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T640 Integrated loop processor

Reference manual & User guide

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ISSUE STATUS OF THIS MANUAL

Section	Issue
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Notes

1 Sections are up-dated independently and so may be at different issues.

2 The Title page, and the manual as a whole, always take the issue number of the most recently up-issued section.

3 Within a section, some pages in this manual may be at later issues than others. This happens if those pages have been individually up-issued and retro-fitted into the existing manual to bring it up-to-date. However, the issue number of the whole section – as listed in the above table – is always the issue number of the most recently up-issued page(s) in that section.

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Declaration of Conformity

Manufacturer:	Eurotherm Limited Faraday Close, Worthing, West Sussex, BN13 3PL, United Kingdom
Product type:	Integrated Loop Processor & ancillary parts
Models:	T640 Loop Processor (status level A4 or higher) T640C Loop Processor (status level I10 or higher) T710 Sleeve (status level A2 or higher) T901 Memory Module (all status levels) T950 Security Key (all status levels)
Safety specification:	EN61010-1: 2001
EMC emissions specification:	EN61326-1: 2006 Class A
EMC immunity specification:	EN61326-1: 2006 Industrial locations

Eurotherm Limited hereby declares that the above products conform to the safety and EMC specifications listed. Eurotherm Limited further declares that the above products comply with the EMC Directive 2004/108/EC, and also with the Low Voltage Directive 2006/95/EC.

Signed: Mark W Green Dated: 27 Sept 2012

Signed for and on behalf of Eurotherm Limited.
Mark Green
(R&D Director)

CE

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Chapter 1 INTRODUCTION

THE T640

The T640 is the first in the range of T600 Series controllers. It is a multi-purpose 2- or 4-loop controller with a high-speed peer-to-peer communications link and a well-established block-structured database, allowing it to integrate tightly into a Network 6000 distributed control system — where its full versatility and power can be realised. See Figure 1-1. For small yet complex applications, T640's comprehensive front-panel displays and push-buttons mean that it can also work perfectly well on its own as a totally independent controller.

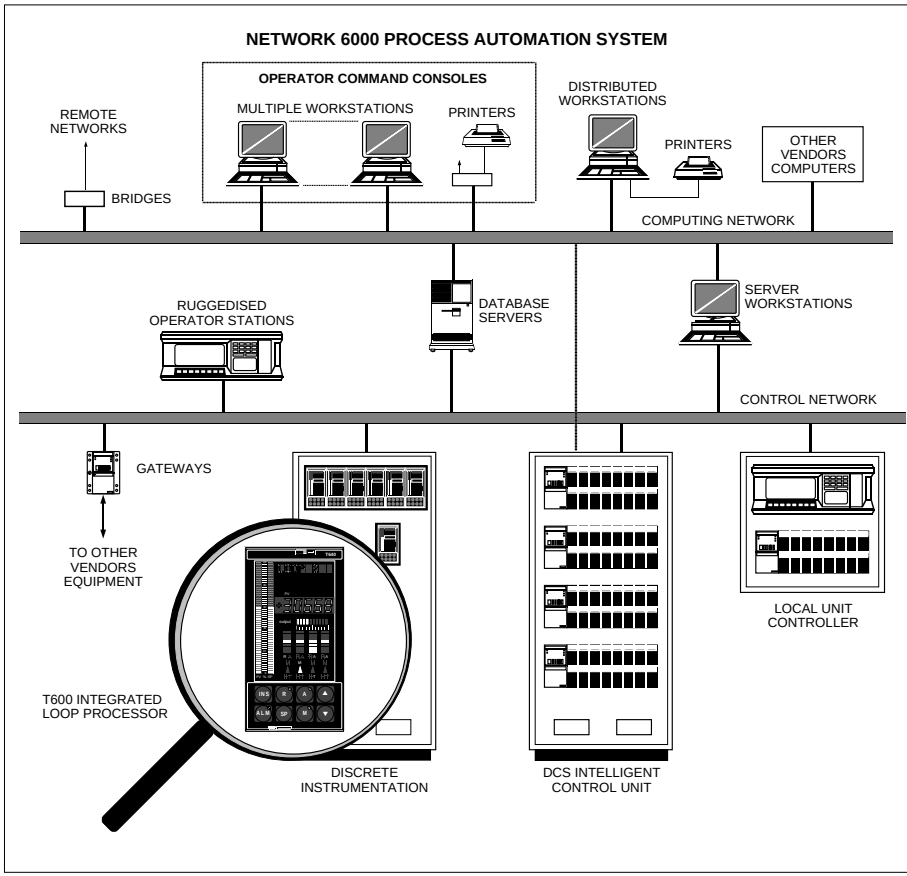


Figure 1-1 Network 6000 distributed control system

Summary of T640's main features

- Block structured configuration — up to four PID loops in separate tasks
- Large library of LIN blocks supported
- Strategies downloadable from the PC-based LINtools configurator
- Internal switch-selectable pre-configured strategies supplied in the instrument
- Clear front-panel text, numeric, and bargraph displays, and controller pushbuttons
- Front-panel overview of all four loops, with detail of one selected loop
- Front-panel monitor/edit access to all parameter values, protected by IR security key
- Front-panel inspection of block interconnections
- Automatic logging of front-panel parameter changes, date- and time-stamped
- High-speed peer-to-peer communications for easy connection to the LIN via bridge
- Serial port option for Bisync slave interface or MODBUS, or for linking internal serial bus to external fascias and remote I/O
- High-level and thermocouple I/O options
- Removable memory module for quick unit replacement and strategy portability
- IP65 front-panel seal, with instrument and database access from front of panel
- DC or universal AC mains supply options
- Sequencing available as an option
- Front-panel messages can be displayed in languages other than English
- Support for 'foreign' templates

What's in this manual

Table 1-1 summarises the contents of the *T640 Reference Manual & User Guide* in a concise form. Use the *Table of Contents* at the beginning of the manual for a more detailed breakdown of what's in the individual chapters, and/or the *Index* at the back to locate particular topics.

What's not in this manual

If you wish to configure your own strategies for running in the T640, you will need to refer to the *LIN Product Manual* (Part No. HA 082 375 U999) for details on all the LIN-based function blocks, their parameters and input/output connections — these are found in the *LIN Blocks Reference Manual* section.

Chapter		Topics
1	Introduction	Summary of T640 features, packaging, & place in the wider network
2	Installation & startup	Getting T640 going, from unpacking to power-up
3	Hands-on tutorial	Practical experience in using the T640 controls, with a real strategy
4	User interface	Using T640 — front-panel controls & displays explained
5	Standard strategies	Details of the four simple pre-configured control strategies supplied in ROM
6	Changes logfile	How T640 records every change to a loaded database
7	T640 task organisation	How the running of T640 & the control strategy interact. Timing optimisation
8	Data coherence	The concept of 'data coherence' and how T640 achieves it
9	Inside T640	Internal hardware, pcbs, and communications
10	Error conditions & diagnostics	Error displays & diagnostic messages
11	Specifications	Hardware & software specs. Resources supported. Example I/O circuits
12	Ordering information	How to order T640 with its various options & accessories
	Appendix A	Setting up early boards (Issue 6 and older)
	Appendix B	MODBUS/JBUS-LIN communications. Implementation in the T640
	Appendix C	Front-panel foreign language support. Customising the standard messages

Table 1-1 Topics covered by this manual

You will need this data to be able to select, interconnect, and parameterise the blocks in your control strategies. How to use the PC-based LINtools database configurator to create and download control strategies and sequences is described in the *T500 LINtools Product Manual* (Part No. HA 082 377 U999).

General information on installing, commissioning and using the LIN is given in Section 2 of the product manual you are now reading, in the *LIN/ALIN Installation & User Guide* (Part No. HA 082 429 U005).

Getting started

The quickest way to get going with your T640 is to turn directly to Chapter 3 and work through the 'hands-on' tutorial set out there. For this, all you will need is a T640 instrument, a power supply, a piece of wire, and a screwdriver.

If you are new to the T640, there is no substitute for actual practical experience with the instrument — just reading about it is not the same!

The tutorial will quickly teach you how to navigate around T640's user interface — the front panel — and also introduce you to the simplest of the 'standard' control strategies supplied in the memory module. After that, you will be ready to start customising a selected T640 strategy to suit your plant control needs, based on the detailed information given in Chapter 5, *Standard strategies*.

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Chapter 2 INSTALLATION & STARTUP

This chapter presents important safety and EMC information and describes how to install, configure, and power up the loop processor.

The main topics covered are:

- Safety & EMC information
- Unpacking your T640
- Installation
- Connections & wiring
- Hardware configuration
- Binary RS422 configuration
- Modbus RS422/485 configuration
- Software file types
- Control strategies & sequences
- Powerup routine
- Powerup displays.

SAFETY & EMC INFORMATION

Please read this section before installing the processor.

This unit meets the requirements of the European Directives on Safety and EMC. It is also a UL-recognised component, meeting the requirements of UL3121-1. However, it is the responsibility of the installer to ensure the safety and EMC compliance of any particular installation.

Installation requirements for EMC

This unit conforms with the essential protection requirements of the EMC Directive 89/336/EEC, amended by 93/68/EEC, by the application of a technical construction file.

This unit satisfies the emissions and immunity standards for industrial environments.

To ensure compliance with the European EMC directive certain installation precautions are necessary as follows:

- **General guidance.** For general guidance refer to the Eurotherm Process Automation *EMC Installation Guide* (Part No. HG 083 635 U001).

- **Relay outputs.** When using relay or triac outputs it may be necessary to fit a filter suitable for suppressing the conducted emissions. The filter requirements will depend on the type of load. For typical applications we recommend Schaffner FN321 or FN612.
- **Use with standard mains socket.** If the unit is plugged into a standard power socket, it is likely that compliance to the commercial and light industrial emissions standard is required. In this case to meet the conducted emissions requirement, a suitable mains filter should be installed. We recommend Schaffner types FN321 and FN612.
- **Routing of wires.** To minimise the pickup of electrical noise, the low voltage DC connections and the sensor input wiring should be routed away from high-current power cables. Where it is impractical to do this, use shielded cables with the shield grounded at both ends.

Installation safety requirements

This controller complies with the European Low Voltage Directive 73/23/EEC, amended by 93/68/EEC, by the application of the safety standard EN61010-1:1993/A2:1995.

Personnel

Installation must be carried out only by authorised personnel.

Protective earth connection



NOTE. A *protective* earth terminal (see symbol inset), in contrast to a *functional* earth terminal, is one that is bonded to conductive parts of an equipment for safety purposes and is intended to be connected to an external protective earthing system.

The following safety measures should be observed:

- Before any other power input connection is made, the protective earth terminal shall be connected to an external protective earthing system.
- Whenever it is likely that protection has been impaired, the unit shall be made inoperative. Seek advice from the nearest manufacturer's service centre.
- The mains supply wiring must be terminated in such a way that, should it slip in the cable clamp, the earth wire is the last wire to become disconnected.

WARNING!

Any interruption of the protective conductor inside the unit, or of the external protective earthing system, or disconnection of the protective earth terminal, is likely to make the unit dangerous under some fault conditions. Intentional interruption is prohibited.

Protection from hazardous voltages

In order to meet the requirements of EN61010 and UL3121-1 in terms of protection from hazardous voltages, the following installation conditions are mandatory:

- The unit must be mounted in a cabinet or enclosure requiring a tool or key to gain access to wiring terminals.
- Wiring to all I/O terminals must not be capable of subjecting the terminals to voltages outside their isolation capability. In the case of ports having an isolation specified as 'none', voltages at these terminals must not be allowed to exceed 30V rms and 42.4V peak or 60Vac.

Wiring

It is important to connect the controller in accordance with the wiring data given in this handbook. Wiring installations must comply with all local wiring regulations. Any wiring that is 'Hazardous Live' (as defined in EN61010 and UL3121-1) must be adequately anchored.

Disconnecting device

In order to comply with the requirements of safety standard EN61010 and UL3121-1, the unit shall have one of the following as a disconnecting device, fitted within easy reach of the operator, and labelled as the disconnecting device for the equipment:

- A switch or circuit breaker complying with the requirements of IEC947-1 and IEC947-3
- A separable coupler that can be disconnected without the use of a tool
- A separable plug, without a locking device, to mate with a socket outlet in the building.

Overcurrent protection

To protect the unit against excessive currents, the power supply to the unit and power outputs must be wired through independent external fuses or circuit breakers. A minimum of $0.5mm^2$ or 16awg wire is recommended. Use independent fuses for the instrument supply and each relay output. Suitable fuses are T type, (IEC 127 time-lag type, UL-recognised) as follows;

- Instrument supply: 85 to 264 Vac, 2A, (T).
- Instrument supply: 19 to 55 Vdc, 5A, (T).
- Relay outputs: 2A (T).

Installation category voltages

The unit should not be wired to a three phase supply with an unearthed star connection. Under fault conditions such a supply could rise above 264Vac with respect to ground and the unit would not be safe.

Voltage transients across the power supply connections, and between the power supply and ground, must not exceed 2.5kV. Where occasional voltage transients over 2.5kV are expected or measured, the power installation to both the instrument supply and load circuits should include transient limiting devices, e.g. using gas discharge tubes and metal oxide varistors.

Conductive pollution

Electrically conductive pollution (e.g. carbon dust, water condensation) must be excluded from the cabinet in which the unit is mounted. To ensure the atmosphere is suitable, install an air filter in the air intake of the cabinet. Where condensation is likely, for example at low temperatures, include a thermostatically controlled heater in the cabinet.

Ventilation

Ensure that the enclosure or cabinet housing the unit provides adequate ventilation/heating to maintain the operating temperature of the unit within the limits indicated in the Specification (see Chapter 11).

Current measurement

Where the instrument I/O is used to measure current, provision must be made in the installation to prevent hazardous voltages arising at the T640 terminals by failure or removal of burden resistors. For example, a protected current source could be used.

Electrostatic discharge handling precautions

Caution

Electrostatic sensitivity. Some circuit boards inside the unit contain electrostatically sensitive components. To avoid damage, before you remove or handle any board ensure that you, the working area, and the board are electrostatically grounded. Handle boards only by their edges and do not touch the connectors.

Safety symbols marked on the unit

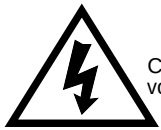
Various safety/warning symbols are marked on the unit, which have the following meanings:



Caution! Refer to the accompanying documents



Protective earth terminal



Caution! Mains voltages present



Alternating current



Direct current

Keeping the product safe

To maintain the unit in a safe condition, observe the following instructions.

Misuse of equipment

Note that if the equipment is used in a manner not specified in this handbook or by Eurotherm Process Automation, the protection provided by the equipment may be impaired.

Service and repairs

This unit has no user-serviceable parts, except for the power supply fuse which should be replaced by authorised personnel only. Contact your nearest Eurotherm Process Automation agent for repair.

Cleaning instructions

Use a suitable antistatic vacuum cleaner to keep the unit and all associated air inlets/outlets clear of dust buildup. Wipe the front panel with a damp cloth to keep it clean and the operator legends and displays clearly visible. Mild detergents may be used to remove grease, but do not use abrasive cleaners or aggressive organic solvents.

Safe usage of alkaline manganese batteries

The 12V alkaline manganese batteries used in the T950 security key must be stored in a suitable manner, handled and used correctly, and disposed of safely when spent. Read the information given in the following COSHH statement.

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ALKALINE MANGANESE BATTERIES — COSHH STATEMENT

Product:	12V ALKALINE MANGANESE DIOXIDE CELLS		
Part numbers:	Duracell™ MN21, Panasonic™ RV08, or equivalents		
HAZARDOUS INGREDIENTS			
Name	% by weight	OSHA PEL	ACGIH TLV
Potassium hydroxide (KOH)	8	2mg/m^3(C)	2mg/m^3(C)
Manganese dioxide (MnO_2)	37	5mg/m^3(C)	5mg/m^3(C)
Zinc (Zn)	15	15mg/m^3(C)	10mg/m^3(C)
Carbon (C)	4	3.5mg/m^3(C)	3.5mg/m^3(C)
Steel	18	10mg/m^3(C)	10mg/m^3(C)
Brass	2	10mg/m^3(C)	10mg/m^3(C)
Mercury	none added	0.05mg/m^3(C)	0.05mg/m^3(C)

PHYSICAL DATA			
Property	KOH	MNO_2	Zn
Boiling point (°C)	1320	N/A	907
Vapour pressure (mm Hg)	N/A	N/A	1mm @ 487°C
Vapour density (air=1)	N/A	N/A	N/A
Solubility in water	50%	0%	0%
Specific gravity (water=1)	2.0	5.0	7.14
Melting point (°C)	360	535	420
State & colour	Clear liquid	Black powder	Grey powder

FIRE AND EXPLOSION DATA			
Flash point (method used)	N/A	Extinguishing media	N/A
Flammable limits (LEL & PEL)	N/A		
Special fire-fighting procedures and unusual fire hazards	Fire-fighters should use self-contained breathing apparatus when a large number of cells are involved in a fire. Cells may release toxic zinc fumes when exposed to fire.		

HEALTH HAZARD DATA	
NOTE. These compounds and metals are contained in a sealed can. Potential for exposure should not exist unless the battery leaks, is exposed to high temperature, is swallowed, or is mechanically, physically, or electrically abused.	
Routes of entry	Inhalation: YES. Skin: YES. Ingestion: YES.
Acute/chronic health hazards	The most likely risk is acute exposure when a cell leaks. Potassium hydroxide (KOH) is caustic and skin contact can cause burns. Eye contact with KOH may cause permanent eye injury. Potential does not exist for chronic exposure.
Carcinogenity	NTP: NO. IARC Monograph: NO. OSHA Regulated: NO.
Signs/symptoms of exposure	Skin and eye contact with KOH may cause chemical burns.
Medical conditions generally aggravated by exposure	An acute exposure will not generally aggravate any medical condition.

continued…

…continued

FIRST AID PROCEDURES	
Skin contact	If leakage from a cell contacts the skin, flush immediately with water and cover with dry gauze.
Eye contact	Flush with copious amounts of water for 15 minutes and seek medical assistance.
Inhalation of vapour	If vapour is inhaled, remove to fresh air.

REACTIVITY DATA	
Stability	Stable.
Conditions to avoid	DO NOT heat, disassemble, or recharge.
Hazardous decomposition or byproducts	When heated, cells may emit caustic vapours of KOH.

PRECAUTIONS FOR SAFE HANDLING, USE, AND DISPOSAL	
Spill or leak procedures	Avoid skin and eye contact. Do not inhale vapours. Neutralise leaked material with weak acidic solution (e.g. vinegar), and/or wash away with copious amounts of water.
Waste disposal method	Dispose of spent batteries in small quantities with normal waste. Do not accumulate, but if unavoidable, quantities of 5 gallons or more should be disposed of in a secure landfill, as should leaking cells, regardless of quantity. Do not incinerate batteries since cells may explode at high temperature. Disposal should be in accordance with all applicable national and local regulations.
Handling and storage	Avoid mechanical or electrical abuse. Use neoprene, rubber, or latex-nitrile gloves when handling leaking cells. Store at room temperature.
Other precautions	Do not attempt to recharge. Install cells in accordance with equipment instructions. Do not dispose of in fire. Replace all batteries in equipment at the same time. Do not mix battery systems such as alkaline and zinc carbon in the same equipment. Do not carry batteries loose in pocket or bag.

SPECIAL PROTECTION INFORMATION	
Respiratory protection	None under normal conditions.
Ventilation	Subsequent to a fire, provide as much ventilation as possible.
Protective gloves	Use neoprene, rubber, or latex-nitrile gloves when handling leaking cells.
Eye protection	Wear safety glasses when handling leaking cells.
Other protective clothing/equipment	None.

ABBREVIATIONS USED IN THIS DOCUMENT	
ACGIH	American Council of Governmental Industrial Hygienists
IARC	International Agency for Research on Cancer
OSHA	Occupational Safety and Health Administration (US)
NTP	National Toxicology Program (US)
PEL	Permissible Exposure Limit
TLV	Threshold Limit Values

UNPACKING YOUR T640

Unpack the instrument and accessories carefully and inspect the contents for damage. Keep the original packing materials in case re-shipment is required. If there is evidence of shipping damage, please notify Eurotherm Process Automation or the carrier within 72 hours and retain the packaging for inspection by the manufacturer's and/or carrier's representative.

Handling precautions

Caution

Electrostatic sensitivity. Some circuit boards inside the T640 contain electrostatically sensitive components. To avoid damage, before you remove or handle any board ensure that you, the working area, and the board are electrostatically grounded. Handle boards only by their edges and do not touch the connectors.

Package contents

Check the package contents against your order codes, using the labels on the components to help you. Product labelling includes:

- Outer packaging label. Shows the full instrument order code, instrument serial number, hardware build level, and software issue number.
- Antistatic bag label. Shows the full instrument order code, instrument serial number, and hardware build level.
- Sleeve labels. Two labels, one outside and one inside showing the sleeve order code and sales order number.
- Instrument label. One on the instrument, identical to the antistatic bag label.
- Memory module label. One label showing the software issue number.
- Security key label. Shows access, area, and ID code.

INSTALLATION

Dimensions

Figure 2-1 shows the DIN-size aperture needed for panel-mounting the T640. Also shown are the unit's overall dimensions, the mounting clamps, panel section, terminal cover and screw, and the access for cabling.

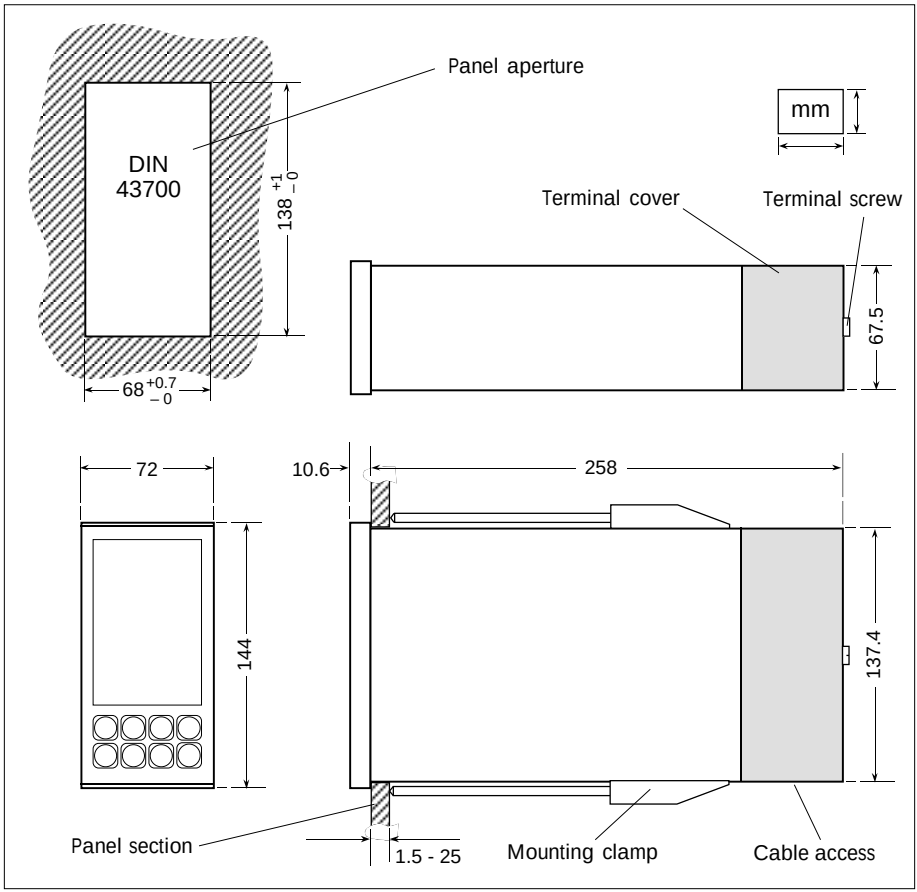


Figure 2-1 T640 principal dimensions

Panel mounting

Insert the sleeve in the aperture and fit the two clamps as shown in Figure 2-2. To fit a clamp, position it flat on the sleeve, locating the hook in the slot. Slide the clamp away from the panel to engage the hook firmly, and snap the two feet into the two small recesses. Screw the clamp rod in to hold the sleeve lightly in position. Fit the second clamp in the same way. Finally, tighten up both clamps to exert a moderate retaining force. To avoid panel distortion, do not overtighten. The maximum recommended torque is 0.6Nm.

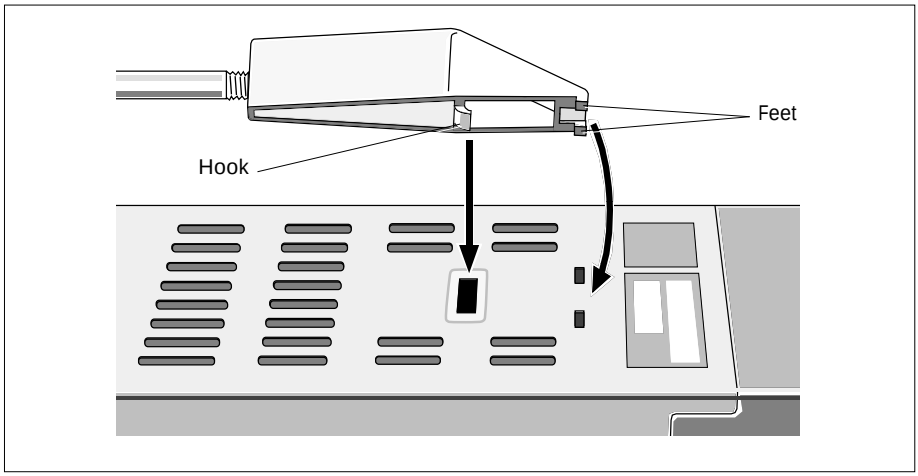


Figure 2-2 Fitting a clamp to the sleeve

Clamp removal

See Figure 2-3. Slacken off the clamp by at least 2mm and insert a screwdriver blade between the feet at the end of the clamp body. **Lift** the screwdriver handle to lever the clamp towards the panel and disengage it. **Do not press downwards** — this could cause damage!

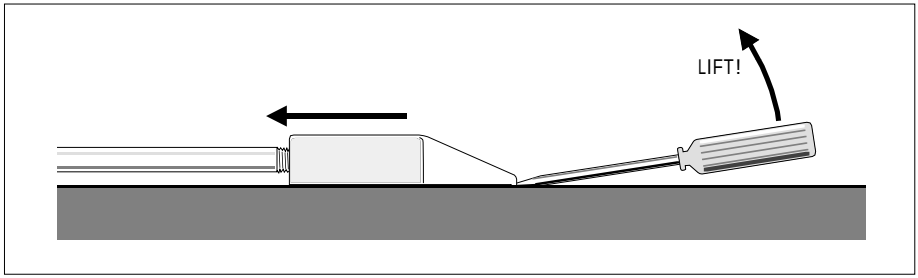


Figure 2-3 Removing a clamp from the sleeve

Removing T640 from sleeve

Withdrawing the T640 from its sleeve is done entirely from the front of the mounting panel, without disturbing any of the system wiring.

Caution

Repeated removal/replacement of the T640 under power erodes edge connectors. Check connectors periodically and replace a board if excessive burning or pitting is seen. Anti-static precautions must be observed when handling the unit out of its sleeve.

See Figure 2-4. To unlock the T640 insert a small screwdriver blade into the slot in the retaining clip at the bottom of the fascia and slide the clip to the left as far as it will go. Repeat this for the clip at the top of the fascia, but slide it to the right. To withdraw the unit use the extractor tool supplied in the accessory kit (Part No. BD 082253). Hold the tool at an angle of about 45°, insert the hook into the opening under the 'SP-W' pushbutton, then level the tool and pull the unit from the sleeve. Remember to lock both retaining clips after refitting the unit in the sleeve.

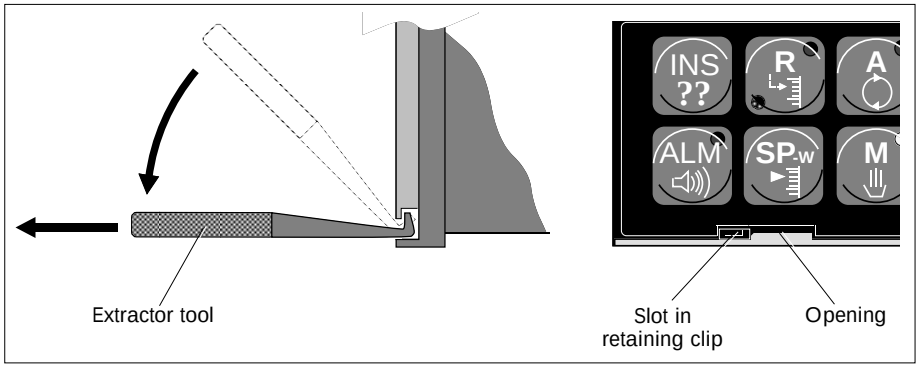


Figure 2-4 Withdrawing T640 from the sleeve

CONNECTIONS & WIRING

Electrical connections to the T640 are made via three blocks of customer screw terminals at the rear of the sleeve, protected by a terminal cover. Wiring passes through the opening in the base of the terminal cover. All connections are low current and a 16/0.20 cable size is adequate. The maximum cable size for these terminals is 2.5mm^2. 'Bootlace' type ferrules are strongly recommended.

Power input. The instrument supply should be fused externally in accordance with local wiring regulations. The mains option accepts 90 - 265 Vac, 45 - 65 Hz, the DC option 19 - 55 Vdc. Power input depends on the application and configuration, and on the I/O cards fitted, but is a nominal maximum of 25VA per T640. Please refer to Chapter 11, *Specifications*, for further details.

Terminal cover removal

See Figure 2-5. With the sleeve upright unscrew the retaining screw and pull the cover away from the cover bracket and cable clamp assembly. To remove the bracket, lift it to free the hooks from the tabs, then withdraw it from the sleeve. Refitting the bracket and cover is the reverse procedure.

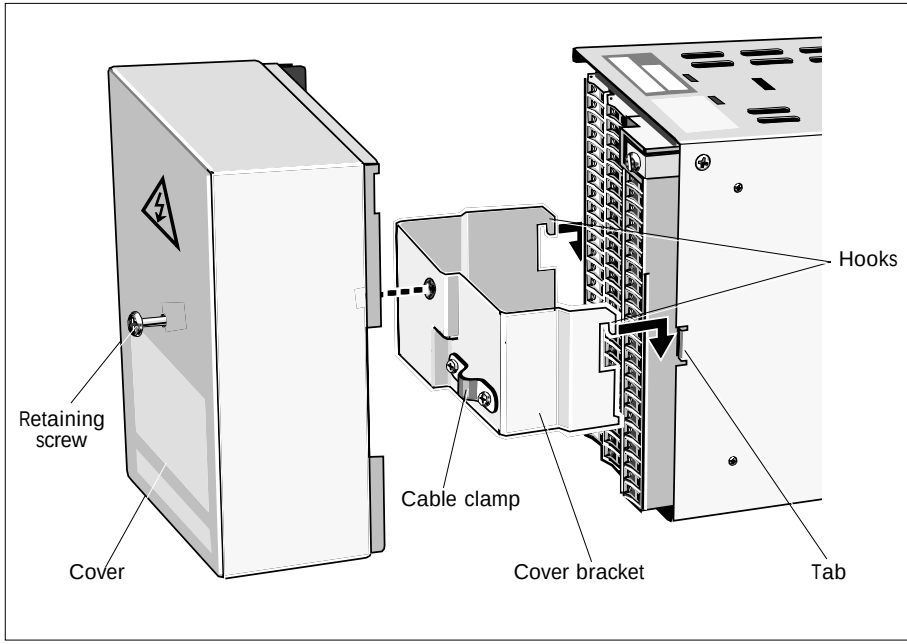


Figure 2-5 Removing the terminal cover

Customer terminals

Figure 2-6 shows the customer terminals (example). Other configurations are possible depending on the I/O and power supply ordered. The Figure shows the MAINS option motherboard terminal block with safety cover, and Site 1 I/O and Site 2 I/O terminal blocks. Wire connectors, securing screws, and terminal identification labels are also shown. Connect a good local earth to the M4 screw terminal. *Do not* connect an external earth directly to terminals 1 and 2.

Mains safety cover

This fits over the mains screw terminals to prevent accidental contact with the live screws. To remove the cover loosen the two screws and pull it off. To replace the cover insert its two legs fully into the corresponding terminals and tighten up the screws securely.

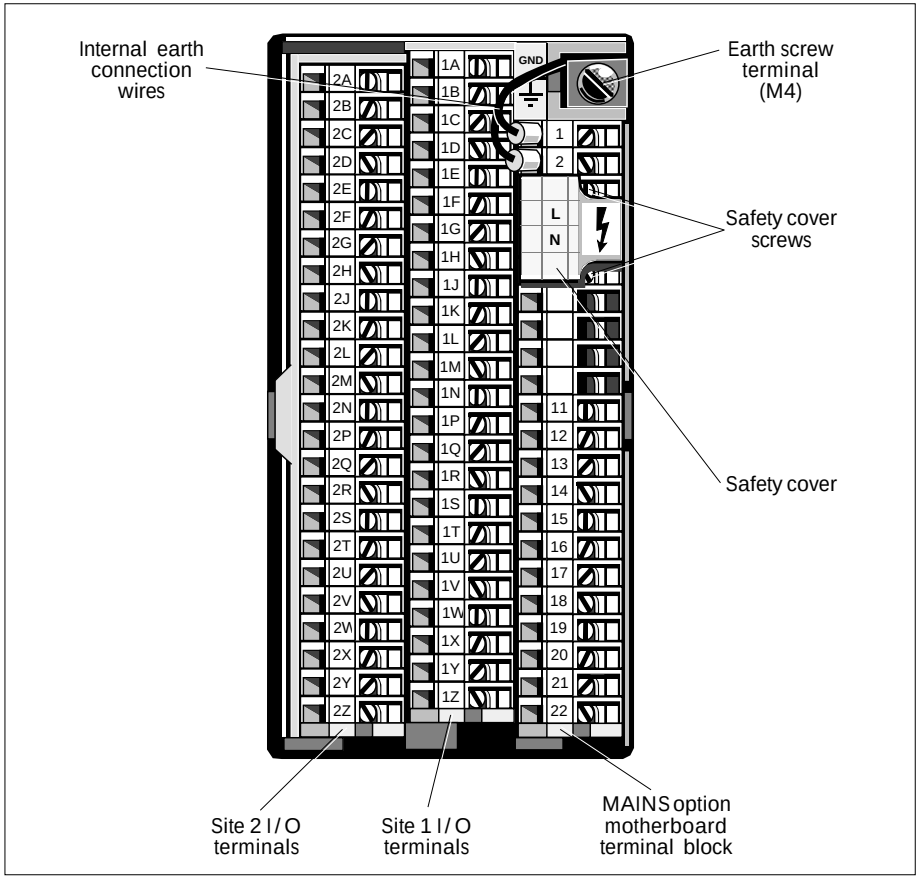


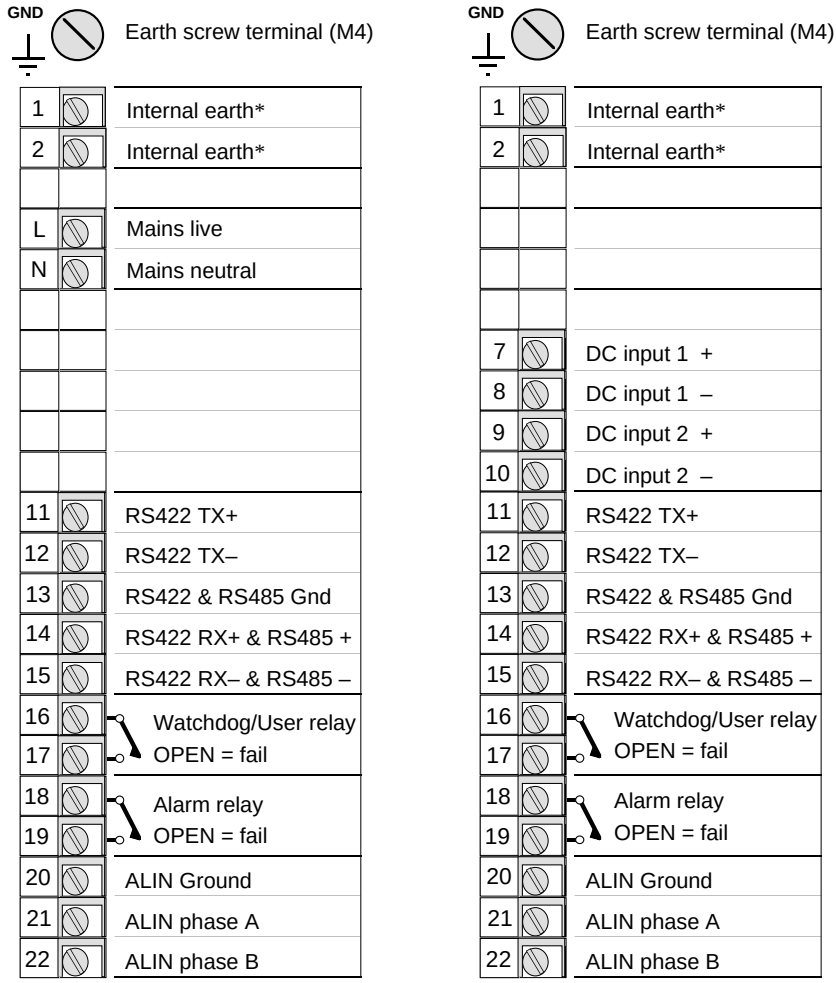
Figure 2-6 Customer terminals (example)

Terminal designations

Motherboards

Table 2-1 shows the terminal designations for two motherboard terminal block options, with the ac MAINS option on the left and the DC option on the right of the table.

The uses of these terminals and how they connect to T640's internal circuitry are described in later sections.



*Factory-connected externally

Table 2-1 Customer terminals for AC (left) & DC (right) T640 motherboard options

High-level I/O boards

Table 2-2 shows terminal designations for the high-level I/O board options, fitted in sites 1 (right) and 2 (left). Note that Site 1 terminals are labelled **1A**to **1Z**, and Site 2 terminals are **2A** to **2Z**. The table also shows the software function blocks in the control database that link to each terminal or set of terminals. These are explained below.

Terminal (*SiteNo=2*)			Linked block
2A	Current output +	Channel 3	AN_OUT *OutType* = mA
2B	Current output –		
2C	TX power supply +		
2D	TX power supply –		
2E	Analogue input, Channel 1		AN_IP: *InType* = Volts
2F	Analogue input, Channel 2		AN_IP: *InType* = Volts
2G	Analogue ground		
2H	Analogue input, Channel 3		AN_IP: *InType* = Volts
2J	Analogue input, Channel 4		AN_IP: *InType* = Volts
2K	Analogue ground		
2L	Analogue output,Channel 1		AN_OUT: *OutType* = Volts
2M	Analogue output,Channel 2		AN_OUT: *OutType* = Volts
2N	Analogue ground		
2P	Digital input	Bit0	DG_IN: *InType* = Volts
2Q	Digital input	Bit1	
2R	Digital input	Bit2	
2S	Digital input	Bit3	
2T	Digital output,	Bit0	DG_OUT
2U	Digital output,	Bit1	
2V	Digital output,	Bit2	
2W	Digital output,	Bit3	
2X	(*Not connected*)		
2Y	Digital ground		
2Z	Digital ground		

Terminal (*SiteNo=1*)			Linked block
1A	Current output +	Channel 3	AN_OUT *OutType* = mA
1B	Current output –		
1C	TX power supply +		
1D	TX power supply –		
1E	Analogue input, Channel 1		AN_IP: *InType* = Volts
1F	Analogue input, Channel 2		AN_IP: *InType* = Volts
1G	Analogue ground		
1H	Analogue input, Channel 3		AN_IP: *InType* = Volts
1J	Analogue input, Channel 4		AN_IP: *InType* = Volts
1K	Analogue ground		
1L	Analogue output,Channel 1		AN_OUT: *OutType* = Volts
1M	Analogue output,Channel 2		AN_OUT: *OutType* = Volts
1N	Analogue ground		
1P	Digital input	Bit0	DG_IN: *InType* = Volts
1Q	Digital input	Bit1	
1R	Digital input	Bit2	
1S	Digital input	Bit3	
1T	Digital output,	Bit0	DG_OUT, DGPULS_4 N.B. In DGPULS_4 block, Bit0 - Bit3 correspond to *Chan1* - *Chan4*, resp.
1U	Digital output,	Bit1	
1V	Digital output,	Bit2	
1W	Digital output,	Bit3	
1X	*Pullup: 15V out OR 24V in		
1Y	Digital ground		
1Z	Digital ground		

NB. SiteNo, Channel, & Bit numbers refer to the associated I/O function block's corresponding parameters
*Pullup connects internally to digital outputs of both sites

Table 2-2 Customer terminals for high-level I/O options — Site 2 (left) & Site 1 (right)

Thermocouple I/O boards

Table 2-3 shows Site 1 & 2 terminal designations for the thermocouple I/O board options, together with their associated software function blocks.

Terminal *(SiteNo=2)*			Linked block
2A		Current output +	AN_OUT *OutType* = mA
2B		†Output kill' input	**Channel 1**
2C		Current output –	
2D		(*Do not connect!**)	AN_IP *InType* = mV_Int, mV_Ext
2E		Thermocouple +	**Channel 1**
2F		(*CJC sensor*)†	
2G		Thermocouple –	
2H		(*Do not connect!**)	AN_IP *InType* = mV_Int, mV_Ext
2J		Thermocouple +	**Channel 2**
2K		(*CJC sensor*)†	
2L		Thermocouple –	
2M		Isolated digital input +	Bit0
2N		Isolated digital input –	
2P		Isolated digital input +	Bit1
2Q		Isolated digital input –	DG_IN: *InType* = Volts
2R		Isolated digital input +	Bit2
2S		Isolated digital input –	
2T		Analogue input, Channel 3	AN_IP: *InType* = Volts, Hz
2U		Analogue output,Channel 2	AN_OUT: *OutType* = Volts
2V		Analogue ground	
2W		Digital output, Bit0	DG_OUT, DGPULS_4 **N.B. In DGPULS_4 block, Bit0 - Bit2 correspond to *Chan1* - *Chan3*, resp.**
2X		Digital output, Bit1	
2Y		Digital output, Bit2	
2Z		Digital ground	

Terminal *(SiteNo=1)*			Linked block
1A		Current output +	AN_OUT *OutType* = mA
1B		†Output kill' input	**Channel 1**
1C		Current output –	
1D		(*Do not connect!**)	AN_IP *InType* = mV_Int, mV_Ext
1E		Thermocouple +	**Channel 1**
1F		(*CJC sensor*)†	
1G		Thermocouple –	
1H		(*Do not connect!**)	AN_IP *InType* = mV_Int, mV_Ext
1J		Thermocouple +	**Channel 2**
1K		(*CJC sensor*)†	
1L		Thermocouple –	
1M		Isolated digital input +	Bit0
1N		Isolated digital input –	
1P		Isolated digital input +	Bit1
1Q		Isolated digital input –	DG_IN: *InType* = Volts
1R		Isolated digital input +	Bit2
1S		Isolated digital input –	
1T		Analogue input, Channel 3	AN_IP: *InType* = Volts, Hz
1U		Analogue output,Channel 2	AN_OUT: *OutType* = Volts
1V		Analogue ground	
1W		Digital output, Bit0	DG_OUT, DGPULS_4 **N.B. In DGPULS_4 block, Bit0 - Bit2 correspond to *Chan1* - *Chan3*, resp.**
1X		Digital output, Bit1	
1Y		Digital output, Bit2	
1Z		Digital ground	

NB. SiteNo, Channel, & Bit numbers refer to the associated I/O function block's corresponding parameters.
*These terminals are used to factory-calibrate the CJC sensors. *Connecting to them could invalidate the calibration*.
†Way occupied by sensor.

Table 2-3 Customer terminals for thermocouple I/O options — Site 2 (left) & Site 1 (right)

Linking the terminals to I/O software function blocks

To effect the link you must configure where applicable a suitable I/O block's *SiteNo* (site number), *Channel*, *InType*, or *OutType* parameters as indicated in Tables 2-2 and 2-3. Other block parameters can be configured to specify operating modes, ranges, power-up states, etc., as detailed in the *LIN Blocks Reference Manual*.

Examples — high-level I/O option

- Table 2-2 shows that to provide an isolated current analogue output via terminals 2A and 2B, you must run an **AN_OUT** block in the T640 with its *SiteNo* parameter = **2**, *Channel* = **3**, and *OutType* = **mA**.
- To provide a non-isolated voltage analogue output via terminals 2L and 2N (ground), run an **AN_OUT** block with *SiteNo* = **2**, *Channel* = **1**, and *OutType* = **Volts**.

Examples — thermocouple I/O option

- Table 2-3 shows that to provide a thermocouple input (with internal cold-junction compensation) via terminals 1E and 1G, you must run an **AN_IP** block in the T640 with its *SiteNo* parameter = **1**, *Channel* = **1**, and *InType* = **mV_Int**. (Setting *InType* = **mV_Ext** specifies external CJC.)
- To provide a frequency/totalisation input via terminals 1T and 1V (ground), run an **AN_IP** block with *SiteNo* = **1**, *Channel* = **3**, and *InType* = **Hz**.
- To provide digital outputs from a **DGPULS_4** block via terminals 2W, 2X, 2Y, and 2Z (ground), you only have to set *SiteNo* = **2** — there are no *Channel* or *OutType* parameters in this block. The block outputs its *Chan1*, *Chan2*, and *Chan3* digital signals via terminals 2W, 2X, and 2Y respectively, relative to 2Z as ground.

Consult Chapter 11, *Specifications*, for a list of all software blocks supported by the T640 and for information on the level of this support for specific block parameters provided by the various I/O boards available. The *LIN Blocks Reference Manual* (Part No. HA 082 375 U003) gives full details of all LIN-based software block parameters, but must be read in conjunction with the specific I/O board data given in Chapter 11.

Some examples of I/O circuits are also given in Chapter 11.

T640 zero volts schematic

Figure 2-7 shows schematically T640's internal zero volts and power supply arrangements, and associated customer screw terminals. The power supply units feed the main CPU, I/O board(s), front panel, and RS422/485 power supply unit, via a low voltage power supply bus. The GND terminal connects directly to the instrument case, and via wires to terminals 1 and 2, which must not be used for external connection.

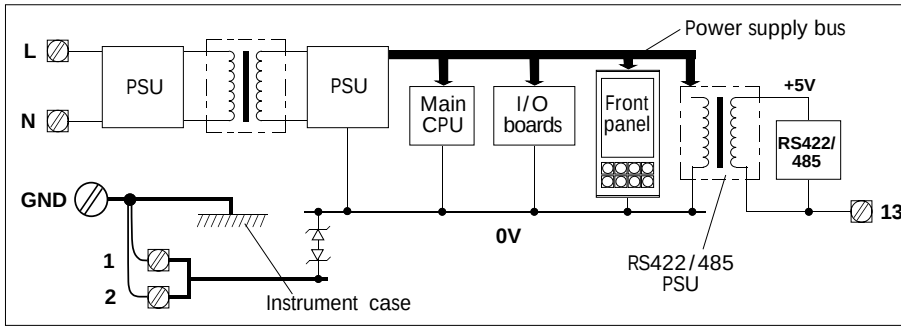


Figure 2-7 T640 internal zero volts & power supplies schematic

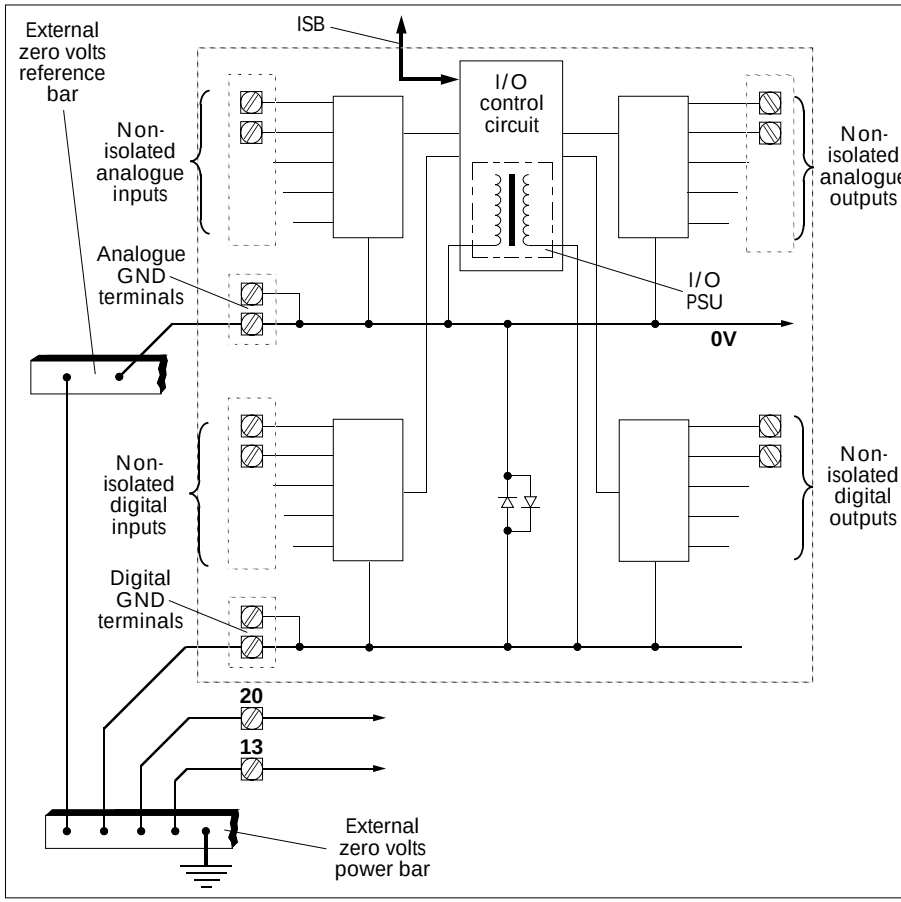


Figure 2-8 T640 I/O zero volts & power supplies schematic

I/O zero volts schematic

Figure 2-8 shows the (generalised) I/O zero volts and power supply arrangements, and associated customer screw terminals. The number and designations of terminals associated with the non-isolated analogue inputs and outputs depend on what I/O options are fitted (Tables 2-2 and 2-3 show those currently available). The I/O control circuit communicates via the ISB (Internal Serial Bus). Connect the analogue ground terminal(s) to an external zero volts reference bar as shown.

The number and designations of terminals associated with the non-isolated digital inputs and digital outputs also vary with I/O option. Connect the digital ground(s) to an external zero volts power bar, which should be connected to a clean instrument earth.

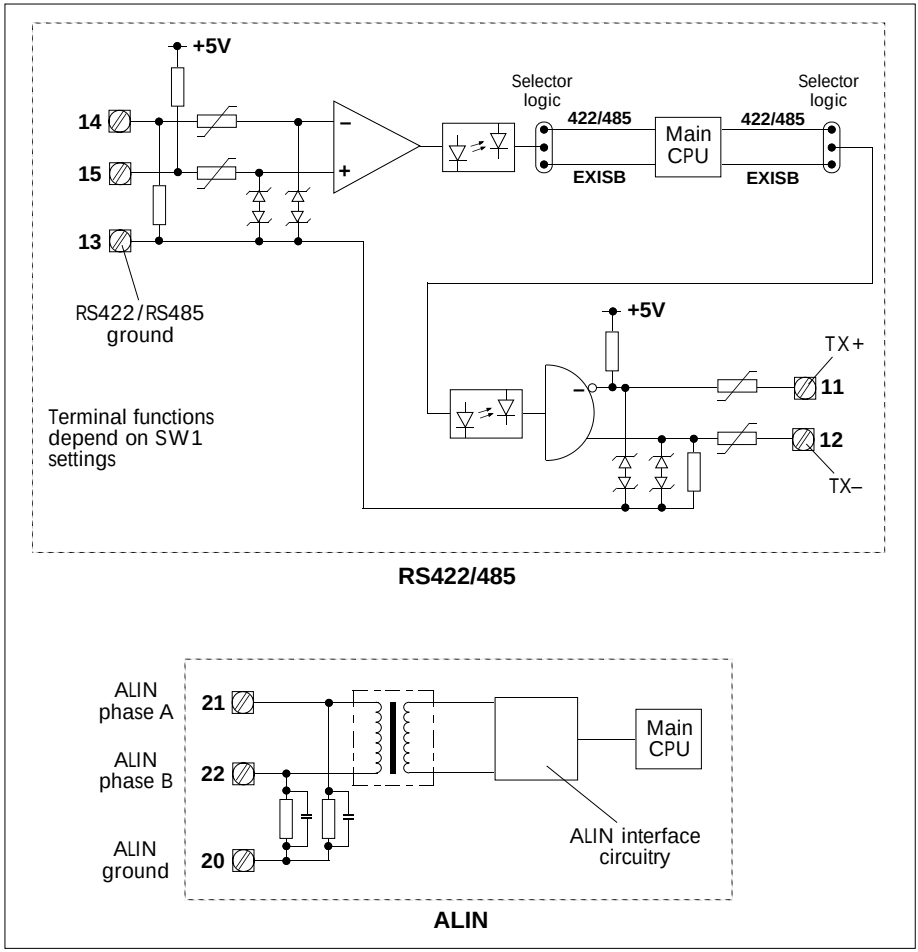


Figure 2-9 T640 communications zero volts schematic

Communications zero volts schematic

Figure 2-9 shows the RS422/485 and ALIN comms connections with associated customer screw terminals. The main CPU is opto-isolated from the RS422/485 transmit/receive terminals.

NOTE. The ALIN cable screen and the RS422/485 cable screen should each be grounded at one point only.

HARDWARE CONFIGURATION

Status level information

The information given in this chapter refers to T640s with hardware status levels of 12 or higher. For older hardware please refer to Appendix A, *Setting Up Early Boards*, as well as the present chapter.

To view status level information, remove the T640 from its sleeve (see Figure 2-4) and check the printed label on the side of the unit. Below the order code is a line of code ending with a letter (the software status level) and a number (the hardware status level). E.g. in the code **W29073/001/1/2900/J12**, the software status level is 'J', and the hardware status level is '12'.

Internal layout

Figure 2-10 shows T640's internal layout (example). The motherboard is the main electronics board on which all I/O board options are mounted. It carries two configuration DIL switchbanks 1 and 2, and the memory module in its socket. The figure shows an I/O board in Site 1, and an expansion-type I/O board in Site 2. Other I/O options and arrangements are possible, depending what was ordered.

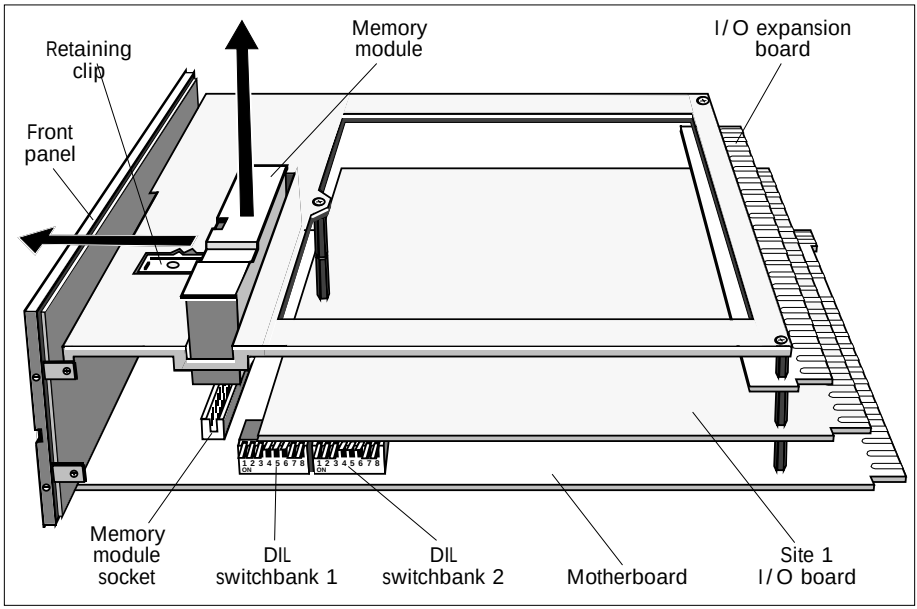


Figure 2-10 T640 internal layout (example)

Memory module removal

See Figure 2-10. Use a screwdriver blade to slide the retaining clip towards the front panel as far as it will go, then pull the module out of its socket. Replacement is the reverse procedure.

Caution

The module can be pushed fully home only if it is the right way round. Check this before applying excessive force, which can damage the pins.

Memory module compatibility

If you transfer an application program by moving the T901 memory module from a T640 with v3/4 software or earlier (corresponding to a 12.5MHz processor clock speed), to a newer T640 (25MHz clock speed), the T640 will fail to start.

This is because pre-v3/5 software does not recognise the new clock speed, and displays 'POWER ON - RESET' and 'CPU' on the front-panel.

The 25MHz processor clock speed was introduced at T640 hardware status level 6 — see the *Status level information* section above for how to determine status information. 25MHz T640s are supported by v3/5 and 4/x software.

Note that although v4/x software does run on original hardware — status level 5 or earlier, it does so with limited functionality (see *Memory requirements* section below). If transferring application programs between the two using the T901 memory module, you are strongly recommended to upgrade all existing T640s to v3/5 or 4/x software, according to the functionality required.

T640 v3/5 software provides a smooth upgrade path for v3/x software users. This version allows movement of T901 memory modules containing user application software across T640 hardware with 12.5MHz (original) and 25MHz (current) processor clock speeds. Note that the T901 contains both Eurotherm software and the user application program.

NOTE. There are no application problems if you copy your strategy (e.g. using LINfiler) from v3/x to v4/x software, when running on the appropriate T640 hardware.

Memory requirements

Many existing T640s — up to hardware status level 4 — are fitted with 128K of RAM, but some very early units are fitted with only 64K. V4/x software needs 256K of RAM — status level 5 onwards — to support all the optional functionality, although it does function with 128K if the sequencing option (M004) is not required. The memory requirement situation is summarised as follows:

RAM	pre-v4/x software (status level A)	v4/x software (status level B)
64K	All features function except sequencing	Does not function — shows 'Error 64K RAM'
128K (St. Level ≤4)	All features function	All features function except sequencing
256K (St. Level ≥5)	All features function [Configuration should not exist]	All features function

Main fuse

See Figure 2-11. The motherboard carries the T640 power supply fuseholder. The fuse is a 20 × 5 mm 250Vac antisurge cartridge fuse rated at 500mA (AC option), or 2A (DC option). Unscrew the fuse cap anticlockwise to remove. The fuse should be replaced by authorised personnel only. Note that a fuse may fail owing to ageing, but if it fails because of a fault with the unit, please refer to your nearest Eurotherm Process Automation agent.

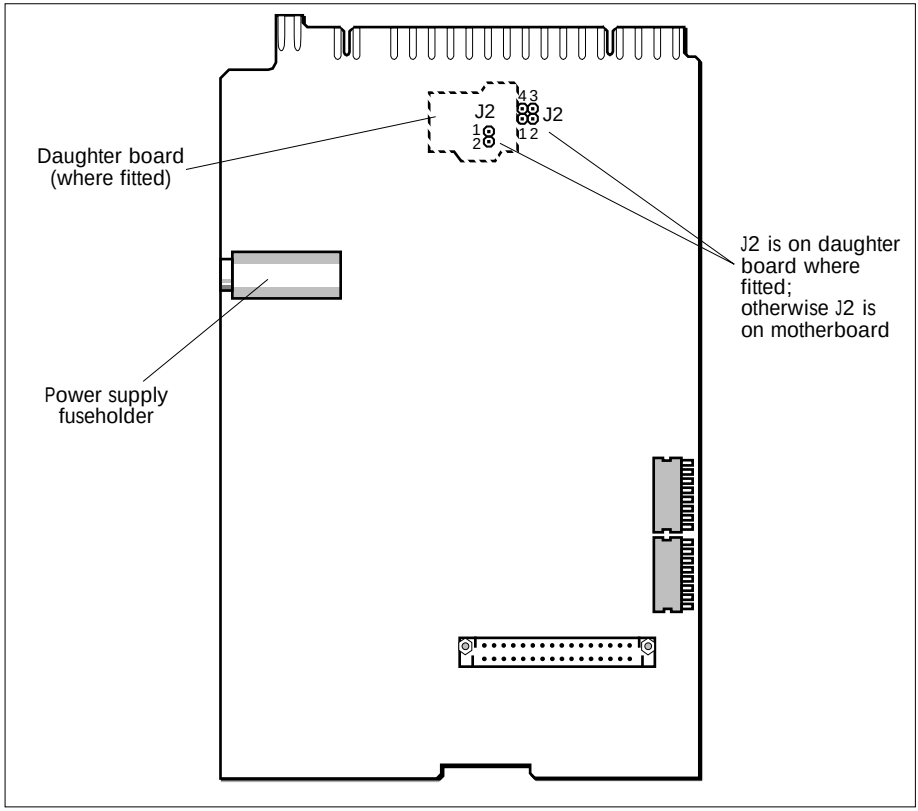
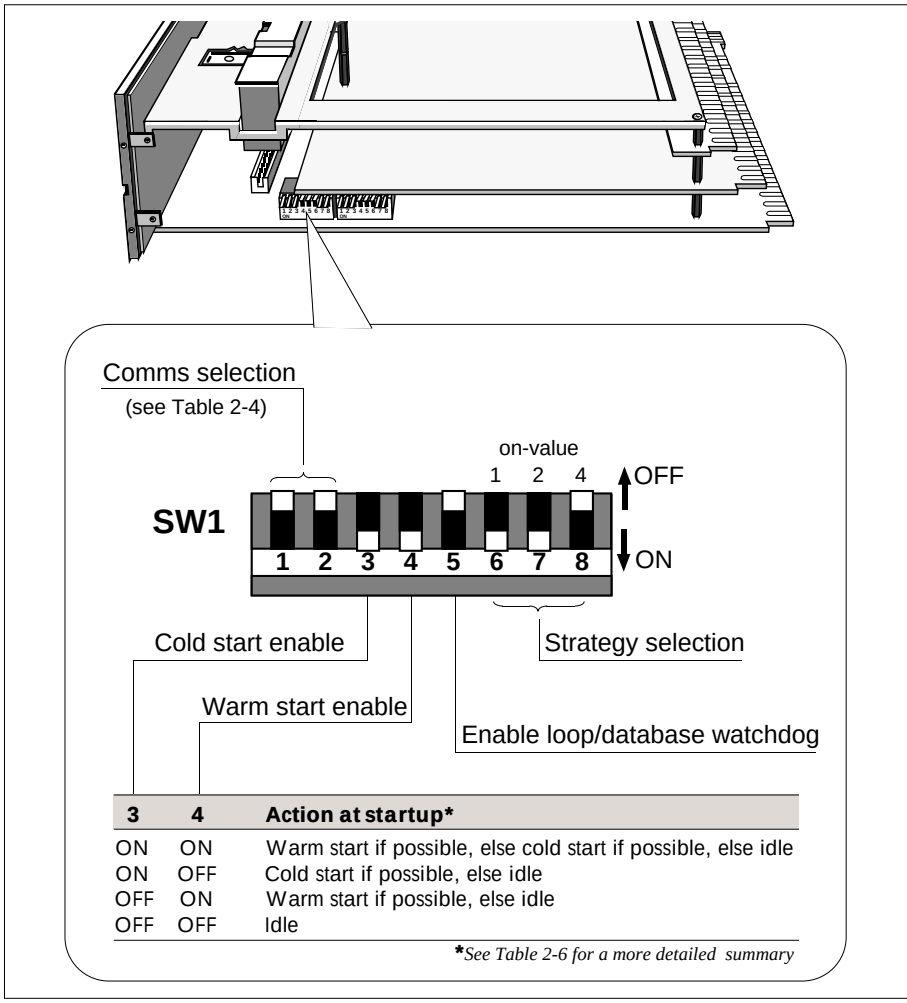


Figure 2-11 T640 motherboard showing fuse & jumper locations

Switchbank 1

Figure 2-12 shows the location and functions of the eight switches in DIL switchbank 1.

- Switches 1 and 2, together with one jumper link, configure the type of communications used by the T640 via its serial port. See Table 2-4 below in the section *Serial communications jumper link & switches*. These switches and the link are set at the factory according to the comms option ordered and should generally be left as supplied.
- Switches 3 and 4 configure the way the T640 powers up, and are usually both set to ON for normal operation. T640's power-up routine is explained in detail later in the section *Power-up routine*.



3	4	Action at startup*
ON	ON	Warm start if possible, else cold start if possible, else idle
ON	OFF	Cold start if possible, else idle
OFF	ON	Warm start if possible, else idle
OFF	OFF	Idle

**See Table 2-6 for a more detailed summary*

Figure 2-12 SW1 location and functions

- Switch 5, when set to ON, causes the watchdog relay contacts — customer terminals 16 & 17 — to open if a loop (user task) stops running or if the database halts. This function is in addition to the relay's normal actions, i.e. CPU failure watchdog (closed = healthy, open = failure), and user alarm (via the T600 block's *UsrAlm* field). With switch 5 OFF, the relay does not respond to loop or database halts.

- Switches 6, 7, and 8 select the number of a preconfigured ‘standard’ strategy to be loaded to RAM and if possible run in the T640. The strategy selected is the sum of the ‘values’ of the three switches (OFF = 0, ON = ‘value’ as shown in Figure 2-12). E.g. strategy #3 has been selected in the figure. Setting these three switches all OFF prevents any standard strategy being loaded. Running standard strategies is explained in Chapter 5, *Standard strategies*.

Switchbank 2

Figure 2-13 shows the ALIN address DIL switchbank 2, and an example setup (7A hex).

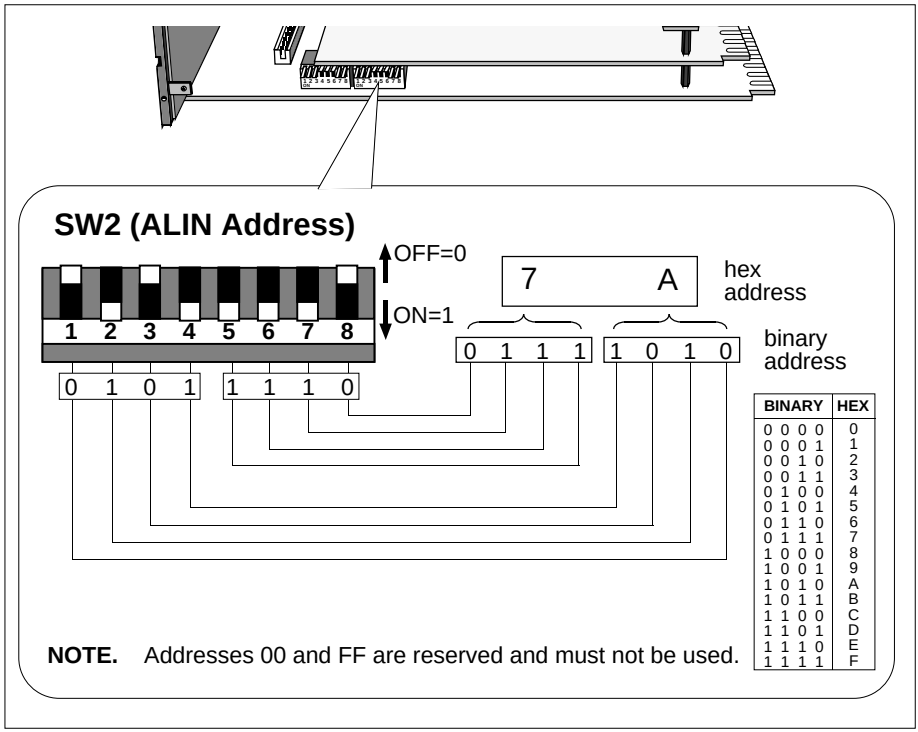


Figure 2-13 SW2 — ALIN address setup (example)

This bank of switches is used to set up the address of the T640 on the ALIN. Figure 2-13 shows how to set them up and read them, using the hexadecimal address **7A** as an example. Note that switch 1 is the least significant bit, and switch 8 the most significant, i.e. they are in ‘reverse order’. **Note also that addresses 00 and FF must not be used.**

Serial communications jumper link & switches

NOTE. The following applies to boards at hardware status level 12 or later. For older boards, please refer to Appendix A, *Setting up early boards.* You can determine the status level of your T640 by consulting its internal data label — see the *Status level information* section on page 2-21.

A jumper link (J2), together with switches 1 and 2 of Switchbank 1, are factory-set to configure the motherboard according to what serial comms option was ordered. You can check that these are set as required — the jumper and switches are located on the motherboard where shown in Figure 2-11. Table 2-4 shows the switch settings and jumper links for the five possible comms options.

Required comms option	DIL switch SW1/1	SW1/2	Jumper link J2 daughter b'd fitted	no daughter b'd
Binary RS422	OFF	OFF	Not fitted	1-2† or Not fitted
Modbus RS422	ON	OFF	Not fitted	1-2† or Not fitted
Modbus RS485	ON	OFF	1-2	2-3
External ISB (RS422)*	Don't care	ON	Not fitted	1-2† or Not fitted
External ISB (RS485)*	Don't care	ON	1-2	2-3

*†1-2 non-functional 'parked' position *Not implemented at current issue*

Table 2-4 Comms option switch & jumper link settings

BINARY RS422 CONFIGURATION

Table 2-4 shows the hardware settings required for communication via an RS422 serial link using binary (BISYNC) protocol.

The T640 must also have an appropriate S6000 category function block running in the database — allowing it to emulate a TCS System 6000 instrument, or to be supervised by a T1000 or other suitable instrument over the serial link. Addresses (instrument numbers, 0-127) are allocated via the S6000 block's *Instr_No* parameter, and baud rates via the T600 header block's *BinSpd1* and *BinSpd2* parameters.

Refer to the *LIN Blocks Reference Manual* for details on S6000 and T600 function blocks.

MODBUS RS422/485 CONFIGURATION

To configure the hardware for MODBUS comms, set up the motherboard switches and jumper links as shown in Table 2-4. Note that jumper link J2 determines the medium used — RS422 or RS485.

A MODBUS configuration — 'gateway file' — must be created and downloaded to the T640 to run alongside the regular LIN control database. This gateway file (.GWF filename extension) defines the communication between the LIN database (.DBF file) and

the MODBUS device(s) connected to the T640 via the serial link. The MODBUS configuration also specifies slave/master status, slave address, comms data rate and parity/stop bits. (For more data, see Appendix B, *MODBUS/JBUS-LIN communications*.)

Using the LINtools MODBUS configurator is fully described in the *T500 LINtools User Guide*, together with general information on MODBUS.

SOFTWARE FILE TYPES

Table 2-5 lists the different file types that are found in the T640's EEPROM and EPROM (ROM) memory areas. Some of these files are supplied already installed — those marked with * in the table. Others appear automatically when you use the instrument, or may be downloaded from a PC. EEPROM and ROM reside in a removable memory module, which allows a new strategy to be plugged directly into an existing controller, or conversely allows a strategy to remain if the controller must be changed. (Accessing and replacing the memory module was described earlier in this chapter, in the section *Hardware configuration*. T640's internal architecture is described in Chapter 9, *Inside T640*.) Further details on these files are given in the relevant sections of this manual.

Filename	Extension	File type
Control strategy name	.DBF	Control strategy database (parameters, connections, etc.)
Control strategy name	.RUN	T640 coldstart filename (i.e. last database run)
Control strategy name	.GWF	MODBUS configuration file ('GateWay File')
Sequence name	.SDB	Sequence database
System filename	.LIB	*Library of system routines in ROM area
Factory-set filename	.PKn	*Standard strategy in compressed format (n = 1-7, the strategy no.)
Control strategy name (current)	.TPD	Tepid data file
Control strategy name	.Lnn	Logfile of database changes via the INS pushbutton (nn = 01 - 99)
Language name	.LNG	Non-English language front-panel messages
Action filename	.STO	Compiled version of all actions in an action file
Record filename	.RCD	Record file used by RECORD block

Table 2-5 T640 file types

CONTROL STRATEGIES & SEQUENCES

LINtools

Control strategies (.DBF files), actions and action files (.STO files), and sequences (.SDB files) to be run in a T640 may be configured and downloaded using the LINtools package installed in a PC. This is described in the T500 Product Manual (Part no. HA 082 377 U999). You will need to consult the LIN Product Manual (Part no. HA 082 375 U999) for full details on how to configure the control strategy function blocks to run in the T640 instrument.

Standard strategies

Instead of creating your own control strategies from scratch, you can use one of the pre-configured 'standard' strategies supplied with the instrument. These strategies may be run as supplied, with only block parameter values edited to suit your plant requirements. This parameter editing can be done directly via T640's front panel, as described in Chapter 4, *User interface*. The tutorial in Chapter 3 also gives you some practice at editing the parameter values of a standard strategy via the front panel.

Alternatively you can use one of the standard strategies as a starting-point and more extensively edit it in LINtools' control configurator, by adding and removing blocks and connections to create a new strategy that more exactly meets your requirements.

Chapter 5, *Standard strategies*, describes the T640 preconfigured strategies and how to load and run them.

POWER-UP ROUTINE

I/O cards

I/O cards power up with their outputs 'killed' (i.e. tri-stated or low, depending on the particular card). The T640 ISB (internal serial bus) starts before the user tasks start, although initially the I/O card outputs are not written to, and hence remain in their killed state.

Database acquisition

The database is acquired in a manner depending on the type of startup:

- If a warm start occurs the database is the one in RAM, provided it is uncorrupted. If it is corrupted, the last-loaded database file (.RUN, stored in EEPROM), overlaid with 'tepid data', is used. Please refer to the section below for more details on tepid data.
- If a cold start occurs the database is loaded from EEPROM
- Otherwise, the database is loaded from one of the standard pre-configured strategies
- If no valid source is found, a null database is created.

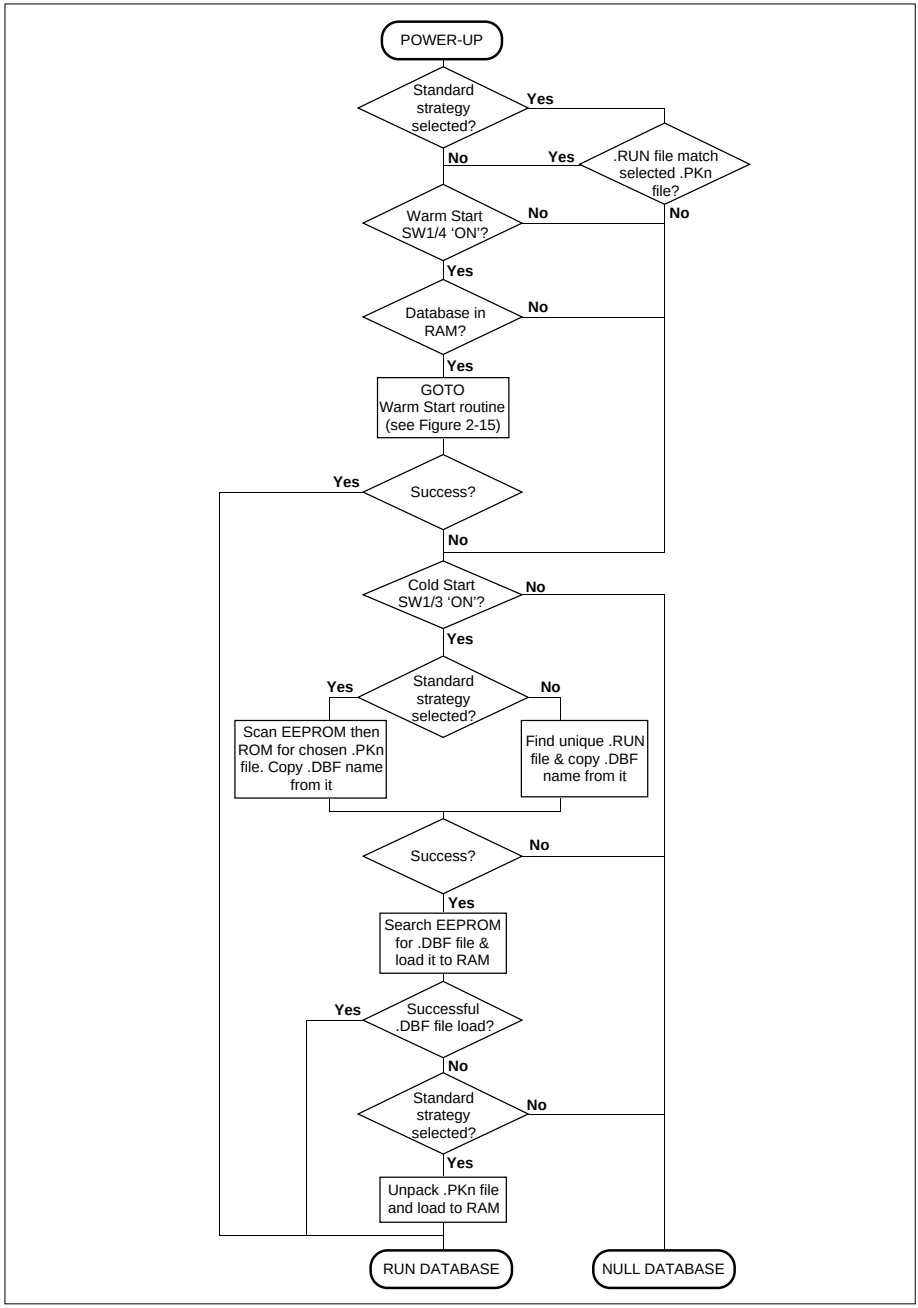


Figure 2-14 T640 power-up routine

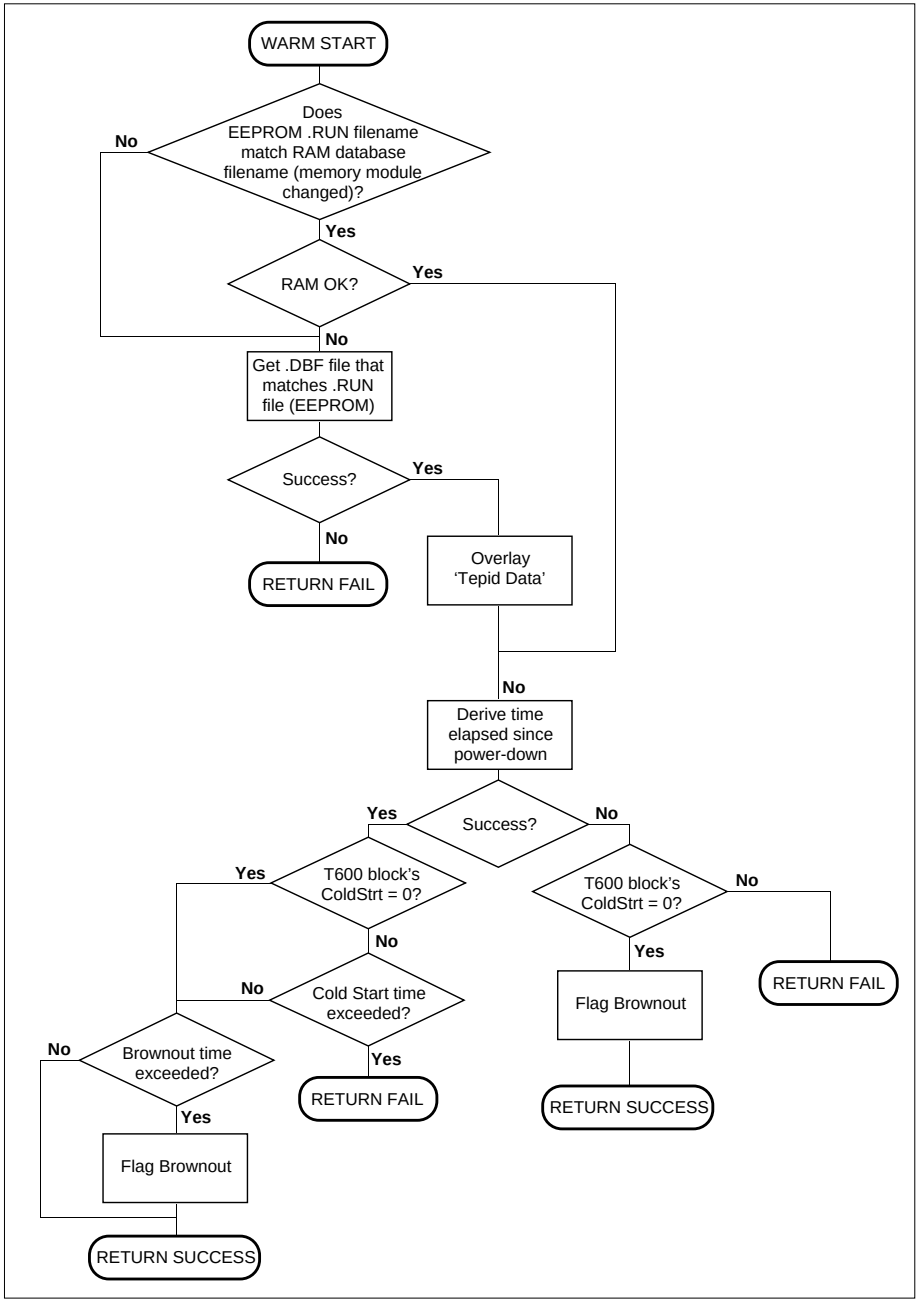


Figure 2-15 T640 warm start routine (& see Figure 2-14)

Figure 2-14 charts the events that occur when T640 is powered up. Figure 2-15 shows the warm start routine that may be called during power-up, and should be read in conjunction with Figure 2-14. As there is no hardware realtime clock in the T640, it must derive elapsed time since power-down (needed in the warm start routine) from a clock it maintains over the peer-to-peer communications. If this is not possible, power-up follows the alternative route shown in Figure 2-15. After loading, the entire database is subjected to a sumcheck test.

User task startup

Chapter 7, *T640 Task organisation*, gives information on user tasks, etc.

Before user tasks start, the output blocks execute their power-up defaults, as defined by their *OPTIONS/PwrFlLo* parameters, or in the case of a cold start, as specified at strategy configuration time. This is needed to ensure that the *InitDmnd* value (in the MAN_STAT block) is itself initialised, and causes the real plant outputs to attain their power up states. Output blocks with sumcheck errors do not execute at all; hence their outputs remain 'killed'.

User tasks now start executing. The MODE block selects manual mode — if *ManPwrUp* is TRUE — and the manual station initialises the *Demand* parameter.

Tepid data

At the end of each task iteration a package of data is assembled in a .TPD file in RAM, ready to be written to EEPROM should a power-down occur. This data — 'tepid data' — includes each loop's local setpoint (SL), output (OP), and operating mode (MODE). In the event of a power-down, there is enough time for the tepid data in the .TPD file to be transferred rapidly to EEPROM, ready to be used if required during a subsequent warm start routine (see Figure 2-15). The tepid data is 'coherent' (see Chapter 8, *Data Coherence*) because it is assembled only from completed tasks.

Also contained in the tepid data package are any of the up to eight fields named in a single TP_CONN block in the database, whose block name is specified in the T600 header block's *AnConBlk* parameter.

Alternatively, an AN_CONN and a DG_CONN block (specified in the T600 block's *AnConBlk* and *DgConBlk* parameters, respectively) can be used to define tepid data, but only if a TP_CONN block is not being used. In this case the tepid data consists of all *PV*n analogue values of the AN_CONN block, and all *W Field*n and *B Field*n bit-values of the DG_CONN block. By wiring these two blocks to a selection of important parameters that must survive a warm start — and writing to these parameters via the two blocks — you ensure that their values are held as tepid data during a power-down.

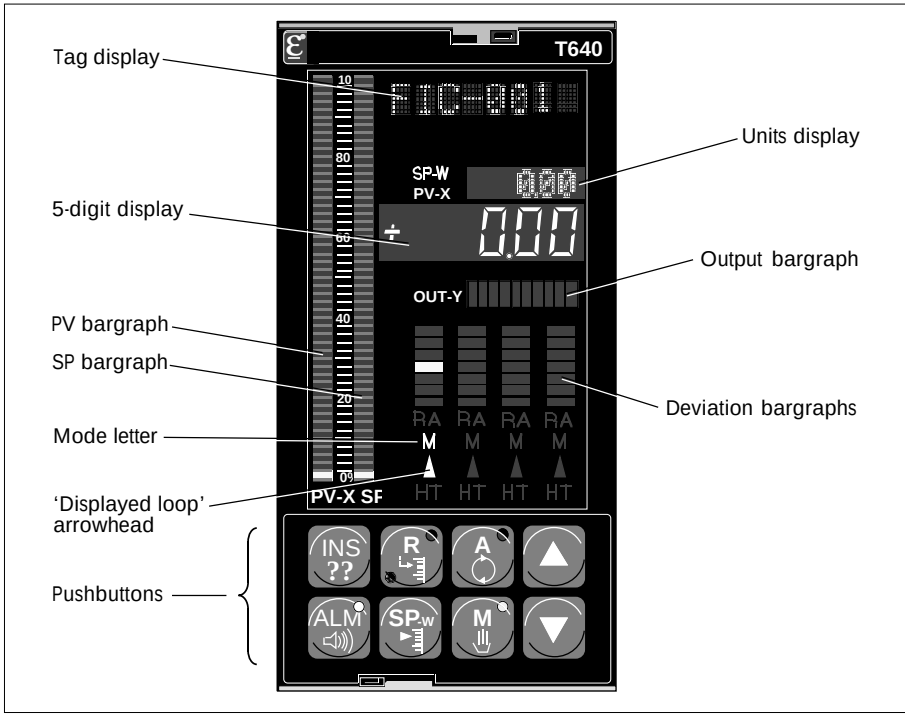


Figure 2-16 T640 front panel — principal features

Motherboard DIL switchbanks

DIL switchbank SW1, switches 3 and 4, determine how T640 starts up after a power interruption — as charted in Figures 2-14 and 2-15. For normal T640 operation both switches should be 'ON' to provide full warm start and cold start capability.

The location of SW1 was shown in Figure 2-12, and the functions of switches 3 and 4 briefly summarised. Table 2-6 below provides more detail on the effect of the four possible switch setting combinations.

Sw 3	Sw 4	T640 power-up routine & final state
OFF	OFF	T640 idle; database not loaded.
OFF	ON	Do warm start, i.e. checksum database in memory. If OK, run database from where it stopped. If corrupted, try tepid start, i.e. get .RUN file if possible, overlay tepid data and run database. If tepid start fails, clear memory and idle without running database.
ON	OFF	Do cold start, i.e.: count xxx.RUN files. If exactly one exists, try to load and run xxx.DBF. If this fails, or unique xxx.RUN file does not exist, idle without running database.
ON	ON	*Power interruption < ColdStrt:* do warm or tepid start. If this fails, do cold start (as above). *Power interruption ≥ ColdStrt:* do cold start

Table 2-6 T640 switchbank SW1, switches 3 & 4 functions

Brownout alarm

A brownout time is specified in the T600 block, which sets the *BrownOut* alarm bit if power is lost for more than this time.

POWER-UP DISPLAYS

This section describes the messages normally displayed on T640's front panel during power-up. For full details of all the front-panel displays and controls, refer to Chapter 4, *User interface*. The hands-on tutorial presented in Chapter 3 also familiarises you with the front panel power-up messages.

Normal power-up

Figure 2-16 shows the principal features of T640's front panel.

A **Power-on Reset** message normally flashes briefly in the red tag display when T640 is powered up, while the front panel awaits communications from the main CPU. Then, **WarmStrt Trying**, **TepidSrt Trying**, or **ColdStrt Trying**, flash to tell you the type of startup procedure T640 is attempting. If a standard strategy is being loaded for the very first time, **Un Pack DataBase** flashes in the tag display as the .PK*n* file is being decompressed. Finally, the fascia adopts the normal display as described in Chapter 4.

Error conditions

A number of error conditions can arise during the power-up process, which are reported on the front-panel displays as messages or error codes. These are described in Chapter 10, *Error conditions & diagnostics*. Please refer there for details.

Chapter 3 HANDS-ON TUTORIAL

PREPARING THE T640 FOR THIS TUTORIAL

As supplied, your T640 has the strategy on which this tutorial is based stored in its ROM area — in a file called SINGLE.PK1. To make access to this file possible you will have to delete another file with the same extension, called T640C1.PK1, stored in the T640's EEPROM. If you don't, the EEPROM file will run instead of the ROM file and the tutorial will be impossible to follow. Don't worry about deleting the file — it is also supplied on the floppy disk accompanying this manual, and can easily be reinstated in EEPROM if required.

NOTE. The reasons for having to delete this file are to do with the way a T640 powers up. This is detailed in Chapter 2 in the section *Power-up routine*, and also in Chapter 5, under *Running a default standard strategy*.

Deleting the T640C1.PK1 file

To do this you will need to run the LINtools package on a PC installed with an ALIN card, allowing it to communicate with the T640. Please refer to the *T500 LINtools Product Manual* (Part No. HA 082 377 U999) for details. The procedure is, briefly:

1 Withdraw the T640 from its sleeve and note the ALIN address (hex) set up on DIL switchbank SW2, on the motherboard. (Refer to Chapter 2 for details on how to carry out these operations, and the precautions to be taken. How to read SW2 is explained in Figure 2-13 in the *Hardware configuration* section.)

2 Replace the T640 in its sleeve, then connect customer terminals 21 and 22 to the ALIN card installed in the PC. Use a short twisted pair cable terminated with an RJ11 jack plug for the ALIN card, and bootlace ferrules for the T640. (Accessing the customer terminals is described in Chapter 2, and Table 2-1 shows the ALIN terminals and their phases. The literature accompanying the ALIN card describes how to make the connections.)

3 Connect the T640 to an appropriate power supply and power up both the PC and T640. (Table 2-1 shows the power input terminals for the AC and the DC motherboard options.)

4 Run the LINtools package on the PC, and select the LINfiler option via the UTIL softkey.

5 Attach a LINfiler column to the T640's E: drive (EEPROM). Use the ALIN address noted in step 1. (If this doesn't work, the ALIN phases may be wrongly connected — try swapping the terminal 21 and 22 connections.)

6 Tag the T640C1.PK1 file and delete it by pressing the <Delete> function key.

AIMS OF THIS TUTORIAL

This tutorial will give you 'hands-on' experience of the T640, and at the same time acquaint you with the simplest of the four pre-configured 'fixed-function' control strategies supplied in ROM. This is **#1**, a single control loop. The other three fixed-function strategies are all designed around this loop, so what you learn here will help you configure them as well, via T640's front-panel pushbuttons and displays.

Note that in this tutorial the T640 operates as a stand-alone instrument — no network or communications are involved.

Much of the information given here can also be found in other parts of this manual. Refer there if you want more comprehensive information.

HARDWARE REQUIRED FOR THE TUTORIAL

- T640 instrument (prepared for use in the tutorial, as described in the previous section).
- Short wire link, terminated (ideally) with bootlace ferrules.
- Terminal screwdriver.
- Digital multimeter (optional).
- An appropriate power supply — DC: 19-55V (25W), MAINS: 90-265Vac, 45-65Hz.

INSTALLING YOUR T640

If you have not already done so, please refer to Chapter 2, *Installation & startup*, for details on unpacking your T640.

Note that for this tutorial there is no need to panel-mount the instrument — it can simply rest on a bench in its sleeve, with the rear terminal cover removed.

Connecting the power supply

Remove the terminal cover and cable clamp from the rear of the T640 to access the customer terminals. Figure 3-1 shows the cover and clamp.

First determine which option you have — DC or AC mains. You can see this from Figure 3-2 and also from the order code label on the sleeve (the second field is DC or MAINS, respectively).

With the power switched off, wire the power supply to the terminals shown in the figure, according to your option. Do not power up yet!

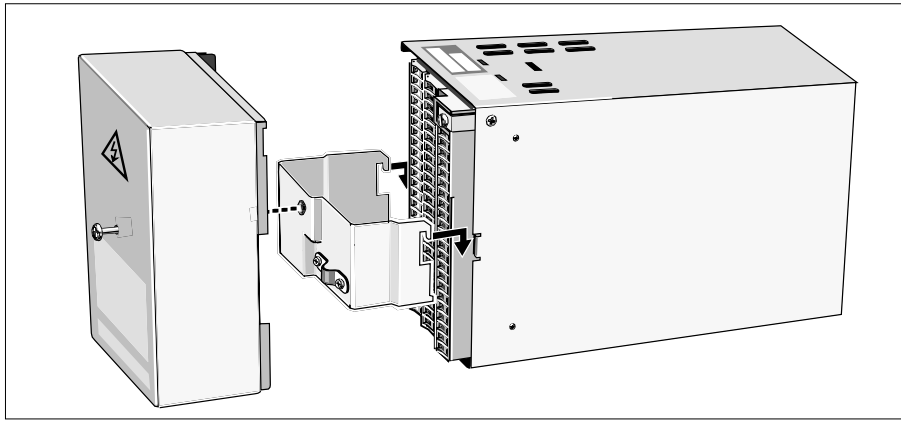


Figure 3-1 Terminal cover removal

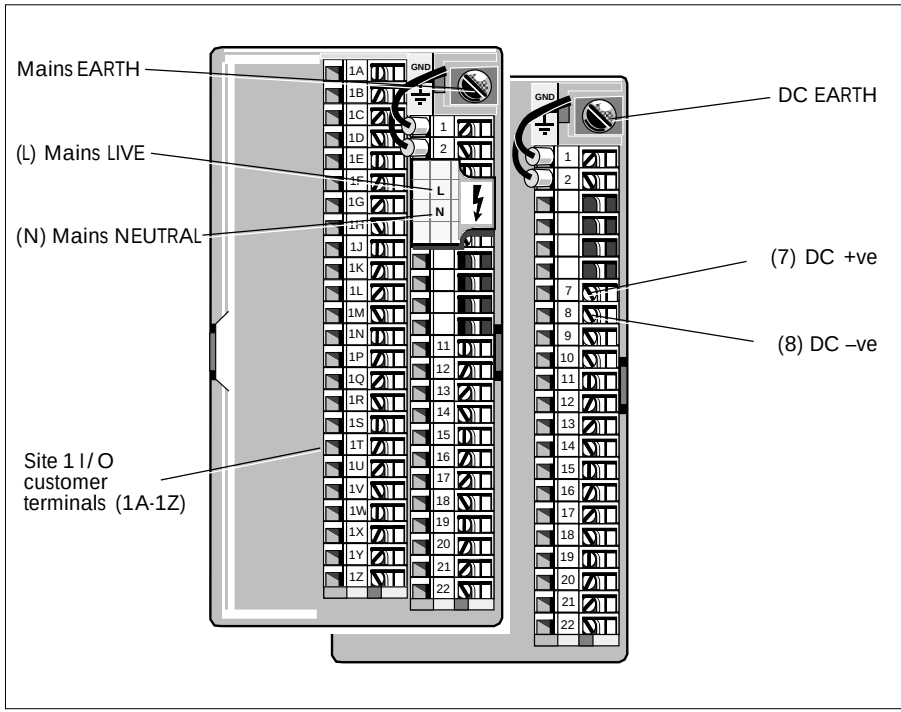


Figure 3-2 Customer terminals — MAINS (left) and DC (right) options

SWITCH SETTINGS

A bank of eight on-board switches must be configured for this tutorial. To access them you have to remove the T640 from its sleeve.

Removing the T640 from its sleeve

Caution

Handling precautions. Some of the circuit boards inside the T640 contain electrostatically sensitive components. To avoid damage, before you remove or handle any board ensure that you, the working area, and the board are electrostatically grounded. Handle boards only by their edges and do not touch the connectors.

Connector erosion. Repeated removal/replacement of the T640 under power erodes edge connectors. Check connectors periodically and replace a board if excessive burning or pitting is seen.

See Figure 3-3. To unlock the T640 insert a small screwdriver blade into the slot in the retaining clip at the bottom of the fascia and slide the clip to the left as far as it will go. Repeat this for the clip at the top of the fascia, but slide it to the right. To withdraw the unit use the extractor tool supplied in the accessory kit (Part No. BD 082253). Hold the tool at an angle of about 45°, insert the hook into the opening under the 'SP-W' pushbutton, then level the tool and pull the unit from the sleeve.

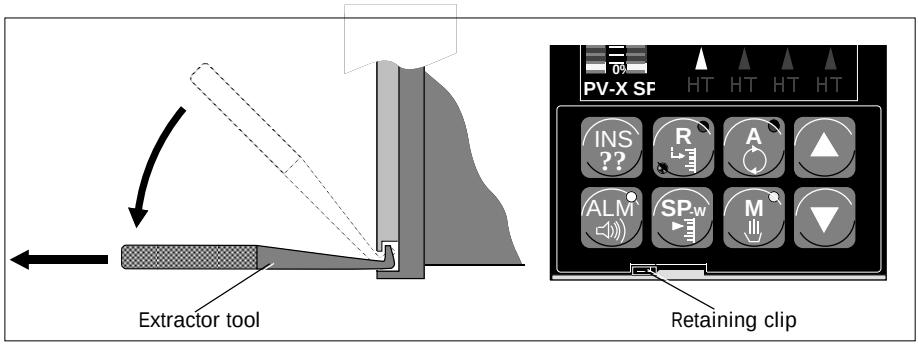


Figure 3-3 Removal of T640 from sleeve

Setting the switches

Figure 3-4 shows the location of switchbank 1 (SW1) on the T640 motherboard, and also SW1 in detail. Set the switches as shown. Note that for this tutorial the settings of the switchbank SW2 switches are 'don't care'.

Replace the unit in its sleeve. You are now ready to power up the T640, but before doing this you should be introduced to fixed-function strategy #1 — a single control loop.

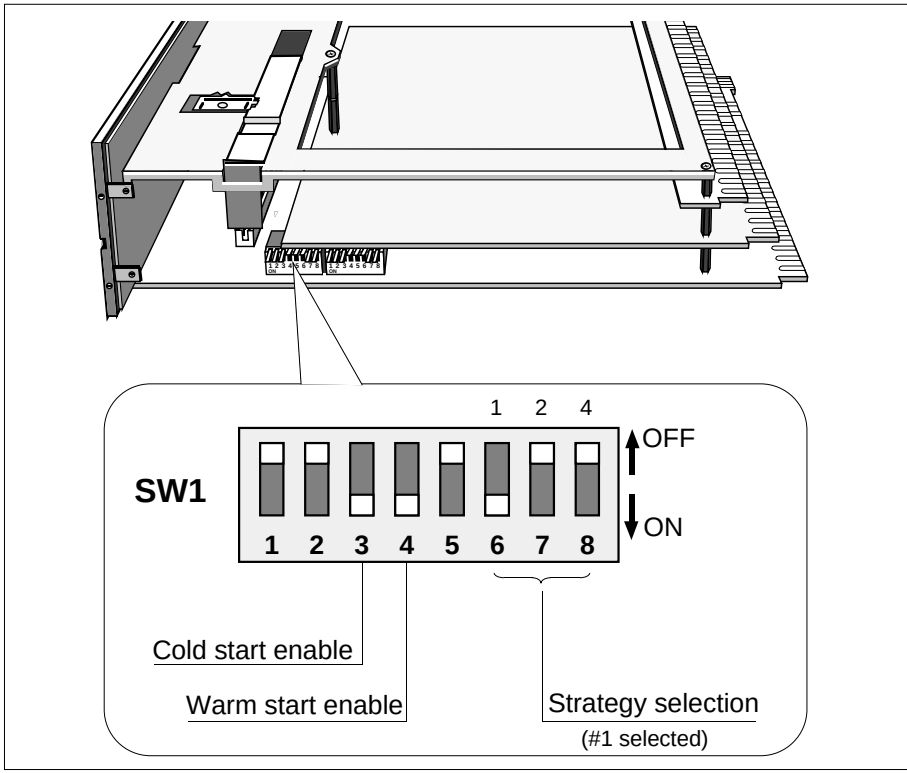


Figure 3-4 SW1 location and settings

STRATEGY #1 — SINGLE LOOP CONTROLLER

This simple strategy is a single loop controller using one 'I/O site', i.e. the column of terminals labelled 1A to 1Z. Figure 3-5 shows an example P & I (piping and instrumentation) diagram for the strategy, with the T640 connected to a flow-control valve and an orifice-plate flow sensor. The measured flow PV is input to the T640, where a PID (proportional-integral-derivative) calculation compares PV with the setpoint to produce a 3-term control output 3T OUT. This is fed to the valve controlling the flow.

Figure 3-6 shows the same control scheme but highlights very schematically the three main areas of software inside the T640 that are responsible for running the strategy. The 'PV input' software takes in the measured PV as an analogue voltage and applies ranging, conditioning, limiting, and alarms, before passing the signal to the 'PID control' area.

Here, the setpoint and PV are fed into the PID algorithm which calculates a value for the control output needed to be applied to the valve to achieve optimum flow control. Other operations done in the PID control area include ranging, limiting, alarm detection, control mode selection, manual intervention, and application of PID algorithm tuning constants.

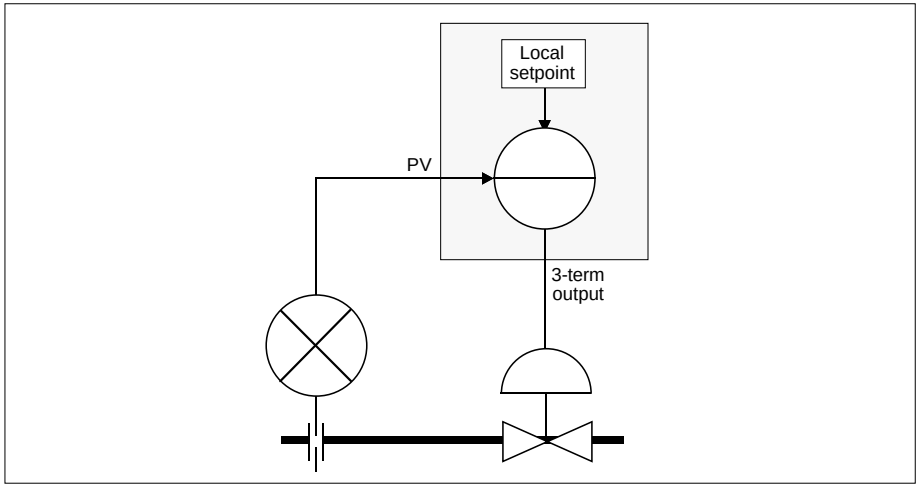


Figure 3-5 Example P & I diagram for strategy #1

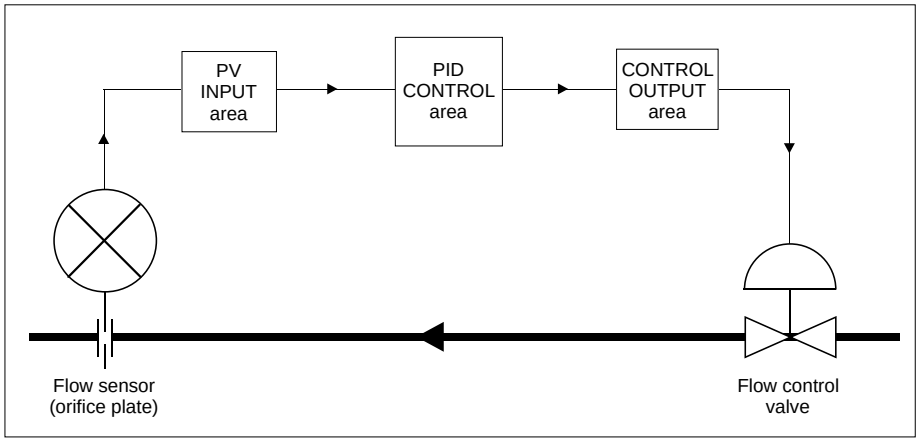


Figure 3-6 Main software areas — strategy #1

The last area — 'Control output' — handles output conditioning, ranging, power-up and failure modes.

This tutorial will show you how to access these software areas — via T640's front-panel buttons and displays — and configure their parameters to suit your particular plant control requirements.

POWER-UP

Power-up messages

Switch on the power to the instrument. You may be quick enough to see the message **Power-on** flashing briefly in the red *tag display* at the top of the fascia (see Figure 3-7). Then **ColdStrt Trying** flashes, telling you that T640 is attempting a 'cold startup' of the single loop database (strategy #1). Next, if the strategy is being loaded for the very first time, you will see **Un Pack Database** flashing in the tag display as the strategy #1 file (which you selected via SW1) is being decompressed from storage in ROM. You may also hear the clicking of a relay closing and opening just after these messages.

Finally, the fascia adopts the normal display shown in Figure 3-7.

NOTES. 1) Slightly different power-up messages may appear if someone else has used the T640 before you — e.g. **TepidSrt Trying** or **WarmStrt Trying**.

2) If what has just been described fails to happen and you get an error message (e.g. **Err 6001**), first check that you have set SW1 correctly. If necessary, refer to Chapter 10, *Error conditions & diagnostics*, for further information.

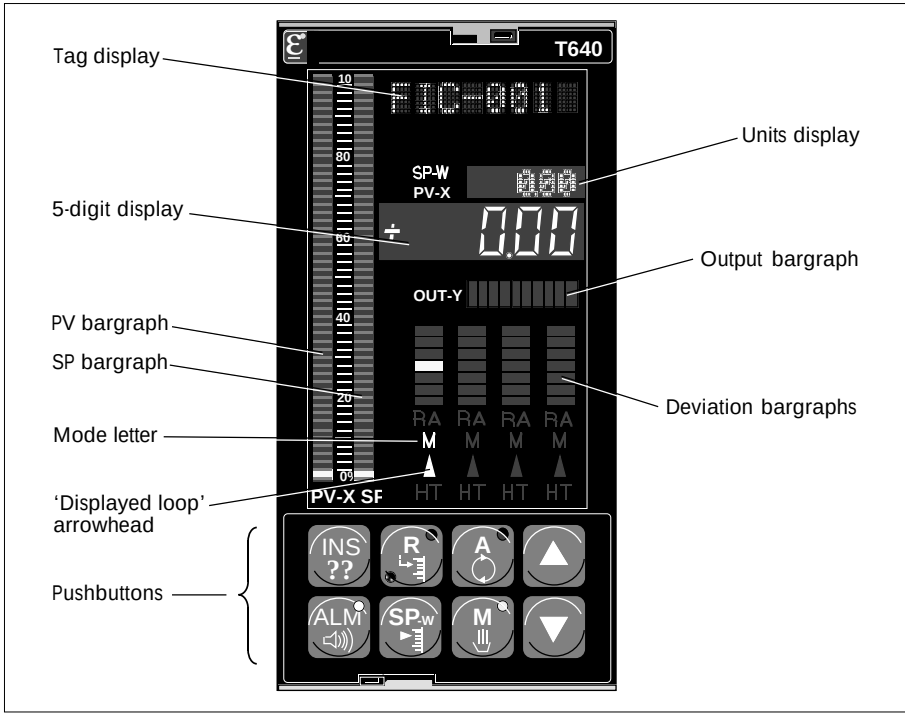


Figure 3-7 T640 front panel — initial power up

The initial display

Refer to Figure 3-7. **FIC-001** in the red tag display is the loop's 'tagname', appropriate to a flow controller. Note that you can select an alternative tagname if you wish — see Table 5-5 in Chapter 5 — but 'FIC-001' will do for this tutorial. The green **0.00** appearing in the *units display* — accompanied by the glowing green **SP-W** legend — shows the loop's setpoint (SP) value. The red *5-digit display* shows the current PV value (also **0.00**), accompanied by the glowing red **PV-X** legend.

The two *bargraphs* at the left of the fascia, sharing a 0-100% scale, also display PV and SP as red and green vertical bars, respectively. They presently indicate zero — only the bottom LEDs are lit.

Note the brownish-yellow letter **M** flashing above the green arrowhead just above the set of pushbuttons, together with the flashing yellow LED in the **M** (Manual) pushbutton. The brown letter M means that the loop displayed on the fascia is in Manual mode, and its flashing — together with the flashing button yellow LED — means that manual mode selection has been forced by an alarm condition.

Finally, note that the **ALM** (alarm) button shows a steadily-glowing red LED. This draws your attention to the fact that an alarm condition exists somewhere in the instrument.

INVESTIGATING THE ALARM CONDITION

Whenever the **ALM** button LED is lit you can quickly trace the source of the alarm as follows. (Figure 3-8 shows these how the **ALM** button works.)

1. Press **ALM** briefly. The tag display shows **LOOP 1**, and **LOOP** appears in the green units display. This tells you that the alarm is in Loop 1.
2. Press **ALM** again. The tag display shows **SETP1**, and **BLOCK** appears in the green units display. This localises the alarm condition to a specific area of the control database called a 'function block', the name of the block in this case being 'SETP1'. (Function blocks are explained in more detail below.)
3. To see if there are any other Loop 1 blocks in alarm, press the 'raise' ▲ button. The tag display now shows **PV__1**, indicating that a block called 'PV__1' is also in alarm.
4. Investigate the PV__1 block's alarm by pressing **ALM** again. The tag display shows **Hardware**, with **SubFd** showing in the units display. This tells you that the particular type of alarm involves the T640 hardware in some way, 'Hardware' being the name of the Alarm 'subfield' within the affected block. (Subfields are explained in the *Function blocks* section below.)
5. To see if there are any other alarms in the PV__1 block, press the 'lower' ▼ button. This changes the tag display to **OCctdel**, which indicates that an open circuit has been detected on the PV input. This is not surprising since you have not connected anything to the input terminals other than the power supply! Note that the hardware alarm you just saw is itself due to the open-circuit condition rather than to any other hardware fault, though this would not always be the case.

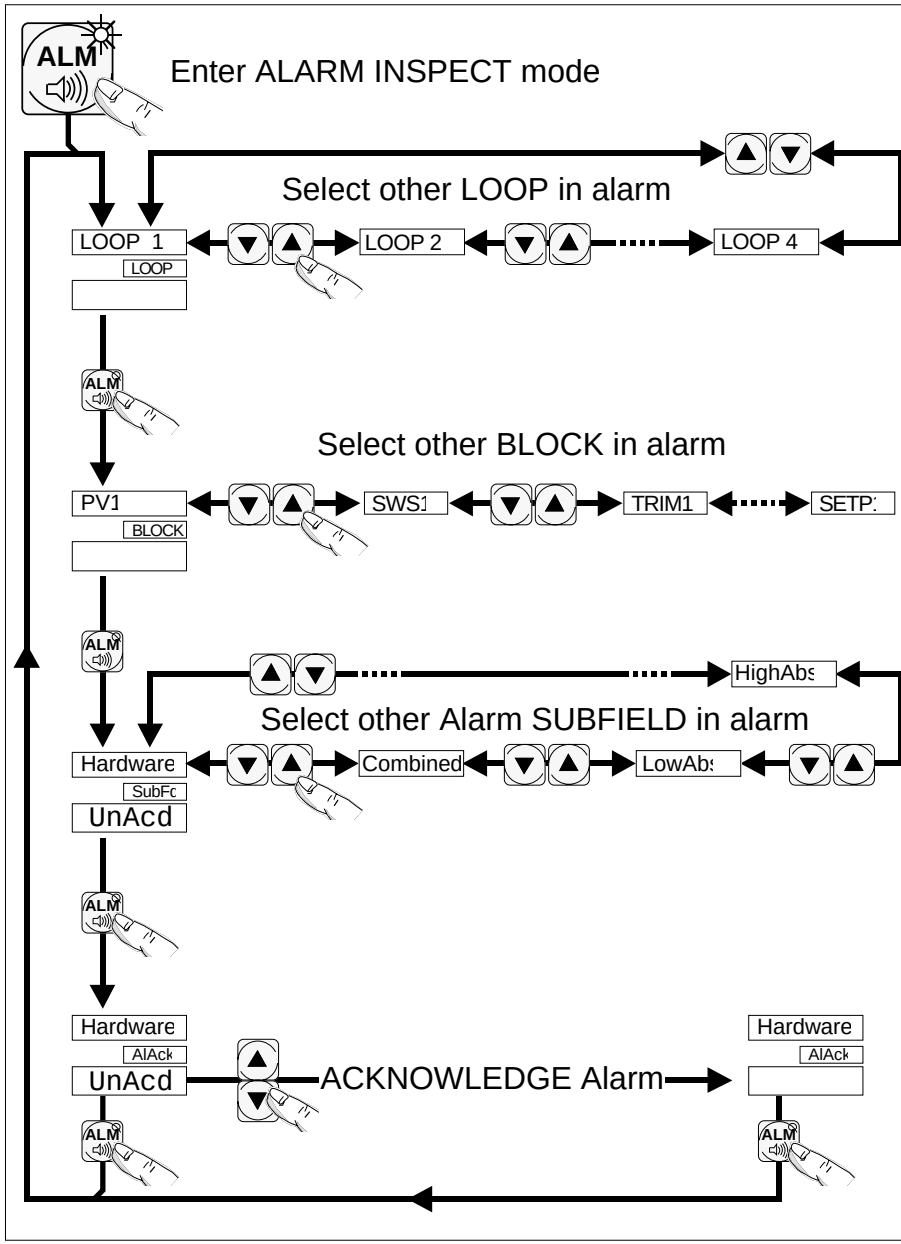


Figure 3-8 Alarm inspect button functions — ALM

6 Press ▼ again. **Combined** appears in the display. This is the 'combined' or 'common' alarm that is always asserted when any other alarm in a block trips.

7 Finally, escape from the 'alarm inspect mode' by briefly pressing any one of the **R**, **A**, **M**, or **SP-W** buttons. If you do nothing for two minutes a timeout will in any case operate to revert the fascia to its normal display automatically.

WATCHDOG RELAY

The clicking you may have heard when you powered up the T640 was due (in part) to the closing and opening of the *Watchdog relay*. The contacts of this relay are connected to customer terminals 16 and 17. The watchdog relay is normally closed when the T640 is running and its CPU is healthy. It opens on CPU or power failure, but has also been configured to open if an alarm occurs and remains open until the alarm condition has been cleared.

You can check this by connecting a multimeter set to measure resistance across terminals 16 and 17. These will be open circuit, indicating an alarm condition — the hardware alarm in the PV__1 block.

FUNCTION BLOCKS

Blocks

Figure 3-6 (on page 3-6) divided the control database into three broad areas. In fact, each of these areas is further subdivided into pre-defined packages of software, having defined and specialised functions in the running of the control strategy. These are the *function blocks*, or 'blocks' for short. Every block has a tagname for reference, and can perform its own specific task in the strategy, e.g. the block called PV__1 is an *analogue input* block type that takes in analogue signals from the plant, processes them, and passes the results on to other blocks in the strategy via 'wiring' between the blocks.

Other block types perform such tasks as setpoint generation, PID calculation, digital input, analogue output, mathematical and logical operations, and so on.

Fields & subfields

Each block includes a collection of database values — *fields* — some of which are subdivided into *subfields*. Note that in the four fixed-function strategies, all the necessary blocks have been installed and wired together for you — all you need do is set some of the block fields to specific values to tailor the strategy to your own plant requirements.

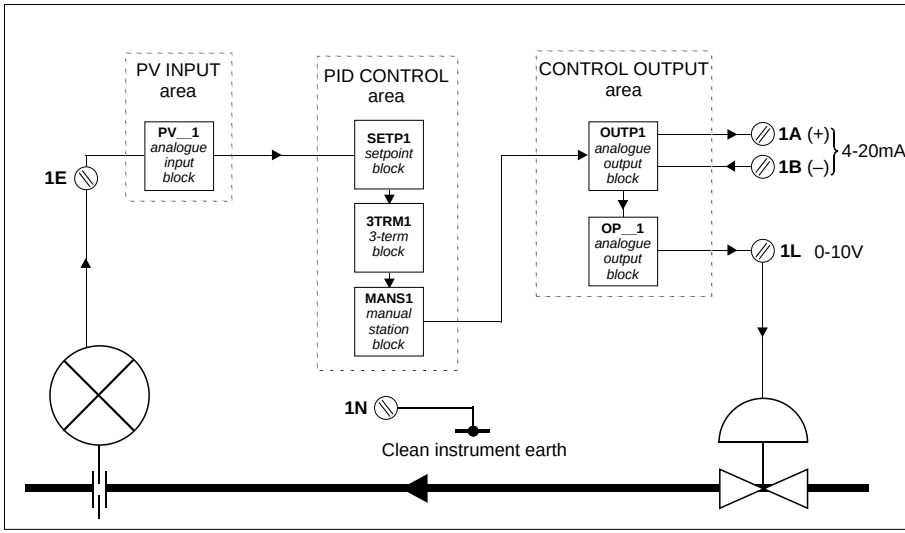


Figure 3-9 Strategy #1 schematic

Alarm fields

Alarm conditions are represented in each block by an **Alarms** data field. This field is further divided into subfields, which become TRUE when the corresponding alarm condition arises. It was these subfields that you just inspected via the ALM pushbutton.

Figure 3-9 shows strategy #1 in a little more detail, with some of the blocks named and their block types indicated. Also, some of the customer terminals are shown, where plant can be connected. You will need this information to progress with the tutorial.

Block functions

PV input area

As already stated, **PV__1** is an analogue input block that takes in a voltage signal from the plant (the orifice plate in this example) via terminal 1E. PV__1 ranges the input signal to engineering units, filters, characterises, and conditions it (e.g. applies square-root for an orifice plate signal). PV__1 also checks for alarm conditions including I/O hardware, out-of-range and open-circuit inputs. And as you have just seen, the block detected the fact that its input is in open-circuit.

PID control area

In the PID control area of the database, the **SETP1** (setpoint) block generates a resultant setpoint from the local setpoint you can enter via the front panel, and subjects it (and PV) to ranging, high/low limits, trim, rate limits, and also provides absolute and deviation alarms. The **3TRM1** (3-term) block generates a 3-term control output from PV and SP, and lets you alter the loop's tuning constants. The **MANS1** (manual station) block applies high and low limits to the control output.

Control output area

In the control output area, **OUTP1** is an analogue output block configured to provide an isolated 4-20mA control output to the plant, via T640's hardware. This is available on customer terminals 1A and 1B, as shown in the Figure. Also available — via another analogue output block **OP__1** configured to output volts — is a 0-10V control output on terminal 1L. (Any of terminals 1G, 1K, and 1N provide the analogue ground.) The 0-10V output follows the 4-20mA output. Figure 3-2 showed the I/O customer terminals 1A-1Z.

SIMULATING A FEEDBACK LOOP

Figure 3-9 shows that the 0-10V control output appears on terminal 1L — which could in a real plant be connected to a suitable control valve. The PV input from the orifice plate would be connected to terminal 1E for input to the PV__1 block. You can simulate this control loop by feeding the control output back to the PV input. Do this by simply connecting a wire between terminals 1L and 1E.

Note that within a few moments of connecting the wire the red **ALM** button light goes out (showing the alarm condition has cleared), the **M** button's yellow LED stops flashing (meaning that normal 'un-forced' manual mode now operates), and the watchdog relay closes (which you may see on the multimeter if still connected).

If you now press the **ALM** button, the message **NoAlm** appears in the tag display, meaning no detected alarm condition now exists in the instrument.

With the control loop complete, you can now investigate the strategy further.

DISPLAYING & ALTERING THE LOCAL SETPOINT

The resultant setpoint is currently 0.00 units, as shown in the green units display (see Figure 3-7). Alter this to about 50 units as follows:

1 Press the **SP-w** button to display the local setpoint (0.00) in the red 5-digit display.

With **SP-w** pressed, **SetLocal** appears in the tag display to remind you what is being displayed. The setpoint's units ('**Eng1**') are shown in the green units display.

2 Keeping **SP-w** pressed, hold down the ▲ button and watch the local setpoint value increase — slowly at first, then more and more rapidly. Raise it to about 50 units, then release both buttons. The new resultant setpoint shows in the green units display — it should equal the local setpoint you just configured. Also, the green SP vertical bargraph now displays the resultant setpoint in percentage units. (These happen to equal the engineering units, with the default ranges currently configured.)

Note the negative value now displayed by the Loop 1 deviation bargraph — i.e. the red LEDs are lit below the central green zero LED. Full-scale (all 3 segments lit) represents about 10% deviation (PV–SP).

3 Try lowering SP again to zero, by pressing **SP-w** and ▼ together. Note how the green units display shows **Limit** if you try to reduce SP below zero. This tells you that you have hit a configured low limit of 0.00 on the setpoint value. Similarly, you meet another limit if you try to raise SP above 100.00 units.

4 Finally, restore SP to about 50 units.

NOTE. While you have been varying SP, the PV value — as shown by the PV bargraph and the red 5-digit display — has remained at zero. This is because the control loop is still in manual mode and is therefore exerting no control action. Automatic mode will be looked at next.

SELECTING ANOTHER OPERATING MODE

Automatic mode

With SP still at about 50 units, press the **A** button to select automatic mode. Its green LED lights — confirming that auto mode has been adopted — and the **M** button's yellow LED goes out. As soon as auto is selected the control output begins to rise due to the action of the PID algorithm in the PID control area of the strategy.

NOTE. While **A** is pressed, **OUTPUT** appears in the tag display and the fascia shows the current control output value and its units (%).

You can see the control output displayed in the horizontal output bargraph, labelled **OUT-Y**. Each of its yellow segments represents about 10% of full range output.

The (simulated) PV value also rises, of course, and shows itself on the red **PV-X** vertical bargraph at the left of the fascia, and also in the 5-digit display. Once the controller has settled down in auto, PV and SP should adopt the same value in this simulation.

The deviation bargraph now shows zero deviation, with just the central green LED lit. The letter **A** glows in green below the deviation bargraph denoting automatic mode for this loop.

Manual mode

You can press the **M** button at any time to select manual mode. Note that pressing **M** also displays the control output value and units. But in manual mode you can alter the output, not just display it.

Try raising the control output to 100% by pressing **M** and at the same time pressing the ▲ button. You will see the PV and deviation bargraphs rise to their maximum indications. '**Limit**' appears in the green units display, because PV has reached its configured limit.

Remote mode

Pressing the **R** button cannot select remote mode in this simple loop simulation. Instead, the **A** button's green LED (and the letter **A** below the deviation bargraph) flashes indicating that 'forced automatic' mode has been adopted. This happens if you try to select remote when it has not been enabled, or if the remote setpoint is invalid. Control action is still exerted in this mode. If you don't want remote mode to be selectable you can disable ('mask') the **R** button. This is explained later under *Pushbutton masking* on page 3-24.

Press **A** to restore normal automatic mode.

POWER INTERRUPTIONS

Warm start

Remember when you powered up the T640 at the start of the tutorial you saw the message **ColdStrt Trying**, and the instrument performed a cold start. After a cold start the database is initialised and therefore in its default state. Remember also that you set the SW1 switches to enable both cold and warm starts. This enables the T640 to perform a warm start if possible. After a successful warm start the instrument resumes running the control strategy having remembered or regenerated all the database values as they were at the moment of power interruption. Try a warm start now:

1. Check that you have automatic mode selected, and a PV value other than the default of 0.00.
2. Switch off the power to the T640, either at source or by withdrawing the instrument from its sleeve.
3. Restore the power after a few minutes. The message **WarmStrt Trying** flashes in the tag display, and after a few moments the fascia adopts the state it had at power-down, i.e. a warm start has been performed.

Cold start

Now try interrupting the power with the warm start enable switch OFF:

1. Access the interior of the T640 and set SW1 switch 4 to OFF — but leave switch 3 ON.
2. Re-insert the T640 in its sleeve to restore power. A cold start is performed, and the strategy starts in its default state, having 'forgotten' your modifications to it.

Tepid start

A 'tepid' start is a type of warm start, but not quite as good because only some of the database values are restored at power up — including local setpoints, control outputs, and operating modes. Tepid starts occur when the RAM database has been corrupted; it's possible that you may have seen one when you powered up the T640 at the start of this tutorial.

(For more information please refer to Chapter 2, under *Power up routine*.)

INSPECTING & EDITING THE DATABASE

Using INS

This section of the tutorial shows you how to inspect and modify parts of the database to tailor the strategy to your particular needs. The first thing you will look at is ranging the setpoint and process variable engineering units. After that you will go on to apply high and low limits to the local setpoint (SL), and then configure absolute and deviation alarms on PV. Finally in this section, you will set up a new decimal point position for the front-panel display.

The function block concerned with this part of the control strategy is the **SETP1** (setpoint) block, which was shown in Figure 3-9 in the 'PID control area' of the database. To carry out modifications you must access the relevant fields inside the SETP1 block. To do this you use the **INS** ('inspect') pushbutton on the front panel.

Table 3-1 lists each of the configurable fields within the SETP1 block, together with its default value, target setting, and a brief description of its function in the strategy. This list will be useful when you are navigating around the fields to configure them. Note that a complete list of blocks and fields for each of the fixed-function strategies is given in the setup sheet included in this manual (at the end of Chapter 5).

Block	Field	Subfield	Default	Setting	Description
SETP1	HR_SP		100.00	75.00	Engineering unitshigh for SP and PV
	LR_SP		0.00		Engineering units low for SP and PV
	HL_SP		100.00		High limit on SP
	LL_SP		0.00		Low limit on SP
	HL_SL		100.00	60.00	High limit on SL
	LL_SL		0.00		Low limit on SL
	Alarms	HighAbs	2		Alarm priority on HAA
		LowAbs	2		Alarm priority on LAA
		HighDev	2		Alarm priority on HDA
		LowDev	2		Alarm priority on LDA
	HAA		100.00	70.00	High absolute alarm on PV
	LAA		0.00	30.00	Low absolute alarm on PV
	HDA		100.00	10.00	High deviation alarm on PV
	LDA		100.00	10.00	Low deviation alarm on PV
	Dis_DP		2	3	Decimal point position

Table 3-1 Configurable fields in the SETP1 (setpoint) block

Configuring ranges and limits

Figure 3-10 shows how the **INS** button works.

1 Press the **INS** button briefly. **LOOP 1** appears in the tag display — this is the loop ready to be inspected, and it is the loop that contains the SETP1 block. The green units display shows **LOOP** (meaning 'loop access mode').

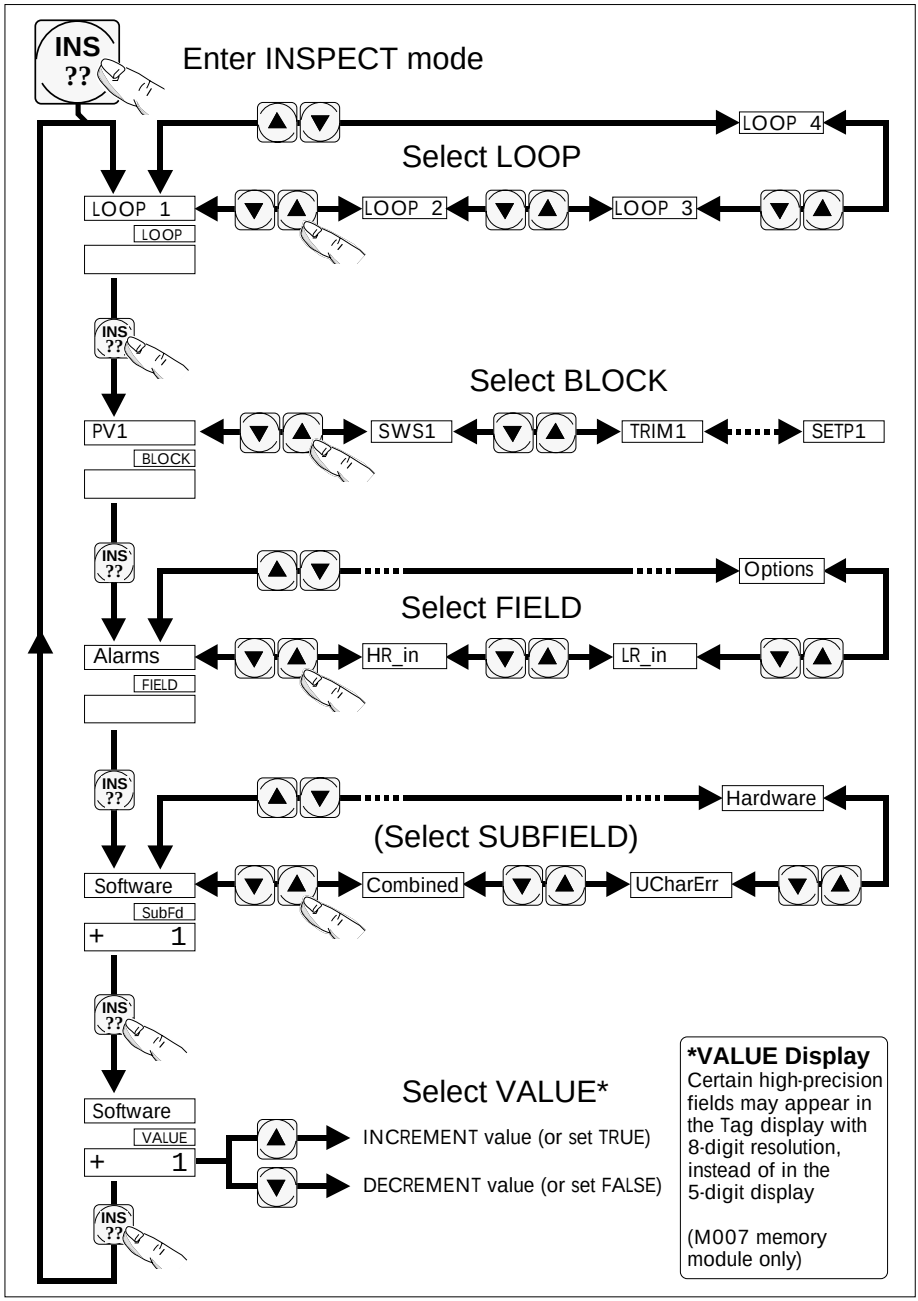


Figure 3-10 Inspect button functions — INS

NOTE. If you now press either ▲ or ▼ you will see another 'loop' — **LOOP 4** — in the tag display. Loop 4 is not actually a *control* loop, but is a second independently-running section of the database ('user task 4') that you can access via the **INS** button. Loop 4 contains, among other items, configuration data on T640 communications, which do not concern us here.

2 With **LOOP 1** in the display, press **INS** again. The units display changes to **BLOCK**, denoting 'block access mode', and the tag display now shows the name of the first block in the Loop 1 (i.e. 'User task 1') area of the database. This block may or may not be the one you want (**SETP1**) depending on how the T640's memory module has been programmed at the factory.

3 In any case, now press the ▼ button to move down to the next block in Loop 1 and see its name in the tag display.

4 Press ▼ again repeatedly to see all the blocks in Loop 1 that you can access for inspection or modification. There are 13 altogether. Use ▲ to move up the list again, if you go past the block you require. Access the **SETP1** block.

5 With **SETP1** in the tag display, press **INS** again. This gets you into 'field access mode' as shown by **FIELD** in the units display. The tag display now shows the first accessible field in the SETP1 block, which is called **HR_SP**. This field stores the high range in engineering units for SP and PV. Its current (default) value is shown in the red 5-digit display as **+100.00**. In the next step you will alter this value, but before doing this try accessing the other fields in the SETP1 block using the ▲ and ▼ buttons to move around the list. There are 12 fields in all (see Table 3-1). Get back to HR_SP for the next step.

6 With the HR_SP field selected, press **INS** again. **VALUE** appears in the units display, telling you that you can update the field value. Press ▲ to raise the value, or ▼ to lower it, to the one you require (subject to any configured limits). For this tutorial, lower the high range to 75.000 engineering units.

7 You now want to move on to the HL_SL field in the block, which specifies a high limit value for the local setpoint SL. Press **INS** three times to return to 'field access mode' with HR_SP still accessed (T640 has remembered your selections). Then press ▼ once to access **LR_SP** (which you will leave at zero) and then three more times to reach **HL_SL**. Adjust this to 60.000 by pressing **INS** to get into 'value update mode' as before, then use ▲ or ▼ as needed. Then return to field access mode by pressing **INS** three times.

Configuring absolute and deviation alarms

In this stage of the tutorial you set new values for the high and low absolute and deviation alarms.

1. Access the **HAA** field in the SETP1 block, as before. (If you've forgotten how to do this, have a look at the previous section again to remind yourself!). **HAA** specifies the high absolute alarm limit on PV, i.e. the PV value which if exceeded trips the high absolute alarm (which you will inspect soon). Its default value is 100.00. Press **INS** to access value update mode and lower the HAA value to 70.000 units. Press **INS** three times to return to field access mode.
2. In the same way, set **LAA** (low absolute PV alarm) to 30.000, and set **HDA** & **LDA** (high and low deviation alarms, respectively) to 10.000 each.

Configuring the decimal point

1. Access the **Dis_DP** field, which stores the decimal point position used in the 5-digit and the units displays. To do this quickly you can, once into field access mode, just press the ▲ button once to get you directly to the end of the field list, which is cyclic.
2. Set **Dis_DP** to 3 (decimal places), then press **A** to return to the normal display and see the effect of this change.

Alarm subfields

In this next stage of the tutorial you inspect the subfields of the **Alarms** field in the SETP1 block. To do this:

1. Use the **INS** button as before to access the **Alarms** field in the SETP1 block.
2. Press **INS** again. This time, instead of entering 'value update mode' you see **SubFd** in the green units display, denoting 'subfield access mode'. This is because the Alarms field consists of a set of *subfields*, unlike the range and limit fields you have met so far. The first subfield accessed is shown in the tag display — **Software** — and its current value appears in the 5-digit display — **1**. This is the *priority* of the Software alarm, which you should not alter at this stage. (You would alter it in the same way as described above, using the **INS** and ▲/▼ buttons.)
3. Still in subfield access mode, press ▼ to move to the next subfield in the Alarms field — **HighAbs**. This is the PV high absolute alarm, which trips if PV exceeds the high limit (specified in the **HAA** parameter). Its priority of 2 should be left as is.
4. Go on to inspect the rest of the Alarm subfields in the same way. Finally return to the normal fascia display by pressing the **A** button. You may have noticed that if you do nothing for two minutes a timeout operates automatically to escape from 'inspect mode'.

EFFECT OF THE ALARM SETTINGS AND LIMITS ON THE FRONT-PANEL DISPLAYS

You can see the effects on the fascia displays of the limits and alarm levels just configured. Start by setting SP to about 50 units with the loop in auto. Let the displays settle.

Inspecting absolute and deviation alarm settings

1. To see these values directly on the PV-X and SP-W bargraphs, press and hold down ▲ and ▼ together. **ALM_SET** ('alarm settings') appears on the tag display. On the PV bargraph the upper and lower limits (HAA and LAA) appear as a pair of reverse-lit segments superimposed on the bar. This display lets you see immediately where PV is in relation to the limits. At the same time the high and low deviation limits (HDA and LDA) are superimposed on the SP bargraph as reverse-lit segments. These mark the levels above and below the current SP-value, which move up and down with it. If PV goes outside these levels a deviation alarm trips.

Effect of local setpoint limit

The setpoint limit you set up (in HL_SL) shows itself when you try to adjust the local setpoint:

1. Raise the setpoint as far as possible by pressing **SP-w** together with ▲. When the value reaches 60.000, **Limit** appears in the units display.

Annunciation of absolute and deviation alarms

Produce alarm conditions and see the effects on the displays:

1. Lower the setpoint (from 60) to about 20 engineering units. The green **SP-W** bargraph starts to flash as soon as the setpoint has fallen far enough to trip the high deviation alarm. At the same time the deviation bargraph also flashes, and the **ALM** button light comes on. Shortly after this, when PV has fallen below its low limit (in LAA), the **PV-X** bargraph starts flashing to warn you that the low absolute alarm has tripped.

   NOTE. You may also have heard the watchdog relay click open, which it is configured to do by any priority 2 alarm.

2. After a while, when the fascia has settled and control has been regained (PV = SP), only the low absolute alarm remains. Trace this alarm via the **ALM** button. You should find **LowAbs** (and **Combined**) alarms in the SETP1 block.
3. Finally, restore the setpoint to about 50 units to clear all alarms.

INSPECTING & EDITING THE PV INPUT AREA

This section gives you some more practice at using the **INS** button to access the fields in the **PV__1** (analogue input) block. Remember, PV__1 takes in and conditions the signal from the orifice plate (in this example). Specifically, you will inspect and edit the input filter time constant, and apply a square root function to the signal from the orifice plate. Table 3-2 lists the PV__1 block's configurable fields and target settings.

Block	Field	Subfield	Default	Setting	Description
PV__1	Filter		1.00	2.00	Input filter
	RomChar		None		Input conditioning
	Alarms	Hardware	2		Alarm priority
		OutRange	2		Alarm priority
		OCctdel	2		Alarm priority
	HR_in		10.00		Input voltage high
	LR_in		0.00		Input voltage low
	Options	Invert	FALSE		Input conditioning
		Sqrt	FALSE	TRUE	Input conditioning

Table 3-2 Configurable fields in the PV__1 (analogue input) block

Start this section with the T640 set up as at the end of the previous section.

1. Press **INS** twice to access block inspect mode, then press ▼ (if needed) to bring up the PV__1 block.
2. Press **INS** again to access the first field in the PV__1 block — **Filter**.
3. Press **INS** again, then increase the value of the filter time to 2.00 (seconds) using the ▲ and ▼ buttons.
4. Press **INS** three times to return to field inspect mode.
5. Access the **RomChar** field and inspect its contents by pressing **INS** again (to access VALUE mode) and using ▲/▼. As you edit the ROM-based characterisation functions stored in the RomChar field you may notice the front-panel displays altering to re-establish control under the new conditions you are creating! Return the RomChar value to **None** (the default) before continuing.
6. Access the **Options** field in the usual way. This field lets you apply an inversion to the input signal, and/or a square root function.
7. Press **INS** to see the Options subfields. The first is **Invert** which is **FALSE** by default — i.e. no inversion.
8. Press ▼ to move to the second subfield — **Sqrt** (square root).
9. Press **INS** again and set the value to **tru** (TRUE) using ▲. (▼ restores **FALSE**.) You will see the front panel respond as PV changes value.
10. Finally, press the **A** button to return to the normal display.

SAVING A DATABASE

Now that you have reconfigured several of the fields in the control strategy you will want to save it to EEPROM, where it will be safe and effectively permanent. At the moment your customised strategy exists only in RAM, which although battery-backed in the T640 is inherently a volatile memory medium.

To save your database currently in RAM you must access a function block called **T60_00**. (The last two digits are the *node number*, and may differ from '**00**'. Ignore this in the tutorial!) This block contains a field called **Options**. Within Options is a subfield called **FullSave**. You set this TRUE to activate the save to EEPROM.

1. Press **INS** to access loop inspect mode.
2. Press ▲ or ▼ to move to **LOOP 4**, which is the user task containing the T60_00 block.
3. Press **INS** again to inspect the blocks in Loop 4. The first one is **USR_ALM**, which stores the alarm priority needed to trip the watchdog alarm relay (currently set at 2).
4. Move to the next block — **T60_00** — and press **INS** to see the **Options** field, which is the only accessible field in this block.
5. Press **INS** again to see the Options subfields, and move down the list until you reach **FullSave**.
6. Press **INS** and set the value to **tru** by pressing ▲. The message **SAVING . .** appears in the tag display as the save is executed, and the value of the subfield automatically returns to **FALSE**. After a few moments the tag display reports **Save OK**. Press **A** to return to normal mode.

Saved databases

Your customised database is now safely stored in EEPROM — under the same filename that the original default database had. But note that the original fixed-function default strategies will always reside in ROM and could be made to overwrite your customised strategy!

To avoid this, if you intend to keep a customised strategy in EEPROM, **do not reset the SW1 strategy-select switches (switches 6, 7, and 8 in Figure 3-4)**. If you do, there is a risk that at power-up a new strategy will replace your customised one in EEPROM.

It is OK to power up with the switches set to the *original* strategy that you subsequently customised (#1 in this case). This is because when the T640 sees that the EEPROM already contains the strategy indicated by the switches, it loads it directly from EEPROM to RAM and runs it *without* 'unpacking' (decompressing) a default database from ROM.

You can test the effect of your save as follows:

1. Remove the T640 from its sleeve and set the warm start enable switch to OFF. (Leave the cold start enable switch at ON, and the strategy-select switches at #1.) Figure 3-4 shows the required SW1 switches. This action now ensures that the T640 cannot do a warm start, only a cold start.

2 Power up again by replacing the T640 in its sleeve. You will see a cold start performed but all your saved field values are preserved in your customised strategy. Check this using **INS**.

3 Finally, return the warm start enable switch to ON.

INVESTIGATING THE LOOP SETUP 'SWITCHES'

There is a set of 16 'software switches' or bits within a block called **SWS_1**, in the PID control area of the strategy. You can use them to specify the way the control loop operates. The SWS_1 bits select such things as the T640 power-up mode, inversion of control output action, on/off control action, pushbutton disabling ('masking'), and the tagname that appears in the loop's tag display. Table 3-3 lists the SWS_1 bitfields.

Try switching some of these bits from their default states (all but one are FALSE) to see how they affect the control action.

Power-up/power-fail mode

1 Press **INS** twice to access block inspect mode, then press ▼ as required to bring up the **SWS_1** block.

2 Press **INS** again to see the only accessible field in the SWS_1 block — **W Field1**. This consists of 16 subfields called **Bit0** to **BitF** (hexadecimal 'F' is decimal '15').

3 Press **INS** again, to access **Bit0**. Table 3-3 tells you that this bit selects the power-up mode. Remember that power-up occurs after unexpected power interruptions — not just when you switch on the T640. TRUE causes the loop to adopt manual mode on power-up with zero electrical output for safety — i.e. 0V or 4mA. FALSE (the default) causes the loop to maintain its last mode and output value on power-up.

Block	Field	Subfield	Default	Setting	Description
SWS_1	W Field1	Bit0	FALSE	tru	Power up mode
		Bit1	FALSE		PV fail mode
		Bit2	FALSE		tru - inverse output action
		Bit3	FALSE		tru - inverse PID
		Bit4	FALSE	tru	tru - On/Off control
		Bit5	FALSE		tru - setpoint tracks PV if not AUTO
		Bit6	FALSE		tru - PV/SP Out = SP
		Bit7	FALSE		tru - inverse ratio setting
		Bit8	FALSE		tru - Mask R
		Bit9	FALSE		tru - Mask A
		BitA	FALSE		tru - Mask M
		BitB	tru		Tag FIC-001
		BitC	FALSE		Tag LIC-001
		BitD	FALSE		Tag PIC-001 } If all bits FALSE, tag is **LOOP 1**
		BitE	FALSE		Tag TIC-001
		BitF	FALSE		Tag AIC-001

Table 3-3 Configurable fields in the SWS_1 (digital connection) block

4 Press **INS** and alter Bit0's value to **tru**, then return to the normal display by pressing **A**.

5 Now simulate a power interruption by switching the power off then on, and watch the front panel displays. The T640 powers up in manual mode, and the control output falls to zero. Check this by pressing the **M** button and reading the 5-digit display, which should indicate **0.00%** output. Restore control by re-selecting auto mode (press **A**). Restore Bit0 to FALSE.

PV fail mode

1 Use the **INS** button to access **Bit1** of the SWS_1 block. This bit determines what happens to the control output should the process variable input PV fail. In Bit1's default state (FALSE), the control output holds at its last value on PV failure. With Bit1 TRUE, however, the output falls to electrical zero (i.e. 0V or 4mA) on PV fail.

2 Set Bit1 to **tru** and press **A** to return to automatic mode. While **A** is pressed, note the control output value in the 5-digit display.

3 Now simulate a PV failure by disconnecting the wire attached to terminal 1E. Notice that the control loop adopts 'forced manual' mode — indicated by the flashing yellow LED in the **M** button, and that the control output drops immediately to zero. (Press **M** to check this.)

4 Reconnect terminal 1E and press **A** to restore control.

5 Reset Bit1 to **FALSE**, return to auto mode, then repeat the PV fail simulation. This time the control output holds at its current value despite the loss of PV and adoption of forced manual mode.

6 Finally, reconnect PV, press **A**, and allow equilibrium to return.

On/off control

1 Use the **INS** button to access **Bit4** of the SWS_1 block. This bit selects on/off control action (TRUE) or normal continuous control action (FALSE). With on/off action the control output is either at 0% or 100% of range, with nothing in between.

2 Set Bit4 to **tru** and watch the chaos on the front panel as the simulated PV oscillates above and below the setpoint trying to attain equilibrium! Restore Bit4 to FALSE.

NOTE. With a suitable *Deadband* value selected (via the **3TRM1** block), on/off control can be applied successfully in appropriate plant situations.

Tracking of PV by the setpoint

1 Access **Bit5** of the SWS_1 block. When TRUE, this bit forces the local setpoint to track (i.e. follow) the process variable PV whenever the controller is not in automatic mode. (It may be safer for SL to keep equal to PV in the event of a loss of control, so that when control is eventually restored and auto mode resumed, there will not be a sudden and possibly damaging change in control output value.)

2. Set Bit5 to **tru** and return to the normal display in auto mode (press **A**).
3. Now select manual mode by pressing the **M** button, then attempt to change the local setpoint by pressing **SP-w** together with either ▲ or ▼. You won't be able to!
4. Get back to auto mode and try again. Alter the setpoint to be as far as possible from the current PV-value — e.g. to zero — then quickly switch back to manual mode. Note how the setpoint rapidly equalises with PV.
5. Now raise the control output, by pressing **M** and ▲ together. Remember that in this simulation the output is being used as a PV input, so you are also raising PV. Notice how the green SP bargraph tracks the rising red PV bargraph, *but not further than the limit you configured earlier*.

Pushbutton masking

This may be necessary if you want to prevent an operator selecting a particular mode via the front-panel pushbuttons. Note that button-masking does not prevent modes being changed by other means, e.g. automatically during a failure mode, or over the comms network. When TRUE, **Bit8**, **Bit9**, and **BitA** disable the **R**(emote), **A**(uto), and **M**(anual) mode select pushbuttons, respectively.

1. Access the **Bit9** subfield of the SWS_1 block, and alter its value to **tru**. Return to the normal display by pressing **M**.
2. Now try to select auto by pressing **A**. You will not succeed, and the message **MASKED** appears in the tag display for about 3 seconds to tell you why.

   NOTE. You may have seen the **MASKED** message at the start of this tutorial if you pressed **R** or **A** before you connected the piece of wire to close the control loop. These buttons are automatically masked in this strategy as a safety precaution in certain alarm conditions.

3. Restore Bit9 to FALSE.

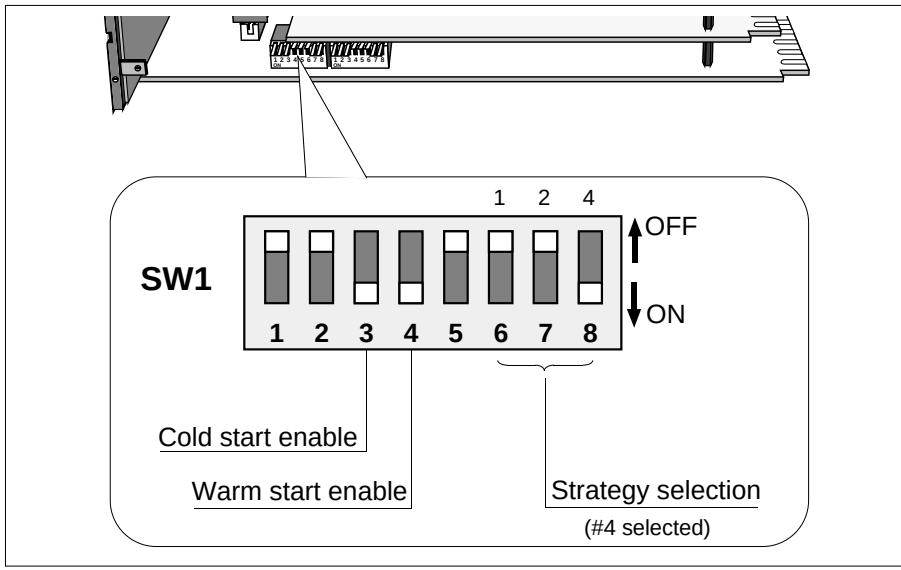


Figure 3-11 SW1 location and settings — strategy #4

HANDLING MORE THAN ONE CONTROL LOOP

You have nearly completed this tutorial, which has used as its example strategy #1 — a single control loop. When there are two, three, or four control loops in a strategy the front-panel display is able to show you a summary of the status of all the loops at once, together with a more detailed display of one selected loop.

To see how this works in practice, load strategy #4, which has three control loops in it.

1 Withdraw the T640 from its sleeve and set the strategy select switches to #4. Figure 3-11 shows the required SW1 switch positions.

2 Replace the T640 in its sleeve to power it up. After the initial database unpacking, strategy #4 starts to run, and you now see three deviation bargraph displays illuminated, instead of just one, each applying to one of the control loops.
Under one of the deviation bargraphs will be the green arrowhead; this identifies the loop currently selected to occupy the main fascia displays. Its loop tagname is displayed in the tag display at the top of the fascia, and the rest of the displays refer only to this selected loop.

3 Select a different loop for main display by holding down ▲ or ▼ to cycle around the available loops. Let go when the required loop is indicated by the green arrowhead. The main display now applies to your selected loop, whose tagname appears in the tag display.

4 Try altering a variable of the current loop, e.g. raise its setpoint (by pressing **SP-w** and ▲ together). Note that the front-panel buttons also work only on the currently-selected loop. This applies also to the **ALM** and **INS** pushbuttons.

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Chapter 4 USER INTERFACE

This chapter describes how to use the T640 front-panel pushbuttons and displays to carry out all the basic operations. The front-panel can also indicates failure states; please refer to Chapter 10, *Error conditions & diagnostics*, for details. The present chapter concentrates on the normal running of the T640.

Figure 4-1 shows the front panel, with a typical display.

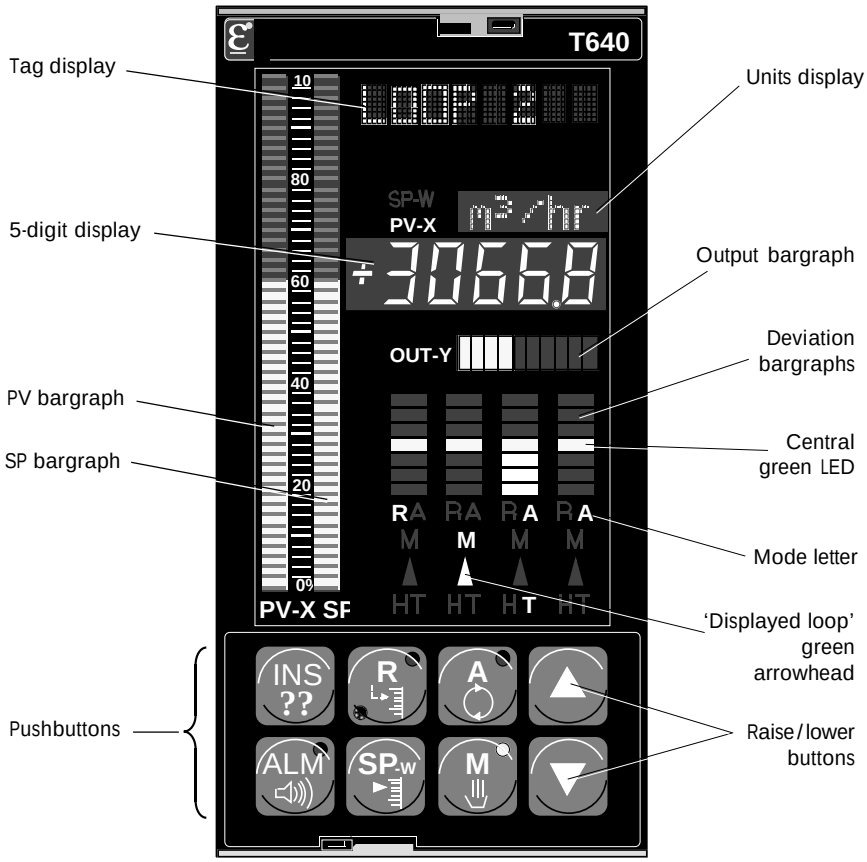


Figure 4-1 T640 front panel — the operator interface

OPERATOR DISPLAYS & CONTROLS

Summary loop displays

Figure 4-1 shows the front panel. Four summary displays show red deviation bargraphs of T640's four loops — Loops 1 to 4 from left to right. *DevnBar*, in the SETPOINT block, specifies the bargraph span as ±3, ±10 (default), or ±30% deviation. PV can be displayed instead, to 100% of range, if *DevnBar* = Abs_PV. The central green LED glows if the bargraph is showing deviation; the bottom red LED glows if PV is being displayed. A flashing bargraph means the loop is in absolute or deviation alarm.

Operating mode letters glow to show selected modes for each loop: **R** = Remote, **A** = Auto, **M** = Manual, **T** = Track, **H** = Hold). Flashing signifies a 'forced' mode. A totally blank loop summary display and inaccessible main display mean the loop contains no configured blocks, or the related T600 block *FPdisn* parameter is TRUE.

Main loop display

This details the status of one of the four loops, indicated by a green arrowhead under the related summary bargraph. To select a loop for main display, hold down a raise ▲ or lower ▼ button. If a loop's MODE block *SelDisp* parameter is TRUE it will always occupy the main display and cannot be deselected. The following features apply only to the loop selected for main display.

Tag display

This red display normally shows the TAG block's *TAG* field. With no TAG block, the PID/PID_CONN block name, or SETPOINT block name, or the default **LOOP *n*** message appears. Special displays can override the normal display, as described in later sections.

PV-X bargraph display

Red display normally showing the SETPOINT (or PID) block's *PV* value in 2% steps.

SP-W bargraph display

Green display normally showing the SETPOINT (or PID) block's *SP* value in 2% steps.

5-digit display

Red display normally showing the *PV* value of the SETPOINT (or PID) block in engineering units. The **PV-X** legend (see Figure 4-1) glows red only when *PV* is being displayed.

Units display

Green display normally showing the engineering units associated with the 5-digit display. It can also show the SETPOINT block's *SP* value (*Show_SP* TRUE). In this case the **SP-W** legend glows green.

NOTE. Pressing ▲ or ▼ displays units in this case.

Output bargraph

Yellow display normally showing the loop's control output, i.e. the MAN_STAT block's *MeasPos* value, or its *OP* value if *MPosDisp* is FALSE, or if absent the PID block's *OP* value. All segments lit represents 95% of full range. Note that each bargraph segment can also be driven individually via the MAN_STAT block's *UserBar* parameter.

Mode changes

You interact with the main display loop via the eight front-panel pushbuttons. Press **M**(anual), **A**(uto) or **R**(emote) to select the related mode — strategy permitting. The button's top-right LED glows if the mode is adopted; both **R** LEDs glow green in 'computer remote' mode. A flashing LED signifies a 'forced' mode. If a mode button is inhibited (by the MODE block's *PBmasks* parameter, or by a *SelMode* bit), the tag display is overridden by the word **MASKED** for 3 seconds and no mode-change occurs.

Output display

Holding down a mode button also displays the current value of the control output in the 5-digit display and its units in the units display. The word **OUTPUT** or **MeasPos** appears in the tag display (with **A** or **R** pressed), or **MS_Dmnd** (with **M** pressed). For the simple PID block only **OUTPUT** appears.

Changing the output

With **M** pressed and the controller in Manual, press ▲ or ▼ to vary the value of the MAN_STAT block's *Demand* field (or the PID block's *OP* field). Full-range change takes about 12 seconds.

Output parameters — quick access

With any of **M**, **A**, or **R** pressed, press **INS** (Inspect) repeatedly to scroll the 5-digit display through the MAN_STAT block's primary output parameter values.

These are: *OP* (OUTPUT), *Demand* (MS_Dmnd), *MeasPos* (MeasPos), *PV* (MS_Input), and *Track* (MS_Track), identified in the tag display. Only *OP* and *Track* are available from simple PID blocks.

Setpoint display

Press **SP-W** to display the SETPOINT (or PID) block's *SL* value in the 5-digit display. When in Remote mode the corresponding remote setpoint is seen. With **SP-W** pressed, **SetLocal** or **RemoteSP** appears in the tag display.

Changing the setpoint

To vary the value of *SL*, press **SP-W** together with ▲ or ▼. Full-range change takes about 30 seconds.

Setpoint parameters — quick access

With **SP-W** pressed, press **INS** repeatedly to scroll the 5-digit display through the primary setpoint parameter values. These are: *SL* (SetLocal), *SP* (SetPoint), *RemoteSP*, *ComRemSP*, and *TrimSP*, identified in the tag display. *ComRemSP* is not available from simple PID blocks.

Absolute & deviation alarm settings — viewing

Press ▲ and ▼ together to superimpose the absolute alarm settings on the PV-X bargraph, and the deviation alarm settings on the SP-W bargraph, as pairs of reverse-lit LEDs. The tag display shows **ALM_SET**.

Absolute & deviation alarm annunciation

For the main loop on the display, an absolute alarm flashes the red PV-X bargraph and a deviation alarm flashes the green SP-W bargraph. For the four summary loop displays, either alarm flashes the relevant summary deviation bargraph.

DATABASE ACCESS

The **INS** button lets you inspect and edit database parameters. Two access modes are available — 'Full' and 'Partial' — requiring a 'Full' or 'Partial' security key (unless the need for a key is overridden in the T600 block). If necessary, refer to the *Security key* section at the end of this chapter for how to use the key.

Both modes work in the same way, but Partial mode can access only a limited set of blocks and fields. Parameter changes during database access are automatically logged by the T640 in a special EEPROM file — see Chapter 6, *Changes logfile*.

To access the current database, press **INS** repeatedly as required to cycle through the following hierarchy of database access modes; the green units display shows the access level reached.

Figure 4-2 shows how the **INS** button works.

1 Loop Access mode

The first **INS** press selects this mode, and **LOOP** appears in the green units display. Unless overridden, a security key must be active for initial entry into this mode.

> NOTE. If the message **'No Key'** appears in the tag display, you will not be permitted to access inspect mode without a valid security key — see below in the section *Security key* for details.

Press ▲ or ▼ to select a loop for inspection, indicated as **LOOP *n*** (or **Cached**) in the red tag display. The initially selected loop is the same as the main display loop. (Press **ALM** to see the *loop repeat rate*, in seconds, in the 5-digit display.)

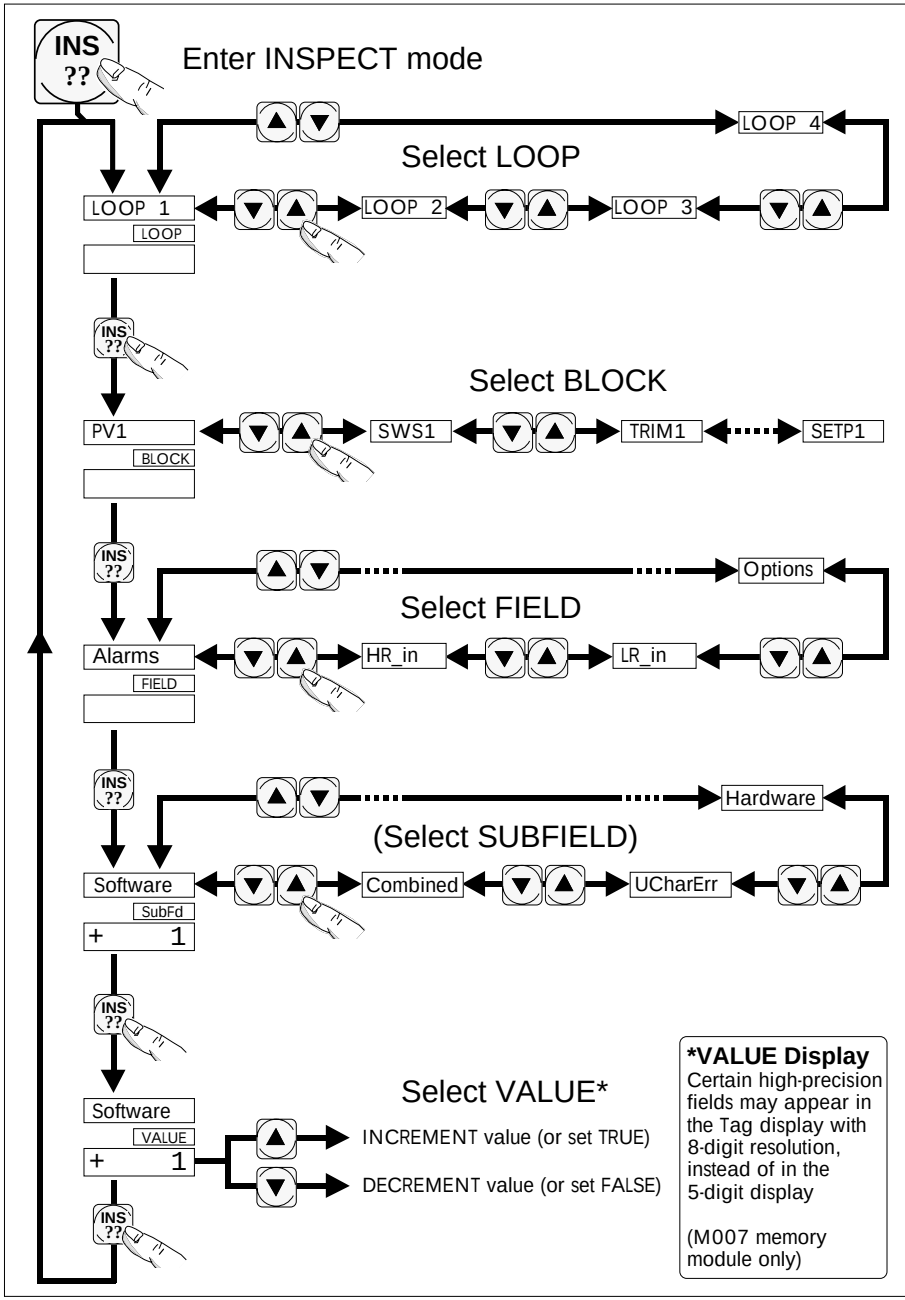


Figure 4-2 Inspect button functions — INS

2 Block Access mode

The second **INS** press selects this mode, and **BLOCK** appears in the units display. Press ▲ or ▼ to select a block for inspection. Block tagnames appear in the tag display in execution order. (Press **ALM** to see the block *Type* in the Tag display.)

3 Field Access mode

The third **INS** press selects this mode, and **FIELD** appears in the units display. Press ▲ or ▼ to select a field for inspection. The tag display shows the field's name, and the 5-digit display shows its value (format permitting). (Press **ALM** to see the field's *units* in the Tag display.)

4 Value Update mode, Connection Enquiry mode, Subfield Access mode

The fourth **INS** press selects one of these three modes, depending on the type of field accessed:

- **Value Update mode.** **VALUE** appears in the units display, or **Ronly** (read-only) if update is not permitted. Press ▲ or ▼ to vary the field value, indicated in the 5-digit display (or in the tag display if text). **Limit** in the units display indicates that a limit has been reached. Pressing **INS** at this point returns you to Loop Access mode. Further **INS** pressing cycles through the access mode hierarchy, retaining your latest selections.

  NOTE. Some high precision AGA8DATA block fields — supported by the T640 M007 memory module — may display in the *Tag display* with 8-digit resolution, instead of in the 5-digit display. The display format is 'standard form', with a multiplier displayed in the 5-digit display. E.g. **2.18000** in the Tag display with **– E 2** in the 5-digit display represents a field value of **0.0218000**. Press ▲ or ▼ to increment or decrement the value.

- **Connection Enquiry mode.** If the field has a connection into it, barring manual update, **Conn.** appears in the units display. The tag display shows the first 8 characters defining the source point. Press ▲ or ▼ to see the rest. Press **INS** to return to Loop Access mode.

- **Subfield Access mode.** If this is a subfield, **SubFd** appears in the units display. Press ▲ or ▼ to select a subfield within the current field. The tag display shows the field's name, and the 5-digit display shows its value (format permitting).

5 Subfields

If this is a subfield, the fifth **INS** press selects subfield **VALUE** or **Conn.** modes, used as already described.

Quitting database access modes

Pressing **R**, **A**, **M**, or **SP-W** immediately reverts the T640 to standard operation. A time-out can also be set in the T600 block to revert the display after a defined period of no button activity.

ALARM DISPLAY & INSPECTION

Whenever any unacknowledged alarms exist in the loop occupying the main display, the highest priority alarm name flashes in alternation with the standard message in the tag display. Unacknowledged alarms elsewhere display **LP *n* ALM**, where ***n*** is the relevant loop number.

Any alarm in the instrument — in any of the loops — lights the red LED in the **ALM** button. The LED flashes if any alarm is unacknowledged; otherwise it remains steady.

Alarm inspection via the ALM button

The **ALM** button lets you quickly locate and acknowledge alarms, wherever they are. Figure 4-3 shows how the **ALM** button works.

1. Press **ALM** to enter Loop (Alarm Inspect) mode, indicated by **LOOP** in the green units display. The tag display flashes the highest priority alarm name current in the database, and the corresponding loop is entered for inspection, whether or not it is in the main display. (If no alarm exists anywhere — **ALM** button LED unlit — **NoAlm** is displayed and you cannot enter loop mode.) Once in loop mode, you can press ▲ or ▼ to select another loop for inspection if required; only loops in alarm are accessed.
2. Press **ALM** again to display the name of the block with the highest priority alarm in the entered loop. **BLOCK** appears in the units display. (The units display will show **NoAlm** if the loop has since cleared itself of alarms, and you remain in loop mode. In this case you can select another loop in alarm using ▲ or ▼.)
3. Press **ALM** again. The tag display shows the alarm name within the block. The units display shows **SubFd**, and the 5-digit display indicates **UnAcd** if the alarm is unacknowledged, or is blank if acknowledged.
4. Press **ALM** again to enter Alarm Acknowledge mode, indicated by **AlAck** in the units display. To acknowledge the alarm, press ▲ or ▼.
5. Press **ALM** again to return to Loop Alarm Inspect mode.

Quitting alarm inspection modes

Pressing **R**, **A**, **M**, or **SP-W** immediately reverts the T640 to standard operation. A timeout (in the T600 block) can also be set for automatic reversion after a defined period of no button activity.

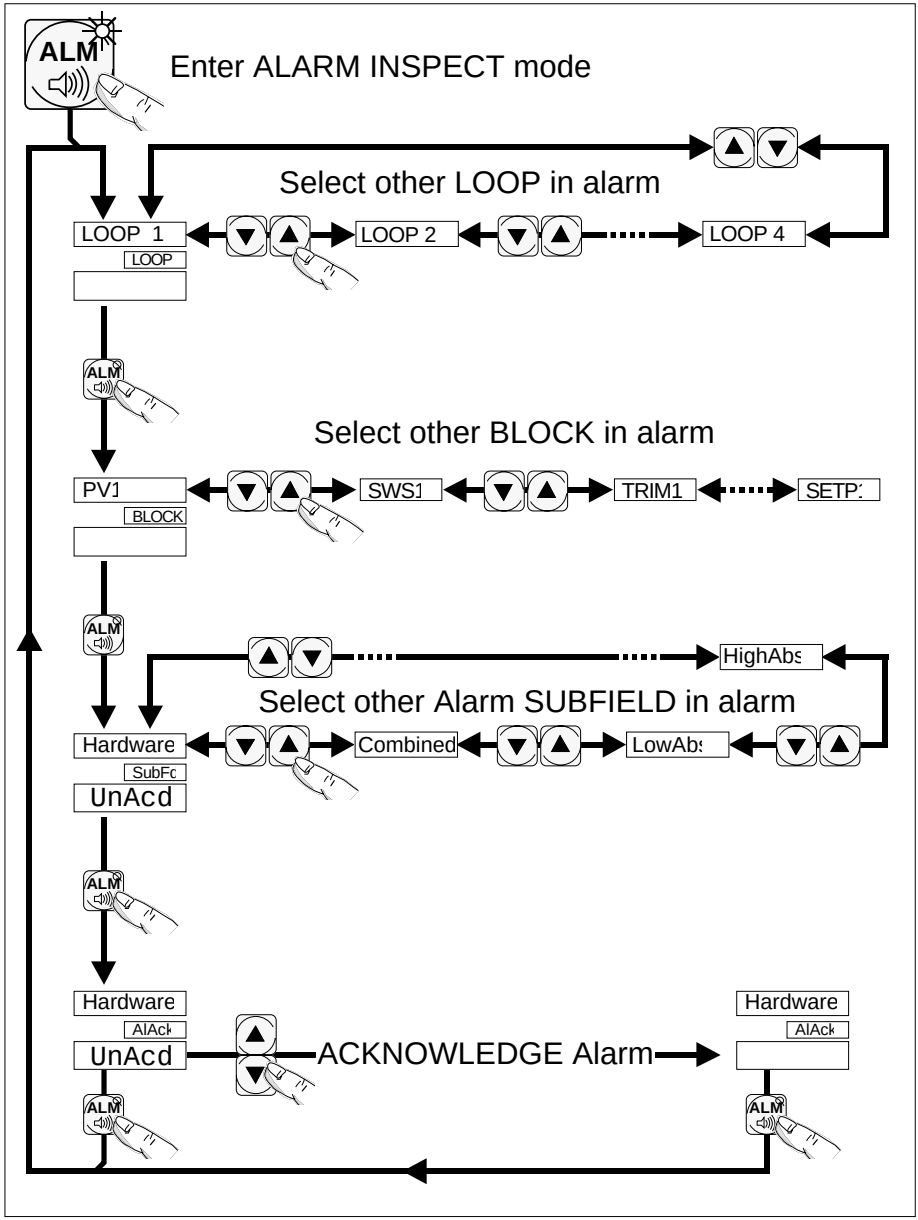


Figure 4-3 Alarm inspect button functions — ALM

SECURITY KEY

Access to T640's database via the **INS** pushbutton is protected by the T950 infrared-operating security key. (Using **INS** is described in an earlier section: *Database access*.)

Key parameters

Each key is factory-programmed with three parameters whose values are marked on the key label. There is also a space for entering the keyholder's name. The parameters are:

- **Access.** Specifies how much of the database is accessible to the keyholder. **Full** accesses all parameters; **Partial** accesses the limited default set of parameters specific to each function block (or a set defined during strategy configuration in LINtools). Note that the T600 block's *NoKeyFul* and *NoKeyPrt* parameters if set TRUE allow full or partial access respectively without needing a security key.
- **Area.** Specifies by an area number (1 - 8) what databases are accessible to the keyholder. The area number must match the T600 block's *AreaNo* parameter to gain access (except when *AreaNo* is zero, allowing any key access the database). A key can also have an Area of zero, giving it access only to zero-*AreaNo* databases.
- **ID Code.** Identifies each key with a unique 13-bit number (0 - 8191). Every time the key is used to change a database, a record is logged in a file that includes all the key's parameters. This means that all changes are traceable to a particular keyholder. (See Chapter 6, *Changes logfile*, for details)

Using the key

Figure 4-4 shows the T950 security key.

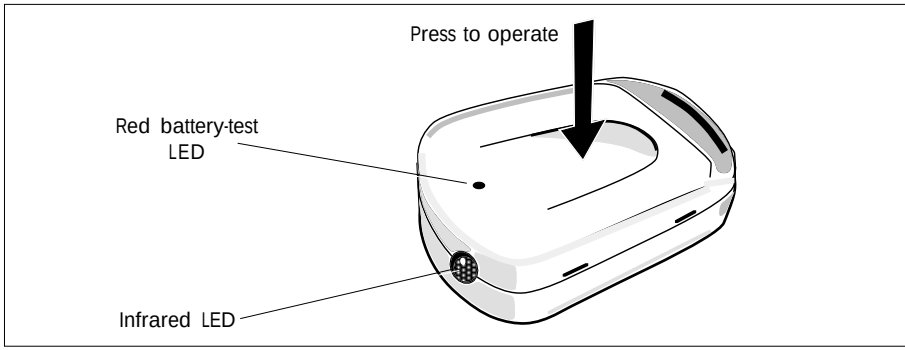


Figure 4-4 Security key — operation

1 Press **INS** on the front panel. If no key is needed for access, loop access mode is immediately entered and **LOOP** shows in the units display. Otherwise, **No Key** appears in the tag display and you proceed to step 2.

2 Hold the key about 15cm from T640's front-panel, aiming the infrared LED at the **OUT-Y** legend to the left of the output bargraph (see Figure 4-1). The IR sensor is here behind the fascia. Press **INS**, then squeeze the key briefly to click the internal switch. If the security key is valid the tag display replies with **LOOP**, and loop access mode is entered. Invalid keys display **Bad Key**.

NOTE. The battery-test LED on the case should glow when the switch is pressed, indicating a healthy key battery. If not, replace the battery (described below).

While the T640 is in INSpect mode the key is not needed. But if no pushbuttons are pressed for a time specified by the T600 block's *TimeOut* parameter, the fascia reverts to the normal display. Re-entering INSpect mode then needs a security key again.

Battery replacement

Caution

Observe anti-static precautions when handling the security key with its lid open.

Replace the battery if the battery-test LED fails to light when the key is operated, and at least every two years. Use a 12V alkaline manganese battery, e.g. Duracell™ MN21, Panasonic™ RV08, or equivalent of overall length 27.5 - 28.5, diameter 9.62 - 10.62 (mm).

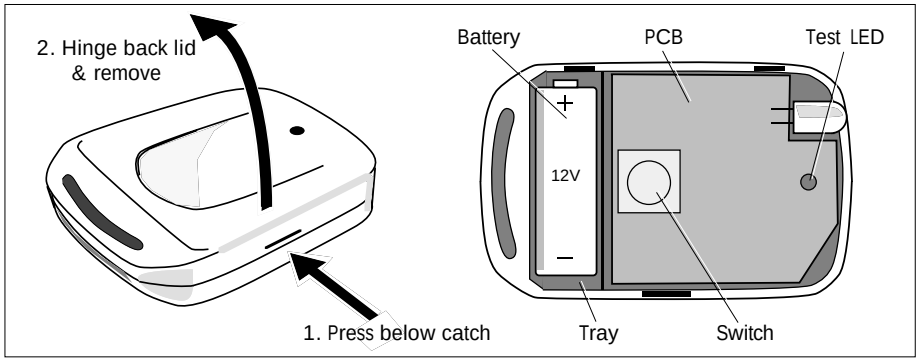


Figure 4-5 Security key — battery replacement

1 See Figure 4-5. Press just below the lid catch, hinge back the lid and remove it completely. The interior of the key is shown on the right of the figure.

2 Extract the battery and fit a replacement, ensuring correct polarity. This is marked on the tray underneath the battery, and also on the printed circuit board. Test the new battery by pressing the switch. The battery-test LED should light.

3 Replace the lid by positioning it over the pair of hinges, then snapping it shut securely over the lid catch.

Chapter 5 STANDARD STRATEGIES

This chapter describes the preconfigured 'standard' control strategies supplied with your T640. The four 'fixed-function' strategies supplied in the T640's ROM are described in some detail, but the seven more advanced strategies stored in EEPROM are only summarised. You are referred to where more comprehensive information can be obtained on all strategies.

PURPOSE OF THE STANDARD STRATEGIES

In general, control strategies are created on a PC within the LINtools package then downloaded to the T640 across the LIN or ALIN. As an alternative, however, you can load and run one of the pre-configured 'standard strategies' supplied inside each T640, instead of creating your own strategies from scratch. Once a standard strategy is loaded you can, directly via the front panel, alter any default parameter values to suit your plant requirements, then save the customised database for future use (via the T600 block's *FullSave* or *PartSave* parameters — see the *LIN Blocks Reference Manual*). Accessing the database is described in Chapter 4, *User interface*. The tutorial in Chapter 3 also gives you some practice at editing the parameter values of a standard strategy via the front panel.

Another approach is to use one of the standard strategies as a starting-point for more extensive editing in LINtools' control configurator. By adding and removing blocks and connections you create a new strategy that more exactly meets your requirements.

You can also create your own entirely new 'standard strategies', loadable via the motherboard DIL switches in the same way as the regular standard strategies. This is described later in the section, *User-created standard strategies*.

SUMMARY OF THE STANDARD STRATEGIES

Strategy types

The strategy databases are of two types: a set of relatively basic 'fixed-function' strategies stored in T640's ROM, and a more advanced and adaptable set stored in EEPROM. Copies of all the strategies are also supplied on floppy disk, and can if required be downloaded to the T640 via an ALIN link using LINtools' LINfiler utility.

The strategies are supplied in a compressed — 'packed' — format, in files called ***name*.PK*n***, where *name* is the strategy database name and *n* is the number that must be set up on switches 6, 7, and 8 of SW1 to select the strategy. The T640 'unpacks' a .PK*n* file to create a regular **.DBF** file with the same root filename, ready to be downloaded to RAM and run.

Strategies supplied in EEPROM

Seven pre-configured strategies are supplied in T640's EEPROM, summarised in Table 5-1. Sources of further information are given in the next section.

n	Name	Summary
1	T640C1	Two simple PID control loops, each acting as a standalone controller, or as a cascade slave or master to another controller. Both analogue & time-proportioned digital outputs are provided.
2	T640C2	Two cascade pairs of PID controllers. Pair 1 has loop 1 as slave & loop 2 as master. Pair 2 has loop 3 as slave & loop 4 as master. Each pair can be standalone, or can accept a remote setpoint to the master. Both analogue & time-proportioned digital outputs are provided.
3	T640C3	Two simple PID control loops with raise/lower digital outputs, each acting as a standalone controller, or as a cascade slave to another controller. The use of position feedback for display purposes, or of limit switch feedback signals, is optional.
4	T640C4	Two PID control loops: loop 1 controls to a remote setpoint in ratio to loop 3's PV. The ratio is set and displayed on a ratio station in loop 2. Loop 3 can accept a remote setpoint from another controller, as can the ratio station. Both analogue & time-proportioned digital outputs are provided.
5	T640C5	Two PID flow control loops with temperature- and pressure-corrected flow measurements. Each loop can act as a standalone controller, or as a cascade slave to another controller. Both analogue & time-proportioned digital outputs are provided.
6	T640C6	Two PID control loops with heat/cool type outputs, each acting as a standalone controller, or as a cascade slave to another controller. Both analogue & time-proportioned digital outputs are provided for the heat and the cool outputs of each loop. Note that separate PID control functions and displays are used for the heat and the cool phases of each loop — the first loop uses loop 1 (heat) and loop 2 (cool); the second loop uses loop 3 (heat) and loop 4 (cool).
7	T640T1	Two simple PID control loops, acting standalone or together as a cascade pair. Loop 1 has two inputs: mV to suit direct plant wiring, and V to suit a Hi-Level input from a transmitter (1-5V etc.). The control output is a current source. Only one input should be used in any strategy; the other is put in manual with PV configured low. Loop 1 is the Slave if Cascade control is enabled. Loop 2 has one mV input to suit direct plant wiring. The control output is a voltage source (0-10V etc.). Loop 2 is the Master if Cascade control is enabled.

Table 5-1 Summary of the strategies supplied in EEPROM as .PKn files

Strategies supplied in EPROM (ROM)

Four pre-configured 'fixed-function' strategies are supplied in T640's ROM. Note that the files stored in ROM are write-protected. Table 5-2 summarises these strategies.

n	Name	Summary
1	SINGLE	A single loop controller
2	DUAL	A dual loop controller
3	DUAL_CS	A dual loop controller internally pre-wired in cascade
4	DUAL_RT	A dual loop controller with ratio station

Table 5-2 Summary of the fixed-function strategies supplied in ROM as .PKn files

FURTHER INFORMATION ON STANDARD STRATEGIES

This chapter concentrates on the four fixed-function strategies supplied in ROM, and says no more about the strategies supplied in the T640's EEPROM. You can find out more about the standard strategies via the PC-based LINtools package, and — for the EEPROM strategies — by accessing special text files.

Complete strategy specification via LINtools

For a *complete* specification of any of the standard strategies you should load it from the disk supplied with this manual into the LINtools configurators, where you will be able to see and print out all the block structure diagrams and every parameter value and block connection. You will also be able to read the in-built 'help' comments on each feature of the strategy, and modify the strategy as far as required.

Text files on the strategies supplied in EEPROM

Text files are supplied on the floppy disk accompanying this manual that describe the six strategies in Table 5-1 in some detail. (These are not available for the fixed-function strategies.) You can view them as simple text files on a PC, and print them out on most printers. The files are of two types — *filename*.DOC and *filename*.ADJ, *filename* being the name of the strategy.

.DOC files. The .DOC files contain comprehensive descriptions of the strategies, including I/O allocation, operator & engineer interfacing, control implementation, failure responses, and power-up conditions.

.ADJ files. The .ADJ files list the strategies' 'user-adjustable' parameters. These have been selected to let you tailor the strategy to your precise needs, via T640's partial inspect mode. If you intend to change any parameters in a database you must refer to this list first. Check through the entire list to make sure that you also adjust all *related* parameters appropriately. ***Parameters omitted from the .ADJ lists are considered essential for correct operation of the database and should not be changed.***

CREATING YOUR OWN 'STANDARD STRATEGIES'

To convert any strategy residing in EEPROM — *filename*.DBF — into a switch-selectable 'standard strategy' #*n*, you must create a dummy file called *filename*.PK*n* and store it in EEPROM (via the LINfiler utility in LINtools) in place of the original standard strategy compressed file. The dummy .PK*n* file can be empty, as its only function is to link *n* to the chosen root filename.

When you select standard strategy #*n* via the motherboard DIL switches (Figure 5-1 reminds you how to do this) your custom strategy will load and run. The method works because the T640 does not attempt to unpack (decompress) the dummy .PK*n* file provided the corresponding .DBF file already exists in EEPROM.

OTHER DOCUMENTS

Refer to the *T500 LINtools Product Manual*, Part No. HA 082 377 U999, for full details on how to use LINtools, and also to the *LIN Product Manual*, Part No. HA 082 375 U999, for information on individual function blocks and LIN/ALIN installation.

RUNNING A DEFAULT STANDARD STRATEGY

Running a default — as supplied in compressed format — standard strategy is a particular case of powering up the T640 and running any other strategy. (For a more complete picture of what happens when you power-up the instrument, refer to Chapter 2 in the section *Power-up routine*.)

To run one of the standard strategies for the first time:

1. First determine if the required .PK*n* compressed strategy file is stored in EEPROM or in ROM — see Tables 5-1 and 5-2. If in EEPROM, go to step 3.
2. Because of the order in which T640 searches its memory areas at power-up, if the strategy required is in ROM you must erase the .PK*n* file in EEPROM that has the same *n*-value (if one exists). E.g. to run the fixed-function strategy called 'SINGLE' (stored as **SINGLE.PK1** in ROM), first erase the file **T640C1.PK1** in EEPROM, using LINtools' LINfiler utility. You can always restore the erased file later if required, from the backup copy supplied on disk.
3. Withdraw the T640 from its sleeve (taking the necessary anti-static precautions — see Chapter 2) and set switches 6, 7, and 8 of switchbank 1 to the strategy number required. (Figure 5-1 reminds you of their location and how to set them.)
4. Set switch 3 of SW1 ON to enable a cold start. (*Other SW1 switches*: Switch 4 should also be ON if you want warm start capability. Leave other switches as required for your T640 configuration.)
5. Power up the T640. Assuming that the selected strategy was not previously being run when power-down occurred, the T640 searches its EEPROM area for a .PK*n* file with the same *n*-value as that specified by switches 6, 7, and 8. If it finds a matching file, it uses this to establish the name of the required strategy. If no match is found in EEPROM, the T640 then searches the ROM area. (If a match still cannot be found — i.e. the .PK*n* file is missing — the T640 adopts an idle state and no database is run.)

   NOTE. This memory area search-order is why step 2 is necessary.

6. Having determined the required filename, the T640 then checks if the corresponding .DBF file is already in EEPROM. (It won't be if this is the first time the strategy is being used. If it were found, the database would be loaded directly to RAM and run.) If not found, the T640 'unpacks' the compressed .PK*n* file, loads it to RAM and runs it. An 'unpacking database' message appears on the front panel while this happens.

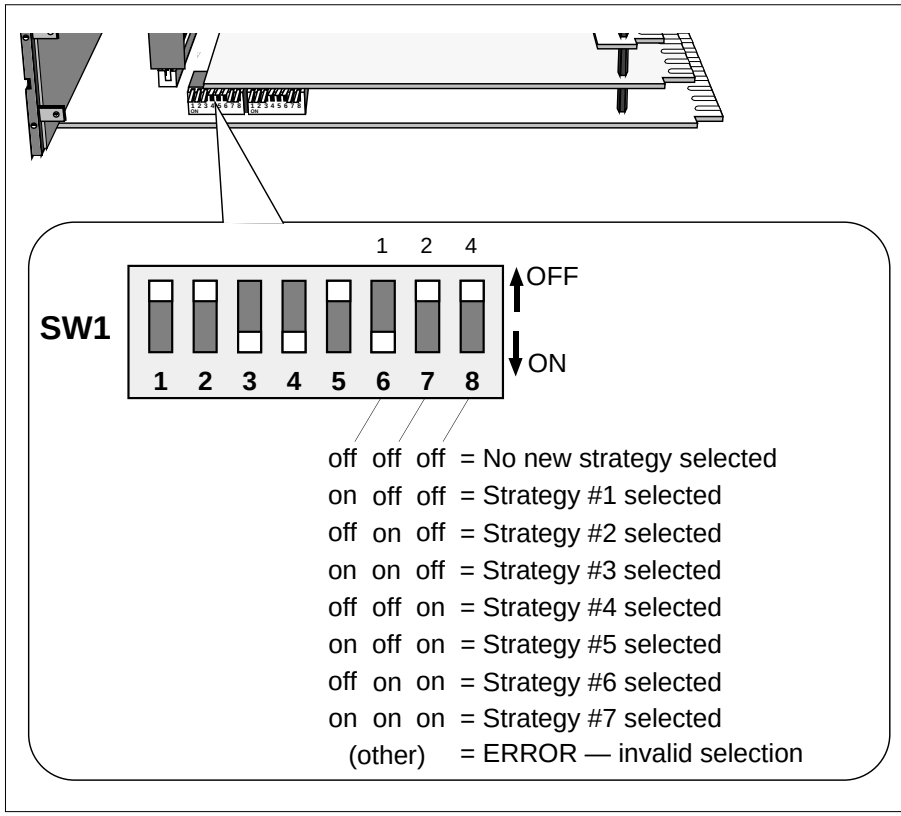


Figure 5-1 SW1 switch settings for strategy selection

NOTE. The SW1 strategy selection switches need only be set to the required standard strategy number the first time that strategy is run. Once the correct strategy has been run, a *filename*.RUN file and a *filename*.DBF file exist in EEPROM. These files ensure that the same database runs on powerup, provided that the selection switches are still set to either the correct strategy number or to 'no new strategy selected' (all off). The drawback with simply leaving the switches set is that, should the *filename*.PK*n* file get deleted or replaced with one having a different *filename*, the T640 will next powerup in the idle state, or run the wrong strategy, respectively.

To avoid these possibilities, you are recommended to set the standard strategy selection switches the first time a new standard strategy is run (to generate the correct .DBF and .RUN files), then power down the T640 and ***turn the switches off***. Subsequently the T640 will make its warm/cold start decision based on the .RUN file, independently of the possibly missing or corrupted .PK*n* file.

FIXED-FUNCTION STRATEGY DESIGN PRINCIPLES

The four fixed-function strategies have been designed to be as straightforward to configure and use as possible:

- All the control loops follow the same design with the same function blocks and the same I/O allocations on each I/O site (see Table 5-2). The variations are kept to a minimum and are clearly identified.
- The number of parameters that must be set up is minimal.
- All settable parameters have usable default values.
- Partial access is available without a security key by default.
- The only connections required to get something happening are the PV and the 3T OUT terminals.

FIXED-FUNCTION STRATEGIES — MOTHERBOARD CUSTOMER TERMINALS

Table 5-3 lists the fixed-function strategy motherboard terminal functions, for both the MAINS and the DC options. Where relevant, the table also indicates the names of function blocks having parameters that affect the operation of the corresponding I/O.

Pin	Assignment	Description	Blocks
1	Internal earth	Do not connect these terminals externally!	
2	Internal earth		
L	Mains live	Live & neutral mains input terminals.	
N	Mains neutral	(MAINS option motherboard only — blank in DC option.)	
7	DC source 1 +ve	DC option power input terminals. PRIMARY supply.	
8	DC source 1 –ve	(DC option motherboard only — blank in MAINS option.)	
9	DC source 2 +ve	DC option power input terminals. BACKUP supply.	
10	DC source 2 –ve	(DC option motherboard only — blank in MAINS option.)	
11	RS422 TX+	Serial communication connections.	SL661
12	RS422 TX–	If RS485 is selected pins 11 and 12 are unused, & pins 14 and 15	
13	RS422 (RS485) Gnd	become RS485+ and RS485– respectively.	
14	RS422 RX+ (RS485+)	(See *T640 User Guide* for details on setting serial comms. switches & jumpers.)	
15	RS422 RX– (RS485–)		
16	Watchdog 1	Relay output whose contacts are closed in normal operation.	USR_ALM
17	Watchdog 2	They open on power loss or CPU failure. They have been configured to also open on alarm.	
18	Alarm 1	Relay output whose contacts are closed in normal operation. They open on power	
19	Alarm 2	loss or CPU failure. They also open if any alarm of priority 11 to 15 occurs.	
20	ALIN Gnd	ALIN peer-to-peer communications connections.	
21	ALIN Phase A	Connections should be made: Gnd to Gnd, Phase A to Phase A,	
22	ALIN Phase B	and Phase B to Phase B.	

Table 5-3 Motherboard terminal assignments (MAINS & DC options)

STRATEGY #1 — SINGLE CONTROL LOOP

Strategy #1 is a single-loop controller with a repeat time of about 160ms per scan. Figure 5-2 shows a 'P & I' diagram for the strategy, involving a flow-control valve and an orifice plate flow sensor, by way of example.

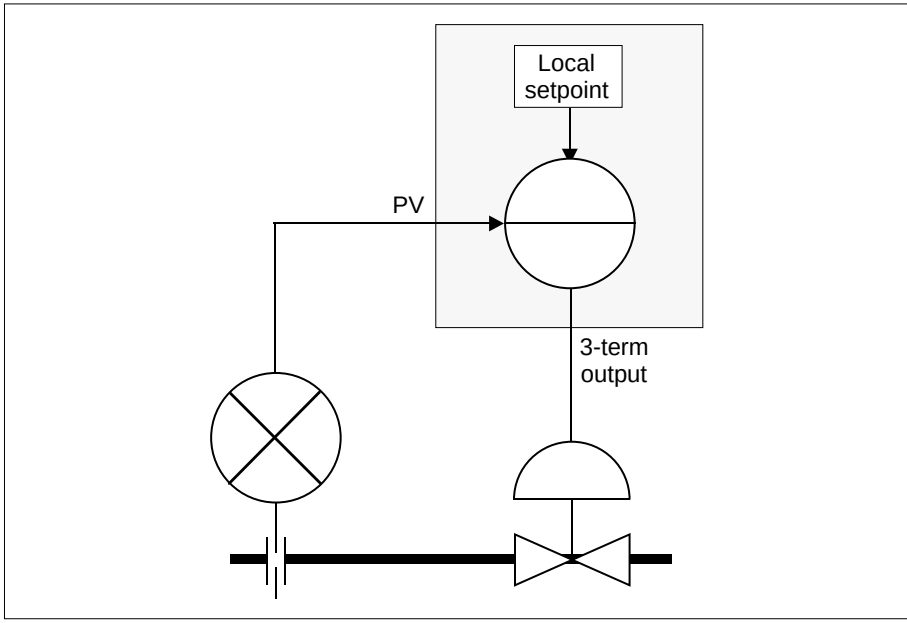


Figure 5-2 Example P & I diagram for strategy #1

Strategy #1 schematic

Figure 5-3 shows schematically the main function blocks in the strategy, the principal signal flows between them, and their associated customer terminals. Details of each terminal and block are given in the tables that follow.

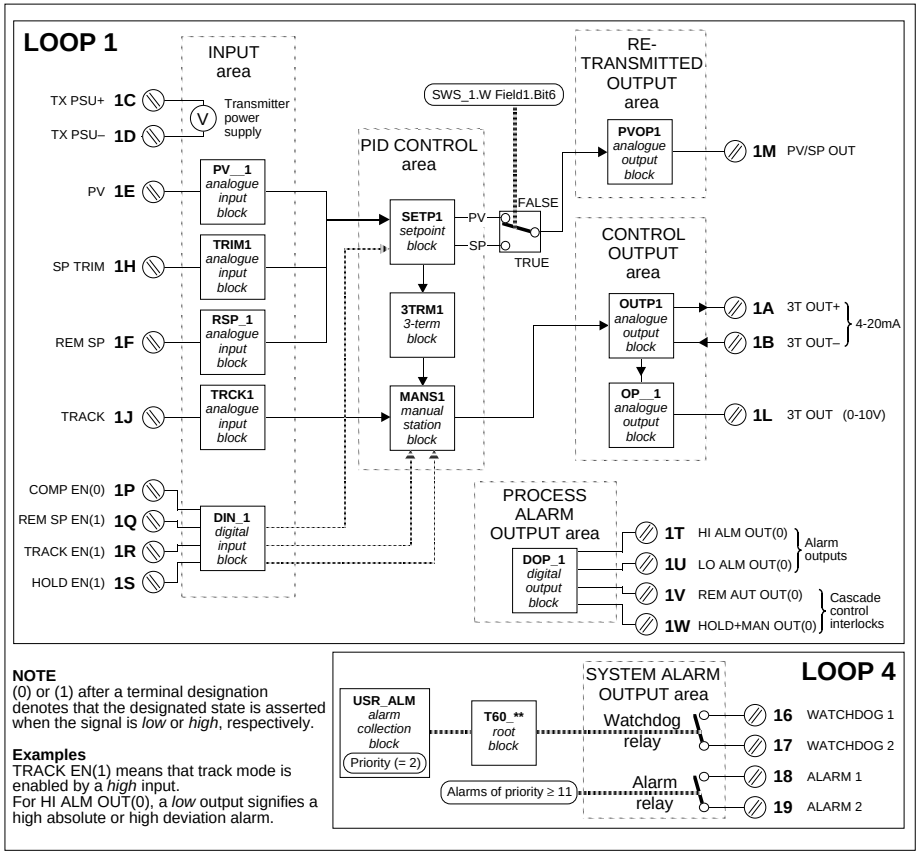


Figure 5-3 Strategy #1 schematic

Strategy #1 I/O customer terminals

Strategy #1 uses a single I/O board located in site 1 of the T640, accessible via customer terminals 1A to 1Z. Table 5-4 lists these terminations and their functions, and also where relevant the names of function blocks having parameters that affect the operation of the corresponding I/O.

Pin	Assignment	Description	Blocks
1A 1B	3T OUT +VE 3T OUT –VE	Isolated 4-20mA output signal. This is the control output, limited by the manual station block MANS1.	SWS_1
1C 1D	TX Power Supply+ TX Power Supply–	Isolated 24 volt transmitter power supply.	
1E	PV	Process variable voltage input.	PV__1
1F	REM SP RAT TRIM	Remote Setpoint voltage input. If the remote setpoint input is broken or not connected the loop reverts to its local setpoint. (Not Strategy #4) Ratio trim input. (Strategy #4 only — see under *Strategy #4 — Ratio control* for details)	RSP_1 TRIM3
1G	Analogue Gnd	Reference ground for analogue signals	
1H	SP TRIM RATIO BIAS	Setpoint trim voltage input Ratio bias input. (Strategy #4 only — see under *Strategy #4 — Ratio control* for details)	TRIM1
1J	TRACK	The control output is forced to this value if the TRACK EN (1) signal is high.	TRCK1
1K	Analogue Gnd	Reference ground for analogue signals	
1L	3T OUT	Control output signal as a voltage	OP__1 SWS_1
1M	PV/SP OUT	Retransmitted process variable or setpoint output as a voltage. Process variable is the default.	PVOP1 SWS_1
1N	Analogue Gnd	Reference ground for analogue signals	
1P	COMP EN(0)*	When high this digital input disables parameter changes via the comms links. It does not prevent parameters being read. This input does not affect MODBUS.	DIN_1
1Q	REM SP EN(1)	When high this digital input allows the remote setpoint to be selected from the front panel provided a signal is connected to REM SP.	DIN_1
1R	TRACK EN(1)	When high this digital input forces the control output to follow the TRACK input	DIN_1
1S	HOLD EN(1)	When high this digital input forces the control output to freeze.	DIN_1
1T	HI ALM OUT(0)	This digital signal goes low if the controller is in high absolute alarm or high deviation alarm	DOP_1
1U	LO ALM OUT(0)	This digital signal goes low if the controller is in low absolute alarm or low deviation alarm	DOP_1
1V	REM AUT OUT(0)	This digital output goes low if the controller is not in Auto with its remote setpoint selected. In cascade this signal should be connected from the slave to the TRACK EN(1) of the master to allow bumpless transfer from local control to cascade. It is also necessary to connect the retransmitted process variable, PV/SP OUT, of the slave to the TRACK input of the master.	DOP_1
1W	HOLD+MAN OUT(0)	This digital output goes low if the controller is in Hold or Manual modes. In cascade this signal should be connected from the master to the REM SP EN(1) of the slave to allow procedureless changes of mode. It also ensures that if the master is removed that the slave goes into local control.	DOP_1
1X	Ext Supply In 24 volts	The digital outputs pull to 15V. If 24V is connected to this pin, the digital outputs pull up to 24V. If not used as an input, this pin may be used as a low-current 15V source to drive inputs via relays or opto-couplers.	
1Y	Digital Gnd	Reference ground for digital signals.	
1Z	Digital Gnd	Reference ground for digital signals.	

*(0) or (1) denotes bit asserted when low or high, respectively

Table 5-4 Site 1 I/O customer terminal assignments

Strategy #1 function blocks and parameters

This strategy has two 'user tasks' — seen as **LOOP 1** and **LOOP 4** in the tag display — that you can access via the **INS** pushbutton to configure their function blocks. The parameters in Loop 1 deal with configuration of the control loop itself, and those in Loop 4 cover system alarms and general instrument setup.

When you come to configure these parameters you will find the *setup sheets* helpful, because they list the default values of all fields, and include a spare column for you to record your customised values where required. You may want to use photocopies of the printed setup sheets as your working documents. The setup sheets for all strategies are found under *Setup sheets — all strategies* on page 5-33.

Loop 1

Table 5-5 lists the **Loop 1** parameters for strategy #1, together with explanations of their functions.

NOTE. The order of the blocks in the table may not match their order of appearance when you access them via the **INS** button.

Block	Field	Subfield	Description
SL661			This block needs attention only if Bisync communications are to be used.
	Instr_No		Slave address of the control loop's 6366 emulation on the Bisync communications bus.
SWS_1			This is a set of optional switches for setting up the loop
	W Field1		
		Bit0	This defines the power up mode. TRUE: the loop goes into manual on power up with 'zero' output*. FALSE: the loop maintains its last mode and output on power up. 'Zero' means low electrical output irrespective of any ranging or loop inversion.
		Bit1	On PV fail the loop will go from AUTO into FORCED MANUAL. This bit determines the action of the control output. TRUE: 'Zero' output will be forced FALSE: the last output will be maintained. ('Zero' means low electrical output — 0V or 4mA — irrespective of any ranging or loop inversion.)
		Bit2	TRUE inverts the output action, and hence the control action, after the manual station. 100% OP ≡ 4mA; 0% OP ≡ 20mA. This should be set TRUE if the actuator has reverse control action for safety reasons. This bit affects both the 4-20mA and voltage control outputs. It does not affect PV/SP OUT.
		Bit3	This inverts the control action before the manual station. It does not affect the relationship between the output reading and the true electrical output. This may be set true to reverse the action of the loop.
		Bit4	This selects On-Off control. See also 3TRM1.Deadband
		Bit5	FALSE: the local setpoint will remain unchanged. TRUE: the local setpoint will track the process variable if the controller is not in AUTO. Note: the local setpoint will always track the remote setpoint when remote is selected.

***NB.** If the HOLD EN(1) input is high at power-up, hold mode wins and the last output is maintained, despite Bit0's being TRUE.

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Block	Field	Subfield	Description
		Bit6	FALSE: the second analogue output will be the retransmitted PV TRUE: the second analogue output will be the retransmitted SP
		Bit7	TRUE: Inverse ratio setting is used. Normal: loop1 SP = loop2 PV / ratio setpoint; Inverse: loop1 SP = loop2 PV * ratio setpoint *Loop1 only - Ratio controller only*
		Bit8	TRUE: Mask R push-button
		Bit9	TRUE: Mask A push-button
		BitA	TRUE: Mask M push-button
		BitB	TRUE: loop tag is FIC-001. Note: BitC has priority over BitB, BitD has priority over BitC and BitB etc. Also loop 2 tags are FIC-002 etc. (If none set, tag defaults to LOOP 1 or LOOP 2.)
		BitC	TRUE: loop tag is LIC-001
		BitD	TRUE: loop tag is PIC-001
		BitE	TRUE: loop tag is TIC-001
		BitF	TRUE: loop tag is AIC-001
RSP_1*			This block processes the remote setpoint input. Status.BrkDtctd is used in conjunction with the input REM SP EN(1) to enable the remote setpoint. If the remote setpoint input is broken the loop reverts to its local setpoint. *If no remote setpoint is required all parameters in this block can be left as default.*
	Filter		A first order filter with the time constant set will be applied to the input.
	HR_in		The input voltage representing high range
	LR_in		The input voltage representing low range
	Options		Only options believed relevant are described. Some options have defaults relevant to the I/O hardware and should not be changed.
		Invert	TRUE maps HR_in to SETP1.LR_SP and LR_in to SETP1.HR_SP
		Sqrt	TRUE applies a square root function to the input
DIN_1			This block processes the digital inputs
	Invert		This field inverts the sense of the digital inputs on a bit by bit basis. Bit4 to Bit7 are not supported by the hardware. Setting them will have no effect.
		Bit0	TRUE inverts COMP EN(0) If this input is unused do not alter the default. If this input is used it will be normal to invert its action so that a high input is required to enable parameter changes over the communication networks.
		Bit1	FALSE inverts REM SP EN(1) It should not be necessary to alter the default
		Bit2	TRUE inverts TRACK EN (1) It should not be necessary to alter the default
		Bit3	TRUE inverts HOLD EN(1) If this input is unused do not alter the default. If this input is used it will be normal to invert its action.
PV__1			This block processes the process variable input. Alarms.Combined will cause the controller to go into Forced Manual if an alarm with non-zero priority occurs. See SWS_1.W Field1.Bit0.
	Filter		A first order filter with the time constant set will be applied to the input.
	RomChar		This is used to select input linearisation. The common thermocouple and resistance thermometer inputs are available.

*The RSP_1 block is absent from Strategy #4 (ratio controllers)

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Block	Field	Subfield	Description
	Alarms		Although other alarms than those listed below are available, their priority should left at 0. Process alarms may be set in SETP1. The alarms listed below should be left at the priority set unless there is a reason to change them. A reason to change them might be to stop individual alarms affecting the Watchdog relay, or to make alarm acknowledgement necessary (priority ≥6). Note: if a zero priority is set, the alarm condition will no longer select Forced Manual.
		Hardware	(*Default = 2*)
		OutRange	(*Default = 2*)
		OCctdel	(*Default = 2*)
	HR_in		The input voltage representing high range
	LR_in		The input voltage representing low range
	Options		Only options believed relevant are described. Some options have defaults relevant to the I/O hardware and should not be changed.
		Invert	TRUE maps HR_in to SETP1.LR_SP and LR_in to SETP1.HR_SP. TRUE will also have the effect of inverting the control loop.
		Sqrt	TRUE applies a square root function to the input
TRIM1			This input provides a trim to the setpoint. This trim input in engineering units is added to the setpoint whether it is local or re mote. *If no trim is required all parameters in this block can be left as default.*
	MODE		This should be left at MANUAL if a manual trim or no trim are required. Set this input to AUTO if a trim is to be provided as an input signal, SP TRIM
	PV		If MODE is set to MANUAL this input may be used to manually input a setpoint trim.
	HR		This sets the high range in engineering units. HR_in maps to HR. Because trim works in engineering units HR and LR are used to scale the trim input against SETP1 HR_SP and LR_SP.
	LR		This sets the low range in engineering units. LR_in maps to LR. It would not be unusual for LR to be the same value as HR but negative to give a symmetrical trim.
	Filter		A first-order filter with the time constant set applied to the input.
	HR_in		The input voltage representing high range
	LR_in		The input voltage representing low range
	Options		Only options believed relevant are described. Some options have defaults relevant to the I/O hardware and should not be changed.
		Invert	TRUE maps HR_in to LR and LR_in to HR
		Sqrt	TRUE applies a square root function to the input
SETP1			This block provides all the setpoint processing and alarms.
	HR_SP		The high range of the process variable and setpoint in engineering units. The block is internally connected so that the process variable and remote setpoint share the same ranges as HR_SP and LR_SP
	LR_SP		The low range of the process variable and setpoint in engineering units.
	HL_SP		This sets a high limit for the setpoint including any trim whether the setpoint is local or remote.
	LL_SP		This sets a low limit for the setpoint including any trim whether the setpoint is local or remote.
	HL_SL		This sets a high limit for the local setpoint.
	LL_SL		This sets a low limit for the local setpoint.

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Block	Field	Subfield	Description
	Alarms		These are the process alarms of the control loop. Note: Priority 0 disables the alarm completely. An alarm with 0 priority no longer affects the digital output: HI ALM OUT(0) or LO ALM OUT(0) Priority 6-15 need to be acknowledged. Priority 11-15 open the Alarm relay. Alarms with priority set equal to USR_ALM.Priority open the Watchdog relay
		HighAbs	PV exceeds HAA
		LowAbs	PV is less than LAA
		HighDev	PV-SP exceeds HDA
		LowDev	SP-PV exceeds LDA
	HAA		High absolute alarm setting
	LAA		Low absolute alarm setting
	HDA		High deviation alarm setting
	LDA		Low deviation alarm setting
	Dis_DP		Sets the number of digits displayed to the right of the decimal point. This parameter is for display purposes only and has no effect on the ranging.
DOP_1			This block processes the digital outputs. The default values in this block need not normally be altered.
	Invert		This field inverts the sense of the digital outputs on a bit by bit basis. Bit4 to Bit7 are not supported by the hardware. Setting them will have no effect.
		Bit0	FALSE inverts HI ALM OUT(0)
		Bit1	FALSE inverts LO ALM OUT(0)
		Bit2	TRUE inverts REM AUT OUT(0)
		Bit3	TRUE inverts HOLD+MAN OUT(0)
PVOP1			This block processes the retransmitted process variable or setpoint. See SWS_1.W Field1.Bit5
	HR_out		The output voltage representing high range
	LR_out		The output voltage representing low range
3TRM1			This block performs PID ('3-term') control. The default values of XP, TI, and TD allow a measure of control, but should be set to more appropriate values for your application.
	TimeBase		This sets the time units for TI and TD
	XP		This set the proportional band for control
	TI		This sets the integral time constant
	TD		This sets the derivative time constant
	Deadband		This sets the hysteresis band if On/Off control is selected. See SWS_1.W Field1.Bit3. The value set is applied symmetrically above and below the setpoint.
TRCK1			This input processes the TRACK input. *If TRACK is not required all parameters in this block can be left as default.*
	MODE		If the track input is being provided as an input signal, this should be left AUTO. Selecting MANUAL will cause the control output to adopt the value set in PV if TRACK EN(1) goes high.
	PV		If MODE is set to MANUAL this input may be used to manually input a TRACK value.
	HR_in		The input voltage representing 100% output
	LR-in		The input voltage representing 0% output

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Block	Field	Subfield	Description
MANS1			This block provides output processing from 3TRM1. The output range is fixed at 0-100%.
	HL_OP		High limit for the control output in %
	LL_OP		Low limit for the control output in %
OP_1			This block processes the control voltage output. It follows the 4-20mA output. Output inversion cannot be performed by reversing the values in HR_out and LR_out. SWS_1.W Field1.Bit1 does this.
	HR_out		The output voltage representing 100% (0% if SWS_1.W Field1.Bit2 is TRUE)
	LR_out		The output voltage representing 0% (100% if SWS_1.W Field1.Bit2 is TRUE)

Table 5-5 Loop 1 parameters

Loop 4

Table 5-6 lists the **Loop 4** parameters for strategy #1, together with explanations of their functions.

Block	Field	Subfield	Description
USR_ALM			This block controls watchdog relay output.
	Priority		(Range: 0-15) The priority of the alarms that are required to open the relay must match this setting.
T60_**			This block contains the basic options of the controller as an instrument. The ** in the name will be replaced by the node number in hex when the strategy is loaded. E.g. C6
	Options		Many of the subfields have no relevance to this application. They are included here because they appear during use of the INS button.
		FPdis1	Leave as default (FALSE)
		FPdis2	Leave as default: TRUE in the single loop controllers, FALSE in the dual loop controllers
		FPdis3	Leave as default: TRUE in all but ratio controller, FALSE in ratio controller
		FPdis4	Leave as default (TRUE)
		NoKeyPrt	The default (TRUE) allows access to the normally settable parameters without using the security key. This should normally be set to FALSE before the controller is put on to plant.
		NoKeyFul	This should be left as default (FALSE). Setting this TRUE allows access to all the parameters in the controller without the use of a full access key.
		LEDtest	If set TRUE all the LEDs on the front panel light. It resets itself to FALSE
		CommsDis	This is internally wired and may be used only for reading the state of the ALIN and Bisync communications. TRUE: parameter 'writes' inhibited; FALSE: communications fully enabled
		FullSave	If set TRUE the parameters in the running database are saved to file. These parameters will be used on cold start. This or PartSave should be used after configuration to ensure the set up is not lost. It resets itself to FALSE
		PartSave	This is the same as FullSave except local setpoints, control outputs and control modes are not saved. This allows tuning parameters to be set up and saved during commissioning without overwriting the start up conditions.
		BinSpd1 BinSpd2	Bisync baud rate:

	BinSpd1	BinSpd2
Baud rate = 9600*	FALSE	FALSE
4800	FALSE	TRUE
1200	TRUE	FALSE
300	TRUE	TRUE

**default*

		Protectd	Leave as default (TRUE)
		E2Form1	This and E2Form2 when used together in sequence will reformat the EEPROM filing system. The sequence is relatively complex to make it unlikely that the EEPROM is reformatted accidentally.
		E2Form2	(*See previous*)

Table 5-6 Loop 4 parameters

STRATEGY #2 — DUAL CONTROL LOOP

Strategy #2 is a dual-loop controller. The difference between the single loop (strategy #1) and the dual loop controllers is simply the inclusion of the second loop. This loop is identical to the first, except that its I/O is assigned to site 2 of the T640 (terminals 2A to 2Z).

Note that terminal 2P is unused as COMP EN(0), because 1P is used to disable communications for the whole instrument.

One loop or two?

If only one loop is needed the single loop controller should be chosen in preference to the dual for the following reasons:

- With only one loop implemented the single loop has a faster update rate — approximately 160ms. The update rate of each loop in the dual loop controller is around 300ms.
- If the second loop in the dual loop strategy is not connected to anything, Loop 2 process variable alarms will appear and remain permanently annunciated.

Figure 5-4 shows a 'P & I' diagram for the strategy, involving flow-control valves and orifice plate flow sensors, by way of example.

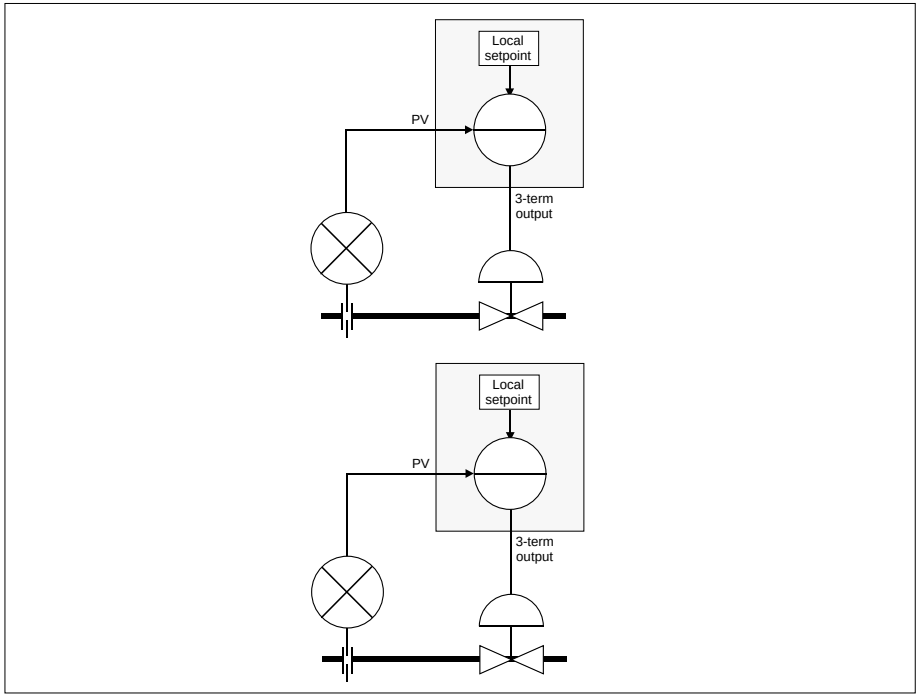


Figure 5-4 Example P & I diagram for strategy #2

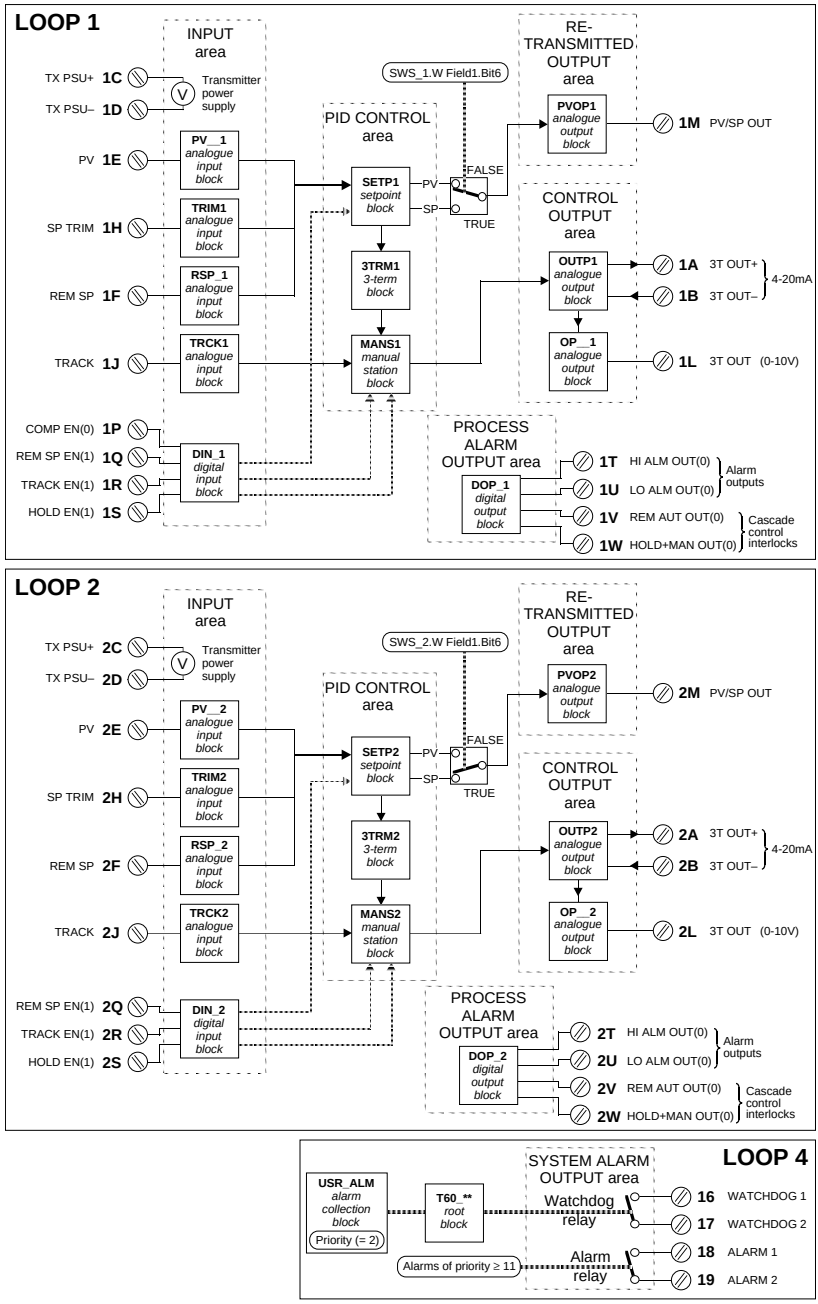


Figure 5-5 Strategy #2 schematic

Strategy #2 schematic

Figure 5-5 shows schematically the main function blocks in the strategy, the principal signal flows between them, and their associated customer terminals. Details of each terminal and block are given in the tables that follow.

Strategy #2 I/O customer terminals

Strategy #2 uses a pair of I/O boards located in sites 1 and 2 of the T640, accessible via customer terminals 1A to 1Z (site 1) and 2A to 2Z (site 2). Site 1 terminals are identical to those given for strategy #1 (see Table 5-4 on page 5-9). Table 5-7 lists site 2 terminations and their functions, and also where relevant the names of function blocks having parameters that affect the operation of the corresponding I/O.

Pin	Assignment	Description	Blocks
2A 2B	3T OUT +VE 3T OUT –VE	Isolated 4-20mA output signal. This is the control output.	SWS_2
2C 2D	TX Power Supply+ TX Power Supply–	Isolated 24 volt transmitter power supply.	
2E	PV	Process variable voltage input.	PV__2
2F	REM SP	Remote Setpoint voltage input. If the remote setpoint input is broken or not connected the loop reverts to its local setpoint.	RSP_2
	RAT TRIM	Ratio trim input. (See under *Strategy #4 — Ratio control* for details)	TRIM3
2G	Analogue Gnd	Reference ground for analogue signals	
2H	SP TRIM	Setpoint trim voltage input	TRIM2
2J	TRACK	The control output is forced to this value if the TRACK EN (1) signal is high.	TRCK2
2K	Analogue Gnd	Reference ground for analogue signals	
2L	3T OUT	Control output signal as a voltage	OP__2 SWS_2
2M	PV/SP OUT	Retransmitted process variable or setpoint output as a voltage. Process variable is the default.	PVOP2 SWS_2
2N	Analogue Gnd	Reference ground for analogue signals	
2P	(*Unused*)		
2Q	REM SP EN(1)	When high this digital input allows the remote setpoint to be selected from the front panel provided a signal is connected to REM SP.	DIN_2
2R	TRACK EN(1)	When high this digital input forces the control output to follow the TRACK input	DIN_2
2S	HOLD EN(1)	When high this digital input forces the control output to freeze.	DIN_2
2T	HI ALM OUT(0)	This digital signal goes low if the controller is in high absolute alarm or high deviation alarm	DOP_2
2U	LO ALM OUT(0)	This digital signal goes low if the controller is in low absolute alarm or low deviation alarm	DOP_2

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Pin	Assignment	Description	Blocks
2V	REM AUT OUT(0)	This digital output goes low if the controller is not in Auto with its remote setpoint selected. In cascade this signal should be connected from the slave to the TRACK EN(1) of the master to allow bumpless transfer from local control to cascade. It is also necessary to connect the retransmitted process variable, PV/SP OUT, of the slave to the TRACK input of the master.	DOP_2
2W	HOLD+MAN OUT(0)	This digital output goes low if the controller is in Hold or Manual modes. In cascade this signal should be connected from the master to the REM SP EN(1) of the slave to allow procedureless changes of mode. It also ensures that if the master is removed that the slave goes into local control.	DOP_2
2X	(*Unused*)		
2Y	Digital Gnd	Reference ground for digital signals.	
2Z	Digital Gnd	Reference ground for digital signals.	

Table 5-7 Site 2 I/O customer terminal assignments

Strategy #2 function blocks and parameters

This strategy has three 'user tasks' — seen as **LOOP 1**, **LOOP 2**, and **LOOP 4** in the tag display — that you can access via the **INS** pushbutton to configure their function blocks. The parameters in Loops 1 and 2 deal with configuration of the respective control loops themselves, and those in Loop 4 cover system alarms and general instrument setup.

When you come to configure these parameters you will find the *setup sheets* helpful, because they list the default values of all fields, and include a spare column for you to record your customised values where required. You may want to use photocopies of the printed setup sheets as your working documents. The setup sheets for this strategy are found under *Setup sheets — all strategies*, on page 5-34.

Loop 1

Loop 1 parameters are identical to those given for strategy #1 (see Table 5-5 on page 5-10).

Loop 2

Table 5-8 lists the **Loop 2** parameters for strategy #2, together with explanations of their functions.

NOTE. The order of the blocks in the table may not match their order of appearance when you access them via the **INS** button.

Block	Field	Subfield	Description
SL662			This block needs attention only if Bisync communications are to be used.
	Instr_No		Slave address of the control loop's 6366 emulation on the Bisync communications bus.
SWS_2			This is a set of optional switches for setting up the loop
	W Field1		
		Bit0	This defines the power up mode. TRUE: the loop goes into manual on power up with 'zero' output*. FALSE: the loop maintains its last mode and output on power up. 'Zero' means low electrical output irrespective of any ranging or loop inversion.
		Bit1	On PV fail the loop will go from AUTO into FORCED MANUAL this bit determines the action of the control output TRUE: 'Zero' output will be forced FALSE: the last output will be maintained. 'Zero' means low electrical output irrespective of any ranging or loop inversion.
		Bit2	TRUE inverts the output action, and hence the control action, after the manual station. 100% OP ≡ 4mA; 0% OP ≡ 20mA. This should be set TRUE if the actuator has reverse control action for safety reasons. This bit affects both the 4-20mA and voltage control outputs. It does not affect PV/SP OUT.
		Bit3	This inverts the control action before the manual station. It does not affect the relationship between the output reading and the true electrical output. This may be set true to reverse the action of the loop.
		Bit4	This selects On-Off control. See also 3TRM2.Deadband
		Bit5	FALSE: the local setpoint will remain unchanged. TRUE: the local setpoint will track the process variable if the controller is not in AUTO. Note: the local setpoint will always track the remote setpoint when remote is selected.
		Bit6	FALSE: the second analogue output will be the retransmitted PV TRUE: the second analogue output will be the retransmitted SP
		Bit7	TRUE: Inverse ratio setting is used. Normal: loop1 SP = loop2 PV / ratio setpoint; Inverse: loop1 SP = loop2 PV * ratio setpoint *Loop1 only - Ratio controller only*
		Bit8	TRUE: Mask R push-button
		Bit9	TRUE: Mask A push-button
		BitA	TRUE: Mask M push-button
		BitB	TRUE: loop tag is FIC-001. Note: BitC has priority over BitB, BitD has priority over BitC and BitB etc. Also loop 2 tags are FIC-002 etc.
		BitC	TRUE: loop tag is LIC-001
		BitD	TRUE: loop tag is PIC-001
		BitE	TRUE: loop tag is TIC-001
		BitF	TRUE: loop tag is AIC-001

***NB**. If the HOLD EN(1) input is high at power-up, hold mode wins and the last output is maintained, despite Bit0's being TRUE.

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Block	Field	Subfield	Description
RSP_2			This block processes the remote setpoint input. Status.BrkDtctd is used in conjunction with the input REM SP EN(1) to enable the remote setpoint. If the remote setpoint input is broken the loop reverts to its local setpoint. *If no remote setpoint is required all parameters in this block can be left as default.*
	Filter		A first order filter with the time constant set will be applied to the input.
	HR_in		The input voltage representing high range
	LR_in		The input voltage representing low range
	Options		Only options believed relevant are described. Some options have defaults relevant to the I/O hardware and should not be changed.
		Invert	TRUE maps HR_in to SETP2.LR_SP and LR_in to SETP2.HR_SP
		Sqrt	TRUE applies a square root function to the input
DIN_2			This block processes the digital inputs
	Invert		This field inverts the sense of the digital inputs on a bit by bit basis. Bit4 to Bit7 are not supported by the hardware. Setting them will have no effect.
		Bit0	(*Unused*)
		Bit1	FALSE inverts REM SP EN(1) It should not be necessary to alter the default
		Bit2	TRUE inverts TRACK EN (1) It should not be necessary to alter the default
		Bit3	TRUE inverts HOLD EN(1) If this input is unused do not alter the default. If this input is used it will be normal to invert its action.
PV__2			This block processes the process variable input. Alarms.Combined will cause the controller to go into Forced Manual if an alarm with non-zero priority occurs. See SWS_2.W Field1.Bit0.
	Filter		A first order filter with the time constant set will be applied to the input.
	RomChar		This is used to select input linearisation. The common thermocouple and resistance thermometer inputs are available.
	Alarms		Although other alarms than those listed below are available, their priority should left at 0. Process alarms may be set in SETP2. The alarms listed below should be left at the priority set unless there is a reason to change them. A reason to change them might be to stop individual alarms affecting the Watch Dog relay. Note: if a zero priority is set the alarm condition will no longer select Forced Manual.
		Hardware	(*Default = 2*)
		OutRange	(*Default = 2*)
		OCctdel	(*Default = 2*)
	HR_in		The input voltage representing high range
	LR_in		The input voltage representing low range
	Options		Only options believed relevant are described. Some options have defaults relevant to the I/O hardware and should not be changed.
		Invert	TRUE maps HR_in to SETP2.LR_SP and LR_in to SETP2.HR_SP. TRUE will also have the effect of inverting the control loop.
		Sqrt	TRUE applies a square root function to the input

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Block	Field	Subfield	Description
TRIM2			This input provides a trim to the setpoint. This trim input in engineering units is added to the setpoint whether it is local or re mote. If no trim is required all parameters in this block can be left as default.
	MODE		This should be left at MANUAL if a manual trim or no trim are required. Set this input to AUTO if a trim is to be provided as an input signal, SP TRIM
	PV		If MODE is set to MANUAL this input may be used to manually input a setpoint trim.
	HR		This sets the high range in engineering units. HR_in maps to HR. Because trim works in engineering units HR and LR are used to scale the trim input against SETP1 HR_SP and LR_SP.
	LR		This sets the low range in engineering units. LR_in maps to LR. It would not be unusual for LR to be the same value as HR but negative to give a symmetrical trim.
	Filter		A first order filter with the time constant set applied to the input.
	HR_in		The input voltage representing high range
	LR_in		The input voltage representing low range
	Options		Only options believed relevant are described. Some options have defaults relevant to the I/O hard-ware and should not be changed.
		Invert	TRUE maps HR_in to LR and LR_in to HR
		Sqrt	TRUE applies a square root function to the input
SETP2			This block provides all the setpoint processing and alarms.
	HR_SP		The high range of the process variable and setpoint in engineering units. The block is internally connected so that the process variable and remote setpoint share the same ranges as HR_SP and LR_SP
	LR_SP		The low range of the process variable and setpoint in engineering units.
	HL_SP		This sets a high limit for the setpoint including any trim whether the setpoint is local or remote.
	LL_SP		This sets a low limit for the setpoint including any trim whether the setpoint is local or remote.
	HL_SL		This sets a high limit for the local setpoint.
	LL_SL		This sets a low limit for the local setpoint.
	Alarms		These are the process alarms of the control loop. Note: Priority 0 disables the alarm completely. An alarm with 0 priority no longer affects the digital output: HI ALM OUT(0) or LO ALM OUT(0) Priority 6-15 need to be acknowledged. Priority 11-15 open the Alarm relay. Alarms of priority equal to USR_ALM.Priority will open the Watchdog relay.
		HighAbs	PV exceeds HAA
		LowAbs	PV is less than LAA
		HighDev	PV-SP exceeds HDA
		LowDev	SP-PV exceeds LDA
	HAA		High absolute alarm setting
	LAA		Low absolute alarm setting
	HDA		High deviation alarm setting
	LDA		Low deviation alarm setting
	Dis_DP		Sets the number of digits displayed to the right of the decimal point. This parameter is for display purposes only and has no effect on the ranging.

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Block	Field	Subfield	Description
DOP_2			This block processes the digital outputs. The default values in this block need not normally be altered.
	Invert		This field inverts the sense of the digital outputs on a bit by bit basis. Bit4 to Bit7 are not supported by the hardware. Setting them will have no effect.
		Bit0	FALSE inverts HI ALM OUT(0)
		Bit1	FALSE inverts LO ALM OUT(0)
		Bit2	TRUE inverts REM AUT OUT(0)
		Bit3	TRUE inverts HOLD+MAN OUT(0)
PVOP2			This block processes the retransmitted process variable or setpoint. See SWS_2.W Field1.Bit5
	HR_out		The output voltage representing high range
	LR_out		The output voltage representing low range
3TRM2			This block performs PID control. The defaults for XP, TI and TD are provided only to allow control to happen. These require setting to appropriate values.
	TimeBase		This sets the time units for TI and TD
	XP		This set the proportional band for control
	TI		This sets the integral time constant
	TD		This sets the derivative time constant
	Deadband		This sets the hysteresis band if On/Off control is selected. See SWS_2.W Field1.Bit3. The value set is applied symmetrically above and below the setpoint.
TRCK2			This input processes the TRACK input. *If TRACK is not required all parameters in this block can be left as default.*
	MODE		If the track input is being provided as an input signal, this should be left AUTO. Selecting MANUAL will cause the control output to adopt the value set in PV if TRACK EN(1) goes high.
	PV		If MODE is set to MANUAL this input may be used to manually input a TRACK value.
	HR_in		The input voltage representing 100% output
	LR-in		The input voltage representing 0% output
MANS2			This block provides output processing from 3TRM2. The output range is fixed at 0-100%.
	HL_OP		High limit for the control output in %
	LL_OP		Low limit for the control output in %
OP__2			This block processes the control voltage output. It follows the 4-20mA output. Output inversion cannot be performed by reversing the values in HR_out and LR_out. SWS_2.W Field1.Bit1 does this.
	HR_out		The output voltage representing 100% (0% if SWS_2.W Field1.Bit2 is TRUE)
	LR_out		The output voltage representing 0% (100% if SWS_2.W Field1.Bit2 is TRUE)

Table 5-8 Loop 2 parameters

Loop 4

Loop 4 parameters are identical to those given for strategy #1 (see Table 5-6 on page 4-10).

STRATEGY #3 — DUAL CONTROL LOOP (CASCADE)

Strategy #3 is a dual-loop controller. The difference between it and strategy #2 is that the two controllers are internally pre-wired for remote setpoint cascade operation with bumpless transfer.

Figure 5-6 shows a 'P & I' diagram for the strategy in which — by way of example — the outflow from a tank is controlled by the slave loop, according to a remote setpoint output from the master loop. The master loop derives its output from a local setpoint and a measured variable from the tank (e.g. fluid level).

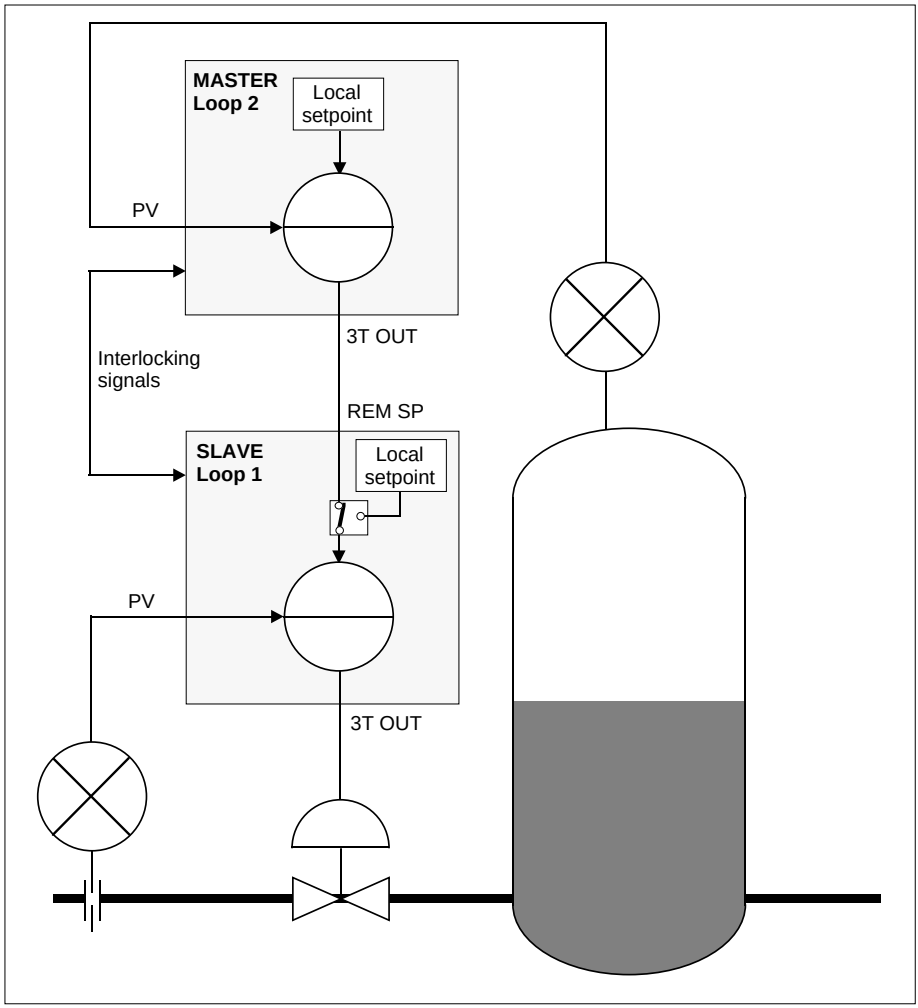


Figure 5-6 Example P & I diagram for strategy #3

The purpose of the interlocking signals indicated in the Figure is to provide bumpless, procedureless transfer between modes of operation. Table 5-9 shows the pin assignments corresponding to these interlocks, with Loop 2 as the master controller and Loop 1 the slave. For completeness the Figure also lists the 3T OUT to REM SP connection — not strictly an 'interlock signal'.

MASTER Pin	Function		SLAVE Pin	Function
2L	3T OUT	→	1F	REM SP
2J	TRACK	←	1M	PV OUT
2W	HOLD+MAN OUT(0)	→	1Q	REM SP EN(1)
2R	TRACK EN(1)	←	1V	REM AUT OUT(0)

Table 5-9 Cascade interlocking signals — strategy #3

Note that Table 5-9 is given for information only. All the interconnections shown have been made within the strategy in software, so you do not need to wire them externally.

Cascading a pair of loops

Although you don't need to physically wire the interlock signals between Loops 1 and 2 if you are using strategy #3 as supplied, you will find Table 5-9 useful if you want to cascade a different pair of loops. As examples, you may want to cascade the disconnected pair of loops supplied in strategy #2 (dual loop), or even two loops running in different instruments.

NOTE. All Eurotherm Process Automation controllers have these interlocks available.

In these cases you decide which loop is to be the master and which the slave, then wire-link the customer terminals associated with each loop — as indicated in Table 5-9. Remember that the number prefix in customer terminal designations must match the I/O site involved — e.g. **2L** is the 3-term output for site **2** I/O, but **1L** is the 3-term output for site **1** I/O, so you will have to interpret the table according to your I/O sites.

Strategy #3 schematic

Figure 5-7 shows schematically the main function blocks in the strategy, the principal signal flows between them, and their associated customer terminals. Details of each terminal and block are given in the tables that follow.

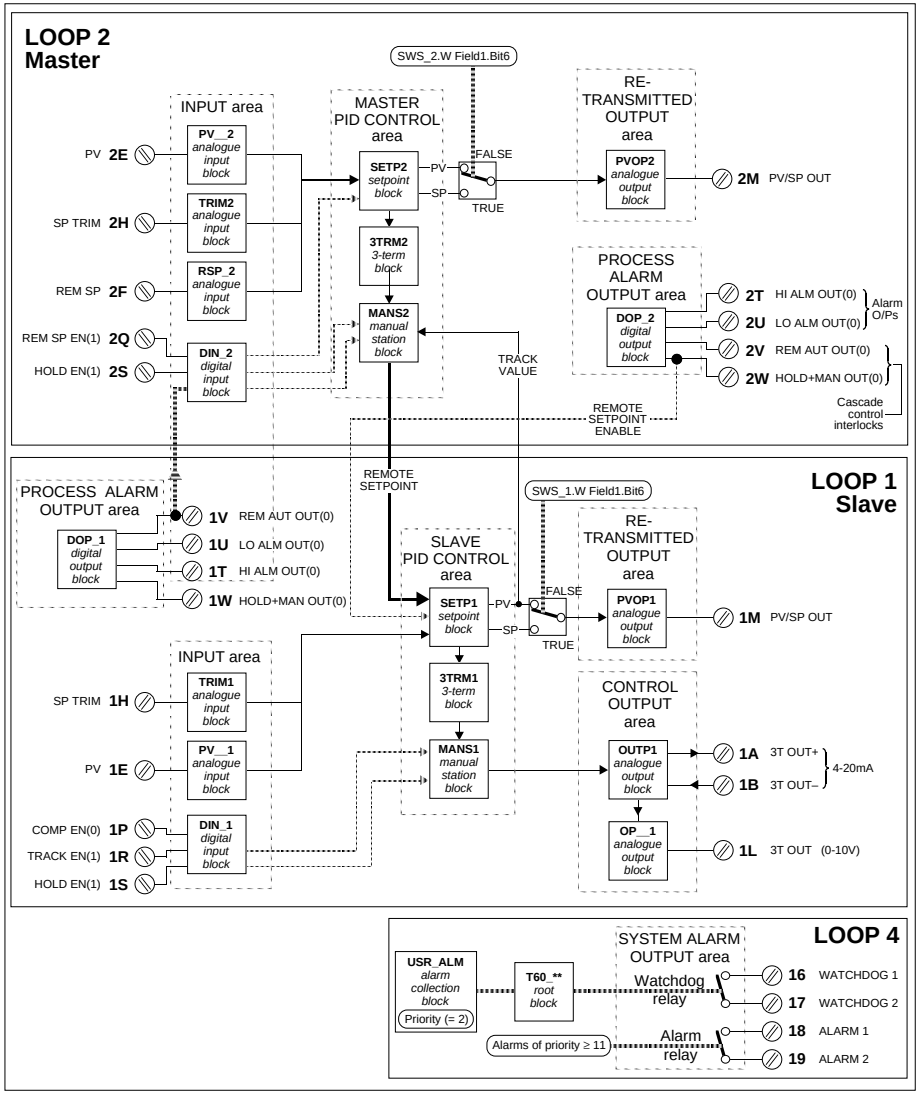


Figure 5-7 Strategy #3 schematic

Strategy #3 organisation

Master & slave

The strategy has been internally connected to make Loop 2 the master controller, and Loop 1 the slave controller.

Blocks & connections

Strategy #3 is similarly-structured to strategy #2, but has the following additions that work behind the scenes:

- Two extra database interconnections are present —

  3TRM1.Status.HiLimFrc to **3TRM2.Options.FrcHiLim**
  3TRM1.Status.LoLimFrc to **3TRM2.Options.FrcLoLim**

  These cause the master, Loop 2, to behave as if in output limit when the slave, Loop 1, goes into output limit. This has the effect of inhibiting integral term wind-up in the master controller, and gives faster return to control.

- Range blocks have been added to re-range the 'analogue' internal connections between the loops. Loop 2's output is still ranged 0-100% and loop 1's PV and SP ranges are chosen to represent engineering units. Note that these range blocks are not accessible via the **INS** button for configuration.

Loop update rates

The loop update rates have been chosen to let the slave run faster than the master. The update rate of Loop 1 is 220ms, and of Loop 2 is 420mS.

Strategy #3 — operator interface

Cascade control is selected by putting the slave Loop1 into Remote mode (press the **R** button) and putting the master Loop 2 into Auto mode (press **A**).

> NOTE. If these conditions are not true, Loop 1 will be in the mode selected and Loop 2 will be tracking it.

The sequence in which the modes are selected does not matter as the interlocking signals ensure no illegal modes occur:

- If Loop 1's **R** button is pressed before Loop 2's **A** button, Loop 1's **A** indicator will flash indicating the mode 'Primed'. In operation, Primed is identical to Auto, except that as soon as Loop 2 is put into Auto, Loop 1 goes into Remote.
- If Loop 2's **A** button is pressed before Loop 1's **R** button, Loop 2's **A** indicator will light but the **T** indicator will remain lit indicating that Track is overriding Auto. When Loop 1's **R** button is pressed, Loop 2 is no longer forced to track and cascade control begins.

Strategy #3 I/O customer terminals

Strategy #3 uses a pair of I/O boards located in sites 1 and 2 of the T640, accessible via customer terminals 1A to 1Z (site 1) and 2A to 2Z (site 2). These terminations and their functions are almost the same as those for strategy #2, given in Tables 5-4 and 5-7.

The exceptions are that the following terminals have no function in the strategy —

- Pin 1F, **REM SP**
- Pin 1Q, **REM SP EN(1)**
- Pin 2J, **TRACK**
- Pin 2R, **TRACK EN(1)**
- Pin 2P, **COMP EN(0)**

Strategy #3 function blocks and parameters

This strategy has three 'user tasks' — seen as **LOOP 1**, **LOOP 2**, and **LOOP 4** in the tag display — that you can access via the **INS** pushbutton to configure their function blocks. The parameters in Loops 1 and 2 deal with configuration of the respective control loops themselves, and those in Loop 4 cover system alarms and general instrument setup. The three loops are almost the same as those of strategy #2, which were tabulated in Tables 5-5, 5-8, and 5-6.

The exceptions are that —

- The block **RSP_1** and its input REM SP, pin 1F, are present but have no function
- The block **TRCK2** and its input TRACK, pin 2J, are present but have no function.

When you come to configure these parameters you will find the *setup sheets* for this strategy helpful, because they list the default values of all fields, and include a spare column for you to record your customised values where required. You may want to use photocopies of the printed setup sheets as your working documents. The setup sheets for this strategy are found under *Setup sheets — all strategies* on page 5-34.

STRATEGY #4 — DUAL CONTROL LOOP (RATIO)

Strategy #4 is a dual-loop controller — Loops 1 and 2 — having in addition a ratio station in Loop 3. All loop interconnections are internally pre-wired in the database.

Figure 5-8 shows a 'P & I' diagram for the strategy in which — by way of example — a pair of flow rates are controlled to maintain a fixed ratio between them.

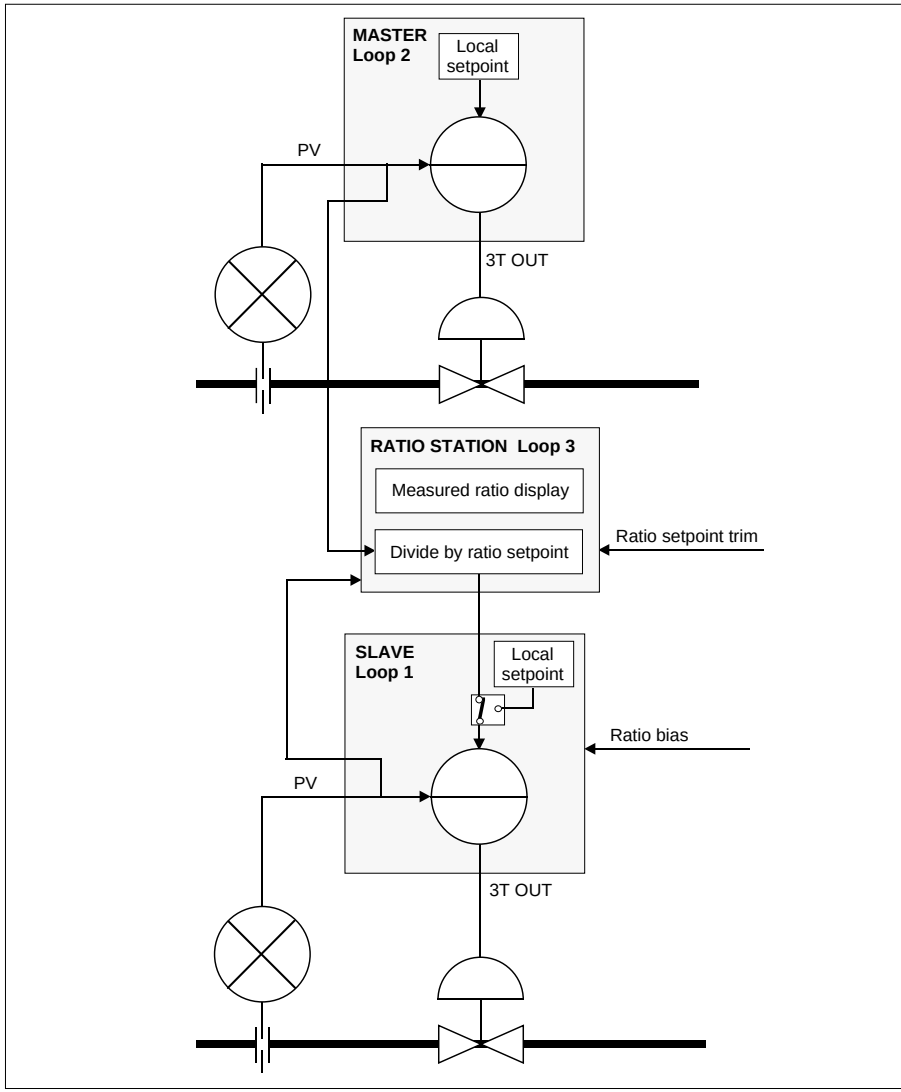


Figure 5-8 Example P & I diagram for strategy #4

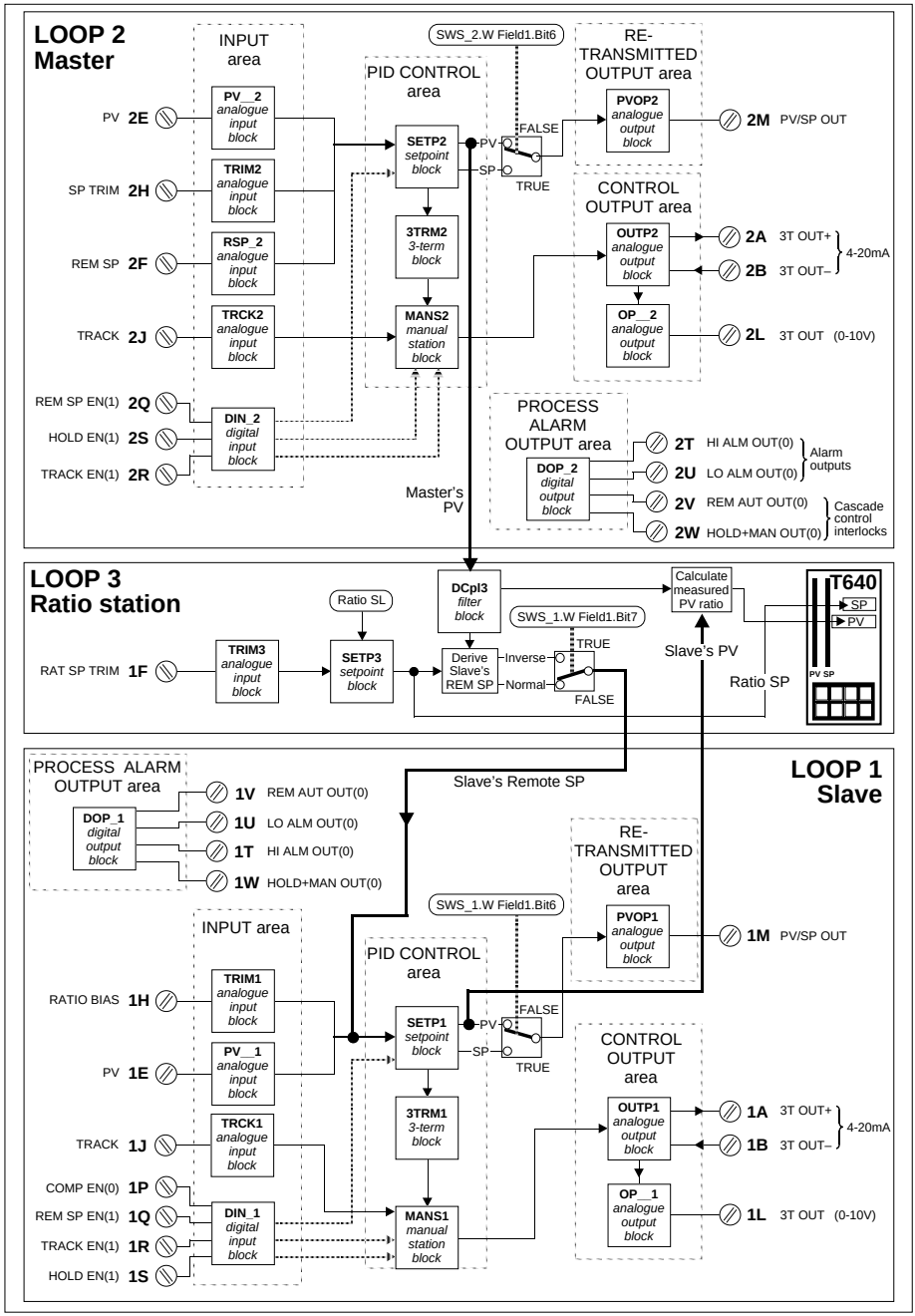


Figure 5-9 Strategy #4 schematic

Strategy #4 schematic

Figure 5-9 shows schematically the main function blocks in the strategy, the principal signal flows between them, and their associated customer terminals. Details of each terminal and block are given in the tables that follow.

Strategy #4 organisation

Master, slave, & ratio station

The strategy has been internally connected to make Loop 2 the master controller, Loop 1 the slave, and Loop 3 the ratio station.

Normal & inverse ratios

The ratio value may be entered and displayed as the ratio of Loop 1's PV to Loop 2's PV, or the other way round. See **SWS_1.Bit7** in Table 5-5 on page 5-10.

Normal and *inverse* ratio are defined as follows:

- **Normal** — Loop1 SP = Loop2 PV / ratio setpoint
- **Inverse** — Loop1 SP = Loop2 PV * ratio setpoint

Modes

Loop 1 can to go into ratio mode for all operating modes of Loop2. However if Loop 2's process variable PV becomes invalid, Loop 1 reverts to Auto mode. Ratio control will only resume once Loop 2's PV has re-established and Loop 1's **R** button is re-pressed.

With Loop 2 not used for control, the T640 can be used as a single loop controller with ratio input.

Ratio setpoint trim

The ratio Setpoint trim input is customer terminal 1F, in place of the unused remote setpoint input for Loop 1. The function block **RSP_1** does not exist

Ratio bias

The function of ratio bias is achieved through Loop 1's SP TRIM. This input operates to make the bias function as [*Ratio* + *bias*], or [(1/*Ratio*) + *bias*], depending on the ratio setting option.

NOTE. Ratio bias does not perform the function [1/(*Ratio* + *bias*)].

Filtering

SETP2.PV is filtered before calculating the remote setpoint for **SETP1**. The filter is also applied prior to the measured ratio calculation. The filter prevents open-loop disturbances in Loop 2's PV affecting the closed-loop performance of Loop 1.

Loop update rates

The update rate of each loop is 320ms.

Strategy #4 — operator interface

The ratio setpoint is adjusted by selecting Loop 3 and raising or lowering the setpoint.

Ratio control is achieved by pressing the **R** button when Loop 1 is selected. If Loop 1 is not in Remote mode, the two loops will act independently, although the measured ratio is still shown.

Strategy #4 I/O customer terminals

Strategy #4 uses a pair of I/O boards located in sites 1 and 2 of the T640, accessible via customer terminals 1A to 1Z (site 1) and 2A to 2Z (site 2). These terminals and functions are almost the same as those for strategy #2, given in Tables 5-4 and 5-6. The exception is terminal 1F, which is here the *Ratio Trim* input instead of the *Remote Setpoint* input.

Strategy #4 function blocks and parameters

This strategy has four 'user tasks' — seen as **LOOP 1**, **LOOP 2**, **LOOP 3** and **LOOP 4** in the tag display — that you can access via the **INS** pushbutton to configure their function blocks. The parameters in Loops 1 and 2 deal with configuration of the respective slave and master control loops, those in Loop 3 deal with the ratio station, and those in Loop 4 cover system alarms and general instrument setup. Loops 1, 2, and 4 are the same as those of strategy #2, which were tabulated in Tables 5-5, 5-8, and 5-6.

Loop 3's configurable blocks and parameters, associated with the ratio station, are listed in Table 5-10 below.

When you come to configure these parameters you will find the *setup sheets* for this strategy helpful, because they list the default values of all fields, and include a spare column for you to record your customised values where required. You may want to use photocopies of the printed setup sheets as your working documents. The setup sheets for this strategy are found under *Setup sheets — all strategies* on page 5-34.

NOTE. The order of the blocks in the table may not match their order of appearance when you access them via the **INS** button.

Block	Field	Subfield	Description
SL663			This block needs attention only if Bisync communications are to be used.
	Instr_No		Slave address of the control loop's 6366 emulation on the Bisync communications bus.
DCpl3			This block filters SETP2.PV before calculating the remote setpoint for SETP1. The filter is also applied prior to the measured ratio calculation.
	Filter		First-order filter time constant.

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Block	Field	Subfield	Description
TRIM3			This input provides a trim to the ratio setpoint. This trim input is added to the setpoint directly. If no trim is required all parameters in this block can be left as default.
	MODE		This should be left at MANUAL if a manual trim or no trim are required. Set this input to AUTO if a trim is to be provided as an input signal, SP TRIM
	PV		If MODE is set to MANUAL this input may be used to manually input a ratio setpoint trim.
	HR		This sets the high range: HR_in maps to HR. Because trim works by direct addition to the setpoint, HR and LR are used to scale the trim input against SETP1 HR_SP and LR_SP.
	LR		This sets the low range: LR_in maps to LR. It would not be unusual for LR to be the same value as HR but negative to give a symmetrical trim.
	Filter		A first-order filter with the time constant set applied to the input.
	HR_in		The input voltage representing high range
	LR_in		The input voltage representing low range
	Options		Only options believed relevant are described. Some options have defaults relevant to the I/O hardware and should not be changed.
		Invert	TRUE maps HR_in to LR and LR_in to HR. TRUE also inverts the effect of the trim signal.
		Sqrt	TRUE applies a square root function to the input
SETP3			This block is used to enter the ratio setpoint and calculate the measured ratio for display.
	HR_SP		The high range of the ratio setpoint. HR_SP and LR_SP should be chosen to give a clear display on the PV and SP bargraphs of loop 3 which take their ranges from these parameters.
	LR_SP		The low range of the ratio setpoint.
	HL_SP		This sets a high limit for the setpoint including any trim.
	LL_SP		This sets a low limit for the setpoint including any trim.
	HL_SL		This sets a high limit for the local setpoint.
	LL_SL		This sets a low limit for the local setpoint.
	Alarms		These are the process alarms of the control loop. Note: Priority 0 disables the alarm completely. Priority 6-15 need to be acknowledged. Priority 11-15 open the Alarm relay. Alarms of priority equal to USR_ALM.Priority will open the Watchdog relay.
		HighAbs	The measured ratio exceeds HAA
		LowAbs	The measured ratio is less than LAA
		HighDev	The measured ratio exceeds the set ratio by HDA
		LowDev	The measured ratio is less than the set ratio by LDA
	HAA		High absolute alarm setting
	LAA		Low absolute alarm setting
	HDA		High deviation alarm setting
	LDA		Low deviation alarm setting
	Dis_DP		Sets the number of digits displayed to the right of the decimal point. This parameter is for display purposes only and has no effect on the ranging.

Table 5-10 Loop 3 parameters — strategy #4 (ratio station)

SETUP SHEETS — ALL STRATEGIES

Tables 5-11 to 5-14 list all four strategies' configurable fields and their default values, together with a very brief description of their function. The loops apply to all the strategies, except where indicated. You may want to photocopy these pages and record your customised parameter values on them.

Loop 1

Block	Field	Subfield	Default	Setting	Description
SL661	Instr_No		1		BiSynch address
SWS_1	W Field1	Bit0	FALSE		Power up mode
		Bit1	FALSE		PV fail mode
		Bit2	FALSE		tru - inverse output action
		Bit3	FALSE		tru - inverse PID
		Bit4	FALSE		tru - On/Off control
		Bit5	FALSE		tru - setpoint tracks PV if not AUTO
		Bit6	FALSE		tru - PV/SP Out = SP
		Bit7	FALSE		tru - inverse ratio setting
		Bit8	FALSE		tru - Mask R
		Bit9	FALSE		tru - Mask A
		BitA	FALSE		tru - Mask M
		BitB	tru		Tag FIC-001
		BitC	FALSE		Tag LIC-001
		BitD	FALSE		Tag PIC-001
		BitE	FALSE		Tag TIC-001
		BitF	FALSE		Tag AIC-001
RSP_1	Filter		0.00		Input filter
	HR_in		10.00		Input voltage high
	LR_in		0.00		Input voltage low
	Options	Invert	FALSE		Input conditioning
		Sqrt	FALSE		Input conditioning
DIN_1	Invert	Bit0	FALSE		tru inverts COMP EN(0)
		Bit1	tru		FALSE inverts REM SP EN(1)
		Bit2	FALSE		tru inverts TRACK EN(1)
		Bit3	FALSE		tru inverts HOLD EN(1)
PV__1	Filter		1.00		Input filter
	RomChar		None		Input conditioning
	Alarms	Hardware	2		Alarm priority
		OutRange	2		Alarm priority
		OCctdel	2		Alarm priority
	HR_in		10.00		Input voltage high
	LR_in		0.00		Input voltage low
	Options	Invert	FALSE		Input conditioning
		Sqrt	FALSE		Input conditioning

continued…

…continued

Block	Field	Subfield	Default	Setting	Description
TRIM1	MODE		MANUAL		Operating mode (AUTO or MANUAL)
	PV		0.00		Trim setting if MANUAL
	HR		100.00		Engineering units high
	LR		0.00		Engineering units low
	Filter		0.00		Input filter
	HR_in		10.00		Input voltage high
	LR_in		0.00		Input voltage low
	Options	Invert	FALSE		Input conditioning
		Sqrt	FALSE		Input conditioning
SETP1	HR_SP		100.00		Engineering unitshigh for SP and PV
	LR_SP		0.00		Engineering units low for SP and PV
	HL_SP		100.00		High limit on SP
	LL_SP		0.00		Low limit on SP
	HL_SL		100.00		High limit on SL
	LL_SL		0.00		Low limit on SL
	Alarms	HighAbs	2		Alarm priority on HAA
		LowAbs	2		Alarm priority on LAA
		HighDev	2		Alarm priority on HDA
		LowDev	2		Alarm priority on LDA
	HAA		100.00		High absolute alarm on PV
	LAA		0.00		Low absolute alarm on PV
	HDA		100.00		High deviation alarm on PV
	LDA		100.00		Low deviation alarm on PV
	Dis_DP		2		Decimal point position
DOP_1	Invert	Bit0	tru		FALSE inverts HI ALM OUT(0)
		Bit1	tru		FALSE inverts LO ALM OUT(0)
		Bit2	FALSE		tru inverts REM AUT AUT(0)
		Bit3	FALSE		tru inverts HOLD+MAN OUT(0)
PVOP1	HR_out		10.00		Output voltage high
	LR_out		0.00		Output voltage low
3TRM1	TimeBase		Secs		Control settings time base (TI & TD)
	XP		100.00		Proportional band
	TI		10.00		Integral time
	TD		0.00		Derivative time
	Deadband		0.00		Hysteresis for On/Off control
TRK1	MODE		AUTO		Operating mode (AUTO or MANUAL)
	PV		0.00		Track setting if MANUAL
	HR_in		10.00		Input voltage high
	LR-in		0.00		Input voltage low
MANS1	HL_OP		100.00		High limit on control output
	LL_OP		0.00		Low limit on control output
OP__1	HR_out		10.00		Output voltage high
	LR_out		0.00		Output voltage low

Table 5-11 Setup sheet for Loop 1 — all strategies

Loop 2

Block	Field	Subfield	Default	Setting	Description
SL662	Instr_No		1		BiSynch address
SWS_2	W Field1	Bit0	FALSE		Power up mode
		Bit1	FALSE		PV fail mode
		Bit2	FALSE		tru - inverse output action
		Bit3	FALSE		tru - inverse PID
		Bit4	FALSE		tru - On/Off control
		Bit5	FALSE		tru - setpoint tracks PV if not AUTO
		Bit6	FALSE		tru - PV/SP Out = SP
		Bit7	FALSE		tru - inverse ratio setting
		Bit8	FALSE		tru - Mask R
		Bit9	FALSE		tru - Mask A
		BitA	FALSE		tru - Mask M
		BitB	tru		Tag FIC-001
		BitC	FALSE		Tag LIC-001
		BitD	FALSE		Tag PIC-001
		BitE	FALSE		Tag TIC-001
		BitF	FALSE		Tag AIC-001
RSP_2	Filter		0.00		Input filter
	HR_in		10.00		Input voltage high
	LR_in		0.00		Input voltage low
	Options	Invert	FALSE		Input conditioning
		Sqrt	FALSE		Input conditioning
DIN_2	Invert	Bit0	FALSE		(*Unused*)
		Bit1	tru		FALSE inverts REM SP EN(1)
		Bit2	FALSE		tru inverts TRACK EN(1)
		Bit3	FALSE		tru inverts HOLD EN(1)
PV__2	Filter		1.00		Input filter
	RomChar		None		Input conditioning
	Alarms	Hardware	2		Alarm priority
		OutRange	2		Alarm priority
		OCctdel	2		Alarm priority
	HR_in		10.00		Input voltage high
	LR_in		0.00		Input voltage low
	Options	Invert	FALSE		Input conditioning
		Sqrt	FALSE		Input conditioning
TRIM2	MODE		MANUAL		Operating mode (AUTO or MANUAL)
	PV		0.00		Trim setting if MANUAL
	HR		100.00		Engineering units high
	LR		0.00		Engineering units low
	Filter		0.00		Input filter
	HR_in		10.00		Input voltage high

continued…

…continued

Block	Field	Subfield	Default	Setting	Description
	LR_in		0.00		Input voltage low
	Options	Invert	FALSE		Input conditioning
		Sqrt	FALSE		Input conditioning
SETP2	HR_SP		100.00		Engineering unitshigh for SP and PV
	LR_SP		0.00		Engineering units low for SP and PV
	HL_SP		100.00		High limit on SP
	LL_SP		0.00		Low limit on SP
	HL_SL		100.00		High limit on SL
	LL_SL		0.00		Low limit on SL
	Alarms	HighAbs	2		Alarm priority on HAA
		LowAbs	2		Alarm priority on LAA
		HighDev	2		Alarm priority on HDA
		LowDev	2		Alarm priority on LDA
	HAA		100.00		High absolute alarm on PV
	LAA		0.00		Low absolute alarm on PV
	HDA		100.00		High deviation alarm on PV
	LDA		100.00		Low deviation alarm on PV
	Dis_DP		2		Decimal point position
DOP_2	Invert	Bit0	tru		FALSE inverts HI ALM OUT(0)
		Bit1	tru		FALSE inverts LO ALM OUT(0)
		Bit2	FALSE		tru inverts REM AUT AUT(0)
		Bit3	FALSE		tru inverts HOLD+MAN OUT(0)
PVOP2	HR_out		10.00		Output voltage high
	LR_out		0.00		Output voltage low
3TRM2	TimeBase		Secs		Control settings time base (TI & TD)
	XP		100.00		Proportional band
	TI		10.00		Integral time
	TD		0.00		Derivative time
	Deadband		0.00		Hysteresis for On/Off control
TRK2	MODE		AUTO		Operating mode (AUTO or MANUAL)
	PV		0.00		Track setting if MANUAL
	HR_in		10.00		Input voltage high
	LR-in		0.00		Input voltage low
MANS2	HL_OP		100.00		High limit on control output
	LL_OP		0.00		Low limit on control output
OP__2	HR_out		10.00		Output voltage high
	LR_out		0.00		Output voltage low

Table 5-12 Setup sheet for Loop 2

Loop 3

Block	Field	Subfield	Default	Setting	Description
SL663	Instr_No		1		BiSync address
DCpl3	Filter		0.00		Ratio Decoupling Filter
TRIM3	MODE		MANUAL		Operating mode (AUTO or MANUAL)
	PV		0.00		Trim setting if MANUAL
	HR		100.00		Ratio trim high
	LR		0.00		Ratio trim low
	Filter		0.00		Input filter
	HR_in		10.00		Input voltage high
	LR_in		0.00		Input voltage low
	Options	Invert	FALSE		Input conditioning
		Sqrt	FALSE		Input conditioning
SETP3	HR_SP		100.00		Ratio high range for SP and PV
	LR_SP		0.00		Ratio low range for SP and PV
	HL_SP		100.00		High limit on SP
	LL_SP		0.00		Low limit on SP
	HL_SL		100.00		High limit on SL
	LL_SL		0.00		Low limit on SL
	Alarms	HighAbs	2		Alarm priority on HAA
		LowAbs	2		Alarm priority on LAA
		HighDev	2		Alarm priority on HDA
		LowDev	2		Alarm priority on LDA
	HAA		100.00		High absolute alarm on PV (measured ratio)
	LAA		0.00		Low absolute alarm on PV
	HDA		100.00		High deviation alarm on PV
	LDA		100.00		Low deviation alarm on PV
	Dis_DP		3		Decimal point position

Table 5-13 Setup sheet for Loop 3 — strategy #4 (ratio)

Loop 4

Block	Field	Subfield	Default	Setting	Description
USR_ALM	Priority		2		Watch dog relay alarm setting (0-15)
T60_**	Options	NoKeyPrt	tru		FALSE - key required
		NoKeyFul	FALSE		FALSE - key required
		BinSpd1	FALSE		Bisynch baud rate.
		BinSpd2	FALSE		Default gives 9600 baud

Table 5-14 Setup sheet for Loop 4 — all strategies

COMMUNICATING WITH THE T640

There are three ways in which the T640 may be integrated into a system — via the ALIN, via TCS binary Bisync protocol, and via MODBUS/JBUS. (Please refer to Chapter 2 under *Hardware Configuration* for communications configuration information.)

Communicating on the ALIN

This is always available and gives tight integration into the Eurotherm Process Automation LIN system. Blocks have been included in the fixed function strategies specifically for caching. The most important of these are PID_CONN blocks, which allow interaction with the control loops. The names of the PID_CONN blocks are:

PIDC1** for Loop 1, **PIDC2**** for Loop 2, and **PIDC3**** for Loop 3,

where ****** is the instrument node number. For example, if the ALIN address of the instrument were 88, Loop 1's control block would be named **PIDC188**. T640 automatically substitutes the node number for ******.

Furthermore, eleven diagnostic blocks are provided for the instrument as a whole. For details on the operation of these blocks, please refer to the *LIN Blocks Reference Manual* (Part No. HA 082 375 U003). Table 5-15 lists these block types and their names.

Block type	Block name
DB_DIAG	DDIAG_**
EDB_DIAG	EDIAG_**
LIN_DEXT	LDEXT_**
ALINDIAG	ALIND_**
XEC_DIAG	XDIAG_**
T600TUNE	T600T_**
EDB_TBL	ETBL_**
ROUTETBL	ROUTE_**
RTB_DIAG	RDIAG_**
ISB_DIAG	IDIAG_**
ISB_DEXT	IDEXT_**

Table 5-15 Diagnostic blocks in the T640 fixed function strategies

TCS binary Bisync protocol

As an option, the T640 can be fitted with RS422/RS485 communications. Each loop will emulate a 6366 as far as communications is concerned. This allows the T640 to be integrated into existing 6000 instrument-based systems. Setting up the RS422 node address is done within the SL661, SL662 and SL663 blocks.

MODBUS/JBUS

This too requires the RS422/RS485 option. To set up and download the MODBUS tables to the T640, you need T500 LINtools. A full explanation of the configuration of the MODBUS interface is given in the *T500 User Guide* (Part No. HA 082 377 U005).

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Chapter 6 CHANGES LOGFILE

LOGFILES

The T640 maintains in EEPROM a logfile of every parameter change made via the front panel database access mechanism, i.e. via the **INS** button. (Please refer to Chapter 4, *User interface*, for full details on database access and use of this button.) The logfile contains a complete record of what was changed, when it was changed, and by whom.

Logfile organisation

The logfile adopts the same root filename as the .DBF file from which the database was loaded, but with extension **.L*nn***, where *nn* is the logfile number, ranging from 01 to 99. When a logfile becomes full (i.e. has reached 1Kbyte) it closes and its number is written to the T600 block's *Log_File* parameter. The previously held file is deleted. When more logfile data is generated a new file with incremented logfile number is automatically created. Thus the T600 block logfile number defines a file that may be safely uploaded. If *Log_File* is '0', there is no file to upload. Only the two most recent logfiles are retained in memory: the currently open file and the last closed one.

A logfile can be closed before it is full if another type of file (e.g. a strategy file) is added to EEPROM to make the logfile no longer the latest file. This is because T640's filing system allows data to be appended only to the last file in EEPROM.

Logfile records

There are two possible records in a log file:

- **Inspect Mode entry.** This record shows the date of entry into Database Inspect mode, and which security key was used to access the mode. One of these records is written to file only if parameter changes were actually made.

  Each record is a single text line of the format

  `dd/mm/yy T:aakkkk`

  where: `dd/mm/yy` = the date in day/month/year representation
  `T` = type of security key (P = partial, F = full, G = global, ignoring area no.)
  `aa` = area number (0 - 63)
  `kkkk` = security key number (0 - 4095).

- **Parameter Change entry.** This record shows a single instance of parameter updating. In order to control file size when the operator is 'nudging' to the value, there must be a significant time gap between nudges to result in more than one record. Where a change in direction occurs the peaks in each direction are logged (as a minimum). The time logged is the time that the final value was written.

  Each record is a single text line of the format

  `hh:mm:ss block.field.subfield = value`

  or, for a change of mode,

  `hh:mm:ss LOOP n = X`

  where: `hh:mm:ss` = the time in hours/minutes/seconds (24hr) representation
  `block` … = the full path of the point being modified
  `value` = the new value
  `n` = the loop number
  `X` = the new mode, i.e. **`M`**, **`A`**, or **`R`**.

Example logfile record

```
21/01/93 F:  3:2345
01:12:15 T640C6C3.Options.FPdisl = TRUE
01:12:18 T640C6C3.Options.NoKeyFul = FALSE
01:12:25 LOOP 4 = M
```

Logfile saving

The recording of database changes via the front-panel to a logfile normally occurs invisibly, as a background operation. However, sometimes the T640 must re-order its filing system, e.g. when a logfile becomes full, or after a database download or save. This process can take a noticeable amount of time, and can cause an apparent sluggishness in response when operators try to make database changes via the front panel. (Version 4/1 software has an enhanced filing system that does not suffer from this problem.)

V3/3 of the software includes a front-panel message to advise the operator when this process is occurring. The message '**LOG SAVE**' is displayed in the tag display, followed by '**Save OK**'.

NOTE. During this file-saving operation the T640 power must not be interrupted. Doing so could possibly corrupt the filing system. Although the v4/1 enhanced filing system does not suffer from this corruption problem, ***it is still strongly recommended that power is not removed during file save operations***.

Chapter 7 T640 TASK ORGANISATION & TUNING

The T640 performs all its in-built and user-programmed instructions serially, i.e. one at a time. The first section of this chapter describes these various software functions —*tasks* — and their scheduling within the instrument. An understanding of the timings and priorities of these helps you to use the instrument at maximum efficiency.

The next section describes *user tasks* and their associated loops and servers. User task software structure and server operation is also outlined.

Finally, user task *tuning*, by varying minimum repeat rates via the T600 block, is described.

TASK SCHEDULING

T640 tasks

A task is a unit of software in the T640 that is responsible for carrying out particular duties at certain times, usually while the database is running. There are fifteen recognisable tasks in the T640. Most tasks are fixed and cannot be varied by the user. Others, the *user tasks*, are programmable; these are discussed in more detail in the next section.

Priorities

Each task has a running priority based on its importance to the efficient and safe operation of the T640. Priorities are numbered from 1 (highest) to 15 (lowest). A task, once started, will run to completion unless it is interrupted at any time by a task of higher priority. In this case the lower priority task suspends activities until the higher priority task has run to completion, at which point it resumes running. These interruptions are hierarchical; several tasks may be held in suspension by higher priority tasks at any one time.

Table 7-1 lists all T640's tasks in priority order, summarising their functions and scheduling. More detail is given for some of these tasks in the following sections.

Functions of tasks

Network task

This task is repeat driven approximately every 15ms. It performs housekeeping for all transactions over the ALIN, whether initiated by this node or as replies to messages from other nodes.

Task	Function	Schedule
1. Rx	Processes received messages over the ALIN	Event driven
2. Binary	Processes received messages over the RS422 binary comms	Event driven
3. Network	Housekeeping for all transactions over the ALIN	Every 15ms approx.
4. Front panel	Scans front-panel pushbuttons. Generates front panel displays and security key logfiles	Every 80ms
5. MODBUS receive	Processes received RS422/485 MODBUS comms	Event driven
6. User task 1 server	Runs user task 1 (loop 1)	Every MinRpt1 secs*
7. User task 2 server	Runs user task 2 (loop 2)	Every MinRpt2 secs*
8. User task 3 server	Runs user task 3 (loop 3)	Every MinRpt3 secs*
9. User task 4 server	Runs user task 4 (loop 4) and sequencing	Every MinRpt4 secs*
10. Cache block server	Processes connections into & out of cached blocks	Every 100ms
11. LLC	Monitors ALIN link low level status. Applies timeouts to transmitted messages. Reprograms ALIN hardware if errors are detected.	Every 100ms approx.
12. Load	Loads a database on remote request	Event driven
13. NFS	Network Filing System. Processes ALIN filing system request	Event driven
14. MODBUS	MODBUS database management	(Periodic)
15. Scan	Collates alarm information	Continuous
16. Bgnd	'Null task'. Provides environment for CPU's execution, whilst no other tasks run	Only when dbase halted

*Or less often, subject to CPU loading

Table 7-1 T640 task scheduling

Front panel task

This task is repeat driven every 80ms. It is responsible for the scanning of front panel pushbuttons, and the generation of front panel displays. It is also responsible for generating the security key logfiles.

User task 1 server - user task 4 server

These servers are responsible for running the (up to) four user tasks. They are repeat driven, the rate being as requested by the user in the *MinRpt* fields of the T600 block, subject to the requested repeat rates not exceeding the maximum permitted CPU loading. (See under *User task tuning*.)

User task 1 server has the highest priority, and user task 4 server the lowest.

Cache block server task

This server is responsible for processing connections into and out of cached blocks. It is repeat driven at a minimum rate of once per 100ms. The actual repeat rate, derived by the T640, depends on the available CPU power after allowing for the user tasks.

LLC task

This task runs every 100ms, approximately, and monitors the low level status of the ALIN link. It applies timeouts to transmitted messages, and also reprograms the ALIN hardware if error conditions are detected.

Load task

This task is event driven, and is run only when a remote request to load a database is received.

NFS task

Network Filing System. This task processes ALIN filing system requests and is event driven. Note that owing to the low position of the NFS task in the priority structure, filing system requests get a much larger share of CPU time when the database is halted.

Scan task

This task is run continuously while the database is running. Its purpose is to collate alarm information and sumchecking of the database.

Bgnd task

This 'background' task performs no specific operation. Its only purpose is to provide a task environment for the CPU to execute in, while there are no other tasks running. Bgnd task is not run at all while the database is running.

USER TASKS

Terms

A *user task* is an element of strategy, i.e. a piece of software, programmed into the T640 by the control engineer, which is nominally associated with a loop. By *loop* is meant the complete feedback control loop, consisting of the unit of plant under control together with its controller. Note that it is possible to associate more than one user task with a single loop, when more complex control is needed— this is the case in standard strategy #6 (called T640C6), for example (see Chapter 5).

A *server* is a fixed software task within the T640 that executes a user task, or that processes cached blocks.

User task servers

Server interactions

There are five servers in the T640, one for each of the user tasks, and one for the cached blocks (see Table 7-1). The servers are prioritised, repeat-rate driven, and fully coherent (as described in Chapter 8). T640's block structured database is completely compatible with that of the T100/T1000 instruments, and supports cached blocks in the same way.

Server 1 has the highest priority, and server 5 the lowest. Interruption of one server by another of higher priority has already been described above under *Task Scheduling*. The user task servers are set to run no more than once every task repeat time, as specified by the corresponding T600 block *MinRpt*n parameter.

Figure 7-1 shows schematically how the five servers interact with each other according to their priorities. The shaded bars represent running tasks and the unshaded portions represent suspended tasks. Note that each user task produces values that are to be displayed on T640's front panel, represented in Figure 7-1 as 'outputs'.

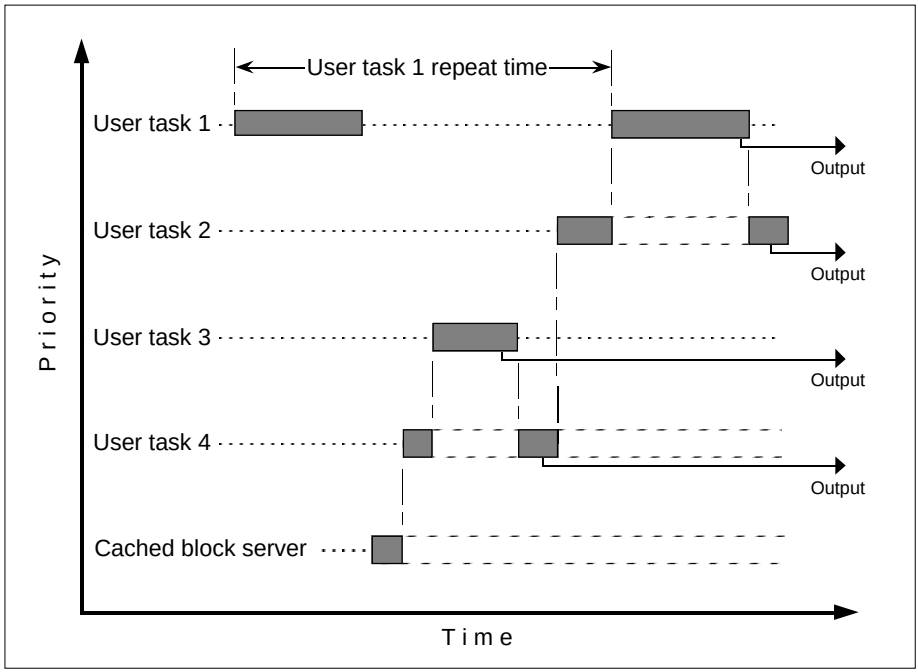


Figure 7-1 User task server interactions

Front panel interface

Please refer to the schematic in Figure 7-2. Each user task has a 'logical front panel' associated with it and maintained by it, where its 'outputs' destined for display are held. The *front panel* task (see Table 7-1) generates front panel displays from the data held in these logical front panels.

The *summary* display area of each logical front panel is always connected, via the front panel task, to the corresponding summary display area of the 'physical' (real) front panel. But the *detailed* display area of only one logical front panel can be connected to the physical front panel at any one time, to produce the main loop display. This is determined by the position of the front panel 'loop select switch', set by pressing the raise/lower pushbuttons (described in the *User Guide*).

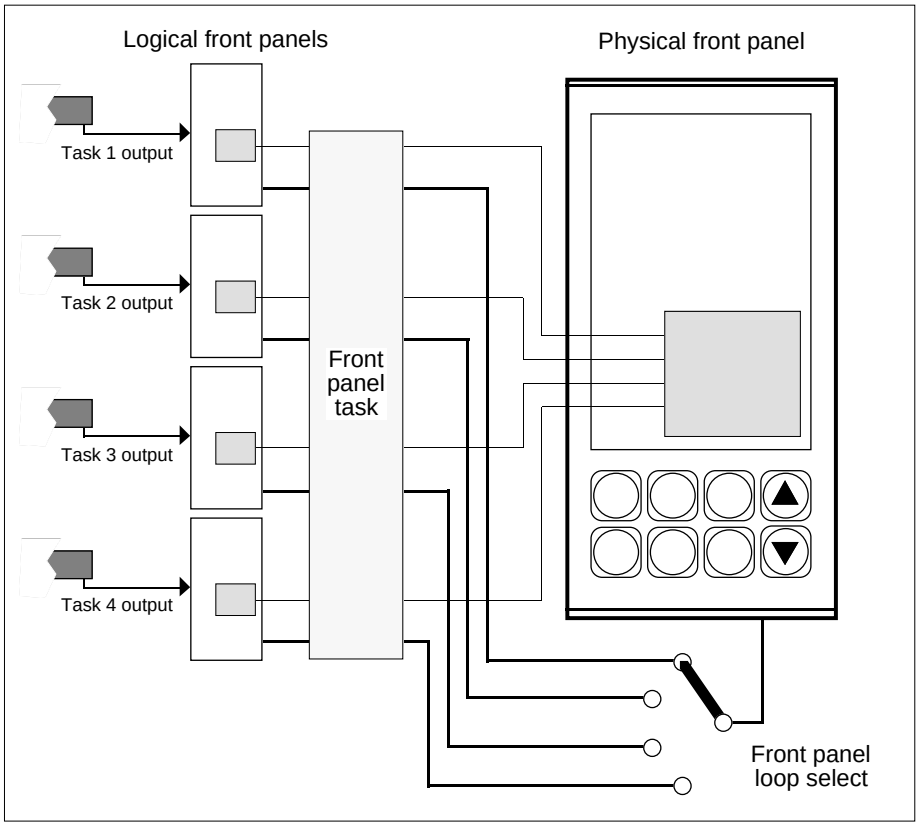


Figure 7-2 T640's logical & physical front panels

User task server operation

As already explained, a higher priority user task server always interrupts the running of a lower priority user task server. It follows from this that whenever a given user task is running, all higher priority user tasks must have run to completion. This fact is fundamental to achieving coherence of data flow between tasks.

Figure 7-3 shows schematically the sequence of events that occurs during the running of a user task server. These are as follows:

1 The user task requests that all I/O hardware read the required data and be brought fully 'up to date'. The task is suspended until this has been carried out.

2 The user task is then marked as 'busy'. During the 'busy' period no writes are allowed to any of the blocks in the user task. Any write attempts are directed to a queue, with the exception of single connections into cached blocks.

3 All connections sourced from higher priority tasks are then copied into their destination blocks in this user task. This occurs as a single, indivisible, operation. (As was noted above, all higher priority tasks must have run to completion.)

4 The blocks and their associated intra-task connections are then executed in order.

5 All connections sourced from this user task are then copied into their destination blocks in all higher priority user tasks, as a single, indivisible, operation. (Again, as was noted above, all higher priority tasks must have run to completion.)

6 Any pending queued writes, generated in step 2, are then performed.

7 Finally, the task 'busy' flag is removed.

Note that this structure results in the least work being carried out by the highest priority task. Note also that tasks may be suspended under the control of the strategy — via the T600 block's *UsrTask*n parameters — thereby allowing them to be event driven.

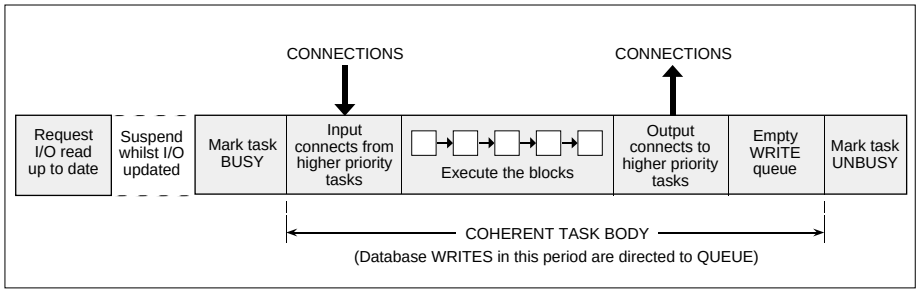


Figure 7-3 User task server operation

USER TASK TUNING

Repeat times & execution times

The T600 block's four parameters *MinRpt1* to *MinRpt4* let you specify the minimum repeat time for each user task. When these are set to zero, the T640 takes this to mean 'as short as possible'.

At database startup time the T640 estimates the execution time of each user task, compares the estimate with the requested *MinRpt*n time, and so derives an estimated percentage of total CPU power required for each task. If the required CPU power exceeds what is available, T640 automatically increases the user task minimum repeat times to workable values.

Note that the T640's estimates can be approximations only. Many block types have varying execution times that depend on operating parameter values, and dynamic changes to ALIN loading — e.g. increasing numbers of remote instruments starting to cache blocks within the local instrument. These factors can make the original estimates inaccurate.

Automatic dynamic tuning

To compensate for the variable nature of user task execution times, T640 continuously monitors the spread of CPU loading across its various tasks — both user tasks and system tasks — and adjusts user task repeat rates dynamically to ensure a fair spread of CPU allocation. This 'dynamic tuning' is adequate for most applications, but where task repeat timing is critical, you may want to adjust the *MinRpt*n values in the T600 block to get the best performance for your particular system.

Dynamic tuning attempts to adjust user task repeat rates to allow the Scan task to complete one database scan typically every 2 seconds, but never less often than once every 4 seconds.

Manual tuning

The T600TUNE block lets you monitor execution times and repeat times for all the user tasks and the cached block server. It also shows the percentage CPU usage by the various user and system tasks in the instrument. Bear in mind the prioritised nature of the user tasks when adjusting repeat rates (1 is the highest priority, 4 the lowest). The reported execution time for a user task may include a period of suspension whilst higher priority tasks execute.

Rapidly fluctuating repeat times for the lower priority tasks usually indicates an attempt to allocate too much total CPU time to the user tasks. A slight increase in some or all of the *MinRpt*n values should cure this.

The percentage CPU power allocated to the four user tasks should total approximately 65% (T600TUNE displays units of 0.1%). If the sum is less than this it should be safe to reduce *MinRpt*n values.

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Chapter 8 DATA COHERENCE

DATA FLOW BETWEEN TASKS

Coherence is an important aspect of control strategies involving more than one user task, i.e. 'loop'. Data flow is defined as being *coherent* if during any single execution of a task the data input into it from outside the task is a 'snapshot' — unchanging during the execution of the task — and represents the values output from other tasks that have completed their execution.

Data coherence, by definition, refers to connections that are 'remote' (i.e. linking different tasks). Connections that are limited to within a task (i.e. 'local'), are simply dealt with by being copied from source to destination immediately before executing the destination block.

For any task, there are three important types of remote connection. These types, and the way in which the T640 ensures their data coherence, are as follows.

1. Connections into this task from other tasks in the same instrument (node)

In order to ensure that multiple uses (in this task) of the same value (from another task) always use the same iteration of the value, such connections are copied prior to the execution of all the executable blocks of this task — i.e. a 'snapshot' is taken of all values external to this task.

Two types of connection apply here — those from higher priority tasks to lower priority tasks, and those from lower priority tasks to higher priority tasks:

- **Higher to lower priority.** For coherence it is clear that whenever connections out of a task are used, all their values must result from the same iteration of that task. Owing to the priority structuring of the tasks, any connections from a higher priority task into a lower priority task will meet this requirement. This is because a lower priority task cannot interrupt a higher priority task, which therefore always runs to completion. Hence, these connections are dealt with by a 'snapshot' copying at the start of the lower priority task.
- **Lower to higher priority.** A low priority task may be interrupted by a higher priority task before completion, and so be 'caught' with an incoherent set of output values. To avoid these invalid values being passed on, the last action of task execution is for the lower priority task to copy its set of coherent connections as a 'snapshot' to the higher priority task. In this way, the values passed on are always the last set of coherent values from a complete task execution.

2. Connections into this task from other tasks in other physical instruments

Connections between nodes are actually effected by the use of cached blocks. The process of cached block transmission, and reception at the destination end, is coherent for all the data within that block.

At the destination end, the cached block exists on a cached block server. Connections from this cached block to other blocks effectively become inter-server connections within the same node, the coherence of which is guaranteed — see **1.** above.

3. Connections out of this task to another node

This type of connection results in data flow that is *not* coherent, because the data is transmitted across the network as individual field writes, rather than as whole-block updates. If coherence is required, cache the block(s) in the opposite direction, via an AN_CONN block for example. This is illustrated in Figure 8-1, where block A coherently connects to block B across the LIN via the AN_CONN block (bold lines), but the connection is non-coherent when routed via cached block B.

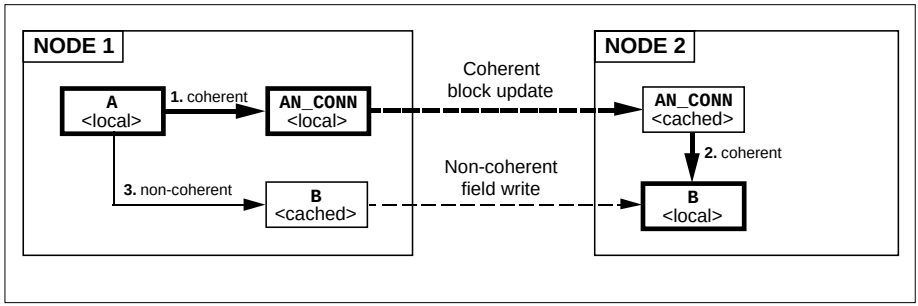


Figure 8-1 Coherent & non-coherent data flow across the network

Chapter 9 INSIDE T640

INTERNAL LAYOUT

Please refer to Chapter 2, *Installation & startup*, for details of T640's dimensions, internal physical and electrical layout, and hardware configuration. The present chapter deals with the software and hardware blocks functioning within the T640.

FUNCTIONAL BLOCKS

Figure 9-1 shows a functional block schematic of the T640. The main functional blocks are: the motherboard, the front panel, the I/O sub-assemblies (up to two), and the rear-panel customer screw terminals.

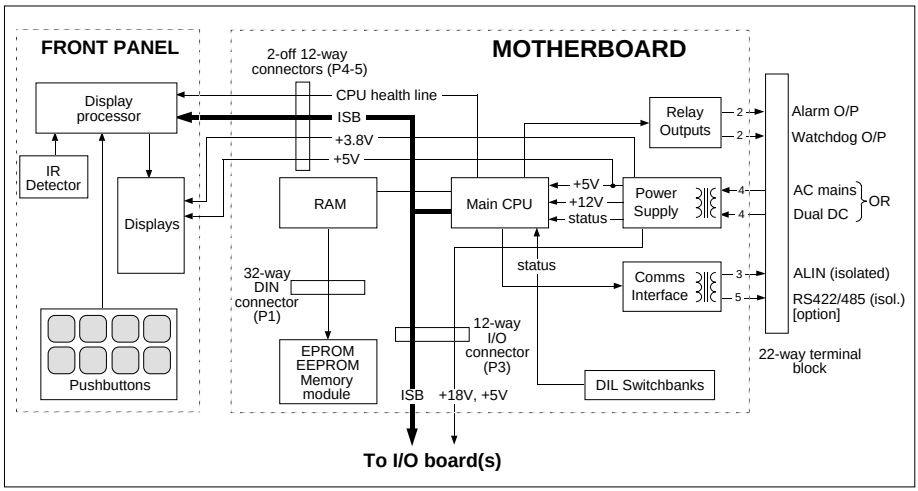


Figure 9-1 T640 Functional block schematic

Motherboard

The motherboard is the main electronics board in the instrument to which all other sub-assemblies connect. It carries the main CPU, communications electronics, power supply, and the two configuration DIL switchbanks.

Main CPU

The main CPU has its own limited I/O to read the configuration DIL switches and the power supply status. It also provides a watchdog output to indicate the health of the processor, and a common alarm output. Both these outputs are available at the rear connectors.

Details on the operation of the watchdog and alarm outputs are given in Chapter 10, *Error conditions & diagnostics*.

Memory

Memory consists of EPROM for T640 firmware, EEPROM for databases, standard strategies and logfiles, and static RAM for the working memory and operational data (running database with setpoints etc.). The RAM is maintained by a Supercap. This obviates the need for a battery in the instrument, and means that the T640 resumes its exact control conditions in the event of a power failure of up to 24 hours. Key operating parameters, controller modes, setpoints, etc., are passed to EEPROM on power-down to ensure that the controller returns to its correct operating conditions if the power fails for more than 24 hours. (Refer to Chapter 2 for details of T640's power-up routines.)

The EEPROM (and EPROM) memory resides in a removable memory module. This allows a new strategy to be plugged directly into an existing controller, or conversely allows a strategy to remain if the controller must be changed. (Chapter 2 describes memory-module and T640 unit replacement.)

Table 9-1 summarises the major T640 file types. Further details on these files are given in the relevant sections of this manual.

Filename	Extension	File type
Control strategy name	.DBF	Control strategy database (parameters, connections, etc.)
Control strategy name	.RUN	T640 coldstart filename
System filename	.LIB	Library of system routines in EPROM area
Factory-set filename	.PKn	Standard strategy in compressed format (n = 1-7, the strategy no.)
Control strategy name (current)	.TPD	Tepid data file
Control strategy name	.Lnn	Logfile of database changes via the INS pushbutton (nn = 01 - 99)
Language name	.LNG	Non-English language front-panel messages

Table 9-1 T640 File types

Comms ports

There are three communications ports — two serial, and one peer-to-peer. The two serial ports are the internal serial bus, and the Bisync/MODBUS port, available as options at the rear panel via an isolated RS422/485 driver on the motherboard. Jumpers and motherboard switches select which port is connected via the driver. (Chapter 2 specifies these jumper and switch configurations.) The third port is the peer-to-peer ALIN channel.

Internal Serial Bus (ISB). The ISB communicates between the main CPU, the I/O card(s), and the front panel. It also supports remote I/O and external faceplates from the rear connections (*not available at this release*). The external link is half duplex, using a 5-wire RS485-derivative physical and electrical interface to the I/O cards. The front panel and any internally fitted I/O cards are directly coupled to the main processor at logic levels.

The ISB is asynchronous, with 1 start bit, 8 data bits, 1 control bit, and 1 stop bit, operating at 78.125kbits/second. This speed allows messages to be transferred with negligible delay.

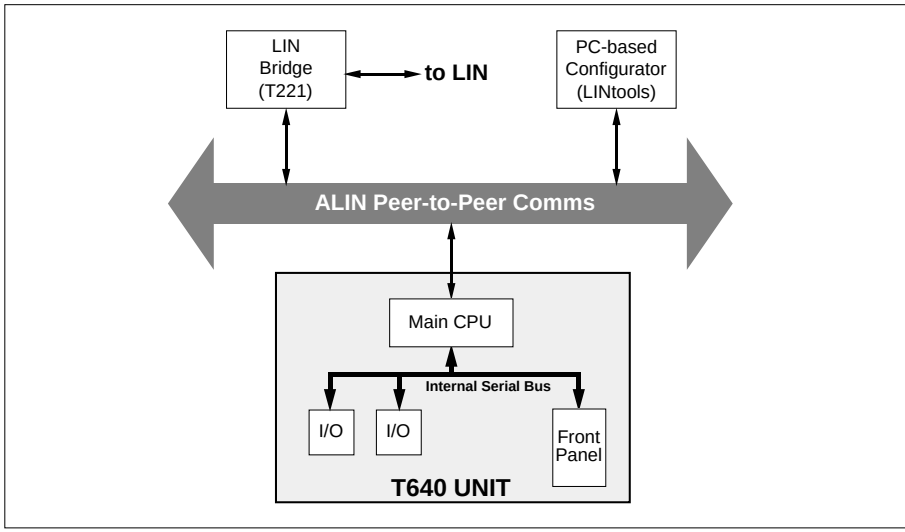


Figure 9-2 ALIN communications schematic

The main processor acts as master on this communications bus; no other nodes can transmit without being invited to. Each slave node on the bus is given a node number, in the range 0 - 15. Node number 15 is reserved for the front panel, and node numbers 0 - 7 are allocated to I/O cards. Each I/O card has switches for setting up its ISB node number.

Bisync/MODBUS Port. This port provides a Bisync slave interface for connection to existing supervisors or to industry-standard MODBUS units (selectable via SW1/1), via the RS422/485 driver .

ALIN peer-to-peer comms. A high-speed (2.5Mbaud) short-distance form of the LIN, the ALIN is the main communications channel in the instrument, used for configuration, supervision, and inter-instrument communication. See Figure 9-2. It supports all current LIN features — block attachments, field writes, file transfers, etc. — except channel redundancy. ALIN and LIN can be interconnected via a T221 bridge.

ALIN is provided by an ARCNET physical layer and uses the same, though enhanced, application layer as the LIN. The peer-to-peer enhancements — synchronised realtime clock and time-stamped alarms — are provided by the T221 bridge.

Power supplies

T640 has two power supply options — DC input, and AC input. See Chapter 11, *Specifications*, for details.

DIL switchbanks

Switchbanks 1 and 2 set T640's comms function and address, startup procedure, standard strategy selection, and also enable/disable a loop failure watchdog alarm. (Refer to Chapter 2 for switchbank functions.) Chapter 5 details the pre-configured standard strategies stored in the T640.

Front panel

The front panel display sub-assembly is an intelligent unit controlled by its own microprocessor. It communicates with the main CPU on the motherboard via the internal serial bus (see Figure 9-1). The display features are specified in Chapter 11. Using the front panel and the security key are described in Chapter 4, *User interface*.

I/O sub-assemblies

The T640 can be supplied with several I/O options, in the form of I/O boards that mount on the motherboard and communicate with it via the ISB. Note that a T640's I/O is not restricted to its own direct inputs, as it can access data from other instruments across the ALIN. For full descriptions and specifications of the available I/O, see Chapter 11, *Specifications*. Chapter 2 (*Hardware configuration* section) shows an example of how I/O boards fit inside the T640

Customer screw terminals

Full details of the rear-panel screw terminals are given in Chapter 2 in the *Connections & wiring* section.

Chapter 10
ERROR CONDITIONS & DIAGNOSTICS

This chapter deals with T640's error conditions, diagnostic messages, safety features, and alarm strategy. Power-up messages tell you what T640 is doing or attempting to do when power is restored, and subsequently database alarms and hardware/software faults are signalled as special front-panel messages, or 4-digit hex codes which can be looked up in Table 10-1.

The aims of T640's safety features are to report abnormal and fault conditions to the outside world, to prevent — as far as is practicable — unsafe conditions occurring, and if they do occur, to restore the system to a safe state as quickly as possible.

POWER-UP DISPLAYS

Normal power-up

Power-on Reset. normally flashes briefly in the red tag display when T640 is powered up, while the front panel awaits communications from the main CPU. Then, **WarmStrt Trying**, **TepidSrt Trying**, or **ColdStrt Trying**, flash to tell you the type of startup procedure T640 is attempting. If a standard strategy is being loaded for the very first time, **Un Pack Database** flashes in the tag display as the file is being decompressed. Finally, the fascia adopts the normal display (as described in Chapter 4).

ERROR CONDITIONS

- **CPU FAIL** flashes in the 5-digit display if the CPU fails to establish comms to the fascia. This message can also mean a watchdog failure (see later under *CPU watchdog*, incorrect motherboard comms option SW1/2 setting (see Table 2-4 in Chapter 2, *Hardware configuration* section), or an absent/faulty memory module.
- **HALTED** in the tag display, with **Error** flashing in the 5-digit display, means the user task in the main display has halted.
- **Err *hhhh*** flashing brightly in alternation with the normal tag display means a filing system or database system error (e.g. coldstart file access failure) identified by a 4-digit hex code *hhhh*. Filing system alarms override database alarms on the front panel. To clear them, press the ▲ and ▼ keys simultaneously. Table 10-1 lists all the hex code error numbers and their meanings.

■ **Database alarms.** Unacknowledged alarms in the loop occupying the main display cause the tag display to bright flash the highest priority alarm name in alternation with the standard message. Unacknowledged alarms elsewhere display **LP *n* ALM**, where ***n*** is the relevant loop number. Please refer to Chapter 4, *Alarm display & inspection* section, for further details on alarm display, inspection, and acknowledgement.

Error	Meaning
6001	Failure to load MODBUS database
6002	Failure to start MODBUS database
8201	Device not mounted/compatible (not formatted, or corrupt)
8202	Invalid device specified
8203	Error performing I/O to device (write/read protected by wrong switch settings)
8204	Feature not implemented
8205	Formatting error
8206	Physical device not present
8207	Device full
8208	File not found
8209	No handles for file (not enough memory to open file and note its state)
820A	Bad filename
820B	Verify error
820C	File locked, already in use
820D	File read-only
8301	Bad template
8302	Bad block number
8303	No free blocks
8304	No free database memory
8305	Not allowed by block create
8306	In use
8307	Database already exists
8308	No spare databases
8309	Not enough memory
8320	Bad library file (corrupt ROM file)
8321	Invalid template in library
8322	Bad server (corrupt file when loading)
8323	Cannot create EDB entry
8324	Bad file version
8325	Bad template spec
8326	Unable to make block remote
8327	Invalid parent
8328	Corrupt data in .DBF file
8329	Corrupt block spec
832A	Corrupt block data
832B	Corrupt pool data
832C	No free resources
832D	Template not found
832E	Template resource fault
8330	Cannot start

continued …

… continued

Error	Meaning
8331	Cannot stop
8332	Empty database
8333	Configurator in use
8340	.DBF file write failed
8341	More than one .RUN file found
8342	.RUN file not found
834A	Connection source is not an output
834B	Multiple connection to same input
834C	Connection destination not input
834D	No free connection resources
834E	Bad connection source/destination block/field
834F	Invalid connection destination
8350	Warmstart switch is disabled
8351	No database was running
8352	Real-time clock is not running
8353	Root block clock is not running
8354	Coldstart time was exceeded
8355	Root block is invalid
8356	More than two PID or 3_TERM blocks in a 2-loop controller
8357	Coldstart switch is disabled
8360	Unsynchronised Block Types
8361	DB/Filing system mismatch
8362	Unsynchronised Secondary
8363	Operation forbidden whilst CPUs synchronising
8364	Power-up data inhibits run
8365	POST hardware failure
8366	Not fixed-function strategy
8367	Default strategy missing
8901	Network timeout
8902	Rejected by local node
8903	Rejected by remote node
8904	Not implemented
8905	Not active on local node
8906	Not active on remote node
8907	Transmit failure
8908	Failed to get memory
8909	Decode packet
890A	Remote file system busy
8999	Network node invalid
FFFF	(*Unspecified error*)

Table 10-1 T640 Error numbers & their meanings

ALARM STRATEGY

Alarm priorities

Alarm priorities in the T640 follow the convention established in all LIN-based instruments. They can be set in individual blocks via their *Alarms* fields and are defined as:

- 0 (lowest priority) = alarm disabled.
- 1 -5 = annunciated with auto acknowledge. These alarms are annunciated only while the alarm condition persists, and clear themselves when the alarm condition clears, without needing manual acknowledgement.
- 6-10 = annunciated with manual acknowledge. These alarms do not automatically clear when the alarm condition disappears, but remain active until manually acknowledged.
- 11-15 (top priority) = annunciated with manual acknowledge and alarm relay. These alarms work in the same way as priority 6-10 alarms but in addition they trip the T640 hardware alarm relay (see below) and set the T600 block's *Status*/*Alarm* bit.

Alarm annunciation

Annunciated alarms are indicated on the controller front panel by means of the red LED in the ALM button, and also via the tag display. Please refer to Chapter 4 for further details.

Alarm events

As an alarm state changes, into or out of alarm, (occurring at block execution time) this event is advised to an alarm event system where it is date/time stamped (*not implemented at Issue 1*). A supervisor may attach to the alarm events of an instrument (*not at Issue 1*). Once so attached, the instrument checks at regular intervals to see if any new alarm events have occurred and transmits them to the supervisor.

To ensure consistent date/time stamping, the date/time is regularly copied across the peer-to-peer communications link, via the T221 bridge (*not implemented at Issue 1*).

Alarm relay

The alarm relay's contacts are closed when energised and in the no-alarm condition. When a priority 11-15 alarm occurs in the T640, or if the database halts, the contacts open. They also open if the relay is de-energised, i.e. fail safe operation.

CPU WATCHDOG

Watchdog output

The instrument is provided with a watchdog output on the main processor unit, which flags an alarm condition if the processor fails. If the watchdog trips, the processor is reset and restarted.

Watchdog relay

A relay output is provided to indicate that the watchdog has tripped. The contacts are closed when energised and in the healthy condition, but open if the CPU fails. Additionally, the front panel 5-digit display flashes **CPU FAIL** until the processor has been restarted.

Loop fail

The CPU can also force the watchdog into alarm, to flag if a loop (user task) fails to run, or if the database halts. This facility may be enabled/disabled via the motherboard DIL switchbank SW1, switch 5 (see Figure 2-12 in Chapter 2, *Hardware configuration* section). If a loop fails to run, the outputs assume the state defined in the *OPTIONS*/*CPUFlLo* field of the output block (e.g. 'low').

User alarm

The watchdog relay can also act as a general-purpose user alarm, via the T600 block's *UsrAlm* field. A TRUE input to *UsrAlm* from the control strategy opens the relay contacts. A FALSE input closes them, but is overridden by a watchdog alarm.

Main processor (CPU) fail

Both I/O cards and the front panel microprocessor can detect failure of the main CPU, by virtue of there being no activity on the internal serial bus. In this case the front panel replaces the normal 5-digit PV display with a flashing **CPU FAIL** message. The I/O cards can be programmed with action to be performed on main processor fail, e.g. outputs hold or outputs low. If the database stops, either due to a fault, or as a result of a command over the LIN, this will also cause the I/O cards to adopt their CPU-fail state.

Forced manual mode

In user tasks with MODE blocks, the block adopts forced manual mode under error conditions (i.e. sumcheck, open circuit PV, or other strategy-defined conditions).

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Chapter 11 SPECIFICATIONS

T640 BASE UNIT

Panel cut-out & dimensions

Please refer to Chapter 2, under *Installation*, for details.

Mechanical

Fascia dimensions:	height 144mm, width 72mm.
Mounting panel aperture:	height 138 +1 –0 mm, width 68 +0.7 –0 mm.
Behind mounting panel:	depth 258mm (measured from panel front).
Front of mounting panel:	depth 10.6mm.
Weight:	2.15kg.

Environmental

Storage temperature:	–10°C to +85°C, at humidity of 5-95% (non-condensing).
Operating temperature:	0°C to +50°C. The enclosure must provide adequate ventilation, and heating if required to avoid condensation at low temperatures.
Atmosphere:	Unsuitable for use above 2000m or in explosive or corrosive atmospheres.
Front panel sealing:	to meet EN60529: IP65.
EMC emissions:	to meet EN50081-2 (Group 1; Class A).
EMC immunity:	to meet EN50082-2.
Electrical safety:	to meet EN61010 and UL3121-1, Installation category II. Voltage transients on any mains power connected to the unit must not exceed 2.5kV. Electrically conductive pollution must be excluded from the cabinet in which the unit is mounted.
Isolation:	All isolated inputs and outputs are double-insulated as specified in EN61010 to provide protection against electric shock. (Isolation levels for particular I/O types are stated in the relevant section of the specification for the I/O board concerned.)
Vibration:	to meet BS2011 Part 2.1, Test Fc, Table CII, 'Equipment intended for large power plant and general industrial use' (2g, 10-55 Hz).
Shock:	to meet BS2011 Part2.1, Test Ea, Table II, 'General test for robustness, handling and transport' (15g, 11ms).

Front panel displays

PV bargraph:	red 51-segment vertical % display (flashable via block).
SP bargraph:	green 51-segment vertical % display (flashable via block).
Output bargraph:	yellow 10-segment horizontal display (segments individually addressable).
Numeric display:	5-digit, red 7-segment.
'PV-X' legend:	lit red when PV indicated in Numeric display.
Tag display:	8-character, red dot-matrix (user-configurable).
Units display:	5-character, green dot-matrix (eng. units or SP).
'SP-W' legend:	lit green when SP indicated in Units display.

Loop status summary

deviation/PV bargraph:	4-off red 7-segment vertical displays, settable via block to 1/2/3%, 1/5/10%, or 10/20/30% deviation; or to 100% PV. Central bicolour LED glows green when deviation shown.
loop mode:	A(uto), R(emote/ratio) green lit single letters M(anual), H(old), T(rack) orange lit single letters.
loop selected:	green lit arrow symbol under deviation/PV bargraph.

Pushbuttons

loop control: 6-off membrane pushbuttons with symbols—

R (with green LED)	R
A (with green LED)	A
M (with orange LED)	M
SP	SP-W
'raise'	▲
'lower'	▼
parameter access: INS pushbutton	INS ??
alarm acknowledge: ALM pushbutton (with red LED)	ALM

(space)	!	"	#	$	%	&	'	(	)	*	+	,	−	.	/
32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47
Ø	1	2	3	4	5	6	7	8	9	:	;	<	=	>	?
48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63
@	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79
P	Q	R	S	T	U	V	W	X	Y	Z	[	\	]	↑	_
80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95
`	a	b	c	d	e	f	g	h	i	j	k	l	m	n	o
96	97	98	99	100	101	102	103	104	105	106	107	108	109	110	111
p	q	r	s	t	u	v	w	x	y	z	{	|	}	~	Δ
112	113	114	115	116	117	118	119	120	121	122	123	124	125	126	127
А	Б	В	Г	Д	Е	Ж	З	И	Й	К	Л	М	Н	О	П
128	129	130	131	132	133	134	135	136	137	138	139	140	141	142	143
Р	С	Т	У	Ф	Х	Ц	Ч	Ш	Щ	Ъ	Ы	Ь	Э	Ю	Я
144	145	146	147	148	149	150	151	152	153	154	155	156	157	158	159
¡	¿	α	β	γ	δ	ε	η	θ	λ	μ	ν	π	ρ	σ	τ
160	161	162	163	164	165	166	167	168	169	170	171	172	173	174	175
ϕ	χ	ψ	ω	Γ	Δ	Θ	Λ	Ξ	Σ	Φ	Ψ	Ω	£	¥	Å
176	177	178	179	180	181	182	183	184	185	186	187	188	189	190	191
å	Ä	ä	à	á	â	æ	Æ	ç	É	è	é	ë	ê	ì	í
192	193	194	195	196	197	198	199	200	201	202	203	204	205	206	207
ï	î	N̄	n̄	Ñ	ñ	Ø	ø	Ö	ö	ò	ó	ô	Œ	œ	Ü
208	209	210	211	212	213	214	215	216	217	218	219	220	221	222	223
ü	ù	ú	û	x̄	ȳ	ε̇	±	≅	≈	≠	∫	√	-1	-2	2
224	225	226	227	228	229	230	231	232	233	234	235	236	237	238	239
-3	3	°	⬆	⬆⬇		⬇	▌	▬	➡	⬅	↓	←	→	°C	°F
240	241	242	243	244	245	246	247	248	249	250	251	252	253	254	255

Table 11-1 Dot-matrix display character set (representational)

Dot-matrix display character set

Table 11-1 shows (in representative typefaces) the complete set of characters displayable by the two dot-matrix front-panel displays — the Tag display and the Units display. The number under each character is its decimal code, used to specify that character for display via the LINtools configuration package. Codes 0 to 31 are reserved and are not user-accessible.

Please refer to the *T500 LINtools User Guide* for further details.

Relays

Alarm relay:	SPST. Max. contact voltage 30Vrms, 60Vdc. Max. current 1A at 24V ac/dc. Isolation 60Vrms, 60Vdc.
Watchdog relay:	SPST. Max. contact voltage 30Vrms, 60Vdc. Max. current 1A at 24V ac/dc. Isolation 60Vrms, 60Vdc.

Power supplies

Mains version

Input voltage range:	90 - 265 Vac rms.
Input frequency range:	45 - 65 Hz.
Maximum peak input current:	1.1A.
Power rating:	25VA.
Holdup time:	20ms.
Power supply fuse:	T-type (IEC 127 time-lag type) UL-recognised. 20 × 5 mm 250Vac antisurge cartridge, 500mA.

DC version

Number of inputs:	2 — Channel 1 (main input), channel 2 (backup).
Input voltage range:	19 - 55 V (including rectified 48Vac).

NOTE. Installation must ensure that neither positive nor negative rails of the DC supply can exceed 100V peak with reference to safety earth.

Power rating:	25VA.
Holdup time:	20ms.
Power supply fuse:	T-type (IEC 127 time-lag type) UL-recognised. 20 × 5 mm 250Vac antisurge cartridge, 2A.

T950 Security key

Battery:	12V alkaline manganese dioxide type, of overall length 27.5-28.5 mm, diameter 9.62-10.62 mm. E.g. Duracell™ MN21, Panasonic™ RV08, or equivalent. (Refer to Ch2 for safety precautions.)

ALIN

The ALIN runs on screened twisted pair. Phase A, pin 21, should be bussed to other Phase A signals and likewise Phase B, pin 22. The cable screen should be connected to ALIN Gnd, pin 20. The ALIN connections are galvanically isolated within the T640 to assist with noise rejection and simplify system wiring. The key specifications of the ALIN are summarised as follows:

Cable type:	screened twisted pair.
Line impedance:	100Ω, nominal.
Network topology:	single non-branching network.
Network terminations:	100Ω at each end.
Maximum load:	16 nodes. (With active hubs: 8 per hub port.)
Maximum length:	100 metres.
Grounding:	single point ground per system.

RS422 COMMUNICATIONS

Selection:	Via motherboard DIL SW1 & jumper link (see Chapter 2).
Protocols supported:	MODBUS and BISYNC.
Transmission standard:	5-wire RS422 (0-5V).
Line impedance:	120Ω - 240Ω twisted pair.
Line length:	1220m (4000ft) maximum at 9600 baud.
Units per line:	16 instruments electrical maximum, expandable to 128 electrical maximum by nesting of 8245 Comms Buffers.
Port isolation:	75V max. with reference to safety earth.

RS485 COMMUNICATIONS

Selection:	Via motherboard DIL SW1 & jumper link (see Chapter 2).
Protocols supported:	MODBUS.
Transmission standard:	3-wire RS485 (0-5V).
Line impedance:	120Ω - 240Ω twisted pair.
Line length:	1220m (4000ft) maximum at 9600 baud.
Units per line:	16 instruments electrical maximum.
Port isolation:	75V max. with reference to safety earth.

BISYNC PROTOCOL

Selection:	Via motherboard DIL SW1 & jumper link (see Chapter 2).
Conforms to:	ANSI-X3.28 - 2.5 - A4 Revision 1976 — binary version.
Medium:	RS422.
Implementation:	Via appropriate T6000 category function block running in the T640 (see the *LIN Blocks Reference Manual*).
Addresses:	128 maximum, software-selectable via the S6000 function block's *Instr_No* parameter.
Data rate:	Software-selectable, via T600 function block's *BinSpd1* & *BinSpd2* parameters, from 300, 1200, 4800, & 9600 baud.
Character length:	11 bits made up of — 1 start + 8 data + 1 parity (even) + 1 stop.

MODBUS PROTOCOL

Selection:	Via motherboard DIL SW1 & jumper links (see Chapter 2).
Transmission mode:	MODBUS RTU (8-bit) supported.
Medium:	RS422 or RS485.
Implementation:	Via 'gateway' file (.GWF) configured via T500 LINtools MODBUS configurator and stored in the T640 together with the database file (.DBF).
Slave addresses:	254 maximum, software-selectable via T500 LINtools MODBUS configurator.
Data rate:	Software-selectable (via LINtools) from 110, 150, 300, 600, 1200, 2400, 4800, and 9600 baud.
Parity & stop bits:	Software-selectable (via LINtools) from none, odd, and even parity, with 1 or 2 stop bits.

SOFTWARE

Maximum resources supported

The table shows the default maximum resources supported by the T640. (This information is also available in the local DB_DIAG blocks.)

Resource	Default Maximum
Blocks	256
Templates	50
Libraries	32
EDBs	8
Featts	128
Teatts	10
Servers	5
Connections	512

Note that if a database is loaded having more resources than the default maximum, the maximum is set to the new value — which may mean there is not enough memory to load the whole database. In this case it is the connections that disappear first. Featts are an exception. When a database is saved there are generally no Featts present because they are created dynamically at runtime, preventing the default maximum from being overridden.

Maximum sequencing resources supported

Resource	Maximum
Simultaneous independent sequences	10
SFC actions	50
Steps	150
Action associations	600
Actions	300
Transitions	225
Servers	5
Sequence execution rate	(*determined by repeat rate of User Task 4 loop*)

Function blocks supported

T640 supports the level of block structuring normally only found in advanced DCS systems. Each of the four control loops occupies its own task, which allows it to be set — via the T600 block's *MinRpt*n parameters — to run at a rate appropriate to its function in the strategy (see Chapter 7, on *T640 task organisation & tuning*, for details). The general purpose blocks can be distributed between these tasks, T640's internal architecture ensuring data coherence. (See Chapter 8 for details on data coherence and how it is achieved.)

Up to 250 function blocks can be configured, depending on the size of the blocks and the number of connections. For a list of blocks supported by the T640 and full details of how to configure them, please refer to the *LIN Blocks Reference Manual* (Part No. HA 082 375 U003), which is part of the *LIN Product Manual* (Part No. HA 082 375 U999).

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HIGH-LEVEL I/O

Layout

The high-level I/O electronics resides on a main I/O board mounted next to the motherboard, which plugs into the central rear-panel 24-way terminal block (I/O site 1). These terminals can carry only half the available I/O; the second half can be accessed at the left-hand rear-panel 24-way terminal block (I/O site 2) via an expansion I/O board, fitted next to the main board. (Figure 2-10 in the *Hardware configuration* section of Chapter 2 shows this layout.)

T640 rear-panel customer connections

Please refer to Chapter 2, under *Connections & wiring* (*Customer terminals*), for details.

Input ranges

The appropriate 0-5 V or 0-10 V range is automatically selected by the software when you configure the analogue input or output block in the control database. However, you can override the software and select the 0-1.25 V range specifically by connecting together the two pins of Jumper 1, and those of Jumper 2, on the main high-level I/O board. These are located as shown in Figure 11-1. Both analogue inputs and voltage analogue outputs are forced to the 1.25V range by these jumper links.

Burden resistors. If internal burden resistors have been specified (HIB and HGB options), or if external burden resistors are fitted to the customer screw terminals, the analogue input block's range parameters — LR_in and HR_in — must be appropriately configured to suit the plant's current input range. Consult Table 11-2.

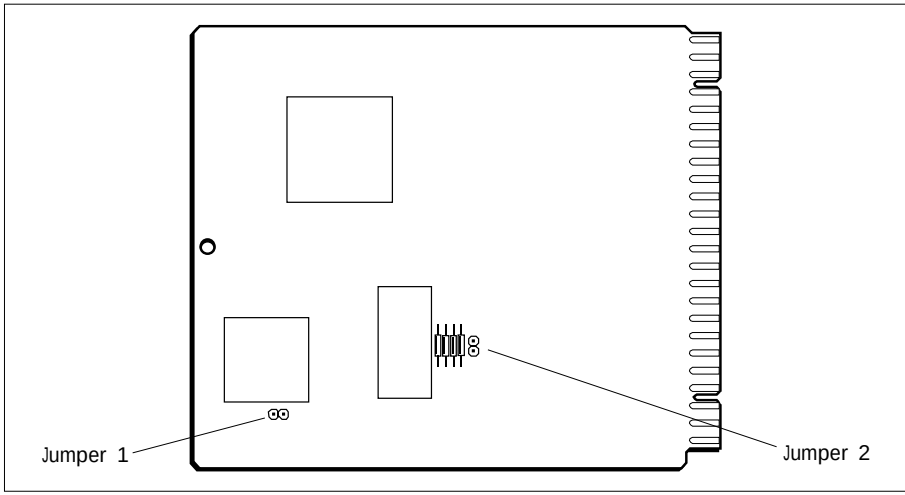


Figure 11-1 High-level I/O board showing 0 - 1.25V range jumpers

Option	Burden resistor	Plant input	AN_IP block setup: LR_in	HR_in
HIB	250Ω	0 - 20 mA	0V	5V
		4 - 20 mA	1V	5V
HGB	62Ω	0 - 20 mA	0V	1.24V
		4 - 20 mA	0.248V	1.24V
External	250Ω	0 - 20 mA	0V	5V
		4 - 20 mA	1V	5V
	50Ω	0 - 20 mA	0V	1V
		4 - 20 mA	0.2V	1V

Table 11-2 Range settings for burden resistors

Calibration. The 1.25V range is supplied with a nominal calibration accuracy of better than 5%. If required, the board may be recalibrated to an accuracy of 0.05% via the AI_CALIB and AO_CALIB blocks (see the *LIN Blocks Reference Manual*).

NOTE. *In the T640 HI and HIB options the 1.25V range is uncalibrated at the present issue of hardware. This state is not flagged by the STATUS/BadCal bit.*

LIN blocks parameters not supported

The *LIN Blocks Reference Manual* lists the LIN I/O blocks supported by the T640, and describes in generic terms every parameter in those blocks. However, certain parameters are not supported, or are only partially supported, by the high-level I/O board. Table 11-3 lists these board-specific parameters.

Block type	Parameter		Support
AN_IP	InType		V option only
	CJ_temp		*Not supported*
	LeadRes		*Not supported*
	STATUS	PSUshort	*Not supported*
		BrkWarn	*Not supported*
		BrkDtctd	Not supported when burden resistors in use
AN_OUT	STATUS	FaultCct	Voltage outputs: short circuit only Current outputs: not supported
		OverDrv	*Not supported*
		Killed	*Not supported*
	ALARMS	CctFault	Voltage outputs: short circuit only Current outputs: not supported
		OvrDrive	*Not supported*
DG_IN	Thresh		*Not supported*
	InType		Volts option only
DG_OUT	Pullup		*Not supported*
DGPULS_4 [1]	Pullup		*Not supported*

[1] With high-level boards in both T640 sites, only site 1 can support a DGPULS_4 block.

Table 11-3 High-level I/O board LIN blocks parameter support

Hardware organisation

Figures 11-2 to 11-4 are block schematics outlining the organisation of the high-level I/O board hardware. Figure 11-2 shows the non-isolated analogue I/O, Figure 11-3 shows the digital I/O, and Figure 11-4 shows the current outputs and transmitter power supplies.

Analogue inputs

Channels:	8.
Input range:	0-5 V and 0-10 V, with software-selectable range. 0-1.25 V range jumper-selectable (see *Input ranges* above).
Absolute max. input:	15V, 0.25W with internal burdens.
Isolation:	None.
Resolution:	0.025%.
Accuracy:	0.05% of range.

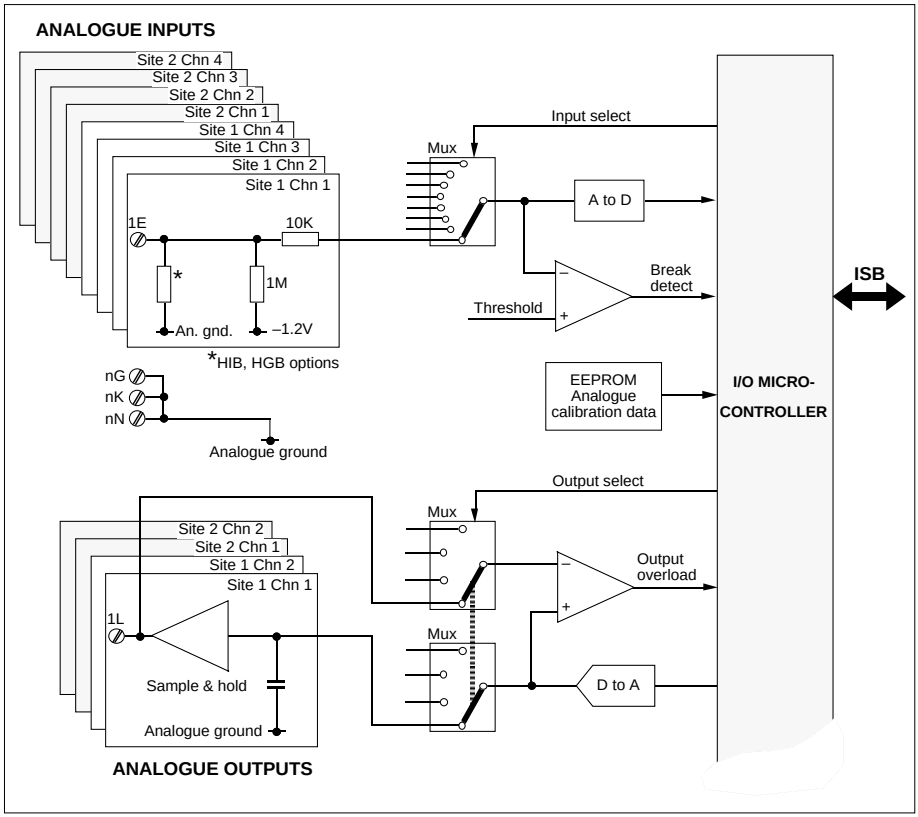


Figure 11-2 Analogue input & output block schematic

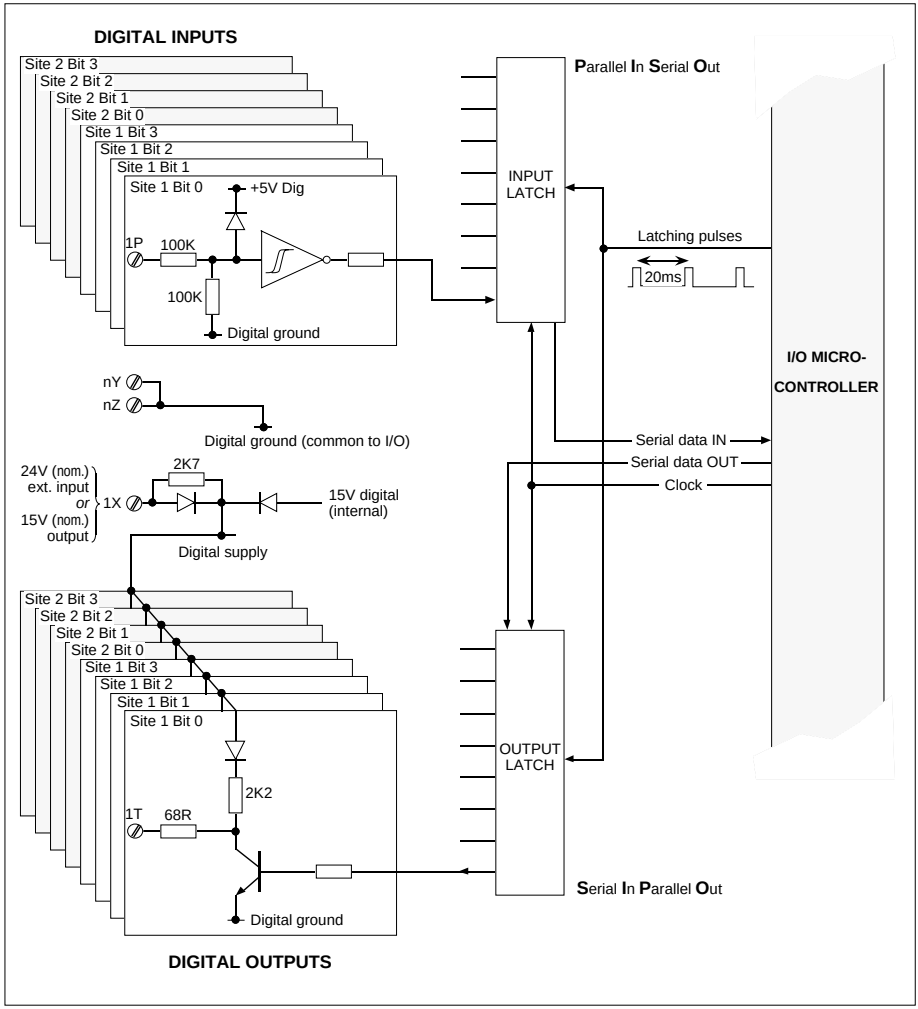


Figure 11-3 Digital input & output block schematic

Gain drift:	30ppm/°C.
Offset drift:	65µV/°C.
Input impedance:	1 MΩ pull-down to –1.2V.
Break detection:	within 1 sample. Protection strategy selected from within the configuration (up-scale, down-scale, etc.).
Sample rate:	9ms per configured input. Only the configured inputs are scanned. The fastest loop update cannot be less than 20ms.

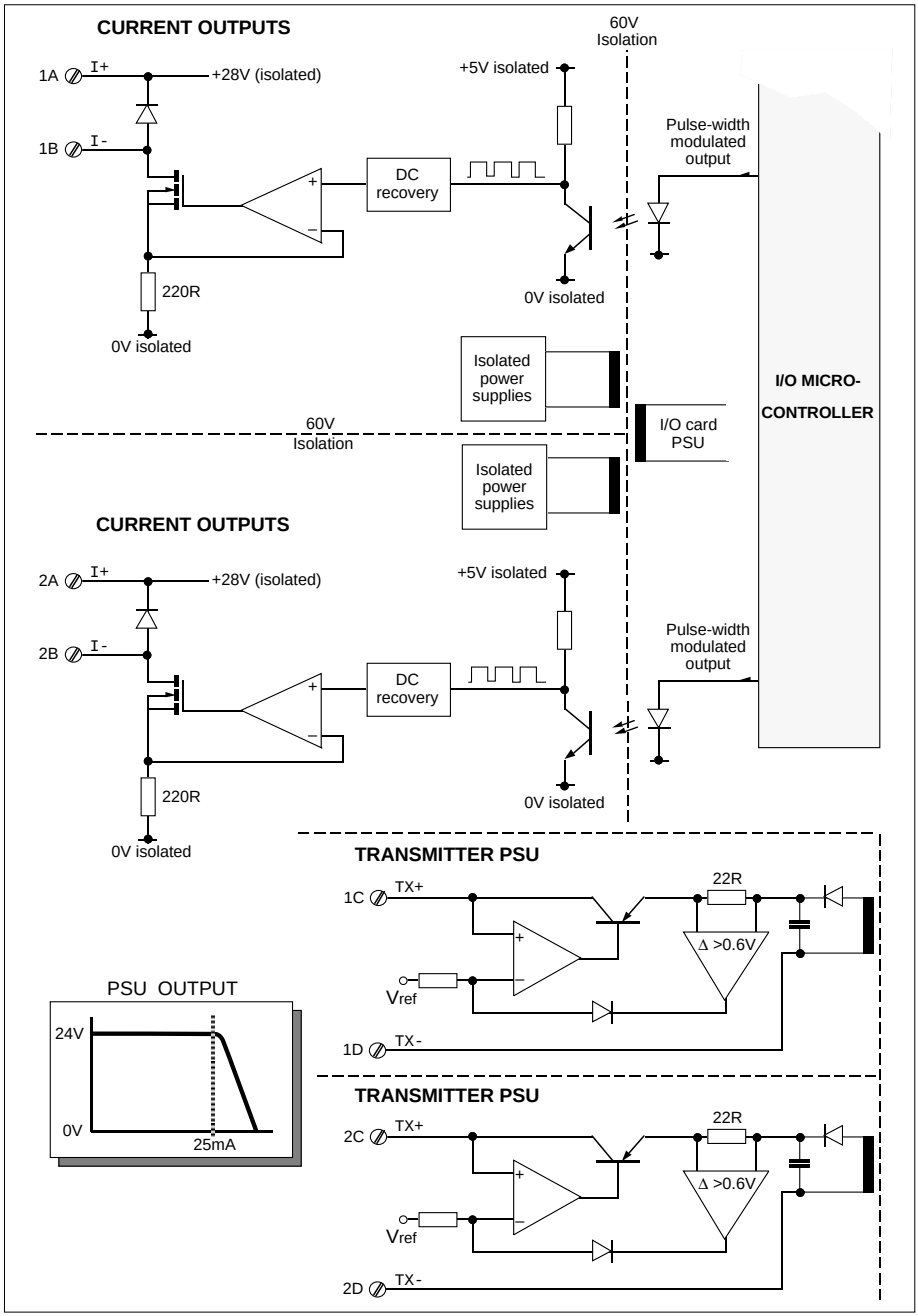


Figure 11-4 Current output & transmitter PSU block schematic

Internal burden resistors

Values:	HIB option — 250R. HGB option — 62R.
Power:	0.25W.
Tolerance:	0.1%.
Temperature coefficient:	15ppm/°C.

NOTE. Tolerances and temperature coefficients must be added to the specified analogue input tolerances.

Transmitter power supplies

Channels:	2.
Voltage:	24V ±5%.
Current:	0-22 mA.
Current limit:	30mA maximum.
Isolation:	60V ac rms or dc working.

Voltage analogue outputs

Channels:	4.
Output range:	0-5 V and 0-10 V, with software-selectable range 0-1.25 V range jumper-selectable (see *Input ranges* above).
Resolution:	12 bits. (1.25 and 2.5 mV, for the 5 and 10 V ranges resp.)
Accuracy:	0.05% of range.
Gain drift:	30ppm/°C.
Offset drift:	70µV/°C.
Current drive:	±5 mA.
Overload detection:	triggered if the output cannot maintain the desired voltage.
Isolation:	none.

Current analogue outputs

Channels:	2.
Output range:	0-20 mA. (Rangeable 0-10 mA, 0-20 mA, 4-20 mA etc.)
Over-range:	22mA.
Resolution:	5µA.
Accuracy:	0.1%.
Gain drift:	80ppm/°C.
Offset drift:	0.9µA/°C.
Output drive:	0-1 kΩ.
Isolation:	60V ac rms or dc working.

Digital inputs

Channels:	8.
Thresholds:	logic 1: 7.5V minimum logic 0: 2.5V maximum.
Hysteresis:	1.0V minimum, 3.5V maximum.
Input voltage:	28V maximum.
Input impedance:	200kΩ for inputs <10V, 100kΩ for inputs >10V.
Isolation:	none.

Digital outputs

Channels:	8.
Output levels:	logic 0: 0V logic 1: 15V (14.0V-15.5V internal supply, or external supply).
External supply:	dual function: as input: 15.5V minimum, 28V maximum. as output: 14.0V minimum, 15.5V maximum, (≤ 7mA) sourced via 2K7 resistor. (Allows hardware pullup of up to 8 digital inputs.)
Drive impedance:	logic 0: 68Ω, 25mA maximum sink current to maintain logic 0 output level. (37mA absolute maximum sink current.) logic 1: 2.2kΩ.
Isolation:	none.

General

The environmental, physical, and electrical specifications for this assembly are the same as for the base unit.

I/O calibration procedure

Please refer to the *LIN Blocks Reference Manual*, under *Calibration methods*, for generic information on calibrating I/O using the AI_CALIB and AO_CALIB blocks. The following information relates specifically to the high-level I/O board.

Complete re-calibration

In order to perform a complete re-calibration of the instrument you need not calibrate *all* channels. Only the following *four* I/O points need to be re-calibrated:

- One analogue input channel (e.g. channel 1 site 1 — terminal **1E**).
- One analogue output channel (e.g. channel 1 site 1 — terminal **1L**).
- Current output (channel 3 site 1 — terminals **1A**, **1B**).
- Current output (channel 3 site 2 — terminals **2A**, **2B**); only if the expansion I/O board is fitted.

NOTE. Power the instrument off, then on, to ensure that the new calibration data is applied to all channels.

Limited calibration

Re-calibration of only one of the above points does not affect the calibration state of the others, which therefore do not have to be re-calibrated. For example, if you re-calibrate one analogue input channel, only the set of analogue input channels will be automatically re-calibrated after powering down and up.

I/O circuits

Figures 11-5 to 11-7 show schematically some ways to use the high-level I/O.

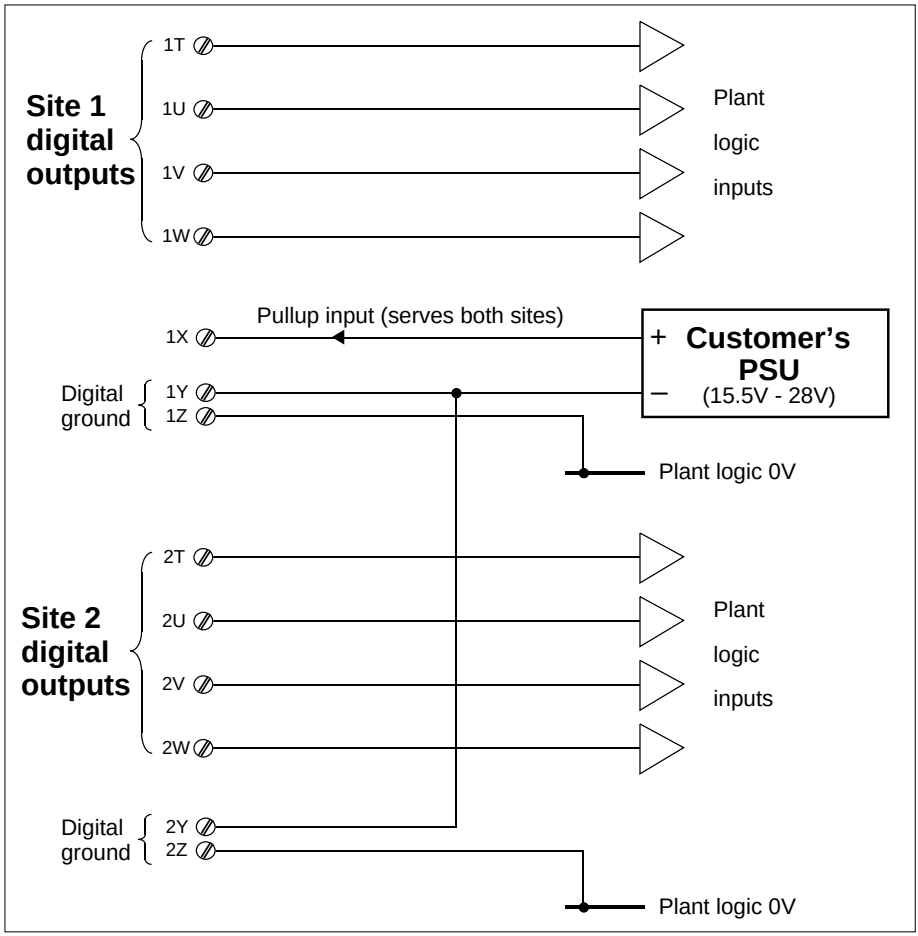


Figure 11-5 Digital outputs driving plant logic using customer's PSU

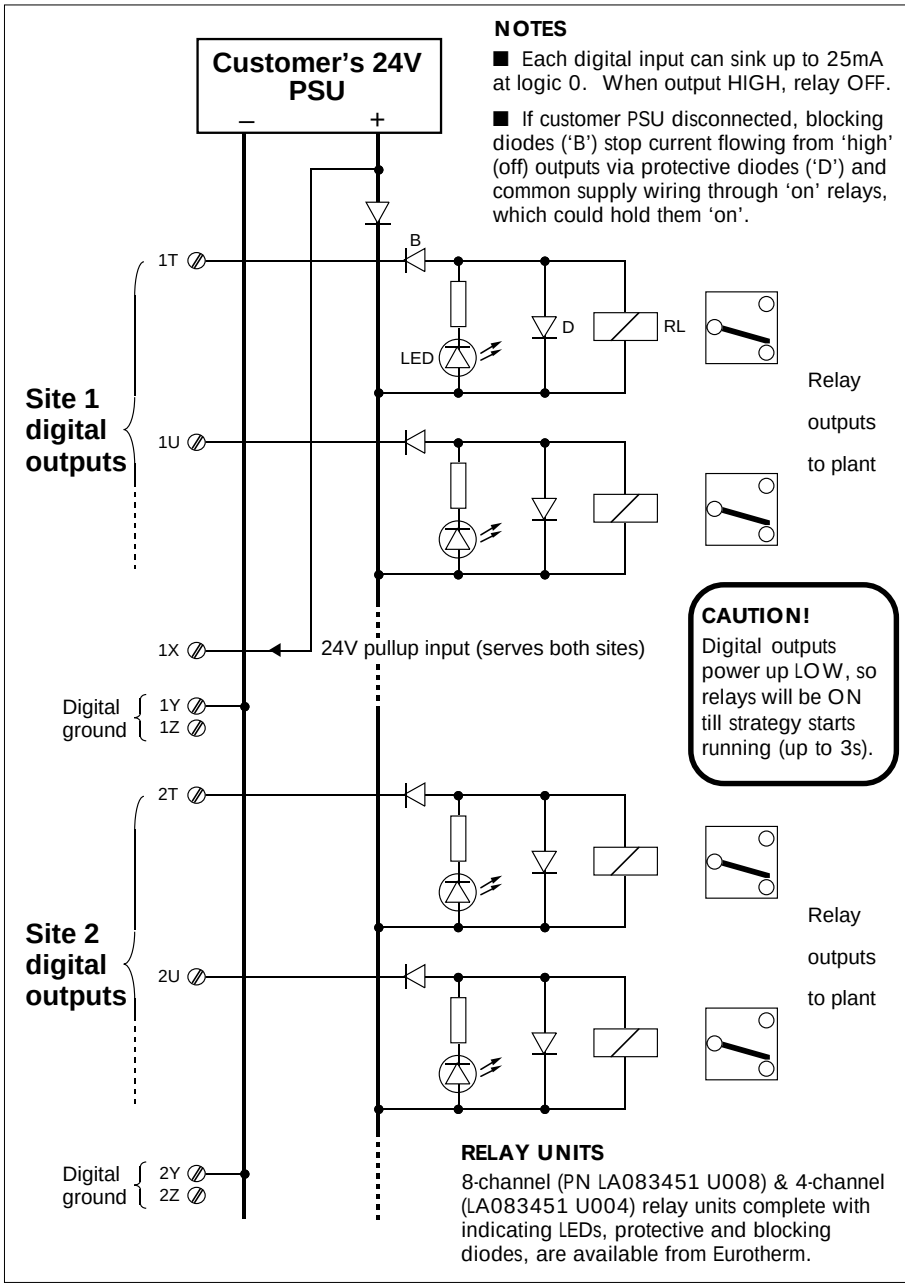


Figure 11-6 Digital outputs operating relays (current sinks) with pullup via customer's PSU

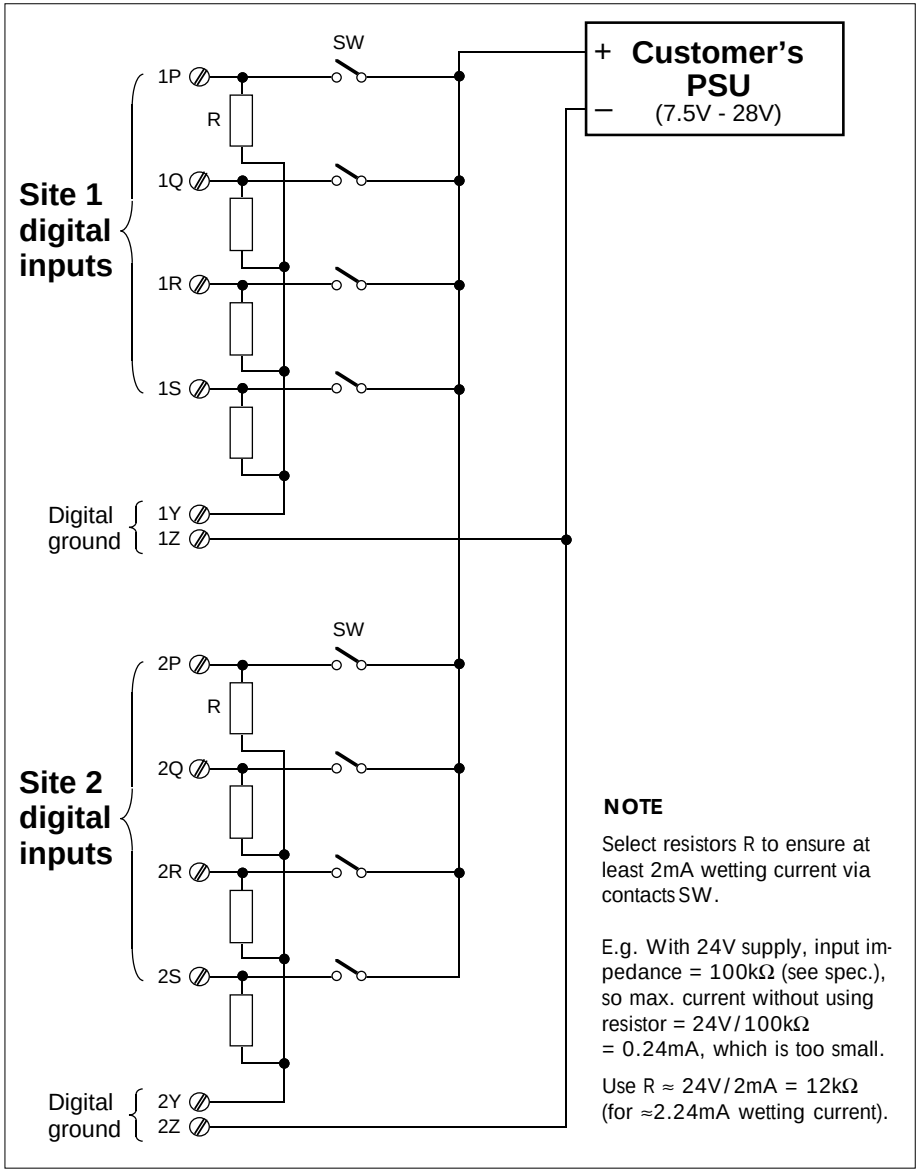


Figure 11-7 Digital input contact-sensing using customer's PSU

THERMOCOUPLE I/O

Layout

The thermocouple I/O electronics resides on a single card mounted next to the motherboard, plugging into the central rear-panel 22-way terminal block (I/O site 1). A second thermocouple I/O card, identical to the first but independently configurable, may be fitted to the left-hand rear-panel 22-way terminal block (I/O site 2).

T640 Rear-panel customer connections

Please refer to Table 2-3 in Chapter 2, in the *Connections & wiring* (*Customer terminals*), section for details.

Hardware configuration

There is no hardware configuration required on the thermocouple I/O board. The appropriate input and output ranges are automatically selected when you configure the corresponding input or output block in the control database.

LIN blocks parameters not supported

The *LIN Blocks Reference Manual* lists the LIN I/O blocks supported by the T640, and describes in generic terms every parameter in those blocks. However, certain parameters are not supported, or are only partially supported, by the thermocouple I/O board.

Table 11-4 lists these parameters.

Break detection & break protection

This information is given in addition to that appearing in the *LIN Blocks Reference Manual*, *AN_IP block* section.

The isolated thermocouple inputs (channels 1 & 2) and the non-isolated high-level analogue input (channel 3, *Volts* mode) all support input break detection. As such, the *BrkDetct* bit in the *Options* field should be set to TRUE when using these inputs. A break detection is annunciated by the TRUE state of *BrkDtctd* in the *Status* field. (Note that the *BadBrk* bit will be TRUE in the *Status* field if detection is not enabled on these inputs.)

Upon detection of an input break, the AN_IN block adopts a protection strategy according to the setup of two *Options* bits, namely *BreakUp* and *HoldDect*. If *HoldDect* is TRUE the processed input *PV* holds its last good value, and will do so until the input break is corrected. If *HoldDect* is FALSE and *BreakUp* is TRUE, *PV* goes to highscale (*HR*). If both *HoldDect* and *BreakUp* are FALSE, *PV* goes to lowscale (*LR*). These actions are summarised in Table 11-5.

Block type	Parameter		Support
AN_IP	InType		mV options only on Ch 1 & Ch 2 V or Hz options on Ch 3
	LeadRes		*Not supported*
	STATUS	PSUshort	*Not supported*
		BrkWarn	*Not supported*
		BrkDtctd	mV & V modes only
	OPTIONS	BrkDetct	mV & V modes only
		BreakUp	mV & V modes only
		HoldDect	mV & V modes only
AN_OUT	STATUS	FaultCct	Ch 1 only (current output), open circuit only
		OverDrv	Ch 1 only (current output)
		Killed	Ch 1 only (current output)
	ALARMS	CctFault	Ch 1 only (current output), open circuit only
		OvrDrive	Ch 1 only (current output)
DG_IN	Thresh		*Not supported*
	InType		Only Volts supported
DG_OUT	Pullup		Only 24V and External supported
DGPULS_4 [1]	Pullup		Only 24V and External supported
	Mode3		DUAL_PLS mode not supported
	Mode4		*Not supported*

Table 11-4 Thermocouple I/O board LIN blocks parameter support

	AN_IP.Options. bit setting:		
Result on break	BrkDetct	BreakUp	HoldDect
PV to highscale (HR)*	TRUE	TRUE	FALSE
PV to lowscale (LR)*	TRUE	FALSE	FALSE
PV holds last good value	TRUE	don't care	TRUE

*Direction reversed if *Options.Invert* bit TRUE

Table 11-5 Thermocouple I/O board break modes

Hardware organisation

Figures 11-8 to 11-12 are block schematics outlining the organisation of the low-level I/O board hardware. Figure 11-8 shows the thermocouple inputs, Figure 11-9 the non-isolated analogue I/O, Figure 11-10 the isolated current outputs, Figure 11-11 the isolated digital inputs, and Figure 11-12 shows the non-isolated digital outputs.

mV/thermocouple inputs

Block type:	AN_IP.
Channels:	2.
Resolution:	> 14 bits.
Accuracy @ 25°C:	0.1% of mV range.
Temperature drift:	< ±[0.7mV + 0.008% of reading]/°C @ 99% confidence (< ±[0.3mV + 0.003% of reading]/°C typically).
Input Isolation:	250V ac rms or dc working.
Break detection:	within 1 sample period (with options to go high-scale, low-scale or retain last good value).
50/60Hz rejection:	60dB SMR, 120dB CMR (software-selectable between 50Hz and 60Hz).

Low level (mV) input mode

Input ranges:	–14.2 to +77mV, –7.1 to +38.5mV, –3.5 to +19.2mV, and –1.8 to +9.6mV (software-selectable).
Absolute max. input:	24V.

Thermocouple input mode

Input ranges:	J	–210 to +1200 °C
	K	–270 to +1372 °C
	T	–270 to +400 °C
	S	–50 to +1767 °C
	R	–50 to +1767 °C
	E	–270 to +1000 °C
	B	0 to 1820 °C
	N	0 to 1300 °C
	W	1000 to 2300 °C
	W3	0 to 2490 °C
	W5	0 to 2320 °C
	MoRe	0 to 1990 °C
CJC accuracy @ 25°C:	–0.25°C to +1.1°C	
CJC ambient rejection:	30:1 typically	

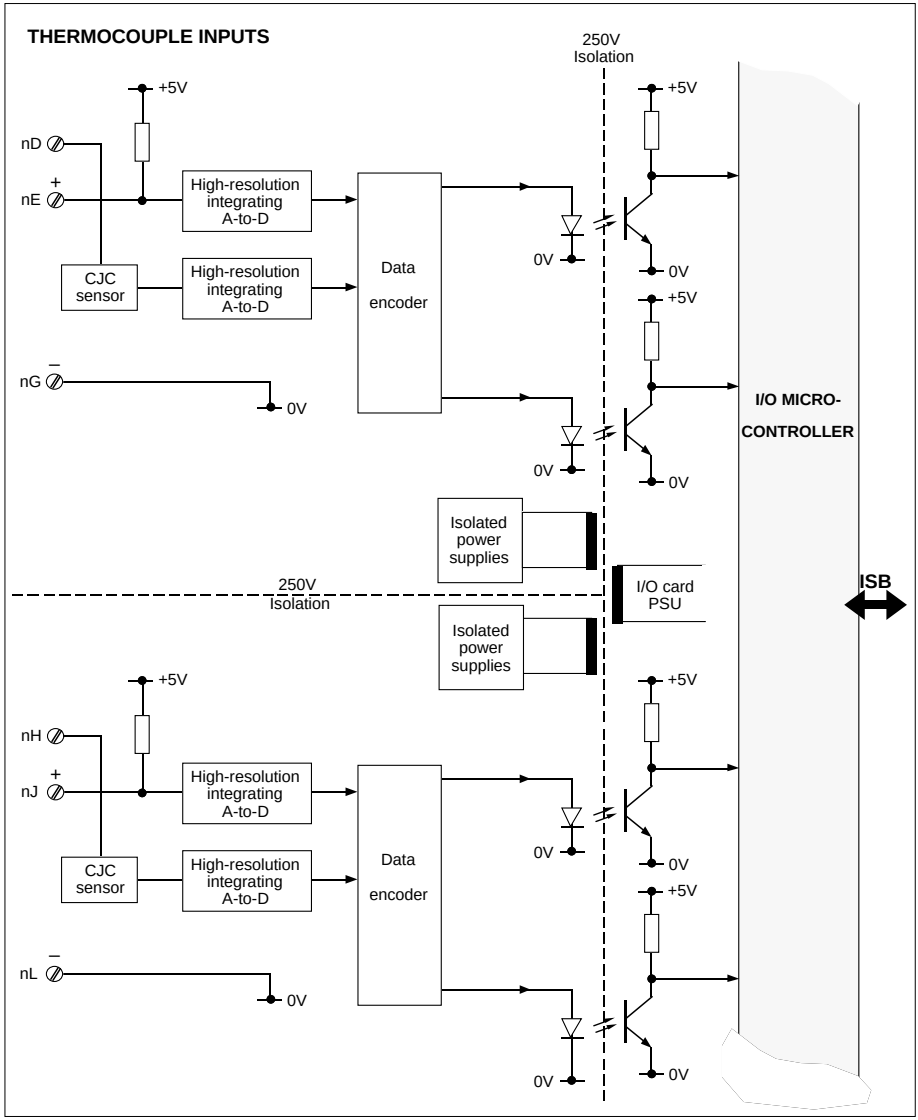


Figure 11-8 Thermocouple inputs block schematic (n=1, 2)

Analogue input

Block type:	AN_IP.
Channels:	1, non-isolated (software-selectable between voltage and frequency input modes).
Absolute max. input:	20V.
Isolation:	none.

Voltage input mode

Block type:	AN_IP
Input ranges:	0 to 10 V, 0 to 5 V, 0 to 2.5 V and 0 to 1.25 V (software-selectable).
Out of range capability:	±10%
Accuracy @ 25°C:	0.1% of scale
Resolution:	> 14 bits for 0-10V, 0-5V, and 1-5V rangings
Temperature drift:	< ±[100µV + 0.008% of reading]/°C @ 99% confidence (< ±[40µV + 0.004% of reading]/°C, typically)

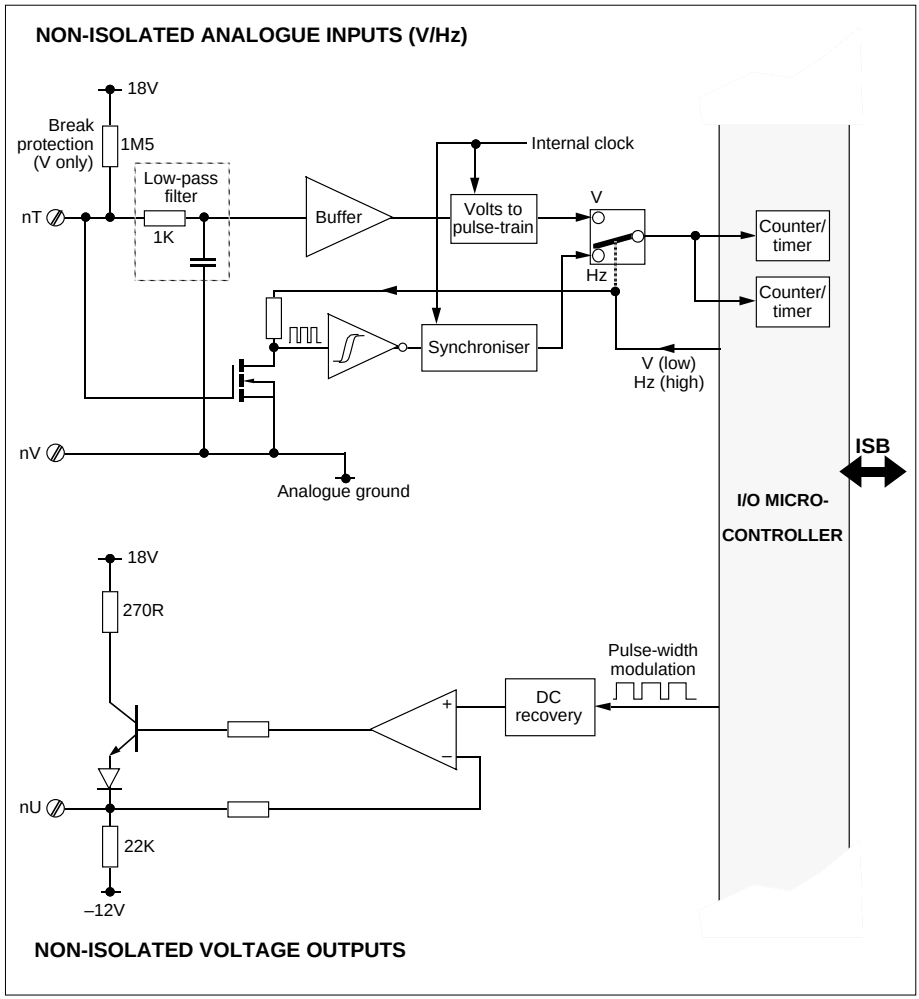


Figure 11-9 Non-isolated analogue input/output block schematic (n=1, 2)

Break detection:	within 1 sample period (with options to go high-scale, low-scale, or retain last good value)
50/60Hz rejection:	60dB SMR (software-selectable between 50 and 60 Hz)

Frequency input mode

Block type:	AN_IP
Input ranges:	0.01Hz to 30kHz, 0.01Hz to 3kHz, 0.01Hz to 300Hz, 0.01Hz to 30Hz (software-selectable).
Over-range capability:	up to 48kHz
Input threshold:	1.5 to 3.5 V
Input range operating:	up to 15V
Over/under-range capability:	–9 to +18 V
Input impedance:	1.5MΩ for in-range signal; 1kΩ for out-of-range signal
Resolution:	> 14 bits
Min. pulse length:	8µs
Response time:	above 20Hz: 200ms maximum below 20Hz: waveform period + 200ms maximum
Accuracy:	0.02% of reading
Timebase accuracy:	0.05% over 5 years
Gain drift:	< 1ppm/°C

Totalisation

Max. totalisation rate:	1kHz — with simultaneous frequency measurement (*LoFloTot* = TRUE) 48kHz — without simultaneous frequency measurement (*HiFloTot* = TRUE)

Process output

Block type:	AN_OUT
Channels:	1.
Output range:	0 to 20mA. (can be software ranged as 0-10mA, 0-20mA, 4-20mA, etc.).
Isolation:	50V ac rms or dc working.
Accuracy @ 25°C:	0.1% of scale .
Resolution:	12 bits (5µA).
Temperature drift:	< ±[0.4µA + 0.008% of reading]/°C @ 99% confidence (< ±[0.2µA + 0.004% of reading]/°C, typically).

Output drive capability:	0 to 1kΩ.
Output fault detection:	*Load fail detect* — triggered if the output cannot maintain the desired current level, *Over-driven detect* — triggered if the output is overdriven by a larger current.
Output kill:	forces the output to low-scale current output, and to a low-impedance state (<1V drop at 20mA). (Kill activated by connecting Kill terminal to I+ terminal, reported in flag *Status.Killed*).

Analogue output

Block type:	AN_OUT.
Channels:	1.
Output range:	0 to 10V (can be software ranged as 0-10V, 0-5V, 1-5V, etc.).
Accuracy:	0.1% of scale.
Resolution:	12 bits (2.5mV).
Temperature drift:	< ±[160µV + 0.009% of reading]/°C @ 99% confidence (< ±[60µV + 0.004% of reading]/°C, typically).
Output current drive:	+5mA (source), –0.3mA (sink).
Isolation:	none.

Digital inputs

Block type:	DG_IN.
Channels:	3 (individually isolated).
Input isolation:	250V rms ac or dc working.
Input type:	current sinking (polarised but accepts ac).
Input voltage:	nominally 24V. absolute max. ±40V.
Threshold tolerance:	min. input for logic ‘1’: 13.7V max. input for logic ‘0’: 5.8V.
Input current:	max. current for logic ‘0’: 0.1mA min. current for logic ‘1’: 0.9mA max. current at 30V: 4.0mA.

Digital outputs

Block types:	DG_OUT or DGPULS_4
Channels:	3 (non-isolated)

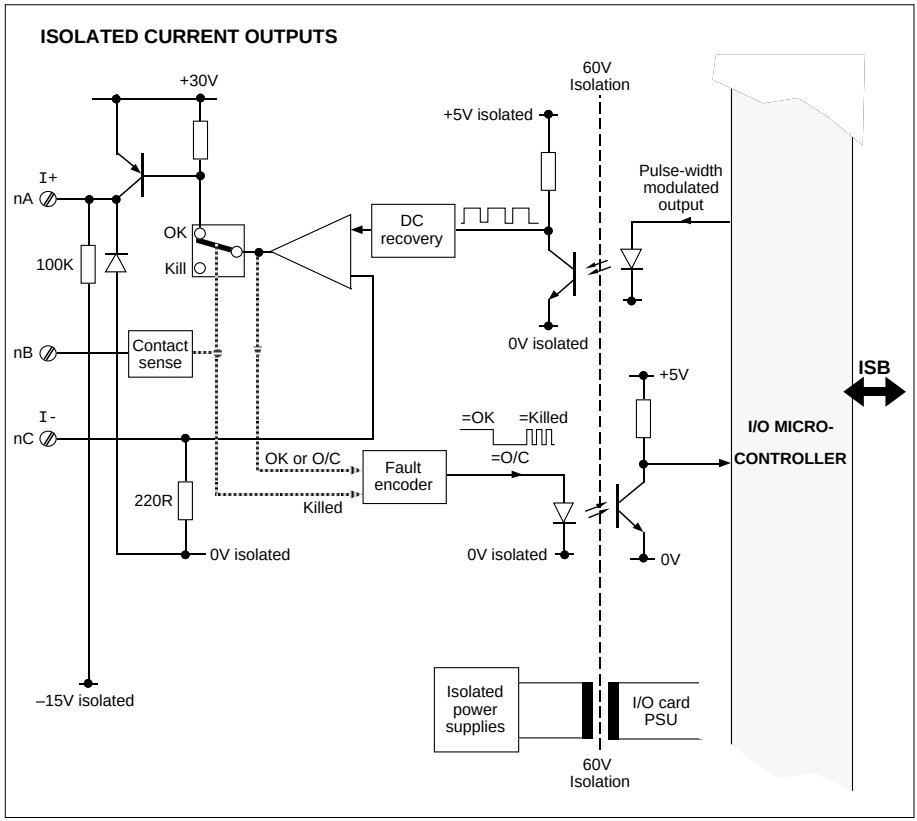


Figure 11-10 Isolated current output block schematic (n=1, 2)

Output levels:	software-selectable between: 24V (nom.) internal pull-up, or external pull-up (open-drain)
Internal pull-up:	21.5V to 24.6V via 3.6kΩ
External pull-up:	60V absolute maximum
Sink current:	120mA maximum; <1V drop at 40mA
Fan-in/fan-out:	Maximum of 2 isolated digital inputs can be driven from a single non-isolated digital output
Isolation:	none.

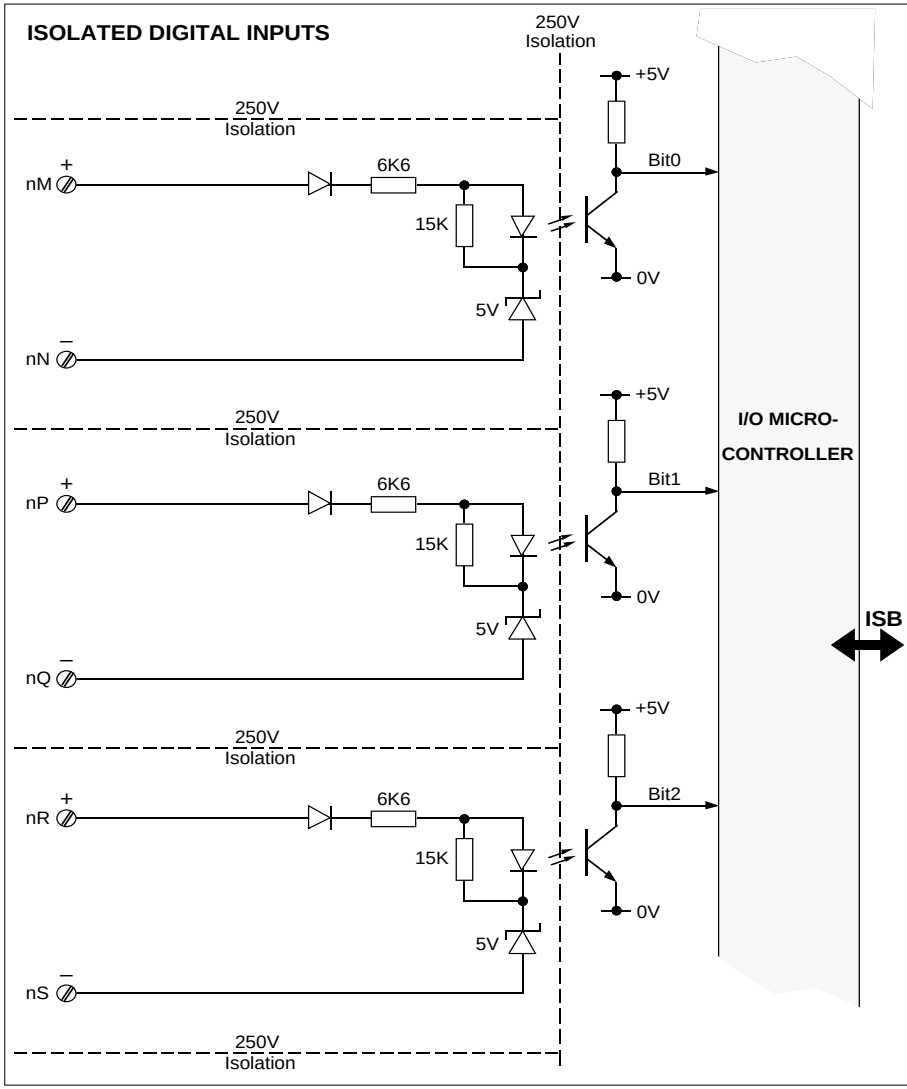
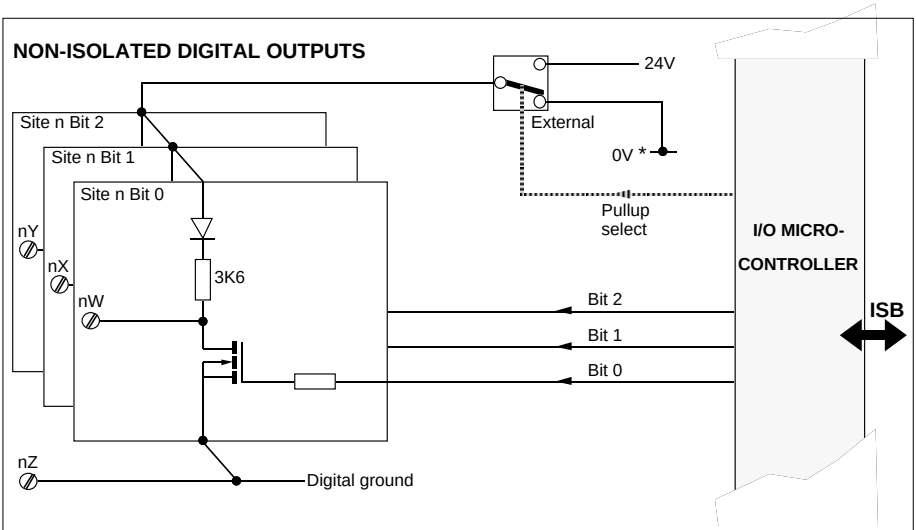


Figure 11-11 Isolated digital inputs block schematic (n=1, 2)

General

The environment, physical, and electrical specifications for the Thermocouple I/O assembly are the same as for the base unit. The confidence limit specifications quoted above have been generated in accordance with BS4889 — Appendix A.



***NOTE — Outputs to high-impedance logic**
During power-up (≤3s) output transistor is OFF till database takes control.
To prevent logic 1 being output, 0V temporarily connected automatically.

Figure 11-12 Non-isolated digital outputs block schematic (n=1, 2)

I/O calibration procedure

Please refer to Chapter 2 of the *LIN Blocks Reference Manual* (Part No. HA 082 375 U003), for generic information on calibrating I/O using the AI_ CALIB and AO_CALIB function blocks.

The following information relates specifically to the thermocouple board.

Partial re-calibration

To calibrate a particular channel of the thermocouple I/O board you need not completely re-calibrate the *whole* card. The following channels are calibrated as separate operations:

- mV/thermocouple input 1 (the input 1 CJC facility must be calibrated at this time)
- mV/thermocouple input 2 (the input 2 CJC facility must be calibrated at this time)
- Analogue input - voltage mode
- Analogue input - frequency mode
- Process output
- Analogue output

Chapter 12 ORDERING INFORMATION

ORDERING OPTIONS

The T640 can be ordered as a complete package including sleeve and memory module. The order codes required for this are given in Table 12-1. Sleeves (T710), security keys (T950), memory modules (T901), burden resistor/diode kits, and ALIN terminator kits are separately orderable using the order codes listed in Tables 12-2 to 12-5.

T640 ORDER CODES

CODE	DESCRIPTION
	Base unit
T640	Integrated Loop Processor
	Power supply
MAINS	Universal mains 90 to 265 volts ac rms
DC	19 to 55 volts dc power supply
	Serial communications
422	RS422 Bi-Synch or MODBUS serial communications
485	RS485 MODBUS comms
ExISB	(*Not yet available*)
—	None fitted
	Site 1 high-level I/O board
HI	0-5V or 0-10V input range automatically selected by database
HG	Jumpers set for 0-1.25V fixed input range
HIB	As HI but with internal burden resistors fitted
HGB	As HG but with internal burden resistors fitted
	Site 2 high-level I/O expansion board*
HI **HG**	Expands board specified in Site 1, but with no burden resistors
HIB **HGB**	Expands board specified in Site 1, but with internal burden resistors fitted
—	No board fitted in Site 2
	Site 1 low-level I/O board
TC	Thermocouple I/O option
RT	(*Not yet available*)
	Site 2 low-level I/O board
TC	Thermocouple I/O option
RT	(*Not yet available*)

*The range specified for Site 2 high-level I/O (**I** or **G** code) must follow that specified for Site 1

continued …

… continued

CODE	DESCRIPTION
	Memory module
M001	2-loop Integrated Loop Processor
M002	4-loop Integrated Loop Processor
M003	(*Not yet available*)
M004	4-loop Integrated Loop Processor with sequencing
M006	Fixed-function Integrated Loop Processor (*High-level I/O only*)
M007	Advanced features. Required to support the AGA8DATA block
M101-105	Pre-packaged applications. Contact Eurotherm Sales Office for details
—	None fitted
	Sleeve
T710	Supplied in a T710 sleeve
T750	Supplied in a T750 sleeve
—	None supplied
	Calibration certificate
CERT	Calibration certificate supplied
—	None supplied
	Configuration sheet
CONF	Factory-configured to supplied configuration sheet
—	Supplied with I/O settings as specified in the I/O codes
	Labelling language
EN	English
FR	French
GE	German
IT	Italian
SW	Swedish
SP	Spanish
PO	(*Not yet available*)
CY	(*Not yet available*)
US	American

Example: T640/MAINS/—/HI/HI/M001/T710/—/—/EN

Table 12-1 T640 order codes

T710 SLEEVE (ORDERED SEPARATELY)

CODE	DESCRIPTION
	Base unit
T710	DIN sleeve
	Power supply connector assembly
MAINS	Universal mains 90 to 265 volts ac rms
DC	19 to 55 volts dc power supply

continued …

… continued

CODE	DESCRIPTION
	Site 1 connector assembly
H	High-level I/O
	Site 2 connector assembly
H	High-level I/O [Only if H specified in Site 1]
—	No I/O specified for Site 2
	Labelling language
EN	English
FR	French
GE	German
IT	Italian
SW	Swedish
SP	Spanish
PO	(*Not yet available*)
CY	(*Not yet available*)
US	American

Example: T710/DC/H/H/EN

Table 12-2 T710 sleeve order codes

T950 SECURITY KEY

CODE	DESCRIPTION
	Base unit
T950	Infrared security key
	Access
FULL	Full access to all parameters provided
PARTIAL	Partial access to parameters provided
	Area
AREA n	Key operates only instruments with specified area code *n*, or zero area code. [*n* =1 to 8]
—	Key operates only instruments with zero area code
	Labelling language
EN	English
FR	French
GE	German
IT	Italian
SW	Swedish
SP	Spanish
PO	(*Not yet available*)
CY	(*Not yet available*)
US	American

Example: T950/PARTIAL/AREA 3/EN

Table 12-3 T950 security key order codes

T901 MEMORY MODULE (ORDERED SEPARATELY)

CODE	DESCRIPTION
	Base unit
T901	Memory module
	Controller function
M001	2-loop control
M002	4-loop control
M003	(*Not yet available*)
M004	4-loop control with sequencing
M006	Fixed-function Integrated Loop Processor
M007	Advanced features. Required to support the AGA8DATA block
M101-105	Pre-packaged applications. Contact Eurotherm Sales Office for details
	Labelling language
EN	English
FR	French
GE	German
IT	Italian
SW	Swedish
SP	Spanish
PO	(*Not yet available*)
CY	(*Not yet available*)
US	American

Example: T901/M001/EN

Table 12-4 T901 memory module order codes

BURDEN RESISTOR/DIODE & ALIN TERMINATOR KITS

Encapsulated plug-in modules for insertion in T640's rear-panel customer screw terminals are orderable using the codes listed in Table 12-5. Burden resistors, burden diodes, and ALIN terminating resistors are available.

CODE	DESCRIPTION
	High-level mA kit
LA 082 728	4-off double 250R burden resistor plug-in modules 2-off burden diode plug-in modules
	ALIN terminator kit
LA 082 586 U001	82R terminating resistor plug-in module
LA 082 586 U002	100R terminating resistor plug-in module

Table 12-5 Rear-panel plug-in module kits

Appendix A SETTING UP EARLY BOARDS

This appendix describes how to set up early boards — i.e. Issue 6 (hardware status level 11) and older — which used Jumpers 2, 4, 5, and 6, as well as DIL switch SW1 to configure the communications options. With Issue 7 boards (status level 12 onwards) your SW1 setting and Jumper 2 alone specify the required comms option. You must read this appendix in conjunction with Chapter 2, *Installation & Startup*.

The main topics covered are:

- T640 zero volts schematics
- Hardware configuration

T640 ZERO VOLTS SCHEMATICS

Communications zero volts schematic

Figure A-1 shows the RS422/485 and ALIN comms connections with associated customer screw terminals. The main CPU is opto-isolated from the RS422/485 transmit/receive terminals. Factory-set jumpers (J4, J5, and others not shown) configure the motherboard for RS422, RS485, or external ISB (Internal Serial Bus) operation. See next section.

NOTE. The ALIN cable screen and the RS422/485 cable screen should each be grounded at one point only.

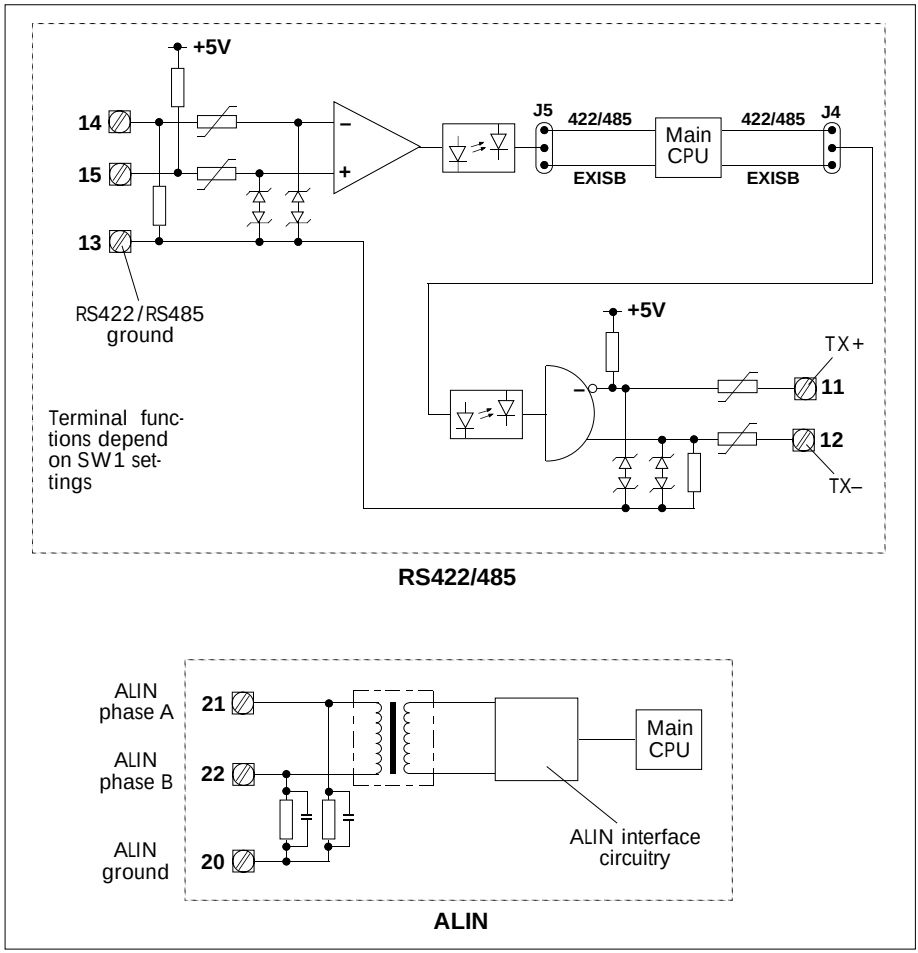


Figure A-1 T640 communications zero volts schematic

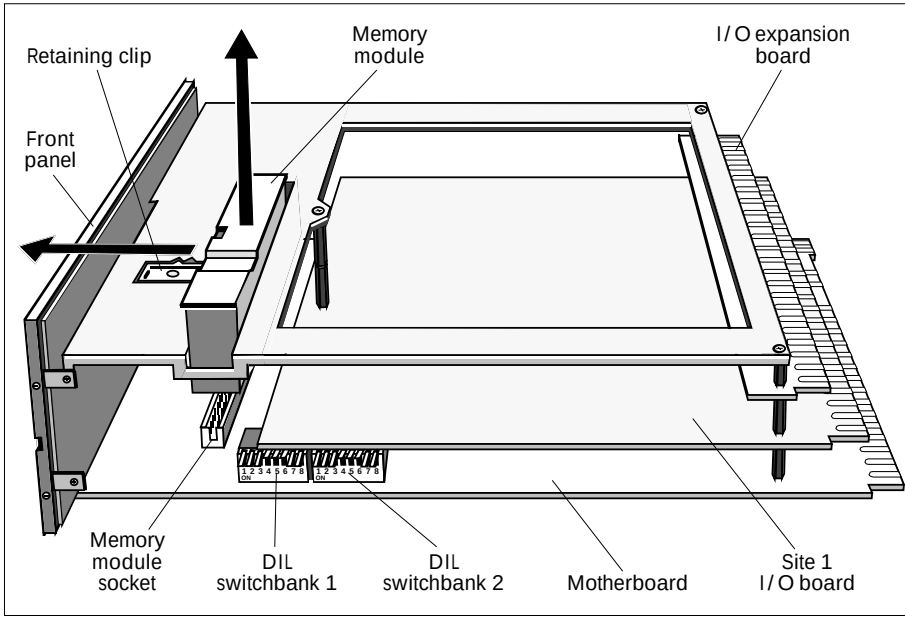


Figure A-2 T640 internal layout (example)

HARDWARE CONFIGURATION

Internal layout

Figure A-2 shows T640's internal layout (example). The motherboard is the main electronics board on which all I/O board options are mounted. It carries two configuration DIL switchbanks 1 and 2, and the memory module in its socket. The figure shows an I/O board in Site 1, and an expansion-type I/O board in Site 2. Other I/O options and arrangements are possible, depending what was ordered.

Memory module removal

See Figure A-2. Use a screwdriver blade to slide the retaining clip towards the front panel as far as it will go, then pull the module out of its socket. Replacement is the reverse procedure.

Caution

The module can be pushed fully home only if it is the right way round. Check this before applying excessive force, which can damage the pins.

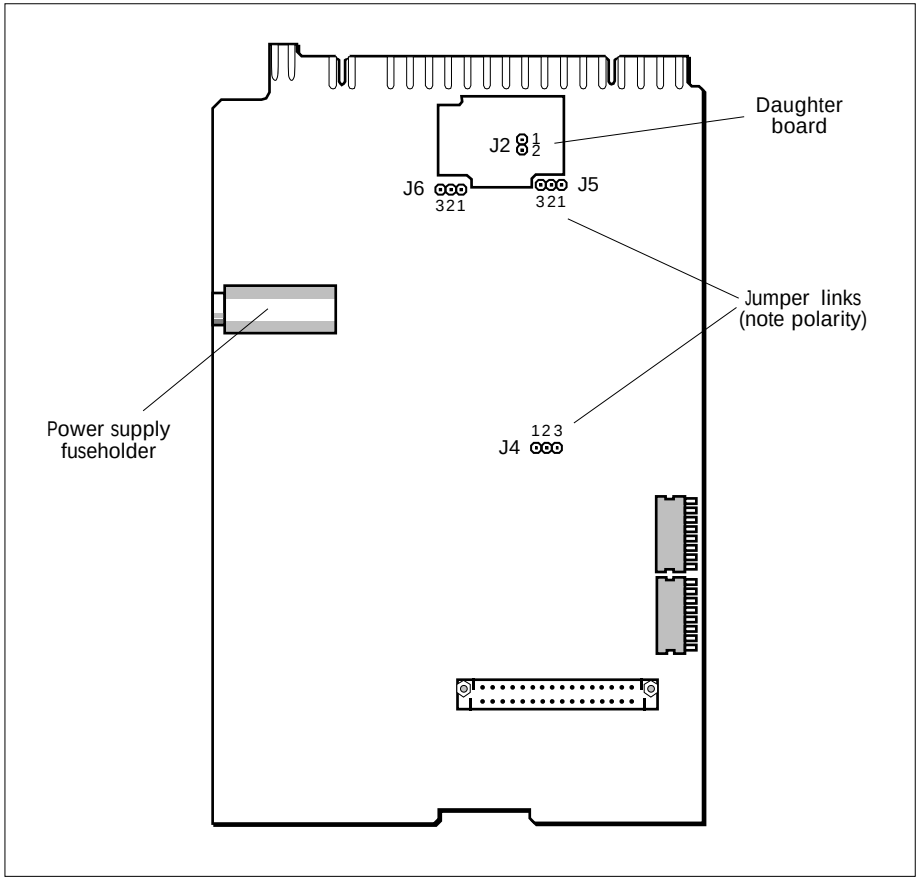
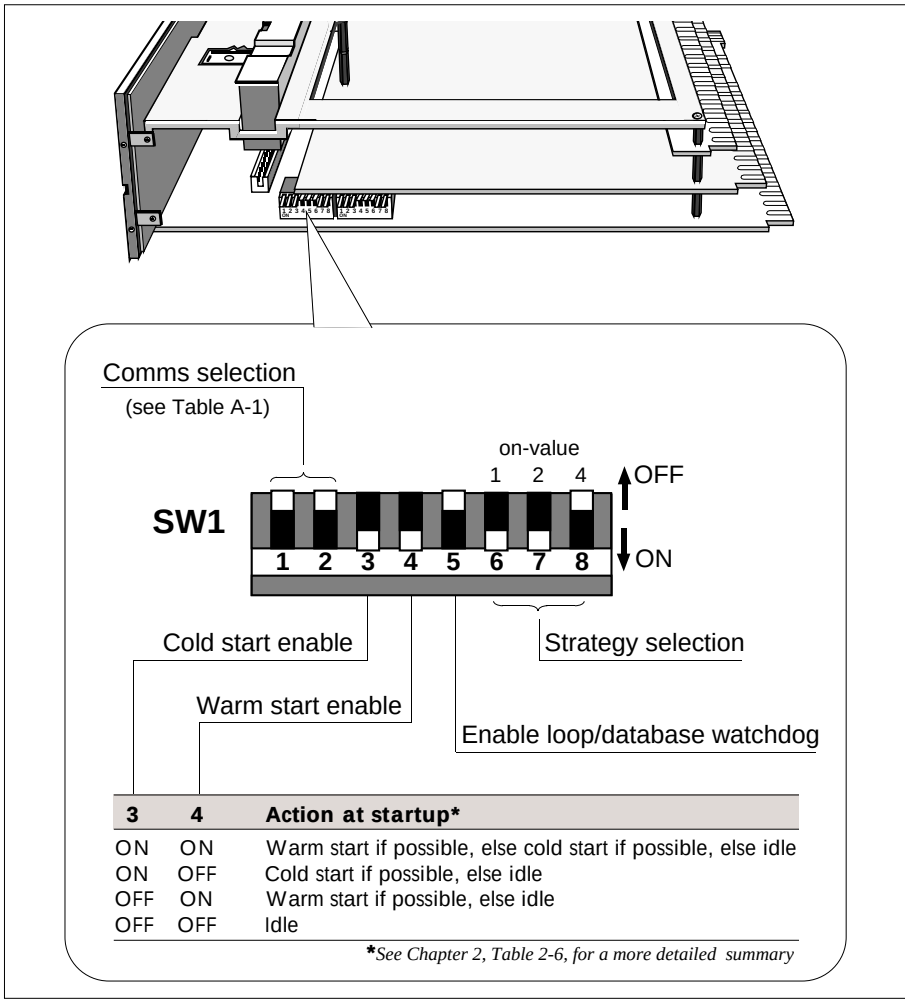


Figure A-3 T640 motherboard showing fuse & jumper locations

NOTE. Refer to the *Memory module compatibility* section under *Hardware configuration*, Chapter 2, for important information on transferring memory modules between T640s.

Main fuse

See Figure A-3. The motherboard carries the T640 power supply fuseholder. The fuse is a 20×5 mm 250Vac antisurge cartridge fuse rated at 500mA (AC option), or 2A (DC option). Unscrew the fuse cap anticlockwise to remove. The fuse should be replaced by authorised personnel only. Note that a fuse may fail owing to ageing, but if it fails because of a fault with the unit, please refer to your nearest Eurotherm Process Automation agent.



3	4	Action at startup*
ON	ON	Warm start if possible, else cold start if possible, else idle
ON	OFF	Cold start if possible, else idle
OFF	ON	Warm start if possible, else idle
OFF	OFF	Idle

**See Chapter 2, Table 2-6, for a more detailed summary*

Figure A-4 SW1 location and functions

Switchbank 1

Figure A-4 shows the location and functions of the eight switches in DIL switchbank 1.

- Switches 1 and 2, together with four jumper links, configure the type of communications used by the T640 via its serial port. See Table A-1 below in the section *Serial communications jumper links & switches*. These switches and links are set at the factory according to the comms option ordered and should generally be left as supplied.

Serial communications jumper links & switches

Four jumper links (J2, J4, J5, and J6), together with switches 1 and 2 of Switchbank 1, are factory-set to configure the motherboard according to what serial comms option was ordered. You can check that these are set as required — the jumpers and switches are located on the motherboard where shown in Figure A-3. Table A-1 shows the switch settings and jumper links for the five possible comms options.

Required comms option	DIL switch SW1/1	SW1/2	Jumper links J2	J4	J5	J6
Binary RS422	OFF	OFF	Not fitted	2-3	2-3	2-3
Modbus RS422	ON	OFF	Not fitted	2-3	2-3	2-3
Modbus RS485	ON	OFF	1-2	2-3	2-3	2-3
External ISB (RS422)*	Don't care	ON	Not fitted	1-2	1-2	1-2
External ISB (RS485)*	Don't care	ON	1-2	1-2	1-2	1-2

**Not implemented at Issue 6*

Table A-1 Comms option switch & jumper link settings

Appendix B
MODBUS/JBUS COMMUNICATIONS

This chapter tells you about the implementation of the MODBUS/JBUS communications in the T640.

The main topics covered are:

- Overview of the MODBUS communications (§1)
- Principles of operation (§2)
- Downloading the configuration (§3)
- Using the diagnostic table (§4)
- MODBUS diagnostic function codes (§5)
- MODBUS exception responses (§6)
- Notes on MODBUS/JBUS implementation (§7)

1 OVERVIEW OF THE MODBUS COMMUNICATIONS

The MODBUS/JBUS communications provide a serial interface to the T640 LIN database. By using the techniques of block caching, the communications may have access to data in other nodes distributed on the LIN as well as blocks in the local database. The product operates in one of two modes:

- **MODBUS slave.** This allows a PLC or supervisory system configured as a MODBUS master and connected to MODBUS to access data in the T640 LIN database, and in nodes connected to the LIN.
- **MODBUS master.** This allows the T640 to acquire data from MODBUS slaves such as PLCs, and incorporate it into its display or control strategies.

1.1 Main features

- The mapping between the database and the MODBUS address space is entirely user-configurable for both digitals and registers.
- Digitals may be mapped as single bits, 8 bit bytes or 16 bit words.
- Analogue Values map to single 16 bit registers with definable decimal point (Floating-point numbers as well as Integers.)
- Long Integer 32-bit totals may be mapped to a pair of registers.

- Configuration can be done using the T500 LINtools MODBUS configurator running on a PC — see the *T500 LINtools Product Manual*, Part No. HA 082 377 U999.
- Diagnostic and status registers allow the database to control the MODBUS interface.
- The communications support the MODBUS RTU (8-bit) transmission mode. Note that support for the ASCII (7-bit) mode is not provided.

1.2 T640 software structure

The T640 communications keep a copy of relevant parameters in MODBUS tables which may be individually configured for either digital or register data. This copy is updated from the LIN database by a scanner task running in the T640.

The T640 supports 16 separate tables, whose size is configurable. The MODBUS data area does not detract from the space available for the continuous database.

Figure B-1 schematises the T640 software structure.

1.3 MODBUS/JBUS function codes supported

Table B-1 lists the MODBUS function codes supported by the T640, together with their maximum scan counts, i.e. the maximum number of registers or bits that can be read or written in a single MODBUS transmission of this type. For full details on MODBUS messages and functions please refer to the Gould *Modicon MODBUS Protocol Reference Guide*.

Code	Function
1	Read digital output status
2	Read digital input status
3	Read output registers
4	Read input registers
5	Write single digital output
6	Write single output register
7	Fast read of single byte (*not configurable in master*)
8	Diagnostics (*not configurable in master*) (supports subcodes 0, 1, 2, 3, 4, A, C, D, E, F, 10, 11, 12 — see Table B-3)
15	Write multiple digital outputs
16	Write multiple output registers

Table B-1 MODBUS function codes supported

Note that the T640 makes no distinction between inputs and outputs. Thus any register or bit assigned in the T640 can be accessed as both an input or an output as convenient. This follows the JBUS implementation of MODBUS.

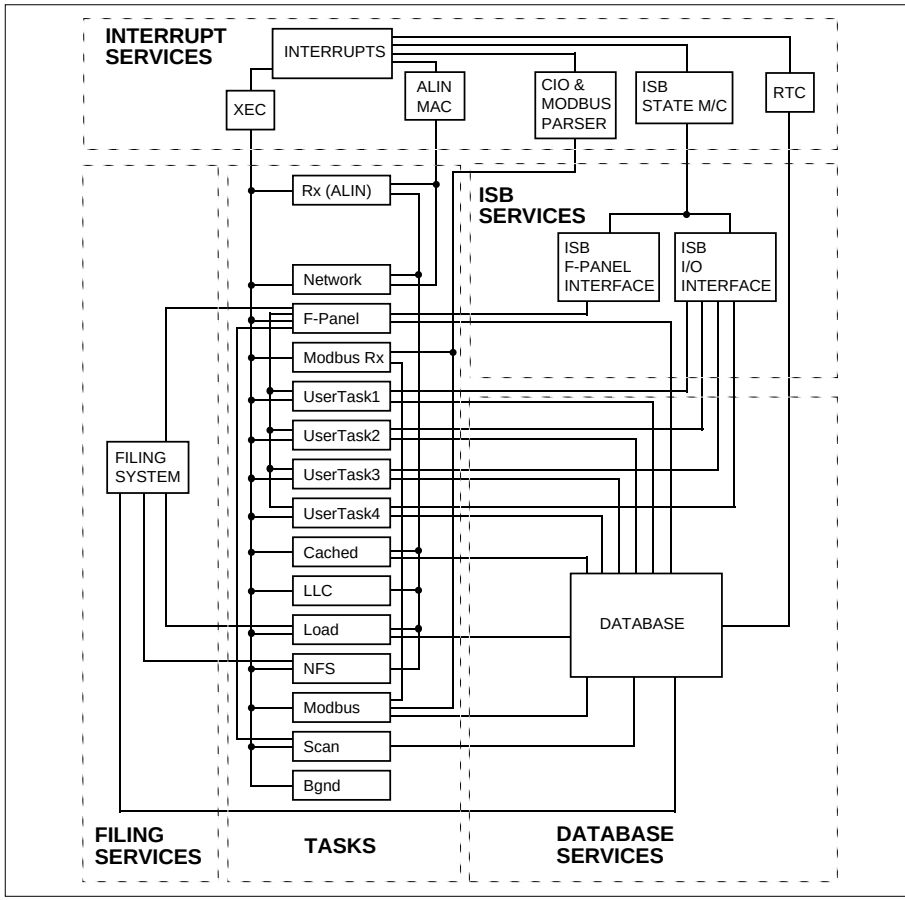


Figure B-1 T640 software structure

2 PRINCIPLES OF OPERATION

The T640 functions as a standard controller on the LIN, and can communicate with other LIN/ALIN nodes via cached blocks and communication blocks.

The T640 operates in one of two modes, either as a MODBUS *master* or a MODBUS *slave*. The configuration and operation in these two modes have a number of similarities, but there are also significant differences. The operation of the two modes is described here.

The LIN database groups data into blocks of related data. For example, a block can represent an input, an output, a controller, and so on. The LIN configurators and display packages recognise different types of block, and handle them appropriately.

In contrast, the MODBUS registers and bits are simply a list of data points. In general there is no predefined structuring of these points into blocks or loops, etc., and most implementations define the allocation of registers differently.

The MODBUS interface involves the mapping of data from the standard T640 database to the MODBUS registers and digitals.

2.1 Slave mode

In slave mode the MODBUS interface has two main purposes:

- To allow a remote system — a MODBUS master on the serial link — to read from and write to fields within standard blocks in the LIN system. The slave is passive and cannot itself acquire data from or write data to other instruments on the link.
- To allow the master to translate data into a LIN format.

The mapping between registers and blocks is inherently bidirectional; it is up to the master to manage how it interacts with a particular register or point.

Figure B-2 shows a possible mapping of MODBUS registers to points in a LIN database where the mapping between the two systems is completely defined by the user.

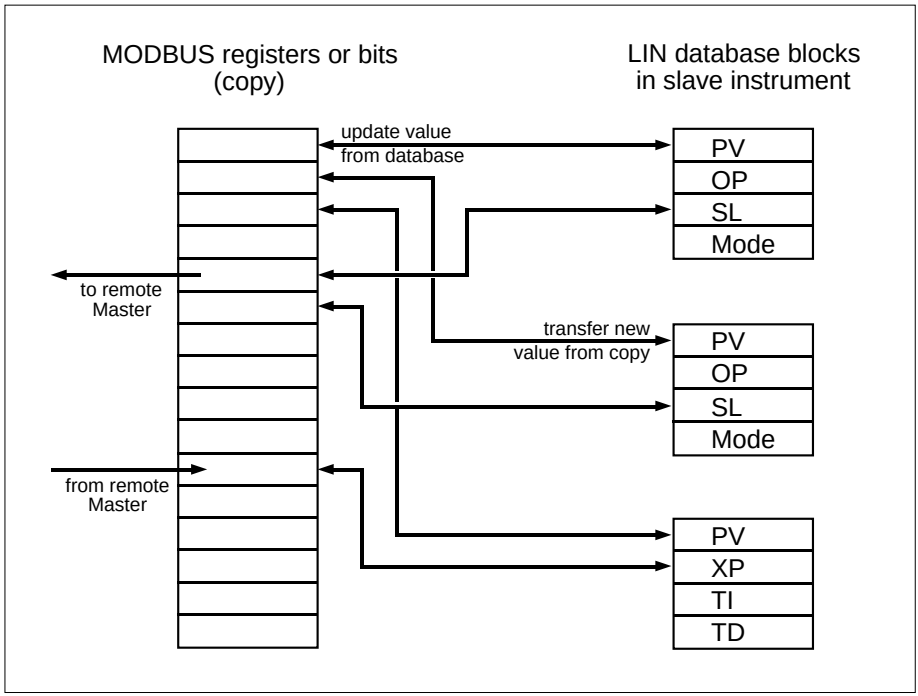


Figure B-2 LIN slave mode operation

The configuration allows gaps to be left in the MODBUS data areas for future expansion. The gaps can be written and read if required, and this allows a system of 'letterboxes' to be set up that can be exploited by some systems. Note that the data in the gaps does not interact with the standard Unit controller/supervisor database.

The T640 functions by keeping a copy of relevant parameters in MODBUS format. This copy is updated from the LIN database by a scanner task running in the T640. This technique increases the speed and predictability of transactions on the serial lines, but at the expense of a scanner task, and memory for the copy data in the T640.

When a master writes a value via the MODBUS, the data is written into the copy and is transferred to the LIN database asynchronously by the scanner task running in the T640. This data is transferred to the database only if the data written across the MODBUS is different from the value already in the table.

The scanner task regularly looks at each value in each table. If it finds that the value has been changed across the MODBUS, it transfers the new data to the database. If the value has not been changed, the value in the copy is instead updated from the database.

When a master reads a value across the MODBUS, the data is transmitted from the copy. The master is responsible for polling the data to discover when the registers have changed.

NOTE. To minimise communications efficiently it makes sense to group dynamic data together so it will be available in contiguous table entries for a multi parameter read.

2.2 Master mode

In master mode the MODBUS interface has two main purposes:

- To allow the T640, as MODBUS master on the serial link, to read values from or write values to registers in a remote slave device such as a PLC.
- To read data from a slave and translate it into a standard LIN data block.

The 16 available MODBUS tables, each configurable for digital or register data, allow support of up to 16 slave devices, subject to data type.

Figure B-3 shows a possible mapping between a LIN database and MODBUS registers. The mapping between the two systems user-defined. The configuration allows gaps to be left in the MODBUS data registers if required.

The MODBUS interface functions by keeping a copy of relevant parameters in MODBUS format. This copy is updated by a task that polls slaves across the MODBUS network. In addition, a scanner task compares the values in the database with the copy, and is responsible for keeping the two sets of data in line.

When the polling task detects that a value has changed from the previous value in the copy, it updates the copy and tells the scanner task to transfer the value to the database.

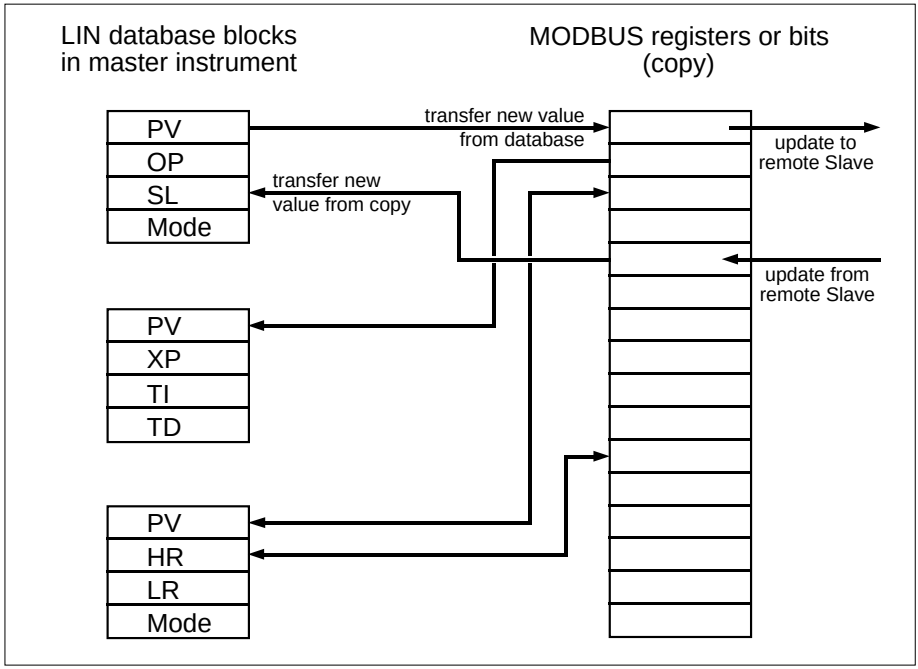


Figure B-3 LIN master mode operation

The scanner task looks at each value in the copy. If it finds that the value has been changed by the polling task it transfers the new value to the database. If it finds that the value in the database is different from the value in the image, it requests that the value is changed by writing across the MODBUS.

In master mode the user can define, for each table, the MODBUS function codes available to the MODBUS interface. This allows global read or write protection if required for data in a particular slave device. In addition, the user can write-protect each connection between the database and a register or set of digitals. This allows the system to protect either the value in the database, or the value in the MODBUS, from unwanted changes.

2.3 Master mode polling sequence

2.3.1 Read operations

The master cycles consecutively through the tables in its MODBUS configuration, and polls the slaves allocated to these tables across the MODBUS serial link. For each table, only one poll is made per cycle. The time to do a complete cycle of all the tables is called the polling period. Thus, if a table is longer than the maximum count specified in the configuration (i.e. *Count* exceeds *Scan count*), it will take two or more polling periods to update all the data in that table. Clearly, if a table has to be read in several parts its overall update rate will be reduced.

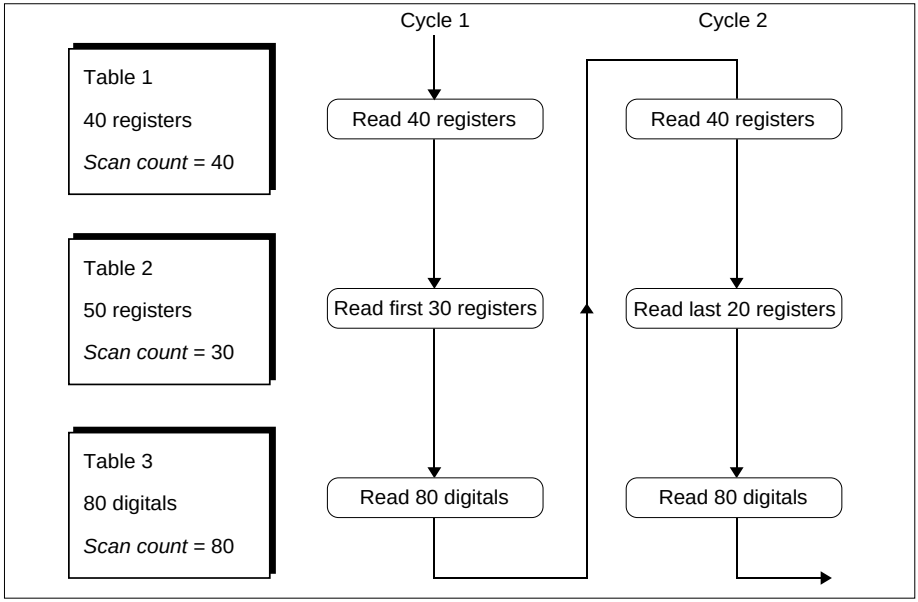


Figure B-4 Polling sequence (example)

Figure B-4 illustrates two cycles of an example polling sequence. For Table 2, the number of registers it contains (50) exceeds its maximum register count (30), so it takes two polling cycles to be fully updated.

2.3.2 Write operations

If the scan task has detected that a value in one of the MODBUS slaves needs to be updated, it requests the polling task to write the new value across the MODBUS network. The polling task is allowed to insert a maximum of *one* such write operation between consecutive read operations. So in the example of Figure B-4, up to three writes could be made per polling cycle.

2.4 Refresh rates and timing information

This section describes the calculations used for determining refresh rates.

2.4.1 T640 slave mode timing

Response times. Time from end of command until first character of the response:

Minimum	3.5 character periods
Normal	12ms (9600 baud)
Maximum	Probably 50ms (9600 baud) (Subject to hold-off by User Tasks)

The cycle time depends on the T640 (slave) response time and the transit time on the serial link, which is about 14ms plus 1.15ms per byte at 9600 baud. It also depends on the execution time of the master.

NOTE. In order to achieve coherence, the MODBUS task is at a lower priority than the User Tasks. Heavily-loaded User Tasks can delay the T640 replies. Use the T600TUNE block to monitor the repeat rate of the lowest priority User Task in use. If this is being 'held off' owing to heavy loading, similar hold-offs will occur to the MODBUS task, and response times will be affected accordingly.

Scan period. The scan period is the time for all the data in the copy areas of all the tables to be updated. This is a function of the number of parameters mapped onto the MODBUS address space, and the number of writes made from the master to blocks that are cached within the slave.

Writing to local blocks does not affect this figure. But the data is updated in only one direction each scan, so that if data is written from the copy to the database, it is not updated from the database to the copy until the following scan.

Data is transferred from the MODBUS image to the database only if the value has been changed by the master.

The scan period is calculated from the following formula, with a minimum value of 100ms:

$$\text{scan period} = (m \times nt) + (r \times 3.5) + (d \times 3.5) + (w \times 100)\ \text{ms}$$

where
- m = minimum period (100ms)
- nt = number of tables
- r = number of registers
- d = number of digitals (or sets of digitals)
- w = number of writes to remote (cached) blocks per scan period.

Example:

For a system with a table of 16 registers and a table with 16 digital descriptors, but no values connected to cached blocks, the scan period is:

$$(100 \times 2) + (16 \times 3.5) + (16 \times 3.5) + (0 \times 100) = 312\text{ms}$$

2.4.2 T640 master mode timing

There are two factors to consider here:

- The time to update the copy images by polling the slave devices across the MODBUS network.
- The time to update the database from the copy data collected by the polling routines.

In the T640, the functions are handled by two separate tasks, and so they are effectively independent — provided that only a limited number of change data transmissions are occurring across the MODBUS link.

Poll period. The following formula gives an approximation for the poll period assuming that no values are being written.

$$\text{poll period} = (n \times m1) + (nr \times tr) + (nd \times td) \text{ ms}$$

where
- n = number of messages involved in acquisition
- $m1$ = message overheads and turnaround time
- nr = number of registers to scan
- tr = time to transmit register
- nd = number of digitals to scan
- td = time to transmit one bit

This is the best case, when the master is only polling slaves on the MODBUS network. If the system is also writing, it performs a maximum of one write between each poll operation. The time to write a value is approximately:

$$m1 + t1 \text{ ms}$$

where
- $m1$ = message overheads and turnaround time
- $t1$ = time to transmit value

Scan period. The scan period is the time for all the data in all the tables to be updated with respect to the database. This is a function of the number of parameters mapped onto the MODBUS address space, the number of writes made to blocks that are cached and the number of writes made to slaves across the MODBUS network.

Data is transferred to the database, or transmitted to the slaves, only if the value has been changed.

The scan period is calculated from the following formula, with a minimum value of 100ms:

$$\text{scan period} = (m \times nt) + (r \times 3.5) + (d \times 3.5) + (wc \times 100) + (wm \times 100) \text{ ms}$$

where
- m = minimum period (100ms)
- nt = number of tables
- r = number of registers
- d = number of digitals (or sets of digitals)
- wc = number of writes to remote (cached) blocks per scan period
- wm = number of writes across the MODBUS per scan period.

Example:

For a system with a table of 16 registers and a table with 16 digital descriptors,

$$\text{scan period} = (100 \times 2) + (16 \times 3.5) + (16 \times 3.5) + (0 \times 100) + (0 \times 100) = 312\text{ms}$$

To calculate the cycle time (i.e. poll period) for the task polling the slaves, assume the system runs at 9600 baud. The slave turnaround time is 50ms, the T640 turnaround time is about 10ms, and the transit time on the serial link is about 14ms, plus 1.15ms per byte at 9600 baud — which is about 0.14ms per bit. Each register contains two bytes, and so needs 2.3ms transmission time. Two messages are involved in the acquisition.

The best case poll period, when the system is only polling the slaves, is therefore:

$$(2 \times [50 + 10 + 14]) + (16 \times 2.3) + (16 \times 0.14) = 187\text{ms}.$$

The time for a write to a slave is:

$$(50 + 10 + 14) + 2.3 = 76\text{ms}.$$

Thus if the system made one write between each scan, the cycle time would be:

$$187 + (2 \times 76) = 339\text{ms}$$

The update period for the scanner to database task:

$$(100 \times 2) + (16 \times 3.5) + (16 \times 3.5) + (0 \times 100) + (0 \times 100) = 312\text{ms}$$

NOTE. The T640 turnaround time of about 10ms can be significantly increased by User Task hold-off if the User Tasks are heavily-loaded.

2.5 Memory use and requirements

An area of memory is allocated to map the database parameters to the MODBUS address space. This memory is allocated to tables, each table representing a series of consecutive registers or bits in the MODBUS address space. The table contains an image of the data in the MODBUS address space, and a descriptor for each register, bit, or set of bits mapped onto that address space.

2.5.1 Current configuration sizes and limits

Memory for tables	4 Kbytes
Maximum number of tables	16
Minimum entries per table	1
Maximum entries per table	Digital bits — 999
(limited by memory usage)	Registers — 200

2.5.2 Memory requirements for the tables

Overhead	18 bytes per table
Image data — registers	2 bytes per register
Image data — digitals	1 bit per digital (*rounded up — see below*)
Descriptors — registers	6 bytes/entry (*whether connected or not*)
Descriptors — digitals	8 bytes/entry (*whether connected or not*)

Digital image data. The storage requirement of digital image data is calculated by converting the total number of bits in the table to 8-bit bytes, then rounding this number of bytes up to the nearest **2-byte boundary**, i.e. the nearest even number. This means that total bit-counts of from 1 to 16 need 2 bytes of storage space, from 17 to 32 bits need 4 bytes, from 33 to 48 bits need 6 bytes, and so on.

The calculation can be done using the following formula, assuming truncation and integer arithmetic:

$$2 \times \text{INT}((bitcount + 15)/16) \text{ bytes.}$$

Examples.

1 A register table with 40 values occupies:

$$18[\text{overhead}] + (40 \times 2)[\text{data}] + (40 \times 6)[\text{descriptors}] = 338 \text{ bytes.}$$

2 The requirements for a digital table depend on how the data is mapped between the MODBUS and the database. The examples below show the two extremes for mapping 64 bits to the database. In case **a** the bits are mapped onto the database in 16-bit units, needing only 4 descriptors. In case **b** each bit is separately mapped to a different point in the database, needing a total of 64 descriptors.

a $18[\text{overhead}] + 8[\text{data}] + (4 \times 8)[\text{descriptors}] = 58 \text{ bytes.}$

b $18[\text{overhead}] + 8[\text{data}] + (64 \times 8)[\text{descriptors}] = 538 \text{ bytes.}$

2.6 Data conversion

The conversion of data between standard MODBUS format and the LIN database format is described here.

2.6.1 Data conversion of digitals

MODBUS digital signals can be mapped onto database bitfields, booleans and alarms. The following rules apply to mapping these types into the MODBUS address space.

- Bitfields can be mapped individually or as a complete set of 8 or 16 bits onto the MODBUS address space.
- Booleans are mapped onto a single bit in the MODBUS address space.
- Alarms are mapped onto a single bit in the MODBUS address space. A value of '1' for this bit corresponds to the 'In alarm' status.

2.6.2 Data conversion of registers

All data types can be mapped onto single registers in the MODBUS address space. However, special care should be taken when mapping database values that require more than 16 bits — in particular 32 bit integers and floating point numbers.

- **Values requiring up to 16 bits of storage.** Database values that require up to 16 bits of storage (one or two bytes) are mapped directly onto a single register. This includes 8- and 16-bit integers, booleans, alarms and bitfields.

  Long signed 32-bit integers: When these values are transferred from the database to a MODBUS register they are truncated, and only the low order 16 bits are written. When the register is being transferred from the MODBUS to the database, the value is sign-extended into the high-order 16 bits.

Long unsigned 32-bit integers: When these values are transferred from the database to a single MODBUS register they are truncated, and only the low-order 16 bits are written. When the register is being transferred from the MODBUS to the database, the high-order 16 bits are assumed to be zero.

Floating-point numbers: When these values are transferred from the database to a MODBUS register they are scaled according to the decimal point you specify, converted to an integer with rounding, limited to the range –65536 to +65535, and then truncated to 16 bits. This allows applications to work either with signed numbers (–32768 to +32767) or with unsigned numbers (0 to +65535).

When the register is being transferred from the MODBUS to the database, it is treated as a signed number in the range –32768 to +32767, scaled according to the decimal point specified and then written to the database.

- **Values requiring up to 32 bits of storage.** 32-bit fields representing values where precision must be preserved may be connected to a pair of MODBUS registers. The two parts are stored in standard PC format in two consecutive registers, of which the first must be at an even address. This method of linking is enabled by entering D (double precision) in the DP field of the first register. The scanner task ensures data coherency.

  32-bit totals: Two-register mapping of long integers is used for the Total and Target fields of the TOTAL and TOT_CONN blocks.

3 DOWNLOADING THE CONFIGURATION

The T640 database and MODBUS configurations can be downloaded from any device capable of downloading a database to a standard T640. Note that the database and MODBUS configurations should both be stored on the same device and have the same root filenames, but with different extensions — .DBF and .GWF respectively.

The operator flags the appropriate .DBF file, or specifies its name (depending on the downloading device), then initiates the download operation as normal. This causes the downloading device to send a command to the target T640 giving the name and location of the specified database file. The T640 now takes over the loading of the new system. It stops the current system, loads the specified database file, and saves it to EEROM. The T640 then uses the name of the database file — but with a .GWF extension — to load the new MODBUS configuration. When the file has been loaded into memory and saved to EEROM, the T640 restarts the system with the new configuration.

4 USING THE DIAGNOSTIC TABLE

The diagnostic table is a special set of registers — fixed at 32 — containing status and control bits to allow the database to interact with the MODBUS drivers. A diagnostic table allows you to control the MODBUS operation, or present diagnostic information to the database. Generally, you need configure only one diagnostic table per MODBUS configuration.

The registers of a diagnostic table are in two distinct sets. The first sixteen — the *internal diagnostic registers* — at default addresses 0 - 15. The last sixteen — the *MODBUS table status and control registers* — are at addresses 16 - 31. These two sets of registers are described next.

4.1 Internal diagnostic registers

The first set of registers (with default addresses 0 to 15) are for internal diagnostic use, and are read-only to the user. They present general information on the operation of the MODBUS and their functions are independent of whether the instrument is operating as a master or a slave. Table B-2 lists these registers and their functions.

Offset	Function
0	(*Unused*)
1	(*Unused*)
2	Diagnostic register, bits currently allocated: Bit 5 — Slave in listen-only mode
3	Query data as transmitted by function code 8 sub code 0
4	Input delimiter as transmitted by function code 8 sub code 3
5	(*Unused*)
6	(*Unused*)
7	Count of error messages sent by slave
8	(*Unused*)
9	(*Unused*)
10	(*Unused*)
11	Master polling task: cycle period in 4 ms ticks
12	Scanner task: time to check all tables in 4 ms ticks
13	Scanner task: time used last time scheduled in 4 ms ticks
14	Scanner task: time used for last delay in 4 ms ticks.
15	(*Unused*)

Table B-2 Internal diagnostic registers 0 - 15

4.2 MODBUS table status and control registers

The second set of registers (with default addresses 16 to 31) lets you monitor and control individual tables in the configuration. Each register in the diagnostic table is automatically allocated to an entire table in the configuration. Specifically, the diagnostic register at default address 16 is assigned to table 1, the register at address 17 is assigned to table 2, and so on up to table 16.

The functions of this second set of registers depends on whether the system is working in master or slave mode.

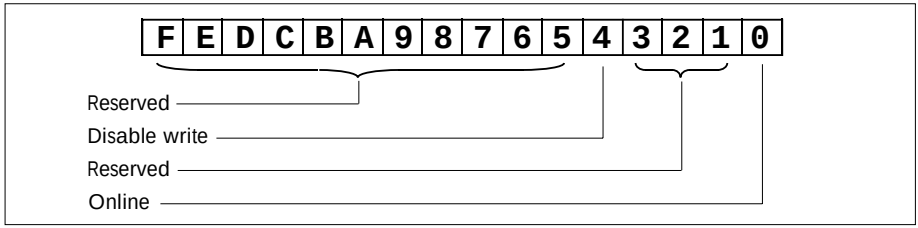


Figure B-5 Slave mode diagnostic registers

4.2.1 Slave mode diagnostic table registers

The slave mode diagnostic register includes bits that allow monitoring and control of the associated MODBUS table by an application running in the database. Figure B-5 shows the allocation of the bits in the register.

The values in the register are used in the following way:

- **Disable write** Setting this bit disables writes across the MODBUS serial link to the associated table. The slave will return error code 8 (see Table B-4, *Exception responses*).
- **Online** This bit is set to 1 if the table has been written to or read from in the period defined in *Time out* in the SETUP menu.

4.2.2 Master mode diagnostic table registers

The master mode diagnostic register (Figure B-6) includes bits which allow control by a database sequence of read/write operations when required by the application.

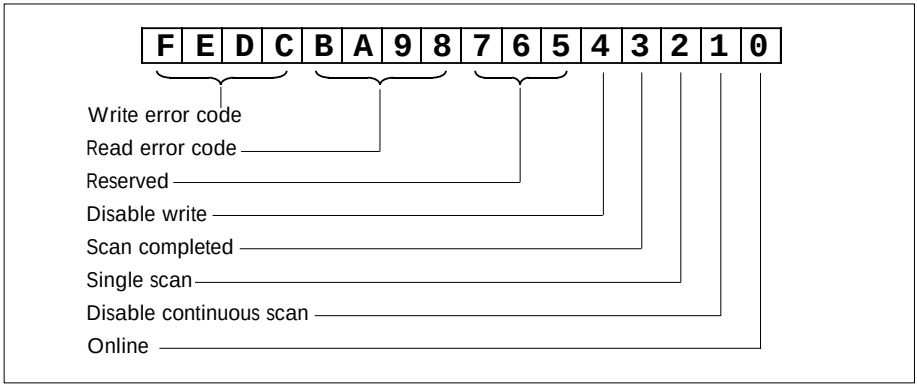


Figure B-6 Master mode diagnostic registers

The values in the register are used in the following way:

- **Write error code** Normally zero. Otherwise it contains the error code associated with the last write to this table (see Table B-4, *Exception responses*).

- **Read error code** Normally zero. Otherwise it contains an error code associated with the reading of this table (see Table B-5).
- **Disable write** Setting this bit to 1 stops the master writing to the slave across the serial link. Note that when this bit is reset to 0, a write is forced to **all** the values in the table.
- **Scan completed** This sets to 1 when the master has completed a scan of the slave. When operating in single scan mode, it indicates that the scan is finished and the data is available for use. It resets when the *single scan* bit is set, as described in the example below.
- **Single scan** This is used in conjunction with the *disable continuous scan* bit. It allows a database sequence to initialise a single scan.
- **Disable continuous scan** Setting this bit to 1 stops the master polling the slave across the serial link.
- **Online** This sets to 1 when the slave is responding to the scanning routines.

The *single scan* and *scan completed* bits are used together when a slave can be polled only under specific circumstances. A small sequence must be implemented to ensure that these bits are used correctly. In addition the *disable continuous scan* bit **must** be set.

The suggested sequence for these operations is:

1. Reset the *single scan* bit
2. Wait till *scan completed* reset
3. Set the *single scan* bit
4. Wait till *scan completed* set
5. The data is now valid
6. Loop back to step 1

5 MODBUS DIAGNOSTIC FUNCTION CODES

Table B-3 summarises how the common MODBUS diagnostic function codes have been supported by the T640 in slave mode. The diagnostics are accessed via MODBUS function code 8.

Diagnostic sub-code	Data sent	Description
0000	xxxx	Echoes the data sent
0001	0000	Restarts
	FF00	Resets the diagnostic counters, and re-enables responses if the slave had been placed in Listen-only mode by sub-code 4.
0002	xxxx	Returns the diagnostic register. (In the current versions, the returned data is always zero.)

Table B-3 continued …

… Table B-3 continued

Diagnostic sub-code	Data sent	Description
0003	ABxx	Changes ASCII delimiter. (This echoes the data sent.)
0004	0000	Forces Listen-only mode. There is NO response to this function.
000A	0000	Resets all counters.
000B		(*Not supported*)
000C	0000	Returns the number of CRC errors detected in messages addressed to this slave.
000D	0000	Returns the number of error messages returned by this slave.
000E	0000	Returns the number of correct messages addressed to this slave.
000F	0000	Returns a count of the number of times the slave has not responded to a valid message (e.g. due to an unsupported function, or a buffering problem in the slave).
0010	0000	Always returns 0.
0011	0000	Always returns 0.
0012	0000	Returns the count of character errors received at the slave, i.e. (overrun + parity + framing) errors.
0013		(*Not supported*)
0014		(*Not supported*)

Table B-3 MODBUS diagnostic function codes

6 MODBUS EXCEPTION RESPONSES

6.1 Slave mode error codes

Table B-4 lists the error codes that may be returned in an exception response from a T640 in slave mode.

Code	Name	Meaning (current implementation)
01*	Illegal function	The function is illegal, or not supported within the MODBUS interface.
02*	Illegal data address	The address referenced does not exist in the slave device.
03*	Illegal data value	The value in the data field is invalid.
04	Failure in associated device	
05	Acknowledge	
06	Busy, rejected message	
07	NAK-negative acknowledgement	
08*+	Write error	The data has been write-protected via a bit in the appropriate table diagnostic register.

Table B-4 continued …

… Table B-4 continued

Code	Name	Meaning (current implementation)
09+	Zone overlap	
0A+	Header error	
0B+	Slave absent	
0C+	CRC error	
0D+	Transmission blocked	

Table B-4 Exception responses from a slave

**Codes implemented in the T640 slave mode. +Supplementary codes defined by the JBUS specification.*

6.2 Master mode error codes

When the T640 is operating in master mode, any error codes received from an attached slave are stored in bits (8 to B), or (C to F) of the appropriate diagnostic register (see §4.2.2).

In addition, if the master detects an error, it can store one of the codes listed in Table B-5 in these bits.

Code	Name	Meaning (current implementation)
0D	Write inhibited	The server has requested that a value is written to a slave, but none of the write codes has been enabled for the table.
0E	Incorrect length	The length of the response message does not correspond with that expected.
0F	Slave Time out	No response was detected in the period defined in the *Time out* parameter

Table B-5 Error codes stored by master in diagnostic status register (bits 8-B or C-F)

7 NOTES ON MODBUS/JBUS IMPLEMENTATION

Although based on the original MODBUS specification, other manufacturers' implementations vary slightly in the correspondence between the actual register or bit addresses in the PLC and the MODBUS/JBUS address, i.e. the 'protocol address'. It is the protocol address that you configure in the Eurotherm Process Automation MODBUS interface.

7.1 MODBUS (AEG-MODICON)

Read-only ('input') and read/write ('output') registers and bits are assigned to separate tables, each with its own address-offset relative to the MODBUS protocol address. Table B-6 summarises this.

Data type	MODBUS function codes Read	Write	PLC address	Protocol address
Output bits	01	05, 15	00001+X	X
Input bits	02	—	10001+X	X
Output registers	03	06, 16	40001+X	X
Input registers	04	—	30001+X	X

Table B-6 PLC address offsets for different data types

It is the MODBUS function code that determines the value of the offset required, and therefore whether a given MODBUS protocol address is directed at an input or output, in a bit or register table.

7.2 JBUS (APRIL)

In the JBUS implementation there is a direct correspondence between a register or bit address and the MODBUS protocol address, and no distinction is made between input and output (or indeed internal) PLC registers. Thus MODBUS function codes 01 and 02 are treated identically, as are codes 03 and 04. All PLC data thus conforms to a single address range.

7.3 Other products

Other manufacturers' 'MODBUS interface' implementations (e.g. Siemens S5 and TSX7 Series of PLCs) conform to the MODICON principle of separate tables for different types of data exchange, but the correspondence between PLC base address and MODBUS protocol address is *user-configurable*.

Appendix C
FRONT-PANEL FOREIGN LANGUAGE SUPPORT

The standard messages displayed on the T640 front panel can be reconfigured. Alternative front-panel messages are defined within a **.LNG** file stored in EEPROM. If the T640 finds a .LNG file at power-up, it uses the messages contained in the file for the front panel. If no .LNG file is found, the default (English language) messages are used.

This facility is intended to allow the T640 to display messages in languages other than English. Currently, a French language .LNG file is supplied with the T640.

FILE STRUCTURE

The front-panel message file contains a number of null-terminated strings from the ASCII character set (with the T640 character code extension). There are forty-one 8-character (plus null terminator) strings, and ten 5-character (plus null terminator) strings.

Table C-1 lists the English language strings and their equivalents for the French language .LNG file. Brief explanations of the displays are also given.

English	French	When displayed...
Trying	TEST	Alternates with Warm/Tepid/ColdStart
WarmStrt TepidStrt ColdStrt	DemChaud DemTiede DemFroid	Indicates type of database start being attempted
Un Pack Database	DeCompr. B.donnee	Alternates to indicate a standard strategy is being decompressed
HALTED	ARRET	Loop not running
INVALID	INVALIDE	Invalid button combination pressed
ALM_SET	VISU_ALM	Pressing raise & lower buttons together, to display absolute & deviation alarm settings
OUTPUT MS_Dmnd MeasPos MS_Input MS_Track	SORTIE DEMANDE POSITION ENTREE POURSUIT	Output Inspect messages (M/A/R pressed)
MASKED	MASQUE	Attempting a masked mode change

Table C-1 continued …

… Table C-1 continued

English	French	When displayed…
SetLocal SetPoint RemoteSP ComRemSP TrimSP	CONS. L CONSIGN CONS. E CONS. C DecaCONS	Setpoint Inspect messages (SP pressed)
NoChange	SansChgt	Attempting to change displayed loop when prohibited by strategy
No Key	Cle.abs	Attempting to enter database inspect mode without a security key
Bad Area	MauvZone	Attempting to enter database inspect mode with a key having the wrong area number
Bad Key	Mauv.Cle	Attempting to enter database inspect mode with an invalid key
NoBlock	SansBloc	Attempting to enter database inspect mode when there are no blocks in the current loop
LOOP1 LOOP2 LOOP3 LOOP4 CACHED	BOUCLE 1 BOUCLE 2 BOUCLE 3 BOUCLE 4 IMAGE	Indicate the current loop number / cached in database loop inspect mode
LP 1 ALM LP 2 ALM LP 3 ALM LP 4 ALM CACH ALM	ALM BCL1 ALM BCL2 ALM BCL3 ALM BCL4 ALM IMAG	Indicate an alarm in a loop other than the currently-displayed loop
SAVING.. Save OK	SAUVEG.. SAUV OK	Indicate a database ‘FullSave’ or ‘PartSave’ in progress
TRUE FALSE BadField	VRAI FAUX Mauv.PRM	TAG block is being used to generate the tag display (for the display of boolean fields, or where a bad fieldname is given)
NoAlm	ssALM	Attempting to enter alarm inspect mode when there are no alarms
LOOP BLOCK FIELD Ronly SubFd Conn. VALUE AlAck	BOUCL BLOC PARAM LECT PRMSe CONN. VALEU ACQAL	Indicate which database inspect mode is operative
NoPrt	ssPrt	Attempting to enter block inspect mode in partial database inspect, when there are no blocks in this loop with partial inspect fields
Limit	Limit	Limit reached on raise / lower

Table C-1 Format of the French language.LNG file

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