LUMINATOR TECHNOLOGY GROUP

C525 – Berlin BVG 2020

Electroacoustic Loudspeaker System

System Functional Description (SFD)

LUMINATOR TECHNOLOGY GROUP

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REVISION HISTORY

Revision	Date	Author	Description
A	2022-12-14	Daniel Hall	First Official Release
B	2023-01-12	Daniel Hall	• Formatting Corrections • 4.2.1.7.1: Added turn of 'Station' rotary switch to 'Speak' to accept PCU call • 4.2.1.7.1: Figure 27 updated • 4.2.1.7.1: Added operation modes • 2.2.1.3: Corrected Block diagram • 4.2.1 Added VoIP format • 4.2.3 Updated Fallback mode description to include UIC description • 4.2.4 Updated Tow mode to clarify operation. • 4.2.5 Removed audio priority configuration • 4.2.8 Removed audio priority configuration • Added Test Mode Section (4.2.5) • 4.3.2 Added Diagnostic event table • Added Section 5 Software Configuration Item Summary • 4.2.1.9 Departure tone section updated to include 2 tones. • All Component Descriptions updated
C	2023-01-25	Daniel Hall	• Figure 26 PCU locations corrected • Figure 3,4 and 5: Added FBU to WGT1 car • Section 3.2.8 TRSPK section corrected • Grammatical corrections • Section 1.1 corrected transit authority • Section 2.2.1.1: Corrected departure tone to 2 types of tone • Section 4.2.1.9 Added information to departure tones • Section 2.2.1.2: Corrected FEU count in BOM • Section 3.2.4: Update HS dimensions • Section 3.2.5: Updated FEU Weight, Dimensions and 3D drawing • Section 3.2.6: Updated PCU Weight, Drawing and IP rating • Section 3.2.7: Updated CSPK Drawing and weight. • Section 3.2.8: Updated TRSPK Weight, IP rating and drawing. • Section 3.2.9: Updated IP rating. • Section 3.2.10: EXT-SPK-V3 updated interface • Section 3.2.11 EXT-SPK V4 updated electrical and audio characteristics, material and operating temperature. • Section 3.2.12 LICH: Updated weight. • Added New section: 4.2.5 Multiple Unit Operation • Updated Figures 3, 4, 7 and 8 for multiple unit operation
D	2023-05-15	Daniel Hall	• Section 2.2.1.1: Added Special Announcements • Section 4.2.1.2 Added PA-INT/EXT is not to be played over EXT-SPK-V4 • Section 3.2.11: Added EXT-SPK-V4 only for Special Announcements • New Section 4.2.6 Special Announcements

			• Figures 4, 5 and 7 Ethernet backbone updated • New Section 2.3.1.1 IP Address List • New Section 4.3.1.3 Ports and Sockets • Section 3.2.1: CCU+ added change to eMMc memory size • CCU+ Table 6: Added Aluminum Cover Finish • AAC Table 9: Added Aluminum Cover Finish • GM Table 12: Added Harness Length 600mm • GM Table 13: Added NC3MXX Connector • CSPK Table 22: Amended width 135.25mm and depth 40.6mm • TRSPK Table 24: Amended Width 135.25 and depth 36.25 • SSPK Table 27: Added Gasket 0.8mm • EXT-SPK-V4 Table 30: Added depth 49.3mm • Section 4.2.1.6 and Figure 26 IC Function modified • Section 4.2.1.7.1 and Figure 28 PCU Call request modified • Section 4.2.8 Audio Priorities modified • Section 4.2.1.8 Automated announcements updated • Section 3.2.6 PCU: Added passenger facing LED color description to function
E	2023/06/01	Daniel Hall	• Section 4.3.1.1 Updated IP List • Section 2.3.1.1 Updated IP List • Section 4.2.1.2 Correction to Information • Section 4.2.1.4 Corrected section title • Section 4.2.1.6Corrected IC operation and flow diagram • Section 4.2.1.71. Added SIP
F	2024/01/05	Daniel Hall	• Table 6 CCU+: Audio Amplifier: Electrical characteristics updated
G	2024/05/07	Daniel Hall	• Table 31 EXT-SPK-V4 Interfaces updated to reflect new connector for CO#1 • Figure 19 EXT-SPK-V4 Image updated to reflect new connector for CO#1 • Section 2.2.1.1 Electroacoustic Audio System Overview updated to match CO#5 • Section 4.2.6 Special Announcement updated to match CO#5 • Section 4.2.1.7.2 Updated to include CO#3 TCMS activation of Emergency alarm

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1 Introduction

1.1 Purpose

This document presents the system technical description of the Electroacoustic Loudspeaker System for the C525 Berlin BVG2020 project.

It is submitted to fulfil the following requirements:

- Transit Authority: Berliner Verkehrsbetriebe (BVG)
- Car Builder: Alstom
  - Alstom: Requirements CbC RevD 2022/10/17
- Standards:
  - IEEE,1558-2004, Standard for Software Documentation for Rail Equipment and Systems
  - EN50657:2017, Railways Applications - Rolling stock applications - Software on Board Rolling Stock, ref.
  - EN50125-1 Railway applications – Environmental conditions for equipment – Part1: Rolling stock and on-board equipment.
  - EN50121-3-2:2016+A1:2019 Railway Applications – Electromagnetic Compatibility
  - EN50155:2017 Railway Applications – Rolling Stock – Electronic Equipment
  - EN 45545 Railway Applications – Fire Protection on Railway Vehicles
  - EN 60849 Sound Systems for Emergency Purposes
  - VDV 160:2002 Basic Requirements to Electrical Equipment of Light Vehicles in Metro Vehicles
  - VDV 166-3 Requirements for the Vehicle Control in Light Rail Vehicles and Metro Vehicles – Part 3 System Diagnostic Messages

1.2 Scope

The System Functional Description presented in the following pages provides a technical description of the following systems of the Passenger Information Systems:

- Electroacoustic Audio System

The current project does not implement any safety-related, safety-critical or vital functions. The scope of the current system design is limited to what is described in this document.

1.3 Definitions, Acronyms, and Abbreviations

Table 1.1: Abbreviations & Acronyms

Acronym/Abbreviation	Description
ACC	Audio Coach Controller
CCU+	Cab Control Unit +
CDRL	Contractual Documentation Requirement List
CSPK	Cab Loudspeaker
dB	Decibel
DPCU	Disabled Passenger Communication Unit

ELA	Electroacoustic Audio System
FBU	Radio Control Switch
FEU	Front End Unit
IC	Intercom
ICT	Information & Communication Technology
LICH	Line In Connector Harness
MST	Maintenance and Service Tool
OBU	On Board Unit
OCC	Operation Control Centre
OCC-PA	Operation Control Centre Public Announcement
PA	Public Announcement
PA-INT	Public Address Interior
PA-INT/EXT	Public Address Interior/Exterior
PCM	Pulse Code Modulation
PCU	Passenger Communication Unit
POST	Power-On Self-Test
PRA	Pre-Recorded Announcement
PTE	Portable Test Equipment
PTT	Push-To-Talk
SCI	Software Component Item
SFD	System Functional Description
SIP	Session Initiation Protocol
SPL	Sound Pressure Level
SSPK	Saloon Loudspeaker
TCMS	Train Control Management System
TR	Train Radio
TRDP	Train Real time Data Protocol
TRSPK	Train Radio Loudspeaker

1.4 References

The following documents are referenced within this document.

1. ***CDRL 048 3044287 Electrical Interfaces***
2. ***CDRL 037-01 3044274 Cab Control Unit+ (CCU+) Datasheet***
3. ***CDRL 037-02 3044275 Audio Coach Controller (ACC) Datasheet***
4. ***CDRL 037-04 3044283 Driver Handset (HS) Datasheet***
5. ***CDRL 037-05 3044276 Passenger Communication Unit (PCU) Datasheet***
6. ***CDRL 037-06 3044278 Cab Loudspeaker (CSPK) Datasheet***
7. ***CDRL 037-07 3044279 Train Radio Loudspeaker (TRSPK) Datasheet***
8. ***CDRL 037-08 3044280 Saloon Loudspeaker (SSPK) Datasheet***
9. ***CDRL 037-09 3044281 Ext Loudspeaker (EXT-LSPK-V3) Datasheet***
10. ***CDRL 037-10 3044282 Ext Loudspeaker (EXT-LSPK-V4) Datasheet***
11. ***CDRL 037-12 3044284 Line In Conn Harness(LICH) Datasheet***
12. ***IEC 61375-2-3 2015 Edition 1.0***

2 General

2.1 Train Configuration Overview

The project is to supply Electroacoustic Audio System for the 5 car MZ and 9 car XLZ BVG2020 tram types.

2.1.1 MZ 5 Car BVG2020

The below figure details the MZ 5 Car BVG2020 configuration

Figure 1 MZ 5 BVG2020 Car Configuration

2.1.2 XLZ 9 Car BVG2020

The below figure details the XLZ 9 Car BVG2020 configuration

Figure 2 XLZ 9 BVG2020 Car Configuration

2.1.3 MZ 5 Car – Coupled

The MZ 5 Car units may operate in a coupled consist. The consist may contain a maximum of 2 MZ 5 car units.

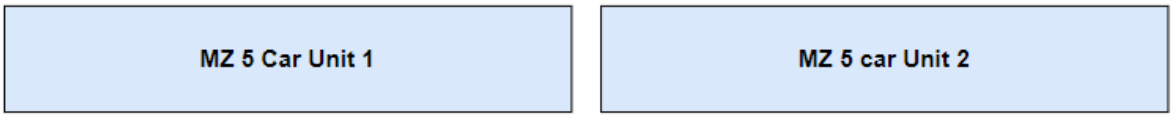

Figure 3 MZ 5 Car Coupled

2.2 System Functionality Overview

The Electroacoustic Loudspeaker System (ELA) provides an integrated solution for audio information broadcast over the train. This system does not implement safety related functionality and/or vital functions.

2.2.1 Electroacoustic Audio System (ELA)

2.2.1.1 Electroacoustic Audio System Overview

The ELA provides the following functionalities:

- Driver Public Announcement to Internal Loudspeakers (PA-INT).
- Driver Public Announcement to Internal and External loudspeakers (PA-INT/EXT).
- Crew Public Announcement to Internal loudspeakers (PA-CREW), through Line In Connector Harness.
- Operational Control Centre Public Announcement to Internal Loudspeakers (PA-OCC).
- Half Duplex communication between Driver and Operational Control Centre (OCC-TR).
- Half Duplex communication between Drivers (IC).
- Half Duplex communication between Driver and Passenger Communication Units (PCU-CCU) in the following modes:
  - Passenger Call Request
  - Passenger Emergency Call.
- Broadcast of Digital Voice Announcements received from the On Board Unit (OBU) to the Interior, exterior and cab loudspeaker.
- Train Radio Panic mode, allowing for remote monitoring of the cab Gooseneck Microphone audio output through the Train Radio
- Fall-Back mode operation. In the event of software failure or network error the ELA system provides for a PA fallback mode, utilizing the UIC train lines.
- Support of coupling for Towing/Pushing of a coupled unit through providing Public Address announcement functionality to Internal and External speakers.
- Departure tone playback. Provision for the playback of 2 different departure tones as selected via TCMS.
    1. Continuous 330Hz departure tone.
    2. Alternating 1900HZ 60 ms on/ 60 ms off
- TCMS diagnostic message reporting
- Ambient noise automatic volume adjustment.
- Multiple Unit operation: The ELA system supports the coupling of 2 MZ 5 Car units.
- Special Announcements: The ELA system supports audio play back of special announcements message over EXT-SPK=V4.

2.2.1.2 PIS Bill of Material

The below tables provide the Bill of Materials for both MZ 5 Car and XLZ 9 Car Trams.

Table 2 MZ 5 Car BOM

No	LTG Part Number	Alstom Part Number	Description	Car Number				
				WGT9	WGT8	WGT5	WGT2	WGT1
1	9020060-01-01	500639759	Cab Control Unit + (CCU+)	1	0	0	0	1
2	9020020-02-02	500639760	Audio Coach Controller (ACC)	0	1	0	1	0
3	9020031-01-02	500639761	Passenger Communication Unit (PCU)	2	4	0	4	2
4	9003104	500639766	Gooseneck Microphone (GM)	1	0	0	0	1
5	9003102	500639767	Cab Loudspeaker (CSPK)	1	0	0	0	1
6	9003103	500639824	Train Radio Speaker (TRSPK)	1	0	0	0	1
7	9003101	500639765	Saloon Loudspeaker (SSPK)	3	2	2	2	3
8	9003105	500639763	External Loudspeaker V3 (EXT-SPK-V3)	2	2	0	2	2
9	9003106	500639764	External Loudspeaker V4 (EXT-SPK-V4)	2	0	0	0	2
10	9002058-002	500639752	Driver Handset (HS)	1	0	0	0	1
11	9002219	500655260	Line In Connector Harness (LICH)	1	0	1	0	1
12	9002220	500651822	Front End Unit (FEU)	1	0	0	0	1

Table 3 XLZ 9 Car BOM

No	LTG Part Number	Alstom Part Number	Description	Car Number								
				WGT9	WGT8	WGT7	WGT6	WGT5	WGT4	WGT3	WGT2	WGT1
1	9020060-01-01	500639759	Cab Control Unit + (CCU+)	1	0	0	0	0	0	0	0	1
2	9020020-02-02	500639760	Audio Coach Controller (ACC)	0	1	0	0	0	0	0	1	0
3	9020031-01-02	500639761	Passenger Communication Unit (PCU)	2	4	0	2	0	2	0	4	2
4	9003104	500639766	Gooseneck Microphone (GM)	1	0	0	0	0	0	0	0	1
5	9003102	500639767	Cab Loudspeaker (CSPK)	1	0	0	0	0	0	0	0	1
6	9003103	500639824	Train Radio Speaker (TRSPK)	1	0	0	0	0	0	0	0	1
7	9003101	500639765	Saloon Loudspeaker (SSPK)	3	2	2	2	2	2	2	2	3
8	9003105	500639763	External Loudspeaker V3 (EXT-SPK-V3)	2	2	0	2	0	2	0	2	2
9	9003106	500639764	External Loudspeaker V4 (EXT-SPK-V4)	2	0	0	0	0	0	0	0	2
10	9002058-002	500639752	Driver Handset (HS)	1	0	0	0	0	0	0	0	1
11	9002219	500655260	Line In Connector Harness (LICH)	1	0	0	0	1	0	0	0	1
12	9002220	500651822	Front End Unit (FEU)	1	0	0	0	0	0	0	0	1

2.2.1.3 ELA Block Diagram

The below figures provide a block diagram of both the MZ 5 Car and XLZ 9 Car Trams.

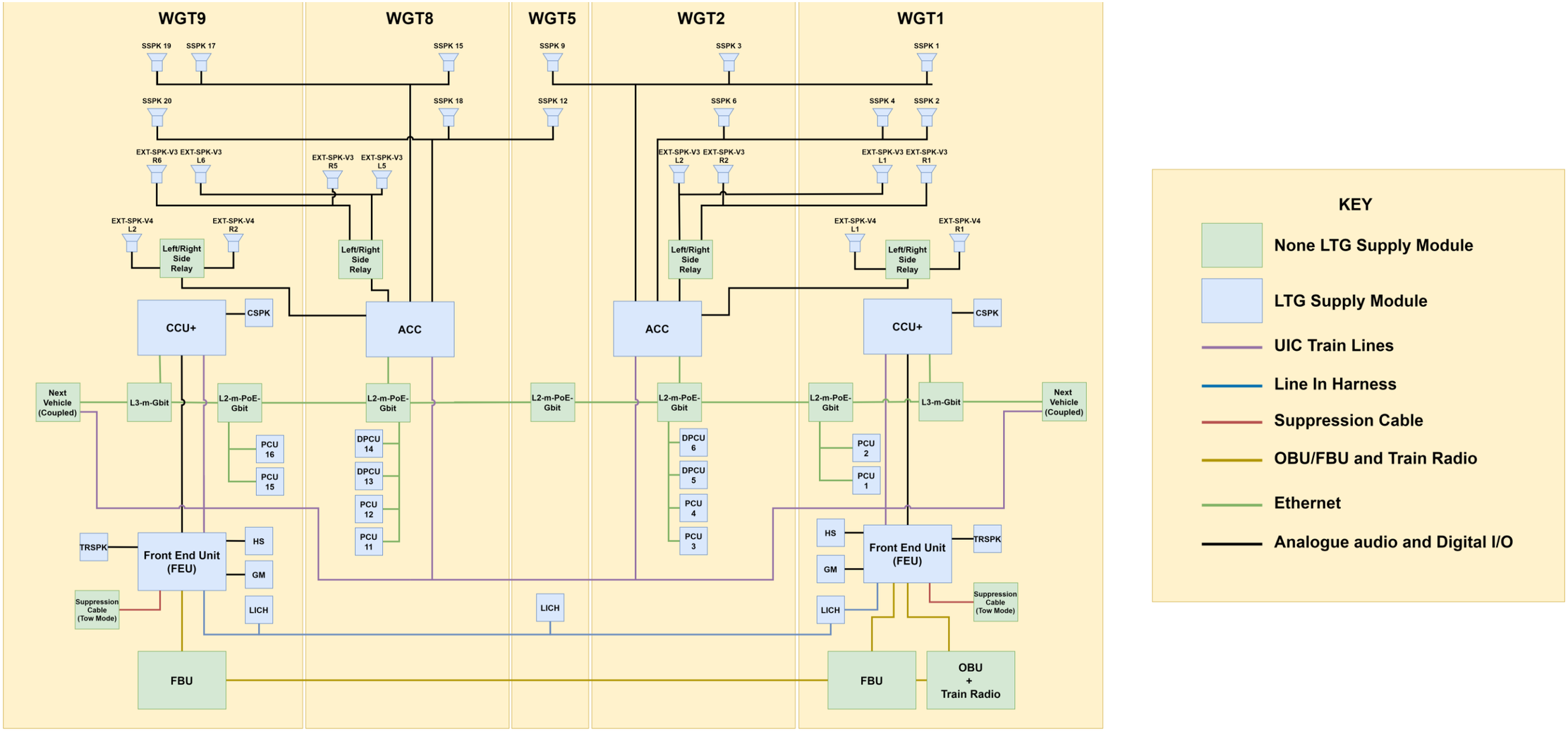

Figure 4 MZ 5 Car Block Diagram

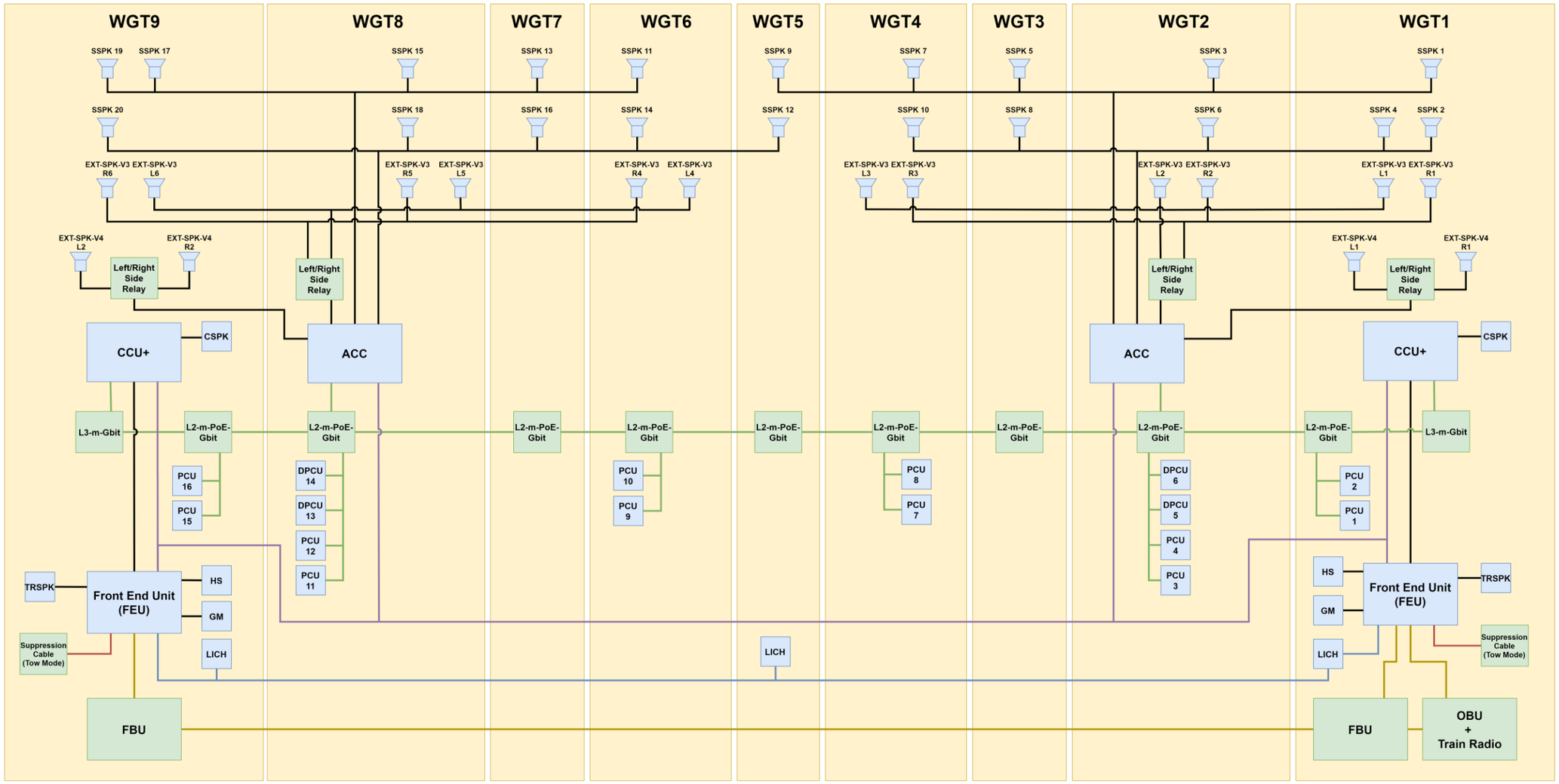

Figure 5 XLZ 9 Car Block Diagram

2.2.1.4 Train Radio Block Diagram

The below block diagram illustrates the distribution of the audio and control information from the Train Radio to the ELA system. The train is installed with a single Train Radio located in WGT1 car and integrated into the On Board Unit (OBU) (Not LTG Supply). The OBU utilizes an audio and control bus to forward Train Radio audio and control information between the ELA system via the FBU modules located in the WGT1 and WGT 9 cars. Thus the train radio interface directly to the ELA is the FBU modules.

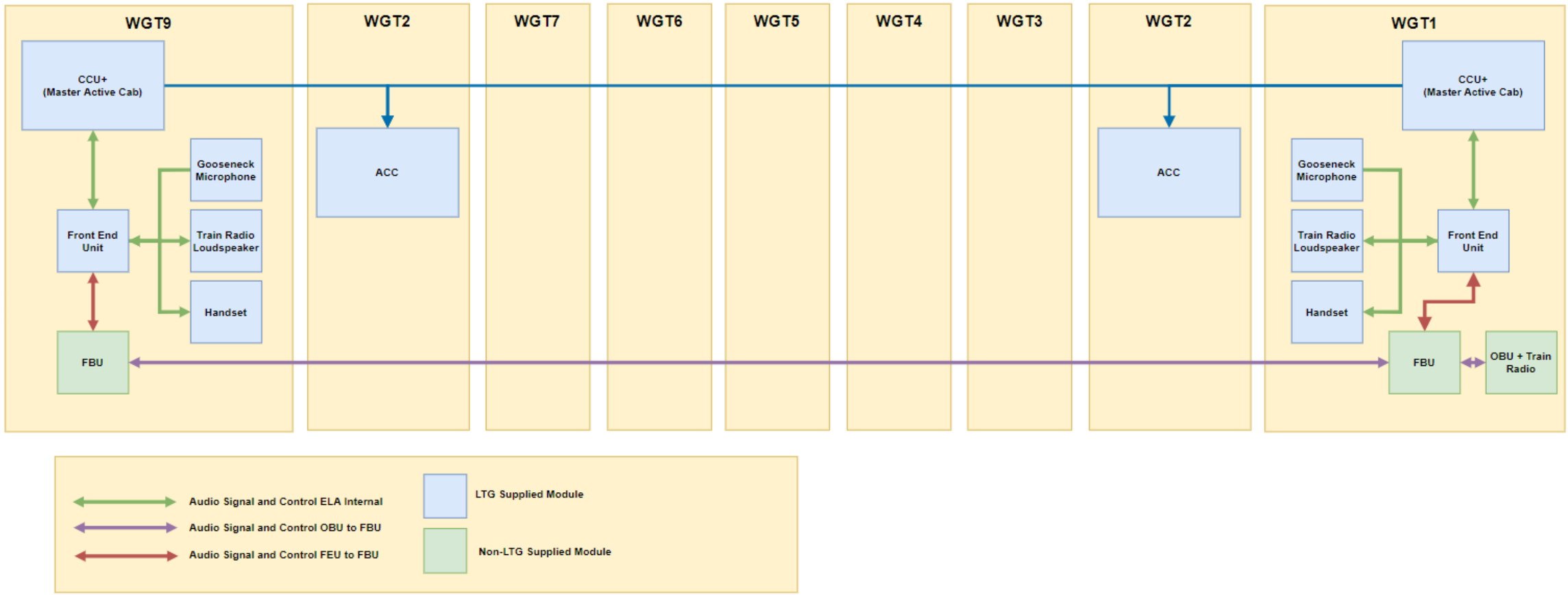

Figure 6 Train Radio Block Diagram

2.3 Information and Communication Technology (ICT) Block Diagram

2.3.1 Ethernet Messaging

The below diagram provides the ELA block diagram for Ethernet messaging. The ELA system will utilize the train network (Not LTG Supply) to implement Train Real time Data Protocol messaging (TRDP) for the distribution of audio through Voice over Internet Protocol (VoIP). Status and control messaging between modules will also be sent over TRDP. The central point of communication between the ELA and the Train Control Management System (TCMS) will be the CCU+ in the active cab (Master CCU+). If no cab is active then the master CCU+ will default to the WGT 9 car.

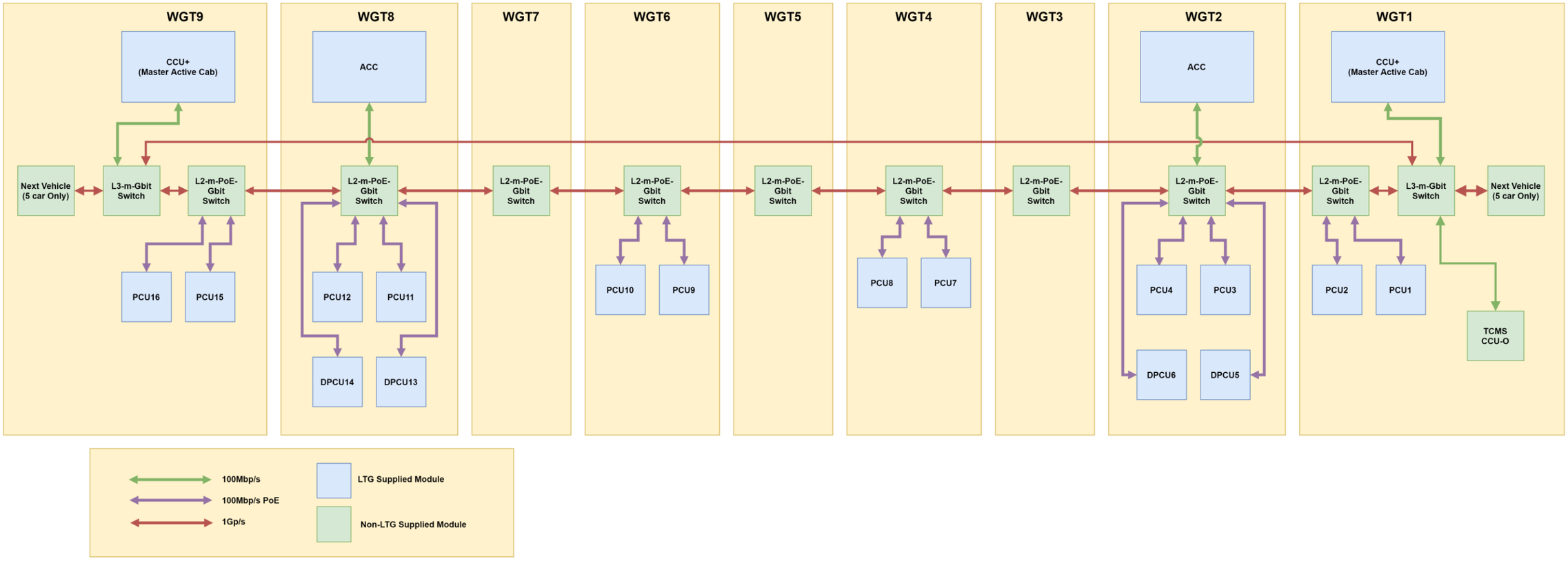

Figure 7 Ethernet Block Diagram

2.3.1.1 IP Addressing

The following table contains the IP address, switch and port details for all equipment

Table 4 IP Address, Switch and Port Details

Car	Device	IP	Switch	Port
WGT1	CCU+	192.168.10.110	L3-m-Gbit	X5
	PCU B6	192.168.10.103	L2-m-PoE-Gbit	X7
	PCU A1	192.168.10.92	L2-m-PoE-Gbit	X8
	CCUO1	10.0.0.16	TBC	TBC
	CCUO2	10.0.0.18	TBC	TBC

	Coupler	N/A	L3-m-Gbit	X9
WGT2	ACC	192.168.10.90	L2-m-PoE-Gbit	X10
	PCU A2	192.168.10.93	L2-m-PoE-Gbit	X7
	PCU B5	192.168.10.102	L2-m-PoE-Gbit	X8
	DPCU A2	192.168.10.104	L2-m-PoE-Gbit	X1
	DPCU B5	192.168.10.108	L2-m-PoE-Gbit	X2
WGT4	PCU B4	192.168.10.101	L2-m-PoE-Gbit	X7
	PCU A3	192.168.10.94	L2-m-PoE-Gbit	X8
WGT6	PCU A4	192.168.10.95	L2-m-PoE-Gbit	X7
	PCU B3	192.168.10.100	L2-m-PoE-Gbit	X8
WGT8	ACC	192.168.10.91	L2-m-PoE-Gbit	X10
	PCU B2	192.168.10.99	L2-m-PoE-Gbit	X7
	PCU A5	192.168.10.96	L2-m-PoE-Gbit	X8
	DPCU B2	192.168.10.106	L2-m-PoE-Gbit	X1
	DPCU A4	192.168.10.105	L2-m-PoE-Gbit	X2
WGT9	CCU+	192.168.10.111	L3-m-Gbit	X5
	PCU A6	192.168.10.97	L2-m-PoE-Gbit	X7
	PCU B1	192.168.10.98	L2-m-PoE-Gbit	X8
	Coupler	N/A	L3-m-Gbit	X9

2.3.2 UIC Trainline

The below block diagram details the ELA system connectivity using the UIC trainlines. The UIC train lines are utilized in the event of a fallback mode activation.

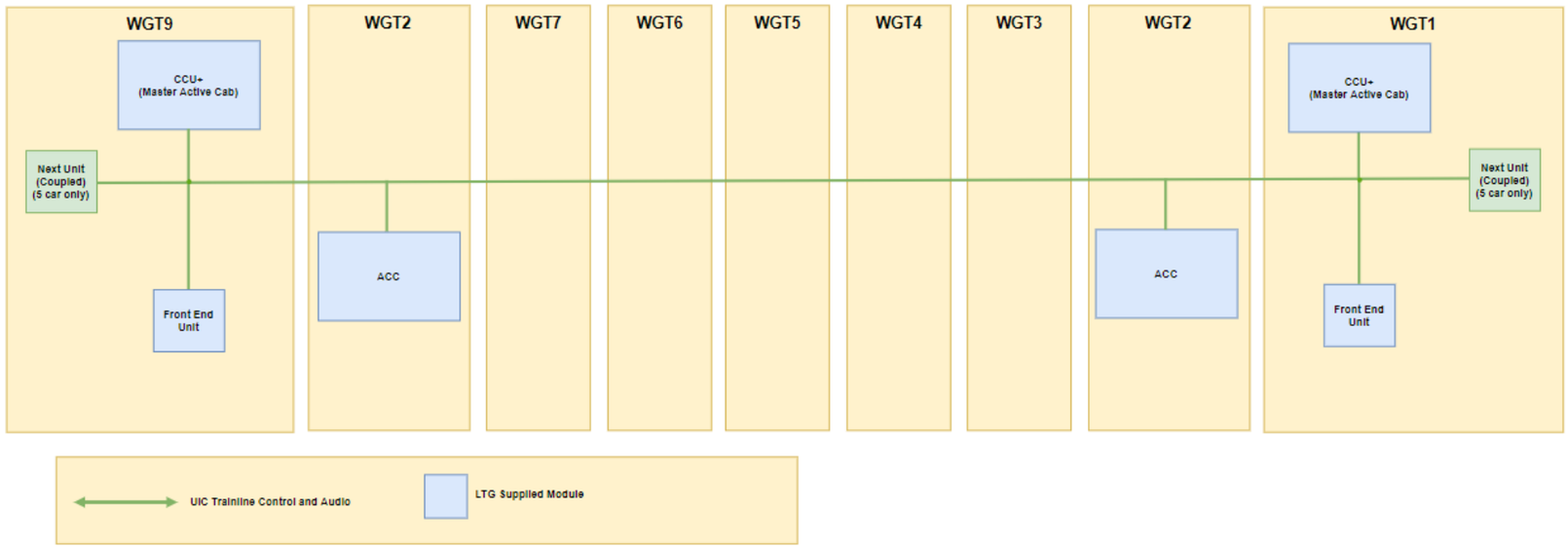

Figure 8 UIC Trainline Block diagram

2.4 Interfaces

The below table details all ELA interfaces with external sub systems. For further details in each instance please refer to the device and connector ID in referenced document ***CDRL 048 3044287 Electrical Interfaces***.

Table 5 ELA Sub System Interfaces

No	ELA Device	Sub System	ID	Description
1	FEU	OBU and Cab Controls	X6	Digital and Analogue inputs from the On Board Unit (OBU) to the Front End Unit (FEU). Provides automatic digital announcement distribution from the OBU to the ELA
2	FEU	Train Radio	X7	Digital and Analogue Input and Output between Front End Unit (FEU) and Train Radio. Line in Connector Harness input for ancillary microphone
3	FEU	Legacy Trainlines	X2	Digital and Analogue Input and Output between FEU and coupled legacy Tram. Provides necessary signaling to provide internal and external speaker Public Address announcements when in Tow mode
4	FEU	UIC Train Lines	X3	100Vpp Max FEU interface to UIC train lines for audio functionality in the event of ethernet failure
5	CCU+	UIC Train Lines	X2	CCU+ interface to UIC train lines for audio functionality in the event of ethernet failure
6	CCU+	100Mbs Ethernet	X7	See **Section 4.11.3** Supported Protocols.
7	ACC	UIC Train Lines	X4	ACC interface to UIC train lines for audio functionality in the event of ethernet failure
8	ACC	100Mbs Ethernet	X7	See **Section 4.11.3** Supported Protocols.
9	PCU	100Mbs Ethernet	X2	See **Section 4.11.3** Supported Protocols.
10	PCU	Ancillary Device input	X1	Provides digital Input for secondary PCU alarm activation device. i.e. emergency handle.
11	PCU	Activation Output	X3	Digital output to TCMS for PCU activation

3 Equipment Description

3.1 List of LRUs

Refer to Appendix A

3.2 PIS Equipment Description

3.2.1 Cab Control Unit + (CCU+)

Figure 9 Cab Control Unit + (CCU+)

A CCU+ is fitted into each cab, where the device interfaces to the Front End Unit (FEU), UIC train lines, Cab loudspeaker and 100Mbps comfort train network. The CCU+ is the central control for all audio functionalities. The device is powered from 24Vdc, finished in a black powder coating the CCU+ has an Ingress protection rating of IP54. Several external LEDS provide status diagnosis. For further details please refer to reference 2 CDRL 037-01 3044274 Cab Control Unit+ (CCU+) Datasheet.

Table 6 CCU+ Technical Data

Parameter / feature		Description
Processing	Processor	IMX6 core, Arm cortex A9, 1Ghz
	RAM memory	4 GB of DDR3L-1866
	Storage	4GB MLC/2GB SLC eMMC for OS, APP and Critical data
Electrical	EMC	Compliant to EN50121-3-2:2016 (Complies to EN50155:2017)
	Input Voltage	Nominal Voltages: 24V, Voltage range as per EN50155 :2017

	Insulation and voltage withstand	Compliant to EN50155:2017: • Voltage withstand 500VAC or 750VDC • Insulation: >20MΩ at 500VDC
	Reverse polarity protection	Yes (Complies to EN50155:2017).
	Voltage interruptions Class	S2 as per EN50155:2017
	Supply changeover class	C1 as per EN50155:2017
	Inrush current	Limited to 5x the nominal current
	Power consumption	Typical 20 W
Environmental	Operating Temperature	Class OT4 as per EN50155 :2017, equivalent to Class TX as per 50125-1 :2014 inside a vehicle compartment: -40°C to +70°C
	Storage temperature	-40°C to +85°C.
	Shock and vibration	Compliant to EN 61373:2010 performance for Category 1 body mounted equipment. Class B. (Therefore, complies to EN50155:2017)
Fire	Fire behavior	Compliant to NFPA 130 Compliant to EN45545-2 HL2
Mechanical	Ingress Protection	IP54
	Dimensions	• Width: 225 mm • Height: 85 mm • Depth: 170 mm
	Finish	• Black powder coated steel • Aluminium Cover
	Weight	2,2 kg ± 10%
Other features	Hardwired PA Bypass	A software independent backup Manual PA and radio to PA functionality mode is available. This will provide a high integrity level for the PA functionality. In this mode PA performances are limited (No AGC available for Microphone input)
	Audio amplifier	• Maximum RMS power: 15W • Harmonic distortion: less than 1% • Minimum impedance: 4Ω

Table 7 CCU+ Interfaces

Parameter	Connector Label	Description
Power	X1	One 3-Pin Male Phoenix connector for input power.24V
Analog UIC 568	X2	One 9-Pin Male D-sub connector for UIC 568.
Handset interface	X3	One 9-Pin Female D-Sub connector, Interface to FEU (Handset Interface)
Gooseneck Microphone	X4	One 15-Pin Female D-Sub connector Interface to FEU (Gooseneck Interface)
Radio Interface	X5	One 25-Pin Male D-Sub connector Interface to FEU (Train Radio and Cab Loudspeaker))
USB	X6	One Female USB A connector
Ethernet	X7	One 4-Pin Female M12 D-coded connectors for Ethernet 10/100Mbps
Pushbuttons and Indicators	X8	One 25-Pin Female D-Sub connector, Digital IO and IO power supply (24V)

Table 8 CCU+ LED Status Indicators

Indicator	Description
Power	• LED lights up Green when power is connected • LED is OFF otherwise
X7 Status	• LED lights up Yellow when it is a 100Mbps link and there is no activity. • LED flashes Yellow when it is a 100Mbps link and there is activity. • LED lights up Green when it is a 10Mbps link and there is no activity. • LED flashes Green when it is a 10Mbps link and there is activity. • LED is OFF when link is down
Status	• LED lights Green when there is a system fault (e.g. configuration fault) • LED flashes Green when software application is running and there is no fault detected on the system. • LED is OFF when software application is not running.

3.2.2 Audio Coach Controller (ACC)

Figure 10 Audio Coach Controller (ACC)

The Audio Coach Controller (ACC) provides amplification of audio information before distribution to the External and Internal Loudspeakers. The ACC features 4 independent audio amplifiers powered from 2 power supplies, providing increased redundancy and control. The device is powered from 24Vdc, finished in a black powder coating. Several external LEDS provide status diagnosis. For further details please refer to reference 3 CDRL 037-02 3044275 Audio Coach Controller (ACC) Datasheet

.

Table 9 ACC Technical Data

Parameter / feature		Description
Processing	Processor	IMX6 core, Arm cortex A9, 1Ghz
	RAM memory	2 GB of DDR3L-1866
	Storage	4 GB MLC/2GB SLC eMMC for OS, APP and Critical data
Electrical	EMC	Compliant to EN50121-3-2:2016 (Complies to EN50155:2017)
	Input Voltage	Nominal Voltages: 24V, Voltage range as per EN50155 :2017

	Insulation and voltage withstand	Compliant to EN50155:2017: • Voltage withstand 500VAC or 750VDC • Insulation: >20MΩ at 500VDC
	Reverse polarity protection	Yes (Complies to EN50155:2017).
	Voltage interruptions Class	S2 as per EN50155:2017
	Supply changeover class	C1 as per EN50155:2017
	Inrush current	Limited to 5x the nominal current
	Power consumption	Typical 40 W
Environmental	Operating Temperature	Class OT4 as per EN50155 :2017, equivalent to Class TX as per 50125-1 :2014 inside a vehicle compartment: -40°C to +70°C
	Storage temperature	-40°C to +85°C.
	Shock and vibration	Compliant to EN 61373:2010 performance for Category 1 body mounted equipment. Class B. (Therefore, complies to EN50155:2017)
Fire	Fire behavior	Compliant to NFPA 130 Compliant to EN45545-2 HL2
Mechanical	Ingress Protection	IP54
	Dimensions	• Width: 225 mm • Height: 116.5 mm • Depth: 170 mm
	Finish	• Black powder coated steel • Aluminium Cover
	Weight	2.5 kg ± 10%
Other features	Hardwired PA Bypass	A software independent backup Manual PA and radio to PA functionality mode is available. This will provide a high integrity level for the PA functionality. In this mode PA performances are limited (No AGC available for Microphone input)
	Audio amplifier	• Maximum RMS power: 30W • Harmonic distortion: less than 0.5% • Minimum impedance: 4Ω

Table 10 ACC Interfaces

Parameter	Connector Label	Description
Power	X1	One 3-Pin Male Phoenix connector for input
Analog Interface	X2	One 15-Pin Female D-Sub connector for analog interface
RS485	X3	One 9-Pin Female D-Sub connector for RS485
Analog UIC 568	X4	One 9-Pin Male D-sub connector for UIC 568
External Microphone	X5	One 15-Pin Male D-Sub connector for an external microphone
USB	X6	One Female USB A Connector
Ethernet	X7	One 4-Pin Female M12 D-coded connectors for Ethernet 10/100Mbps
Audio Amplifiers outputs	X8	One 12-Pin Male Deutsch DT connector for four amplifier outputs

Table 11 ACC LED Status Indicators

Indicator	Description
Power 1	• LED lights up Green when power is connected • LED is OFF otherwise
Power 2	• LED lights up Green when power is connected • LED is OFF otherwise
X7 Status	• LED lights up Yellow when it is a 100Mbps link and there is no activity. • LED flashes Yellow when it is a 100Mbps link and there is activity. • LED lights up Green when it is a 10Mbps link and there is no activity. • LED flashes Green when it is a 10Mbps link and there is activity. • LED is OFF when link is down
AMP Fault 1	• LED lights up Red when there is a fault with Amplifier 1 • LED is OFF otherwise
AMP Fault 2	• LED lights up Red when there is a fault with Amplifier 2 • LED is OFF otherwise
AMP Fault 3	• LED lights up Red when there is a fault with Amplifier 3 • LED is OFF otherwise
AMP Fault 4	• LED lights up Red when there is a fault with Amplifier 4 • LED is OFF otherwise
Status	• LED lights Green when there is a system fault (e.g. configuration fault) • LED flashes Green when software application is running and there is no fault detected on the system. • LED is OFF when software application is not running.

3.2.3 Gooseneck Microphone (GM)

Figure 11 Gooseneck Microphone (GM)

The Gooseneck microphone (GM) is interfaced with the Front End Unit (FEU) and is the primary communication interface for the driver. The GM allows the driver to carry out IC, OCC-TR, PA and PCU audio functions

.

Table 12 GM Technical Data

Parameter / feature		Description
Electrical	EMC	Compliant to EN50121-3-2
Environmental	Operating Temperature	-25°C to +70°C

	Storage Temperature	-45°C to +80°C
	Shock and vibration	Compliant to EN 61373
Fire	Fire behavior	Compliant to NFPA 130 EN45545-2 HL2
Mechanical	Dimensions	• Length: 950.4 mm • Harness Length: 600mm • Base Diameter 64 mm
	Finish	Black powder coating
	Weight	1.2 Kg +/- 10%

Table 13 GM Interfaces

Parameter	Connector Label	Description
Audio	GNM	NC3MXX connector audio input to FEU

3.2.4 Driver Handset (HS)

Figure 12 Driver Handset (HS)

The Driver Handset (HS) is provided for train radio communication. Interfaced to the Front End Unit (FEU), it acts secondary to the Gooseneck Microphone (GM) during train radio communication. During an ongoing Train radio call if the HS is removed then the call is automatically transferred from the GM and Train Radio Speaker (TRSPK) to the HS. For further details please refer to reference 4 CDRL 037-04 3044283 Driver Handset (HS) Datasheet.

.

Table 14 HS Technical Data

Parameter / feature		Description
Electrical	EMC	Compliant to EN50121-2-3

Environmental	Operating Temperature	-25°C to +55°C
	Storage Temperature	-40°C to +55°C
	Shock and vibration	Compliant to EN 61373:2010 Class A Cat 1
	Ingress Protection	IP54 Back Enclosure (When Connector Mated) IP30 Handset
Fire	Fire behavior	Compliant to NFPA 130 Compliant to EN45545-2 HL2
Mechanical	Dimensions	Base Length: 211.2 mm Base Width 68.58 mm Depth 98.31 mm
	Finish	Face Plate: Aluminium Black powder coated Handset casing and Cradle: Lexan 940 Black
	Weight	0.59Kg +/- 10%

Table 15 HS Interfaces

Parameter	Connector Label	Description
Audio and PTT	HAS1	9-Pin Female D-Sub - Interface to the Front End Unit (FEU)

3.2.5 Front End Unit (FEU)

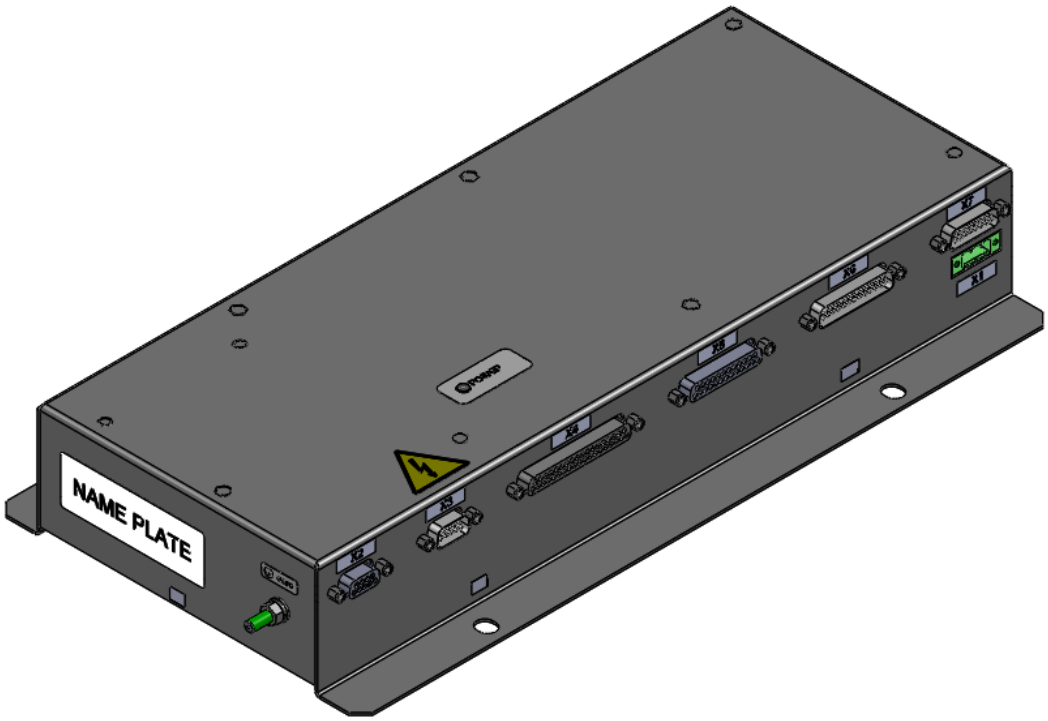

Figure 13 Front End Unit (FEU)

The Front End Unit (FEU) Interfaces the Train Radio, Legacy train lines, On Board Unit (OBU), Driver Handset, Gooseneck Microphone and Cab desk buttons to the (CCU+). The FEU interfaces directly to the Train Radio Loudspeaker (TRSPK) where OCC radio communication is output prior to the HS been lifted. For interoperability of legacy trams the FEU also interfaces directly with the legacy train lines, for PA audio distribution in Tow mode. The FEU also interfaces with the LTG supplied Line In Connector Harness, allowing for the connection of a periphery microphone for use by tram crew.

Table 16 FEU Technical Data

Parameter / feature		Description
Electrical	EMC	Compliant to EN50121-3-2:2016 (Complies to EN50155:2017)
	Input Voltage	Nominal Voltages: 24V, Voltage range as per EN50155 :2017
	Insulation and voltage withstand	Compliant to EN50155:2017: • Voltage withstand 500VAC or 750VDC • Insulation: >20MΩ at 500VDC
	Reverse polarity protection	Yes (Complies to EN50155:2017).
	Voltage interruptions Class	S2 as per EN50155:2017
	Supply changeover class	C1 as per EN50155:2017
	Inrush current	Limited to 5x the nominal current
	Power consumption	Typical 20 W
Environmental	Operating Temperature	Class OT4 as per EN50155 :2017, equivalent to Class TX as per 50125-1 :2014 inside a vehicle compartment: -40°C to +70°C
	Storage temperature	-40°C to +85°C.
	Shock and vibration	Compliant to EN 61373:2010 performance for Category 1 body mounted equipment. Class B. (Therefore, complies to EN50155:2017)
Fire	Fire behavior	Compliant to NFPA 130 Compliant to EN45545-2 HL2
Mechanical	Ingress Protection	IP40
	Dimensions	• Width: 194.31 mm • Height: 60.58 mm • Length: 368.3 mm
	Finish	Galvanised Steel
	Weight	2.8Kg +/- 10%

Table 17 FEU Interfaces

Parameter	Connector Label	Description
Power	X1	One 3-Pin Male Phoenix connector for input power.24V
Legacy Train Lines	X2	9-Pin Female D-Sub, TE Connectivity, Legacy Train line interface
UIC Train Lines	X3	9-Pin Male D-Sub, TE Connectivity. UIC Train line interface
CCU+ Interface	X4	37-Pin Female D-Sub, TE Connectivity, CCU+ Inputs and Outputs
Handset interface	X5	25-Pin Female D-Sub, TE Connectivity. HS, TRSPK and GM connection

OBU and Cab Buttons	X6	25-Pin Male D-Sub, TE Connectivity, OBU and Cab buttons
Radio Interface	X7	15-Pin Male D-Sub, TE Connectivity. Train radio interface and Line in connector harness

Table 18 FEU LED Status Indicators

Indicator	Description
Power	• LED lights up Green when power is connected • LED is OFF otherwise

3.2.6 Passenger Communication Unit (PCU)

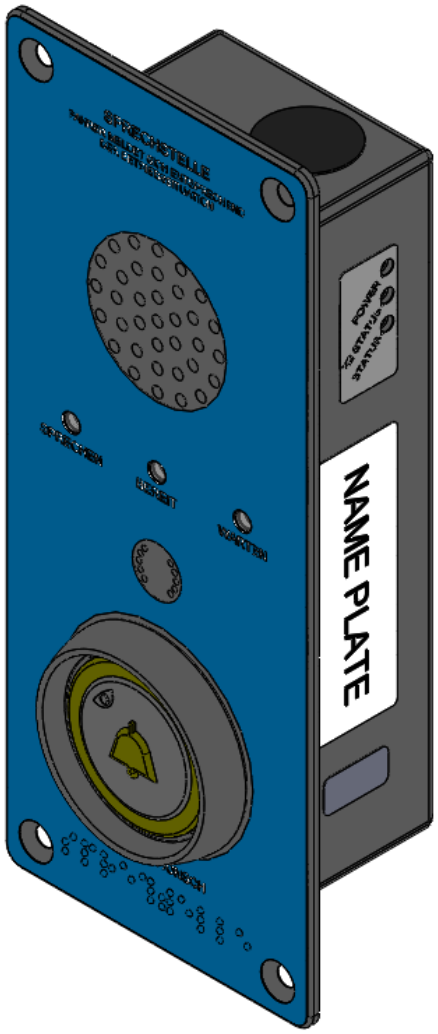

Figure 14 Passenger Communication Unit (PCU)

The Passenger Communication Unit (PCU) features a microphone, speaker, three status LED (Ready (Orange), Talk (Green), Wait/Listen(Red)) and talk request button. On activation the PCU provides half duplex communication between Driver and Passenger. On PCU activation a secondary contact informs

the TCMS of the activation. The PCU is powered using Power over Ethernet (PoE). For automatic volume adjustment of the audio system the microphone of the PCU is used to monitor the ambient saloon sound pressure level.

Each PCU can be activated through directly pressing the activation button or through secondary means of a digital input connected to an ancillary device such as Emergency handle. Where a PCU is used in areas with access for people with reduced mobility (PCUs 11, 12, 5 and 6), this input is not used. For further details please refer to reference 5 CDRL 037-05 3044276 Passenger Communication Unit (PCU) Datasheet.

Table 19 PCU Technical Data

Parameter / feature		Description
Processing	Processor	IMX6 core, Arm cortex A7, 528Mhz
	RAM memory	512MBytes of DDR3L-1866
	Storage	4GB MLC/2GB SLC eMMC for OS, APP and Critical data
Electrical	EMC	Compliant to EN50121-3-2:2016 (Complies to EN50155:2017)
	Input Voltage	IEEE 802.3af and IEEE 802.3at PoE/PoE+ standard
	Insulation and voltage withstand	Compliant to EN50155:2017: • Voltage withstand 500VAC or 750VDC • Insulation: >20MΩ at 500VDC
Environmental	Operating Temperature	Class OT4 as per EN50155 :2017, equivalent to Class TX as per 50125-1 :2014 inside a vehicle compartment: -40°C to +70°C
	Storage temperature	-40°C to +85°C.
	Shock and vibration	Compliant to EN 61373:2010 performance for Category 1 body mounted equipment. Class B. (Therefore, complies to EN50155:2017)
Fire	Fire behavior	Compliant to NFPA 130 Compliant to EN45545-2 HL2
Mechanical	Ingress Protection	IP53
	Dimensions	• Width: 95 mm • Height: 230 mm • Depth: 53.3 mm
	Finish	• Faceplate: Stainless steel brushed • Enclosure: Black powder coating
	Weight	1.4 Kg +/- 10%

Table 20 PCU Interfaces

Parameter	Connector Label	Description
External pushbutton interface	X1	One 5-pin Female M12 B-Coded connector for external buttons. Provides input for external activation device
Ethernet	X2	One 4-pin Female M12 D-Coded connector for Ethernet 10/100Mbps with PoE
TCMS	X3	3-pin male Phoenix Combicon. Informs TCMS of PCU Activation

Table 21 PCU LED Status Indicators

Indicator	Description
Power	• LED lights up Green when power is connected • LED is OFF otherwise
Ethernet	• LED lights up Yellow when it is a 100Mbps link and there is no activity. • LED flashes Yellow when it is a 100Mbps link and there is activity. • LED lights up Green when it is a 10Mbps link and there is no activity. • LED flashes Green when it is a 10Mbps link and there is activity. • LED is OFF when link is down
Status	• LED lights Green when there is a system fault (e.g configuration fault) • LED flashes Green when software application is running and there is no fault detected on the system. • LED is OFF when software application is not running.

3.2.7 Cab Loudspeaker (CSPK)

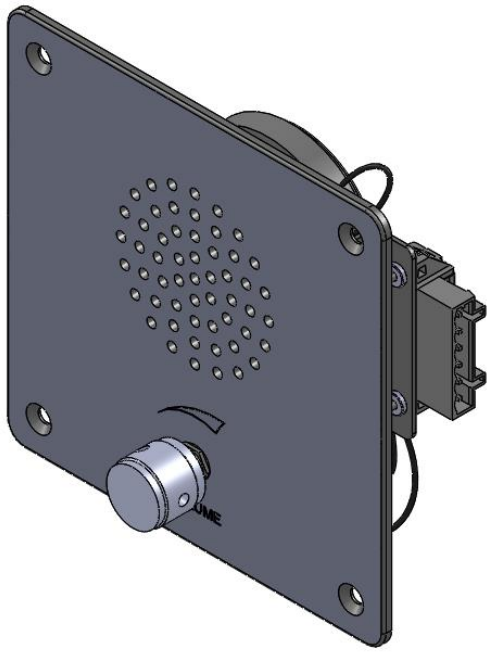

Figure 15 Cab Loudspeaker (CSPK)

The Cab Loudspeaker (CSPK) is a compact loudspeaker which features integrated volume control. Installed in the Cab areas the CSPK is interfaced to the CCU+. It is responsible for transmission of audio signals from PA, IC and PCU functions into the cab area. For further details please refer to reference 7 CDRL 037-06 3044278 Cab Loudspeaker (CSPK) Datasheet.

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Table 22 CSPK Technical Data

Parameter / feature		Description
Electrical	Continuous Power Handling	8W
	Maximum Power	15W

	Impedance	4Ohm/8Ohm
	Frequency Response	200Hz – 20KHz, -10dB
	Average SPL	88dB @ 1W, 1m distance
Environmental	Operating Temperature	OT3 -25°C to +70°C
	Storage Temperature	-40°C to +100°C
	Ingress Protection	IP54 (Front)
	Shock and Vibration	Compliant to EN61373:2010 Cat1 Class B
Fire	Fire behavior	Compliant to EN45545 HL2
Mechanical	Dimensions	Width 135.25mm Height 130 mm Depth 40.6mm
	Finish	Stainless Steel Brushed
	Weight	0.9Kg +/- 10%

Table 23 CSPK Interfaces

Parameter	Connector Label	Description
Interface to CCU+	SPK	WAGO 6-pin male. Interface connection to CCU+

3.2.8 Train Radio Loudspeaker (TRSPK)

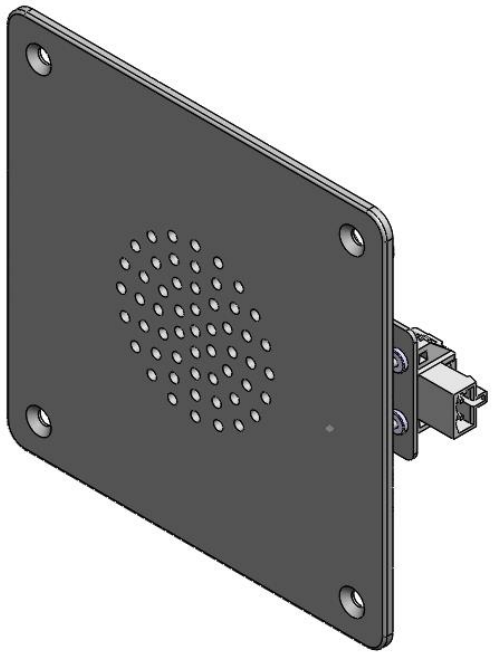

Figure 16 Train Radio Loudspeaker (TRSPK)

Located in the cab area the Train Radio Loudspeaker (TRSPK) interfaces with the Front End Unit (FEU). The TRSPK is responsible for playing audio information received via the train radio while in OCC-TR mode. The TRSPK is only operational in this mode while the handset remains in the cradle. For further details please refer to reference 8 CDRL 037-07 3044279 Train Radio Loudspeaker (TRSPK) Datasheet.
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Table 24 TRSPK Technical Data

Parameter / feature		Description
Electrical	Continuous Power Handling	8W
	Maximum Power	15W
	Impedance	4Ohm/8Ohm
	Frequency Response	200Hz – 20KHz, -10dB
	Average SPL	88dB @ 1W, 1m distance
Environmental	Operating Temperature	OT3 -25°C to +70°C
	Storage Temperature	-40°C to +100°C
	Ingress Protection	IP64 (Front)
	Shock and Vibration	Compliant to EN61373:2010 Cat1 Class B
Fire	Fire behavior	Compliant to EN45545 HL2
Mechanical	Dimensions	Width 135.25mm Height 130 mm Depth 36.2mm

	Finish	Stainless Steel Brushed
	Weight	0.8Kg +/- 10%

Table 25 TRSPK Interfaces

Parameter	Connector Label	Description
Interface to FEU	SPK	WAGO 2-Pin Male, Audio interface to FEU

3.2.9 Saloon Loudspeaker (SSPK)

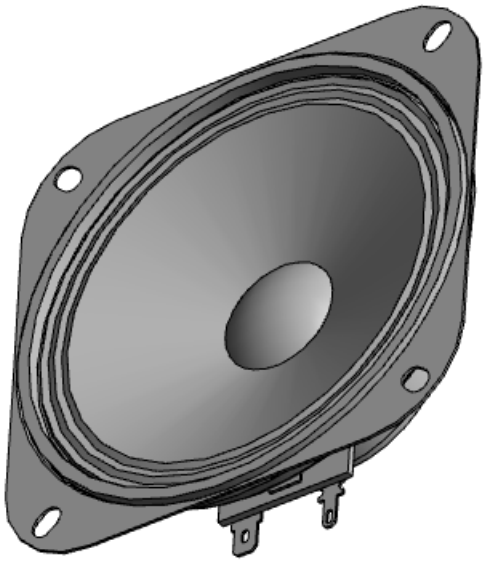

Figure 17 Saloon Loudspeaker (SSPK)

The Saloon Loudspeaker (SSPK) is a compact design. Located in the saloon areas the SSPK interfaces directly with the ACC modules. Providing audio signal distribution.to the Saloon areas. For further details please refer to reference 9 CDRL 037-08 3044280 Saloon Loudspeaker (SSPK) Datasheet

Table 26 SSPK Technical Data

Parameter / feature		Description
Electrical	Continuous Power Handling	20W
	Maximum Power	30W
	Impedance	4Ohm/8Ohm
	Frequency Response	100Hz – 13KHz, -10dB

	Average SPL	90dB @ 1W, 1m distance
Environmental	Operating Temperature	-25°C to +70°C
	Storage Temperature	-40°C to +70°C
	Ingress Protection	IP53
	Shock and Vibration	Compliant to EN61373:2010 Cat1 Class B
Fire	Fire behavior	Compliant to EN45545 HL2
Mechanical	Dimensions	Width 102mm Height 102 mm Depth 36mm (36.8mm with Gasket)
	Finish	Steel
	Weight	0.16Kg +/-10%

Table 27 SSPK Interfaces

Parameter	Connector Label	Description
Interface to ACC	SPK	Speaker terminals: 4.8 x 0.8 mm (+) and 2.8 x 0.8 mm (−) . Audio connection to ACC+

3.2.10 External Loudspeaker V3 (EXT-SPK-V3)

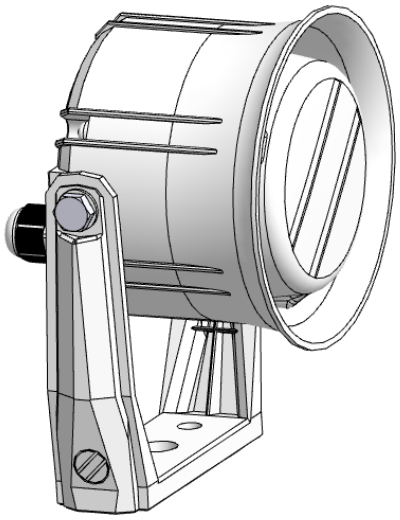

Figure 18 External Loudspeaker (EXT-SPK-V3)

The external loudspeaker V3 (SPK-EXT V3) is a compact loudspeaker used for external audio announcements to passengers. It is prepared to be mounted outside the train cars. For further details please refer to reference 10 CDRL 037-09 3044281 Ext Loudspeaker (EXT-LSPK-V3) Datasheet.

Table 28 EXT-SPK-V3 Technical Data

Parameter / feature		Description
Electrical	Continuous Power Handling	6W
	Maximum Power	10W
	Impedance	8Ohm
	Frequency Response	380Hz – 20KHz, -10dB
	Average SPL	100dB @ 1W, 1m distance
Environmental	Operating Temperature	-40°C to +100°C
	Storage Temperature	-40°C to +100°C
	Ingress Protection	IP67
	Shock and Vibration	Compliant to EN61373 Cat1 Class B
Fire	Fire behavior	Compliant to NFPA 130
Mechanical	Dimensions	Diameter: 97 mm Width (with bracket) 101mm Depth 66.5mm Height 137.5mm
	Finish	Black
	Weight	0.35Kg +/- 10%

Table 29 EXT-SPK-V3 Interfaces

Parameter	Connector Label	Description
Interface to ACC	SPK	500mm meter cable from speaker (Alstom to supply connector)

3.2.11 External Loudspeaker V4 (EXT-SPK-V4)

Figure 19 External Loudspeaker V4 (EXT-SPK-V4)

The external loudspeaker (SPK-EXT V4) is a compact 8 cm (3.3“) full-range speaker with waterproof polypropylene cone, good bass reproduction and balanced frequency response. Especially suitable as built-in speaker for music reproduction and as driver for 100 V network column speakers. It can be used for audio announcements to passengers. It is prepared to be mounted outside the train cars. For further details please refer to reference 11 CDRL 037-10 3044282 Ext Loudspeaker (EXT-LSPK-V4) Datasheet. The EXT-SPK-V4 speakers are located on the exterior of the lead vehicles (WGT 1 and 9), for announcement of special messages to disabled passengers. The EXT-SPK-V4 are only used for the playback of special announcements.

Table 30 EXT-SPK-V4 Technical Data

Parameter / feature		Description
Electrical	Continuous Power Handling	15W
	Maximum Power	25W
	Impedance	8Ohm
	Frequency Response	100Hz – 20KHz, 10dB
	Average SPL	84dB @ 1W, 1m distance
Environmental	Operating Temperature	-40°C to +80°C
	Storage Temperature	-40°C to +80°C
	Ingress Protection	IP65
Fire	Fire behavior	EN45545-2 Compliant

Mechanical	Dimensions	• Diameter: 90 mm • Depth 49.3mm
	Finish	White Plastic ASA
	Weight	0.2Kg +/- 10%

Table 31 EXT-SPK-V4 Interfaces

Parameter	Connector Label	Description
Interface to ACC	SPK	2 pin Receptacle Faston Type connector

3.2.12 Line In Connector Harness (LICH)

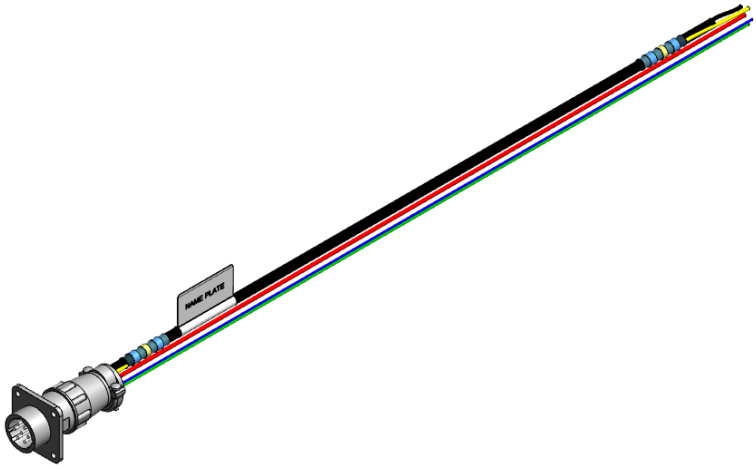

Figure 20 Line In Connector Harness(LICH)

The Line In Connector Harness (LICH) allows the connection of an external Microphone (Not LTG Supply) to the audio bus. For further details refer to reference 12 CDRL 037-12 3044284 Line In Conn Harness(LICH) Datasheet.

Table 32 LICH Technical Data

Parameter / feature		Description
Electrical	EMC	Compliant to EN50121-3-2
Environmental	Operating Temperature	-25°C to +70°C
	Storage Temperature	-45°C to +80°C
Fire	Fire behavior	Compliant to NFPA 130 EN45545-2 HL2
Mechanical	Dimensions	Length: 500 mm Width 32.54 mm
	Finish	Metal

	Weight	0.09 Kg +/- 10%

Table 33 LICH Interfaces

Parameter	Connector Label	Description
Microphone Input	X1	TE CONNECTIVITY CIRCULAR CONNECTOR 211401-3 7 CONTACTS

4 Functional Description

4.1 Cab Controls

The ELA system interfaces with 3 (Non-LTG supply) cab control consisting of:

- **'Station' Non Latching Rotary Switch.** The Station rotary switch has 3 positions:
  - **Clear:** Cancels PCU talk request, and IC modes
  - **Speak:** Controls driver talk privilege for PCU talk request, IC and PCU Emergency Call
  - **0:** Default position of the switch which the switch returns to on release.
- **'Speakers' Non Latching Rotary Switch.** The Speakers rotary switch has 3 positions:
  - **Internal:** PA-INT activation
  - **Internal/External:** PA-INT/EXT activation
  - **0:** Default position of the switch which the switch returns to on release.
- **Gooseneck Microphone PTT:** The GM PTT is only used for Driver talk privilege through the GM during OCC-TR

All controls are interfaced to the ELA system through the FEU

4.2 ELA Functional Description

4.2.1 Normal Mode

While in normal mode all audio signal distribution between End devices (CCU+, ACC and PCU) is completed through Voice Over Internet Protocol (VOIP)

Table 34 VOIP Format

Format	Sampling Rate	Sampling Size
PCM	16Khz	16bit

4.2.1.1 Driver Public Announcement to Internal Loudspeakers (PA-INT).

The ELA system has a specific mode for Internal Public announcements (PA-INT). To enter the PA-INT mode the driver rotates and holds the Cab desk Speaker rotary switch to the Internal position.

Once active audio from the Gooseneck Microphone is routed to the local CCU+ via the FEU. The CCU+ will then distribute the audio through VoIP to the ACC modules and non-active cab CCU+ for playback over the internal and non-active cab loudspeaker

The driver may exit PA-INT mode by releasing the Speaker rotary switch, which returns to the 0 position.

It is not possible to make a PA-INT announcement from an inactive cab.

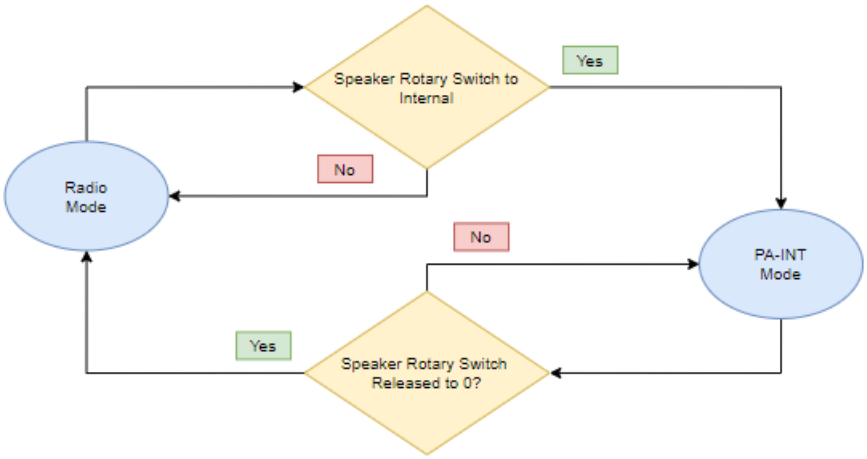

Figure 21 PA-INT flow diagram

4.2.1.2 Driver Public Announcement to Internal and External loudspeakers (PA-INT/EXT).

The ELA system has a specific mode for Internal and External Public announcements (PA-INT/EXT). To enter the PA-INT/EXT mode the driver rotates and holds the Cab desk Speaker rotary switch to the External position.

Once active audio from the Gooseneck Microphone is routed to the local CCU+ via the FEU. The CCU+ will then distribute the audio through VoIP to the ACC modules and non-active cab CCU+ for playback over the internal, external and non-active cab loudspeaker

The driver may exit PA-INT/EXT mode by releasing the Speaker rotary switch, which returns to the 0 position.

The PA-INT/EXT is not played over the EXT-SPK-V4 speakers

It is not possible to make a PA-INT/EXT announcement from an inactive cab.

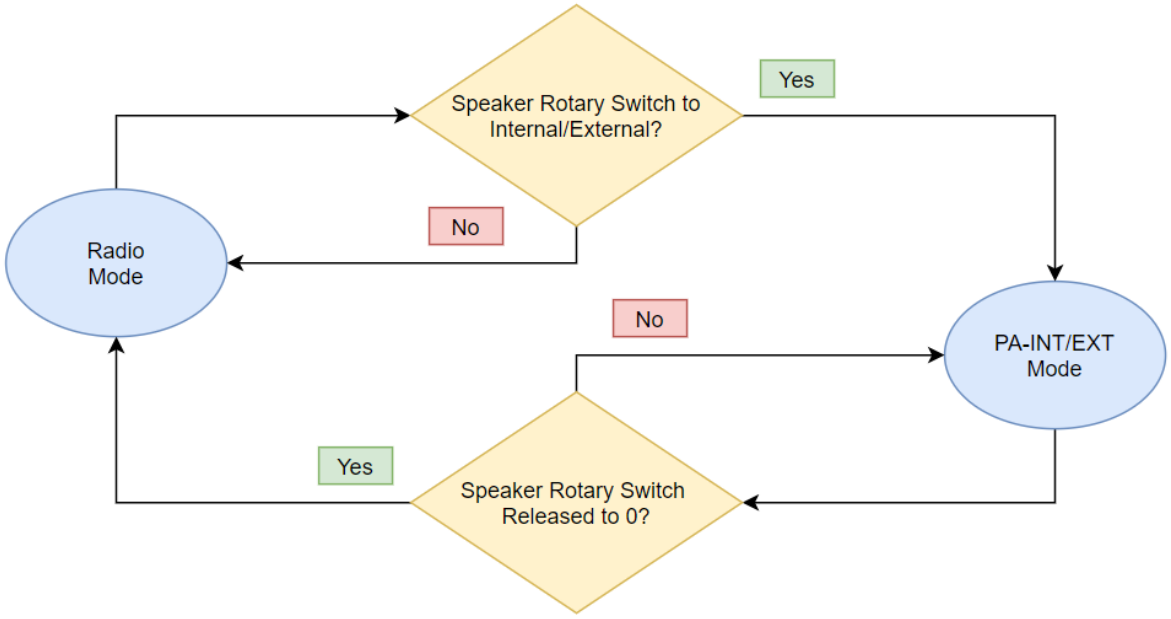

Figure 22 PA-INT/EXT Flow diagram

4.2.1.3 Crew Public Announcement to Internal loudspeakers (PA-CREW).

The ELA system allows for the connection of an ancillary microphone (Not LTG Supply) through a Line In Connector Harness (LICH) to the Front End Unit (FEU) via the FEU X7 connector. The harnesses are located in both cabs and the middle car, in both 5 car MZ and 9 car ELZ formations. The Microphone is intended for use by the train crew, enabling Public announcements through Interior speakers.

Once a microphone is connected Train Crew can make Public Announcements through the internal speakers to passengers through pressing a PTT button on the ancillary microphone.

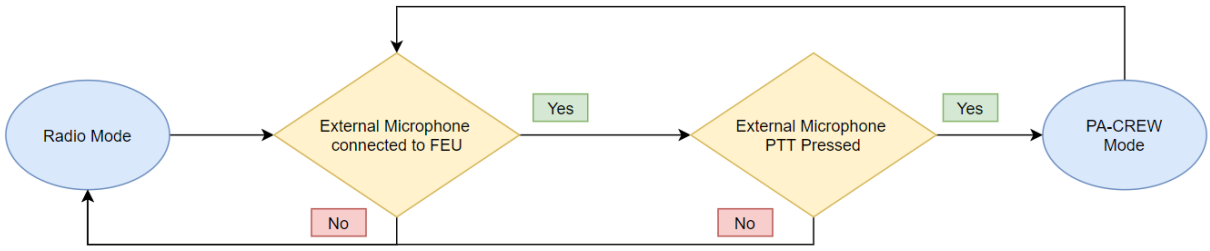

Figure 23 PA-CREW Mode Flow Diagram

4.2.1.4 OCC-PA to Internal speakers (PA-OCC).

The ELA system has a specific mode for Public Announcements from the Operational Control Centre (PA-OCC). PA-OCC mode is active when the On-Board Unit (OBU) input to the Front End Unit (X6, pin 10, FAW) is pulled low. At this point the analogue audio signal sent from the OBU to the FEU (X6, pins 20 & 8) is routed to the CCU+. The CCU+ digitizes the information for distribution over the comfort ethernet

network using VoIP. On receipt of the audio data the ACC will play the announcement over the Internal speakers..

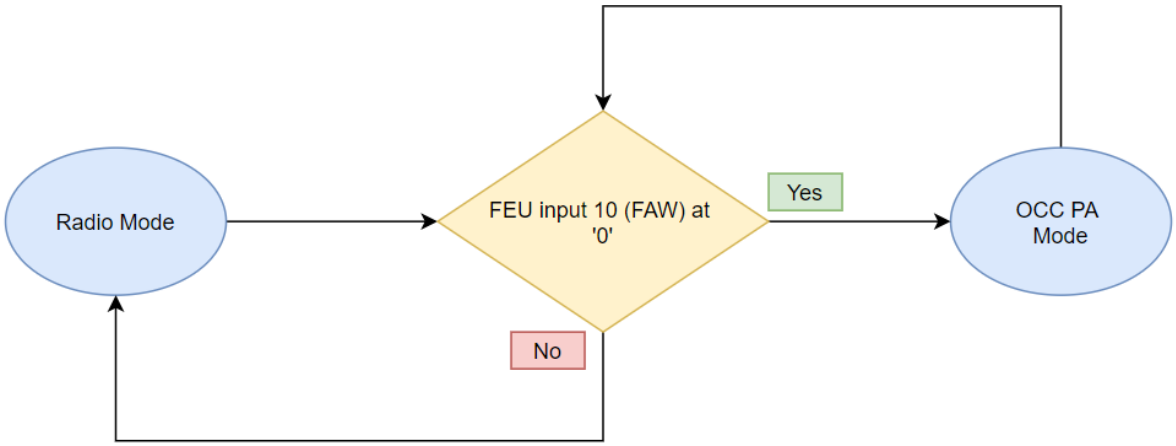

Figure 24 OCC_PA Flow diagram

4.2.1.5 Half Duplex communication between Driver and OCC (OCC-TR).

The ELA system provides functionality for Half-Duplex communication between the Operational Control Centre (OCC) and the Driver. By default the ELA system is in Train Radio mode. With no other mode selected pressing the Cab desk PTT button will route audio from the Gooseneck Microphone (GM) directly to the Train Radio interface, through the FEU. Any audio received from the train radio is played over the Train Radio Loudspeaker.

The driver can switch to using the Driver Handset (HS) at any time through lifting the HS from the console. When this occurs incoming audio is switched from the TRSPK to the HS Earpiece and the Gooseneck Microphone (GM) input to the CCU+ closes as the HS microphone input opens. Talk privilege is gained by the driver through pressing the HS PTT button. This is reversable through placing the handset back onto the cradle.

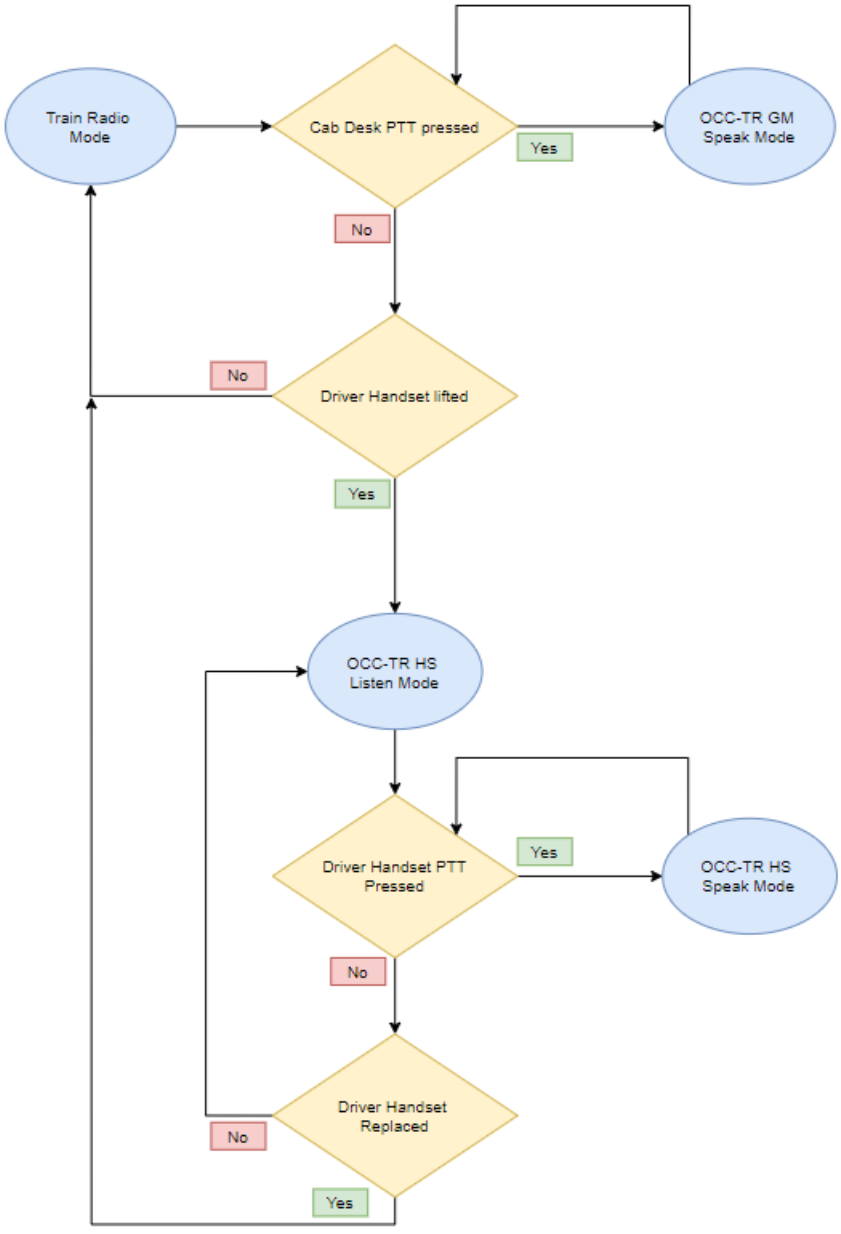

Figure 25 OCC-TR Flow diagram

4.2.1.6 Half Duplex Communication between Drivers (IC).

The ELA system provides Half Duplex communication between cabs (IC). The system is to handle IC call initiation with the following logic:

- IC call initiated from active cab will be sent to all non-active cabs.
- IC call initiated from a non-active cab will only be sent to the active cab

Both Non-active and active cabs can initiate an IC call through rotating the ‘Station’ rotary switch to the ‘Speak’ position. Once initiated the non-initiating cab will play an alert message through the CSPK. The non-initiating cab may accept the call through rotating the ‘Station’ rotary switch to the ‘Speak’ position. At which point the alert tone played through the CSPK is stopped

While the non-initiating cab holds the ‘station’ rotary switch in the ‘speak’ position, the non-initiating cab has talk privilege and audio is routed from the non-initiating cab GM to the initiating cab CSPK. When the non-initiating cab releases the ‘station’ rotary switch to the ‘0’ position, talk privilege is passed to the initiating cab and audio is routed from the initiating cab GM to the non-initiating cab CSPK.

Operators in the non-initiating cabs control talk back privilege through rotating the ‘Station’ rotary switch to the ‘Speak’ position. While rotated and held in this position the non-initiating cab has talk back privilege, with audio routed from the non-active cab GM to the active cab CSPK. When the non-initiating cab ‘Station’ rotary switch is released to the ‘0’ position. Talk back privilege is returned back to the initialing cab.

Either cab can terminate the IC call through turning the ‘Station’ rotary switch to the ‘Clear’ position.

The IC call enters ‘Parked’ mode if an ELA function with higher priority is activated. When the IC call is parked the Intercom indicator will flash. Once the higher priority function is ended the, IC function will exit parked mode, indicated by the intercom indicators (Non LTG supplied) turning on in both cabs.

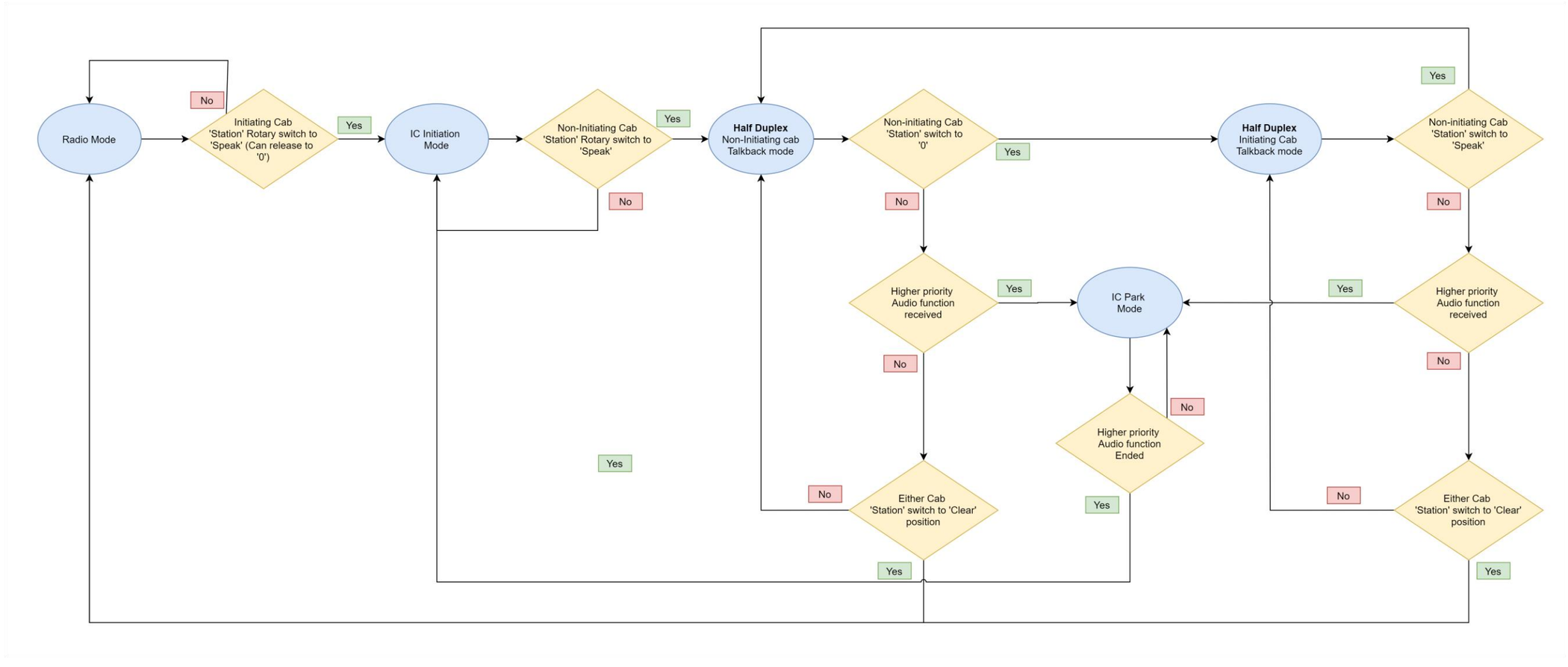

Figure 26 IC Flow Diagram

4.2.1.7 Half Duplex communication between Driver and PCU(PCU).

The PCU alarms are arranged in the following order within the 5 car MZ and 9 car XLZ

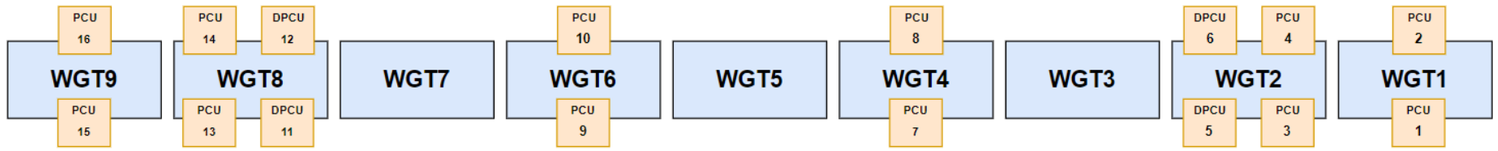

Figure 27 PCU/DPCU locations

The ELA system provides Half-Duplex communication between PCU alarm stations and the Driver. The PCU modules provide 2 specific modes of operation.

4.2.1.7.1 Passenger Call Request

A Passenger call Request can be made through both PCU and alarms for people with reduced Mobility DPCU. The request is made through pressing the PCU button. On activation the PCU alarm notifies the master CCU+ of its activation via TRDP and SIP, The CCU+ in turn notifies the TCMS of the PCU activation and location via TRDP.

After activation the PCU ‘Wait’ LED will illuminates for 0.5 seconds. After 0.5 seconds the PCU ‘Wait’ LED will then start to flash. By default the system will play no alarm tone through the active cab CSPK. The system supports a configurable item which when active causes an audible alarm to play in the active cab on PCU talk request activation. The alarm tone will be stored in the CCU+.

The driver can accept the PCU call and enter Driver to Passenger Talkback mode through moving the ‘Station’ rotary switch to the ‘speak’ position. At this point the PCU Wait LED will turn on and any audible alarm will be cancelled. When the ‘Station’ rotary switch is released back to the ‘0’ position by the driver, the ELA system enters PCU Driver Listen mode. On the PCU the ‘Wait/Listen’ LED turns off and the ‘Speak’ LED illuminates. Audio received by the PCU microphone is then transferred to the active cab CSPK.

The driver can regain talk priority through turning and holding the ‘Station’ rotary switch in the ‘Speak’ position. While the rotary switch is held in this position the ELA enters PCU-Driver Speak Mode.

The Driver can cancel the PCU talk request by turning the ‘’Station’ Rotary switch to the ‘Clear’ position. This can only be done after the driver has first accepted the PCU call. Once this is done the talk request is effectively cancelled. Audio is no longer distributed between the PCU and cab, and the PCU status LED returns to having the ‘Ready’ LED illuminated.

In the event of multiple PCU Passenger Call request activations the active PCU’s become parked and enter a queue of first in first out order. Once the first PCU in the queue has been addressed and the call cleared by the driver the next PCU in the que becomes active, starting in the PCU talk request wait mode. While parked the PCU ‘Wait’ LED flashes. In the event of an Emergency Call function the active PCU will become parked and is placed into the first position in the que if a PCU alarm que is present.

The below Figure 27 details a Flow diagram of the Passenger Call Request. It highlights 4 specific modes:

- PCU Talk Request Wait
  - Mode activated on the initiation of the Passenger Call Request.
  - On the PCU the ‘Wait’ LED illuminates for 0.5 seconds, after which the LED will start to flash.
  - In the active cab the Intercom request indicator will flash (Alstom Control)
  - Alarm tone plays through the CSPK if configurable parameter is set.
- PCU Talk Request Driver Listen
  - When the ‘Station’ rotary switch is moved to the ‘0’ position the Passenger talk request enters PCU Talk Request Driver Listen mode.
  - The PCU ‘Wait’ LED turns off and the PCU ‘Speak’ LED turns on.
  - Audio is now transmitted from the PCU microphone to the active Cab Loudspeaker.
- PCU Talk Request Driver Speak
  - When the ‘Station’ rotary switch is held in the ‘Speak’ position the Passenger talk request enters PCU Talk Request Driver Speak mode.
  - The PCU ‘Speak’ LED turns off and the PCU ‘Wait’ LED turns on.
  - Audio is now transmitted from the Gooseneck Microphone to the active PCU speaker.
- PCU Talk Request Parked
  - The PCU Talk Request Parked mode occurs when either:
    - A higher priority audio request is received
    - An Emergency PCU call is received.
    - Multiple PCU alarms active.
  - The PCU ‘Wait’ LED starts to flash.
  - On completion of the higher priority audio function or PCU Emergency call the PCU Talk request enters PCU talk request wait mode, where the driver will need to accept the call to continue.

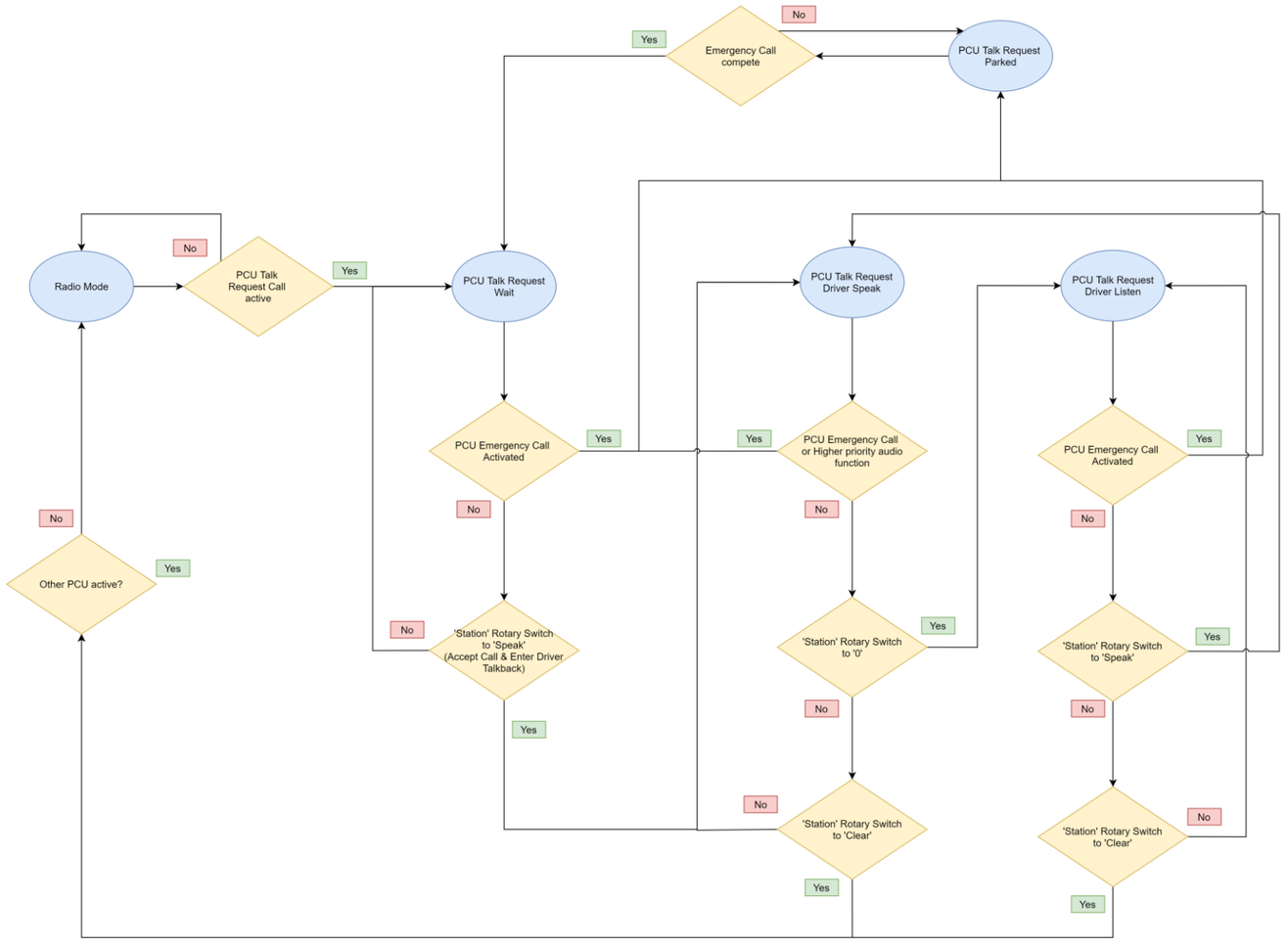

Figure 28 Passenger Call Request Flow Diagram

4.2.1.7.2 Passenger Emergency Call

Passenger Emergency Calls are activated through 2 means:

- PCU external emergency signal (PCU X1 Pins 2 (+24V) and 3(0V)).
  - If activated via the PCU external emergency signal the PCU alarm notifies the master CCU+ of its activation via TRDP, The CCU+ in turn notifies the TCMS of the PCU activation and location via TRDP. The TCMS is also notified of the PCU Emergency call activation through an auxiliary output (X3 Pins 1 (+24V) and 2 (0V)) on the PCU module.
- TCMS to master CCU+ request via TRDP, through activation of the Emergency Door Release signal.
  - On TCMS activation request the CCU+ will activate the doors associated PCU device. Once activated the CCU+ will inform the TCMS of the PCU activation.

PCU's located in areas for people with reduced mobility (DPCU) do not have this function (PCUs 11, 12, 5 and 6). On activation the PCU 'Wait' LED illuminates briefly before the 'Speak' LED illuminates. The ELA system enters 'PCU-EMER Driver listen mode'. The audio signal from the PCU microphone is then routed to the active cab CSPK without further input from the driver.

On activation audio from the PCU microphone will be played through the CSPK. Similar to the Passenger Call request the system features a configurable parameter that when set activates an audible tone to be played through the Active cab loud speaker on PCU Emergency call activation. By default this parameter will be set to off so as no tone is played. The alarm audio tone will be merged with audio received from the active PCU.

The driver can control the speak privilege through turning the ‘Station’ rotary switch to the ‘Speak’ position, when operated the ELA system enters ‘PCU-EMER Driver speak mode’. When rotated to this position audio from the GM is played through the active PCU loudspeaker, the PCU microphone is turned off, the PCU ‘Wait’ LED illuminates and the PCU ‘Speak’ LED is turned off. If the parameter for an audio alarm tone is set to play an alarm tone then the alarm tone will be canceled on the first occurrence of the driver moving the ‘Speak’ rotary switch to the ‘Speak’ position.

In the event of alarm activation from PCU external emergency signal, the alarm may only be cancelled through resetting of the emergency activation input to the PCU. This task is to be performed by the train crew. If the alarm is activated via TCMS request the PCU alarm will remain active until the TCMS activation request is removed

In the event of multiple PCU Emergency call activation the active PCU’s become queued in a first in first out order. Once the first PCU in the queue has been addressed and the call cleared by the train crew resetting the active PCU, the next PCU in the stack becomes active. PCU’s waiting in the stack have their respective ‘Wait’ LED’s illuminated.

The below Figure 28 details a flow diagram of PCU Emergency call operation which identifies 3 modes

1. PCU Emergency Driver Listen Mode
    - First mode following activation of a PCU Emergency call, mode also accessed through driver releasing ‘Speak’ rotary switch to the ‘0’ position.
    - PCU ‘Wait’ LED illuminates briefly before turning off and the PCU ‘Speak’ LED illuminates.
    - Audio from the PCU microphone is routed to the active cab Cab Loudspeaker.
    - If parameter is set audible tone is merged with PCU audio and played through active cab CLS.
1. PCU Emergency Driver Speak Mode
    - Mode activated through driver rotating the ‘Speak’ rotary switch to the ‘0’ position.
    - PCU ‘Speak’ LED turns off. PCU ‘Wait’ LED turns on
    - Audio is routed from the Gooseneck Microphone to the active PCU speaker.
    - In the first instance of this mode being entered if the configurable PCU Emergency alarm tone is active it will be silenced.
1. PCU Emergency Parked Mode
    - Mode entered only for PCU call that are queued (Not detailed in flow diagram)
    - PCU ‘Wait’ LED flashes

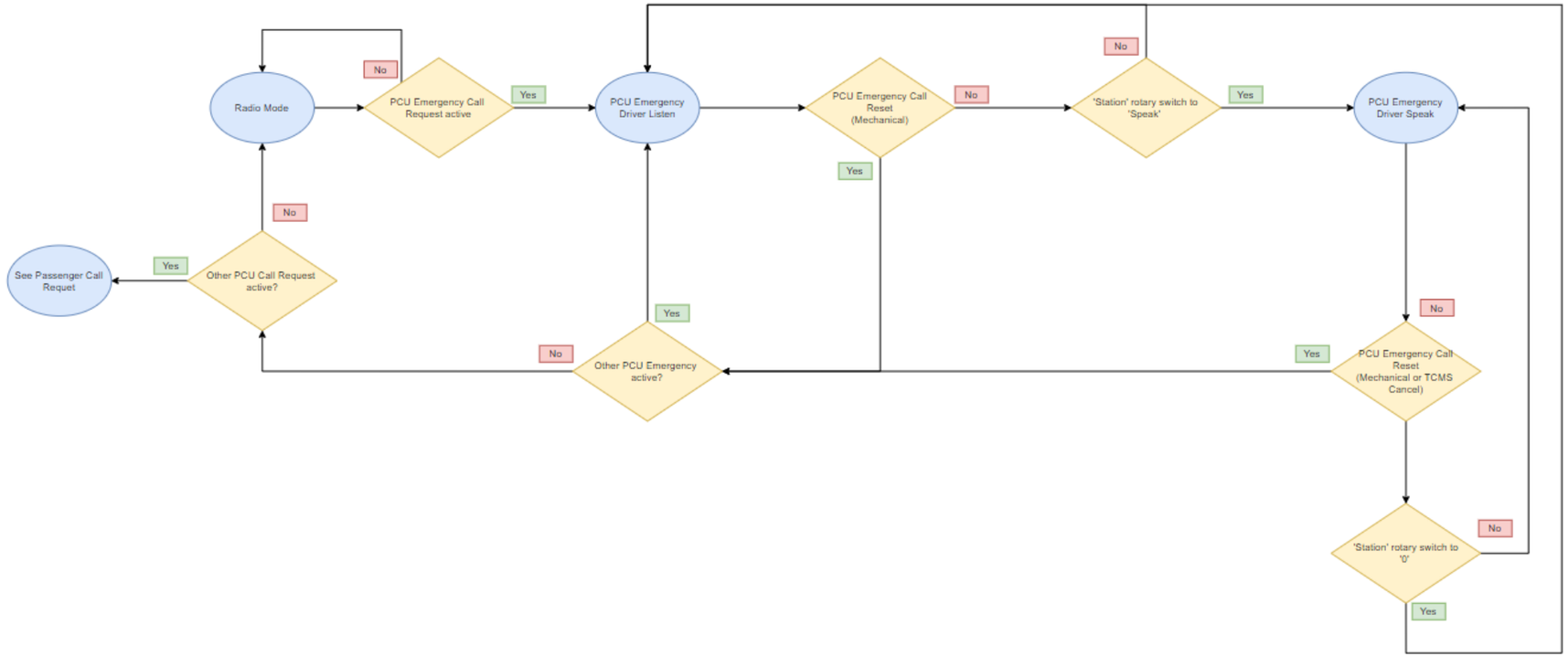

Figure 29 PCU Emergency Call Flow Diagram

4.2.1.8 Automated Announcements (AA)

The ELA system provides audio distribution of automated announcements received from the On-Board Unit (OBU) located in WGT1. Automatic Announcement audio signals are received in analogue format from the OBU through FEU Connector X6 pins 5 and 18. The OBU interfaces the below inputs to the Front End Unit (FEU) X6 connector in WGT1, with regard to where the automated announcements are to be played.

Pin FEU	Pin OBU	ID	Function to Input State			
			DVA Internal	DVA External	No Action	No Action
1	20b	DAG ON	0	1	0	1
4	14b	DAG LSA	0	1	1	0

Figure 30 OBU AA Interface to FEU

4.2.1.9 Departure Tone

The ELA supports playback of 2 different departure tones over the External loudspeakers. Selection of tone to be played as well as start and stop of the tone will be completed through TCMS TRDP communication to the master CCU+. The following departure tones will be supplied by Alstom.

1. Continuous 330Hz departure tone.
2. Alternating 1900HZ 60 ms on/ 60 ms off

The departure tones will be stored as .wav file type on both CCU+. The system will allow the tones to be changed through upload of a new tone through the MST tool.

4.2.2 Train Radio Panic Mode

The ELA system features a Panic Mode. Panic Mode is entered through the receipt of TCMS request to the CCU+. Once Panic Mode is entered the Gooseneck Microphone (GM) input to the CCU+ opens and all audio received from the GM by the CCU+ is sent to the train radio.

4.2.3 Fallback Mode

In the event of failure to the train network or Software failure of the CCU+ the ELA system will enter Fallback mode. While in fallback mode the following audio functions remain available:

- OCC-TR
- OCC-PA
- PA-INT/EXT

While in fallback mode the ELA will utilize the UIC train lines for audio signal control and distribution. The UIC train lines consist of 3 pairs, with further details of their use provided in the below table.

Table 35 UIC Train Lines

UIC Pair	Description
PA AF	PA Analogue audio signal
PA EN	PA Enable signal (+24v)
PA PR	PA Priority signal (+24V)

In the event that the failure causing fallback mode clears during operation the system will revert back to normal operation.

4.2.4 Tow mode

The ELA System supports the coupling of 2 Tram sets for Towing/Pushing operation. The ELA system is designed to support this formation on the premise that a coupling Tram set may utilize an older audio system with requiring output/input of a 100Vpp audio signal.

Electrical coupling between the 2 vehicles is made through the use of a 'Suppression Cable'. The suppression cable consists of 2 pairs, 1 control pair and 1 audio signal pair. The suppression cable input to the ELA system is through the FEU X2 connector and denoted as Legacy Trainlines.

Through the use of the Suppression cable the ELA system allows for 2 intervehicle functions. These functions and corresponding control characteristics are detailed below in Table 33

Table 36 Tow Mode Function

Function	Control Line Signal	
	Control Inside	Control Outside
PA Interior (PA-INT)	+24V	0V
PA Interior/Exterior (PA-INT/EXT)	0V	+24V

Control of these functions from the modified unit is the same as within normal mode (Rotation of the 'Speaker' rotary switch to either the internal or external position).

When the modified unit receives audio input via the suppression cable, the audio function requested is played respective to its position in the Audio priority tables detailed in 4.2.8 Audio Priorities. Such that if a higher priority function is in progress or appears during input stream, the audio input will not be played.

4.2.5 Multiple Unit Operation (Coupled)

The ELA system supports the operation of 2 MZ 5 Car units coupled. When operated in this mode the ethernet and UIC train lines of both vehicle are connected.

While in Multiple unit operation all functionality is available as previously described in Normal Mode.

4.2.6 Special Announcements

The ELA system provides a Special announcement feature. Upon door release the CCU+ will stream a announcement for playback over all EXT-SPK-V4 speakers.

The announcement to be played is stored on the CCU+ with the following characteristics:

- File Type: .wav
- Maximum size is 10Mb

The audio file will be played over the EXT-SPK-V4 speakers upon master CCU+ receipt of Door Released signal from the TCMS.

The audio file shall be configurable, allowing the end user to change the audio file through the MST.

4.2.7 Test Mode

Through the Maintenance and Service Tool (MST) the ELA system can be set to Test Mode. The below table details the ELA actions when entering test mode and any subsequent response from system stimulus/action.

Action	ELA Response
Test Mode Activated from MST	• Test tone is played over all SSPK • Test tone is played through all PCU speakers • Test tone is played through all CSPK • Status LED's on all PCU illuminate
'Speaker' rotary switch to 'Internal' position	• Test tone stops playing through SSPK. • Test tone is played through all CSPK • GM audio transmitted to SSPK
'Speaker rotary switch to '0' position	• GM audio is no longer streamed to SSPK • Test tone resumes play through all SSPK
PCU push button pressed	• Test tone stops playing on the PCU • Audio from the PCU microphone is looped to the PCU speaker • PCU status LED's turn off
PCU push button released	• PCU microphone is deactivated. • Test tone resumes on the PCU speaker • PCU status LED's illuminate
Test Mode deactivated	• All test functions clear • ELA resumes Normal Mode operation

4.2.8 Audio Priorities

The below tables detail the default audio priorities of the ELA system, with item 1 indicating the highest priority:

Driver Gooseneck Microphone		
Item	**Mode**	**Description**
1	Panic Mode	Panic Mode
2	OCC-TR	Speech connection between Driver and train Radio
3	PA-INT/EXT	Public Announcement to either Interior or Interior and Exterior speakers
4	IC	Speech connection between the Driver and non-active cab
5	PCU	Speech connection between driver and passenger intercom

Table 37 Gooseneck Microphone Audio Priority Table

Interior Loudspeaker		
Item	**Mode**	**Description**
1	OCC-PA	PA announcement to Internal speakers
2	PA	Driver Announcement to Passengers
3	DVA	Automatic Announcement
4	PA-CREW	Tram Crew PA via the Line in Connector Harness

Table 38 Interior Speaker Audio Priority Table

Cab Loudspeaker

Item	Mode	Description
1	IC	Intercom between cabs
2	PCU-Driver Listen	PCU Emergency call to the Driver
3	DVA	Automatic Announcements

Table 39 Cab Loudspeaker Audio Priority Table

Train Radio		
Item	**Mode**	**Description**
1	Panic Mode	GM audio to Train Radio
2	OCC-PA	OCC-PA announcement to Internal
3	OCC-TR	Voice communication between Driver and OC

Table 40 Train Radio Audio Priority Table

4.2.9 TCMS Communication for the reporting of ELA error and status information.

The master CCU+ Master will report the following status information to the TCMS via TRDP:

- Passenger Call Request Activation
- PCU Communication mode status
- PCU failure event
    - Loss of communication
    - Configuration file error
- ACC failure event
    - Loss of communication
    - Configuration file error
- CCU+ failure event
    - Loss of communication
    - Configuration file error

In the event of failure of the master CCU+ the remaining CCU+ will take over as the Master CCU+ . If the failure is cleared the process will reverse with the original CCU+ resuming as Master.

4.2.10 Ambient noise dependent automatic volume adjustment.

The ELA system features automatic ambient noise volume adjustment in the saloon areas. Each PCU microphone samples the ambient Sound Pressure Level (SPL) in the saloon area. This measurement is communicated to the Master CCU+ via Ethernet communication. The CCU+ will calculate the required change to SPL and communicate this to the ACC. The ACC can then adjust the playback volume of any announcements in the saloon by at least +6dB to a basic 75dB

If a failure occurs preventing automatic volume adjustment, such as Ethernet connectivity or Software failure of the ACC. The volume level defaults to a fixed hardware dependent value.

4.2.11 Adjustable System Variables

The ELA system allows for the adjustment of several system variables through Web Browser connection to the CCU+. These parameter include:

- Volume adjustment of the minimum volume for the Cab Loudspeaker
- PCU activation Cab Speaker Alert tone parameter On/Off
- Gooseneck Microphone input level for the following modes:
    - PCU Talk
    - PA

  - IC
  - OCC-TR
- Volume adjustment parameter for Interior, Exterior and PCU speakers
- Saloon automatic ambient noise level adjustment slope.
- Departure audio tone file
- PCU Alarm tone audio file

4.3 Interface Specifications

4.3.1 IP Network Specifications

This section provides specifications for IP Network.

- ELA networked devices have their own unique MAC address.
- ELA networked devices have a unique host-name (unique on a consist basis).
- Ethernet port specifications:
  - IEEE 802.3
  - 100Base-TX
  - Supports 10 Mbits/sec full duplex
  - Supports 100 Mbits/sec full duplex
  - Supports auto-negotiation
  - Supports auto-sensing
  - Supports auto-crossing
  - Supports Ethernet frame size between 64 and 1518 byte;
  - IEEE 802.3 flow control is disabled.
  - IEEE 802.3af and IEEE 802.3at PoE/PoE+ (PCU Only).

4.3.1.1 IP Address List

Table 41 IP Address List

Car	Device	IP	Switch	Port
WGT1	CCU+	192.168.10.110	L3-m-Gbit	X5
	PCU B6	192.168.10.103	L2-m-PoE-Gbit	X7
	PCU A1	192.168.10.92	L2-m-PoE-Gbit	X8
	TCMS	192.168.10.200	L3-m-Gbit	X8
	Coupler	TBC	L3-m-Gbit	X9
WGT2	ACC	192.168.10.90	L2-m-PoE-Gbit	X10
	PCU A2	192.168.10.93	L2-m-PoE-Gbit	X7
	PCU B5	192.168.10.102	L2-m-PoE-Gbit	X8
	DPCU A2	192.168.10.104	L2-m-PoE-Gbit	X1
	DPCU B5	192.168.10.108	L2-m-PoE-Gbit	X2
WGT4	PCU B4	192.168.10.101	L2-m-PoE-Gbit	X7
	PCU A3	192.168.10.94	L2-m-PoE-Gbit	X8
WGT6	PCU A4	192.168.10.95	L2-m-PoE-Gbit	X7
	PCU B3	192.168.10.100	L2-m-PoE-Gbit	X8
WGT8	ACC	192.168.10.91	L2-m-PoE-Gbit	X10
	PCU B2	192.168.10.99	L2-m-PoE-Gbit	X7
	PCU A5	192.168.10.96	L2-m-PoE-Gbit	X8
	DPCU B2	192.168.10.106	L2-m-PoE-Gbit	X1

	DPCU A5	192.168.10.105	L2-m-PoE-Gbit	X2
WGT9	CCU+	192.168.10.111	L3-m-Gbit	X5
	PCU A6	192.168.10.97	L2-m-PoE-Gbit	X7
	PCU B1	192.168.10.98	L2-m-PoE-Gbit	X8
	Coupler	TBC	L3-m-Gbit	X9

4.3.1.2 Supported Protocols

Link Layer:

- IEEE 802.3.

Network Layer Protocols:

- IPv4
- ARP
- ICMP
- IGMP v3.

Internet Layer Protocols:

- Echo.

Transport Layer Protocols:

- TCP
- UDP
- RTP.
- TRDP
- SIP

Application Layer Protocols:

- SFTP server
- SFTP client
- SSH server
- SNTP client
- DHCP client
- IPTDir Client.

4.3.1.3 Required Ports/Sockets

The following section details the Ports/Sockets the ELA system requires to be open on the Train Ethernet network:

- 443 (HTTPS)
- 80 (HTTP)
- 22 (SSH)
- 123 (NTP)
- 53 (DNS)
- 5060 (SIP)
- 17224 (TRDP UDP PD)
- 17225 (TRDP UDP/TCP MD)
- 10000 – 20000 (RTP Dynamic Range)

4.3.2 Maintenance and Diagnostics

The ELA system provides a Maintenance and Service Tool (MST) through web browser connection to the CCU+. The MST tool allows for the following functions:

- Software update of:
  - CCU+
  - ACC
  - PCU
- Diagnostic logfile download from both ACC, PCU and CCU+ modules
- Setting and adjustment of system variables through configuration file upload.
- Live diagnostic information
- Upload of sound files for departure tone and PCU cab speaker alarm tone.
- Viewing of current software version deployment on all CCU+, ACC and PCU modules
- Stop/Start of System test mode

The ELA system from start-up continually self-monitors operational aspects of the system. In the event of a failure occurring the event is recorded by the CCU+. If the event clears during operation the clearing of the failure is also recorded within the CCU+ logfiles. The ELA system is able to detect the event information for the following items detailed in the below table.

Fault Name	Fault Description	System Limitation	Corrective Action
CCU+ Configuration File Failure	Configuration file corrupted or invalid	If CCU+ is master, master responsibility moved to second CCU+. If not possible system enters fallback mode	Update Configuration file
CCU+ Network Timeout	Network Error	If CCU+ is master, master responsibility moved to second CCU+. If not possible system enters fallback mode	Validate Network
ACC Configuration File Failure	Configuration file corrupted or invalid	Automatic volume adjustment no longer possible through effected ACC	Update Configuration file
ACC Network Timeout	Network Error	System to enter fallback mode	Validate Network
PCU Configuration File Failure	Configuration file corrupted or invalid	Automatic volume adjustment no longer possible through effected ACC	Update Configuration file
PCU Network Timeout	Network Error	PCU operation for Emergency and Passenger talk request no possible	Validate Network

5 Software Configuration Item Summary

This section presents the list of Software Component Items (SCI) for the ELA System. The software packages described below are single files with the following elements:

- Software Applications
- Operating Software
- Configuration File
- Bootloader

Table 42 SCI List

No	SCI ID	PN	OS	Item Host	Upload Method
1	CCU+ SOFT PCK	8606080	Linux	CCU+	MST, SFTP
2	CCU+ Config	8603176	Linux	CCU+	MST, SFTP
3	ACC SOFT PCK	8606081	Linux	ACC	MST, SFTP
4	ACC Config	8603177	Linux	ACC	MST, SFTP
5	PCU SOFT PCK	8606082	Linux	PCU	MST, SFTP
6	PCU Config	8603178	Linux	PCU	MST, SFTP

Appendix A

List of LRUs and LLRUs

Appendix A - Table 1: LRU List

Luminator Part No.	LRU Description
9020060-01-01	1190 Cab Control Unit + (CCU+)
9020020-02-02	1190 Audio Coach Controller (ACC)
9020031-01-02	1190 Passenger Communication Unit (PCU)
9003104	1190 Gooseneck Microphone (GM)
9003102	1190 Cab Loudspeaker (CSPK)
9003103	1190 Train Radio Speaker (TRSPK)
9003101	1190 Saloon Loudspeaker (SSPK)
9003105	1190 External Loudspeaker V3 (EXT-SPK-V3)
9003106	1190 External Loudspeaker V4 (EXT-SPK-V4)
9002058-002	1190 Driver Handset (HS)
9002219	1190 Line In Connector Harness (LICH)
9002220	1190 Front End Unit (FEU)