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Rail

WESTRACE Application Manual

for WESTRACE MkI

WRTOAPPM
Issue 11.0

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This is the Application Manual for WESTRACE Vital Signalling Equipment.

WESTRACE equipment is designed to be used for railway signalling purposes and, as such, safety is of paramount importance.

Safety Warning

WESTRACE MkI equipment is designed to be used for railway signalling purposes and, as such, safety is of paramount importance.

SAFETY WARNING

WESTRACE MkI is a safety-critical system.

WESTRACE MkI equipment must be configured, installed and maintained in accordance with the rules and guidelines provided in this manual and the manuals to which it refers.

Responsibility

Note:

The Railway Operating Authority is responsible for ensuring a safe maintenance environment and a safe manual operating environment in the event of a failed interlocking.

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1

1. Introduction

This manual defines how to apply WESTRACE safely and correctly for railway signalling applications.

1.1 New in This Issue

This issue of the *WESTRACE Application Manual* (Issue 11.0) contains the following changes:

- additions to section 4.1.4 “Restart Circuit”
- addition of section 4.2.3.13 “VLOM Hot Standby”
- addition of section 4.3.3.9 “VROM Hot Standby”
- minor fixes and improvements throughout

1.2 Purpose of Manual

This manual enables experienced Signal Engineers to determine their WESTRACE hardware requirements and to safely and correctly apply the hardware.

1.3 Scope

This manual applies to all static (fixed) installations of WESTRACE equipment and not to mobile applications such as the WESTECT OBC.

1.4 References

This manual refers to the following WESTRACE manuals. All are available from Invensys Rail.

[SOM]	WESTRACE System Overview Manual, WRTOOVER: describes the WESTRACE system, what it is used for and what it consists of.
[FLM]	WESTRACE First-Line Maintenance Manual, WRTFLMM: describes maintenance procedures to quickly and accurately diagnose system problems so that correct operation is restored (including WESTECT trackside equipment).
[CS]	WESTRACE Configuration System User Manual, WRTOCS: describes the use and application of the Configuration Sub System (CSS) and Configuration Check Sub System (CCSS).
[CSS]	WESTRACE Configuration Sub-System User Manual, WRTOCSS: describes how to use the configuration tools for the programming and checking of VLM-based WESTRACE systems. This includes the configuration of the WESTECT Communications Module which may be installed in a WESTRACE system.
[CCSS]	WESTRACE Configuration Check Sub-System User Manual, WRTOCCSS: describes the use and application of the CCSS which is a DOS-based tool. CCSS is used to check that the correct application logic is installed in a VLM-based WESTRACE system.
[GCSS]	WESTRACE Graphical Configuration Sub-System User Manual, WRTOGCSS: describes how to use the configuration tools for the programming and checking of HVLM (and later) based WESTRACE systems. This includes the configuration of the WESTECT Communications Module which may be installed in a WESTRACE system.
[GSIM]	WESTRACE Graphical Simulator User Manual, WRTOGSIM: describes how to configure GSIM to test WESTRACE installation logic. GSIM is a Windows® application that simulates the operation of WESTRACE logic and trackside equipment. Railway Signal Engineers use GSIM to validate configuration data before it is applied in the field, and for principles testing.
[MOV]	MoviolaW User Manual, WRTOMOLA: describes how to set up and use MoviolaW to display and record the state of a WESTRACE system. MoviolaW is a suite of Windows®-based diagnostic and recording tools for WESTRACE Vital Signalling Systems and other railway systems.
[ICS]	WESTRACE Installation Check System User Manual, WRTO_ICS: describes the use and application of the ICS to check that the application logic is installed correctly in an HVLM (and later) based WESTRACE system.
[ISIM]	WESTRACE Interlocking Simulator User Manual, WRTOISIM: describes how to set up the Interlocking Simulator to test WESTRACE application data and optionally non-vital control (Interlogic data) for railway signal interlockings.
[PCGE]	PC Graphic Editor (PCGE) User Manual, WRTOPCGE: describes how to set up and use PCGE to create graphical screen layouts and the underlying logic associated with an interlocking's mnemonics; for use with GSIM and MoviolaW.

1.5 Relationship with Other Manuals

Nine manuals describe and support the WESTRACE system. Each manual has a specific purpose and is available from Invensys Rail. Figure 1.1 shows the relationship between the WESTRACE manuals and other related manuals. These manuals are described in the WESTRACE System Overview Manual [SOM].

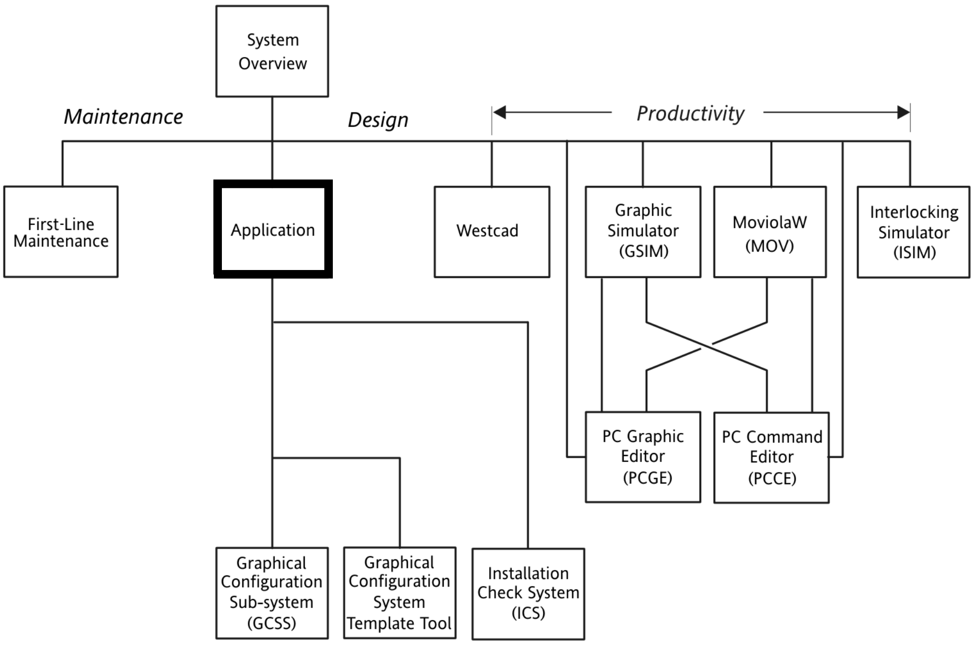


Figure 1.1 WESTRACE and Related Manuals

1.6 Conventions

This manual highlights important information as follows:

'Action Point'—identifies a task or a requirement for performing a task.

Note: ***'Note'—highlights important information.***

Caution: ***'Caution'—highlights the possibility of damage to equipment, but not necessarily danger to personnel when handling, operating or maintaining equipment.***

SAFETY WARNING

'Safety Warning'—highlights information relating to safety hazards. Failure to follow these warnings may lead directly or indirectly to serious equipment damage, or serious injury or death of personnel.

1.7 Organisation of this Manual

This manual includes:

Chapter 1	**Introduction**—describes how this manual relates to the WESTRACE system.
Chapter 2	**System Design**—defines the top-level design of a WESTRACE system.
Chapter 3	**System Application**—describes how to determine the requirements for selecting, powering, and communicating with WESTRACE Modules.
Chapter 4	**Module Application**—provides a brief description of WESTRACE modules, their external connection, and other application-specific information.
Chapter 5	**Installing WESTRACE**—describes the practices required to ensure safety integrity and reliability of WESTRACE.
Chapter 6	**Testing and Commissioning**—describes the tests required to ensure safe operation of fully assembled WESTRACE systems.
Appendix A	**Module Descriptions**—describes the fundamental features of each WESTRACE module.
Appendix B	**Module Operation**—describes the structure, operation and the safety assurance for WESTRACE modules.
Appendix C	**Hot Standby Operation**—describes hot standby configuration of WESTRACE interlockings.
Appendix D	**Non-Vital Communication Protocols**—describes non-vital communication protocols supported by WESTRACE.
Glossary	Defines special terms that may be found in this manual.

1.8 Terminology

The term VLM is used in a generic sense when referring to Vital Logic Modules. If the information is specific to a particular vital logic module, then the particular module will be mentioned.

At present, the following types of Vital Logic Module are in service:

- VLM1 (this module was previously known as VLM)
- HVLM128
- VLM5
- VLM6.

The term 'Diagnostic Module' is used in a generic sense. If the information is specific to a particular diagnostic module, then the particular module will be mentioned.

At present, the following types of Diagnostic Module are in service:

- NCDM (for VLM6);
- NVC/DM (for HVLM128 or VLM5);
- DM128 (for HVLM128);
- DM64 (for VLM1).

The term 'Non-Vital Configuration' is used when discussing non-vital data that is downloaded to NCDM or NVC/DM modules. It equates to 'CED' when discussing older WESTRACE technology.

The term 'Vital PROM Data' is used when discussing vital data that is downloaded to EPROMs fitted to vital logic modules.

2. System Design

This chapter defines the top level design of a WESTRACE system.

2.1 Introduction

WESTRACE uses relay equivalent logic that provides Railway Signal Engineers with familiar conventions, standards, and flexibility of design.

The WESTRACE design process involves:

- many of the skills that Railway Signal Engineers already have, plus;
- additional tasks defined in this chapter.

The application of processor based interlockings in areas traditionally controlled by relay based interlockings must be carefully considered, especially in regard to the impact on operating procedures and rules under failure conditions.

WESTRACE's modular design and features make it suitable for controlling a large range of signalling installations—from the smallest junction with one set of points and three signals to complex layouts with many points and signals.

It may be necessary, for larger interlockings, to divide the interlocking into two or more areas each controlled by its own WESTRACE; each WESTRACE communicating with its neighbour via vital telemetry links.

SAFETY WARNING

WESTRACE is a safety system. To achieve and maintain the intended level of protection, the equipment must be designed, maintained, and operated in accordance with the instructions in this manual.

2.2 Design Process

This section describes the WESTRACE design process. Parts of the design process are also described in the WESTRACE CS Manual and the WESTRACE GCSS Manual.

Figure 2.1 depicts the WESTRACE design process based on using GCSS to design an HVLM, VLM5 or VLM6 based system.

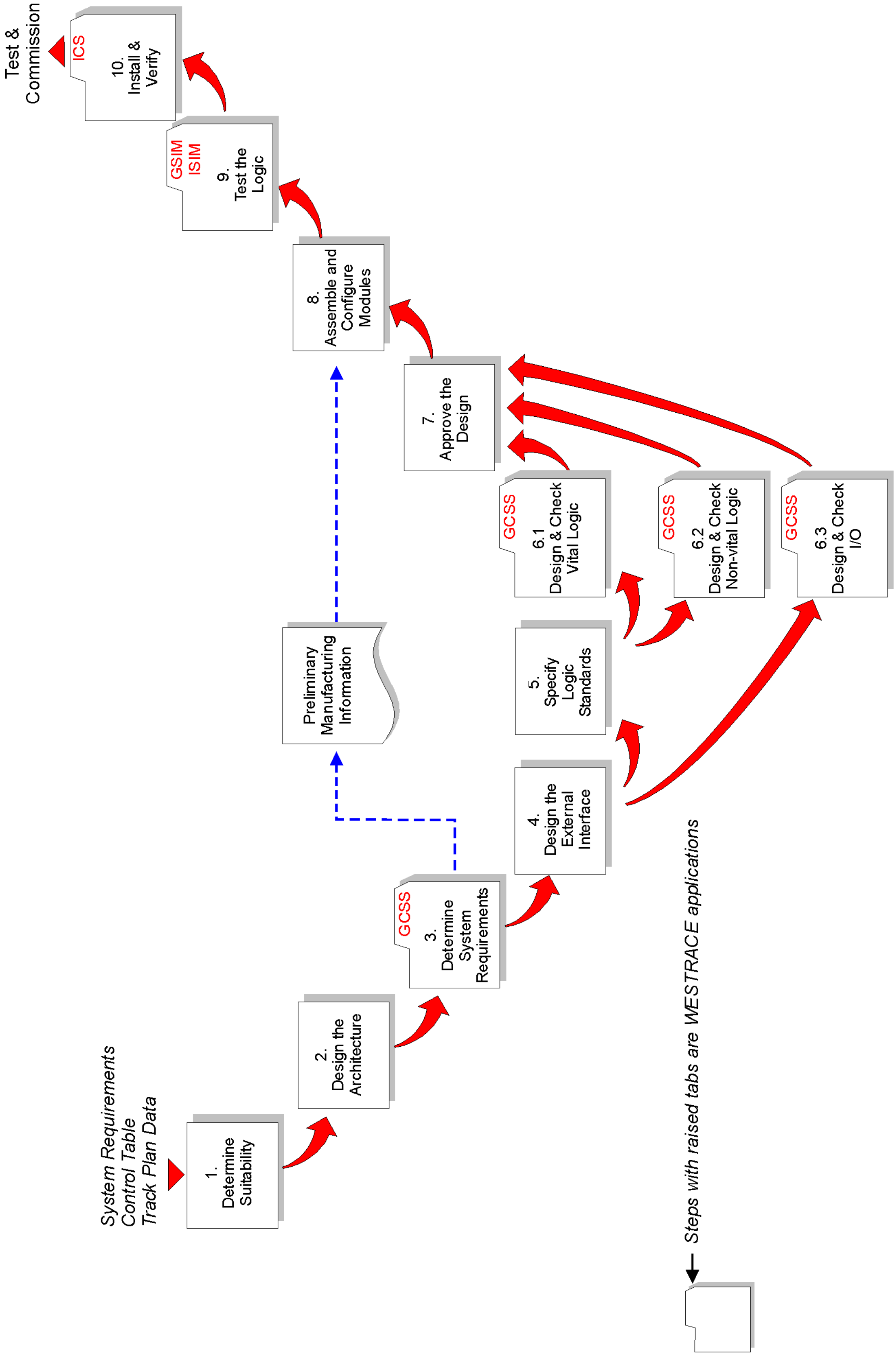


Figure 2.1 Design Process Flowchart—WESTRACE

2.2.1 Determine Suitability

Investigate, specify, design and agree on the following before deciding the type of interlocking:

- System requirements;
- Safety requirements;
- External standards and requirements;
- Control tables, scheme plan, track plan and signalling plan;
- Other pertinent information as applicable.

Determine the suitability of WESTRACE:

- Does WESTRACE have appropriate capacity for the interlocking? See section 2.2.3;
- Are the inputs and outputs located at appropriate distances for cabling?
- Is the environment (such as temperature range) suitable for WESTRACE?
- Are the operating voltages of the signalling equipment to be controlled compatible with the voltages available in the WESTRACE equipment?
- Are the signal lamps suitable for direct control from WESTRACE lamp driver modules?
- Is the proposed non-vital control system compatible with the WESTRACE non-vital communications protocols?

Full details of the WESTRACE modules are provided in Chapter 4 and Appendix A.

2.2.2 Design the Architecture

Determine the appropriate architecture for the WESTRACE system.

System architecture considerations include:

- supporting network architecture (using Information Technology (IT) expertise);
- single or multiple VLM system. A multi-VLM system is used when a single VLM system has insufficient capacity or when some remote I/O is required;
- stand-alone or standby configuration. Standby improves system availability by duplicating all hardware;
- interfaces with adjacent interlockings;
- local and remote control facilities;
- local and remote diagnostic facilities.

See section 2.3 for examples of typical WESTRACE system block diagrams:

- Figure 2.2 Simple WESTRACE Systems with Local Panel—Typical—HVLM128 or VLM5
- Figure 2.3 Simple WESTRACE System with Local Panel—Typical—VLM6 with NCDM
- Figure 2.4 Multiple WESTRACE Systems with Local Panel and Duplicated Communications Bearers—Typical—HVLM128 or VLM5
- Figure 2.5 Multiple WESTRACE Systems with Local Panel—Typical—VLM6 with NCDM
- Figure 2.6 Master-Slave WESTRACE System with Local Panel and Single Bearer—Typical—HVLM128 or VLM5
- Figure 2.7 Master-Slave WESTRACE System with Local Panel—Typical—VLM6 with NCDM
- Figures 2.8 Multiple WESTRACE System with Physical Separation Between Systems—Typical—HLVM128 or VLM5
- Figure 2.9 Multiple WESTRACE System with Physical Separation Between Systems—Typical—VLM6 with NCDM
- Figure 2.10 Multiple Address WESTRACE System with Physical Separation Between Systems—Typical—Older Configuration
- Figure 2.11 Hot standby WESTRACE System (simplified)—Typical—HVLM128 or VLM5
- Figure 2.12 Hot standby WESTRACE System (simplified)—Typical—VLM6 with NCDM

Assemble all information from sources such as control tables, scheme plan, and track plan.

2.2.3 Determine System Requirements

Details of these items are in subsequent subsections.

- Determine the VLM, diagnostic and non-vital communications modules. See sections 2.2.3.1 to 2.2.3.3.
- Determine the number of vital communications connections over a network.
- Determine type and number of vital serial communications modules – depends on whether the interlocking is a single or multi-WESTRACE system, and on any required inter-interlocking connections. See section 2.2.3.4.
- Determine type and number of vital parallel I/O modules—depends on the nature of the railway signalling equipment being controlled. See section 2.2.3.6.
- Determine whether a WESTECT Communications Module is required—only applicable when the WESTRACE system is functioning as a WESTECT ATP Encoder.
- Check that there are sufficient slots to accommodate the required modules. If not, the interlocking will need to be split into a multi-WESTRACE system. See section 2.2.3.8.
- Calculate the total module communication time and check that it is within the specified limits. If not, the interlocking will need to be split into a multi-WESTRACE system. See section 2.2.3.9.
- Determine the power supply requirements for each WESTRACE. See section 2.2.3.10.

2.2.3.1 Vital Logic Module

Each WESTRACE system requires one VLM.

Four types of VLM are available, with these capacities:

- VLM6—4000 mnemonics, approximately 1800 rungs;
- VLM5—4000 mnemonics, approximately 1800 rungs;
- HVLM128—2500 mnemonics, approximately 750 rungs;
- VLM1—1000 mnemonics, approximately 300 rungs.

For more details, see section 3.2.1.1.

The type of VLM chosen influences the types of other modules which may be used. Table 2.1 summaries the possible combinations.

Table 2.1 Influence of VLM type on selection of other Modules

VLM	Diagnostic Module	NVC	VTC	Vital Comms Over Network
VLM6	NCDM	NCDM or NVC232 or NVC422	EVTC232 or VTC232	Yes
VLM5	NVC/DM	NVC/DM or NVC232 or NVC422	EVTC232 or VTC232	No
HVLM128	NVC/DM or DM128	NVC232 or NVC422	EVTC232 or VTC232	No
VLM1	DM	NVC232 or NVC422	VTC232	No

The VLM6 is the preferred module. It uses the latest technology, has greater capacity, is suitable for stand-alone or hot standby systems and when used with NCDM it supports vital communication over a network.

VLM5 is similar to the VLM6, however the VLM5 does not support vital communication over a network. The VLM5 safety case was incomplete at the publication date of this manual. Please ensure it is suitable before use.

The HVLM128 is similar to the VLM6 but has less capacity does not support vital communication over a network.

The older VLM1 module is now only used in situations where VLM1 compatibility is a requirement.

2.2.3.2 Diagnostic Module

Each WESTRACE system requires one Diagnostic Module.

At present, the following types of Diagnostic Module are in service:

- NCDM (for VLM6);
- NVC/DM (for HVLM128 or VLM5);
- DM128 (for HVLM128);
- DM64 (for VLM1).

The **NCDM** is the preferred diagnostic module. It is suitable for stand-alone or hot standby systems, supports the Diagnostic Protocol over both network and serial interfaces, and can be connected to a PC running MoviolaW, Getlog or NGetlog (see [FLM]).

The NVC/DM provides up to three Diagnostic Protocol serial interfaces, and can be connected to a PC running MoviolaW or Getlog (see [FLM]).

The DM64 and DM128 provide two different text-based serial interfaces, and may be connected to a PC running MoviolaW, a terminal emulator, or the Diagnostic Logging Package (see [FLM]).

2.2.3.3 Non-Vital Communications

Four types of non-vital communication modules are available:

- NCDM—provides one Ethernet compliant network interface and up to two RS232 or RS485 interfaces;

    The network interface supports up to 16 network sessions using the WSA/S2 or WSL/S2 protocol and supports the transfer of at least 256 inputs and outputs per protocol session at 10 Mbits/sec;

    - Each serial interface supports up to 62 WSA/S2 or WSL/S2 housing addresses and supports the transfer of at least 256 inputs and outputs per housing address at up to 64000 bps;
- NVC/DM—provides up to six RS232 or RS485 interfaces and transfers up to 4096 inputs and outputs using the WSA/S2 or WSL/S2 protocol at up to 64000 bps;
- NVC232—provides a single RS232 interface and transfers up to 48 inputs and 64 outputs using the WSA/S2 protocol at up to 4800 bps;
- NVC422—provides a single RS422 interface and transfers up to 48 inputs and 64 outputs using the WSA/S2 protocol at up to 4800 bps.

A WESTRACE system may contain either one NCDM module or one NVC/DM module and up to ten NVC232 or NVC422 modules. The NCDM is the preferred option.

2.2.3.4 Vital Communications—Serial

Two types of VTC module are available:

- EVTC232—provides a single RS232 interface and transfers up to 66 inputs and outputs;
- VTC232—provides a single RS232 interface and transfers up to 17 inputs and outputs.

Each WESTRACE system may contain up to eight VTC modules. The EVTC232 is the preferred option.

2.2.3.5 Vital Communications—Network

A VLM6 used in conjunction with an NCDM supports vital communication over a network for up to 16 connections to one or more connected WESTRACE systems. Each vital communication connection over a network transfers up to 182 inputs and outputs (26 bytes with 7 data bits and 1 parity bit).

2.2.3.6 Vital Parallel I/O

Three types of vital parallel I/O modules are available:

- VROM50—provides 8 relay outputs;
- VPIM50—provides 12 relay inputs;
- VLOMFT110—provides 12 steady or flashing 110V lamp outputs.

2.2.3.7 WESTECT Communications Module

A WESTECT ATP Encoder system must include a WCM.

2.2.3.8 Slot Usage

A four-housing WESTRACE system contains 60 slots.

Determine whether the required modules will fit into a single WESTRACE system by adding up the slots required by each module. Refer to Chapter 3.

Note: ***All VLM modules require three slots when used in Invensys Rail applications. An NCDM occupies one slot when used in conjunction with a VLM6.***

Divide the system into multiple housings if there are insufficient slots. Use vital communication over the network to connect the systems, alternatively add EVTC modules to connect the systems. This may require a relocation of modules.

Use GCSS (or CSS) to place all modules in housings.

2.2.3.9 Module Communication Time

Each VLM imposes a maximum communication time limit for transferring data to input and output modules. Section 3.2.1.3 specifies the time required by each module.

Determine whether the VLM can support the required number of modules by adding up the communication times for each module.

Divide the system into multiple housings if the maximum communication time is exceeded. Use vital communication over the network to connect the systems, alternatively add EVTC modules to connect the systems. This may require a relocation of modules.

2.2.3.10 Estimate Power Supply

Ensure there are enough power supplies to power all modules.

The simple solution is to fit a Power Supply Module (PSU) in each housing. However if the system is small or there is some restriction, fewer PSUs might be adequate.

Calculate the total requirements of each WESTRACE system using the values and formulas provided in section 3.3. The number of PSUs required can be determined as well as the total WESTRACE 24 Vdc power consumption.

The power consumption of the different serial and parallel I/O modules varies for each of the voltage rails.

The 24 Vdc power for a WESTRACE system should be sourced from a no-break supply; generally this will be a battery and float charger.

Estimate the power supply requirements for relays and lamps controlled by the WESTRACE system separately.

2.2.4 Design the External Interfaces

Design the external interfaces including, as required:

- connections to power supply;
- restart circuit (see section 4.1.4);
- OPCRs (see section 4.1.8);
- vital communication over a network;
- vital serial communications (see section 3.8);
- non-vital network communications;
- non-vital serial communications;
- parallel inputs and outputs;
- in-line surge suppressors (see section 4.13);
- earthing and bonding (see section 5.1);
- lightning and surge protection (see section 5.4).

Note: ***Additional protection is required for WESTRACE equipment in lightning-prone locations (see section 5.4) or generally electrically noisy areas.***

2.2.5 Specify Logic Standards

Determine any standards and prototype circuits that should be used in the design.

2.2.6 Design & Check Application Logic, Inputs and Outputs

The logical relationship between inputs, outputs, internal states and timers is defined using GCSS for VLM6, VLM5 or HVLM based systems:

- GCSS v6.0 or later if the system includes a VLM6 or NCDM;
- GCSS v5.2 or later if the system includes an NVC/DM;
- GCSS v5.0 or later if the system includes a VLM5.

Use CSS for VLM1 based systems.

Use the control table and track plan data for the signalling system to develop a GCSS or CSS installation file.

The GCSS or CSS will generate print-outs or files for checking and approval of the system design. The system design must be checked and approved before the system is tested and commissioned.

See [GCSS] or [CSS], as appropriate for further details.

2.2.6.1 Vital Logic

Prepare the vital logic for the VLM. Add this data to the GCSS or CSS installation file.

2.2.6.2 Non-Vital Logic

Prepare the non-vital logic for the NCDM or NVC/DM (if used) and determine the required network or non-vital serial port configuration. Add this data to the GCSS installation file.

2.2.6.3 Inputs and Outputs

Prepare the inputs from and outputs to equipment external to the WESTRACE application. Add this data to the GCSS installation file.

2.2.7 Approve the Design

Before the design is principles tested, the complete design must be:

- checked by a Signal Engineer;
- independently approved by a different Signal Engineer.

2.2.8 Test the Logic

Invensys Rail recommends that both the vital and non-vital logic be tested prior to installing equipment in the field to:

- ensure the logic works;
- save time;
- avoid interrupting rail operations.

CSS has a simulation function to test the logic of the systems designed in CSS. GCSS does not provide a simulation facility. Invensys Rail recommends testing systems designed in GCSS with GSIM or ISIM.

WESTRACE GSIM (**G**raphic **Sim**ulator) is a PC application that enables Railway Signal Engineers to validate the railway signal logic and perform principle testing before programming PROMs and using them on the target hardware (or in WESTRACE ISIM for further testing). GSIM3 or later is also able to simulate the NVC/DM non-vital logic.

WESTRACE ISIM (**I**nterlocking **Sim**ulator) is a WESTRACE and S2 based tool that enables Railway Signal Engineers to test railway signalling logic and optionally non-vital control (Interlogic data) for railway signal interlockings in the office prior to commissioning a system.

2.2.9 Assemble and Configure Modules

Assemble the WESTRACE system hardware according to the requirements determined in this section and the GCSS or CSS reports that depict the placement of modules in the WESTRACE housing(s).

Configure the WESTRACE modules for site specific conditions as indicated in table 2.2.

Table 2.2 Module Configuration

Module	Details
VLM	Set CED Version switches (refer GCSS Installation Assembly Details report) Set installation address on Vital Backplane Card (refer GCSS Installation Assembly Details report)
NCDM	Set Non-Vital Configuration Version switches
NVC/DM	Set Non-Vital Configuration Version switches
NVC	Set switches to select data transfer rate, address etc
DM	Set switches to select data transfer rates and other options

See Appendix A for full details.

Compatibility

WESTRACE modules and application data have a compatibility index. It ensures the installation works correctly.

Table 2.3 shows the range of compatibility index values that may be used by each company in the Invensys Rail group.

Table 2.3 Module Compatibility Index–Values

Company	Compatibility Index Range
WSA	3-31
DIMETRONIC	32-63
WSL	64-95
Safetran	96-127

All modules within an installation must have the same compatibility index.

An installation will not start up when it is fitted with modules that have different compatibility indices.

Ensure:

- Compatible WESTRACE modules are used (see section 2.2.3);
- Communicating WESTRACE systems have acceptable compatibility indices, see above.

2.2.10 Install Vital PROM Data or Non-Vital Configuration and Verify

a) Load the approved Vital PROM Data into PROMs and install in the sockets on the VLC card.

b) Load the approved Non-Vital Configuration into the NCDM or NVC/DM.

c) Use ICS (or CCSS) to check that the correct application data is installed in a system. See [ICS] or [CCSS] as appropriate.

2.2.11 Check and Commission

The installation should be checked for correspondence. It may not be necessary to repeat functional checks performed in simulation.

Check the system to verify:

- correspondence between the system and its inputs and outputs;
- that field equipment such as signals and points operate to plan;
- that no significant changes have occurred during the design process.

Commission the system.

2.3 Typical System Block Diagrams

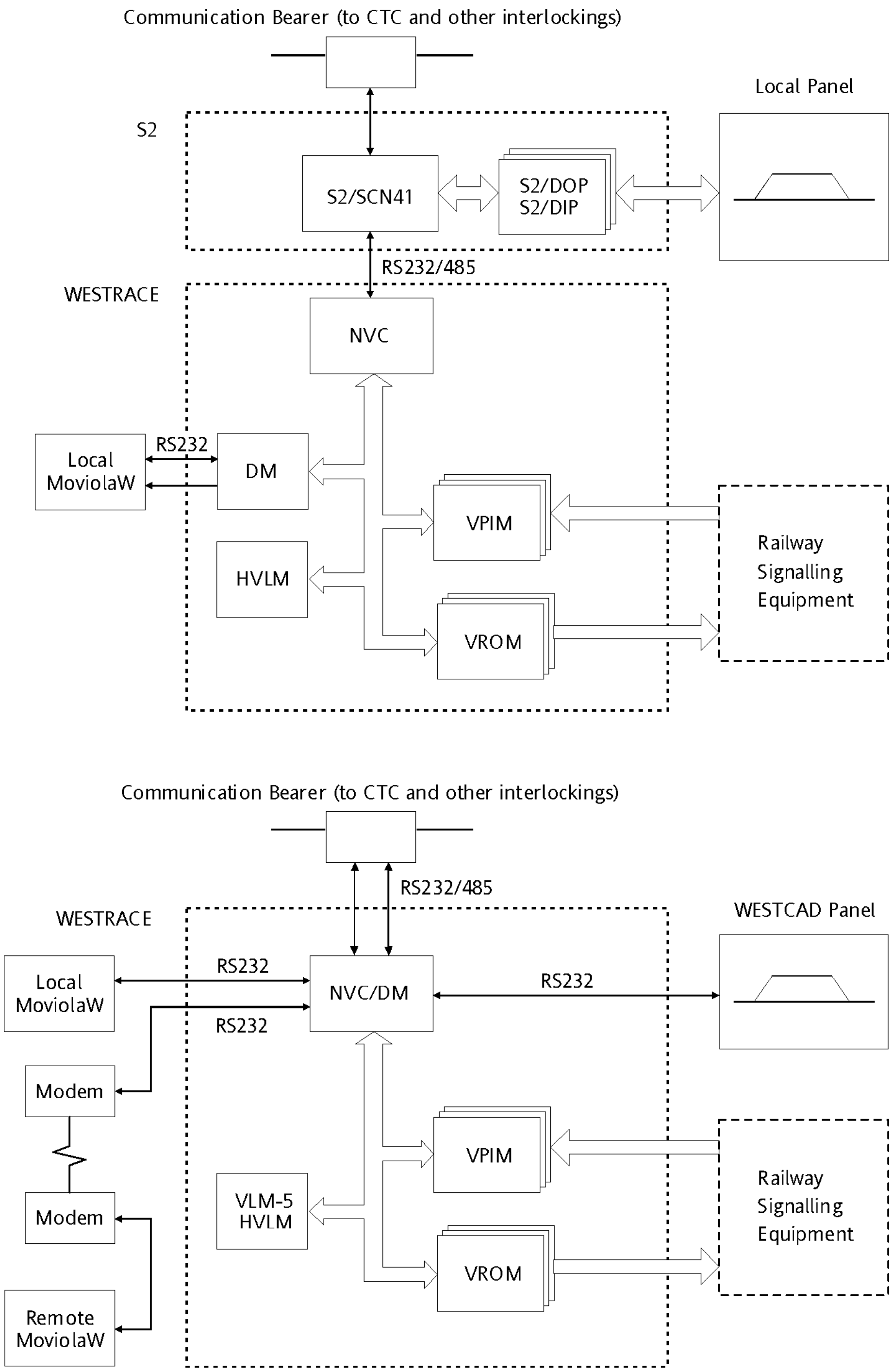
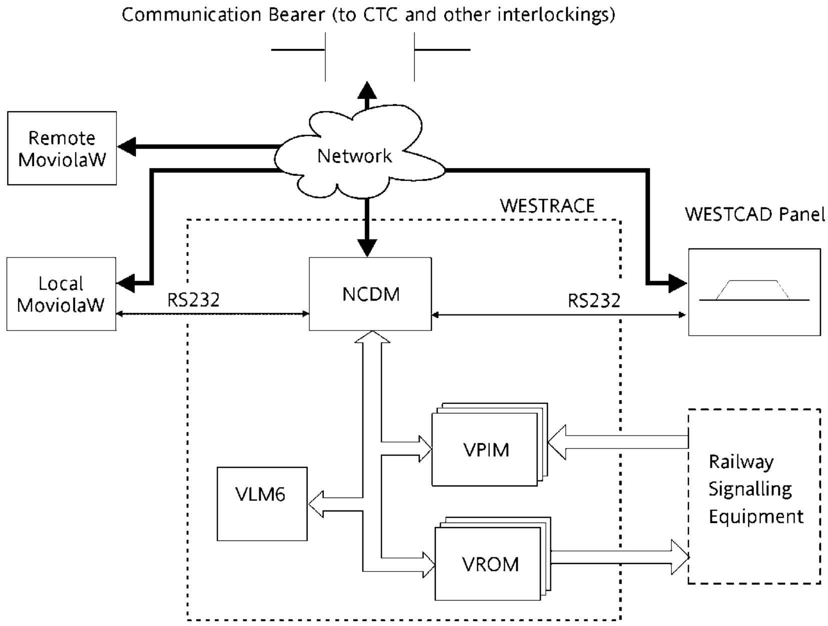


Figure 2.2 Simple WESTRACE Systems with Local Panel–Typical–HVLM128 or VLM5



This example shows multiple network connections.
All of these connections are established through a single network port on the NCDM.

Figure 2.3 Simple WESTRACE System with Local Panel–Typical–VLM6 with NCDM

2

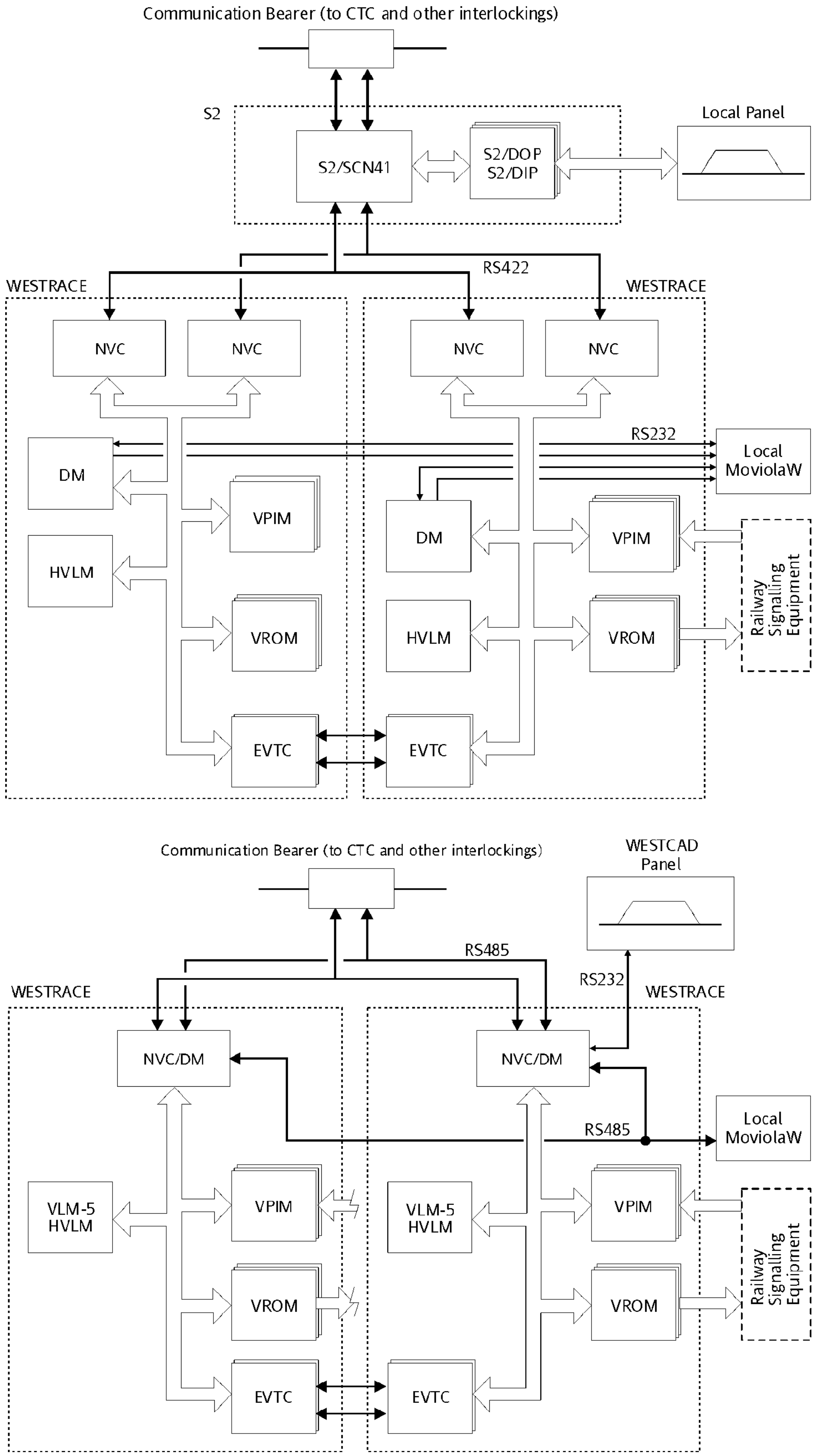


Figure 2.4 Multiple WESTRACE Systems with Local Panel and Duplicated Communications Bearers—Typical—HVLM128 or VLM5

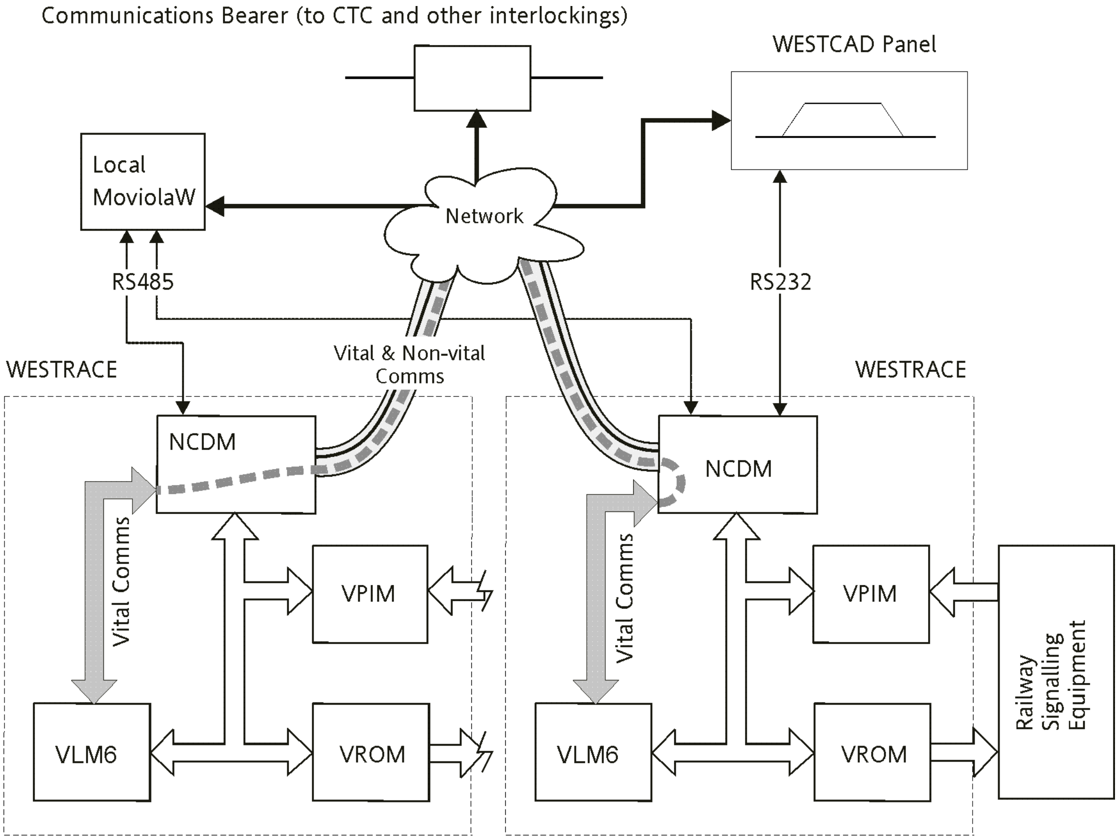


Figure 2.5 Multiple WESTRACE Systems with Local Panel—Typical—VLM6 with NCDM

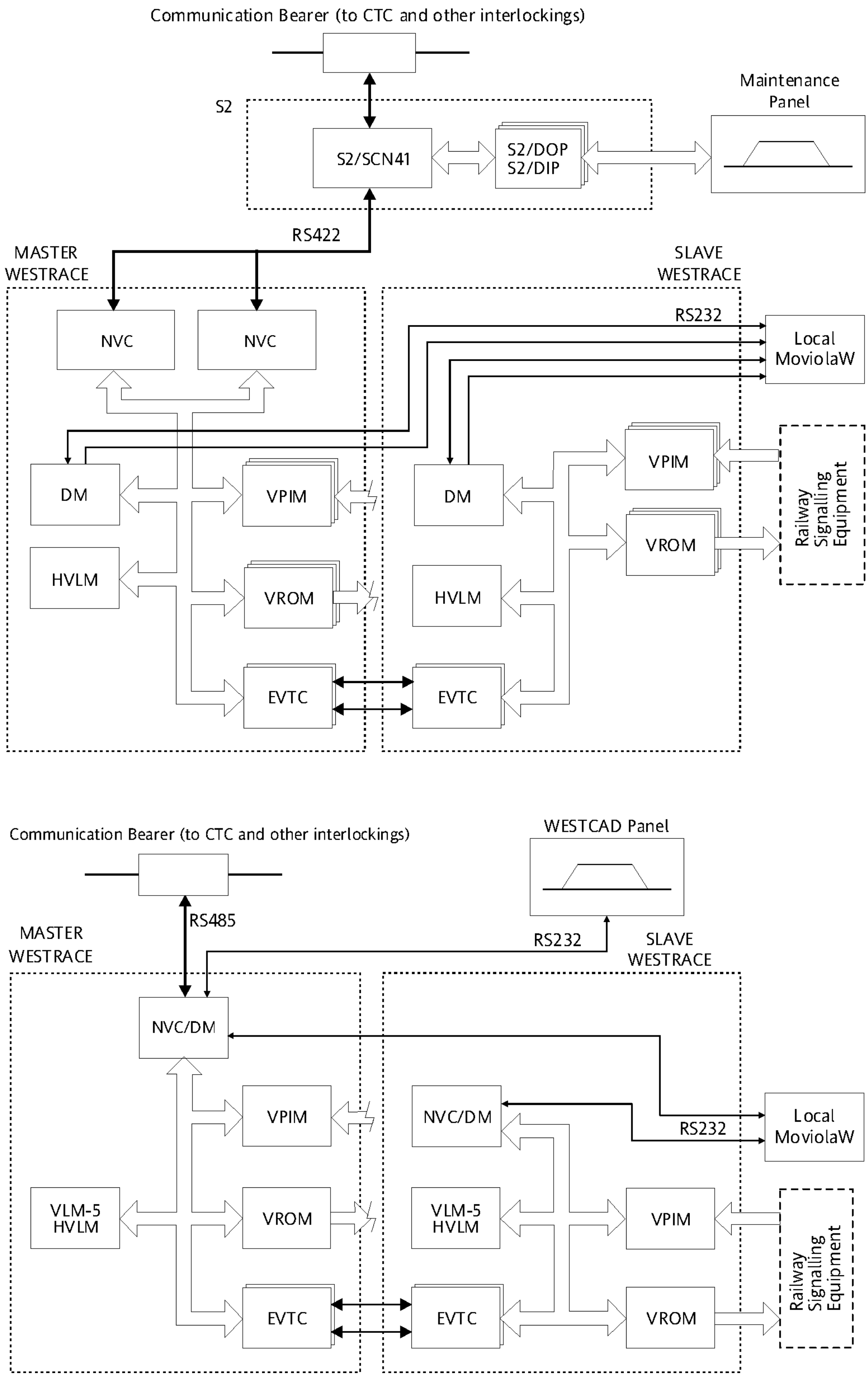


Figure 2.6 Master-Slave WESTRACE System with Local Panel and Single Bearer–Typical–HVLM128 or VLM5

The master system is normally used to process the majority of the logic.

The slave WESTRACE can be used for local processing, if required.

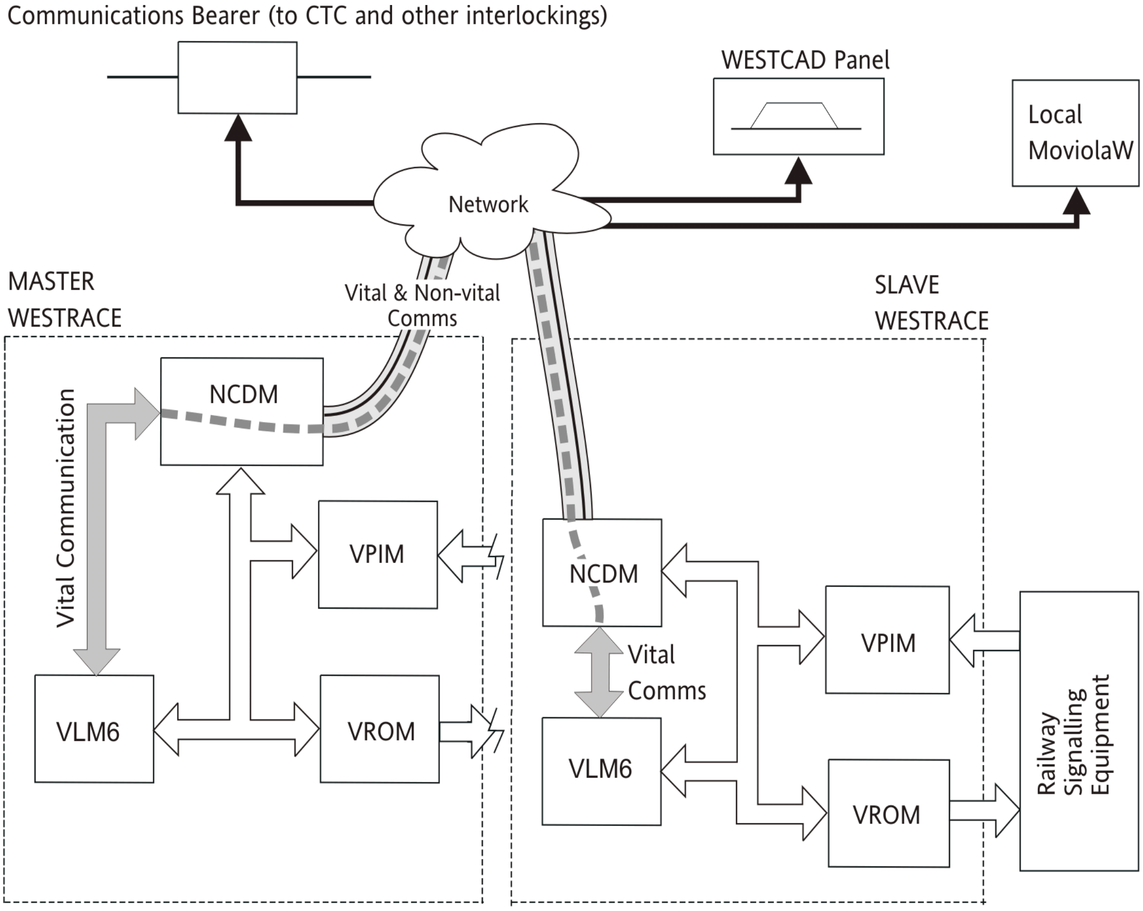


Figure 2.7 Master-Slave WESTRACE System with Local Panel—Typical—VLM6 with NCDM

The master system is normally used to process the majority of the logic.

The slave WESTRACE can be used for local processing, if required.

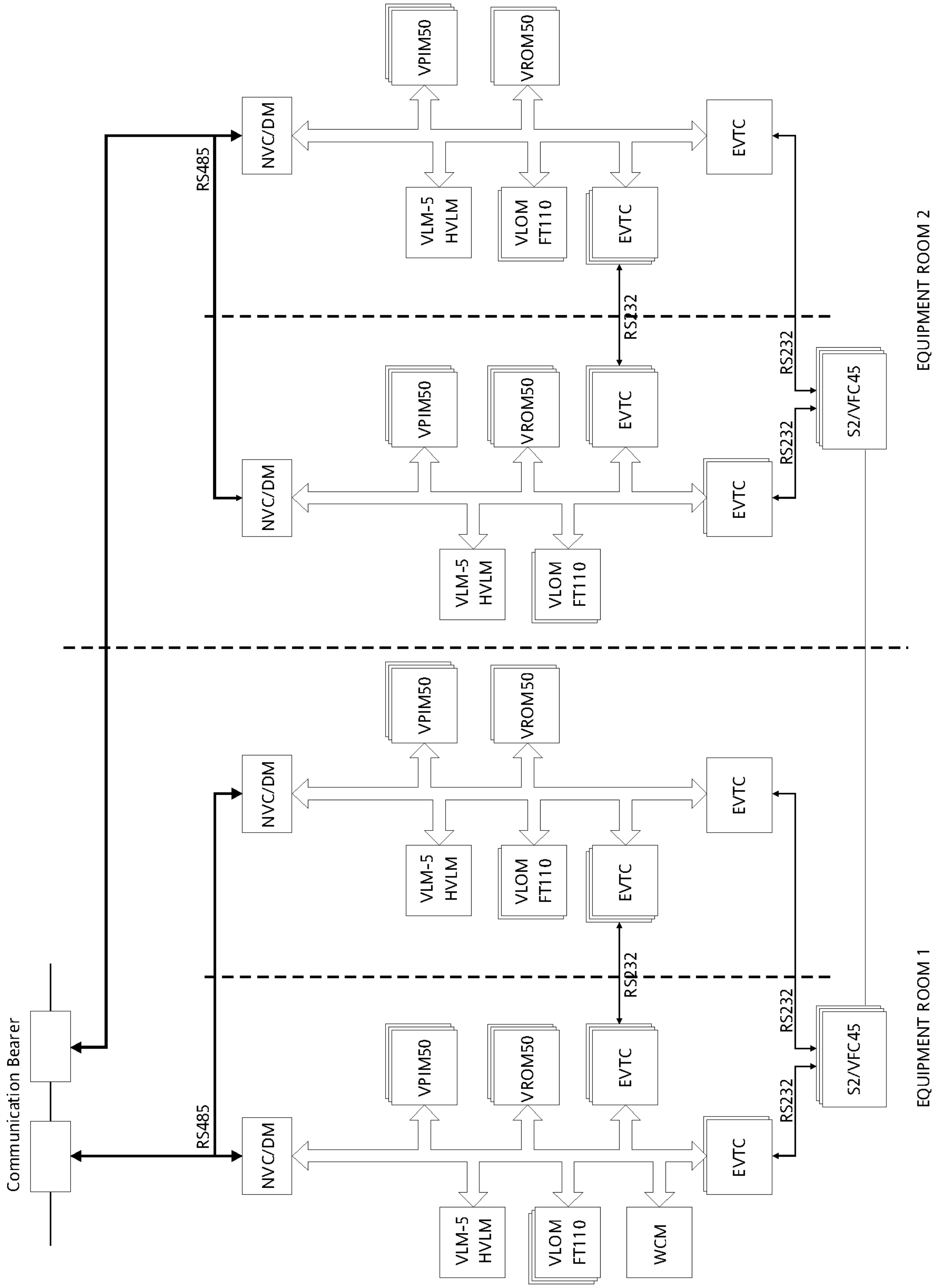


Figure 2.8 Multiple WESTRACE System with Physical Separation Between Systems – Typical – HLVM128 or VLM5

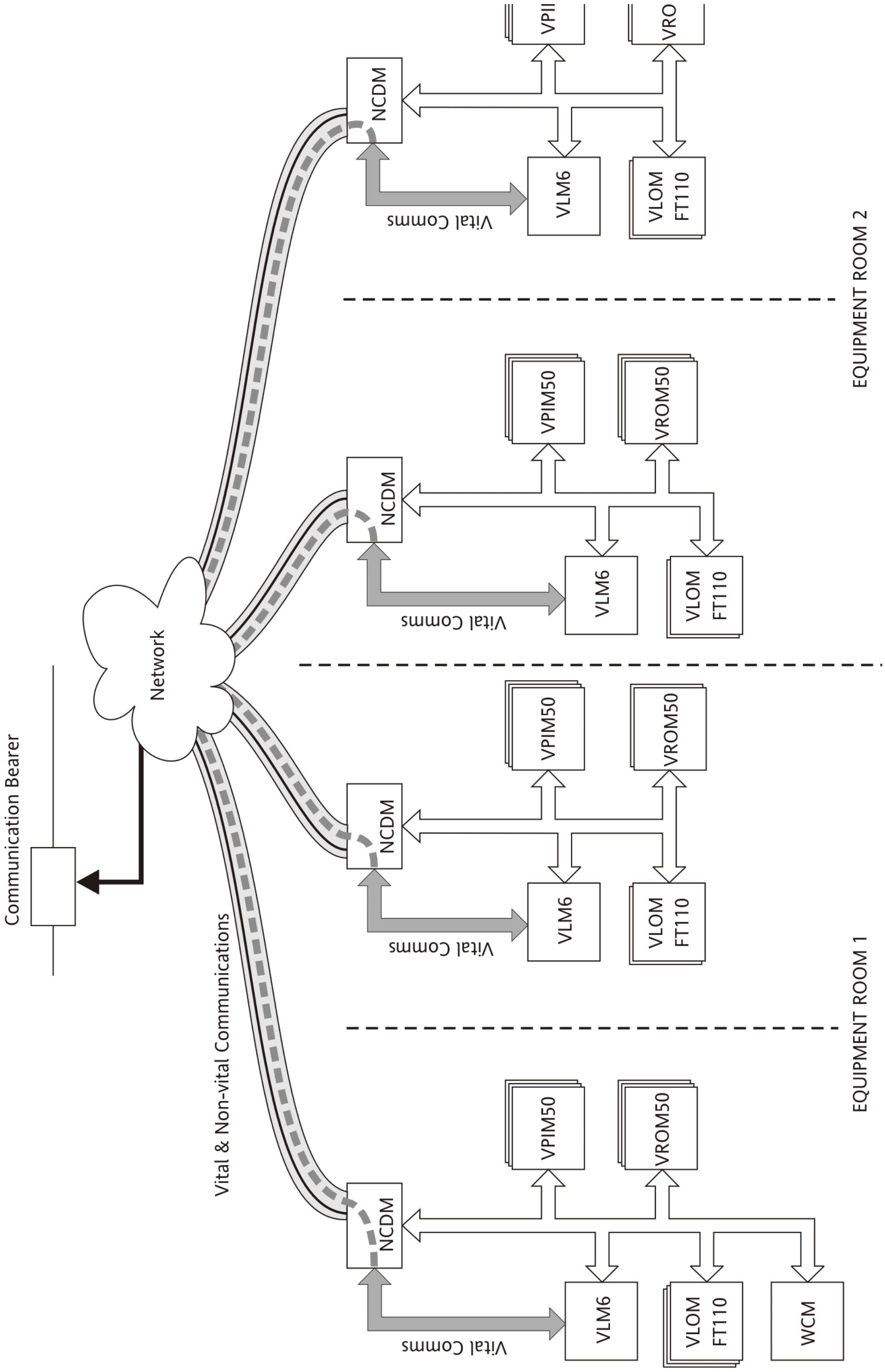


Figure 2.9 Multiple WESTRACE System with Physical Separation Between Systems–Typical–VLM6 with NCDM

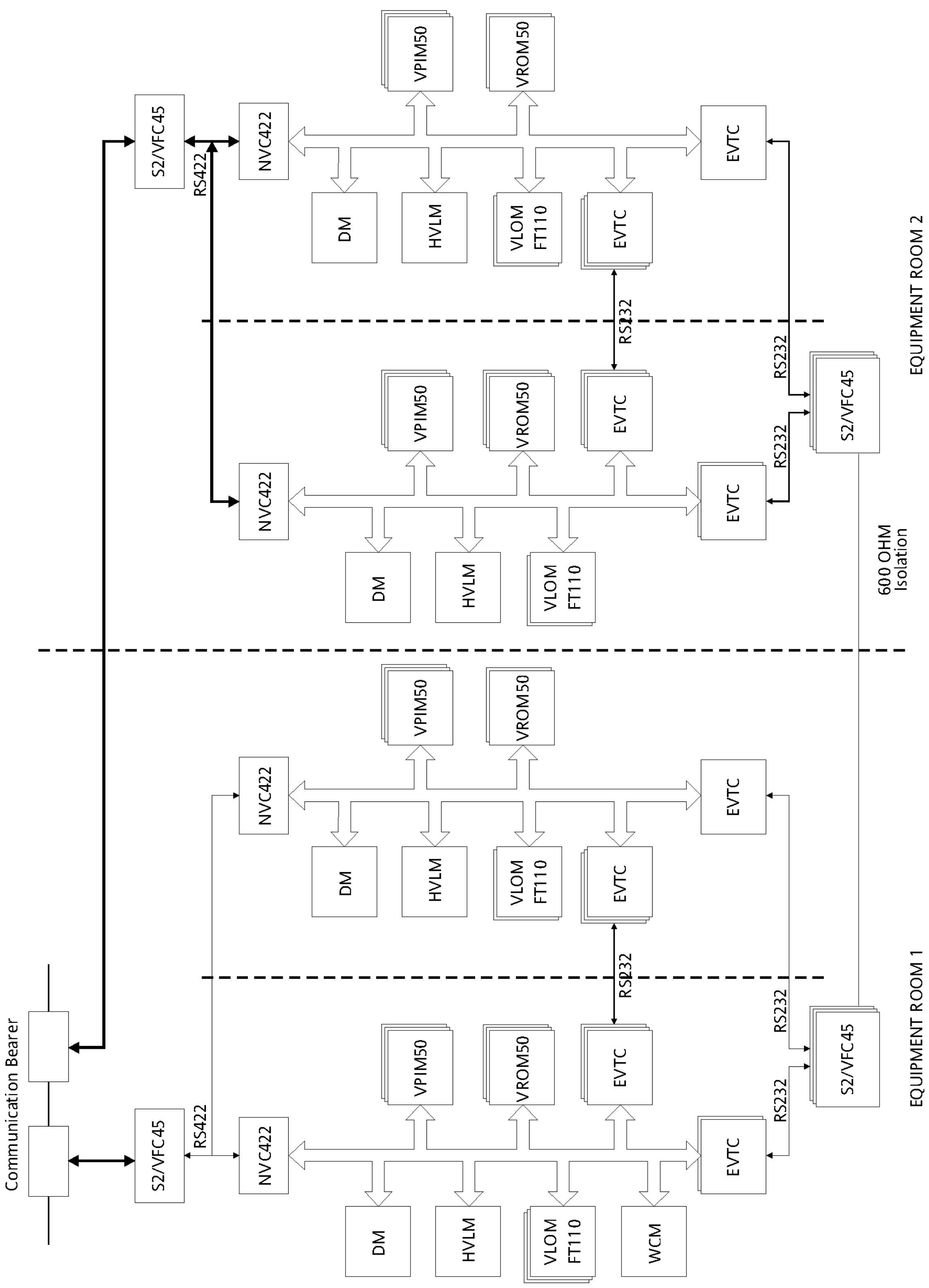


Figure 2.10 Multiple Address WESTRACE System with Physical Separation Between Systems – Typical – Older Configuration

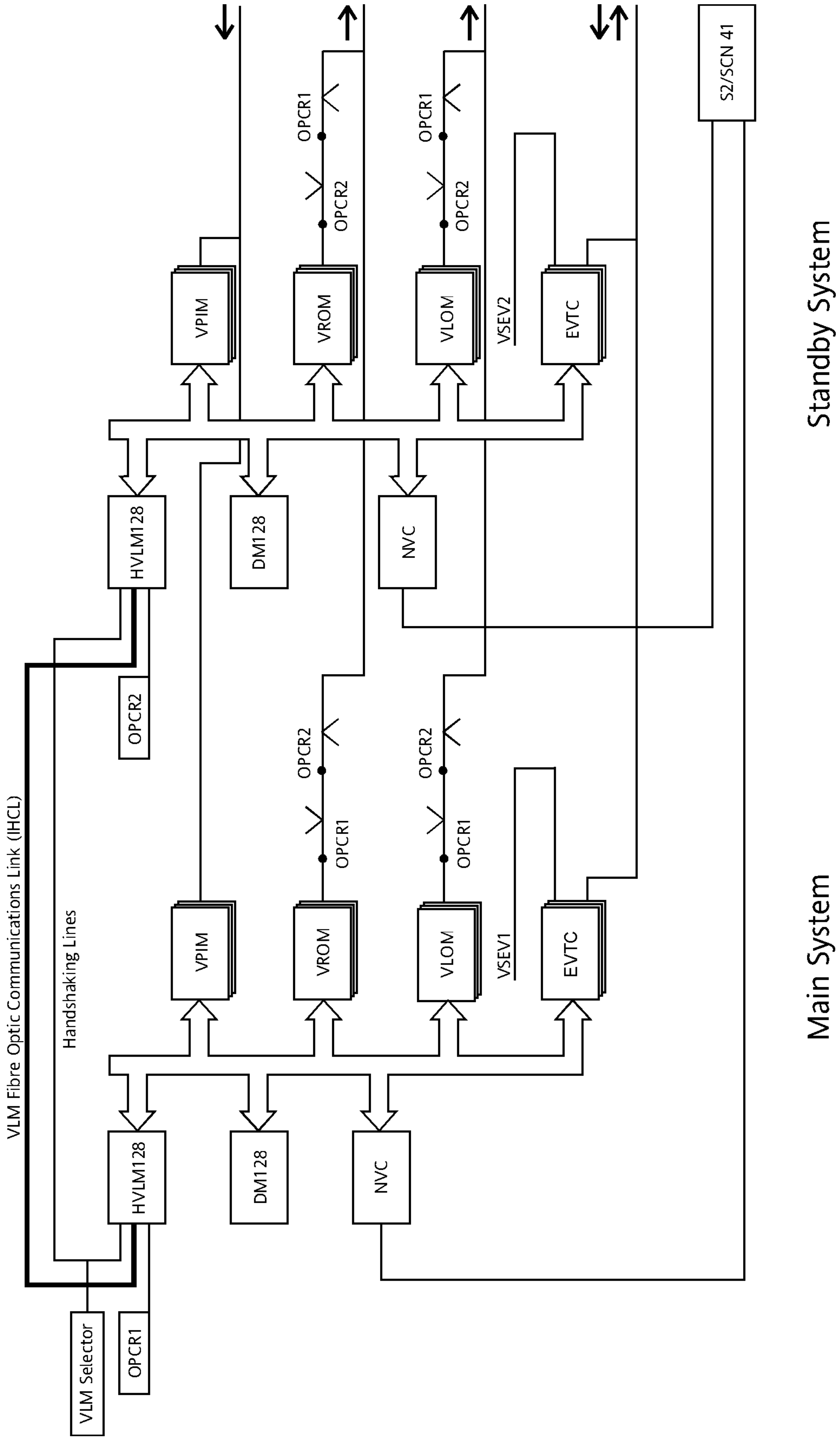


Figure 2.11 Hot standby WESTRACE System (simplified)—Typical—HVLM128 or VLM5

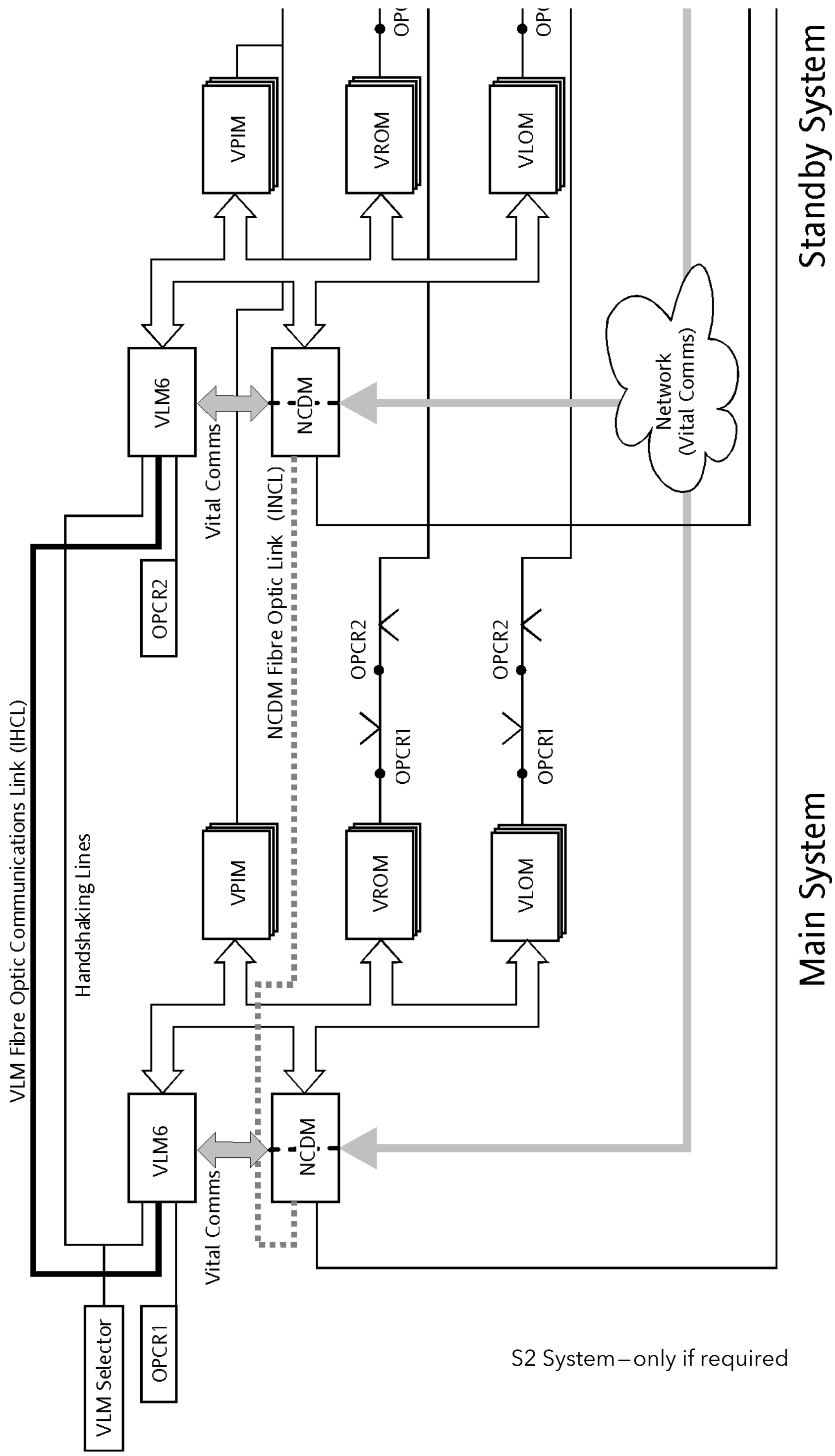


Figure 2.12 Hot standby WESTRACE System (simplified)—Typical—VLM6 with NCDM

3. System Application

This chapter describes how to determine the system requirements for:

- allocating WESTRACE modules;
- power supplies;
- communications.

3.1 WESTRACE Components

Table 3.1 is a list of WESTRACE components and their variations at the release time of this manual.

Refer to the Invensys Rail web site (http://www.invensysrail.com) for the latest product information.

You can download a listing of our complete product range or a Short-Form Catalogue that contains a pictorial and descriptive summary of our major product groups, with references to our data sheets.

These can be found under 'Product' on the web page menu bar.

Table 3.1 WESTRACE Modules

Name	Description	Slot	Part No.
110V ARR LEFT	110V Surge Arrester External Cables from Left	-	2650 1103 02
110V ARR RIGHT	110V Surge Arrester External Cables from Right	-	2650 1103 12
50V ARR LEFT	50V Surge Arrester External Cables from Left	-	2650 1103 01
50V ARR RIGHT	50V Surge Arrester External Cables from Right	-	2650 1103 11
Backplane	VLE System Backplane	-	2650 1126 01
Battery	Lithium Battery for DM and DM128	-	4496/3-18
Battery	Lithium Battery for NVC/DM	-	6104 5004 9
Blanker	System Continuity Card	1	4650 1057 01
CEC	Configuration Element Card (part of VLM1)	1	3650 1101 01
CIMFIM	Communications Interface Module, Filter & Interface Module (part of NVC/DM)	1	2650 1231 01
CIMPM	Communications Interface Module, Protection Module (for CIMFIM)	-	2690 1064 01
DM	Diagnostic Module (used with VLM1)	1	3650 1099 11
DM128	Diagnostic Module (used with HVLM128)	1	3650 1099 12
EC1	Expansion Cable 1	-	3650 1144 01
EC2	Expansion Cable 2	-	3650 1145 01
EC3	Expansion Cable 3	-	3650 1146 01
EPROM	CED EPROM for VLM1	-	4985/369
EPROM	CED EPROM for HVLM128	-	2680 0004 35

Table 3.1 WESTRACE Modules *(Continued)*

Name	Description	Slot	Part No.
EEPROM (DIL)	CED EEPROM for VLM5	-	TBA
EEPROM (PLCC)	CED EEPROM for VLM6 (AMD AM29F010B)	-	612450626
EEPROM adapter	PLCC to DIL adapter (Aries 32-653000-11-RC)		616580141
EVTC232	Enhanced Vital Telemetry Continuous RS232 (used with HVLM128 and VLM5)	1	3650 1129 13
HOPC50PFM	HVLM OPC50 Protection Filter Module (for OPC50 when part of VLM5 and HVLM128)	-	2650 1140 01
HSYS1HSG	HVLM Single Card cage complete with Backplane, HVBC + EC1	-	1690 1056 01
HSYS2HSG	HVLM Double Card cage complete with Backplane, HVBC + ECs (for single PSU24)	-	1690 1057 01
HSYS2HSG	HVLM Double Card cage complete with Backplane, HVBC + ECs (for dual PSU24)	-	1690 1057 02
HSYS3HSG	HVLM Triple Card cage complete with Backplane, HVBC + ECs (for single PSU24)	-	1690 1058 01
HSYS3HSG	HVLM Triple Card cage complete with Backplane, HVBC + ECs (for dual PSU24)	-	1690 1058 02
HSYS3HSG	HVLM Triple Card cage complete with Backplane, HVBC + ECs (for triple PSU24)	-	1690 1058 03
HSYS4HSG	HVLM Quadruple Card cage complete with Backplane, HVBC (for single PSU24)	-	1690 1059 01
HSYS4HSG	HVLM Quadruple Card cage complete with Backplane, HVBC (for dual PSU24)	-	1690 1059 02
HSYS4HSG	HVLM Quadruple Card cage complete with Backplane, HVBC (for triple PSU24)	-	1690 1059 03
HSYS4HSG	HVLM Quadruple Card cage complete with Backplane, HVBC	-	1690 1059 04
HVBC	Hot Standby Vital Backplane Card (used with VLM5 and HVLM128)	-	4663/222
HVLC128	Hot Standby Vital Logic Card (part of HVLM128)	1	3650 1141 11
HVLM128	Hot Standby Vital Logic Module	1	–
LEC	Logic Evaluation Card (part of NVC/DM)	1	2650 1230 01
NCDM	Network Communication Diagnostic Module–style 1: comprises NCDC and NCD PFM	1	–
NCD PFM	Network Communication Diagnostic Protection Filter Module–Style 1 (obsolete)	-	4663/271
NCDC PFM	Network Communication Diagnostic Protection Filter Module–Style 2	-	B47000/138E A
NCDC	Network Communication Diagnostic Card–Style 1 (Mod D Rev 7)	1	4663/270
NCDC	Network Communication Diagnostic Card–Style 2 (Mod E Rev 8)	1	TBA

Table 3.1 WESTRACE Modules *(Continued)*

Name	Description	Slot	Part No.
NVC/DM	Complete Non-Vital and Communications Module. Includes LEC, CIMFIM and software	2	2690 1065 01
NVC232	Non-Vital Telemetry RS232	1	3650 1139 14
NVC232CT	Non-Vital Telemetry RS232, clock reconstruction, tri-state	1	3650 1139 13
NVC232T	Non-Vital Telemetry RS232, tri-state	1	3650 1139 12
NVC422-M	Non-Vital Telemetry RS422, tri-state	1	3650 1139 10
NVC422-NM	Non-Vital Telemetry RS422, clock reconstruction, tri-state	1	3650 1139 11
OPC50	Output Power Card 50 V (part of VLM1, VLM5, VLM6, HVLM128)	1	3650 1102 04
OPC50PFM	OPC50 Protection Filter Module (for OPC50)	-	3650 1136 04
PSU EXP1	PSU Expansion Cable for Double Card cage	-	3650 1147 01
PSU EXP2	PSU Expansion Cable for Triple Card cage	-	3650 1148 01
PSU EXP3	PSU Expansion Cable for Quadruple Card cage	-	3650 1149 01
PSU24	Power Supply Unit 24V	-	3650 1131 01
PSU24PFM	PSU24 Protection Filter Module (for PSU24)	-	3650 1104 01
SDB232	Serial Daughter Board 232 (for CIMFIM)	-	2650 1232 01
SDB485	Serial Daughter Board 485 (for CIMFIM)	-	2650 1233 01
SIO232PFM	Serial Interface Protection Filter Module RS232 (used with VTC232, EVTC232, WCM, NVC232, DM, DM128)	-	3650 1123 01
SIO422PFM	Serial Interface Protection Filter Module RS422 (for NVC422)	-	2650 1138 01
SYS1HSG	Single card cage complete with Backplane, VBC + EC1	-	1690 1027 01
SYS2HSG	Double card cage complete with Backplanes, VBC + ECs	-	1690 1028 01
SYS3HSG	Triple card cage complete with Backplanes, VBC + ECs	-	1690 1029 01
SYS4HSG	Quadruple card cage complete with Backplanes, VBC + ECs	-	1690 1030 01
UHSYS1HSG	Single Card cage complete with Backplane, UHVBC + EC1	-	1690 1067 01
UHSYS2HSG	Double Card cage complete with Backplane, UHVBC + ECs (for single PSU24)	-	1690 1068 01
UHSYS2HSG	Double Card cage complete with Backplane, UHVBC + ECs (for dual PSU24)	-	1690 1068 02
UHSYS3HSG	Triple Card cage complete with Backplane, UHVBC + ECs (for single PSU24)	-	1690 1069 01
UHSYS3HSG	Triple Card cage complete with Backplane, UHVBC + ECs (for dual PSU24)	-	1690 1069 02
UHSYS3HSG	Triple Card cage complete with Backplane, UHVBC + ECs (for triple PSU24)	-	1690 1069 03

Table 3.1 WESTRACE Modules *(Continued)*

Name	Description	Slot	Part No.
UHSYS4HSG	Quadruple Card cage complete with Backplane, UHVBC (for single PSU24)	-	1690 1070 01
UHSYS4HSG	Quadruple Card cage complete with Backplane, UHVBC (for dual PSU24)	-	1690 1070 02
UHSYS4HSG	Quadruple Card cage complete with Backplane, UHVBC (for triple PSU24)	-	1690 1070 03
UHSYS4HSG	Quadruple Card cage complete with Backplane, UHVBC	-	1690 1070 04
UHVBC	Universal Hot standby Vital Backplane Card (Used by HVLM128, VLM5 or VLM6)	-	4663/268
VBC	VLM Backplane (used by VLM1)	-	3650 1105 01
VLC	Vital Logic Card (part of VLM1)	1	3650 1100 10
VLC5	Vital Logic Card 5 (part of VLM5)	1	4663/269
VLC6	Vital Logic Card 6 (part of VLM6)	1	3650 1141 12
VLM	See VLM1, HVLM128, VLM5 or VLM6	–	–
VLM1	Vital Logic Module 1	1	–
VLM5	Vital Logic Module 5	1	–
VLM6	Vital Logic Module 6	1	–
VLOM110PFM	VLOM Protection Filter Module 110 V (used with VLOMFT110)	-	3650 1135 04
VLOMAB	Vital Lamp Output Module Analogue Board (2 form part of VLOMFT110)	2	
VLOMFS110	Vital Lamp Output Module 12 x Steady/Flash 110 V, (6 Lamps)	3	1690 1018 01
VLOMFT110	Vital Lamp Output Module 12 x Steady/Flash 110 V, (12 Lamps)	3	1690 1020 01
VLOMSS110	Vital Lamp Output Module 12 x Steady/Flash 110 V, (6 Lamps)	3	1690 1017 01
VPIM50	Vital Parallel Input Module 50 V (12 inputs)	2	1690 1007 01
VPIM50PFM	VPIM50 Protection Filter Module (for VPIM50)	-	3650 1112 01
VPIMAB	Vital Parallel Input Module Analogue Board (part of VPIM50)		
VPIODB	VPIO Digital Board (part of VLOMFT110, VROM50, VPIM50)	1	
VROM50	Vital Relay Output Module 50 V (8 Outputs)	2	1690 1023 01
VROM50PFM	VROM50 Protection Filter Module (for VROM50)	-	3650 1137 04
VROMAB	Vital Relay Output Module Analogue Board (part of VROM50)	1	
VTC232	Vital Telemetry Continuous RS232	1	3650 1129 10
WCM	WESTECT Communication Module (RS232)	1	3650 1129 12
WNCM	WESTRACE Network Communication Module (VLC6 and NCDC mated together)	2	3650 1141 13

Note: ***A 12-lamp VLOM requires two VLOM PFMs.***

3.2 Allocating Modules

Note: ***The VLM is allocated to housing number one.***

Each WESTRACE System must contain a single VLM.

Each WESTRACE System must contain at least two vital modules in addition to the VLM.

The NCDM is allocated to housing 1, adjacent to the VLM6.

Only one diagnostic module (NCDM, NVC/DM, DM128 or DM) may be used per installation.

3.2.1 System Capacity

Ensure the system requirements are met by the WESTRACE system.

3.2.1.1 Logic Processing

The maximum system capacity is listed in table 3.2.

Table 3.2 WESTRACE System Capacity Specifications

FUNCTION	VLM1	HVLM128	VLM5	VLM6	NCDM	NVC/DM
Mnemonics	1000	2500	4000	4000	40000	40000
Internal Latches	384	2057	3357	3357	15000	15000
SR Latches	-	-	-	-	2000	2000
Timers	96	200	300	300	3000	3000
Time-of-day Timers	-	-	-	-	10	10
Approximate limit to number of logic rungs	300[1]	750[1,2]	1800[1,2]	1800[1,2]	15000[1]	15000[1]

1. Capacity depends on the complexity of the rungs.
2. Reduce by 30% for hot standby.

Note: ***An internal latch is any mnemonic that is not declared to be an input, an output, a timer start, or timer expired.***

3.2.1.2 Limits on Number of Modules

The number of modules is limited by the GCSS (or CS) to the maximum that can be fitted into a four-housing system and table 3.3.

Table 3.3 Module Number Limits

Module	Maximum Number	Slots per Module
VPIM50	26	2
VROM50	26	2
VLOMFT110	18	3
VTC232, EVTC232	8	1
WCM	1	1
DM, DM128	1	1
NCDM	1	1
NVC/DM	1	2
NVC232, NVC422	10	1

3.2.1.3 Communication Time Limits

A finite amount of time is required for the VLM to communicate with each module in the System. Different modules require different times.

The limits for total communications time are:

- 333 ms for VLM6;
- 333 ms for VLM5;
- 200 ms for HVLM;
- 100 ms for VLM1.

This restriction is enforced by CS (but not GCSS). The communication time required by each module is listed in table 3.4.

Table 3.4 Module Communication Times

Module	Communication Time (ms)
VPIM	1.8
VROM	2.3
VLOMFS	2.8
VLOMFT	4.8
VTC	7.8
EVTC	13.6
WCM	13.8
NVC	3.5
NVC/DM	25 when used with HVLM128 33 when used with VLM5
NCDM	15 when used with VLM6
DM	15.0
DM128	15.0

3.2.1.4 Housings System Conventions

Figures 3.1 to 3.3 shows the numbering convention and number of slots available for interface modules on each housing. Figures 3.1 to 3.3 also shows the recommended positions of the DM, NVC/DM and NCDM modules. By convention, the housings are numbered from top to bottom, 1 to 4, and the slots from right to left, 1 to 15. The diagram depicts the housings viewed from front.

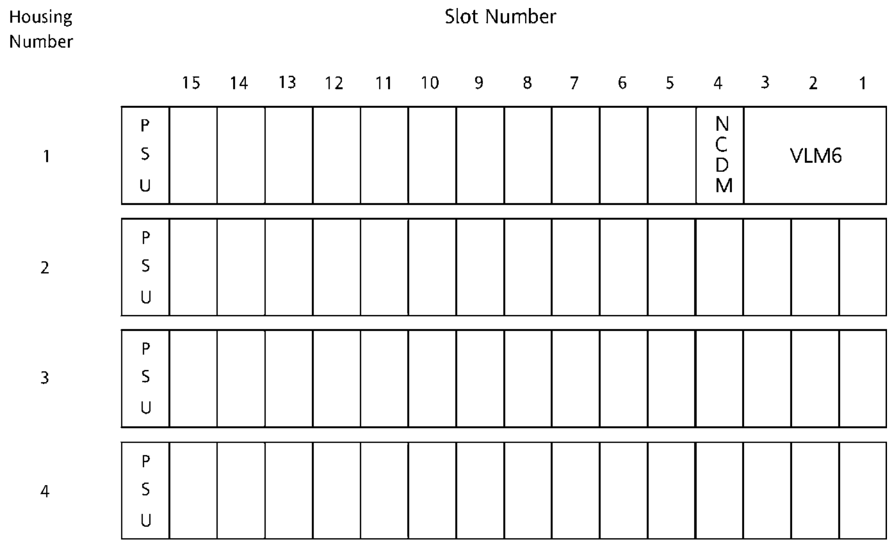


Figure 3.1 WESTRACE Housing & Slot Nomenclature – VLM6 & NCDM Configuration

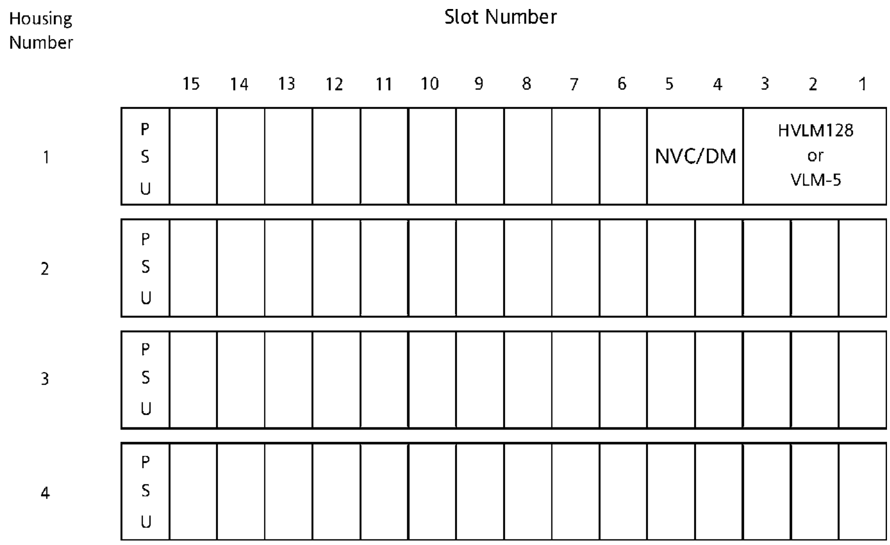


Figure 3.2 WESTRACE Housing & Slot Nomenclature – HVLM128 or VLM5 & NVC/DM Configuration

Housing Number		Slot Number														
		15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
1	PSU	DM												HVLM or VLM		
2	PSU															
3	PSU															
4	PSU															

Figure 3.3 WESTRACE Housing & Slot Nomenclature—Older Configuration

3.2.1.5 Slot Availability

Some slots are automatically allocated by the configuration system and are not available for interface modules (see figures 3.1 to 3.3):

- a VLM6, VLM5 or HVLM occupies slots 2 and 3 and a blanker fills slot 1 of housing number 1 although GCSS and ICS will show the VLM6, VLM5 or HVLM in slots 1 and 2;
- an NCDM occupies slot 4;
- a VLM1 occupies slots 1, 2 and 3.

Invensys Rail recommends:

- an NCDM occupies slot 4;
- an NVC/DM occupies slots 4 and 5;
- a DM or DM128 occupies slot 15.

Although the diagram shows one PSU per housing, the actual number of PSUs required in a multi housing system, and the total power taken from the external +24 V source, depends on the configuration of the installation (see section 3.3).

The types of modules available and the number of slots occupied by each module are listed in section 3.1.

3.3 Power Supply

Ensure that sufficient power is provided for the WESTRACE system.

The external power supply to any WESTRACE equipment (B24) must be from a guaranteed no-break supply. This will normally be a float charged battery. The required supply voltage is 24 V nominal (20 to 30 V instantaneous).

Table 3.5 shows power outputs generated by PSU and OPC from the B24.

Table 3.5 Output Power

Output Power Capabilities (Watts)					
MODULE	**+5V**	**+12V**	**-12V**	**+12V (power)**	**VSEV**
PSU	25	6	6	30	-
OPC	-	-	-	-	8

Table 3.6 shows the maximum power consumption or each WESTRACE module.

Table 3.6 Power Consumption of WESTRACE Modules

Module Maximum Power Consumption (Watts)						
MODULE	**+5V**	**+12V**	**-12V**	**+12V (power)**	**VSEV**	**B24**
VLC6	3.3	-	-	-	-	-
VLC5	2.0	-	-	-	-	-
HVLC	1.8	-	-	-	-	-
VLC	0.9	-	-	-	-	-
CEC	0.1	-	-	-	-	-
OPC	0.2	-	-	-	-	15.0
VPIM	1.1	0.2	0.3	-	-	-
VROM	1.25	0.6	0.1	1.3	-	-
VLOM 12 Outputs	1.25	0.6	0.6	5.0	-	-
VLOM 6 Outputs	1.25	0.6	0.6	3.0	-	-
WCM	1.2	-	-	-	1.0	-
EVTC or VTC	1.2	-	-	-	1.0	-
NVC	0.8	-	-	-	-	1.0
NVC/DM	7.0	-	-	-	1.0	8.0
NCDM	4.2	-	-	-	1.0	2.5
DM or DM128	2.0	-	-	0.6	-	-

3.3.1 Calculating Power Requirements

Note: ***Power consumption quoted for VROM +5 V is the maximum power at start-up.***

Never connect more than one NVC module to the VSEV.

3.3.1.1 Determine the Number of PSUs

Invensys Rail recommends using one PSU per housing (although a single PSU can supply multiple housings).

Tally the wattage taken from the +5 V by each module. If the total is greater than or equal to the output of a single PSU, use up to three additional PSUs.

Repeat the calculation for the +12 V, -12 V and +12 V (power) supplies.

A limit of four PSUs cannot be exceeded.

For example, a typical installation may contain:

Module Type	**Qty**
(VLC6 + OPC)	1
VPIM	5
VROM	8
VLOM	4
NCDM	1

The power consumption totals taken from the internal supplies by the modules from the PSU(s) are:

+5 V	=	28.2 W	=	2 PSU
+12 V	=	8.2 W	=	2 PSU
-12 V	=	4.7 W	=	2 PSU
+12 V (power)	=	30 W	=	2 PSU

Thus two PSUs are required.

3.3.1.2 Determine Power Consumption

Determine the power required from the external 24 V supply.

The PSU has an efficiency of approximately 66%. Thus the power taken from the external 24 V supply by the PSU to supply the internal power for a module will be 1.5 times the sum of the total power drawn from the internal supplies.

The power drawn from the external 24 V supply will be:
Total Internal Power × 1.5 + OPC + NCDM
= ((28.2+ 8.2 + 4.7 + 30) × 1.5) + 15 + 2.5
= (71.1 × 1.5) + 15 + 2.5
= 106.65 + 15 + 2.5
= 124.15 W

This figure for power taken from the external 24 V supply does not include provision for the signalling loads themselves (such as relays and lamps).

Note: ***Use the correct power source for NVC and NVC/DM B24 supply:***

- ***a single NVC may be supplied from VSEV;***
- ***multiple NVCs should be supplied from B24 (can be via an OPC repeat contact to prevent communications when WESTRACE is not running);***
- ***NCDM and NVC/DM should be supplied from B24 directly (an OPC repeat contact will prevent using diagnostics after shutdown).***

3.4 Fusing

Ensure that all signalling supplies to the WESTRACE installation are suitably fused or protected against overcurrent.

Fuse values depend on the local configuration. We recommend a fuse value of 1.5 times the maximum expected current.

Choose fuses and circuit breaker ratings to provide adequate discrimination.

The 24 V supply to housings can be provided either through a single fuse, or through individual fuses. If individual fuses are used, always insert the fuse for the top housing **last** when powering the system.

NCDC PFM Fusing

Note: ***We recommend that you power the NCDC PFM through the same fuse as the top WESTRACE housing.***

Failure to power the NCDC PFM in this way on a hot-standby system can lock up serial communications if individual housing fuses are used and one blows.

3.5 Network Communication

A WESTRACE system configured with a NCDM provides a single 10 baseT, Ethernet compliant network interface. The interface uses the UDP/IP protocol suite as the underlying protocol.

The NCDM Non-Vital Configuration allows the configuration of:

- Default gateway address;
- Five additional gateway addresses;
- Subnet mask.

The network interface supports a total of 48 configurable network sessions. These sessions can be configured as either:

- Vital Communication sessions (only available when the NCDM is used in conjunction with a VLM6);
- Non-Vital Communication sessions (for connection to external control systems and external diagnostic systems).

Note: ***When 'store and forward' communication equipment is used as part of the network infrastructure, the transmission of stored data following re-establishment of the communication link after a loss of communication should be disabled otherwise excessive network traffic may cause the NCDM to shutdown.***

3.6 Vital Communication Over a Network

Vital communication over a network allows the transfer of logic states between WESTRACE systems. A WESTRACE system may be connected to up to 16 other systems using vital communications over a network.

Each WESTRACE system may be arranged as a hot standby or stand-alone installation.

Each vital communication session can transfer up to 182 inputs and up to 182 outputs (26 bytes with 7 data bits and 1 parity bit).

3.6.1 Data Integrity

The vital communication protocol used by WESTRACE has the following features to assure the integrity of transferred data:

- Parity bits and 'true' and 'complement' representation are used to protect the data in vital communication messages in the same way as communications between the VLM6 and other modules within a WESTRACE system are protected.
  A message is discarded when the 'true' and 'complement' representations are not coherent or a parity error is detected;
- A CRC error detection code is included in the 'true' and 'complement' representations of each vital communication message so that any corruption which occurs during transmission can be detected.
  This is checked by the receiver and corrupted messages are discarded;
- Unique installation addresses for both the transmitting and receiving WESTRACE, and the vital port number (8-23) for each WESTRACE are included in every vital message.
  The receiver checks these and discards incorrectly addressed messages.

Ensure:

- Only vital data is transferred over vital communication sessions;
- Communicating WESTRACEs are compatible (see section 3.6.2).

3.6.2 Compatibility

The vital communication protocol used by WESTRACE protects against incompatible vital messaging:

- Module compatibility index—communication can only occur between modules with acceptable (normally identical) compatibility indices;
- The application data version of the remote WESTRACE must match the data version contained in the local interface file;
- Source and destination network addresses;
- Vital port numbers.

These message fields are checked by the receiver and incompatible messages are discarded.

Ensure:

- Compatible WESTRACE modules are used when WESTRACEs are required to communicate vitally;
- The interface file for each WESTRACE reference the correct application data version in the other WESTRACE;
  It may be necessary to update the application data (vital CED) in both WESTRACEs of a communicating pair when the application data of one WESTRACE is changed;
- Source address, destination address and vital port numbers are correct and compatible in both WESTRACEs;
  Source and destination address and vital port numbers are set up when configuring the WESTRACE installation interface file using the WESTRACE Graphical Configuration Sub-system. See reference [GCSS].

3.6.3 Time and Sequence Integrity

The vital communication protocol used by WESTRACE has the following features to assure time and sequence integrity:

- A Receive Timestamp (time when the last message was sent to the remote system) to enable the round trip time of a message to be determined.
  The receiver assumes a message to be delayed and discards it when the Receive Timestamp in the message differs from the current installation time by more than a pre-defined value;
- A Transmit Timestamp to enable the sequence of the message to be determined;
  The receiver discards the message when the Transmit Timestamp in the current message is found to be the same as or earlier than the last valid Transmit Timestamp received.

Ensure that the communications network is designed to minimise unacceptable delays to messages as this can lead to session failure. See section 3.6.4.1.

3.6.4 Loss of Communication (LOC)

3.6.4.1 Session Failures

The vital communication session will be considered 'timed out' if no valid vital communication message is received within the configurable Loss Of Communication (LOC) period (see section 3.6.4.2).

This causes the VLM6 to:

- De-energise the #LOC (Loss Of Communication #) reserved mnemonic;
- Assume that all input states associated with the failed session are de-energised.

Apart from the above, both WESTRACE systems will continue operating normally (ie not shutdown) in the event of a vital communication session failure.

Ensure that de-energised vital communication inputs are always a safe state.

3.6.4.2 LOC Time-out Period

The VLM6 uses the Loss of Communication (LOC) timeout period for each vital communication over a network to determine:

- When de-energised states are assumed for inputs associated with a vital communication session;
- The acceptable limit for round trip time of a vital message.

Table 3.7 identifies the recommended LOC timeout values for two WESTRACE installations communicating vitally over a network. It includes:

- Combinations of installations with the minimum, maximum and practical cycle times;
- Stand-alone and hot standby configurations.

The practical cycle time is the anticipated maximum cycle expected for applications of main WESTRACE (interlocking function only) and WESTRACE Object Controller (vital I/O function only).

Table 3.7 LOC Timeout Values—Recommended—Two WNC Installations with Vital Comms Over a Network

Local Installation		Remote Installation					
		Stand-alone			Hot Standby		
		Minimum Cycle Time	Maximum Cycle Time	WNC Practical Cycle Time	Minimum Cycle Time	Maximum Cycle Time	WNC Practical Cycle Time
Stand-alone	Minimum Cycle Time	1.8 s	3.3 s	2.7 s	2.4 s	3.5 s	2.9 s
	Maximum Cycle Time	2.5 s	4.0 s	3.4 s	3.1 s	4.2 s	3.6 s
	WNC Practical Cycle Time	2.2 s	3.7 s	3.1 s	2.8 s	3.9 s	3.3 s
Hot Standby	Minimum Cycle Time	2.2 s	3.7 s	3.1 s	2.8 s	3.9 s	3.3 s
	Maximum Cycle Time	2.7 s	4.2 s	3.6 s	3.3 s	4.4 s	3.8 s
	WNC Practical Cycle Time	2.4 s	3.9 s	3.3 s	3.0 s	4.1 s	3.5 s

Note: ***The LOC timeout value may be configured with values less than those shown above, however this may result in some messages being discarded as delayed due to the asynchronous cycle times of the connected systems.***

When the LOC time out value is set to the same value as the VLM6 cycle time, any loss of message will cause the VLM6 to revert to de-energised states.

Use the GCSS to configure practical LOC values.

Note: ***See Appendix A in reference [GCSS] to confirm the correct units to use when configuring LOC through the GCSS.***

3.6.5 Communication Media

The vital communication protocol used by WESTRACE is designed for use on transmission systems where unauthorised access can be excluded.

Vital communication over a network could be exposed to the following threats:

- Hacking (deliberate unauthorised interference);
- Excessive network traffic (unauthorised use of the network).

Sections 3.6.5.1 and 3.6.5.2 define the rules and guidance which must be applied to the communication media as protection against these threats.

SAFETY WARNING

Observe the following restrictions.

3.6.5.1 Hacking

Hacking is defined as the unauthorised access to communication bearers. The hacker may be able to corrupt, re-transmit, or introduce illegal messages into the system.

The defences against hacking are:

- No public access to the communication media;
- A complex message format.

Reduce the risk of hacking by ensuring:

- A dedicated railway network is used to render the communication media less susceptible to outside disturbances;
- Networks used for administration purposes are not connected to networks used for vital communication, unless the network used for vital communication is protected by a firewall of an equivalent safety integrity;
- Third party communication media (hired or otherwise) are not used;
- Access to the network is physically restricted to authorised persons.

3.6.5.2 Excessive Network Traffic

Excessive network traffic or network flooding may occur as a result of unauthorised use of the network. Network flooding can cause unacceptable delays in the delivery of vital or non-vital messages which may result in the loss of control of the railway.

Protect against network flooding by:

- Use of a sub-netting addressing scheme to minimise unnecessary transmission of messages;
- Restricting the use of the network to vital and non-vital communications for controlling the railway.

3.7 Non-Vital Communication Over a Network

Non-Vital communication over a network allows the WESTRACE system to interface with other WESTRACE systems, external control systems and external diagnostic systems.

WESTRACE supports the non-vital communication protocols described in Appendix D.

3.7.1 Data Integrity

The non-vital communication protocols used by WESTRACE have the following features to assure integrity of transferred data:

- The data message is protected by:

    A Block Check Sum Character (BCC) or Cyclic Redundancy Code (CRC);
    - A Block Check Sum Character (BCC) provided by the underlying UDP/IP protocol suite.
- The data message includes:

    A unique session ID;
    - A housing or diagnostic address;
    - Read and Read/Write passwords;
    - Network (IP) addresses.

Ensure:

- Only non-vital data is transferred over non-vital communication sessions;
- Identifying IDs, addresses and passwords are correctly set when using the WESTRACE Graphical Configuration Sub-system. See reference [GCSS].

3.7.2 Time and Sequence Integrity

The non-vital communication protocols used by WESTRACE have the following features to assure time and sequence integrity of the transferred data:

- A Receive Timestamp to enable the round trip time of the message to be determined;

    The receiver assumes a message to be delayed and discards it when the Receive Timestamp in the message differs from the current installation time by more than a pre-defined value;
- A Transmit Timestamp to enable the sequence of the message to be determined;

    The receiver discards the message when the Transmit Timestamp in the current message is found to be the same or earlier than the last valid Transmit Timestamp received.

Ensure that the communications network is designed to minimise unacceptable delays to messages as this can lead to session failure. See section 3.7.3.2.

3.7.3 Loss of Communication (LOC)

3.7.3.1 Session Failure

The session will be considered 'timed out' if no valid communication message is received within the configurable Loss Of Communication (LOC) period (see section 3.7.3.2).

The NCDM will then:

- De-energise the configurable 'session OK' state;
- Assume that all input states associated with the failed session are de-energised;
- Assume logout for diagnostic sessions;
- Assume WSL S2 server is unconfigured.

3.7.3.2 LOC Timeout Period

The NCDM uses the Loss of Communication (LOC) timeout period for each non-vital network communication session to determine:

- When de-energised states are assumed for inputs associated with the non-vital network communication session;
- The acceptable limit for round trip time.

The LOC timeout value is configurable through the GCSS. All non-vital network communication sessions–5 seconds.

Use the GCSS to configure the LOC value.

Note: ***See Appendix A in reference [GCSS] to confirm the correct units to use when configuring LOC through the GCSS.***

3.7.4 Communication Media

The communication media requirements for vital communication over a network (see section 3.6.5) should also be applied to non-vital communication over a network.

3.8 Vital Serial Interfaces to WESTRACE

Vital serial communications modules transfer logic states between WESTRACE systems. A WESTRACE system may be connected to up to eight other systems using these serial links.

A VTC module can transfer up to 17 inputs and outputs, an EVTC can transfer up to 66 inputs and outputs.

3.8.1 Data Integrity

The vital serial protocols used by WESTRACE have the following features to assure the integrity of transferred data:

- Parity bits and 'true' and 'complement' representation are used to protect the data in each serial message in the same way as are communications between the VLM and other modules within a WESTRACE system protected;
  A message is discarded when the 'true' and 'complement' representations are not coherent or a parity error is detected;
- The unique installation address of the receiving WESTRACE, and the vital serial port number (0-7) are included in each message;
  The receiver checks these and discards incorrectly addressed messages;
- A CRC error detection code is included in each message so that any corruption which occurs during transmission can be detected;
  This is checked by the receiver and corrupted messages are discarded.

Ensure:

- Only vital data is transferred over the vital communication sessions;
- Communicating WESTRACEs are compatible (see section 3.8.2).

3.8.2 Compatibility

Every vital WESTRACE module has a compatibility index. Communication can only occur between modules having acceptable (normally identical) indices.

A VLM will not complete start-up with incompatible modules.

Vital modules will discard messages from an incompatible module.

All modules supplied by Invensys Rail are compatible with each other but are incompatible with modules supplied by WRSL.

Ensure:

- Compatible modules are used in a WESTRACE system;
- All port numbers are correctly allocated.

3.8.3 Timing

Vital serial links introduce delays which the application engineer must accommodate when designing application logic otherwise it is possible for the interlocking logic to oscillate or lock up.

Ensure that delays in the vital serial links do not cause:

- Logic 'races';
- Logic oscillations;
- Unsafe operation due to delayed inputs or inputs arriving out of order.

3.8.4 Link Failures

The link will be considered 'failed' if no valid vital serial message is received for a period of two seconds.

This causes the VLM to:

- De-energise the #LOIC (Loss Of Input Channel #) reserved mnemonic;
- Assume that all input states associated with the failed link are de-energised;
- Set a bit in subsequent outgoing messages to inform the VLM at the other end that messages are not being received; which in turn will cause the other VLM to set its #LOOC (Loss of Output Channel #) reserved mnemonic.

Apart from the above, both WESTRACE systems will continue operating normally (ie not shutdown) in the event of a vital serial link failure.

Ensure that de-energised vital serial inputs are always a safe state.

3.8.5 Communication Media

Dedicated wire pairs are the preferred communication medium when using WESTRACE equipment to transfer vital serial information to other WESTRACE equipment or other systems.

SAFETY
WARNING

Observe the following restrictions applying to serial data.

It is possible to use WESTRACE with radio or other non-dedicated wire links, however the communication could be exposed to the following threats:

- Storage and re-transmission;
- Link cross talk;
- Hacking (deliberate unauthorised interference);
- Messages routed to the wrong destination.

Sections 3.8.5.1 to 3.8.5.4 define the rules and guidance that must be applied to the communication media as protection against these threats.

3.8.5.1 Storage and Re-transmission

The threat of storage and re-transmission is posed by any medium that is capable of storing a message and re-transmitting it at a later time. The message may be sent either as a solicited action, or at any time. Examples are intelligent modems and intelligent repeater systems.

When choosing the transmission media:

- Do not use intelligent modems or intelligent radio equipment;
- Ensure the link is under local control and no local buffers exist;
- Do not use service links (hired or otherwise) because it is unlikely that a link from a third party can be guaranteed to have no means of storage or re-transmission.

3.8.5.2 Link Cross Talk

Link cross talk is the receipt of information by a receiver from a communication path that the receiver is not connected to, but may be in close physical proximity.

This includes the threat of inadvertent connection between two circuits resulting from a fault in the communication system, and cross talk between systems which are not necessarily in physical proximity. For example, via anomalous radio propagation.

Reduce the risk of cross talk by ensuring:

- Each WESTRACE system has a unique address;
- The communications link is not shared with other users;
- The communication frequency is not repeated in different locations;
- The most selective receiver possible is chosen (the bandwidth of the receiver should match the bandwidth of the received signal);
- That frequencies which are susceptible to anomalous modes of propagation are not used.

3.8.5.3 Hacking

Hacking is defined as the unauthorised access to communication bearers. The hacker may be able to corrupt, re-transmit, or introduce illegal messages into the system.

The defences against hacking are:

- No public access to the communication channel;
- A complex message format.

Reduce the risk of hacking by ensuring:

- Point to point links are used to render the links less susceptible to outside disturbances;
- Directional antennae are used for radio communication systems;
- Transmitting power is maximised and receiver sensitivity is minimised;
- Frequencies which are commonly available to the general public are not used;
- To modulate the data or convert to radio frequencies as close as possible to the source (modulated data is more difficult to hack);
- Third party links (hired or otherwise) are not used;
- Directly modulated radio is used.

3.8.5.4 Messages Routed to Wrong Destination

The use of high quality communications equipment will reduce the risk of incorrect routing of messages because of equipment failures.

3.9 Hot Standby

Applications requiring high system availability can use the hot standby configuration of the WESTRACE interlocking, and optionally of WESTRACE object controllers. Two identical WESTRACE installations are used; one installation controls the railway while the other is maintained in an identical state via high-speed data links between the two.

The CONF1 and CONF2 links on the WESTRACE's VLM determine whether the WESTRACE is primarily intended ('biased') to operate as the online unit or the standby unit. (See section 4.1.6, Setting WESTRACE Operational Mode.)

Both WESTRACEs in a hot-standby pair must have the same installation address.

Either WESTRACE automatically takes control of the railway (operates stand-alone) if:

- one unit fails or is switched off during normal operation;
- only one unit is powered at startup.

See also:

- section 4.2.3.13 "VLOM Hot Standby";
- section 4.3.3.9 "VROM Hot Standby";
- figure 4.27 for master-slave usage of hot-standby NCDMs;
- figure 4.33 for master-slave usage of hot-standby NVC/DMs;
- Appendix C, Hot Standby Operation.

Note: ***Hot standby only becomes available at completion of the WESTRACE Application Delay (see [GCSS]), which is typically several minutes after power-up.***

3.9.1 Order of Power-Up

Do one of the following to ensure that the online-biased unit takes control:

- Power both units at the same time.
- Power the online-biased unit first, then the standby-biased unit any time after.

Caution: ***Neither unit takes control if the online-biased unit is powered between 10 seconds after the standby unit is powered and before the standby unit completes its online initialisation phase (typically takes several minutes). A 'sync period expired' message is issued and both units shut down if this occurs.***

The standby unit takes control if the online unit is powered-up after the standby unit completes its online initialisation phase (typically takes several minutes). See also figure C.2.

3.9.2 Changeover

The standby-biased WESTRACE immediately takes over if the online-biased unit fails. You can then power-off the online unit, repair or replace it, and power it up again. The online unit then synchronises with the other one and takes over standby operation (regardless of its online bias link).

If the online-biased WESTRACE fails and you power-off both units, re-apply power to the standby unit. It automatically operates as the online unit even though it is biased for standby operation.

3.9.3 General Application Information

Take the following information into account when designing a hot standby system.

3.9.3.1 Loss of Communication Extension During Changeover

A Hot Standby system configured with either vital serial communication or vital communication over a network may extend the Loss Of Communication period under the following circumstances:

- The Online System is about to declare Loss Of Communication for a vital communication connection (ie LOC timeout should occur in less than one VLM cycle time);
- A change-over occurs.

Under the circumstances described above, the LOC period is extended by one VLM cycle. Figure 3.4 illustrates the signal aspects that may be observed as a result.

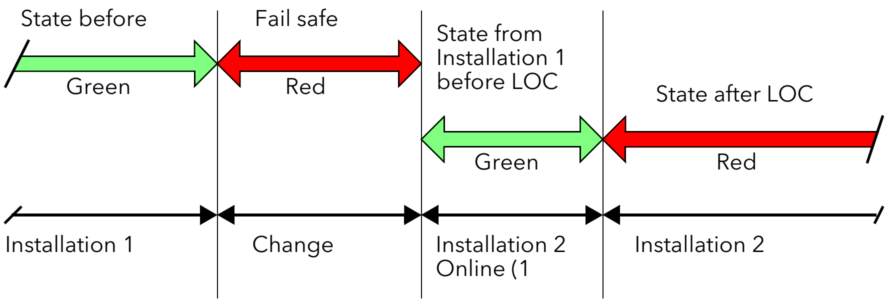


Figure 3.4 LOC Extension During Change-over

Note: ***The Application Engineer should be aware of the scenario illustrated by figure 3.4.***

Ensure the scenario illustrated in this section is taken into consideration when designing the system.

3.9.3.2 NCDM Reserved States—Online

The NCDM in the online installation maintains the reserved state mnemonics associated with itself. These mnemonics may indicate a fault with the NCDM and may require attention. See [GCSS] for details.

3.9.3.3 NCDM Reserved States—Standby

The NCDM in the online installation maintains the reserved state mnemonics associated with the other NCDM in the hot standby system. See [GCSS] for details.

3.9.3.4 VLM6 Reserved States

The VLM6 in the online installation maintains the reserved state mnemonic 'CONFLT'. See [GCSS] for details.

3.9.4 Hot Standby Configuration using WNCM

A hot standby system can use a WESTRACE Network Communication Module (ie VLC6 and NCDC). Figure 3.5 shows the minimum configuration.

Note: ***The NCDM is specifically designed for Hot Standby operation. Network sessions and serial ports configured with control system protocols do not transmit when the NCDM is in a Standby installation, so external switching of the NCDM transmit circuits is not necessary. Only the WESTRACE in Online Mode transmits vital application data over the network.***

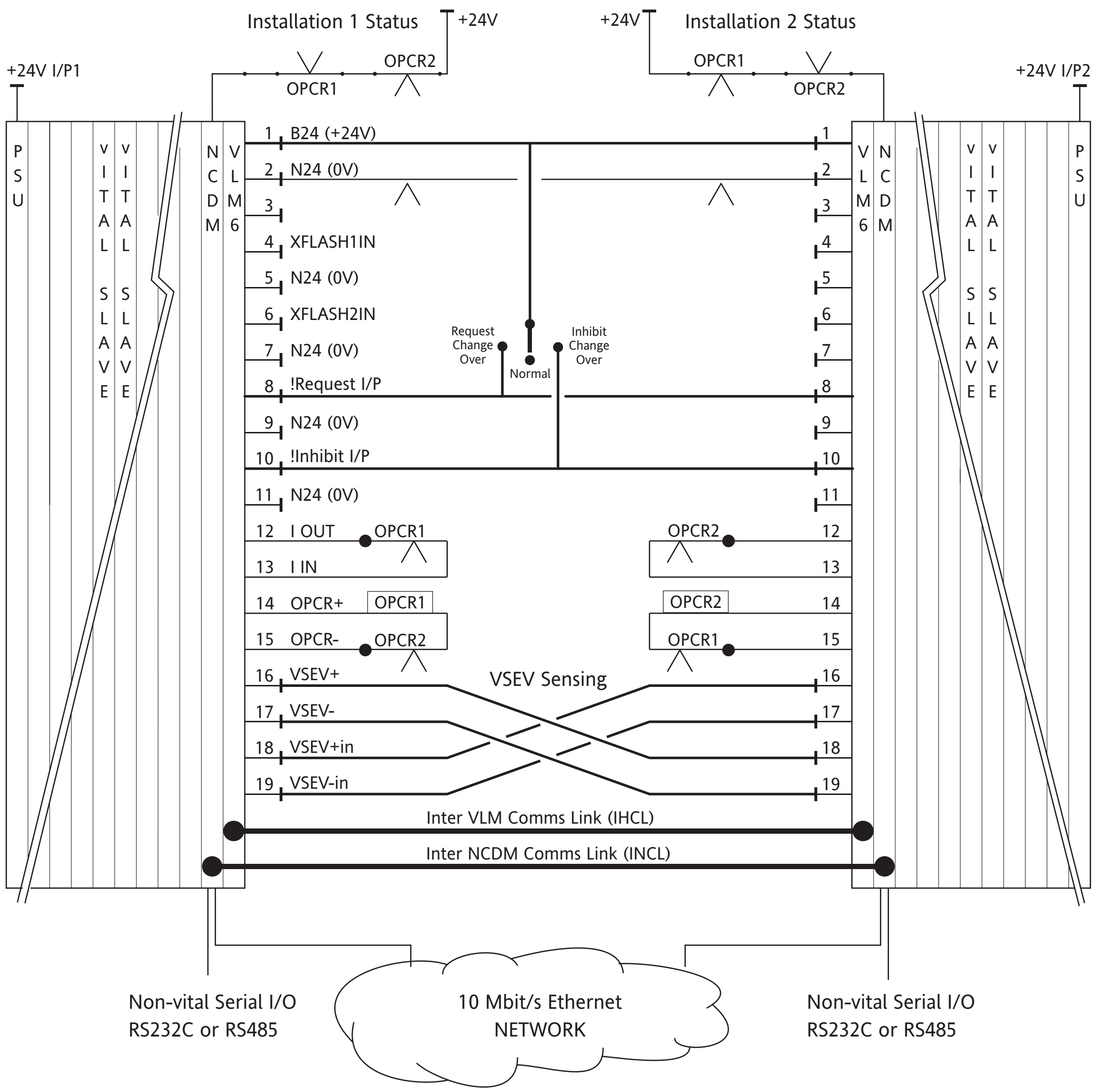


Figure 3.5 Hot Standby Configuration – VLM6 and NCDM

Wire the transmit circuits of:

- vital serial links (VTC or EVTC), and;
- non-vital serial links (NVC);

through OPCR contacts to ensure that only the vital serial modules and non-vital serial modules associated with the online installation are connected to the communications circuit.

Vital parallel inputs are normally commoned but may be connected by OPC repeat relays.

Vital parallel outputs must be powered from an OPC relay-switched power supply, however the outputs may be commoned or switched by OPC repeat relays.

For hot-standby WESTRACEs, fit fibre-optic links between:

- the IHCL[1] Tx connector of each main and standby VLM;
- the IHCL Rx connector of each main and standby VLM;
- the INCL[2] Tx connector of each main and standby NCDM;
- the INCL Rx connector of each main and standby NCDM.

See figures 3.6–3.8.

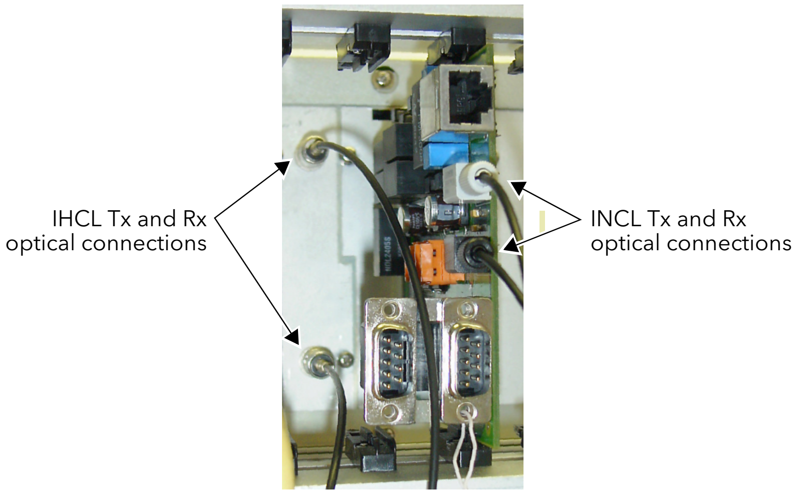


Figure 3.6 Connections – INCL and IHCL

Note: ***Take extreme care not to damage the IHCL and INCL fibre-optic cables used to link hot-standby VLM6s and NCDMs. The fibre-optic cables are fragile, and sharp bends can stress or fracture them, causing high losses or intermittent communications.***

[1] IHCL: Inter-HVLM Communications Link
[2] INCL: Inter NCDM Communications Link

3.9.5 Hot Standby Configuration Using VLM5

A hot standby system can use a VLM5 vital processor. Figure 3.7 shows the minimum configuration.

Note: ***The NVC/DM has been validated for Hot Standby operation, but only as a diagnostic module (emulating a DM128 or DM5).***

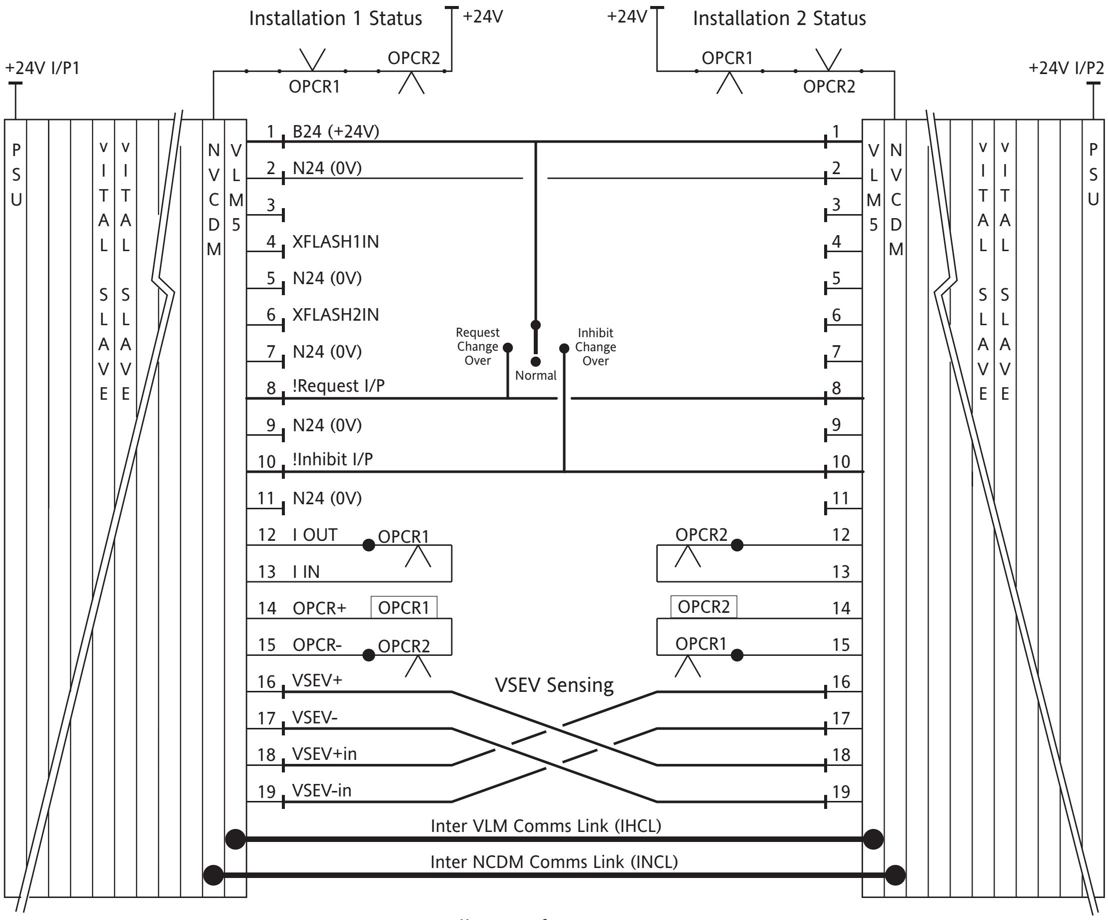


Figure 3.7 Hot Standby Configuration–VLM5

Wire the transmit circuits of:

- vital serial links (VTC or EVTC), and;
- non-vital serial links used for external control systems (NVC or NVC/DM);

through OPCR contacts to ensure that only the vital serial modules and non-vital serial modules associated with the online installation are connected to the communications circuit.

Vital parallel inputs are normally commoned but may be connected by OPC repeat relays.

Power vital parallel outputs from an OPC relay-switched power supply; however, you may common the outputs or switch them by OPC repeat relays.

Note: ***Take extreme care not to damage the IHCL and INCL fibre-optic cables used to link hot-standby VLM5s and NVCDMs. The fibre-optic cables are fragile, and sharp bends can stress or fracture them, causing high losses or intermittent communications.***

3.9.6 Hot Standby Configuration Using HVLM128

A hot standby system can use a HVLM128 vital processor. Figure 3.8 shows the minimum configuration.

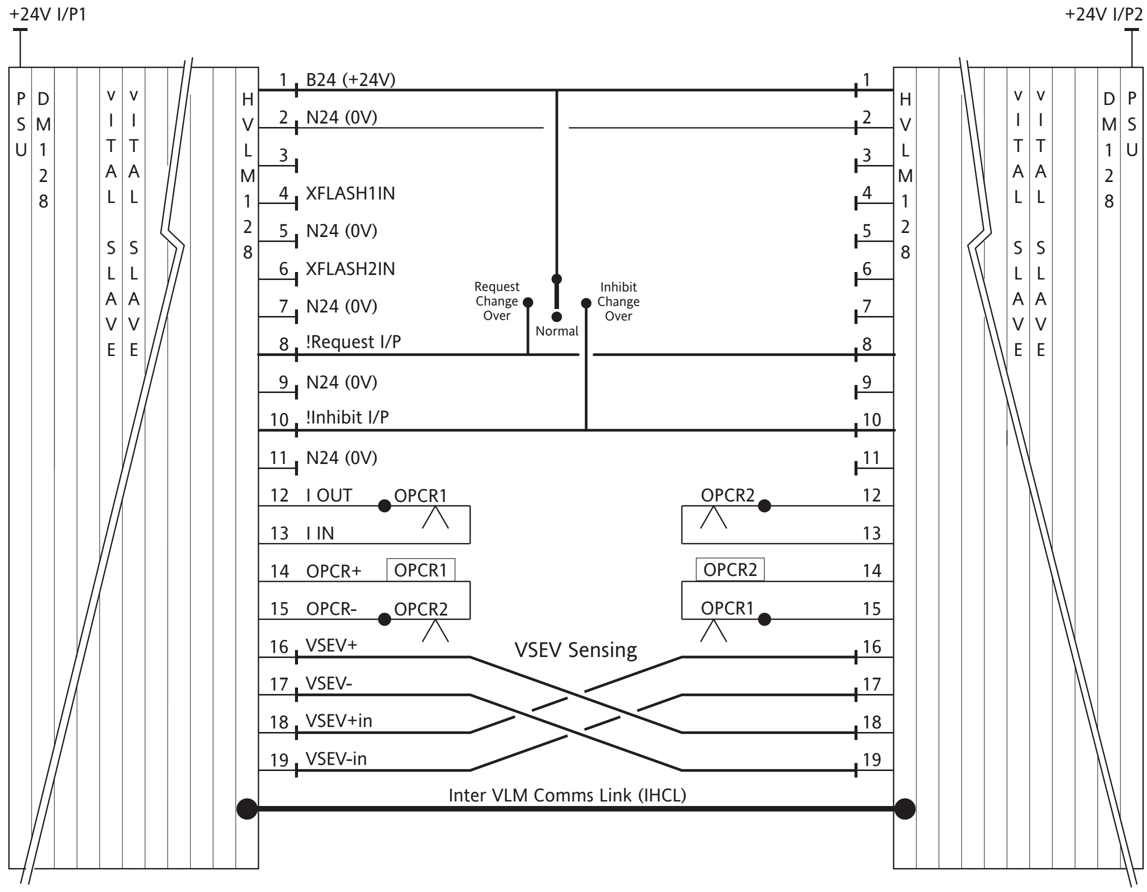


Figure 3.8 Hot Standby Configuration – HVLM128

Wire the transmit circuits of:

- vital serial links (VTC or EVTC), and;
- non-vital serial links used for external control systems (NVC);

through OPCR contacts to ensure that only the vital serial modules and non-vital serial modules associated with the online installation are connected to the communications circuit.

Vital parallel inputs are normally commoned but may be connected by OPC repeat relays.

Vital parallel outputs must be powered from an OPC relay switched power supply, however the outputs may be commoned or switched by OPC repeat relays.

Note: ***Take extreme care not to damage the IHCL fibre-optic cables used to link hot-standby HVLM128s. The fibre-optic cables are fragile, and sharp bends can stress or fracture them, causing high losses or intermittent communications.***

3.10 Installation Performance Times

3.10.1 System Response Times

The response time for each type of system is such that the actual minimum and maximum WESTRACE system response times can be calculated for a particular system configuration. The response times are in the form of component times, that can be combined for particular system configurations to produce an overall system response time.

The response time comprises an input time, two vital logic module cycles to process the information, and an output time.

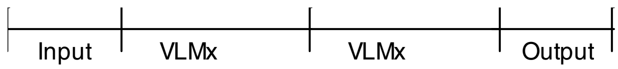


Figure 3.9 Response Time–WESTRACE Installation

The response time for an installation is calculated as shown in figure 3.9.

An input can be either a parallel input (VPIM) or a serial input (EVTC).

An output can be either a parallel output (VROM) or a serial output (EVTC). All serial transmissions are assumed to be successful.

Table 3.8 shows the worst case times to be used when calculating system response times.

Table 3.8 Response Times–Worst Case–Individual Items

Item	Time (Seconds)
Parallel Input (de-energised)	0.5
Parallel Output	0.3
Serial Input	0.225
Serial Output	0.675
Network Input	0.05
Network Output	0.05
HVLM128 (Minimum Stand Alone)	0.5
HVLM128 (Minimum Hot Standby)	0.75
HVLM128 (Maximum)	1.0
VLM5 (Minimum Stand Alone)	0.5
VLM5 (Minimum Hot Standby)	0.75
VLM5 (Maximum)	1.3
VLM6 (Minimum Stand Alone)	0.55
VLM6 (Minimum Hot Standby)	0.75
VLM6 (Maximum)	1.3

Note: ***Add an extra 0.4 seconds for an energised parallel input.***

The WESTRACE System Response times for an HVLM128 based system will not be greater than those shown in table 3.9.

Table 3.9 WESTRACE System Response Times–Worst Case–for a HVLM128-Based System

WESTRACE Installation type	Worst Case for Minimum Stand Alone Cycle (Seconds)	Worst Case for Minimum Hot Standby Cycle (Seconds)	Worst Case for Maximum Stand Alone or Hot Standby Cycle (Seconds)
Parallel Input to Parallel Output	1.8	2.3	2.8
Parallel Input to Serial Output	2.175	2.675	3.175
Serial Input to Parallel Output	1.525	2.025	2.525
Serial Input to Serial Output	1.9	2.4	2.9

The WESTRACE System Response times for a VLM5 based system will not be greater than those shown in table 3.10.

Table 3.10 WESTRACE System Response Times–Worst Case–for a VLM5-Based System

WESTRACE Installation type	Worst Case for Minimum Stand Alone Cycle (Seconds)	Worst Case for Minimum Hot Standby Cycle (Seconds)	Worst Case for Maximum Stand Alone or Hot Standby Cycle (Seconds)
Parallel Input to Parallel Output	1.8	2.3	3.4
Parallel Input to Serial Output	2.175	2.675	3.775
Serial Input to Parallel Output	1.525	2.025	3.125
Serial Input to Serial Output	1.9	2.4	3.5

The WESTRACE System Response times for a VLM6 based system will not be greater than those shown in 3.11.

Table 3.11 WESTRACE System Response Times—Worst Case—for a VLM6-Based System

WESTRACE Installation type	Worst Case for Minimum Stand Alone Cycle (Seconds)	Worst Case for Minimum Hot Standby Cycle (Seconds)	Worst Case for Maximum Stand Alone or Hot Standby Cycle (Seconds)
Parallel Input to Parallel Output	1.9	2.3	3.4
Parallel Input to Serial Output	2.275	2.675	3.775
Serial Input to Parallel Output	1.625	2.025	3.125
Serial Input to Serial Output	2.0	2.4	3.5
Network Input to Parallel Output	1.45	1.85	2.95
Network Input to Serial Output	1.825	2.225	3.325
Serial Input to Network Output	1.375	1.775	2.875
Parallel Input to Network Output	1.65	2.05	3.15
Network Input to Network Output	1.2	1.6	2.7

3

3.11 Installation Reversion Times

The reversion time for a particular system configuration can be calculated in the same way as installation Performance Times using the response times in table 3.8 plus the times in table 3.12.

Table 3.12 Reversion Times–General

Item	Time (Seconds)
Fleeting Output time	1.0
Serial Communications	0.9
Loss of channel time-out, VTC or EVTC	2
Vital Communications over Network	See table 3.7

Figure 3.10 shows the Reversion Time for normal operation of a WESTRACE installation.

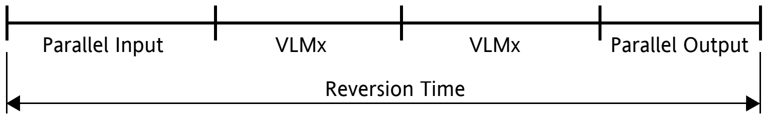


Figure 3.10 Reversion Time–Normal WESTRACE Installation Operation

Figure 3.11 shows the Reversion Time for a WESTRACE installation including a fleeting output.

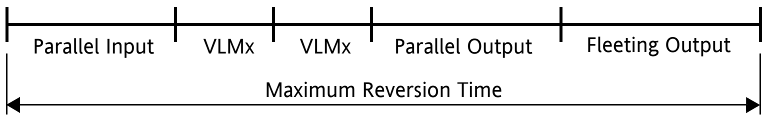


Figure 3.11 Reversion Time–WESTRACE Installation Operation Including a Fleeting Output

Figure 3.12 shows the Reversion Time for WESTRACE Systems connected by a Vital Serial link and including a fleeting output.

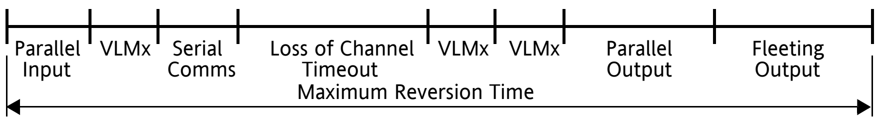


Figure 3.12 Reversion Time–WESTRACE Systems–Vital Serial Link Including a Fleeting Output

Figure 3.13 shows the Reversion Time for WESTRACE System network input to parallel output.

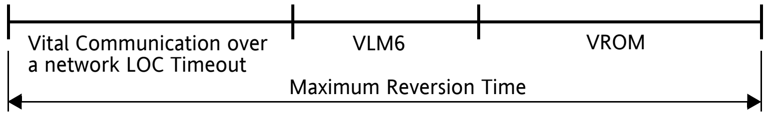


Figure 3.13 Reversion Time–WESTRACE System Network Input to Parallel Output

Figure 3.14 shows the Reversion Time for WESTRACE System network input to network output.

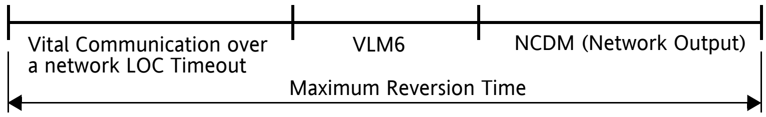


Figure 3.14 Reversion Time–WESTRACE System Network Input to Network Output

3.12 Reactive Fail Safety

Vital parallel output modules (VROMs and VLOMs) conform to the general functional block diagram (figure 3.15).

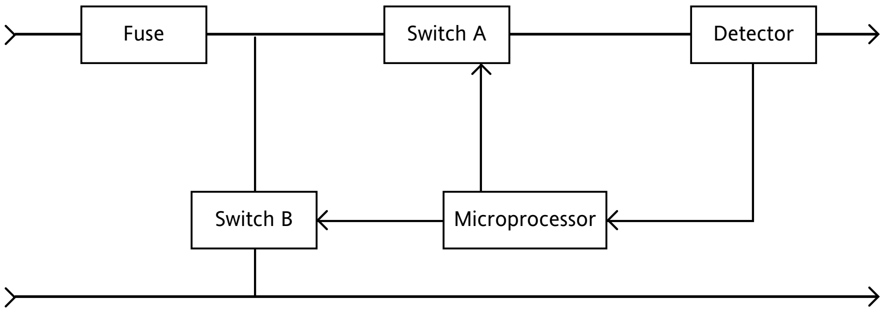


Figure 3.15 Vital Parallel Output Module Block Diagram

Switch A, controlled by the microprocessor, is closed to provide the output. Failure of switch A or the circuitry controlling it, can lead to a falsely energised output. This output will be detected and action taken to de-energise the output within a finite time. A falsely energised output which persists for less than a given time is referred to as a fleeting output. (If it was to persist for longer than this, it would be classified as a wrong side failure).

The sequence of operation of the Vital Parallel Output Module software under these conditions is summarised as follows:

a) detect incorrect output;

b) attempt to blow fuse;

c) check for incorrect output;

d) if output is now correct then continue normal operation;

e) if output is still incorrect, instigate System Negation.

3.12.1 Fleeting Output Duration

The time for which the fleeting output exists is dependent on whether step d) or e) above is reached. If step e) is reached, the term 'Long Fleeting Output' is used; if step d) is reached, the term 'Short Fleeting Output' is used.

The Vital Parallel Output Module and the VLE cannot guarantee that the fuse will blow. The only fail safe time is that which results if step e) is reached, the Long Fleeting Output Time.

The times for the two types of fleeting output are given in the table below, together with the probability of their occurrence per individual vital parallel output circuit. These times are based on HRD-4 Standard (British Telecom).

Table 3.13 Fleeting Outputs for the VLE and OPCR

	VLOM (ms)	VROM (ms)	Mean Time Between Occurrence per Output Circuit
Short	300	200	1.75×10^6 hrs
Long	950	950	1.75×10^8 hrs

The times for fleeting outputs quoted above are based on the following conditions:

a) Short Fleeting Outputs;

The time quoted is for the Vital Parallel Output Module to successfully blow the fuse. That is, it does not include any allowance for the response time of the device being driven by that output;

b) Long Fleeting Outputs;

The time quoted includes an allowance of 150 milliseconds for the OPCR total drop away time. The actual release time depends on the characteristics of the relay used for the OPCR. The time quoted does not include any allowance for the response time of equipment driven by WESTRACE outputs other than the OPCR as previously described.

3.12.2 Application Rules

SAFETY WARNING

Observe the application rules detailed in this section.

3.12.2.1 Overall Wrong Side Failure

Both long and short fleeting outputs are classified as right side failures of the VLE.

Ensure that the signalling system design is safety tolerant of fleeting outputs (including the issues of sections 3.12.2.2 to 3.12.2.4) and cannot result in an overall wrong side failure.

3.12.2.2 Insufficient Response Time

Analyse the response time of the equipment to be driven by WESTRACE outputs to determine if a fleeting output will result in an unsafe condition.

Provide a suitable defence against WESTRACE allowing an unsafe action before the end of the fleeting output duration.

3.12.2.3 Prevent False Energising

Use a WESTRACE timer set to greater than 300 ms on any input driven directly from a WESTRACE output. This ensures that a fleeting output cannot be recognised as a valid input.

3.12.2.4 Illegal Signal Aspects

Consider possible adverse reactions by a train driver on seeing an illegal aspect (where a signal is controlled by a VLOM).

3.12.3 Reliability and Availability

The Application Engineer must consider the effect of a shutdown on a railway from a safety perspective.

3.12.4 Application Guidance

SAFETY WARNING

Minimise the duration of a fleeting output or eliminate the possibility of one producing an unsafe output by following the guidelines in this section.

3.12.4.1 General

Select a relay for the OPCR with the fastest possible drop-away time.

Vitally AND (Boolean) two of the parallel outputs from separate modules to generate one output for fast operating safety critical equipment. This will produce a composite defence against wrong side failure.

Using two outputs from the same module would reduce, but not eliminate, the possibility of a fleeting output causing a wrong side failure so AND outputs must come from different modules.

Examples of this can be found in [GCSS].

3.12.4.2 Output Loads Driven by VROM

Use vital slow-to-pick relays or fail safe delay-pick-up timers driving relays on the VROM outputs to allow time for system negation before a fleeting output can produce an unsafe condition.

Individually disabling relay outputs with front contacts of the OPCR will result in the relay dropping away faster than if the power feed to the VROM is disabled. This is due to the VROM having an input filter whose stored energy will continue to supply power to the VROM for a finite time after the power source is removed, plus the slugging effect of the VROM output circuit. The resultant worst case is an additional delay of 21 milliseconds.

3.12.4.3 Output Loads Driven by VLOM

The input filter stored energy problem, identified above for the VROM, does not exist with the VLOM because the VLOM input filter energy storage capacity is not significant.

Avoid backfeed when disabling the power to the VLOM (see section 4.1.8.4). In particular, you must isolate hot standby outputs with OPCR contacts.

4. Module Application

This chapter provides a brief description of WESTRACE modules, their external connection, and other application-specific information.

More detailed information is provided in:

- Appendix A—Module Descriptions;
- Appendix B—Module Operation.

4.1 Vital Logic Module

This section describes the:

- Vital Logic Module-6 (VLM6);
- Vital Logic Module-5 (VLM5);
- Hot Standby Vital Logic Module (HVLM);
- Vital Logic Module (VLM1).

The VLM6, VLM5 and HVLM are processor based sub-systems that will operate in an installation that is either in a Hot Standby configuration or a stand-alone system configuration.

- Configured as Hot Standby, they will operate in Online Mode or Standby Mode.
- Configured as stand-alone, they will operate in Online Mode only.

A VLM6, VLM5 or an HVLM that is in Online Mode will be in control of the railway.

A VLM1 cannot be configured as Hot Standby.

4.1.1 Module Components

The VLM6 comprises three separate printed circuit boards.

- VLC6—Vital Logic Card 6.
- OPC—Output Power Card.
- UHVBC—Universal Hot Standby Vital backplane card.

The VLM5 comprises three separate printed circuit boards.

- VLC5—Vital Logic Card 5.
- OPC—Output Power Card.
- HVBC—Hot Standby Vital Backplane Card. The UHVBC may also be used.

The HVLM comprises three separate printed circuit boards.

- HVLC—Hot Standby Vital Logic Card.
- OPC—Output Power Card.
- HVBC—Hot Standby Vital Backplane Card. The UHVBC may also be used.

The VLM1 comprises four separate printed circuit boards.

- VLC–Vital logic card.
- CEC–Configuration element card.
- OPC–Output Power Card.
- VBC–VLM backplane.

4.1.2 External Connections–VLM6, VLM5 and HVLM

All external connections to the:

- VLM6 are made via the HOPC PFM which plugs directly into the UHVBC
- HVLM or VLM5 are made via the HOPC PFM which plugs directly into the HVBC or UHVBC.

The HOPC PFM External Connector is a 19 way Weidmueller SLA socket that accepts a Weidmueller BLA plug (supplied with the module).

The VLM6, VLM5 and HVLM are pin compatible with the OPC backplane.

Figure 4.1 depicts the external connection details of the HOPC PFM.

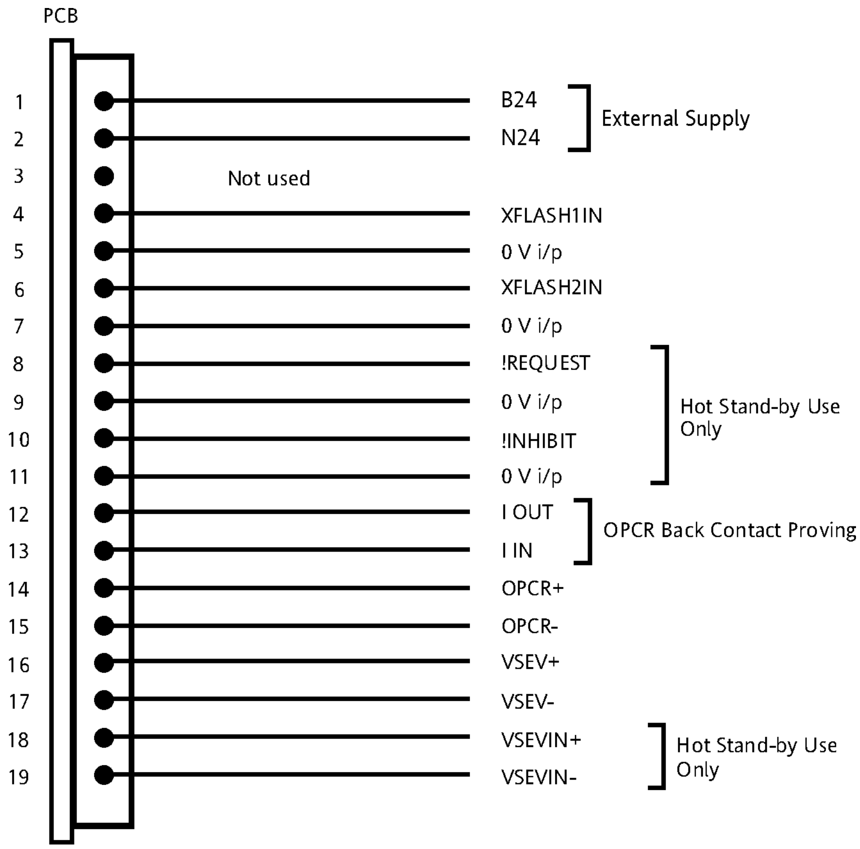


Figure 4.1 External Connections–HOPC PFM–VLM6, VLM5 & HVLM

B24 & N24

Maximum current 4 A

OPCR relay Connections

Relay coil (OPCT+ and OPCT-) and proving connections (I Out and I In):

- Keep short (less than 2 metres);
- Use twisted pair;
- Avoid proximity to noisy circuits (eg. other relays).

XFLASH1IN & XFLASH2IN

Normally left open.

Used to synchronise VLOM flashing output on adjacent WESTRACEs. Connect XFLASH1IN or XFLASH2INto an external source.

Frequency	0.5 Hz min. 1.33 Hz max.
Mark (high) Space (low) Ratio	1:1 or 670:330

VSEV+ and VSEV-

Outputs for communications power to Vital Serial (EVTC and VTC) and optionally non-vital serial (NVC) modules.

Maximum current	1.0 A
Maximum NVC	1 (high start up load prevents more).

!Inhibit and !Request

Connect to individual switches as shown in figure 4.2.

Off	Automatic Change over Mode.
!Inhibit	Online VLM will not attempt changeover.
!Request	Online VLM requests standby VLM to take control.

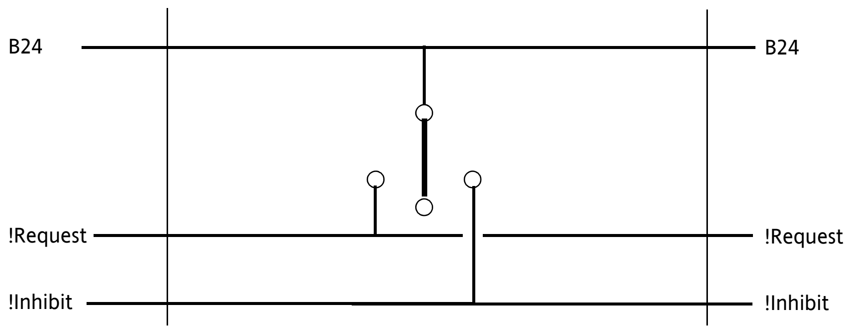


Figure 4.2 Changeover Switches–HOPC PFM

The switch should provide:

- momentary action for the !Request selector input;
- latched action for the !Inhibit selector input, and;
- a latched centre off position.

Note: ***VLMs will ignore change over requests before the OPCR drive is present.***

VLMs ignore change over requests during an OPCR exercise.

Do not operate both inputs simultaneously (!Inhibit prevails).

A request for change over must not be present for more than one cycle to avoid the possibility of the Hot Standby system toggling.

4.1.3 External Connections—VLM1

All external connections to the VLM1 are made via the OPC PFM which has tails with plugs attached to plug into connectors 4 and 5 on the VBC.

The OPC PFM External Connector is a 15 way Weidmueller SLA socket that accepts a Weidmueller BLA plug (supplied with the module).

Figure 4.3 depicts the external connection details of the OPC PFM.

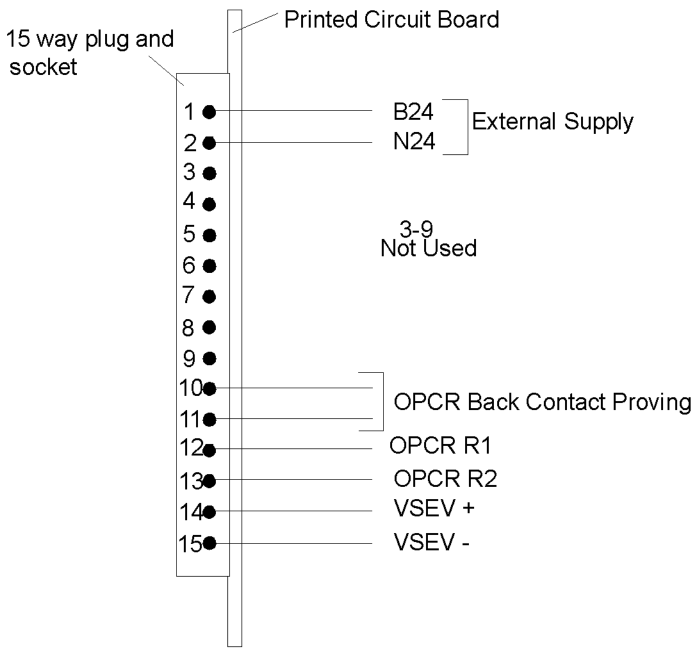


Figure 4.3 External Connections—OPC PFM—VLM1

Connections to terminals 10 through 15 should be kept as short as possible (not more than 2 metres) and should not be run near sources of electrical noise (for example, avoid running wires to or from relays other than the OPCR in the same conduit).

The maximum continuous current that passes in each of the connections is:

24 V supply	4 A
OPCR Drive	0.8 A
VSEV	1 A
OPCR Back Contact	20 mA

4.1.4 Restart Circuit

Fit a 'one-shot restart circuit' to WESTRACE installations to provide automatic controlled restart:

- after a shutdown;
- after short power disruptions (power down for at least 40 s).

Figure 4.5 shows a power supply with a typical one-shot restart circuit for a single-WESTRACE system, and figure 4.6 shows a typical circuit for a multiple-WESTRACE system. In both circuits, the OPCR dropping (due to the shutdown or power disruption) starts a sequence (figure 4.4) that results in the power being automatically restored.

Customers may require different restart delays from those shown below. These are determined by the time-delay relays RESTART J1R and RESTART J2R in figures 4.5 and 4.6.

The three RESTART relays need not be vital relays unless required by the Railway Authority.

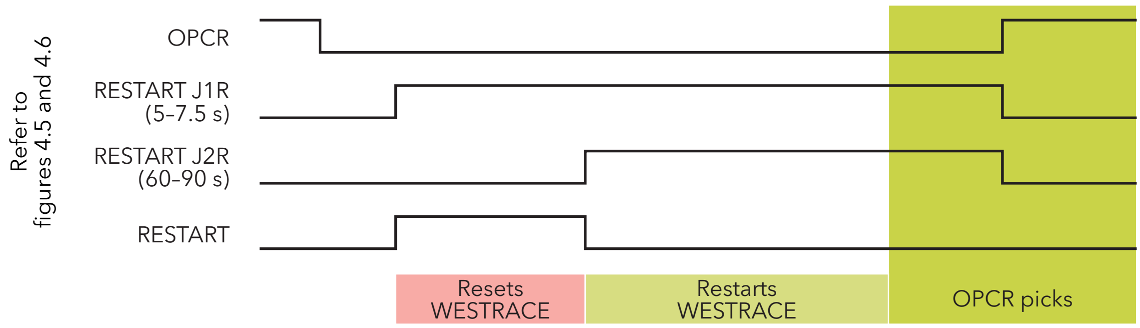


Figure 4.4 One-Shot Restart – Timing Diagram

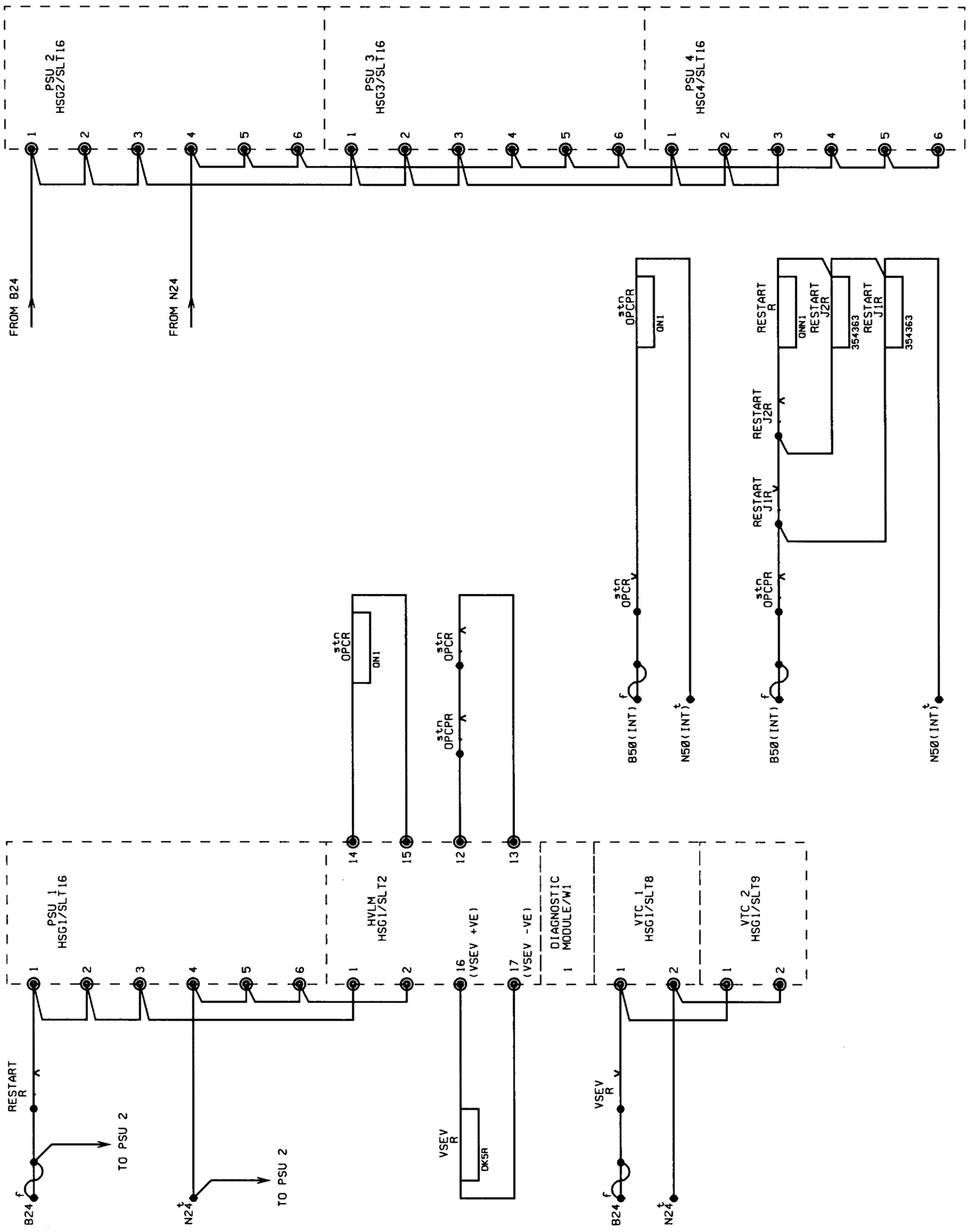


Figure 4.5 One-Shot Restart Circuit–Typical–Single WESTRACE

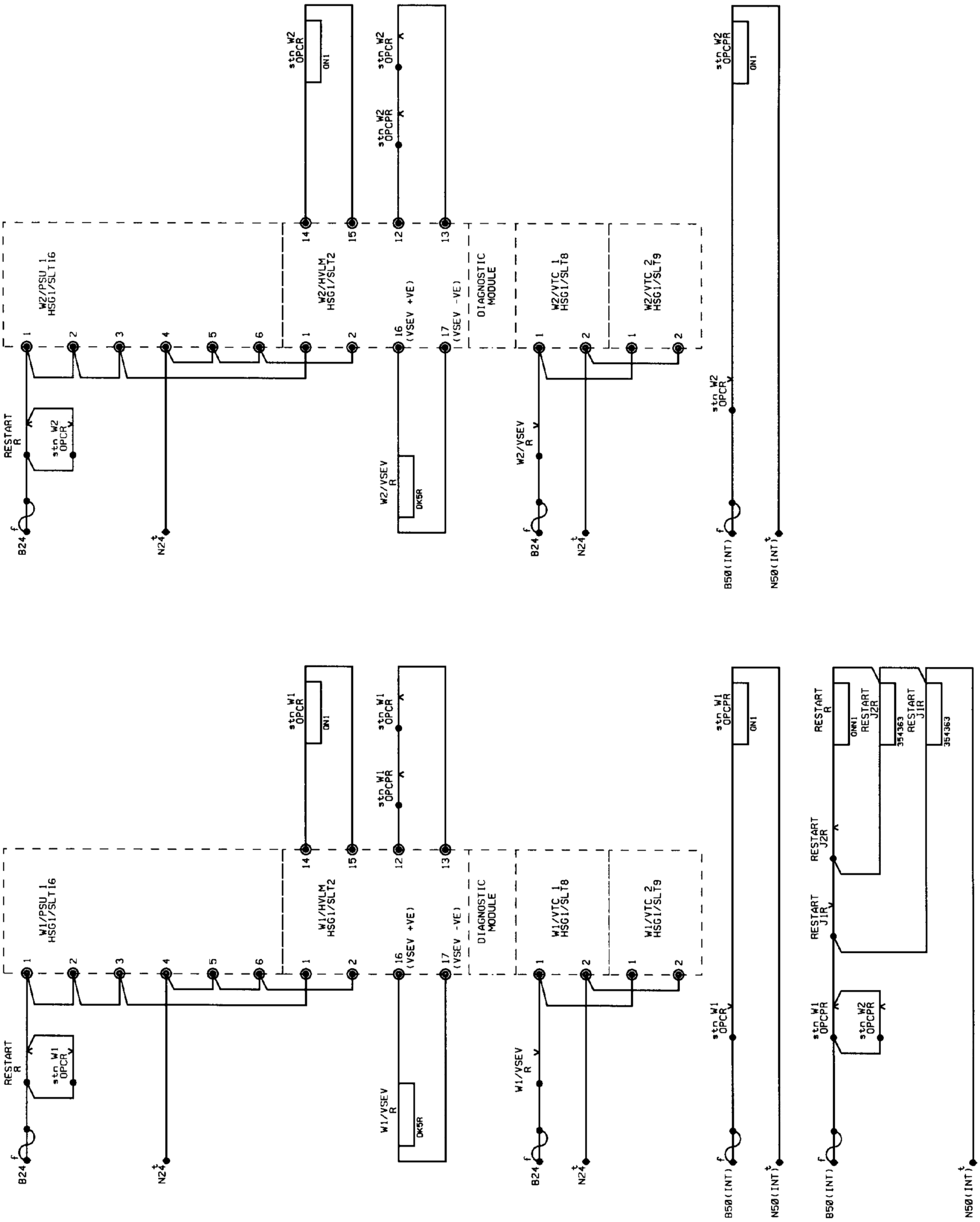


Figure 4.6 One-Shot Restart Circuit—Typical—Multiple WESTRACE

4.1.5 WESTRACE Address

Each WESTRACE installation must have a unique address. This address is contained in the CED (Vital PROM Data) EPROMs (or Non-Vital Configuration)and must also be set on links on the UHVBC, HVBC or VBC.

Set the links on the UHVBC or HVBC in accordance with the Installation Report (see figure A.11) produced by the GCSS (or CSS).

If the address in the Vital PROM Data (or Non-Vital Configuration) differs from that on the UHVBC, HVBC or VBC, the installation will not operate. This address is also used to identify vital serial messages between installations. To ensure that addresses are not re-used, a range of addresses have been allocated to Invensys Rail.

SAFETY WARNING

Invensys Rail allocates addresses and maintains records of all address allocations.

4.1.6 Setting WESTRACE Operational Mode

The VLM6, VLM5 and HVLM can operate in hot standby or stand-alone configuration. In a pair of installations intended to operate in hot standby configuration, one installation is biased online and the other is non-biased. The CONF1 and CONF2 links on the UHVBC or HVBC set the configuration.

Refer to:

- section A.1.2.3 for details about the UHVBC;
- section A.2.2.3 or section A.3.2.3 for details about the HVBC;
- section A.4.2.4 for details about the VBC.

4.1.7 Setting Version Number of the Application Data

The VLC6, VLC5 or HVLC (or CEC) incorporates an 8-way DIL switch that is used to set the version number of the application data.

Set the switches in accordance with the GCSS Installation Report (figure A.11).

See:

- section A.1.2.1 for details of the VLC6 (VLM6);
- section A.2.2.1 for details of the VLC5 (VLM5);
- section A.3.2.1 for details of the HVLC (HVLM).
- section A.4.2.2 for details of the CEC (VLM1).

4.1.8 Output Power Control Relay (OPCR)

The OPCR is the final arbiter of system safety for all parallel outputs. The failure of any part of the system which, once detected, cannot be isolated by graceful degradation will cause the OPCR to be de-energised.

Use the OPCR to disable all vital parallel outputs (VROM and VLOM) by using:

- a front contact of the OPCR in series with each vital parallel output, or;
- a front contact in series with the external signalling supply to each vital parallel output module (see section 4.1.8.2).

The application of OPCR contacts for VLOM outputs is further described in section 4.2.

SAFETY WARNING

OPCR contacts must NOT be inserted in the common return for two or more outputs.

Locate the OPCR as close as possible to the VLE. The coil must only be connected to the OPC, using industry approved wire, such that the OPCR cannot be energised by any source other than the VLE.

The OPCRs of a hot standby WESTRACE must be connected to ensure that two systems cannot be online simultaneously.

There is no need to provide an OPCR when a WESTRACE System does not have any parallel outputs and is not operating in hot standby.

4.1.8.1 Type of Relay for Use as the OPCR

The output to the OPCR is derived from the VLM and the voltage is 50 V.

SAFETY WARNING

The relay used for the OPCR must be a vital signalling relay to BRB Spec 930 (such as Invensys Rail Style QN1).

The minimum coil resistance of the OPCR must be 833 ohms.

Select an OPCR that has the fastest possible release time, and highest possible percentage release to minimise the overall shutdown time.

To ensure the correct and reliable operation of OPCR exercising, the OPCR together with any repeater OPCR relays must be:

- fully released in less than 140 milliseconds, and;
- fully picked-up in not more than 440 milliseconds.

4.1.8.2 OPCR Contact Rating

The OPCR contacts will have a maximum current rating of 3 A (BRB Spec) unless relays with heavy duty contacts are used.

Carefully consider the load that each contact of the OPCR will be required to switch, and whether it is appropriate for the contacts to be used in series with the supply to the module or in series with the individual outputs.

4.1.8.3 OPCR Repeater Relays

SAFETY WARNING

If repeater relays are required to provide sufficient OPCR contacts, then the additional time for the repeats to open their front contacts will extend the system's potential fleeting output time.

All repeats should be controlled by the primary OPCR and should be fed from the same fuse. For example, see figure 4.7.

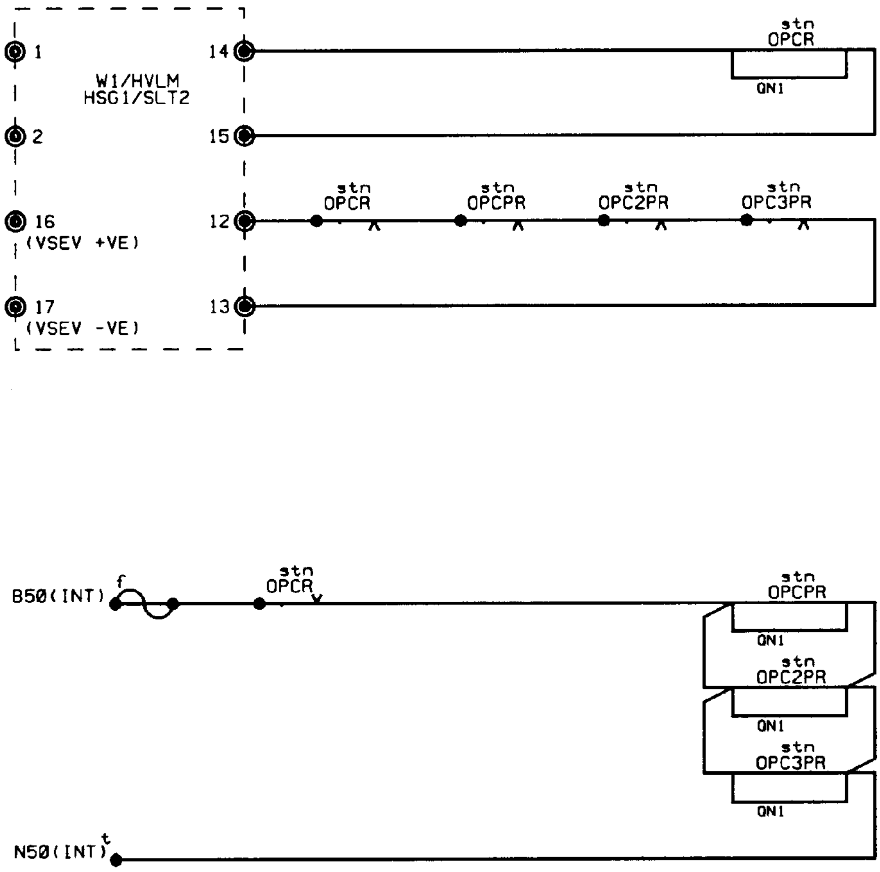


Figure 4.7 Repeater relays controlled by primary OPCR

Back contacts of the OPCR and all repeats must be wired in series in the back contact proving circuit (see section 4.1.8.6).

4.1.8.4 Providing Energised Outputs

The OPCR may be used to provide energised outputs when the OPCR is de-energised.

Use the back contacts of the OPCR to provide energised outputs while the OPCR is de-energised, for example, to provide signal Red Retaining.

Note: ***When this feature is used, each of the outputs that is powered in this way must also be disabled by an OPCR front contact, placed in series with the normal system output, to prevent backfeeds.***

4

4.1.8.5 Control of Multiple Equipment

SAFETY WARNING

Using an OPCR contact to disable multiple items of safety equipment may affect system negation.

The shut-down time for one piece of equipment may be effectively increased if the equipment is being powered by residual stored energy in wiring or another piece of equipment controlled by the same OPCR contact even though the OPCR has de-energised.

Ensure the energy stored in the equipment and wiring is not be of sufficient magnitude to significantly delay the negation of a safety critical piece of equipment.

4.1.8.6 Exercising the OPCR

SAFETY WARNING

Exercise the OPCR periodically (period not to exceed one month).

Invensys Rail strongly recommends the OPCR be exercised automatically to protect against the possibility of it failing to de-energise when required due to it being continuously energised for long periods.

Note: ***The VLM cannot detect that the OPCR is stuck until it is exercised.***

The OPCR output may be configured to periodically exercise the OPCR—this comprises de-energising and re-energising the output to the OPCR within 1 second. The 1 second time period is not sufficient to cause alarms in the system, lamp failure alarms for example.

Use application logic to automatically exercise the OPCR by controlling the EXOPCR mnemonic and monitoring a back contact of each OPCR and any repeat relays (see figure 4.7).

The VLM sets the OPCRFLT mnemonic when it detects an OPCR failure (such as a failure during exercising of the OPCR).

SAFETY WARNING

An OPCRFLT may indicate that the OPCR cannot isolate outputs should a potential wrong side failure occur. It must be resolved urgently.
Ensure that the system is shut down (using NOPCR) or appropriate alarms are generated when OPCRFLT becomes logic 0.

Configure WESTRACE to automatically test the OPCR as described below or implement procedures to do it manually. Typical application logic can be found in reference [GCSS].

a) Select an appropriate time to exercise the OPCR to prevent interference to traffic. Typically, use WESTRACE timers to set minimum and maximum delays (up to 2.5 days) since the last exercise;

b) Wait until all read signals are set and wait until the appropriate track circuits are clear if flicker of these aspects could a problem.

All VLMs (master, slave, object controllers etc) should exercise their OPCR in a similar manner. Exercise slave or object controller WESTRACEs at the same time as the master to prevent auto signal flashing.

When OPCR exercising fails (OPCRFLT becomes logic 0), the fault could be:

- The OPCR was not energised when exercising was requested.
- The OPCR failed to de-energise during exercising.
- The OPCR failed to re-energise on completion of exercising.

4.1.9 Vital Serial Enable Voltage (VSEV)

The Vital Serial Enable Voltage (VSEV) output from the OPC is used to enable:

- transmission of messages from the vital serial modules;
- transfer of the data between the VLM6 and NCDM.

The VSEV is only present when the OPCR is energised (it is not disabled during automatic exercising of the OPCR). The VSEV is the final arbiter of safety for vital serial messages in the same manner as the OPCR for vital parallel outputs and will disable vital serial outputs at the same time as the OPCR disables vital parallel outputs.

a) Install links 25 and 26 on the UHVBC to enable vital data transfer between VLM6 and NCDM. See figure 4.8;

b) Wire the VSEV output to the VSEV inputs of each VTC, EVTC, and WCM modules in a system.

The VSEV may not have sufficient capacity to drive all modules. Instead, connect the B24 supply through a front contact of the OPCR so the supply is interrupted when the OPCR is exercised.

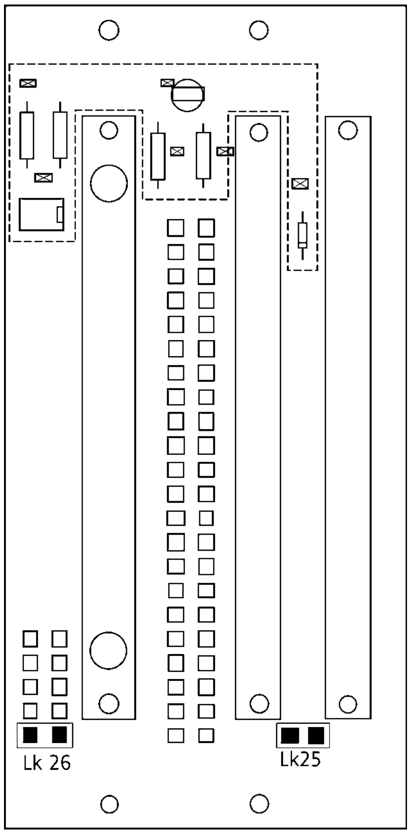


Figure 4.8 Universal Hot Standby Vital Backplane Card (UHVBC)—Links 25 & 26

Note: ***Lk25 and Lk26 MUST be open when the UHVBC is used with VLM5 or HVLM modules.***

4.2 Vital Lamp Output Modules (VLOM)

Any application of the VLOM must be in accordance with the information provided in section 3.12.

4.2.1 Module Components

Twelve-output modules comprise:

- a single Digital Board;
- two Analogue Boards (one on each side).

4.2.2 External Connections

External connections to the VLOM are made via the VLOM PFM.

The VLOM PFM External Connector is a 19 way Weidmueller SLA socket that accepts a Weidmueller BLA plug (supplied with the module).

Figure 4.9 shows the external connection details of the VLOM PFM.

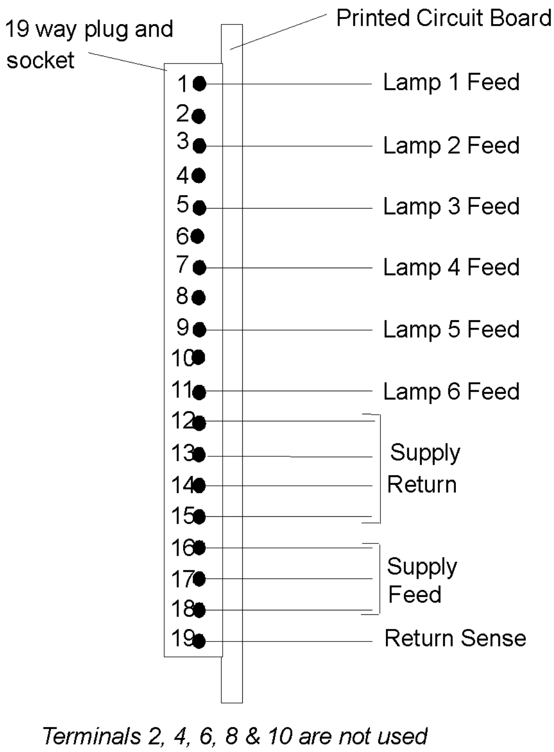


Figure 4.9 External Connections–VLOM PFM

Typical Wiring to VLOM (including Red Retaining)

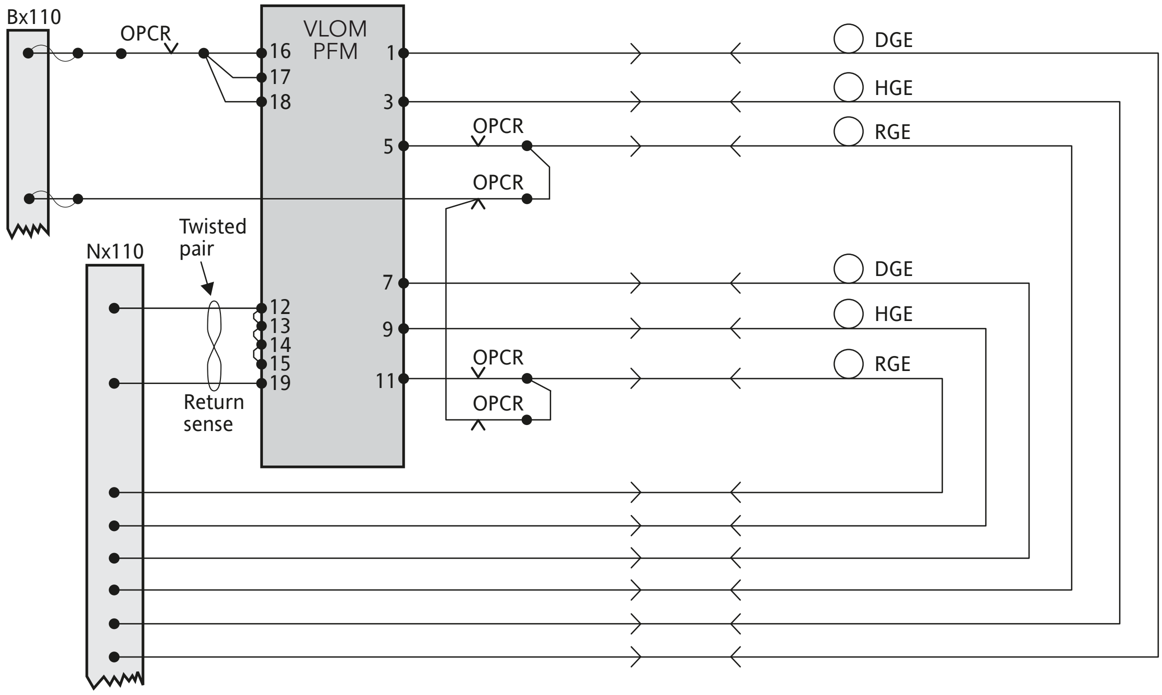


Figure 4.10 Typical Wiring to VLOM (Showing Application of OPCR for Red Retaining)

See also:

- figure 4.11—alternative VLOM hot-standby circuit
- figure 4.12—alternative VLOM hot-standby circuit with red retaining

SAFETY WARNING

The Specific Application Rules (section 4.2.3) must be followed to maintain the intended level of protection provided by WESTRACE.

VLOM Connection Rules

- For Safety reasons and the operation of graceful degradation, the return sense terminal (19):
  - **must** be connected to a separate terminal on the bus bar to those from the module supply return, and;
  - **not be** looped back to the return at the connector.
- For Safety reasons and to provide sufficient current carrying capacity to allow the VLOM to function under maximum load conditions:
  - connection **must** be made to all Module Supply Feed terminals (16, 17, & 18) with cable of sufficient size for the maximum load, and;
  - connection must be made to all Module Supply Return terminals (12, 13, 14 & 15) with cable of sufficient size for the maximum load.
- The VLOM outputs **must not** be connected to any other power supply busbar.
- Lamps driven by the VLOM **must** have individual returns to the supply return bus-bar, to prevent backfeeds through other outputs.
- For safety and performance reasons, VLOM external connections **must not** be earthed.

4.2.3 Specific Application Rules

SAFETY
WARNING

These Specific Application Rules must be followed to maintain the intended level of protection provided by WESTRACE.

4.2.3.1 Output Capability

VLOMs are designed for driving lamps, and must not be used to drive any other device without reference to Invensys Rail.

VLOM outputs must not be connected to VPIM inputs because the cold filament test pulses may defeat the VPIM sampling.

4.2.3.2 Limitation of Lamp Types

VLOMs have been designed to operate within the quoted range of 18–24 watts:

- 2 pole single filament lamps;
- 3 pole double filament lamps, with separate external filament change-over;
- Invensys Rail LED signals.

Any lamps which do not fall into this category may not be suitable for use with VLOM modules (for example, 2 pole double filament lamps with a low wattage second filament).

The cold filament detection current pulses may be sufficient to illuminate the 3.5 W filament of a 2 pole twin filament 18+3.5 W lamp. If any doubt exists about the suitability of the VLOM reference should be made to Invensys Rail.

4.2.3.3 Internal Fusing

The internal fuse provided for protection and graceful degradation is rated at 1.5 A. This fuse is not a field replaceable item.

4.2.3.4 External Fusing of Outputs

Any external fusing of outputs should provide sufficient discrimination to ensure that the external fuse is the one that is blown under overload conditions (maximum 1 A).

4.2.3.5 Fusing of VLOM Signalling Supply

If external fusing is employed, the fuse rating must be large enough to allow graceful degradation to take place. For the VLOM, this rating should about two times the current drawn by the number of lamps which may be normally lit. The minimum rating that should be used is three amps.

4.2.3.6 Return Sense Cabling

Protect against spurious noise affecting the Ground Sense detection by:

- Minimising the length of the return sense cable;
- Twist the return sense cable with the NX110 cable to the VLOM.

4.2.3.7 Cold Filament Detection

Although cold filament detection is defined as non-vital, it is an essential requirement in the total system safety. It provides a diverse check on the correct operation of the output detector within the VLOM, and must be used at all times.

If the facility of filament checking and failure reporting is not used in a particular system, by driving a Maintenance Technicians Alarm Panel for example, it is still essential that a 'filament failure' is reported to the Technician because this may in fact be a VLOM failure which requires investigation by the Technician.

Caution: ***High capacitance cables may result in the cold filament detection test passing even when the bulb is not present.***

Ensure the total capacitive load of the cable with the bulb removed is less than:

- 1 µF for ac power;
- 10 µF for dc power.

4.2.3.8 Filament Proving

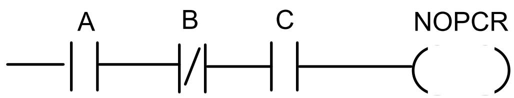
The hot filament proving current is 130 mA ± 30 mA, which is not sufficient to fully illuminate a 12 V SL35 lamp. Thus the filament proving confirms that the filament is intact and drawing current, but does not confirm that the lamp is adequately bright.

Many LED signals, including those supplied by Invensys Rail, draw significantly less than the current proving level. You may need to connect a load in parallel with the signal module (that must not be able to hold the current proving on its own) or use a variant of the signal with a dummy load incorporated. Please refer to our website (http://www.invensysrail.com) data sheets section for latest information on current proving LED signals.

4.2.3.9 Failure of Single Red Lamp Driver Output

If a lamp output is sensed to be wrongly energised, the VLOM will attempt to blow the fuse of the output to the lamp. This could result in a signal being unable to display a red aspect due to the shutting down of a single output.

Invensys Rail recommends that Railways which do not use lamp changeover, and instead use high-reliability twin-filament or LED lamps, consider using the following additional logic to cater for the above:



Where:

- A is the red lamp output mnemonic;
- B is the red lamp filament proving mnemonic;
- C is the module fault mnemonic.

NOPCR will result in system shutdown with all red lamps illuminated over back contacts of the OPCR.

4.2.3.10 Lamp Voltage

The voltage of a lamp driven by the VLOM is dependent upon the interconnecting cable impedance, the external signalling supply and the tolerances within the VLOM. All new installations, or changes to VLOM, or changes to interconnecting cables, must have the associated lamp voltages checked.

4.2.3.11 Use of Signalling Multicore Cable

Where VLOM outputs are connected to Signalling Multicore Cable, physically adjacent cores in the same layer of the cable should be used where possible.

4.2.3.12 Backfeeds into Outputs

You must configure external wiring to ensure that backfeeds cannot be applied to VLOM outputs.

Note: ***Never feed an external voltage to a VLOM output.***

This includes hot-standby VLOM pairs, whose outputs must never be directly connected together (paralleled).

Any potential external feed must be isolated for modules in hot standby, typically by using a front contact of the WESTRACE's OPCR (figure 4.11).

See also section 4.2.3.13 "VLOM Hot Standby".

4.2.3.13 VLOM Hot Standby

Figure 4.11 shows a pair of VLOMs wired for hot standby.

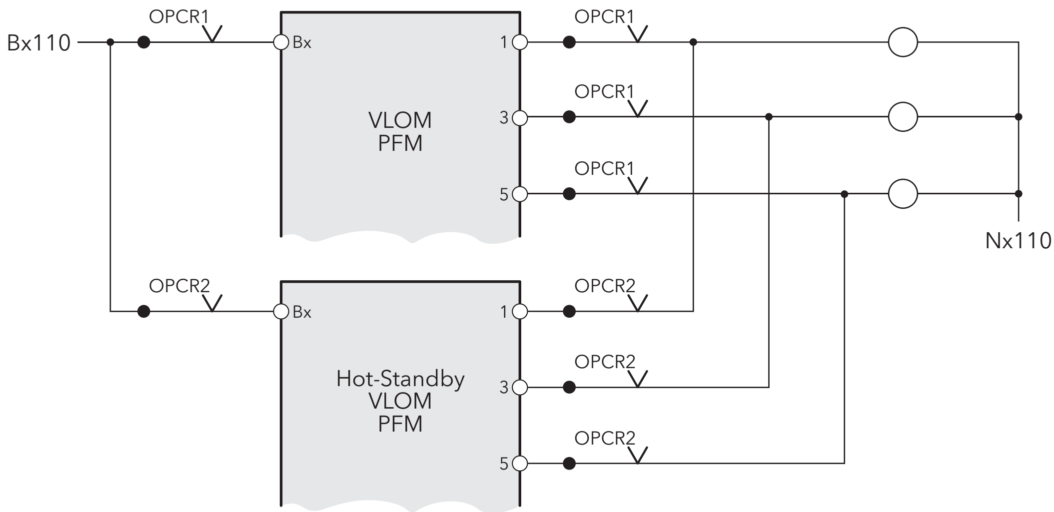


Figure 4.11 Example VLOM Hot-Standby Circuit (three of six outputs shown)

Note: ***Be sure to include an OPCR front contact in the Bx110 supply and in each output of the two hot-standby VLOMs. (The OPCR contacts in the Bx110 feeds are necessary to prevent the standby VLOM from shutting down.)***

Figure 4.12 shows a pair of VLOMs wired for hot standby and red retaining. (See also figure 4.10, which shows a red retaining circuit for a standalone VLOM.)

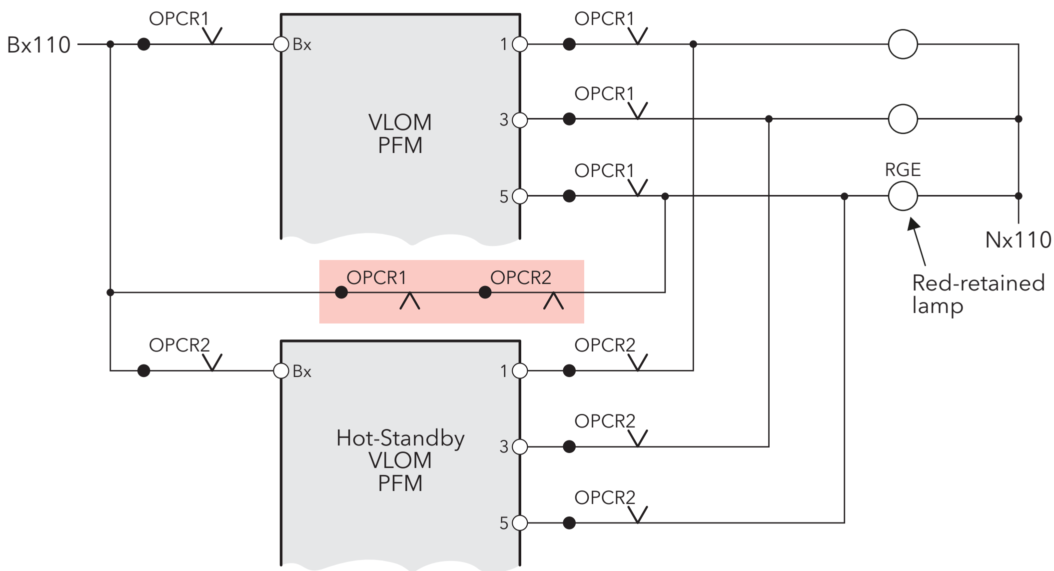


Figure 4.12 Example VLOM Hot-Standby Circuit with Red Retaining (one of six outputs shown)

4.2.3.14 Driving LED Signals

VLOMs are capable of directly driving some LED signals.

There are large variations in signal types and constructions and in the power supplies that interface to the LEDs. It is therefore not possible to provide a blanket statement of the suitability for any signal type.

The Invensys Rail series of mainline LED signals can be driven directly—provided the guidelines below are followed. General issues for other signals are explained below and users must ensure that arrangements are adequate. Also see the latest application notes on the Invensys Rail web site: http://www.invensysrail.com

The current drawn by Invensys Rail mainline signals is below the proving current for the VLOM.

Connect a resistor[3] (Rint) in parallel with the 110 Vac signal element in the signal head as shown in figure 4.13.

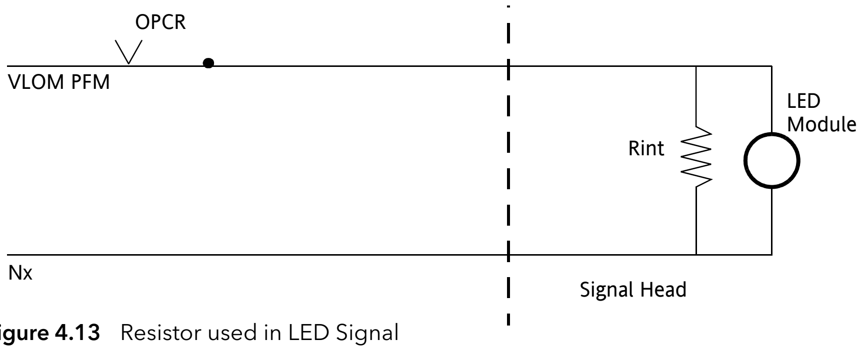


Figure 4.13 Resistor used in LED Signal

The lamp proving and cold filament checking will function but will have a slightly different meaning. The current drawn by these signal elements is substantially constant with voltage and with failed LEDs. LEDs are arranged in parallel strings and any failures will be obvious and should be reported by train drivers. The proving circuit will verify that current flows through the wiring and power supply and this will generally be adequate assurance given the high reliability of LEDs and the redundancy of the connection.

The LED elements are fitted with secondary surge suppression. Additional primary protection at the signal head may be required in lightning-prone areas.

Other LED Signals

Ensure the suitability of other signals, including:

- Will the lamp proving operate correctly?
- Will the cold filament checking operate correctly?
- Will the test pulses with the lamp on be visible?
- Will cold filament checking test pulses be visible?
- Is the VLOM output rating exceeded?
- Is transient protection adequate?

[3] The Invensys Rail application note "Proving Operation of LED Signals" (available from http://www.invensysrail.com) provides guidance in selecting this resistor value.

4.2.3.15 Earth Leakage

Maximum allowable earth leakage currents may be exceeded where there are multiple lamps driven from a single supply. This happens when outputs are not double cut and the cable to ground capacitance is great enough to enable excessive current.

Select a defence against excessive earth leakage currents such as:

- an isolating transformer or separate supply for each VLOM;
- a 1:1 isolating transformer on selected VLOM outputs.

4.3 Vital Relay Output Module (VROM)

It is important that any application of the VROM be in accordance with the information provided in section 3.12.

4.3.1 Module Components

VROM Modules comprise a digital board and an analogue board.

4.3.2 External Connections

The VROM PFM External Connector is a 19 way Weidmueller SLA socket that accepts a Weidmueller BLA plug (supplied with the module).

Figure 4.14 shows the external connection details of the VROM PFM.

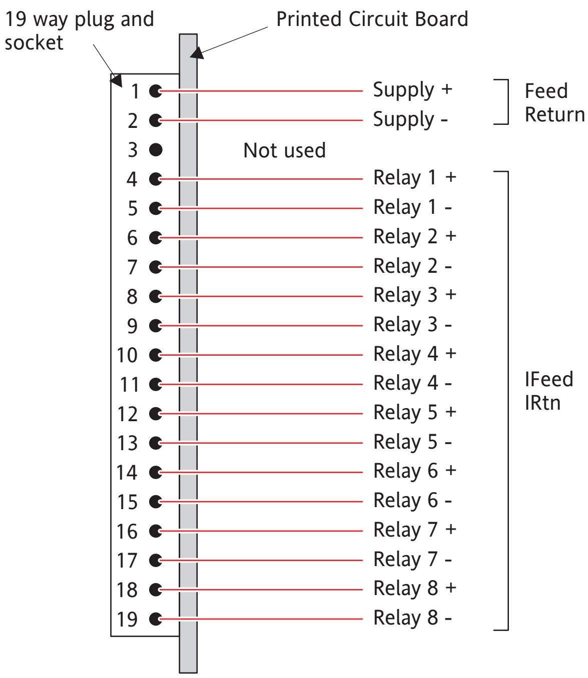


Figure 4.14 External Connections – VROM PFM

SAFETY WARNING

The following specifications for connecting outputs from the system must be met to maintain the intended level of protection provided by WESTRACE.

4.3.2.1 Commoned Outputs

The VROM outputs are designed as fully floating outputs. If loads with common returns are used, the Application Engineer must take into account that there are possible failure modes in the VROM due to backfeeds which could cause more loads to be energised than those selected. Either common returns should not be used or any common return must be proven in a fail safe manner.

4.3.2.2 Earthing

VROM external connections must not be earthed.

4.3.3 Specific Application Rules

SAFETY WARNING

The Specific Application Rules must be followed to maintain the intended level of protection provided by WESTRACE.

4.3.3.1 Internal Fusing

The internal fuse provided for protection and graceful degradation is rated at 0.5 A. This fuse is not a field replaceable item.

4.3.3.2 External Fusing of Outputs

Any external fusing should provide sufficient discrimination to ensure that the external fuse is the one that is blown in an overload situation.

The maximum value of any external fuse on an output should be 0.25 A.

4.3.3.3 Fusing of VROM Signalling Supply

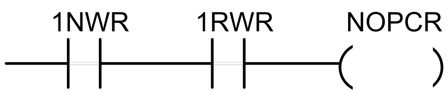
Use a fuse large enough (ie greater than 2.5 A) to allow graceful degradation to take place when external fusing is employed.

4.3.3.4 Maximum Load and Bipolar Operation

When a pair of VROM outputs are used to drive a bipolar load, the continuous load must be within the specification for the output. A transient overload is permitted, when driving a bipolar load, of up to twice the rated load for one output for up to 250 milliseconds.

When two uni-polar outputs are configured back to back to produce a polarised line circuit, cross check the two outputs in the Application Logic to prevent both outputs from being energised at the same time.

For example:



4.3.3.5 Vital Relay Output

All relay outputs are isolated from each other and from ground and may provide the equivalent of double-cut line circuits. However, it should be noted that a dormant failure of the VROM PFM could result in output returns being connected to earth.

Include earth testing of VROM outputs in periodic maintenance schedules.

4.3.3.6 External Signalling Supply

The external signalling supply (nominal = 50 V) must be smoothed such that any ac component does not exceed the following thresholds:

- minimum = 42 V
- maximum = 60 V

The module will not operate with full wave rectified, unsmoothed dc, however no damage will be caused to the module.

4.3.3.7 Use of Signalling Multicore Cable

Use (where possible) physically adjacent cores in the same layer of the cable when VROM outputs are connected to Signalling Multicore Cable.

4.3.3.8 Backfeeds into Outputs

Caution: ***Under no circumstances is external wiring to be configured so that backfeeds are able to be applied to VROM outputs, other than when two outputs are configured in a bipolar arrangement or when hot-standby outputs are connected together.***

See also section 4.3.3.9 "VROM Hot Standby".

4.3.3.9 VROM Hot Standby

Figures 4.15 and 4.16 show two methods of wiring a pair of VROMs for hot standby.

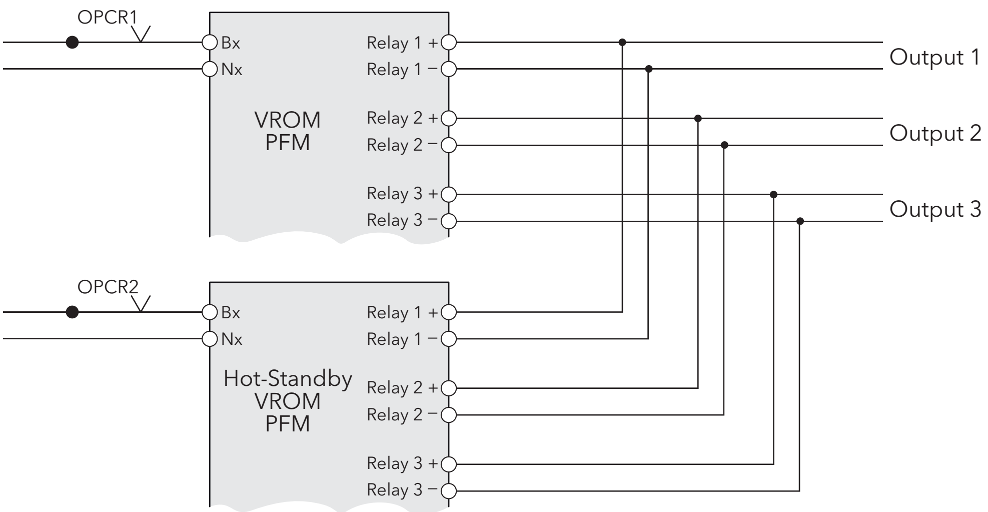


Figure 4.15 VROM Hot-Standby Circuit–option 1 (three of eight outputs shown)

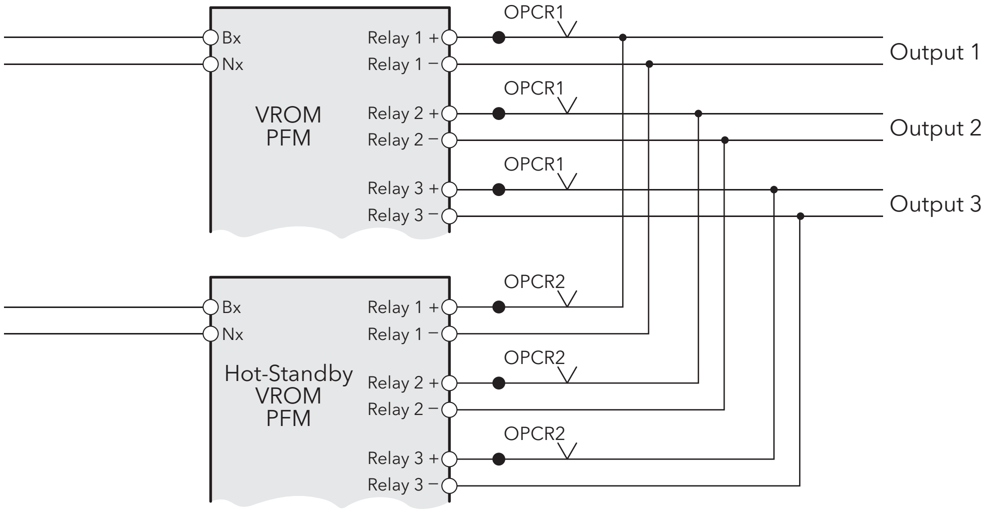


Figure 4.16 Example VROM Hot-Standby Circuit–option 2 (three of eight outputs shown)

4.4 Vital Parallel Input Module (VPIM)

4.4.1 Module Components

VPIM Modules comprise a digital board and an analogue board.

4.4.2 External Connections

External connections to the VPIM are made via the VPIM PFM.

The VPIM PFM External Connector is a double stacked 24 way Weidmueller SLA socket that accepts a Weidmueller BLA plug (supplied with the module).

Figure 4.17 depicts the external connection details of the VPIM PFM.

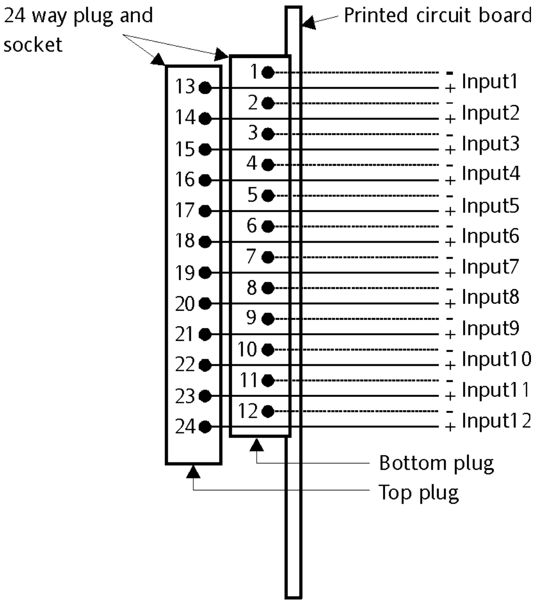


Figure 4.17 External Connections–VPIM PFM

SAFETY WARNING

The following specifications for connecting input signals to the system must be met to maintain the intended level of protection provided by WESTRACE.

The VPIM is designed to accept signalling inputs to the following specifications:

- all inputs are double cut, that is relay contacts in series with both the positive and negative connections to each input;
- all inputs are fully independent, that is there is no commoning between inputs, with the exception of the facility to configure inputs back-to-back as described in the VPIM Specific Application Rules in the following section;
- all inputs are earth free.

The Application Engineer may need to implement a system that requires inputs to be configured differently from that previously described. For example, to accommodate conditions such as:

- commoned input negatives;
- inputs earthed on one side.

Ensure that the proposed configuration is safe.

This safety assurance must take into account the possible effect of unintended circumstances, such as:

- bent pins in connectors;
- dormant earth faults in the PFM;
- broken return conductors;
- back feeds;
- sneak paths.

4.4.3 Specific Application Rules

SAFETY WARNING

The Specific Application Rules must be followed to maintain the intended level of protection provided by WESTRACE.

4.4.3.1 VPIM Input Limits, ac Immunity and Internal Fusing

The VPIM will respond to voltages on its inputs in the following manner:

De-energised	10.5 Vdc max, -100 Vdc min
Energised	100 Vdc max, 30 Vdc min
Input Impedance	4 kΩ ± 800 Ω
ac Immunity (normal operation)	40 Vac, 45 Hz to 11 kHz

An input overload protection fuse will blow when the voltage applied across the input to the VPIM reaches a maximum of 120 Vdc or peak ac.

The VPIM is not specified for fail-safe operation below 45 Hz or over 11 kHz.

4.4.3.2 DC Immunity of VPIM Inputs

The VPIM has a relatively high input impedance and could interpret a leakage voltage as an energised input.

Assess the risk of such dc leakage and take appropriate precautions to keep it well below the vital dc threshold voltage.

4.4.3.3 Fleeting or Intermittent Inputs

The VPIM incorporates both filtering and sampling techniques, which are described in detail in section B.7.2 of this manual. These techniques are employed to prevent intermittent inputs being accepted by, and possibly confusing, the logic in the system.

Carefully consider the effects of the filtering and sampling of the VPIM when designing a WESTRACE System for a particular application.

4.4.3.4 Inputs Driven from Outputs

If an input is driven from a processor based interlocking output, such as from a VROM, the input filtering may not be sufficient to reject a fleeting output, and thus filtering must be provided in the Application Logic by the use of a time delay.

Do **not** connect VLOM outputs to VPIM inputs because the cold filament test pulses may adversely affect the input sampling by the VPIM.

Inputs may not be able to be driven directly by electronic track circuit outputs or the like; this is entirely dependant on the output stage of the electronic device.

Advice on compatibility should be sought from Invensys Rail: Level 7,
380 Docklands Drive, Docklands, Victoria 3008, Australia
http://www.invensysrail.com

4.4.3.5 Bipolar Inputs

All inputs are polarity sensitive and may be configured back-to-back to provide the equivalent of a pair of biased relays at the end of a two wire polarised line circuit.

Cross check the two inputs in the application logic to ensure that they are not both energised at the same time.

4.4.3.6 Wiring to Inputs

Use physically adjacent cores in the same layer of the cable for each input where VPIM inputs are connected to Signalling Multicore Cable.

Wiring to the positive and negative input terminals should be run in the same route and be approximately of the same length to minimise differential interference.

4.5 WESTECT Communication Module (WCM)

4.5.1 Module Components

WCM modules comprise a single printed circuit board.

4.5.2 External Connections

External Connections to the WCM are made via the SIO232 PFM.

The SIO232 PFM External Connectors are a DB25 plug and socket for an RS232C interface, and a 2 way Weidmueller SLA socket that accepts a Weidmueller BLA plug for power (supplied with the module).

Figure 4.18 depicts the external connection details of the SIO232 PFM.

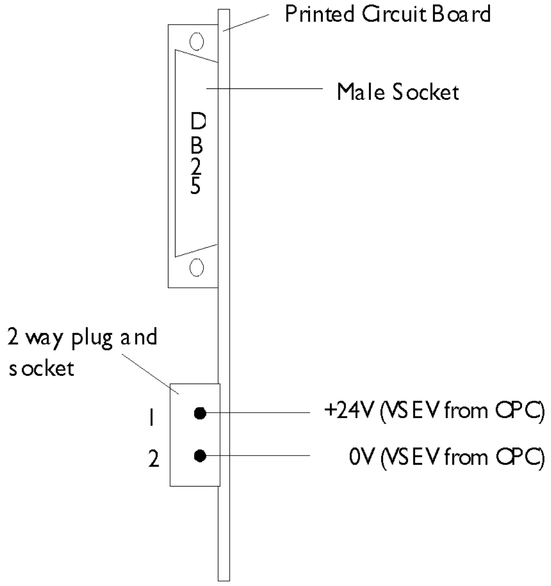


Figure 4.18 External Connections–SIO232 PFM–WCM

Table 4.1 DB25 Pinout–SIO232 PFM–WCM

Pin	Function
1	Chassis Ground
2	Transmit Data (TxD)
3	Receive Data (RxD)
4	Request to Send (RTS)
5	Clear to Send (CTS)
7	Signal Ground (GND)
8	Data Carrier Detect (DCD)
17	Receive Clock (RXC)
20	Data Terminal Ready (DTR)
24	Transmit Clock (TXC)

This module communicates using RS232C and is configured as a DTE.

4.5.3 Specific Application Rules

4.5.3.1 Communication Medium

The WCM is designed to transmit data over a dedicated link to the Radio Control Module (RCM) as part of the WESTECT ATP system.

Any other proposed application should be referred to Invensys Rail.

4.5.3.2 Earthing of Signal Ground Line

Do **not** connect the signal ground line to earth because this may result in an unsafe situation if there is an undetected earth fault(s) in the PFM.

Earth the cable screen, if fitted, in accordance with section 5.2.3.

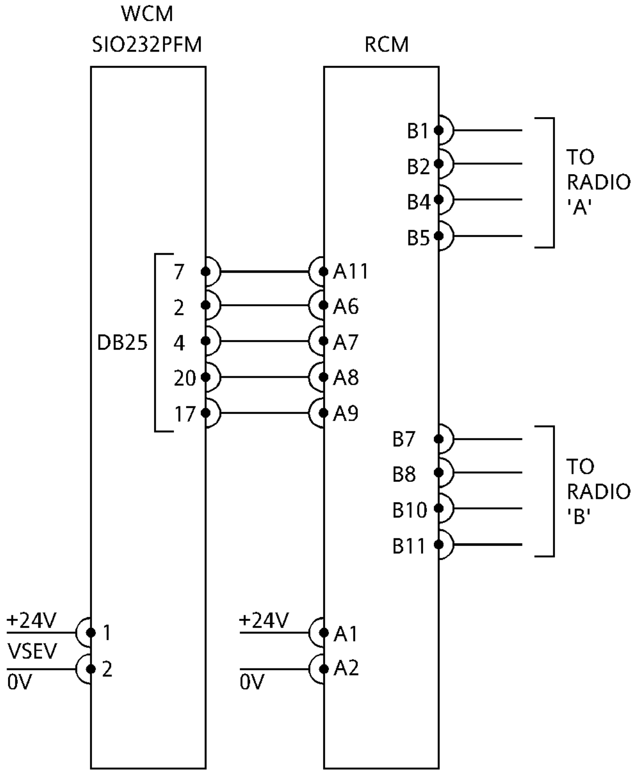


Figure 4.19 WCM Typical Wiring

4.6 EVTC and VTC

This section describes the Enhanced Vital Telemetry Continuous Module (EVTC) and the Vital Telemetry Continuous Module (VTC).

EVTC modules cannot be used with the VLM1.

4.6.1 Module Components

EVTC (or VTC) modules comprise a single printed circuit board.

4

4.6.2 External Connections

External Connections to the EVTC (or VTC) are made via the SIO232 PFM.

The SIO232 PFM External Connectors are a DB25 plug and socket for an RS232C interface, and a 2 way Weidmueller SLA socket that accepts a Weidmueller BLA plug for power (supplied with the module).

Figure 4.20 depicts the external connection details of the SIO232 PFM.

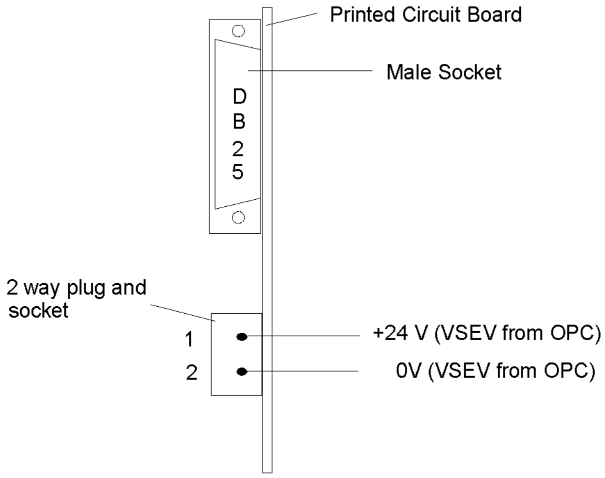


Figure 4.20 External Connections–SIO232 PFM–EVTC or VTC

Table 4.2 DB25 Pinout–SIO232 PFM–EVTC & VTC

Pin	Function
1	Chassis Ground
2	Transmit Data (TxD)
3	Receive Data (RxD)
4	Request to Send (RTS)
5	Clear to Send (CTS)
7	Signal Ground (GND)
8	Data Carrier Detect (DCD)
17	Receive Clock (RXC) (in)
20	Data Terminal Ready (DTR)
24	Transmit Clock (TXC) (out)

This module communicates using RS232C and is configured as a DTE.

For communication purposes, interface cabling and interface parameters must satisfy the guidelines of SCI V.24 for the signal elements shown. The characteristics of the signal are 1200 bit/s, duplex synchronous, 8 data bits and no parity (CRC checksum is used, which is a much more powerful method for error detection).

4.6.3 Specific Application Rules

SAFETY WARNING

The Specific Application Rules defined in this section must be complied with.

4.6.3.1 Communication Medium

The communication medium must be carefully chosen and the guidance defined in section 3.8.5 complied with.

4.6.3.2 Reversion

The VLE will set all EVTC (or VTC) input logic states to de-energised if communication is lost for more than 2 seconds. This is the time allowed for perturbations on the line in order to achieve a high degree of robustness and reliability.

4.6.3.3 Implications of Failure of EVTC (or VTC) Links

It is possible for the link to fail in one or both directions, resulting in the VLE Loss of Input Channel (LOIC) and VLE Loss of Output Channel (LOOC) indications as appropriate. These are reserved logic states (refer Configuration System Manual).

In the event of a failure, it must not be assumed that any action required at the far end of the link, as a result of logic states sent via the EVTC (or VTC) link, has been carried out. If confirmation is required, a proving input must be provided and its logic state sent back to the near end via the EVTC (or VTC) link.

The reason for this requirement is that the EVTC (or VTC) link could fail in one direction only and there is no hand shaking between ends.

4.6.3.4 Connection to Other Communication Systems

The EVTC (or VTC) may be connected to systems other than other EVTCs (or VTCs), provided such systems comply with appropriate standards for communications and safety. Reference should be made to Invensys Rail to ensure compatibility.

4.6.3.5 Earthing of Signal Ground Line

Do not connect the signal ground line to earth because this may result in an unsafe situation if there is an undetected earth fault(s) in the PFM.

Earth the cable screen, if fitted, in accordance with section 5.2.3.

4.6.3.6 Inter-System Communications

Figure 4.21 illustrates the relationship between inputs and outputs of a connected pair of EVTC (or VTC) modules. Figure 4.23 illustrates the connection details for a pair of EVTC (or VTC) modules.

The EVTC (or VTC) outputs are controlled as latches in the ladder logic. There is a one-to-one relationship between the outputs of one EVTC (or VTC) and the inputs on the corresponding EVTC (or VTC). The inputs are used as 'contacts' in the ladder of the second system. This is illustrated in figure 4.22.

Users may wish to apply the same mnemonic for the input as for the corresponding output.

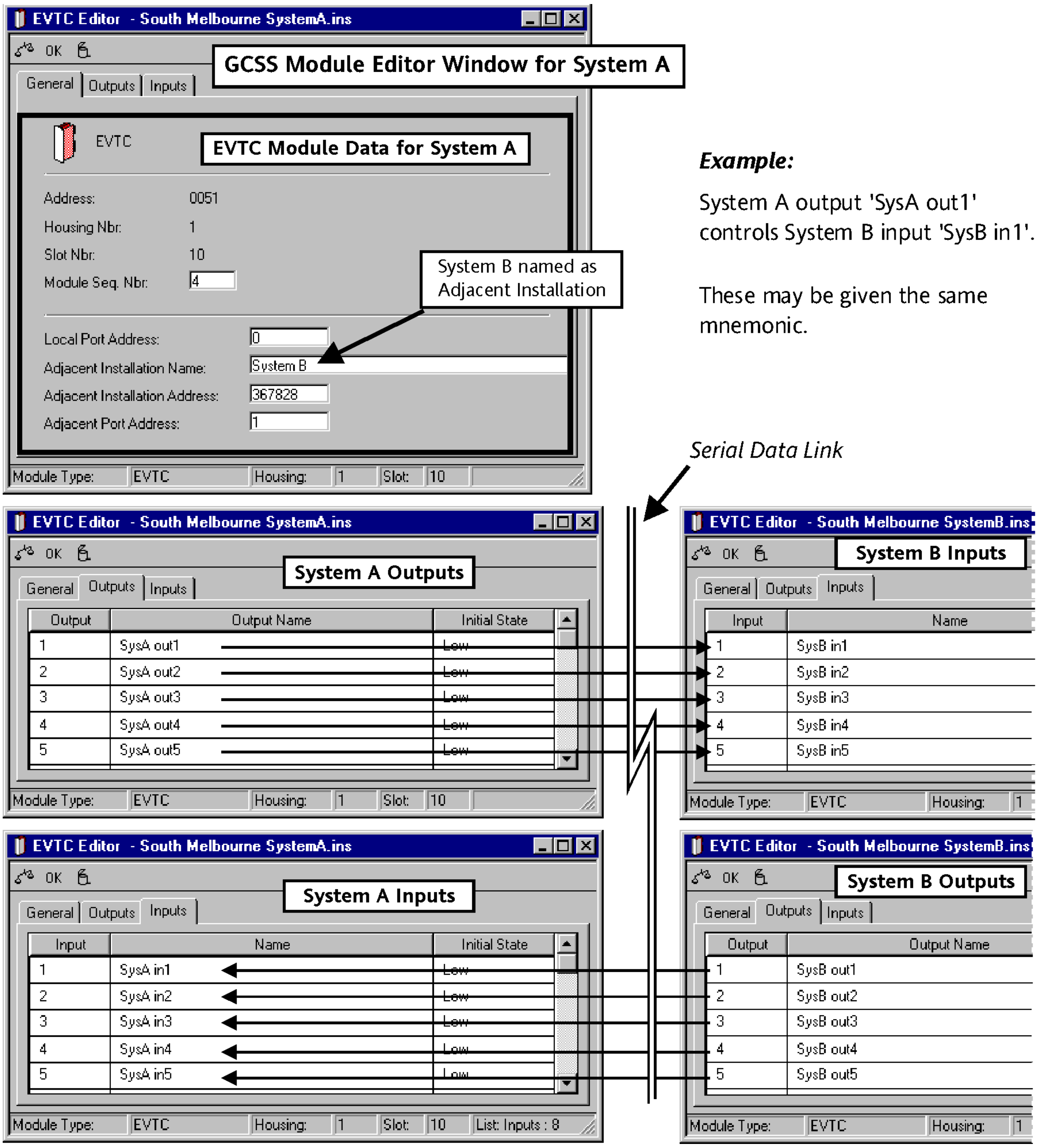


Figure 4.21 Module Outputs and Inputs – EVTC or VTC

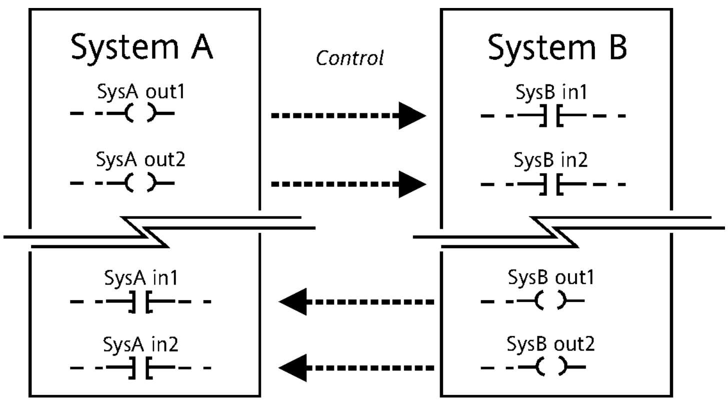


Figure 4.22 Ladder Logic for EVTC (or VTC) Communications

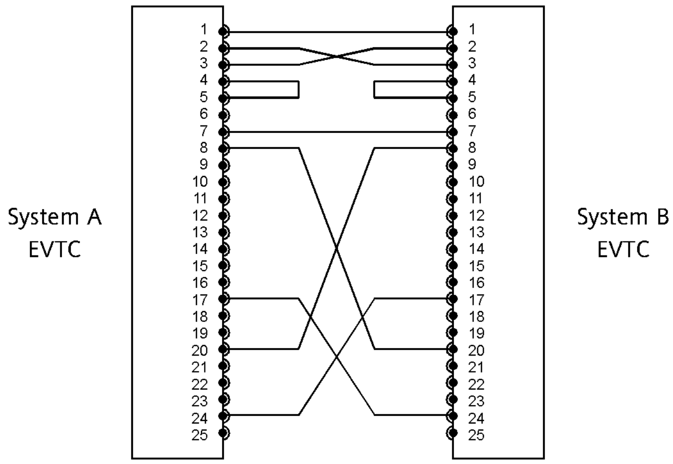


Figure 4.23 Connection Details – Directly-Connected EVTC (or VTC) Modules

4.7 Network Communication Diagnostic Module (NCDM)

The NCDM replaces older NVC and DM modules and works with the VLM6 vital processing module. It can also operate as a stand-alone non-vital logic processor (without the VLM6).

Note: ***The NCDM is currently validated for use with the VLM6 only. The GCSS 6.0 does not support a configuration of NCDM with a VLM5 or HVLM vital processor.***

Functions

The main functions of the NCDM are to:

- Evaluate non-vital application logic;
- Exchange of vital application data between WESTRACE systems (when used in conjunction with a VLM6);
- Exchange of non-vital application data between WESTRACE systems using the WSA/S2 protocol (serial or network);
- Exchange configured logic states with control centres and control computers, using various serial and network protocols;
- Exchange of configured logic states with external non-vital parallel I/O modules using the WSA/S2 protocol (serial only);
- Exchange of configured logic states with the associated vital processor;
- Receive all logic states from the vital processor, for logging purposes;
- Regularly scan all WESTRACE modules for detected faults;
- Log all changes to vital and non-vital logic states, all detected faults and other significant occurrences, and store them in the non-volatile memory;
- Allow an external diagnostic system (such as MoviolaW) to extract logged data and other diagnostic information, via a serial or network interface;
- Allow an external system to download or upload the Non-Vital Configuration;
- Allow the external system to upload the Vital PROM Data.

Non-Vital Timers

The NCDM internal timers are designed to not 'under' time, however they may 'overtime' by up to 15 seconds per 24 hours.

Take the accuracy of the NCDM timers into consideration when configuring timers with a duration greater than 45 minutes.

NCDM Real Time Clock

A real time clock (RTC) is used for internal timestamping of faults, events and operations logged for diagnostic purposes. The accuracy of the RTC is stated as 'better than ± 2 minutes per month @ 25°C' which is approximately ± 4.3

seconds per day. The module should have its time synchronised with the connected external diagnostic system or control system when greater accuracy of time stamping is required.

SAFETY WARNING

The NCDM must not be used for processing:

- ***safety critical logic;***
- ***vital communications.***

Note: ***All of the NCDM's internal states are returned to their default settings whenever it is re-powered. This occurs during normal WESTRACE startup, and if the NCDM self-restarts to overcome an error condition.***

4

4.7.1 Module Components

An NCDM comprises:

- a Network Communication Diagnostic Card NCDC, which performs the following functions:
  - Non-vital logic evaluation;
  - Communications processing;
  - Diagnostic logging;
  - Fault detection and logging.
- a Network Communication Diagnostic Protection and Filter Module NCD PFM (two styles—see figure 4.25).

Table 3.1 lists these components along with their functions and part numbers.

The NCD(C) PFM is fitted with the following external communication ports:

- One network port for a 10 baseT Ethernet compliant network.
- Two serial ports (configurable as RS232 or RS485) for the serial interface;

Network Interface

The external network cable terminates at an RJ45 connector on the back of the NCD PFM.

The NCD PFM:

- Provides transient protection and filtering of the Ethernet signal lines;
- Converts the signal between a 10 baseT Ethernet signal and CMOS levels.

Serial Interface

The external serial cables terminate at DB9 connectors on the back of the NCD PFM.

The NCD PFM:

- Provides transient protection and filtering to remove high frequency noise for the serial signal lines;
- Converts the signal between RS232 or RS485 levels and CMOS levels.

NCDC-PFM Interface

The CMOS-level Ethernet and serial signals pass between the NCDC and the NCD PFM via a 96-pin connector at the rear of the NCDC. The NCD PFM is responsible for communications, signal level processing, protection filtering and isolation functions.

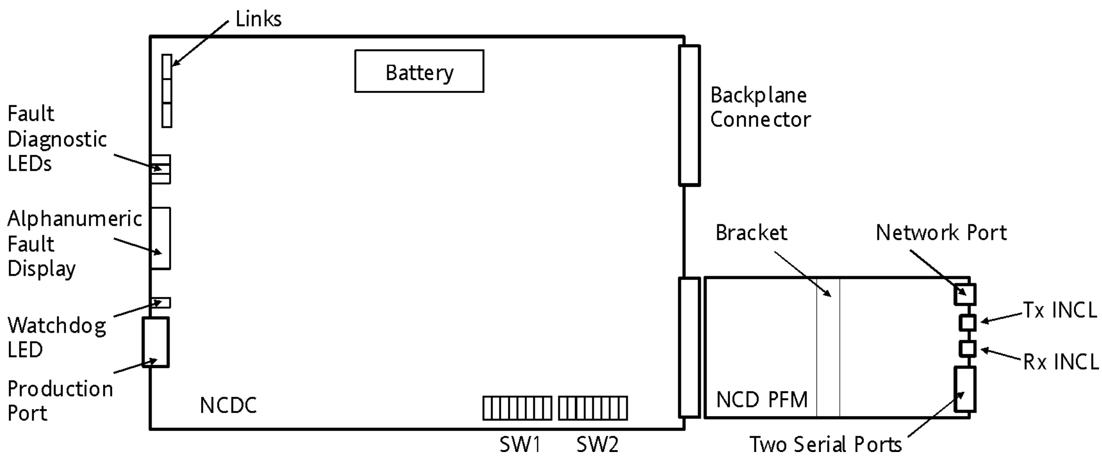


Figure 4.24 View from Component Side—NCDM (Mod D Rev 7 NCDC shown)

4.7.2 External Connections

Non-Vital Configuration and system software upgrades are made through the Production port on the front edge of the NCDC. See section 4.7.2.5.

The following external connections are made through the NCD PFM:

- Serial ports;
- Network port;
- Inter NCDM Communications Link (INCL);
- Serial power;
- Installation status.

Style 1: NCD PFM

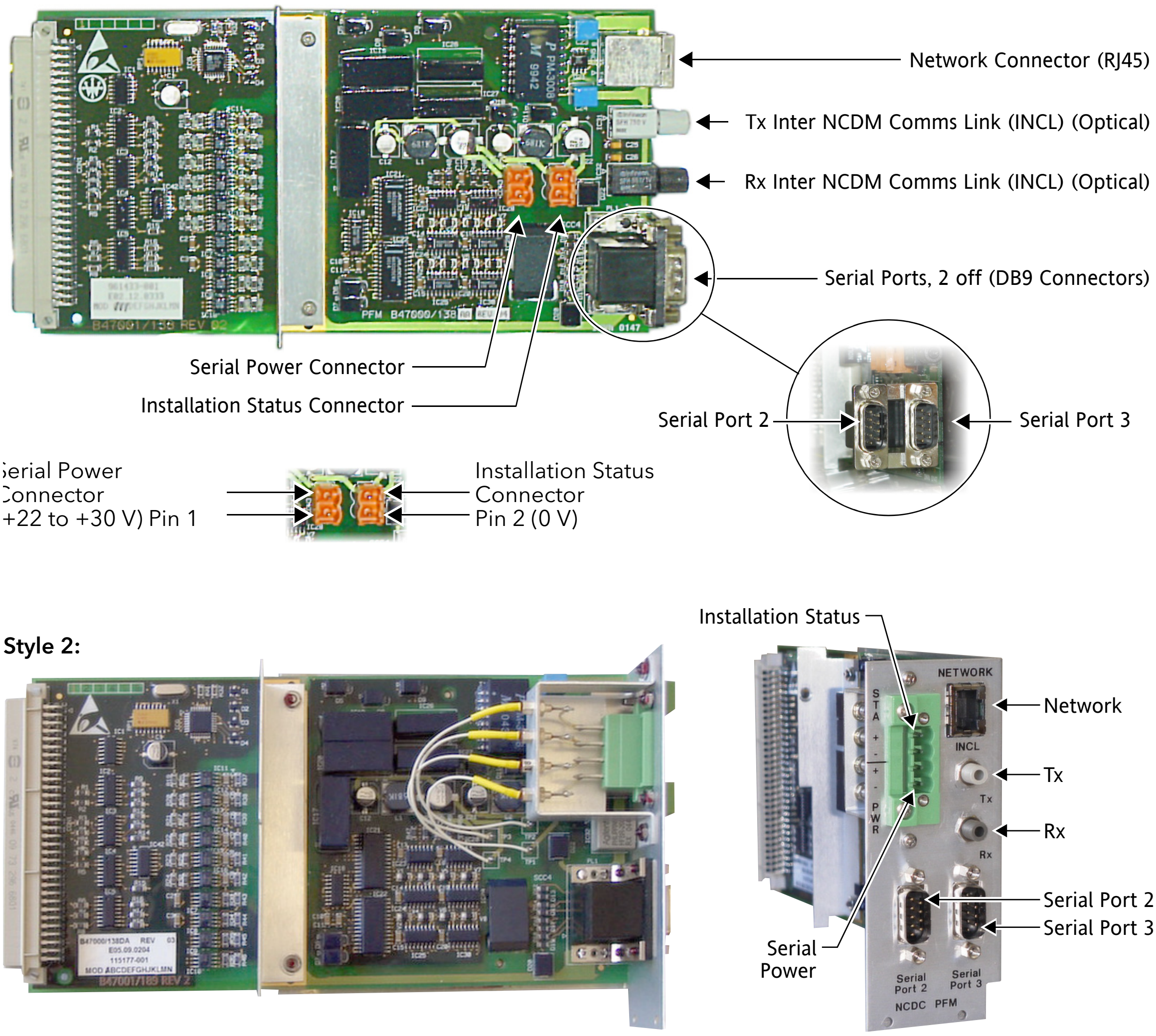


Figure 4.25 External Connectors on the Two Styles of NCD PFM–NCDM

Note: ***The NCDM serial ports 2 and 3 should be labelled on the WESTRACE housing and the external serial cables should also be labelled to ensure the correct connections are made.***

4.7.2.1 Serial Power Connection (Con3)

Serial power should come from a permanent B24 supply so that serial communication can be maintained after system shutdown. Table 4.3 and figure 4.25 show the serial power terminals for a Style 1 NCD PFM. For Style 2 (NCDC PFM), these terminals are brought to the board's connector panel and labelled **PWR**.

See also "NCDC PFM Fusing" on page 3-13.

Table 4.3 Serial Power Connector Pinout–NCD PFM–NCDM

NCD PFM Pin Number (see figure 4.25, Style 1)	Signal
1	+22 to +30 V
2	Common (0V)

4.7.2.2 Installation Status Connection (Con4)

Installation status power should come from a permanent B24 supply via OPCR contacts, so that the status of the installation within a hot standby system can be determined by the NCDM. Table 4.3 and figure 4.25 show the installation status terminals for a Style 1 NCD PFM. For Style 2 (NCDC PFM), these terminals are brought to the board's connector panel and labelled **STA**.

Table 4.4 Installation Status Connector Pinout–NCD PFM–NCDM

NCD PFM Pin Number (see figure 4.25, Style 1)	Signal
1	+22 to +30 V
2	Common (0V)

4.7.2.3 Network Connection

A network port is provided for connection to external network infrastructure. This connection is made via a female RJ45 connector on the rear of the NCD(C) PFM as shown in figure 4.25.

Use the GCSS to configure the network port and session configurations (eg protocol, session ID etc).

The configuration is stored in the NCDM Non-Vital Configuration.

Available Port Signals

Table 4.5 lists the set of signals provided by the network port.

Table 4.5 RJ45 Pinout–Network Connection–NCD(C) PFM–NCDM

Pin Number	Signal Name	Signal Source
1	Tx+	NCDM
2	Tx-	NCDM
3	Rx+	External Equipment
4	Not used	-
5	Not used	-
6	Rx-	External Equipment
7	Not used	-
8	Not used	-

4.7.2.4 Serial Connections

Two configurable serial ports are provided for connection to external control and diagnostic systems. These connections are made via male DB9 connectors on the rear of the NCD(C) PFM, as shown in figure 4.25.

The two ports are numbered Port 2 and Port 3. Port 2 is the connector on the left and Port 3 is the connector on the right (closest to the PCB).

Use the GCSS to configure each port as part of the Non-Vital Configuration for RS232C or RS485 signal levels. RS232C is used for point-to-point links only, and RS485 may be used for point-to-point or multi-drop links.

All serial port configuration (eg protocol, data transfer rate, clock reconstruction etc) is stored in the NCDM Non-Vital Configuration.

RS422 equipment may be connected to an NCDM port configured for RS485 as a point-to-point link. Some RS422 equipment may be suitable for multi-drop operation. Check with the supplier.

Both serial port interfaces are powered by the Serial Power Connector (see section 4.7.2.1).

Available Port Signals

The set of signals provided by each port vary depending on the interface type.

RS232C Connection

Table 4.6 DB9 Pinout—RS232C Connection—NCD PFM—NCDM

Pin Number	Signal Name	Signal Source
1	DCD	External equipment
2	RxD	External equipment
3	TxD	NCDM
4	DTR	NCDM
5	ISOGND	(Common)
6	CLKOUT	NCDM
7	RTS	NCDM
8	CTS	External equipment
9	CLKIN	External equipment

Data transfer pins—RxD and TxD.

The NCDM is wired as a DTE (Data Terminal Equipment) device, so:

- RxD is an input;
- TxD is an output.

Clock signals—CLKIN and CLKOUT.

For use with synchronous protocols, ie WSA/S2. See *Clock Signals* on page 4-42.

Modem handshaking signals:

- generated by the modem:
    - DCD (Data Carrier Detect);
    - CTS (Clear To Send).

  The NCDM can be configured to use or ignore either or both of these signals. If the NCDM uses them, it will not transmit unless both signals are asserted.

- generated by the NCDM
    - DTR (Data Terminal Ready), continuously asserted;
    - RTS (Request To Send):
      - asserted on control system ports when NCDM has data to transmit;
      - continuously asserted on diagnostic ports.

RS485 Connection

Table 4.7 DB9 Pinout–RS484 Connection–NCD PFM–NCDM

Pin Number	Signal Name	Signal Source
1	RxD-	External equipment
2	RxD+	External equipment
3	TxD+	NCDM
4	TxD-	NCDM
5	ISOGND	(Common)
6	CLKOUT+	NCDM
7	CLKOUT-	NCDM
8	CLKIN-	External equipment
9	CLKIN+	External equipment

RS485 uses a subset of the RS232C signals. Modem handshaking signals (RTS, CTS, DTR and DCD) are not available.

Serial ports configured as RS485 may be connected through Invensys Rail modems (eg S2/VFC45) but may not be suitable for commercial modems because of the absence of handshaking signals.

Clock Signals

This section is only applicable for the WSA/S2 protocol.

The NCDM serial interfaces do not provide 'transmit clock' and 'receive clock' pins. Instead, they provide 'clock output' (CLKOUT) and 'clock input' (CLKIN) pins.

The *transmit* clock signal can be configured (in the GCSS Non-Vital Configuration) to be either:

- generated by the NCDM and appearing on the CLKOUT pin, or;
- generated as a copy of the CLKIN (CLKOUT will also be a copy of CLKIN).

The *receive* clock signal can be:

- generated by the NCDM and appearing on the CLKOUT pin;
- generated as a copy of CLKIN on the NCDM;
- reconstructed from the incoming data signal (it is then not necessary to connect anything to the CLKIN pin).

Note: ***NCDM modules must use clock reconstruction if a clock signal is not provided.***

Note: ***When clock reconstruction is enabled, that interface's clock output (CLKOUT) runs at 16 times the data rate and therefore cannot be used as an external clock for another device.***

Application issues

- There is only one clock input (CLKIN) for each interface and this can be used for Transmit, Receive or both. The latter case also requires that the external equipment uses a single clock—this can be supplied from either the external Transmit or Receive.
- Clock reconstruction requires that:
  - the external data rate generator has a frequency error of less than 0.3%;
  - the maximum data rate is 38400 bps.
- Figures 4.26 and 4.27 show the clock, transmit and receive connections recommended when using the NCDM in serial master-slave applications. Use the NCDM's CLKOUT and CLKIN (rather than clock reconstruction) to synchronise both transmit and receive data whenever possible.

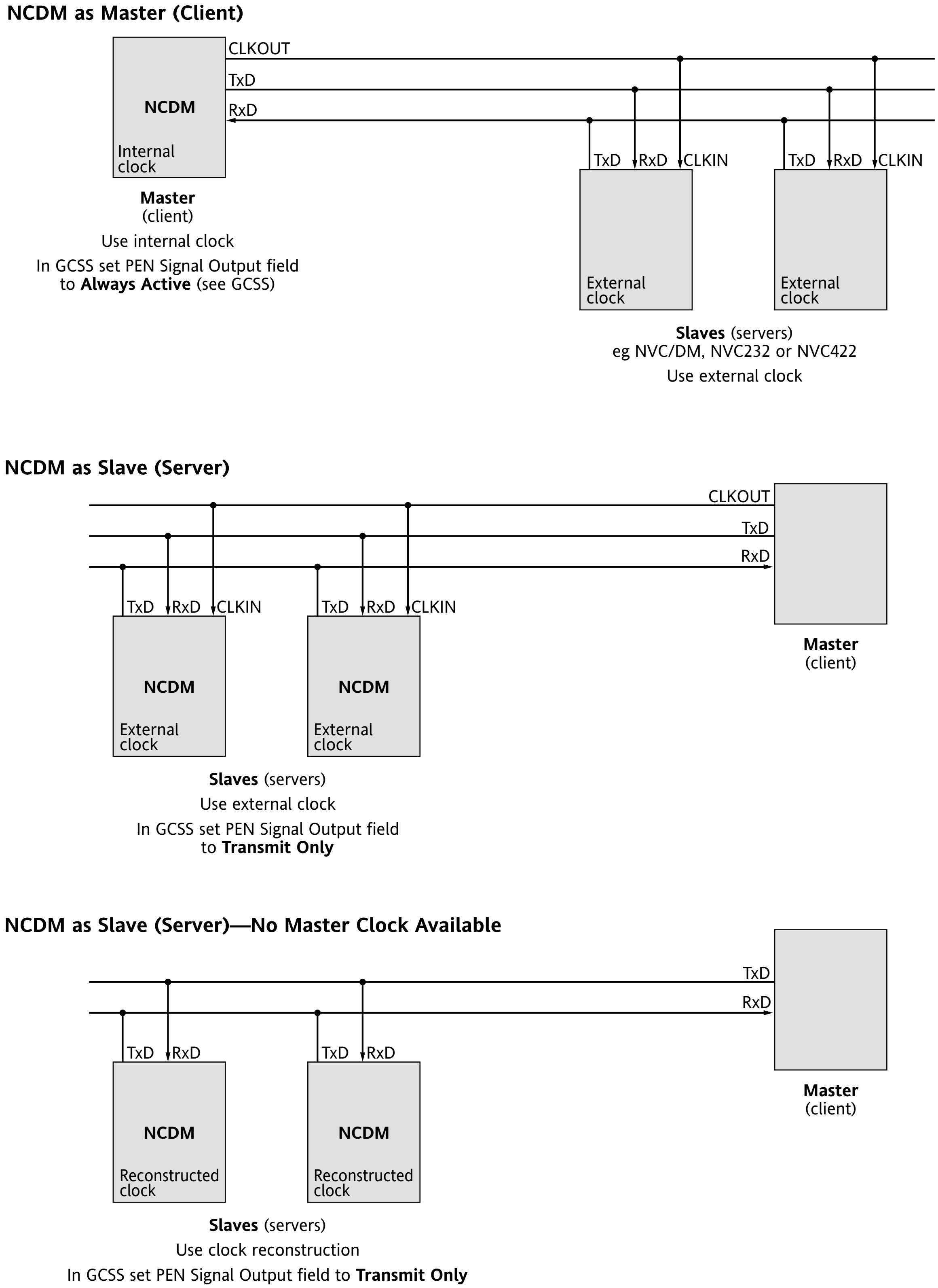


Figure 4.26 Serial Master-Slave Examples—NCDM

Hot-Standby NCDMs

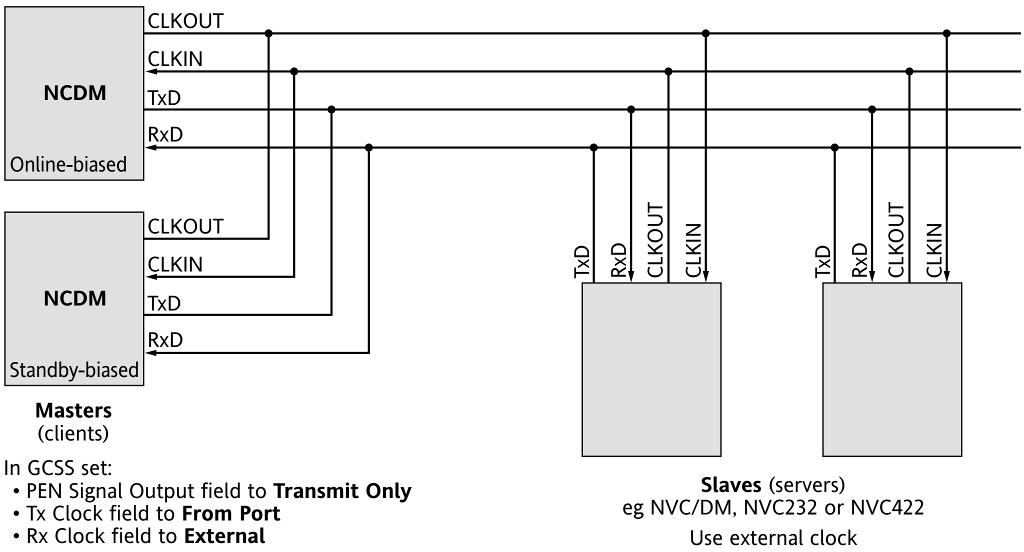


Figure 4.27 Serial Master-Slave Examples–Hot-Standby NCDMs

4.7.2.5 Production Port

This port is a male DB9 connector on the front edge of the NCDC. Signal levels are RS232C and the connector pinouts are shown in table A.45 in Appendix A.

The port supports a 3-wire (RxD, TxD & COMMON) connection to a PC running GCSS or ICS and operates at either 9600 bps or 115200 bps.

Use the GCSS to upgrade the NCDM Non-Vital Configuration through the Production port.

System software upgrades are also made through this port using the Zmodem protocol configured for 38400 bps.

Note: ***No protection or filtering is provided on this port so it must only be used for temporary connections, while the interlocking is not controlling the railway.***

4.7.3 Redundant Serial Port Interface for Control Systems

The system availability can be improved by using redundant control system communication circuits (usually between the control centre and the field).

Configure both ports as a *duplicated pair* and use two diverse bearers to connect the NCDM with the remote location.

Ports configured as a duplicated pair must use the same protocol, but other parameters (eg data transfer rate) can be different.

Change over from one port to the other is controlled by the office. The office will normally force a change over to the standby bearer if it fails to receive a reply from the NCDM on the online bearer. The actual mechanism depends on the protocol being used.

4.7.3.1 WSA/S2 Slave

The office transmits each message on *both* links; one of which is the designated online link.

The NCDM primary port is set online at power-up. The NCDM will only use data from the online port and will only reply using the online port. All messages received on the offline port will be echoed back to the office without change.

The office can force a port change over by setting the Port bit (bit 6 of the control byte).

The offline port will become active when the active port times out with a Loss of Communication (LOC).

The NCDM will set the Port bit in the reply to 0 for the port that is online or 1 for the port that is offline.

4.7.3.2 WSL/S2 Slave

There are currently two different schemes for handling WSL/S2 duplicated links:

- The WRSL method uses the Inhibit bit. The NCDM will ignore a received message with the Inhibit bit set, although it will still reply to the message in the normal way. The port is considered to be in Standby Mode.
- The Dimetronic method does not use the Inhibit bit (it is always clear); instead, only one of the ports is 'configured' at any one time. On receipt of a 'card fit data' message (which causes the port to become configured, ie online), the NCDM will change the state of the other port to 'unconfigured'.

4.7.4 Hardware Settings

Signal level—set for each serial port by configuring the correct signal type in the Non-Vital Configuration.

Non-Vital Configuration Version number—set using a switch bank and must match the value stored in the Non-Vital Configuration.

Diagnostic protocol passwords—can be changed during operation through MoviolaW (see [GCSS]). Reset by a hardware link to the default passwords specified in the Non-Vital Configuration.

IP Address selection—set using switch 3 of switch bank 2. This setting is only applicable when the NCDM is used in a hot standby system.

Offline modes—set using links and switches:

- *Maintenance Mode* allows the Non-Vital Configuration to be downloaded or uploaded using GCSS or ICS;
- *Production Mode* allows the NCDM system software to be upgraded.

See section A.11 on page A-89 for more details.

4.7.5 Non-Vital Configuration Settings

NCDM Non-Vital Configuration:

- is entered using the GCSS, compiled, then downloaded to the NCDM;
- can be downloaded by ICS to the NCDM from an image file created by GCSS (GCSS and ICS version 6.2 and above).

The Non-Vital Configuration contains configuration parameters and non-vital application logic.

Refer to [GCSS] for more information.

NAPPDEL Precaution

Although the NCDM has a non-vital application delay timer NAPPDEL, we recommend that you instead use the APPDEL timer to manage startup delays.

Using NAPPDEL on hot-standby systems will result in the non-vital application delay timer running the first time there is a changeover from the online to the standby WESTRACE, and this is normally highly undesirable.

Caution: ***We recommend that hot-standby systems do not use NAPPDEL in the logic, and that you set the NAPPDEL value to zero.***

4.7.6 Specific Network Port Application Rules

The NCDM can be configured to interface with multiple systems through the network.

For example:

- Control systems (local control panel or centralised train control);
- Diagnostic systems;
- Other WESTRACE systems.

The control inputs may be received from multiple sources, such as:

- Main CTC;
- Zone CTC;
- Local Control Panel.

Design the system to eliminate any unwanted effects of multiple control inputs.

This could include:

- Ensuring the control systems select which is in control independent of the NCDM;
- Selecting the source via the NCDM application data.

4.7.6.1 Operating Distance Restrictions

The network port is 10 baseT Ethernet compliant and can support data transfer over twisted pair cable up to 50 metres in length.

The use of external network infra-structure is required for data transfer over longer distances.

A shielded 10 baseT Ethernet cable is highly recommended to improve reliability.

4.7.6.2 Timeout

The timeout values for the network port and network sessions are configurable in the range 1–20 seconds. The recommended value is 5 seconds for all network sessions.

Note: ***The NCDM does not use the network port timeout value. It detects loss of network connection based on hardware signal level detection.***

4.7.6.3 Network Storm Limitation

A network storm can be caused if network equipment such as switches, routers and hubs are inadvertently connected in a loop. This results in excessive network traffic arriving at the NCDM, which exhausts its processing capability.

The NCDM detects this situation and automatically restricts the number of incoming network packets. However, the algorithm it uses may cause intermittent loss of inputs, resulting in unintended but safe operation. This is a known and unavoidable limitation.

4.7.7 Specific Serial Port Application Rules

The NCDM may be configured to receive control inputs from multiple sources. For example:

- Main bearer;
- Standby bearer;
- Local control system.

Design the system to eliminate any unwanted effects of multiple control inputs.

This could include:

- Ensuring the remote control system selects the transmit bearer;
- Selecting the source via the application data.

4.7.7.1 Operating Distance Restrictions

RS232C

Use RS232C for data transfer rates up to 20 kbps over cables up to 15m in length.

Operation at higher data transfer rates (eg 57600 bps) is possible over shorter cable lengths.

Shielded cable is highly recommended for improved reliability.

For longer cable lengths and higher data transfer rates, RS485 is preferred.

RS485

The RS485 specification allows for long cable runs at high data rates (eg 1200 m at 64000 bps). Such distances are only practical where all nodes are solidly referenced to the same potential. Rail environments are subject to high earth potential differences caused by lightning strikes and traction faults that have historically caused failures in drivers and receivers.

Practical rail environment recommendations are:

- Do not run RS485 outside of buildings (unless you can positively guarantee the fault potential difference with respect to signal ground will **never** exceed 5V). Consider use of fibre optic modems and optical fibres instead.
- Connect the signal ground on all nodes. Ensure this does not induce earth loops.
- Fit 120 Ω 0.25 W termination resistors at the ends of cables. Do not fit resistors at intermediate nodes.

Refer to the public domain specifications for further details.

4.7.7.2 Earthing of Signal Ground Line

Do not connect the signal ground line to earth because this may result in an unsafe situation if there is an undetected earth fault(s) in the PFM.

Earth the cable screen, if fitted, in accordance with section 5.2.3.

4.7.7.3 Timeout

The control system port timeout is configurable in the range 1 - 60 seconds. The recommended value is 10 seconds. In this case, the office must ensure that it sends a message to the NCDM at least once every 10 seconds.

To help detect configuration errors, the NCDM has an 'address timeout' which is the maximum permissible time between messages sent to or received from a particular S2 address.

The address timeout is the port timeout multiplied by the number of addresses handled by the port. Thus if a port has to handle four S2 addresses, the maximum time between messages to a particular address is 40 seconds.

As an example, suppose port 2 on the NCDM is configured for addresses 1, 2, 7 and 12 but the office is (incorrectly) configured for addresses 1, 2, 8 and 12. The NCDM will ignore messages sent to address 8, and will not receive messages for address 7. After 40 seconds it will flag a 'port 2, address 7 timeout' fault code (2079h) See Appendix A, page A-105.

The diagnostic port timeout is configurable in the range 1 - 60 seconds. The recommended value is 30 seconds. If no message is received from the master within this time, the NCDM will terminate the session and hang up the modem (if used).

4.7.7.4 Recommended Modem

To minimise line errors on a remote connection to a WESTRACE that uses an NCDM, be sure to use an industry-recognised brand of modem.

We recommend the VFC/45 modem(Invensys Rail part number 2650108210).

Note: ***If the NCDM uses the WSL/S2 protocol, the modem must support WSL/S2 frames: 1 start bit, 8 data bits, 2 stop bits and even parity.***

4.8 Non-Vital Communications and Diagnostic Module (NVC/DM)

The NVC/DM replaces older NVC and DM modules and works with the HVLM and the VLM5 vital processing modules. It can also operate as a stand-alone non-vital logic processor.

Functions

The main functions of the NVC/DM are to:

- Evaluate non-vital application logic;
- Exchange configured logic states with control centres, control computers, external non-vital parallel I/O modules and the vital processor, using various serial protocols;
- Receive all logic states from the vital processor, for logging purposes;
- Regularly scan all WESTRACE modules for detected faults;
- Log all changes to vital and non-vital logic states, all detected faults and other significant occurrences;
- Allow an external diagnostic system (such as MoviolaW) to extract logged data and other diagnostic information, via a serial interface;
- Allow an external system to download or upload the Non-Vital Configuration.

Note: ***The NVC/DM has been validated for Hot Standby operation but only as a diagnostic module (emulating a DM128 or DM5).***

NVC/DM Real Time Clock

A real time clock (RTC) is used for internal timestamping of faults, events and operations logged for diagnostic purposes. The accuracy of the RTC is stated as 'better than ± 2 minutes per month @ 25°C' which is approximately ± 4.3 seconds per day. The module should have its time synchronised with the connected external diagnostic system or control system when greater accuracy of time stamping is required.

SAFETY

WARNING

The NVC/DM must not be used for processing:

- ***safety critical logic;***
- ***vital communications.***

4.8.1 Module Components

An NVC/DM comprises the following components:

- Logic Evaluation Card (LEC).
- Communications Interface Module Filter & Interface Module (CIMFIM).

A CIM Protection Module (CIMPM) is plugged into the rear of the CIMFIM. See figure 4.30.

The CIMFIM is fitted with one or more daughter boards of the following types (one for each of the six external ports):

- Serial Daughter Board 232 (SDB232), for RS232C level ports
- Serial Daughter Board 485 (SDB485), for RS485 level ports

The CIMFIM connects to the CIM Protection Module (CIMPM).

The external serial cables terminate at DB9 connectors on the back of the CIMPM. The CIMPM card provides transient protection for the serial signal lines, that pass to the CIMFIM via the lower backplane connector on the CIMFIM.

The CIMFIM provides filtering to remove high frequency noise, then routes the signals to the serial interface daughter boards. The daughter boards convert the signals between RS232C or RS485 levels and CMOS levels.

The CMOS-level serial signals pass between the LEC and the CIMFIM via a 96-pin connector near the front of the board. The LEC is responsible for all logic and communications processing functions.

Table 3.1 lists these components along with their functions and part numbers.

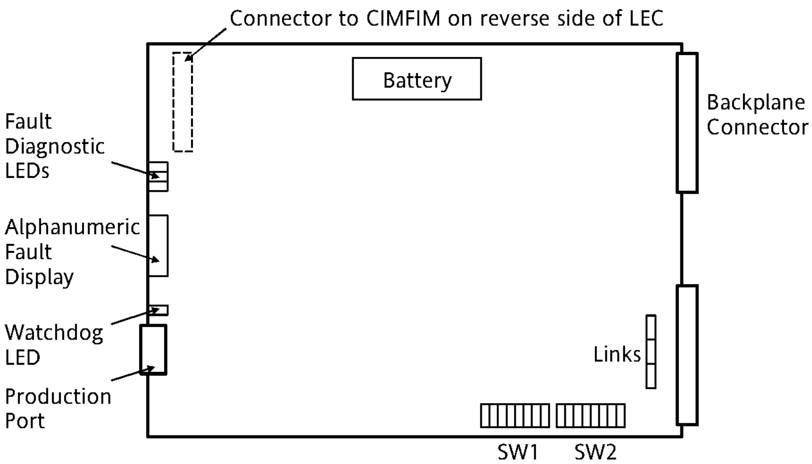


Figure 4.28 LEC–NVC/DM Module–Component Side View

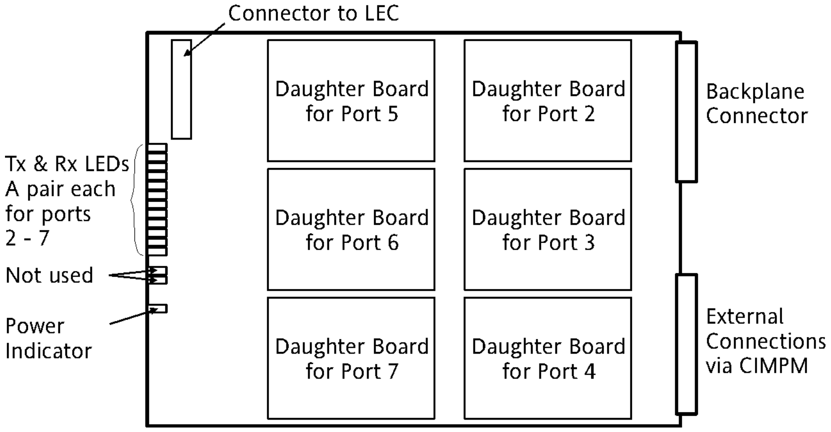


Figure 4.29 Component Side View–CIMFIM–NVC/DM

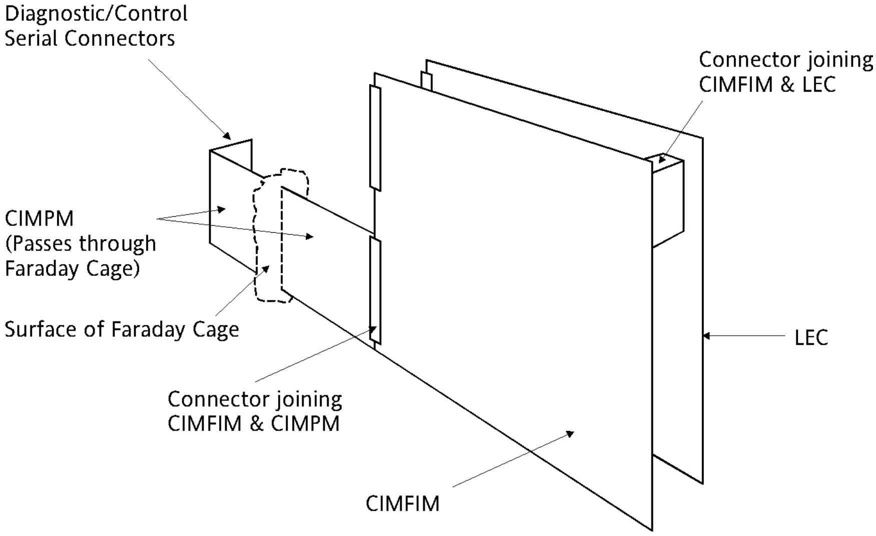


Figure 4.30 Assembly–LEC, CIMFIM and CIMPM–NVC/DM

4.8.2 External Connections

Non-Vital Configuration and system firmware upgrades are made through the Production port on the front edge of the LEC. See section 4.8.2.3.

Diagnostic, telemetry and serial power connections to the NVC/DM are through connectors on the CIMPM. See figure 4.31.

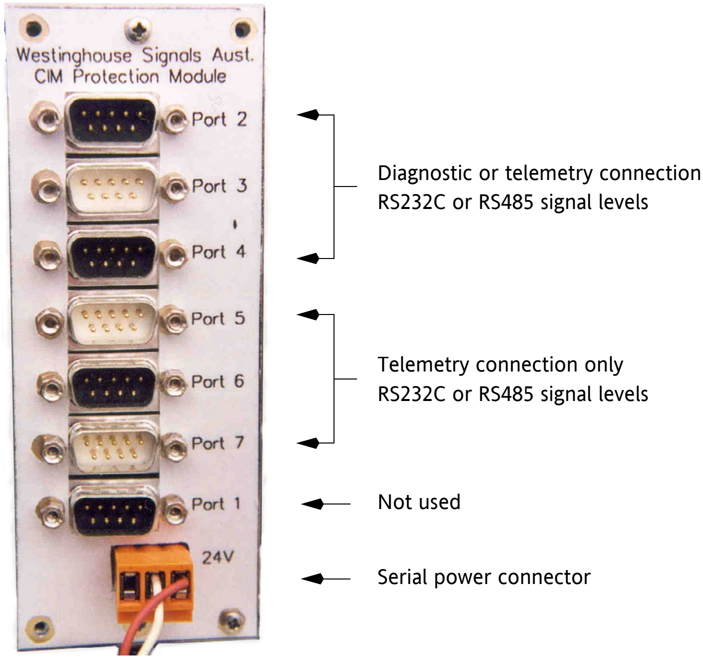


Figure 4.31 Serial and Power Connectors–CIMPM–NVC/DM

4.8.2.1 Serial Power Connection

Serial power should come from a permanent B24 supply so that diagnostics can be accessed after system shutdown.

Table 4.8 Serial Power Pinout–CIMPM–NVC/DM

Pin Number	Signal
1	+24 ±6 Vdc
2	Common (0V)
3	Not used

4.8.2.2 Diagnostic and Telemetry Serial Connections

Six configurable serial ports are provided for connection to external control and diagnostic systems. These connections are made via male DB9 connectors on the rear of the CIMPM, as shown in figure 4.31.

The six ports are numbered Port 2 to Port 7. The Port 1 connector is not currently used.

Each port may be configured for RS232C or RS485 signal levels by installing the appropriate daughter board. RS232C is used for point-to-point links only, RS485 may be used for point-to-point or multi-drop links.

All other port configuration (eg. data transfer rate, clock reconstruction etc) is done using GCSS and stored in the NVC/DM Non-Vital Configuration.

RS422 equipment may be connected to an NVC/DM port configured for RS485 as a point-to-point link. Some RS422 equipment may be suitable for multi-drop operation. Check with the supplier.

All six serial port interfaces are powered by the Serial Power Connector (see section 4.8.2.1).

Available Port Signals

The set of signals provided by each port vary depending on the interface type.

RS232C Connection

See table A.59, Appendix A, page A-143.

Data transfer pins—RxD and TxD.

The NVC/DM is wired as a DTE (Data Terminal Equipment) device, so:

- RxD is an input;
- TxD is an output.

Clock signals—CLKIN and CLKOUT.

For use with synchronous protocols, ie WSA/S2. See *Clock Signals* on page 4-57.

Modem handshaking signals:

- generated by the modem:
    - DCD (Data Carrier Detect);
    - CTS (Clear To Send).

  The NVC/DM can be configured to use or ignore either or both of these signals. If it uses them, it will not transmit unless both signals are asserted.

- generated by the NVC/DM
    - DTR (Data Terminal Ready), continuously asserted;
    - RTS (Request To Send):
      - asserted on telemetry ports when NVC/DM has data to transmit;
      - continuously asserted on diagnostic ports.

RS485 Connection

See table A.60, Appendix A, page A-143.

RS485 uses a subset of the RS232C signals. Modem handshaking signals (RTS, CTS, DTR and DCD) are not available.

These ports can be connected through Invensys Rail modems (eg S2/VFC45) but may not be suitable for commercial modems because of the absence of handshaking signals.

4

Clock Signals

This section is only applicable for the WSA/S2 protocol.

The NVC/DM serial interfaces do not provide 'transmit clock' and 'receive clock' pins. Instead, they provide 'clock output' (CLKOUT) and 'clock input' (CLKIN) pins.

The *transmit* clock can be configured (in the GCSS Non-Vital Configuration) to be either:

- generated by the NVC/DM and appearing on the CLKOUT pin, or;
- generated by the external receiver connected to the CLKIN pin on the NVC/DM.

The *receive* clock can be:

- generated by the NVC/DM and appearing on the CLKOUT pin;
- generated by the external transmitter connected to the CLKIN pin on the NVC/DM;
- reconstructed from the incoming data signal (it is then not necessary to connect anything to the CLKIN pin).

Note: ***NVC/DM modules must use clock reconstruction if a clock signal is not provided.***

Note: ***When clock reconstruction is enabled, that interface's clock output (CLKOUT) runs at 16 times the data rate and therefore cannot be used as an external clock for another device.***

Application issues

- There is only one clock input (CLKIN) for each interface and this can be used for Transmit, Receive or both. The latter case also requires that the external equipment uses a single clock—this can be supplied from either the external Transmit or Receive.
- Clock reconstruction requires that:
  - the external data rate generator has a frequency error of less than 0.3%;
  - the maximum data rate is 38400 bps.
- Figures 4.32 and 4.33 show the clock, transmit and receive connections recommended when using the NVC/DM in serial master-slave applications.
  Use the NVC/DM's CLKOUT and CLKIN (rather than clock reconstruction) to synchronise both transmit and receive data whenever possible.

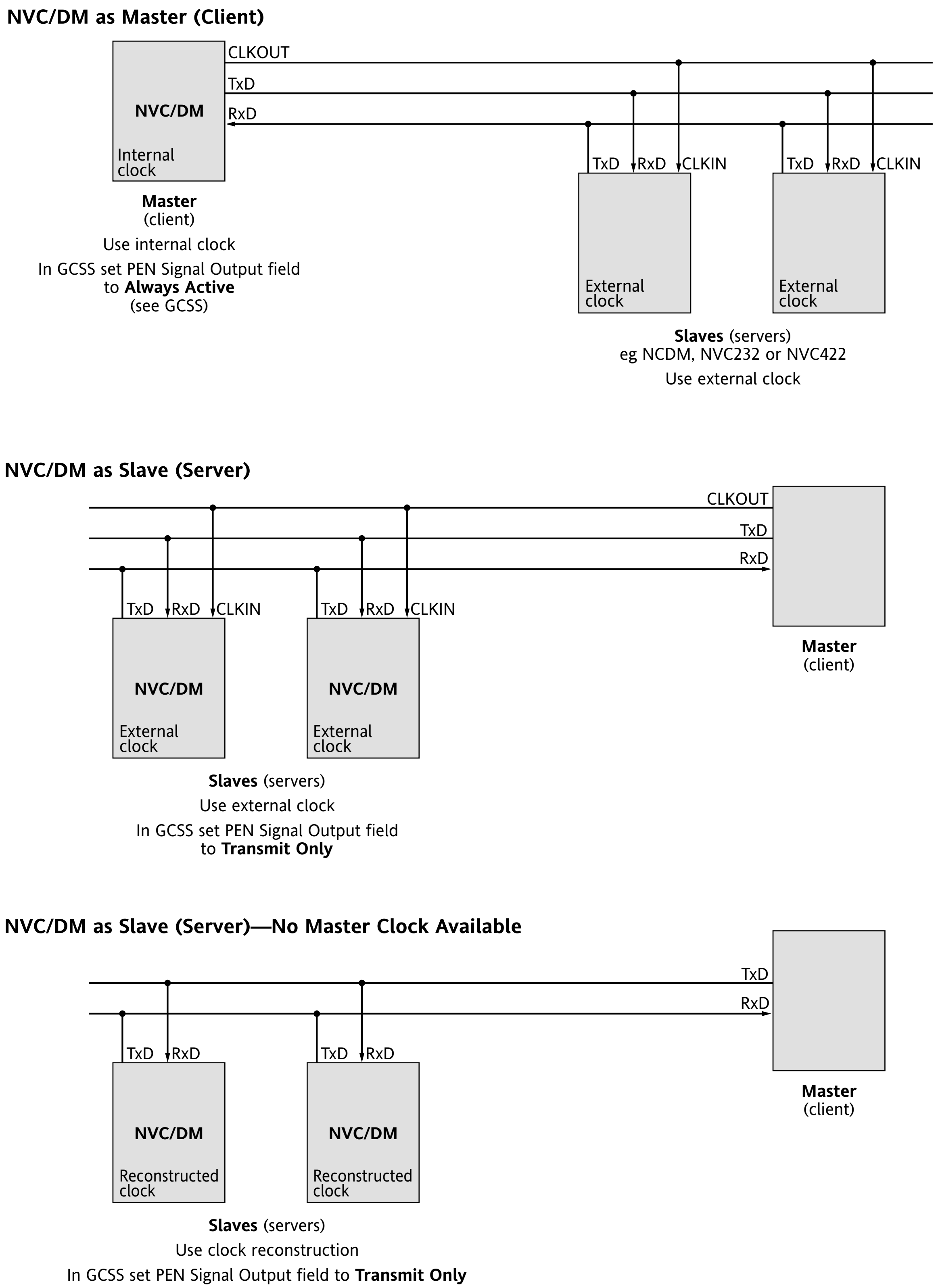


Figure 4.32 Serial Master-Slave Examples—NVC/DM

Hot-Standby NVC/DMs

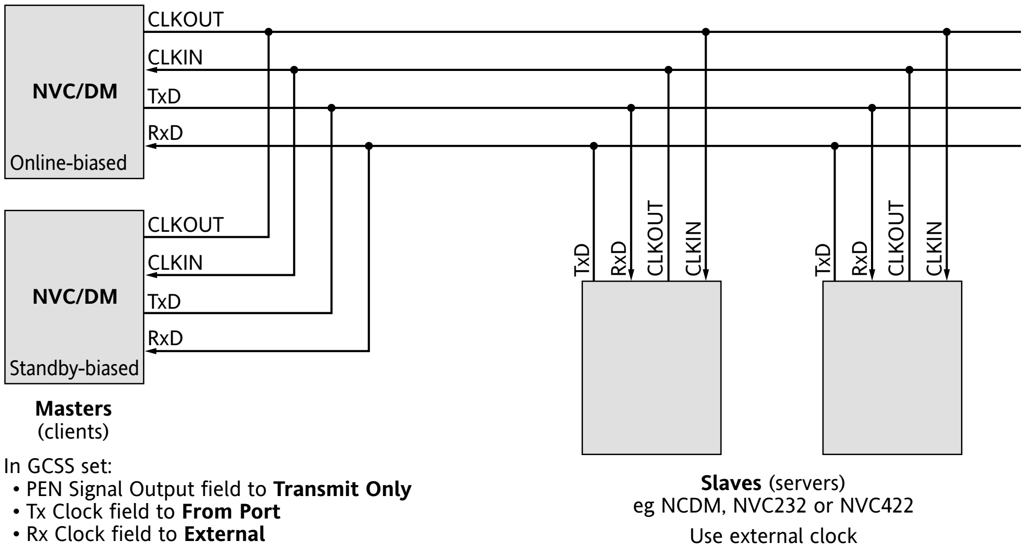


Figure 4.33 Serial Master-Slave Examples–Hot-Standby NVC/DMs

4.8.2.3 Production Port

This port is a male DB9 connector on the front edge of the card. Signal levels are RS232C and the connector pinouts are shown in table A.61, Appendix A, page A-144.

The port supports a 3-wire (RxD, TxD & COMMON) connection to a PC running GCSS or ICS and operates at either 9600 bps or 115200 bps. Non-Vital Configuration and system firmware upgrades to the NVC/DM are made through this port from the configuration system (GCSS).

Note: ***No protection or filtering is provided on this port so it must only be used for temporary connections, while the interlocking is not controlling the railway.***

4.8.3 Redundant Telemetry

The system availability can be improved by using redundant telemetry (usually between the control centre and the field). Configure two ports as a *duplicated pair* and use two diverse bearers to connect the NVC/DM with the remote location.

Ports configured as a duplicated pair must use the same protocol, but other parameters (eg data transfer rate) can be different.

Change over from one port to the other is controlled by the office. If the office fails to receive a reply from the NVC/DM on the online bearer, it will normally force a change over to the standby bearer. The actual mechanism depends on the protocol being used.

4.8.3.1 WSA/S2 Slave

The office transmits each message on *both* links; one of which is the designated online link.

The NVC/DM primary port is set online at power-up. The NVC/DM will only use data from the online port and will only reply using the online port. All messages received on the offline port will be echoed back to the office without change.

The office can force a port change over by setting the Port bit (bit 6 of the control byte).

The NVC/DM will set the Port bit in the reply to 0 for primary or 1 for secondary on line.

4.8.3.2 WSL/S2 Slave

There are currently two different schemes for handling WSL/S2 duplicated links:

- The WSL method uses the Inhibit bit. The NVC/DM will ignore a received message with the Inhibit bit set, although it will still reply to the message in the normal way. The port is considered to be in Standby Mode.
- The Dimetronic method does not use the Inhibit bit (it is always clear); instead, only one of the ports is ‘configured’ at any one time. On receipt of a ‘card fit data’ message (which causes the port to become configured, ie online), the NVC/DM will change the configuration of the other port.

4.8.4 Hardware Settings

Signal level – set for each serial port by installing the correct type of serial daughter board on the CIMFIM (SDB232 for RS232C, or SDB485 for RS485).

Non-Vital Configuration Version number – set using a switch bank and must match the value stored in the Non-Vital Configuration.

Diagnostic protocol passwords – can be changed during operation through MoviolaW (see [GCSS]). Reset by a hardware link the default passwords specified in the Non-Vital Configuration.

Offline modes – set using links and switches:

- *Maintenance Mode* allows the Non-Vital Configuration to be downloaded or uploaded using GCSS or ICS;
- *Production Mode* allows the NVC/DM system software to be upgraded.

See section A.12 on page A-121 for more details.

4.8.5 Non-Vital Configuration Settings

NVC/DM Non-Vital Configuration:

- is entered using the GCSS, compiled, then downloaded to the NVC/DM;
- can be downloaded by ICS to the NVC/DM from an image file created by GCSS (GCSS and ICS version 6.2 and above).

The Non-Vital Configuration contains:

- Non-vital application logic;
- Configuration parameters.

Refer to [GCSS] for more information.

4.8.6 Specific Application Rules

The NVC/DM may be able to receive control inputs from multiple sources, for example:

- Main bearer;
- Standby bearer;
- Local control system.

Design the system to eliminate any unwanted effects of multiple control inputs.

This could include:

- Ensuring the remote control system selects the transmit bearer;
- Selecting the source via the application data.

4.8.6.1 Operating Distance Restrictions

RS232C

Use RS232C for data transfer rates up to 20 kbps over cables up to 15m in length.

Operation at higher data transfer rates (eg 57600 bps) is possible over shorter cable lengths.

Shielded cable is highly recommended for improved reliability.

For longer cable lengths and higher data transfer rates, RS485 is preferred.

RS485

The RS485 specification allows for long cable runs at high data rates (eg 1200 m at 64000 bps). Such distances are only practical where all nodes are solidly referenced to the same potential. Rail environments are subject to high earth potential differences caused by lightning strikes and traction faults that have historically caused failures in drivers and receivers.

Practical rail environment recommendations are:

- Do not run RS485 outside of buildings (unless you can positively guarantee the fault potential difference with respect to signal ground will **never** exceed 5V). Consider use of fibre optic modems and optical fibres instead.
- Connect the signal ground on all nodes. Ensure this does not induce earth loops.
- Fit 120 Ω 0.25 W termination resistors at the ends of long cable runs (eg 100 m at 9600 bps or 10 m at 64000 bps). Do not fit resistors at intermediate nodes.

Refer to the public domain specifications for further details.

4.8.6.2 Earthing of Signal Ground Line

The signal ground line should not be connected to earth because this may result in an unsafe situation if there is an undetected earth fault(s) in the PFM. The cable screen, if fitted should be earthed in accordance with section 5.2.3.

4.8.6.3 Timeout

The telemetry port timeout is fixed at 10 seconds. The office must ensure that it sends a message to the NVC/DM at least once every 10 seconds.

To help detect configuration errors, the NVC/DM has an 'address timeout' which is the maximum permissible time between messages sent to or received from a particular S2 address.

The address timeout is the port timeout multiplied by the number of addresses handled by the port. Thus if a port has to handle four S2 addresses, the maximum time between messages to a particular address is 40 seconds.

As an example, suppose port 5 on the NVC/DM is configured for addresses 1, 2, 7 and 12 but the office is (incorrectly) configured for addresses 1, 2, 8 and 12. The NVC/DM will ignore messages sent to address 8, and will not receive messages for address 7. After 40 seconds it will flag a 'port 5, address 7 timeout' fault code (5079h) See Appendix A, page A-136.

The timeout is 30 seconds for a diagnostic port. If no message is received from the master within this time, the NVC/DM will terminate the session and hang up the modem (if used).

4.9 Non-Vital Communications Module (NVC)

4.9.1 Module Components

NVC modules comprise an NVC card fitted with an S2/SDB4x daughter board.

The particular daughter board depends on the application (whether RS232C- or RS422-level outputs, clock reconstruction, or tri-state circuits are required). Table 3.1 lists the range of NVC modules, along with their functions and part numbers.

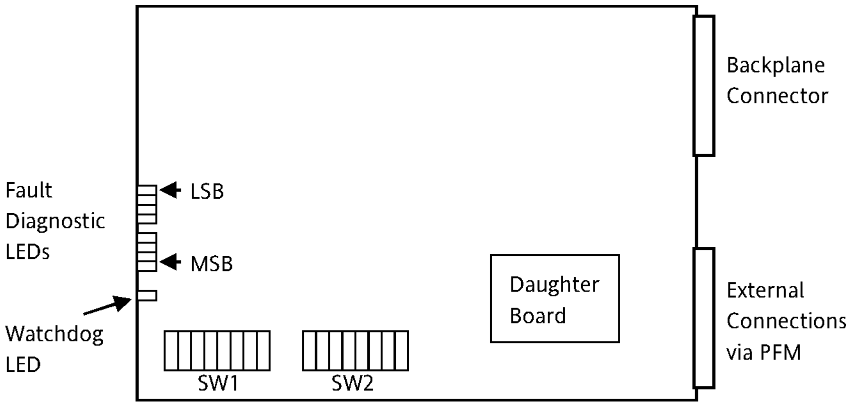


Figure 4.34 View from Component Side–NVC

4.9.2 External Connections

See section A.13 for details about NVC modules.

NVC modules are connected using either RS232C or RS422 level outputs (RS422 is recommended for multiple NVC modules). Figures 4.35, 4.36 and 4.37 illustrate some typical WESTRACE NVC module configurations.

Figure 4.35 illustrates a single NVC module communicating via a modem.

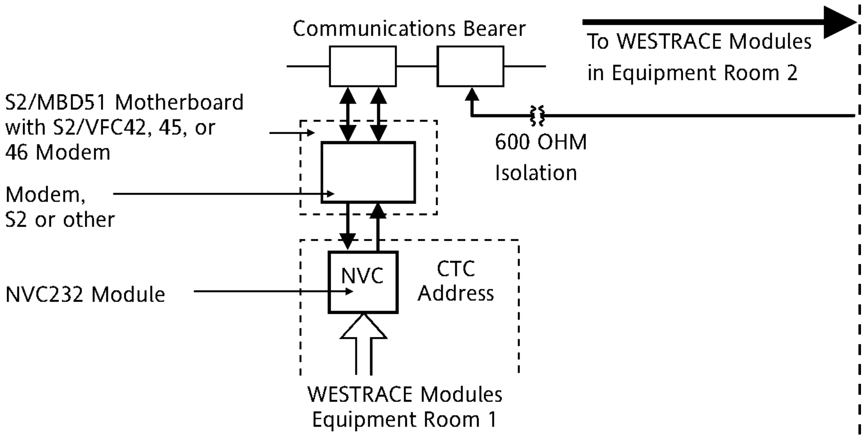


Figure 4.35 Communicating via Modem–Single NVC

Figure 4.36 illustrates multiple NVC modules communicating via a single modem. The use of NVC422 is recommended for multiple NVC modules because parallel configurations of NVC modules use tri-state output.

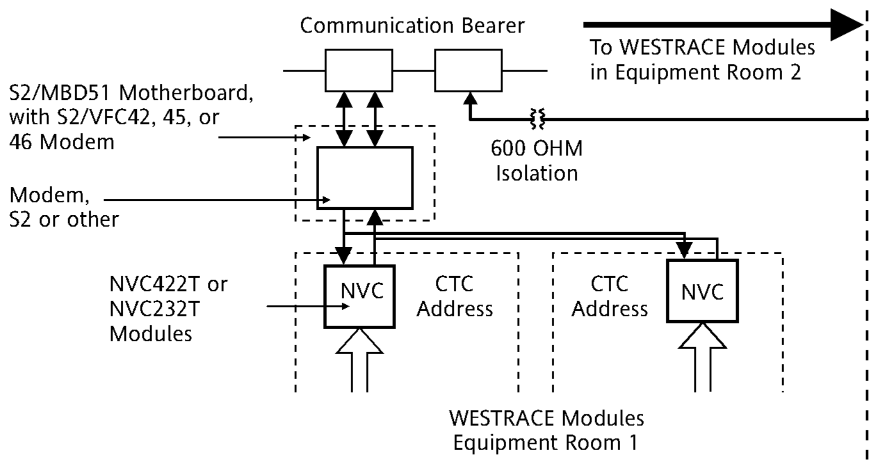


Figure 4.36 Communicating via Modem – Multiple NVC

Figure 4.37 illustrates a single NVC module communicating without a modem. NVC modules require clock reconstruction where there is no external clock connection from the S2/SCN4x.

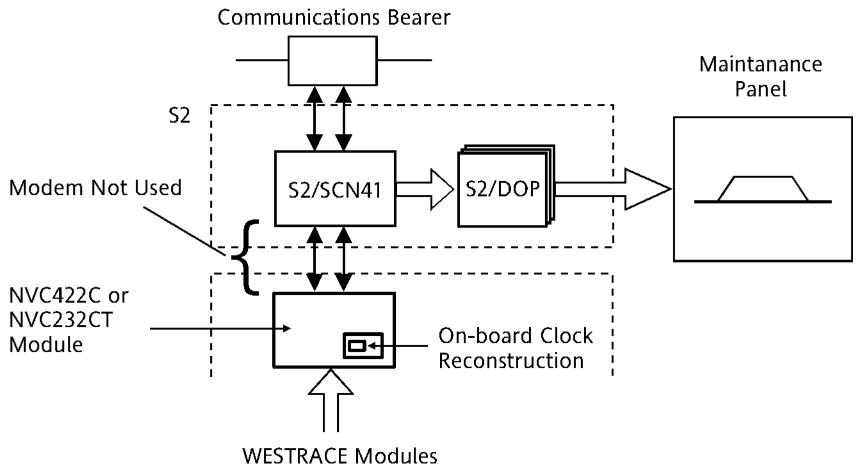


Figure 4.37 Communicating without a Modem – Single NVC

Figure 4.38 illustrates multiple NVC modules communicating without a modem. NVC modules require clock reconstruction where there is no external clock connection from the S2/SCN4x. Tri-state communications from either an NVC422 or NVC232 would be suitable in this example.

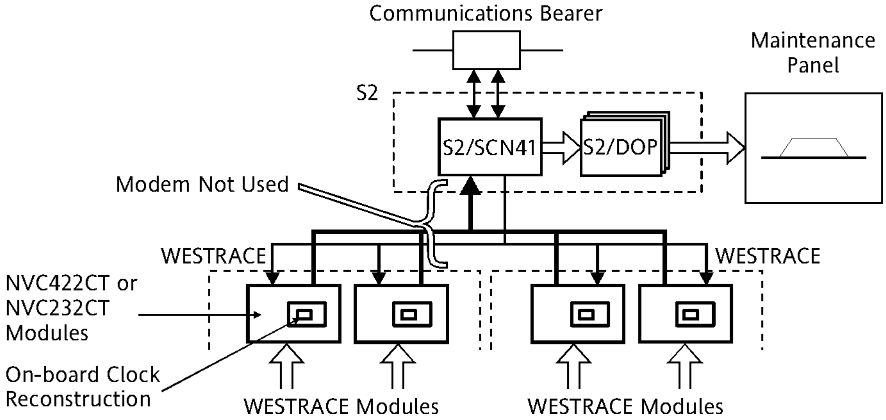


Figure 4.38 Communicating without a Modem—Multiple NVC

In the case of either NVC422 or NVC232, the external connections are one to one. The particular application determines which connections are made. Tables are provided in sections 4.9.2.1 and 4.9.2.2 as general guides for connecting each connector pin to S2 devices. Other types of modems would be connected according to their requirements.

Figure 4.39 illustrates an example of a typical multiple NVC422 to S2/SCN4x configuration. In this illustration, clock reconstruction is not provided by the NVC422 modules and the following inputs and outputs are not carried through to the S2/SCN4x:

- Pin 4—Transmit Clock +
- Pin 5—Transmit Clock –
- Pin 6—Data Carrier Detect
- Pin 7—unused
- Pin 12—Clear to Send
- Pin 13—Request to Send

Similarly for RS232C connections, pins pertaining to modems (or unused) would not be connected.

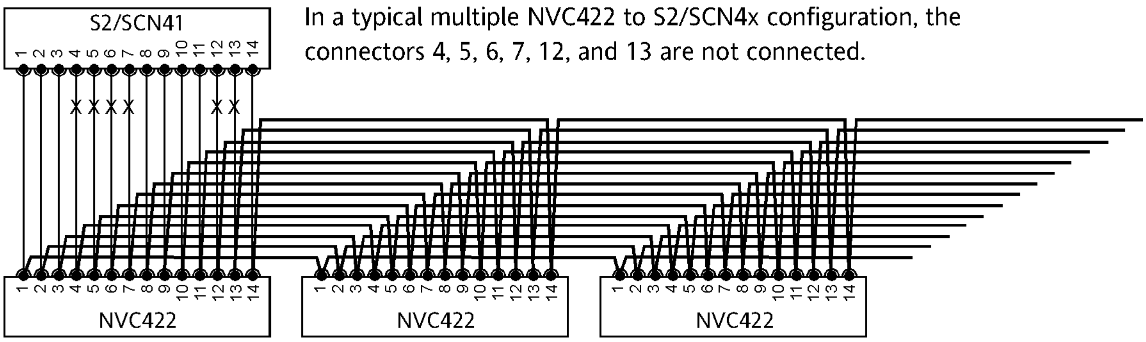


Figure 4.39 Connection Details for Multiple Modules without Modem—NVC

4.9.2.1 RS232C Connections

External Connections to the NVC232 are made via the SIO232PFM.

The SIO232 PFM External Connectors are a DB25 plug and socket for RS232C interface, and a 2 way Weidmueller SLA socket that accepts a Weidmueller BLA plug for power (supplied with the module).

Figure 4.40 depicts the external connection details of the SIO232 PFM.

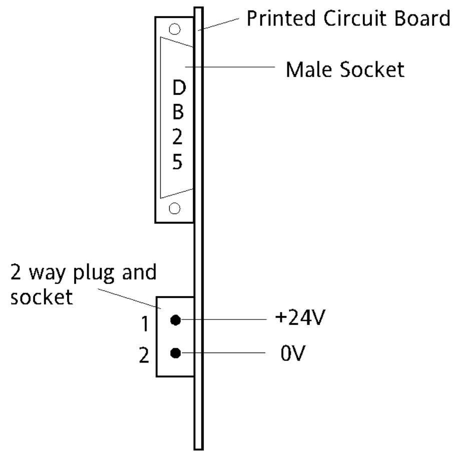


Figure 4.40 External Connections–SIO232 PFM–NVC232

Table 4.9 DB25 Pinout–SIO232 PFM–NVC232

Pin	Function
1	Chassis Ground
2	Transmit Data (TxD)
3	Receive Data (RxD)
4	Request to Send (RTS)
5	Clear to Send (CTS)
7	Signal Ground (GND)
8	Data Carrier Detect (DCD)
17	Receive Clock (RXC)
20	Data Terminal Ready (DTR)
24	Transmit Clock (TXC)

This module communicates using RS232C and is configured as a DTE.

The following table is a general guide for connecting each SIO232 PFM connector pin to either an S2/MBD51 Modem Motherboard or an S2/SCN4x Scanner. In a typical application, a connection would be carried through for columns marked '✓'.

Other types of modems would be connected according to their requirements.

Note: ***Ensure that all modem motherboard jumpers are correctly set for the operational environment.***

Table 4.10 DB25 Pinout–SIO232 PFM to S2/MBD51 Modem or S2/SCN4x Scanners (no modem)

Pin	Function	S2/MBD51 VFC45	S2MBD51 VFC46	S2/SCN41 or 42
2	TxD	✓	✓	✓
3	RxD	✓	✓	✓
4	RTS	✓		
5	CTS	✓	✓	
7	GND	✓	✓	✓
8	DCD			
17	RXC	✓	✓	✓
20	DTR			
24	TXC	✓	✓	

Note: ***NVC232 modules must have clock reconstruction if a clock is not provided (for example, if a modem is not used).***

4.9.2.2 RS422 Connections

External Connections to the NVC422 are made via the SIO422PFM.

The SIO422 PFM External Connectors are a 14 way ribbon header for an RS422 interface, and a 2 Way Weidmueller SLA socket that accepts a Weidmueller BLA plug for power (supplied with the module).

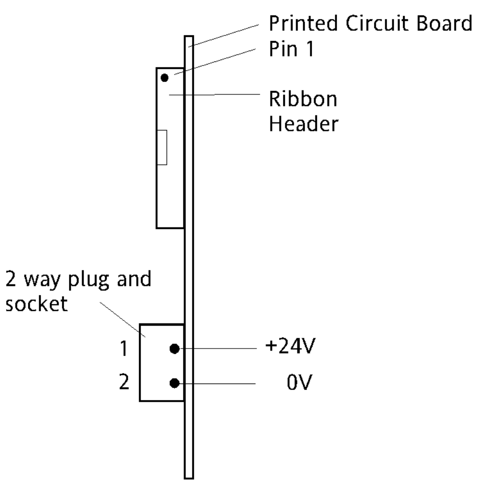


Figure 4.41 External Connections–SIO422 PFM–NVC422

Figure 4.42 illustrates the RS422 connector pins and pin numbering.

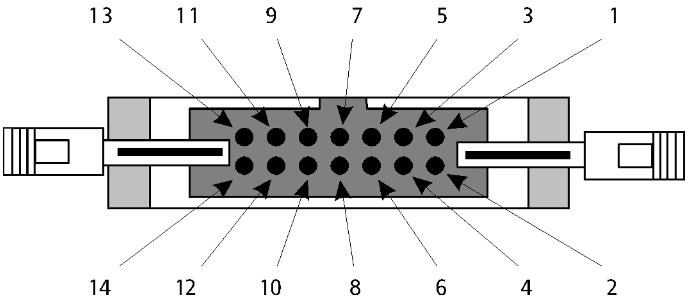


Figure 4.42 RS422 Connector Pin Numbering–SIO422 PFM–NVC422

Table 4.11 14-Way Ribbon Header Pinout–SIO422 PFM–NVC422

Pin	Function
1	0 Volts (O V)
2	Received Clock + (RXC +)
3	Received Clock - (RXC -)
4	Transmit Clock + (TXC +)
5	Transmit Clock - (TXC -)
6	Data Carrier Detect (DCD)
7	Not Used
8	Transmit Data + (TxD+)
9	Transmit Data - (TxD-)
10	Receive Data + (RxD+)
11	Receive Data - (RxD-)
12	Clear to Send (CTS)
13	Request to Send (RTS)
14	0 Volts (O V)

The SIO422PFM permits direct ribbon cabling from either a S2/SCN motherboard or a MBD51 (S2VFC modem motherboard) for direct insertion into a telemetry system using S2 HDLC protocol.

Where multiple NVCs are in use either in a single WESTRACE system or in multiple WESTRACE systems (larger interlockings), the NVC ribbon connections can be multi-dropped.

The following table is a general guide for connecting each SIO422PFM connector pin to either an S2/MBD51 Modem Motherboard or an S2/SCN4x Scanner. In a typical application, a connection would be carried through for columns marked '✔'.

Other types of modems would be connected according to their requirements.

Note: ***Ensure that all modem motherboard jumpers are correctly set for the operational environment.***

Table 4.12 RS422 Pinout—SIO422 PFM to S2/MBD51 Modem Motherboards or S2/SCN4x Scanners (no modem)

Pin	Function	Name	Signal Level	S2/MBD 51 VFC42	S2/MBD 51 VFC45	S2/MBD 51 VFC46	S2/SCN4 1 or 42
1	0 Volt Line	0 V	RS422	✓	✓	✓	✓
2	Receive Clock +	RXC +	RS422	✓	✓	✓	✓
3	Receive Clock -	RXC -	RS422	✓	✓	✓	✓
4	Transmit Clock +	TXC +	RS422	✓[1]	✓	✓	
5	Transmit Clock -	TXC -	RS422	✓[1]	✓	✓	
6	Data Carrier Detect	DCD	O/C	✓	✓	✓	
8	Transmit Data +	TxD +	RS422	✓	✓	✓	✓
9	Transmit Data -	TxD -	RS422	✓	✓	✓	✓
10	Receive Data +	RxD +	RS422	✓	✓	✓	✓
11	Receive Data -	RxD -	RS422	✓	✓	✓	✓
12	Clear to Send	CTS	O/C	✓	✓	✓	
13	Request to Send	RTS	O/C	✓	✓	✓	
14	0 Volt Line	0 V	RS422	✓	✓	✓	✓

1. The S2/VFC42 Modem will operate without a synchronising clock from the transmit data signal to the modem. The modem will synchronise to the data signal, given appropriate links on the S2/MBD51 Motherboard.

Note: ***NVC422 modules must have clock reconstruction if a clock is not provided.***

The 0 V line at the PFM must be connected to the 0 V line at every device sharing the RS422 interface.

When directly connecting the S2/MBD51 modem motherboard and the S2/MBD54 scanner motherboard, the connections for Receive Data and Transmit Data must be crossed.

4.9.3 NVC Configuration

The following are switch selectable on the NVC:

Slave Address (Telemetry System Address):	0-63
Data Transfer Rate:	600, 1200, 2400, 4800
Data Word Length:	32, 48, 64, 128
System Bit:	0 or 1
Telfail	On or Off
Modem Handshaking:	On or Off

NVC232 and NVC422 modules which offer clock reconstruction are fitted with daughter boards which also must be configured for data transfer rate.

Full details are provided in section A.13.

4.9.4 Specific Application Rules

4.9.4.1 Two NVCs Used as a Pair

Two NVCs can be configured as a pair in the main and Standby Mode. Both NVCs are provided with output information from the VLE, but only one is used to input controls to the VLE (the online or primary one).

The online NVC is selected by using the Application Logic to modify the reserved mnemonic NVCSEL.

When NVCSEL is set (logic 1) the primary NVC is online. When NVCSEL is reset (logic 0) the secondary NVC is online. The default value of NVCSEL is logic 1 (primary NVC selected).

NVCSEL may be controlled using Vital inputs or Non-Vital inputs. If a Non-Vital input from the NVC pair is used, care should be taken to ensure that the state of NVCSEL does not oscillate.

4.9.4.2 NVC Used for Vital Serial Channels

The NVC is, by definition, non-vital and must not be used for any vital serial channel.

4.9.4.3 NVC Used for Non-Vital Serial Channels

A WESTRACE system can be connected to non-vital control systems via non-vital serial communication modules (NVCs).

Two of the possible ten non-vital serial modules may be configured as a pair, for example, in an on-line and standby configuration. If a pair of non-vital serial modules is configured as a pair, then both may be used for output at all times, but only one shall be used for input at any one time. The active NVC is selected within the application logic (Refer to the CS or GCSS Manual).

4.9.4.4 Earthing of Signal Ground Line

The signal ground line should not be connected to earth because this may result in an unsafe situation if there is an undetected earth fault(s) in the PFM. The cable screen, if fitted should be earthed in accordance with section 5.2.3.

4.10 DM and DM128

This section describes the Diagnostic Module (DM) and the Diagnostic Module 128 (DM128).

4.10.1 Module Components

DM modules comprise a single printed circuit card.

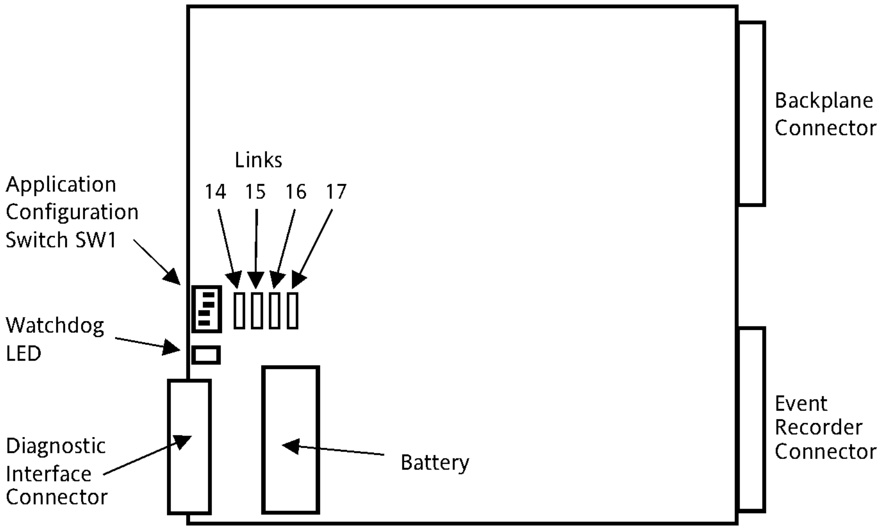


Figure 4.43 Layout–DM128

4.10.2 External Connections

External Connections to the DM are made via the SIO232PFM for the Event Recorder and via the front of the module for the Diagnostic Interface.

The SIO232 PFM External Connectors are a DB25 plug and socket for an RS232C interface, and a 2 way Weidmueller SLA socket that accepts a Weidmueller BLA plug/SLA (not used).

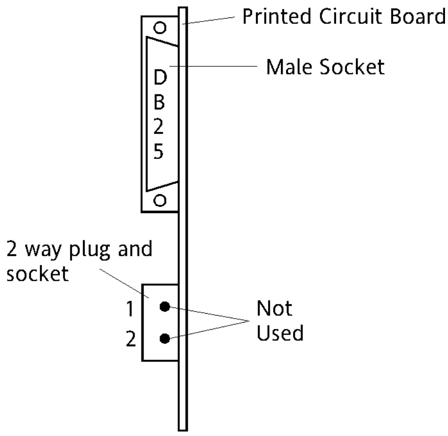


Figure 4.44 External Connections–SIO232 PFM–DM Module

See section 4.9.2.1 for SIO232 PFM DB25 connection details.

4.10.3 Event Recorder Interface (ERI)

Table 4.13 DB25 Pinout—Event Recorder Interface—DM Module

Pin	Function
2	Transmit Data (TxD)
5	Clear to Send (CTS)
7	Signal Ground (GND)

4.10.3.1 Signal

The Signal is simplex asynchronous, data output only, and is selectable from 1200 bits/s or 4800 bits/s. It comprises 1 start bit, 7 data bits, 1 parity bit, even, and 1 stop bit.

4.10.3.2 Electrical

The Electrical characteristics of the interface circuits conform to CCITT V.24 (EIA RS232C).

4.10.3.3 Functional

The subset of CCITT V.24 circuits provided by the ERI are:

Table 4.14 CCITT V.24 Circuit Subsets—Event Recorder Interface—DM Module

CCITT Circuit	Name	Direction of Signal
103	Transmitted Data	Output
102	Signal Ground	-
106	Clear To Send (CTS)	Input

4.10.3.4 Procedural

The ERI transmits serial data via Transmitted Data Circuit 103 if the CTS is not turned OFF via Circuit 106.

4.10.4 Diagnostic Interface (DI)

Table 4.15 DB25 Pinout–Diagnostic Interface–DM Module

Pin	Function
2	Transmit Data (TxD)
3	Receive Data (RxD)
7	Signal Ground (GND)

4.10.4.1 Signal

The Signal is Duplex Asynchronous, selectable from 1200 bits/s or 4800 bits/s and comprises 1 start bit, 7 data bits, 1 parity bit, even, and 1 stop bit.

4.10.4.2 Electrical

The Electrical characteristics of the interface circuits conform to V.24 (EIA RS232C).

4.10.4.3 Functional

The subset of CCITT V.24 circuits provided by the ERI are:

Table 4.16 CCITT V.24 Circuit Subsets–Diagnostic Interface–DM Module

CCITT Circuit	Name	Direction with Reference to DI
103	Transmitted Data	Output
104	Received Data	Input
102	Signal Ground	-

4.10.4.4 Procedural

The DI receives serial data via Received Data Circuit 104 and transmits data via Transmitted Data, Circuit 103.

4.10.5 Setting Data Transfer Rate, Language, Echo

The DM is equipped with switches to set interface data transfer rates.

The DM128 has links for setting:

- interface data transfer rates;
- mnemonic language default;
- command echo default.

See section A.14 for details about the DM, and section A.15 for details about the DM128.

4.10.6 Specific Application Rules

Only one DM module may be installed in a system. Its position is allocated by the GCSS (or CS) to slot 15 in housing 1.

4.11 Power Supply Unit (PSU)

4.11.1 Module Components

PSU Modules comprise a single printed circuit board.

4.11.2 External Connections

External connections to the PSU are made via the PSU PFM.

The PSU PFM External Connector is a 6 way Weidmueller SLA socket that accepts a Weidmueller BLA plug (supplied with the module).

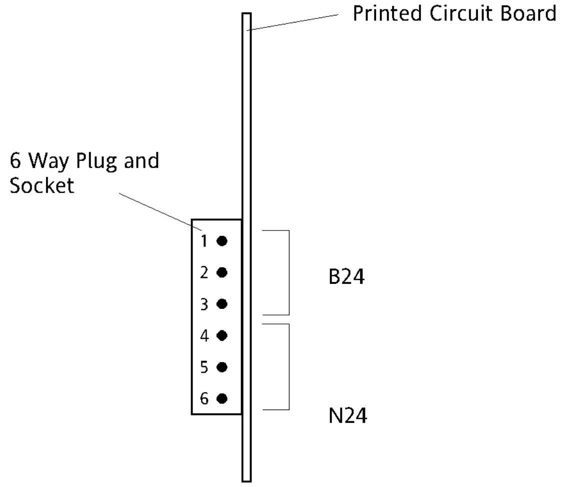


Figure 4.45 External Connections–PSU PFM–PSU

4.11.3 External 24 Vdc Supply

The absolute limits of the input voltage, including ripple and noise are:

- Maximum Instantaneous Voltage 30 V
- Minimum Instantaneous Voltage 20 V

The WESTRACE System is designed to operate from a nominal 24 Vdc supply. Typically this will be a battery and float charger that ensures continuity of supply during mains outages.

4.11.4 Specific Application Rules

4.11.4.1 Earthing of External Supply

For the PSU PFM protection to be assured the external supply connections must not be earthed. An internal PFM failure could result in the negative side of the signalling supply being earthed.

4.11.4.2 Internal Logic Supplies

Under no circumstances should the internal logic supplies be connected to earth or the external signalling supply.

4.12 Vital Logic Equipment Backplane (BPLANE)

4.12.1 Backplane Addressing

Each system may comprise up to 4 backplanes, each backplane having its address links set as illustrated in figure 4.50 and as described in the following table.

Three 2 way links are provided on the backplane to allow the backplane number to be set. For each link, the centre pin is linked to the top pin to represent a "1" and to the bottom pin to form a "0".

The link settings to allow the setting of the number of the backplane are:

Table 4.17 Link Settings for Backplane Addressing

Backplane No.	LK3	LK2	LK1
1	0	0	1
2	0	1	0
3	1	0	0
4	1	1	1

4.12.2 Connection of !RESET

The !RESET is the reset line from the PSU to processor based modules. It should only be connected on the first backplane regardless of the number of PSU modules in use.

The link setting to allow connection of !RESET to the backplane is:

Table 4.18 Link Setting for !RESET to the Backplane

Backplane	LK4
1	1
2	0
3	0
4	0

A '1' indicates the link should be made and a '0' indicates that the link should not be made.

The backplane with LK4 made must contain a PSU.

4.12.3 Backplane Continuity

Unused slots on the backplane (where modules are not fitted) should be fitted with Blanker cards to maintain continuity of Health Monitoring, Second Negation Signals and Fault Diagnostics.

If Blanker cards are not fitted the system will not operate.

4.12.4 Multiple Card Housing Systems

To expand the capability of the equipment from a single card housing up to four card housings, it is necessary to expand the interconnections between modules. On a single backplane, signals between modules are either co-ordinated on a bus system, or chained together in a daisy chain. An example of the former is the "IMB", an example of the latter is the "Second Negation signal".

To expand the signals, the bussed signals are transferred to other backplanes by an impedance controlled bus extension. The daisy chained signals within the backplane loop are treated differently—in this case the loop is broken, and continued to other backplanes where the daisy chain is continued. The loop is eventually restored by a link from the last backplane. In all cases, the links are carefully impedance controlled.

Interconnections between backplanes are made by multicore cable, the cable is made up of cores carrying individual bus signals, each bus signal also having a protective 0 V core.

4.12.4.1 Maximum Link Lengths

The length of links is as per cable assembly drawings. It is not permissible to alter the length of links, as this is determined by the impedance controlling termination circuit. Housings are supplied with all cables.

4.12.4.2 PSU Rails

A housing may have an internal PSU, or it may be powered from another housing having an internal PSU.

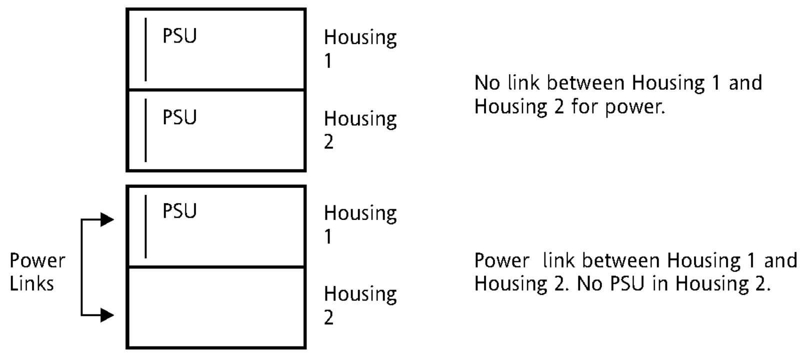


Figure 4.46 Internal Power Linking—PSU to PSU

Where only one PSU is fitted in a multicard frame system it must be fitted in Housing 1.

Power rail linking is performed by looping between the 6 pin Molex plugs (Con17) on each backplane.

The power linking requires all 6 pins connected as described in the following sections.

4.12.4.3 Physical Connections

The VLE Backplane is fitted with three pairs of 37-way D type sockets and a 6-way connector to facilitate the interconnections between racks. Two pairs of 37-way sockets are used for connecting bussed signals between backplanes. Each connector of a pair being connected in parallel with the other connector of the same pair (Con19 is in parallel with Con21, and Con18 is in parallel with Con20).

The remaining two 37-way sockets are used for connecting daisy chained signals between racks for Health Monitoring, Second Negation and Fault Diagnostics signals. The following diagrams show how three different types of Expansion Cable (EC1 to EC3) are used on the backplane for 1, 2, 3 and 4 rack systems.

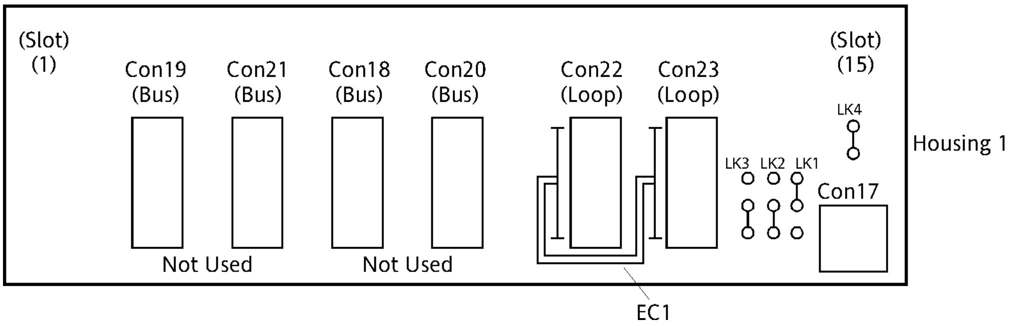


Figure 4.47 Single Housing System

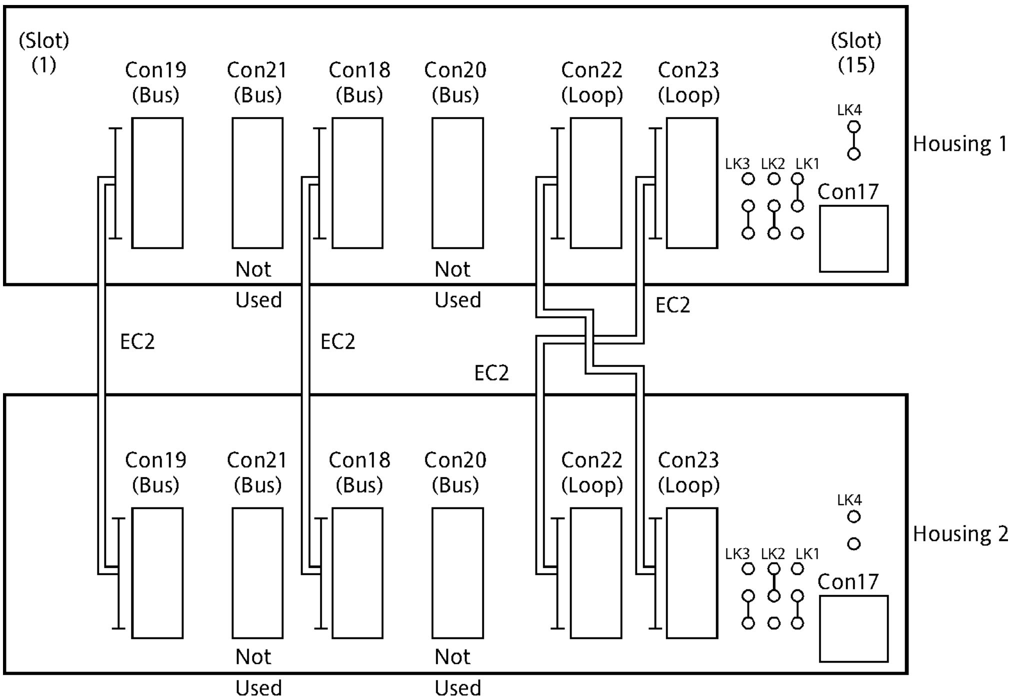


Figure 4.48 Two Housing System

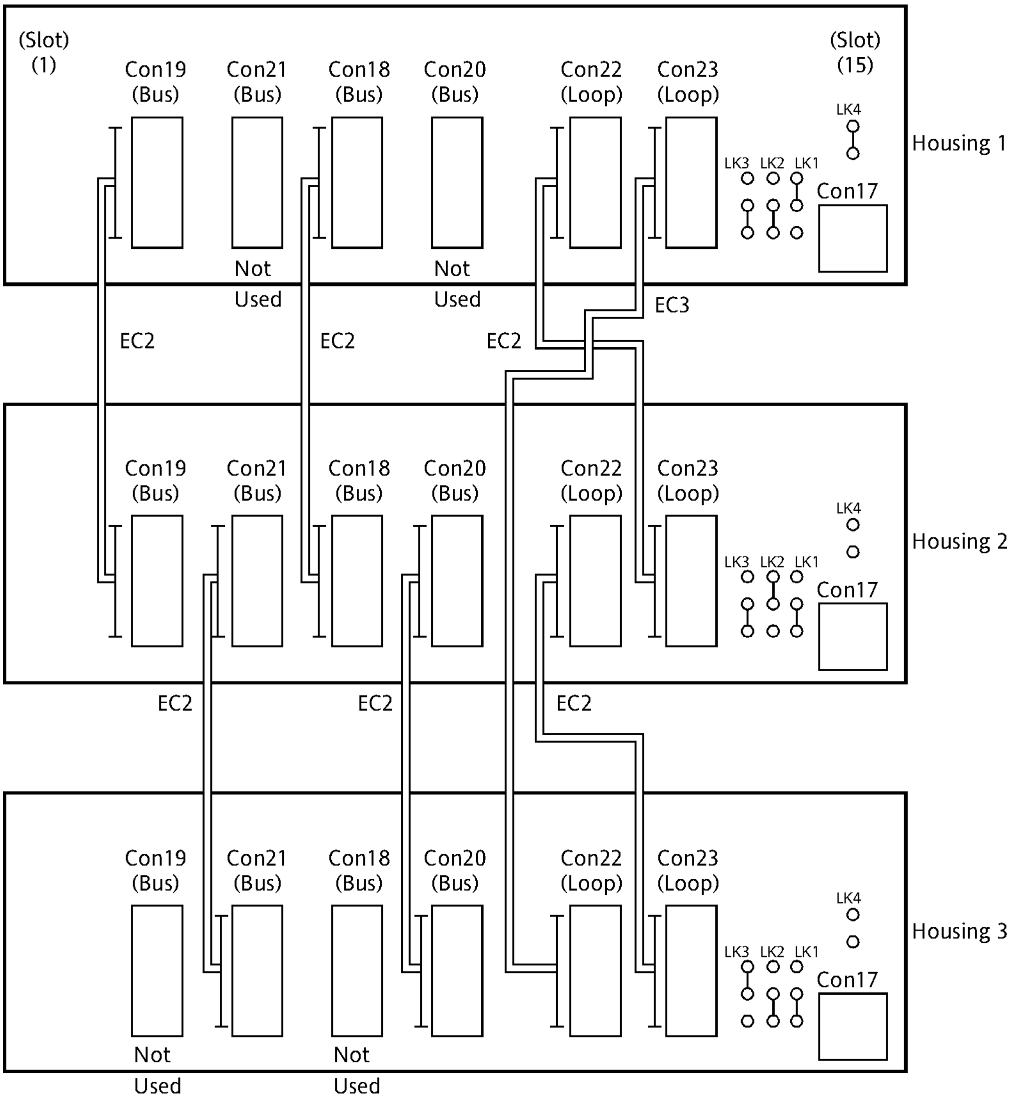


Figure 4.49 Three Housing System

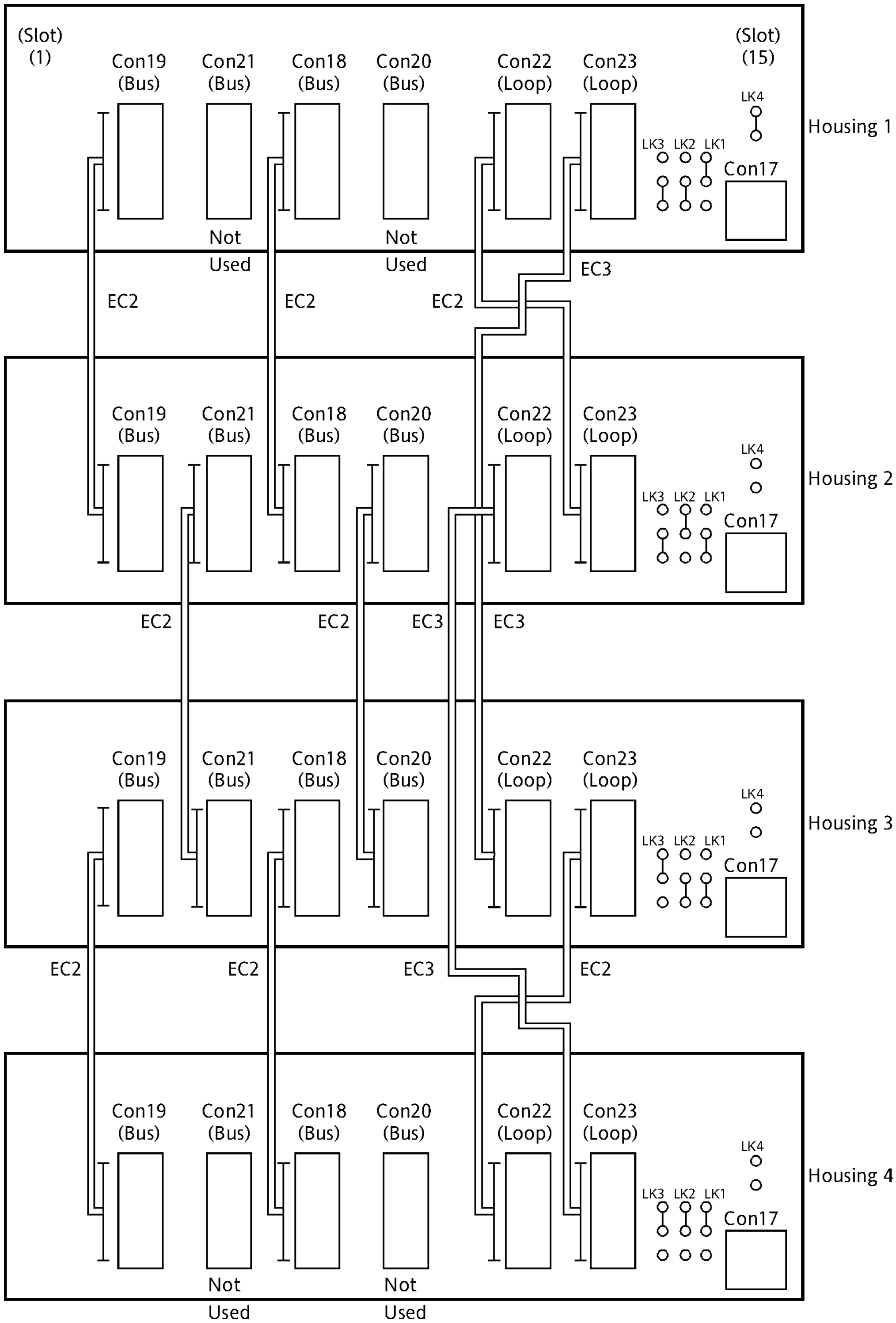


Figure 4.50 Four Housing System

4.13 Surge Arresters

Surge Arresters are used external to the parallel input modules (VPIM) and output modules (VLOM & VROM) when there in a danger of damage from voltages induced in the cable runs. Typically, surge arresters are used whenever cable leaves the signalling equipment room or location case.

SAFETY WARNING

The surge arresters have been designed to prevent the possibility of cross feeds between similar functions in the event of failure to short circuit of multiple components. Commercial arresters such as three terminal gas discharge tubes are unsuitable and their use could lead to a wrong side failure.

The surge arresters provide two levels of primary protection from external transient voltages using gas discharge tubes and MOVs.

Surge arresters are available in voltage ranges to suit the standard input and output voltages (see figure 4.51). Versions are available for left and right cable entry (see figure 4.52).

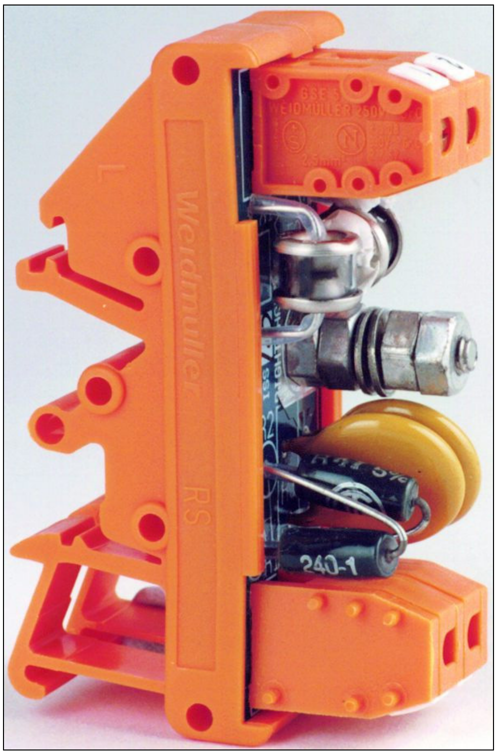


Figure 4.51 Surge Arrester–Weidmuller

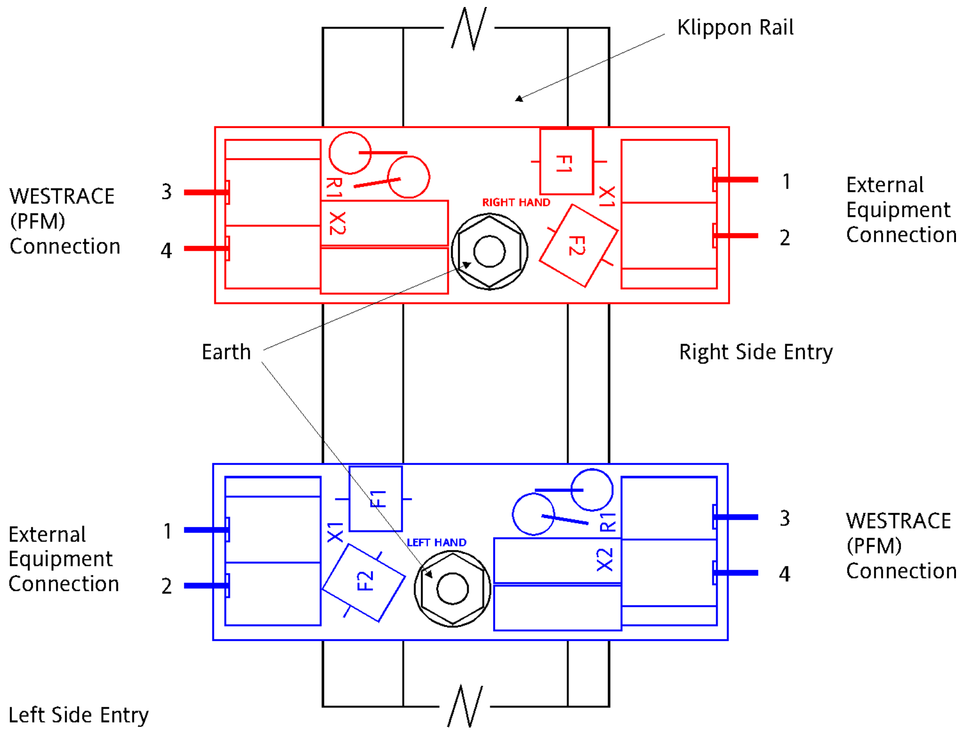


Figure 4.52 Surge Arresters (Left and Right Side Entry)

Cassette style surge arrestors by Elsafe Australia:

- Type 555175 (50 Vdc), and;
- Type 216660 (110 Vac);

are suitable alternatives. See figure 4.53.

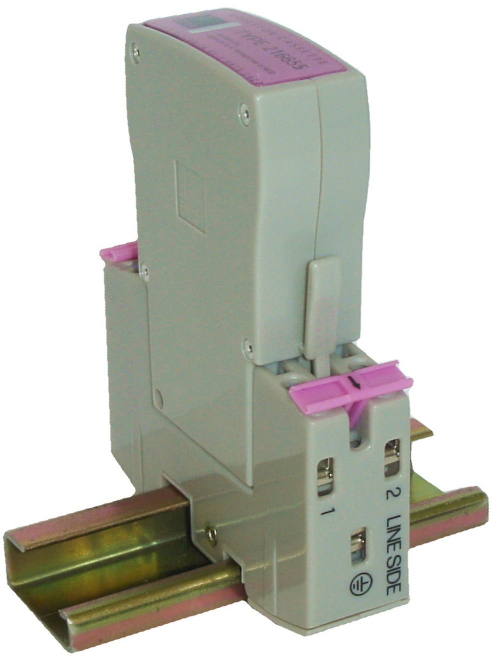


Figure 4.53 Surge Arrester—Elsafe

5. INSTALLING WESTRACE

The safety integrity and reliability of WESTRACE requires good installation practice.

WESTRACE uses high technology electronic components that, when the equipment is unprotected, are more susceptible to interference from external electrical noise and extremes of temperature than conventional relay interlockings. The WESTRACE system, including its conductive, shielded card housings and PFM modules, have been carefully designed to protect against the adverse effects of the harsh, railway signalling environment. Adherence to the practice detailed in this section, and maintenance of a clean environment, will ensure that these are fully effective and that the equipment will operate safely and reliably.

5.1 Earthing and Bonding Practice

5.1.1 Definitions

See the Glossary for meanings of special terms.

5.1.2 General

SAFETY WARNING

The earthing and bonding guidelines described in this section must be followed to ensure that metalwork potentials are kept within safe levels in both electrified and non electrified territory.

This section defines the practice to be applied in the installation of earthing and bonding of WESTRACE and other associated equipment that is connected to it. This practice will maximise the reliability of a working system and simultaneously ensure that metalwork potentials are kept within safe levels in both electrified and non electrified territory.

Inspect all installations for compliance with earthing and bonding practice as part of the commissioning procedure.

WESTRACE housings are constructed from aluminium that has been treated with a conductive finish. The combination of the panels, the ventilated top and bottom covers and the PFMs with the screen part way along, form a Faraday cage that will effectively prevent interference from entering or leaving properly earthed housings. The protective cage must be earthed to be fully effective.

5.1.3 Provision of Earth Points

5.1.3.1 Connection to Earth

Earth connections points should comply with the Rail Authority's practice and the requirements detailed in this section.

The actual form of earth connection will depend on the local conditions. A single buried earth for a location case may be effective in some areas while a comprehensive earth mat may be necessary for poorly conductive soils or in electrified territory. The earth impedance must be less than 15 Ω and should ideally be below 5 Ω as measured by an ac earth impedance meter. The earth impedance should be maintained for all soil and climatic conditions.

5.1.3.2 Earth Point

Provide a star earth point (see figure 5.1) or earth bus bar for each equipment location. It must be solidly connected to the earth connection as detailed in section 5.1.5. This point shall have sufficient capacity for all earth connections and should allow removal of individual earths for fault finding. The earth point should be located as near as practical to the cable entry.

a) All metal work including location case panels, relay frames, doors and hatches shall be bonded directly to this earth point;

b) All transformer chassis and earth screens shall be bonded directly to this earth point;

c) All electronic equipment earths, including the WESTRACE earth, shall be bonded directly to this point;

d) Surge arresters should be located as near as practical to the earth point and the arrester earths should be solidly bonded to the earth point.

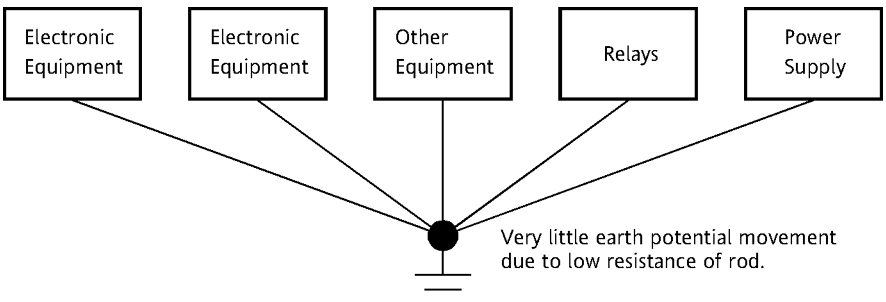


Figure 5.1 Star Earth Connection

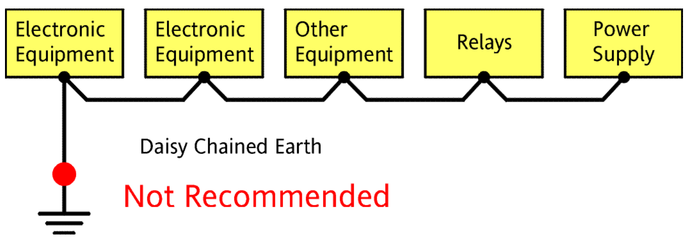


Figure 5.2 Daisy Chained Earth

5.1.4 Equipment Earthing

All WESTRACE equipment and all associated metal work, such as power supplies, S2 telemetry and relay panels within a rack should electrically bonded with 4 mm² braid as shown in figure 5.3. Each equipment rack should then be connected to a common, star earth point as shown in figure 5.1. Daisy chained earth wiring, as shown in figure 5.2 is not as effective and should not be used even when low earth currents from electronic equipment are involved.

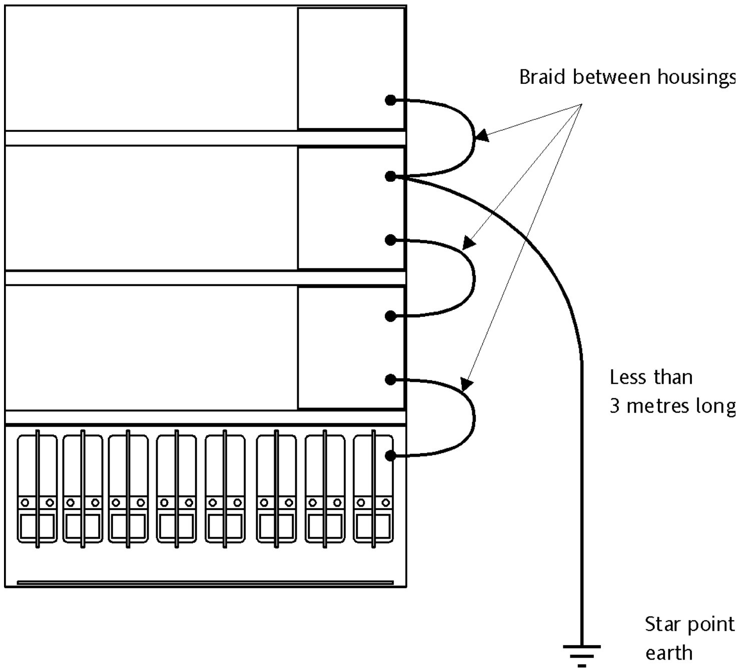


Figure 5.3 Earthing on WESTRACE Housings

5.1.5 Earth Wiring

SAFETY
WARNING

The guidelines for Earth wiring detailed in this section must be followed.

a) All earth conductors shall be kept as short as possible so as to minimise their resistance and inductance;

b) Earth conductors shall be routed so as to be free of sharp bends and kinks so as to minimise their inductance. The minimum radius of any bend shall be 150 mm;

c) Earth conductors and other location wiring shall be routed so as to minimise the amount of other wiring parallel to and in close proximity to earth conductors;

d) Earth conductors:

from arresters to an arrester earth terminal;

- from an arrester earth terminal of a slave location case to a master location case;
- shall not run parallel to or in close proximity to any other conductor.

e) Earths shall be wired separately, and not 'daisy chained';

f) For connecting earth terminals to buried earths, or traction bonds, and for interconnecting earth terminals in a multi case location, the earth conductor shall have a cross sectional area of 10 mm^2;

g) Where the distance from an earth terminal to the buried earth exceeds 10m, two parallel conductors shall be used;

h) The distance from an earth terminal to a buried earth should not exceed 20m;

i) Between surge arresters and an earth terminal, or bus bar, the earth conductor shall have a cross sectional area of 10 mm^2;

j) For bonding between metalwork, the earth conductor shall have a cross sectional area of 10 mm^2.

The aim of Star Earth is to ensure that noise superimposed on an equipment earth lead is not passed to other equipment due to earth sharing.

5.2 Wiring and Connections

5.2.1 Interference from Electrical Noise

SAFETY WARNING

The guidelines for prevention of interference from electrical noise detailed in this section must be followed.

A major threat to the safety and reliability of any electronic based equipment is it susceptibility to interference from electrical noise. This noise may either enter the equipment by radiation (through the air) or conduction (through attached cables).

The WESTRACE housings provide protection against radiated interference and the WESTRACE PFMs provide protection against conducted interference. This protection will be maximised when:

a) The earthing and bonding practices defined in the previous section are fully applied;

b) All wiring into and out of WESTRACE is kept as short as possible;

c) All input and output wiring is run in symmetrical pairs. For example, communications bearers should be run as one pair of a quad and parallel inputs and outputs should be run as adjacent conductors in signalling cables. These pairs should also be kept in the same ducting in any case wiring;

d) Primary surge protection (see section 5.3.1) should be used on cables that are run outside any location or building;

e) All wiring should be run to minimise the possibility of pickup of noise from adjacent cables. This requires the separation of those cable that may be particularly noisy from cables connected to WESTRACE. In particular, earths from surge arresters should be taken directly to the earth star point both incoming cables and the earth cable should not be run parallel to the WESTRACE side of the arresters.

5.2.2 Security of Input and Output Wiring

SAFETY WARNING

The guidelines for security of input and output wiring detailed in this section must be followed.

All vital wiring to WESTRACE must be performed and maintained according to the Rail Authority requirements applicable to interlockings. This includes the grade of insulation, the installation, checking, testing and inspection procedures.

System Design should minimise the possibility of connection of an incorrect wiring loom to a WESTRACE PFM connector. The following rules must be applied:

a) All wiring for each PFM connector must be loomed into an individual cable. The set of looms to any equipment housing should prevent or restrict connection to an incorrect PFM;

b) Each wiring loom must be clearly labelled to identify the PFM that it connects to;

c) All stranded cables should be crimped so that conductors and insulation are securely gripped. Klippon bootlace Ferrules are recommended;

d) Each cable plug must be clearly labelled to identify polarity (can be keyed) and its matching socket on the PFM;

e) Each PFM socket must be clearly labelled to identify polarity and its matching plug on the cable loom;

f) The cable loom to a particular PFM socket must be suitably attached to the housing rail above the socket or formed through its own discrete opening in a cable duct.

5.2.3 Screened Cable

Use of screened cable is recommended for RS232-C level signals. The screening extends the WESTRACE shield to the whole of the cable and reduces radiated interference from noise in adjacent conductors. Cable screening should be terminated at the WESTRACE housing earth.

Cable screens are normally only earthed at the WESTRACE end (as shown in figure 5.4) as it is possible to induce currents between different earth potentials that can be coupled into the conductors. This method should be used unless problems are found.

However, in some instances where common earth points are used, improved shielding can be obtained by earthing the screen at both ends (as shown in figure 5.5). It should only be used where problems are associated with single point earthing of the screen.

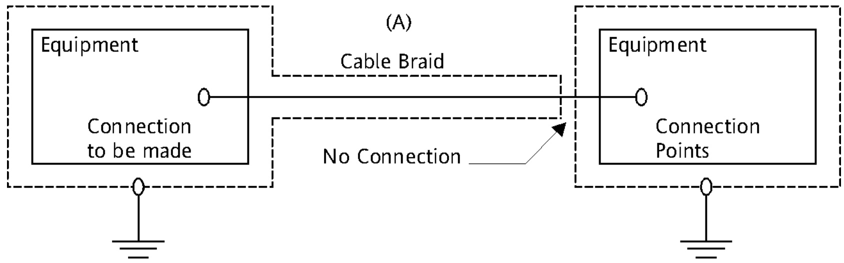


Figure 5.4 A–Shielded Cable Earthed a One End

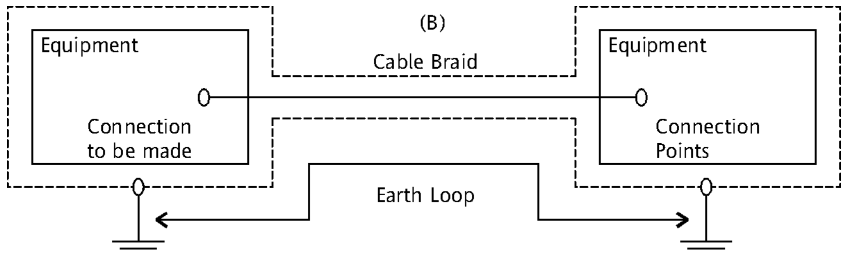


Figure 5.5 B–Shielded Cable Earthed at Both Ends

5.3 Surge Protection

External primary surge protection may be necessary on WESTRACE inputs and outputs that extend beyond the location case or relay room.

Each WESTRACE system uses PFM modules on all inputs and outputs. These modules perform the dual functions of protection of the input circuitry from low energy transient voltages and filtering high frequency electrical interference.

The PFM modules use a Tranzorb rated at 1.5 J maximum energy dissipation. These turn on very rapidly (within 1.5 ps) to shunt voltages that exceed their clamping level, thereby protecting the WESTRACE modules.

An attempt to clamp a high energy electrical transients that exceeds the power rating of the Tranzorbs may cause them to a short circuit. A continued application of fault current could later lead to an open circuit in the Tranzorb or PCB tracks. This could allow subsequent damage to the WESTRACE modules and put the equipment out of service.

Primary protection should be used where there is possibility of exceeding the energy rating of these devices. A guideline is that any cable runs more than 200m outside the location case or relay room should be fitted with primary surge protection. The cable runs, inductive nature of the load, likelihood of lightening strikes, electrification, and performance history should all be considered when assessing the need. It is always safer to fit a surge arrester where there is any doubt.

Primary protection is normally slower to start operating than the Tranzorbs on the PFMs. It should be designed so that the clamp voltage, once fired, limits the power dissipation within PFMs to acceptable levels.

5.3.1 Selection of Primary Surge Protection

Invensys Rail can supply primary surge protection matched to the WESTRACE inputs and outputs. For details of these devices refer to section 4.13.

It is important that no dormant fault can lead to lines being shorted together with the resultant, unintended energisation of inputs or outputs. This requires an unbalanced approach as shown in figure 5.6.

Balance surge protection, with protection devices to earth on both lines must not be used.

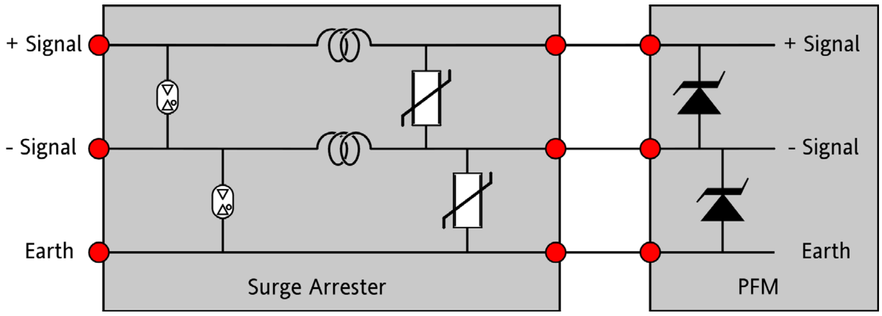


Figure 5.6 Surge Arresters—Correct Connection of

The Surge Arrester is comprised of a single printed circuit board which is used to produce the four variations. There are two voltage versions, each with a left and right hand variant (see section 4.13):

- 50 Vdc Left & Right Side Entry Versions for VPIM50 and VROM50;
- 110 Vac Left & Right Side Versions for VLOM110.

The configuration of the Surge Arrester involves the correct wiring of the unit depending on the choice of left or right side application. The installation of the left and right Side Entry variations are shown in figure 5.7.

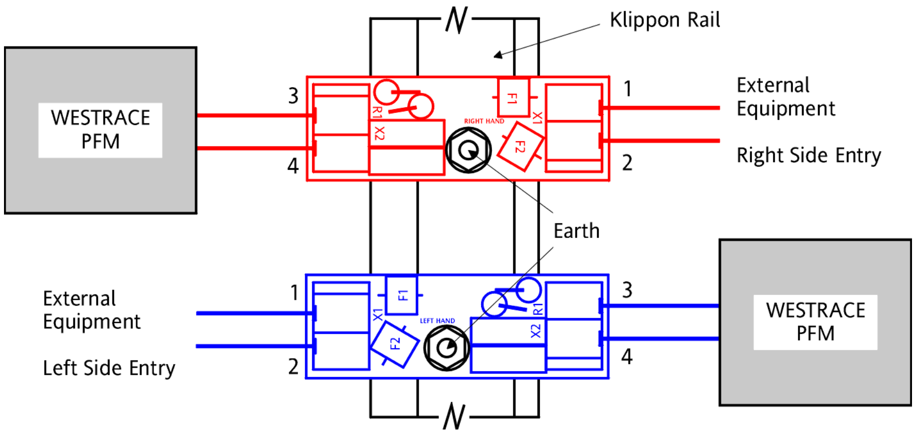


Figure 5.7 Surge Arresters—Wiring to

5.3.2 Location of Surge Arresters

Any surge arresters shall be mounted as close as is practical to the earth terminal, or bus bar, such as to minimise the length of earth conductor.

Equipment and cabling shall be arranged such as to minimise the distance between the point of entry into a location of a circuit requiring the use of an arrester, and the arrester.

Where it is impractical to mount arresters close to the point of entry of a cable, the cable shall be routed within a location such that it does not run parallel and in close proximity to any cable not requiring the use of an arrester. Also the incoming cable shall be routed such that it does not run parallel to, or in close proximity to, its continuation after the connection to the arrester.

Correct and incorrect cable runs are illustrated in figure 5.8.

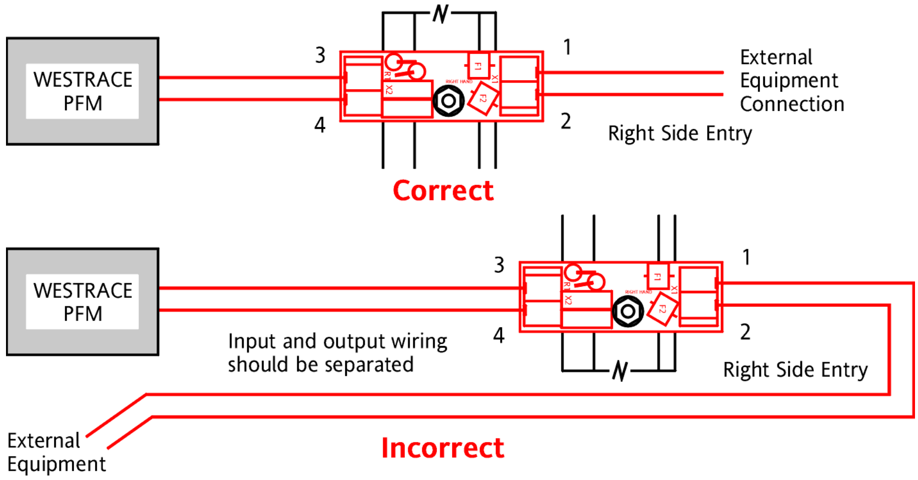


Figure 5.8 Surge Arresters—Cable Runs to

5.3.3 Earthing of Surge Arresters

SAFETY WARNING

The guidelines for earthing of surge arresters detailed in this section must be followed.

Surge arresters must be solidly earthed to the system star earth point. A separate cable must be run from the arresters to the earth point. The earth cable should not be run adjacent to any post protected inputs or outputs.

5.3.4 PSU Protection

Use an appropriate filter before the WESTRACE PSU for further protection. (A typical installation would require a Shaffner filter FN685-16/03, however, power supplies and system requirements vary.)

5.4 Lightning and Surge Protection

Additional protection is required for WESTRACE equipment in lightning-prone locations. For high-lightning areas, provide:

- an isolating transformer fitted with earth screens;
- CRITEC MT-U (or equivalent) surge arrester between the incoming supply and power distribution rack (see figure 5.9).

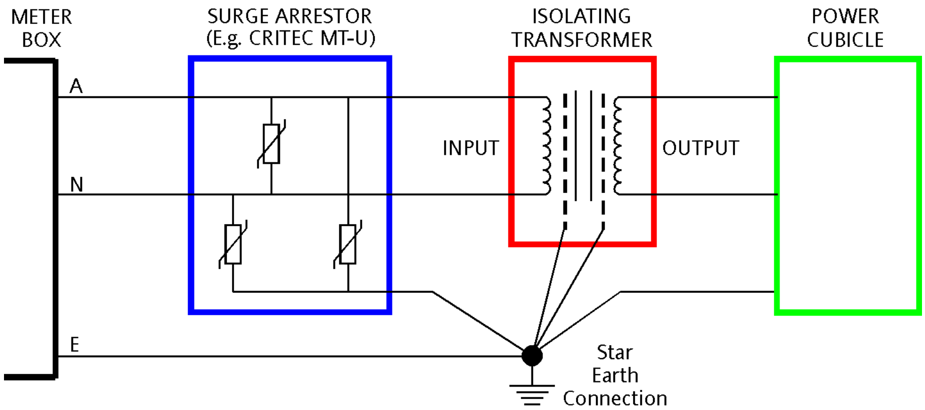


Figure 5.9 High Lightning Areas—Recommended Isolating Transformer and Surge Arrester

5.5 Environmental Precautions

5.5.1 Electrostatic Sensitive Devices (ESSD)

SAFETY WARNING

The guidelines for handling of electrostatic sensitive devices detailed in this section must be followed.

WESTRACE Modules contain devices which are sensitive to static electricity—ESSD.

An electrostatic sensitive device (ESSD) is an electronic component which may be damaged, or degraded by exposure to static electricity. All components are static sensitive to some extent; MOS and CMOS devices are particularly susceptible, because of their high input impedance.

Damage may occur at voltages of as little as 70 V. Static electricity voltages of 10 kV and greater are typical. While we associate static transfer with an observable and painful arc, this only occurs at high voltages. Most of the time we are completely unaware of static and its transfer and are unaware that we may be causing damage to ESSDs.

Static electricity is generated by normal movement, for instance by walking across a synthetic carpet, or by sitting on a chair.

Damage caused by static usually degrades a component, leading to partial operation or reduced life expectancy. Sometimes static will cause an apparently temporary malfunction and in extreme cases, total irreversible failure. However, it is the 'hidden' effect, the latent degradation, which is most serious.

The possibility of failures due to static damage must be eliminated, because degradation of system reliability reduces system safety.

The minimum precautions to protect WESTRACE equipment against damage from static electricity are:

a) Turn off the 24 V WESTRACE supply before any work is performed on the system;

b) Use a conductive wrist strap that is connected to the housing earth point;

c) Store or transport modules in an antistatic bag (if they are not inserted in a card housing);

d) Use a conductive wrist strap to replace Vital PROM Data or Non-Vital Configuration PROMs and place the module on a grounded earth mat.

5.5.2 Mobile Phones and Portable Transceivers

Mobile phones and portable transceivers emit an RF signal that may interfere with electronic equipment.

SAFETY WARNING

Mobile phones and portable transceivers must not be operated within 5 metres of WESTRACE equipment.

5.5.3 Lithium Batteries

The following modules have lithium batteries installed:

- Diagnostic Modules DM and DM128;
- Network Communication Diagnostic Module (NCDM);
- Non-vital Communications and Diagnostic Module (NVC/DM);
- Diagnostic Logging Module (DLM);
- Train Protection Modules (TPMA and TPMB).

Handling Lithium Batteries

Under normal operating conditions, lithium batteries are safe. However the following should always be observed.

Packaging

Package all modules with batteries in a *non-conductive anti-static bag*. An electrically conductive bag may short the battery terminals causing premature discharge of the battery.

Transport

The carriage of lithium batteries by air is subject to the latest edition of the International Civil Aviation Organisation (I.C.A.O.) document 'Technical Instructions For The Safe Transport of Dangerous Goods by Air' 9248-AN/905.

Damage

The electrolyte lithium batteries contain is highly corrosive. If a battery is damaged:

- ensure unnecessary personnel do not enter the affected area
- ventilate the immediate area
- avoid contact with any liquid or internal components by wearing the appropriate safety equipment
- thoroughly wash the affected area with clean water and allow to dry.

Any electronic modules that may have been in contact with the electrolyte should be packaged with an appropriate safety warning and be returned to Invensys Rail Systems for inspection.

Disposal

Dispose of the battery according to any local regulations.

Do not:

- short the terminals together
- attempt to recharge
- crush
- disassemble
- incinerate or heat above 100°C (212°F)
- attempt to solder the cell.

6. Testing and Commissioning

SAFETY WARNING

The WESTRACE Vital signalling system is used to control the safe movement of trains and any installation of which it forms a part must be subjected to the same checks and tests as would be applied to any Vital Signalling System.

This chapter describes the additional tests required to ensure the safe application of WESTRACE equipment.

It assumes that the modules and housing assemblies that form the system have previously been tested and proved. This chapter describes only the requirements applicable to fully assembled systems.

All WESTRACE systems must be fully tested prior to being placed in service. Tests should be performed using the actual hardware and application data that is intended to be included in the final configuration.

6.1 Testing Precautions

Note: ***WESTRACE modules can be damaged by wrong connections or high voltages. Switch off the power supply and verify all connections and power supply voltages before plugging in modules.***

Do not apply high voltages during testing (such as by meggering or hypot) to:

- modules;
- input and output cables to items such as signals, points, or track circuits, when connected to WESTRACE PFMs.

WESTRACE modules contain electrostatic sensitive devices (ESSDs).

Observe antistatic precautions when handling WESTRACE modules. Refer to section 5.5.1 for precautions to be taken.

6.2 Test Records

Keep formal records of all checks and tests performed on any WESTRACE system and its associated equipment.

The test records should be made on any specific test documentation supplied or in a log book.

6.3 Simulation

Newly-designed or modified railway signal logic should be tested before it is used in service to reduce interruptions which are costly and annoying to customers.

Use the WESTRACE simulation tools (GSIM and ISIM) to validate railway signal logic before installation.

6.3.1 GSIM

The WESTRACE Graphical Simulator is a PC tool used for office simulation of WESTRACE. It enables Railway Signal Engineers to test WESTRACE installation logic by providing a graphic on-screen computer simulation of railway signalling systems interacting with a simulation of field equipment.

GSIM4 can simulate the non-vital logic on the NCDM and NVC/DM.

See reference [GSIM] for more information.

6.3.2 ISIM

The WESTRACE Interlocking Simulator is a PC tool for testing WESTRACE application data for railway signal interlockings in the office in real time. Specifically it enables a Principle Test Engineer to test WESTRACE vital logic and Interlogic non-vital logic prior to installation in the field.

See reference [ISIM] for more information.

6.4 Pre-Test Checks

6.4.1 Earthing and Bonding

SAFETY WARNING

All metalwork must be bonded and earthed in accordance with section 5.1.

6.4.2 External Wiring

Check all wiring to ensure that it is in accordance with the approved design and also for integrity of the insulation (Bell or Megger testing).

6.4.3 Power Supplies

Check all external power supplies to ensure that the voltage is within limits and that the polarity is correct prior to connection to the system.

6.4.4 External Loads

Check all external loads that are to be connected to the system ensure that they comply with the output specifications of the particular WESTRACE module to which they are connected.

6.4.5 Module Checks

Perform the following checks prior to the installation of modules into a card frame. Use the appropriate System documentation as a reference:

- Each module is the correct type (such as input or output, voltage, flashing or steady);
- Each module is the correct issue;
- Each module is correctly configured.

The module should further be checked for debris and loose components and then be installed in the correct slot in the system card frame.

6.4.6 System Address

Check the System Address, set in the links on the UHVBC, HVBC or VBC, to ensure that they correspond with the details provided on the approved Installation Assembly printout.

6.4.7 Application Data Version

Check the version of the Application Data installed in the system (on EPROM) to ensure that it corresponds with the approved Installation Data.

Also check the setting of the switches that set the version number. Appropriate references are listed in section 6.4.8.

6.4.8 Module Configuration

The WESTRACE System comprises some modules which must be configured before being plugged into the system and powered up.

The setting of switches and links to configure modules is fully described for each module type in Appendix A.

Refer to the following for further information:

Vital Logic Module (VLM6)	page A-2
Vital Logic Module (VLM5)	page A-16
Hot Standby Vital Logic Module (HVLM)	page A-33
Vital Logic Module (VLM1)	page A-51
Network Communications Diagnostic Module (NCDM)	page A-89
Non-vital Communications and Diagnostic Module (NVC/DM)	page A-121
Non-vital Communications Module (NVC)	page A-147
Diagnostic Module (DM)	page A-155
Diagnostic Module 128 (DM128)	page A-160

6.5 System Testing

SAFETY WARNING

The tests detailed in this section must be carried out and the and results recorded to provide evidence that the System meets safe installation standards.

6.5.1 General

Connect a computer(s) running a diagnostic tool to the Diagnostic Module during testing to:

- record the results of tests, and;
- monitor the inputs, outputs, timers and internal latches.

MoviolaW is the recommended diagnostic tool for VLM6, VLM5 and HVLM-based WESTRACE systems. See [MOV] for details.

6.5.2 Application Logic

It is essential that the application logic is tested sufficiently to ensure that for any combination of inputs, only the intended outputs are generated.

Perform this testing in simulation by using:

- the ISIM interlocking simulator (for VLM6, VLM5 and HVLM), see [ISIM];
- the GSIM graphics simulator for VLM6, VLM5 or HVLM-based systems, see [GSIM];
- the CSS Simulator for VLM-based systems, see [CSS].

For VLM-based systems, the application logic will have been functionally tested, checked, and approved, as described in the Configuration System Manual. In addition, *Invensys Rail recommends that a sample test is undertaken, particularly where external equipment timing may be a factor*.

6.5.3 Tests

Perform the following:

- Check that the system initiates correctly on power-up.
- Verify that the installed Application Data is correct.
- Ensure that the OPCR energises and that VSEV is generated.
- Check voltage and polarity of VSEV on serial modules.
- Check the operation of the Diagnostic Module.
- Check the correct operation of all assigned inputs and outputs using a meter to monitor the voltage and the computer(s) connected to the Diagnostic Module to check the current Input/Output state.
- Check that vital serial connections are operating correctly.
- Check that non-vital serial connections are operating correctly.

6.6 Functional and Factory Testing

It is preferable that as much of a system as possible is tested in the factory before dispatch to site.

Forward all test results recorded during any off site testing to the installation site with the equipment.

Perform the pre-test checks detailed in section 6.4 prior to factory testing.

Perform the tests detailed in section 6.5 during Factory Testing.

Use simulators to test the application data [GSIM], [ISIM], [CSS].

6.7 Site Testing

SAFETY WARNING

It is essential that the system is fully tested before being placed in service. Any testing which could not be performed off site must be carried out on the installed equipment on site.

As an example, site testing will include:

- through testing;
- proving of parallel inputs;
- testing interfaces to existing equipment;
- check of filament proving;
- verification of non-vital control and indications;
- checking that no system timing problems exist;
- checking of alarms, vital and non-vital.

Perform the pre-test checks detailed in section 6.4 prior to any Site Testing.

Test on site any application logic not tested by simulation. Functional testing of the application logic can be performed using the object equipment in a manner similar to that which would be used to test relay based interlockings.

6.7.1 Purpose

The purpose of on-site testing is to:

- verify that all on-site work has been carried out correctly and that the complete system functions correctly;
- to obtain the 'checksum' for the current version of the data.

The ICS or CCSS is also used to check that the installed VLE contains the same Application Logic as was originally designed, approved and tested.

6.7.2 Records

It is mandatory that formal records of the on-site CCSS or ICS checks are kept.

6.8 Commissioning

Ensure that any test equipment does not adversely affect the safe operation of the system and all test equipment is formally removed before the system is put to use.

Where it has not been possible to connect and test functions prior to commissioning, then these must be tested during commissioning.

It should be noted that if deficiencies are discovered in controls or interlocking during commissioning, then all functions affected must be considered as defective and dealt with accordingly.

6.9 Stageworks

Where stageworks are to be implemented, it is essential that all rules specified above for Testing and Commissioning are fully complied with.

Appendix A: Module Descriptions

This appendix describes:

- characteristics;
- function;
- operation;
- configuration, and;
- external connections;

of each WESTRACE module.

A

A.1 Vital Logic Module (VLM6)

All WESTRACE systems have a Vital Logic Module as its processing core. The VLM6 is one of the Vital Logic Module types in service.

A WESTRACE Hot Standby system comprises a pair of fully duplicated installations in a symmetrical arrangement, such that one installation is in 'on-line' mode (in control of the railway), whilst the other is in 'standby' mode. Each installation has an VLM6 at the processing core and the service provided by a particular installation is determined by setting links on a backplane card.

A.1.1 VLM6 Description

The VLM6 comprises two printed circuit boards:

- VLC6 (Vital Logic Card);
- OPC (Output Power Card).

The individual boards are interconnected by means of the VLE backplane, and also by a Universal Hot Standby Vital Backplane Card (UHVBC). Links on this card (CONF1 and CONF2) determine the service provided by the particular WESTRACE installation as described in section A.1.2.3.

A VLM6 occupies slots 2 to 3 in housing 1 of a WESTRACE installation. The OPC is in Slot 2 and the VLC6 is in Slot 3. *Slot 1 in housing 1 must have a Blanker card inserted*.

A.1.1.1 VLM6 Vital Logic Card (VLC6) Description

The VLC6 is the system's central processing module. It controls communications between the system modules and performs all Application Logic processing to determine the current state of all vital and non-vital outputs.

The VLC6 contains in PROM the Configuration Element Data (CED) generated by the GCSS. It has configuration data version switches (SW1) that it uses to ensure the CED in PROM is the correct version.

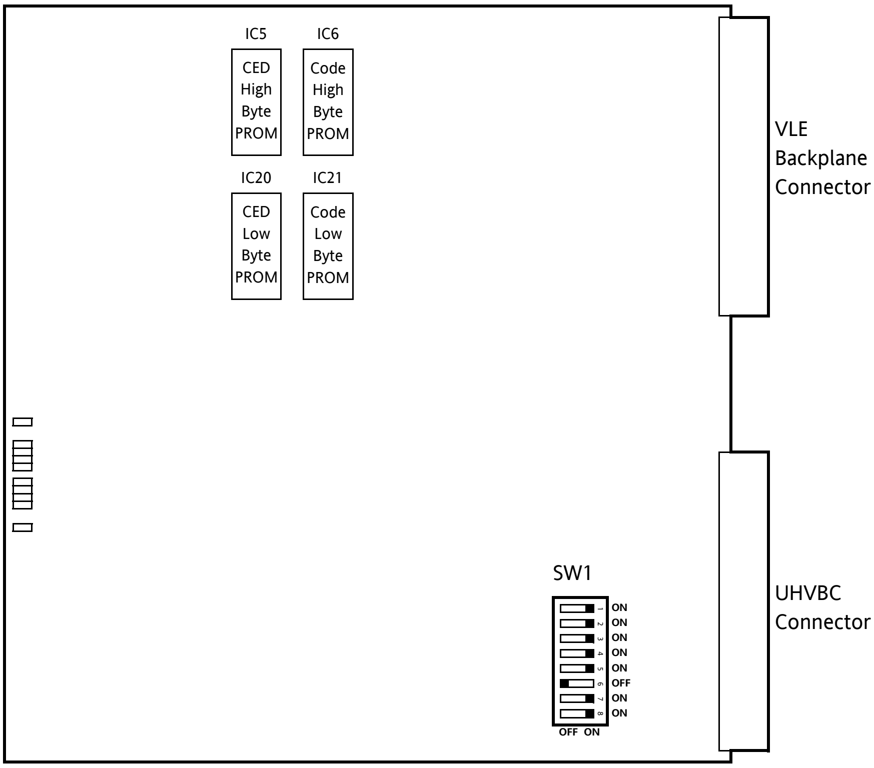


Figure A.1 VLC6–Layout–VLM6

A.1.1.2 VLM6 Output Power Card (OPC) Description

The OPC produces power to drive the OPCR and VSEV. The VSEV enables outputs for the vital communications modules and the OPC isolates power from both of these outputs when safe operation of the system cannot be guaranteed.

A.1.1.3 VLM6 Universal Hot Standby Vital Backplane Card (UHVBC) Description

The UHVBC is a small, half height, printed circuit board installed directly behind the lower connectors of the VLM.

It provides:

- a direct connection between the OPC and VLC cards (HVLC, VLC5 or VLC6), that constitute the VLM;
- 24 links (LK 1 to LK 24, see figure A.2) that determine the unique physical address of the WESTRACE installation. The setting of these links is checked against the data contained in the Application Data PROMS, thereby preventing installation and execution of an incorrect version of application data;
- 2 links (CONF1 & CONF2, see figure A.2 and table A.2) that determine the operation of the VLM. The setting of these links determines whether the VLM is operating in Stand-alone or Hot Standby mode. If it is in Hot Standby Mode they are also determine whether it is the default On Line or Standby system;
- 2 links (LK 25 and LK 26, see figures A.2 and A.3, and table A.2) provide VSEV voltage to the VLC when these links are made.

Caution: ***Links LK 25 and LK 26 must be open if the UHVBC is used with an HVLC or VLC5, otherwise the VSEV voltage may be shorted to ground.***

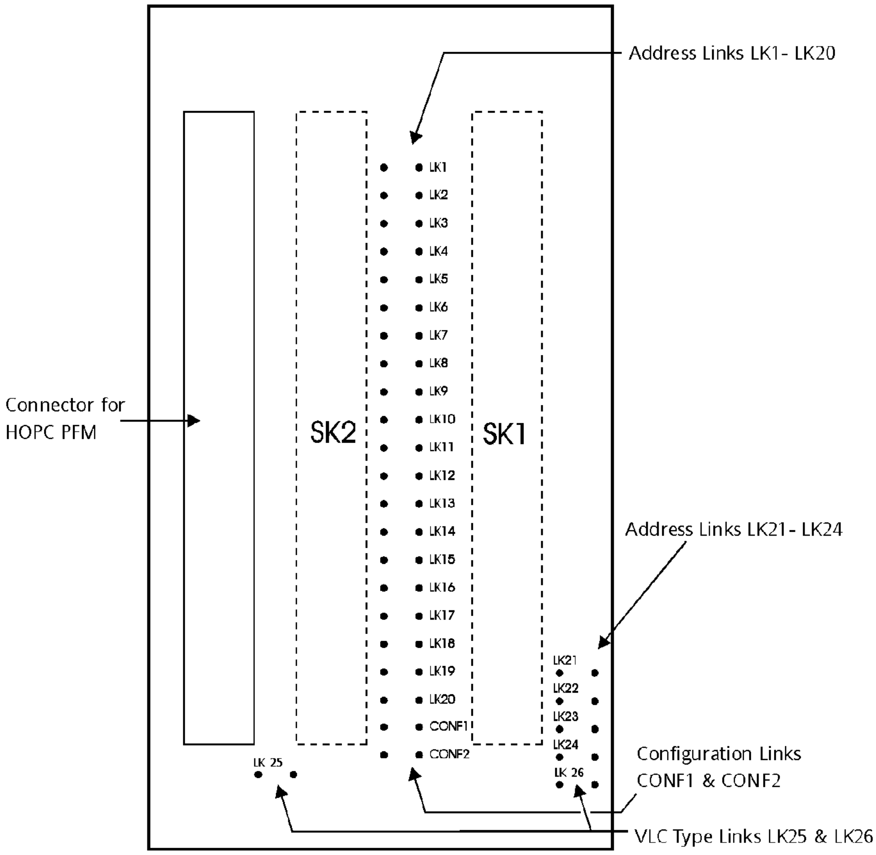


Figure A.2 UHVBC—Rear Side View—VLM6

Note: ***CONF1 and CONF2 in figure A.2 correspond to J25 and J26 on the GCSS Installation Report (figure A.3).***

A.1.2 VLM6 Configuration

A.1.2.1 VLM6 Vital Logic Card (VLC6) Configuration

The CED is contained in two PROMs, a high byte and a low byte (see figure A.1). The low byte PROM is in socket IC20 and the high byte PROM is in socket IC5.

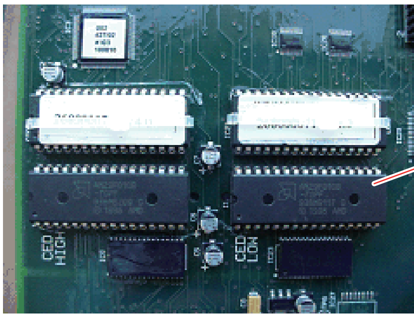
The settings for switch SW1 are provided on the Installation Report generated by GCSS from the Application Data. Figure A.3 shows an example for Installation Reports generated in GCSS 6 and GCSS 7.

VLM6 PROMs are of the EEPROM type.

VLM6 PROM Configurations

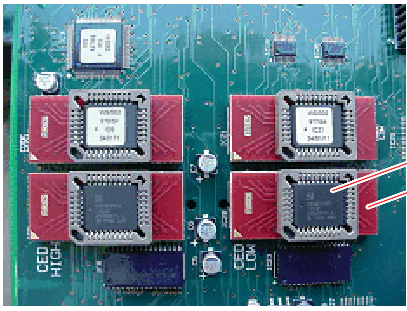
There are three possible VLM6 PROM configurations:

- DIL (dual-in-line)—fitted to early VLM6 boards
- square PLCC (plastic leaded chip carrier)—fitted to later VLM6 boards
- VLM6 boards fitted with PLCC-to-DIL adapters, to take PLCC PROMs



Early configuration, now obsolete (DIL PROMs)

DIL PROM

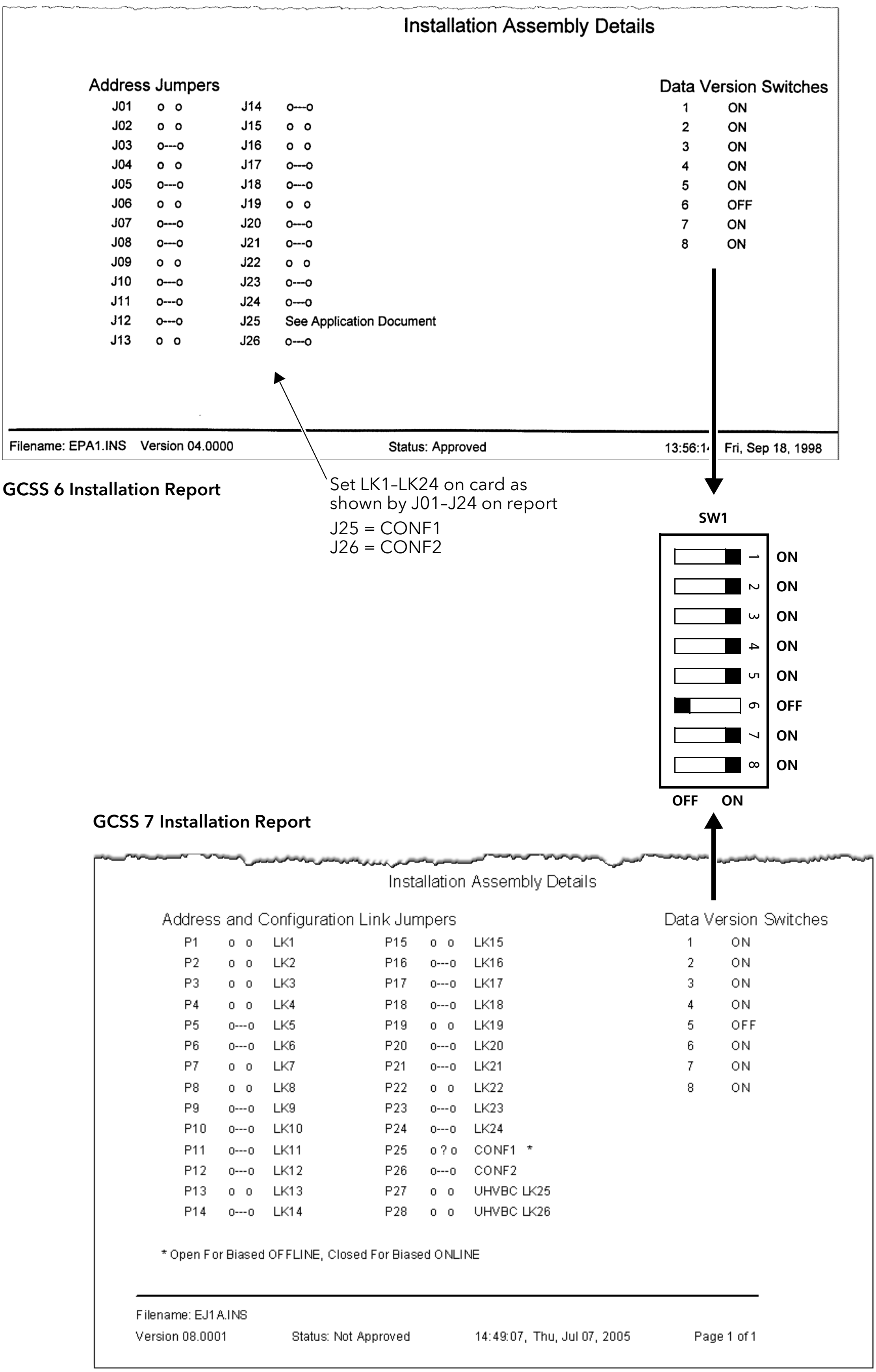


Hybrid configuration (PLCC PROMs in adapters)

PLCC PROM

PLCC-to-DIL adapter

Figure 0.1 VLM6 PROM Configurations



Installation Assembly Details

Address Jumpers

J01	o o	J14	o---o
J02	o o	J15	o o
J03	o---o	J16	o o
J04	o o	J17	o---o
J05	o---o	J18	o---o
J06	o o	J19	o o
J07	o---o	J20	o---o
J08	o---o	J21	o---o
J09	o o	J22	o o
J10	o---o	J23	o---o
J11	o---o	J24	o---o
J12	o---o	J25	See Application Document
J13	o o	J26	o---o

Data Version Switches

1	ON
2	ON
3	ON
4	ON
5	ON
6	OFF
7	ON
8	ON

Filename: EPA1.INS Version 04.0000 Status: Approved 13:56:1 Fri, Sep 18, 1998

Installation Assembly Details

Address and Configuration Link Jumpers

P1	o o	LK1	P15	o o	LK15
P2	o o	LK2	P16	o---o	LK16
P3	o o	LK3	P17	o---o	LK17
P4	o o	LK4	P18	o---o	LK18
P5	o---o	LK5	P19	o o	LK19
P6	o---o	LK6	P20	o---o	LK20
P7	o o	LK7	P21	o---o	LK21
P8	o o	LK8	P22	o o	LK22
P9	o---o	LK9	P23	o---o	LK23
P10	o---o	LK10	P24	o---o	LK24
P11	o---o	LK11	P25	o ? o	CONF1 *
P12	o---o	LK12	P26	o---o	CONF2
P13	o o	LK13	P27	o o	UHVBC LK25
P14	o---o	LK14	P28	o o	UHVBC LK26

Data Version Switches

1	ON
2	ON
3	ON
4	ON
5	OFF
6	ON
7	ON
8	ON

* Open For Biased OFFLINE, Closed For Biased ONLINE

Filename: EJ1A.INS
Version 08.0001 Status: Not Approved 14:49:07, Thu, Jul 07, 2005 Page 1 of 1

Figure A.3 Typical GCSS Installation Reports and SW1 Settings—VLM6

A.1.2.2 VLM6 Output Power Card (OPC) Configuration

None

A.1.2.3 VLM6 Universal Hot Standby Vital Backplane Card (UHVBC) Configuration

Links LK1 to LK24 on the card must be set to the physical address of the system as shown on the GCSS Installation Report (figure A.3).

Links CONF1 and CONF2 must be set to the intended operation of the system (hot standby or stand-alone) as defined in the application data for the WESTRACE. See table A.2.

Note: ***On the GCSS 6 Installation Report, CONF1 and CONF2 correspond to J25 and J26 respectively.***

The setting of links LK25 and LK26 must correspond to the intended VLC type to be used in the installation:

Table A.1 CONF1, CONF2, LK25, LK26—Link Settings

Link	Closed	Not Closed
CONF1	Biased to On-line	Biased to Off-line
CONF2	Stand-alone	Hot Standby
LK25[1]	VLC6	VLC5 and HVLC
LK26[1]	"	"

1. LK25 and LK26 must be open or closed together.

A.1.3 VLM6 Indications

A.1.3.1 VLM6 Vital Logic Card (VLC6) Indications

A.1.3.1.1 Start Up Indications

Diagnostic LEDs display the module type code, shortly followed by a firmware version code (reflecting the firmware version installed in the module). Firmware version is displayed for approximately 8 seconds, after which all diagnostic LEDs extinguish.

A.1.3.1.2 Operation Indications

A single green Watchdog LED and a single yellow Watchdog LED are provided to indicate the module is operating correctly and to indicate the mode of operation:

- In On-line mode, the VLC6 flashes the green LED once per cycle, and the yellow LED to indicate IMB communications.
- In Standby mode, the VLC6 flashes the yellow LED once per cycle.

A

A.1.3.1.3 Fault Codes

The VLM6 fault codes written to the Fault Diagnostic Latch have the following meaning during normal operation. Some fault codes have different meanings during power-on initialisation and these have been explicitly declared.

The term 'Initialisation' refers to VLM6 Initialisation. Some VLM6 fault codes are used only in the VLM6 Standby Mode, and some, only in the VLM6 On-line Mode. These codes have been explicitly declared.

Module Sequence Numbers

In order for the module sequence numbers in the GCSS housing printout to match the module sequence numbers in the VLM6 fault codes, it is necessary for the GCSS user to assign sequence number 1 to the NCDM.

Block Fault Codes

Table A.2 Fault Codes–Block–VLM6

CODE(H)	FAULT DESCRIPTION	ACTION
01	Second Negation Error	Indicates fault on other modules
03	PROM Checksum Error	Replace VLM6
04	Stack Guard Error	"
05	RAM Error	"
06	Interrupt Errors	"
07	Termination Error	"
08	Processor Error	"
09	Stack Error	"
0A	Run Time Error A	"
0B	Run Time Error B	"
0C	Run Time Error C	"
0D	Run Time Error D	"
0E	Run Time Error E	"
0F	Run Time Error F	"
10	Run Time Error G	"
11	Run Time Error H	"
12	Run Time Error I	"
13	Run Time Error J	"
14	Run Time Error K	"
15	Run Time Error L	"
16	Run Time Error M	"
17	Run Time Error N	"
18	Run Time Error O	"
19	Run Time Error P	"
1A	Run Time Error Q	"

Table A.2 Fault Codes—Block—VLM6 *(Continued)*

CODE(H)	FAULT DESCRIPTION	ACTION
1B	Run Time Error R	"
1C	Run Time Error S	"
1D	Run Time Error T	"
1E	Run Time Error U	"
1F	Run Time Error V	"
20	Run Time Error W	"
21	Run Time Error X	"
22	Run Time Error Y	"
23	Run Time Error Z	Replace VLM6
2D	Health Monitoring Time Error	Indicates fault on other modules
2E	Health Monitoring Health Error	"
2F	Health Monitoring Scheduling Error	Replace VLM6
31	Master IMB Startup Timeout	"
32	Too Few IMB Calls	"
33	Master IMB Interface Error Too Many IMB Calls	"
34	Error code with system shutdown is the result of the invalid number of self test calls error STIMBTooFewSTCalls. Error code *without system shutdown* indicates IMB timeout of the non-vital diagnostic module. IMB Database Error	Replace VLM6 if shutdown occurred. Replace diagnostic module if shutdown did not occur.
35	Master IMB Timeout Module 01	Check other modules to identify one that caused VLM shutdown—ie reported a failure other than IMB timeout. Replace the identified module.
36	Master IMB Timeout Module 02	"
37	Master IMB Timeout Module 03	"
38	Master IMB Timeout Module 04	"
39	Master IMB Timeout Module 05	"
3A	Master IMB Timeout Module 06	"
3B	Master IMB Timeout Module 07	"
3C	Master IMB Timeout Module 08	"
3D	Master IMB Timeout Module 09	"
3E	Master IMB Timeout Module 10	"
3F	Master IMB Timeout Module 11	"
40	Master IMB Timeout Module 12	"
41	Master IMB Timeout Module 13	"
42	Master IMB Timeout Module 14	"
43	Master IMB Timeout Module 15	"
44	Master IMB Timeout Module 16	"
45	Master IMB Timeout Module 17	"

A

Table A.2 Fault Codes–Block–VLM6 *(Continued)*

CODE(H)	FAULT DESCRIPTION	ACTION
46	Master IMB Timeout Module 18	"
47	Master IMB Timeout Module 19	"
48	Master IMB Timeout Module 20	"
49	Master IMB Timeout Module 21	"
4A	Master IMB Timeout Module 22	"
4B	Master IMB Timeout Module 23	"
4C	Master IMB Timeout Module 24	"
4D	Master IMB Timeout Module 25	"
4E	Master IMB Timeout Module 26	"
4F	Master IMB Timeout Module 27	"
50	Master IMB Timeout Module 28	"
51	Master IMB Timeout Module 29	"
52	Master IMB Timeout Module 30	"
53	Master IMB Timeout Module 31	"
54	Master IMB Timeout Module 32	"
55	Master IMB Timeout Module 33	"
56	Master IMB Timeout Module 34	"
57	Master IMB Timeout Module 35	"
58	Master IMB Timeout Module 36	"
59	Master IMB Timeout Module 37	"
5A	Master IMB Data Error Module DM	Replace diagnostic module
5B	Master IMB Data Error Module 01	Replace module 01
5C	Master IMB Data Error Module 02	Replace module 02
5D	Master IMB Data Error Module 03	Replace module 03
5E	Master IMB Data Error Module 04	Replace module 04
5F	Master IMB Data Error Module 05	Replace module 05
60	Master IMB Data Error Module 06	Replace module 06
61	Master IMB Data Error Module 07	Replace module 07
62	Master IMB Data Error Module 08	Replace module 08
63	Master IMB Data Error Module 09	Replace module 09
64	Master IMB Data Error Module 10	Replace module 10
65	Master IMB Data Error Module 11	Replace module 11
66	Master IMB Data Error Module 12	Replace module 12
67	Master IMB Data Error Module 13	Replace module 13
68	Master IMB Data Error Module 14	Replace module 14
69	Master IMB Data Error Module 15	Replace module 15
6A	Master IMB Data Error Module 16	Replace module 16

Table A.2 Fault Codes–Block–VLM6 *(Continued)*

CODE(H)	FAULT DESCRIPTION	ACTION
6B	Master IMB Data Error Module 17	Replace module 17
6C	Master IMB Data Error Module 18	Replace module 18
6D	Master IMB Data Error Module 19	Replace module 19
6E	Master IMB Data Error Module 20	Replace module 20
6F	Master IMB Data Error Module 21	Replace module 21
70	Master IMB Data Error Module 22	Replace module 22
71	Master IMB Data Error Module 23	Replace module 23
72	Master IMB Data Error Module 24	Replace module 24
73	Master IMB Data Error Module 25	Replace module 25
74	Master IMB Data Error Module 26	Replace module 26
75	Master IMB Data Error Module 27	Replace module 27
76	Master IMB Data Error Module 28	Replace module 28
77	Master IMB Data Error Module 29	Replace module 29
78	Master IMB Data Error Module 30	Replace module 30
79	Master IMB Data Error Module 31	Replace module 31
7A	Master IMB Data Error Module 32	Replace module 32
7B	Master IMB Data Error Module 33	Replace module 33
7C	Master IMB Data Error Module 34	Replace module 34
7D	Master IMB Data Error Module 35	Replace module 35
7E	Master IMB Data Error Module 36	Replace module 36
7F	Master IMB Data Error Module 37	Replace module 37

Specific VLM6 Initialisation Fault Codes

Table A.3 Fault Codes–Specific Initialisation–VLM6

CODE(H)	FAULT DESCRIPTION	ACTION
80	CED Checksum Error	Replace CED PROM
81	CED GCSS Compatibility Index Error	"
82	CED UHVBC Link Error	Check installation address and UHVBC linking
83	CED UHVBC Link Parity Error	"
84	CED Data Version Error	Check data version switch settings
85	CED Data Error	Replace CED PROM
86	IIHCL Data Consistency Error	"
87	CED Number Of Logic States Error	"
88	CED Module Number Error	"
89	CED Slave Kind Error	"
8A	CED Module Compatibility Index Error	Replace CED PROM
8B	CED Module Compatibility Index Parity Error	"
8C	CED Module Type Error	"
8D	IHCL Message Sequence Error	Replace VLM6
8E	IHCL Compatibility Index Error	"
8F	IHCL Timer Checksum Error	"
90	CED Timer Error	Replace CED PROM
91	CED Initial Data Error	"
92	CED Global Data Error	"
93	CED Fixed Data Error	"
94	CED Variable Data Error	"
95	CED Node Type Error	"
96	CED Depth Error	"
97	CED Pointer Error	"
98	IHCL Installation Address Error	Check installation address and VBC linking.
99	CED Logic Error	Replace CED PROM
9A	CED Number of Logic States Error	"
9B	CED Number of Timers Error	"
9C	Invalid Timer Calculation Error	Replace VLM6
9D	Invalid Timer Count Error	"
9E	OPCR State Error	"
9F	Mnemonic Error	"
A0	IMB Data Length Error	Indicates fault on another module
A1	Invalid Timer Error	Replace VLM6

Table A.3 Fault Codes–Specific Initialisation–VLM6 *(Continued)*

CODE(H)	FAULT DESCRIPTION	ACTION
A2	IMB Communication Time Error	Indicates fault on another module
A3	SCC Hardware Error	Replace VLM6
A4	IMB Module Number Error	Indicates fault on another module
A5	IMB Parity Error	"
A6	CED Initial State Error	Replace CED PROM
A7	Sequence Error	Replace VLM6
A8	IMB Port Address Range Error	Indicates fault on another module
A9	SCC Hardware Error	Replace VLM6
AB	Sync Period Expired with no IHCL Message Error	"
AC	CED Message Byte Number Error	Replace CED PROM
AD	CED Message Bit Number Error	"
AE	IMB Input Message Length Error	Indicates fault on another module
AF	Invalid System Configuration Data Error	Replace VLM6
B0	Consistency Error	"
B1	IHCL GCSS Version Number Error	Check data version switch settings
B5	Parameter Error	Replace VLM6
B6	Output Message Length Error	"
B8	Semaphore Error	Indicates fault on DPRAM
BD	DPRAM Initialisation Error	Replace VLM6
C0	Non-vital Message Error	Indicates fault on DPRAM
C1	IMB Number I/O Bits Error	Indicates fault on another module
C4	IMB Timeout Error	"
C5	IMB Scheduler Error	"
C6	CED Invalid Data Error	Replace CED PROM
C7	CED System Configuration Error	"
C8	CED Layout Error	"
C9	Timer Difference Error	Replace VLM6
CA	Timer Expiry Difference Error	"
D2	Logic Sequence Error	"
D3	Depth Check Error	"
D4	Sequence Error	"
D5	Sequence Error	"
D6	Progress Error	"
D7	Invalid Data Error	"
D9	IHCL Number of Logic States Error	Replace CED ROM

A

Table A.3 Fault Codes—Specific Initialisation—VLM6 *(Continued)*

CODE(H)	FAULT DESCRIPTION	ACTION
DA	Too Many Invalid IHCL Messages Received Error	Replace VLM6
DB	Last Pointer Error	Replace CED ROM
DC	OPCR Initialise Error	Check supply to OPC. Power off system and restart after 40 seconds. Replace the OPC or OPC PFM when the fault persists.
DD	NOPCR Error	Replace VLM6
DF	Initial Maximum Time Error	Reduce the number of timers, the logic, or the I/O capacity of the VLM6. Replace the VLM6 if the problem persists.
E0	Initial Minimum Time Error	Increase the number of timers, the logic, or the I/O capacity of the VLM6. Replace the VLM6 if the problem persists.
E1	Initial Sequence Error	Replace VLM6
E2	Maximum Time Error	"
E3	Minimum Time Error	"
E4	Sequence Error	"
E6	CED Checksum Error	Replace CED PROM
E7	Comp Read Data Error	Replace VLM6
E8	Comp Read Pointer Error	"
E9	Comp Write Pointer Error	"
EF	CED DRAM Fixed Data Error	Replace CED PROM
F0	Number of Timers Error	"
F1	Number of Comp Timers Error	"
F2	Cycle Time > 1.3 sec Error	Too much logic and too many modules. Check installation design.
F3	Delay 150 ms Error	Replace VLM6
F4	APPDEL Value Error	"
F6	Time Stamp Error	"
F8	Time Stamp Error	"
FA	Time Stamp Error	"
FC	CED DPRAM Variable Data Error	Replace CED PROM
FD	Time Stamp Error	Replace VLM6
FE	Mode State Error	"
FF	PIT Access Error	"

A.1.3.2 VLM6 Output Power Card (OPC) Indications

None

A.1.3.3 VLM6 Universal Hot Standby Vital Backplane Card (UHVBC) Indications

None.

A.1.4 VLM6 External Connections

All external connections to the VLM6 are made via the HOPC PFM which plugs directly into the UHVBC. The HOPC PFM External Connector is a 19 way plug and socket Klippon type BLA/SLA. Figure A.4 shows the external connection details of the HOPC PFM.

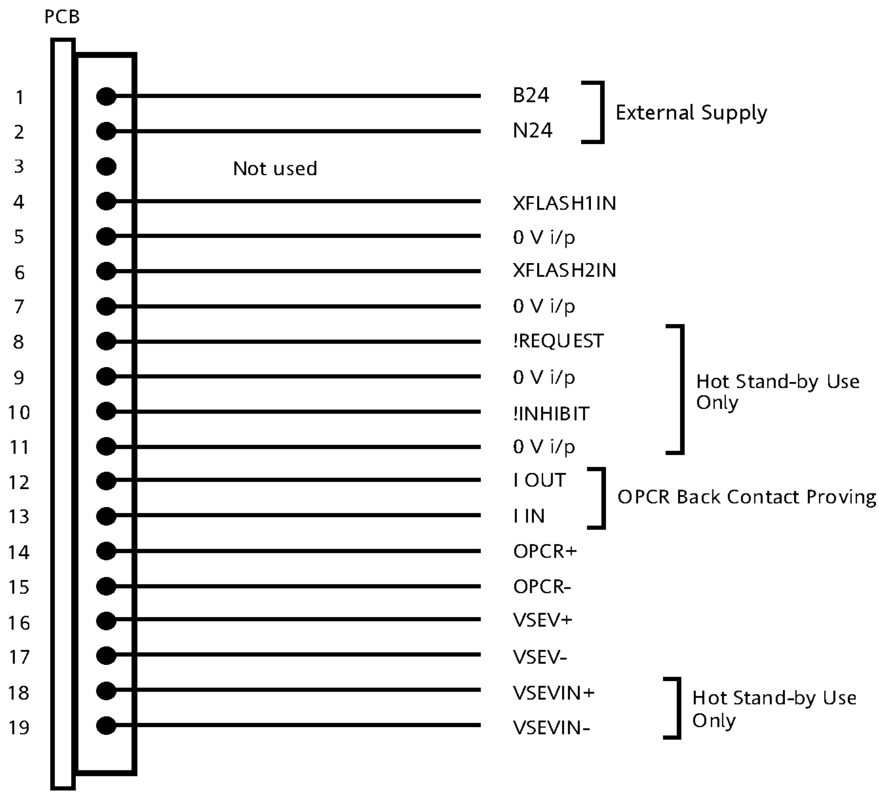


Figure A.4 External Connections – HOPC PFM – VLM6

The maximum continuous current that passes in each of the connections is:

24 V supply	4 A
OPCR Drive	0.8 A
VSEV	1 A
OPCR Back Contact	20 mA

See figure 3.6 for IHCL (Inter-HVLM Communications Link) and INCL (Inter-NCDM Communications Link) fibre-optic connections between hot-standby WESTRACEs.

A.2 Vital Logic Module (VLM5)

All WESTRACE systems have a Vital Logic Module as its processing core. The VLM5 is one of the Vital Logic Module types in service.

A WESTRACE Hot Standby system comprises a pair of fully duplicated installations in a symmetrical arrangement, such that one installation is in 'on-line' mode (in control of the railway), whilst the other is in 'standby' mode. Each installation has an VLM5 at the processing core and the service provided by a particular installation is determined by setting links on a backplane card.

A.2.1 VLM5 Description

The VLM5 comprises two printed circuit boards:

- VLC5 (Vital Logic Card);
- OPC (Output Power Card).

The individual boards are interconnected by means of the VLE backplane, and also by a Hot Standby Vital Backplane Card (HVBC). Links on this card (CONF1 and CONF2) determine the service provided by the particular WESTRACE installation.

A VLM5 occupies slots 2 to 3 in housing 1 of a WESTRACE installation. The OPC is in Slot 2 and the VLC5 is in Slot 3. *Slot 1 in housing 1 must have a Blanker card inserted*.

A.2.1.1 VLM5 Vital Logic Card (VLC5) Description

The VLC5 is the system's central processing module. It controls communications between the system modules and performs all Application Logic processing to determine the current state of all vital and non-vital outputs.

The VLC5 contains in PROM the Configuration Element Data (CED) generated by the GCSS. It has configuration data version switches (SW1) that it uses to ensure the CED in PROM is the correct version.

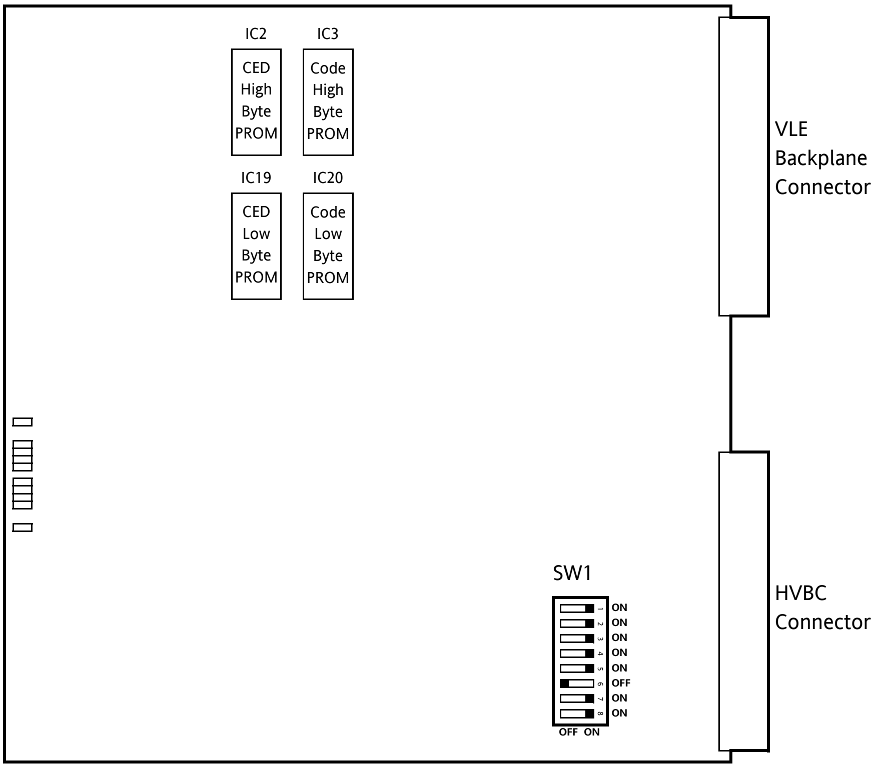


Figure A.5 Layout–VLC5–VLM5

A.2.1.2 VLM5 Output Power Card (OPC) Description

The OPC produces power to drive the OPCR and VSEV. The VSEV enables outputs for the vital communications modules and the OPC isolates power from both of these outputs when safe operation of the system cannot be guaranteed.

A.2.1.3 VLM5 Hot Standby Vital Backplane Card (HVBC) Description

Note: ***A UHVBC can also be used provided LK25 and LK26 are not closed. See sections A.1.1.3 and A.1.2.3 for details.***

The HVBC is a small (half height) printed circuit board installed directly behind the lower connectors of the VLM5.

It provides:

- a direct connection between the OPC and VLC5 cards, that constitute the VLM5;
- 24 links (LK1 to LK24, see figure A.6) that determine the unique physical address of the WESTRACE installation. The setting of these links is checked against the data contained in the Application Data PROMS, thereby preventing installation and execution of an incorrect version of application data;
- 2 links (CONF1 and CONF2, see figures A.6 and A.7, and table A.2) that determine the operation of the VLM5. The setting of these links determines whether the VLM5 is operating in Stand-alone or Hot Standby mode. If it is in Hot Standby Mode they are also determine whether it is the default On Line or Standby system.

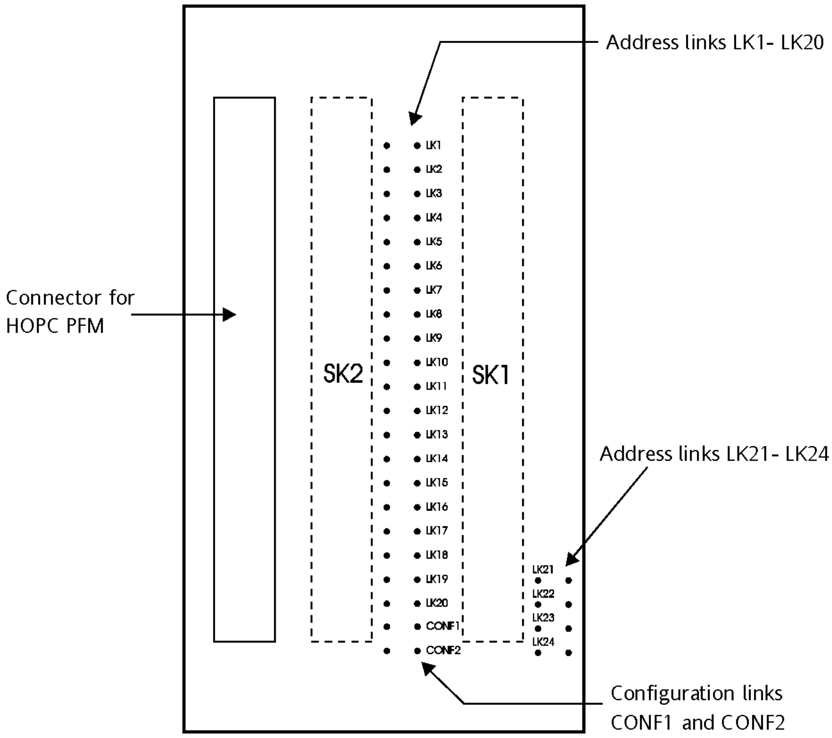


Figure A.6 HVBC—Rear Side View—VLM5

Note: ***CONF1 and CONF2 in figure A.6 correspond to J25 and J26 on the GCSS Installation Report. See figure A.7.***

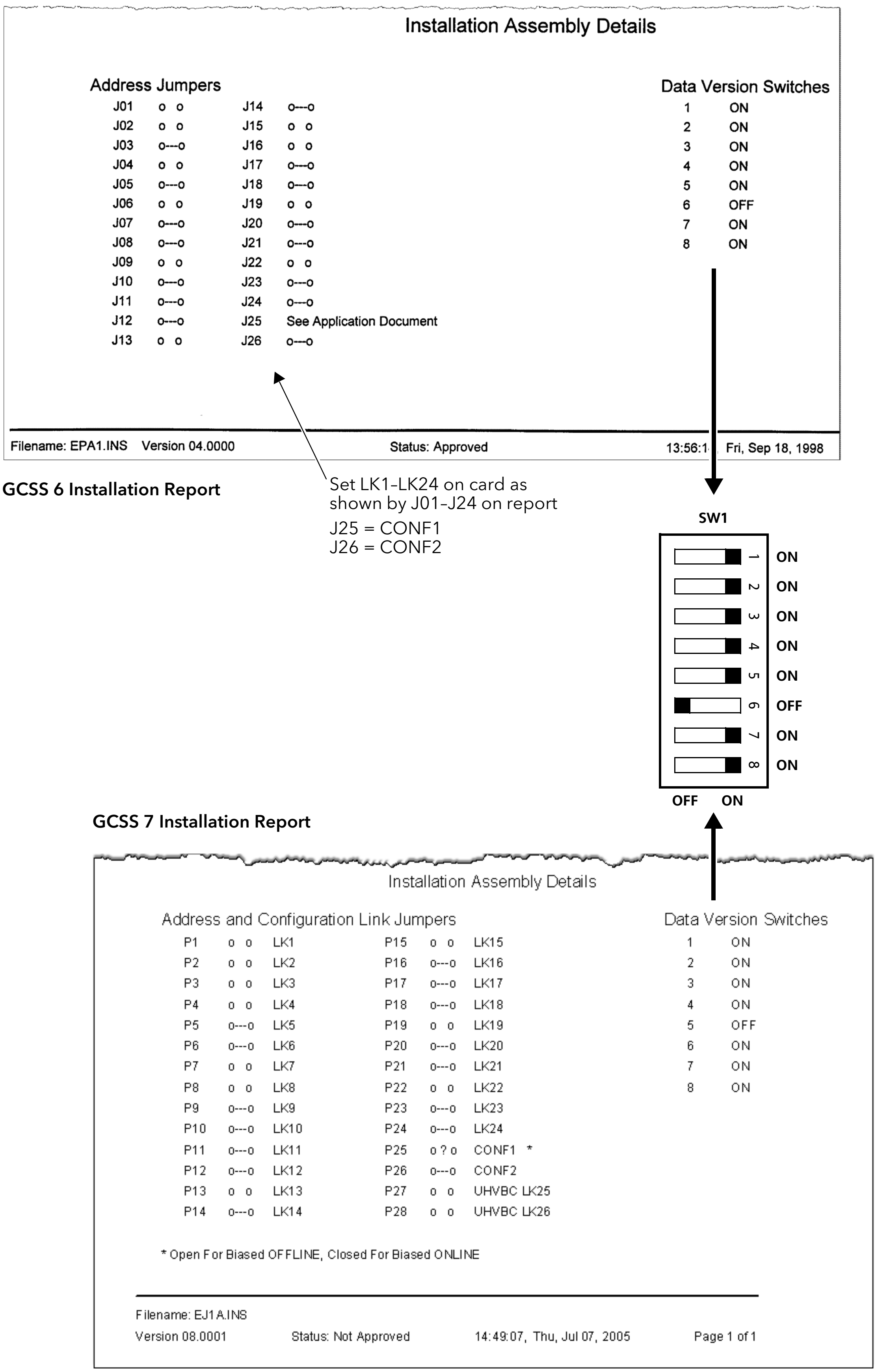
A.2.2 VLM5 Configuration

A.2.2.1 VLM5 Vital Logic Card (VLC5) Configuration

The CED is contained in two PROMs, a high byte and a low byte (see figure A.5). The low byte PROM is in socket IC19 and the high byte PROM is in socket IC2.

The settings for switch SW1 are provided on the Installation Report generated by GCSS from the Application Data. Figure A.7 shows an example for installation reports generated in GCSS 6 and GCSS 7.

A



Installation Assembly Details

Address Jumpers

J01	o o	J14	o---o
J02	o o	J15	o o
J03	o---o	J16	o o
J04	o o	J17	o---o
J05	o---o	J18	o---o
J06	o o	J19	o o
J07	o---o	J20	o---o
J08	o---o	J21	o---o
J09	o o	J22	o o
J10	o---o	J23	o---o
J11	o---o	J24	o---o
J12	o---o	J25	See Application Document
J13	o o	J26	o---o

Data Version Switches

1	ON
2	ON
3	ON
4	ON
5	ON
6	OFF
7	ON
8	ON

Filename: EPA1.INS Version 04.0000 Status: Approved 13:56:1 Fri, Sep 18, 1998

GCSS 6 Installation Report

GCSS 7 Installation Report

Installation Assembly Details

Address and Configuration Link Jumpers

P1	o o	LK1	P15	o o	LK15
P2	o o	LK2	P16	o---o	LK16
P3	o o	LK3	P17	o---o	LK17
P4	o o	LK4	P18	o---o	LK18
P5	o---o	LK5	P19	o o	LK19
P6	o---o	LK6	P20	o---o	LK20
P7	o o	LK7	P21	o---o	LK21
P8	o o	LK8	P22	o o	LK22
P9	o---o	LK9	P23	o---o	LK23
P10	o---o	LK10	P24	o---o	LK24
P11	o---o	LK11	P25	o ? o	CONF1 *
P12	o---o	LK12	P26	o---o	CONF2
P13	o o	LK13	P27	o o	UHVBC LK25
P14	o---o	LK14	P28	o o	UHVBC LK26

Data Version Switches

1	ON
2	ON
3	ON
4	ON
5	OFF
6	ON
7	ON
8	ON

* Open For Biased OFFLINE, Closed For Biased ONLINE

Filename: EJ1A.INS
Version 08.0001 Status: Not Approved 14:49:07, Thu, Jul 07, 2005 Page 1 of 1

Figure A.7 Typical GCSS Installation Reports and SW1 Settings—VLM5

A.2.2.2 VLM5 Output Power Card (OPC) Configuration

None

A.2.2.3 VLM5 Hot Standby Vital Backplane Card (HVBC) Configuration

Links LK1 to LK24 on the card must be set to the physical address of the system as shown on the GCSS Installation Report (figure A.7).

Links CONF1 and CONF2 must be set to the intended operation of the system (hot standby or stand-alone) as defined in the application data for the WESTRACE. See table A.6.

Note: ***On the GCSS 6 Installation Report, CONF1 and CONF2 correspond to J25 and J26 respectively.***

Table A.4 CONF1, CONF2 – Link Settings

Link	Closed	Not Closed
CONF1	Biased to On-line	Biased to Off-line
CONF2	Stand-alone	Hot Standby

A.2.3 VLM5 Indications

A

A.2.3.1 VLM5 Vital Logic Card (VLC5) Indications

A.2.3.1.1 Start Up Indications

Diagnostic LEDs display the module type code, shortly followed by a firmware version code (reflecting the firmware version installed in the module). Firmware version is displayed for approximately 8 seconds, after which all diagnostic LEDs extinguish.

A.2.3.1.2 Operation Indications

A single green Watchdog LED and a single Yellow Watchdog LED are provided to indicate the module is operating correctly and to indicate the mode of operation.

In On-line mode, the VLC5 flashes the green LED once per cycle and the yellow LED around the IMB communications.

In Standby mode, the VLC5 flashes the yellow LED once per cycle.

A.2.3.1.3 Fault Codes

The VLM5 fault codes written to the Fault Diagnostic Latch have the following meaning during normal operation. Some fault codes have different meanings during power-on initialisation and these have been explicitly declared.

The term ‘Initialisation’ refers to VLM5 Initialisation. Some VLM5 fault codes are used only in the VLM5 Standby Mode, and some, only in the VLM5 On-line Mode. These codes have been explicitly declared.

Module Sequence Numbers

In order for the module sequence numbers in the GCSS housing printout to match the module sequence numbers in the VLM5 fault codes, it is necessary for the GCSS user to assign the highest sequence number to the NVC/DM.

Block Fault Codes

Table A.5 Fault Codes–Block–VLM5

CODE(H)	FAULT DESCRIPTION	ACTION
01	Second Negation Error	Indicates fault on other modules
03	PROM Checksum Error	Replace VLM5
04	Stack Guard Error	"
05	RAM Error	"
06	Interrupt Errors	"
07	Termination Error	"
08	Processor Error	"
09	Stack Error	"
0A	Run Time Error A	"
0B	Run Time Error B	"
0C	Run Time Error C	"
0D	Run Time Error D	"
0E	Run Time Error E	"
0F	Run Time Error F	"
10	Run Time Error G	"
11	Run Time Error H	"
12	Run Time Error I	"
13	Run Time Error J	"
14	Run Time Error K	"
15	Run Time Error L	"
16	Run Time Error M	"
17	Run Time Error N	"
18	Run Time Error O	"
19	Run Time Error P	"
1A	Run Time Error Q	"
1B	Run Time Error R	"
1C	Run Time Error S	"
1D	Run Time Error T	"
1E	Run Time Error U	"
1F	Run Time Error V	"
20	Run Time Error W	"
21	Run Time Error X	"
22	Run Time Error Y	"
23	Run Time Error Z	Replace VLM5

Table A.5 Fault Codes—Block—VLM5 *(Continued)*

CODE(H)	FAULT DESCRIPTION	ACTION
2D	Health Monitoring Time Error	Indicates fault on other modules
2E	Health Monitoring Health Error	"
2F	Health Monitoring Scheduling Error	Replace VLM5
31	Master IMB Startup Timeout	"
32	Too Few IMB Calls	"
33	Master IMB Interface Error Too Many IMB Calls	"
34	Error code with system shutdown is the result of the invalid number of self test calls error STIMBTooFewSTCalls. Error code *without system shutdown* indicates IMB timeout of the non-vital diagnostic module. IMB Database Error	Replace VLM5 if shutdown occurred. Replace diagnostic module if shutdown did not occur.
35	Master IMB Timeout Module 01	Check other modules to identify one that caused VLM shutdown—ie reported a failure other than IMB timeout. Replace the identified module.
36	Master IMB Timeout Module 02	"
37	Master IMB Timeout Module 03	"
38	Master IMB Timeout Module 04	"
39	Master IMB Timeout Module 05	"
3A	Master IMB Timeout Module 06	"
3B	Master IMB Timeout Module 07	"
3C	Master IMB Timeout Module 08	"
3D	Master IMB Timeout Module 09	"
3E	Master IMB Timeout Module 10	"
3F	Master IMB Timeout Module 11	"
40	Master IMB Timeout Module 12	"
41	Master IMB Timeout Module 13	"
42	Master IMB Timeout Module 14	"
43	Master IMB Timeout Module 15	"
44	Master IMB Timeout Module 16	"
45	Master IMB Timeout Module 17	"
46	Master IMB Timeout Module 18	"
47	Master IMB Timeout Module 19	"
48	Master IMB Timeout Module 20	"
49	Master IMB Timeout Module 21	"
4A	Master IMB Timeout Module 22	"
4B	Master IMB Timeout Module 23	"
4C	Master IMB Timeout Module 24	"
4D	Master IMB Timeout Module 25	"
4E	Master IMB Timeout Module 26	"
4F	Master IMB Timeout Module 27	"
50	Master IMB Timeout Module 28	"

A

Table A.5 Fault Codes—Block—VLM5 *(Continued)*

CODE(H)	FAULT DESCRIPTION	ACTION
51	Master IMB Timeout Module 29	"
52	Master IMB Timeout Module 30	"
53	Master IMB Timeout Module 31	"
54	Master IMB Timeout Module 32	"
55	Master IMB Timeout Module 33	"
56	Master IMB Timeout Module 34	"
57	Master IMB Timeout Module 35	"
58	Master IMB Timeout Module 36	"
59	Master IMB Timeout Module 37	"
5A	Master IMB Data Error Module DM	Replace diagnostic module
5B	Master IMB Data Error Module 01	Replace module 01
5C	Master IMB Data Error Module 02	Replace module 02
5D	Master IMB Data Error Module 03	Replace module 03
5E	Master IMB Data Error Module 04	Replace module 04
5F	Master IMB Data Error Module 05	Replace module 05
60	Master IMB Data Error Module 06	Replace module 06
61	Master IMB Data Error Module 07	Replace module 07
62	Master IMB Data Error Module 08	Replace module 08
63	Master IMB Data Error Module 09	Replace module 09
64	Master IMB Data Error Module 10	Replace module 10
65	Master IMB Data Error Module 11	Replace module 11
66	Master IMB Data Error Module 12	Replace module 12
67	Master IMB Data Error Module 13	Replace module 13
68	Master IMB Data Error Module 14	Replace module 14
69	Master IMB Data Error Module 15	Replace module 15
6A	Master IMB Data Error Module 16	Replace module 16
6B	Master IMB Data Error Module 17	Replace module 17
6C	Master IMB Data Error Module 18	Replace module 18
6D	Master IMB Data Error Module 19	Replace module 19
6E	Master IMB Data Error Module 20	Replace module 20
6F	Master IMB Data Error Module 21	Replace module 21
70	Master IMB Data Error Module 22	Replace module 22
71	Master IMB Data Error Module 23	Replace module 23
72	Master IMB Data Error Module 24	Replace module 24
73	Master IMB Data Error Module 25	Replace module 25
74	Master IMB Data Error Module 26	Replace module 26
75	Master IMB Data Error Module 27	Replace module 27
76	Master IMB Data Error Module 28	Replace module 28
77	Master IMB Data Error Module 29	Replace module 29
78	Master IMB Data Error Module 30	Replace module 30

Table A.5 Fault Codes–Block–VLM5 *(Continued)*

CODE(H)	FAULT DESCRIPTION	ACTION
79	Master IMB Data Error Module 31	Replace module 31
7A	Master IMB Data Error Module 32	Replace module 32
7B	Master IMB Data Error Module 33	Replace module 33
7C	Master IMB Data Error Module 34	Replace module 34
7D	Master IMB Data Error Module 35	Replace module 35
7E	Master IMB Data Error Module 36	Replace module 36
7F	Master IMB Data Error Module 37	Replace module 37

Specific VLM5 Initialisation Fault Codes

Table A.6 Fault Codes–Specific Initialisation–VLM5

CODE(H)	FAULT DESCRIPTION	ACTION
80	CED Checksum Error	Replace CED PROM
81	CED GCSS Compatibility Index Error	"
82	CED VBC Link Error	Check installation address and VBC linking
83	CED VBC Link Parity Error	"
84	CED Data Version Error	Check data version switch settings
85	CED Data Error	Replace CED PROM
86	CED Data Error	"
87	CED Number Of Logic States Error	"
88	CED Module Number Error	"
89	CED Slave Kind Error	"
8A	CED Module Compatibility Index Error	Replace CED PROM
8B	CED Module Compatibility Index Parity Error	"
8C	CED Module Type Error	"
8D	CED Module Compatibility Index Error	"
8E	CED Module Compatibility Index Parity Error	"
8F	CED Module Type Error	"
90	CED Timer Error	"
91	CED Initial Data Error	"
92	CED Global Data Error	"
93	CED Fixed Data Error	"
94	CED Variable Data Error	"
95	CED Node Type Error	"
96	CED Depth Error	"
97	CED Pointer Error	"
98	CED Timer Error	"
99	CED Logic Error	"
9A	CED Global Data Error	"
9B	CED Fixed Data Error	"

A

Table A.6 Fault Codes—Specific Initialisation—VLM5 *(Continued)*

CODE(H)	FAULT DESCRIPTION	ACTION
9C	CED Variable Data Error	"
9D	CED Logic Error	"
9E	CED Slave Kind Error	"
A0	IMB Data Length Error	Indicates fault on another module
A1	IMB Slave Kind Error	"
A2	IMB Communication Time Error	"
A3	IMB Slave Kind Error IMB Communication Type Error	"
A4	IMB Module Number Error	"
B8	IMB Module Number Error	"
B9	IMB Module Type Error	"
BA	IMB Data Error	"
BB	IMB Module Number Error	"
BC	IMB Module Type Error	"
BD	IMB Message Byte Number Error	"
BE	IMB Message Bit Number Error	"
BF	IMB Output Message Length Error	Indicates fault on another module
C0	IMB Last Pointer Error	"
C1	IMB Number I/O Bits Error	"
C2	IMB Module Number Error	"
C3	IMB Slave Kind Error	"
C4	IMB Timeout Error	"
C5	IMB Scheduler Error	"
C6	Invalid Result	Replace VLM5
C7	CED System Configuration Error	Replace CED PROM
C8	CED Layout Error	"
CF	CED System Configuration Error	"
D0	Invalid Result	"
D6	Progress Error	Replace VLM5
D9	Module Number Error	Replace CED PROM
DA	Module Number Error	"
DB	Last Pointer Error	"
DF	Initial Maximum Time Error	Replace VLM5
E0	Initial Minimum Time Error	"
E1	Initial Sequence Error	"
E5	CED Checksum Error	Replace CED PROM
E6	CED Layout Error	"
E7	Comp Read Data Error	Replace VLM5
E8	Comp Read Pointer Error	"
E9	Comp Write Pointer Error	"

Table A.6 Fault Codes–Specific Initialisation–VLM5 *(Continued)*

CODE(H)	FAULT DESCRIPTION	ACTION
EA	Comp Number Logic States Data Error	"
EB	CED Compatibility Index Error	Replace CED PROM
EC	CED VBC Link Error	Check installation address and VBC linking
ED	CED Parity Error	Replace CED PROM
EE	CED Version Error	Check data version settings
EF	Module Number Error	Replace CED PROM
F0	Number of Timers Error	Replace VLM5
F1	Number of Comp Timers Error	"
F3	Delay 150 ms Error	"
F5	CED Slave Kind Error	Replace CED PROM
F8	CED Module Type Error	Replace CED PROM
F9	CED Module Number Error	"
FA	CED Module Type Error	"
FB	CED Last Module Pointer Error	"
FC	CED Output Message Length Error	"
FD	Invalid System Configuration Data Error	Replace VLM5
FE	Mode State Error	"

A

Specific VLM5 Standby Mode Fault Codes

Table A.7 Fault Codes–Specific Standby Mode–VLM5

CODE(H)	FAULT DESCRIPTION	ACTION
80	IHCL CED Checksum Error	Replace CED PROM
81	IHCL Installation Address Error	Check installation address and VBC linking
82	IHCL GCSS Version Number Error	Check data version switch settings
83	IHCL CED Checksum Error	Replace CED PROM
84	IHCL Installation Address Error	Check installation address and VBC linking
85	IHCL GCSS Version Number Error	Check data version switch settings
86	IHCL Data Consistency Error	Replace CED PROM
87	IHCL Data Consistency Error	"
88	CED Number of Logic States Error	"
89	CED Initial State Error	"
8A	CED Initial State Error	"
8B	Sync Period Expired With No IHCL Message Error	Replace VLM5
8C	Too Many Invalid IHCL Messages Received Error	"
8D	Invalid IHCL Message Error	"
8E	Compatibility Index Error	"
8F	Timer Checksum Error	"
90	Invalid IHCL Message Error	"
91	Compatibility Index Error	"

Table A.7 Fault Codes—Specific Standby Mode—VLM5 *(Continued)*

CODE(H)	FAULT DESCRIPTION	ACTION
92	Timer Checksum Error	"
93	CED Number of Logic States Error	Replace CED PROM
94	SCC Hardware Error	Replace VLM5
95	SCC Hardware Error	Replace VLM5
96	SCC Hardware Error	"
97	SCC Hardware Error	"
98	Invalid Data Error	"
99	Invalid Data Error	"
9E	OPCR State Error	"
9F	OPCR State Error	"
A0	IMB Data Length Error	Indicates fault on another module
A1	IMB Slave Kind Error	"
A2	IMB Communication Time Error	"
A3	IMB Slave Kind Error IMB Communication Type Error	"
A4	IMB Module Number Error	"
A5	IMB Parity Error	"
A6	IMB Module Number Error	"
A7	IMB Module Type Error	"
A8	IMB Port Address Range Error	"
A9	IMB Parity Error	"
AA	IMB Module Number Error	"
AB	IMB Module Type Error	"
AC	IMB Message Byte Number Error	"
AD	IMB Message Bit Number Error	"
AE	IMB Input Message Length Error	"
AF	IMB Last Pointer Error	"
D2	Logic Sequence Error	Replace VLM5
D3	Logic Sequence Error	"
D4	Logic Sequence Error	"
D5	Logic Sequence Error	"
E2	Maximum Time Error	"
E3	Minimum Time Error	"
E4	Sequence Error	"
E6	CED Checksum Error	Replace CED PROM
E7	Logic Sequence Error	Replace VLM5
E8	Logic Sequence Error	"
F0	Number of Timers Error	"
F1	Number of Comp Timers Error	Replace VLM5

Table A.7 Fault Codes–Specific Standby Mode–VLM5 *(Continued)*

CODE(H)	FAULT DESCRIPTION	ACTION
F2	Cycle Time > 1.3 sec Error	Too much logic and too many modules. Check installation design
F3	Delay 150 ms Error	Replace VLM5
F8	CED Module Type Error	Replace CED PROM
F9	CED Module Number Error	"
FA	CED Module Type Error	"
FB	CED Last Module Pointer Error	"
FC	CED Output Message Length Error	"
FE	Mode State Error	Replace VLM5
FF	PIT Access Error	"

Specific VLM5 On-Line Mode Fault Codes

Table A.8 Fault Codes–Specific On-line–VLM5

CODE(H)	FAULT DESCRIPTION	ACTION
9A	CED Number of Logic States Error	Replace CED PROM
9B	CED Number of Timers Error	"
9C	Invalid Timer Calculation Error	Replace VLM5
9D	Invalid Timer Count Error	"
9E	OPCR State Error	"
9F	OPCR State Error	"
A0	IMB Data Length Error	Indicates fault on another module
A1	IMB Slave Kind Error	"
A2	IMB Communication Time Error	"
A3	IMB Slave Kind Error IMB Communications Type Error	"
A4	IMB Module Number Error	"
A5	IMB Parity Error	"
A6	IMB Module Number Error	"
A7	IMB Module Type Error	"
A8	IMB Port Address Range Error	"
A9	IMB Parity Error	"
AA	IMB Module Number Error	"
AB	IMB Module Type Error	"
AC	IMB Message Byte Number Error	Indicates fault on another module
AD	IMB Message Bit Number Error	"
AE	IMB Input Message Length Error	"
AF	IMB Last Pointer Error	"
B0	IMB Module Number Error	"
B1	IMB Module Type Error	"
B2	IMB Module Number Error	"

A

Table A.8 Fault Codes—Specific On-line—VLM5 *(Continued)*

CODE(H)	FAULT DESCRIPTION	ACTION
B3	IMB Module Type Error	"
B4	IMB Message Byte Number Error	"
B5	IMB Message Bit Number Error	"
B6	IMB Output Message Length Error	"
B7	IMB Last Pointer Error	"
B8	IMB Module Number Error	"
B9	IMB Module Type Error	"
BA	IMB Data Error	"
BB	IMB Module Number Error	"
BC	IMB Module Type Error	"
BD	IMB Message Byte Number Error	"
BE	IMB Message Bit Number Error	"
BF	IMB Output Message Length Error	"
C0	IMB Last Pointer Error	"
C1	IMB Number I/O Bits Error	"
C2	IMB Module Number Error	"
C3	IMB Slave Kind Error	"
C4	IMB Timeout Error	"
C5	IMB Scheduler Error	"
C6	Invalid Timer Calculation Error	Replace VLM5
C7	Invalid Timer Count Error	"
C8	Invalid Timer Error	"
C9	Timer Difference Error	"
CA	Timer Expiry Difference Error	"
CB	Invalid Timer Error	"
CC	Timer Difference Error	"
CD	Timer Expiry Difference Error	"
CE	Timer Data Error	Replace VLM5
D1	Invalid Data Error	"
D2	Logic Sequence Error	"
D3	Depth Check Error	"
D4	Logic Sequence Error	"
D5	Depth Check Error	"
D6	Progress Error	"
D7	Invalid Data Error	"
D8	Invalid Data Error	"
DC	OPCR Initialise Error	Check supply to OPC. Power off system and restart after 40 seconds. Replace OPC or OPC PFM when fault persists.
DD	NOPCR Error	Replace VLM5
DE	NOPCR Error	"

Table A.8 Fault Codes–Specific On-line–VLM5 *(Continued)*

CODE(H)	FAULT DESCRIPTION	ACTION
E2	Maximum Time Error	"
E3	Minimum Time Error	"
E4	Sequence Error	"
E6	CED Checksum Error	Replace CED PROM
E7	Comp Read Data Error	Replace VLM5
E8	Comp Read Pointer Error	"
E9	Comp Write Pointer Error	"
EA	Comp Number Logic States Data Error	"
EF	CED Module Number Error	Replace CED PROM
F0	Number Of Timers Error	"
F1	Number Of Comp Timers Error	"
F2	Cycle Time > 1.3 sec Error	Too much logic and too many modules. Check installation design
F3	Delay 150 ms Error	Replace VLM5
F4	APPDEL Value Error	"
FE	Mode State Error	"

A.2.3.2 VLM5 Output Power Card (OPC) Configuration

None

A.2.3.3 VLM5 Hot Standby Vital Backplane Card (HVBC) Configuration

None.

A.2.4 VLM5 External Connections

All external connections to the VLM5 are made via the HOPC PFM which plugs directly into the HVBC.

The HOPC PFM External Connector is a 19 way plug and socket Klippon type BLA/SLA.

Figure A.8 depicts the external connection details of the HOPC PFM.

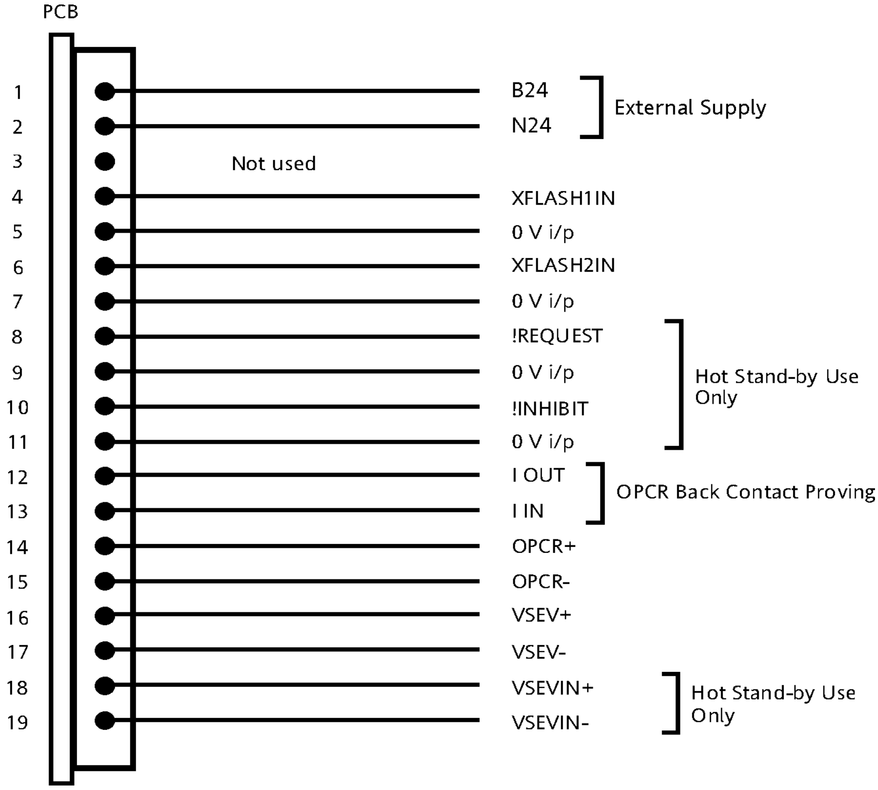


Figure A.8 External Connections—HOPC PFM—VLM5

The maximum continuous current that passes in each of the connections is:

24 V supply	4 A
OPCR Drive	0.8 A
VSEV	1 A
OPCR Back Contact	20 mA

A.3 Hot Standby Vital Logic Module (HVLM128)

All WESTRACE systems have a Vital Logic Module as its processing core. The HVLM128 is one the Vital Logic Module types in service. This section covers the HVLM128 variant of the module although there are other variants.

A WESTRACE Hot Standby system comprises a pair of fully duplicated installations in a symmetrical arrangement, such that one installation is in 'on-line' mode (in control of the railway), whilst the other is in 'standby' mode. Each installation has an HVLM at the processing core and the service provided by a particular installation is determined by setting links on a backplane card.

A.3.1 Description

The HVLM comprises two (2) printed circuit boards:

- HVLC (Hot Standby Vital Logic Card);
- OPC (Output Power Card).

The individual boards are interconnected by means of the VLE backplane, and also by a Hot Standby Vital Backplane Card (HVBC). Links on this card (CONF1 and CONF2) determine the service provided by the particular WESTRACE installation.

An HVLM occupies slots 2 to 3 in housing 1 of a WESTRACE installation. The OPC is in Slot 2 and the HVLC is in Slot 3. *Slot 1 in housing 1 must have a Blanker card inserted*.

A.3.1.1 Hot Standby Vital Logic Card (HVLC)

The HVLC is the system's central processing module. It controls communications between the system modules and performs all Application Logic processing to determine the current state of all vital and non-vital outputs.

The HVLC contains in PROMs the Configuration Element Data (CED) generated by the GCSS. The card has data version configuration switches (SW1) that it uses to confirm the CED in PROM is the correct version.

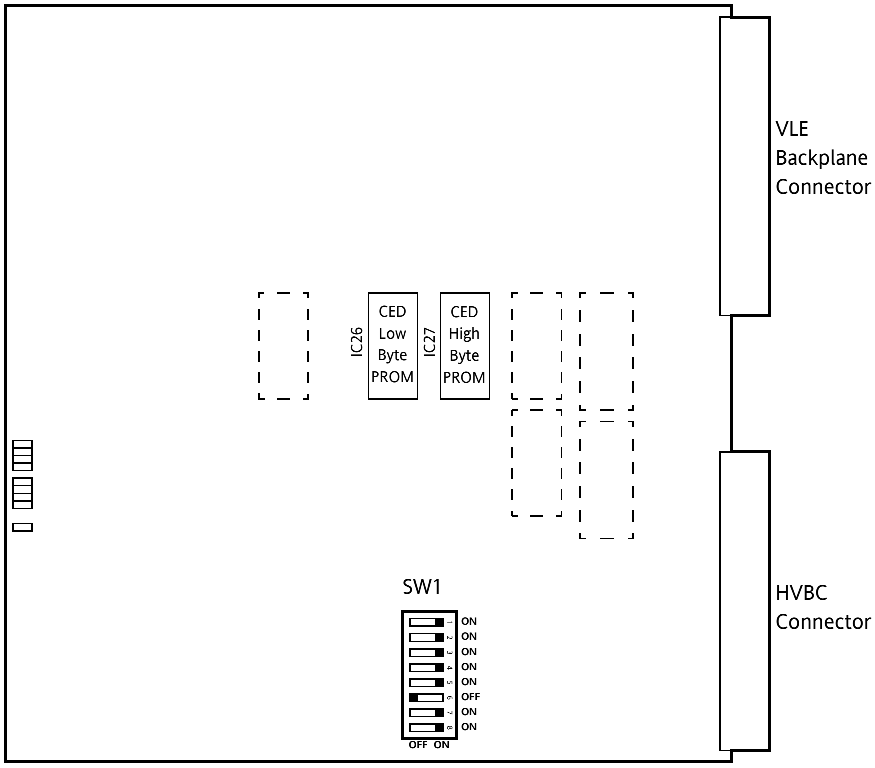


Figure A.9 Layout—HVLC—HVLM

A.3.1.2 Output Power Card (OPC)

The OPC produces power to drive the OPCR and VSEV. The VSEV enables outputs for the vital communications modules and the OPC isolates power from both of these outputs when safe operation of the system cannot be guaranteed.

A.3.1.3 Hot Standby Vital Backplane Card (HVBC)

Note: ***A UHVBC can also be used provided LK25 and LK26 are not closed. See sections A.1.1.3 and A.1.2.3 for details.***

The HVBC is a small, half height, printed circuit board installed directly behind the lower connectors of the HVLM.

It provides:

- a direct connection between the OPC and HVLC cards, that constitute the HVLM;
- 24 links (LK1 to LK24) that determine the unique physical address of the WESTRACE installation. The setting of these links is checked against the data contained in the Application Data PROMS, thereby preventing installation and execution of an incorrect version of application data;
- 2 links (CONF1 andCONF2, see figures A.10 and A.11, and table A.12) that determine the operation of the HVLM. The setting of these links determines whether the HVLM is operating in Stand-alone or Hot Standby mode. If it is in Hot Standby Mode they are also determine whether it is the default On Line or Standby system.

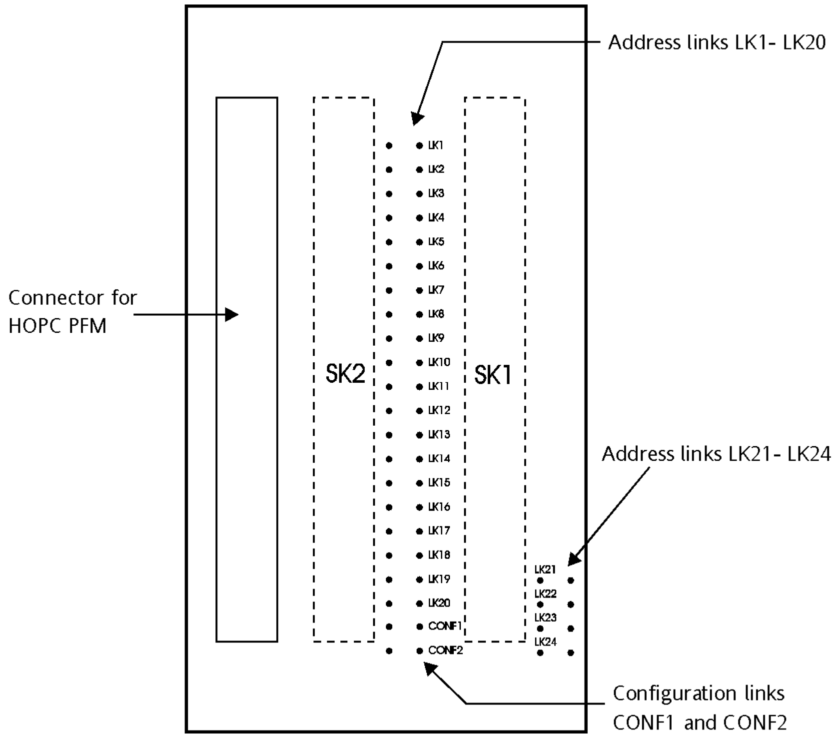


Figure A.10 Rear Side View—HVBC—HVLM

Note: ***CONF1 and CONF2 in figure A.10 correspond to J25 and J26 on the GCSS Installation Report (figure A.11).***

A.3.2 Configuration

A.3.2.1 Hot Standby Vital Logic Card (HVLC)

The CED is contained in two PROMs, high byte and low byte (see figure A.9). The low byte PROM is in socket IC26 and the high byte PROM is in socket IC27.

The settings for switch SW1 are provided on the Installation Report generated by GCSS from the Application Data. Figure A.11 shows an example for Installation Reports generated in GCSS 6 and GCSS 7.

Installation Assembly Details

Address Jumpers

J01	o o	J14	o---o
J02	o o	J15	o o
J03	o---o	J16	o o
J04	o o	J17	o---o
J05	o---o	J18	o---o
J06	o o	J19	o o
J07	o---o	J20	o---o
J08	o---o	J21	o---o
J09	o o	J22	o o
J10	o---o	J23	o---o
J11	o---o	J24	o---o
J12	o---o	J25	See Application Document
J13	o o	J26	o---o

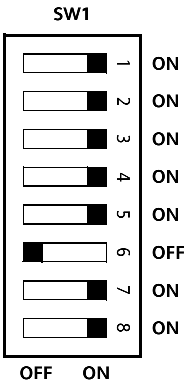
Data Version Switches

1	ON
2	ON
3	ON
4	ON
5	ON
6	OFF
7	ON
8	ON

Filename: EPA1.INS Version 04.0000 Status: Approved 13:56:1 , Fri, Sep 18, 1998

GCSS 6 Installation Report

Set LK1-LK24 on card as shown by J01–J24 on report
J25 = CONF1
J26 = CONF2



GCSS 7 Installation Report

Installation Assembly Details

Address and Configuration Link Jumpers

P1	o o	LK1	P15	o o	LK15
P2	o o	LK2	P16	o---o	LK16
P3	o o	LK3	P17	o---o	LK17
P4	o o	LK4	P18	o---o	LK18
P5	o---o	LK5	P19	o o	LK19
P6	o---o	LK6	P20	o---o	LK20
P7	o o	LK7	P21	o---o	LK21
P8	o o	LK8	P22	o o	LK22
P9	o---o	LK9	P23	o---o	LK23
P10	o---o	LK10	P24	o---o	LK24
P11	o---o	LK11	P25	o ? o	CONF1 *
P12	o---o	LK12	P26	o---o	CONF2
P13	o o	LK13	P27	o o	UHVBC LK25
P14	o---o	LK14	P28	o o	UHVBC LK26

Data Version Switches

1	ON
2	ON
3	ON
4	ON
5	OFF
6	ON
7	ON
8	ON

* Open For Biased OFFLINE, Closed For Biased ONLINE

Filename: EJ1A.INS
Version 08.0001 Status: Not Approved 14:49:07, Thu, Jul 07, 2005 Page 1 of 1

Figure A.11 Typical GCSS Installation Reports and SW1 Settings–HVLM128

A.3.2.2 Output Power Card (OPC)

None

A.3.2.3 Hot Standby Vital Backplane Card (HVBC)

The links LK1 to LK24 must be set to the physical address of the system shown by J01 to J24 on the GCSS Installation Report. See figure A.11.

Links CONF1 and CONF2 must be set to the intended operation of the system (hot standby or stand-alone) as defined in the application data for the WESTRACE. See table A.12.

Note: ***On the GCSS 6 Installation Report, CONF1 and CONF2 correspond to J25 and J26 respectively.***

Table A.9 CONF1, CONF2–Link Settings

Link	Closed	Not Closed
CONF1	Biased to On-line	Biased to Off-line
CONF2	Stand-alone	Hot Standby

A.3.3 Indications

A.3.3.1 Hot Standby Vital Logic Card (HVLC)

A.3.3.1.1 Start Up Indications

Diagnostic LEDs display the module type code, shortly followed by a firmware version code (reflecting the firmware version installed in the module). Firmware version is displayed for approximately 8 seconds, after which all diagnostic LEDs extinguish.

A.3.3.1.2 Operation Indications

The module commences flashing the green watchdog LED to indicate the module is operational and working correctly.

The module flashes the yellow On-Line LED to indicate when it starts executing application logic.

A.3.3.1.3 Fault Codes

The HVLM fault codes written to the Fault Diagnostic Latch have the following meaning during normal operation. Some fault codes have different meanings during power-on initialisation and these have been explicitly declared.

The term 'Initialisation' refers to HVLM Initialisation. Some HVLM fault codes are used only in the HLVM Standby Mode, and some, only in the HVLM On-line Mode. These codes have been explicitly declared.

Module Sequence Numbers

In order for the module sequence numbers in the GCSS housing printout to match the module sequence numbers in the HVLM fault codes it is necessary for the GCSS user to assign the highest sequence number to the NVC/DM.

Block Fault Codes

Table A.10 Fault Codes–Block–HVLM

CODE(H)	FAULT DESCRIPTION	ACTION
01	Second Negation Error	Indicates fault on other modules
03	PROM Checksum Error	Replace HVLM
04	Stack Guard Error	"
05	RAM Error	Replace HVLM
06	Interrupt Errors	"
07	Termination Error	"
08	Processor Error	"
09	Stack Error	"
0A	Run Time Error A	"
0B	Run Time Error B	"
0C	Run Time Error C	"
0D	Run Time Error D	"

Table A.10 Fault Codes–Block–HVLM *(Continued)*

CODE(H)	FAULT DESCRIPTION	ACTION
0E	Run Time Error E	"
0F	Run Time Error F	"
10	Run Time Error G	"
11	Run Time Error H	"
12	Run Time Error I	"
13	Run Time Error J	"
14	Run Time Error K	"
15	Run Time Error L	"
16	Run Time Error M	"
17	Run Time Error N	"
18	Run Time Error O	"
19	Run Time Error P	"
1A	Run Time Error Q	"
1B	Run Time Error R	"
1C	Run Time Error S	"
1D	Run Time Error T	"
1E	Run Time Error U	"
1F	Run Time Error V	"
20	Run Time Error W	"
21	Run Time Error X	"
22	Run Time Error Y	"
23	Run Time Error Z	"
2D	Health Monitoring Time Error	Indicates fault on other modules
2E	Health Monitoring Health Error	"
2F	Health Monitoring Scheduling Error	Replace HVLM
31	Master IMB Startup Timeout	Replace HVLM
32	Too Few IMB Calls	"
33	Master IMB Interface Error Too Many IMB Calls	"
2D	Health Monitoring Time Error	Indicates fault on other modules
2E	Health Monitoring Health Error	"
2F	Health Monitoring Scheduling Error	Replace HVLM
31	Master IMB Startup Timeout	"
32	Too Few IMB Calls	"
33	Master IMB Interface Error Too Many IMB Calls	"
34	Error code with system shutdown is the result of the invalid number of selftest calls error STIMBTooFewSTCalls. Error code *without system shutdown* indicates IMB timeout of the non-vital diagnostic module. IMB Database Error	Replace HVLM if shutdown occurred. Replace diagnostic module if shutdown did not occur.

Table A.10 Fault Codes–Block–HVLM *(Continued)*

CODE(H)	FAULT DESCRIPTION	ACTION
35	Master IMB Timeout Module 01	Check other modules to identify one that caused VLM shutdown–ie reported a failure other than IMB timeout. Replace the identified module.
36	Master IMB Timeout Module 02	"
37	Master IMB Timeout Module 03	"
38	Master IMB Timeout Module 04	"
39	Master IMB Timeout Module 05	"
3A	Master IMB Timeout Module 06	"
3B	Master IMB Timeout Module 07	"
3C	Master IMB Timeout Module 08	"
3D	Master IMB Timeout Module 09	"
3E	Master IMB Timeout Module 10	"
3F	Master IMB Timeout Module 11	"
40	Master IMB Timeout Module 12	"
41	Master IMB Timeout Module 13	"
42	Master IMB Timeout Module 14	"
43	Master IMB Timeout Module 15	"
44	Master IMB Timeout Module 16	"
45	Master IMB Timeout Module 17	"
46	Master IMB Timeout Module 18	"
47	Master IMB Timeout Module 19	"
48	Master IMB Timeout Module 20	"
49	Master IMB Timeout Module 21	"
4A	Master IMB Timeout Module 22	"
4B	Master IMB Timeout Module 23	"
4C	Master IMB Timeout Module 24	"
4D	Master IMB Timeout Module 25	"
4E	Master IMB Timeout Module 26	"
4F	Master IMB Timeout Module 27	"
50	Master IMB Timeout Module 28	"
51	Master IMB Timeout Module 29	"
52	Master IMB Timeout Module 30	"
53	Master IMB Timeout Module 31	"
54	Master IMB Timeout Module 32	"
55	Master IMB Timeout Module 33	"
56	Master IMB Timeout Module 34	"
57	Master IMB Timeout Module 35	"
58	Master IMB Timeout Module 36	"
59	Master IMB Timeout Module 37	"
5A	Master IMB Data Error Module DM	Replace diagnostic module
5B	Master IMB Data Error Module 01	Replace module 01

A

Table A.10 Fault Codes–Block–HVLM *(Continued)*

CODE(H)	FAULT DESCRIPTION	ACTION
5C	Master IMB Data Error Module 02	Replace module 02
5D	Master IMB Data Error Module 03	Replace module 03
5E	Master IMB Data Error Module 04	Replace module 04
5F	Master IMB Data Error Module 05	Replace module 05
60	Master IMB Data Error Module 06	Replace module 06
61	Master IMB Data Error Module 07	Replace module 07
62	Master IMB Data Error Module 08	Replace module 08
63	Master IMB Data Error Module 09	Replace module 09
64	Master IMB Data Error Module 10	Replace module 10
65	Master IMB Data Error Module 11	Replace module 11
66	Master IMB Data Error Module 12	Replace module 12
67	Master IMB Data Error Module 13	Replace module 13
68	Master IMB Data Error Module 14	Replace module 14
69	Master IMB Data Error Module 15	Replace module 15
6A	Master IMB Data Error Module 16	Replace module 16
6B	Master IMB Data Error Module 17	Replace module 17
6C	Master IMB Data Error Module 18	Replace module 18
6D	Master IMB Data Error Module 19	Replace module 19
6E	Master IMB Data Error Module 20	Replace module 20
6F	Master IMB Data Error Module 21	Replace module 21
70	Master IMB Data Error Module 22	Replace module 22
71	Master IMB Data Error Module 23	Replace module 23
72	Master IMB Data Error Module 24	Replace module 24
73	Master IMB Data Error Module 25	Replace module 25
74	Master IMB Data Error Module 26	Replace module 26
75	Master IMB Data Error Module 27	Replace module 27
76	Master IMB Data Error Module 28	Replace module 28
77	Master IMB Data Error Module 29	Replace module 29
78	Master IMB Data Error Module 30	Replace module 30
79	Master IMB Data Error Module 31	Replace module 31
7A	Master IMB Data Error Module 32	Replace module 32
7B	Master IMB Data Error Module 33	Replace module 33
7C	Master IMB Data Error Module 34	Replace module 34
7D	Master IMB Data Error Module 35	Replace module 35
7E	Master IMB Data Error Module 36	Replace module 36
7F	Master IMB Data Error Module 37	Replace module 37

Specific HVLM Initialisation Fault Codes

Table A.11 Fault Codes–Specific Initialisation–HVLM

CODE (H)	FAULT DESCRIPTION	ACTION
80	CED Checksum Error	Replace CED PROM
81	CED GCSS Compatibility Index Error	"
82	CED VBC Link Error	Check installation address and VBC linking
83	CED VBC Link Parity Error	Check installation address and VBC linking
84	CED Data Version Error	Check data version switch settings
85	CED Data Error	Replace CED PROM
86	CED Data Error	"
87	CED Number Of Logic States Error	Replace CED PROM
88	CED Module Number Error	"
89	CED Slave Kind Error	"
8A	CED Module Compatibility Index Error	"
8B	CED Module Compatibility Index Parity Error	"
8C	CED Module Type Error	"
8D	CED Module Compatibility Index Error	"
8E	CED Module Compatibility Index Parity Error	"
8F	CED Module Type Error	"
90	CED Timer Error	"
91	CED Initial Data Error	"
92	CED Global Data Error	"
93	CED Fixed Data Error	"
94	CED Variable Data Error	"
95	CED Node Type Error	"
96	CED Depth Error	"
97	CED Pointer Error	"
98	CED Timer Error	"
99	CED Logic Error	"
9A	CED Global Data Error	"
9B	CED Fixed Data Error	"
9C	CED Variable Data Error	"
9D	CED Logic Error	"
9E	CED Slave Kind Error	"
A0	IMB Data Length Error	Indicates fault on another module
A1	IMB Slave Kind Error	"
A2	IMB Communication Time Error	"
A3	IMB Slave Kind Error IMB Communication Type Error	"
A4	IMB Module Number Error	"
B8	IMB Module Number Error	Indicates fault on another module

A

Table A.11 Fault Codes—Specific Initialisation—HVLM *(Continued)*

CODE (H)	FAULT DESCRIPTION	ACTION
B9	IMB Module Type Error	"
BA	IMB Data Error	"
BB	IMB Module Number Error	"
BC	IMB Module Type Error	Indicates fault on another module
BD	IMB Message Byte Number Error	"
BE	IMB Message Bit Number Error	"
BF	IMB Output Message Length Error	"
C0	IMB Last Pointer Error	"
C1	IMB Number I/O Bits Error	"
C2	IMB Module Number Error	"
C3	IMB Slave Kind Error	"
C4	IMB Timeout Error	"
C5	IMB Scheduler Error	"
C6	CED Invalid Data Error	Replace CED PROM
C7	CED System Configuration Error	"
CF	CED System Configuration Error	"
D0	Invalid Result	"
D6	Progress Error	Replace HVLM
D9	Module Number Error	
DA	Module Number Error	
DB	Last Pointer Error	
DF	Initial Maximum Time Error	Replace HVLM
E0	Initial Minimum Time Error	"
E1	Initial Sequence Error	"
E5	CED Checksum Error	Replace CED PROM
E7	Comp Read Data Error	Replace HVLM
E8	Comp Read Pointer Error	"
E9	Comp Write Pointer Error	"
EA	Comp Number Logic States Data Error	"
EB	CED Compatibility Index Error	Replace CED PROM
EC	CED VBC Link Error	Check installation address and VBC linking
ED	CED Parity Error	Replace CED PROM
EE	CED Version Error	Check data version settings
EF	Module Number Error	
F0	Number of Timers Error	Replace HVLM
F1	Number of Comp Timers Error	"
F3	Delay 150 ms Error	"
F5	CED Slave Kind Error Initial Progress Error	Replace CED PROM Replace HVLM

Table A.11 Fault Codes–Specific Initialisation–HVLM *(Continued)*

CODE (H)	FAULT DESCRIPTION	ACTION
F8	CED Module Type Error	Replace CED PROM
F9	CED Module Number Error	"
FA	CED Module Type Error	"
FB	CED Last Module Pointer Error	"
FC	CED Output Message Length Error	"
FD	Invalid System Configuration Data Error	Replace HVLM
FE	Mode State Error	"

Specific HVLM Standby Mode Fault Codes

Table A.12 Fault Code–Specific Standby Mode–HVLM

CODE(H)	FAULT DESCRIPTION	ACTION
80	IHCL CED Checksum Error	Replace CED PROM
81	IHCL Installation Address Error	Check installation address and VBC linking
82	IHCL GCSS Version Number Error	Check data version switch settings
83	IHCL CED Checksum Error	Replace CED PROM
84	IHCL Installation Address Error	Check installation address and VBC linking
85	IHCL GCSS Version Number Error	Check data version switch settings
86	IHCL Data Consistency Error	Replace CED PROM
87	IHCL Data Consistency Error	"
88	CED Number of Logic States Error	"
89	CED Initial State Error	"
8A	CED Initial State Error	"
8B	Sync Period Expired With No IHCL Message Error	Replace HVLM
8C	Too Many Invalid IHCL Messages Received Error	"
8D	Invalid IHCL Message Error	"
8E	Compatibility Index Error	"
8F	Timer Checksum Error	"
90	Invalid IHCL Message Error	Replace HVLM
91	Compatibility Index Error	"
92	Timer Checksum Error	"
93	CED Number of Logic States Error	Replace CED PROM
94	SCC Hardware Error	Replace HVLM
95	SCC Hardware Error	"
96	SCC Hardware Error	"
97	SCC Hardware Error	"
98	Invalid Data Error	"
99	Invalid Data Error	"
9E	OPCR State Error	"
9F	OPCR State Error	"

A

Table A.12 Fault Code–Specific Standby Mode–HVLM *(Continued)*

CODE(H)	FAULT DESCRIPTION	ACTION
A0	IMB Data Length Error	Indicates fault on another module
A1	IMB Slave Kind Error	"
A2	IMB Communication Time Error	"
A3	IMB Slave Kind Error IMB Communication Type Error	"
A4	IMB Module Number Error	"
A5	IMB Parity Error	"
A6	IMB Module Number Error	"
A7	IMB Module Type Error	"
A8	IMB Port Address Range Error	"
A9	IMB Parity Error	"
AA	IMB Module Number Error	"
AB	IMB Module Type Error	"
AC	IMB Message Byte Number Error	"
AD	IMB Message Bit Number Error	"
AE	IMB Input Message Length Error	"
AF	IMB Last Pointer Error	"
D2	Logic Sequence Error	Replace HVLM
D3	Logic Sequence Error	"
D4	Logic Sequence Error	"
D5	Depth Check Error	"
E2	Maximum Time Error	"
E3	Minimum Time Error	"
E4	Sequence Error	Replace HVLM
E6	CED Checksum Error	Replace CED PROM
E7	Logic Sequence Error	Replace HVLM
E8	Logic Sequence Error	"
F0	Number of Timers Error	Replace HVLM
F1	Number of Comp Timers Error	"
F2	Cycle Time > 1 sec Error	Too much logic and too many modules–check installation design
F3	Delay 150 ms Error	Replace HVLM
F8	CED Module Type Error	Replace CED PROM
F9	CED Module Number Error	"
FA	CED Module Type Error	"
FB	CED Last Module Pointer Error	"
FC	CED Output Message Length Error	"
FE	Mode State Error	Replace HVLM
FF	PIT Access Error	"

Specific HVLM On-Line Mode Fault Codes

Table A.13 Fault Codes—Specific On-line Mode—HVLM

CODE(H)	FAULT DESCRIPTION	ACTION
9A	CED Number of Logic States Error	Replace CED PROM
9B	CED Number of Timers Error	"
9C	Invalid Timer Calculation Error	Replace HVLM
9D	Invalid Timer Count Error	"
9E	OPCR State Error	"
9F	OPCR State Error	"
A0	IMB Data Length Error	Indicates fault on another module
A1	IMB Slave Kind Error	"
A2	IMB Communication Time Error	"
A3	IMB Slave Kind Error IMB Communications Type Error	"
A4	IMB Module Number Error	"
A5	IMB Parity Error	"
A6	IMB Module Number Error	"
A7	IMB Module Type Error	Indicates fault on another module
A8	IMB Port Address Range Error	"
A9	IMB Parity Error	"
AA	IMB Module Number Error	"
AB	IMB Module Type Error	Indicates fault on another module
AC	IMB Message Byte Number Error	"
AD	IMB Message Bit Number Error	"
AE	IMB Input Message Length Error	"
AF	IMB Last Pointer Error	"
B0	IMB Module Number Error	"
B1	IMB Module Type Error	"
B2	IMB Module Number Error	"
B3	IMB Module Type Error	"
B4	IMB Message Byte Number Error	"
B5	IMB Message Bit Number Error	"
B6	IMB Input Message Length Error	"
B7	IMB Last Pointer Error	"
B8	IMB Module Number Error	"
B9	IMB Module Type Error	"
BA	IMB Data Error	"
BB	IMB Module Number Error	"
BC	IMB Module Type Error	"
BD	IMB Message Byte Number Error	"
BE	IMB Message Bit Number Error	"
BF	IMB Output Message Length Error	"

Table A.13 Fault Codes—Specific On-line Mode—HVLM *(Continued)*

CODE(H)	FAULT DESCRIPTION	ACTION
C0	IMB Last Pointer Error	"
C1	IMB Number I/O Bits Error	"
C2	IMB Module Number Error	"
C3	IMB Slave Kind Error	"
C4	IMB Timeout Error	"
C5	IMB Scheduler Error	"
C6	Invalid Timer Calculation Error	Replace HVLM
C7	Invalid Timer Count Error	"
C8	Invalid Timer Error	"
C9	Timer Difference Error	Replace HVLM
CA	Timer Expiry Difference Error	"
CB	Invalid Timer Error	"
CC	Timer Difference Error	"
CD	Timer Expiry Difference Error	Replace HVLM
CE	Timer Data Error	"
D1	Invalid Data Error	"
D2	Logic Sequence Error	"
D3	Depth Check Error	"
D4	Logic Sequence Error	"
D5	Depth Check Error	"
D6	CED Invalid Data Error Progress Error	Replace CED PROM Replace HVLM
D8	Invalid Data Error	Replace HVLM
DC	OPCR Initialise Error	Check supply to OPC. Power off system and restart after 40 seconds. If fault persists replace OPC or OPC PFM
DD	NOPCR Error	Replace HVLM
DF	NOPCR Error	"
E2	Maximum Time Error	"
E3	Minimum Time Error	"
E4	Sequence Error	"
E6	CED Checksum Error	Replace CED PROM
E7	Comp Read Data Error	Replace HVLM
E8	Comp Read Pointer Error	"
E9	Comp Write Pointer Error	"
EA	Comp Number Logic States Data Error	"
EF	CED Module Number Error	Replace CED PROM
F0	Number Of Timers Error	"
F1	Number Of Comp Timers Error	"
F2	Cycle Time > 1 sec Error	Too much logic and too many modules—check installation design

Table A.13 Fault Codes–Specific On-line Mode–HVLM *(Continued)*

CODE(H)	FAULT DESCRIPTION	ACTION
F3	Delay 150 ms Error	Replace HVLM
F4	APPDEL Value Error	"
F6	APPDEL Progress Error	"
F7	Normal Progress Error	"
FE	Mode State Error	Replace HVLM

A.3.3.2 Output Power Card (OPC)

None

A.3.3.3 Hot Standby Vital Backplane Card (HVBC)

None.

A

A.3.4 External Connections

All external connections to the HVLM are made via the HOPC PFM which plugs directly into the HVBC.

The HOPC PFM External Connector is a 19 way plug and socket Klippon type BLA/SLA.

Figure A.12 depicts the external connection details of the HOPC PFM.

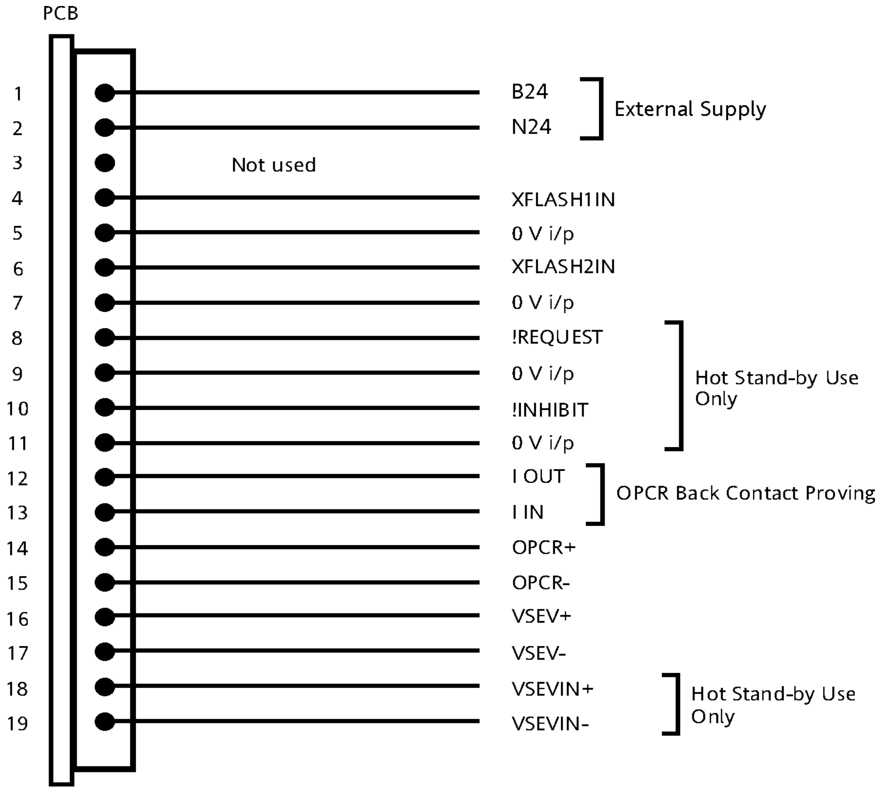


Figure A.12 External Connections–HOPC PFM–HVLM

The maximum continuous current that passes in each of the connections is:

24 V supply	4 A
OPCR Drive	0.8 A
VSEV	1 A
OPCR Back Contact	20 mA

A.4 Vital Logic Module (VLM1)

All WESTRACE systems have a Vital Logic Module as its processing core. The VLM1 is one the Vital Logic Module types in service.

A.4.1 Description

The VLM1 comprises three (3) printed circuit boards:

- VLC (Vital Logic Card);
- CEC (Configuration Element Card);
- OPC (Output Power Card).

These boards are interconnected by means of the VLE backplane, and also by a Vital Backplane Card (VBC).

A VLM1 occupies slots 1 to 3 in housing 1 of a WESTRACE system. The OPC is in Slot 1, the CEC is in Slot 2 and the VLC is in Slot 3.

A.4.1.1 Vital Logic Card (VLC)

The VLC is the system's central processing module. It controls communications between the system modules and performs all Application Logic processing to determine the current state of all vital and non-vital outputs.

A.4.1.2 Configuration Element Card (CEC)

The CEC contains in PROMs the Application Data generated by the CS. It has configuration version switches (SW1) which the VLC uses to ensure Configuration Application Data in PROM is the correct version.

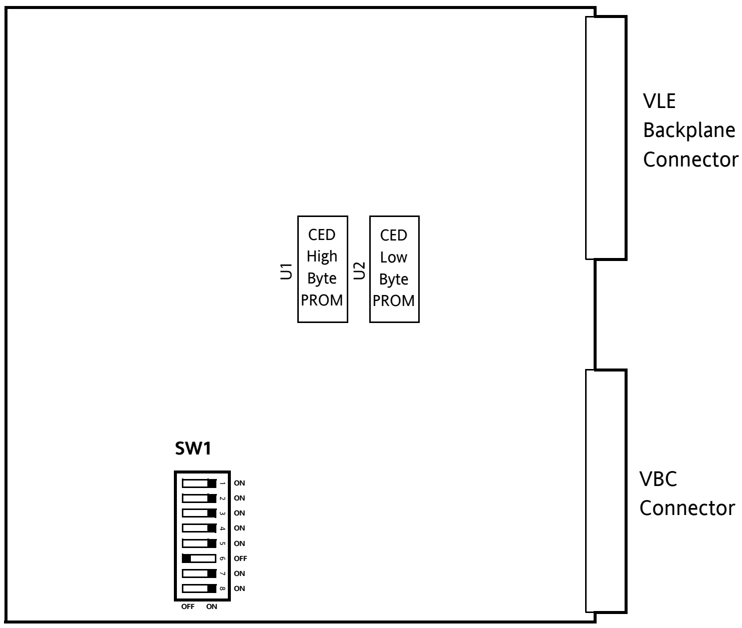


Figure A.13 Layout–CEC–VLM1

A.4.1.3 Output Power Card (OPC)

The OPC produces power to drive the OPCR and VSEV. The VSEV enables outputs for the vital communications modules and the OPC isolates power from both of these outputs when safe operation of the system cannot be guaranteed.

A.4.1.4 Vital Backplane Card (VBC)

The VBC is a small, half height printed circuit board installed directly behind the lower connectors of the VLM1.

The VBC provides:

- a direct connection between the OPC, CEC and VLC cards, which constitute the VLM1;
- 24 links (LK1 to LK24) which determine the unique physical address of the WESTRACE installation. The setting of these links is checked against the data contained in the Application Data PROMS, thereby preventing installation and execution of the wrong Application Data.

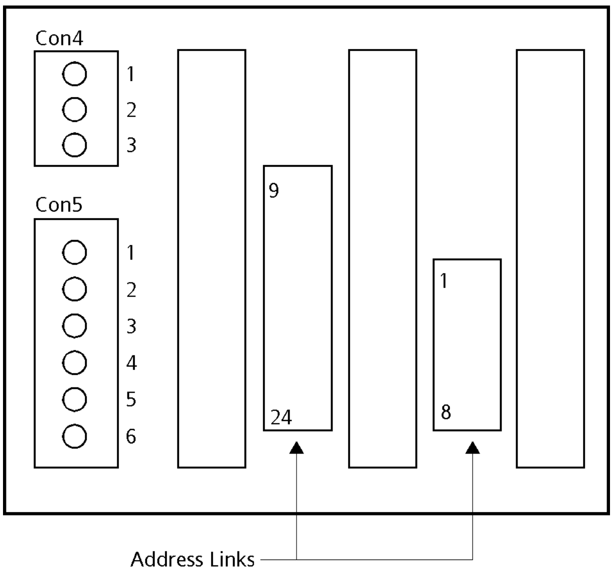


Figure A.14 General Arrangement from Rear–VBC–VLM1

A.4.2 Configuration

A.4.2.1 Vital Logic Card (VLC)

None

A.4.2.2 Configuration Element Card (CEC)

The CED is contained in two PROMs, high byte and low byte (see figure A.13). The high byte PROM is in socket U1 HIGH. The low byte PROM is in socket U2 LOW.

The settings for switch SW1 (figure A.15) are provided on the Installation Assembly Details Printout generated by the CS from the Application Data.

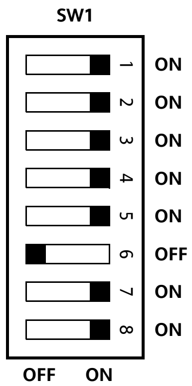


Figure A.15 Example SW1 Settings–CEC–VLM1

A.4.2.3 Output Power Card (OPC)

None

A.4.2.4 Vital Backplane Card (VBC)

Details of the setting of the links LK1 to LK24 (see figure A.14) must correspond to the physical address of the system in the Application Data printout.

A.4.3 Indications

A.4.3.1 Vital Logic Card (VLC)

A.4.3.1.1 Start Up Indications

Diagnostic LEDs display the module type code, shortly followed by a firmware version code (reflecting the firmware version installed in the module). Firmware version is displayed for approximately 8 seconds, after which all diagnostic LEDs extinguish.

A.4.3.1.2 Operation Indications

The module commences flashing the green watchdog LED to indicate the module is operational and working correctly.

A.4.3.1.3 Fault Codes

Table A.14 Fault Codes—VLM1

CODE(H)	FAULT DESCRIPTION	ACTION
00	No Fault	Not a fault
01	Second Negation Error	Indicates fault on other modules
03	PROM Checksum Error	Replace VLM1
04	Stack Guard Error	"
05	RAM Error	"
06	Interrupt Error	"
07	Termination Error	"
08	Processor Error	"
09	Stack Error	"
0A	Run Time Error A	"
0B	Run Time Error B	"
0C	Run Time Error C	"
0D	Run Time Error D	"
0E	Run Time Error E	"
0F	Run Time Error F	"
10	Run Time Error G	"
11	Run Time Error H	"
12	Run Time Error I	"
13	Run Time Error J	"
14	Run Time Error K	"
15	Run Time Error L	"
16	Run Time Error M	"
17	Run Time Error N	"
18	Run Time Error O	"
19	Run Time Error P	"
1A	Run Time Error Q	"
1B	Run Time Error R	"
1C	Run Time Error S	"
1D	Run Time Error T	"
1E	Run Time Error U	"
1F	Run Time Error V	"
20	Run Time Error W	"
21	Run Time Error X	"
22	Run Time Error Y	Replace VLM1
23	Run Time Error Z	"
2D	Health Monitoring Time Error	Indicates fault on other modules
2E	Health Monitoring Health Error	"
2F	Health Monitoring Scheduling Error	"

Table A.14 Fault Codes–VLM1 *(Continued)*

CODE(H)	FAULT DESCRIPTION	ACTION
33	Master IMB Interface Error	"
34	Master IMB Timeout Module DM	Replace the DM module
35	Master IMB Timeout Module 01	Check other modules to identify one that caused VLM shutdown–ie reported a failure other than IMB timeout. Replace the identified module.
36	Master IMB Timeout Module 02	"
37	Master IMB Timeout Module 03	"
38	Master IMB Timeout Module 04	"
39	Master IMB Timeout Module 05	"
3A	Master IMB Timeout Module 06	"
3B	Master IMB Timeout Module 07	"
3C	Master IMB Timeout Module 08	"
3D	Master IMB Timeout Module 09	"
3E	Master IMB Timeout Module 10	"
3F	Master IMB Timeout Module 11	"
40	Master IMB Timeout Module 12	"
41	Master IMB Timeout Module 13	"
42	Master IMB Timeout Module 14	"
43	Master IMB Timeout Module 15	"
44	Master IMB Timeout Module 16	"
45	Master IMB Timeout Module 17	"
46	Master IMB Timeout Module 18	"
47	Master IMB Timeout Module 19	"
48	Master IMB Timeout Module 20	"
49	Master IMB Timeout Module 21	"
4A	Master IMB Timeout Module 22	"
4B	Master IMB Timeout Module 23	"
4C	Master IMB Timeout Module 24	"
4D	Master IMB Timeout Module 25	"
4E	Master IMB Timeout Module 26	"
4F	Master IMB Timeout Module 27	"
50	Master IMB Timeout Module 28	"
51	Master IMB Timeout Module 29	"
52	Master IMB Timeout Module 30	"
53	Master IMB Timeout Module 31	"
54	Master IMB Timeout Module 32	"
55	Master IMB Timeout Module 33	"
56	Master IMB Timeout Module 34	"
57	Master IMB Timeout Module 35	"
58	Master IMB Timeout Module 36	"
59	Master IMB Timeout Module 37	"

Table A.14 Fault Codes—VLM1 *(Continued)*

CODE(H)	FAULT DESCRIPTION	ACTION
5A	Master IMB Data Error Module DM	Replace DM module
5B	Master IMB Data Error Module 01	Replace Module 01
5C	Master IMB Data Error Module 02	Replace Module 02
5D	Master IMB Data Error Module 03	Replace Module 03
5E	Master IMB Data Error Module 04	Replace Module 04
5F	Master IMB Data Error Module 05	Replace Module 05
60	Master IMB Data Error Module 06	Replace Module 06
61	Master IMB Data Error Module 07	Replace Module 07
62	Master IMB Data Error Module 08	Replace Module 08
63	Master IMB Data Error Module 09	Replace Module 09
64	Master IMB Data Error Module 10	Replace Module 10
65	Master IMB Data Error Module 11	Replace Module 11
66	Master IMB Data Error Module 12	Replace Module 12
67	Master IMB Data Error Module 13	Replace Module 13
68	Master IMB Data Error Module 14	Replace Module 14
69	Master IMB Data Error Module 15	Replace Module 15
6A	Master IMB Data Error Module 16	Replace Module 16
6B	Master IMB Data Error Module 17	Replace Module 17
6C	Master IMB Data Error Module 18	Replace Module 18
6D	Master IMB Data Error Module 19	Replace Module 19
6E	Master IMB Data Error Module 20	Replace Module 20
6F	Master IMB Data Error Module 21	Replace Module 21
70	Master IMB Data Error Module 22	Replace Module 22
71	Master IMB Data Error Module 23	Replace Module 23
72	Master IMB Data Error Module 24	Replace Module 24
73	Master IMB Data Error Module 25	Replace Module 25
74	Master IMB Data Error Module 26	Replace Module 26
75	Master IMB Data Error Module 27	Replace Module 27
76	Master IMB Data Error Module 28	Replace Module 28
77	Master IMB Data Error Module 29	Replace Module 29
78	Master IMB Data Error Module 30	Replace Module 30
79	Master IMB Data Error Module 31	Replace Module 31
7A	Master IMB Data Error Module 32	Replace Module 32
7B	Master IMB Data Error Module 33	Replace Module 33
7C	Master IMB Data Error Module 34	Replace Module 34
7D	Master IMB Data Error Module 35	Replace Module 35
7E	Master IMB Data Error Module 36	Replace Module 36
7F	Master IMB Data Error Module 37	Replace Module 37
80	CED Checksum Error	Replace CED PROM
81	CED CSS Compatibility Index Error	"

Table A.14 Fault Codes – VLM1 *(Continued)*

CODE(H)	FAULT DESCRIPTION	ACTION
82	CED VBC Link Error	Check installation address and VBC linking
83	CED Parity Error	"
84	CED Data Version Error	Check data version switch settings
85	CED Data Error	Replace CED PROM
86	CED Data Error	"
87	CED No Logic States Error	"
88	CED Module Number Error	"
89	CED Slave Kind Error	"
8A	CED Module Compatibility Index Error	"
8B	CED Module Compatibility Index Parity Error	"
8C	CED Module Type Error	"
8D	CED Module Compatibility Index Error	"
8E	CED Module Compatibility Index Parity Error	"
8F	CED Module Type Error	"
90	CED Timer Error	"
91	CED Initial Data Error	"
92	CED Global Data Error	"
93	CED Fixed Data Error	Replace CED PROM
94	CED Variable Data Error	"
95	CED Node Type Error	"
96	CED Depth Error	"
97	CED Pointer Error	"
98	CED Timer Error	"
99	CED Logic Error	"
9A	CED Global Data Error	"
9B	CED Fixed Data Error	"
9C	CED Variable Data Error	"
9D	CED Logic Error	"
9E	CED Backplane Address Error	"
9F	CED Mnemonic Error	"
A0	IMB Data Length Error	Indicates fault on other modules.
A1	IMB Slave Kind Error	"
A2	IMB Communication Time Error	"
A3	IMB Slave Kind Error	"
A4	IMB Module Number Error	"
A5	IMB Parity Error	"
A6	IMB Module Number Error	"
A7	IMB Module Type Error	"
A8	IMB Port Address Range Error	"
A9	IMB Parity Error	"

A

Table A.14 Fault Codes—VLM1 *(Continued)*

CODE(H)	FAULT DESCRIPTION	ACTION
AA	IMB Module Number Error	"
AB	IMB Module Type Error	"
AC	IMB Message Byte Number Error	"
AD	IMB Message Bit Number Error	"
AE	IMB Input Message Length Error	"
AF	IMB Last Pointer Error	"
B0	IMB Module Number Error	"
B1	IMB Module Type Error	"
B2	IMB Module Number Error	"
B3	IMB Module Type Error	"
B4	IMB Message Byte Number Error	"
B5	IMB Message Bit Number Error	Indicates fault on other modules.
B6	IMB Input Message Length Error	"
B7	IMB Last Pointer Error	"
B8	IMB Module Number Error	"
B9	IMB Module Type Error	"
BA	IMB Data Error	"
BB	IMB Module Number Error	"
BC	IMB Module Type Error	"
BD	IMB Message Byte Number Error	"
BE	IMB Message Bit Number Error	"
BF	IMB Output Message Length Error	"
C0	IMB Last Pointer Error	"
C1	IMB Number I/O Bits Error	"
C2	IMB Module Number Error	"
C3	IMB Slave Kind Error	"
C4	IMB Timeout Error	"
C5	IMB Scheduler Error	"
C8	Invalid Timer Error	Replace VLM1
C9	Timer Difference Error	"
CA	Timer Expiry Difference Error	"
CB	Invalid Timer Error	"
CC	Timer Difference Error	"
CD	Timer Expiry Difference Error	"
CE	Timer Data Error	"
D2	Logic Sequence Error	"
D3	Depth Check Error	"
D4	Logic Sequence Error	"
D5	Depth Check Error	"

Table A.14 Fault Codes–VLM1 *(Continued)*

CODE(H)	FAULT DESCRIPTION	ACTION
DC	OPCR Initialise Error	Check supply to OPC. Power off system and restart after 40 seconds. If fault persists replace OPC or OPC PFM
DD	NOPCR Error	Replace VLM1
DE	NOPCR Error	″
DF	Initial Maximum Time Error	″
E0	Initial Minimum Time Error	″
E1	Initial Sequence Error	Replace VLM1
E2	Maximum Time Error	″
E3	Minimum Time Error	″
E4	Sequence Error	″
E6	CED Checksum Error	Replace CED PROM
E7	Comp Read Data Error	Replace VLM1
E8	Comp Read Pointer Error	″
E9	Comp Write Data Error	″
EA	Comp No. Logic States Data Error	″
F0	Number Of Timers Error	″
F1	Number Of Comp Timers Error	″
F2	Cycle Time > 1 sec Error	Too much logic and too many modules–check installation design.
F3	Delay 150 ms Error	Replace VLM1
F4	APPDEL Value Error	″

A.4.3.2 Configuration Element Card (CEC)

None

A.4.3.3 Output Power Card (OPC)

None

A.4.3.4 Vital Backplane Card (VBC)

None.

A

A.4.4 External Connections

All external connections to the VLM1 are made via the OPC PFM which has tails with plugs attached to plug into connectors 4 and 5 on the VBC.

The OPC PFM External Connector is a 15 way plug and socket Klippon type BLA/SLA.

Figure A.16 depicts the external connection details of the OPC PFM.

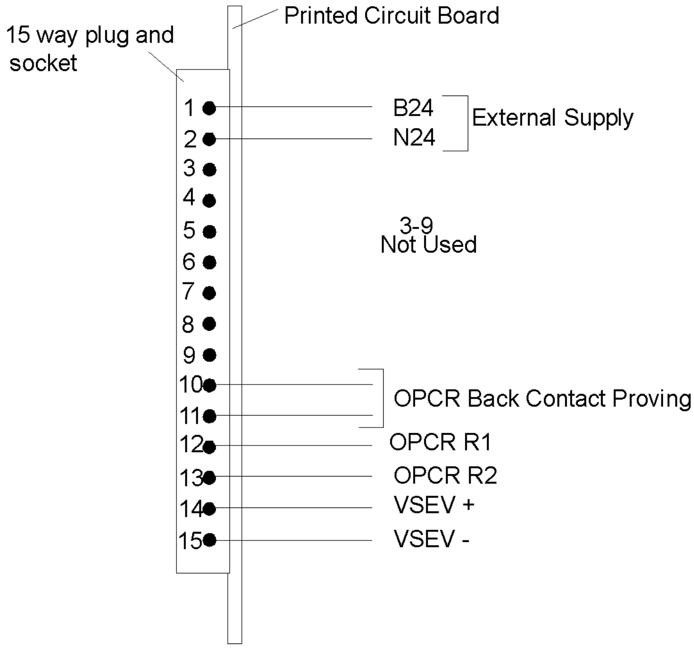


Figure A.16 External Connections—OPC PFM—VLM1

The maximum continuous current that passes in each of the connections is:

24 V supply	4 A
OPCR Drive	0.8 A
VSEV	1 A
OPCR Back Contact	20 mA

A.5 Vital Lamp Output Modules (VLOM)

A.5.1 Description

The VLOM is the interface between WESTRACE and signalling lamps. VLOM outputs directly drive signal lamps and other nominated equipment. The output may be steady, flashing or off.

The VLOM modules with 12 lamp outputs comprise three printed circuit boards:

- VPIO Digital Board (VPIODB);
- two VLOM Analogue Boards (VLOMAB).

A.5.2 Particulars

The VLOM is available with an ac lamp output voltage of 110V. VLOM modules have a flashing output (signified with 'F') and they are available with twelve lamp outputs (signified with 'T'); VLOMFT110.

A.5.3 Characteristics of VLOM 110

Table A.15 Characteristics – VLOM 110

Nominal Signalling Voltage (V_{sig} Input)	110 Vac
External Fuse Protection	3.0 A
Vsig Input (min.)	100 Vac
Vsig Input (max)	130 Vac
Lamp proving current levels	< 100 mA, lamp off > 160 mA, lamp on

A maximum of 26 VLOM modules may be installed in any one system. Refer to the WESTRACE Application Manual for further details.

A.5.4 Function

The VLOM requires an external signalling supply that is switched to source six (or twelve) voltages to drive up to six (or twelve) signalling lamps simultaneously.

The VPIODB is processor based and is responsible for interfacing with both the VLM and the VLOMAB(s). It performs the module's self-tests, housekeeping, monitoring of the analogue card's integrity and Health Monitoring functions.

Lamp Outputs are not isolated from the signalling supply, and use a common return. The VLOM provides Vital Hot filament proving and non-vital cold filament detection.

The VLOM will attempt to isolate an incorrectly energised output by attempting to blow an on-board fuse. If this action is unsuccessful, the VLOM will initiate second negation (shutdown) without delay.

The fuse blowing process is known as *graceful degradation*.

A.5.5 Configuration

None

A.5.6 Indications

A.5.6.1 Start Up

Diagnostic LEDs display module type code, shortly followed by a firmware version code (reflecting the firmware version installed in the module). Firmware version is displayed for approximately 8 seconds, after which all diagnostic LEDs will extinguish.

A.5.6.2 Operation

The module will commence flashing the green watchdog LED to indicate the module is operational and working correctly.

A.5.6.3 Fault Codes

Table A.16 Fault Codes–VLOM

CODE(H)	FAULT DESCRIPTION	ACTION
00	No Fault	Not a fault.
01	Second Negation Error	Indicates a fault on other modules.
02	Module Type Error	Replace VLOM
03	EPROM Checksum Error	"
04	Stack Guard Error	"
05	RAM Error	"
06	Interrupt Error	"
07	Termination Error	"
08	Processor Error	"
09	Stack Error	"
0A	Run Time Error A	"
0B	Run Time Error B	"
0C	Run Time Error C	"
0D	Run Time Error D	"
0E	Run Time Error E	"
0F	Run Time Error F	"
10	Run Time Error G	"
11	Run Time Error H	"
12	Run Time Error I	"
13	Run Time Error J	Replace VLOM
14	Run Time Error K	"
15	Run Time Error L	"
16	Run Time Error M	"
17	Run Time Error N	"

Table A.16 Fault Codes–VLOM *(Continued)*

CODE(H)	FAULT DESCRIPTION	ACTION
18	Run Time Error O	″
19	Run Time Error P	″
1A	Run Time Error Q	″
1B	Run Time Error R	″
1C	Run Time Error S	″
1D	Run Time Error T	″
1E	Run Time Error U	″
1F	Run Time Error V	″
20	Run Time Error W	″
21	Run Time Error X	″
22	Run Time Error Y	″
23	Run Time Error Z	″
24	IMB Timeout Error	″
25	IMB Address Error	″
26	IMB Address Parity Error	″
27	IMB CI Transfer Error	″
28	IMB Transfer Type Error	″
29	IMB Message Length Error	″
2A	IMB True Byte Error	″
2B	IMB Check Message Error	″
2C	IMB Inconsistency Error	″
2D	Health Monitoring Time Error	Indicates a fault on other modules
2E	Health Monitoring Health Error	″
2F	Health Monitoring Scheduling Error	Replace VLOM
30	Module Type and Fault Code Error	″
31	ST IMB Start Up Timeout	″
32	ST IMB Too Few IMB Calls	″
33	ST IMB Too Many IMB Calls	″
34	ST IMB Too Few ST Calls	″
80	Negation Fail Error	Replace VLOM
81	Initialise Program Check Error	″
82	Progress Check Error	″
83	Cycle Time Error	″
84	CPU Speed Error	″
85	Variable Corruption Error	″
8C	Gain Check Offset Base Error	″
8D	Gain Check Offset Ch 1 Error	″
8E	Gain Check Offset Ch 2 Error	″
8F	Gain Check Offset Ch 3 Error	″
90	Gain Check Offset Ch 4 Error	″

A

Table A.16 Fault Codes—VLOM *(Continued)*

CODE(H)	FAULT DESCRIPTION	ACTION
91	Gain Check Offset Ch 5 Error	"
92	Gain Check Offset Ch 6 Error	"
93	Gain Check Offset Ch 7 Error	"
94	Gain Check Offset Ch 8 Error	"
95	Gain Check Offset Ch 9 Error	"
96	Gain Check Offset Ch 10 Error	"
97	Gain Check Offset Ch 11 Error	"
98	Gain Check Offset Ch 12 Error	"
99	Gain Check Detect Base Error	"
9A	Gain Check Detect Ch 1 Error	"
9B	Gain Check Detect Ch 2 Error	"
9C	Gain Check Detect Ch 3 Error	"
9D	Gain Check Detect Ch 4 Error	"
9E	Gain Check Detect Ch 5 Error	"
9F	Gain Check Detect Ch 6 Error	"
A0	Gain Check Detect Ch 7 Error	"
A1	Gain Check Detect Ch 8 Error	"
A2	Gain Check Detect Ch 9 Error	"
A3	Gain Check Detect Ch 10 Error	"
A4	Gain Check Detect Ch 11 Error	"
A5	Gain Check Detect Ch 12 Error	"
AA	ADC Target Error	"
AB	ADC Reference Error	"
BD	Diverse Gain Filter Hi Base Error	Replace VLOM
BE	Diverse Gain Filter Hi Ch 1 Error	"
BF	Diverse Gain Filter Hi Ch 2 Error	"
C0	Diverse Gain Filter Hi Ch 3 Error	"
C1H	Diverse Gain Filter Hi Ch 4 Error	"
C2H	Diverse Gain Filter Hi Ch 5 Error	"
C3	Diverse Gain Filter Hi Ch 6 Error	"
C4	Diverse Gain Filter Hi Ch 7 Error	"
C5	Diverse Gain Filter Hi Ch 8 Error	"
C6	Diverse Gain Filter Hi Ch 9 Error	"
C7H	Diverse Gain Filter Hi Ch 10 Error	"
C8	Diverse Gain Filter Hi Ch 11 Error	"
C9	Diverse Gain Filter Hi Ch 12 Error	"
D7	Ground Test Filter Det Base Error	"
D8	Ground Test Filter Det Brd 1 Error	Check PFM mating with this module, else Replace VLOM or PFM
D9	Ground Test Filter Det Brd 2 Error	Check PFM mating with this module, else Replace VLOM or PFM

Table A.16 Fault Codes–VLOM *(Continued)*

CODE(H)	FAULT DESCRIPTION	ACTION
DA	Ground Test Filter Line Base Error	Replace VLOM
DB	Ground Test Filter Line Brd 1 Error	Check PFM mating with this module, else Replace VLOM or PFM
DC	Ground Test Filter Line Brd 2 Error	Check PFM mating with this module, else Replace VLOM or PFM
EA	True Decode Parity Error	Replace VLOM
EB	Comp Decode Parity Error	"
F0	Gain Check Invalid Data	"
FA	Ground Test Invalid Data	"
FC	Cold Proving Filter Error	"
FD	Cold Proving Lamp Error	"

A

A.5.7 External Connections

External connections to the VLOM are made via the VLOM PFM.

The VLOM PFM External Connector is a 19 way plug and socket Klippon type BLA/SLA.

Figure A.17 depicts the external connection details of the VLOM PFM.

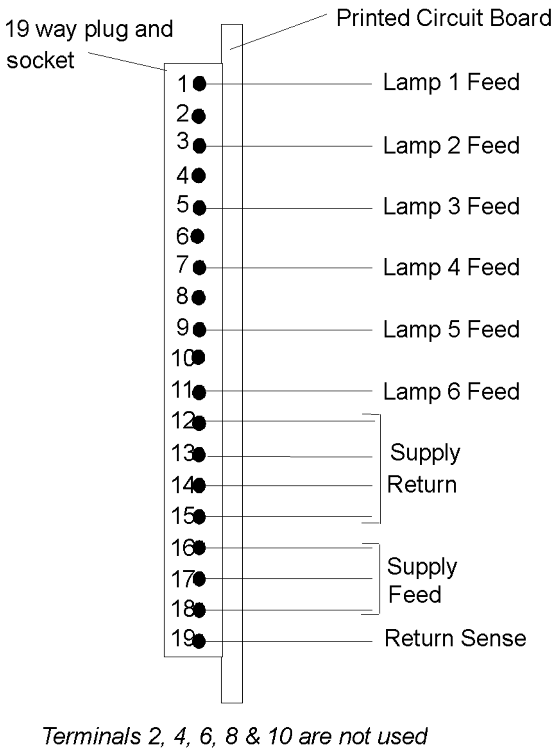


Figure A.17 External Connections–VLOM PFM–VLOM

The Return Sense must be connected to the Supply Return Bus Bar. We recommend that the return sense and supply return be run as a twisted pair.

A.6 Vital Relay Output Modules (VROM)

A.6.1 Description

The VROM directly drives the coils of signalling relays. It is comprised of two printed circuit boards:

- VPIO Digital Board (VPIODB);
- VROM Analogue Board (VROMAB).

A.6.2 Particulars

The VROM is available with a relay output voltage of 50 Vdc.

A.6.3 Characteristics of VROM 50

Table A.17 Characteristics – VROM 50

Nominal Signalling Supply Voltage[1]	50 Vdc
Signalling Supply Input (minimum, trough Voltage)	42 Vdc
Signalling Supply Input (maximum, peak Voltage)	60 Vdc
External Fuse Protection	2.5 A
Output Load	3 W nominal per output 18 W max. continuous output per module

1. Signalling Supply Voltage Ripple must be semi smooth and within the input load minimum and maximum shown.

A.6.4 Function

The VROM requires an external signalling supply from which it generates eight isolated voltage sources to drive up to eight signalling relays simultaneously.

The VPIODB is processor based and it interfaces with the VLM and the VROMAB. It performs self-testing, housekeeping, monitoring of the analogue card's integrity and Health Monitoring functions for the module.

Whenever the VROM detects an incorrectly energised output (according to the internal state), the module will attempt to isolate the particular output by blowing an in-line fuse. If this action is unsuccessful, the VROM will initiate system negation (shutdown) without delay.

The process of fuse blowing is known as *graceful degradation*.

A.6.5 Configuration

None

A.6.6 Indications

A.6.6.1 Start Up

Diagnostic LEDs display the module type code, shortly followed by a firmware version code (reflecting the firmware version installed in the module). The firmware version is displayed for approximately eight seconds, after which all diagnostic LEDs will extinguish.

A.6.6.2 Operation

The module will commence flashing the green watchdog LED to indicate the module is operational and working correctly.

A.6.6.3 Fault Codes

Table A.18 Fault Codes—VROM

CODE(H)	FAULT DESCRIPTION	ACTION
00	No Fault	Not a fault
01	Second Negation Error	Indicates fault on other modules.
02	Module Type Error	Replace VROM
03	EPROM Checksum Error	"
04	Stack Guard Error	"
05	RAM Error	"
06	Interrupt Error	"
07	Termination Error	"
08	Processor Error	"
09	Stack Error	"
0A	Run Time Error A	"
0B	Run Time Error B	"
0C	Run Time Error C	"
0D	Run Time Error D	"
0E	Run Time Error E	"
0F	Run Time Error F	"
10	Run Time Error G	"
11	Run Time Error H	"
12	Run Time Error I	"
13	Run Time Error J	"
14	Run Time Error K	"
15	Run Time Error L	"
16	Run Time Error M	"
17	Run Time Error N	Replace VROM
18	Run Time Error O	"
19	Run Time Error P	"
1A	Run Time Error Q	"

Table A.18 Fault Codes—VROM *(Continued)*

CODE(H)	FAULT DESCRIPTION	ACTION
1B	Run Time Error R	"
1C	Run Time Error S	"
1D	Run Time Error T	"
1E	Run Time Error U	"
1F	Run Time Error V	"
20	Run Time Error W	"
21	Run Time Error X	"
22	Run Time Error Y	"
23	Run Time Error Z	"
24	IMB Timeout Error	"
25	IMB Address Error	"
26	IMB Address Parity Error	"
2B	IMB Check Message Error	"
2C	IMB Inconsistency Error	"
2D	Health Monitoring Time Error	Indicates a fault on other modules
2E	Health Monitoring Health Error	"
2F	Health Monitoring Scheduling Error	Replace VROM
30	Module Type and Fault Code Error	"
31	ST IMB Start Up Timeout	"
32	ST IMB Too Few IMB Calls	"
33	ST IMB Too Many IMB Calls	"
34	ST IMB Too Few ST Calls	"
8C	True IMB Parity Error	"
8D	Comp IMB Parity Error	"
8E	True Channel Status Base Error	"
8F	True Channel Status Ch 1 Error	"
90	True Channel Status Ch 2 Error	"
91	True Channel Status Ch 3 Error	"
92	True Channel Status Ch 4 Error	"
93	True Channel Status Ch 5 Error	"
94	True Channel Status Ch 6 Error	Replace VROM
95	True Channel Status Ch 7 Error	"
96	True Channel Status Ch 8 Error	"
97	Comp Channel Status Base Error	"
98	Comp Channel Status Ch 1 Error	"
99	Comp Channel Status Ch 2 Error	"
9A	Comp Channel Status Ch 3 Error	"
9B	Comp Channel Status Ch 4 Error	"
9C	Comp Channel Status Ch 5 Error	"
9D	Comp Channel Status Ch 6 Error	"

A

Table A.18 Fault Codes—VROM *(Continued)*

CODE(H)	FAULT DESCRIPTION	ACTION
9E	Comp Channel Status Ch 7 Error	"
9F	Comp Channel Status Ch 8 Error	"
A0	ADC Voltage Reference Error	"
A1	ADC Target Failure	"
A2	True Relay Test Base Error	"
A3	True Relay Test Ch 1 Error	"
A4	True Relay Test Ch 2 Error	"
A5	True Relay Test Ch 3 Error	"
A6	True Relay Test Ch 4 Error	"
A7	True Relay Test Ch 5 Error	"
A8	True Relay Test Ch 6 Error	"
A9	True Relay Test Ch 7 Error	"
AA	True Relay Test Ch 8 Error	"
AB	Comp Relay Test Base Error	"
AC	Comp Relay Test Ch 1 Error	"
AD	Comp Relay Test Ch 2 Error	"
AE	Comp Relay Test Ch 3 Error	"
AF	Comp Relay Test Ch 4 Error	"
B0	Comp Relay Test Ch 5 Error	"
B1	Comp Relay Test Ch 6 Error	"
B2	Comp Relay Test Ch 7 Error	"
B3	Comp Relay Test Ch 8 Error	"
B4	U Woggle Test Base Error	"
B5	U Woggle Test Ch 1 Error	"
B6	U Woggle Test Ch 2 Error	Replace VROM
B7	U Woggle Test Ch 3 Error	"
B8	U Woggle Test Ch 4 Error	"
B9	U Woggle Test Ch 5 Error	"
BA	U Woggle Test Ch 6 Error	"
BB	U Woggle Test Ch 7 Error	"
BC	U Woggle Test Ch 8 Error	"
BD	V Woggle Test Bad Result Error	"
BE	V Woggle Test Base Error	"
BF	V Woggle Test Ch 1 Error	"
C0	V Woggle Test Ch 2 Error	"
C1	V Woggle Test Ch 3 Error	"
C2	V Woggle Test Ch 4 Error	"
C3	V Woggle Test Ch 5 Error	"
C4	V Woggle Test Ch 6 Error	"
C5	V Woggle Test Ch 7 Error	"

Table A.18 Fault Codes–VROM *(Continued)*

CODE(H)	FAULT DESCRIPTION	ACTION
C6	V Woggle Test Ch 8 Error	"
C7	Invalid Comp Sample	"
C8	Invalid Comp Relay State	"
C9	Cycle Time Error	"
CA	Invalid Comp Relay State	"
CB	Invalid Comp Relay State	"
CC	Invalid Comp Relay State	"
CD	CPU Speed Error	"
CE	Variable Corruption Error	"
CF	Init Program Check Error	"
D0	Life Program Check Error	"

A.6.7 External Connections

The VROM PFM External Connector is a 19 way plug and socket Klippon type BLA/SLA.

Figure A.18 depicts the external connection details of the VROM PFM.

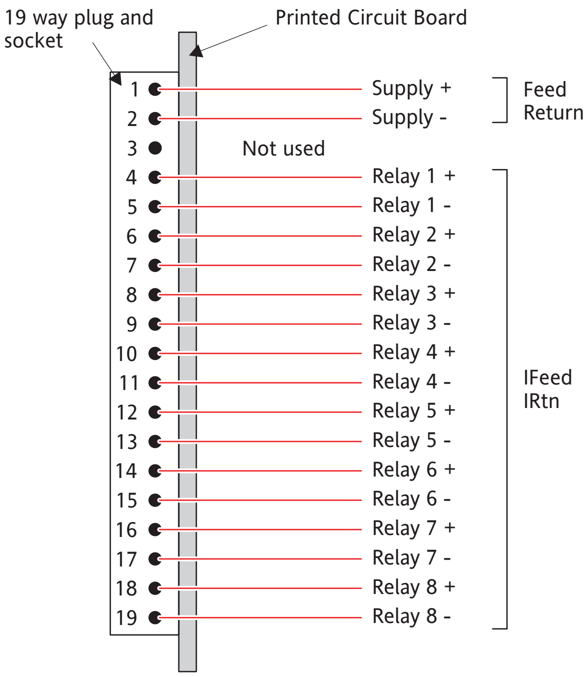


Figure A.18 External Connections–VROM PFM–VROM

A.7 Vital Parallel Input Modules (VPIM)

A.7.1 Description

The VPIM is the interface between WESTRACE and signalling inputs such as point detection and track circuits. VPIM inputs connect directly to external signalling equipment.

The VPIM module is comprised of two printed circuit boards:

- VPIO Digital Board (VPIODB), and;
- VPIM Analogue Board (VPIMAB).

A.7.2 Particulars

The VPIM is available with an input voltage of 50 Vdc.

A.7.3 Characteristics of VPIM 50

Table A.19 Characteristics–VPIM 50

Nominal Voltage	50 Vdc
De-energised Input Voltage range	–100 V to +10.5 V
Energised Input Voltage range	30 V to 100 V

A.7.4 Function

The VPIODB is processor based and it interfaces with the VLM and the VPIMAB. It performs self-testing, housekeeping, monitoring of the analogue card's integrity and Health Monitoring functions for the module.

All VPIM inputs have a non-vital filter to permit operation with inputs with high levels of ac. The VPIM samples the input channels, and rejects any input that is changing at a rate between 45Hz and 11kHz. All inputs to the VPIM are filtered to reject fleeting inputs.

Each VPIM input is individually fused to protect the module from over voltage.

A.7.5 Configuration

None.

A.7.6 Indications

A.7.6.1 Start Up

Diagnostic LEDs display the module type code, shortly followed by a firmware version code (reflecting the firmware version installed in the module). The firmware version is displayed for approximately 8 seconds, after which all diagnostic LEDs will extinguish.

A.7.6.2 Operation

The module will commence flashing the green watchdog LED to indicate the module is operational and working correctly.

A.7.6.3 Fault Codes

Table A.20 Fault Codes—VPIM

CODE(H)	FAULT DESCRIPTION	ACTION
00	No Fault	Not a fault
01	Second Negation Error	Indicates fault in another module
02	Module Type Error	Replace VPIM
03	EPROM Checksum Error	"
04	Stack Guard Error	"
05	RAM Error	"
06	Interrupt Error	"
07	Termination Error	"
08	Processor Error	"
09	Stack Error	"
0A	Run Time Error A	"
0B	Run Time Error B	"
0C	Run Time Error C	"
0D	Run Time Error D	"
0E	Run Time Error E	"
0F	Run Time Error F	"
10	Run Time Error G	"
11	Run Time Error H:	"
12	Run Time Error I	"
13	Run Time Error J	"
14	Run Time Error K	"
15	Run Time Error L	"
16	Run Time Error M	"
17	Run Time Error N	"
18	Run Time Error O	"
19	Run Time Error P	"
1A	Run Time Error Q	"

A

Table A.20 Fault Codes—VPIM *(Continued)*

CODE(H)	FAULT DESCRIPTION	ACTION
1B	Run Time Error R	Replace VPIM
1C	Run Time Error S	"
1D	Run Time Error T	"
1E	Run Time Error U	"
1F	Run Time Error V	"
20	Run Time Error W	"
21	Run Time Error X	"
22	Run Time Error Y	"
23	Run Time Error Z	"
24	IMB Timeout Error	"
25	IMB Address Error	"
26	IMB Address Parity Error	"
27	IMB CI Transfer Error	"
28	IMB Transfer Type Error	"
29	IMB Message Length Error	"
2A	IMB True Byte Error	"
2B	IMB Check Message Error	"
2C	IMB Inconsistency Error	"
2D	Health Monitoring Time Error	Indicates fault in another module
2E	Health Monitoring Health Error	"
2F	Health Monitoring Scheduling Error	Replace VPIM
30	Module Type and Fault Code Error	"
31	ST IMB Start Up Timeout	"
32	ST IMB Too Few IMB Calls	"
33	ST IMB Too Many IMB Calls	"
34	ST IMB Too Few ST Calls	"
B4	Progress Check Error	"
BE	Sampler Spacing Test Error	"
C8	Self Test Error	"
D2	ADC Test Pattern Error	"
DC	ADC Voltage Reference Error	"

A.7.7 External Connections

External connections to the VPIM are made via the VPIM PFM.

The VPIM PFM External Connector is a double stacked 24 way plug and socket Klippon type BLA/SLA.

Figure A.19 depicts the external connection details of the VPIM PFM.

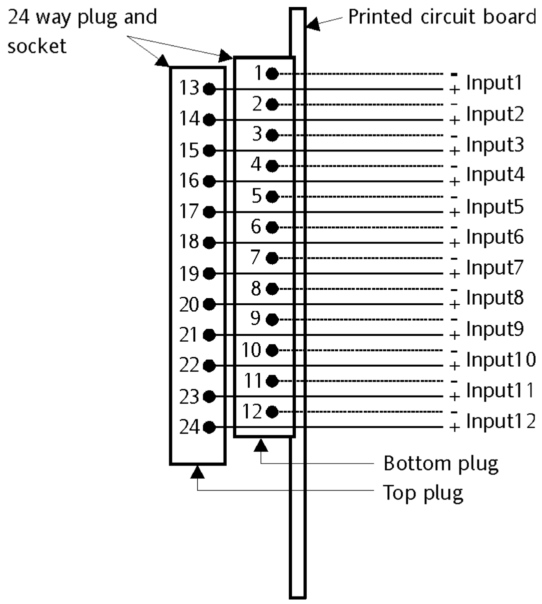


Figure A.19 External Connections–VPIM PFM–VPIM

A.8 Vital Telemetry Continuous Module (VTC)

A.8.1 Description

The VTC module enables vital data communication between two WESTRACE installations by providing continuous data transfer.

A.8.2 Particulars

The VTC is comprised of a single printed circuit board.

It communicates using RS232-C and is configured as a DTE.

The address of the module is defined in the Application Data for the system, held in PROMs on the VLM or CEC where it is used.

A.8.3 Function

The VTC continuously transmits data over a dedicated serial channel to another VTC.

Two forms of the data are transmitted; the True and Complement representations of the data. These messages are formed into code words, and the two code words are transmitted separately over the serial channel.

If in any two second period either VTC fails to receive a correct 'pair of code words' from the serial channel, it will indicate a 'Loss of Input Channel' (LOIC) status to the VLM by setting LOIC to logic state 0. This status will remain until the VTC receives a correct pair of code words.

When LOIC is set to logic state 0, the VLM ensures that all inputs derived from the VTC message are set to logic state 0 to ensure safety. All data received from the VTC during this period is ignored, and will remain so until the LOIC status is set to logic state 1 by the receipt of valid code words.

The VTC derives power for its communication circuits from an external 24 Vdc supply, generated by the OPC (as part of the VLM). This supply is known as the Vital Serial Enable Voltage (VSEV). Removal of this voltage positively prevents the VTC from transmitting and receiving data. This is done when the VLM cannot assure the integrity of the data and hence the safety of the system under failure conditions. Removal of the VSEV occurs simultaneously with de-energising of the OPCR.

The VTC is processor based and it interfaces with the VLM. It performs self-testing, housekeeping and Health Monitoring functions for the module.

Note: ***Do not connect the signal ground line to earth, as this may result in an unsafe condition though the introduction of earth loops and induced earth potentials.***

A.8.4 Configuration

None.

A.8.5 Indications

A.8.5.1 Start Up

Diagnostic LEDs display the module type code, shortly followed by a firmware version code (reflecting the firmware version installed in the module). The firmware version is displayed for approximately 8 seconds, after which all diagnostic LEDs will extinguish.

A.8.5.2 Operation

The module will commence flashing the green watchdog LED to indicate the module is operational and working correctly.

A.8.5.3 Fault Codes

Table A.21 Fault Codes–VTC

CODE(H)	FAULT DESCRIPTION	ACTION
00	No Fault	Not a fault
01	Second Negation Error	Indicates a fault on other modules.
02	Module Type Error	Replace VTC
03	EPROM Checksum Error	"
04	Stack Guard Error	"
05	RAM Error	"
06	Interrupt Error	"
07	Termination Error	"
08	Processor Error	"
09	Stack Error	"
0A	Run Time Error A	"
0B	Run Time Error B	"
0C	Run Time Error C	"
0D	Run Time Error D	"
0E	Run Time Error E	"
0F	Run Time Error F	"
10	Run Time Error G	"
11	Run Time Error H:	"
12	Run Time Error I	"
13	Run Time Error J	"
14	Run Time Error K	Replace VTC
15	Run Time Error L	"
16	Run Time Error M	"
17	Run Time Error N	"
18	Run Time Error O	"

A

Table A.21 Fault Codes—VTC *(Continued)*

CODE(H)	FAULT DESCRIPTION	ACTION
19	Run Time Error P	"
1A	Run Time Error Q	"
1B	Run Time Error R	"
1C	Run Time Error S	"
1D	Run Time Error T	"
1E	Run Time Error U	"
1F	Run Time Error V	"
20	Run Time Error W	"
21	Run Time Error X	"
22	Run Time Error Y	"
23	Run Time Error Z	"
24	IMB Timeout Error	"
25	IMB Address Error	"
26	IMB Address Parity Error	"
27	IMB CI Transfer Error	"
28	IMB Transfer Type Error	"
29	IMB Message Length Error	"
2A	IMB True Byte Error	"
2B	IMB Check Message Error	"
2C	IMB Inconsistency Error	"
2D	Health Monitoring Time Error	Indicates a fault in another module
2E	Health Monitoring Health Error	"
2F	Health Monitoring Scheduling Error	Replace VTC
30	Module Type and Fault Code Error	"
31	ST IMB Start Up Timeout	"
32	ST IMB Too Few IMB Calls	"
33	ST IMB Too Many IMB Calls	"
34	ST IMB Too Few ST Calls	"
80	True IMB Parity Error	"
81	Comp IMB Parity Error	Replace VTC
97	Hardware Timer Error	"
98	Corrupt Data or Operating Error	"
99	Corrupt Data Input	"
9A	Primary Loc Error	"
9B	Corrupt Data or Transmit Error	"
9C	Insufficient Time Lapse	"
9D	True Output Parity Check Error	"
9E	Comp Output Parity Check Error	"

A.8.6 External Connections

External Connections to the VTC are made via the SIO232 PFM.

The SIO232 PFM External Connectors are a DB25 plug and socket for RS232 interface, and a 2 way plug and socket Klippon type BLA/SLA for power.

Figure A.20 depicts the external connection details of the SIO232 PFM.

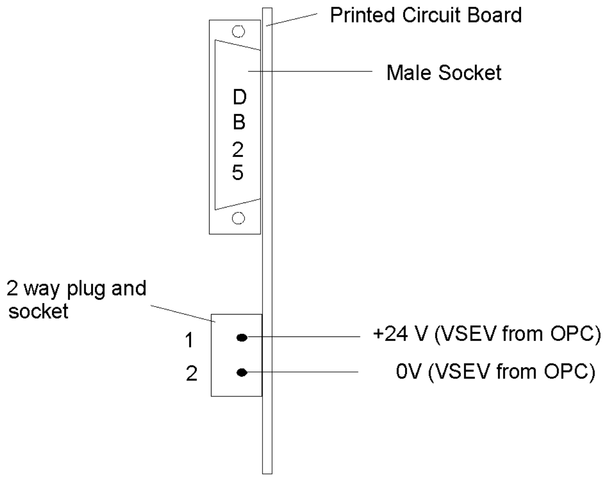


Figure A.20 External Connections–SIO232 PFM–VTC

Table A.22 DB25 Pinout–SIO232 PFM–VTC

Pin	Function
1	Chassis Ground
2	Transmit Data (TxD)
3	Receive Data (RxD)
4	Request to Send (RTS)
5	Clear to Send (CTS)
7	Signal Ground (GND)
8	Data Carrier Detect (DCD)
17	Receive Clock (RXC)
20	Data Terminal Ready (DTR)
24	Transmit Clock (TXC)

This module communicates using RS232-C and is configured as a DTE.

A.9 Enhanced Vital Telemetry Continuous Module (EVTC)

A.9.1 Description

The EVTC enables vital data communication between two WESTRACE installations by providing continuous data transfer between the installations.

Note: ***The EVTC does not work with VLM1.***

A.9.2 Particulars

The EVTC comprises a single printed circuit board.

It communicates using RS232-C and is configured as a DTE.

The address of the module is defined in the Application Data for the system, held in PROMs on the VLM.

A.9.3 Function

The EVTC continuously transmits data over a dedicated serial channel to another EVTC.

Two forms of the data are transmitted; the True and Complement representations of the data. These messages are formed into code words, and the two code words are transmitted separately over the serial channel.

If in any two second period either EVTC fails to receive a correct "pair of code words" from the serial channel, it will indicate a "Loss of Input Channel" (LOIC) status to the HVLM by setting LOIC to logic state 0. This status will remain until the EVTC receives a correct pair of code words.

When LOIC is set to logic state 0, the VLM ensures that all inputs derived from the EVTC message are set to logic state 0 to ensure safety. All data received from the EVTC during this period is ignored, and will remain so until the LOIC status is set to logic state 1 by the receipt of valid code words.

The EVTC derives power for its communication circuits from an external 24 Vdc supply, generated by the OPC (as part of the VLM). This supply is known as the Vital Serial Enable Voltage (VSEV). Removal of this voltage positively prevents the EVTC from transmitting and receiving data. This is done when the VLM cannot assure the integrity of the data and hence the safety of the system under failure conditions. Removal of the VSEV occurs simultaneously with de-energising of the OPCR.

The EVTC is processor based and it interfaces with the VLM. The processor performs self-testing, housekeeping and Health Monitoring functions for the module.

Note: ***Do not connect the signal ground line to earth, as this may result in an unsafe condition though the introduction of earth loops and induced earth potentials.***

A.9.4 Configuration

Transmit Clock

Many PCM systems require Tx and Rx data to be synchronised with the PCM's own transmit clock.

Set the Transmit Clock switch thus:

Switch Position 1 = OFF	Internal clock—used when EVTC is connected a modem.
Switch Position 1 = ON	External clock—used when interfacing to carrier communication systems that require synchronised clocks for both transmitted and received data. The EVTC takes an external receive data clock and generates both the transmit data clock and the transmit data from it. Applies to EVTC module (3650 1129 13) Issue 2.0 or later.

A

A.9.5 Indications

A.9.5.1 Start Up

Diagnostic LEDs display the module type code, shortly followed by a firmware version code (reflecting the firmware version installed in the module). The firmware version is displayed for approximately 8 seconds, after which all diagnostic LEDs will extinguish.

A.9.5.2 Operation

The module will commence flashing the green watchdog LED to indicate the module is operational and working correctly.

A.9.5.3 Fault Codes

Table A.23 Fault Codes—EVTC

CODE(H)	FAULT DESCRIPTION	ACTION
00	No Fault	Not a fault
01	Second Negation Error	Indicates a fault on other modules.
02	Module Type Error	Replace EVTC
03	EPROM Checksum Error	"
04	Stack Guard Error	"
05	RAM Error	"
06	Interrupt Error	"
07	Termination Error	"
08	Processor Error	"
09	Stack Error	"
0A	Run Time Error A	"
0B	Run Time Error B	"
0C	Run Time Error C	"
0D	Run Time Error D	"
0E	Run Time Error E	"
0F	Run Time Error F	"
10	Run Time Error G	"
11	Run Time Error H:	"
12	Run Time Error I	"
13	Run Time Error J	"
14	Run Time Error K	"
15	Run Time Error L	"
16	Run Time Error M	"
17	Run Time Error N	"
18	Run Time Error O	"
19	Run Time Error P	"
1A	Run Time Error Q	"
1B	Run Time Error R	"
1C	Run Time Error S	"
1D	Run Time Error T	"
1E	Run Time Error U	"
1F	Run Time Error V	"
20	Run Time Error W	"
21	Run Time Error X	Replace EVTC
22	Run Time Error Y	"
23	Run Time Error Z	"
24	IMB Timeout Error	"
25	IMB Address Error	"

Table A.23 Fault Codes–EVTC *(Continued)*

CODE(H)	FAULT DESCRIPTION	ACTION
26	IMB Address Parity Error	"
27	IMB CI Transfer Error	"
28	IMB Transfer Type Error	"
29	IMB Message Length Error	"
2A	IMB True Byte Error	"
2B	IMB Check Message Error	"
2C	IMB Inconsistency Error	"
2D	Health Monitoring Time Error	Indicates fault in another module
2E	Health Monitoring Health Error	"
2F	Health Monitoring Scheduling Error	Replace EVTC
30	Module Type and Fault Code Error	"
31	ST IMB Start Up Timeout	"
32	ST IMB Too Few IMB Calls	"
33	ST IMB Too Many IMB Calls	"
34	ST IMB Too Few ST Calls	"
80	True IMB Parity Error	"
81	Comp IMB Parity Error	"
97	Hardware Timer Error	"
98	Corrupt Data or Operating Error	"
99	Corrupt Data Input	"
9A	Primary Loc Error	"
9B	Corrupt Data or Transmit Error	"
9C	Insufficient Time Lapse	"
9D	True Output Parity Check Error	"
9E	Comp Output Parity Check Error	"

A

A.9.6 External Connections

External Connections to the EVTC are made via the SIO232 PFM.

The SIO232 PFM External Connectors are a DB25 plug and socket for RS232 interface, and a 2 way plug and socket Klippon type BLA/SLA for power.

Figure A.21 depicts the external connection details of the SIO232 PFM.

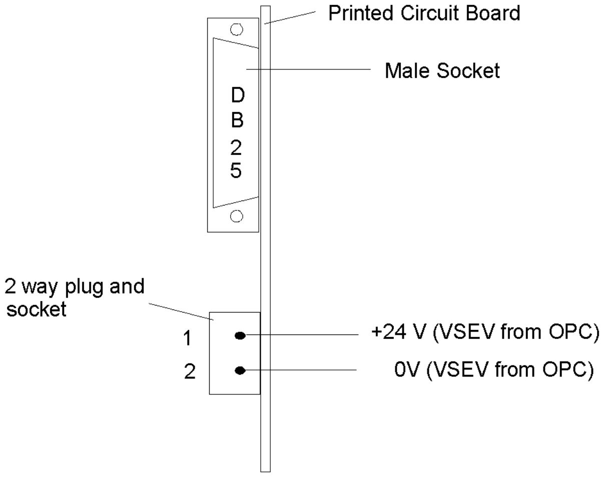


Figure A.21 External Connections–SIO232 PFM–EVTC

Table A.24 DB25 Pinout–SIO232 PFM–EVTC

Pin	Function
1	Chassis Ground
2	Transmit Data (TxD)
3	Receive Data (RxD)
4	Request to Send (RTS)
5	Clear to Send (CTS)
7	Signal Ground (GND)
8	Data Carrier Detect (DCD)
17	Receive Clock (RXC)
20	Data Terminal Ready (DTR)
24	Transmit Clock (TXC)

This module communicates using RS232-C and is configured as DTE.

A.10 WESTECT Communications Module (WCM)

A.10.1 Description

The WCM enables communication of vital signal status information from a WESTECT encoder to WESTECT OBC equipment located on a train.

A.10.2 Particulars

The WCM comprises a single printed circuit board.

It communicates using RS232-C and is configured as a DTE.

A.10.3 Function

The WCM continuously transmits data over a dedicated serial link to track side radio communications equipment as used in the WESTECT ATP system.

Two forms of data are transmitted; the True and Complement representations of the data. These messages are formed into one packet of code words, and the packet is transmitted over the serial channel.

The WCM derives power for its communication circuits from an external 24 Vdc supply, generated by the OPC (as part of the VLM). This supply is known as the Vital Serial Enable Voltage (VSEV). Removal of this voltage positively prevents the WCM from transmitting data. This is done when the VLM cannot assure the integrity of the data and hence the safety of the system under failure conditions. Removal of the VSEV occurs simultaneously with de-energising of the OPCR.

The WCM is processor based and it interfaces with the VLM. It performs the self-testing, housekeeping and Health Monitoring functions for the module.

Note: ***Do not connect the signal ground line to earth, as this may result in an unsafe condition though the introduction of earth loops and induced earth potentials.***

A.10.4 Configuration

None.

A.10.5 Indications

A.10.5.1 Start Up

Diagnostic LEDs display the module type code, shortly followed by a firmware version code (reflecting the firmware version installed in the module). The firmware version is displayed for approximately 8 seconds, after which all diagnostic LEDs will extinguish.

A

A.10.5.2 Operation

The module will commence flashing the green watchdog LED to indicate the module is operational and working correctly.

A.10.5.3 Fault Codes

Table A.25 Fault Codes–WCM

CODE(H)	FAULT DESCRIPTION	ACTION
00	No Fault	Not a fault
01	Second Negation Error	Indicates a fault on other modules.
02	Module Type Error	Replace WCM
03	EPROM Checksum Error	"
04	Stack Guard Error	"
05	RAM Error	"
06	Interrupt Error	"
07	Termination Error	"
08	Processor Error	"
09	Stack Error	"
0A	Run Time Error A	"
0B	Run Time Error B	"
0C	Run Time Error C	"
0D	Run Time Error D	"
0E	Run Time Error E	"
0F	Run Time Error F	"
10	Run Time Error G	"
11	Run Time Error H:	"
12	Run Time Error I	"
13	Run Time Error J	"
14	Run Time Error K	"
15	Run Time Error L	"
16	Run Time Error M	"
17	Run Time Error N	Replace WCM
18	Run Time Error O	"
19	Run Time Error P	"
1A	Run Time Error Q	"
1B	Run Time Error R	"
1C	Run Time Error S	"
1D	Run Time Error T	"
1E	Run Time Error U	"
1F	Run Time Error V	"
20	Run Time Error W	"

Table A.25 Fault Codes—WCM *(Continued)*

CODE(H)	FAULT DESCRIPTION	ACTION
21	Run Time Error X	"
22	Run Time Error Y	"
23	Run Time Error Z	"
24	IMB Timeout Error	"
25	IMB Address Error	"
26	IMB Address Parity Error	"
27	IMB CI Transfer Error	"
28	IMB Transfer Type Error	"
29	IMB Message Length Error	"
2A	IMB True Byte Error	"
2B	IMB Check Message Error	"
2C	IMB Inconsistency Error	"
2D	Health Monitoring Time Error	Indicates fault in another module
2E	Health Monitoring Health Error	"
2F	Health Monitoring Scheduling Error	Replace WCM
30	Module Type and Fault Code Error	"
31	ST IMB Start Up Timeout	"
32	ST IMB Too Few IMB Calls	"
33	ST IMB Too Many IMB Calls	"
34	ST IMB Too Few ST Calls	"
81	Codeword True Order Error	"
82	Codeword Complement Order Error	"
83	Codeword Pair Time Error	"
84	Complement Data Parity Error	"
85	True Data Parity Error	Replace WCM
86	Codeword Count Error	"

A.10.6 External Connections

External Connections to the WCM are made via the SIO232 PFM.

The SIO232 PFM External Connectors are a DB25 plug and socket for RS232 interface, and a 2 way plug and socket Klippon type BLA/SLA for power.

Figure A.22 depicts the external connection details of the SIO232 PFM.

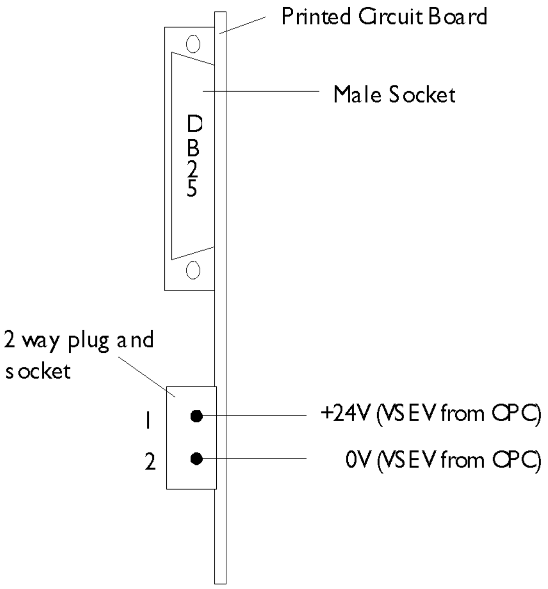


Figure A.22 External Connections–SIO232 PFM–WCM

Table A.26 DB25 Pinout–SIO232 PFM–WCM

Pin	Function
1	Chassis Ground
2	Transmit Data (TxD)
3	Receive Data (RxD)
4	Request to Send (RTS)
5	Clear to Send (CTS)
7	Signal Ground (GND)
8	Data Carrier Detect (DCD)
17	Receive Clock (RXC)
20	Data Terminal Ready (DTR)
24	Transmit Clock (TXC)

This module communicates using RS232-C and is configured as DTE.

A.11 Network Communication Diagnostic Module (NCDM)

A.11.1 Description

The NCDM module provides network and serial interfaces, non-vital logic processing and data logging of time stamped vital and non-vital logic changes and WESTRACE system faults. It may be used as part of a WESTRACE system or as a stand-alone communication and logic processing module.

It has one network port and two external serial ports. The network port and external serial ports are configured for function and communication protocol by the Non-Vital Configuration that is downloaded into non-volatile memory on the module. The physical interface for each external serial port (RS232 or RS485) is configured as part of the communication protocol in the Non-Vital Configuration.

The network can be used for a diagnostic interface. This uses the Diagnostic Protocol and is connected to MoviolaW or NGETLOG.

The serial ports can be used for a diagnostic interface. These use the Diagnostic Protocol and are connected directly or through a modem to MoviolaW or GetLOG. Software packages designed for earlier WESTRACE diagnostic modules (eg DM or DM128) will not work with NCDM.

A maximum of five Diagnostic Protocol (network or serial) Communication Sessions are supported by the NCDM.

The network port can be used for a control system interface. This uses the S2 protocols (WSL or WSA). The WSA/S2 protocol can be configured to operate as a master (client) or slave (server). The NCDM can support up to 16 network sessions for control systems.

The network port can route vital communication between VLM6 modules. The NCDM can support up to 16 vital communication sessions.

The external serial ports can be used for a control system interface. These use the S2 protocols (WSL or WSA) and may be configured to emulate a WSA or WSL S2 field station or a WSA S2 office. Typically, these ports are connected to a local control system (eg WESTCAD), a remote CTC system or an S2 based local panel. The external serial ports can be configured for connection to redundant bearers for external communications availability.

The NCDM has one internal serial port (Production port) available for commissioning purposes to configure the NCDM and upload vital and non-vital configuration data.

Only one NCDM module may be installed in a WESTRACE system. It occupies the slot adjacent to the VLM in housing 1.

Note: ***GCSS v6.0 supports the configuration of NCDM with VLM6 only. The term 'Non-Vital Configuration' equates to 'CED' in older WESTRACE technology.***

A.11.2 Particulars

A.11.2.1 Circuit Boards

The NCDM comprises:

- the main circuit board (NCDC);
- the Network Communication Diagnostic Protection and Filter Module (NCD PFM[4]), which is the PFM for the NCDM.

The NCD PFM supports:

- one 10baseT Ethernet interface, type RJ45;
- two configurable serial ports, RS232-C or RS485 signal level (DB9);
- INCL.

A.11.2.2 External Ports

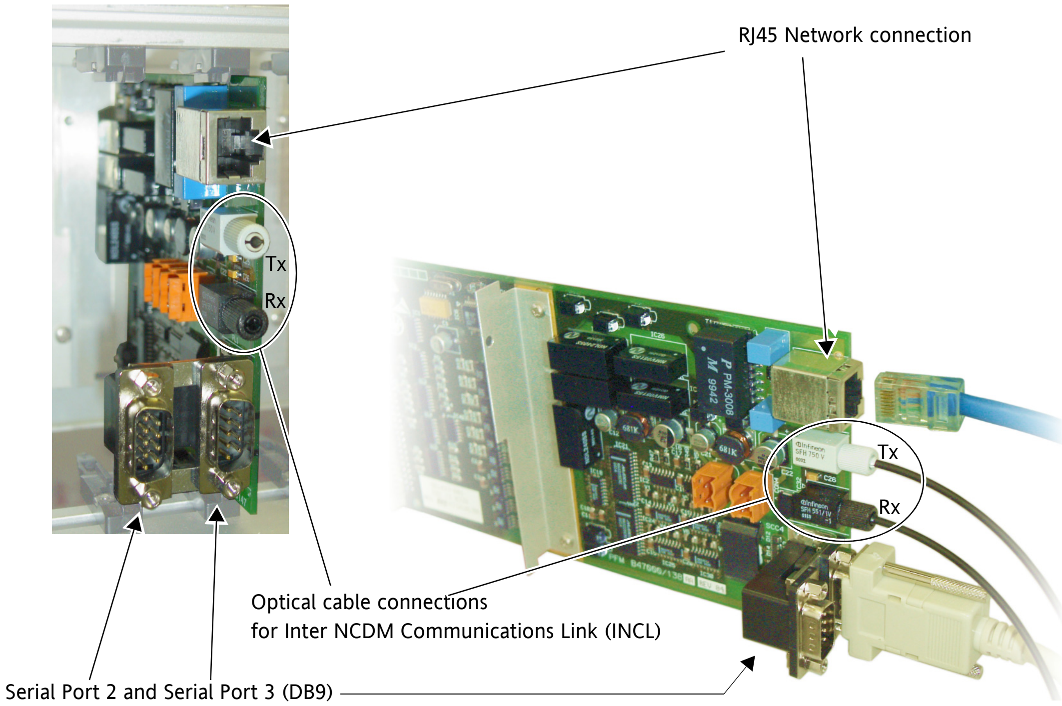
Table A.27 shows how port numbers are allocated. Figure A.23 illustrates the physical port connectors at the rear of the NCD PFM.

Table A.27 Port number allocation – NCDM

Configuration Port No:	Type	Used For
2	Serial 2	Diagnostic or control system connection
3	Serial 3	"
8	IMB	The IMB interface to the VLM (internal)
9	INCL	Inter NCDM Communication Link (Hot Standby)
A	VLM6	Dedicated interface to the VLM6 (internal)
B	Network	Diagnostic, control system or vital communications

[4] There are two styles of NCD PFM – see figure A.23.

Style 1: NCD PFM



Style 2:
NCDC PFM

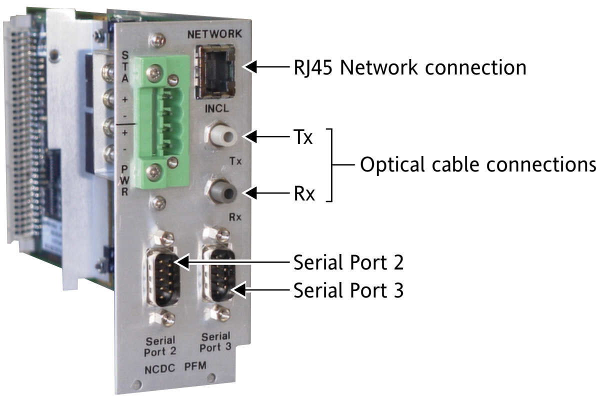


Figure A.23 External Ports on the Two Styles of NCD PFM—NCDM

A.11.2.3 Serial Control System Ports or Network Control System Sessions

Each serial control system port or network control system session can be connected to:

- a control centre;
- a control computer;
- S2 field stations (serial port only);
- WESTRACE Installations (for WESTRACE to WESTRACE non-vital communication).

Network control system sessions are made over a 10 BaseT Ethernet compliant network.

Serial control system connections can be direct through a permanently connected modem or as a duplicated communication pair.

Network Control System Session

Each network control system can be configured as either:

- a slave (server) where the NCDM may be configured with the WSA/S2 or WSL/S2;
- a master (client) where the NCDM may be configured with the WSA/S2.

Individual network control sessions are configured with an individual session ID and an individual S2 address within the S2 address range. At least 16 network control system sessions are supported.

Serial Control System Port

Each Serial Control System port can be configured as either:

- a *slave*, where the NCDM operates as a WSA/S2 or WSL/S2 field station;
- a *master*, where the NCDM operates as a WSA/S2 office.

Serial control ports can appear in a range of S2 addresses.

A.11.2.4 Serial Diagnostic Ports or Network Diagnostic Sessions

Up to five diagnostic communication sessions can be supported by NCDM. These may be a combination of serial diagnostic or network diagnostic sessions.

Network Diagnostic Sessions

Each network diagnostic session operates as an intermittent network connection, where the session is connected to the external diagnostic equipment (eg MoviolaW) only when required.

No fault is logged if the session is logged off, however a fault will be logged if this connection fails while the session is logged on.

Serial Diagnostic Ports

Each serial diagnostic port can be configured as:

a) a permanent direct connection, where the port is connected directly to the external diagnostic equipment (eg MoviolaW).

   A fault will be logged if this connection fails.

b) an intermittent connection, where the port is connected to the external diagnostic equipment only when required.

   No fault will be logged.

c) a dial-in connection, where the port is connected to a Hayes compatible modem. Remote external diagnostic equipment can dial in and interrogate the NCDM.

d) a dial-out connection, where dial-in is not possible, but the NCDM will initiate a dial-out to remote external diagnostic equipment in the event of a fault.

e) a dial-in/out connection which allows both dial-in and dial-out.

For options c), d), and e), a fault will *not* be logged if the external diagnostic equipment hangs up, but will be logged if the NCDM cannot communicate with the modem.

A.11.2.5 Production Port

The Production port is on the front of the module. This port is used for downloading the Non-Vital Configuration from the GCSS and uploading the Non-Vital Configuration and Vital PROM Data to the ICS.

A.11.2.6 Serial Power Supply

The NCDM derives operational power for its serial communication ports from a separate isolated power supply. The isolated power supply input is connected to the installation 24V power supply by the connector CON3. The ports are disabled when this power is not present.

A.11.2.7 Installation Status

The NCDM derives an indication of the status of the installation from an OPCR switched 24 V input.

The installation status input is connected to the installations switched 24V signal by CON4.

The installation status is only used by the NCDM when configured to operate in a hot standby system.

A.11.3 Function

The main functions of the NCDM are:

- Evaluate non-vital logic;
- Route vital communication messages from the associated VLM6 to other WESTRACE installations and from other WESTRACE installations to the associated VLM6;
- Exchange configured non-vital logic states with control centres, control computers, other WESTRACE installations, external WSA/S2 field stations and the vital processor (HVLM128, VLM5 or VLM6);
- Log all changes to vital and non-vital logic states, all detected WESTRACE system faults and other significant operational occurrences (known as 'operations');

  The NCDM can store up to 250,000 change of state events, 200 system faults and 100 operations in non-volatile RAM (NVRAM);

  The logging capacity is 3 days for a small interlocking without an external diagnostic system connected, or 6 hours for a large interlocking without an external diagnostic system connected;

  The NCDM has its own Real Time Clock for time and date stamping of logged events, WESTRACE system faults and operations. The time and date can be set from a control centre or through a diagnostic port;
- Allow an external diagnostic system such as MoviolaW to extract logged data and view current logic states;
- Allow an external system to upload the Non-Vital Configuration data or Vital PROM Data.

Timestamp Synchronisation

Where a system consists of more than one WESTRACE installation, it is important that the time of day in each installation is the same so that their events can be correlated by time.

A typical real time clock will drift by 2 seconds a day, so two installations may drift apart by 4 seconds a day (24 minutes over 12 months).

To ensure time synchronisation of a system consisting of more than one WESTRACE installation, an external diagnostic system should be used to synchronise the installation's clocks by sending regular 'set time' commands.

A.11.4 Operation

The NCDM has four operating modes:

Table A.28 Operating Modes–NCDM

Mode	Description	Indications
Normal	Normal operation.	Watchdog LED flashes: • **green** for stand-alone or on-line operation; • **orange** for standby operation.
Maintenance	Used for downloading a new Non-Vital Configuration.	Watchdog LED flashes **red**. Display shows 'Mnt '
Production	Used for downloading new software.	Watchdog LED **Off**. Display shows 'Prd '.
Shutdown	NCDM has shutdown because of a fatal internal fault.	Watchdog LED not flashing. Display shows a 3-digit fault code.

Unless otherwise specified, the functionality described here relates to Normal mode only.

A.11.4.1 Selecting Maintenance Mode

Maintenance mode is manually selected by either:

- connecting a special 'Maintenance' cable to the Production port and then restarting the NCDM. See section A.11.7.7 for details, or;
- setting one of the on-board switches, then restarting the NCDM (see "SW2 Switch Bank" on page A-97.)

A.11.4.2 Selecting Production Mode

Production mode is selected either:

- automatically, if the NCDM software is detected as being invalid, or;
- manually, using the on-board jumpers on a Mod D Rev 7 NCDC or a pushbutton on a Mod E Rev 8 NCDC, then restarting the NCDM (see "PROD" on page A-96).

A

A.11.5 Configuration

The NCDC is the NCDM's main circuit board. The current style is the Mod D Rev 7 NCDC (figure A.24), on which you set modes using jumper pins.

A.11.5.1 Hardware Settings

Figure A.24 shows the switch banks and jumpers used to configure the Mod D Rev 7 NCDC. Number 1 switch or jumper pin is indicated by a small triangle symbol.

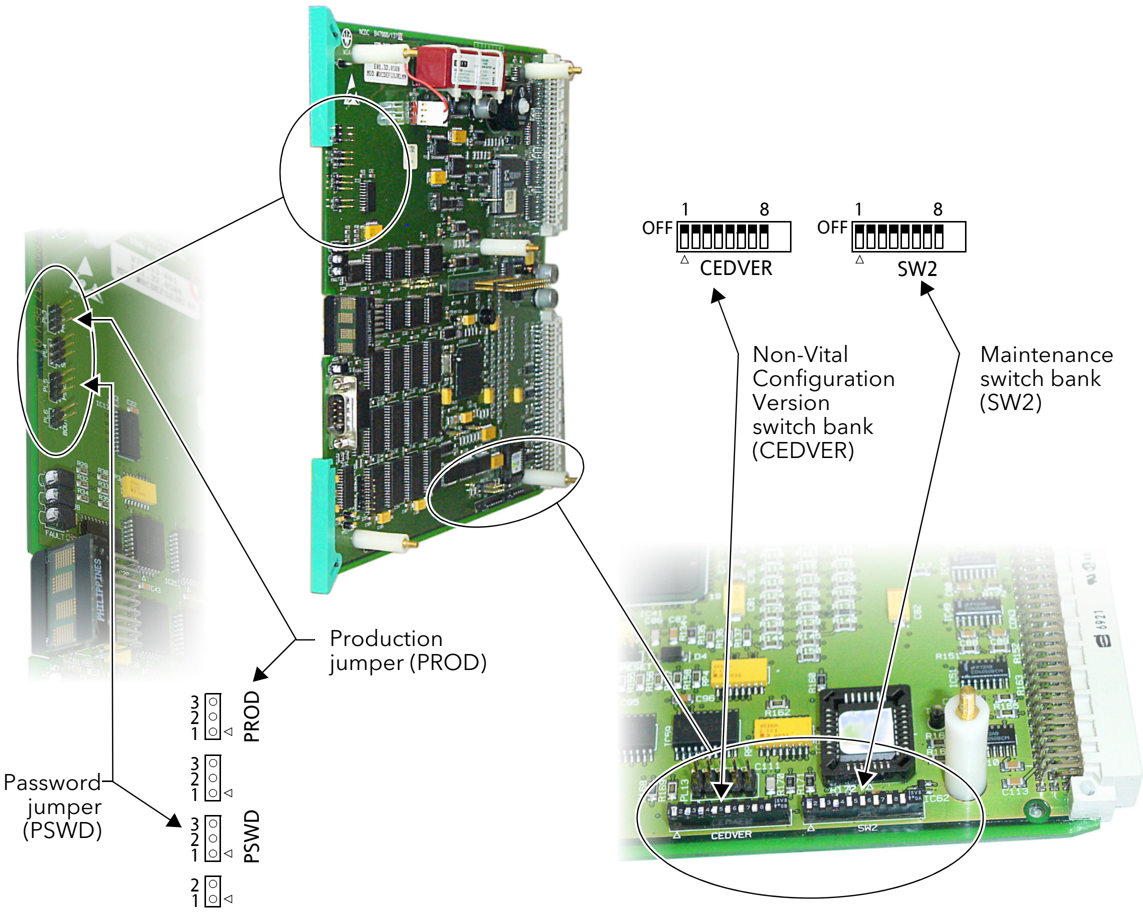


Figure A.24 Configuration Switches and Jumpers—Mod D Rev 7 NCDC

Jumpers and Pushbuttons

PROD

To enter Production mode, short pins 1 & 2 of the PROD jumper together while restarting the NCDM.

PSWD

You can change the Diagnostic Mode passwords during operation of the NCDM. To reset them to the values stored in the Non-Vital Configuration, short pins 1 & 2 of the PSWD jumper together while restarting the NCDM.

Note: ***Store the PROD and PSWD jumpers on pins 2 and 3 when the modes are not set.***

Switches

CEDVER Switch Bank

The NCDM uses the version number set by the CEDVER switch bank to ensure that the correct Non-Vital Configuration is stored in PROM. Switch 1 is the least significant bit and switch ON is zero.

Note: ***CED version is hex coded on the switch bank.***

SW2 Switch Bank

This switch bank is used for the following purposes:

- putting the NCDM into Maintenance mode;
- setting the data transfer rate for the Production port;
- setting the IP Address used in a hot standby system.

Set the switches according to table A.29 and restart the NCDM to activate the desired configuration.

Table A.29 Switch Bank 2–Valid Settings–NCDM

Switch	Setting
1	OFF for Normal mode ON to select Maintenance Mode
2	OFF for 9600 bits per second ON for 115200 bits per second
3	OFF for Secondary IP address ON for Primary IP Address (hot standby system only)
4–8	Not used. Normally left in the **Off** position.

The NCDM will stay in Maintenance mode until switch 1 is returned to OFF and the system is rebooted.

A

A.11.5.2 Non-Vital Configuration

The majority of the NCDM configuration is done using the GCSS and is stored in the Non-Vital Configuration data.

The Non-Vital Configuration includes:

- default passwords;
- initial values for non-vital logic states;
- non-vital application logic and timer details;
- Configuration details for each serial port, such as:

  protocol;
  - basic serial parameters (eg data transfer rate, handshaking, RS 232c or RS 485 signal level);
  - clock signal usage (input, output or reconstructed from data);
  - protocol parameters (eg data word length, addresses, inter-scan delay);
  - default dial-out telephone numbers (diagnostic ports only);
  - I/O bit mappings (control system ports only);
- Configuration details for each network session, such as:

  session ID;
  - protocol;
  - protocol parameters;
  - I/O bit mappings (control system sessions only).

A.11.5.3 Replacing the NCDM

A replacement NCDM must be configured to suit the particular location. Usually this means the replacement must be configured to exactly match the NCDM being replaced.

Before beginning, you must:

a) Obtain permission from the Signaller and adhere to the Railway Authority's safety requirements

b) Power down the WESTRACE installation.

Remove the NCDM from the WESTRACE Housing

a) Remove the front panel of the WESTRACE housing.

b) Observe the anti-static procedures.

c) Remove the NCDM from the housing using the built in card ejectors.

   Where the NCDM is used in a WESTRACE system that includes a VLM6, both the NCDM and VLM6 must be removed.

d) Separate the NCDC from the VLC6.

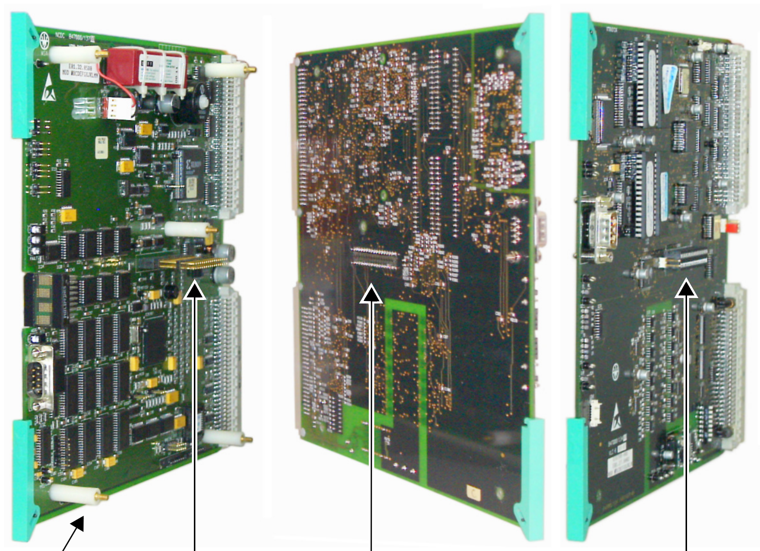


Figure A.25 Separating the NCDC and VLC6

Install the Non-Vital Configuration

There are five parts to this task:

a) Ensuring you have the right equipment;

b) Setting the Non-Vital Configuration version switches on the NCDC;

c) Switching the NCDM to Maintenance Mode;

d) Installing the NCDM into the housing;

e) Down loading the new Non-Vital Configuration to the NCDM.

SAFETY WARNING

WESTRACE must not be controlling an interlocking while downloading a Non-Vital Configuration.
Disconnect the network cable from the NCD PFM prior to power-up of a newly-installed NCDM. Otherwise an unintended IP Address in the NCDM Non-Vital Configuration may cause a shutdown of an adjacent NCDM on the network due to detection of a duplicated IP Address.

Equipment Required

- A personal computer (PC) loaded with:
  - the Graphical Configuration Subsystem (GCSS version 6 or later);
  - the correct Non-Vital Configuration for the NCDM;
  - the Installation Check System (ICS).
- A 'standard' cable as described in figure A.36 to connect the serial port on the PC to the Production port on the NCDC.
  Alternatively, a 'maintenance' cable (figure A.36) may be used. The 'maintenance' cable configuration causes the NCDM to automatically start

in 'Maintenance' mode. See "Setting the Maintenance Mode" (page A-100) and "When the maintenance cable was used to set Maintenance Mode" (page A-101).

- A copy of the WESTRACE Graphical Configuration Subsystem Manual.

Setting Non-Vital Configuration version switches

The NCDM requires that the Non-Vital Configuration version must be that set by the CEDVER switches. This protects against loading an incorrect version. See figure A.26.

Note: ***CED version is hex coded on the CEDVER switch bank.***

Set the switches on the NCDC to define the Non-Vital Configuration version specified on the GCSS printout for the Non-Vital Configuration.

Switch 1 is the least significant bit. Switch ON is zero.

For example, to set Non-Vital Configuration version 1, you set switch 1 OFF and switches 2-8 ON (figure A.26). To set Non-Vital Configuration version 5, switches 1 and 3 are OFF, all others are ON.

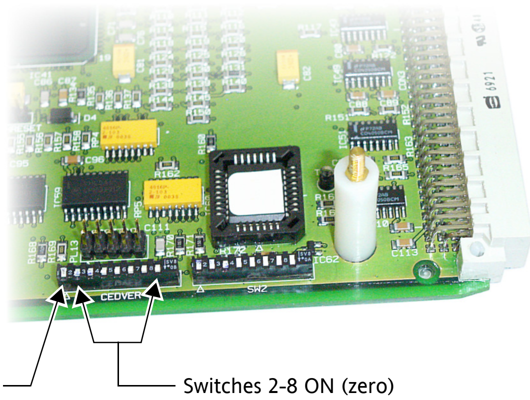


Figure A.26 Setting Non-Vital Configuration—Version 1 Example (Mod D Rev 7 NCDC shown)

Setting the Maintenance Mode

Select 'Maintenance mode' either by connecting a maintenance cable to the Production port, or by setting switch 1 of switch bank SW2 to ON. See section A.11.4.1 for details.

Refitting the NCDM

Refit the NCDM into the housing. Insertion is the reverse of removal described in "Remove the NCDM from the WESTRACE Housing" (page A-98) with the exception of not replacing the front panel.

Downloading the Non-Vital Configuration

a) Connect the cable of choice between the Production port and the PC; see figure A.27.

b) Power up WESTRACE.

Ensure that the NCDM has entered Maintenance mode (the watchdog LED should be flashing red and the fault display should show 'MNT ').

c) Download the Non-Vital Configuration according to the instructions in the WESTRACE Graphical Configuration Subsystem Manual.

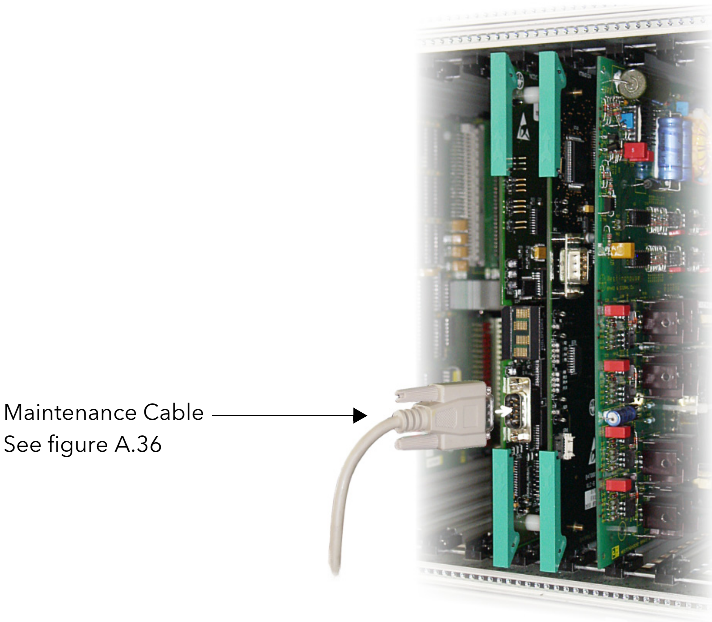


Figure A.27 Production Port – Connecting – NCDM

Verify the Data

The Non-Vital Configuration must be verified before the system is returned to service.

a) Ensure the NCDM is in maintenance mode and the PC is connected to the NCDM Production port;

b) Run ICS according to the instructions in the WESTRACE Installation Check System Manual;

c) Complete procedural checking and sign off as per the WESTRACE Installation Check System Manual.

Restore the System

When the maintenance cable was used to set Maintenance Mode

a) Power down WESTRACE;

b) Remove the cable from the Production port;

c) Refit the front panel to the housing(s);

d) Power up WESTRACE;

e) Allow WESTRACE to run for several minutes; ensure that no fault codes are displayed;

f) Advise the Signaller of completion.

When Switch Bank SW2 was used to set Maintenance Mode

a) Power down WESTRACE.

b) Remove the NCDM from the housing.

c) Set switch 1 of switch bank SW2 to OFF (Maintenance Mode OFF). See figure A.24.

d) Refit the NCDM into the housing. Replacement of the NCDM is the reverse of the procedure described in "Remove the NCDM from the WESTRACE Housing" (page A-98).

e) Refit the front panel to the housing(s).

f) Power up WESTRACE.

g) Allow WESTRACE to run for several minutes; ensure that no fault codes are displayed.

h) Advise the Signaller of completion

A.11.5.4 Battery Installation

A lithium battery is used to maintain logged data in non-volatile memory and the real-time clock when the NCDM is powered down. The battery has a very long life and in normal circumstances it is unlikely to require replacement. The NCDM is usually shipped with the battery connected.

To replace the battery:

a) Have a replacement battery of the same type as the original plus cable ties readily at hand. See figure A.28.

b) Snip the cable ties holding the old battery to the printed circuit board.

c) Remove the battery lead from the pins.

For a standing battery connector (figure A.28), first separate the two circuit boards by removing the five stand-off screws then releasing the connector near the centre of the boards (figure A.25).

d) Connect the replacement battery to the pins. You have a short period to do this before data is lost.

e) Fix the replacement battery to the circuit board using the new cable ties.

f) Snip off the excess length of cable ties.

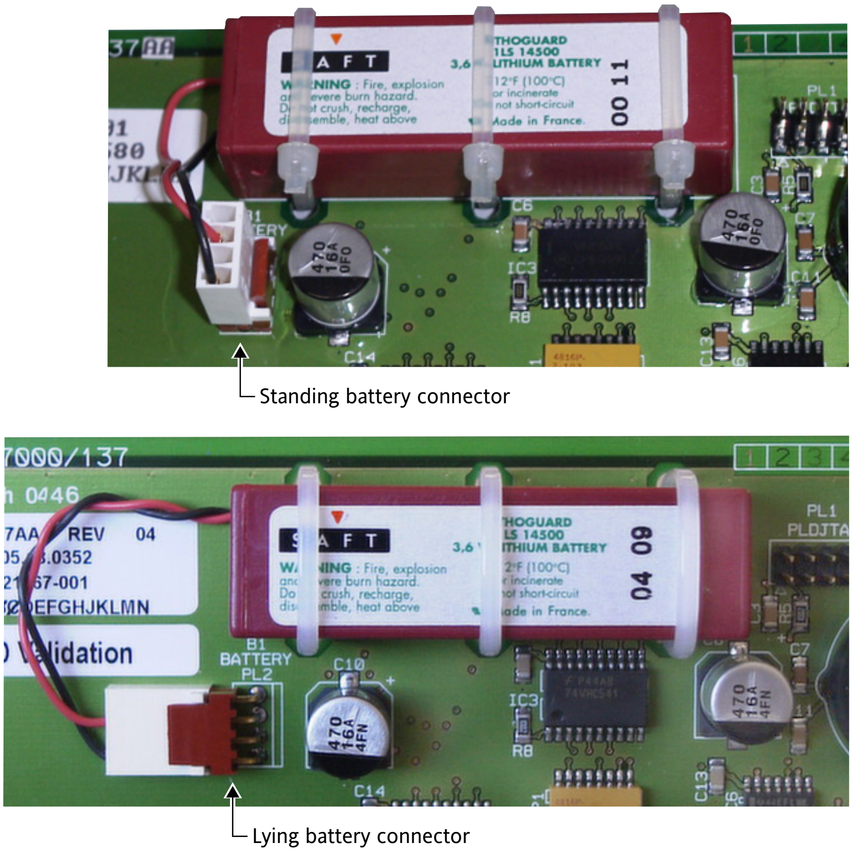


Figure A.28 Lithium Battery—Two Connector Types—NCDM

Handling Lithium Batteries

Observe the instructions elsewhere in this manual.

A.11.6 Indications

The ‘user interface’ of the NCDM comprises LEDs and a four digit alphanumeric display.

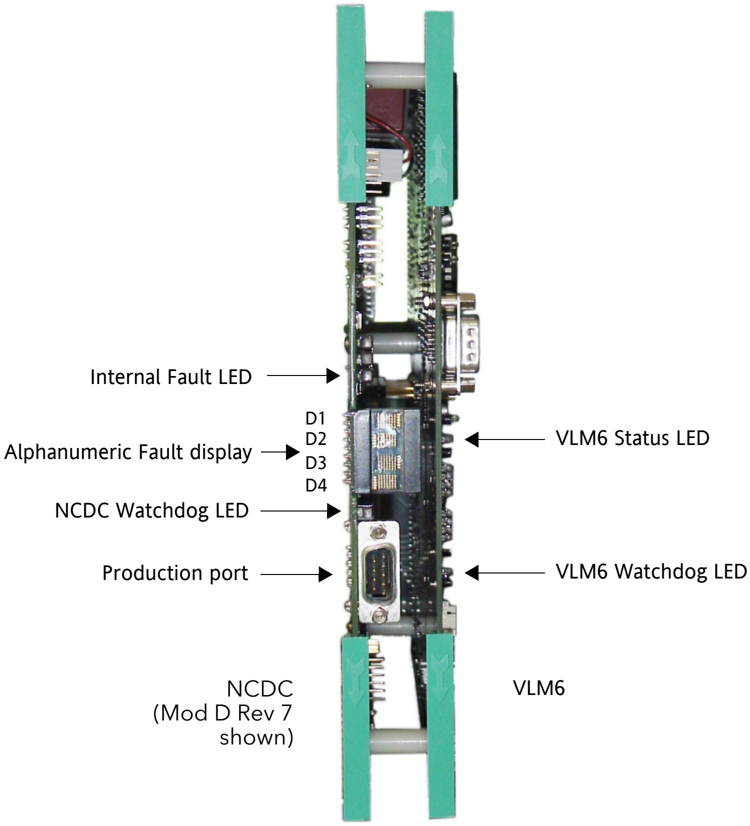


Figure A.29 User Interface–NCDC and VLM6–NCDM

A.11.6.1 Network Communication Diagnostic Card LEDs

The NCDC has two front panel LEDs:

- *Internal fault LED* (red)–illuminated whenever there is a non-fatal internal NCDM fault. These faults require attention, but are not serious enough to cause the NCDM to shutdown;
- *Watch dog LED* (normally green)–flashes at a regular interval if all is well with the NCDM. During the first minute or so of operation, the LED may flash at a faster than normal rate. It should then flash at a similar rate as the watchdog LED on the VLM;

  This LED flashes:

  orange when the NCDM is in the Standby Installation of a Hot Standby System;
  - *red* when the NCDM is in Maintenance mode.

A.11.6.2 NCD PFM LEDs

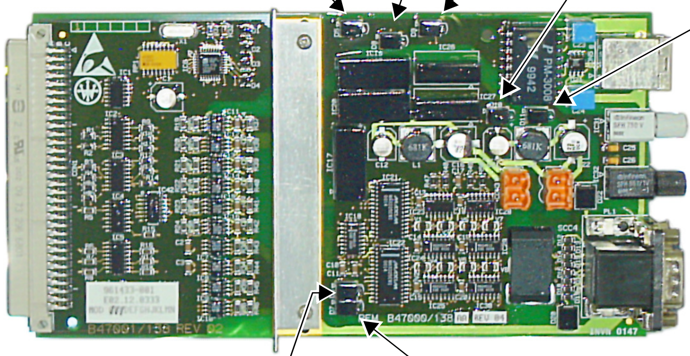


Figure A.30 User Interface–NCD PFM–NCDM

The NCD PFM has 7 LEDs:

- *Serial LED (D6 & D7)*–for each of the 2 serial ports. Flashes red when data is transmitted and flashes green when data is received;
- *Network LED (D5)*–for the network port. Flashes red when data is received and flashes green when data is transmitted;
- *Power Indicator LED (D10 & D11)* (green)–for each of the serial ports. Indicates the +24 V comms power supply is present;
- *Power Indicator LED (D9)* (green)–indicates the +5 V power supply is present;
- *Installation Status LED (D8)* (green)–indicates the NCDM is in the on-line installation.

See section A.11.6.5 for further information about these indicators.

A.11.6.3 Alphanumeric Display

The alphanumeric display can only show one fault at any time. However, all fault codes which occur are logged by the NCDM and can be examined using external diagnostic equipment.

Shutdown Mode

The alphanumeric display will show the applicable fault code if the NCDM shuts down because of an internal fault. See table A.37.

Normal Mode

Within the first 12 seconds of the NCDM operating in this mode, the alphanumeric display will show start-up information (see section A.11.6.4) and then it will be blank unless a fault is detected.

During operation, a 'non-fatal' fault may occur which will cause the NCDM to display a fault code but continue to operate. In the event of multiple faults being present simultaneously, the NCDM will display the code for the first of the following that applies:

a) 'TIME' if the NCDM real time clock has not been set;

b) a non-fatal NCDM fault code, see table A.38;

c) 'FLT 'when more than one non-fatal faults have occurred;

d) 'DIAG' when one or more WESTRACE system faults have not been uploaded by the external diagnostic equipment;

e) 'BAT ' if the NCDM battery voltage is low.

Maintenance Mode

The alphanumeric display will show the following when the NCDM is in this mode:

- 'MNT ' when ready to download a new Non-Vital Configuration;
- progress messages during and after a Non-Vital Configuration download.

A.11.6.4 Start Up

The alphanumeric display shows a sequence of information (in hexadecimal) during start-up.

Table A.30 Start-up Display Sequence – NCDM

Time After Start-up	Information	Details
0–4 secs		Display shows various states followed by 'RUN' to indicate the application software is running.
4–6 secs–	Lamp test	All segments/dots illuminate to verify they are functional.
6–9 secs	Backplane address	Display shows 'A *hh*' where '*hh*' is the backplane address of the slot holding the Network Diagnostic Card (NCDC).
9–12 secs	Software version	Display shows 'V *hh*' where '*hh*' is the version number of the NCDM software.

The NCDM will indicate incompatible application and bootloader software by displaying 'Err '.

A.11.6.5 Operation

A correctly operating NCDM will show the following:

Table A.31 Operation Indicators–Normal–NCDM

Indicator	Condition
Internal Fault LED	Off
Alphanumeric display	Blank
Watchdog LED	Regularly flashing green when in an on-line installation. Regularly flashing orange when in a stand-by installation.
Serial LED(s)	Flashes green when the NCDM is receiving messages though the associated serial port. These LEDs will flash irrespective of whether the message is addressed to the NCDM. Flashes red when the NCDM is transmitting messages through the associated serial port.
Network LED(s)	Flashes green when the NCDM is receiving messages though the associated network port. These LEDs will flash irrespective of whether the message is addressed to the NCDM. Flashes red when the NCDM is transmitting messages through the associated network port.
Power Indicators	Steady green
Installation status	Steady green for on-line installation in stand-by system.

Note: ***The watchdog LED flashes red when the NCDM is in Maintenance mode.***

The Serial and Network LEDs may appear to be ON rather than flashing when the data rate is high.

A.11.6.6 Fault Detection

A.11.6.6.1 WESTRACE Module Faults

During the first 16 seconds after power up, all WESTRACE modules display in sequence via their diagnostic LEDs:

- backplane address;
- software version;
- the value 00 (all LEDs off) to indicate 'no fault'.

During operation, each module will generate a non-zero fault code if a fault is detected.

The NCDM polls each module in turn to read this information, and will record any changes. These changes are stored in the order that they are polled by NCDM, which may not necessarily be the order in which they occurred.

A.11.6.6.2 NCDM Faults

In the event of an internal NCDM fault, the NCDM will either:

- display a code on the alphanumeric display, log a fault, and continue operating. This action is taken for 'non-fatal' faults (such as a comms port failure, low battery, or date/time not set), which do not compromise safe operation of the NCDM;
- shutdown the NCDM and display a code on the alphanumeric display. This action is taken for a 'fatal' fault (such as software or hardware malfunctioning). A fault will be logged when the system is restarted.

When an internal fault is the cause of an NCDM shutdown:

a) the NCDM will lose communications with the VLM;

b) the VLM will display a fault code (typically 34h) because of the communications loss but the VLM will keep running because the NCDM is a non-vital module;

The only way to clear the VLM fault code is to restart the WESTRACE system.

At this point, all NCDM communications ports are disabled and will stay that way until WESTRACE is restarted.

A.11.6.7 Fault Codes

The alphanumeric display comprises four digits; D1, D2, D3 and D4 reading from top to bottom on the display (figure A.31). Figures A.32 to A.34 show the alphanumeric display being read left to right where the left position corresponds with the top position in figure A.29.

D1	D2	D3	D4

Figure A.31 Four Digit Alphanumeric Display—NCDM

The hexadecimal numbers shown by this display identify the following:

- the class of fault (internal NCDM fault, port fault, or module network session fault);
- the port number and module address or network session, if appropriate;
- a code identifying the fault.

Digit D1 identifies the port. The other three digits (D2–D4) display:

- the fault code;
- module address, or;
- network session number.

The following nomenclature is used in the diagrams and tables below:

p	port number (hex)
mm	module or session (hex)
f	fault code (hex)

A.11.6.7.1 Port Faults

Digit D1 identifies the faulty port. Digits D2 and D3 are set to zero and digit D4 is the fault code.

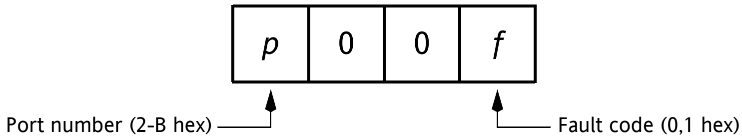


Figure A.32 Alphanumeric Display–Port Fault–NCDM

The port number used are:

2 = Serial port 2;
3 = Serial port 3;
8 = IMB port;
9 = INCL port;
A = VLM6 port;
B = Network port.
For example, **`A001`** indicates a fault code **`1`** on port **`A`** (the VLM6 port).

Port Codes in General

Table A.32 shows valid port fault codes.

Table A.32 Fault Codes–Port Codes in General–NCDM

CODE(H)	FAULT DESCRIPTION	ACTION
*p*000	Port OK	None.
*p*001	Port time out or fail: a. Timeout when waiting for an incoming message (serial server port). b. Failure to get a response from any external server (serial client port). c. Detected failure of Ethernet link (network port)	Serial or network LED flashing green: • check the port configuration in Non-Vital Configuration; • replace the NCDM if the configuration is correct. Serial or network LED off: • check the comms link cabling and connections; • replace the protection module or the NCDC.

External Port, Module and Session Codes

Table A.33 Fault Codes–Ext. Port–Module and Session–NCDM

CODE(H)	FAULT DESCRIPTION	ACTION
A001 8001	VLM6 port time-out. IMB port time-out.	This code is displayed if the VLM shuts down for any reason. Try the following if this code is on display and the VLM is still running: a. Restart WESTRACE. b. Check to ensure the VLM and NCDM Non-Vital Configurations are consistent with respect to transfer states passed between them. Normally GCSS ensures that this is the case. c. Check to ensure that only one NCDM and no DM is installed. d. Replace the NCDM.
9001	INCL port time-out.	An NCDM in an On-line installation displays this code if it does not receive an INCL acknowledgment message from the NCDM in the Stand-by installation. Try the following if this code is on display: a. Check the INCL Rx link to the NCDM in the On-line installation; b. Check the INCL Tx link on the NCDM in the Stand-by installation; c. Replace the NCD PFM in the On-line installation. d. Check the INCL Rx link to the NCDM in the Stand-by installation; e. Check the INCL Tx link on the NCDM in the On-line installation; f. Replace the NCD PFM in the Stand-by installation.

Internal Port Codes

The following code is not displayed. It is reported in the fault log only.

Table A.34 Fault Codes–Internal Port–NCDM

CODE	DESCRIPTION
p000	The port ***p*** has recovered and is now operational.

A.11.6.7.2 Module or Session Faults

Digit D1 identifies the port to which the module-network session is connected. Digits D2 and D3 identify the module address or session number, and digit D4 is the fault code.

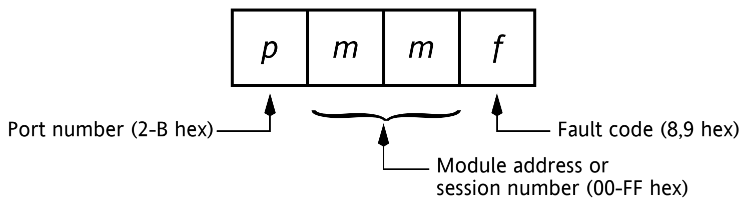


Figure A.33 Alphanumeric Display–Module or Session Fault–NCDM

The NCDM reports on faults for connected module addresses or session numbers. The fault code is interpreted from the alphanumeric display as described here. Module or session faults in the range:

`00-7F` are reported by the NCDM in an on-line WESTRACE,

`80-FF` are reported by the NCDM in a standby WESTRACE.

In all cases, a fault code of zero means 'no fault'.

For example, a fault code of '21B8' on an NCDM indicates a fault code 8 on the module with address 0x1B (serial port 2).

Table A.35 shows valid fault codes.

Table A.35 Fault Codes–Module or Session–NCDM

CODE(H)	FAULT DESCRIPTION	ACTION
***pmm*9**	Communication to an address has timed out. **Slave port**–timeout when waiting for a valid message addressed to address or session ID ***mm*** (hex) on port ***p*** (hex). **Master port–**timeout waiting for a valid response from the S2 field address or session ID ***mm*** (hex) on port ***p*** (hex).	**Slave port** a. Check that the control system master is sending data to this address or session ID. b. Check the addresses or session IDs stored in the Non-Vital Configuration to see if they match the addresses or session IDs sent by the office. **Master port** a. Check that the slave at this address or session ID is functioning correctly. b. Check that the addresses or session IDs stored in the Non-Vital Configuration match those of the connected slave.

Other Module or Session Codes

The following code is not displayed. It is reported in the fault log only.

Table A.36 Fault Codes–Other–Module or Session–NCDM

CODE(H)	DESCRIPTION
***pmm*8**	Address or session ID ***mm*** (hex) on port ***p*** (hex) has recovered from a fault and is now operational.

A.11.6.7.3 Internal faults

Digit D1 is blank and Digits D2 to D4 display the fault code (000-FFF).

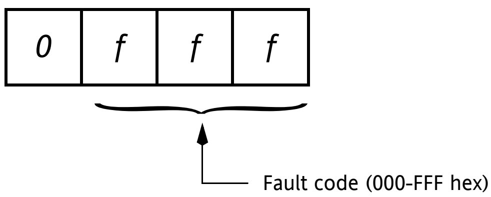


Figure A.34 Alphanumeric Display–Internal Fault–NCDM

The first action should be to restart WESTRACE. Next, find the displayed fault code in the tables below and take the recommended action. All of these fault codes, plus any read from the fault latches of other WESTRACE modules are logged to the NCDM fault buffer in the order they are detected by the NCDM.

Fatal NCDM Fault Codes

These faults cause the NCDM to shut down.

Table A.37 Fault Codes–Fatal–NCDM

CODE(H)	FAULT DESCRIPTION	ACTION
003	Application Checksum Error	Replace NCDM
004	Stack Guard Band Error	"
005	RAM Error	"
009	Stack Error	"
080	Non-Vital Configuration checksum error	Download new Non-Vital Configuration
084	Non-Vital Configuration version number error	Confirm that the version switches are correctly set. Download new Non-Vital Configuration if the switches are correctly set.
100	Build error	a. Check the NCDM configuration parameters for their range and correct any that are out of range. b. Ensure that all WSA/S2 protocol sessions over the network port have unique housing addresses for client and server sessions. c. Ensure that parameters for the vital communication ports (configured for the VLM6) are matched by the NCDM configuration. d. Re-build the NCDM configuration and load it onto an NCDM.
101	Out of memory	Replace NCDM
102	Operating system error	"
103	Internal error	"
104	Task suspended	Replace NCDM
105	NVRAM error	"
107	Comms buffer error	"
108	Non-Vital Configuration format version error	Download new Non-Vital Configuration
109	Watchdog restart	Replace NCDM
10A	No VLM Non-Vital Configuration copy	Restart WESTRACE
10B	Wrong VLM Non-Vital Configuration copy	"
10C	VLM interface versions mismatch	Check the NCDM and VLM Non-Vital Configuration versions.
10D	VLM address mismatch	Check the NCDM Non-Vital Configuration and WESTRACE installation details
10F	Wrong IMB slot	Move NCDM to the correct backplane slot
112	Duplicate IP Address	a. Check the NCDM Non-Vital Configuration for correct IP address. b. Check other equipment connected to the network for a duplicate IP address. In a Stand-by system: Ensure the secondary IP address configuration switch is set correctly.

Table A.37 Fault Codes–Fatal–NCDM *(Continued)*

CODE(H)	FAULT DESCRIPTION	ACTION
113	Duplicate Session Id	a. Ensure that the Application Session Id is unique for all sessions over the network port. b. Ensure that each diagnostic port address is unique and different from any Application Session Id. c. Correct the NCDM configuration where necessary, then re-build it and load it onto an NCDM.

Non-Fatal NCDM Fault Codes

These faults are logged and displayed by the NCDM. The NCDM continues operating.

Table A.38 Fault Codes–Non-Fatal–NCDM

CODE(H)	FAULT DESCRIPTION	ACTION
10E	IMB data error	No action required.
111	Timing error	"
800	NVRAM is invalid.	Could be due to an old or faulty battery. Replace the battery when the error occurs on start-up, otherwise replace the NCDC. Note: NVRAM is always cleared when the NCDM is configured or re-configured; such an error is logged upon first start-up.
801	Event log store was invalid, therefore reset.	"
802	Fault log store was invalid, therefore reset.	"
803	Operations log store was invalid, therefore reset.	"
804	SR Latch output states in NVRAM are invalid.	"
805	Phone numbers in the NVRAM are invalid.	Could be due to an old or faulty battery. Replace the battery when the error occurs on start-up, otherwise replace the NCDC. Note: NVRAM is always cleared when the NCDM is configured or re-configured; such an error is logged upon first start-up.
806	Passwords in the NVRAM are invalid	"
810	Error reading from fault bus or reading from a backplane address. (FDet read error).	Check that all cards are in place and if the error is still persistent, replace the NCDM.
900	Vital message length or small channel port number out of range for messages to VLM6.	Check configuration of vital sessions on the network port.
901	Invalid BCC on non-vital message from VLM6.	Check configuration of the VLM6 interface.
902	Big channel message length out of range on message from VLM6.	"
903	NCDM could not obtain DPRAM semaphore.	Check the VLM6-NCDM interface; replace one or other of the modules.
904	Error in Hot Stand-by INCL.	Check INCL hardware. Ensure that both NCDMs have the same configuration.
90C	Invalid session number.	Ensure the same Session ID is used for connecting installations.
90D	Message delayed.	Check network hardware.
90E	Message repeated or earlier.	"

A

Table A.38 Fault Codes—Non-Fatal—NCDM *(Continued)*

CODE(H)	FAULT DESCRIPTION	ACTION
90F	Session occupied.	Check for unexpected equipment on the network. Ensure that only one remote installation is connected at any time (for same Port ID).
910	Session or IP changed.	No action required.
911	Invalid Rx timestamp.	Check network hardware.
BAT	Low battery	Replace battery
F11	Main cycle not synchronized (NCDM cannot keep up with VLM.)	Check the NCDM and VLM Non-Vital Configurations.
F21	Software version number lost	Replace NCDM
F22	Module information error	"
F23	Fault bus error	"
F24	Fault detection NVRAM error	"
TIME	Time has not been set	Set correct time through MoviolaW, CTC or Getlog. It is possible to set the time via the S2 protocols.
DIAG	There are faults stored in the Fault Buffer.	Connect or check and restart an external diagnostic system and request the fault codes from the Fault Buffer.

Other NCDM Codes

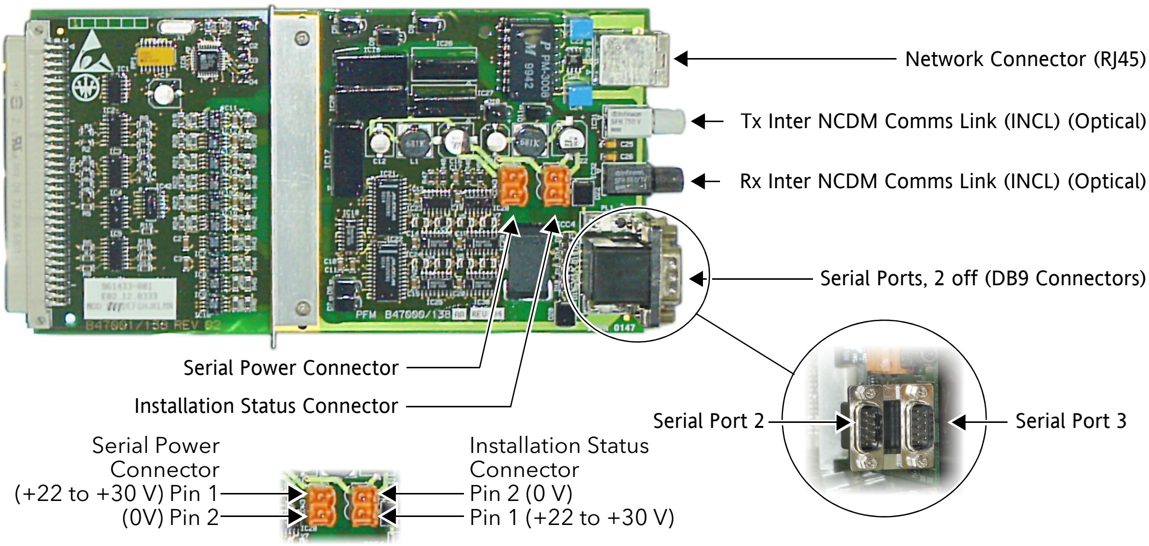
The following codes are not displayed. They are reported in the fault log only.

Table A.39 Fault Codes—Other (Not Displayed)—NCDM

CODE(H)	DESCRIPTION
F00	Recovered from low battery condition
F01	Low battery (corresponds to 'BAT' display)
F10	Recovered from VLM out-of-sync error
F30	Time has been set, i.e. an invalid time/date error has been corrected
F31	Date/time not set (corresponds to 'TIME' display)
F40	Network port re-enabled
F41	Network port disabled
F50	Vital link up
F51	Vital link down

A.11.7 External Connections

Style 1: NCD PFM



Style 2:

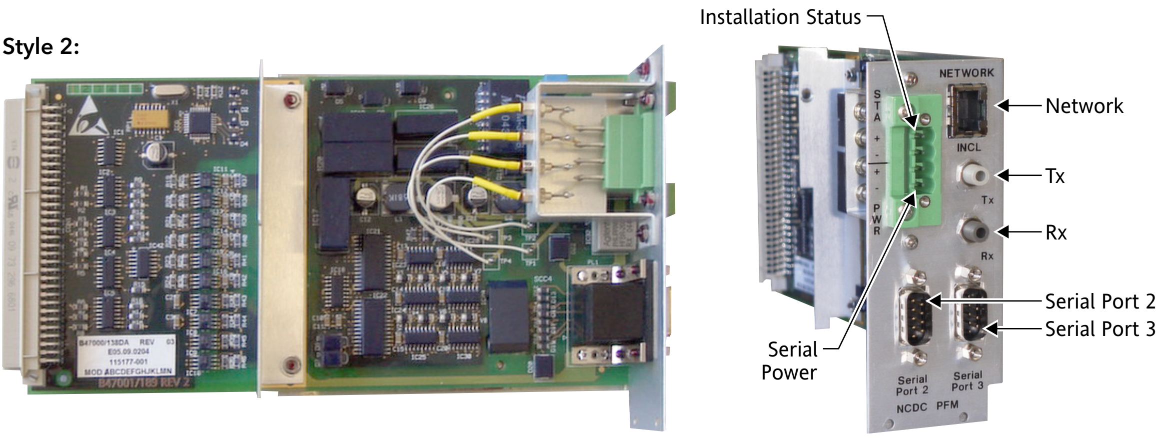


Figure A.35 External Connectors on the Two Styles of NCD PFM–NCDM

A.11.7.1 Serial Power Connector

Table A.40 and figure A.35 show the serial power terminals for a Style 1 NCD PFM (via a Klippon removable screw terminal plug). For Style 2 (NCDC PFM), these terminals are brought to the board's connector panel and labelled **PWR**.

Table A.40 Serial Power Connector Pinout–NCD PFM–NCDM

NCD PFM Pin Number (see figure A.35, Style 1)	Signal
1	+22 to +30 V
2	Common (0V)

See also "NCDC PFM Fusing" on page 3-13.

A.11.7.2 Installation Status Connector

Table A.41 and figure A.35 show the installation status terminals for a Style 1 NCD PFM (via a Klippon removable screw terminal plug). For Style 2 (NCDC PFM), these terminals are brought to the board's connector panel and labelled **STA**.

Table A.41 Installation Status Connector Pinout–NCD PFM–NCDM

NCD PFM Pin Number (see figure A.35, Style 1)	Signal
1	+22 to +30 V
2	Common (0V)

A.11.7.3 Serial Connectors

The serial interface is a pair of male DB9 connectors configured as either RS232 or RS485 (figure A.35). The DB9 on the left is serial port 2, and the DB9 on the right (closest to the PCB) is serial port 3.

RS232-C Connection

Table A.42 DB9 Pinout–RS232 Connection–NCD PFM–NCDM

Pin Number	Signal Name	Signal Source
1	DCD	External equipment
2	RxD	External equipment
3	TxD	NCDM
4	DTR	NCDM
5	ISOGND	(Common)
6	CLKOUT	NCDM
7	RTS	NCDM
8	CTS	External equipment
9	CLKIN	External equipment

RS485 Connection

Table A.43 DB9 Pinout–RS485 Connection–NCD PFM–NCDM

Pin Number	Signal Name	Signal Source
1	RxD-	External equipment
2	RxD+	External equipment
3	TxD+	NCDM
4	TxD-	NCDM
5	ISOGND	(Common)
6	CLKOUT+	NCDM
7	CLKOUT-	NCDM
8	CLKIN-	External equipment
9	CLKIN+	External equipment

A.11.7.4 Network Connector

The network interface is an RJ45 connector with the following configuration:

Table A.44 RJ45 Pinout–Network Connection–NCD PFM–NCDM

Pin Number	Signal Name	Signal Source
1	Tx+	NCDM
2	Tx-	NCDM
3	Rx+	External Equipment
4	Not used	-
5	Not used	-
6	Rx-	External Equipment
7	Not used	-
8	Not used	-

A.11.7.5 INCL Connector

The INCL interface comprises a transmit (White) and receive (Black) fibre optic connectors. Figure A.35 shows these connectors. The INCL interface is designed for a 2.2 mm outside diameter fibre with a 1 mm polymer fibre core. The transmitter and receiver connections are designed such that no special tooling is required to achieve optical termination.

A

Note: ***Take extreme care not to damage the INCL fibre-optic cables. These cables are fragile, and sharp bends can stress or fracture them, causing high losses or intermittent communications.***

A.11.7.6 Production Port

This port is a male DB9 connector on the front edge of the card (see figure A.27). Signal levels are to RS232-C standard and the connector pinout is shown in table A.45. This port is only enabled when the NCDM is in Maintenance mode.

Table A.45 DB9 Pinout–Production Port–NCDM

Pin Number	Signal	Comments
1	N/C	
2	RxD input	
3	TxD output	
4	N/C	
5	Common	
6	N/C	
7	RTS output	Always active
8	MAINT input	Selects maintenance mode
9	SPEED input	Selects maintenance mode data transfer rate

A.11.7.7 Cabling Details

A cable with any of the configurations in figure A.36 will allow a personal computer to connect to the:

- Production port (a DB9 connector on the front edge of the NCDC);
- Serial diagnostic port, if configured (a DB9 connector at the rear of the housing).

Either a standard serial cable or a maintenance cable can be connected to the diagnostic port. The interconnection of pins 7, 8 and 9 on the maintenance cable has no effect when connected to a serial diagnostic port.

Plugging a maintenance cable into the Production port and restarting the WESTRACE installation will cause the NCDM to switch to its Maintenance Mode of operation. The wiring of the cable determines the data transfer rate as follows:

- A maintenance cable with interconnection of pins 7, 8 *and* 9 will cause the NCDM to select the 115 kbps data transfer rate;
- A maintenance cable *without* pin 9 connected to pins 7 and 8 will cause the NCDM to select the 9.6 kbps data transfer rate.

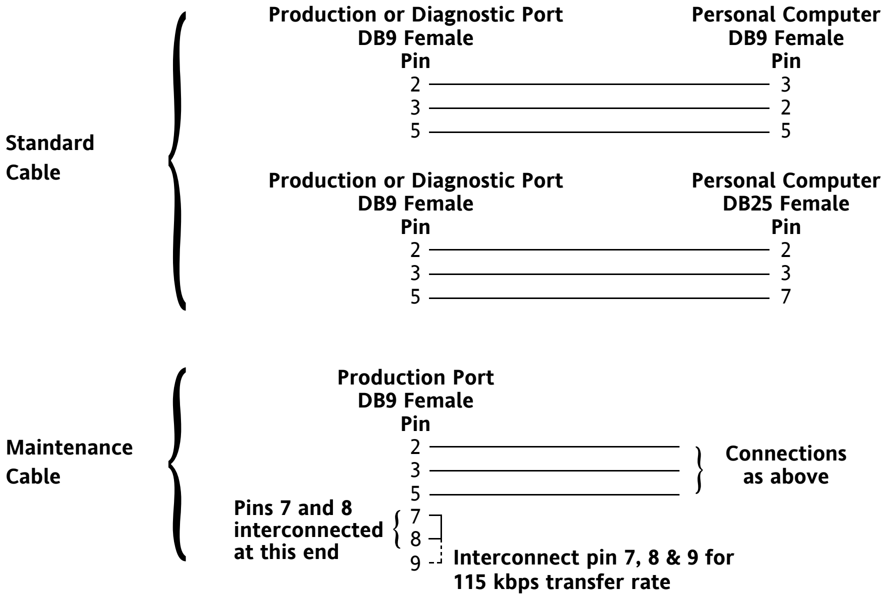


Figure A.36 Cable Configuration Details—NCDM

A.11.7.8 Connecting a Diagnostic System

Most WESTRACE installations will have a permanently connected MoviolaW. An installation can be configured to allow remote access via Hayes compatible modem or through the network.

Types of Diagnostic System

Two diagnostic systems are available:

- MoviolaW—Windows based logging and display utility;

Provides the following services:

- Real time graphical display of the state of the interlocking;
- Records for later playback, events (logic state changes) which occur after MoviolaW commences running;
- Extraction of historical fault information from an NCDM (although not historical event or operation information);
- Basic maintenance functions such as setting the time and displaying communication statistics;

- GETLOG—a command line utility for serial communications, NGETLOG—a command line utility for network communications;

  Provide the following services:

  - Extraction of historical and real time event, fault and operation information which is displayed and stored in text form;
  - Basic maintenance functions such as setting the time and displaying communication statistics;
  - Simpler to install and configure than MoviolaW;
  - Can support larger systems than MoviolaW.

Requirements

You will need:

- A personal computer (PC) loaded with MoviolaW or GETLOG or NGETLOG;
- The MoviolaW display files for the particular installation, plus the following configuration files:
  - `*.ins` (for vital installation);
  - `*.ncd` (for non-vital (NCDM) installation);
  - `*.wip` (for both vital and non-vital installations);
  - `*.imp` (for vital installation).
- For GETLOG and NGETLOG, it is useful to have the Vital and Non-Vital Configuration image (`.img`) files for the installation;
- The passwords for accessing the particular NCDM;

  For MoviolaW, the passwords for a particular NCDM are stored in the MoviolaW `.ini` file, and are configured using the MoviolaW NCDM driver software;

  For GETLOG and NGETLOG, the password must be specified on the command line;
- A cable to connect between:
  - the serial port(s) on the PC and the serial Diagnostic port (figure A.36), or;
  - the network port on the PC and a network hub associated with the WESTRACE installation;
- The user manual for the chosen diagnostic system.

Procedure

a) Connect the PC to a configured diagnostic port or network session at the rear of the housing. See figure A.35 and refer to the local documentation;

b) Start up the chosen diagnostic system;

c) Follow the guidelines for fault finding.

A.12 Non-vital Communications and Diagnostic Module (NVC/DM)

A.12.1 Description

The NVC/DM module provides multiple serial interfaces, non-vital logic processing and data logging of time stamped vital and non-vital logic changes and WESTRACE system faults. It may be used as part of a WESTRACE system or as a stand-alone communication and logic processing module.

It has one configuration communication port and up to six external I/O ports. Each port is configured for function and communication protocol by the Non-Vital Configuration that is downloaded into non-volatile memory on the module. The physical interface for each port is configured by a separate plug-on daughter board.

Up to three of the ports can be used for a diagnostic interface. These use the Diagnostic protocol and are connected directly or through a modem to MoviolaW or GETLOG. Software packages designed for earlier WESTRACE diagnostic modules (eg DM and DM128) will not work with NVC/DM.

The remaining ports use either S2 protocol (WSL or WSA) and may be configured to emulate a WESTRONIC S2 field station or a WSA S2 office. Typically, these ports are connected to a local control system (eg WESTCAD), a remote CTC system or an S2 based local panel. The ports may be configured for connection to redundant bearers for external communications availability.

Only one NVC/DM module may be installed in a WESTRACE system. Normally it occupies the two slots (4 and 5) adjacent to the VLM in housing 1.

Note:

The NVC/DM only works with the HVLM128 and VLM5.

The NVC/DM has been validated for Hot Standby operation but only as a diagnostic module (emulating a DM128 or DM5).

The term 'Non-Vital Configuration' equates to 'CED' for older WESTRACE technology.

A.12.2 Particulars

A.12.2.1 Circuit Boards

The NVC/DM comprises:

- two main circuit boards:
  - Logic Evaluation Card (LEC);
  - Communications Interface Module Filter and Interface Module (CIMFIM);
- up to six I/O daughter boards;
- the Communications Interface Module Protection Module (CIMPM) which is the PFM for the NVC/DM.

Each daughter board:

- provides the physical interface for either a diagnostic or telemetry serial port;
- provides either of RS232-C or RS485 signal levels, type SDB232 and SDB485 respectively.

A.12.2.2 External Ports

Table A.46 shows how port numbers are allocated. Figure A.49 illustrates the physical port connectors at the rear of the CIMPM.

Table A.46 Allocation of Port Numbers – NVCD/DM

Port No:[1]	Type	Used For
1	-	Do not use
2	Serial	Diagnostic or non-vital telemetry connection
3	"	"
4	"	"
5	"	Non-vital telemetry connection only
6	"	"
7	"	"
8	IMB	The IMB interface to the VLM (internal)

1. See figure A.49.

Telemetry Ports

Each telemetry port can be connected to:

- a control centre;
- a control computer;
- S2 field stations.

Telemetry connections can be direct through a permanently connected modem.

Each telemetry port may be configured as either:

- a *slave port*, where the NVC/DM operates as a WSA/S2 or WSL/S2 field station;
- a *master port*, where the NVC/DM operates as a WSA/S2 office.

NVC/DM telemetry ports can appear as a range of S2 addresses.

Diagnostic Ports

Each diagnostic port can be configured as:

a) a permanent direct connection, where the port is connected directly to the external diagnostic equipment (eg MoviolaW);

   A fault will be logged if this connection fails;

b) an intermittent connection, where the port is connected to the external diagnostic equipment only when required;

   No fault will be logged;

c) a dial-in connection, where the port is connected to a Hayes compatible modem. Remote external diagnostic equipment can dial in and interrogate the NVC/DM;

d) a dial-out connection, where dial-in is not possible, but the NVC/DM will initiate a dial-out to remote external diagnostic equipment in the event of a fault;

e) a dial-in/out connection which allows both dial-in and dial-out.

For options c), d), and e), a fault will *not* be logged if the external diagnostic equipment hangs up, but will be logged if the NVC/DM cannot communicate with the modem.

A.12.2.3 Production Port

The Production Port is on the front of the module. This port is used for downloading the Non-Vital Configuration from the GCSS and uploading the Non-Vital Configuration and Vital PROM Data to the ICS.

A.12.2.4 Serial Power Supply

The NVC/DM derives operational power for its communication ports from a separate isolated power supply. The ports are disabled when this power is not present.

A.12.3 Function

The main functions of the NVC/DM are:

- Evaluate non-vital logic;
- Exchange configured logic states with control centres, control computers, external WSA/S2 field stations and the vital processor (HVLM128 or VLM5);
- Log all changes to vital and non-vital logic states, all detected WESTRACE system faults and other significant operational occurrences (known as 'operations');

  The NVC/DM can store up to 250,000 change of state events, 200 system faults and 100 operations in non-volatile RAM (NVRAM);

  The logging capacity is 3 days for a small interlocking without an external diagnostic system connected, or 6 hours for a large interlocking without an external diagnostic system connected;

  The NVC/DM has its own Real Time Clock for time and date stamping of logged events, WESTRACE system faults and operations. The time and date can be set from a control centre or through a diagnostic port;
- Allow an external diagnostic system such as MoviolaW to extract logged data and view current logic states;
- Allow an external system to upload the Non-Vital Configuration and Vital PROM Data.

Timestamp Synchronisation

Where a system consists of more than one WESTRACE installation, it is important that the time of day in each installation is the same so that their events can be correlated by time.

A typical real time clock will drift by 2 seconds a day, so two installations may drift apart by 4 seconds a day (24 minutes over 12 months).

To ensure time synchronisation of a system consisting of more than one WESTRACE installation, an external diagnostic system should be used to synchronise the installation's clocks by sending regular 'set time' commands.

A.12.4 Operation

The NVC/DM has four operating modes:

Table A.47 Operating Modes—NVC/DM

Mode	Description	Indications
Normal	Normal operation.	Watchdog LED flashes **green**.
Maintenance	Used for downloading a new Non-Vital Configuration.	Watchdog LED flashes **red**.
Production	Used for downloading new firmware.	Watchdog LED **off**. Display shows **Prd**.
Shutdown	NVC/DM has shutdown because of a fatal internal fault.	Watchdog LED not flashing. Display shows a 3-digit fault code.

Unless otherwise specified, the functionality described here relates to Normal mode only.

A.12.4.1 Selecting Maintenance Mode

Maintenance mode is manually selected by either:

a) connecting a special 'Maintenance' cable to the Production Port and then restarting the NVC/DM. See section A.12.7.4 for details;

b) setting one of the on-board switches and then restarting the NVC/DM. See figure A.37, and "S2 Switch Bank" on page A-127.

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A.12.4.2 Selecting Production Mode

Production mode is selected either:

- automatically, if the NVC/DM firmware is detected as being invalid, or;
- manually, by setting one of the on-board jumpers and then restarting the NVC/DM. See "PROD Jumper" (page A-126).

A.12.5 Configuration

A.12.5.1 Hardware Settings

Figure A.37 illustrates the switch banks and jumpers used to configure the NVC/DM. Number 1 switch or jumper pin is indicated by a small triangle symbol in each case.

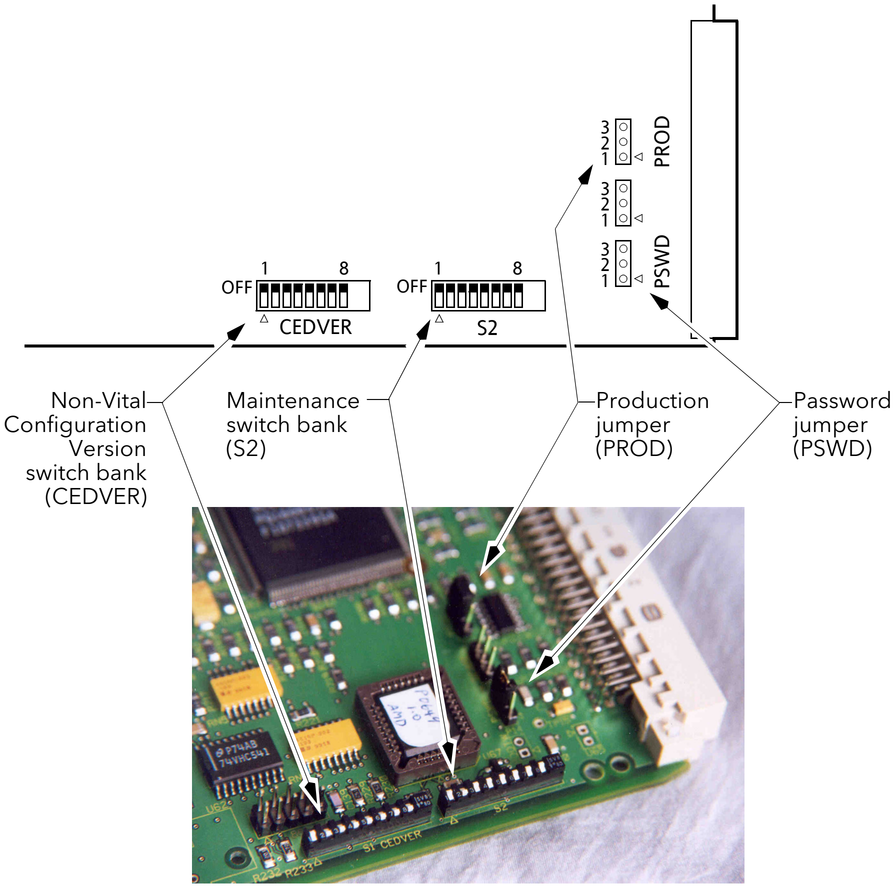

Figure A.37 Configuration Switches and Jumpers—NVC/DM

Jumpers

PROD Jumper

Production mode is entered by shorting pins 1 & 2 of the PROD jumper and then restarting the NVC/DM.

PSWD Jumper

The Diagnostic Mode passwords can be changed during operation of the NVC/DM. They can be reset to the values stored in the Non-Vital Configuration by shorting pins 1 & 2 of the PSWD jumper and then restarting the NVC/DM.

Note: ***Store the PROD and PSWD jumpers on pins 2 and 3 when the modes are not set.***

Switches

CEDVER Switch Bank

The NVC/DM uses the version number set by the CEDVER switch bank to ensure the correct Non-Vital Configuration is stored in PROM. Switch 1 is the least significant bit and switch ON is zero.

S2 Switch Bank

This switch bank is used for two purposes:

- putting the NVC/DM into Maintenance mode;
- setting the data transfer rate for the Production Port.

Set the switches according to table A.48 and restart the NVC/DM to activate the desired configuration.

Table A.48 Switch Bank S2—Valid Settings—NVC/DM

Switch	Setting
1	OFF for Normal mode ON to select Maintenance Mode
2	OFF for 9600 bits per second ON for 115200 bits per second
3-8	Not used; normally left in the OFF position

The NVC/DM will stay in Maintenance mode until switch 1 is returned to OFF and the system is rebooted.

A.12.5.2 Non-Vital Configuration

The majority of the NVC/DM configuration is done using the GCSS and is stored in the Non-Vital Configuration.

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The Non-Vital Configuration includes:

- default passwords;
- initial states of non-vital logic states;
- non-vital application logic and timer details;
- Configuration details for each port, such as:
  protocol;
  - basic serial parameters (eg data transfer rate, handshaking);
  - clock signal usage (input, output or reconstructed from data);
  - protocol parameters (eg data word length, addresses, inter-scan delay);
  - default dial-out telephone numbers (diagnostic ports only);
  - I/O bit mappings (telemetry ports only).

A.12.5.3 Replacing the NVC/DM

A replacement NVC/DM must be configured to suit the particular location. Usually this means the replacement must be configured to exactly match the NVC/DM being replaced.

Before beginning, you must:

a) Obtain permission from the Signaller and adhere to the Railway Authority's safety requirements;

b) Power down the WESTRACE installation.

Remove the NVC/DM from the WESTRACE Housing

a) Remove the front panel of the WESTRACE housing;

b) Observe the anti-static procedures;

c) Remove the NVC/DM from the housing using the WESTRACE card extraction tool. See figure A.38.

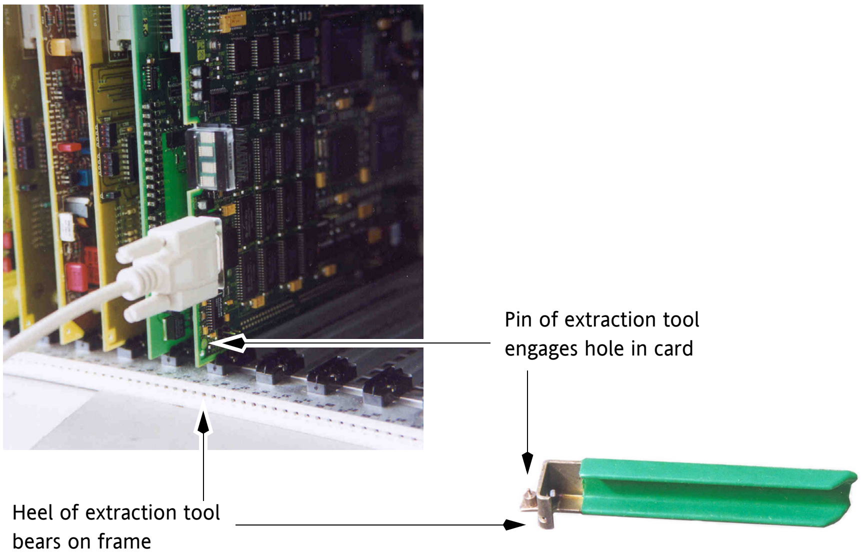

Figure A.38 Removing a Card From the WESTRACE Housing

Fit Daughter Boards

There is one daughter board for each active serial port (except the Production port). The replacement NVC/DM must use daughter boards of identical type and in the same locations as the removed NVC/DM. This is defined in the local documentation.

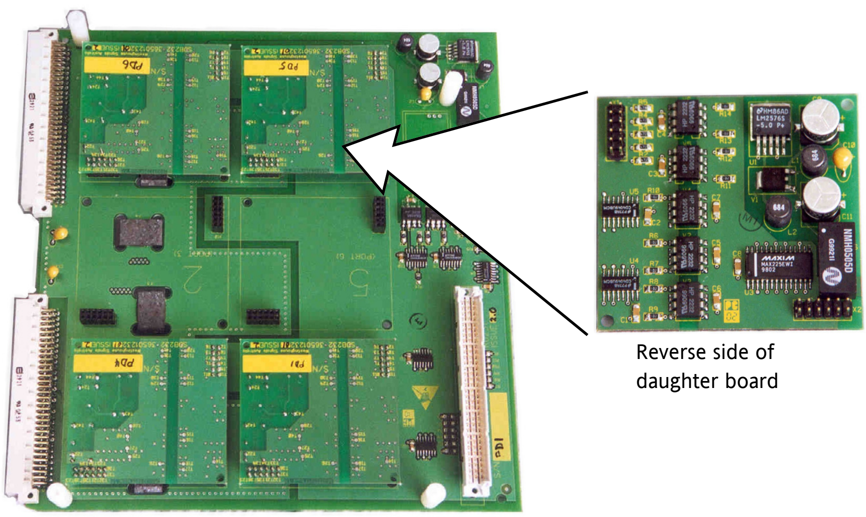

Figure A.39 CIMFIM With Four Daughter Boards–NVC/DM

There are two types of daughter board:

- SDB232 for RS232-C communications;
- SDB485 for RS485 communications.

Working daughter boards may be swapped from the removed NVC/DM to the replacement NVC/DM if required.

a) Separate the CIMFIM from the LEC; see figure A.40;

b) Remove and insert daughter boards as required;

   Each daughter board is attached to the CIMFIM by two connectors;

   Ensure that all plug pins properly mate with the sockets. It is possible to connect the daughter boards with only half the pins actually plugged into the socket;

c) Re-connect the CIMFIM to the LEC.

Note: ***Ensure that the PROD and PSWD jumpers on the LEC board are absent or stored on pins 2 and 3.***

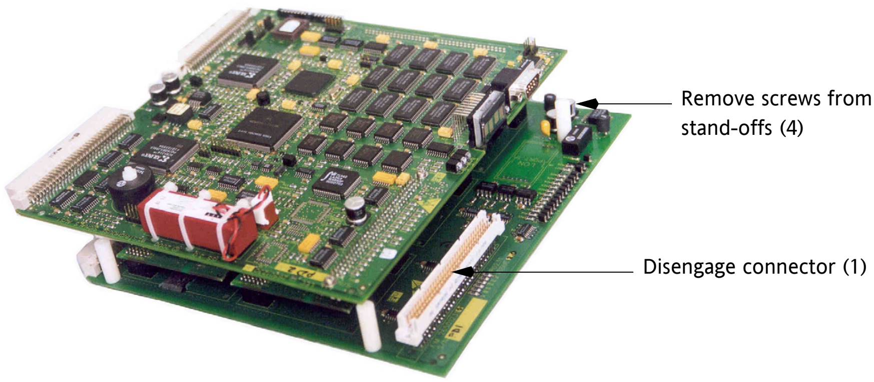

Figure A.40 Separating the LEC and CIMFIM – NVC/DM

Install the Non-Vital Configuration

There are five parts to this task:

a) Ensuring you have the right equipment;

b) Setting the Non-Vital Configuration version switches on the NVC/DM LEC;

c) Switching the NVC/DM to Maintenance Mode;

d) Installing the NVC/DM into the housing;

e) Down loading the new Non-Vital Configuration to the NVC/DM.

SAFETY WARNING

WESTRACE must not be controlling an interlocking while downloading a Non-Vital Configuration.

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Equipment Required

- A personal computer (PC) loaded with:
  - the Graphical Configuration Subsystem (GCSS version 6 or later);
  - the correct Non-Vital Configuration for the NVC/DM;
  - the Installation Check System (ICS).
- A 'standard' cable as described in figure A.51 to connect the serial port on the PC to the Production port on the NVC/DM LEC module.

  Alternatively, a 'maintenance' cable as described in figure A.51 may be used. The 'maintenance' cable configuration causes the NVC/DM to automatically start in 'Maintenance' mode. See “Setting the Maintenance Mode” on page A-130.
- A copy of the WESTRACE Graphical Configuration Subsystem Manual.

Setting Non-Vital Configuration version switches

The NVC/DM requires that the Non-Vital Configuration version must be that set by the CEDVER switches. This protects against loading an incorrect version. See figure A.41.

Set the switches on the LEC to define the Non-Vital Configuration version specified on the GCSS printout for the Non-Vital Configuration.

Switch 1 is the least significant bit. Switch ON is zero.

For example, to set Non-Vital Configuration version 1, you set switch 1 OFF and switches 2-8 ON. This is illustrated by figure A.41. To set Non-Vital Configuration version 5, switches 1 and 3 are OFF, all others are ON.

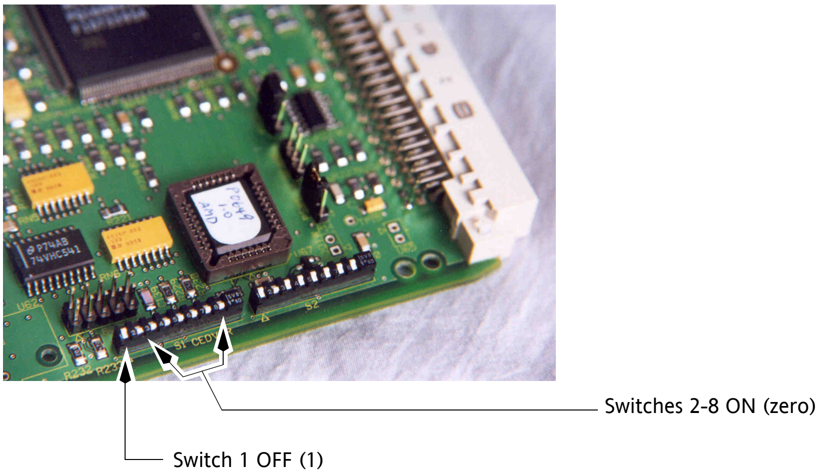

Figure A.41 Non-Vital Configuration–Setting Version 1–NVC/DM

Setting the Maintenance Mode

Select 'Maintenance mode' either by connecting a Maintenance Cable to the Product Port, or by setting switches 1 and 2 of switch bank S2 to ON. See section A.12.4.1 for details.

Refitting the NVC/DM

Refit the NVC/DM into the housing. Insertion is the reverse of removal described in "Remove the NVC/DM from the WESTRACE Housing" (page A-128) with the exception of not replacing the front panel.

Downloading the Non-Vital Configuration

a) Connect the cable of choice between the Production Port and the PC; see figure A.42;

b) Power up WESTRACE;

   Ensure that the NVC/DM has entered Maintenance mode (the watchdog LED should be flashing red);

c) Download the Non-Vital Configuration according to the instructions in the WESTRACE Graphical Configuration Subsystem Manual.

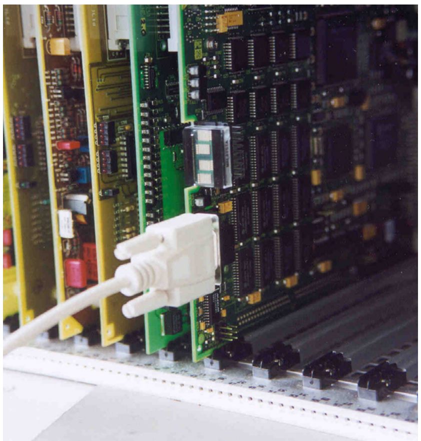

Figure A.42 Production Port–Connecting–NVC/DM

Verify the Data

The Non-Vital Configuration must be verified before the system is returned to service.

a) Ensure the NVC/DM is in maintenance mode and the PC is connected to the NVC/DM Production Port;

b) Run ICS according to the instructions in the WESTRACE Installation Check System Manual;

c) Complete procedural checking and sign off as per the WESTRACE Installation Check System Manual.

Restore the System

When the Maintenance Cable was used to set Maintenance Mode

a) Power down WESTRACE;

b) Remove the cable from the Production Port;

c) Refit the front panel to the housing(s);

d) Power up WESTRACE;

e) Allow WESTRACE to run for several minutes; ensure that no fault codes are displayed;

f) Advise the Signaller of completion.

When Switch Bank S2 was used to set Maintenance Mode

a) Power down WESTRACE;

b) Remove the NVC/DM from the housing;

c) Set switch 1 of switch S2 to OFF (Maintenance Mode OFF). See figure A.37;

d) Refit the NVC/DM into the housing. Replacement of the NVC/DM is the reverse of the procedure described in "Remove the NVC/DM from the WESTRACE Housing" on page A-128;

e) Refit the front panel to the housing(s);

f) Power up WESTRACE;

g) Allow WESTRACE to run for several minutes; ensure that no fault codes are displayed;

h) Advise the Signaller of completion.

A.12.5.4 Battery Installation

A lithium battery is used to maintain logged data in non-volatile memory and the real-time clock when the NVC/DM is powered down. The battery has a very long life and in normal circumstances it is unlikely to require replacement. The NVC/DM is usually shipped with the battery connected.

To replace the battery:

a) Have a replacement battery of the same type as the original plus cable ties readily at hand. See figure A.43;

b) Snip the cable ties holding the old battery to the printed circuit board;

c) Remove the battery lead from the pins;

d) Connect the replacement battery to the pins. You have a short period to do this before data is lost;

e) Fix the replacement battery to the circuit board using the new cable ties;

f) Snip off the excess length of cable ties.

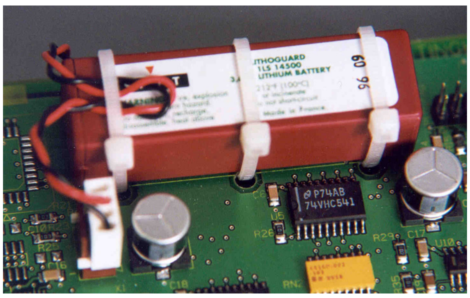

Figure A.43 Lithium Battery – NVC/DM

Handling Lithium Batteries

Observe the instructions elsewhere in this manual.

A.12.6 Indications

The 'user interface' of the NVC/DM comprises LEDs and a four digit alphanumeric display.

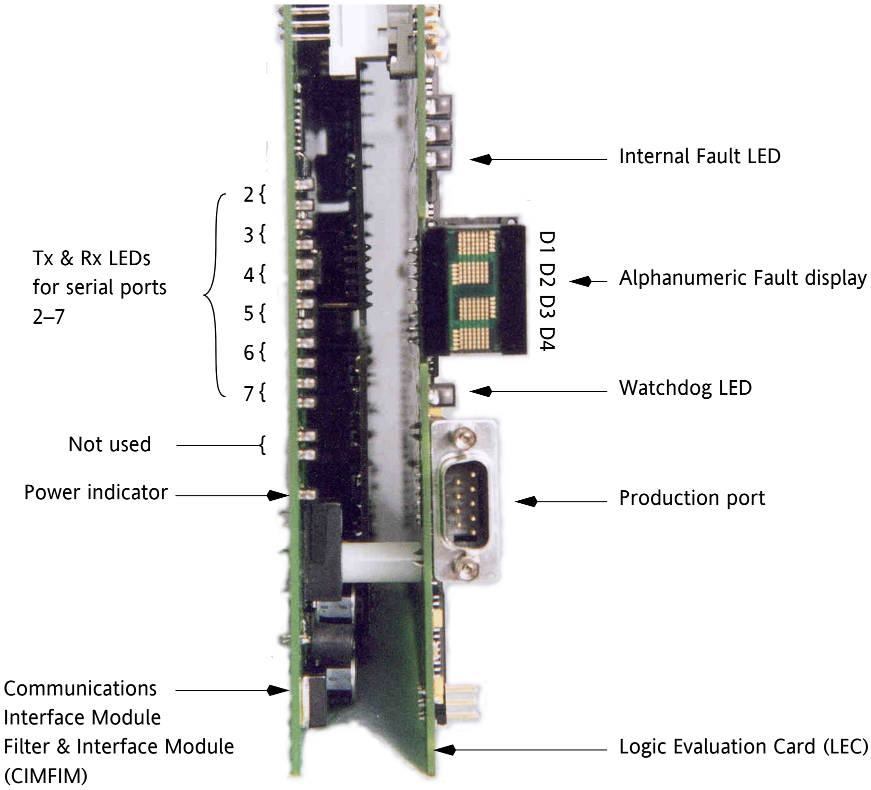

Figure A.44 User Interface–NVC/DM

A.12.6.1 Logic Evaluation Card LEDs

The LEC has two front panel LEDs:

- *Internal fault LED* (red)—illuminated whenever there is a non-fatal internal NVC/DM fault. These faults require attention, but are not serious enough to cause the NVC/DM to shutdown;
- *Watch dog LED* (normally green)—flashes at a regular interval if all is well with the NVC/DM. During the first minute or so of operation, the LED may flash at a faster than normal rate. It should then flash at the same rate as the green watchdog LED on the VLM.
  This LED flashes *red* when the NVC/DM is in Maintenance mode.

A.12.6.2 Communications Interface Module LEDs

The CIMFIM has 13 front panel LEDs:

- *Transmit LED* (yellow)—for each of the 6 serial ports. Flashes when data is transmitted;
- *Receive LED* (green)—for each of the 6 serial ports. Flashes when data is received;
- *Power Indicator LED* (green)—indicates the +24 V comms power supply is present.

See section A.12.6.5 for further information about these indicators.

A.12.6.3 Alphanumeric Display

The alphanumeric display can only show one fault at any time. However, all fault codes which occur are logged by the NVC/DM and can be examined using external diagnostic equipment.

Shutdown Mode

The alphanumeric display will show the applicable fault code if the NVC/DM shuts down because of a fatal internal fault. See table A.55.

Normal Mode

Within the first 12 seconds of the NVC/DM operating in this mode, the alphanumeric display will show start-up information (see section A.12.6.4) and then it will be blank unless a fault is detected.

During operation, a 'non-fatal' fault may occur which will cause the NVC/DM to display a fault code but continue to operate. In the event of multiple faults being present simultaneously, the NVC/DM will display the code for the first of the following that applies:

a) 'TIME' if the NVC/DM real time clock has not been set;

b) a non-fatal NVC/DM internal fault code, see table A.56;

c) a port fault code (lowest numbered port take precedence), see table A.51;

d) an S2 address fault code (lowest numbered S2 address takes precedence), see section A.12.6.7.2);

e) 'FLT ' where one or more WESTRACE system faults have not been uploaded by the external diagnostic equipment;

f) 'BAT ' if the NVC/DM battery voltage is low.

Maintenance Mode

The alphanumeric display will show the following when the NVC/DM is in this mode:

- blank display when ready to download a new Non-Vital Configuration;
- progress messages during and after a Non-Vital Configuration download.

Production Mode

The alphanumeric display will show the following when the NVC/DM is in this mode:

- 'Prd ' when ready to download new firmware;
- progress messages during and after a firmware download.

A.12.6.4 Start Up

The alphanumeric display shows a sequence of information (in hexadecimal) during start-up:

Table A.49 Start-up Display Sequence – NVC/DM

Time after Start-up	Information	Details
0–4 secs		Ignore.
4–6 secs.	Lamp test	All segments/dots illuminate to verify they are functional.
6–9 secs.	Backplane address	Display shows 'A *hh*' where '*hh*' is the backplane address of the slot holding the Logic Evaluation Card (LEC).
9–12 secs.	Software version	Display shows 'V *hh*' where '*hh*' is the version number of the NVC/DM software.

A.12.6.5 Operation

A correctly operating NVC/DM will show the following:

Table A.50 Normal Operation Indicators – NVC/DM

Indicator	Condition
Internal Fault LED	Off
Alphanumeric display	Blank
Watchdog LED	Regularly flashing green
Serial Rx LED(s)	Flashes green when the NVC/DM is receiving messages though the associated serial port. These LEDs will flash irrespective of whether the message is addressed to the NVC/DM.
Serial Tx LED(s)	Flashes yellow after the NVC/DM has transmitted a message through the associated serial port.
Power Indicator	Steady green

Note: ***The watchdog LED flashes red when the NVC/DM is in Maintenance mode.***

The Rx and Tx LEDs may appear to be ON rather than flashing for high data rates.

A

A.12.6.6 Fault Detection

A.12.6.6.1 WESTRACE Module Faults

During the first 16 seconds after power up, all WESTRACE modules display in sequence via their diagnostic LEDs:

- backplane address;
- software version;
- the value 00 (all LEDs off) to indicate 'no fault'.

During operation, each module will generate a non-zero fault code if a fault is detected.

The NVC/DM polls each module in turn to read this information, and will record any changes. These changes are stored in the order that they are read, which may not necessarily be the order in which they occurred.

A.12.6.6.2 NVC/DM Faults

In the event of an internal NVC/DM fault, the NVC/DM will either:

- display a code on the alphanumeric display, log a fault, and continue operating. This action is taken for 'non-fatal' faults (such as a comms port failure, low battery, or date/time not set), which do not compromise safe operation of the NVC/DM;
- force a reset of the NVC/DM hardware. This action is taken if the NVC/DM software or hardware appears to be malfunctioning. A fault will be logged when the system restarts.

In many cases, the restart will clear the fault and the NVC/DM will resume normal operation.

When an internal fault is the cause of an NVC/DM restart:

a) the NVC/DM will temporarily lose communications with the VLM;

b) the VLM will display a fault code (typically 34h) because of the communications loss but the VLM will keep running because the NVC/DM is a non-vital module.

This VLM fault code will persist even after communications between the VLM and NVC/DM are returned to normal. The only way to clear the fault code is to restart the WESTRACE system.

If a second fault occurs within the first minute of operation after an NVC/DM restart:

a) the NVC/DM will conclude that the fault is permanent;

b) the NVC/DM will shutdown and display a fault code on the alphanumeric display.

At this point, all NVC/DM communications ports are disabled and will stay that way until WESTRACE is restarted.

A.12.6.7 Fault Codes

The alphanumeric display comprises four digits; D1, D2, D3 and D4 reading from top to bottom on the display. See figure A.44. Figures A.45 to A.48 show the alphanumeric display being read left to right where the left position corresponds with the top position in figure A.44.

D1	D2	D3	D4

Figure A.45 Four Digit Alphanumeric Display—NVC/DM

The hexadecimal numbers shown by this display identify the following:

- the class of fault (internal NVC/DM fault, port fault, or an S2 address fault);
- the port number or S2 address as appropriate;
- a code identifying the fault.

Digit D1 is dedicated to identifying a port. The other three (D2–D4) are shared between identifying an S2 address and providing a fault code.

The tables below show a value for each digit but in some instances the value can vary. In those cases, the value of the digit is represented by a mnemonic as follows:

p	port number (hex)
mm	S2 address (hex)
f	fault code (hex)

A.12.6.7.1 Port faults

Digit D1 identifies the faulty port. Digits D2 and D3 are set to zero and digit D4 is the fault code.

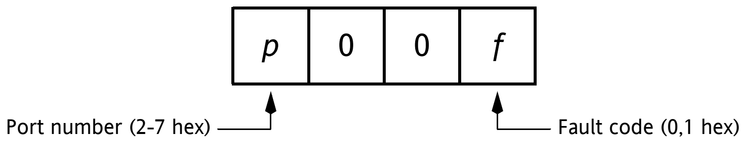

Figure A.46 Alphanumeric Display—Port Fault—NVC/DM

For example, `8001` indicates a fault code `1` on port `8`. The table below shows valid port fault codes.

Table A.51 Fault Codes–Port Codes in General–NVC/DM

CODE (H)	FAULT DESCRIPTION	ACTION
p001 The range for ***p*** is 2 to 7.	Port time out Timeout (10s) when waiting for an incoming message (slave port). Failure to get a response (within 10s) from any external slave (master port).	Serial Rx LED flashing: • check the serial port configuration in Non-Vital Configuration; • replace the NVC/DM if the configuration is correct. Serial Rx LED off: • check the comms link cabling and connections; • replace the protection module, the related daughter board or the NVC/DM.
8001	VLM port time-out.	It is normal for this code to be displayed if the VLM shuts down for any reason. Try the following if this code is on display and the VLM is still running: a. Restart WESTRACE. b. Check to ensure the VLM and NVC/DM CEDs are consistent with respect to transfer states passed between them. Normally GCSS ensures that this is the case. c. Check to ensure that only one NVC/DM and no DM is installed. d. Replace the NVC/DM.

Other Port Codes

This code is not displayed. It is reported in the fault log only.

Table A.52 Fault Codes–Port Codes–Other–NVC/DM

CODE (H)	DESCRIPTION
p000	The port ***p*** has recovered and is now operational.

A.12.6.7.2 Telemetry Address Faults

NVC/DM telemetry ports can appear as a range of S2 addresses.

The NVC/DM reports on faults for connected S2 addresses. The fault code is interpreted from the alphanumeric display as described here.

An address fault indicates:

- *slave port*– no messages for this particular address have been received from the S2 office;
- *office port*– no response has been received from the S2 field station at this particular address.

These should not be confused with port faults, which indicate no messages at all are being received at a particular port.

Digit D1 identifies the port to which the S2 address is connected. Digits D2 and D3 identify the S2 address, and digit D4 is the fault code.

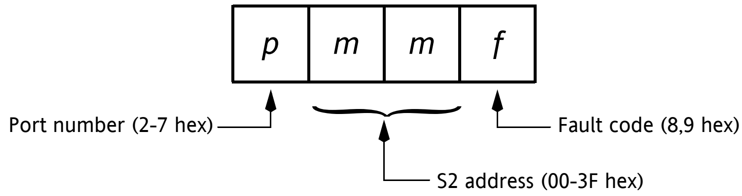

Figure A.47 Alphanumeric Display–S2 Address Fault–NVC/DM

For example, `21B9` indicates a fault code `9` on the S2 address `1B` (33 octal) connected to telemetry port 2.

The table below shows valid S2 address fault codes.

Table A.53 Fault Codes–S2 Address–NVC/DM

CODE (H)	FAULT DESCRIPTION	ACTION
***pmm*9**	Communication to an S2 address has timed out. **Slave port**–timeout when waiting for a valid message addressed to address ***mm*** (hex) on port ***p*** (hex). **Master port**–timeout waiting for a valid response from the S2 field address ***mm*** (hex) on port ***p*** (hex).	**Slave port** Check that the telemetry master is sending data to this address. (Use S2 test link or similar.) Check the addresses stored in the Non-Vital Configuration to see if they match the addresses sent by the office. **Master port** Check that the slave at this address is functioning correctly. (Use S2 test link or similar.) Check that the addresses stored in the Non-Vital Configuration match those of the field stations.

Other Telemetry codes

This code is not displayed. It is reported in the fault log only.

Table A.54 Fault Codes–Telemetry–Other–NVC/DM

CODE (H)	FAULT DESCRIPTION
***pmm*8**	S2 address ***mm*** (hex) on port ***p*** (hex) has recovered from a fault and is now operational.

A.12.6.7.3 Internal faults

Three digits (D2–D4) show the fault code (000–FFF) as defined by the tables below. Digit D1 is always blank.

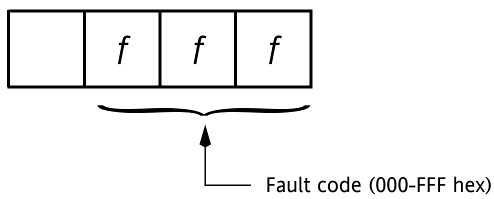

Figure A.48 Alphanumeric Display–Internal Fault–NVC/DM

The first action should be to restart WESTRACE. Next, find the displayed fault code in the tables below and take the recommended action. All of these fault codes, plus any read from the fault latches of other WESTRACE modules are logged to the NVC/DM fault buffer in the order they are detected by the NVC/DM.

Fatal NVC/DM Fault Codes

These faults cause the NVC/DM to restart. If the fault persists, the NVC/DM will shut down.

Table A.55 Fault Codes—Fatal—NVC/DM

CODE (H)	FAULT DESCRIPTION	ACTION
003	Application Checksum Error	Replace NVC/DM
004	Stack Guard Band Error	"
005	RAM Error	"
009	Stack Error	"
080	Non-Vital Configuration checksum error	Download new Non-Vital Configuration
084	Non-Vital Configuration version number error	Confirm that the version switches are correctly set. If the switches are correct, download new Non-Vital Configuration.
100	Build error	Download new Non-Vital Configuration
101	Out of memory	Replace NVC/DM
102	Operating system error	"
103	Internal error	"
104	Task suspended	"
105	NVRAM error	"
107	Comms buffer error	"
108	Non-Vital Configuration format version error	Download new Non-Vital Configuration
109	Watchdog restart	Replace NVC/DM
10A	No VLM Non-Vital Configuration copy	Restart WESTRACE
10B	Wrong VLM Non-Vital Configuration copy	"
10C	VLM interface versions mismatch	Check the NVC/DM and VLM Non-Vital Configuration versions.
10D	VLM address mismatch	Check the NVC/DM Non-Vital Configuration and WESTRACE installation details
10E	IMB data error	Replace NVC/DM. Could also be a faulty backplane or VLM.
10F	Wrong IMB slot	Move NVC/DM to the correct backplane slot
111	Timing error	Replace NVC/DM

Non-fatal NVC/DM Fault Codes

Table A.56 Fault Codes – Non-fatal – NVC/DM

CODE	FAULT DESCRIPTION	ACTION
BAT	Low battery	Replace battery
FLT	There are faults in the fault buffer that have not yet been requested by an external diagnostic system.	Request faults from the fault buffer through MovioaW.
F11	Main cycle not synchronized (NVC/DM cannot keep up with VLM.)	Check the NVC/DM and VLM CEDs.
F21	Software version number lost	Replace NVC/DM
F22	Module information error	"
F23	Fault bus error	"
F24	Fault detection NVRAM error	"
TIME	Time has not been set	Set correct time through MoviolaW, CTC or Getlog. It is possible to set the time via the S2 protocols.
DIAG	There are faults stored in the Fault Buffer.	Connect or check and restart an external diagnostic system and request the fault codes from the Fault Buffer.

Other NVC/DM Codes

The following codes are not displayed. They are reported in the fault log only.

Table A.57 Fault Codes – Other – NVC/DM

CODE (H)	FAULT DESCRIPTION
F00	Recovered from low battery condition.
F01	Low battery (corresponds to 'BAT ' display).
F10	Recovered from VLM out-of-sync error.
F30	Time has been set, i.e. an invalid time/date error has been corrected.,
F31	Date/time not set (corresponds to 'TIME' display).

A

A.12.7 External Connections

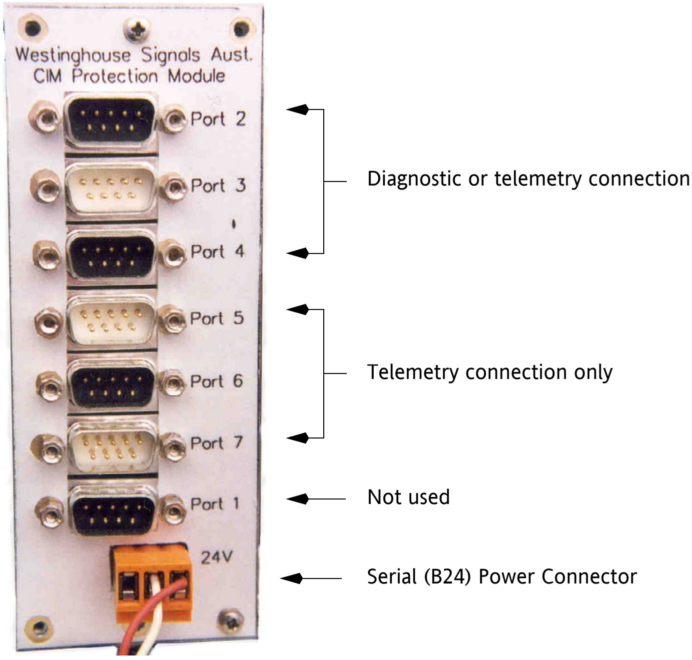

Figure A.49 External Connectors–CIMPM Card–NVC/DM

A.12.7.1 Serial Power Connector

Connection to the serial power interface is via a Klippon removable screw terminal plug with the following connections:

Table A.58 Serial Power Pinout–NVC/DM

Pin Number	Signal
1	+24V
2	Common (0V)
3	Not used

A.12.7.2 Diagnostic and Telemetry Serial Connectors

Each serial interface is a male DB9 connector configured as either RS232 or RS 485. Figure A.49 shows all 7 DB9 connectors. Connector 1 is not used at present.

RS232-C Connection

Table A.59 DB9 Pinout–RS232 Connection–NVC/DM

Pin Number	Signal Name	Signal Source
1	DCD	External equipment
2	RxD	External equipment
3	TxD	NVC/DM
4	DTR	NVC/DM
5	ISOGND	(Common)
6	CLKOUT	NVC/DM
7	RTS	NVC/DM
8	CTS	External equipment
9	CLKIN	External equipment

RS485 Connection

Table A.60 DB9 Pinout–RS485 Connection–NVC/DM

Pin Number	Signal Name	Signal Source
1	RxD-	External equipment
2	RxD+	External equipment
3	TxD+	NVC/DM
4	TxD-	NVC/DM
5	ISOGND	(Common)
6	CLKOUT+	NVC/DM
7	CLKOUT-	NVC/DM
8	CLKIN-	External equipment
9	CLKIN+	External equipment

A.12.7.3 Production Port

This port is a male DB9 connector on the front edge of the card (see figure A.50). Signal levels are to RS232-C standard and the connector pinout is shown in table A.61. This port is only enabled when the NVC/DM is in Maintenance mode.

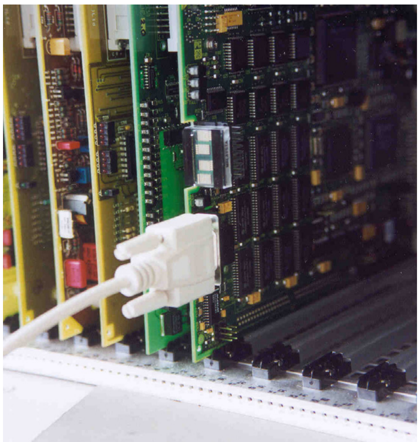

Figure A.50 Production Port—NVC/DM

Table A.61 DB9 Pinout—Production Port—NVC/DM

Pin Number	Signal	Comment
1	N/C	
2	RxD input	
3	TxD output	
4	N/C	
5	Common	
6	N/C	
7	RTS output	Always active
8	MAINT input	Selects maintenance mode
9	SPEED input	Selects maintenance mode data transfer rate

A.12.7.4 Cabling Details

A cable with any of the configurations in figure A.51 will allow a personal computer to connect to the:

- production port (a DB9 connector on the front edge of the LEC);
- diagnostic port (a DB9 connector at the rear of the housing).

The interconnection of pins 7, 8 and 9 on the Maintenance cable has no effect when the cable is connected to a Diagnostic port. When the cable is plugged into the Production port, the interconnection makes the NVC/DM switch to its Maintenance mode of operation and selects the 115 kbps data transfer rate.

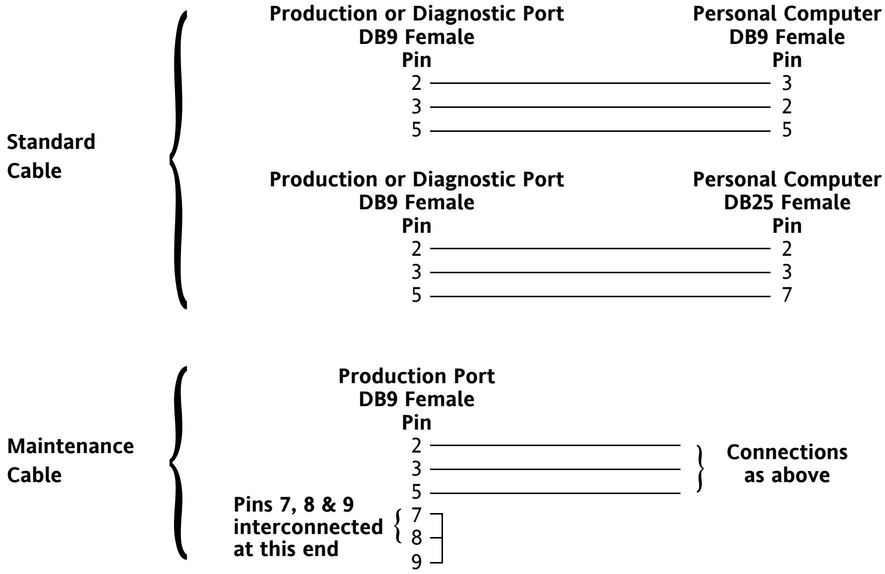

Figure A.51 Cable Configuration Details—NVC/DM

A.12.7.5 Connecting a Diagnostic System

Most WESTRACE installations will have a permanently connected MoviolaW. Some installations allow remote access via Hayes compatible modem.

Types of Diagnostic System

Two diagnostic systems are available:

- MoviolaW—a Microsoft Windows based user friendly utility;
  Provides the following services:
  - Real time graphical display of the state of the interlocking;
  - Records for later playback, events (logic state changes) which occur after MoviolaW commences running;
  - Extraction of historical fault information from an NVC/DM (although not historical event or operation information);
  - Basic maintenance functions such as setting the time and displaying telemetry statistics;
- GETLOG—a command line driven utility;
  Provides the following services:
  - Extraction of historical and real time event, fault and operation information which is displayed and stored in text form;
  - Basic maintenance functions such as setting the time and displaying telemetry statistics;
  - More straight forward to install and configure than MoviolaW;
  - Can support larger systems than can MoviolaW.

Requirements

You will need:

- A personal computer (PC) loaded with MoviolaW or GETLOG;
- The MoviolaW display files for the particular installation;
  For GETLOG, it is useful to have the Non-Vital Configuration image (`.img`) files for the installation;
- The passwords for accessing the particular NVC/DM;
  For MoviolaW, the passwords for a particular NVC/DM are stored in the MoviolaW `.ini` file, and are configured using the MoviolaW NVC/DM driver software;
  For GETLOG, the password must be specified on the command line;
- A cable to connect the serial port(s) on the PC and the Diagnostic port. See figure A.51;
- The user manual for the chosen diagnostic system.

Procedure

a) Connect the PC to a configured diagnostic port at the rear of the housing. See figure A.49 and refer to the local documentation;

b) Start up the chosen diagnostic system;

c) Follow the guidelines for fault finding.

A.13 Non-vital Communications Module (NVC)

A.13.1 Description

The NVC module is a serial data link interface for communication with a local, or remote non-vital control system.

The module communicates synchronous serial data using the WESTRONIC S2 communication protocol. It is normally used to receive controls and return indications to a remote control centre, typically a CTC system. It would either be interfaced to a digital circuit, or to an analogue line using an appropriate modem. It may also be used to interface to a local panel. The NVC operates as a slave device on a master/slave communication regime. It is set with a unique slave address and will only act on data that matches this setting. It will then respond with indication status as defined in the application logic.

The S2 protocol allows S2 fields and WESTRACE NVC modules to communicate on a single communication bearer. NVC modules with tri-state communications output to the bearer using tri-state circuits, and are enabled only when required to place signals on the bearer.

Appropriate bearer interface arrangements must be used where multiple systems are connected to a single bearer. Appropriate tri-state NVC modules must be used.

A.13.2 Particulars

The NVC is comprised of a single printed circuit board. The circuit board has configuration DIP switches which are used to select the NVC's slave address, data transfer rate, data word length and other configuration parameters.

A.13.3 Function

The NVC derives power for its communication circuits from an external 24 Vdc supply. This power supply may be provided by either the OPC (as part of the VLM) or by another source, depending upon the application. Removal of this voltage positively prevents the NVC from transmitting and receiving data.

The NVC is processor based and it interfaces with the VLM. It performs the self-testing and housekeeping functions for the module.

Clock Reconstruction

NVC modules with clock reconstruction should be used when there is no external clock signal (RxC) available. NVC modules capable of clock reconstruction can internally generate the clock signal from received data. The clock signal may be used for communication without using a modem.

Supplying an external clock signal, if available, to an NVC module (without clock reconstruction) will normally provide superior performance. Also see section A.13.4.7.

A.13.4 Configuration

Configuration of the NVC is achieved by the setting of the two switch banks shown below. Refer to the WESTRACE NVC module configuration in the system schematics for the particular WESTRACE installation.

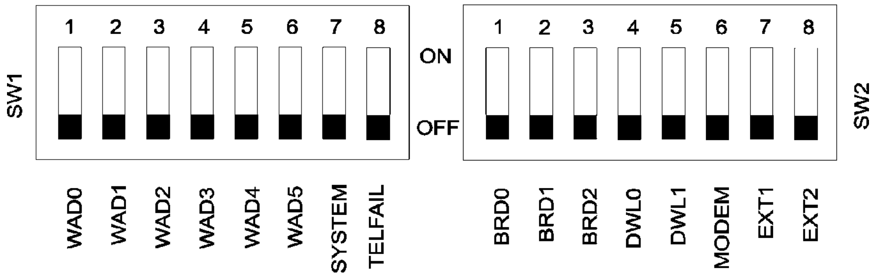

Figure A.52 Configuration Switches—NVC

A.13.4.1 Slave Address

The module's S2 address is configured by SW1/1 to SW1/6 (WAD0–WAD5) where WAD5 is the most significant bit of the 6 bit address, eg for an address of 21 octal the switches are set as follows:

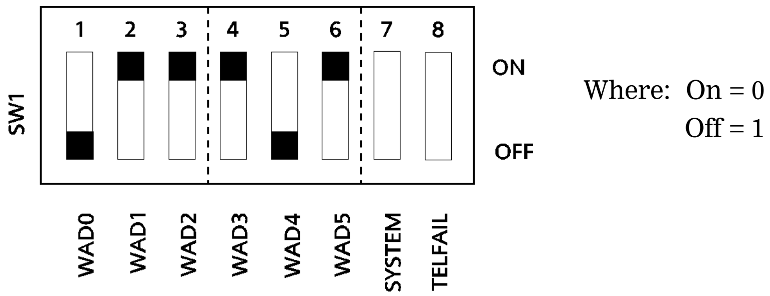

Figure A.53 Slave Address—Setting—NVC

The example shown above from WAD5–WAD0 gives 010 001 (21 octal, or 17 decimal).

A.13.4.2 System Bit

The system bit switch is used to determine in which telemetry system the NVC is operating. This facility is configured by SW1/7 (System). The system bit is a logical 1 when this switch is *On*.

A.13.4.3 Telfail

The Telfail switch is used to determine whether a telemetry failure indication will be passed from the NVC to the VLM for processing by the Application Data. This facility is configured by SW1/8 (Telfail). Telfail processing is required when this switch is *On*.

Note: ***Do not use control bit 0 (zero) for an application when the Telfail switch is set to On. The NVC automatically sets this bit in response to a failure to transmit or receive data.***

The NVC will output a frame if not correctly addressed within a 30 second period.

A.13.4.4 Data Transfer Rate

The data transfer rate is configured by SW2/1 to SW2/3. The switches enable selection of different data transfer rates depending upon the telemetry system configuration. The switches are set as follows:

Table A.62 Data Transfer Rate–Setting–NVC

Data Transfer Rate (bits per second)	BRD0 SW2/1	BRD1 SW2/2	BRD2 SW2/3
600	On	On	On
1200	Off	Off	Off
2400	On	Off	Off
4800	Off	On	Off

All other configurations are illegal.

NVC232 and NVC422 modules which offer clock reconstruction are fitted with daughter boards which must also be configured for data transfer rate.

The daughter board links are positioned as shown by figure A.54. The data transfer rate selection is made according to the illustration.

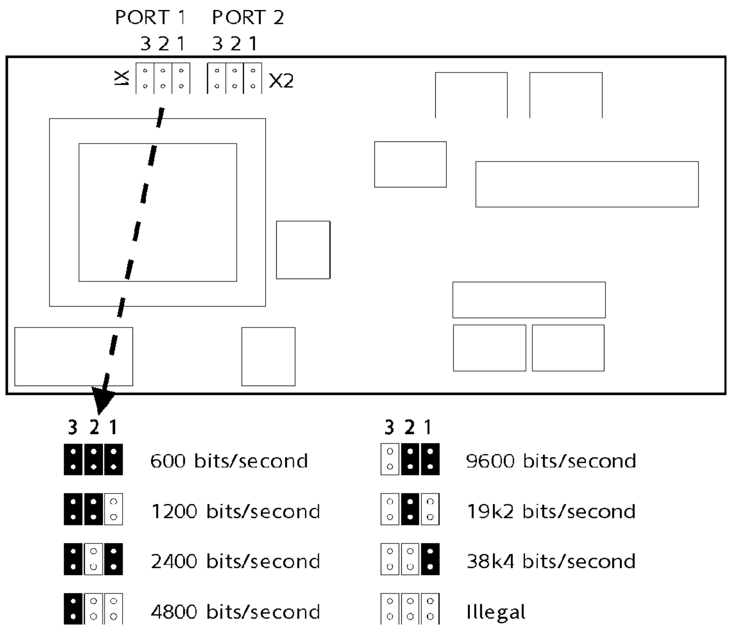

Figure A.54 Clock Reconstruction Daughter Board–NVC

A.13.4.5 Data Word Length

The data word length is configured by SW2/4 to SW2/5 (DWL0-DWL1). These switches enable selection of different data word lengths depending upon the telemetry system configuration.

The switches can be set as follows:

Table A.63 Data Word Length—Setting—NVC

Data Word	DWL0 SW2/4	DWL1 SW2/5
64	Off	Off
32	On	Off
48	Off	On
128	On	On

S2 systems are typically set to 64 bit data word length.

A.13.4.6 Modem

The modem switch is used to determine whether modem handshaking is required. This facility is configured by SW2/6 (modem). Modem handshaking *is* required when this switch is *On*.

A.13.4.7 Transmit Data Clock

The source of the transmit clock can be selected by setting the Ext1 switch on SW2 thus:

Switch Position 7 = OFF — Internal clock—transmit data clock is internally generated without reference to received signals. Typically when NVC is connected to a modem.

Switch Position 7 = ON — External clock—used when interfacing to carrier communication systems that require synchronised clocks for both transmitted and received data.

The NVC takes an external receive data clock and generates both the transmit data clock and the transmit data from it.

Applies to:

- NVC 422 (modem) module (3650 1139 10) Issue 1.3 and later;
- NVC 422 (no modem) module (3650 1139 11) Issue 2.0 and later.

A.13.4.8 Unused

Ext2 switch on SW2 is not used by the NVC and should be set Off.

A.13.5 Indications

A.13.5.1 Start Up

Diagnostic LEDs display the module type code, followed shortly by a firmware version code (reflecting the firmware version installed in the module). The firmware version is displayed for approximately 8 seconds, after which all diagnostic LEDs will extinguish.

There are four additional LEDs on the NVC. They are used to indicate correct operation of the telemetry. The telemetry is connected to serial channel A; serial channel B is not used. There is one LED for transmit and one for receive. These LEDs are labelled on the PCB as TxDAI and RxDAI respectively.

A.13.5.2 Operation

The module will commence flashing the green watchdog LED to indicate the module is operational and working correctly.

When the NVC is receiving valid SDLC telemetry messages, the RxDAI will flash for 20 to 30 milliseconds. This LED will flash irrespective of whether the telemetry message is addressed to the NVC.

The NVC will transmit an indication message when it receives a valid SDLC telemetry message with an address that matches the address set by the switches WAD0-WAD5.

After the message is sent, the NVC flashes the TxDAI LED for 20 to 30 milliseconds.

A.13.5.3 Fault Codes

Table A.64 Fault Codes–NVC

CODE(H)	FAULT DESCRIPTION	ACTION
00	No Fault	Not a fault
02	Module Type Error	Replace NVC
03	EPROM Checksum Error	"
04	Stack Guard Error	"
05	RAM Error	"
06	Interrupt Error	"
07	Termination Error	"
08	Processor Error	"
09	Stack Error	"
0A	Run Time Error A	"
0B	Run Time Error B	"
0C	Run Time Error C	"
0D	Run Time Error D	Replace NVC
0E	Run Time Error E	"
0F	Run Time Error F	"

A

Table A.64 Fault Codes—NVC *(Continued)*

CODE(H)	FAULT DESCRIPTION	ACTION
10	Run Time Error G	"
11	Run Time Error H:	"
12	Run Time Error I	"
13	Run Time Error J	"
14	Run Time Error K	"
15	Run Time Error L	"
16	Run Time Error M	"
17	Run Time Error N	"
18	Run Time Error O	"
19	Run Time Error P	"
1A	Run Time Error Q	"
1B	Run Time Error R	"
1C	Run Time Error S	"
1D	Run Time Error T	"
1E	Run Time Error U	"
1F	Run Time Error V	"
20	Run Time Error W	"
21	Run Time Error X	"
22	Run Time Error Y	"
23	Run Time Error Z	"
24	IMB Timeout Error	"
25	IMB Address Error	"
26	IMB Address Parity Error	"
27	IMB CI Transfer Error	"
28	IMB Transfer Type Error	"
29	IMB Message Length Error	"
2A	IMB True Byte Error	"
2B	IMB Check Message Error	"
2C	IMB Inconsistency Error	"
30	Module Type and Fault Code Error	"
31	ST IMB Start Up Timeout	"
32	ST IMB Too Few IMB Calls	Replace NVC
33	ST IMB Too Many IMB Calls	"
34	ST IMB Too Few ST Calls	"
80	Illegal data transfer Rate Configuration	Check data transfer rate switches

A.13.6 External Connections

A.13.6.1 RS232-C Connections

External Connections to the NVC232 are made via the SIO232PFM.

The SIO232 PFM External Connectors are a DB25 plug and socket for RS232 interface, and a 2 way plug and socket Klippon type BLA/SLA for power.

Figure A.55 depicts the external connection details of the SIO232 PFM.

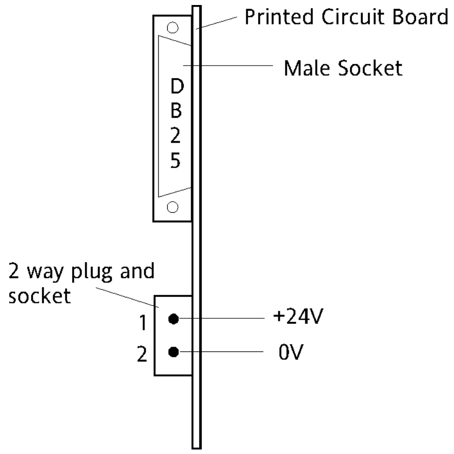

Figure A.55 External Connections–SIO232 PFM–NVC

Table A.65 DB25 Pinout–SIO232 PFM–NVC

Pin	Function
1	Chassis Ground
2	Transmit Data (TxD)
3	Receive Data (RxD)
4	Request to Send (RTS)
5	Clear to Send (CTS)
7	Signal Ground (GND)
8	Data Carrier Detect (DCD)
17	Receive Clock (RxC)
20	Data Terminal Ready (DTR)
24	Transmit Clock (TxC)

This module communicates using RS232-C and is configured as a DTE.

A.13.6.2 RS422 Connections

External Connections to the NVC422 are made via the SIO422PFM.

The SIO422 PFM External Connectors are a 14 way ribbon header for RS422 interface, and a 2 Way plug and socket Klippon type BLA/SLA for power.

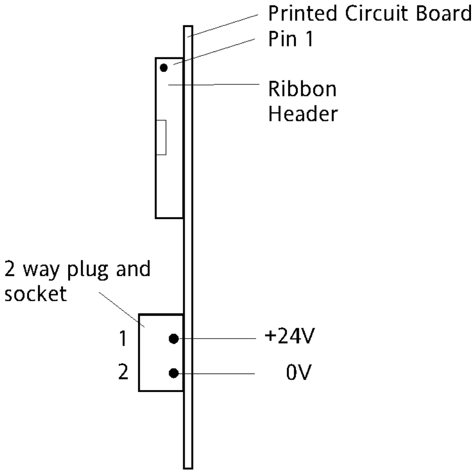

Figure A.56 External Connections–SIO422 PFM–NVC

Figure A.57 and table A.66 show the RS422 pin numbering.

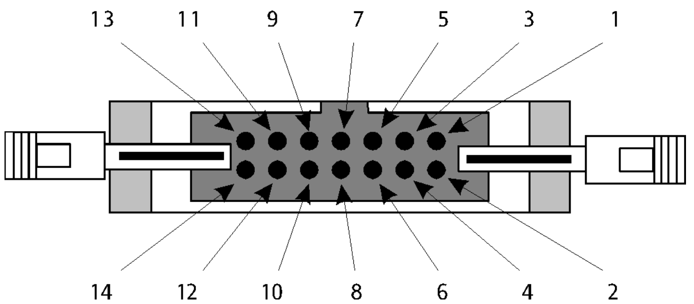

Figure A.57 RS422 Connector Pin Numbering–SIO422 PFM–NVC

Table A.66 14-Way Ribbon Header Pinout–SIO422 PFM–NVC

Pin	Function
1	0 Volts (O V)
2	Received Clock + (RxC +)
3	Received Clock - (RxC -)
4	Transmit Clock + (TxC +)
5	Transmit Clock - (TxC -)
6	Data Carrier Detect (DCD)
7	Not Used
8	Transmit Data + (TxD+)
9	Transmit Data - (TxD-)
10	Receive Data + (RxD+)
11	Receive Data - (RxD-)
12	Clear to Send (CTS)
13	Request to Send (RTS)
14	0 Volts (O V)

A.14 Diagnostic Module (DM)

A.14.1 Description

The is DM used with older VLM modules. It comprises a single printed circuit board and provides two user interfaces, the Technician Interface, and the Event Recorder Interface.

A.14.2 Particulars

Both interfaces are RS232 compatible, and may connect to a dumb terminal. The Event Recorder interface permits the recording of all change of state information and may optionally be connected to a serial storage device or printer. The Technician Interface permits the user to interrogate the VLM's logic states, and display system data pertaining to the particular installation.

Only one DM module can be installed in a system. Its position is allocated by the GCSS or CSS to slot 15 in housing 1.

A.14.3 Function

The DM permits the user to interrogate the WESTRACE system via the Technician Interface. The operation of the Technician Interface is defined in Appendix B. The Event Recorder Interface permits all change of state information relating to the WESTRACE installation to be recorded.

The DM is capable of storing up to 800 prior change of state events, and the most recent module faults in battery-backed non-volatile RAM. The DM has its own Real Time Clock for time and date stamping of events and faults. The time and date are set via the Technician Interface.

The DM does not require external power for communications.

The DM is processor based and it interfaces with the VLM. It performs the self-testing and housekeeping functions for the module.

A.14.4 Operation

During the power up initialisation period following a system reset (and provided no faults are detected), a WESTRACE module writes the following data to its fault code latch:

- backplane address;
- software version number;
- clear fault code values.

The DM polls each module in turn to read this information and it only stores changes to the information. The DM stores the changes it sees first, and since it polls each of the WESTRACE modules in turn, the stored change may not be the first that occurred. In other words, changes recorded in one cycle are in the order they were read, not necessarily the order in which they occurred.

A

A.14.5 Configuration

For full details of the configuration applicable to this installation, refer to the folders in the Signalling Equipment Room.

Configure the module for the installation using the configuration switch SW1.

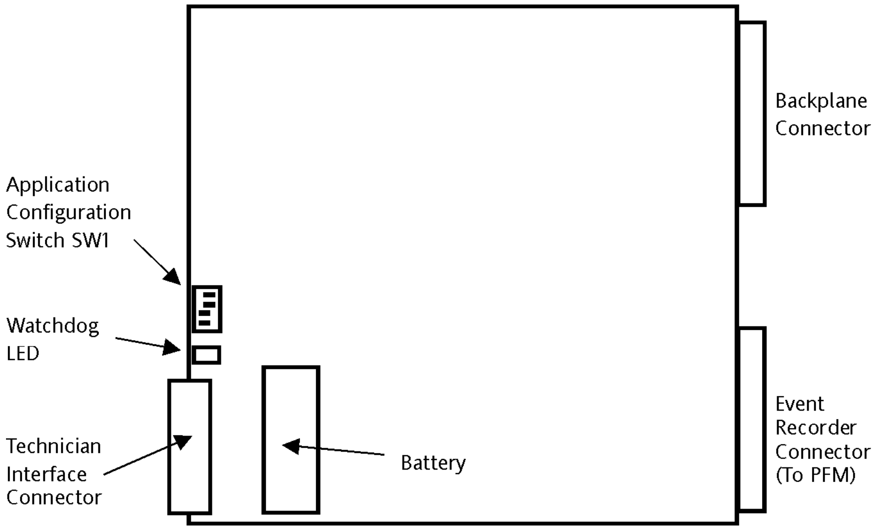

Figure A.58 Layout—DM Module

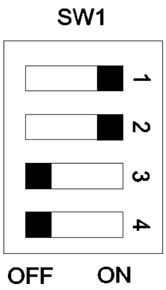

Figure A.59 Configuration Switch—DM Module

A.14.5.1 Data Transfer Rate

The data transfer rates for the Event Recorder interface and the Technician Interface are configured by SW1/1 and SW1/2. These switches are set as follows:

Technician Interface Data Transfer Rate

1200	SW1/1	Off
4800	SW1/1	On

Event Recorder Interface Data Transfer Rate

1200	SW1/2	Off
4800	SW1/2	On

All other switches are not used by the Diagnostic Module and must be set to Off.

A.14.5.2 Battery Installation

A battery is used to maintain data in non-volatile memory during normal operation. The DM is shipped with the battery disconnected so the link adjacent to the negative terminal of the battery (Link 17) must be fitted before the System is powered up.

To prolong battery life, Link 17 should be removed when the unit is taken out of service and put into storage, but only after any data has been extracted.

Handling Lithium Batteries

Observe the instructions elsewhere in this manual.

A.14.6 Indications

A.14.6.1 Start Up

Diagnostic LEDs display the module type code, shortly followed by a firmware version code (reflecting the firmware version installed in the module). The firmware version is displayed for approximately 8 seconds, after which all diagnostic LEDs will extinguish.

Ignore the Red LED that is near the green Watchdog LED.

A

A.14.6.2 Operation

The module will commence flashing the green watchdog LED to indicate the module is operational and working correctly.

Ignore the RED LED that is close to the green Watchdog LED.

A.14.6.3 Fault Codes

None

A.14.7 External Connections

External Connections to the DM are made via the SIO232PFM for the Event Recorder and via the front of the DM module for the Technician Interface.

A.14.7.1 Event Recorder Interface

The SIO232 PFM External Connectors are a DB25 plug and socket for RS232 interface, and a 2 way plug and socket Klippon type BLA/SLA (not used).

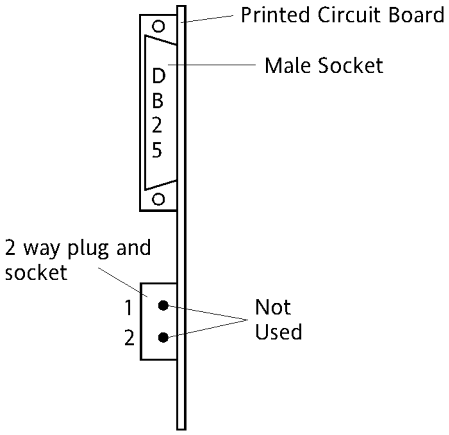

Figure A.60 External Connections–SIO232 PFM–DM Module

Table A.67 DB25 Pinout–Event Recorder Interface–SIO232 PFM–DM Module

Pin	Function
2	Transmit Data (TxD)
5	Clear to Send (CTS)
7	Signal Ground (GND)

Signal

The Signal is simplex asynchronous, data output only, and is selectable from 1200 bits/s or 4800 bits/s. It comprises 1 start bit, 7 data bits, 1 parity bit, even, and 1 stop bit.

A.14.7.2 Technician Interface

The Technician Interface is a DB25 connector on the front edge of the DM module.

Table A.68 DB25 Pinout–Technician Interface–DM Module

Pin	Function
2	Transmit Data (TxD)
3	Receive Data (RxD)
7	Signal Ground (GND)

Signal

The Signal is Duplex Asynchronous, selectable from 1200 bits/s or 4800 bits/s and comprises 1 start bit, 7 data bits, 1 parity bit, even, and 1 stop bit.

A.14.7.3 Cabling Details

A cable with one of the following configurations will allow the connection of a personal computer to either the technician interface or the event recorder interface.

Diagnostic Module DB25 Female Pin	Personal Computer DB25 Female Pin
2	3
3	2
7	7

Diagnostic Module DB25 Female Pin	Personal Computer DB9 Female Pin
2	2
3	3
7	5

Figure A.61 Interface Cable Configuration – DM Module

A.15 Diagnostic Module 128 (DM128)

A.15.1 Description

The DM128 is used with the Hot Standby Vital Logic Module (HVLM128). It comprises a single printed circuit board and provides two user interfaces, the Technician Interface, and the Event Recorder Interface.

A.15.2 Particulars

Both interfaces are RS232 compatible, and may connect to a dumb terminal or a personal computer running MoviolaW. The Event Recorder interface permits the recording of all change of state information and may optionally be connected to a serial printer or other RS232 device. The Technician Interface permits the user to interrogate the HVLM128's logic states, and display system data pertaining to the particular installation.

Only one DM128 module may be installed in a system. Its position is pre-allocated to slot 15 in housing 1.

A.15.3 Function

The DM128 permits the user to interrogate the WESTRACE system via the Technician Interface. The operation of the Technician Interface is defined in Appendix B. The Event Recorder interface permits all change of state information relating to the WESTRACE installation to be recorded.

The DM128 is capable of storing up to 8030 previous change of state events, and the most recent module faults in battery-backed non-volatile RAM. The DM128 contains its own Real Time Clock for time and date stamping of events and faults. The time and date are set via the Technician Interface.

The DM128 does not require external power for communications.

The DM128 is processor based and it interfaces with the HVLM128. It performs self-testing and housekeeping functions for the module.

A.15.4 Operation

During the power up initialisation period following a system reset (and provided no faults are detected), a WESTRACE module writes the following data to its fault code latch:

- backplane address;
- software version number;
- clear fault code values.

The DM128 polls each module in turn to read this information and it only stores changes to the information. The DM128 stores the changes it sees first, and since it polls each of the WESTRACE modules in turn, the stored change may not be the first that occurred. In other words, changes recorded in one cycle are in the order they were read, not necessarily the order in which they occurred.

A.15.5 Configuration

The DM128 is fitted with links or switches as depicted in figure A.62 (later modules have only soldered links preset to 4800 bps).

Configure the module for the installation using:

- links – if switch SW1 is not fitted;
- switches – if switch SW1 is fitted.

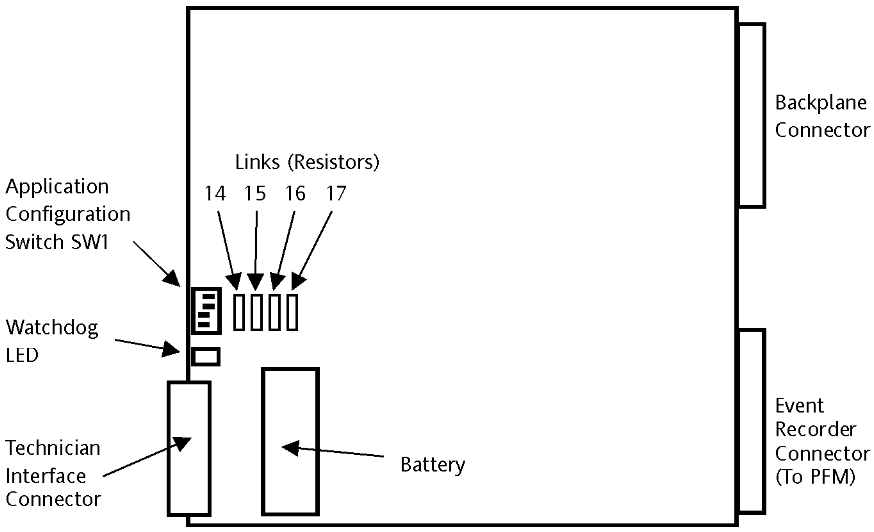

Figure A.62 Layout – DM 128

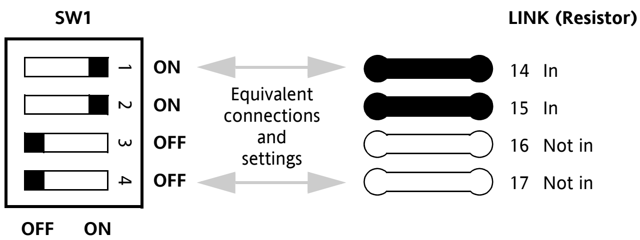

Figure A.63 Links or SW1 Switches – Default Settings – DM128

The SW1 switches 1, 2, 3, and 4 are connected in parallel with the links LK14, LK15, LK16 and LK17, respectively. If a module is fitted with SW1 switches, always use the switches in preference to the links. A switch 'On' corresponds to a link 'In'.

For full detail of the configuration applicable to an installation, refer to the folders in the Signalling Equipment Room. The default settings for the links LK14, LK15, LK16 and LK17 parallel to the power supply are described in the sections that follow. Although links are described, use the equivalent switches (see figure A.63) if SW1 is present.

A.15.5.1 Data Transfer Rate

The data transfer rates for the event recorder interface and the technician interface are configured by LK14 and LK15. The links are set as follows:

Table A.69 Data Transfer Rate – Setting – DM128

Data Transfer Rate	LK14	LK15
1200 bps	Out	Out
2400 bps	In	Out
9600 bps	Out	In
4800 bps (default)	In	In

A.15.5.2 Mnemonic Selection Default

The language used by the DM128 is configured by LK16. The link is set as follows:

Table A.70 Mnemonic Language – Setting – DM128

Printed / Displayed	LK16
Mnemonic Names (default)	Out
Mnemonic Numbers	In

A.15.5.3 Command Echo Default

The echoing of commands by the DM128 is configured by LK17. The link is set as follows:

Table A.71 Echo Command – Setting – DM128

Commands	LK17
Echo Commands (default)	Out
Commands Not Echoed	In

A.15.5.4 Battery Installation

A battery is used to maintain data in non-volatile memory during normal operation. The DM128 is shipped with the battery disconnected so LK18 (operate/ship jumper) must be moved to the 'operate' position before the system is powered up.

To prolong battery life, LK18 should be moved to the 'ship' position if the module is to be taken out of service and put into storage, but only after any data has been extracted.

Dual battery plugs are provided so that the data in non-volatile memory is maintained while changing the battery. The replacement battery should be fitted to the second battery plug before removing the original (flat) battery. This will ensure power is always available to the non-volatile memory.

Caution: ***Do not leave both batteries connected for any longer than necessary to affect the change or you might reduce the life of the new battery.***

Handling Lithium Batteries

Observe the instructions elsewhere in this manual.

A.15.6 Indications

A.15.6.1 Start Up

None.

A.15.6.2 Operation

The module will commence flashing the green watchdog LED to indicate the module is operational and working correctly.

Ignore the red LED that is close to the green Watchdog LED.

A.15.6.3 Fault Codes

None

A.15.7 External Connections

External Connections to the DM128 are made via the SIO232PFM for the Event Recorder and via the front of the DM module for the Technician Interface.

A

A.15.7.1 Event Recorder Interface

The SIO232 PFM External Connectors are a DB25 plug and socket for RS232 interface, and a 2 way plug and socket Klippon type BLA/SLA (not used).

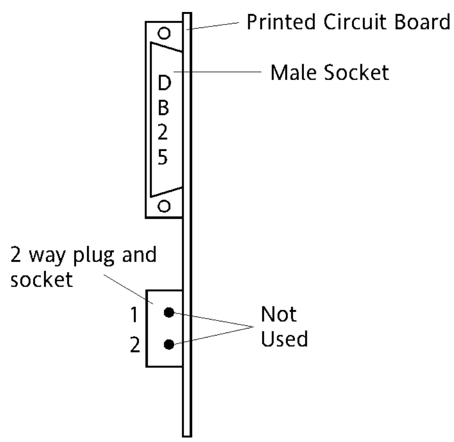

Figure A.64 External Connections – SIO232 PFM – DM128

Table A.72 DB25 Pinout – Event Recorder Interface – SIO232 PFM – DM128

Pin	Function
2	Transmit Data (TxD)
5	Clear to Send (CTS)
7	Signal Ground (GND)

Signal

The Signal is simplex asynchronous, data output only, and is selectable from 1200 bits/s or 4800 bits/s. It comprises 1 start bit, 7 data bits, 1 parity bit, even, and 1 stop bit.

A.15.7.2 Technician Interface

The Technician Interface is a DB25 connector on the front edge of the DM module.

Table A.73 DB25 Pinout – Technician Interface – DM128

Pin	Function
2	Transmit Data (TxD)
3	Receive Data (RxD)
7	Signal Ground (GND)

Signal

The Signal is Duplex Asynchronous, selectable from 1200 bits/s or 4800 bits/s and comprises 1 start bit, 7 data bits, 1 parity bit, even, and 1 stop bit.

A.15.7.3 Cabling Details

A cable with one of the following configurations will allow the connection of a personal computer to either the technician interface or the event recorder interface.

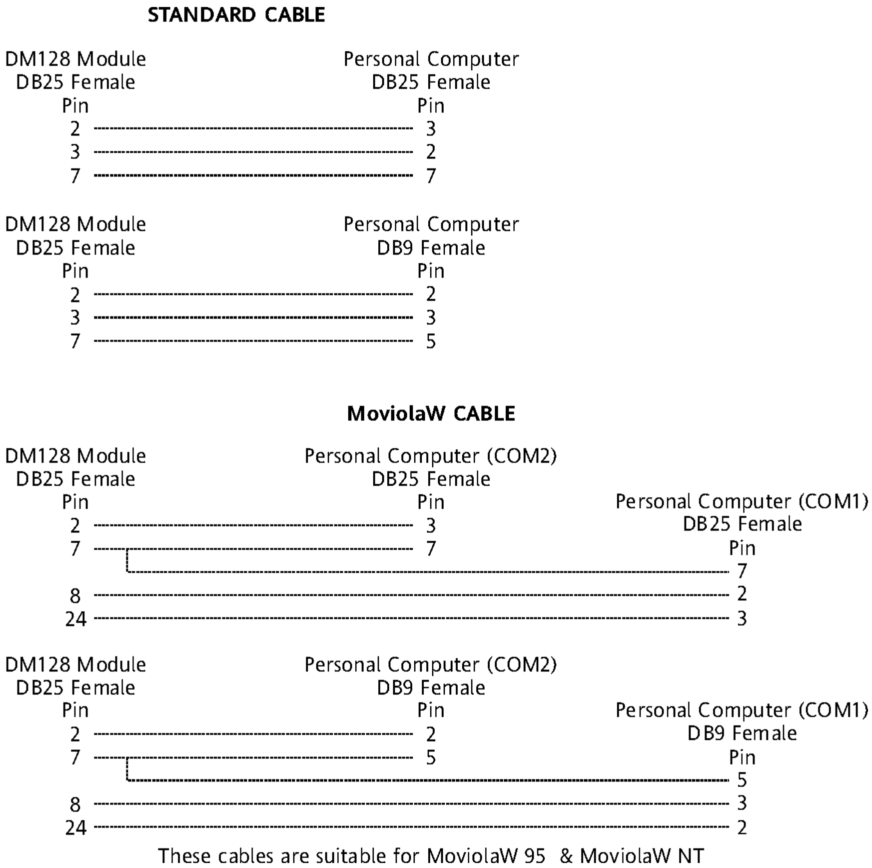

Figure A.65 Interface Cable Configuration – DM128

A

A.16 Power Supply Unit (PSU)

A.16.1 Description

The PSU converts the incoming 24 V supply to the voltage levels required for by all WESTRACE modules.

A.16.2 Particulars

The PSU comprises a single printed circuit board.

A.16.3 Characteristics of PSU 24

Input Voltage Range 20–30 Vdc

Output Voltages as shown:

+ 5 Vdc	@	5 A max
+12 Vdc	@	0.5 A max
–12 Vdc	@	0.5 A max
+12 V Power	@	2.5 A max

Only one PSU can be installed per system housing, however additional PSUs may (optionally) be installed in other housings in multiple housing installations.

The PSU has a pre-assigned position on the VLE backplane. All other positions are occupied by other modules or blanker cards.

A.16.4 Function

The PSU generates the internal power supply voltages, and contains the System Reset line for other VLE modules.

The PSU is not processor based and therefore does not perform self-tests and does not participate in Health Monitoring functions.

The absence of any voltage, or a departure from the voltage specification will lead to the system reset line becoming active which will force a system reset.

A.16.5 Configuration

None

A.16.6 Indications

The PSU contains five red LEDs, which indicate the presence of the input and output voltages. All LEDs should be illuminated when power is applied to the system.

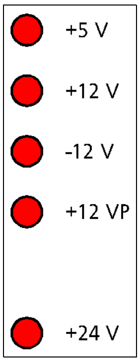

Figure A.66 Power Indicator LEDs – PSU

A.17 Protection and Filter Modules (PFMs)

A.17.1 Description

PFMs are used to isolate the clean internal WESTRACE environment from the 'dirty' external electrical environment by providing screening, filtering and overvoltage protection.

The WESTRACE housing must be fully enclosed and earthed to protect the internal environment from external EMI. Inputs to the system, and outputs from the system have to pass through this barrier so an input/output module specific PFM is used to isolate WESTRACE from external interference. By screening incoming and outgoing signals in this way, the effects of conducted EMI are considerably reduced.

As the PFM is a vital module. PCB tracks are arranged so that short circuits between adjacent tracks will not cause a wrong side failure.

A.17.2 Configuration

None.

A.17.3 Indications

None.

A.18 VLE Backplane

A.18.1 Description

The VLE Backplane is used to interconnect all system modules in the VLE. It comprises a single printed circuit board with parallel tracks and female DIN connectors which straddle those tracks. WESTRACE modules plug into the DIN connectors.

There may be up to four housings and VLE backplanes in a single WESTRACE installation. Each backplane is fitted with DB37 connectors for connection to other VLE backplanes. Special cabling is used for interconnecting backplanes where more than one system backplane is required.

A.18.2 Configuration

Refer to the circuit book in the Signal Equipment Room for information regarding the link settings on the backplane.

A.18.3 Indications

None.

Blanker Card

Description

Blanker cards are used to maintain continuity of vital signals across the VLE backplane. A blanker card and a PFM blanker plate must be fitted in any unused input/output module slot.

Configuration

None.

Indications

None.

A.19 S2/MBD51 Single Modem Motherboard

A.19.1 Description

The S2/MBD51 is a stand-alone motherboard which will enable an interface between S2/VFC42/45/46 modems and any installation requiring communications at RS422, or RS232 levels and a transmission media such as PCM, cable, or open wire at voice frequencies.

A.19.2 Particulars

The S2/MBD51 is comprised of a single printed circuit board and various connectors. There are configuration shunt links to select RS232/422 answer/originate, data transfer rate, constant carrier (RTS), modem outputs stage enable (PTX), 4 wire/2 wire, impedance of modem output/input and constant transmit clock to the S2/VFC42/45/46.

Connectors on the board allow:

- either a S2/VFC42/45/46 to be installed;
- interface communications at RS422, or RS232 levels;
- the connection of a protocol analyser at RS422, or RS232 levels;
- the connection to a line with 4 wires or 2 wires depending upon the type of modem installed;
- the transmit and receive attenuation to be adjusted (by means of a plug on the attenuator board);
- the connection and daisy chaining of the 12V and 0V supply for multiple S2/MBD51 motherboards.

A.19.3 Function

The S2/MBD51 is purely a passive device and as such does not alter the characteristics of the signals flowing through it.

A.19.4 Configuration

The motherboard has two banks of jumpers used for configuration. One is for modem configuration and the other is for line impedance selection.

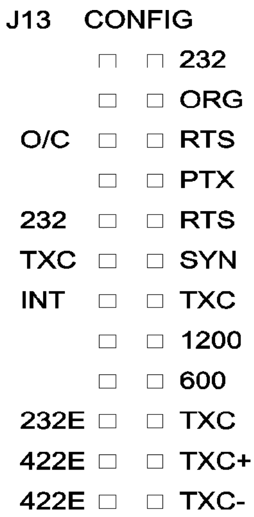

Figure A.67 S2/VFC42/45/46 Modem Configuration J13 – S2/MBD51 Motherboard

Table A.74 Link Description – S2/MBD51 Motherboard

Link	Description	Link In	Used with
232	Selects between RS232 or RS422 for modem interface	Selects RS232	S2/VFC45 only
ORG	Selects the modulation frequency for the modem	Selects ANS	S2/VFC42 only
O/C RTS	Enables modem constant carrier, used for RS422 interface only	Enable Carrier	S2/VFC45/42 only
PTX	Enables modem power transmitter output circuit	Enable Power output	S2/VFC45/42 only
232 RTS	Enable modem constant carrier, used for RS232 interface only	Enable Carrier	S2/VFC45 only
TXC SYN	Selects modem transmit clock synchronised to data	Selects clock not sync to data	S2/VFC42 only
INT TXC	Connects transmit clock output loop back to transmit clock 'IN'	Loop transmit clocks	S2/VFC42 only
1200	Selects modem clock rate at 1200 bps	Selects 1200 bps	S2/VFC45 only
600	Selects modem clock rate at 600 bps	Selects 600 bps	S2/VFC45 only
232E TXC	Connects external transmit clock to modem. Used for RS232 interface only.	Selects External RS232 Transmit Clock	S2/VFC46 only
422E TXC+	Connects external transmit clock to modem. Used for RS422 interface only.	Selects External RS422 Transmit Clock	S2/VFC46 only
422E TXC-	Connects external transmit clock to modem. Used for RS422 interface only.	Selects External RS422 Transmit Clock	S2/VFC46 only

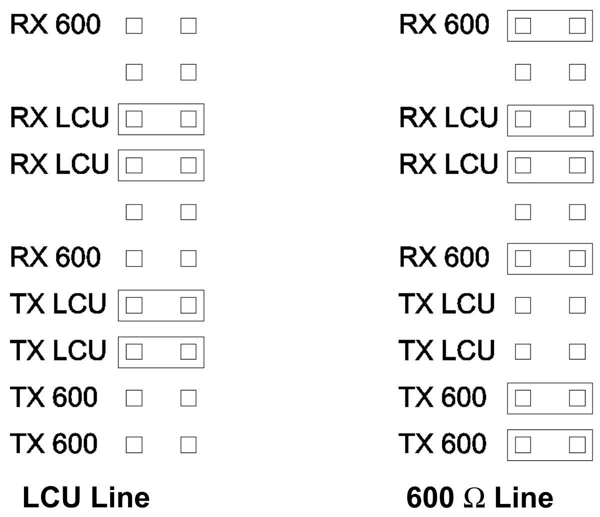

Figure A.68 S2/VFC42/45 Line Impedance Configuration J14 (4 WIRE LINE)

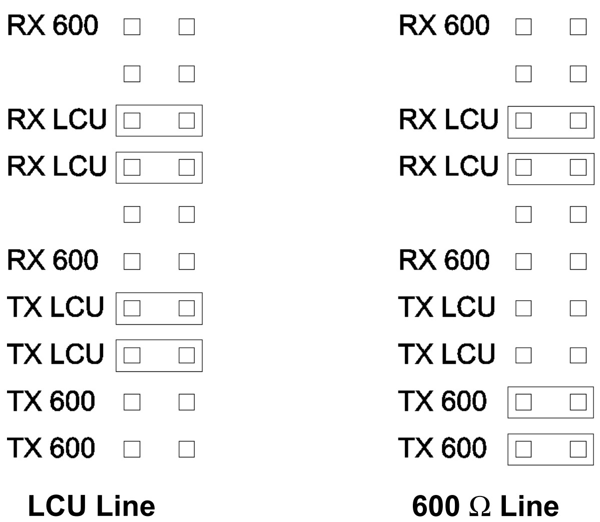

Figure A.69 S2/VFC42 Line Impedance Configuration J14 (2 WIRE LINE)

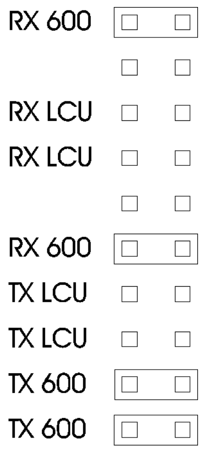

Figure A.70 S2/VFC46 Line Impedance Configuration J14 (all line impedances)

Figure A.71 S2/VFC42/45 Line Wire Configuration J12

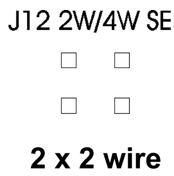

Figure A.72 S2/VFC46 Line Wire Configuration J12

A.19.5 Indications

None.

Appendix B: Module Operation

This appendix describes the:

- structure;
- operation, and;
- module safety assurance;

for WESTRACE modules.

B.1 Vital Logic Module (VLM1)

The VLM1 is the central processing unit for the WESTRACE Vital Logic Equipment (VLE). It receives inputs from vital and non-vital input modules, processes these according to the Application Logic defined by the Application Engineer using the Configuration System (CS), and generates outputs for vital and non-vital output modules.

The VLM1 consists of three cards connected via the VLM Backplane Card (VBC).

The VLM1 occupies slots 1 to 3 of housing number 1.

B.1.1 Description

B.1.1.1 Vital Logic Card (VLC)

The VLC is a double extended Eurocard. It is a digital card using a microprocessor, program and data memory, and external interface components.

The VLC:

- Interfaces to the input and output modules via the Internal Module Bus (IMB);
- Generates the 1Hz flash timing reference (FLASH) for the flashing lamp output modules and generates the dynamic Primary and Secondary Negation signals.

B.1.1.2 Configuration Element Card (CEC)

The CEC is a double extended Eurocard. The Configuration Element Data (CED) is programmed into EPROMs that are installed in sockets on this card. It also has 8 switches specifying the version number of the CED (see section A.4.2.2). These are set to correspond with the installation data version number contained in the EPROMs.

B.1.1.3 Output Power Card (OPC)

The OPC is a double extended Eurocard that receives the:

- Primary Negation signal from the VLC, via the VBC;
- Secondary Negation signal that is routed through all the other vital modules via the VLE Backplane.

The OPC uses both negation systems to generate the Vital Serial Enable Voltage (VSEV) and the drive to the Output Power Control Relay (OPCR).

B.1.1.4 VLM Backplane Card (VBC)

The VBC is a short 3U backplane PCB that:

- Connects the VLC, CEC and OPC, and;
- Routes the external connections to the +24V Supply, the VSEV and the OPCR.

There are 24 links (LK1–LK24) on this card that are used to factory preset the unique installation address. See section A.4.2.4.

The VBC is located below the VLE Backplane, covering slots 1-3 in housing 1.

B.1.2 Operation

B.1.2.1 Power-Up

The VLM1 performs the following sequence of operations from power-up:

a) Performs all internal self-tests to ensure the health of the VLM1;

b) Checks the module configuration of the VLE the installation address and the application data version against that defined in the CED. Initialises all internal states;

c) Ensures that all other vital modules are compatible, that they have satisfactorily completed all their safety checks and that they are operational;

d) Send the vital output modules the default states defined in the CED and allow sufficient time for these to be set on the outputs;

e) Allow time for the VSEV and drive to the OPCR to be generated from the Primary Negation and Secondary Negation waveforms;

f) Repeat the following sequence until all vital input data has been received or failures of vital serial links have been reported. Three seconds are allowed to complete this sequence;

   Read all inputs;

   - Update the internal timer states;
   - Evaluate and store the new internal states as defined by the combination of inputs, internal stored states, timers and Application Logic;
   - Send the vital output modules the default states;

- During this period, the VLM1 starts to send the Configuration Element Data to the Diagnostic Module at a rate of one block per cycle. This process continues until all the CED has been sent.

g) Begin timing the Initialisation Delay time specified in the CED. During this time the VLM1 will continue to operate as in step **f** above;

h) Indicate (APPDEL1), that normal operation by setting the Application Delay logic state;

i) Begin normal operation.

B.1.2.2 Normal Operations

The VLM1 software cycles through the following events during normal operation:

a) Encode Output Messages to all modules;

b) Send Output Messages to and Receive Input Messages from all modules;

c) Decode Input Messages and set relevant internal states for all modules;

d) Evaluate Timers;

e) Evaluate Logic.

The cycle time for the normal operation is variable, dependent on the number and type of modules installed and the quantity of application logic to evaluate. The maximum cycle time is one second.

B.1.2.3 Additional Operations

Additional background functions are also performed by the VLM1:

a) Internal self-tests are performed regularly throughout the VLM1 processing;

b) The Primary Negation signal is generated and the Secondary Negation Signal is not inhibited, while all internal self tests, IMB messages from vital modules, and Health Monitoring of adjacent vital modules are correct;

c) The OPCR will be exercised when requested by the EXOPCR Logic State;

d) All vital modules are checked between data transfers to ensure they have not failed. This only happens if the time between data transfers is too long;

e) Health Monitoring of the two adjacent vital modules is performed;

f) Logic State data is written to the Diagnostic Module each cycle.

B.1.3 Module Safety Assurance

The safe operation of the VLM1 is assured by:

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a) health monitoring of VLM1 microprocessor by adjacent modules;

b) microprocessor Self-tests of RAM, ROM and CPU;

c) ensuring that other vital modules take part in the IMB transfer correctly when requested;

d) each other vital modules ensuring that the VLM1 takes part in IMB transfers at the correct intervals;

e) the VLM1 software generating a dynamic code sequence that is used to produce the VSEV and drive to the OPCR on the OPC;

f) use of two representations and implementations of software for all safety critical functions, for example logic evaluation and timers;

g) use of redundant data storage for logical variables with checks to detect corruption of these;

h) processing of internal states is such that the energised state is always positively identified and its absence results in the de-energised state being assumed.

B.2 Vital Hot Standby Logic Module (HVLM)

The HVLM is an alternative central processing unit for the WESTRACE Vital Logic Equipment (VLE). It receives inputs from vital and non-vital input modules, processes these according to the Application Logic defined by the Application Engineer using the Configuration System (CS), and generates outputs for vital and non-vital output modules.

The HVLM also provides facilities for interconnection with a second WESTRACE system via a fibre optic link so the two systems can be configured as a hot standby set.

The HVLM consists of two cards connected via a small backplane, the Hot Standby Vital Backplane Card (HVBC). The HVLM occupies slots 2 and 3 of housing 1.

B.2.1 Description

B.2.1.1 Hot Standby Vital Logic Card (HVLC)

The HVLC is a double extended Eurocard. It is a digital card using a microprocessor, program and data memory, and external interface components.

The HVLC:

- Interfaces to the input and output modules via the Internal Module Bus (IMB);
- Generates the 1 Hz flash timing reference (FLASH) for the flashing lamp output modules and generates the dynamic Primary and Secondary Negation signals;
- Has a fibre optic transmitter and receiver to transfer data to a second HVLC.

B.2.1.2 Output Power Card (OPC)

The HVLM uses that same OPC as is used by the VLM1.

The OPCRs are wired in an exclusive–or arrangement. A Standby OPCR will remain de-energised by the online OPCR being energised and by the use of the Exercise Switch. Either installation will shut down if detects that its own OPCR is not in the expected state.

The HVLM software will not detect that an OPCR is stuck until it is exercised. Exercising is only available when the installation is online. However, exercising cannot be performed during the application delay period. An HVLM in Standby Mode will not detect that its OPCR is stuck until it enters Online Mode.

An installation that is configured to be stand-alone only detects the state of its OPCR during exercising. It will not shutdown if it detects that its OPCR is not in the expected state.

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Exercising cannot be performed for at least one second after a prior request to exercise. The EXOPCR logic state must remain at logic 0 for at least one cycle before exercising can be performed again.

The OPCRFLT logic state will only be set to logic 0 if a fault has been detected during the exercising of the OPCR.

The fault could be:

a) On receipt of a request to exercise the OPCR, the OPCR was not energised;

b) The OPCR failed to de-energise during exercising;

c) The OPCR failed to energise on completion of exercising.

B.2.1.3 Hot Standby Vital Backplane Card (HVBC)

The HVBC is a short 3U backplane PCB that;

- Connects the VLC and OPC;
- Routes the external connections to the +24V Supply, the VSEV and the OPCR.

There are 24 (LK1–LK24) links on this card that are used to factory preset the unique installation address. See section A.3.2.3.

The HVBC is located below the VLE Backplane, covering slots 1-3 in housing 1.

Each HVLM has two configuration links. One link (CONF1) is used to bias one system of a pair online and the other (CONF2) may be made for stand-alone operation (this is not used in a hot standby pair). See also sections B.2.2.2 and A.3.2.3.

The configurable link (CONF1) on the HVBC can be set to bias the HVBC to operate in:

- Online Mode—link made, or;
- Offline Mode—link not made (non-biased).

In a pair of installations intended to operate in a hot standby configuration, one installation will be biased online and the other will be non-biased (offline). A non-biased HVLM will enter Standby Mode before entering Online Mode when it is powered-up alone. An installation intended to operate in Stand-Alone Mode will be biased online.

An indication is maintained of the mode of an installation. The status of the system can be interrogated by inspecting the MYMODE and SBYSTAT logic states, and from the LEDs on the front panel.

The HVLM will flash the:

- Green LED when in Online Mode, or;
- Orange LED when in Standby Mode.

Note: ***A UHVBC can also be used. See section B.4.1.3.***

B.2.2 Operation

The HVLM operates in the same way as the VLM1 except as defined in this section.

B.2.2.1 Cycle Time

The HVLM cycle time:

- Is fixed at one second when configured for hot standby;
- Varies between 0.5 and 1.0 seconds when operating standalone.

B.2.2.2 Hot Standby Configuration

The mode of operation of an installation is determined by the configurable link CONF2 as follows:

- Link made—'Stand-Alone', or;
- Link not made—'Hot Standby'.

B.2.2.3 Changeover

The system provides two voltage-free selector input contacts, 'Inhibit' and 'Request'. The contacts are active low.

Condition	Outcome
Neither selector input is selected.	The system shall be able to respond to any request to changeover on failure of the connected installation.
Both selector inputs are selected simultaneously.	System changeover is inhibited.
The 'Inhibit' selector input is selected.	The HVLM will not attempt to changeover.
The 'Request' selector input is selected.	The online HVLM will determine whether a changeover is appropriate and if so will initiate the changeover.

If it is necessary to start-up both installations together and it is intended that the non-biased installation is to become online and inhibit changeover, then the application of power to the biased installation shall be delayed by a time sufficient for the non-biased installation to enter Online Mode. Under certain circumstances it may be possible for both installations to shutdown during start-up.

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Condition	Outcome
The HVLM receives a request to changeover via the selector inputs whilst exercising the OPCR.	It will be Ignored
The HVLM receives a request to changeover before the drive to the OPCR is provided.	It will be ignored. However, the MYMODE logic state will be set to indicate that a changeover is occurring. This will only remain for the duration of the request which will be one cycle.

A request to changeover must not be present for more than one cycle (one second) to avoid the possibility of the Hot Standby system toggling.

The RCOVER reserved logic state shall be set by the HVLM software when there is a request to changeover via the selector inputs. The RCOVER reserved logic state shall be set whether the HVLM has acted upon the request to changeover or not.

An installation will not be able to differentiate between an installation in online initialisation, standby initialisation or standby modes.

Condition	Outcome
An installation in Online Mode fails, or responds to a request to changeover whilst the other installation is in Online Initialisation Mode or Standby Initialisation Mode.	The changeover will be unsuccessful and the system will fail.

The changeover time is defined as the time for which any Hot Standby installation output state is set to its most restrictive state. The maximum changeover time is 1.0491 seconds.

In the event of a changeover:

- Timers will be delayed by up to the changeover time;
- The maximum time a vital output will remain in its most restrictive state shall be less than 2.5 s;
- Any vital input which remains de-energised for less than 2.5 s may be lost.

If the Online Mode OPCR does not energise after changeover, shutdown will be invoked.

B.2.3 Module Safety Assurance

B.2.3.1 System Safety Principles and Methods

The following safety principles and methods, in addition to those for the VLM1, apply:

a) The standby HVLM checks that both installations have the same installation address, CED version number and CED checksums;

b) By continual monitoring of the connected installation, the HVLMs ensure that only one installation is in Online Mode at any one time.

B.2.3.2 HVLE Safety Principles and Methods

B.2.3.2.1 Installation Negation

a) The principle of fail-safe design is provided in the HVLE by passing control of the railway to the connected installation if any failures are detected. This is referred to as installation negation;

b) The HVLM is designed to ensure that installation negation occurs before any internal fault can result in incorrect output data being sent to a vital slave module or transferred over the Inter-HVLM-Communications-Link (IHCL);

c) The HVLM will perform installation negation within 351 ms of a vital slave module disabling its IMB interface. The hardware takes up to 10 ms to disable the VSEV and the drive to the OPCR, so the HVLM design is such that the software completes shutdown within 341 ms of a vital slave module disabling its IMB interface;

d) Two defences are provided to guarantee that the VSEV and OPCR drive cannot be re-enabled once the system has negated until the power has been removed and re-applied:
   - The shutdown mechanism provided by the HVLM software is failsafe; once shutdown has occurred the VSEV and the drive to the OPCR are removed and the software stops executing. The software will not restart execution until a system restart occurs.
   - The high integrity hardware start-up circuitry also provides a diverse defence. This is designed to be 'one-shot'; one attempt is made to provide the OPCR drive, there is no further attempt to provide the OPCR drive until the power supply has been removed and re-applied.

B.2.3.2.2 Safety During Changeover

a) The standby HVLM is prevented from entering Online Mode until it has received all the relevant information from the online HVLM. The HVLM will not experience divergence in interlocking strategies as a result of changeover;

b) During a changeover, the system does not transmit vital serial communication messages, and its vital internal logic states and timers are unaffected.

B.2.3.2.3 Self-Tests

The SelfTests software is performed after encoding the serial message and before the start of its transmission to the Standby HVLM.

B.3 Vital Standby Logic Module (VLM5)

The VLM5 is an alternative central processing unit for the WESTRACE Vital Logic Equipment (VLE). It receives inputs from vital and non-vital input modules, processes these according to the Application Logic defined by the Application Engineer using the Configuration System (CS), and generates outputs for vital and non-vital output modules.

The VLM5 also provides facilities for interconnection with a second WESTRACE system via a fibre optic link so the two systems can be configured as a hot standby set.

The VLM5 consists of two cards connected via a small backplane, the Hot Standby Vital Backplane Card (HVBC). The VLM5 occupies slots 2 and 3 of housing 1.

The CEC functionality of earlier VLM modules is onboard the VLM5 by means of PROMs and switches.

B.3.1 Description

B.3.1.1 Vital Logic Card 5 (VLC5)

The VLC5 is a double extended Eurocard. It is a digital card using a microprocessor, program and data memory, Complex Programmable Logic Devices (CPLD) and external interface components. It can be fitted with more program and data memory capacity than can the HVLC and the CPLDs help deter component obsolescence.

The VLC5:

- Interfaces to the input and output modules via the Internal Module Bus (IMB);
- Generates the 1 Hz flash timing reference (FLASH) for the flashing lamp output modules and generates the dynamic Primary and Secondary Negation signals;
- Has a fibre optic transmitter and receiver to transfer data to a second VLC5.

B.3.1.2 Output Power Card (OPC)

The VLM5 uses the same OPC as the VLM1 and HVLM. See section B.2.1.2 for details. Substitute VLM5 where section B.2.1.2 mentions HVLM.

B.3.1.3 Hot Standby Vital Backplane Card (HVBC)

The VLM5 uses the same HVBC as the HVLM. See section B.2.1.3 for details. Where section B.2.1.3 mentions HVLM substitute VLM5.

Note: ***A UHVBC can also be used. See section B.4.1.3.***

B.3.2 Operation

The VLM5 operates in the same way as the HVLM (see section B.2.2) except as defined in this section.

B.3.2.1 Cycle Time

The VLM5 cycle is variable for both Stand-Alone Mode and Hot Standby Mode, with a maximum of 1.3 seconds.

B.3.2.2 Hot Standby Configuration

As for HVLM. See section B.2.2.2.

B.3.2.3 Changeover

As for HVLM. See section B.2.2.3.

B.3.3 Module Safety Assurance

B.3.3.1 System Safety Principles and Methods

The VLM5 follows the same safety principles and methods as the HVLM. See section B.2.3.1.

B.3.3.2 HVLE Safety Principles and Methods

The same HVLE safety principles and methods apply as for the HVLM. See section B.2.3.2.

B.4 Vital Logic Module (VLM6)

The VLM6 is the preferred central processing unit for the WESTRACE Vital Logic Equipment (VLE). It receives inputs from vital and non-vital input modules, processes these according to the Application Logic defined by the Application Engineer using the Configuration System (CS), and generates outputs for vital and non-vital output modules.

When used in conjunction with an NCDM, the VLM6 also provides vital communications over a network to connected WESTRACE systems.

The VLM6 also provides facilities for interconnection with a second WESTRACE system via a fibre optic link so the two systems can be configured as a hot standby set.

The VLM6 consists of two cards connected via a small backplane, the Universal Hot Stand-by Vital Backplane Card (UHVBC). The VLM6 occupies slots 2 and 3 of housing 1.

The CEC functionality of earlier VLM modules is onboard the VLM6 by means of PROMs and switches.

B.4.1 Description

B.4.1.1 Vital Logic Card 6 (VLC6)

The VLC6 is a double extended Eurocard. It is a digital card using a microprocessor, program and data memory, Complex Programmable Logic Devices (CPLD) and external interface components. It can be fitted with more program and data memory capacity than can the HVLC and the CPLDs help deter component obsolescence.

The VLC6:

- Interfaces to the input and output modules via the Internal Module Bus (IMB) and interfaces to the NCDM through the dedicated VLM6–NCDM interface;
- Generates the 1 Hz flash timing reference (FLASH) for the flashing lamp output modules and generates the dynamic Primary and Secondary Negation signals;
- Has a fibre optic transmitter and receiver to transfer data to a second VLC6.

B.4.1.2 Output Power Card (OPC)

The VLM6 uses the same OPC as the VLM5, HVLM and VLM1. See section B.2.1.2 for details. Substitute VLM6 where section B.2.1.2 mentions HVLM.

B.4.1.3 Universal Hot Standby Vital Backplane Card (UHVBC)

The VLM6 uses a UHVBC.

The UHVBC is a short 3U backplane PCB that:

- Connects the VLC and OPC;
- Routes the external connections to the +24V Supply, the VSEV and the OPCR.

There are 24 links (LK1–LK24) on this card that are used to factory preset the unique installation address. See section A.1.2.3.

There are two links (LK25 and LK26) that are used to provide or withhold VSEV voltage to the VLC when they are made or not made. These links are made when the UHVBC is used with VLC6, and not made when it is used with the VLC5 or HVLC. The UHVBC is located below the VLE Backplane, covering slots 1-3 in housing 1.

Each VLM6 has two configuration links. One link (CONF1) is used to bias one system of a pair online and the other (CONF2) may be made for stand-alone operation (this is not used in a hot standby pair). See also sections B.4.2.2 and A.1.2.3.

The configurable link (CONF1) on the HVBC can be set to bias the UHVBC to operate in:

- Online Mode—link made, or;
- Offline Mode—link not made (non-biased).

In a pair of installations intended to operate in a hot standby configuration, one installation will be biased online and the other will be non-biased (offline). A non-biased VLM6 will enter Standby Mode before entering Online Mode when it is powered up alone. An installation intended to operate in Stand-Alone Mode will be biased online.

An indication is maintained of the mode of an installation. The status of the system can be interrogated by inspecting the MYMODE and SBYSTAT logic states, and from the LEDs on the front panel.

The VLM will flash the:

- Green LED when in Online Mode, or;
- Yellow LED when in Standby Mode.

B.4.2 Operation

The VLM6 operates in the same way as the HVLM (see section B.2.2) except as defined in this section.

B.4.2.1 Cycle Time

The VLM6 cycle is variable for both stand-alone and hot standby modes, with a maximum of 1.3 seconds.

B.4.2.2 Hot Standby Configuration

As for HVLM. See section B.2.2.2.

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B.4.2.3 Changeover

As for HVLM. See section B.2.2.3.

B.4.3 Module Safety Assurance

B.4.3.1 System Safety Principles and Methods

The VLM6 follows the same safety principles and methods as the HVLM. See section B.2.3.1.

B.4.3.2 HVLE Safety Principles and Methods

The same HVLE safety principles and methods apply as for the HVLM. See section B.2.3.2.

B.5 Vital Lamp Output Module (VLOM)

The VLOM interfaces railway signalling lamps to the VLM logic. VLOMs are available for use with 110 Volt ac or dc Lamps. The outputs provide current to the associated lamp from an external power supply. Lamp outputs are not isolated from the signalling supply and utilise a common return connection point. Vital Hot filament proving and non-vital Cold filament detection are provided by VLOMs. Both steady output and flashing or steady output modules are available.

B.5.1 Description

A VLOM comprises a set of double extended Eurocard Printed Circuit Boards (PCBs). PCBs are joined by spacing pillars and interconnected by DIN 41612 style connectors to form a module.

The module consists of a Vital Parallel Input Output Digital Board (VPIODB), and one or two Vital Lamp Output Module Analogue Board(s) (VLOMAB). Each VLOMAB has six outputs. A module with one VLOMAB has six outputs, and a module with two VLOMABs has 12 outputs.

The digital board contains the processing, analogue to digital converter and VLE backplane interface circuitry.

The analogue board contains the lamp current switching and isolating circuitry, located in the Dirty Area that is electrically isolated from the Clean Area where the control and testing circuitry resides.

The VLOMAB is produced in two styles, one for fitting to the left of the VPIODB and one to the right of the VPIODB when fitted in the VLE Housings. A left side board is used for 6 output VLOMs

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B.5.2 Operation

Each lamp output may be individually switched. The analogue circuitry is designed to handle both ac and dc supply voltages. The current drawn by each lamp is monitored by a sense circuit. This provides an input via the multiplexer and analogue to digital converter to the processor. The processor thus measures the currents flowing in each of the lamp circuits.

Each individual lamp circuit has a fuse in series with the output. If the processor detects an unacceptable current passing through a lamp circuit that should be in the de-energised state, then it may attempt to isolate the lamp circuit by blowing the fuse. This allows individual lamp outputs to be disabled in case of failures while allowing the other outputs to continue operating Safely– defined as graceful degradation.

The fuse blowing circuit is not safety critical. If it is does not successfully isolate the output, the output will be isolated by system shutdown within the defined fleeting output time.

A separate ground fail connection to the common of the lamp supply verified the integrity of the signalling return.

Non-vital Cold filament detection is carried out by measuring the current that flows when each lamp output is energised for a maximum of 5 milliseconds. The VLOM processes one de-energised lamp output per cycle.

Vital Hot filament proving is achieved by sampling the current passing when the lamp is turned on. The module calculates the rms value of this current based on a set of current measurements. The hot filament proving will correctly detect the presence or absence of a filament when the output is being flashed and will work with transformer coupled signalling lamps.

B.5.3 Module Safety Assurance

Checks are performed to ensure that the sense circuits accurately read test inputs. These checks form the diverse check on the operation of the sense circuit. A failed check will generate a filament proving mnemonic logic state 0. The Application logic **must** use this state as described in section 4.2.3.9.

Malfunction of the lamp switch circuits is detected by software checks. The samples taken for hot filament proving are also used to detect an illegal output, thus safe operation is achieved for ac, or ac derived supplies, with frequencies in the range 45 Hz to 65 Hz.

The ground fail detector is used to prevent the possibility of a false connection between lamp outputs, via failed module output protection circuits or fuse blow components, should the signal return connection between the VLOM and the signalling negative bus bar become disconnected.

The fuse blow function is included for graceful degradation and not for safety reasons.

Although on the VLOM analogue board the circuits are not an inherently fail-safe design, these circuits are monitored so that faults are detected and negated. The sense functions are checked by passing known currents through them.

The safe operation of the VLOM is assured by:

a) health monitoring of VLOM microprocessor by adjacent modules;

b) microprocessor Self-tests of RAM, ROM and CPU;

c) the VLM checking that the VLOM takes part in the IMB transfer correctly when requested;

d) the VLOM checking that the VLM requests IMB transfers at the correct intervals;

e) use of two representations and implementations of software for all safety critical functions, for example, output control;

f) use of redundant data storage for logical variables with checks to detect corruption;

g) self checks on the hardware.

B.6 Vital Relay Output Module (VROM)

The VROM drives 50 Vdc signalling relays based on the VLM logic. There are eight fully isolated outputs per module. The VROM module requires an external signalling supply from which it generates 8 isolated voltage sources to drive the relays. The circuitry is designed so that the outputs may be used to drive a neutral or polar (biased) relay, or a bipolar relay.

B.6.1 Description

A VROM comprises a set of double extended Eurocard Printed Circuit Boards (PCBs). PCBs are joined by spacing pillars and interconnected by DIN 41612 style connectors to form a module. The module consists of the Vital Parallel Input Output Digital Board (VPIODB), and a Vital Relay Output Module Analogue Board (VROMAB).

The digital board contains the processing, analogue to digital converter and VLE backplane interface circuitry.

The analogue board contains the relay interface conditioning and isolating circuitry, located in the Dirty Area, that is electrically isolated from the Clean Area where the control and testing circuitry resides.

B.6.2 Operation

An isolated internal supply (generated from the 50 V signalling supply) is used to drive the relay outputs via an on-board isolated dc-dc converter.

Each relay output is transformer isolated and may be individually switched. The processor monitors each output voltage by dual sense circuits connected via a multiplexer and Analogue to Digital Converter (ADC). No current sensing is performed and so no indication of the state of the external relay is provided. Each output has a transistor switch on the output side of the transformer to isolate any small leakage voltage that may otherwise be present. However, from a safety point of view, it must be assumed that this residual voltage may be present.

Each individual relay output channel has a fuse in series with the output. The processor will attempt to blow the fuse on any output that is incorrectly energised. This allows individual faulty relay outputs to be disabled while allowing other outputs to continue operating safely—defined as graceful degradation.

The fuse blowing circuit is not safety critical. If this does not successfully isolate the output, it will be isolated by system shutdown within the defined fleeting output time.

B.6.3 Module Safety Assurance

Although the VROM analogue board circuits are not of inherently fail safe design, these circuits are monitored so that faults are detected and negated. Sense circuits are checked by applying known voltages to them. The sense test function may be relied upon to detect failures in the relay switch circuits by detecting unacceptable voltage output levels.

The fuse blowing circuits are included for graceful degradation and not for safety.

The sampling of the output voltage is performed at a rate that guarantees safe output control when working from a dc derived from an ac supply between 45 Hz and 65 Hz.

The safe operation of the VROM is assured by:

a) health monitoring of VROM microprocessor by adjacent modules;

b) microprocessor Self-tests of RAM, ROM and CPU;

c) the VLM checking that the VROM takes part in the IMB transfer correctly when requested;

d) the VROM checking that the VLM requests IMB transfers at the correct intervals;

e) use of two representations and implementations of software for all safety critical functions, for example, output control;

f) use of redundant data storage for logical variables with checks to detect corruption;

g) self checks on the hardware.

B.7 Vital Parallel Input Module (VPIM)

The VPIM interfaces the external 50 Vdc signalling inputs to the VLM logic. An external voltage is fed to each input, usually via double cut contacts. This voltage must be above a threshold for the input to be guaranteed as *energised*. It must be below a second threshold to be guaranteed as *de-energised*. Negative voltages and excessive positive voltages are always interpreted as *de-energised*. Each input is electrically isolated from each other and the control circuit.

B.7.1 Description

A VPIM comprises of a set of two double extended Eurocard Printed Circuit Boards (PCBs). PCBs are joined by spacing pillars and interconnected by DIN 41612 style connectors to form a module. Each VPIM has 12 inputs. The module consists of a Vital Parallel Input Output Digital Board (VPIODB), and a Vital Parallel Input Module Analogue Board (VPIMAB).

The digital board contains the processing, analogue to digital converter and VLE backplane interface circuitry.

The analogue board contains the isolation and conditioning circuitry, located in the Dirty Area, that is electrically isolated from the Clean Area where the control and testing circuitry resides.

B.7.2 Operation

The VPIM has a non-vital ac front end filter to allow operation with a high ac component on the input signal. A software filter is used to give vital rejection of interfering ac signals between 45Hz and 11kHz. The VPIM takes 2 sets of samples of inputs every cycle (with a nominal time between taking sets of samples of 90-150 milliseconds). Each set is checked to ensure that it does not contain excessive ac. Each set of samples is then examined. Unless sufficient samples within a set are above the threshold, the present state of the input is taken as de-energised. This filter may not reject low frequency ac below 45 Hz or pulsed dc signals. It will not reject all ac signals above 11 kHz.

A history of this outcome is kept by the VPIM and used to determine the input state to be passed on to the VLM in response to a request from the VLM.

A further level of filtering is used to discriminate against unintended short inputs such as from a bobbing track circuit:

- Four consecutive sets of samples must indicate energised before the input is guaranteed to be taken as energised;
- Two consecutive sets of samples must indicate that the input is de-energised before the transition from energised to de-energised will be recognised.

The filter time will depend on the module cycle time that is in turn dependent on the system complexity and size. The minimum requirements are:

- The input must be present for 360ms before it is guaranteed to be taken as energised, and;
- An input must be absent for 180ms out of a 360ms period before it is guaranteed to be taken as a de-energised.

Each individual input is separately fused to prevent damage to the module in the event that excessive voltages are applied to the input.

The module incorporates regular tests on the health of each input circuit. Any input that fails two consecutive tests will be assumed de-energised for all future reads—referred to as graceful degradation.

B.7.3 Module Safety Assurance

The VPIM is a vital module that achieves the necessary safety levels by a combination of inherently fail-safe conditioning and isolation circuits and proved filtering and buffering circuits.

The safe operation of the VPIM is assured by:

a) health monitoring of VPIM microprocessor by adjacent modules;

b) microprocessor Self-tests of RAM, ROM and CPU;

c) the VLM checking that the VPIM takes part in the IMB transfer correctly when requested;

d) the VPIM checking that the VLM requests IMB transfers at the correct intervals;

e) use of two representations/implementations of software for all safety critical functions;

f) use of redundant data storage for logical variables with checks to detect corruption of these;

g) all input states are passed to the VLM in the true and complement form;

h) self checks on the hardware.

B.8 Vital Telemetry Continuous Module (VTC)

The VTC (Vital Telemetry Continuous Module) can communicate between a similar module in another WESTRACE system. The latest data is sent cyclically to other VTC.

B.8.1 Description

Each VTC consists of a double extended Eurocard printed circuit board. The board contains processing, serial channel interface circuits and the VLE backplane interface circuits.

Switches SW1 and SW2 are not used when the module is configured as a VTC.

B.8.2 Operation

Each VTC used in the system is allocated a port address by the Application Engineer who configures the system by using the CSS or GCSS. This port address is used with the installation address to uniquely identify each vital serial communication link to and from the system. This is achieved by including these two addresses in each message transferred. This function is performed by the VLM when it produces the data to send to the VTC over the IMB.

The data transferred between the VLM and the VTC via the IMB consists of two copies of the same data, one is the complement of the other, these two copies are referred to as the True Data and the Complement Data.

Both the true and complement data received from the IMB are formed into code words, each having its own CRC (Cyclic Redundancy Check) code. The two code words are transmitted separately over the serial channel.

The VTC repeatedly transmits the most recent IMB data over the serial channel:

- LOIC (Loss of Input Channel) is clear (0) when the VTC is reset at power-up;
- The VLM will ensure that the inputs normally received from the VTC are set to the de-energised state when LOIC is clear (0);
- The VTC will clear (0) the LOIC and indicate the LOIC state to the VLM when it fails to receive a correct pair of code words (complementary data packets and correct CRC for each code word) from the serial channel in any 2-second period.
- The VLM will send the LOIC indication in the output message to the VTC so that the installation at the other end of the link may detect the failure of the link.
- The VTC will set (1) LOIC and make the code words available for transfer to the VLM via the IMB upon reception of a correct pair of code words.

B.8.3 Module Safety Assurance

Self-tests form part of the general system safety assurance. These self-tests are performed between the transfer of the true and the complement code words, so that faults in the VTC are detected before transmitting the full output message. The VTC will cause System Negation when it finds a fault that threatens its safe operation.

The safety checking in the VTC requires that the complement message is delayed from the true message to allow all self testing and any necessary System Negation to take place. A block of *Sync* bytes is sent between messages to fulfil this requirement. The receiving VTC will not accept a message unless the timing is correct.

Negation of the VTC is achieved by removing the 24V VSEV (Vital Serial Enable Voltage) from the serial interface circuitry. This prevents data output, because the VSEV powers the output driver circuits.

The safe operation of the VTC is assured by the following:

a) health monitoring of VTC microprocessor by adjacent modules;

b) microprocessor self-tests of RAM, ROM and CPU;

c) the VLM checking that the VTC takes part in the IMB transfer correctly when requested;

d) the VTC checking that the VLM requests IMB transfers at the correct intervals;

e) use of two representations/implementations of software for all safety critical functions;

f) checking for corruption and use of redundant data storage for logic variables.

B.9 Enhanced Vital Telemetry Continuous Module (EVTC)

The Enhanced Vital Telemetry Continuous Module (EVTC) can communicate with a similar module in another WESTRACE system. The latest data is sent cyclically by each EVTC to the other EVTC.

B.9.1 Description

Each EVTC consists of a double extended Eurocard printed circuit board. The board contains processing, serial channel interface circuits and the VLE backplane interface circuits.

Switches SW1 and SW2 are used as described under *Transmit Clock*, Appendix A, page A-81.

B.9.2 Operation

Each EVTC used in the system is allocated a port address by the Application Engineer who configures the system by using the GCSS. This port address is used with the installation address to uniquely identify each vital serial communication link to and from the system. This is achieved by including these two addresses in each message transferred. This function is performed by the VLM when it produces the data to send to the EVTC over the IMB.

The data transferred between the VLM and the EVTC via the IMB consists of two copies of the same data, one is the complement of the other, these two copies are referred to as the True Data and the Complement Data.

Both the True Data and the Complement Data received from the IMB are formed into code words, each having its own CRC (Cyclic Redundancy Check) code. The two code words are transmitted separately over the serial channel.

The EVTC repeatedly transmits the most recent IMB data over the serial channel as described below:

- LOIC (Loss of Input Channel) is clear (0) when the EVTC is reset at power-up.
- The VLM will ensure that the inputs normally received from the EVTC are set to the de-energised state when LOIC is clear (0).
- The EVTC will clear the LOIC (0) and indicate the LOIC state to the VLM when it fails to receive a correct pair of code words (complementary data packets and correct CRC for each code word) from the serial channel in any 2-second period.
- The VLM will send the LOIC indication in the output message to the EVTC so that the installation at the other end of the link can detect the failure of the link.
- The EVTC will set (1) LOIC and make the code words available for transfer to the VLM via the IMB upon reception of a correct pair of code words.

B.9.3 Module Safety Assurance

Self-tests form part of the general system safety assurance. These self-tests are performed between the transfer of the true and the complement code words, so that faults in the EVTC are detected before transmitting the full output message. The EVTC will cause System Negation when finds a fault that threatens its safe operation.

The safety checking in the EVTC requires that the complement message is delayed from the true message to allow all self testing and any necessary System Negation to take place. A block of *Sync* bytes is sent between messages to fulfil this requirement. The receiving EVTC will not accept a message unless the timing is correct.

Negation of the EVTC is achieved by removing the 24V VSEV (Vital Serial Enable Voltage) from the serial interface circuitry. This prevents data output, because the VSEV powers the output driver circuits.

The safe operation of the EVTC is assured by the following:

a) health monitoring of EVTC microprocessor by adjacent modules;

b) microprocessor self-tests of RAM, ROM and CPU;

c) the VLM checking that the EVTC takes part in the IMB transfer correctly when requested;

d) the EVTC checking that the VLM requests IMB transfers at the correct intervals;

e) use of two representations/implementations of software for all safety critical functions;

f) checking for corruption and use of redundant data storage for logic variables.

B.10 Protection & Filter Module

The Protection & Filter Modules (PFMs) provide secondary transient protection and attenuate high frequency interference from entering or leaving the housing.

B.10.1 Description

The PFM is a single height Eurocard PCB fitted with a connector to mate with the lower Module connector on one end and a socket for external wiring on the other. A conductive aluminium screen part way along the module fits to the screen on the housing to complete the *Faraday Cage*.

B.10.2 Operation

Different PFMs are used for the different modules.

The PFMs use Pi LC filters on each input and output line to attenuate high frequency interference that might otherwise enter or leave the housing.

Tranzorbs clamps any high voltage transients to a safe level. External protection may also be required (see section 5.3).

B.10.3 Module Safety Assurance

The PFM, being a Vital Module, is designed to the same physical specification as other vital modules in the system. PCB tracks are arranged such that short circuits between adjacent tracks will not cause a wrong side failure.

High frequency filtering is designed in such a manner as to ensure that filter component failures do not lead to false channel indications, or false outputs to be driven.

Appendix C: Hot Standby Operation

C.1 Introduction

Applications requiring high system availability can use the hot standby configuration of the WESTRACE interlocking and optionally of WESTRACE object controllers. Two identical WESTRACE installations are used. One installation drives the outputs while the second is maintained in an identical state via high speed interconnection data links. The online unit may be selected by inputs and change-over is initiated by online system shutdown.

C.2 Modes of Operation

Both WESTRACE installations are capable of operating in several different modes and certain trigger events will cause them to change mode. Figure C.1 is an installation phase transition diagram showing the main phases for the different modes. An installation in Power-Down Mode or Shutdown Mode is considered to be dormant.

a) Applying power (1) to an installation in Power-Down Mode will move it to the Initialisation Mode.

b) An installation configured for:
- online operation will move first (2) to Online Initialisation Mode and then (4) to the Online Mode;
- standby operation will move first (3) to Standby Initialisation Mode and then (5) to the Standby Mode.

c) Imminent shutdown of the online installation will signal (7) the Standby installation to take over (8) the Online function.

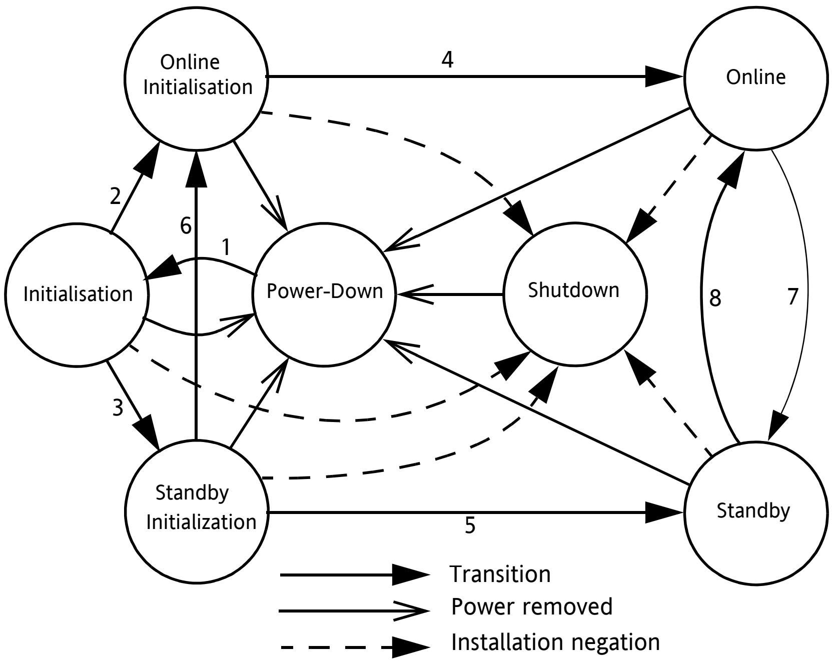


Figure C.1 Initialisation Phase Transition Diagram

C

Any failure in an installation causes it to enter Shutdown Mode (installation negation). If power is removed, it enters Power-Down Mode.

C.2.1 Power-Down Mode

The installation enters Power-Down Mode when the external supply to the installation is switched off. The installation ensures the OPCR and VSEV are de-energised and the IHCL is disabled.

The installation enters Initialisation Mode (see 1 in figure C.1) when the external supply is switched on.

C.2.2 Initialisation

On power-up, the installation performs all internal self tests and then checks the system configuration. On passing the self tests and configuration checks, the installation enters an operating mode and phase according to the flow diagram shown in figure C.2.

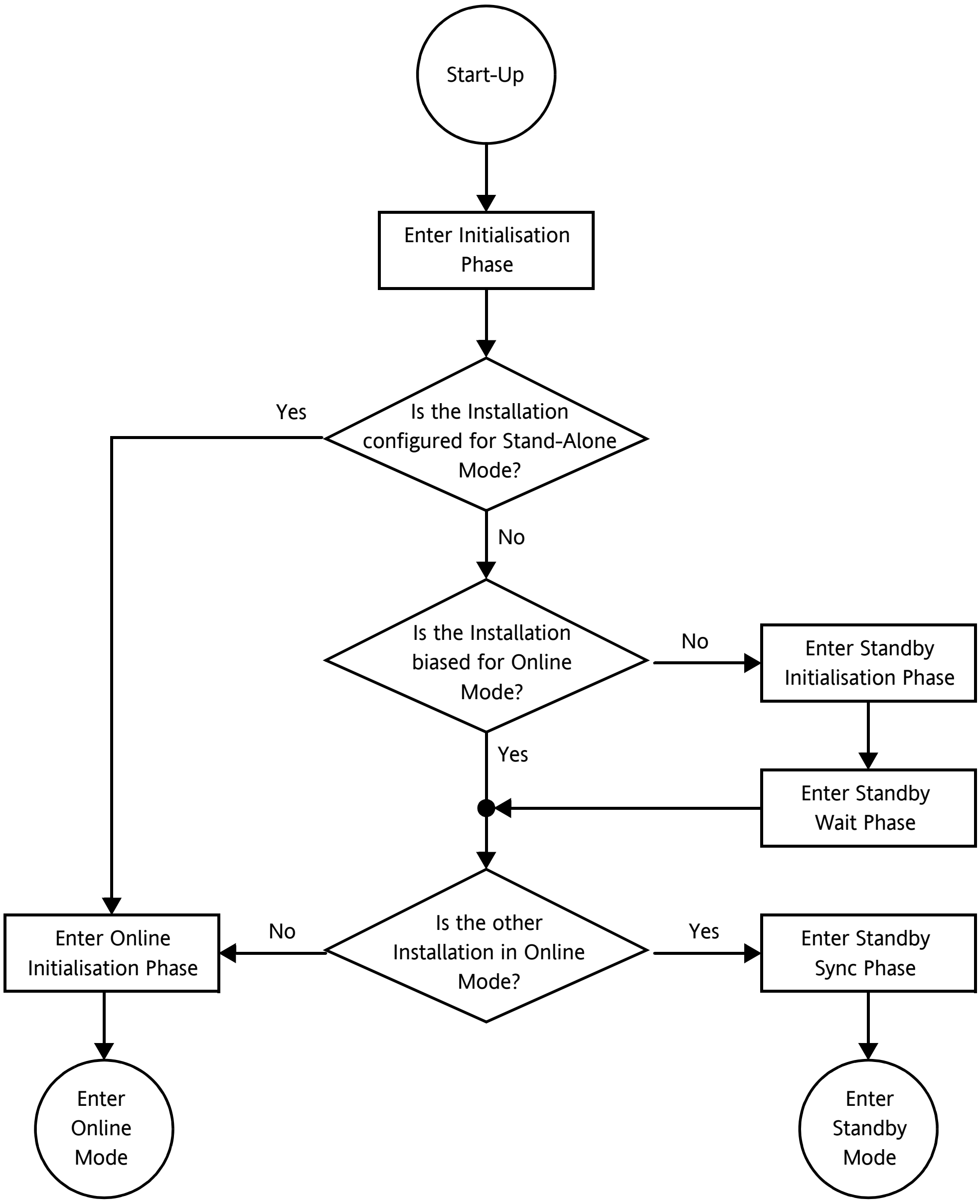


Figure C.2 Start-up Decision Tree – Online or Standby

When an installation is in Online Initialisation Mode or Standby Initialisation Mode and the other installation fails in Online Mode or responds to a request to change-over, the changeover will be unsuccessful and the system will fail. In a hot standby system, changeover should not be attempted until the WESTRACE Application Delay has expired, which is typically several minutes after power-up.

Note: ***Hot standby only becomes available at completion of the WESTRACE Application Delay (see [GCSS]), which is typically several minutes after power-up.***

C

C.2.2.1 Online Initialisation Phase

The installation:

- disables the IHCL;
- ensures the VSEV and OPCR drives are de-energised until the initial output states have been sent to output modules as defined by the initial values of the internal states, and;
- 150 ms has been allowed for those outputs to be acted on;
- then enters Online Mode.

C.2.2.2 Standby Initialisation Phase

The standby-biased installation waits for its Application Delay to expire to allow the online-biased installation to take control of the railway.

C.2.3 Online Mode

The installation in Online Mode is in control of the railway. It reads inputs from slave modules that relate to external stimuli (such as point detection and railway signalling inputs) and processes these safely to provide outputs to slave modules. The slave modules drive the railway signalling apparatus in accordance with the application logic (defined by an Application Engineer).

The installation in Online Mode:

- receives vital inputs and non-vital inputs;
- processes the inputs according to defined application logic (defined by an Application Engineer using the Graphical Configuration System);
- updates the standby installation via the IHCL and INCL and produces vital and non-vital outputs.

C.2.4 Standby Mode

The installation in Standby Mode cannot control the railway. All vital outputs are driven to the de-energised state and its OPCR is de-energised.

The installation in Standby Mode:

- checks that it is correctly receiving vital state updates from the online installation;
- monitors the status of the installation in Online Mode;
- performs health proving functions;
- takes over control of the railway in the event of failure of the installation in Online Mode.

C.2.5 Shutdown Mode

The external supply to the installation is on.

The installation ensures:

- the OPCR and VSEV are de-energised, and;
- the IHCL is disabled.

APPENDIX D: NON-VITAL COMMUNICATION PROTOCOLS

WESTRACE supports the following protocols:

- **Diagnostic Protocol**
  A polled protocol, with the external diagnostic system as the master (client). The external diagnostic system is typically provided by a PC running MoviolaW, NGETLOG or the N(V)CDM diagnostic driver software;
- **WSA/S2 Slave Protocol (Server)**
  A polled control system protocol, with the external control system as the master (client). A WESTRACE system, using this protocol, responds to a polled message with a full data message. The external control system is typically provided by a Centralised Train Control (CTC) system such as WestCAD;
- **WSL/S2 Slave Protocol (Server)**
  A polled control system protocol, with the external control system as the master (client). A WESTRACE system, using this protocol, responds to a polled message with Change of State (COS) data unless a full data message is requested. The external control system is typically provided by a Centralised Train Control (CTC) system such as WestCAD or Small Control Centre (SCC);
- **WSA/S2 Master Protocol (Client)**
  A polled control system protocol, with the WESTRACE system as the master (client). A WESTRACE system configured with this protocol is used to poll connected systems for a reply consisting of a full data message. The WSA/S2 master protocol is typically used for the transfer of non-vital application data between WESTRACE systems.

D

The WESTRACE system:

- can drive one or more S2 field stations;
- appears as just another S2 field station to the control centre.

GLOSSARY

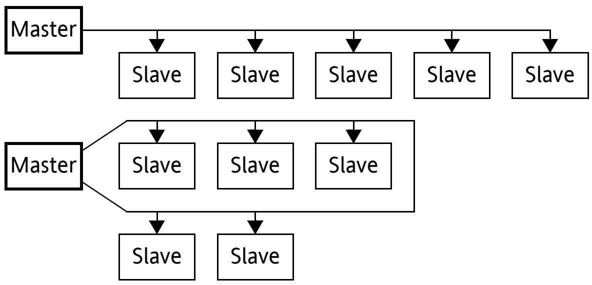
2nd Negation	Part of the *WESTRACE Backplane*. Provides a mechanism for vital WESTRACE modules to negate the system in the event of a fault being detected. See also *Negation*.
Application Logic	The logic that defines how the inputs and outputs for a particular installation are related.
APPDEL	Application Delay Timer. See also *NAPPDEL*.
Approach Locking	The locking which is applied after the signal has cleared to prevent the signal attempting to normalise a route in front of a train.
Aspect	The current state shown by a signal, eg Stop, Caution, Proceed, Reduce Speed etc.
ATP	Automatic Train Protection
AWS	Automatic Warning System
Backplane	Interconnects all *WESTRACE* modules, incorporates the Inter Module Bus, Fault Bus, Health Monitoring, 2nd Negation and various other interfaces.
BCC	Block Checksum Character. A method for validating the integrity of digital data.
Boolean Logic	A method to define and evaluate the logical relationship between digital inputs and outputs. An equation consists of terms which are combined using AND, OR and NOT operators.
bps	Bits per second
Buried Earth	A connection made to earth by means of driving, or burying one, or more earth rods or conductors.
CBI	Computer Based Interlocking–a generic term applied to interlockings using microprocessors.
CCSS	Configuration Check Sub-System–a *WESTRACE* software package that executes on an IBM compatible *PC*. It is used by Signal Engineers to verify that the *CED* fitted to an interlocking is the correct version and has not changed from the source data. Used for *VLM*-based systems.
CEC	Configuration Element Card–the CEC is part of the *VLM*. The *PROMs* containing the *CED* are fitted to the CEC on VLM1-based systems.
CED	Configuration Element Data–configuration data, application logic, module definitions and mnemonic names. The vital CED is stored in *PROMs* which are installed on the VLM1 or HVLM modules. 'Vital PROM Data' is the equivalent term when discussing later vital logic modules. 'Non-Vital Configuration' is the term used when discussing non-vital data that is downloaded to the *NVC/DM* or *NCDM*.
CIM	Communications Interface Module–part of a *NVC/DM*, provides the serial interfaces.

CIMFIM	Communications Interface Module Filter Interface Module–part of a *CIM*, contains level translation and filtering electronics.
CIMPM	Communications Interface Module Protection Module–part of a *CIM*, contains transient protection electronics.
CNVC	Configurable Non-Vital Communication Module
Coil	An internal logic state which forms the output of a logic rung.
Compilation	The process of creating the *CED* from the source file information.
Contact	An internal logic state which is used as an input to a logic rung.
Control System	The interface between the signaller and the railway signalling system. It may take the form of the rail authority's central control centre, or a local hard wired panel, or a control computer.
Control Tables	A method of representing the interlocking functions in a form which is commonly used by Railway Industry.
CRC	Cyclic Redundancy Check–a method for validating the integrity of digital data.
CS	Configuration System–a set of *WESTRACE* software packages that executes on an IBM compatible *PC* and an associated manual. The CS comprises the *CSS* and *CCSS*. Used for *VLM*-based systems.
CSS	Configuration Sub-System–a *WESTRACE* software package that executes on an IBM compatible *PC*. Used by Signal Engineers to design and simulate Application Data for WESTRACE Vital Signalling Systems. Used for *VLM*-based systems. Has been superseded by *GCSS*.
CTSS	*WESTECT ATP* Transponder Configuration Sub-System
Cycle [WESTRACE]	*WESTRACE* is designed to operate cyclically. Each cycle comprises the major phases of accepting input data, evaluating the logic once, delivering output the data and performing health checks.
Cycle Time	The time taken to execute one complete *WESTRACE* cycle. This will vary, unless fixed for hot standby purposes, according to the number of *I/O* modules connected and the logic evaluated.
Diagnostic Module	See *DM*.
Diagnostic System	See *MoviolaW*.
DIL	Dual-In-Line.
DM	Diagnostic Module– a *WESTRACE* module that monitors and records all changes of state and fault information in the WESTRACE system. The DM has external interface ports for interrogation the system and for transmitting data. A collective term which includes the original DM and the DM128. To be replaced by the *NVC/DM* or *NCDM*.
DTC	Direct Traffic Control–a computer-based train control system used to electronically manage and validate train movements in non-signalled territory.
DWL	Data Word Length–specific to the *WSA/S2* protocol and indicates the number of data bits in a message.
EPROM Blowing Form	A printed record of *EPROM* programming.

EPROM Programming	The process of storing data in *EPROMs*.
EEPROM	Electrically-Erasable Programmable Read-Only Memory (*PROM*). Compare with *EPROM*. Used on the VLM5, VLM6 and NCDC.
EPROM	Erasable Programmable Read-Only Memory (*PROM*). Compare with *EEPROM*. Used on the HVLM128 and earlier.
Equipment Room	Any building, fixed or transportable (other than a control centre), housing *WESTRACE* equipment.
Event	A transition in the state of an *ILS*. All events are logged by *WESTRACE*.
Event Log	*MoviolaW* creates event logs of the *WESTRACE* operation and stores these logs for a defined period. Events recorded in the event log can be replayed.
External Diagnostic System	See *MoviolaW*.
EVTC	Enhanced Vital Telemetry Continuous Module—a *WESTRACE* module used for vital communication (66 bit) between two WESTRACE systems. For new installations, EVTC modules are recommended in place of *VTC* modules.
Fail-Safe	The attribute of a process or equipment that ensures that each and every failure or combination of failures results in the system attaining safe condition. Modern safety engineering prefers the term ‘safety critical’ and to define safety integrity levels.
Fatal Fault	A software or hardware fault which makes the continued operation of a module impossible. A fatal fault in a vital module will result in negation of the system before the safe operation of the railway is compromised. See also *Non-fatal Fault*.
Fault Bus	Part of the *WESTRACE Backplane*. Provides a mechanism for WESTRACE modules to report fault codes to the *DM* or *NVC/DM*.
Fault Code	An numerical code which a *WESTRACE* module displays on its front panel fault display and which is logged by the *DM* or *NVC/DM*. This code indicates a self-diagnosed fault in the module, or, in the case of the NVC/DM, an externally connected module. Phase 1 WESTRACE modules use 8 bit fault codes, while the NVC/DM use 16 bit codes.
GCS	Graphical Configuration System—a set of Windows-based *WESTRACE* applications and associated manuals. The GCS comprises the *GCSS* and the *ICS*. Used for all *WESTRACE* using *HVLM128* or later vital logic module based systems.
GCSS	Graphical Configuration Sub-System—a Windows-based *WESTRACE* application used by Signal Engineers to enter data to define the functionality of the WESTRACE system. Used for all *WESTRACE* using *HVLM128* or later vital logic module based systems.
GSIM	Graphic Simulator –a Windows-based *WESTRACE* application that provides graphic on-screen simulation of Local Control Panels and the status of tracks and trackside equipment of the railway under simulation.
HDLC	High-level Data Link Control protocol—a commonly used computer protocol for serial communication. The *WSA/S2* and protocol is based on HDLC.
Health Monitoring	Part of the *WESTRACE Backplane*. Provides a mechanism for vital WESTRACE modules to check the health of each other.

Hot Standby	The arrangement where two *WESTRACE* installations, a main and a standby, run in parallel. The standby system is able to automatically take over in the event of a fault.
Housing	The physical unit used to hold the *WESTRACE* modules in an installation. Up to four housings may be interconnected within the one installation.
HVBC	Hot Standby Vital Backplane Card—a small, half height, printed circuit board installed directly behind the lower connectors of the *HVLM128*.
HVLC	Hot Standby Vital Logic card—is the central processing module for an *HVLM128*.
HVLM128	Hot Standby Vital Logic Module—a *WESTRACE* that controls the operation of each WESTRACE system. It performs all logic processing and supervises communication between each WESTRACE module and itself. Two systems using these modules may be operated as main and standby with automatic changeover on most failure situations.
HVLM128a	Hot Standby Vital Logic Module—same as HVLM128 but with modified capacities.
HVLM PFM	Hot Standby Vital Logic Module Protection and Filter module.
I/O	Input and Output
I/O Assignments	The allocation of mnemonics to specify inputs and outputs.
ICS	Installation Check System—*WESTRACE* software used by the Signal Engineer to verify that the Configuration Data *PROMs* fitted to an installation are valid and are consistent with the approved design. Used for *HVLM128*-based systems.
IHCL	Inter-HVLM Communications Link—a fibre-optic connection used in a hot standby system to transfer data between the main and standby *VLM*s.
INCL	Inter-NCDM Communications Link—a fibre-optic connection used in a hot standby system to transfer data between the main and standby NCDMs.
ILS	Internal Logic State—a one-bit storage element which is associated with a mnemonic name.
Image File	A copy of an installation's vital or non-vital *CED* stored on a *PC* for use by tools such as *MoviolaW*.
IMB	Inter Module Bus—part of the *WESTRACE Backplane*. Provides general purpose parallel data communication between the *VLM* and other WESTRACE modules.
Initialisation (System)	This is a time prior to normal operation when the installation determines the current state of the external inputs.
Installation	A single physical *WESTRACE* system, comprising up to four standard WESTRACE housings. A set of railway signalling application data.
Input	The input to the *VLE*.
ISIM	Interlocking Simulator—a *WESTRACE* tool that enables testing of railway signalling logic in the office prior to commissioning a system.
Ladder Logic	A form of boolean logic that is used to define the application data. It consists of relay equivalent logic and is input using the *GCSS* or *CSS*.
Latches	These are internal logic states within the installation logic and are shown as relay coils in the ladder logic. They do not have a physical input or output.

LEC	Logic Evaluation Card–part of an *NVC/DM*. Performs all (non-vital) logic and communications processing.
LED	Light Emitting Diode
Location Case	A metal cabinet housing *WESTRACE* equipment.
MB	Megabyte
Mnemonic	Abbreviated names that consists of numbers and letters to represent particular logic states or functions.
Module Bit Allocation	This is the process of allocating mnemonics to *I/O* bits on a module.
MoviolaW	MoviolaW is a suite of Microsoft Windows based diagnostic tools for *WESTRACE* Vital Signalling Systems and other railway systems.
Multidrop	A serial cable configuration where multiple slave devices are connected to a single cable coming from a master device. The cable can be a single line or loop configuration. See also *Point-to-point*.



NAPPDEL	Non-Vital Application Delay Timer. See also *APPDEL*.
NCDC	Network Communication Diagnostic Card–the NCDM's main circuit board.
NCD PFM or NCDC PFM	Network Communication Diagnostic Protection and Filter Module
NCDM	Network Communications Diagnostic Module–comprises an NCDC and an NCD PFM.
Negation	Shutting the system down to a safe state.
Non-fatal Fault	Faults such in software, hardware or other equipment that do not compromise the safe operation of the railway. See also *Fatal Fault*.
Non-Vital Telemetry	The means of communicating non-vital data from the *WESTRACE* to an external system such as a local control panel or control centre.
NVC	Non-Vital Communication Module–a *WESTRACE* serial data module used for communicating serially between WESTRACE Installations and a non-vital control system or similar.
NVC/DM	Non-vital Control and Diagnostic Module
NVLM	An acronym representing non-vital logic modules such as the *NVC/DM* or *NCDM*.
OPC	Output Power Card–part of *VLM* and *HVLM128*. A circuit board that controls the *OPCR* and*VSEV*.
OPC-PFM	Output Power Card Protection and Filter Module.
OPCC	Output Power Control Card

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OPCM	Output Power Control Module—comprises an *OPCC*, a *VBC* and an *OPC-PFM*.
OPCPR	Output Power Control RePeat Relay—an additional relay that is switched by a front (normally open) contact on the OPCR. It is used when there are not enough contacts on the OPCR.
OPCR	Output Power Control Relay (or followed relay)—used to isolate parallel outputs when the *WESTRACE* system cannot be guaranteed to be operating safely. This relay is used as the final arbiter of system safety.
Output	The output of the VLE, such as a relay or lamp output.
PC	Abbreviation for Personal Computer (historically, an "IBM compatible" personal computer).
PCGE	Personal Computer Graphic Editor—a *PC* based application used to create graphical display files used by *MoviolaW*, WESTCAD and *GSIM*.
PCM	Pulse Code Modulation
PFM	Protection and Filtering Module—used to isolate the internal WESTRACE environment from the external electrical environment by providing screening, filtering and over-voltage protection.
PIOFLT	Parallel Input Output Fault—a vital mnemonic representing a parallel input or output fault.
PLCC	Plastic Leaded Chip Carrier
PM	Protection Module
Point-to-point	A cable configuration where a separate cable is used to link two systems. See also *Multidrop*.
Printouts	Output from a computer driven printer.
PRM	Portable Radio Monitor
PROM	Programmable Read-Only Memory—a computer memory device that retains its contents without power (ie 'non-volatile'). See also *EEPROM* and *EPROM*.
PROM Program Form	The printed record of *PROM* programming having taken place.
PROM Programming	The process used to store data into *PROM*s.
PSU	Power Supply Unit
PTM	Portable Transponder Module
RAM	Random Access Memory
RS232-C	An electrical interface standard used for serial connection of one device to another (*Point-to-point*) for the purpose of data communications.
RS422	An electrical interface standard that uses differential signal levels allowing operation over longer distances.
RS485	Electrically similar to *RS422* but also supports *Multidrop* operation.
RSE	Railway Signalling Equipment
RTC	Real Time Clock

Rung	A part of Ladder Logic. A rung is the group of logic (relay equivalent contacts) that control a latch or output (relay equivalent coil).
SDLC	Synchronous Data-Link Protocol—see *HDLC*.
SIL	Safety (or sometimes Software) Integrity Level
Simulation	Testing of the *WESTRACE* Application Logic on a *PC* or other device rather than the actual system.
Slot	This is a space in a housing where *WESTRACE* modules can be inserted. WESTRACE modules occupy one or more slots.
Source File	A file that contains the data that has been entered into the *GCSS* or *CSS*.
Surge Arrester	Any device for controlling electrical surges on circuits entering a location, including gas discharge arresters, semiconductor arresters, or arresters combining both types.
Telemetry	Data communication system. The process of transmitting data between two points.
Temporary Approach Control	The process of forcing a timed approach control on a signal to minimise entrance speed. The total process or applying, retaining and removing the control must allow it to be vital.
Time-of-Day Timer	A timer whose output is set at a particular time of day.
Timer	A device or circuit that provides time signals at regular, specified intervals for purposes of controlling a sequence of events or synchronising events in separate operations. Ladder logic uses software timers.
Timestamp	Indicates the date and time at which a logged event, fault or operation occurred.
Transfer States	A set of logic states that will be able to be transferred from the *NVC/DM* to the *VLM* and vice versa.
UHVBC	Universal Hot Standby Vital Backplane Card—interconnects the *VLC*, the *OPCC* and the *OPC-PFM*. Also contains links for setting the installation address.
VBC	Vital Backplane Card—interconnects the *VLC*, the *OPCC*, the *CEC* (original-*VLC* only) and the *OPC-PFM*. Also contains links for setting the installation address.
Vital	Pertaining to system safety. Used an adjective to describe a process, function or equipment that, when not operating correctly, can adversely affect the safety of a system.
Vital Bar	Generic term to refer to Vital Blocking and Temporary Approach Control.
Vital Blocking	Process used to prevent the Signalling System to allow sections of track being allowed to be occupied. The total process or applying, retaining and removing the block must allow the blocking to be vital
Vital Communications	Communication of data that required for the safe operation of the *WESTRACE* system. Vital communication is between WESTRACE systems.
VLC	Vital Logic Card—a general term for the original VLC, the *HVLC,* the *VLC5* and the *VLC6*.
VLC5	Vital Logic Card for the *VLM5*.
VLC6	Vital Logic Card for the *VLM6*.

VLE	Vital Logic Equipment–is the physical *WESTRACE* equipment, both vital and non-vital.
VLM	Vital Logic Module–*WESTRACE* which controls the operation of each WESTRACE system. It performs all logic processing and supervises communication between each WESTRACE module and itself. This is a collective term for the original *VLM1*, the *HVLM128*, the *VLM5* and the *VLM6*.
VLM1	Vital Logic Module1–the name given in the Invensys Rail WESTRACE manuals to the original and largely superseded vital logic module which was known as the VLM.
VLM128	See HVLM128.
VLM128a	See HVLM128a.
VLM5	Vital Logic Module–has essentially the same functionality as the *HVLM128* but has a greater capacity.
VLM6	Vital Logic Module–has essentially the same capacity as the *VLM5* but can also provide vital communications over a network to connected *WESTRACE* systems when used in conjuction with an *NCDM*.
VLOM	Vital Lamp Output Module–*WESTRACE* module used for driving relays or similar loads.
VPIM	Vital Parallel Input Module–*WESTRACE* module used for accepting vital parallel inputs into a WESTRACE installation.
VROM	Vital Relay Output Module–*WESTRACE* module used for driving signalling relays or similar loads.
VSEV	Vital Serial Enable Voltage–a vital control voltage used to enable vital serial communications to and from a *WESTRACE* installation.
VTC	Vital Telemetry Continuous Module–a *WESTRACE* module used for vital communication (17 bit) between two WESTRACE systems.
WCM	*WESTECT* Communication Module–used to communicate signalling information from an interlocking or *WESTECT Encoder* to an *ATP* equipped train. It is used as part of the *WESTECT ATP* system.
WESTECT	**WES**tinghouse automatic train Pro**TECT**ion.
WESTECT ATP	WESTECT Automatic Train Protection is an Invensys Rail proprietary system that overlays on a WESTRACE signalling system and prevents driver error from endangering the train.
WESTECT Encoder	In its simplest form, a WESTECT Encoder comprises a *WESTRACE* system, a communications rack and an antenna system.
WESTRACE	WESTRACE is an acronym for **WES**tinghouse **T**rain **R**adio **A**dvanced **C**ontrol **E**quipment. It is a modular, safety critical, programmable electronic signalling system that has been designed for safety control systems for Railway Signalling.
WESTRACE I/O Module	General term for any module designed to be plugged into a slot in a *WESTRACE* housing, excluding diagnostic and logic processing modules.
WNC	WESTRACE Network Communications–generic name for complete *WESTRACE* system using and *NCDM* to facilitate communications over an Ethernet network.
WNCM	WESTRACE Network Communications Module–comprises the *VLM6* and *NCDM*.

WRSA	Westinghouse Rail Systems Australia, now known as Invensys Rail.
WSA/S2	A serial telemetry protocol developed by Invensys Rail in Asia-Pacific.
WSL/S2	A serial telemetry protocol developed by Invensys Rail in Europe.

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