SIEMENS

Siemens Mobility Intelligent Traffic Systems
Sopers Lane, Poole, Dorset, BH17 7ER

ST950 General Handbook

667/HB/46000/000

for

ST950 Family

THIS DOCUMENT IS ELECTRONICALLY APPROVED

AND HELD IN THE SIEMENS DOCUMENT CONTROL TOOL

All PAPER COPIES ARE DEEMED UNCONTROLLED COPIES

	Prepared By	Checked and Released
Division/BU	Mobility Division, Traffic Solutions	Mobility Division, Traffic Solutions
Department	Engineering	Engineering
Name	P. Cox	D. A. Martin
Function	Lead Engineer	Engineering Manager
Date	April 2021	April 2021

SAFETY INFORMATION

IT IS RECOMMENDED THAT DUE TO THE HAZARDS PRESENT WITHIN THE CONTROLLER CABINET ALL POWER TO THE CABINET IS DISCONNECTED BEFORE REMOVING OR INSTALLING ANY EQUIPMENT INTO THE CABINET. WHERE A RISK ASSESSMENT AND METHOD STATEMENT FOR THE WORKS TO BE COMPLETED AND / OR THE INSTRUCTIONS FOR THE OEM EQUIPMENT BEING INSTALLED OR REMOVED ALLOWS, LIVE WORKING MAY BE CONSIDERED.

Safety of Maintenance Personnel

In the interests of health and safety, when using or servicing this equipment the following instructions must be noted and adhered to:

- Only skilled or instructed personnel with relevant technical knowledge and experience, who are also familiar with the safety procedures required when dealing with modern electrical/electronic equipment are to be allowed to use and/or work on the equipment. All work shall be performed in accordance with the Electricity at Work Regulations 1989 or the relevant local, state and government regulations.
- Such personnel must take heed of all relevant notes, cautions and warnings in this Handbook and any other Document or Handbook associated with the equipment including, but not restricted to, the following:
- The equipment must be correctly connected to the specified incoming power supply.
- The equipment must be disconnected / isolated from the incoming power supply before removing any protective covers or working on any part from which the protective covers have been removed.
- Any power tools must be regularly inspected and tested.
- Any ladders used must be inspected before use to ensure they are sound and not damaged.
- When using a ladder, before climbing it, ensure that it is erected properly and is not liable to collapse or move. If using a ladder near a carriageway, ensure that the area is properly coned and signed.
- Any personnel working on site must wear the appropriate protective clothing, e.g. reflective vests, etc.

In the event of any person working elsewhere on the junction, it is recommended that the Mains Supply to the controller be switched off and the master switch locked in the ‘off’ position.

If you are not certain that the entire system is ELV, you must switch off the Mains Supply to the controller and lock the Master Switch in the 'off' position.

If the controller uses an Expansion Cabinet, and in the exceptional circumstances that the expansion cabinet also needs a mains supply (to be avoided wherever possible), then the supply to the expansion cabinet must also be switched off and the master switch in the expansion cabinet locked in the off position.

To ensure and guarantee isolation the double pole master switch should be opened.

When re-commissioning signals, the following sequence is recommended to ensure that the correct signal startup sequence is followed:

- Switch OFF the controller at the main switch
- Switch ON the lamps at the Manual Panel on/off switch
- Switch ON the controller at the main switch

More specific safety information is given in the text of the handbook, where it relates to particular activities or situations.

For Hardware Fail Flash (HFF) Controllers Only (non UK only):

If the controller needs to be changed to HFF after being installed (non UK only) the following procedure must be followed:

- Ensure that the power to the controller is switched off
- Move the "Flash" switch (S3) on the CPU Card to its non-HFF position
- Run the Controller Self-Test and confirm that it indicates that the controller hardware is set up for HFF. Note that the signals will not flash when the controller is powered because the switch on the CPU Card is in the non-HFF position
- Switch off the power to the controller
- Move the switch on the CPU Card to its HFF position
- Switch on the power to the controller and ensure that the correct traffic signals flash as the controller starts

There are various RJ45 connectors used to connect to peripheral card within the ST950 family of controllers. Most are **not** Ethernet ports and should not be connected to other equipment, including PCs.

To isolate the equipment, the Master Switch must be in the "Off" position.

Removal of the Electricity Board Fuse or Switching the Controller switch or the Manual Panel Signals On/Off switch to "Off" does not guarantee isolation of the equipment.

Controller Configuration

Controllers require specific configuration to enable them to function correctly when installed.

The configuration process is a complex activity and should only be carried out by persons who are adequately trained, have a full understanding of the needs of the county or region were the controller is to be used and are experienced in the tasks to be undertaken.

Safety of Road Users

It is important that all personnel are aware of the dangers to road users that could arise during repair and maintenance of traffic control equipment.

Ensure that the junction area is coned and signed as necessary to warn motorists and pedestrians of any dangers and to help protect the personnel working on the site.

Whilst repairing signals which are in an "all-out" condition, care must be taken to ensure that no spurious signals are lit during testing which could mislead drivers or pedestrians. Particular care is required where pedestrian audible devices are installed, to ensure that no false indications are given during, for example, cable testing. Personnel should also ensure the safety of pedestrians, especially children, who may come into contact with parts of the controller or signal poles.

Safety Warning - Lithium Battery

This equipment may contain a Lithium coin cell (battery) if the optional RTC battery backup kit is installed.

Do not short circuit, recharge, puncture, take apart, incinerate, crush, immerse, force discharge, ingest or expose to temperatures above the declared operating temperature range of the product, otherwise there is a risk of fire or explosion.

Batteries should be handled and stored carefully to avoid short circuits. Do not store in a disorderly fashion or allow metal objects to be mixed with stored batteries. Keep batteries between -30°C and 35°C for prolonged storage.

The battery is a sealed unit which is not hazardous when used according to these recommendations. Do not breathe vapours or touch any internal material with bare hands should the cell become damaged in any way.

Battery disposal method should be in accordance with local, state and government regulations. In many countries, batteries should not be disposed of into ordinary household waste. They must be recycled properly to protect the environment and to cut down on the waste of precious resources.

Important ELV Considerations

Do not connect any device that has not been specifically designed or tested for compatibility with the ST950ELV system. If in doubt, contact Siemens Poole for further information.

ST950ELV compatible equipment such as Helios ELV traffic signals, near-side pedestrian signals and ELV LED regulatory signs are all clearly marked “ELV”. If equipment is not marked “ELV” then additional care should be taken to ensure that it is suitable for use in an ELV system.

To provide the most reliable operation, Siemens ELV controllers use a DC (unsmoothed) lamp supply, which in common with DC powered telecommunication equipment, is negative with respect to earth so as to avoid electrochemical corrosion effects.

To maintain all street voltages within ELV limits, equipment outside the cabinet must be supplied with voltages within the band -48V RMS with respect to earth. Voltages positive with respect to ground / earth will result in overall voltages within the system being in excess of the ELV limit as defined by BS7671.

Care should be taken to ensure that no LV (Mains Voltage) equipment is installed within the ELV street furniture as this will result in risks to personnel and risk of catastrophic failure of ELV equipment should such voltages be applied to the ELV equipment by accident.

The Siemens ELV controller has been designed and proven to meet the following requirements for Protective Extra Low Voltage (PELV) and the operation of a signal compliance monitoring system with ELV voltages:

1) The Siemens ELV system is PELV and the earth is connected all the way through, as allowed for in BS7671 414.4.1. The source is a safety isolating transformer to BS EN 61558-2-6 as allowed in 414.3 (i). Protective Isolation within the controller cabinet is achieved between the PELV circuits and those higher than band I by ALL conductors having insulation rated for the highest voltage 250V, as mandated for in 414.4.2 (iii), and where the parts of the circuits are not wires / conductors, then physical isolation as allowed for in 414.4.2 (v) may be used.

   Any third party ELV sources installed in this system should follow the same guidance, re-isolation and insulation and should adopt the same polarity and voltage range to avoid voltages in excess of ELV band 1 being present in the signalling / street furniture part of the system.

2) Terminations are IP2X (British standard finger proof i.e. not accessible to solid items of 12.5mm or greater).

Any third parties making alterations to such equipment / PELV installations must consider the electrical requirements for PELV and the above in what they do and should only attempt such alterations if they are competent to do so.

The controller monitors its signal outputs for both positive and negative voltages with respect to earth for its conflict system. In order to ensure the ELV voltage band is maintained, positive voltages with respect to earth are clamped by the controller. Should a positive voltage be applied to the signal outputs, the controller will consume current to maintain a maximum positive voltage of approximately 0.8 volts at the controller terminals.

Should a source with a large current sourcing capability be applied, catastrophic damage may result. The extent and results of such damage cannot be predicted or guaranteed.

Change History:

Issue	Change Reference	Date
1	First Issued	Sep 2013
2	40/42V Controller information added	Oct 2013
3	• IC4 View Differences added to section 7.1.1. • Smooth CLF added to section 23. • Last Lamp Failed Monitoring added to section 38. • Web page to download electronic copy of this document added. • Plus other minor improvements.	Sep 2014
4	• New sections added for Site UI (58) and Real Time View (59). • Clarifications added to section 16 'Fail to Part-Time' and section 35 'Hardware Fail Flashing'. • References to more related handbooks added. • Plus other improvements and clarifications.	Jun 2015
5	• Updated with introduction of ST950 Plus+ system	Mar 2020

The electronic version of this handbook can be found on the Siemens Mobility website https://new.siemens.com/uk/en/products/mobility.html in the Road Solutions section under Technical Downloads -> Handbooks -> ST950

Contents

1 INTRODUCTION

1.1 Purpose

This handbook gives details of the facilities available in the Siemens Type 950 (ST950) Family of Traffic Controllers.

The Family consists of three distinct controllers:

The ST950 230V Mains Controller (referred to as the ST950) [1]

The ST950 48V ELV Controller (referred to as the ST950 ELV) [1]

The ST950 Plus+ Controller (referred to as the ST950 Plus+) [2]

[1] These two controllers may be supplied as a fully fitted controller in an outer case, or as a 19" rack with main logic power supplies, CPU Card and lamp switch cards.

[2] This controller is always supplied as a fully fitted controller in an outer case.

A 40/42V ELV Controller is also available for use outside the UK.

Ongoing development means that some of the delivered items may differ in detail from the photographs included in this handbook.

1.2 Contact Us

If you have any comments on this handbook, or need any further information, you can contact us via our contact page
https://www.mobility.siemens.com/global/en/general/contact.html

1.3 Related Documents

667/HE/46950/000	Installation, Commissioning and Maintenance Handbook for the ST950 Controller
667/HE/45950/000	Installation, Commissioning and Maintenance Handbook for the ST950 ELV Controller
667/HE/53000/000	Installation, Commissioning and Maintenance Handbook for the ST950 Plus+ Controller

These handbooks detail the following:

- Safety procedures when working on the ST950 Family of Controllers and their ancillary equipment.
- Basic overview of the controller hardware at module level at a level necessary for installation and maintenance.
- Routine maintenance / inspection procedures.

667/HU/46000/000	User Interface Handbook for ST950 and Stratos Outstation

This handbook details:

- How to set up the user interface connections
- How to use the various user interfaces
- How to perform some common operations, including loading an IC4 configuration

667/HH/46000/000	ST950 Handset Handbook

This handbook details the following:

- Physical description of the RS232 Handset port
- Data entry, display and command formats when using a handset terminal
- User Access Levels
- Details of the controller FLF/FLD faults
- Maintenance handset commands
- The handset commands that allow (for example) timings to be modified
- A table of all recognised handset command mnemonics and their ‘web page’ equivalents

667/HB/46000/001	ST950 Facilities Handbook

This handbook details the following:

- Details of the Traffic Controller modes and facilities of the ST950
- A description of the differences between the ST950 and previous traffic controllers

667/HB/46000/002	ST950 LRT Handbook

This handbook details the following:

- Details of the Light Rail Transit facility available within the ST950

667/HB/46000/003	MOVA7 Handbook for ST950 and Stratos Outstation

This handbook details the following:

- Configuration and operation of the MOVA7 application within the ST950

667/HB/46000/004	UTMC OTU Handbook for ST950 and Stratos Outstation

This handbook details the following:

- Configuration and operation of the UTMC OTU application within the ST950

667/SU/46000/000	ST950 Firmware and Hardware Configurations

This handbook details the following:

- All significant changes to all the firmware and hardware within the ST950
- Compatibility between all issues of firmware and hardware of the ST950
- Compatibility between the ST950 and other traffic products

667/HB/20168/000	Intersection Configurator IC4 Users Handbook

This handbook details:

- The hardware requirements for producing the configuration.
- A brief outline of how to use the configuring system to enter data from the completed customer specification sheets into the computer.

667/HB/32921/007	Handbook Supplement for Monitoring Helios CLS Signals

This handbook details:

- The facility for monitoring Helios CLS without LMF modules using the “LED Lamp Switch” on a 230V ST950LED Controller.

667/HB/45040/000	Isolators & Feeder Pillar General Handbook

This handbook details:

- Guidance for the correct type and location of Feeder pillar.
- Maximum Length of cable between Feeder Pillar and Controller.
- Cut-out requirements and Fusing requirements.

667/RE/29050/000	Siemens OID Elexon Codes

This spreadsheet documents Siemens Traffic product Elexon codes listed by part number.

1.3.1 Related Drawings

667/GA/32910/ETC	ST950 Intelligent Detector Backplane assembly
667/GA/32995/ETC	ST950 I/O Card assembly
667/GA/27087/000	Equipment Mounting Frame assembly

1.4 Pre-Requisites

Anyone using and/or working on an ST950 Controller will need the relevant Installation, Commissioning and Maintenance Handbook.

1.4.1 Qualifications

Only skilled or instructed personnel with relevant technical knowledge and experience, who are also familiar with the safety procedures required when dealing with modern electrical/electronic equipment, are to be allowed to use and/or work on the equipment. All

work shall be performed in accordance with the Electricity at Work Regulations 1989 or the relevant local, state and government regulations.

Any personnel working on an ST950 Controller should have completed the following training courses:

- HA Sector Scheme Sector 8 Modules 5XX
- M609 – Junction Traffic Controller Maintenance for ST950 ELV, and/or
- M609 – Junction Traffic Controller Maintenance for ST950 LV

Training requirements for non UK users may be different.

1.4.2 Required Tools

In addition to a standard Engineer's tool kit, the following tools are required when carrying out any work on the ST950 Controller:

User Interface

One of the following is required depending on the user interface chosen to be used during the installation.

Description	Part Number
Compatible browser + USB cable (A to B)	
Compatible terminal emulator + USB cable (A to B)	
Netbook kit + USB cable (A to B)	667/1/32380/000
Serial handset Techterm + RS232 cable	667/4/13296/001
Old Oyster handset + RS232 cable	667/4/13296/000
Larger Screened Oyster handset + RS232 cable	667/4/13296/002

Cabinet Access

One or more of the following will be required to gain access to the controller cabinet.

Description	Part Number
T-bar key	667/2/20234/000
S-18 key – Main Cabinet *	4/MC 289
Manual Panel key Type 900	667/4/13651/000

* - In some areas, customers specified keys may be used

1.5 Abbreviations

AC	Alternating Current
CLF	Cableless Linking Facility
CLS	Central Light Source
CPU	Central Processing Unit
DC	Direct Current
DFM	Detector Fault Monitor
ELV	Extra Low Voltage
FT	Fixed Time
GSPI	General Serial Peripheral Interface
GPS	Global Positioning System
HFF	Hardware Fail Flash (section 35)
HPU	High Power Unit (for ELV Controllers)
I/O	Input/Output
IC4	Intersection Configurator version 4 (UK controller configuration application)
IRM	Integral Remote Monitoring
LED	Light Emitting Diode
LMF	Lamp Monitor Facility
LPU	Logic Power Unit
LRT	Light Rail Transit
LSLS	Lamp Switch Low-Voltage Serial
LV	Low Voltage (Mains)
mA	milliamps
MDU	Mains Distribution Unit (for Mains Controllers; not ELV)
MOVA	Microprocessor Optimised Vehicle Actuation
ms	milliseconds
MTCS	Master Time Clock System
NTP	Network Time Protocol
OMU	Outstation Monitor Unit
OTU	Outstation Transmission Unit
PCB	Printed Circuit Board
RAM	Random Access Memory
RFL	Reset Fault Log (Handset Command)
RLM	Red Lamp Monitoring
rms	Root Mean Square
ROW	Right Of Way

SDE	Speed Discrimination Equipment
SDE/SA	Speed Discrimination Equipment / Speed Assessment
SVD	Selective Vehicle Detector
UTC	Urban Traffic Control
VA	Vehicle Actuated
wrt	With Respect To

1.6 Third Party Information

Embedded in this product are free software files that you may copy, distribute and/or modify under the terms of their respective licenses, such as the GNU General Public License, the GNU Lesser General Public License, the modified BSD license and the MIT license. In the event of conflicts between Siemens license conditions and the Open Source Software license conditions, the Open Source Software conditions shall prevail with respect to the Open Source Software portions of the software.

On written request within three years from the date of product purchase and against payment of our expenses we will supply source code in line with the terms of the applicable license. For this, please contact us at:

Open Source Clearing
Product Development
Engineering Department
Siemens Mobility Traffic Solutions
Sopers Lane
Poole
Dorset
BH17 7ER
UK

Generally, these embedded free software files are distributed in the hope that they will be useful, but WITHOUT ANY WARRANTY, without even implied warranty such as for MERCHANTABILITY or FITNESS FOR A PARTICULAR PURPOSE, and without liability for any Siemens entity other than as explicitly documented in your purchase contract.

All open source software components used within the product are listed on the controller's web and mass storage device interfaces.

1.7 Trademarks

The following terms used in this document are trademarks of their respective owners:

- USB is a trademark of USB Implementers Forum, Inc.
- SD is a trademark of SD-3C, LLC in the United States, other countries or both.
- Linux is the registered trademark of Linus Torvalds in the U.S. and other countries.

2 ST950 CONTROLLER FAMILY

The Siemens ST950 Controller family is the latest in a long line of highly integrated traffic controllers.

The ST950 and ST950ELV controllers can be supplied either in a single-door outer case with a 6U logic rack and equipment mounting frame or as a free-standing logic rack housing the power supply, CPU Card and Lamp Switch cards.

The ST950 Plus+ controller is always supplied in a single-door outer case with 6U logic rack and equipment mounting frame and associated control cards.

Refer to the ST950 Plus+ Installation & Commissioning Handbook 667/HE/53000/000 for all details on that version of the ST950 controller.

2.1 System Overview

The main features of the ST950 family are:

- Designed to satisfy the requirements of Class X1 of EN50556 (which superseded HD638) and the UK Highways Agency specification TR2500
- 32 phases, 32 stages.
- 8 streams.
- 8 maximum green sets.
- 8 hurry calls which are in priority order.
- 8 uni-directional detector loop units.
- Multi-mode operation with stage ripple change facility for improved intersection capacity.
- Fully integrated MOVA7 and UTMC OTU functionality
- Fully integrated Light Rapid Transport (LRT) mode for use at Tram / Road intersections.
- Fully configurable lamp sequences for worldwide application.
- Fully integral and configurable lamp monitoring of both incandescent and LED signals.
- Flexible part-time and start-up modes, allowing any stream to be sent in and out of part-time mode without affecting any others.
- Cableless linking (Plan) facility with sophisticated plan timetables and 32 plan groups.
- Event timetable which supports actions based on 32 independent events with easy programming.
- Time system with full date details – automatically time synchronised to central system where the controller linked to Siemens UTMC central system.
- Date stamped rolling log providing detailed history of events and faults, coupled with improved presentation to aid recognition of entries.
- Uncomplicated web browser user interface capable of multi-language support

- Support for up to 248 I/O lines via I/O cards and Intelligent Detector Backplanes
- RS232 and USB interfaces for handset, modem and GPS
- Major configuration changes with signals on

The essential differences between the ST900 and the ST950 family of controllers are:

- New CPU Card providing additional functionality and interfaces
- Improved user interfaces including web pages
- I/O card firmware can be updated in-situ.
- Support for existing ST900 equipment such as Gemini and Gemini^2
- Integral MOVA7 and OTU functionality options
- Removable Storage device contains junction specific data allowing fast repair by card replacement and storage device transfer
- Extended features licensed through encrypted license card
- Integrated Ethernet interface
- USB interfaces for handset, memory devices, and license card readers
- The ST800/ST900 Extended System Bus interface is no longer provided on the ST950 which means that the IRM, OTU Card, SDE/SA Card are no longer supported

The essential differences between the ST950 and the ST950 Plus+ controllers are:

- Reduced on-street wiring simplifies and speeds up installation.
- The Plus$^+$ Traffic Controller provides ELV Power and communications, using a four-core armoured cable, to a number of intelligent Plus$^+$ Nodes on the street. The cable connects at the cabinet to a ‘Cabinet Interface Card’ (CIC) via its ‘Cable Termination Backplane’ (CTB).
- Each CIC supports a number of on-street cables (arms) each with individual electronically controlled power switch off capabilities.
- In reserved state the ST950 Plus+ system runs pedestrian stages.

3 ST950 CONTROLLER (LV)

The ST950 is a mains driven Traffic Controller that uses the reliable and proven Mains Lamp Switch Cards as used in the ST900 Controller, offering a total of up to 32 phases per controller.

The main components of the ST950 system are shown in Figure 1.

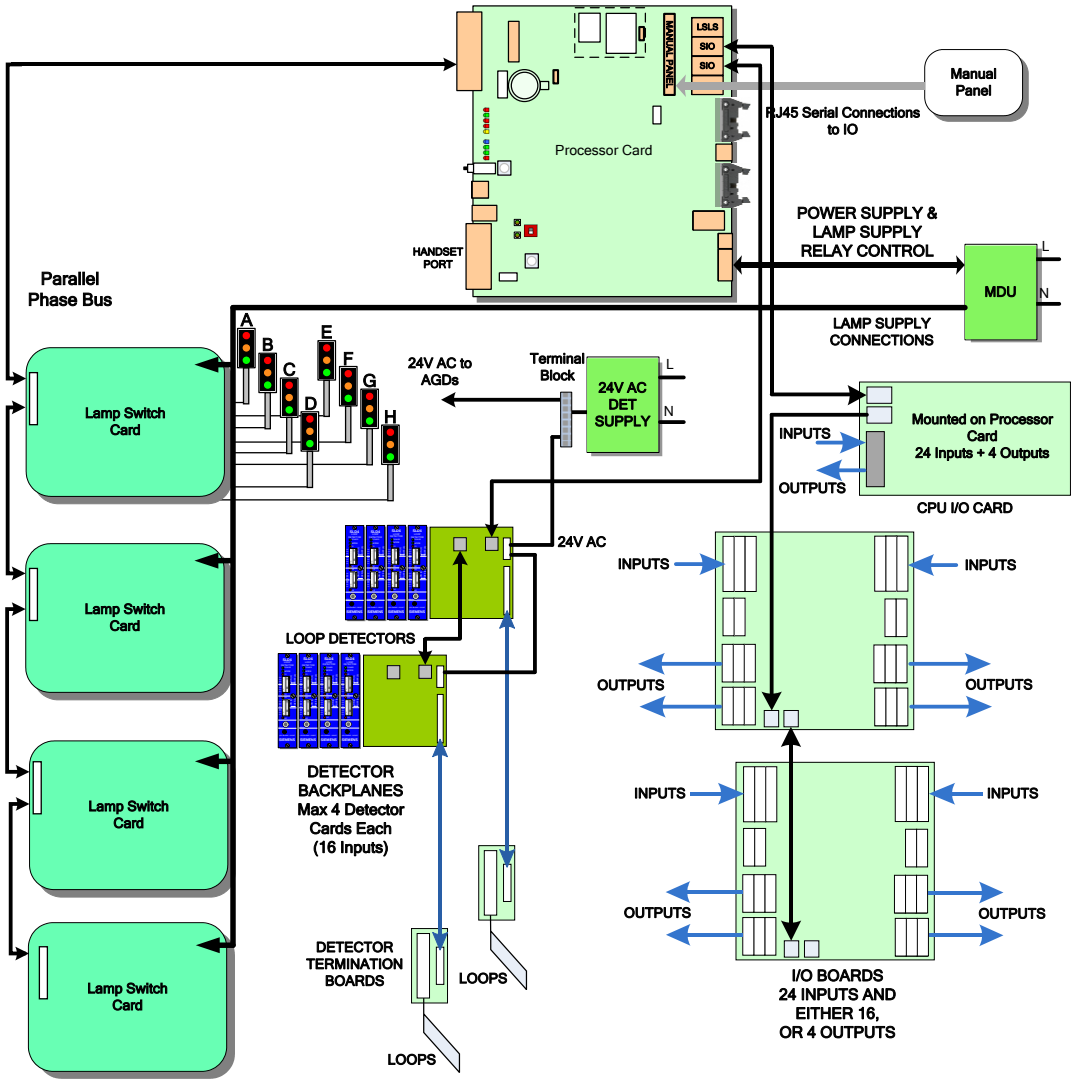


Figure 1 – ST950 System Overview

3.1 The Controller Cabinet

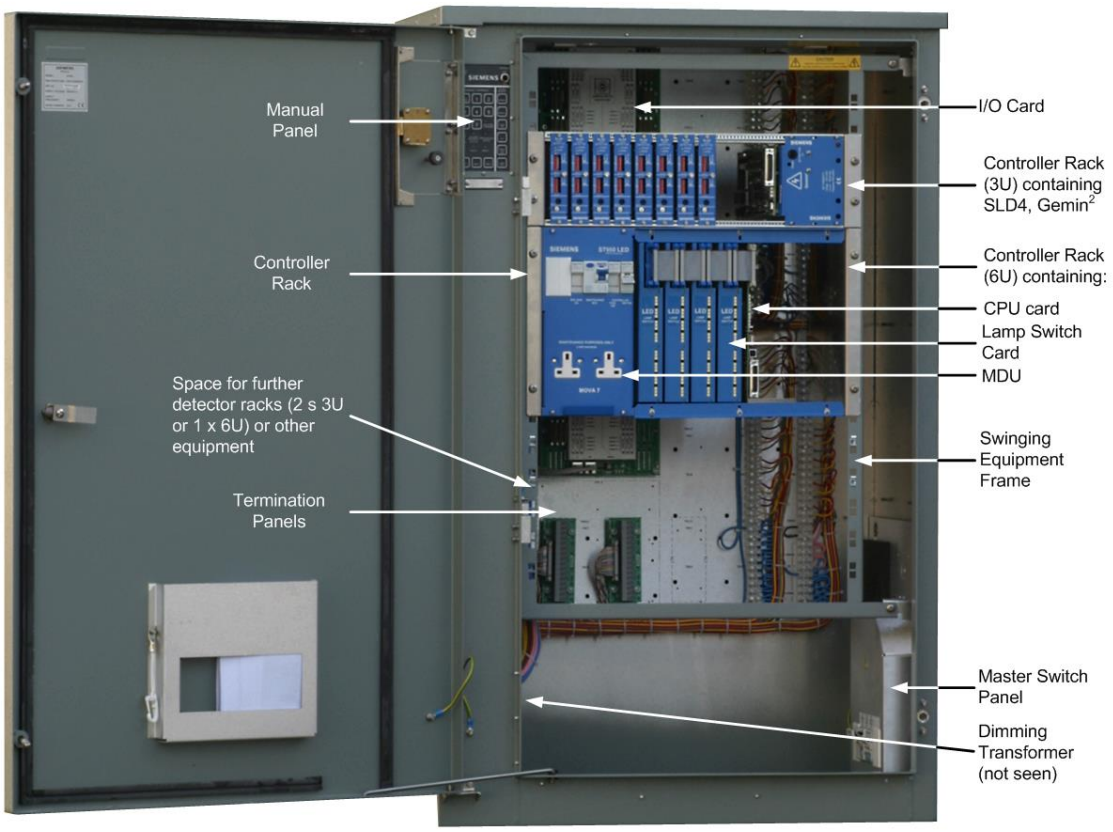


Figure 2 – ST950 Controller Cabinet General Arrangement

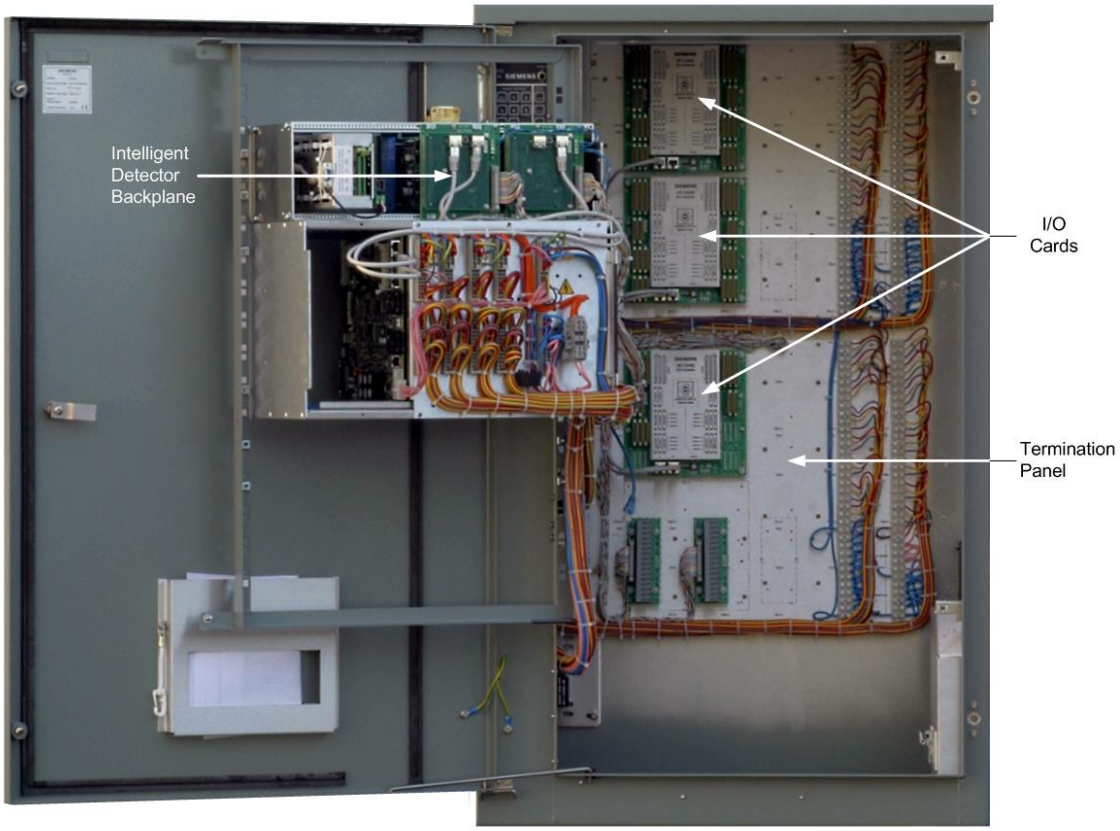


Figure 3 – ST950 Controller Cabinet (Swing Frame Open)

3.2 ST950 Controller Rack

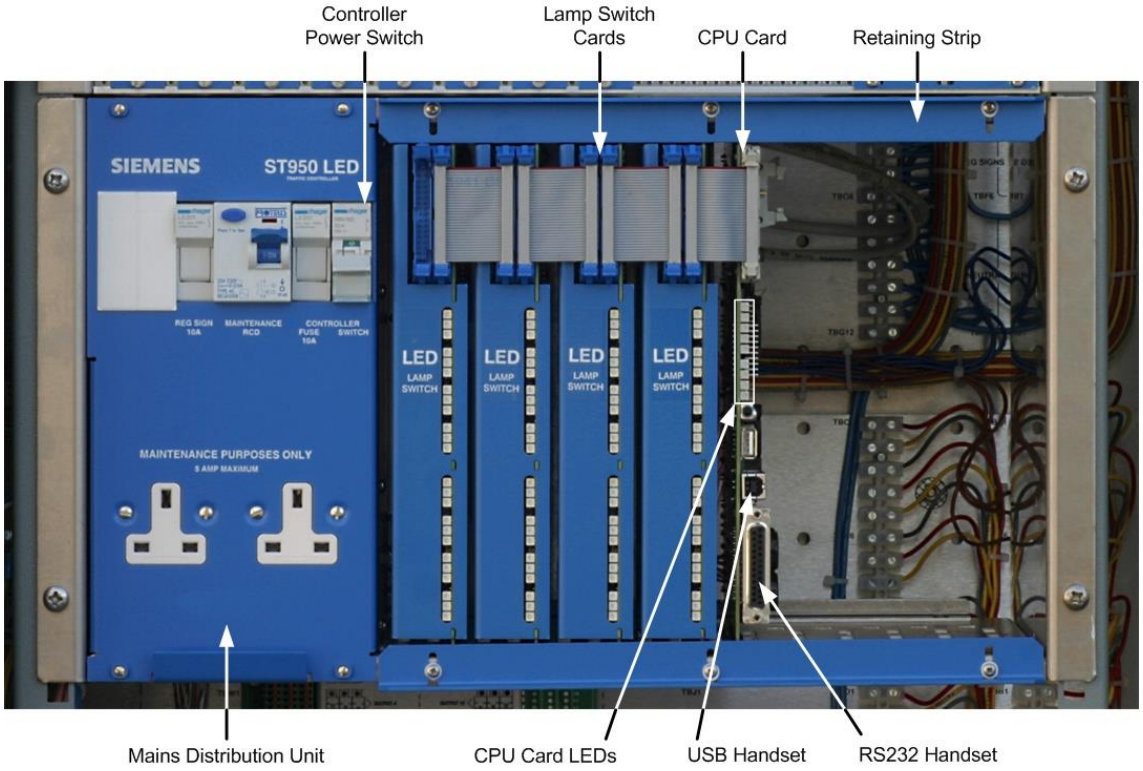


Figure 4 – The ST950 Rack (General Arrangement)

The logic rack can be used in both standard cabinets and for Cuckoo installations.

Note that a standard LED UK power distribution unit is shown in Figure 4; other variants are also available including the standard 20A variant and non-UK variant.

The left-hand part of the rack contains the mains distribution unit (MDU) that contains the logic power supply, the lamp supply relays, the maintenance sockets and the controller's power off/on switch.

Situated in the middle are the four 8-phase Lamp Switch cards, connected to each other and to the CPU Card by the phase bus ribbon cable connectors across the front. Connectors on the back of the rack provide the mains connections to the Lamp Switch cards. Each Lamp Switch card can control up to eight phases, giving a total capability of 32 phases, with the first card being the one closest to the CPU Card (i.e. on the right), with phase A at the top.

3.2.1 ST950 Non UK Controller Racks

The ST950 Non UK variants provide a self contained controller providing all of the power supply and control functions located within a single rack.

The rack variants contain the following:

- MDU containing all controller mains distribution, fusing and switching
- CPU Card with integrated I/O card (16 input / 4 output)
  (Additional I/O cards can be plugged in and located outside of the rack assembly)
- 11” rack with Lamp Switch card(s) providing up to 16 phases (2 LSCs)
- 19” rack with Lamp Switch card(s) providing up to 32 phases (4 LSCs)
- Lamp Switch card variants for 4 & 8 phases per card (4 Phase halogen only)
- Lamp Switch cards for Halogen or LED loads

3.3 Fitting the Controller into Alternative Cabinets (Cuckoo)

The above ST950 and ST950 Non-UK Controller Racks allow the ST950 Controller to be fitted into an enclosure other than an ST950 cabinet – This is known as a ‘Cuckoo’ installation. In the UK, the controller may only be fitted into an HA-approved enclosure.

The procedure for Cuckooing an ST950 controller into an alternative enclosure is very dependent on the type of enclosure and the type and position of existing equipment.

Detailed installation instructions are included in the drawings contained in the kit relevant to the cabinet.

3.4 Mains Input

When considering the connection of the controller to the incoming mains supply, it is important to verify from the supplier that the mains supply short-circuit current does NOT exceed 16,000 Amps.

If the mains supply short-circuit current can exceed 16,000 Amps, refer to Siemens Poole for further information.

The Master Controller Switch is a double-pole isolator and this must be switched off before replacing the Master Controller Fuse.

3.5 MDU

The MDU contains the dim/bright, A, B and SSR relays and the controller logic power supply, providing +5V DC and +24V DC to the cards in the rack.

The following supply voltages may be used:

Nominal Voltage	Minimum Voltage	Maximum Voltage	Frequency	Autonomy
200V to 230V	184V	264V	50/60Hz +/-4%	50ms under max load
110V to 120V	92V	132V		

MDU variants are available as detailed in Table 1 below.

Part Number	Description
667/1/27052/950	Standard UK MDU
667/1/27052/951	Export MDU
667/1/27052/970	UK LED MDU

Table 1 – MDU Variants

3.6 Controller Load Power Consumption & Dimming Transformer Selection

This section describes the method used to determine that the controller can supply the total lamp load required, how to select the correct dimming transformer and how to determine the overall power used for estimation of site running costs.

In order to do this, the power taken by the lamps needs to be calculated. Use the following table to determine the average power taken by the different types of lamps.

It must be noted that up to date information for Helios LED and Nearside units and be found in the Helios General handbook 667/HB/30000/000.

	Part Number	Bright	Dim 120V	Dim 140V	Dim 160V
65W WAIT Indicator – Generic		65	35	-	53
40W WAIT Indicator – Generic		42	22	-	25
50W Tungsten Halogen High Intensity - Generic		63	20	27	33
Regulatory sign (wattage) generic (Use this for estimation of power consumption)		30	Not Dimmed		
Regulatory sign (Volt-Amps) (Use this for calculation of current)		76	Not Dimmed		
LV LED Regulatory Sign	667/1/33510/230	10	Not Dimmed		
Helios CLS LED Signal – with (LMF)	667/1/31500/8xx	34	-	-	13
Helios CLS LED Signal – NLM (no LMF fitted)	667/1/31500/9xx	12	4	4	4
LED Wait (Measured at 48 Volts) See Note 1 Or Nearside Demand Indicator LED	667/1/30210/100 667/1/33602/010 667/1/30675/101	9	-	-	3.5
Red/Green Nearside See Note 1	667/1/33601/010 667/1/33601/510	23	-	-	5

Table 2 – ST950 Lamp Load Per Aspect (Watts)

The 500VA (LED) variant of the dimming transformer only has a single tap of 154V. For all power calculations the value for 160V may be used.

Note 1: The power ratings in table 3 above allow for the additional losses in the transformers required (described below). These power ratings are indicative for the purpose of selection of the correct size of dimming transformer.

If using a 48V Transformer kit, the following are the maximum connections that may be made:

48V AC 50VA Transformer

- 2 Red/Green Nearside if using audio/tactile equipment OR
- 3 Red/Green Nearside if audio/tactile equipment is not being used OR
- 6 Demand Indicators

48V AC 160VA Transformer

- 6 Red/Green Nearside if using audio/tactile equipment OR
- 10 Red/Green Nearside if audio/tactile equipment is not being used OR
- 20 Demand Indicators

3.6.1 Controller Power

Typical supply requirement for a controller including dimming transformer (excluding lamp loads, detectors and OTU) is:

- Typically, 47W (Depends on cards fitted. A fully equipped 32-phase controller requires a maximum of 97W.)
- Siemens SLD4 detectors require 1.5W per unit
- Siemens ST4R/ST4S detectors require 2.4W per unit.
- Sarasota MTS36Z (2 channel) or MTS38Z (4 channel) detectors require 3W per unit. (N.B. The power consumption is the same for both 2 and 4 channel units.)
- Microsense detectors require 6W per unit.

The controller Elexon codes for Siemens products are defined in the Siemens Elexon Codes document 667/RE/29050/000.

3.6.2 Lamp Drive Capability

The following table gives the lamp drive capability of the controller as a whole, each ‘Phase Driver’ (or ‘Lamp Switch’) card and each aspect. The ‘Watts’ and ‘Lamps’ columns are equivalents for the currents shown based on a 230V supply.

It must be noted that up to date information for Helios LED and Nearside units and be found in the Helios General handbook 667/HB/30000/000.

	Max Current (Amps)	Max Power (Watts)	No. of Halogen aspects[1]	No. of LED aspects[2]
Maximum lamp current that a normal ST950 controller can supply excluding regulatory signs and short-term illumination, i.e. red/amber.	20A	4600W	73	N/A
Maximum lamp current that an ST950LED can supply including short-term illumination, i.e. red/amber, but excluding Regulatory Signs. Also see note 1	10A	2300W	N/A	191
Maximum lamp load for one 8-Phase Driver card (including red/amber). Also see note 1	20A	4600W	73	191 Limited by Monitoring Note 5
Maximum current for each four phase group (e.g. phases A to D) for controllers not wired for hardware fail flash.Also see note 2	10A	2300W	36	191
Maximum current for all green aspects on one 8-Phase Driver card wired for hardware fail flash. Also see note 2	10A	2300W	36	191
Maximum current for all red and amber aspects on one 8-Phase Driver card wired for hardware fail flash. Also see note 2	10A	2300W	36	191
Maximum load for one triac output on a Phase Driver card. Also see note 3	4A	920W	14	61
Maximum supply for regulatory signs (assuming 76 volt-amps per sign)	10A	2300W	30 Reg. Signs	30 Reg. Signs
Maximum supply for LED regulatory signs assuming Helios LED (LV). Also see note 4	10A	2300W	60 Reg. Signs	60 Reg. Signs

Table 3 – ST950 Lamp Drive Capability

[1] - Tungsten Halogen loads High Intensity – Generic – 63W

[2] - LED loads are Helios CLS – 667/1/31500/9xx – 12W

In the Unlikely event that Halogen loads are being used, refer to the ST900 General Handbook 667/HB/32900/000 for signal power consumptions and permitted load numbers.

Low power LED signals should only be used on the LED variant of the Lamp Switch Card because the standard Lamp Switch Card is not designed to switch the low power levels experienced with LED signals.

Note 1: The ST950LED controller is not intended to be used with Halogen signals. If Halogen signals are used the main limiting factor is the Supply power available in Dim. 500VA represents just 15 Halogen loads.

The figures quoted for Maximum number of aspects are based on Siemens CLS Heads consuming 14W in Bright and 4W in Dim (154V). Although the LED variant 8 phase driver card has the same drive capability as the standard card this maximum drive capability cannot be reached in an LED configuration with lamp monitoring.

Note 2: The current capability of the Lamp Switch cards depends on whether they are wired for the UK (not hardware fail flash) or for non UK (with hardware fail flash). For a Lamp Switch card not wired for hardware fail flash, the two 10A fuses protect four phases each. For a Lamp Switch card wired for hardware fail flash, one 10A fuse protects the red and amber supply and the other 10A fuse protects the green supply.

Note 3: Where LED Lamp Switch cards are used the maximum load remains at 4A but must be reduced to 2A when lamp monitoring is enabled.

Note 4: The supply for LED regulatory sign on the ST950LED has been reduced to a maximum of 50. This is to allow current taken by other items (such as detection) to avoid exceeding the rating of the 20A supply fuse on a heavily populated controller. If it is necessary to exceed 50 LED regulatory signs on a controller Traffic Engineering at Poole should be contacted for advice.

It is recommended that only LED regulatory signs be used on an ST950LED controller.

Note 5: With an LED Lamp switch card the limit is based on the number of lower power signals that can be monitored on any single aspect output, this being a maximum of 8 for Siemens LV CLS, but may be lower for other products, please see 667/SU/46000 for full details.

3.6.3 Selection of Dimming Transformer

This section details how to select the correct dimming transformer and estimate the power consumed by a controller, using the theoretical junction in Figure 5 as an example.

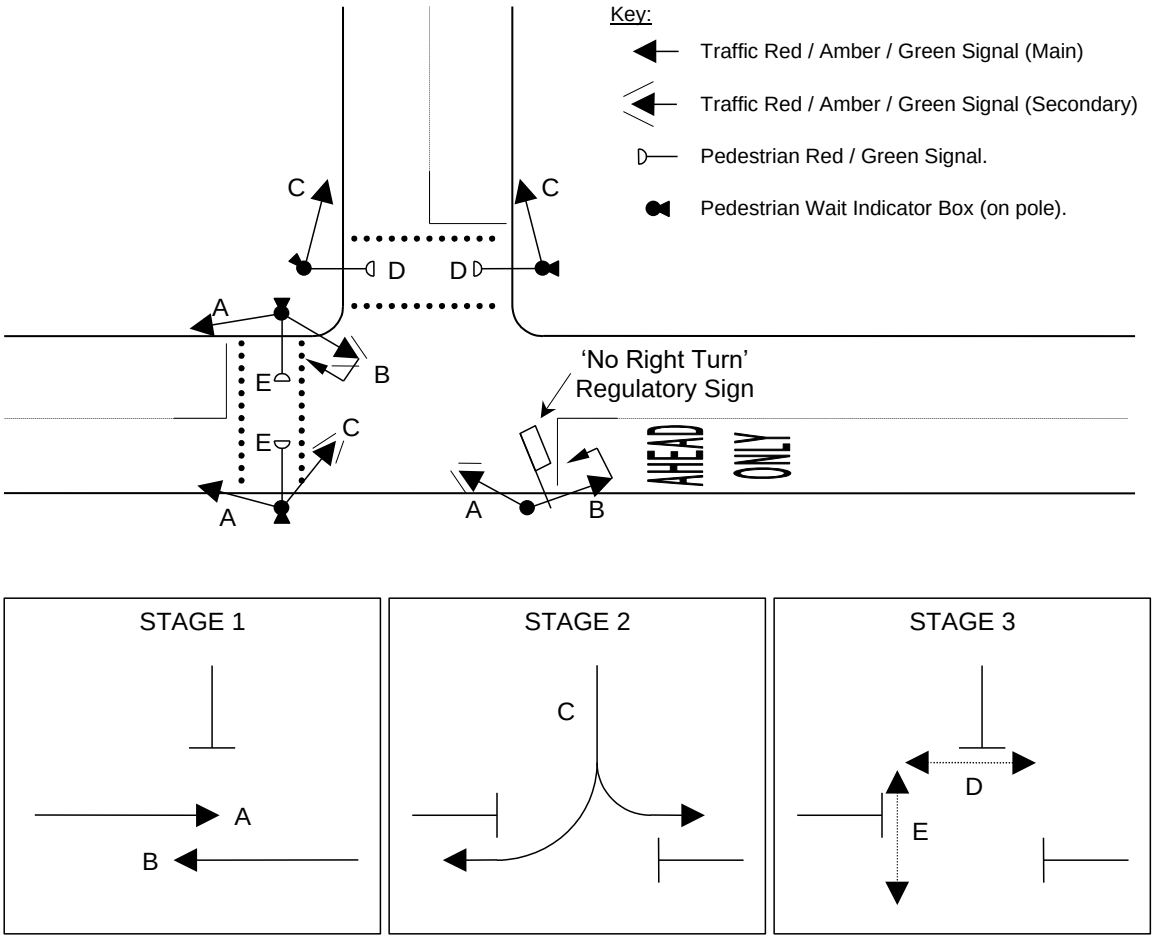


Figure 5 – Theoretical Junction (ST950)

In order to select the correct dimming transformer, the total average signal Lamp Power is required. See Table 2 on page 26 for the power taken by the different types of lamps.

When selecting the dimming transformer the peak lamp power is not used as the transformer can withstand the overload for the 2 second Red / Amber period. Thus for the average power consumption, it is assumed that only one lamp is illuminated on each signal head.

For the theoretical junction (Figure 5) and using Halogen signals with a dimming voltage of 160V, this would be:

One dim lamp per signal head @ 33W x 12 signal heads	396W
Dimmed wait indicators at 3.5W x 4 at 20% duty cycle	3W
Total average signal dimmed lamp power is:	399W

Now using Table 5 below, choose which dimming transformer is required for the dimming voltage required.

For the theoretical junction, using the figure obtained above of 399W and 160V dimming, the transformer required would be the 1.5kVA version. Note that in this case, the same transformer would be chosen regardless of which dimming voltage was required.

	Maximum Lamp Current	Dimming Voltage (154V)
500VA	20A	125 Lamps

Table 4 – ST950 Dimming Transformer Selection for LED Loads[1]

	Maximum Lamp Current	Dimming Voltage Required		
		120V	140V	160V
1.5 kVA	20A	73 Lamps*	55 Lamps	45 Lamps
3.0 kVA	20A	73 Lamps*	73 Lamps*	73 Lamps*

Table 5 – ST950 Dimming Transformer Selection for Halogen Loads[2]

The table shows the maximum 'average signal lamp power' that each dimming transformer is capable of providing at each of the dimming voltages. It also shows the equivalent number of LED & Tungsten Halogen High Intensity lamps (see Table 2).

* The number of lamps shown is limited by the Controller's maximum lamp current (see Table 3).

[1] – Helios CLS LED – NLM (no LMF fitted) – 12W Bright, 4W Dim (all dim voltages)

[2] – 50W Tungsten Halogen High Intensity – 63W Bright, 20W@120V, 27W@140V, 33W@160V

3.7 Intersection's Power Requirements for Running Costs Estimate

Introduction

For use in the UK, power running costs are normally defined by Elexon, however it is possible to estimate the power consumption of an intersection using the following process.

The following worked example is based upon a 230 mains' supply and LED signals and assumes 12 hours in both the bright and dimmed state.

Firstly the total average lamp power for the junction is calculated for both bright and dim states. Secondly the total average lamp power is added to the total average controller power. This gives the total average junction power which can be used to give an estimate of running costs.

Total Average Lamp Power

Total average lamp power is calculated as follows:

For every signal head, only 1 aspect is illuminated on average (at 12W assuming Helios CLS LED – NLM), plus every WAIT indicator is illuminated at 9W and every Regulatory Sign is illuminated at 10W.

Therefore, considering our theoretical junction (Figure 5), we have:

For the bright condition:

12 signal heads each with 1 lamp at 12W (12 x 12W)	144W
4 wait indicators illuminated at 9W & 20% duty cycle (4 x 9W)	7.2W
Total Average Lamp Power is:	151W

For the dim condition:

12 signal heads each with 1 lamp at 4W (12 x 4W)	48W
4 wait indicators illuminated at 3.5W & 20% duty cycle (4 x 4W)	3.2W
Total Average Lamp Power is:	51W

Plus the Un-dimmed Regulatory Signs:

One Regulatory Sign at 30W (1 x 30w)	30W

Total Average Controller Power

Total average controller power is calculated as follows:

Average Controller power + Average Detector Power.

A basic controller with dimming is rated at 18W, and for the purposes of this calculation

Siemens SLD4 detectors require 1.5W per card. See section 3.6.1.

Therefore for our theoretical junction (Figure 5) the total average controller power is:

1 x Controller	18W
2 x Siemens SLD4 Detectors	3W
Total Average Controller Power is:	21W

Therefore, for the theoretical junction for a single 24 hour period:

151W for 12 hours – signals in bright	1812Wh
51W for 12 hours – signals in dim	612Wh
30W for 24 hours – Undimmed Regulatory Sign	720Wh
21W for 24 hours – Controller and Detectors	504Wh
Total Average Junction Power Consumption per day is:	3648Wh

This is equivalent to an Average Power Consumption of: 152W

Note 1: The power used by the regulatory signs (which are not dimmed) for estimation of running costs is approximately 30W. For fusing purposes the regulatory signs are rated at 76 VA due to the inductive nature of the load they present to the supply.

Note 2: The controller power should also include any additional equipment supplied by the controller. This may include, for example, OTU or Auxiliary detector power supply.

Note 3: Many customers may now prefer to use the Elexon codes for each individual device within the site to determine power consumption for billing purposes when using an un-metered supply. Some older devices may not have an Elexon code in which case there is a Generic code. The Elexon Home page can be found here: http://www.elexon.co.uk/Pages/home.aspx

3.7.1 Detector Power Supplies

The Loop Detectors in the ST950 are all powered from 24V AC provided from either 2A or 6A transformer depending on the number and type of Detectors fitted. The maximum number of each type of detector that can be supported by each type of transformer is shown in the table below.

In the ST950 controller, the MDU is not used to power any Loop Detector Cards.

	667/1/27853/000 50VA / 2.0A	667/1/20292/008 160VA / 6.6A
Siemens SLD4 (1.5W / 50mA per detector)	40	132
Siemens ST4R/ST4S (2.4W / 100mA per detector)	20	66
Siemens WiMag Loop Detector Replacement card (23W / 960mA loaded with 2 Access points – each access point consumes approximately 7.4W / 310mA)	2	6
Sarasota MTS36Z or MTS38Z (or any mix) (3W / 125mA per detector)	16	53
Microsense Detectors (6W / 250mA per detector)	8	26

Table 6 – ST950 Detector PSU Selection

When powering detector cards such as SLD4, WiMag and Above Ground Detectors the overall power consumption must be calculated and be within the capacity of the detector supply.

3.7.2 Audible Supplies

The Audible power supplies on the ST950 are designed to provide a DC voltage between 10V and 24V, and typically provide 50mA at 18V DC. This is provided using the Audible Supply Kit. See the ST950 Installation and Commissioning Handbook for more details.

This kit also provides the controlling signal for ‘Tactile Power Supplies’. The tactile power supply obtains its power directly from the pedestrian green drive. The controlling signal allows the controller to switch off the tactile while the green is flashing for example.

Audible and tactile units used must operate correctly over the voltage range 10 to 24V DC. The audible units recommended and supplied by Siemens, which meet this requirement, are: Sonalert Mallory SC628P, Highland Electronics type SC628P and Roxborough type SPCI535A4 and Askari (Tone 22 – variable volume)

Audible: 667/4/04785/000

- Highland Electronics type SC628P*
- Roxborough type SPCI535A4
- Askari (Tone 22 – variable volume)

(* was Sonalert Mallory SC628P)

Tactile:

667/7/17390/000	Separate motor and drive module for mains driven pedestrian green signal
667/7/17390/048	combined motor and drive module for 48v nearside pedestrian green signal
667/1/17390/248	combined motor and drive module, with enable input and fault output for 48V nearside pedestrian green signal

4 ST950ELV CONTROLLER

The Siemens ST950ELV Controller is the latest in a long line of highly integrated traffic controllers providing complete intersection control in one box.

The Siemens ST950 ELV Controller is a mains-powered ELV Traffic Controller which drives and monitors 48V LED signals and meets the requirements of Protective Extra-Low Voltage (PELV). The system is optimised for safety, reduced cabling costs, reduced operating and maintenance costs and extreme reliability in operation.

The ST950 ELV Controller is designed so that there are no on-street voltages that exceed the nominal ELV limit of 50V. This offers increased electrical safety for engineers working on and around the intersection and improved lamp monitoring of very low power LED traffic and pedestrian signals. Another major benefit is simplified cabling in the controller. The standard option offers a 20A maximum lamp load; a high current 40A version is available.

A range of equipment compatible with the ST950 ELV Controller is also available; such as Helios ELV signals (traffic and far-side pedestrian signals), ELV LED Regulatory Signs and an ELV Solar Cell. Siemens near-side pedestrian signals (including Wait and Demand Accepted Indicators) are fully compatible with the ST950 ELV Controller and are clearly marked “ELV”.

The ELV supply allows semiconductor switches to be used, reducing unnecessary heat in the controller, improving reliability and reducing power consumption.

There is an active short circuit protection system on all lamp drive outputs, ensuring that the outputs are protected from damage even under direct short circuit conditions.

For specifics on the 40/42V ELV Controller, see section 4.12

4.1 System Overview

The ST950ELV is an ELV Controller that uses the reliable and proven LSLS Lamp Switch Cards as used in the ST900ELV Controller, offering 32 undedicated switch outputs per card and up to 6 LSLS lamp switch cards per controller.

The ST950ELV Controller looks very similar to the ST900ELV controller and is supplied in a single-door outer case with a 6U logic rack accommodating the CPU Card and power supplies with space for up to 16 x 4 channel detector cards. The ST950ELV is also available as a free-standing logic rack housing the CPU Card, LPU and Lamp Switch cards.

ELV Lamp Switch cards (LSLS) are located within the cabinet. Very large intersections may have additional Lamp Switch, I/O and Intelligent Detector Backplane cards located in an adjacent cabinet for ease of installation and maintenance.

The main components of the ST950 ELV system are shown in Figure 6.

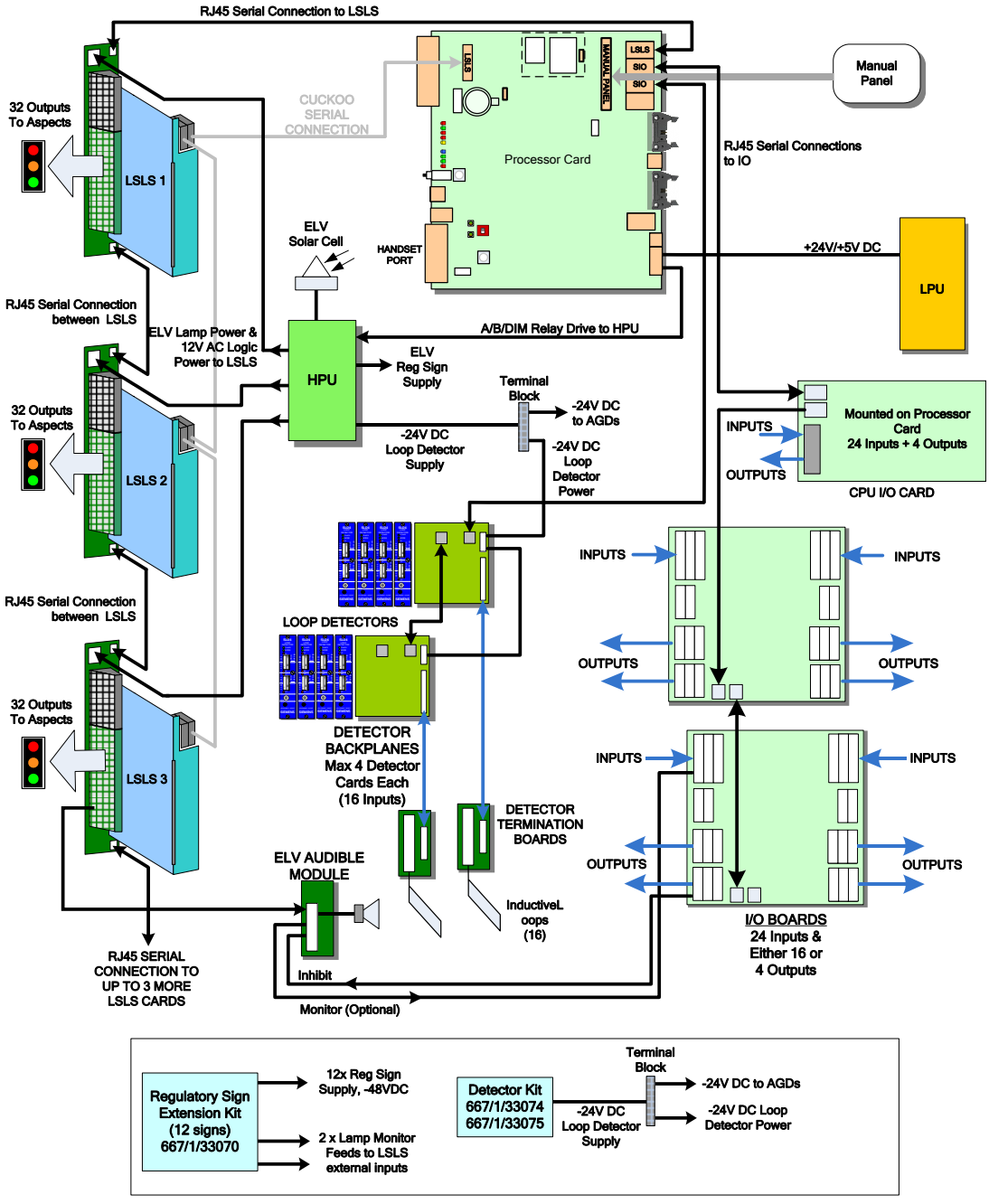


Figure 6 – ST950 ELV System Overview

4.2 ELV Controller Primary Cabinet

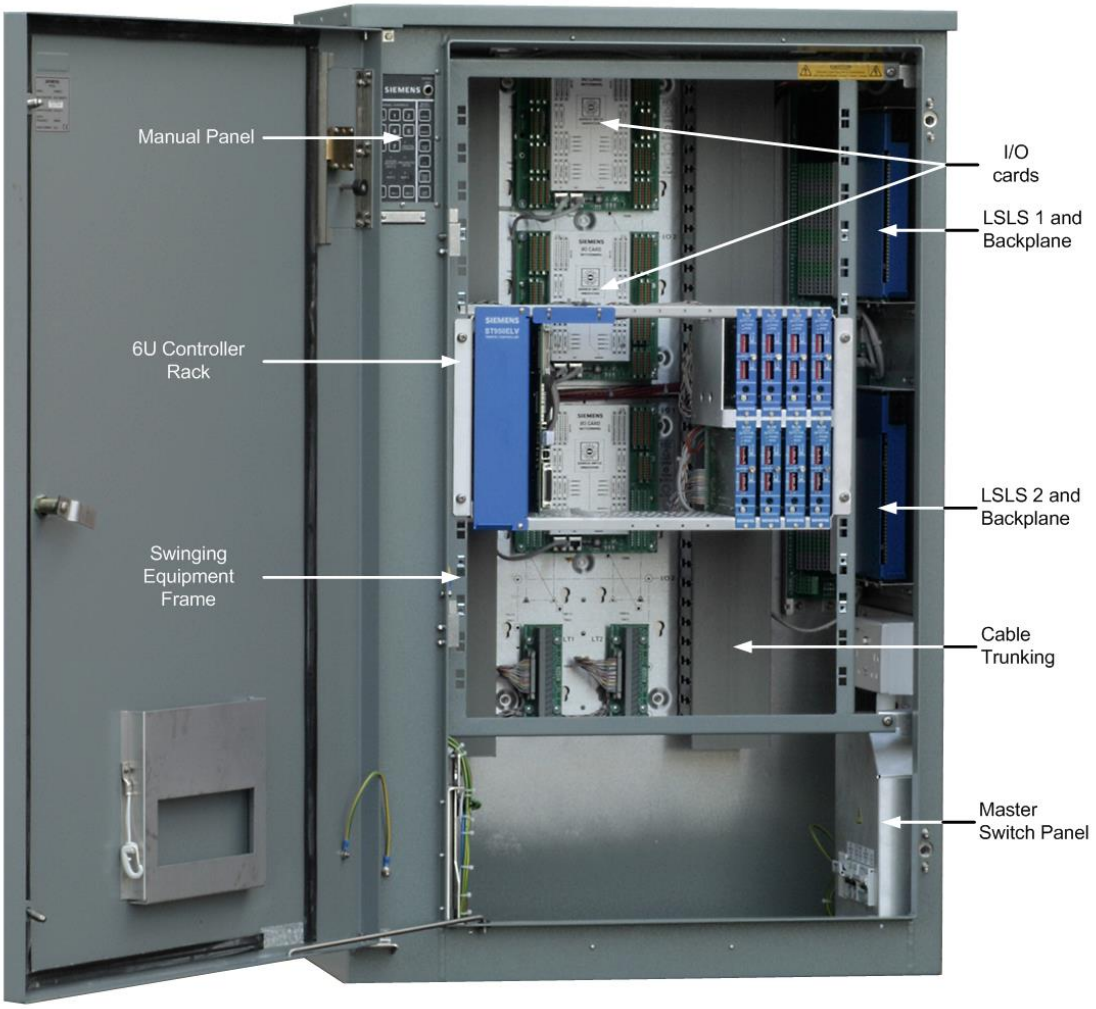


Figure 7 – ST950 ELV Controller Cabinet – View of right side

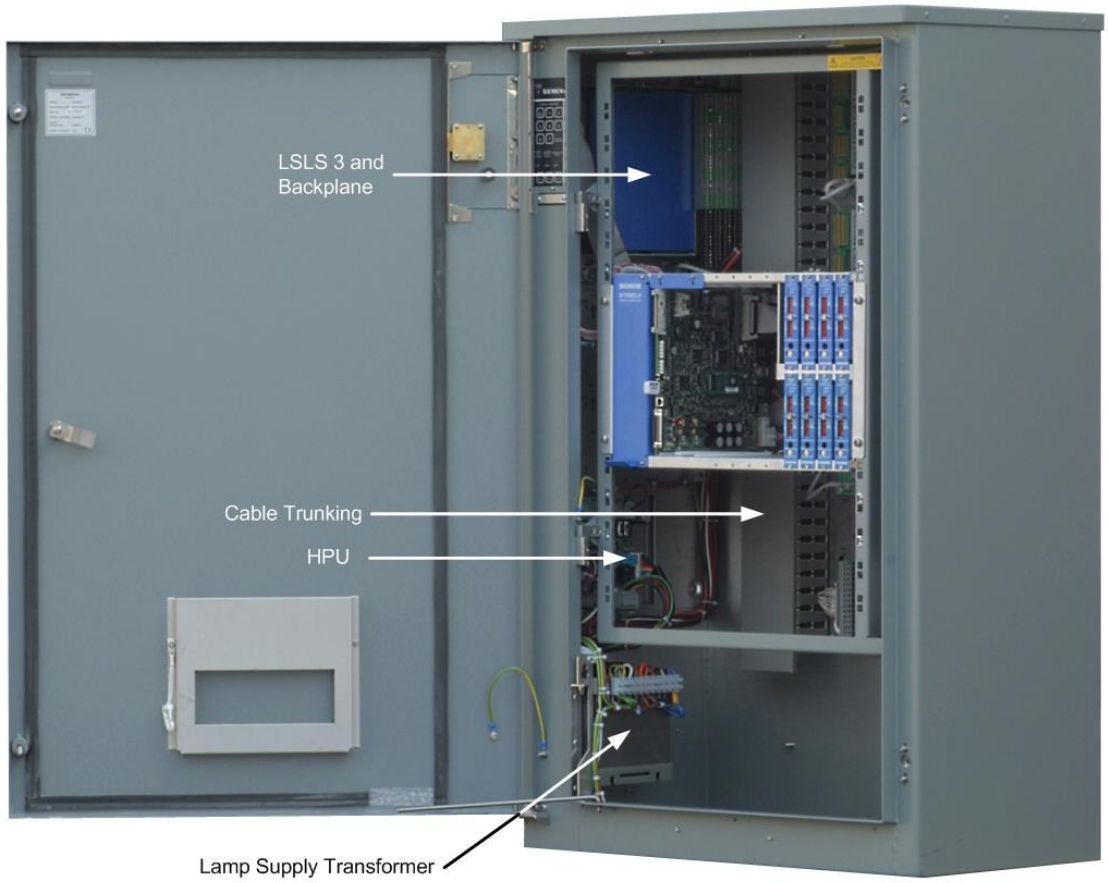


Figure 8 – ST950 ELV Controller Cabinet – View of left side

4.3 ELV Controller Expansion Cabinet

For large junctions, it may be necessary to fit an expansion cabinet, adjacent to the primary cabinet. The Expansion Cabinet Kit does not have a connection to the mains supply and is typically used to house IO cards and their associated cabling. Long-length serial cables are used to connect the IO cards in the expansion cabinet to the in the primary cabinet.

When mains-powered equipment is fitted into the expansion cabinet, an additional ELV Master Switch is required. This kit allows a mains supply to be taken into the expansion cabinet and safely terminated.

When an LSLS is to be fitted into the expansion cabinet, an LSLS Expansion Cabinet Kit is required. This kit includes a 20A lamp transformer, HPU, a single LSLS and LSLS Backplane.

Additional LSLS cards and LSLS backplanes can then be fitted up to a maximum of 3 LSLS cards in the Expansion Cabinet.

When moving parts to an expansion cabinet, just move what is necessary to accommodate incoming cables. The following order is recommended to minimize work:

1. Loop Detectors
2. I/O Cards
3. LSLS Cards

It is not necessary to have a separate Feeder Pillar for the expansion cabinet.

4.4 Fitting the ELV Controller into Alternative Cabinets (Cuckoo)

When fitting an ST950 ELV Controller into an enclosure other than an ST950 cabinet, a different type of 6U rack can be used, a so-called ‘cuckoo’ rack. This rack houses up to three LSLS cards and has two 3U high bays which can be fitted with up to two Intelligent Detector Backplanes, supporting a maximum of eight Loop Detector cards. In the UK, the controller may only be fitted into an HA-approved enclosure.

The procedure for Cuckooing an ST950 ELV Controller into an alternative enclosure is very dependent on the type of enclosure and the type and position of existing equipment.

Detailed installation instructions are included in the drawings contained in the kit relevant to the cabinet.

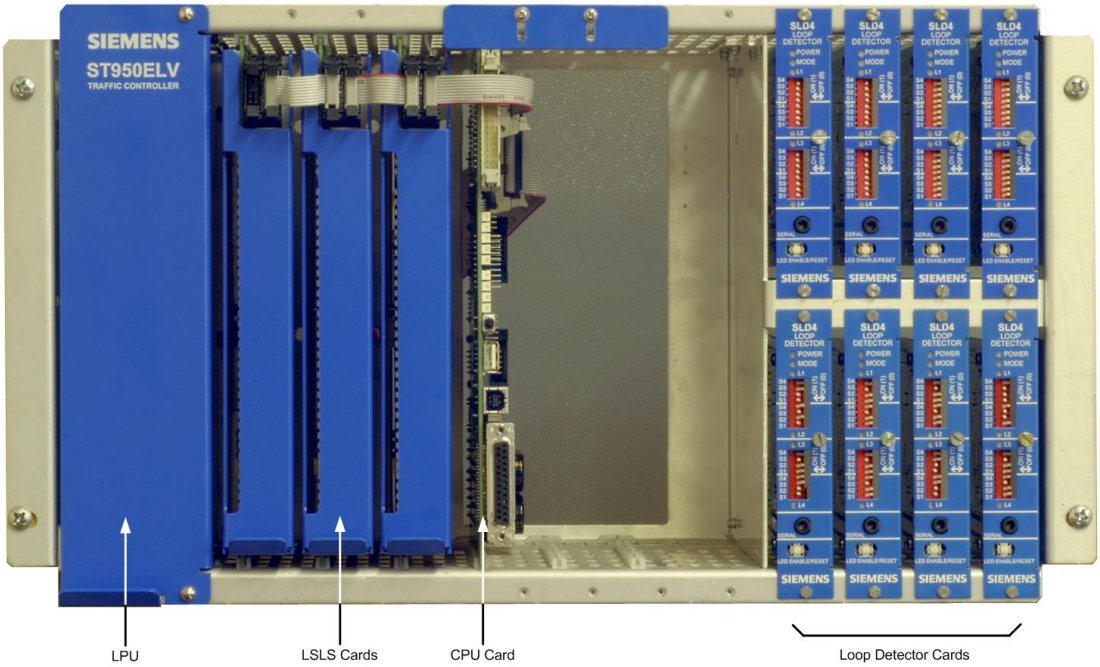


Figure 9 – ST950 ELV Rack for fitting in Alternative Cabinets (front)

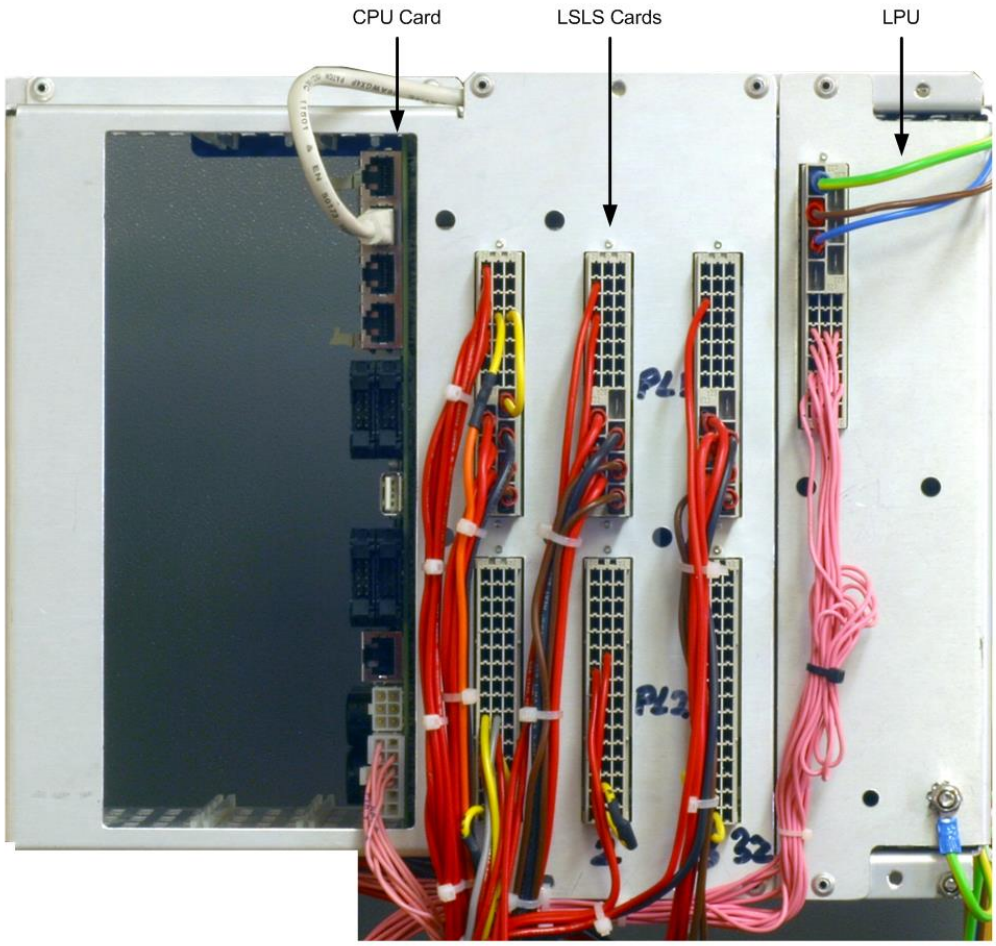


Figure 10 – ST950 ELV Rack for fitting in Alternative Cabinets (rear)

4.5 Mains Input

When considering the connection of the controller to the incoming mains supply, it is important to verify from the supplier that the mains supply short-circuit current does NOT exceed 16,000 Amps.

If the mains supply short-circuit current can exceed 16,000 Amps, refer to Siemens Poole for further information.

The Master Controller Switch is a double-pole isolator and this must be switched off before replacing the Master Controller Fuse.

4.6 Lamp Supply Transformer

The 48V ELV transformer has primary terminations that enable connection to the Mains supplies shown below:

Nominal Voltage	Minimum Voltage*	Maximum Voltage*
250V **	213V	276V
240V	204V	276V
230V	196V	264V
220V	187V	253V
120V	102V	138V
110V	94V	126V

Table 7 – ST950 ELV 48V Lamp Supply Transformer

* Refer to the ST950ELV Installation and Commissioning Handbook 667/HE/45950/000 for the recommended input tap for a specific mains voltage.

** Available from issue 4 onwards of the Lamp Supply Transformer

The nominal secondary voltages are as follows:

- 48V Bright Lamp supply, 27.5V Dim Lamp supply
- 24V Detector supply
- 48V Regulatory Sign supply
- Logic supplies for LSLS cards (one supply per LSLS card)

The transformer has an earthed screen to reject common mode disturbances on the Mains supply.

For the 40/42V ELV Controller, see section 4.12

4.6.1 Low Inrush Lamp Supply Transformer Option

A low inrush lamp supply transformer option (factory fit only*) is available for the ST950 ELV controller that allows the controller to be run from a 25A Electricity Board cutout which many suppliers will provide ***without*** metering.

The transformer is both larger and heavier so a second transformer cannot be mounted in the cabinet. This means that only a 20A controller is available.

* - No upgrade option is available because of the size and weight of the transformer.

4.7 HPU

4.7.1 Introduction

The High Power Unit (HPU) is mounted on the left hand side panel of the controller, above the lamp supply transformer.

The HPU (High Power Unit) receives all the AC voltages from the transformer secondary windings and develops rectified, unsmoothed DC supplies for the LSLS Cards, Reg. Signs

and Detectors. All these supplies have a positive connection to Earth, and are therefore negative DC supplies with respect to Earth.

All supplies taken outside of the cabinet are negative DC supplies and nominally less than -50V DC, conforming to the ELV requirement that they do not exceed 50V.

The functions performed by the HPU are:

- Lamp Supply relays and rectification (earthed -48V / -42V / -40V rms)
- Lamp supply fuse
- Supplies Lamp Supply current up to a maximum of 20A
- Lamp supply and Logic supply distribution to LSLS Cards
- Detector supply (earthed -24V rms)
- Reg. Sign distribution (earthed -48V rms)
- Regulated Solar Cell supply (earthed -24V DC) and sensor input

4.7.2 Solar Cell

An ELV solar cell (part number 506/4/97891/005) enables the controller to identify the light level and thus dim the signals when it is dark. The switch is set to operate at 55 lux and release at 110 lux. Alternatively, time switch control of the change to and from Dim can be provided.

The ELV Solar Cell Kit of Parts (part number 667/1/10039/024) includes the ELV Solar Cell, the relevant wires and GA drawing.

4.7.3 Fail Flash

The HPU contains link positions for use with HFF (Hardware Fail Flash). These determine the lamp supply connections to LSLS Card 1. The standard HPU configuration (used for all UK controllers) disables HFF and the lamp supply to all the LSLS Cards is removed when the controller is shutdown.

For Hardware Fail Flash controllers (non UK only), the link needs to be moved so the lamp supply to LSLS Card 1 remains ON while switching off LSLS Cards 2 and 3. All the signals that are required to flash in HFF are assigned to LSLS Card 1, while all other signals are assigned to the other LSLS Cards.

4.7.4 Fitting Two HPUs

If the total lamp load exceeds 20A or more than 3 LSLS cards are required, then two transformers and two HPU can be fitted.

The allocation of LSLS cards to HPU 1 or HPU 2 is done so that, as far as possible, the total load is distributed evenly across both transformers and HPUs, and in no event does the current drawn from either HPU 1 or HPU 2 exceed 20A.

Note that the number of LSLS cards connected to HPU1 or fitted in the Primary cabinet can be 1, 2 or 3; HPU1 and the primary cabinet does not need to be filled before moving to HPU2 and optionally an expansion cabinet. Also see section 4.9 on page 44 for limits on the number of LSLS cards that can be supported by the controller.

4.8 Logic Power Unit (LPU)

The LPU is powered by the Mains 230V AC supply (or by the Mains 110V AC supply, when the ELV transformer is wired for 110V or 120V input). A switch-mode power supply mounted in the LPU produces +5V and +24V DC supplies used by cards within the cabinet - the controller logic supply. These supplies are never taken outside the cabinet.

The following supply voltages may be used:

Nominal Voltage	Minimum Voltage	Maximum Voltage	Frequency	Autonomy
200V to 230V	184V	264V	50/60Hz ±4%	50ms under max load
110V to 120V	92V	132V		

4.9 LSLS

The LSLS card provides 32 current and voltage monitored switched outputs to the ELV signal aspects. Each LSLS card is fitted into an LSLS backplane on the side panels of the cabinet.

A maximum of 3 LSLS cards can be fitted into an ST950 ELV Controller cabinet. Another 3 LSLS cards can be fitted into an adjacent cabinet, controlled by the same ST950 ELV Controller.

Note that the controller is physically limited to three LSLS cards if the ‘cuckoo’ rack is used (section 4.4).

The LSLS backplane terminates the street cabling, allowing connection of up to 4 wires for each of the 32 aspect drive outputs and gives a total of 64 return terminations.

In addition, the LSLS backplane provides a connection for the power supplied via the HPU; daisy-chained connections for the high speed serial communications from the CPU Card or previous LSLS card; inputs for monitoring regulatory sign current and a means of setting the address of the LSLS card.

Each of the 32 outputs has an associated ‘mimic’ LED showing the status of that output. The LED is tri-colour and shows the appropriate colour assigned to the output (except during Controller Self-Test).

The mimic LEDs can be extinguished automatically while the cabinet door is closed to save power; see the ‘LED’ handset command or web page:

Status and Configuration -> Controller -> Misc

Hardware Fail Flash flashes all the signals on LSLS #1 and extinguishes all the signals on the other LSLS cards, so at least two LSLS cards are required. The IC4 Configurator automatically locates the outputs that are required to flash on to the first LSLS card.

4.10 Controller Load, Power Consumption and Lamp Supply Transformer Selection

This section describes the method used to determine that the controller can supply the total lamp load required, how to select whether one or two lamp supply transformers are required, and how to determine the overall power used for estimation of site running costs.

In order to do this, the power taken by the lamps needs to be calculated. Use the following table to determine the average power taken by the different types of lamps.

The controller Elexon codes for Siemens products are defined in the Siemens Elexon Codes document 667/RE/29050/000.

	Bright 48V	Dim 27.5V
Siemens ELV Regulatory Sign	7 W	Not Dimmed
Siemens Helios ELV (Vehicular or Far-Side Ped Signals)	12 W	4 W
Siemens LED Wait Indicator (for Far-Side Ped Signals)	7 W	2.5 W
Siemens Red/Green Nearside Signals	18 W	3 W
Siemens Ped Demand Indicator (for Near-Side Signals)	6 W	1.2 W

Table 8 – ST950 ELV 48V Lamp Load (Watts)

4.10.1 ELV Controller Load

Detector power requirements are as follows:

- Siemens SLD4 detectors require 1.5W per unit.
- Siemens ST4R/ST4S detectors require 2.4W per unit.
- Siemens WiMag Loop detector replacement cards require 23W per unit. (Fully loaded)
- Sarasota MTS36Z (2 channel) or MTS38Z (4 channel) detectors require 3W per unit. (N.B. The power consumption is the same for both 2 and 4 channel units.)
- Microsense detectors require 6W per unit.

4.10.2 Lamp Drive Capability

The following table gives the lamp drive capability of the controller as a whole, each 'Phase Driver' (or 'Lamp Switch') card and each aspect. The 'Watts' and 'Lamps' columns are equivalents for the currents shown based on a 48V supply and 12W Siemens Helios ELV Signals respectively.

	Max Current (Amps)	Max Power (Watts)	No. of LED Lamps
Max. lamp current that a normal ST950 ELV Controller can supply including regulatory signs and excluding short-term illumination, i.e. red/amber.	20A	960W	80
Max. lamp current that a 'high-current' ST950 ELV can supply including Regulatory Signs but excluding short-term illumination, i.e. red/amber. Also see note below	40A	1920W	160
Max. lamp load for one 32-output LSLS card (including red/amber).	20A	960W	80
Max. load for a single output on an LSLS card.	2A	96W	See Table 10

Table 9 – ST950 ELV 48V Lamp Drive Capability

The high-current ST950ELV Controller uses the 40A Controller Upgrade Kit. This increases the current capability (including regulatory signs) of the Controller to 40A. This option also uses two ELV transformers, see section 4.10.5.

For the 40/42V ELV Controller, see section 4.12

4.10.3 LSLS Output Capability

One LSLS output can drive, and one sensor can monitor, the following loads:

Output Type	Maximum Quantity Note 1	Lamp Monitoring Note 2
Helios ELV (vehicular or far-side ped)	8	Yes
Siemens Red/Green Nearside – Refer to note 5	4	Yes
AGD Red/Green Nearside – Refer to note 5	4	Yes
Siemens Demand Indicator – Refer to note 5	6	Yes
AGD Demand Indicator – Refer to note 5	8	Yes
Siemens LED Wait Indicator – Refer to note 5	6	Yes
AGD Wait Indicator – Refer to note 5	4	Yes
Swarco Low-Level 100mm Cycle Signals	3	Yes
Audible Driver Module – Refer to notes 3 & 4	8	No
Tactile – Refer to note 4	4	No

Table 10 – ST950 ELV 48V LSLS Output Capability

Always refer to 667/SU/46000/000 for compatibility information.

Nearside, Wait or Demand units without an attached ‘ELV’ label must not be connected to the LSLS. Spurious faults and damage to the LSLS may result if this is done. This applies to units of either Siemens or AGD manufacture. See Note 5.

Notes:

1 – Note that the LSLS Backplane only provides terminations for 4 street cores. Also see section 4.11 starting on page 56 for details of number of cores required for long cable runs.

2 – The output drive limits for one LSLS output are also the monitoring limits for one sensor. Even though a sensor may be configured to monitor more than one LSLS output of the same colour, that one sensor can still only monitor the number of signals listed. Example: If a large number of near-side signals are required and so two LSLS outputs are provided for each colour, each output must be monitored by a different sensor. However, if two LSLS outputs are used solely to provide more terminations, then as long as the total number of signals does not exceed the limit, both outputs can be monitored by one sensor. Example: Eight Helios ELV signals on two outputs can be monitored by the same sensor.

3 – Each Audible Driver Module can drive up to 8 audible sounders.

4 – 4 Tactile Units and 1 Audible Driver Module (8 sounders) or 2 Tactile Units and 2 Audible Drivers (16 sounders) can be simultaneously driven from one LSLS output.

5 – Note that only product fitted with a clear ELV label may be connected to the LSLS. Although the part numbers of these products may not have changed, the internal circuitry has - so on no account must a unit without the relevant label be connected, otherwise spurious faults or damage to the LSLS may result. Refer to the document 667/SU/46000/000 for information on the compatible versions.

When signals are required to be lamp monitored, signal types must not be mixed.

Specifically, when lamp monitoring Nearside Signals, it is not allowed to connect Tactile Units or Audible Driver Modules in parallel to the Nearside Signals. In this case, two or more LSLS Outputs must be specified for the pedestrian green aspect in the IC4 Configuration (Phase Type and Conditions page), with lamp monitoring disabled on the outputs used by the Tactile Units or Audible Driver Modules.

When output types are NOT lamp monitored, it is permissible to mix output types. Specifically, it is permissible to connect 2 Tactile Units, 2 Green Nearside Signals (either AGD or Siemens) and one Audible Driver Module (8 sounders) in parallel across one LSLS output.

4.10.4 Lamp Supply Transformer and Power Consumption Example

The following sections detail how to select the correct lamp supply transformer and estimate the power consumed by a controller, using the theoretical junction in Figure 11 as an example:

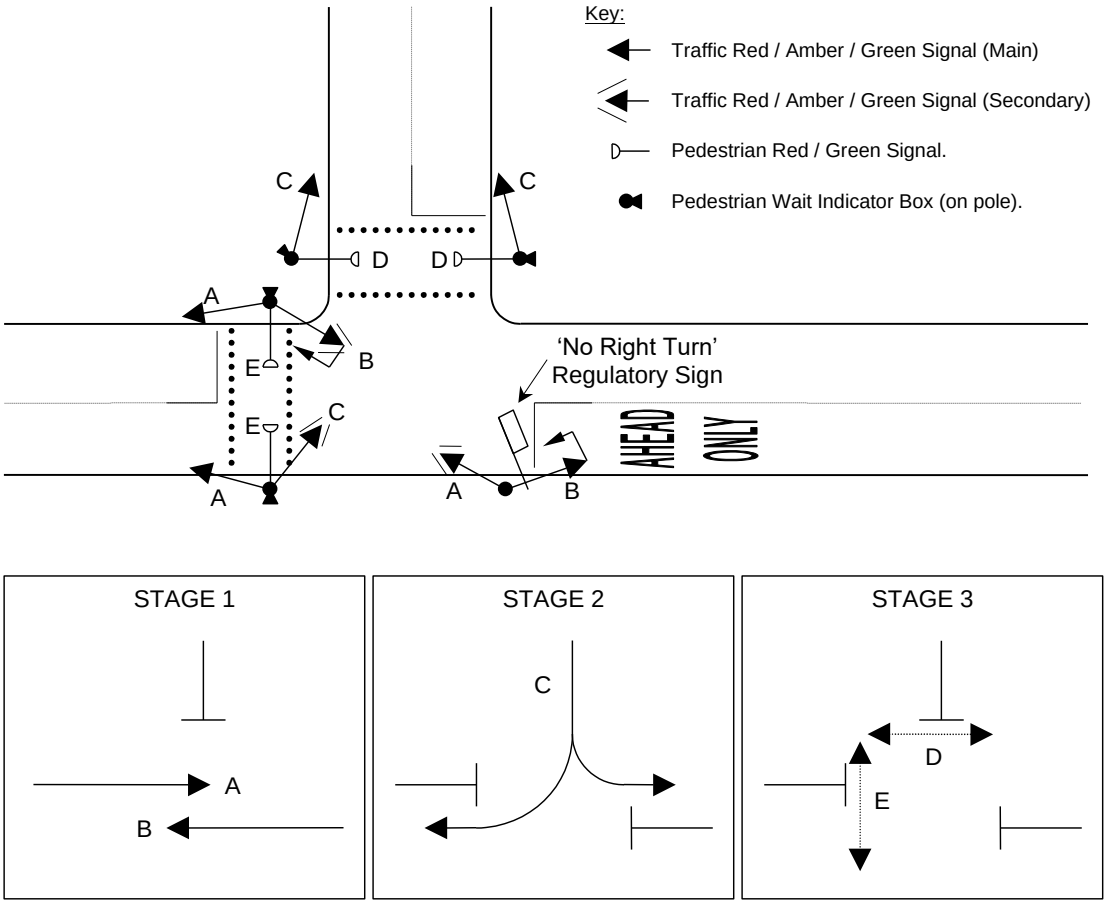


Figure 11 – Theoretical Junction (ST950 ELV)

4.10.5 Selection of Lamp Supply Transformer

In order to select the number of lamp supply transformers, the total average signal Lamp Power is required. See Table 8 on page 45 for the power taken by the different types of lamps.

When selecting the lamp supply transformer the peak lamp power is not used as the transformer can withstand the overload for the 2 second Red / Amber period. Thus for the average power consumption, it is assumed that only one lamp is illuminated on each signal head. However, Pedestrian Red signals illuminated at the same time as the Pedestrian and Wait / Demand Accepted signals must be included.

For the theoretical junction (Figure 11) this would be:

One lamp per signal head @ 12W x 12 signal heads	144W
Wait indicators at 7W x 4 at 20% duty cycle	5.6W
Regulatory Sign at 7W x 1	7W
Total average signal lamp power is:	157W

For the theoretical junction, using the figure obtained above (179W), one transformer would be required.

A single 20A lamp supply transformer is required to power a 20A controller using up to three LSLS Cards. Two 20A lamp supply transformers are required if more than 20A or more than three LSLS Cards are required.

The table below summarises the current capability provided by one or two 20A transformers, the number of LSLS cards each can support and the typical number of phases and signals heads†:

LSLS Cards*	2A Output Switches	Phases (approx)	Lamp Supply Transformer	Max. Lamp Current	Av. Signal Heads per Phase†
1	32	1 – 8	20A	20A	>10
2	64	9 – 16	20A	20A	5 – 10
3	96	17 – 24	20A	20A	3 – 5
2	64	9 – 16	2 x 20A	40A	>10
3	96	17 – 24	2 x 20A	40A	7 – 10
4	128	25 – 32	2 x 20A	40A	5 – 6
5	160	26 – 32	2 x 20A	40A	5 – 6
6	192	26 – 32	2 x 20A	40A	5 – 6

Table 11 – ST950 ELV 48V Current Capability

* Refer to section 4.9 on page 44 for limits on the number of LSLS Cards supported.

† Assuming 12W 48V Helios ELV Signals, 20A allows for approximately 80 signals which will normally mean that 80 signal heads can be supported since usually only one aspect of the phase is lit at any one time. Since the short 2 second Red plus Amber period never occurs on many signals at the same time, the transformer is designed to cope with a short period of overload. A range is given because of the range on the number of phases: e.g. 9 phases would allow an average of 10 signal heads per phase, but with 16 phases this drops to an average of five signal heads per phase. The figures will be lower if a large

number of pedestrian signals are fitted since the current consumed by the Red and Wait Signals is higher than the current consumed by a single 12W Helios ELV Signal (see Table 8 on page 45).

4.10.6 Intersection's Power Requirements for Running Costs Estimate.

Introduction

For use in the UK, power running costs are normally defined by Elexon, however it is possible to estimate the power consumption of an intersection using the following process.

The following worked example is based upon a 230 mains' supply and ELV LED signals and assumes 12 hours in both the bright and dimmed state.

Firstly the total average lamp power for the junction is calculated for both bright and dim states. Secondly the total average lamp power is added to the total average controller power. This gives the total average junction power which can be used to give an estimate of running costs.

Total Average Lamp Power

Total average lamp power is calculated as follows:

For every signal head, only 1 lamp is illuminated on average (at 12W assuming Helios ELV LED lamps), plus every WAIT indicator is illuminated at 7W and every Regulatory Sign is illuminated at 7W.

Therefore, considering our theoretical junction (Figure 11), we have:

For the bright condition:

12 signal heads each with 1 lamp at 12W (12 x 12W)	144W
4 wait indicators illuminated at 12W (4 x 12W) at 20% duty cycle	9.6W
Total Average Lamp Power is:	154W

For the dim condition:

12 signal heads each with 1 lamp at 4W (12 x 4W)	48W
4 wait indicators illuminated at 4W (4 x 4W) at 20% duty cycle	3.2W
Total Average Lamp Power is:	51W

Plus the Un-dimmed Regulatory Signs:

One Regulatory Sign at 7W (1 x 7W)	7W

Total Average Controller Power

Total average controller power is calculated as follows:

Average Controller power + Average Detector Power.

A low inrush ST950ELV controller is rated at 25W, and for the purposes of this calculation Siemens SLD4 detectors require 1.5W per card. See section 3.6.1.

Therefore, for our theoretical junction (Figure 5) the total average controller power is:

1 x ST950ELV Low Inrush Controller	25W
2 x Siemens SLD4 Detectors	3W
Total Average Controller Power is:	28W

Therefore, for the theoretical junction for a single 24 hour period:

154W for 12 hours – signals in bright	1848Wh
51W for 12 hours – signals in dim	612Wh
7W for 24 hours – Undimmed Regulatory Sign	168Wh
28W for 24 hours – Controller and Detectors	672Wh
Total Average Junction Power Consumption per day is:	3300Wh

This is equivalent to an Average Power Consumption of: 137.5W

Note 1: The controller power should also include any additional equipment supplied by the controller. This may include, for example, OTU or Auxiliary detector power supply.

Note 2: Many customers may now prefer to use the Elexon codes for each individual device within the site to determine power consumption for Billing purposes when using an un-metered supply. Some older devices may not have an Elexon code in which case there is a Genetic code. The Elexon Home page can be found here : http://www.elexon.co.uk/Pages/home.aspx

The controller power should also include any additional equipment supplied by the controller.

4.10.7 Detector Power Supplies

Detectors are normally powered from the detector supply on the HPU card, which provides rectified and earthed -24V rms at 2.8A DC. If more current is required, then power the additional detectors from an additional -24V 2A (50VA) or 6.6A (160VA) detector power supply kit. The maximum number of each type of detector that can be supported by each power supply is shown in the table below.

	HPU -24V DC 2.8A	667/1/33075/000 -24V DC 50VA / 2.0A	667/1/33074/000 -24V DC 160VA / 6.6A
Siemens SLD4 (1.5W / 62mA per detector)	45	32	106
Siemens ST4R/ST4S (2.4W / 100mA per detector)	28	20	66
Siemens WiMag Loop Detector Replacement card (23W / 960mA loaded with 2 Access points – each access point consumes approximately 7.4W / 310mA)	2	2	6
Sarasota MTS36Z or MTS38Z (or any mix) (3W / 125mA per detector)	22	16	53
Microsense Detectors (6W / 250mA per detector)	11	8	26

Table 12 – ST950 ELV Detector PSU Selection

When powering detector cards such as SLD4, WiMag and Above Ground Detectors the overall power consumption must be calculated and be within the capacity of the detector supply.

The Detector Supply Output from the HPU is routed to a 12-way terminal block on the side panel of the Cabinet. From this terminal block, power is routed to the Intelligent Detector Backplanes to power the attached Loop Detector Cards. Additionally, Above Ground Detectors may be powered from this supply.

Due to the inrush current drawn by the Detector Supply Transformers, there are limitations to the number of 50VA and 160VA transformers that can be fitted. Do not exceed the quantities in the table below: e.g. if fitting 2 x 160VA transformers, then a maximum of 3 x 50VA transformers can also be fitted

667/1/33075/000 -24V DC 50VA / 2.0A	667/1/33074/000 -24V DC 160VA / 6.6A
10	0
6	1
3	2
0	3

Table 13 – ST950 ELV Detector Transformers

4.10.8 Audible Supplies

The ELV Audible Driver Module derives the power to drive the Audible sounders directly from the green drive of the LSLS card.

Audible sounders used must operate correctly over the voltage range 10 to 24V DC. The audible units recommended and supplied by Siemens, which meet this requirement, are 667/4/04785/000:

- Highland Electronics type SC628P (was Sonalert Mallory SC628P)
- Roxborough type SPCI535A4
- Askari (Tone 22 – variable volume)…

4.10.9 ELV Tactile Units

The following tactile units are recommended.

667/1/17390/248	Combined motor and drive module. Enable input. Fault output
BIC B0302	Combined motor and drive module. No enable input. Fault Output

Where lamp monitoring of the pedestrian green signals is not required, the tactile unit is driven directly from the pedestrian green LSLS output.

Where lamp monitoring of the pedestrian green signals is required, the tactile units must be driven from an additional green LSLS output assigned to the same pedestrian phase green and lamp monitoring of that addition LSLS output should then be disabled.

A number of tactile units may be connected in parallel to each LSLS green output. See section 4.10.3 ‘LSLS Output Capability’ on page 47.

Tactile units without enable input will run for the entire period that the green drive is on.

For ‘parallel pedestrian phases’, i.e. pedestrian phases that appear at ROW concurrently with vehicular phases, the pedestrian phases may remain at green for some time. It is acceptable that Tactile Units are left powered and running in this state; they do not need to be switched off. However, it is recommended that the ‘terminate after minimum green’ option is considered since this will normally mean that the longer pedestrian clearance periods have finished before the usually shorter vehicle-to-vehicle intergreen times finish allowing the new stage to start earlier.

If it is required that the Tactile Units without enable input are switched OFF while the pedestrian green drive is still ON, (e.g. during a flashing green man period) then either a separate pedestrian phase must be configured to run in parallel with the usual pedestrian phase, but with the required timings modified or a tactile unit with an enable input must be used.

Tactile units with an enable input can be disabled during the period that the green drive is on. Typically this is used to switch off the tactile unit after a shorter period than the green drive period. This prevents non-sighted pedestrians from starting to cross near the end of the pedestrian phase green period. The enable input of the tactile unit must be cabled back to the “Normally Open” output of the IO card in the cabinet. When the IO card output is closed, the tactile unit will run when the green drive is on. When the IO card output is open circuit, the tactile unit will not run, even if the green drive is on.

The enable inputs of tactile units can be paralleled (either at the nearside/demand unit or back at the controller cabinet)provided that polarity is maintained (all enable+ connected in parallel and all enable – connected in parallel) in order to save on IO card outputs

When running a tactile unit with input enable facility, if the facility is not to be cabled back to the controller cabinet, then the enable inputs of the tactile unit must be shorted together using a short wire link. Without this link, the tactile unit will not run even if the green drive is on.

Tactile units with an enable input and a fault output additionally have the capability of reporting a fault back to the controller.

The fault output of the tactile unit can be cabled back to an input on the IO card in the controller.

The tactile unit will present either an open circuit or a short circuit on the fault output under the following conditions:

ITE220 / BIC0302 Fault Output	Fault Output
Tactile Unit not powered	Open-circuit
Tactile Unit powered and stalled (held or stuck)	Open-circuit
Tactile Unit powered and motor open or short circuit	Open-circuit
Tactile Unit powered and cone able to rotate	Closed-circuit

Special conditioning in the controller must discriminate between short-duration fault conditions (such as the tactile unit being temporarily held stalled) and a permanent fault that requires maintenance.

When running a tactile unit with fault output where the fault output is not to be cabled back to the controller cabinet, the fault output of the controller is left open-circuit.

Tactile unit fault outputs must **NOT** be paralleled.

4.10.10 ELV Regulatory Sign Expansion Kit

The ELV Regulatory Sign Expansion Kit derives power from the controller mains supply to power additional ELV regulatory signs.

This kit is required if the total number of regulatory signs to be driven from the controller exceeds the HPU capacity of 8.

ELV Regulatory Signs must operate from 33 to 58VDC rectified supply, measured at the ELV Regulatory Sign terminal block. For power budget calculations, ELV Regulatory Sign Extension Kit loading is the same as for signs powered from the HPU regulatory sign supply (7 Watts per sign).

ELV Regulatory Signs Expansion kit: 667/1/33070/000.

4.11 Cabling

When estimating cable core and controller equipment requirements for the ST950 ELV Controller the maximum cable lengths defined in the following tables on pages 60 and 61 must be complied with. There are also two wiring design and installation guides 667/DS/20664/000 LV, and 667/DS/20664/048 ELV, and these should be used for further detailed reference information.

In order to keep the voltage at the signals within their specification, the voltage drop in the installation must be no more than 4% of the incoming supply. The tables should be consulted to ensure that the voltage drop is lower than this maximum for the selected core size, distance and loading. If the voltage drop would exceed 4%, the cores / conductors must be paralleled up to reduce it as instructed by the tables.

In addition the following guidance should be observed:

1. Where multiple cores are required due to long cable runs it must be noted that this may require additional LSLS Outputs (and possibly an additional LSLS Card) in order to accommodate the additional terminations in the LSLS Backplanes.

2. If common ground return connections were used it is possible for the failure of a ground return connection to cause unexpected signal displays, where one or more signals within a given signal head are incorrectly illuminated simultaneously. This lack of ground return connection is not detectable by the controller because the signal voltage presented at the controller terminals does not exceed the required thresholds for conflict or correspondence monitoring. It is therefore **essential** that individual ground returns are used for each green signal.

3. The allowable lamp load per cable run is defined in the following tables. Refer to Table 8 – ST950 ELV 48V Lamp Load (Watts) on page 45 to determine the total lamp load connected to each drive cable and each return cable.

   For each 'out-going' drive cable, determine the total load of all the signals supplied by that cable. This will typically be a single aspect (e.g. one Helios ELV signal) but could be higher where a green drive also powers a tactile unit for example.

   A single LED signal return core (equivalent to the neutral in an LV system) is to be provided for each Red, Amber Signal Head (or Nearside Red / Green Signal). A separate return **MUST** be provided for the green aspect. Where a common return core is used, the highest lamp load that may be illuminated at any one time needs to be determined.

   For a UK traffic signal head, one Helios ELV lamp load 12W is considered the highest for the return cable since only one aspect is ever illuminated; the short red/amber period can be ignored.

   For a near-side pedestrian signal head, the figure is one near-side signal unless it shares the same return with a Demand Indicator or a Tactile Unit.

   Example, assuming a distance of 180 metres using 1.0mm^2 cable:

   - Near-side ped drive cables: 18W each at 180 metres = 2 cores (each)
   - Ped demand indicator drive cable: 6W at 180 metres = 1 core
   - Common return cable for all **BUT** green aspect: 24W (6W+18W) at 180 metres = 3 cores
   - Green aspect return cable 12W at 180metres = 2 cores

4. If required to minimise core usage it is permissible to common signal returns on the same pole as long as the total lamp load dependent on that return is considered and the cable length limitations defined in the table are observed. For example, two 12W RAG traffic signal heads require that a load of 24W is considered with a common return cable. (Note: please also consider the comments given in paragraph 1)

5. Regulatory signs should normally be cabled with a separate drive and return core.

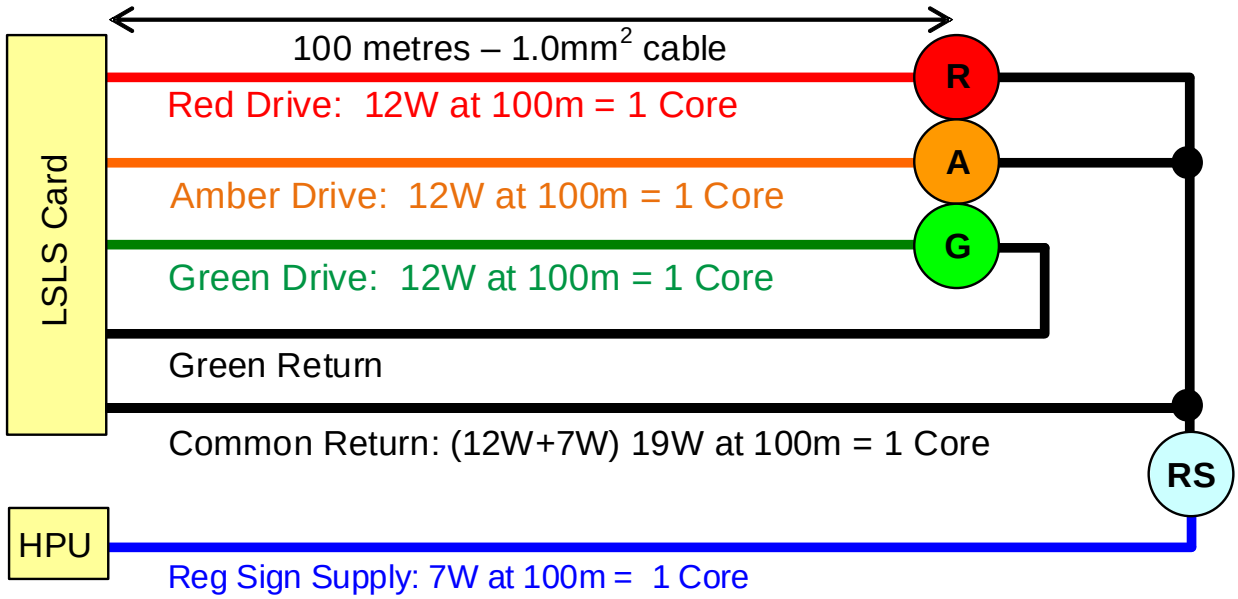
   Where more than one regulatory sign is fitted to a pole, the drive and return for these may be common, as long as total load dependent on those cables is considered and the cable length limitations defined in the table are observed.

   If required to minimise core usage it is permissible to common regulatory sign and traffic signal returns on the same pole as long as the total load dependent on that return is considered and the cable length limitations defined in the table are observed.

   Example, assuming a distance of 100 metres using 1.0mm^2 cable:

   - Reg Sign supply cable: 7W at 100 metres = 1 core

- RAG traffic signal drive cables: 12W at 100 metres = 1 core each (x3)
- RA + Reg Sign common return cable: 19W (12W+7W) at 100 metres = 1 core.
- Green return cable: 12W at 100metres = 1 cor



It should be noted from looking at Table 14 that above 100 metres, 2 cores would be required for the 19W common return, and above 160 metres, 2 cores would also be required for each 12W signal drive cable.

6. Tactile units are to be provided with a separate drive and return core. Tactile units driven from the same phase green LSLS output can share a common drive and return core. For the purposes of assessing acceptable cable run lengths using the table, each tactile unit should be considered to be a 12W load.

   If required to reduce core usage, tactile units may share a return core with any Red/Amber LED signal return core on the same pole (**NOT** Green as this must always have its own return). If this option is exercised each tactile unit should be considered to be a 45W load for the purposes of assessing acceptable cable run lengths using the table. This figure is much higher than their normal running power, but is typical of the power consumed if the tactile device is physically held, stopping the motor.

7. The ELV solar cell should be provided with a drive and return core for connection of the solar cell supply and signal. The solar cell return can be commoned with the LED signal return. Its effect on the voltage drop is so small that it can be ignored.

8. Returns for digital inputs (for above ground detectors and pushbuttons etc on the same pole) may be commoned together, but must remain separate from the LED signal returns.

9. Audible units **must** be provided with a separate drive and return core. Audible units on the same Audible Driver Module may share a common drive and return core (up to

250m) if required to reduce core usage, but **must** remain separate from the LED signal returns and digital input returns.

NO MORE than 3 cores should be connected in parallel. The numbers in the cells within the tables indicate the number of cores required to meet the voltage drop requirement.

For the 40/42V ELV Controller, see section 4.12

Length of Cable Run (metres) – 1.0 mm^2 Cable

Lamp Load (Watts)	5	10	15	20	25	30	35	40	45	50	60	70	80	90	100	110	120	130	140	160	180	200	225	250	275	300	325	350	375	400
7	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2
10	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2
12	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	3	3	3
18	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	3	3	3	3			
20	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	3	3	3	3				
25	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	3	3	3							
30	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	3	3	3	3								
35	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	3	3	3	3										
40	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	3	3	3	3											
45	1	1	1	1	1	1	1	1	1	2	2	2	2	2	3	3	3	3												
50	1	1	1	1	1	1	1	1	2	2	2	2	2	3	3	3	3													
60	1	1	1	1	1	1	2	2	2	2	2	3	3	3	3															
80	1	1	1	1	1	2	2	2	2	2	3	3																		
100	1	1	1	1	2	2	2	2	3	3	3																			
120	1	1	1	2	2	2	3	3	3	3																				

Table 14 – ST950 ELV 48V Cable Lengths: 1.0mm^2

Length of Cable Run (metres) – 1.5 mm² Cable

Lamp Load (Watts)	5	10	15	20	25	30	35	40	45	50	60	70	80	90	100	110	120	130	140	160	180	200	225	250	275	300	325	350	375	400
7	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
10	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2
12	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2
18	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	3	3	3
20	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	3	3	3	3
25	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	3	3	3	3	3		
30	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	3	3	3	3				
35	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	3	3	3	3						
40	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	3	3	3	3							
45	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	3	3	3	3								
50	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	3	3	3	3									
60	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	3	3	3	3											
80	1	1	1	1	1	1	1	2	2	2	2	2	3	3	3	3														
100	1	1	1	1	1	1	2	2	2	2	2	3	3	3																
120	1	1	1	1	1	2	2	2	2	2	3	3																		

Table 15 – ST950 ELV 48V Cable Lengths: 1.5mm²

4.12 40/42V ELV Controller

The ST950 ELV 40/42V Controller uses the same firmware and hardware modules as the 48V controller, except for a unique lamp supply transformer to generate the lower lamp supply voltages required by 40V and 42V signals. To configure the ST950 ELV controller to operate with these lower supply voltages and 40V signals, select the 'ELV40V46059.8DF' default data file and the appropriate 40V LED signal types in the IC4 configuration tool.

4.12.1 40/42V Lamp Supply Transformer

The 40/42V lamp supply transformer provides both 40V and 42V Bright and Dim lamp supply voltages. 40V signals have been characterised for use with the 40/42V Controller. The Controller is supplied wired for 40V, and has primary connections that enable connection to the Main supplies shown below:

Nominal Voltage	Minimum Voltage*	Maximum Voltage*
250V	218V	275V
240V	209V	264V
230V	201V	253V
220V	192V	242V
120V	105V	132V
110V	96V	121V

Table 16 – ST950 ELV 40V Lamp Supply Transformer

* Refer to the ST950ELV Installation and Commissioning Handbook 667/HE/45950/000 for the recommended input tap for a specific mains voltage.

The limited voltage ranges of the 40V signals result in the Mains tolerance being +10/-13%, as in EN50556 'Road traffic signal systems'.

The nominal secondary voltages are as follows:

- 42V Bright Lamp supply, 31V Dim Lamp supply
- 40V Bright Lamp supply, 27V Dim Lamp supply
- 24V Detector supply
- Logic supplies for LSLS cards (one supply per LSLS card)

There is no 48V Regulatory Sign supply.

The transformer has an earthed screen to reject common mode disturbances on the Mains supply.

The transformer has the following coloured secondary wires:

Wire Colour	Designation
Yellow	40V Bright
Red	40V Dim (27V)
White	42V Bright
Grey	42V Dim (31V)

The 40/42V Controller is supplied wired for 40V, with the 40V Bright/Dim wires connected to the HPU, and the 42V Bright/Dim wires terminated in a connector.

The 40/42V transformer is the same size as the 48V low inrush transformer, and allows the controller to be run from a 25A Electricity Board cutout. The transformer size only allows one transformer to be fitted in a Controller cabinet.

4.12.2 40/42V Controller Load and Lamp Drive Capability

The 40V signals have typical power of 7W in Bright and 3W in Dim.

The following table shows the ST950 ELV 40V lamp drive capability.

	Max Current (Amps)	Max Power (Watts)	No. of LED Lamps
Max. lamp current that a normal ST950 ELV 40/42V Controller can supply excluding short-term illumination, i.e. red/amber.	17.5A	700W	100
Max. lamp load for one 32-output LSLS card (including red/amber).	17.5A	700W	100
Max. load for a single output on an LSLS card.	2A	84W	8

Table 17 – ST950 ELV 40V Lamp Drive Capability

4.12.3 40/42V Cabling

The principles outlined in the general ELV cabling, section 4.11, apply. In order to keep the voltage at the 40/42V signals within their specification, the allowable voltage drop in the cables is limited to 3% of the nominal supply. The cable lengths for varying loads are shown in the following tables.

Length of Cable Run (metres) – 1.0 mm² Cable

Lamp Load (Watts)	5	10	15	20	25	30	35	40	45	50	60	70	80	90	100	110	120	130	140	160	180	200	225	250	275	300	325	350	375	400
7	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	3	3	3	3
10	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	3	3	3	3				
14	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	3	3	3	3							
18	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	3	3	3	3										
20	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	3	3	3	3											
25	1	1	1	1	1	1	1	1	2	2	2	2	2	3	3	3	3													
30	1	1	1	1	1	1	1	2	2	2	2	2	3	3	3															
35	1	1	1	1	1	1	2	2	2	2	2	3	3	3																
40	1	1	1	1	1	2	2	2	2	2	3	3																		
45	1	1	1	1	2	2	2	2	2	3	3	3																		
50	1	1	1	1	2	2	2	2	3	3	3																			
55	1	1	1	2	2	2	2	3	3	3																				
60	1	1	1	2	2	2	2	3	3	3																				
70	1	1	1	2	2	2	3	3	3																					
80	1	1	2	2	2	3	3																							

Table 18 – ST950 ELV 40V Cable Lengths: 1.0mm²

Length of Cable Run (metres) – 1.5 mm² Cable

Lamp Load (Watts)	5	10	15	20	25	30	35	40	45	50	60	70	80	90	100	110	120	130	140	160	180	200	225	250	275	300	325	350	375	400
7	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2
10	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	3	3	3	3
14	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	3	3	3	3			
18	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	3	3	3	3						
20	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	3	3	3	3							
25	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	3	3	3	3									
30	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	3	3	3	3											
35	1	1	1	1	1	1	1	1	1	2	2	2	2	2	3	3	3	3												
40	1	1	1	1	1	1	1	2	2	2	2	2	3	3	3	3														
45	1	1	1	1	1	1	1	2	2	2	2	2	3	3	3															
50	1	1	1	1	1	1	2	2	2	2	2	3	3	3																
55	1	1	1	1	1	2	2	2	2	2	3	3	3																	
60	1	1	1	1	1	2	2	2	2	2	3	3																		
70	1	1	1	1	2	2	2	2	2	3	3																			
80	1	1	1	2	2	2	2	3	3	3																				

Table 19 – ST950 ELV 40V Cable Lengths: 1.5mm²

5 THE CPU CARD

The CPU Card holds the controller configuration and performs the function of configuration, control and management. The same CPU Card is used in the ST950 and ST950ELV Controllers. The main external data interfaces of the CPU Card are:

- Interface to the lamp switch cards
- Serial Interfaces (GSPI) to IO Cards and Intelligent Detector Backplanes
- Manual Panel
- RS232 interface to handset or Gemini^2
- USB interfaces
- Ethernet Interface
- High level control of features such as MOVA7 and UTMC OTU

5.1 Controller Microprocessors

There are a number of CPUs on the CPU Card within the Traffic Controller, each with a specific role:

Primary CPU	–	Responsible for the safety timings and low-level sequencing of the traffic signals (e.g. Amber Leaving and Intergreen times) and monitoring the states of the traffic signals.
PHP CPU	–	Responsible for monitoring the states of the traffic signals as well as the switching and low-level monitoring of all the Lamp Switch Cards in an LV Controller. Not used on an ELV Controller.
SEC CPU	–	Responsible for monitoring the state of the traffic signals in an ELV Controller, and in all controllers, this CPU also monitors the operation of the Primary CPU.
EFC CPU	–	Powerful CPU running the Linux operating system that provides interfaces to the outside world and the high-level traffic stage selection (e.g. Stage 1 is next, MOVA7, UTMC OTU functionality).
Fail Flash CPU	–	Just provides the flash strobe for Fail Flash controllers. The flash period is specified in the IC4 configuration.

5.2 Software Architecture

The significant parts of the software in the Traffic Controller can be divided into the following main parts:

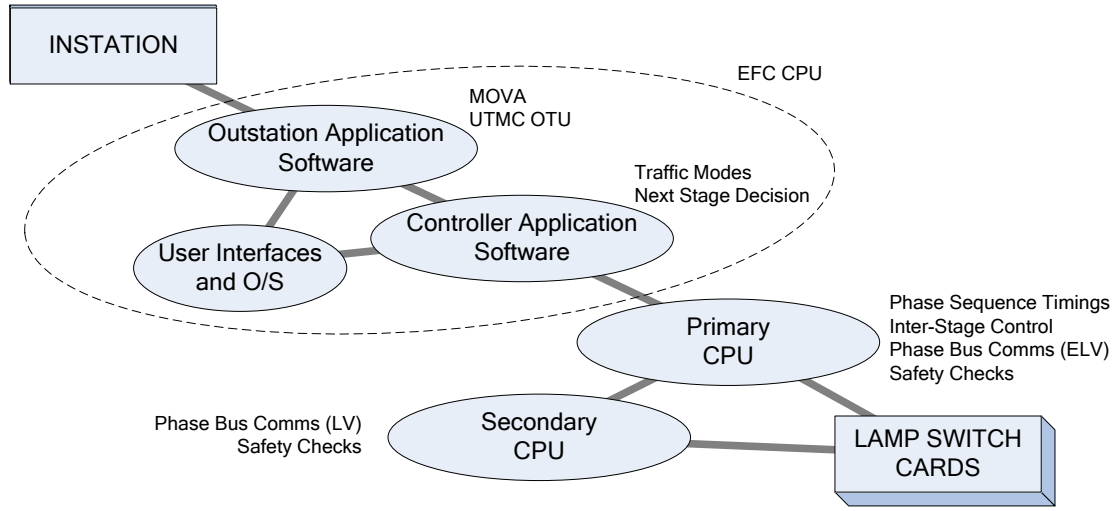


Figure 12 – Software Architecture

The Primary CPU controls and monitors the traffic signals, while a second CPU also monitors the traffic signals:

- In the LV controller the PHP CPU monitors the traffic signals and also plays a part in controlling the traffic signals through its control of the phase bus communications (this is handled by the Primary in the ELV controller).
- In the ELV controller, the SEC CPU monitors communications between the Primary CPU and the lamp switch cards.

These are critical parts of the software and form part of the safety case of the controller. For this reason, this embedded real-time firmware resides in discrete microprocessors.

The Application software parts provide the external interfaces to the user and other equipment, such as a Traffic Instation. This software is required to be more powerful and easier to update. For this reason, this software uses the LINUX Operating System and resides on a more powerful processor; the EFC CPU.

6 ST950 I/O

The ST950 and ST950ELV Controllers use the same types of I/O cards in order to interface to pushbuttons, vehicle detectors and above ground detectors, or to provide a free-standing UTC Interface or for linking between controllers.

6.1 Serial I/O Card

The I/O card provides a rugged interface for up to 24 digital inputs and up to 16 changeover outputs for the connection of pushbuttons, loop detectors and above ground detectors, or to provide a free-standing UTC Interface or for linking between controllers.

A sub-equipped variant of this card is also available, fitted with only 4 changeover outputs. If the IC4 Configuration requires the 24 in / 4 out variant but one is not available, then a 24 in / 16 out card can be fitted in its place.

The I/O card connects to the CPU Card or previous I/O card via the GSPI interface cable through which the card also obtains its power supply.

The first three I/O cards may be fitted in the primary cabinet. Additional I/O cards may be fitted in an adjacent expansion cabinet. This procedure is described in the Installation and Commissioning Handbook.

Inputs

The IO card inputs are compliant to TR2523:2005 as follows:

- Closed-Circuit is indicated when a resistance of 250 Ohms or less is present across the input terminals
- Open-Circuit is indicated when a resistance of 100k Ohms or greater is present across the input terminals
- The open-circuit voltage across the input terminals is less than 50V DC (typically less than 20V DC)
- The short-circuit current is less than 50mA (typically less than 2.5mA)

In practice, any resistance across the input terminals that results in a voltage of greater than 7.5V across the input terminals will be read as Open-Circuit

Any resistance across the input terminals that results in a voltage of less than 2.5V across the input terminals will be read as Closed-Circuit

Outputs

The IO card outputs are volt-free fully isolated outputs that are compliant with TR2523:2005 as follows:

- Maximum ON resistance of 50 Ohms
- When ON, an output is rated at 50mA maximum
- When passing 50mA, the output shall drop no more than 2.5V

- When OFF and output will withstand 75V DC continuous
- When OFF and output will present a resistance of greater than 100k Ohms

- The COMMON, NORMALLY OPEN and NORMALLY CLOSED contacts of each output are isolated from any other output by 3750 volts minimum

6.2 Intelligent Detector Backplane

The Intelligent Detector Backplane provides an interface for up to 4 Loop Detector Cards, each Loop Detector Card connecting to up to 4 loops.

The Intelligent Detector Backplane connects to the CPU Card or previous Intelligent Detector Backplane via a GSPI cable through which the card also obtains its logic power supply.

Note that the Loop Detector cards themselves are powered from a separate detector supply – see section 3.7.1 (LV) or 4.10.7 (ELV). This detector supply is cabled separately to terminations on the back of the Intelligent Detector Backplane.

A twisted ribbon cable provides the connection between the loop detector cards and the road loops, via the loop termination card.

6.3 CPU I/O Card

The CPU I/O card is designed to provide an ‘integrated’ I/O capability for ‘smaller’ controllers. The card is mounted onto the CPU Card as shown below and provides 24

inputs and 4 changeover outputs. All Inputs and outputs are TR2523:2005 compatible. This card has a fixed address: 1.

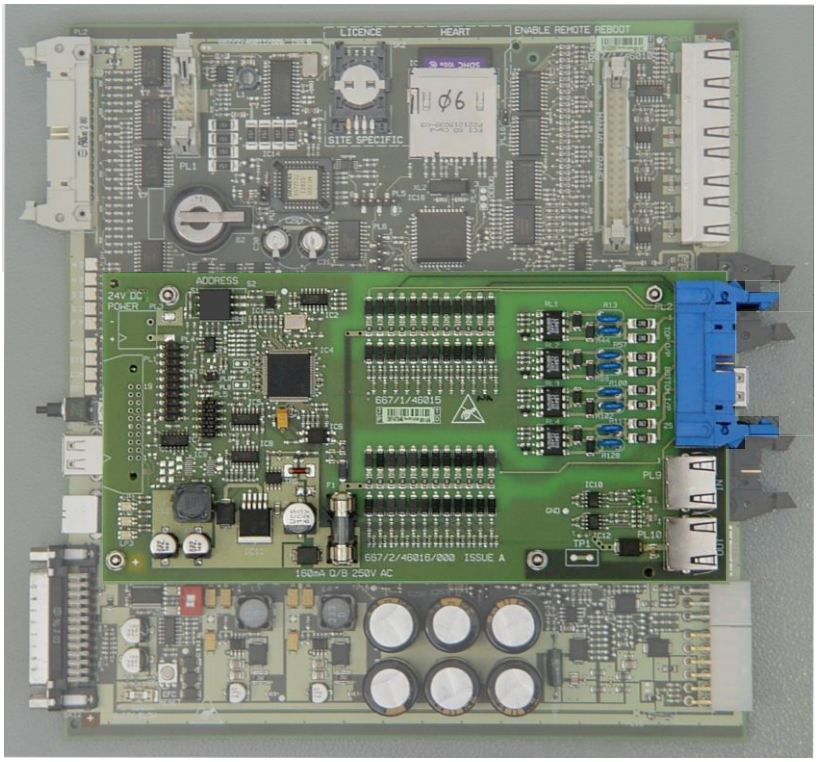


Figure 13 – CPU I/O Card

6.4 WiMag Standard Interface Card

The WiMag Standard Interface Card is used to provide an interface between the Sensys equipment and the traffic controller by mimicking the operation of a 24/4 Serial I/O Card (with 20 detector inputs and 4 fault inputs).

Figure 14 – WiMag Standard Interface Card

This is not be to confused with the WiMag Loop Detector Replacement Card which uses a standard detector pinout so can be used in any position that would normally accept a loop detector, e.g. an Intelligent Detector Backplane. The card provides 4 detect outputs.

Figure 15 – WiMag Loop Detector Card

6.5 Maximum Number of I/O Cards

The total number of I/O cards that can be fitted to the ST950 Controller is limited by the current capability of the controller's 24V DC logic power supply. See Table 20 for details on the mix of cards that can be fitted to the controller. For simplicity, the CPU I/O Card and the WiMag Standard Interface Card should be considered the same as a 24/4 Serial I/O Card.

Backplanes		Max Serial I/O cards						Totals		
IDBs	Loops	Cards	In	Out	24/16	24/4	24/0	In	Out	I/O
0	0	6	144	96	6	0	0	144	96	240
1	16	6	144	84	5	1	0	160	84	244
2	32	5	120	80	5	0	0	152	80	232
		6	144	68	4	1	1	176	68	244
3	48	5	120	80	5	0	0	168	80	248
4	64	5	120	64	4	0	1	184	64	248
5	80	4	96	64	4	0	0	176	64	240
		5	120	48	3	0	2	200	48	248
6	96	4	96	52	3	1	0	192	52	244
7	112	3	72	48	3	0	0	184	48	232
		4	96	36	2	1	1	208	36	244
8	128	3	72	48	3	0	0	200	48	248
		4	96	20	1	1	2	224	20	244
9	144	3	72	32	2	0	1	216	32	248
10	160	2	48	32	2	0	0	208	32	240
		3	72	16	1	0	2	232	16	248
11	176	2	48	20	1	1	0	224	20	244
		3	72	0	0	0	3	248	0	248
12	192	1	24	16	1	0	0	216	16	232
		2	48	4	0	1	1	240	4	244
13	208	1	24	16	1	0	0	232	16	248
14	224	1	24	0	0	0	1	248	0	248
15	240	0	0	0	0	0	0	240	0	240

Table 20 – I/O Card and Detector Backplane Maximums

How to read Table 20:

1) Select the row that includes the required number of Intelligent Detector Backplanes, i.e. the required number of loop detector inputs.

2) Then read across to determine the maximum number of inputs, outputs and Serial I/O Cards that are supported.

Where two values are shown for the I/O cards, the first maximises the number of outputs (sacrificing some inputs), while the second maximises the number of inputs (and reducing the number of outputs available).

Note 1: Any 24/16 card can be replaced with a 24/4 if the outputs are not required. For example, in the first row, six I/O cards are supported in any combination of 24/16 or 24/4 cards.

Note 2: In the Totals columns, the number of inputs includes IDB (detector loops) and SIO (general purpose) inputs.

Each I/O Card draws its power from the 24V DC power supply (located in the MDU of an LV Controller or the LPU of an ELV Controller). The total combination of I/O cards must not draw more than 1000mA. The maximum total number of I/O cards and Backplane controller cards in a system cannot exceed 15. The sum total number of inputs and outputs cannot exceed 248.

The power consumption for each type of I/O card is shown in the Table 21 below. Use this data provided to calculate the overall power supply load:

Card type	Part Number	Power Consumption (mA)
I/O Card (24/16)	667/1/32990/951	150
I/O Card (24/4)	667/1/32990/952	150
Intelligent Detector Backplane	667/1/32910/950	50
WiMag Standard Interface Card	667/1/47221/000	50

Table 21 – I/O Card Power Consumption

7 GENERIC SPECIFICATIONS

7.1 Controller Operation

In common with previous controllers, the ST950 LV and ELV Controllers are phase oriented. Timings and demands are associated with phases and the control philosophy is designed to give right-of-way to phases in an optimum manner.

It is necessary to group phases into stages for Manual Control, operation in Urban Traffic Control Schemes and in Cable-less Linking Schemes. The traffic requirements and safety constraints also condition the grouping of phases into stages.

The controller receives requests for ROW from the following:

a) 'On-street' detection equipment and pedestrian push-buttons

b) The UTC computer

c) Internal MOVA7 Force Bits

d) The Cable-less Linking Facility (CLF)

e) Manual inputs

f) Special requests, e.g. hurry calls

The controller then orders the appearance of phases in accordance with the controller strategy, the current mode operative and the demand requests for ROW. The controller will always change stage cyclically.

The Controller facilities are described in detail in the ST950 Facilities Handbook 667/HB/46000/001.

7.1.1 Timings

All controller timings are provided in the IC4 Configuration file. These timings are subsequently transferred to RAM and FLASH memory during controller initialisation; the FLASH memory preserves the values over power failures.

Once in memory most controller timings can be varied by handset mnemonics or by using the web user interface. Once the data has been loaded from the IC4 Configuration this action cannot be repeated using the same IC4 Configuration file. This prevents the accidental overwriting of any configuration data that may have been set up using the handset.

In the UK some timings considered to be fixed timings cannot be changed by handset, these are typically the Amber Leaving and Red/Amber Starting periods. These timings can, however, be specified as alterable at configuration time to suit other signal sequences, non UK requirements etc.

Some controller timings are considered to be safety timings and can only be changed by a person at the controller, e.g. minimum green, inter-greens and blackout timings. These require the operator to press the 'level 3' access button on the front of the main CPU Card before attempting to modify these timings. For non-UK markets, modification

of level-3 timings can be performed remotely via the web interface without needing to press this button. This requires the 'download to level 3' option to be specifically enabled in the IC4 Configuration.

The IC4 View Differences facility compares an IC4 configuration file with the configuration information stored in the controller and any differences are displayed. For each timing difference, the user has the option to update the controller or IC4. This allows timing changes made to the IC4 configuration to be sent to the controller as though the handset commands had been entered. It also allows timings changes made to the controller to be stored in the IC4 configuration's 8SD file and thus appear on the IC4 screen.

7.2 Phases

There are up to 32 phases (A to Z and A2 to F2) available for use as any of the following types of phase:

- Traffic
- Pedestrian
- Green arrow, filter or indicative
- Dummy
- Switched sign.

Traffic, pedestrian and green arrow phases are considered as real phases and require phase hardware as well as phase software.

Dummy phases require only phase software. As no phase hardware is required the dummy phases are allocated after the real phases. Switched sign phases do not require phase software. They only require the software necessary for switching them on and off and phase hardware.

It is possible to use phase software for a dummy phase and phase hardware for a switched sign phase.

7.3 Stages

There are up to 32 stages (0 to 31) available for use.

Stage 0 is normally used as a manual all-red facility. It may be used as a traffic stage.

Stage 1 normally is the start-up stage and must not be deleted.

Some stages may appear in some modes but not others.

Note: Since a change of mode can occur at any time, the controller may temporarily reside in a stage that is not normally used by the new mode if the controller was in that stage just prior to the change of mode. The controller can be configured to leave the stage as soon as possible (i.e. when all minimum green times have expired) or to leave the stage when normal conditions dictate.

7.4 Streams

Parallel Stage Streaming provides independent control of up to 8 separate intersections, referred to as Streams, from one controller, i.e. the eight intersections may be considered as being controlled by separate controllers, with the exception of certain modes, see detail in the ST950 Facilities Handbook 667/HB/46000/001.

8 DEMANDS AND EXTENSIONS

Demands may be inserted for phases or stages, but extensions may only be inserted for phases.

Demands will only be acted upon when the phase or stage is not at right of way and request (i.e. demand) that the phase / stage gains right of way.

Extensions will only be acted upon when the relevant phase is at right of way and will request that the phase remains at right of way for longer.

9 CALL/CANCEL

There are up to 8 call/cancel units (0 to 7) available which may be used for turning movements or in conjunction with queue loops or switched facilities.

The input to a unit must remain active for the call period before the output goes active and inactive for the cancel period before the output returns to the inactive condition.

If the call/cancel unit were used for a turning movement, the output would be configured to insert an unlatched demand for the appropriate phase to allow for it to be cancelled.

Note that each call/cancel unit therefore will only affect the stream in which the phase resides. No other streams will be affected.

10 HIGH SPEED VEHICLE DETECTION

To provide this facility, specially positioned vehicle loops are required. These should be connected to the Controller through the normal serial I/O cards or Intelligent Detector Backplanes.

On roads where it is required to detect high-speed vehicles to ensure safe passage through an intersection, one of two methods may be used:

SDE (double or triple) where a fixed extension is generated.

SA where a fixed extension is generated after a variable delay dependent on the vehicle speed.

11 ALL-RED DISPLAYS

There are four methods of achieving an all-red display, or extending the intergreen between specific phases:

- By using an ‘all-red’ stage.
- By using the ‘extend all-red’ facility.
- By using the 'intergreen delay' facility
- By using ‘on-crossing detectors’ on a near side pedestrian phase.

An All-Red Stage is a stage during which all signal phases are ‘at no right of way’ and thus display their red signal aspects.

The ‘extend all-red’ facility can extend the all-red condition between conflicting phases in certain stage to stage transitions up to a pre-determined maximum.

The 'intergreen delay' facility can extend the intergreen between one phase losing right-of-way and a specified list of phases gaining right-of-way. In the IC4 Configurator, the list of gaining phases defaults to those phases that conflict with the phase losing right-of-way. This is facility works independently of stage movements and does not affect any other phases losing or gaining right-of-way.

‘On-crossing detectors’ can be configured to extend the clearance period to all conflicting vehicle phases while pedestrians continue to cross.

12 PHASE DELAYS

In order to gain more efficient use of phases during stage to stage transitions, it may be required to delay specific phases from losing or gaining ROW.

There are up to 120 phase delay times (0 to 119) available for different phases on different stage to stage transitions.

The timing range is 0 to 255 seconds in 1-second steps.

Special conditioning can disable and enable individual phase delays and thus is able to change the delay time (by time of day for example) by only enabling one of several phase delays configured for the same phase on the same stage to stage transition.

13 MODES

The following modes are available:

- Start Up see Section 14
- Part-time (All Signals Off or Flashing period) see Section 15
- Urban Traffic Control see Sections 17
- MOVA see section 37
- Emergency Vehicle and (Bus) Priority Modes see Section 18

- Hurry Call see Section 19
- Manual Operation see Section 20
- Manual Step-On, if fitted. see Section 21
- VA, CLF or FT Operation (selected via mode switch)see Section 22
- Cableless Linking (CLF) see Section 23
- Vehicle Actuated (VA) see Section 24
- Fixed Time (FT) / Fixed Vehicle Period (FVP) see Section 25
- Light Rail Transit (LRT) see Section 26

The following factors influence the selection of the modes:

- The status of the incoming 'hurry call' signals
- The status of the UTC and MOVA force signals
- The status of the Priority and LRT Inputs
- The status of the manual select buttons
- Part-time requests
- Time switch/CLF signals
- Conditioning signals
- Integrity of the hardware/software

The mode priorities are defined during controller configuration with the following restrictions, assuming all stipulated modes are utilised:

- Signals off / flashing periods during the Part-time cycle have highest priority after start-up mode.
- Cableless linking mode must be higher priority than VA mode.
- Either VA or fixed time mode is always the lowest priority.
- With the mode priorities defined, the controller adopts the highest priority mode for which the following conditions of entry apply:
- Part-time off (or flashing) period: Part-time off selected by master time clock or special conditions such as queue detectors.
- Hurry call mode: Hurry call applied and any call delay expired.
- UTC and MOVA mode: When the controller has received force bits.
- Manual Control selection: MANUAL selected on the Manual Panel.
- Cableless linking mode: A valid CLF plan is selected by the master time clock.
- Bus/LRT/Emergency Vehicle Priority mode: Entered if a request exists for priority from a special vehicle detector, (e.g. LRT request).
- Vehicle actuated or fixed time mode: Entered if a request does not exist for a higher priority mode.

14 START-UP MODE

The start-up mode is entered to produce a safe 'signals on sequence' when any of the following conditions occur:

- The AC mains supply to the controller is switched on or restored following a mains failure.
- The signals are switched on by means of the SIGNALS ON/OFF switch or the signals isolating switch (if fitted). This facility is optional. The alternative option is that the signals turn on immediately at whatever point in the cycle the controller has reached when the SIGNALS ON/OFF switch is switched on.
- The signals are switched on (by the master time clock for example) after a period of Part-time off / flashing.
- A second red lamp failure that has extinguished one or more streams is manually cleared allowing the stream back on.
- Other failures that are configured to switch off the signals or to send streams into their part-time flashing state are cleared.

15 PART-TIME MODE

When a stream is in 'part-time' mode, all the signals in the stream are usually extinguished allowing the traffic to flow normally. For example, it may be necessary to control the traffic on a roundabout only during peak times, but not during the rest of the day.

The normal method of switching between normal operation and part-time mode is by means of the master time clock at specified times of the day.

An alternative method is by means of queue detectors. If a queue of traffic is detected, normal traffic operations are introduced for a certain period, e.g. 20 minutes. At the end of this period, Part-time mode is re-introduced unless a queue is still being detected, in which case the normal traffic operations will continue until the queue is not detected for a certain length of time.

Alternative signal sequences, e.g. flashing amber for traffic phases during the night may be configured if required (for Non UK Controllers ONLY). For alternative signal sequences, see section 31.

Part-time mode may be introduced by the following methods.

- Time switch event and/or queue detectors (see above)
- Handset (SWS handset command)
- Manual Panel switches (SW1, 2 or 3 as configured)
- Red Lamp Faults (to flashing part-time state for non UK only)
- Correspondence Faults (for non UK only)

It is a requirement in the UK that part-time mode may only be used if accompanied by the Red Lamp Monitoring facility.

16 'FAIL TO PART-TIME' STATE

This configuration option is available primarily for multi-stream non UK controllers. It allows the controller to immediately switch a stream directly into its part-time state (which could be configured as blackout or flashing vehicle ambers for example) when a fault is confirmed on that stream. Note that this facility can be enabled even if part-time mode is not required, i.e. even if the controller is not required to enter part-time by time of day.

This facility is sometimes referred to as 'software fail flash' as it is similar to 'hardware fail flash', but has the advantage that the entire controller does not 'shutdown'.

Correspondence faults will cause the stream(s) on which the faults exist to immediately enter their part-time state, while other streams continue to cycle normally. Once in this state, further faults on reds and ambers can be configured to be ignored, but faults with greens will always cause the whole controller to shut down, removing the lamp supply. It should be noted that if 'Ignore Reds and Yellows during Fail to Part Time' is enabled, Correspondence faults on the Red and Yellow outputs no longer trigger shut down and accordingly these faults are only detected by the Primary CPU, and not the Secondary CPU. (Faults detected by the Secondary CPU always trigger shut down)

Second Red Lamp failures or Last Lamp failures can also be configured to cause streams to enter their part-time flashing state.

The 'Fail to Part-Time' facility does not affect Green-Green and Green-Yellow Conflict monitoring. Conflict monitoring is always performed by both Primary and Secondary CPUs and always requests shut down.

If hardware fail flash is configured (section 35), all streams will enter their hardware flash state on controller shut down (failure mode).

17 URBAN TRAFFIC CONTROL (UTC)

In UTC mode, operations are controlled and monitored by the central computer of an Urban Traffic Control system.

Stage changes are effected by the application of forces and demands. The demands may either be local or simulated by the computer. During UTC mode maximum green timers normally have no effect and are held in a RESET state.

Instation equipment at the central computer office communicates over an IP network to the ST950 internal UTMC OTU.

Control signals are normally transmitted as two 8-bit control words and monitoring signals are returned as two 8-bit reply words.

18 PRIORITY AND EMERGENCY VEHICLE MODE

Priority and Emergency Vehicle modes provide a facility in which appropriate vehicles have priority in gaining and holding ROW over other vehicles.

Selective Vehicle Detectors (SVD) or transponder interrogators which respond only to the appropriate type of vehicle, i.e. buses for Priority mode and ambulances or fire appliances for Emergency Vehicle mode, are used to distinguish the vehicles.

An operation of the priority vehicle detection equipment whilst the priority phase does not have right of way will, in addition to registering as priority demand, register as a normal demand. If a call/cancel unit normally calls the phase, a latching demand may still be registered.

The presence of a Priority Demand will cause Priority or Emergency Vehicle mode to become operational, subject to mode priority considerations. Right of way will then normally go immediately to the Priority Phase, subject to any delay caused by minimum green or inter-green periods timing off or any enforced stage sequences specified for safety or other reasons. Normally, all VA extensions will be curtailed and any VA demands will be skipped.

The Priority Unit will convert further outputs from the SVD while the Priority Phase has right of way into Priority Extensions. The Priority Extensions will hold the Priority Phase at right of way.

Any phases that have their VA extensions curtailed or their VA demands skipped may be compensated next time they have right of way.

After a Priority Demand has been actioned, that demand and/or other Priority Demands may be inhibited for a specified period.

19 HURRY CALL MODE

A ‘hurry call’ demand gives precedence to a particular stage to ensure that a green signal is given to certain vehicles.

Hurry calls may be used at junctions, e.g. near to fire or ambulance stations, to ensure that certain vehicles are given right of way, or in conjunction with queue detectors, to prevent blocking of a junction.

Immediately a valid hurry call is received, the HURRY ACTIVE indicator on the Manual Panel illuminates and remains illuminated until the end of the hold period. A hurry call is valid provided its prevent timer is not active due to a previous hurry call and the delay timer for any higher priority hurry call is not active. A cancel input for each hurry call enables the process to be terminated any time during the delay, hold or prevent periods.

20 SELECTED MANUAL CONTROL

Manual mode selected on the Manual Panel is recognised as a mode for priority purposes. With the ‘MANUAL’ button pressed, manual mode will be selected providing there are no operating conditions for a higher priority mode (see section 13).

During Manual mode, only 7 stages and the all-red condition (normally stage 0) are available to be selected by means of buttons on the Manual Panel.

No stage changes may be made until the last phase minimum green in the current stage has timed off. When the controller is ready to accept a selection, the 'AWAITING COMMAND' indicator illuminates and any subsequent button selection is actioned unless:

- A prohibited stage move is requested.
- The requested stage is deleted by the master time clock.

If any of these conditions occur, the 'PROHIBITED MOVE' indicator illuminates. In the case of (a) the stage can be selected via another stage change which is allowed, e.g. to the all-red stage, but in the case of (b), the stage cannot be selected until the master time clock inhibit is removed. Any phases deleted by the master time clock will not be active during Manual mode.

Note that if the requested stage move is configured to move via an alternative stage, that intermediate stage will run for just its minimum green times and then the controller will move to the requested stage.

When Manual Mode ceases, demands may be automatically inserted for selected non-running phases. These demands are normally inserted to ensure no vehicles are trapped against a red light, unless otherwise requested by a customer.

21 MANUAL STEP-ON MODE

'Manual Step-on mode' can be configured instead or in addition to the 'Manual mode' described in section 20.

Manual step-on provides a single 'step-on' button rather than a number of individual 'stage select' buttons. When the 'step-on' button is pressed, the controller moves to the next stage in a pre-defined sequence.

Manual step-on also provides an 'all-red' button which is normally configured to put all the signals to their 'not at right of way' state, normally red.

A separate 'manual step-on enable' button or switch usually enables the mode.

If a Manual Step-On Panel is used and located behind the Manual Panel door, the Manual facility described in section 20 is normally transferred to an internal Manual Panel.

The 'all-red', 'step-on' and 'enable' inputs to the facility are controlled using special conditioning so they can be configured to use any controller digital inputs or spare buttons on the normal Manual Panel for example. Thus, the controller can be configured to use the normal intersection Manual Panel (see section 33) for both manual and manual step-on modes. For example, Spare Switch 1 (SW1) can be configured to enable the facility, Spare Switch 2 (SW2) used to provide the 'step-on' button and the normal 'All-Red' button used to select the all-red stage.

22 SELECTED FIXED TIME, CLF OR VA MODE

Manually selected ‘FT’, ‘CLF’ and ‘VA’ are selected by mode select buttons on the standard intersection manual panel (see section 33).

The respective mode will only become operative if 'SELECTED FIXED TIME, CLF or VA' mode is a higher priority than the current mode.

These mode select buttons may be used to force the controller to work in VA, CLF or FT mode rather than in a mode that would normally be higher in priority than VA, CLF or FT such as UTC or Priority for example. Because VA or FT is usually configured as the lowest priority mode, SELECTED VA/FT/CLF is treated as a separate mode, and can be configured higher up in the mode priority table.

23 CABLELESS LINKING FACILITY (CLF) MODE

The ‘Cableless Linking Facility’ (CLF) allows a method of linking traffic intersections along routes within an area using timing information derived from the ‘Master Time Clock System’ (see section 28) in their controllers. Different Plans are used during the day to cater for varying traffic patterns.

Each CLF Plan has its own configurable ‘cycle time’. At configured times (known as ‘group times’) within this cycle time, ‘group influences’ are programmed to affect the operation of the controller.

Thus, at a particular time of day, a pre-defined plan can be introduced to enforce a set of fixed duration effects on the controller.

Therefore, several controllers can each have ‘Plans’ designed for them. If they are all introduced at pre-determined times and synchronised by an accurate Master Time Clock System in each controller, it can be seen that the actions of the controllers can be co-ordinated, so as to create a fixed time form of control for a whole area.

New features available from Issue 6 onwards:

- Smooth CLF – available for base-time CLF and provides smooth entry into and between CLF plans.
- CLF Step Size – allowing either a cycle time of up to 250 seconds in 1 second steps, or a cycle time of up to 500 seconds in 2 second steps.

24 VEHICLE ACTUATED (VA) MODE

In VA mode the controller monitors all demands, extensions and maximum green timers every 200 ms to select a suggested stage in order to satisfy as many demands as possible without missing any stage containing a phase with a demand.

If each phase only resides in one stage, each stage will continue until there is a demand for a phase not at right of way (but also see the Arterial Reversion facility)

Even when there is a demand, the stage will continue until all the phases that are at right of way can be terminated. If a phase still running its minimum green time or a

phase is still being extended (and its maximum green time has not yet expired), the controller will remain in that stage.

25 FIXED TIME WORKING MODE

There are four methods of fixed time working:

- Fixed Time mode (FT)
- Linked Fixed Time (LFT)
- Fixed Time to Current Maximums (FTCM)
- Fixed Vehicle Period (FVP) mode on a stand-alone pedestrian stream.

Independent Fixed Time (FT)

Each stream has its own fixed sequence of stages and will move around it independently of the other streams. For each stage, a time period and a next stage is configured.

Linked Fixed Time (LFT)

Fixed time mode can be configured to provide Linking between stage combinations in different streams as an alternative to ‘normal’ fixed time mode which forces moves on each stream independently. A maximum of 32 fixed time steps are provided. Specified for each of these 32 times will be a configured stage combination.

Fixed Time to Current Maximums

The controller operates to VA mode strategy and not to a pre-programmed sequence as in Fixed Time mode, but with Permanent Demands and Extensions.

This method of operation has been created so that the following are possible:

- Phases which appear conditionally may be excluded from having permanent demands and still rely on local demands for their appearance, e.g. pedestrian phases.
- Any set of maximum green timings may be introduced giving eight sets of fixed times switched by the master time clock.

Fixed Vehicle Period (FVP)

The vehicle phase of a stand-alone pedestrian stream appears at green for at least a fixed period. No vehicle detection equipment is required.

If the pedestrian phase is demanded while this period is still running, the vehicle phase remains at green. When the period expires, the vehicle phase loses right of way and the pedestrian phase subsequently appears at green.

If the pedestrian phase is demanded after this fixed vehicle period has expired, the vehicle phase immediately (subject to a configured pedestrian demand delay) loses right of way and the pedestrian phase subsequently appears at green.

26 LIGHT RAIL TRANSIT (LRT)

Traffic Controllers need to be specially configured to control LRT vehicles. Siemens Controllers prior to ST950 are configured to control trams using the Bus Priority mode, with a large amount of Special Conditioning being required to modify and enhance Bus Priority mode to implement the requirements of LRT systems.

On ST950, LRT Mode can be configured to control LRT vehicles without recourse to other modes or Special Conditioning, unless required by particular site considerations.

Up to sixteen LRT facilities called ‘units’ may be managed. Each LRT unit is assigned to one phase, which may be a real or dummy phase. For each LRT unit, the following events may be configured, and are expected to occur in sequence.

a) PREPARE:

The tram is approaching the intersection; typically stage movements are prevented so that the intersection is ready to react to the ‘Advance’ Event.

b) ADVANCE:

The tram is near the intersection; typically the LRT phase is requested and the controller begins to move to a stage to give the tram phase right of way.

c) STOPLINE PRESENCE:

The tram is at the stop-line; if the LRT phase is not active then it is requested.

d) STOPLINE CLEARED:

The tram has passed the stop-line; if the LRT phase is active, then it is terminated since the tram has now passed the LRT Signal. Intergreen Delays extends intergreen to, and thus the appearance of any conflicting phases in the next stage.

e) CANCEL:

The tram has passed through the intersection; the Intergreen Delays cease and the controller resumes normal operation.

27 STAGE MOVEMENT RESTRICTIONS

When a specific stage change is required not to occur for safety or traffic control reasons, it is possible to restrict the move.

The types of restrictions available are:

a) PROHIBITED MOVE:

This is the most restrictive and the effect is for the controller to stay on the same stage and not look for other moves until the stage change conditions are altered.

b) ALTERNATIVE MOVE:

With this, the restricted move is not made but an alternative stage is specified and a move to that stage takes place.

c) IGNORED MOVE:

This is less restrictive than a Prohibited Move in that the restricted move is ignored, but the controller looks for another satisfactory stage change.

The above movement restrictions can apply in one or more modes, as specified in the IC4 configuration. Four sets of tables are available and each mode is allocated to one of these tables, or to no table, if there are no restrictions for that mode.

28 MASTER TIME CLOCK SYSTEM

The master time clock system (MTCS) provides the following facilities:

- A software clock.
- A standby RTC circuit which remains supported during power failures.
- A software timetable (see section 29).
- Plan timings for Cableless linking in software (see section 23).
- Plan influence definitions in software (see section 23).

The software real time digital clock that controls the system has a resolution of one second and records seconds, minutes, hours, day, month, year and day of week.

The clock is by default triggered by the 50Hz or 60Hz signals derived from the AC mains supply, i.e. a convenient source available to all controllers in a linked system permitting synchronisation to be maintained without inter-connection.

Alternatively, the clock can be synchronised to a network time (NTP) over a suitable IP network, or the controller can be fitted with a GPS unit from which the controller can obtain the current time, keeping its clock synchronised.

29 THE EVENT TIMETABLE

There are 64 entries in the Event Timetable. Within each entry the following is specified:

The ‘Day Code’, which is a configurable number that indicates the day or days on which this Event occurs. The Holiday Clock facility allows the timetable to be adjusted during Holiday Periods and on 'Special Days'.

The ‘Time’ at which the event is to be introduced on the days on which the above ‘Day Code’ is valid.

The ‘Timeswitch Setting Command Code’ that indicates what function is to be performed when the time is reached. Possible Codes are one of the following:

a) Isolate; i.e. switch the controller from CLF to VA operation.

b) Introduce a CLF plan (refer to section 23). The number of the Plan to be introduced is also specified.

c) Change the time switch settings to those specified.

Time switch settings can be configured to select alternate time sets for maximum green times, Priority times and DFM, or request/cancel part-time mode for example.

30 LINKING

30.1 Repeat Pulses

The Controller may be linked to other traffic controllers so that a pulse which occurs, or a pulse which is created by a condition occurring, in one controller may be repeated to the other. The function of the pulse when received will depend on the method of control of the intersection.

One function of the facility is to maintain traffic flow through closely associated intersections. When a certain phase gains ROW, a pulse is transmitted to the linked controller to demand a phase along the same route.

Special conditioning is used to provide an output from the controller under pre-defined conditions, e.g. during Red/amber or amber leaving of a particular phase.

30.2 OTU Linking

The ST950 may be linked to other controllers in a UTC scheme when it is required to share an outstation transmission unit (OTU) between more than one controller. In this case the link will only be for connection between the UTMC-OTU application and I/O cards and the other controllers. The operation of the controller will have no effect on the link, however, the IC4 controller configuration may explicitly 'copy' the UTC control and reply bits between the OTU and the controller I/O cards.

30.3 Local Linking

PV1 is normally held active to prevent the pedestrian phase and the release of PV1 is only actioned after a configurable delay period.

A pedestrian demand is serviced while PV1 is inactive and the delay has expired or within a window time after the delay has expired.

The vehicle phase extensions are inhibited during the window time.

A short release pulse (< 300mS) on PV1 does not restart the delay or window timers but does start the link fail timers.

31 ALTERNATIVE SIGNAL SEQUENCES AND FLASHING SIGNALS

31.1 Alternative Signal Sequences (Non UK Only)

For the UK, the signal sequences are fixed and cannot be changed.

For non UK use, there are 8 easily definable lamp sequences, with each phase assigned one of these lamp sequences. Each lamp sequence set defines the signal states (i.e. colours) for at right of way, at no right of way and the Part-time (standby) state. It also defines the power on sequence, the signals off to on sequence, the sequence from normal operation to Part-time and back to normal operation, as well as the sequences between “at right of way” and “at no right of way”. Each sequence can consist of up to 3 steps where the signal states and times can be specified.

Green must always be used for “at right-of-way” for traffic, pedestrian & green arrow phases because of the green conflict facility.

31.2 Wig Wag Signals

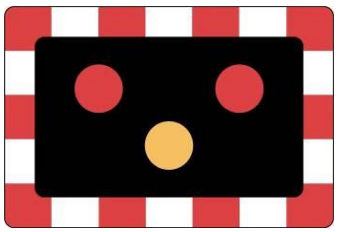


Figure 16 – Flashing Red Wig-Wag Signals

The Siemens Wig-Wag system is a complete solution for the provision of priority signals at fire and ambulance stations. The signals may also be used in other locations such as bridge crossings where there is a need to stop ordinary traffic flow but where it may be difficult for drivers to forecast when they will be required to stop

In the UK, the ST950LED and ST950ELV Traffic Controllers are approved to both TR2500A and TR2513A, which allows them to be used at fire and ambulance stations and at bridges, but not at rail crossings.

The controller can provide stand alone Wig-Wag applications and also full intersections where Wig-Wags are required nearby.

Both LV and ELV Wig-Wag Signals utilise the latest generation of low power CLS LED signals. The Siemens Wig-Wag signals are compliant with TSRGD Diagram 3014 and conform to EN12368. Lamp monitoring is undertaken directly by the controller on both LV and ELV signals, eliminating the need to fit lamp monitoring equipment within the Wig-Wag signals, ensuring power usage is kept to a minimum.

IMPORTANT: As Wig-Wag configurations are more complex to create than intersection configurations it is strongly recommended that they should only be created by Intersection Engineering at Siemens, Poole.

32 INPUTS AND OUTPUTS

32.1 Inputs (I/P)

Inputs into the controller may include the following (refer to the sections given for more information):

- Section 8 – Demands and extensions from detectors
- Section 9 – Call/Cancel detectors
- Section 10 – Extensions from SDE/SA assessors
- Section 11 – Extensions from all-red detectors
- Section 17 – UTC control bits
- Section 18 – Priority Vehicle detectors
- Section 19 – Hurry Call requests
- Section 30 – Links from other controllers

32.2 Outputs (O/P)

Outputs from the controller may include the following:

- Section 17 – UTC reply bits
- Section 19 – Hurry Call Confirmations
- Section 30 – Links to other controllers

32.3 Detector Fault Monitoring (DFM)

DFM is allocated to specified detector inputs and, if required, pedestrian push-button inputs.

This is separate from the specific monitoring applied to pedestrian on-crossing detectors, pedestrian kerbside detectors, and Priority/LRT vehicle detectors.

With the DFM facility, if an input does not change state and remains permanently active or inactive for a specified period, a DFM fault has been confirmed and the following happens:

- The cabinet alarm LED is illuminated.
- Optionally, the input can be forced active or forced inactive.
- Entries will be made in controller's fault logs.

DFM faults can only be cleared if the controller has seen the input change state since reporting the fault. If the input has remained permanently active or inactive since the fault was reported, the DFM fault cannot be cleared.

32.4 Uni-Directional (U/D) Facility

If only vehicles travelling in one direction over a detector are required to activate it, whereas vehicles travelling in the opposite direction are not, the controller includes the Uni-Directional (U/D) facility.

The facility uses two inputs that are connected to two inductive loops that partially overlap on the carriageway, such that vehicles travelling in the required direction activate the ‘A’ loop first, then the ‘U’ loop.

If the ‘A’ loop is activated first, the controller processes the ‘A’ input as normal.

However, if the ‘U’ loop is activated first, the ‘A’ input will be forced to remain inactive (subject to a configurable time-out period), even if the ‘A’ loop input to the controller is actually activated. This condition remains until both inputs return inactive when the vehicle has passed.

33 MANUAL PANEL

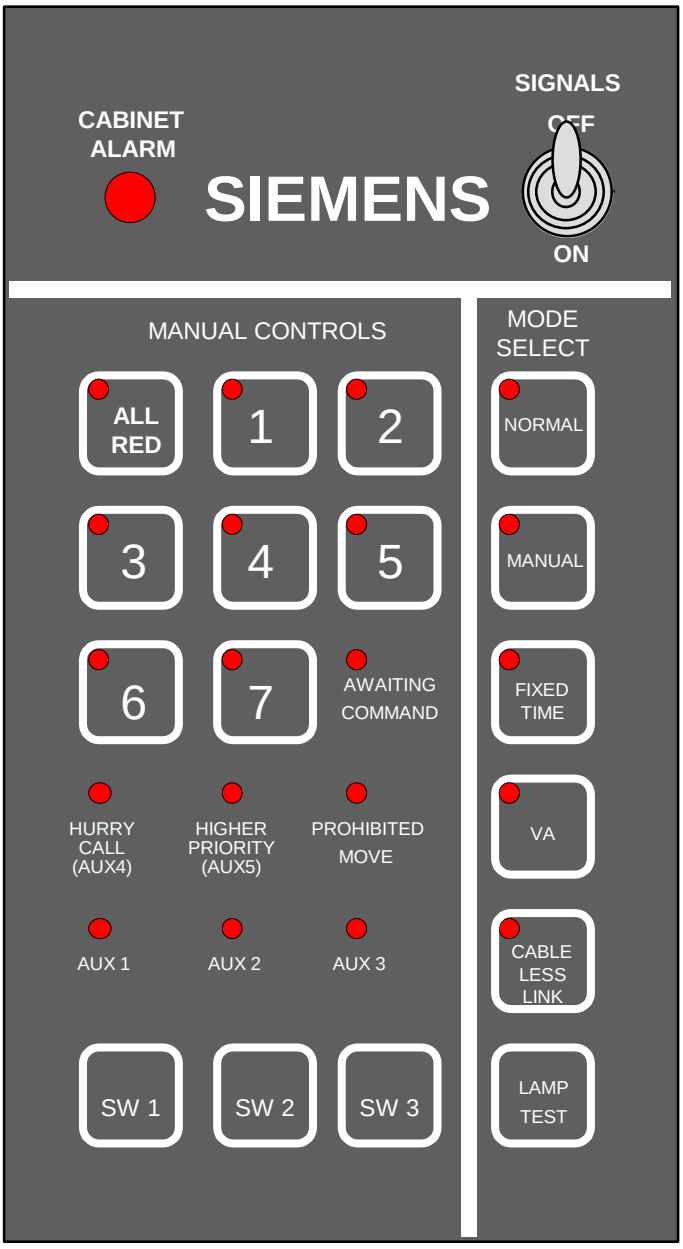


Figure 17 – Intersection Manual Panel

There are 8 stage selection push buttons (0 to 7) available for use during Manual mode, see section 20.

Push button 0 is normally allocated to Stage 0, the manual all-red facility, and is therefore designated ALL RED. Push buttons 1 to 7 may have any 7 of the remaining stages allocated to them.

The SW buttons and AUX LEDs can be configured to provide various customer and site specific facilities.

34 SPECIAL CONDITIONING

There are often special requirements for the operation of a controller, which are not covered by its normal methods of working. This is normally due to the peculiarities of a particular intersection. For example it may be a requirement that demands for a particular phase are inhibited during the first six seconds of appearance of another phase, or a demand for a particular phase is inserted when there is a demand on another phase and an extension on another, etc. Special Conditioning can cater for this type of facility.

The operation required by Special Conditioning is specified at configuration and the data is located in the configuration. This data forms a special software language that is interpreted by the controller.

The following list is included to indicate the type and range of facilities that can be provided by Special Conditioning:

- Ped audible switched off/quiet by time of day
- Dimming by time of day
- Linking to remote pedestrian controllers or other controllers
- Fault recognition of pedestrian controllers
- Limit Green timer
- Hurry call watchdog

For more information, see the IC4 Configurator.

35 HARDWARE FAIL FLASHING FACILITY (NON UK ONLY)

Hardware Fail Flashing is an integral part of the controller configured using various hardware switches and/or links, and does not rely on the main operating controller software[1] or configuration.

The IC4 Configuration needs to be made aware of whether Hardware Fail Flashing is required in order that the controller can be set up to allow the facility, although configuration data does not enable or disable the facility.

[1] The *'Hardware'* Fail Flash facility relies on some small embedded CPUs. On all controller types, HFF uses a flash strobe generated by the Fail Flash CPU and its firmware. This is the only task implemented by this CPU and its software. By implementing this in software, it permits automatic configuration of the flash period. On the ELV Controller, the low-level monitoring and switching circuits on the LSLS Card include a number of small CPUs. Each of these small CPUs controls just two LSLS outputs. It is these devices that independently detect the HFF flash strobe and flash the signals. Also note that using self-contained CPUs reduces the discrete component count, which generally leads to improved reliability.

If the Primary, PHP or SEC CPU firmware requests controller shutdown or the hardware watchdog monitoring the Primary CPU times-out, with the Hardware Fail Flash enabled, some traffic signals will flash while the others are extinguished.

The hardware fail flasher can also be initiated by special conditioning, however normal operation can only be re-instated by operator intervention (i.e. RFL=1 and power off/on). Note that the part-time state can be configured to flash the signals and this can be initiated and removed by special conditioning without operator intervention.

When Hardware Fail Flash is selected, the Lamp Supply to the Red and Amber outputs remains present in Failure Mode / Shutdown so that selected signals can flash. As this is a Failure Mode state, control of the lamp supply to the flashing signals is relinquished by the controller firmware and the firmware can take no further actions. Since the controller cannot take any further actions, Hardware fail flash could be vulnerable to undesirable fault conditions which cannot be prevented by the controller. With the availability of lamp supply to the Red and Amber outputs during Failure Mode this does allow some undesirable signal states to exist which must be accepted by the customer, such as Red or Amber stuck on, or a Green flashing that is shorted to a Flashing Amber. Specific details for LV and ELV controllers can be found in the section on Hardware Fail Flash in the Facilities Handbook.

36 SELF-TEST FACILITY

Self-Test checks as much of the hardware as possible without the controller requiring a configuration. It is a completely separate function provided by the firmware with faults displayed on the handset directly. When the power is switched off and back on again after the Self-Test, the normal operation of the traffic controller is not affected in any way and continues as though nothing has happened.

For more information, refer to the Installation handbook for the controller.

37 MOVA (MICROPROCESSOR OPTIMISED VEHICLE ACTUATION)

The MOVA algorithm monitors the movement of vehicles through an intersection and then adjusts the operation of the controller to optimise its flow.

The ST950 includes the MOVA algorithm and a dedicated MOVA mode, completely separating it from the OTU functionality and UTC mode. Up to four MOVA 'kernels' (instances of the MOVA application) can be enabled with the appropriate licenses, with each MOVA 'kernel' controlling and monitoring one stream of the traffic controller.

The ST950 also continues to support an external MOVA unit. If using a Siemens Gemini2 MOVA unit, also see the Gemini2 Handbook, part number 667/HB/38001/000.

An external MOVA unit uses the controller's UTC interface, which allows it to influence the operation of the controller. This can use the controller's physical inputs and outputs; however a Siemens MOVA unit can also uses serial link, known as 'Serial MOVA' and an 'Semi-Integral MOVA unit'.

38 LAMP MONITORING

The Lamp Monitor provides a means to check that the signals (the lamps) are all working and no failures have occurred.

The controller firmware includes the lamp monitoring facility, which can be enabled by the configuration, and the standard controller hardware includes all the sensors necessary to monitor all the lamps driven by the controller as standard.

In addition to Lamp Monitoring, either Red Lamp Monitoring (RLM) or Last Lamp Failed (LLF) Monitoring can be enabled. Second Red Lamp Failures (Red Lamp Monitoring) can be configured to inhibit the appearance of conflicting pedestrian phases, extinguish the signals or trigger fail-flashing when the second red lamp (on a sensor) fails. Alternatively, the Last Lamp Monitoring Facility can be configured to extinguish the signals or trigger fail-flashing when the current falls below a configurable threshold, i.e. when the last lamp (on a sensor) fails.

39 RIPPLE CHANGE FACILITY

The 'ripple change' facility optimises stage changes at large busy intersections that have phases that overlap into two or more stages.

The ripple change facility is best explained by an example. Consider the following junction:

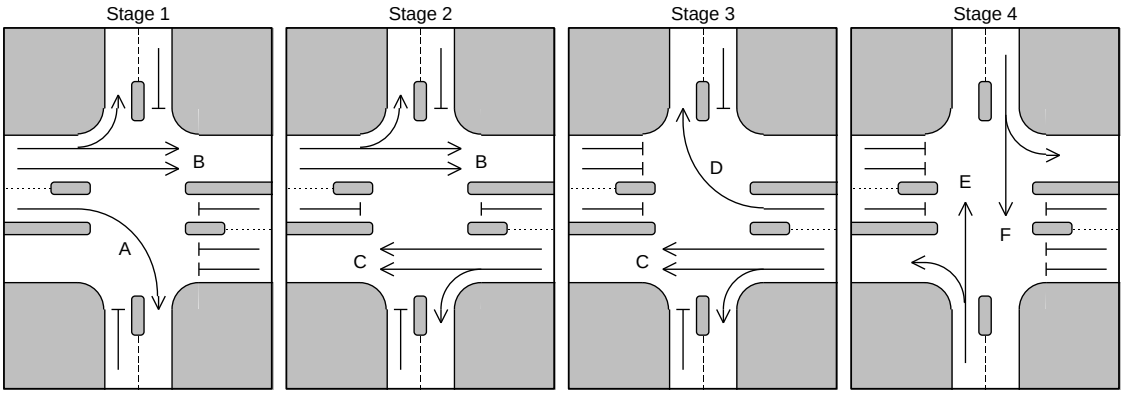


Figure 18 – Ripple Change Example

A traffic controller running in VA mode should move as follows when the extensions cease (either due to a 'gap change' or a 'max change') on certain phases.

It should move from Stage 1 to Stage 2 when the extensions on Phase A cease, allowing Phase C to gain ROW.

It should move from Stage 2 to Stage 3 when the extensions on Phase B cease, allowing Phase D to gain ROW.

Normally the controller does not begin the move from Stage 2 to Stage 3 until Stage 2 (Phase C) has gained ROW. A 'Ripple change' allows the controller to being the move from Stage 2 to Stage 3 while the move from Stage 1 to Stage 2 is still in progress.

The Ripple Change allows Phase B to be terminated as soon as a gap appears after Phase A terminates. This then allows Phase D (and Stage 3) to gain ROW earlier, improving the traffic flow through the intersection.

Without the Ripple Change, Phase B remains at ROW unnecessarily if its traffic flow ceases shortly after Phase A terminates, and this also delays Phase D gaining ROW.

A section has been written below for each new section in the Facilities Handbook. Whether or not each of these should be a new section in the General Handbook is yet to be decided.

40 USER INTERFACE

The primary interface for user actions is a web based interface available locally over the USB handset port and WiFi and on a network via the Ethernet interface. This interface gives access to and control of all areas necessary for day to day maintenance including:

- Fault table (section 41)
- System Log (section 42)
- Remote Reboot (section 44)
- Exporting Site Information (section 46)
- Restoring from Heart (section 48)
- IC4 configuration load (section 55)
- Firmware update (section 56)
- Timing changes
- Live update diagram or 'Site UI' (section 58)
- Real Time View of inputs and phases (section 59)

Handset commands are also available (e.g. for use with simple RS232 handsets) along with a simple text based menu system to allow straightforward maintenance without the need for knowledge of handset commands or use of a PC.

More information can be found in the User Interface Handbook.

41 FAULT TABLE

The Fault Table shows faults and notifications that are currently active.

A *fault* is an abnormal condition which requires corrective action to be taken e.g. a lamp fault.

A *notification* provides information to the user but does not necessarily require any immediate action e.g. signals off.

Help is provided for common Faults and Notifications to provide more information on the cause of the problem and assistance on how to resolve it.

Many faults will be automatically removed from the Fault Table when the condition which caused the fault is removed. Some faults are latched and require manual clearing. A button is displayed next to this latter type of fault which can be used to clear the fault. To clear the fault, press the button and follow the instructions.

If required, it is possible to fit physical "Reset Fault Log" button (to be located within the cabinet) that can be used to request a manual reset of a shutdown fault. This negates the need for the maintenance engineer on street to connect to the user interface of the controller. For example, when the fault is reported and investigated remotely, an engineer is dispatched to the site to replace the faulty part. On reaching the site, the engineer replaces the part, presses this button and then switches the power off/on to clear the fault and resume normal operations. The connection details for the button are provided in the appropriate controller installation handbook (section 1.3).

42 SYSTEM LOG

Important events are recorded in the System Log. The source of the event with the date and time at which the event occurred is recorded along with an indication of its severity:

- E - error
- N - notice
- W - warning
- I - information

43 SITE LOG

The Site Log records significant site events. The following are automatically recorded:

- System firmware update
- IC4 configuration load (8ZP file is stored as an attachment)

It is also possible for the user to create records, either with or without a file attachment.

Attachments can be useful to record site details through diagrams, photographs, documents, etc.

44 REMOTE REBOOT

Where desired the controller can be set up to permit a reboot operation from a remote location when it is in the shutdown state. This operation is performed through the web interface and protected against accidental or continuous use.

Remote reboot allows the controller to be recovered from a shutdown but only under strict conditions:

- The controller is shutdown
- The feature is permitted by a hardware link fitted on the CPU Card
- The controller has been running for at least ten minutes
- There has not been a previous unsuccessful remote reboot attempt
- The correct Remote Reboot Code is provided

45 ASSET INFORMATION

Most boards within the controller carry asset information programmed into the boards at the time of manufacture. This information includes the following about the board:

- Part number
- Issue
- Date of manufacture
- Serial number
- Description

This information is available to the user through the user interface.

46 SITE INFORMATION EXPORT

A summary of the current state of a site can be easily extracted for review and archive. The information can be extracted on demand and takes the form of a single compressed file containing the following information:

- System log
- Summary of current status
- Site log
- Hardware and firmware versions
- Summary of current configuration
- Report of installed licences
- Summary of controller data
- Lamp monitor trace

47 LICENSING

Certain features within the controller are licensed. Licences are distributed and held on the ST950 in Smart Cards. For distribution either a full size (credit card size) or SIM size Smart Card can be used. For storage on the controller, a SIM size Smart Card is used and is fitted in the Smart Card holder on the CPU Card. Licences are easily installed onto a controller either by mounting the licence Smart Card on the CPU Card

or, if a card is already fitted, transferring the licence onto the fitted card using a USB Smart Card reader.

A summary of the available licences is shown in Table 22.

Part Number	Licence Description
667/1/47560/000	LIGHTWEIGHT TUNNEL (VPN)
667/1/47561/000	REMOTE ACCESS
667/1/47562/000	MOVA 7 STRMS 1 AND 2
667/1/47563/000	MOVA 7 STRMS 3 AND 4
667/1/47564/000	UTMC OTU
667/1/47565/000	SERIAL HANDSET
667/1/47566/000	UTMC OTU, MOVA 7 STRMS 1,2
667/1/47567/000	UTMC OTU, MOVA 7 STRMS 1,2,3,4

Table 22 – Available Licences

48 HEART OF THE CONTROLLER

The Heart of the Controller (also known as the Heart) holds a backup of the system which can be used to:

- Clone the system onto a replacement CPU Card if the original requires replacement.
- Return the system to an earlier state.

All aspects of the system are recorded in the backup including firmware, learnt lamp loads, fault logs, configuration and all handset / web page changes made prior to the point at which the backup was taken.

The Heart is implemented using an SD card fitted to the CPU Card.

Backups are created and written to the Heart periodically, usually at 00:30am but this can be changed if required. Backups can also be created and saved on demand using the ‘Controller – Heart – Backup & Restore’ web page; the User Interface Handbook 667/HU/46000/000 contains more information.

49 TIME

The controller maintains two time references: Controller Time and System Time. The relationship between these two times depends on the Time Mode selected: the times may be locked together or run independently. The Time Mode is set to match the use of the controller e.g. standalone (Controller Time).

System Time is used for:

- System log time stamps
- Site log time stamps

- Time of day in GVP applications (e.g. UTMC OTU)

Controller Time is used for:

- CLF
- Timetable
- Holiday clock

Time is preserved during power breaks of up to 48 hours by capacitors fitted to the CPU board. Preservation of up to 30 days can be achieved by fitting an optional coin-cell.

Both daylight saving time and time zones are catered for with the details adjustable through the web interface.

Time can be synchronised to a number of sources including:

- NTP
- GPS
- Mains supply

50 RESERVE STATE

Reserve State is a secure state entered by the controller during times when it is necessary to restart the high level application software e.g. during firmware update.

The Reserve State settings define whether the signals extinguish, flash amber or cycle in fixed time. A time limit can also be configured so for example, the signals of a pedestrian crossing can be held at vehicle green / pedestrian red for a period of time while the application software restarts, but if it does not return because of a fault, the signals can be extinguished.

There are limitations during Reserve State. Because the application software is unavailable during the Reserve State, the controller has no access to external I/O. This includes user interfaces, vehicle detection, pedestrian pushbuttons, UTC control and monitoring, etc. These are all facilities that are controlled by the application software and can be updated by the firmware or configuration update.

51 GREEN ARROWS

A green arrow phase controls vehicle movements via a single aspect green arrow. It is normally associated with a three-aspect Red-Amber-Green phase. The appearance of these two phases needs to be carefully considered.

Where the round green aspect of three-aspect Red-Amber-Green signal is replaced by a green arrow, it is not normally associated with a second phase. The phase operates as a normal three-aspect phase so these phases are not considered ‘green arrow’ phases.

52 INTERGREEN DELAYS

An Intergreen Delay allows the intergreen between a phase losing right of way (ROW) and one or more phases gaining ROW to be extended. Other facilities (e.g. RLM) may still prevent a phase from gaining ROW even though this facility may allow it to gain ROW.

The facility provides for 64 Intergreen Delays.

An Intergreen Delay is characterised by the following configuration items:

- A single phase which enables the Intergreen Delay when it loses ROW
- One or more phases which are delayed if they are gaining ROW when the Intergreen Delay is enabled
- A detector input which whilst active ensures the gaining ROW phases are delayed
- A maximum intergreen period (MIP) which terminates the Intergreen Delay when it expires

Intergreen Delays are configured using the IC4 configurator. The MIP can also be subsequently modified by the user.

53 FAIL TO PART TIME MODE

This mode is available primarily for multi-stream non UK controllers. It allows the controller to immediately switch a stream directly into its part-time state (which could be configured as blackout or flashing vehicle ambers for example) when a fault is confirmed on that stream. Note that this facility can be enabled even if part-time mode is not required, i.e. even if the controller is not required to enter part-time by time of day.

This facility is sometimes referred to as 'software fail flash' as it is similar to 'hardware fail flash', but has the advantage that the entire controller does not 'shutdown'.

Correspondence faults will cause the stream(s) on which the faults exist to immediately enter their part-time state, while other streams continue to cycle normally. Once in this state, further faults on reds and ambers can be configured to be ignored, but faults with greens will always cause the whole controller to shut down, removing the lamp supply. If hardware fail flash is configured all streams will enter their hardware flash state.

Second red lamp failures can also be configured to cause streams to enter their part-time flashing state.

54 MOVA MODE

MOVA mode is a new separate mode for its fully integrated MOVA. This mode has its own unique mode number and position in the mode priority table. The definition of the Force and Confirm Bits for MOVA is different to that used by UTC mode. The typical method of operation is to configure UTC mode higher priority than MOVA mode, so that

UTC mode runs if there are any UTC Force Bits active, otherwise MOVA mode will be permitted.

This enhancement aims to solve the following issues with having one mode for both UTC and MOVA:

- Special Conditioning is required to map the MOVA force and reply bits to the UTC bits.
- Special Conditioning is required if the mode priorities are different.
- UTC may use different control and reply bits.
- UTC may want to use demand-dependent force bits (MOVA never does).
- The priority between Serial-UTC and Serial-MOVA is handled by the Gemini unit, but free-standing or Integral UTC with Serial-MOVA requires this to be done by the controller - inconsistent.

55 IC4 CONFIGURATION LOAD AND QUIET INITIALISATION

An IC4 configuration can be loaded into the controller using either the web interface or the text based menu system (WIZ). In both cases the controller assesses the difference between the configuration currently running and that being loaded and where possible will offer to perform a Quiet Initialisation.

A Quiet Initialisation is the loading of an updated IC4 controller configuration, with the option of the traffic signals remaining illuminated.

If the changes made to the IC4 controller configuration are fundamental, e.g. the phases in stage arrangements are changed, then Quiet Initialisation is not possible and the full reprogramming and initialisation sequence is followed.

56 FIRMWARE UPDATE

Most of the firmware within the controller is stored in non-removal devices. This firmware can be updated by the user. The following firmware can be upgraded in this way:

- CPU card
  - EFC firmware
  - Primary firmware
  - SEC firmware
  - Fail Flash firmware
- GSPI peripheral card
  - GSPI peripheral firmware

The following firmware is stored in a removable device and if upgrade is required then the device must be replaced with a part containing the new firmware:

- CPU card

- PHP firmware

The following firmware is stored in a non-removable device and is not upgradable by the user:

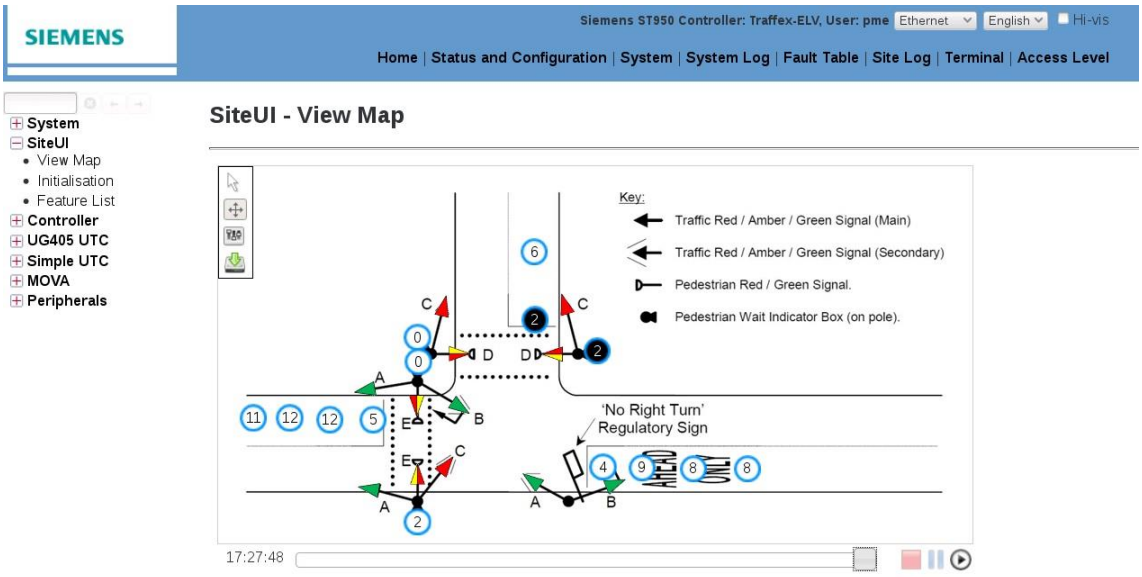
- LSLS card

57 OSS

The Outstation Support Server (OSS) provides centralised management of controllers and other types of outstation units. Installation, licensing, maintenance and use are fully described in 667/HB/31760/100 (Outstation Support Server Handbook).

58 SITE UI

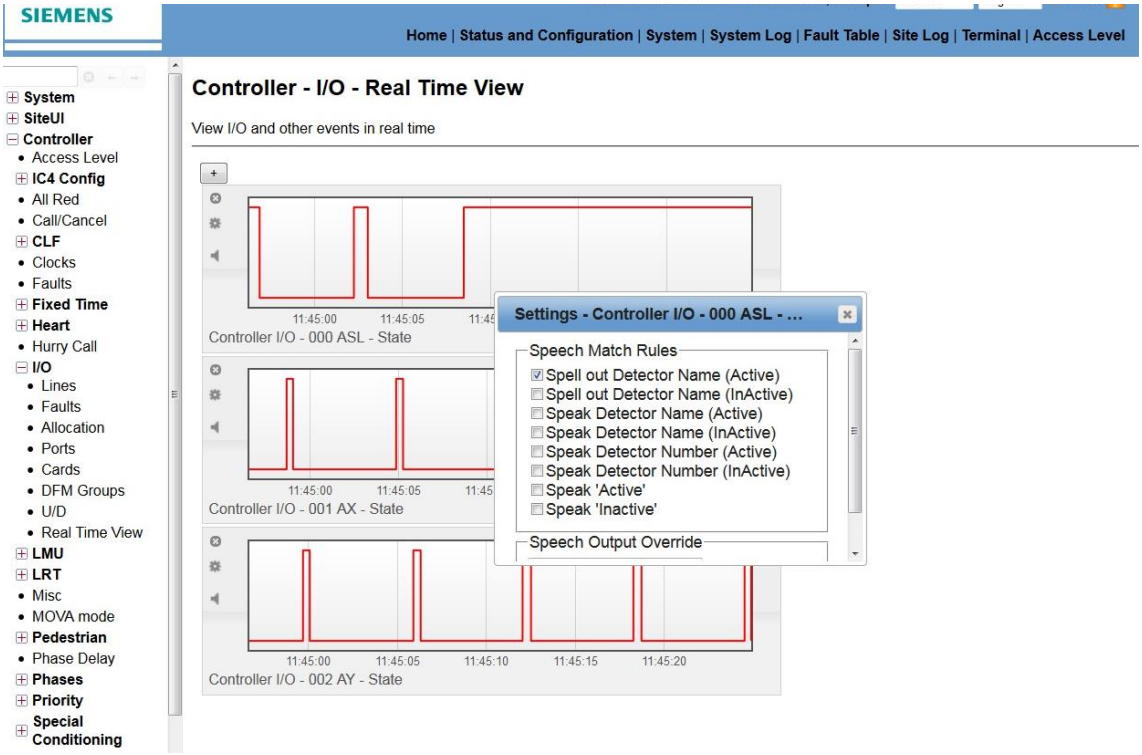
The 'Site UI' provides a live graphical display of the states of Phases, as well as Detector states and counts, giving an overview of the current state of the intersection.



The state of the Traffic Signals can be shown as coloured site-to-scale arrows (as shown above) or Red-Amber-Green traffic signals. There is more information on this feature in the User Interface Handbook (see section 1.3).

59 REAL TIME VIEW

The Real Time View facility displays the live scrolling states of individual I/O lines – as shown in the example below:



For a ‘Talking Controller’, the user can also request that the controller ‘speaks’ the detector name (or number) when it goes active, allowing the engineer to watch the traffic and hear each detector activation.

The Real Time View can also display and speak the states of individual phases, as well as other status information. There is more information on this feature in the User Interface Handbook.

A.1 TECHNICAL SPECIFICATION

Approvals and standards

- Conforms to the UK Highways Agency specification TR2500
- Designed to meet:
  - EN12675 - Traffic signal controllers - Functional safety requirements
  - EN50278 - Road Traffic Signal Systems
  - EN50293 Electromagnetic compatibility. Road traffic signal systems
  - TR2513 - Performance Specification for Wig Wag Signal Control Equipment
  - TR2523 - Traffic Control Equipment Interfacing Specification

Inbuilt modes of operation

- Manual
- Vehicle Actuated
- MOVA (Implements MOVA 7)
- Pedestrian Fixed Vehicle Period
- Part-Time
- Hurry Call
- Fixed Time
- Urban Traffic Control
- LRT
- Pedestrian Vehicle Actuated
- Cableless Linking
- Emergency Priority

Phases and Stages

- Number of hardware phases: 1-32
- (Phase sequences programmable)
- Number of independent streams: 8
- Number of stages: 32
- Number of switched signs: 0-32
- Number of max. green periods per phase: 8
- Number of phase delays: 120
- Number of call and cancel timers: 8
- Number of stage-based all red extension units: 7
- Number of phase-based intergreen delays: 64
- Number of hurry calls: 8
- Number of emergency/priority units: 8

High Speed Vehicle Detection

Integral speed discrimination, double/triple speed assessment

- Number of assessors: 16

Cableless linking facilities

- Number of plans: 16
- Number of groups per plan: 32
- Number of time switch settings: 64
- Number of group influences: 10

- Timing sources 50/60Hz mains, Internal Crystal, NTP network time server or optional GPS clock

Inputs and outputs

- Number of digital inputs: 0-248 compliant to TR2523
- Number of isolated digital outputs: 0-96 compliant to TR2523

  (Actual number of inputs and outputs possible depends on configuration, up to a maximum of 248 in total)

Environmental

- Operating ambient temperature range: -25°C to +70°C

  Use in countries where high levels and long periods of solar radiation are expected may impose restrictions on ST950 hardware configuration. Contact Engineering at Poole for more details on hardware restrictions.
- The controller is proofed against driving rain and sand, dust conditions and industrial pollution. The cabinet rating is IP55.
- The equipment will withstand a temperature of 45°C with a relative humidity of 95%.

Lamp switch (ST950)

- Standard 230V controller
- Lamp switching type: Solid state TRIAC
- Number of phase outputs per lamp switch card: 24 (arranged as 8 x 3 aspect phases)
- Maximum lamp load per output switch:
  - Standard Controller: 4A
  - LED Controller: 4A (limitations apply when lamp monitoring is enabled)
- Maximum number of lamp switch cards: 4
- Maximum total lamp load: 20A
- Lamp supply form: AC
- Lamp supply voltage: As per input supply
- Signal dimming: 120V, 140V, 160V AC rms.
- Note: Dimming not supported for 100V and 110V mains input.

Lamp Switch (ST950ELV)

- Lamp switching type: Solid state FET
- Number of phase outputs per lamp switch card: 32 (each fully configurable as red, yellow or green drives)
- Maximum lamp load per output switch: 2A (A phase may use multiple outputs where higher current required)
- Number of lamp switch cards supported: 6 (3 max per ST950 cabinet)
- Maximum total lamp load: 20A
- Heavy current options: 40A
- Lamp supply form: fully rectified and negative with respect to protective earth

- Nominal lamp supply voltages:
  - 48V Controller: Lamp supply voltage: 48V rms, and Signal dimming: 27.5V rms
  - 40V Controller: Lamp supply voltage 40V rms, and Signal dimming 27V rms
  - 42V Controller: Lamp supply voltage 42V rms, and Signal dimming 31V rms

Other facilities

- Fully integrated MOVA 7 and UTMC OTU functionality - licensed by Smart Card
- Standby mode:
  - Signals off
  - Software flash
- Failure modes:
  - Signals off
  - Hardware fail flash
  - Software flash on a per-stream basis
- Flash type – selectable: flash red or yellow per phase
- Mark/space and flash rate selectable for whole controller
- Web based user interface
- RS232 handset port

Electrical

- Input power supply (+20, -15%):
- 100V, 110V, 220V, 230V, 240V AC rms
- Supply frequency: 50/60Hz ±4%
- Transients: to BS EN50293:2001
- Supply interruption: Continuous operation up to 50ms break
- Supply failure: Automatic restart without operator intervention

Physical

Dimensions

- Outer case: Height: 1160mm Width: 725mm Depth: 420mm
- Rack system: Height: 266mm Width: 482mm Depth: 280mm
  Rack system requires minimum 15mm clearance in front of fixing plane)

Outercase Material / Finish

- Powder coated aluminium
- Grey: Aircraft Grey to BS381C No. 693 Semi-Gloss with Leatherette texture
- Black: RAL 9005, Semi-Gloss with Leatherette texture

Weights

Approximate weight of bare outercase	30Kg
Approximate weight with a 16-phase ST950 controller	75Kg

Approximate weight of ST950ELV controller with single HPU and Lamp Supply Transformer	85Kg
Approximate weight of ST950ELV controller with two HPUs and two Lamp Supply Transformers	100Kg

Security

- Screw-locks.
- S18 lock.
- Optional Yale RKA27C pattern barrel in place of S18 lock.
- Manual Panel door: Yale lock with a 900 pattern barrel.

Compatibility

Able to drive and lamp monitor:

- Standard UK HI incandescent signals
- Standard UK LV regulatory signs
- Siemens Helios LV LED signals
- Siemens Helios ELV signal heads
- Siemens Helios ELV regulatory signs
- Siemens ELV nearside indicators
- Siemens ELV LED wait indicators

Other signals may be compatible – consult 667/SU/46000/000 for details

Cuckoo kits

ST950 and ST950ELV

- Siemens T400, ST800,
- Microsense MTC and Sentinel
- Peek TSC3 and TRX

Upgrade kits

- Siemens ST900 and ST900ELV

Elexon Codes

The following Elexon Codes apply to the ST950 family of Traffic Controllers:

Siemens Description	Manufacturer's Part Number	Charge Code	Nominal Watts
ST950 8/16/24 phase Traffic Controller	667/1/46950/ETC	79 06 018 000 100	18
ST950 ELV Traffic Controller	667/1/45950/0xx	79 06 067 000 100	67
ST950 ELV Low Inrush Traffic Controller	667/1/45950/5xx	79 06 025 001 100	25