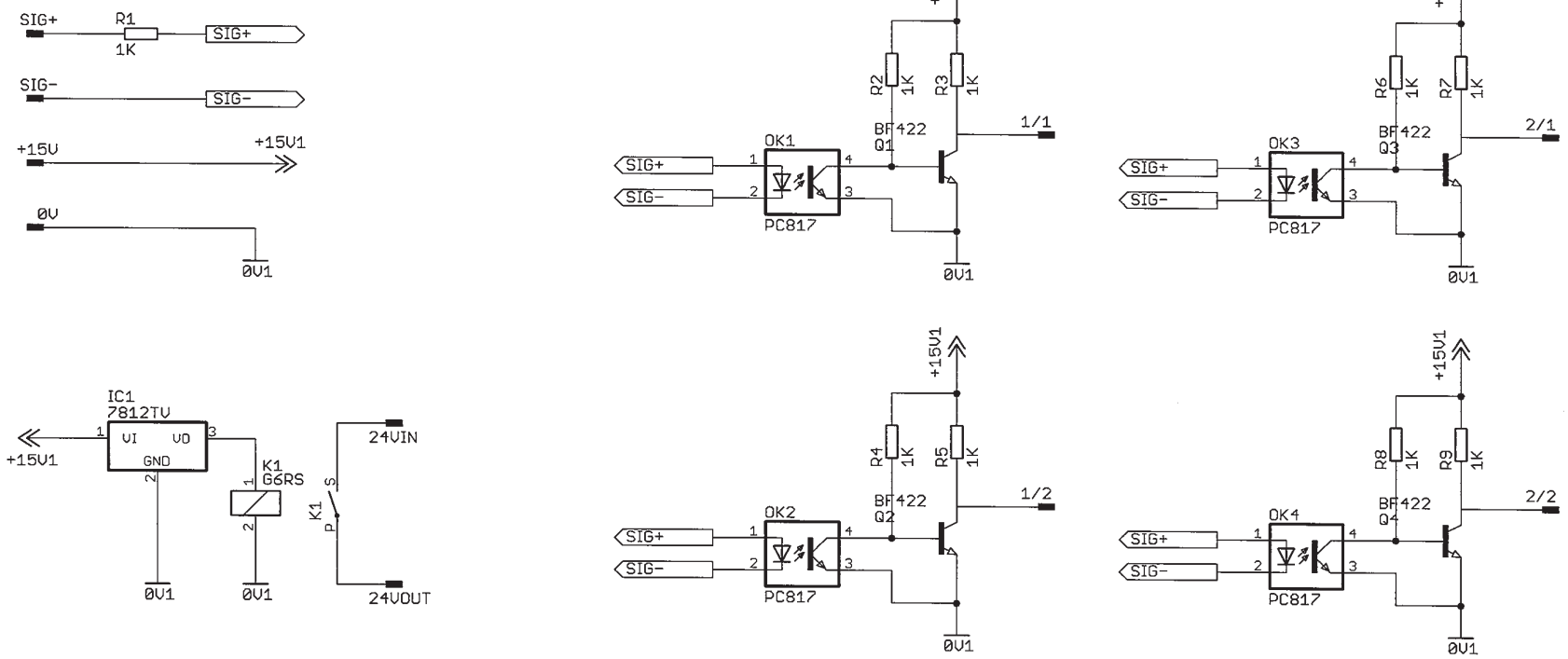
Date	



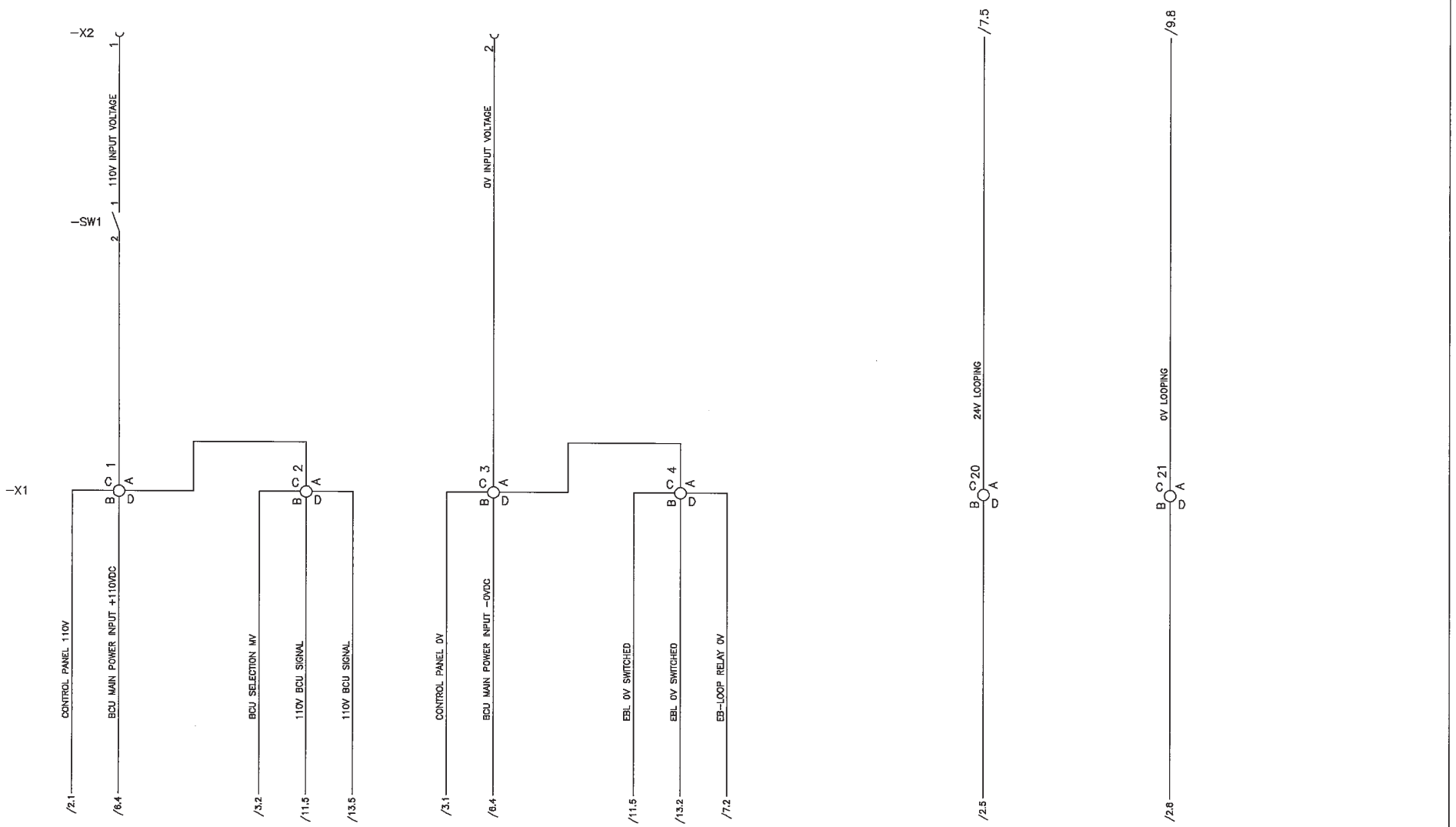
Design / Drawn by: Dzulfaqar	
TITLE: Signal Board	
Document Number: G00.OMN.M01000.YS.1001.A	REV:
Date: 27/10/2014 16:43:37	Sheet: 1/1

1	2	3	4	5	6	7	8

POWER SUPPLIES

110VDC SUPPLY FROM EXTERNAL

24VDC SUPPLY FROM BCU



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A	NEW RELEASE	28OCT14	DFQ			Electronics Repair Centre Dept.		POWER SUPPLIES
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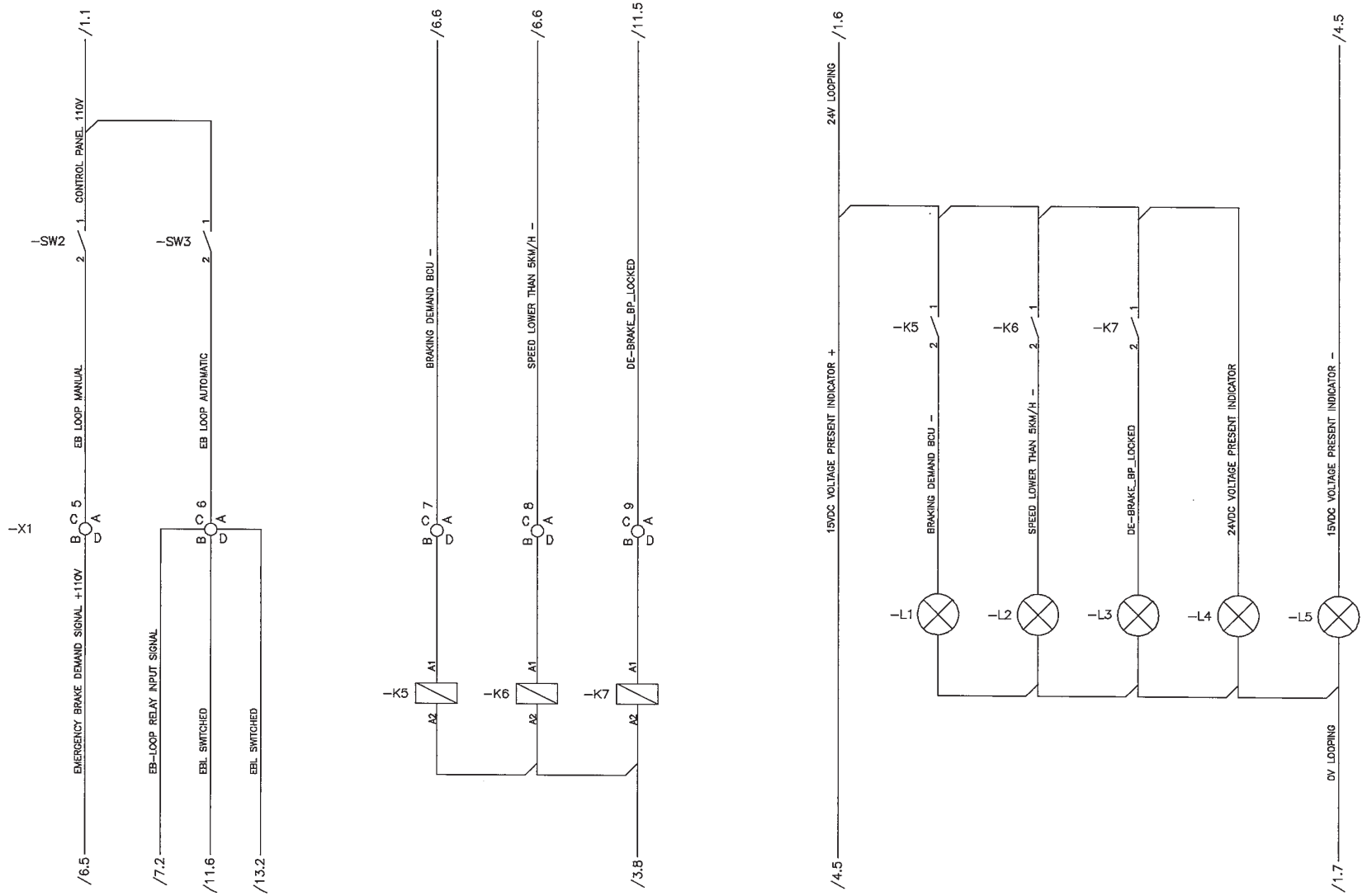
1	2	3	4	5	6	7	8
	BCU DIGITAL INPUTS		BCU RELAY OUTPUTS		BCU DIGITAL/RELAY STATUS INDICATORS		



Rev.	Remark	Date	Name
		Date	28 OCT 2014
		Drawn	Dzulfaqar

TRAIN BRAKE SYSTEM TEST BENCH
ERL Maintenances Support Sdn. Bhd.
Electronics Repair Centre Dept.

E-MAS

TEST BENCH
CONTROL PANEL
TRIGGER AND INDICATOR CIRCUIT
Wiring Diagram

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Date

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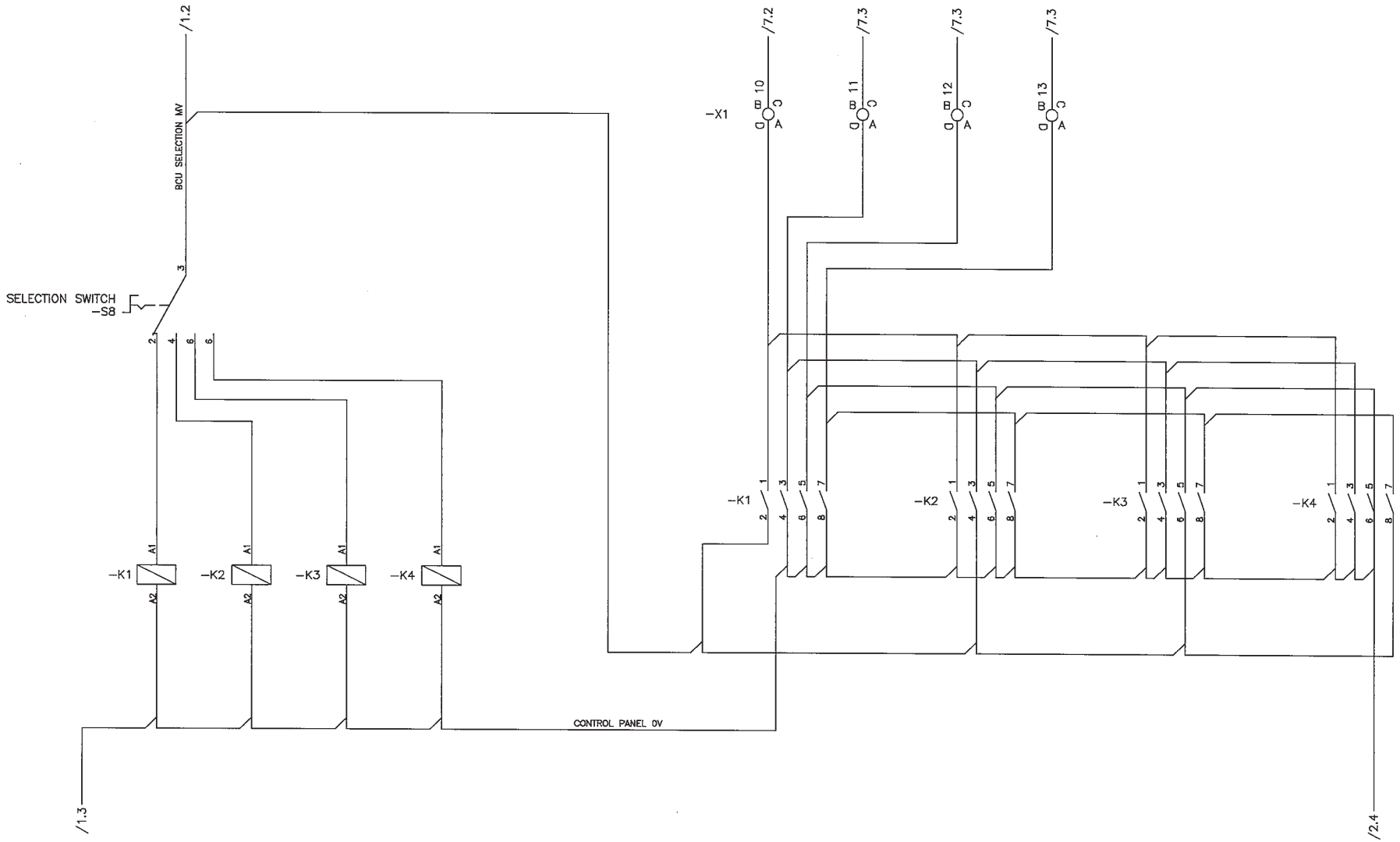
1	2	3	4	5	6	7	8
	BCU DIGITAL INPUTS		BCU RELAY OUTPUTS		BCU DIGITAL/RELAY STATUS INDICATORS		



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A	NEW RELEASE	28OCT14	DFQ			Electronics Repair Centre Dept.		BCU CODING SELECTION
Rev.	Remark	Date	Name					Wiring Diagram

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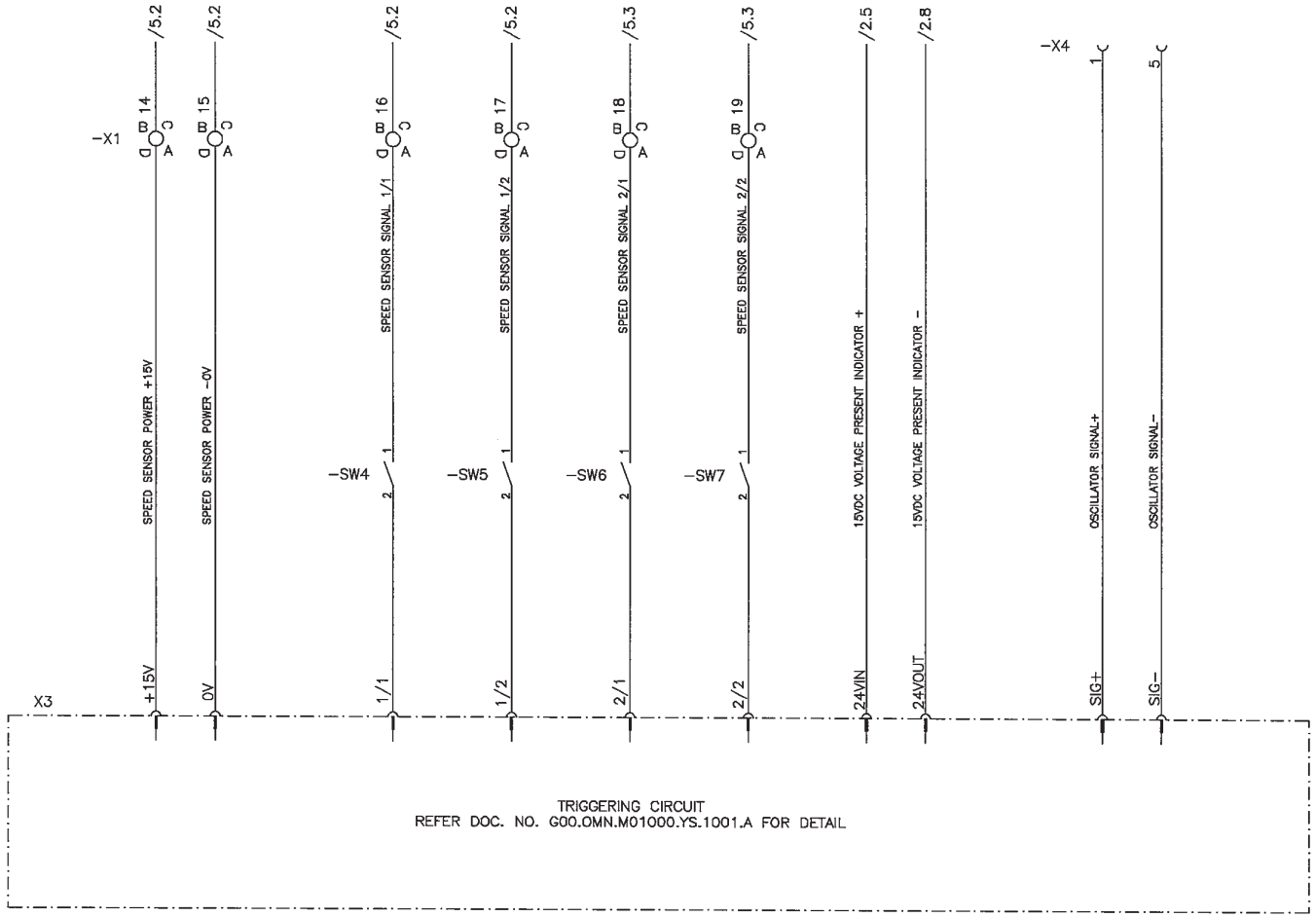
Release			
Date			

1	2	3	4	5	6	7	8
SPEED SENSOR SUPPLY		SPEED SENSOR SIGNALS		15V PRESENT INDICATION			
				OSCILLATOR SIGNAL			



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				Drawn	Dzulfaqar	ERL Maintenances Support Sdn. Bhd.		WSP SPEED SENSOR TRIGGERING Wiring Diagram	
A	NEW RELEASE	28OCT14	DFQ			Electronics Repair Centre Dept.			Release / Date
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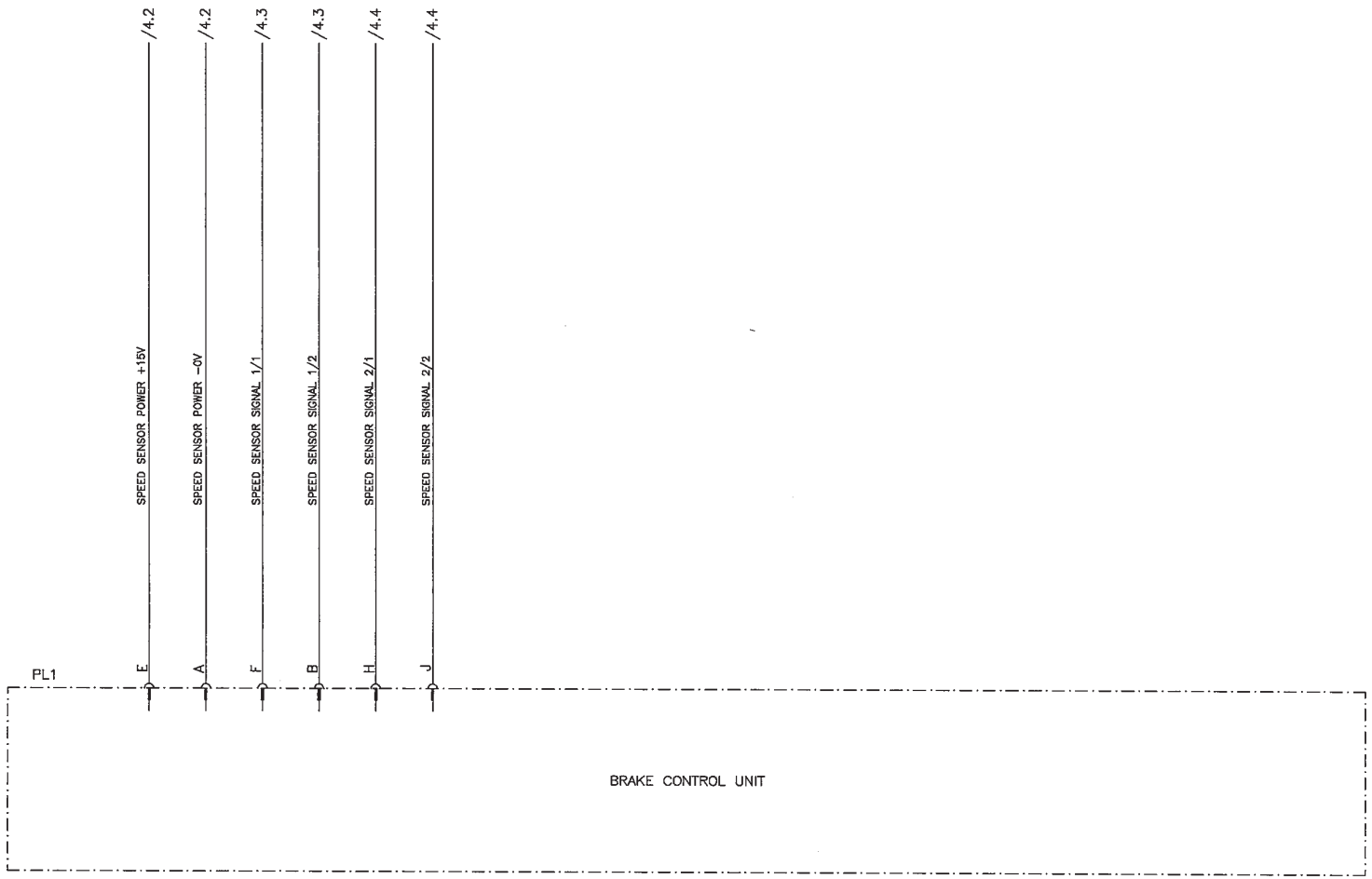
1	2	3	4	5	6	7	8

SPEED SENSOR SUPPLY

SPEED SENSOR SIGNALS



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A	NEW RELEASE	28OCT14	DFQ			Electronics Repair Centre Dept.		PLUG PL1	Release
Rev.	Remark	Date	Name					Wiring Diagram	Date

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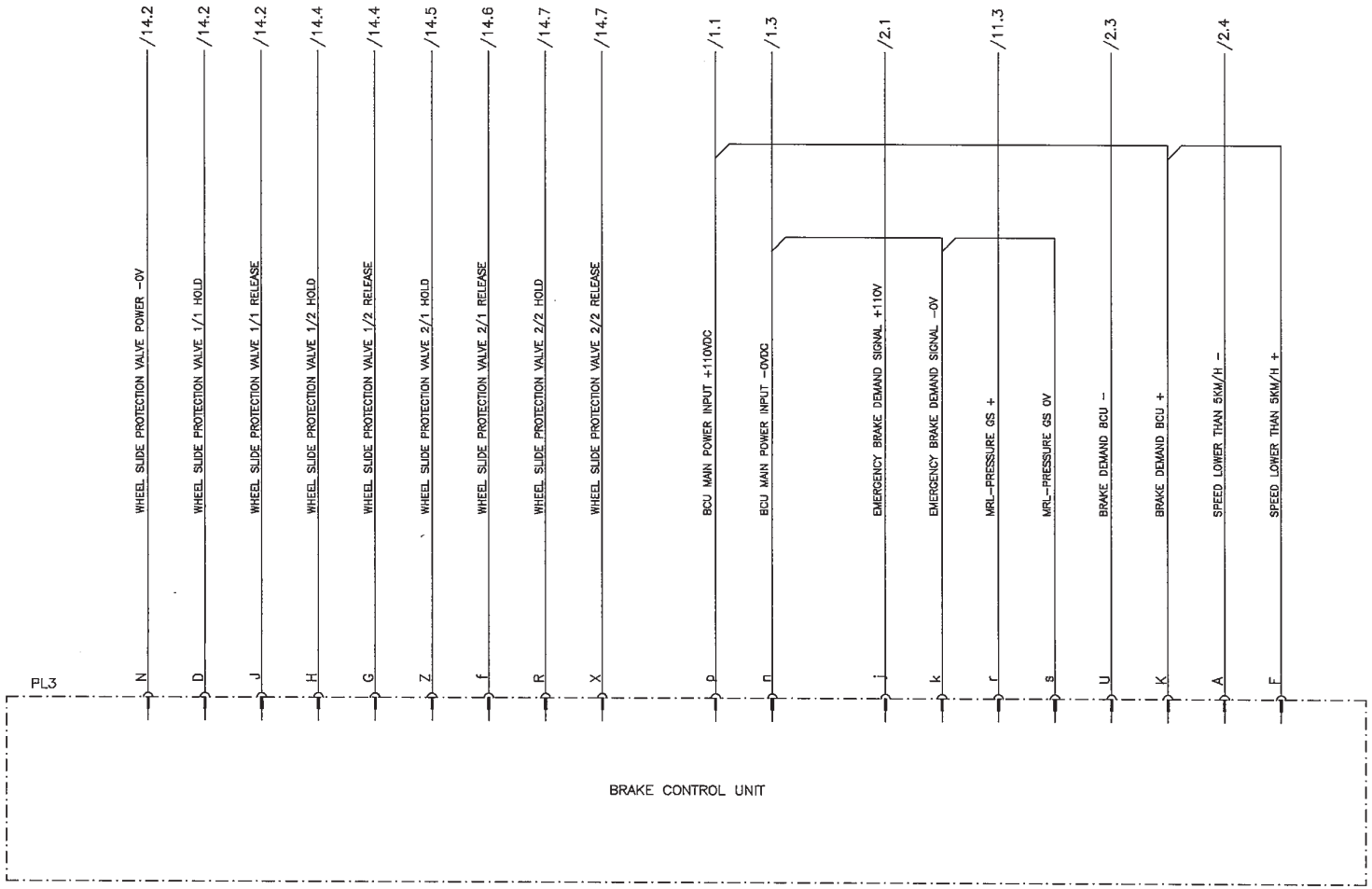
1	2	3	4	5	6	7	8
	WSP VALVE 1/1	WSP VALVE 2/1	BCU MAIN VOLTAGE		MRL–PRESSURE	SPEED LOWER THAN 5	
	WSP VALVE 1/2	WSP VALVE 2/2		L_EMERGENCY BRAKE	BRAKE DEMAND BCU		



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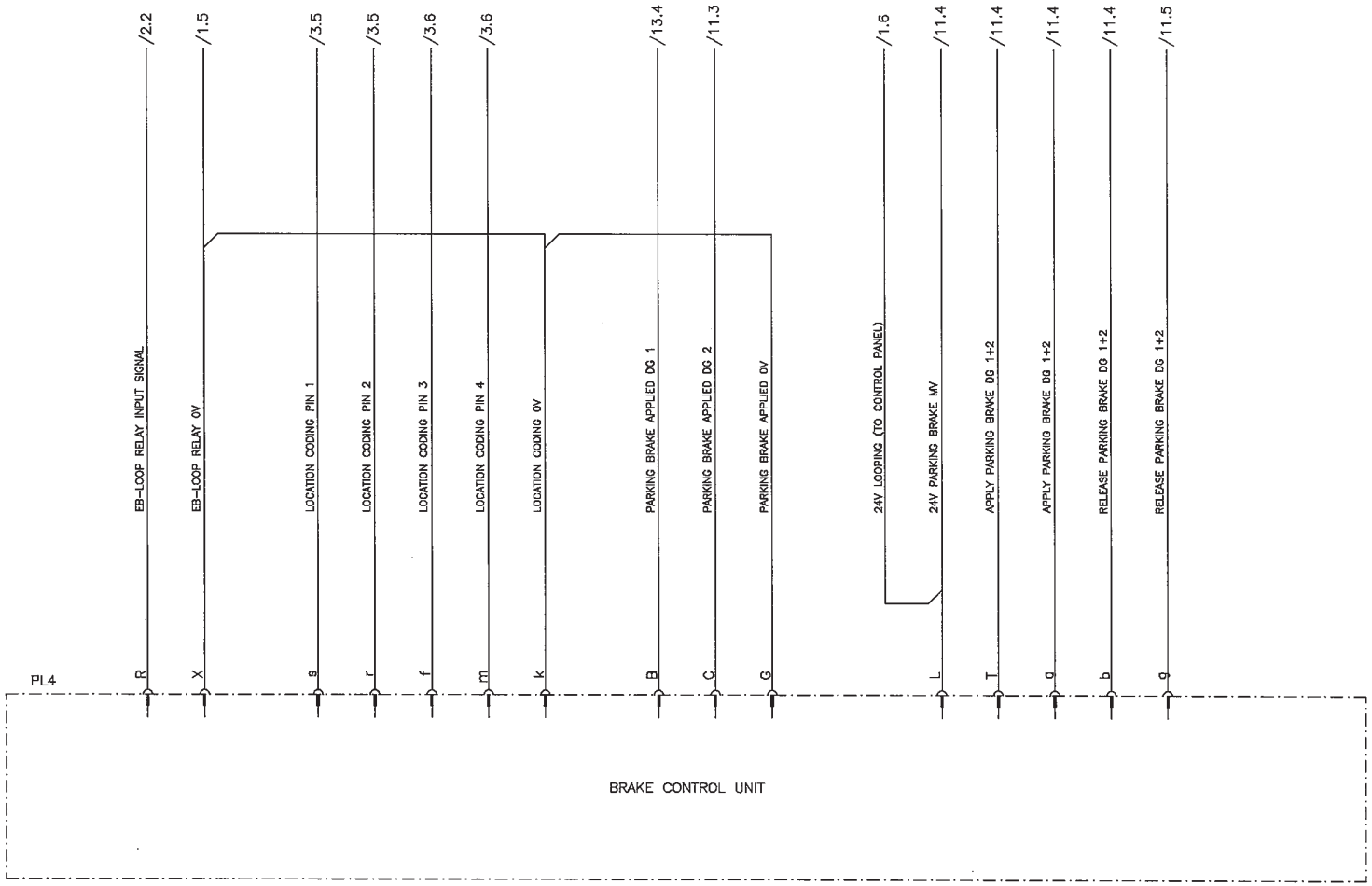
A	NEW RELEASE	28OCT14	DFQ			Electronics Repair Centre Dept.		PLUG PL3	Release
Rev.	Remark	Date	Name					Wiring Diagram	Date

1	2	3	4	5	6	7	8
	EB–LOOP RELAY	LOCATION CODING		PARKING BRAKE CONTROLS			



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				Drawn	Dzulfaqar	ERL Maintenances Support Sdn. Bhd.		BRAKE CONTROL CIRCUIT		
A	NEW RELEASE	28OCT14	DFQ			Electronics Repair Centre Dept.		PLUG PL4	Release	Page 7
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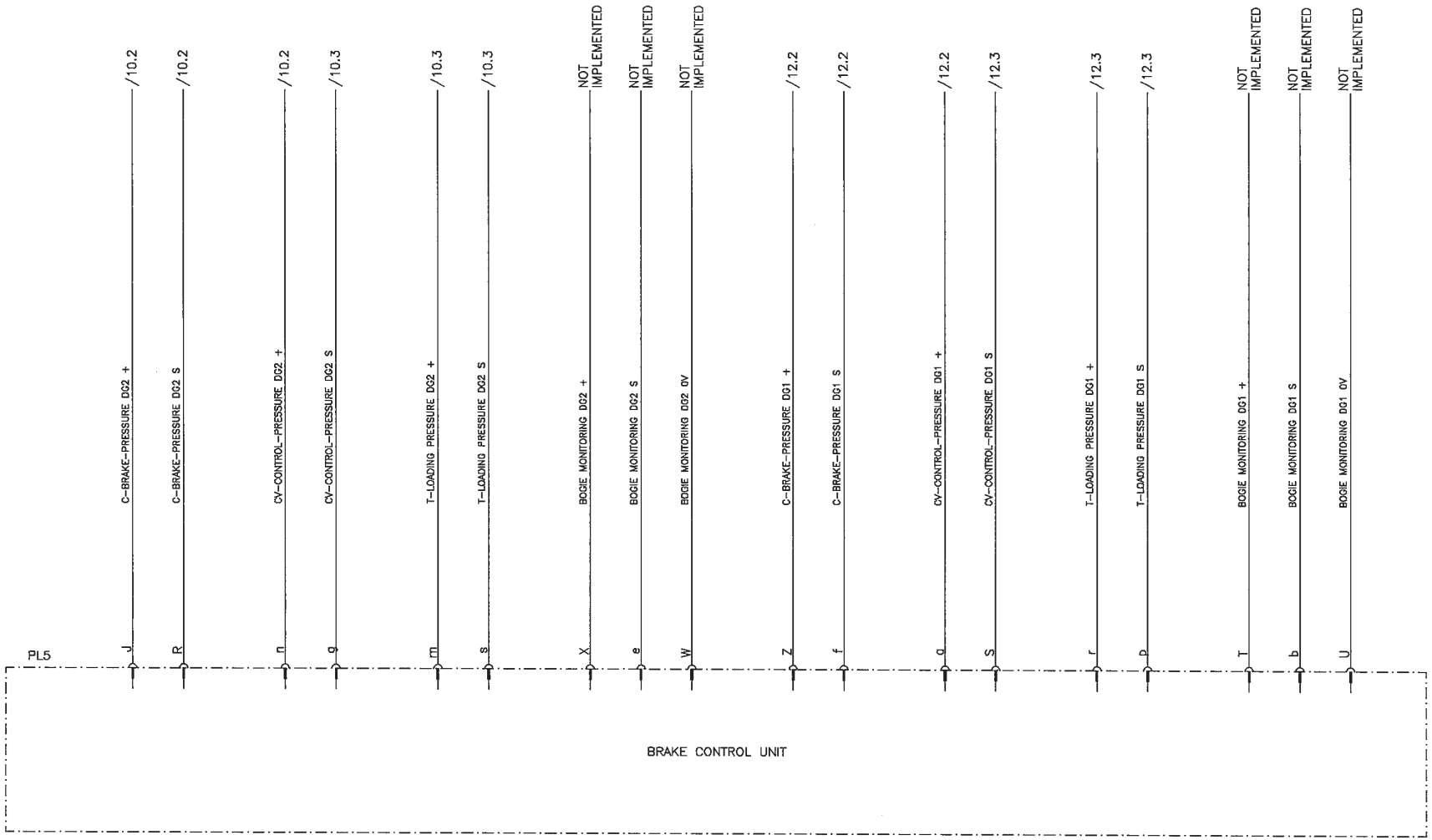
1	2	3	4	5	6	7	8
	C–BRAKE–PRESSURE	T–LOADING PRESSURE		C–BRAKE–PRESSURE	SPEED SENSOR 2	T–LOADING PRESSURE	
	CV–CONTROL–PRESSURE	MONITORING BOGIE 2		CV–CONTROL–PRESSURE		MONITORING BOGIE 1	



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A	NEW RELEASE	28OCT14	DFQ			Electronics Repair Centre Dept.		PLUG PL5	Release	Page 8
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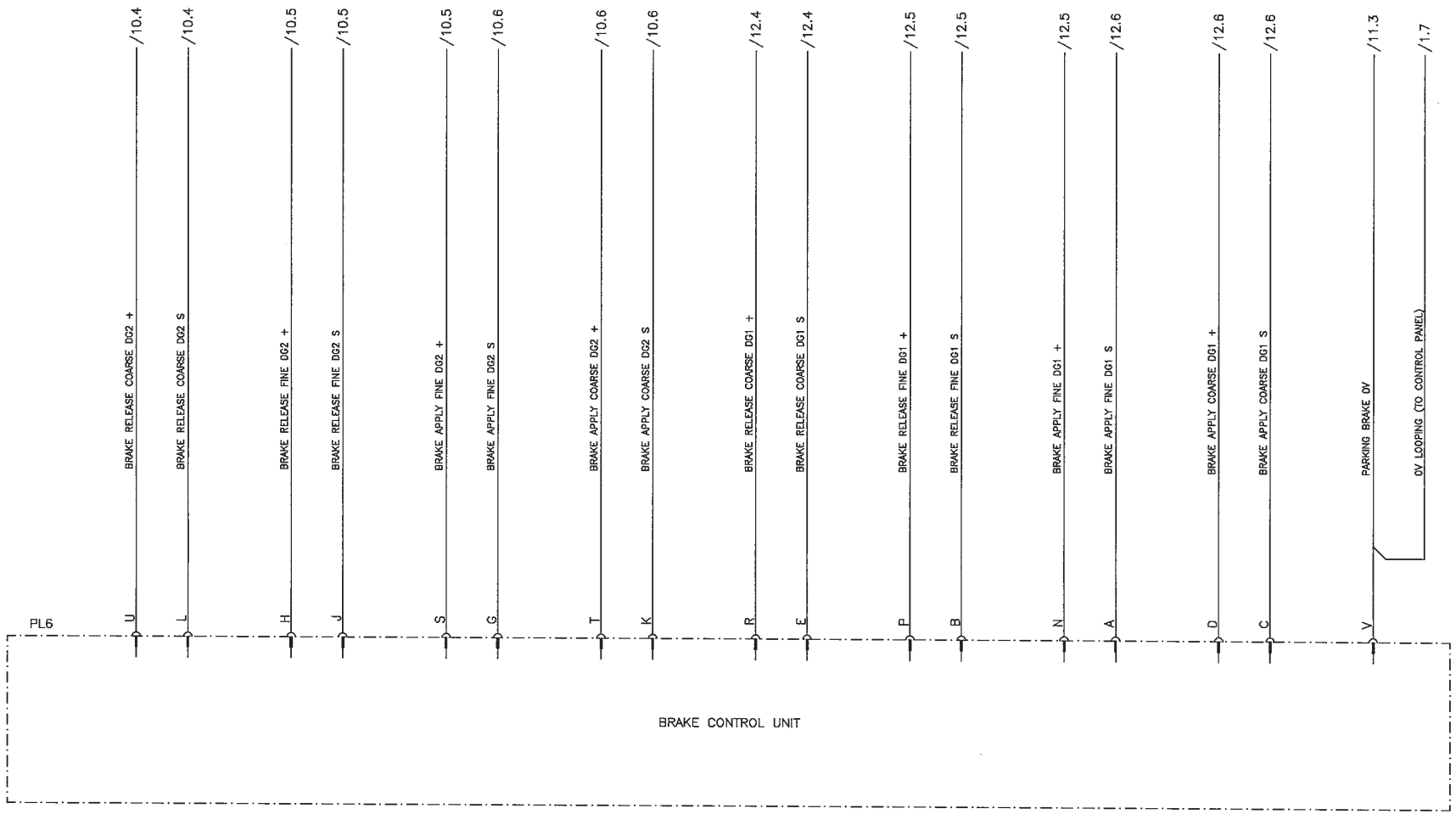
1	2	3	4	5	6	7	8
	BRAKE RELEASE COARSE DG2	BRAKE APPLY FINE DG2		BRAKE RELEASE COARSE DG1	BRAKE APPLY FINE DG1		PARKING BRAKE 0V
	BRAKE RELEASE FINE DG2		BRAKE APPLY COARSE DG2		BRAKE RELEASE FINE DG1		BRAKE APPLY COARSE DG1



				Date	28 OCT 2014	TRAIN BRAKE SYSTEM TEST BENCH	E-MAS	TEST BENCH
				Drawn	Dzulfaqar	ERL Maintenances Support Sdn. Bhd.		BRAKE CONTROL CIRCUIT
A	NEW RELEASE	28OCT14	DFQ			Electronics Repair Centre Dept.		PLUG PL6
Rev.	Remark	Date	Name					Wiring Diagram

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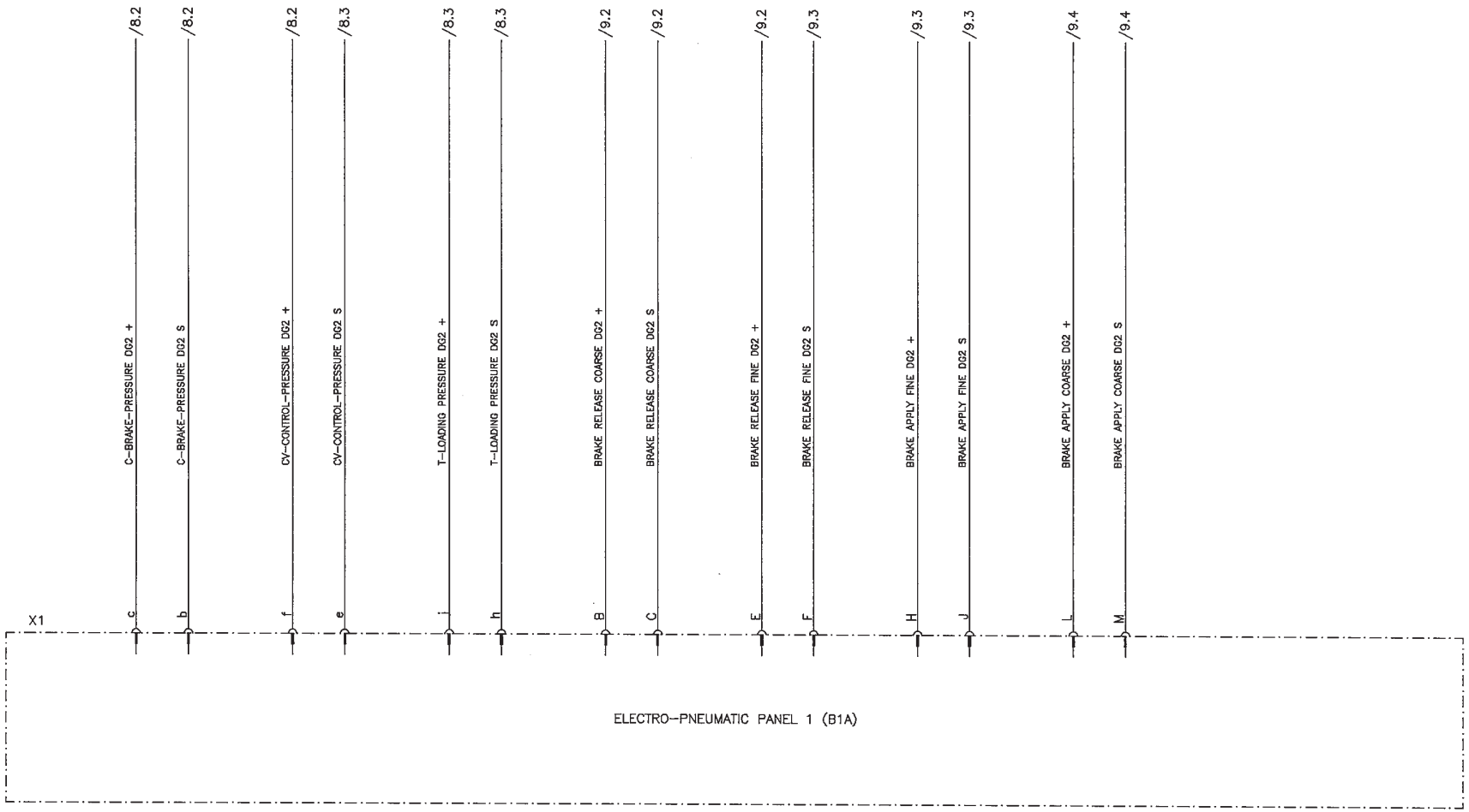
1	2	3	4	5	6	7	8
	C–BRAKE–PRESSURE	T–LOADING PRESSURE		BRAKE RELEASE FINE DG2	BRAKE APPLY COARSE DG2		
	CV–CONTROL–PRESSURE	BRAKE RELEASE COARSE DG2		BRAKE APPLY FINE DG2			



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				Drawn	Dzulfaqar	ERL Maintenances Support Sdn. Bhd.		EP PANEL B1A	
A	NEW RELEASE	28OCT14	DFQ			Electronics Repair Centre Dept.		PLUG X1	Release
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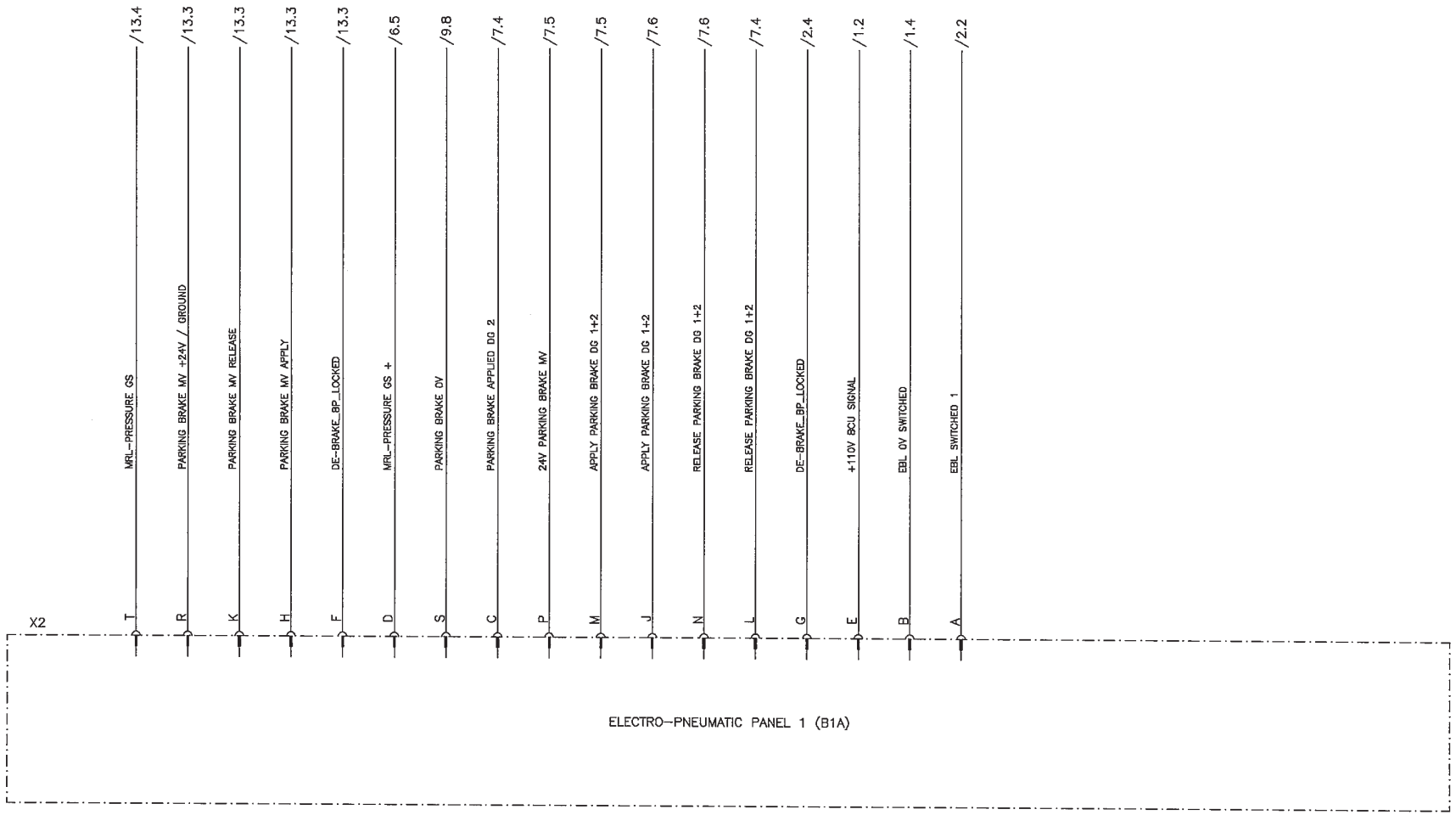
1	2	3	4	5	6	7	8

EP PANEL CONTROLS



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A	NEW RELEASE	28OCT14	DFQ			Electronics Repair Centre Dept.		PLUG X2
Rev.	Remark	Date	Name					Wiring Diagram

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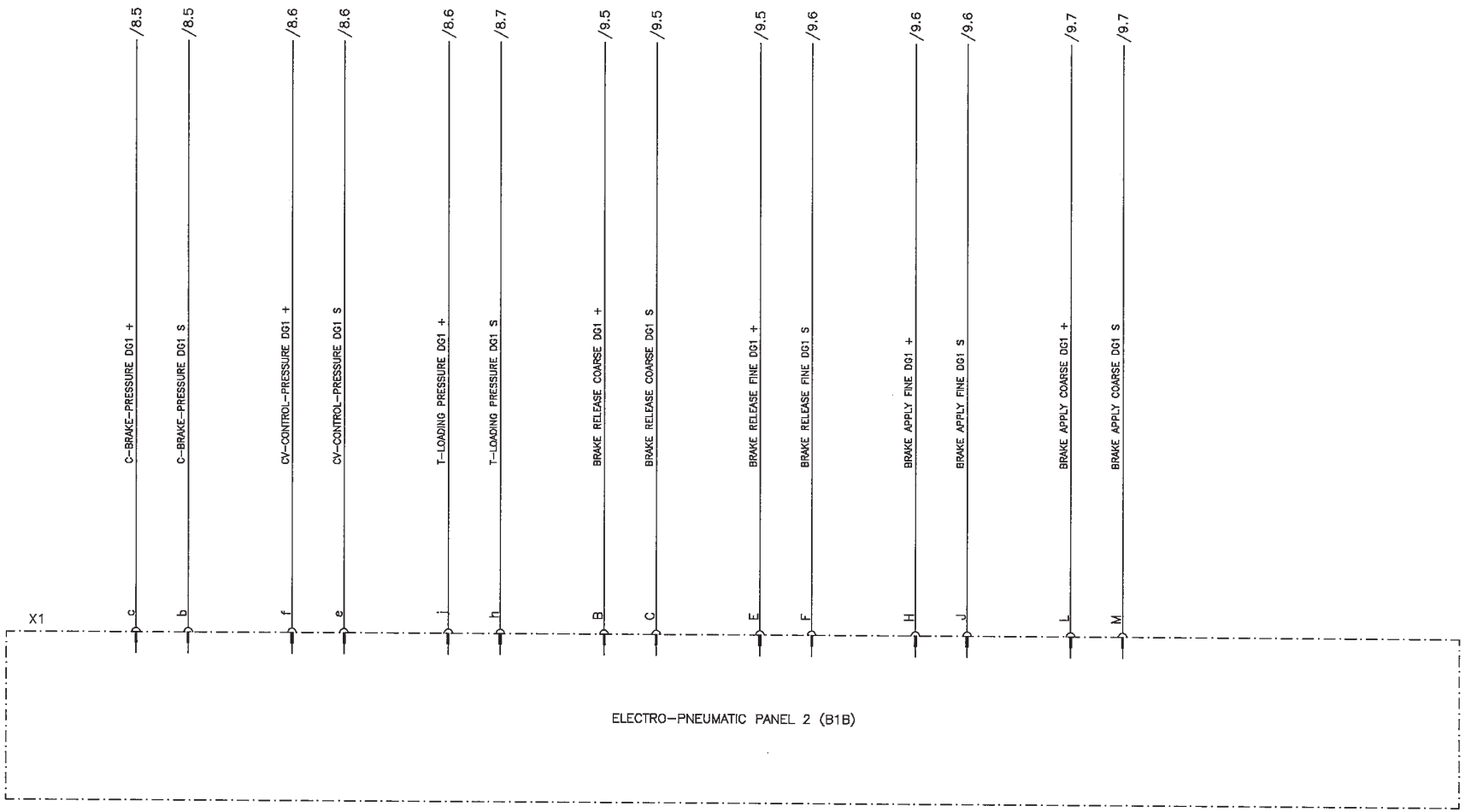
Date	

1	2	3	4	5	6	7	8
	C–BRAKE–PRESSURE	T–LOADING PRESSURE		BRAKE RELEASE FINE DG1	BRAKE APPLY COARSE DG1		
	CV–CONTROL–PRESSURE		BRAKE RELEASE COARSE DG1		BRAKE APPLY FINE DG1		



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A	NEW RELEASE	28OCT14	DFQ			Electronics Repair Centre Dept.	
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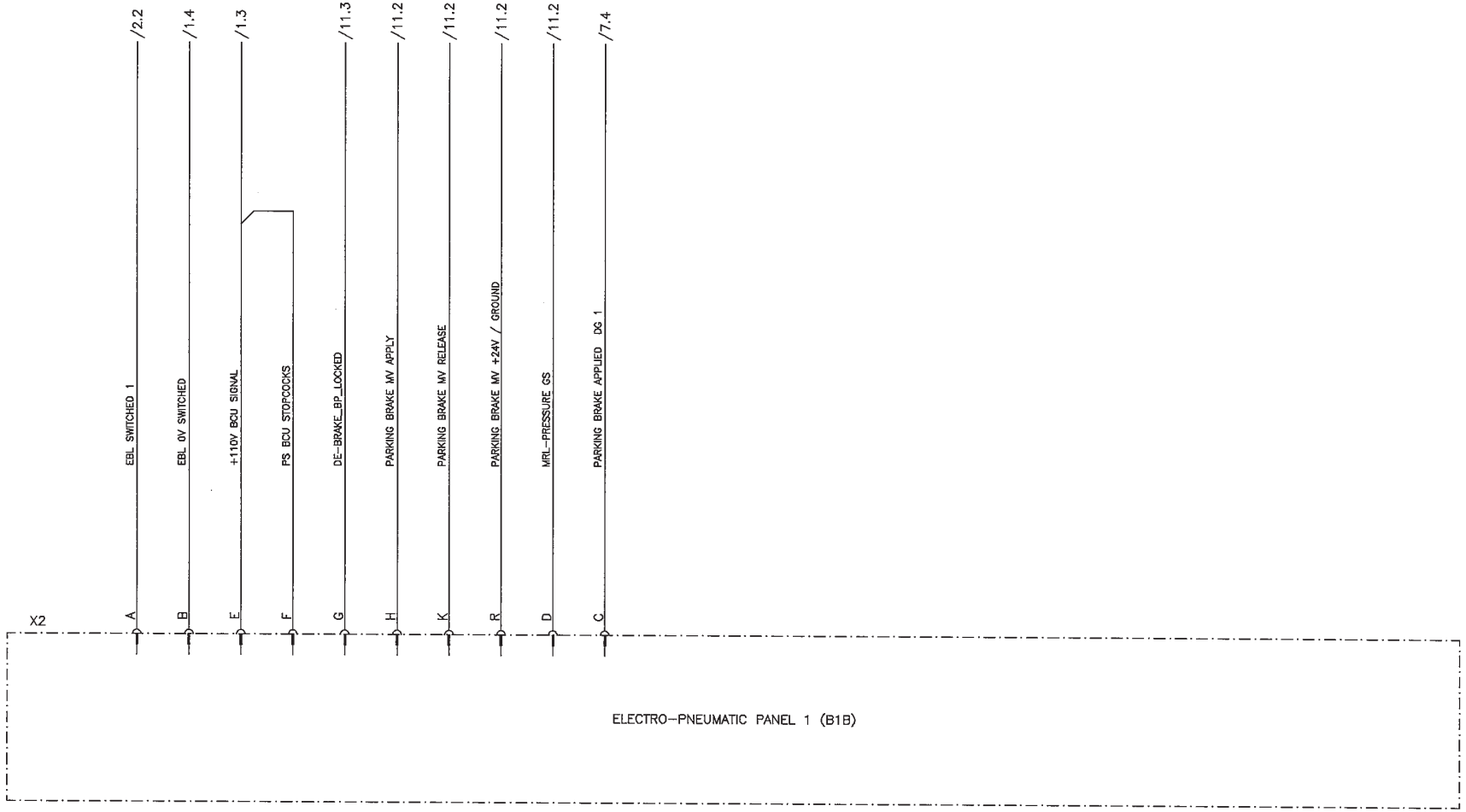
TEST BENCH EP PANEL B1B PLUG X1 Wiring Diagram	Doc. No: G00.OMN.M01000.YW.1001.A	
	Release	Page 12
	Date	14 Sheets

1	2	3	4	5	6	7	8

EP PANEL CONTROLS



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A	NEW RELEASE	28OCT14	DFQ

Date	28 OCT 2014
Drawn	Dzulfaqar

TRAIN BRAKE SYSTEM TEST BENCH
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Electronics Repair Centre Dept.

E-MAS

TEST BENCH
EP PANEL B1B
PLUG X2
Wiring Diagram

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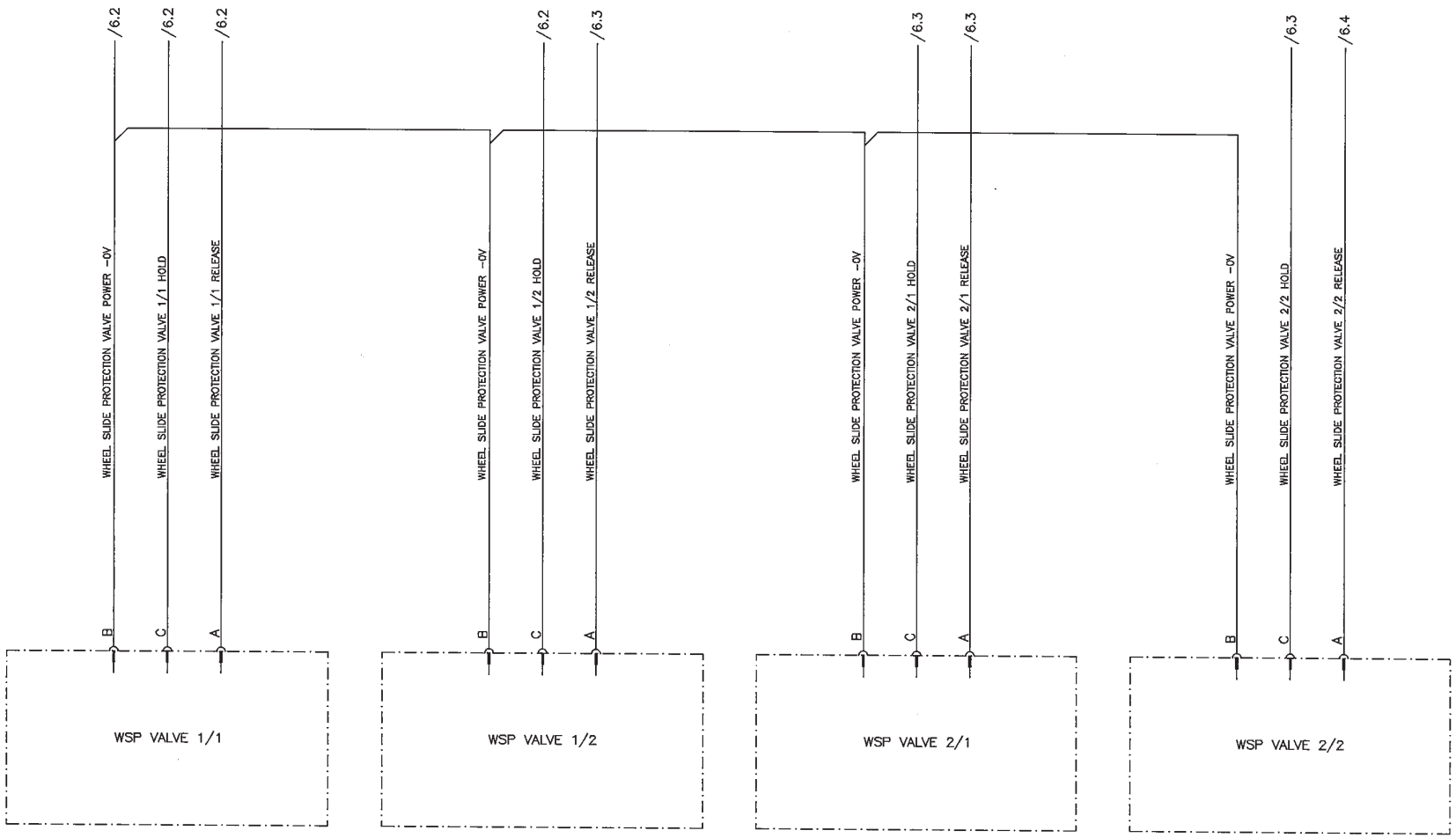
Release		
Date		

1	2	3	4	5	6	7	8
	WSP VALVE 1/1		WSP VALVE 1/2		WSP VALVE 2/1		WSP VALVE 2/2



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A	NEW RELEASE	28OCT14	DFQ		
Rev.	Remark	Date	Name		

TRAIN BRAKE SYSTEM TEST BENCH
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E-MAS

TEST BENCH
WHEEL SLIDE PROTECTION VALVES CONTROL
Wiring Diagram

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