LOS ANGELES COUNTY

METROPOLITAN TRANSPORTATION AUTHORITY

LIGHT RAIL VEHICLE

P2550

RUNNING MAINTENANCE AND SERVICE MANUAL

SECTION 14 COMMUNICATIONS

Metro

AnsaldoBreda

LOS ANGELES COUNTY

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RUNNING MAINTENANCE
AND
SERVICE MANUAL

VOLUME M-01
PART I
THEORY OF OPERATION
SECTION 14 - COMMUNICATIONS

SECTION 14

COMMUNICATIONS

PART I

THEORY OF OPERATION

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SECTION 14

COMMUNICATIONS

14-I-01 INTRODUCTION

This Section of the Running Maintenance and Service Manual is divided into three Parts:

- Part I: Theory of Operation
- Part II: Troubleshooting
- Part III: Maintenance

Each Paragraph is numbered accordingly, to avoid that paragraphs of the same Section, pertaining to a different Part, have the same number.

Part I - Theory of Operation

Part I gives a thorough overview of the System structure and operation, by means of descriptions, figures, photos, schematics, block diagrams and flow charts, together with references to other documents or Sections when needed.

Part II - Troubleshooting

It gives the Maintenance Technicians a path to troubleshoot the System in every condition by means of the available tools:

- The PTU, equipped with the specific SW program
- The IDU
- The Fault Isolation Table

The Part III - Maintenance consists of:

- Preventive Maintenance
- Corrective Maintenance
- Consumable Materials
- Test Equipment, Tools & Special Tools

14-I-01.a LIST OF ABBREVIATIONS, ACRONYMS AND SYMBOLS

The Abbreviations, Acronyms and Symbols commonly used throughout this manual are given below with their related meaning.

Abbreviation	Meaning
Δ/Y	Triangle - Star Transformer
AADS	Automatic Announcement and Display System
AB	AnsaldoBreda
AC/DC	Alternate Current - Direct Current Converter
APS	Auxiliary Power Supply
ATP	Automatic Train Protection
BCU	Brake Control Unit
CB	Circuit Breaker
CCH	Communication control Head
CCI	Cab to Cab Intercom
CCU	Communication control Unit
CM	Coast Motoring
DC/AC	Direct Current - Alternate Current Converter
DC/DC	Direct Current - Direct Current Converter
EB	Emergency Brake
ECU	Electronic Control Unit (Brakes)
EDU	EMI Detector Unit
EXT	Exterior
FSB	Full Service Brake
GPS	Global Positioning System
GTW	Gateway
HRSB	High Rate Service Brake
HSCB	High Speed Circuit Breaker
HV	High Voltage
HVAC	Heating Ventilation & Air Conditioning
HVDS	High Voltage Distribution System
HW	Hardware
ICS	Integrated Circuits
ID	Identification (number)
IDU	Integrated Diagnostic Unit
INT	Interior
KO	Out of Service
LED	Light Emitting Diode
LH	Left Hand Side

Abbreviation	Meaning
LON	Local Operative Network
LRV	Light Rail Vehicle
LV	Low Voltage
LVDS	Low Voltage Distribution System
LVPD	Low Voltage Power Distribution
LVPS	Low Voltage Power Supply
M	Motoring
MBL	Metro Blue Line
MIC	Microphone
MTA	Metropolitan transportation Authority
MV	Medium Voltage
MVB	Multifunction Vehicle Bus
MVPD	Medium Voltage Power Distribution
OK	Working
PA	Public Announcement
PC	Printed Circuit
PGL	Pasadena Gold Line
PIC	Passenger Intercom
PIS	Passenger Information System
PTT	Push To Talk (Button)
PTU	Portable Test Unit
RH	Right Hand Side
ROC	Railway Operating Center
SB	Service Brake
SCEB	Slide Controlled Emergency Brake
SW	Software
TBS	To Be Supplied
TCMS	Train Control and Monitoring System
TCN	Train Communication Network
TCU	Traction control Unit
TWC	Train-to-Wayside Communication
WTB	Wired Train Bus

14-I-01.b LIST OF DEFINITIONS

The Definitions commonly used throughout this manual are given below with their related meaning.

Definition	Meaning
'A' body section	The section of an articulated vehicle containing the pantograph
'B' body section	The section of an articulated vehicle not containing the pantograph
AW0	Empty car operating weight
AW1	Full seated load plus AW0
AW2	Standees at 4 persons per square meter plus AW1
AW3	Standees at 6 persons per square meter plus AW1
AW4	Standees at 8 persons per square meter plus AW1
Front door	The door close to the Operator's Cab
Rear door	The door close to the Articulation Section

14-I-01.c LIST OF MEASUREMENT UNITS AND SYMBOLS

The Measurement Units commonly used throughout this manual are given below with their related meaning.

Definition	Meaning
Ω	Ohm
°C	Celsius degree
°F	Fahrenheit degree
A	Ampere
ac	Alternate Current
dB	Decibel
dc	Direct Current
F	Farad
ft	Foot
H	Henry
Hz	Hertz
in	Inch
kg	Kilogram - approx 2.205 pounds
km	Kilometer - approx 0.621 miles
kN	Kilo-Newton - approx 224.809 pounds force
kVA	Kilo Volt Ampere
kW	Kilo Watt
m	Meter - approx 3.28 feet
Mm	Millimeter - approx 0.0394 inches
ms	Millisecond
Pa	Pascal
rms	Root Mean Square Voltage
rpm	Revolution per Minute
V	Voltage
Vin	Input Voltage
Vpp	Peak to Peak Voltage
W	Watt (Power)

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14-I-02 THEORY OF OPERATION

14-I-02.01 General Description of the System

The main functions that the system is capable of performing are listed below:

- Communications and Video surveillance:
  - Cab to cab communications
  - Cab operator to passenger's communications or automatic announcements. via P.A. System
  - Communication between passengers and operator, on demand of passengers, in case of necessity
  - Passenger compartment video surveillance, with image recording

- Signs:
  - External visualization of destination station message
  - Internal visualization of next station and route messages
  - Visualization of information messages, manually edited by the operator

- Communication with the Way-Side:
  - Communications, by radio, from / to the ROC

The system has been developed in accordance with MTA P2550 requirements. Its functionalities can be grouped into the following blocks:

Public Address

- Audio announcement:
  - Communications from operator
  - Communications from MTA Central Control
  - Automatic announcements

- Visual announcement:
  - Destination information
  - Next Station information
  - Route messages
  - Service or Custom message

Intercom

- Cab-to-Cab Intercom
- Passenger Intercom

Video Surveillance

- Image acquisition
- Image recording

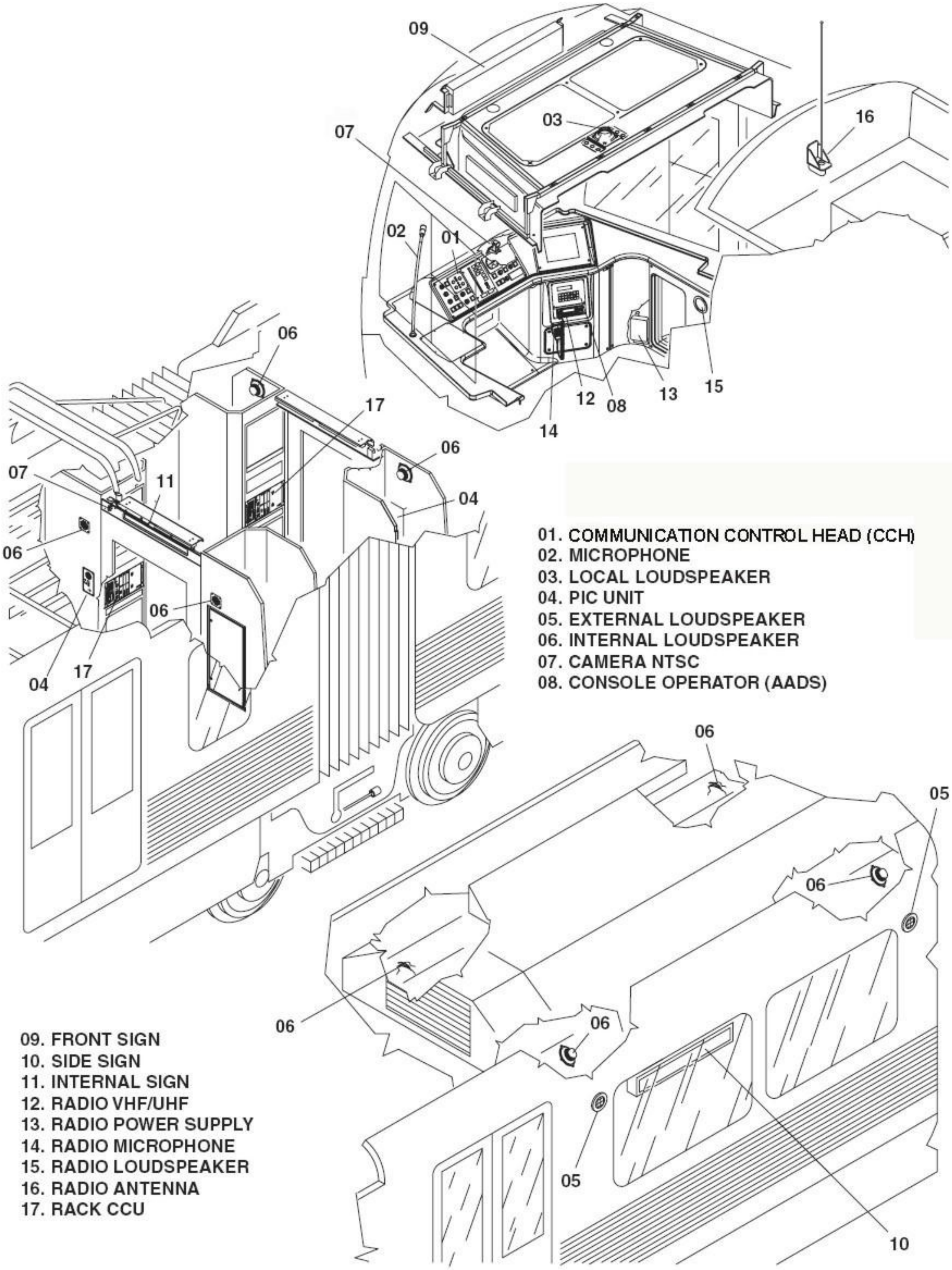

Figure 14-I-02.1 Communication System Components

Figure 14-I-02.2   System-Vehicle Relationship

The Communication System is linked to the other Vehicle Systems through the LVDS Relay Logic and is also directly connected to the TCU (Propulsion system) through an RS 485 connection.

The Communication system acquires the CAB Enable signal from the Operator Console (LVDS). Thanks to this signal, the Communication System knows where the Vehicle/Train Consist is operated from.

In a Train Consist, the Communication Systems of coupled vehicles must communicate one with each other.

The Coupling signal tells the CCU (Communication Control Unit) of the relevant Communication System to enable the communications between the coupled vehicles.

When an emergency is detected, the Image Acquisition (refer to paragraph 14-I-02.02.03.01) recordings will be recorded on a protected partition of the hard drive for 15 minutes.

An Emergency is detected through the following four status signals:

- Emergency Door Loop;
- EB Push Button;
- SCEB;
- Passenger Intercom Activated (PIC).

The Door Status and the ZeroSpeed Signals are used to automatically switch the Next Station Signal to the next step.

ii. System-Equipment Relationship

The “Brain” of the Communication System is the CCU (Communication Control Unit) (refer to paragraph 14-I-02.03.01).

Each CCU (one per Body Section) is connected with the following peripherals, pertaining to the same body section:

- CCH Console and Microphone: for the communications of the Operator (refer to paragraph 14-I-02.03.02);
- PIC for Operator-Passenger communications (refer to paragraph 14-I-02.03.03); -
AADS Alphanumeric console & Keyboard: to set the automatic announcements related to the trip (refer to paragraph 14-I-02.03.06);
- Radio: for radio communications with ROC (refer to paragraph 14-I-02.03.07);
- Video Cameras: to acquire images from inside and outside (refer to paragraph 14-I-02.03.05);
- Loudspeakers: for voice messages (refer to paragraph 14-I-02.03.04); -
Signs: for visual messages (refer to paragraph 14-I-02.02.01.02);
- GPS: for train positioning (refer to paragraph 14-I-02.03.08).

Figure 14-I-02.4 shows the Communication System components and the types of connection used in the Communication System for connecting the CCUs of the same vehicle (Ethernet) and the CCUs of coupled vehicles (RS485).

The CCU is connected with all its peripherals and with the relevant TCU (through an RS 485 connection).

It can be connected to the PTU through an RS 232 or an Ethernet connection.

All the CCUs of a Train Consist (up to eight, two per vehicle) are connected together. The two CCUs of the same vehicle are connected through their J2 and J3 connectors by means of two Ethernet cables.

The CCUs of coupled vehicles communicate through the Coupler using an RS 485 connection for digital signals (Connector J12) and four-pole shielded cable for analog signals (J4 Connector).

[redacted]

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iii. System Performances and Characteristics

The main RS485 line connects all signs, the AADS and the CCH console to the CCU. The Communication settings for this line are:

Baud rate: 9600 bps
Parity: none
Data bits: 8
Stop bits: 1
Communication type HALF DUPLEX

Messages exchanged through the RS485 connection are structured as follows:

Table 14-I-02.1 Main RS485 Message Structure

Byte position	Length (bytes)	Field code	Notes
0	1	STX	Identifies the beginning of each frame
1	1	ID_S	ID of the sender device
2	1	ID_D	ID of the destination device
3	1	CMD	Command ID
4	1	LEN	Number of data bytes eventually following. Its value can be 0 if the command has no data.
5	0..n	DATA	Data
5 + LEN	2	CRC	CRC (computation algorithm)

System Storage Devices:

The Hard Disk installed on the CCU board has a capacity of 40Gbytes.

- 1 Gigabyte FAT partition: It contains audio files, text files, system logs. It is not encrypted, and can be accessed by maintenance crew from the PTU through the Ethernet port to add, modify and/or delete files. The files are organized in directories;
- 2.5 Gigabyte RCB emergency video partition: it is a proprietary format which prevents unauthorized access from the exterior. It can be written only by system software and read by Public Net Safe program in order to examine and export video recordings;
- 36 Gigabyte RCB standard recording partition: it contains standard recordings and, like emergency RCB partition, it cannot be directly accessed.

The flash memory contains some initialization files only, since its storage space is much smaller then the hard disk, access is very slow, and this kind of devices is not good for continuous reading and writing operations.

At system startup, initialization files are read and stored in the system RAM, which offers extremely faster run time access.

14-I-02.02 System Operation

14-I-02.02.01 Public address

The public address feature is meant to provide route information and custom messages to passengers.

14-I-02.02.01.01 Audio Announcement

Audio announcements are managed by the PA system. Sources of the audio announcements are:

- Microphone, pre-amplified on the CCH
- Radio, pre-amplified on the CCH
- Pre-recorded messages stored on the CCU

All sources will be routed after conditioning to the selected PA amplifier with a standard level of 2 Vrms.

Power level can be separately adjusted between exterior and interior audio lines.

Maximum output power is 28 Watt per audio amplifier. Nominal audio line level is 100 Vrms.

a) Communications from the Operator

The operator can make announcements to the passengers by means of the cab gooseneck microphone (refer to Figure 14-I-02.5).

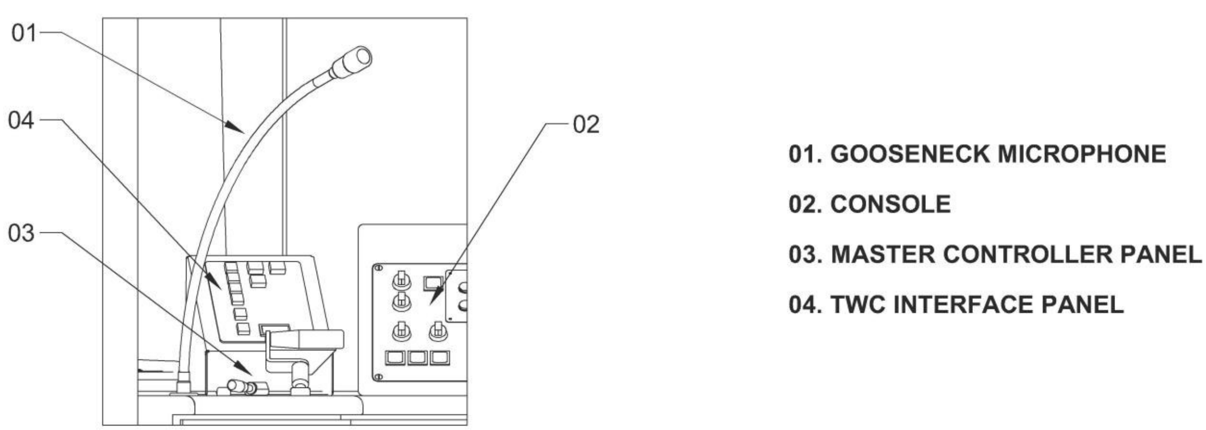

Figure 14-I-02.5 Gooseneck Microphone

To this purpose, the operator must select PA on the MODE selector and MIC on the RADIO/MIC selector on the CCH panel (refer to Figure 14-I-02.6), when the PTT button is pushed (refer to Figure 14-I-02.7), the communication is established and routed by the CCU to the speaker line selected on the CCH panel.

The communication is stopped when the PTT button is released.

To route the PA vocal announcement to the interior or exterior or both loudspeakers, the operator must select INT, EXT or ALL respectively, on the CCH speaker selector.

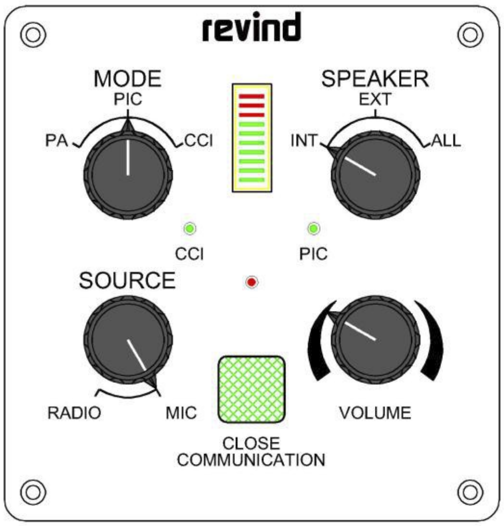

Figure 14-I-02.6 Communication Control Head - CCH

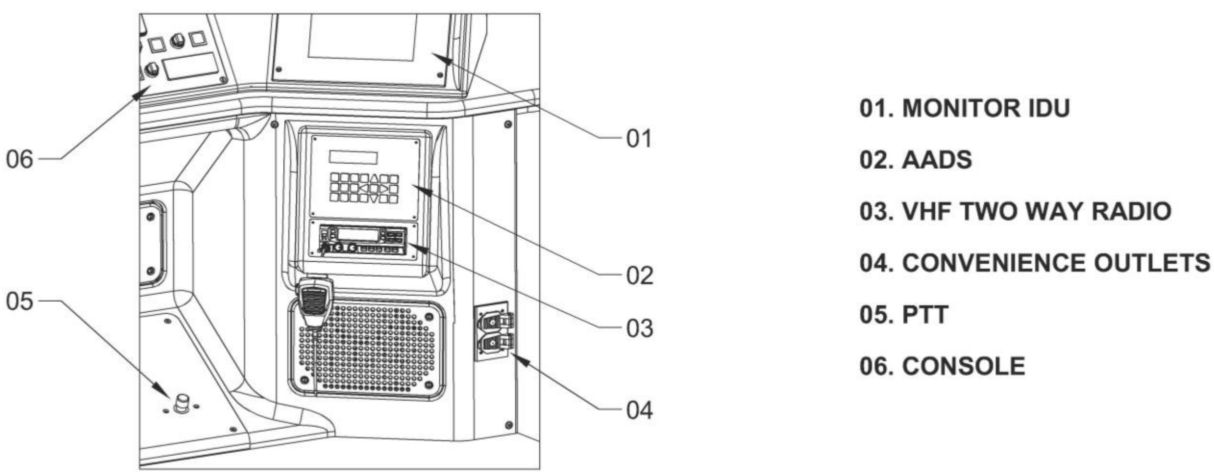

Figure 14-I-02.7 PTT Button

b) Communication from ROC

MTA Central Control (ROC) can make announcements to the passengers via radio.

To do that the operator must select PA on the MODE selector and RADIO on the RADIO/MIC selector on the CCH panel.

When a radio audio output signal is present the communication is established and routed by the CCU to the speaker line selected on the CCH panel.

c) Automatic Announcement

The PA system is capable of issuing automatic announcements by means of prerecorded audible messages of the stations for current route and service or custom messages.

The audible messages are stored in the CCU in MP3 format.

The AADS (refer to Figure 15-01.16) will allow the selection from a route list, service or custom messages list, input train ID number and input operator ID number.

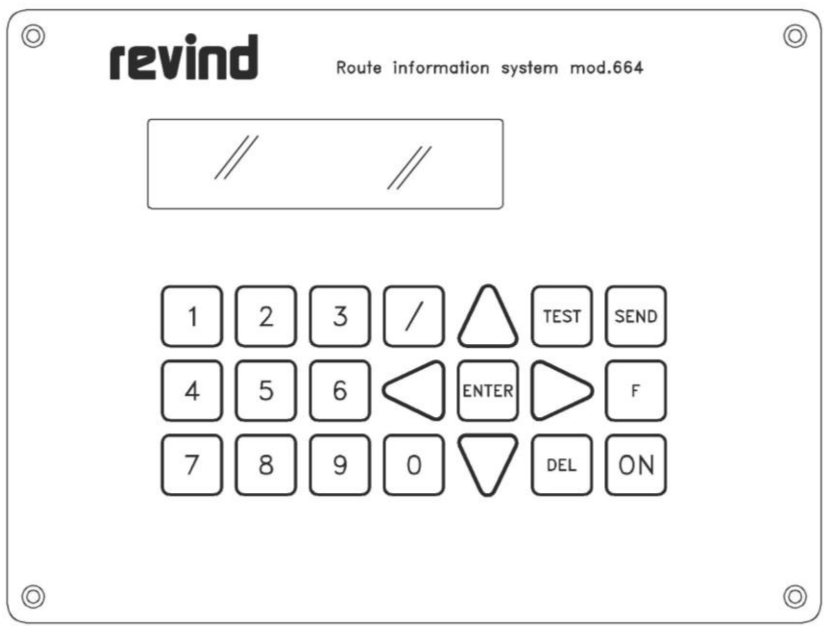

Figure 14-I-02.8 Automatic Announcement and Display System - AADS

14-I-02.02.01.02 Visual Announcement

The system is capable of showing station and destination messages and service or custom messages.

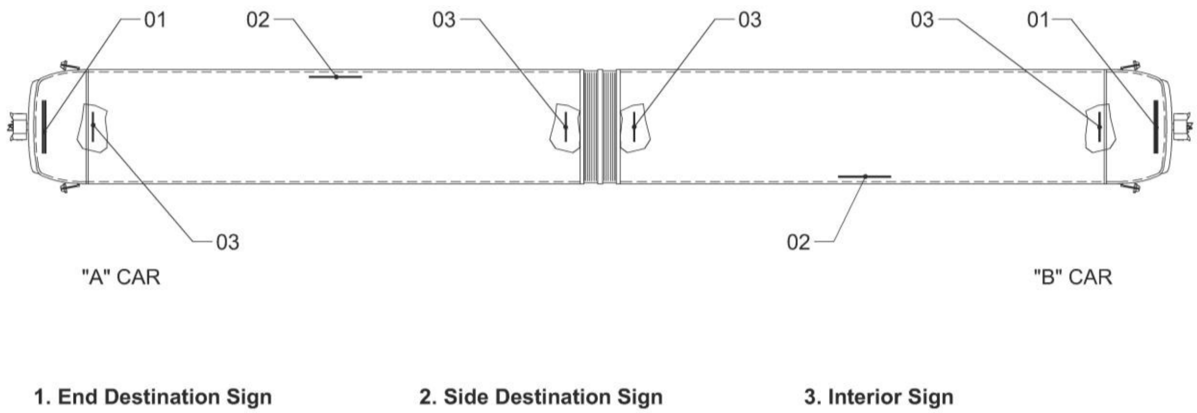

Figure 14-I-02.9 Destination Sign Location

a) Destination Information

When the route has been selected by the operator, the destination message will be displayed on the End Destination Signs and Side Destination Signs.

The destination message will change only when the operator selects another route.

The Side Destination Signs and End Destination Signs can display Public service messages and custom messages.

b) Next station information

When the route has been selected, as soon as the next station message is generated, the Interior Signs will display it.

Next station visual and audible messages are synchronized.

At every message change, a flashing message is activated to alert passengers that a new message has been displayed.

c) Route Messages

At start-up, the last stored route will be visualized on the display.

The operator may scroll the route list by means of the AADS UP/DOWN arrow keys and then select the desired route by pressing ENTER or by editing directly the two-digit ID number and pressing ENTER.

When a route has been selected, the next station is visualized on the display.

Each next station announcement shall be manually triggered by the operator by pressing SEND; the related audible message will automatically be routed to the interior loudspeakers.

The AADS display will then be prearranged with the destination message so that the operator may broadcast it when stopping at the station.

The destination audible message will automatically be routed to the exterior loudspeakers.

After the destination announcement has been broadcasted, the AADS display will be prearranged with the next station message for the next announcement.

Prearranged messages, stations and destination, may be skipped by means of the UP/DOWN arrow keys.

d) Service or Custom Messages.

When AADS is displaying service or custom messages, the operator may scroll them by means of the UP/DOWN arrow keys, announcement shall be manually triggered by the operator by pressing SEND.

14-I-02.02.02 Intercom

The intercom system is meant to allow the vocal communication between cabs and between passengers and the operator.

14-I-02.02.02.01 CAB to CAB Intercom

To initiate a CAB to CAB Intercom communication the operator must enable (Keyed On) the train cab, then select CCI on the MODE selector on the CCH panel and momentarily press the PTT button.

An alert tone will be generated in the other cab and CCI lamp will lit.

To answer, the operator in the called cab must select CCI on the MODE selector on the CCH panel and press the PTT button.

The communication is half duplex to avoid audio interferences in the cab.

When the PTT button is pushed, the microphone is connected to the line, when the PTT button is released, the microphone is disconnected and cab loudspeaker is connected.

To end the communication one of the interlocutors must press the "CLOSE COMMUNICATION" button on the CCH panel.

14-I-02.02.02.02 Passengers Intercom

Passengers can communicate with the operator by means of the PIC unit installed in the passenger compartment after enable (Keyed On) the train cab.

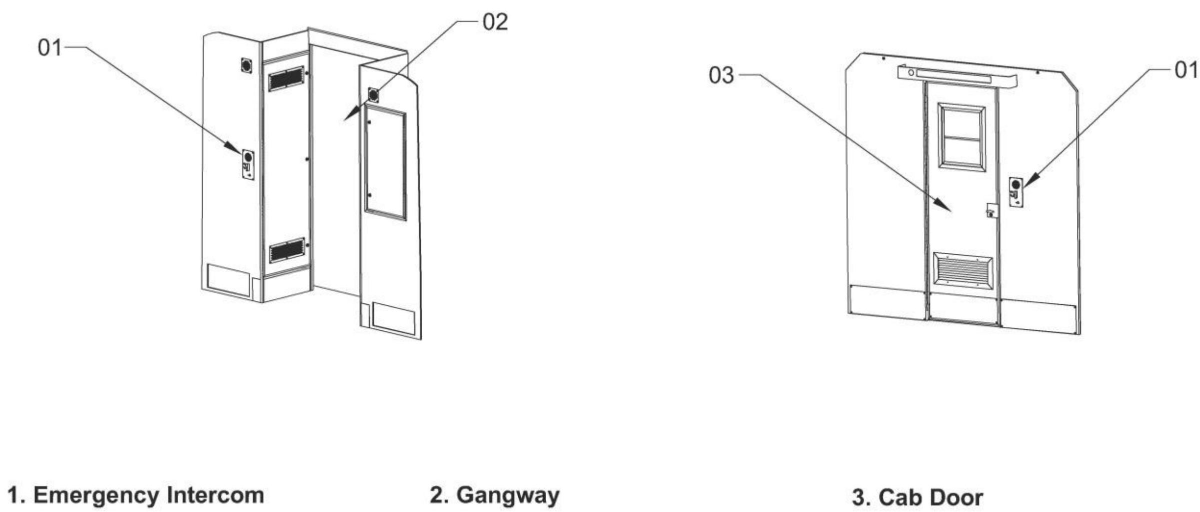

Figure 14-I-02.10 Passenger Intercom Location

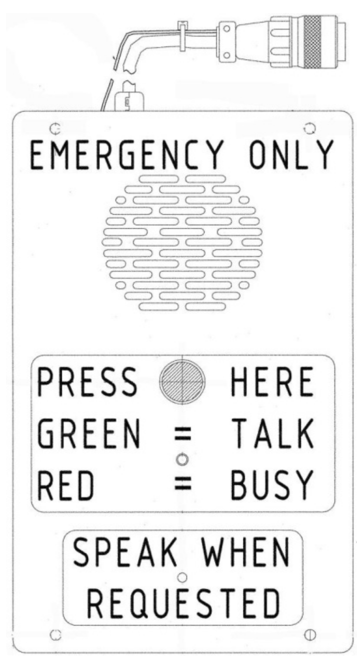

Figure 14-I-02.11 Passenger Intercom

As soon as a passenger presses the “CALL OPERATOR” button, an alert tone is generated inside the active cab on the PIC unit and the PIC lamp switches on.

To enable communication and answer, the operator must select PIC on the MODE selector on the CCH panel and press the PTT button.

An engaged line signal is visualized by means of a LED on the PIC unit panel.

The passenger and the operator can only speak in turn.

The communication can be terminated by the operator by pressing the “CLOSE COMMUNICATION” button on the CCH panel.

14-I-02.02.03 Video Surveillance

The video surveillance function is carried out by means of video cameras installed in the passenger compartment (four, two in each car section) and (one) behind the windshield.

14-I-02.02.03.01 Image Acquisition

The CCU has images acquisition capabilities.

Cameras are connected to the CCU via a video line.

Images acquisition normally operates at 8 frames per second for both the passenger compartment and the cab.

14-I-02.02.03.02 Image Recording

Images are recorded on the removable hard disk with a circular buffering method which overwrites oldest images when disk space goes below a certain threshold.

Recording capacity will permit a minimum of 130 hours of continuous recording at 2-frame per second from each cameras.

Each image has the following text information overlaid:

- Camera ID;
- Date and time;
- Train ID.

14-I-02.02.04 Data Organization and Technical Requirements

The system can mainly deal with two kinds of information flow:

- direct vocal communication (P.A., cab-to-cab, Passenger Intercom)
- recorded visual and audio messages: station names (e.g.: “El Segundo”), generic messages used by the system to manage trip annunciations (e.g.: “Next station is”, or “This is the last station”) and public service messages (e.g.: “We remind passengers that smoking is not allowed… etc”)

This organization of data allows the maximum system flexibility: each message is as short as possible, and when the playing of several messages in sequence is required, this can be obtained by means of associations contained in other text files, managed either by means of a simple text editor or by means of an external user-friendly application.

Messages are identified by a numeric code and stored in suitable directories on the hard disk. Service messages and generic messages are identified by different ranges of values and stored in different directories.

14-I-02.02.04.01 Trip Database Organization

The Trip Database is realized by means of text files, stored in the /trip directory of the Hard Disk, made up of several fields per line. Commas separate fields.

These files are:

- **stations.dat**: this file contains the list of all known stations, with information coded into 7 fields;
- **lines.dat**: this file contains the list of all known lines;
- **route.dat**: it is the list of all routes (a list of stations the train will reach) for all lines;
- **sequence.dat**: for each station, the default audio messages played are: chime and “next station is” + station name. Some station requires more messages to be played: e.g. “this is the end of green line”, “all passengers please exit” etc. The system can deal with these requirements checking, for each station, if the station code is present in sequence.dat, and playing up to five more messages after the station name.
- **[route file name].trt**: it is the sequential list of all the stations which compose a route;
- **genmsg.dat**: this file contains the list of all known generic messages, which can be played in message sequences (e.g.: “This is the last station”, “All passengers please exit” etc.);
- **srvmsg.dat**: this file contains the list of all known service message, which can be played when they are selected from the AADS (e.g.: “We remind passengers that smoking on the train is strictly forbidden”), or simply displayed (e.g.: “Out of service”) or both (e.g. “Train service has been suspended”);

14-I-02.02.04.02 Audio Database Organization

The system uses .wav audio files to play automatic audio announcement, service messages etc.

Audio software can manage two kinds of files, both in .wav format:

- 48 KHz, PCM standard, 16 bit, mono
- same format converted to IMA ADPCM standard, which takes only ¼ of the PCM space

To maximize system performance, all audio files are stored into RAM at boot time.

This ensures instant reaction to play commands issued by software, but uses a lot of system RAM, which is needed also by other processes.

To keep memory occupation as low as possible, IMA ADPCM standard is used for audio files, and comparison between PCM and IMA ADPCM shows no audible differences in system announcements.

14-I-02.02.04.03 System log files

Important system events like faults, alarm etc. are recorded in ASCII log files, stored in the Hard Disk in /System_logs directory.

At boot time, files in /System_logs directory are purged, and only the most recent 5 are kept. Names of log files uniquely identify the CCU, date and time they were created (e.g.: 2006-02-09_10-57-48__159706__2.log, where:

- 2006-02-09_10-57-48 is the system startup date and time
- 159706 is the CCU board serial #, as reported from maintenance program TestRackPC - see MN710-03.doc
- 2 is the CCU hardware SELECT key, as reported from maintenance program TestRackPC.

Each line of a record files contains the date and time the event took place, like in the following example:

2005-12-09 08:45:32 - System UP

2005-12-09 08:45:35 - STATUS for ID=4 [FRONT PANEL] set to FAULT

2005-12-09 08:45:36 - STATUS for ID=2 [INTERNAL PANEL 2] set to FAULT

2005-12-09 09:01:12 - STATUS for ID=2 [INTERNAL PANEL 2] set to FAULT

2005-12-09 09:04:39 - Start alarm - passenger intercom

14-I-02.03 System Components

The complete system (one vehicle) is made of the following items:

Communications and Video surveillance

- Two Communication Control Unit (CCU), one per Electronic Locker;
- Two Communication Control Head (CCH), one per Cab;
- Two microphones, one per Cab;
- Four PIC units, two per Body Section;
- Two cab loudspeakers, one per Cab;
- Eight exterior loudspeakers, four per Body Section;
- Twelve interior loudspeakers, six per Body Section;
- Six cameras, three per Body Section.

Signs:

- Two Automatic Announcements and Display System (AADS), one per Cab.
- Four announcement signs, two per vehicle.
- Two side destination signs, one per vehicle.
- Two end destination signs, one per vehicle.
- Communication With Ground
- Two TK-790 radios, one per Cab.
- Two radio power supplies, one per Cab.
- Two antennas, one per vehicle.
- Two radio loudspeakers, one per Cab.

Figure 14-I-02.12 shows the system block diagram.

[redacted]

14-I-02.03.01 Communication Control Unit (CCU)

A block diagram of the CCU is shown in Figure 14-I-02.13 below.

CCU is made up of a standard 19" rack (6U) fitted with the following boards:

- DC/DC converter, supplying the main 24VDC voltage, +15 and -15VDC service voltages for the system.
- PA final amplifiers, giving the due audio signal amplification for the loudspeakers.
- Each amplifier has a volume control to adjust separately PA power output between interior and exterior loudspeakers.
- Audio router, giving all combinatorial commutation decoding for the communications management, and routing to the train audio interface PA and intercoms lines.

The Audio Router functional block diagram is shown in Figure 14-I-02.14.
The CPU board manages:

- Digital communication to other units in the same vehicle by means of the main RS485 serial line and analog signals.
- Digital communication to CCU of the other vehicle by means of Ethernet line.
- Signal acquisition from field: cab key switch, speed, coupled train and doors status.
- Digital communication to coupled train by means of the coupler RS485 serial line.
- Digital communication to TCU by means of the diagnostic RS485 serial line.
- Images acquisition and recording from security cameras.
- Audio synthesis for automatic announcements.
- Encoding and decoding of PA and Intercom audio signals for audio data exchange between vehicles.

This board is equipped with a 40 GByte removable hard disk.

[redacted]

[redacted]

14-I-02.03.02 Communication Control Head (CCH)

Figure 14-I-02.15 Communication Control Head (CCH)

The CCH is interfaced to the CCU by means of the main RS485 serial line and analog signals, to the microphone, to the radio, to the PTT switch and silent alarm switch.

It is made up of:

- PA Speaker selection: Internal / External / All;
- PA Audio Source selection (Mic/Radio);
- MODE selection: PA, Passenger Intercom, Cab-to-Cab;
- Cab Speaker volume regulation;
- Close Communications Button;
- Warning LEDs for passenger Intercom request, Cab-to-Cab request, Silent Alarm activation;
- LED bar for microphone input audio level verification.

The CCH manages:

- Operation mode selection between PA, PIC and CCI;
- PA source selection from radio and microphone;
- PA routing between loudspeakers: interior, exterior and all;
- Volume control for cab loudspeaker;
- Forwarding to the radio of the silent alarm request;
- Audio signal exchange with the CCU;
- PA level displayed by a VU audiometer;
- PIC and CCI request alert by related lamp and an audible tone on the cab loudspeaker.

[redacted]

14-I-02.03.03 Passenger Intercom Unit (PIC)

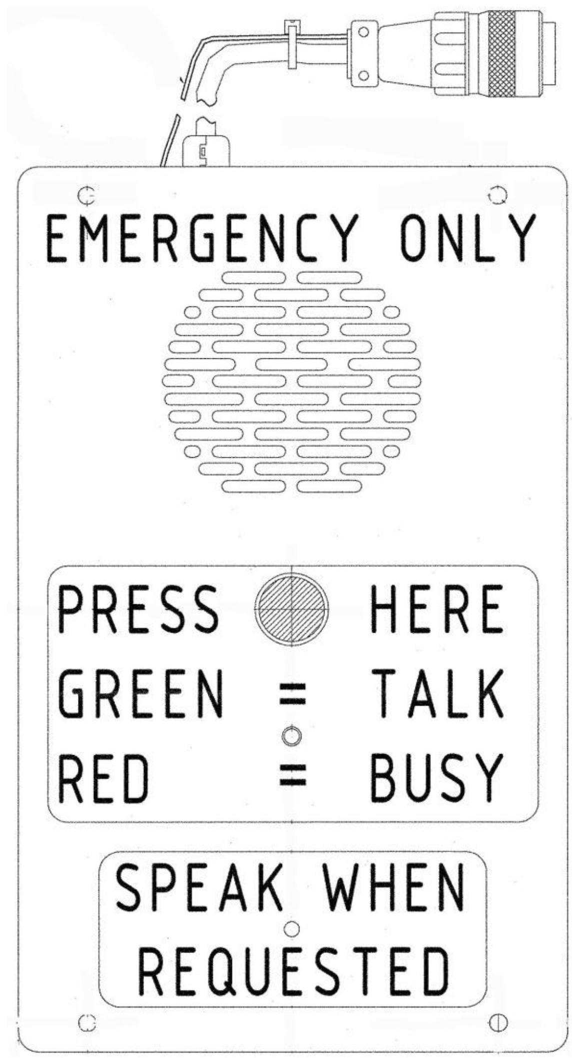

Figure 14-I-02.17 Passenger InterCom - PIC

Each Vehicle is equipped with four PICs, two per car body section.

The PIC unit is a Security Device and is interfaced to the CCU by means of audio and control signals. It manages:

- Intercom communications between passengers and the operator.

A functional block diagram of the PIC unit is shown in Figure 14-I-02.18.

[redacted]

14-I-02.03.04 Loudspeakers

All loudspeakers, except the ones in the cabs, are interfaced to the CCU by means of the isolated 100 V audio lines.

Cab loudspeakers are directly driven from the audio router amplifier.

Interior loudspeakers have 4 taps for power adjustment: 0.25, 0.5, 1, 2 Watt.

External loudspeakers have 3 taps for power adjustment: 1.5, 3, 6 Watt.

14-I-02.03.05 Video Cameras

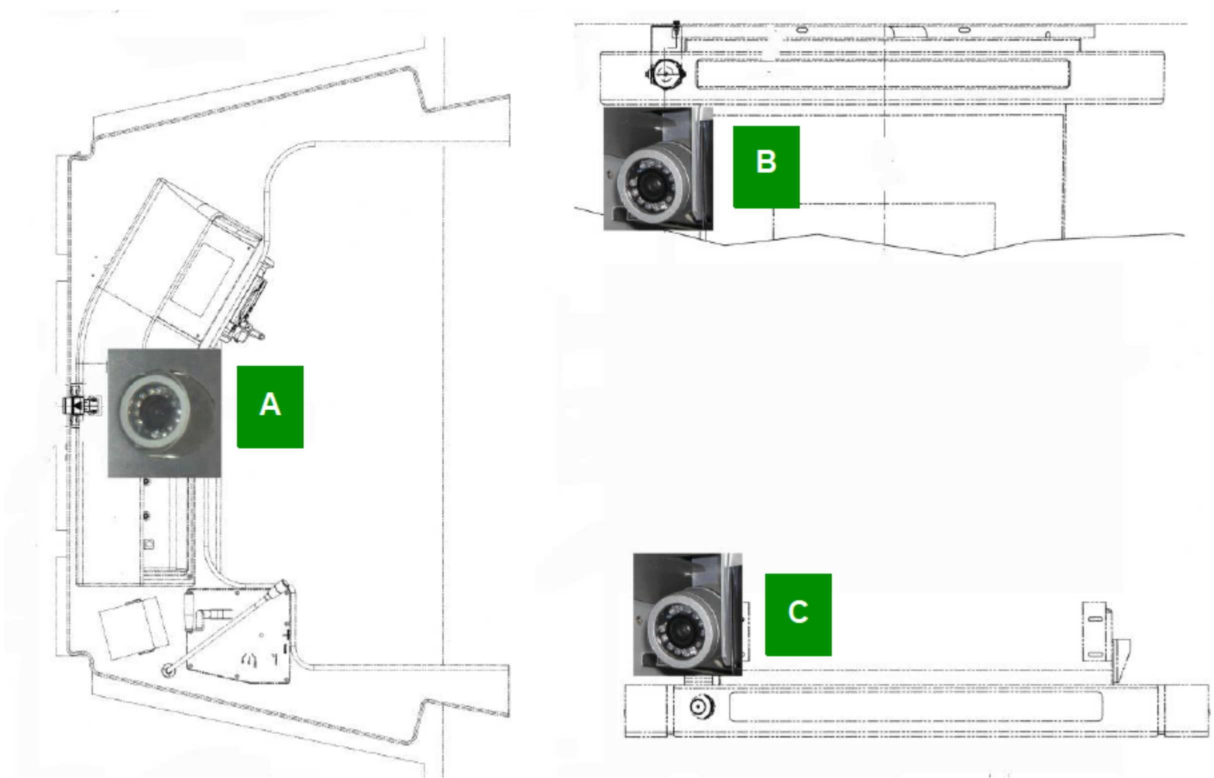

Figure 14-I-02.19 Video Cameras - Location

All cameras are interfaced to the CCU by means of the analog video out line.

Cameras can operate with an environment light down to 0.5 lux @ f=2.

The camera is equipped with a 1/3" CCD.

The CCD diagonal is 1/3" @ 8.5 mm and the aspect ratio is 4/3, therefore horizontal side is 6.8 mm and vertical side is 5.1 mm.

Three Cameras are installed in each Body Section:

- One (A) in the Operator cab, for the view from the cab to the tracks;
- One (B) over the cab door, for the view of the passenger compartment from the cab side;
- One (C) over the aisle, for the view from the aisle towards the cab.

14-I-02.03.06 Automatic Announcement and Display System (AADS)

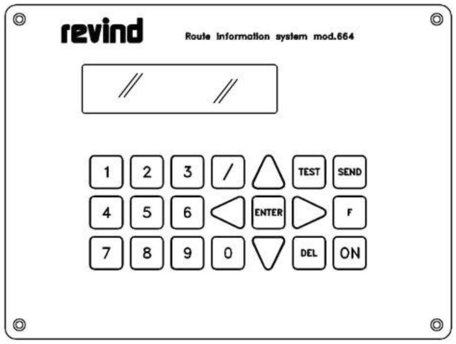

Figure 14-I-02.20 AADS Photograph

AADS is interfaced with the CCU by means of the main RS485 serial line, it manages:

- Route selection and initialization;
- Station selection inside the current route;
- Service and custom messages selection;
- Train and operator ID input;

These operations are performed by means of a keyboard and an alphanumeric display (refer to Figure 14-I-02.20).

A functional block diagram of the AADS is shown in Figure 14-I-02.21 below.

All signs are interfaced to the CCU by means of the main RS485 serial line.

All signs are equipped with alphanumeric transflective LCD. They are back-lit showing yellow fonts on a black background.

There are three types of signs:

- End destination sign.
- Side destination sign.
- Announcement sign.

The messages displayed are:

- The final destination of the selected route on the End and Side destination signs.
- Next station and Public services messages on the announcement signs.

The functional block diagrams of all kind of signs are shown in the following (Figure 14-I-02.22, Figure 14-I-02.23 and Figure 14-I-02.24).

[redacted]

[redacted]

[redacted]

[redacted]

14-I-02.03.06.01 Using the AADS - Menu Navigation and Selections

Many important functions of the PIS (Passenger Information System) are controlled through the AADS.

The navigation through the AADS menus is schematized in Figure 14-I-02.25 (without GPS) and Figure 14-I-02.26 (with GPS).

The following Table 14-I-02.2 help understanding how to use the AADS keys and the meaning of the displayed texts:

- The first line of the display specifies the current menu (“MAIN MENU”), the type of action required (“SEL END STATION”) or the message ready to be played (“NEXT STATION”)
- The second line normally is an item of a list (e.g.: list of stations, list of messages).
- Sometimes, the second line is used to input data (e.g.: Train ID or Operator ID)
- Sometimes the two lines are used to display an error message (e.g.: “*** ERROR ***” / “AUDIO BUSY”) or to confirm that a requested action is in progress (“Executing” / “Please wait”)

Table 14-I-02.2 AADS Keys

KEY	Meaning
<ENTER>	(when scrolling menus): Select the current menu option (when inserting data): Input completed (when scrolling list of data, such as stations): Select current data item (only when first line shows “THIS STATION”): Skip “THIS STATION” announcement and go directly to “DESTINATION” announcement)
<up arrow>	Scroll up the list of data displayed on the second line
<down arrow>	Scroll down the list of data displayed on the second line
<left arrow>	Return to previous menu level
</>	Return to MAIN MENU window
<SEND>	When AADS is displaying the “NEXT STATION” menu window, this will cause the current “next stop” visual and audio announcement to be played. When AADS is displaying “THIS STATION” menu, <Send> plays the opportune audio message and sets the menu to “DESTINATION” When AADS is displaying “DESTINATION”, <Send> plays the opportune message and leaves the same menu, until the train moves. If current window is “Service messages”, the selected message will be displayed on the internal signs and, if the corresponding audio file exists, the CCU will play a chime and then the audio file content according to the speaker selection knob on the CCH panel.
<F>	If AADS is displaying the “next station” menu window, <F> key toggles the “mute” function. The menu headline will display (M) to remind user that muting is active.
<ON>	(ONLY FOR MAINTENANCE OR TEST PURPOSES BY MAINTENANCE CREW - normally the shutdown function is automatic): Allows starting the shutdown procedure. Shutdown is used to turn off the PIS system during tests, to avoid file system corruption which may happen if power supply is simply turned off.

[redacted]

Figure 14-I-02.25 AADS Menu Functional Schematic

[redacted]

14-I-02.03.07 Radio Assembly

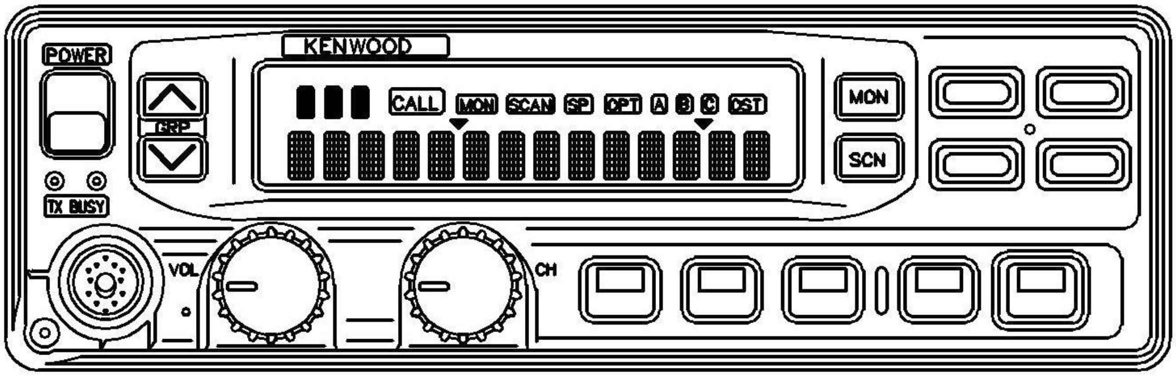

Figure 14-I-02.27 Radio Photograph

The radio TK-790 (refer to Figure 14-I-02.27) is a component produced by Kenwood and bought by the builder under MTA specifications.

The TK-790 radio is interfaced to the CCH by means of audio signal and control signals, it manages:

- Two-way communication between the operator and ROC.
- One way communication from ROC to the passengers by means of the PA system.
- Emergency calls activated by the silent alarm contact.

The radio power supply is a fully isolated DC/DC converter able to supply a nominal voltage of 13.6 Vdc and a maximum current of 25 Amp to the TK-790 radio.

The antenna is mounted on the vehicle roof and it is able to work in railway environment.

The loudspeaker is connected directly to the radio and is independent by the system amplifiers.

A functional block diagram of the Radio assembly is shown in Figure 14-I-02.28.

The Radio Antenna (18.3 inches high) is located on the vehicle roof above the Operator Cab, on both sides (refer to Figure 14-I-02.29).

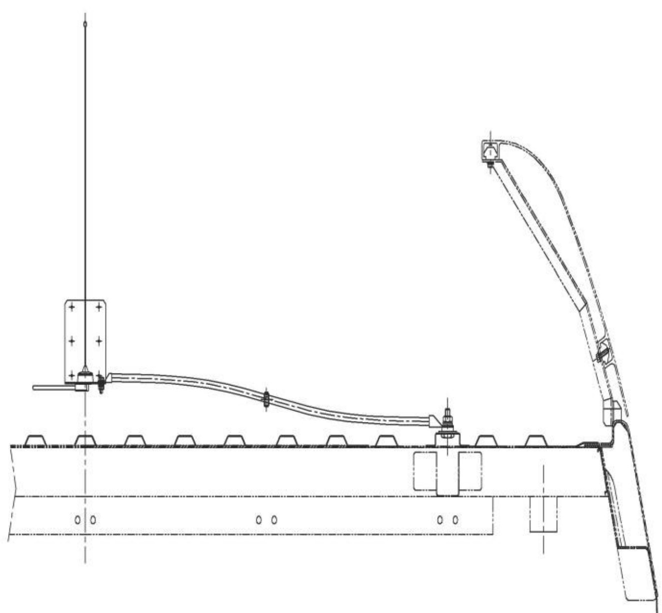

Figure 14-I-02.29 Radio Antenna

14-I-02.03.08 GPS System

The GPS (Global Positioning System) is a satellite navigation system which relies on a constellation of more than two dozen satellites broadcasting precise timing signals by radio to GPS receivers, allowing them to accurately determine their location in any weather, day or night, anywhere on Earth.

GPS also provides a precise time reference.

GPS has become a widely used aid to navigation worldwide, and a useful tool for mapmaking, land surveying, commerce, and scientific uses.

The PIS system uses the following information for trip control and time synchronization:
- Coordinates (expressed in X, Y, Z form)
- Time reference (year, month, day, hour, minutes, seconds).

The GPS is connected to the RS485 “A” line of the CCU.

The GPS Antenna (refer to Figure 14-I-02.30) is located above the ceiling of the Operator Cab in the A Body Section.

14-I-02.03.08.01 Trip Management with GPS

a) Data exchange between GPS, CCU, TCU.

When the GPS is active and reliable, CCU continuously transmits to TCU the coordinates of the current vehicle position (used for event log purposes) as well as information of date and time.

The PIS can’t rely only on GPS data for trip management, because some areas can have a poor signal reception or even a complete lack of signal (tunnels, underground paths etc.).

To maintain a good trip management capability even when GPS is not available or reliable, the CCU receives the current vehicle speed from TCU.

Since the CCU knows, together with the coordinates of each station, also the distance between the different stations, it can evaluate the tram position using either the coordinates from GPS or the speed information from TCU.

This leads to several possible scenarios, described below.

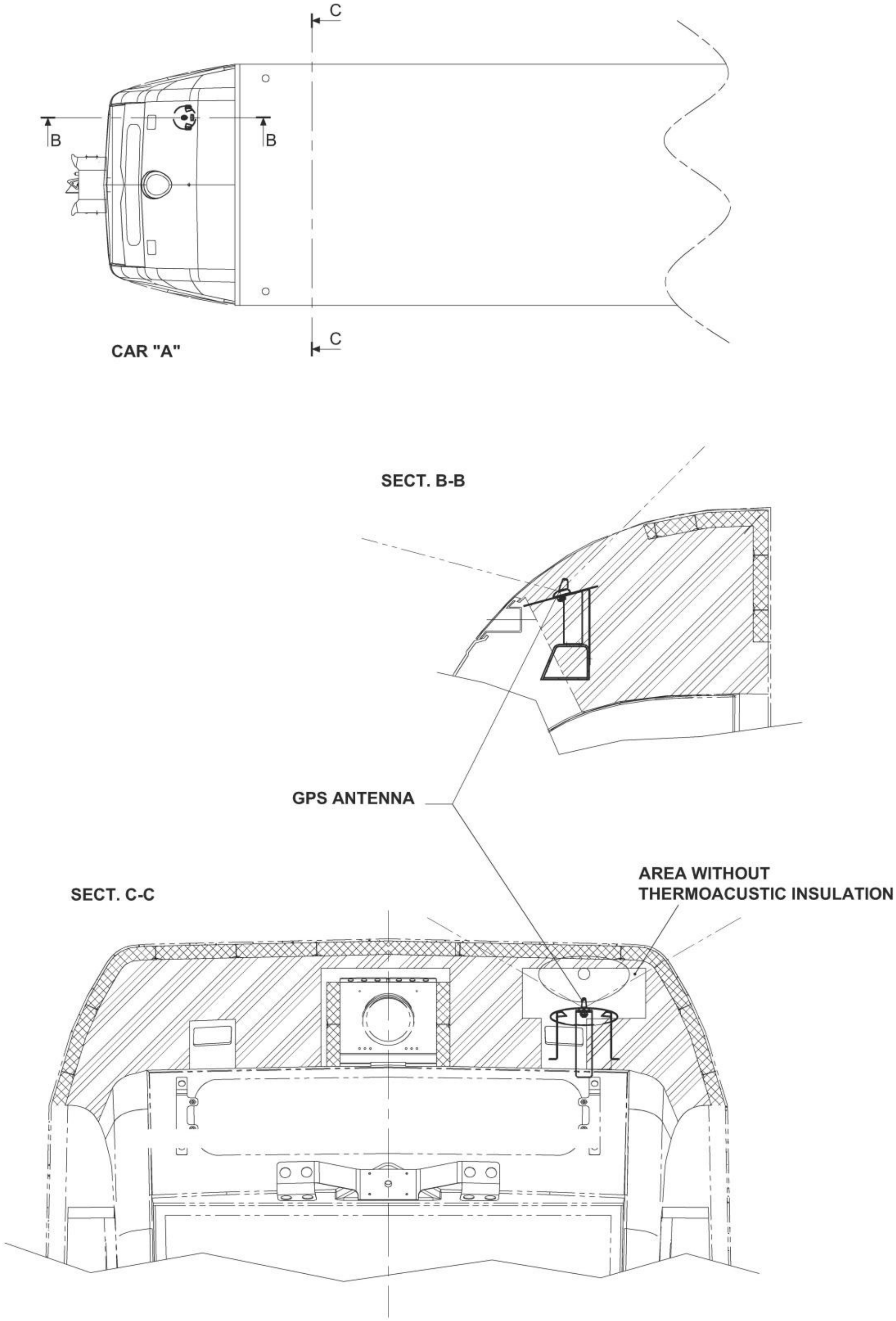

Figure 14-I-02.30 GPS Antenna

[redacted]

b) Information available to CCU for trip management

As seen above, CCU obtains data for trip management from GPS and / or TCU, in form of "dynamic" information:

- Coordinates
- Vehicle speed.
- CCU uses for GPS management other "static" information stored in the flash memory. For each LINE and ROUTE selected, CCU knows:
- Foreseen sequence of stations
- Coordinates of each station
- Distance between stations
- Platform length of each station
- If each station is actually a foreseen stop or is temporarily suppressed

Trip management must consider several scenarios related to GPS fault and TCU fault: the following paragraphs detail how the system reacts to each condition.

c) Different scenarios for trip control activities

As it happens for the vehicle configuration without GPS and speed info from TCU, at system startup the driver must use AADS to:

1. Insert Train ID and Operator ID.
2. Select a LINE.
3. Select a ROUTE.
4. Choose the actual first and last station of the ROUTE if different from the normal ones.
5. Select the stations “disabled” (if any).

The subsequent operations differ in accordance with the possible scenarios.

[redacted]

In this case, from the point of view of trip management, the status of the TCU is not vital, since all required information come from GPS.

If TCU is available, however, speed info is used to keep the system ready to switch to semi-automatic management.

The main steps performed by CCU software in this case are:

1. Read coordinates from GPS.
2. Compare coordinates obtained from GPS with those of the foreseen next station, and compute the distance which separates the train from the next station.
3. Use data transmitted from TCU, if available, to compute the distance covered from the previous station. This will be used in case of GPS fault or lack of signal for switching to semi-automatic management.
4. If the distance is decreasing, when it reaches a predefined threshold, issue the audio message announcing the arrival at the station, and write the name of the station in the internal displays. If the distance is increasing, this means that the expected station has been skipped and the following station of the database becomes the expected next station.
5. When the train stops and opens the doors, the information of distance from previous station covered is reset.
6. When the train closes the doors and accelerates, after the distance from the previous station has reached another predefined threshold, the system issues the message “The next stop is…” to speakers and displays.

[redacted]

Figure 14-I-02.33 Semi-Automatic Management

In case GPS is out of order, or not reliable due to insufficient number of ‘seen’ satellites, the system will lack the information of coordinates, date and time.

Date and time are not vital, because they are known by the TCU, so TCU can supply CCU with those info as it already happens for trams without GPS.

The lack of coordinates doesn't allow the system to be aware of its actual position between two stations of the route, unless it uses the speed information from TCU.

In this case, it is able to compute the distance covered in the time interval between two readings from TCU with the formula:

Distance = reported speed * time interval between readings

Opportunely trimming the time interval between two readings from TCU will increase the precision of the evaluation.

The main steps performed by CCU software in this case are:

1. Read speed from TCU.
2. Use datum to compute the distance covered from the previous station.
3. When the difference between the known distance between previous and next station reaches a predefined threshold, issue the audio message announcing the arrival at the station, and write the name of the station in the internal displays. If the evaluated distance becomes greater than the known distance, this means that the expected station has been skipped and the following station of the database becomes the expected next station.
4. When the train stops and opens the doors, the information of distance from previous station covered is reset.
5. When the train closes the doors and accelerates, after the distance from the previous station has reached another predefined threshold, the system issues the message "The next stop is…" to speakers and displays.

[redacted]

In this case, the trip management is completely manual.

After the initial input of Train ID, Operator ID, LINE selection, ROUTE selection and selection of active stations, the flow of operations follows the schema described in “AADS Menus - MANUAL mode functional schema”.

The operator controls the emission of audio messages (only the announcement of destination is generated automatically after the “THIS STATION” message).

The system changes automatically the indication of “NEXT STATION” on the AADS display when train leaves each station after it has stopped.

- Time synchronization
- GPS active: The date and time information are given by GPS and shared between the two CCUs of the same vehicle by means of the Ethernet line. Each CCU, when polled by its TCU, sends the date and time info to the TCU itself.
- GPS not active: Normally, each rack receives the correct time info via TCU and, if necessary, regulates its internal clock. If one TCU fails, the time stamp is received via Ethernet from the second CPU. If both TCUs in one vehicle have a failure, the real-time clock in each CPU will give the time stamp.

- System restart

If the system, for any reason, has to be restarted in any point of the route, the operator must insert, as usual, Train ID and Operator ID, and select the correct LINE and ROUTE by means of the AADS.

Due to the need of operating with AADS, it is assumed that these operations will take place with the train stopped in one station.

To make system restart independent from GPS and TCU status, the operator, after selecting the ROUTE, must select the actual first station corresponding to the one in which the train is stationary.

d) Position Computation Algorithm

X, Y, Z coordinates allow an easy computation of the distance between two generic points P1 (x1, y1, z1) and P2 (x2, y2, z2), given by the formula:

$$\text{dist} = \sqrt{(x1-x2)^2+(y1-y2)^2+(z1-z2)^2}$$

e) GPS Information Stored Into Log Files

When an alarm condition is detected, the GPS coordinates, if GPS is working correctly, are added at the end of the alarm message recorded into system logs to allow identification of the vehicle location at the moment the alarm.

f) CCU Software Architecture, GPS task

The operating system on the CCU board allows preemptive multitasking.

The software is organized in tasks, and different tasks can share message queues and global variables to allow easy information exchange.

The task dealing with GPS data acquisition continuously polls the GPS and obtains coordinates, date and time.

This information are stored in a shared memory area, and made available to other tasks through a so-called “semaphore” technique which prevents false acquisitions.

14-I-03 APPENDIX

14-I-03.01 Ingress Protection Ratings (IP Codes)

Table 14-I-03-1 Ingress Protection Ratings (IP Codes)

Ingress Protection Classification			
First Digit		**Second Digit**	
IP	**Protection Provided**	**IP**	**Protection Provided**
0	No Protection	0	No Protection
1	Protected against solid objects up to 50mm e.g. accidental touch by hands	1	Protected against vertically falling drops of water e.g. condensation
2	Protected against solid objects up to 12mm e.g. fingers	2	Protected against direct sprays of water up to 15 deg from the vertical
3	Protected against solid objects over 2.5mm e.g. tools	3	Protected against direct sprays of water up to 60 deg from the vertical
4	Protected against solid objects over 1mm e.g. wires	4	Protected against water sprayed from all directions - limited ingress permitted
5	Protected against dust - limited ingress (no harmful deposit)	5	Protected against low pressure jets of water from all directions - limited ingress permitted
6	Totally protected against dust	6	Protected against strong jets of water e.g. for use on shipdecks - limited ingress permitted
		7	Protected against the affects of immersion between 15cm and 1m
		8	Protected against long periods of immersion under pressure

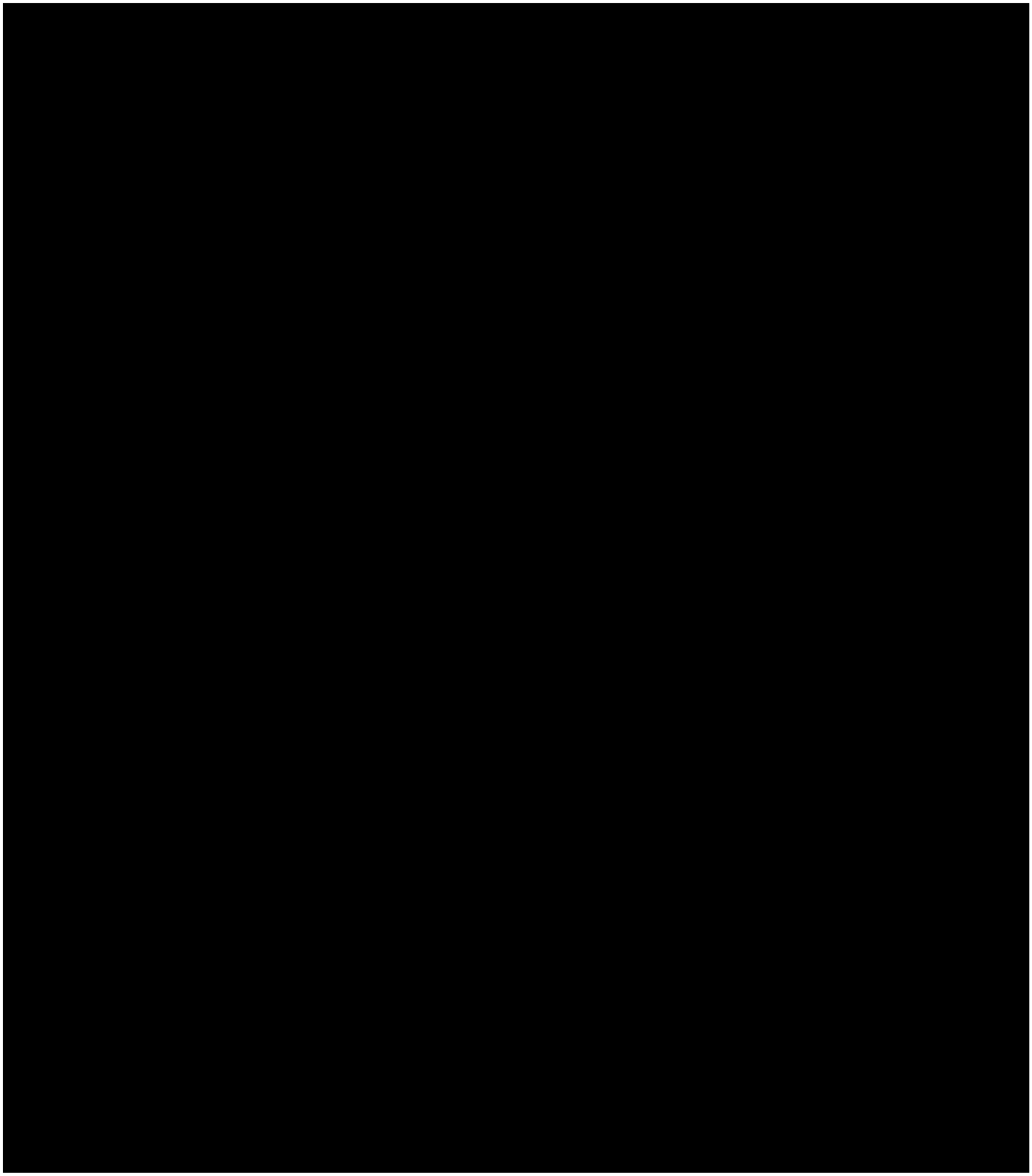

Figure 14-I-03.1 Communication Equipment (1)

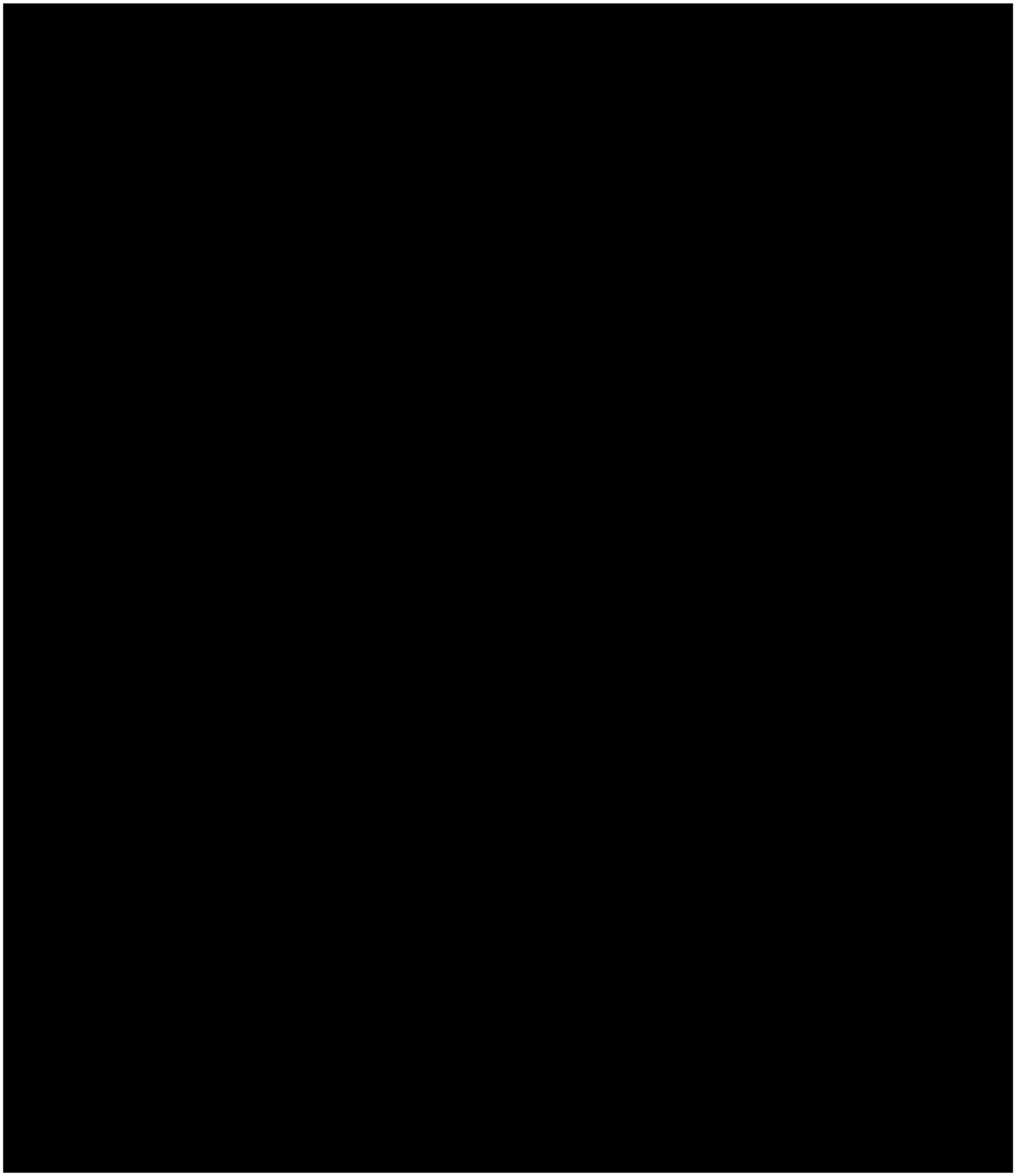

Figure 14-I-03.2 Communication Equipment (2)

[redacted]

[redacted]

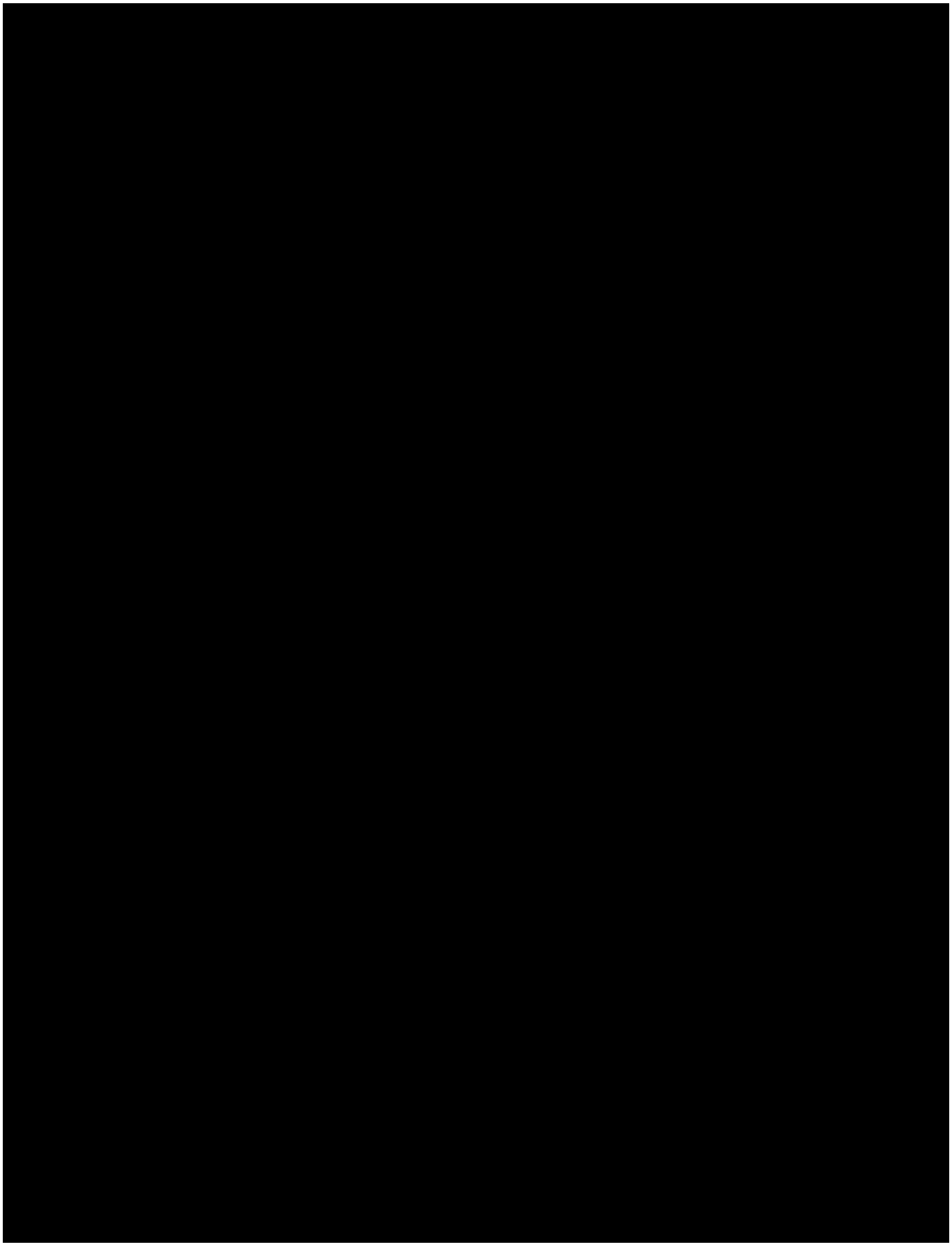

Figure 14-I-03.5 Communication Equipment (5)

[redacted]

[redacted]