Quin Systems Limited

Programmable Transmission System

MiniPTS 4 Installation Manual

Issue 9

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(MAN505)

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Important Notice

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Relevant Directives

The product is designed to be incorporated into a system for the control of machinery, and needs external equipment to enable it to fulfil this function. It must not be relied upon to provide safety-critical features such as guarding or emergency stop functions. It must not be put into service until the machinery into which it has been incorporated has been declared in conformity with the Machinery Directive 89/392/EEC and/or its relevant amendments.

The installation instructions in this manual should be followed in constructing a system which meets requirements.

The product has been tested in typical configurations and meets the EMC Directive 89/336/EEC, when fed from power supplies which meet 89/336/EEC and 92/31/EEC. The product uses only low voltages, and is therefore exempt under 73/23/EEC as amended by 93/68/EEC.

The product as normally supplied has low voltages accessible to touch, and must be mounted within a suitable cabinet to meet any required IP rating to BS EN 60529.

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1. Introduction

This document is the Installation Manual for the MiniPTS 4, a member of the Quin Systems digital Programmable Transmission System (PTS) range.

The systems comprise hardware and software to control one or more servo motors, in conjunction with suitable high power drive systems for the motors. The hardware is highly modular, allowing systems to be easily expanded or upgraded. The software provides full control over all aspects of the system, but has a simple high-level user interface.

PLEASE READ THIS MANUAL BEFORE INSTALLATION.

It is very important that the guidelines for installation are observed, otherwise damage to the system or to the machine may occur. Quin Systems Limited accept no liability for damage or costs arising from incorrect or inadequate installation of the systems, or from incorrect programming of the system for the required application. Digital control systems are not simple, but can be used successfully to control industrial machinery and provide great improvements in reliability, performance and flexibility.

2. Unpacking and Inspection

Inspect the packaging for external signs of damage, if possible before signing the delivery receipt, as this may indicate that it has been mishandled in transit. When unpacking the system, keep all the packaging materials if possible. If it is necessary to ship the system to another site, or to return it for service, the original packing can be re-used.

Inspect the system carefully when it is unpacked. Check for any loose parts, any circuit boards loose in their card guides, cables not connected, or any bending of the case or chassis.

If any defect or damage is suspected, do not connect power to the system. Notify the carrier immediately, and contact your sales office or the Quin Systems Service Department:

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Service Department
Oaklands Business Centre
Oaklands Park
Wokingham
Berkshire RG41 2FD
England

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	support@quin.co.uk
Web site	http://www.quin.co.uk/index.html

3. System Specifications

This section gives the overall specifications of the system, including mechanical details and environmental requirements.

3.1 Mechanical specification

The dimensions of the MiniPTS system are as follows:

Height	297 mm
Width	178 mm
Depth	193 mm
Weight	2 kg

Sufficient additional clearance must be left in front of the system for the serial port connectors on the front panel. The system is designed to be mounted in the normal orientation with the circuit boards vertical, to allow cooling air circulation by convection. There should be at least 50mm clearance above and below the unit to allow the air to circulate. If the unit cannot be mounted with the boards vertical, then a fan must be fitted to blow air through the unit.

3.2 Environmental specification

Temperature:	storage	0 to 100°C
	operating	0 to 45°C
Relative humidity:	20 to 80% non-condensing	

The system may be operated at higher ambient temperatures, but will require additional cooling such as forced air ventilation in order to do so. The system is normally supplied in a case or chassis with ventilation holes top and bottom, and therefore is not protected against dust, particles, or liquids. If necessary, the unit can be supplied in a suitable sealed cabinet. Please contact your sales office or Quin Systems directly for further details.

3.3 Power supply specification

The power supply requirement for the MiniPTS is nominally 24V 0.5A d.c. The system accepts a supply voltage in the range 19–36V d.c. The power supply is protected against reverse voltage connection, but requires an external fuse if the current will exceed 6A.

Additional power supplies are required for the shaft encoders and the external digital input and output signals. Incremental shaft encoders normally require 5V d.c., but other types such as SSI encoders may use different supply voltages, for example 11–28V d.c. The digital inputs and outputs use 24V d.c. for compatibility with PLC systems. The input and output lines are fitted with clamp diodes, which also provide some protection against reverse connection of the i/o supply. However, if the supply is reverse connected then large currents will flow through the protection diodes and they may be damaged unless an external fuse is fitted. Note that the MiniPTS 4 always requires the 24V i/o supply to be connected, as it provides power to the motor enable relay coils. If the optional analogue output isolation is fitted, then this also requires an external ±12–15V power supply.

3.4 Relevant directives

The product is designed to be incorporated into a system for the control of machinery, and needs external equipment to enable it to fulfil this function. It must not be relied upon to provide safety-critical features such as guarding or emergency stop functions. It must not be put into service until the machinery into which it has been incorporated has been declared in conformity with the Machinery Directive 89/392/EEC and/or its relevant amendments.

The installation instructions in this manual should be followed in constructing a system which meets requirements.

The product has been tested in typical configurations and meets the EMC Directive 89/336/EEC, when fed from power supplies which meet 89/336/EEC and 92/31/EEC. The product uses only low voltages, and is therefore exempt under 73/23/EEC as amended by 93/68/EEC.

The product as normally supplied has low voltages accessible to touch, and must be mounted within a suitable cabinet to meet any required IP rating to BS EN 60529.

4. Mounting Details

The MiniPTS 4 system has mounting holes on the rear metal plate, for fixing to the electrical panel inside a cabinet. The unit is fixed with four M5 bolts through holes in the mounting angles. The fixing centres for these bolts are shown in the diagram below.

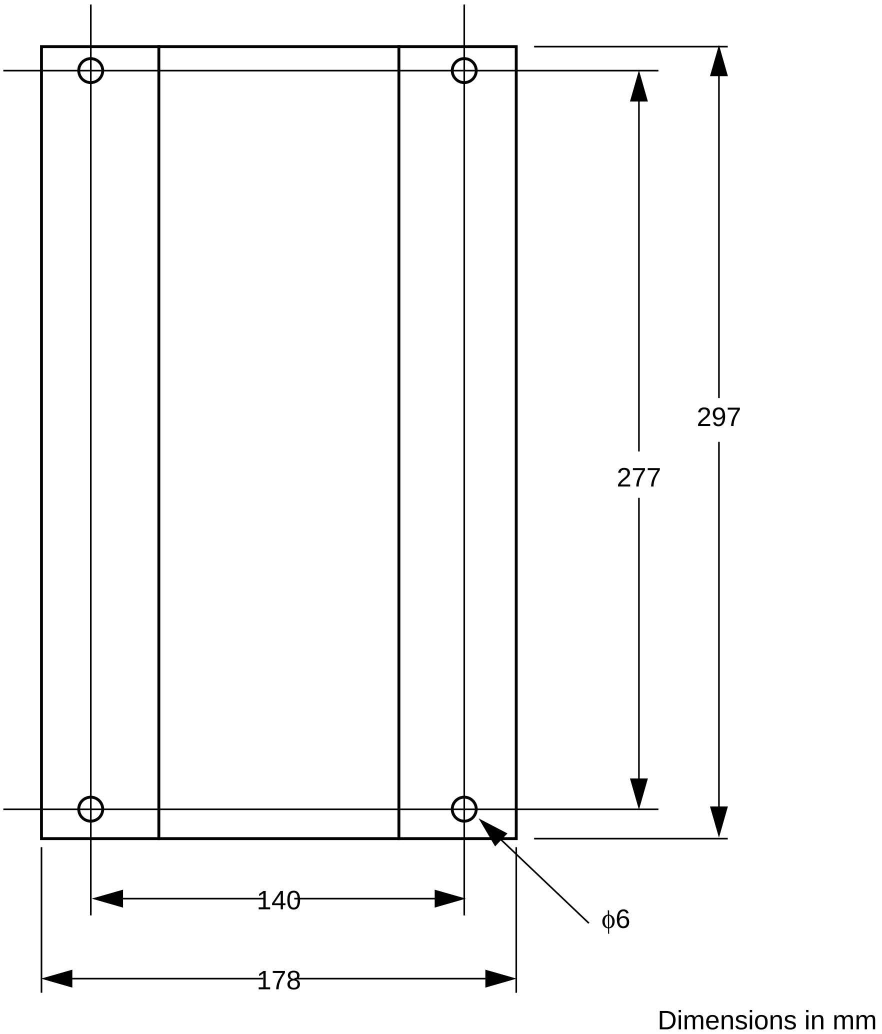


Figure 1. Fixing centres for the MiniPTS 4.

5. Connections

The MiniPTS 4 system has several connectors. Three 9 way D sockets on the front panel of the SRV-4 processor board are used for serial ports. Port A is used for the main programming terminal, while port B is used for options such as the Operator's Panel or the Modbus interface. Port C is used for a serial link to the Quin motor drives. All other connections are made via the backplane board, which has four 9 way D sockets for the four encoders, and two-part screw terminals for all other signals.

The connections for the encoders are on 9 way D sockets S1–S4. All other connections to the motors and external input/output signals are on the main terminal block T1. These connections are also used on the DI-4 four axis Diagnostic Interface when the SRV-4 is used in a rack system. The MiniPTS 4 backplane has two additional terminal blocks. Terminal block T2 provides the external connections for the optional input/output expansion board, and T3 provides the power supply connections for the MiniPTS 4. Note that the motor enable relays are powered from the 24V i/o supply, usually connected on terminal block T1 pins 57 and 59.

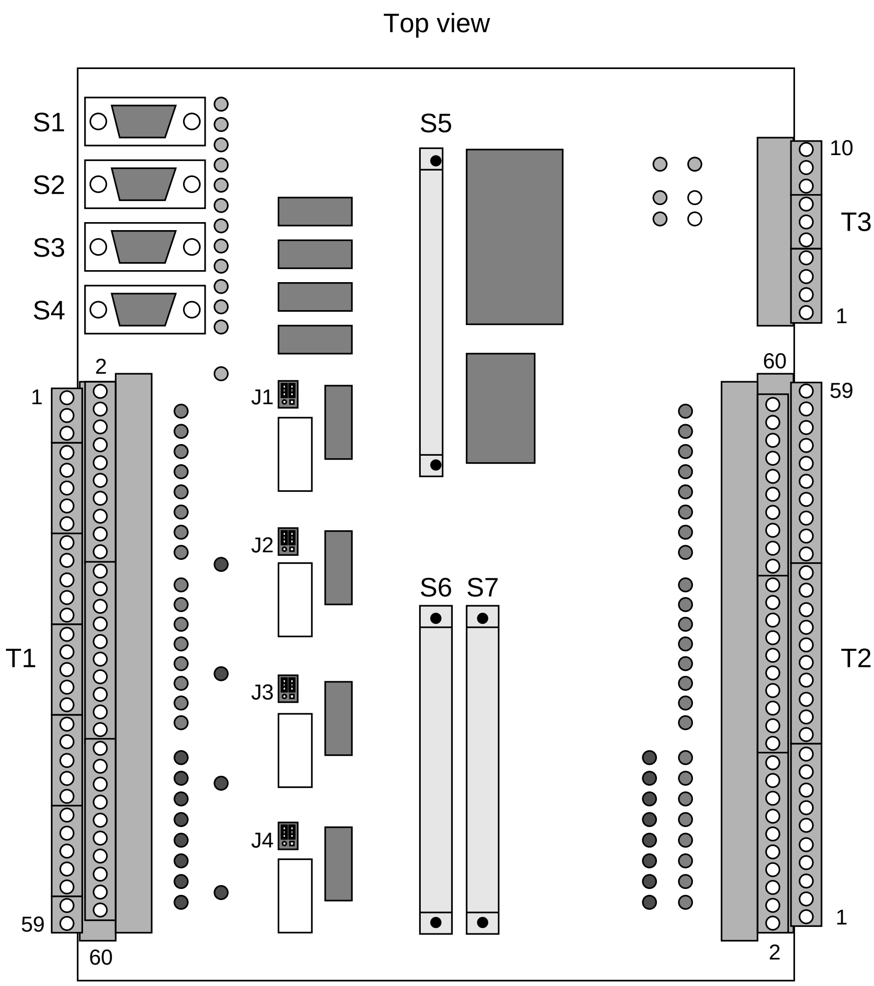


Figure 2. MiniPTS 4 backplane layout

The following table shows the connections on the front panel 9 way D sockets for serial ports A–C. Note that port C does not support the hardware handshake signals RTS and CTS in the RS-232 configuration.

Pin no.	Signal	Pin no.	Signal	
			RS-232	RS-485
1		6		
2	TXD	7	RTS	/TXD
3	RXD	8	CTS	/RXD
4		9		
5	0V			

Table 1: Serial port connections : ports A–C

The tables below show the encoder and power connections for the MiniPTS 4.

S1–S4 pin no.	Signal	S1–S4 pin no.	Signal
1	A	6	/A
2	B	7	/B
3	Z	8	/Z
4	+5VE	9	0VE
5	SCREEN		

Table 2: Encoder connections : S1–S4

T3 pin no.	Signal
10	+24V supply
9	0V supply
8	Screen/earth termination
7	+12V isolation amplifier supply (optional)
6	0V isolation amplifier supply (optional)
5	–12V isolation amplifier supply (optional)
4	Aux supply +V
3	Aux supply 0V
2	Reserved
1	Reserved

Table 3: Power connections : T3

Note that all the screen connections are linked to T3.8 to allow a single earth connection for all the cable screens. They are not connected to the system internal 0V supply. An additional earth connection is normally required to T1.9 or T1.15.

Bottom row		Top row	
T1 pin no.	Signal	T1 pin no.	Signal
1	Encoder 0VE	2	0Vio
3	Encoder +5VE	4	Input 1:1
5	Screen	6	Input 1:2
7	Screen	8	Input 1:3
9	0V	10	Input 1:4
11	Analogue input +	12	Input 1:5
13	Analogue input –	14	Input 1:6
15	0V	16	Input 1:7
17	Analogue output 1	18	Input 1:8
19	Analogue output 0V	20	+24Vio
21	Relay 1 n.o.	22	0Vio
23	Relay 1 common	24	Input 2:1
25	Relay 1 n.c.	26	Input 2:2
27	Analogue output 2	28	Input 2:3
29	Analogue output 0V	30	Input 2:4
31	Relay 2 n.o.	32	Input 2:5
33	Relay 2 common	34	Input 2:6
35	Relay 2 n.c.	36	Input 2:7
37	Analogue output 3	38	Input 2:8
39	Analogue output 0V	40	+24Vio
41	Relay 3 n.o.	42	0Vio
43	Relay 3 common	44	Output 1:1
45	Relay 3 n.c.	46	Output 1:2
47	Analogue output 4	48	Output 1:3
49	Analogue output 0V	50	Output 1:4
51	Relay 4 n.o.	52	Output 1:5
53	Relay 4 common	54	Output 1:6
55	Relay 4 n.c.	56	Output 1:7
57	0Vio	58	Output 1:8
59	+24Vio	60	+24Vio

Table 4: Input/output connections : T1

Top row		Bottom row	
T2 pin no.	Signal	T2 pin no.	Signal
60	Analogue 0V	59	0Vio
58	Analogue input 1+	57	Input 3:1
56	Analogue input 1–	55	Input 3:2
54	Analogue input 2+	53	Input 3:3
52	Analogue input 2–	51	Input 3:4
50	Analogue input 3+	49	Input 3:5
48	Analogue input 3–	47	Input 3:6
46	Analogue input 4+	45	Input 3:7
44	Analogue input 4–	43	Input 3:8
42	Analogue 0V	41	+24Vio
40	Encoder +5VE	39	0Vio
38	Encoder 0VE	37	Input 4:1
36	Encoder 5 A	35	Input 4:2
34	Encoder 5 /A	33	Input 4:3
32	Encoder 5 B	31	Input 4:4
30	Encoder 5 /B	29	Input 4:5
28	Encoder 5 Z	27	Input 4:6
26	Encoder 5 /Z	25	Input 4:7
24	Aux supply +V	23	Input 4:8
22	Aux supply 0V	21	+24Vio
20	0Vio	19	0Vio
18	Output 2:1	17	Input 5:1
16	Output 2:2	15	Input 5:2
14	Output 2:3	13	Input 5:3
12	Output 2:4	11	Input 5:4
10	Output 2:5	9	Input 5:5
8	Output 2:6	7	Input 5:6
6	Output 2:7	5	Input 5:7
4	Output 2:8	3	Input 5:8
2	+24Vio	1	+24Vio

Table 5: I/O expansion connections : T2

6. Electrical Installation

6.1 General

This section gives some guidelines for the electrical installation of the control system. The diagram below shows a typical installation, and will be used to highlight specific areas of interest in the following sections. Note that this is only a very simplified sketch, not a full installation wiring diagram. Details such as isolators, contactors and other switching arrangements are not shown but in most cases should be used. Please refer to the motor and drive manufacturer's instructions for further details on electrical installation.

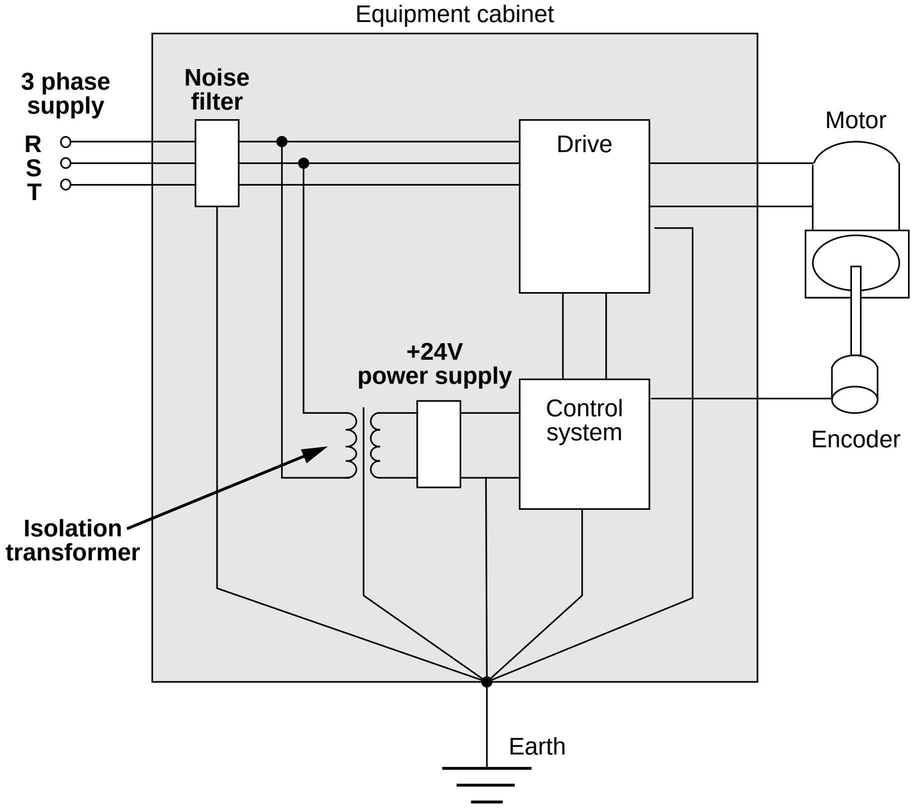


Figure 3. General installation arrangement.

- Use separate trunking to keep all low voltage signal cables (encoder, resolver, command signal) away from three-phase, high current, or high voltage wiring.

6.2 Power supply

The MiniPTS 4 requires +24V d.c. provided by an external power supply. The mains input may be taken from the same three phase mains used for the motors and drives, but care must be taken to avoid introducing noise onto the supply to the control system.

For best results, follow the recommendations below.

- Use an isolation transformer and a line filter in the mains supply to the system. In some cases a line conditioner may be required.

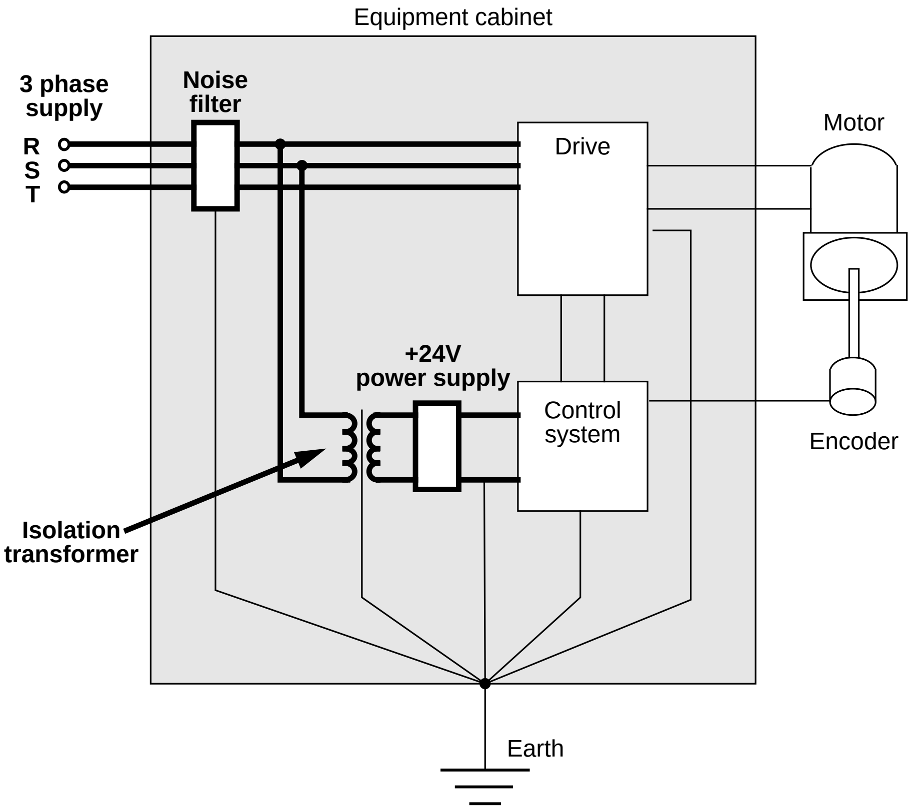


Figure 4. Mains supply installation.

- Do **not** tie the input and output cables from the line conditioner together, or run them close together in a conduit or cable duct.

- Do **not** tie the three phase cables or the single phase supply cables together with any low voltage signal cables.

6.3 Earth connections

Earthing is very important in any electrical installation. It is an essential safety measure to prevent electric shock in case of any failure of the equipment, and is also used for screening between different units. It provides a ground reference point for all units in the system. Incorrect earth connection can result in erratic operation due to noise or earth loops, or may prevent the system from operating at all. These problems can be avoided by careful arrangement of the earth connections, and by such techniques as isolation.

- The earth connections from the isolation transformer and the line conditioner should be made in heavy gauge wire. All the earth connections should be connected together at one point, preferably on the electronics cabinet chassis.

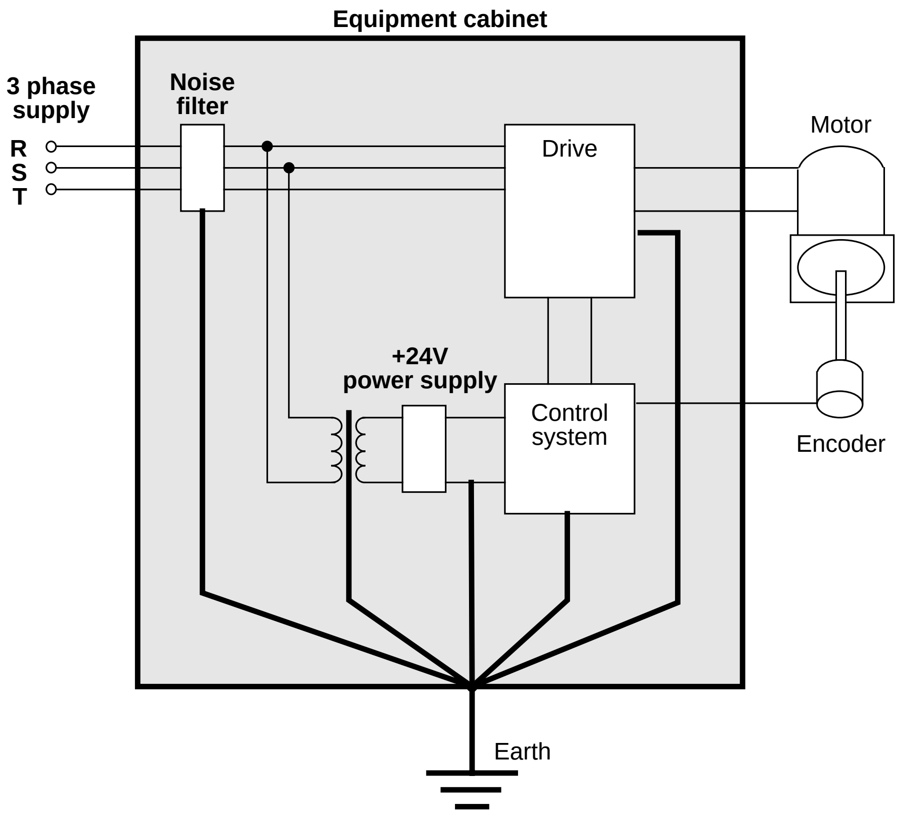


Figure 5. Earth connections.

- Do **not** tie the earth wires together with any low voltage signal cables, or run them close together in the same conduit or cable duct.
- All screened cables should have their screens connected directly to earth, not via the system 0V power supply. This is very important, as otherwise noise and transients picked up in the screen will pass through the system, instead of being dissipated directly to earth.
- Note that the 24V power supply input is isolated, and an earth connection should be made to the internal 0V of the MiniPTS 4, usually at one of the analogue input 0V terminals T1.9 or T1.15. This prevents the unit from floating with respect to the external power supplies.

6.4 Connecting the motor to the drive

The motor should be connected to the drive according to the recommendations of the motor/drive manufacturer(s). A typical brushless d.c. motor is connected with two cables; one carries the power to the motor windings, and the other returns signals from the resolver to the drive for position sensing. The motor should be connected using cables as specified by the manufacturer. These cables usually have a strict specification with regard to size and length.

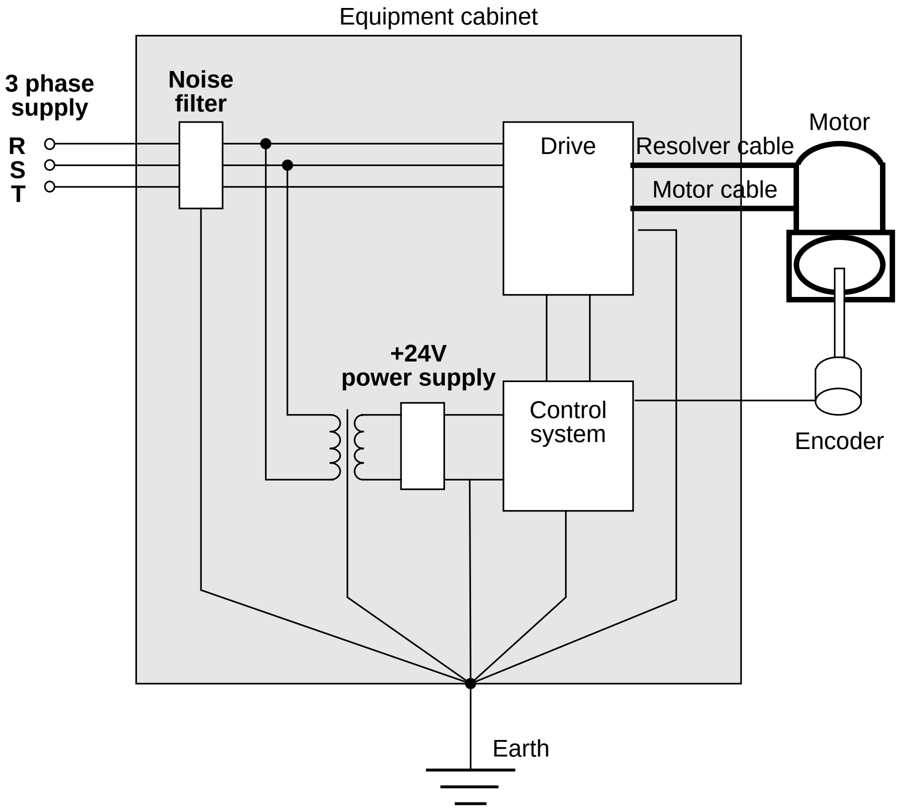


Figure 6. Motor connections.

- Do **not** tie the motor cable and resolver cable together, or run them together in a conduit or cable duct. The motor cable can carry high currents in normal operation, and the resolver cable carries low voltage signals back to the drive. The correct performance and accuracy of the motor and drive depend on the quality of the resolver signals.

- Use a screened cable with individually screened twisted pairs for the resolver signals from the motor to the drive. This prevents crosstalk and noise interfering with the resolver signals, and gives best performance.

6.5 Encoder signals

The position control system depends on the signals from the incremental encoder. These signals indicate both the distance travelled by the motor and the direction of travel. This information is used to calculate the required correction signal to send to the motor drive.

The cables used for the encoder signals should be high quality screened cables. When using the recommended encoders with complementary line driver outputs, the cable should use individually screened twisted pairs, with an overall cable screen as well. The cable screen should be connected directly to the main earth point, not via the control system 0V supply.

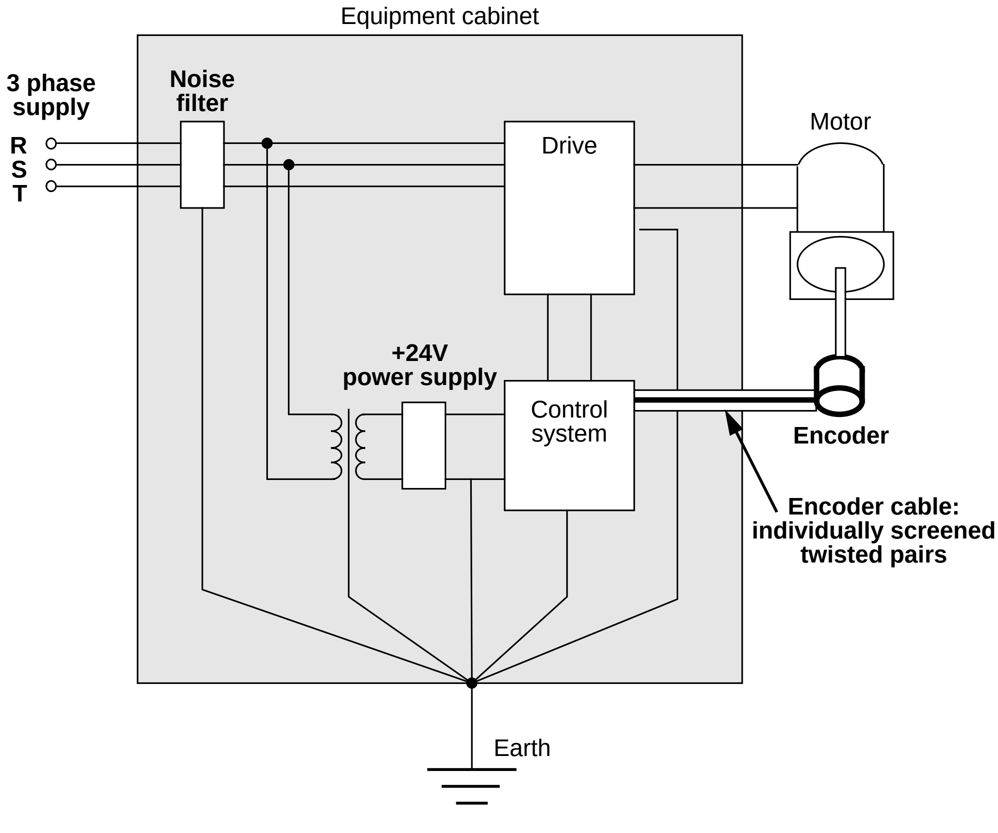


Figure 7. Encoder connection.

The encoder manufacturer’s recommendations for cable type and maximum cable length must be observed. For the line driver output encoders the typical maximum cable length is about 70 m, but this does vary between different encoder manufacturers. It also depends on the cable type and termination used. If the machine installation requires a cable longer than the manufacturer’s recommended maximum length, then it may be necessary to install an additional line driver unit to boost the encoder signals.

The MiniPTS 4 provides full isolation of the encoder input signals. This allows the encoders to be earthed without any danger of creating an earth loop, and prevents any noise picked up in the encoder cable from affecting the control system supply rails. It does require the use of an external power supply to provide the power for the encoders.

The diagram below shows the typical connections to the encoder, showing the pin numbers on the 9 way D sockets and the screw terminal numbers on terminal block T1.

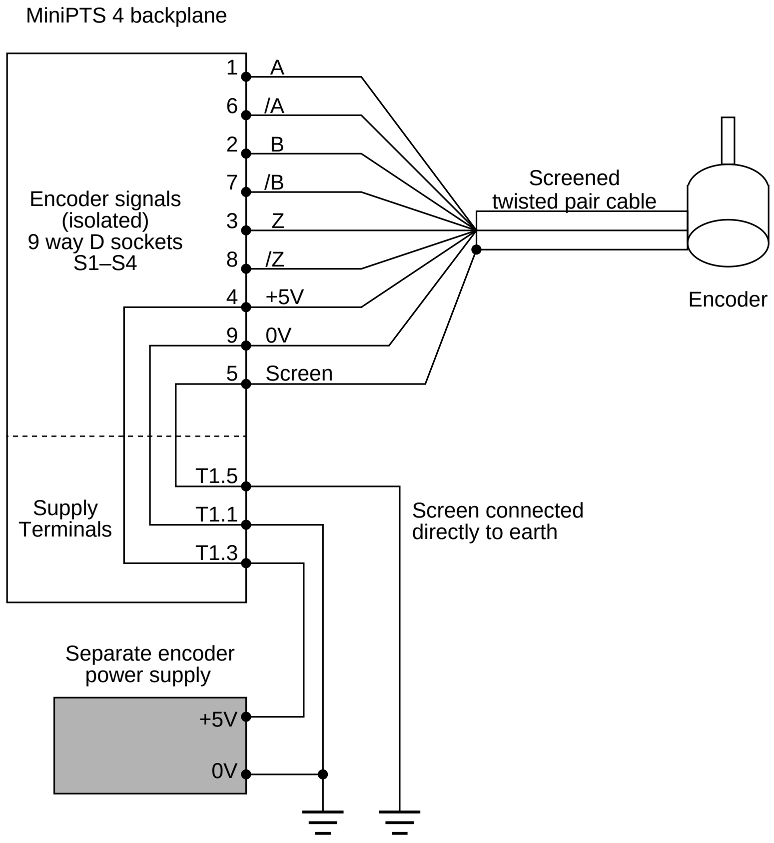


Figure 8. Typical encoder connections.

With some brushless motors, the encoder signals may be derived from the resolver on the motor and provided as an output from the motor drive. In this case, the +5V connection between the encoder input 9 way D socket and the encoder output on the drive is not required. The encoder 0V must still be connected as shown. If the LED indicators on the encoder signals are required then the +5V encoder power supply should still be connected as shown, but the encoder cable does not need a connection to pin 4 of the 9 way D socket.

6.6 Command signal and drive enable

The analogue command signal should be connected to the motor drive command input with a high quality screened twisted-pair cable. The command signal output from the PTS unit is connected to the positive input on the drive, and the 0V cmd signal is connected to the negative or common input on the drive. The cable screen should be connected directly to the main earth point, not to the control system 0V supply.

The motor off relay for each axis should be connected into the motor drive enable input, if available. This allows the controller to shut down the drive immediately when required by the MO motor off command, and on any error condition. The controller simply monitors the motor position when in the motor off state, and does not attempt to control the motor, holding the command signal output at 0V. If the motor off relay is not connected into the drive enable, then the motor and drive remain powered up in the motor off state, and any offset or drift in the drive causes the motor to drift slowly.

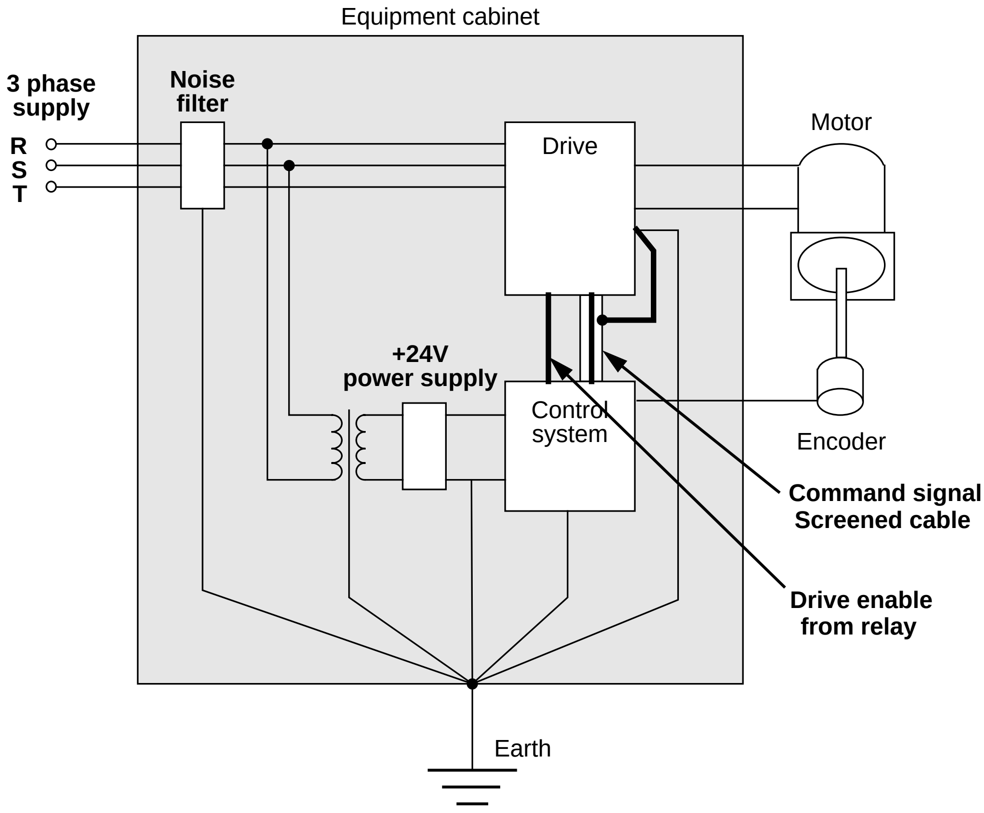


Figure 9. Command signal connection.

- The screened command signal cable should have its screen connected directly to earth, not via the system 0V power supply. This is very important, as otherwise noise and transients picked up in the screen will pass through the system, instead of being dissipated directly to earth.

The command signal output from the MiniPTS 4 may be optionally fully isolated. This facility is not fitted as standard. It allows the command signal to be connected without any danger of creating an earth loop, and prevents any noise picked up in the cable from affecting the control system supply rails. When the isolated analogue output option is used, the output isolation amplifier requires an external power supply.

The diagram below shows typical connections for the analogue output signals to the motor drives, showing the screw terminal numbers on terminal blocks T1 and T3. Note that two different methods of connecting the drive enable signal are shown, with drives 1 and 3 connecting to optocoupled enable inputs and drives 2 and 4 connecting to enable inputs with internal pull-up resistors.

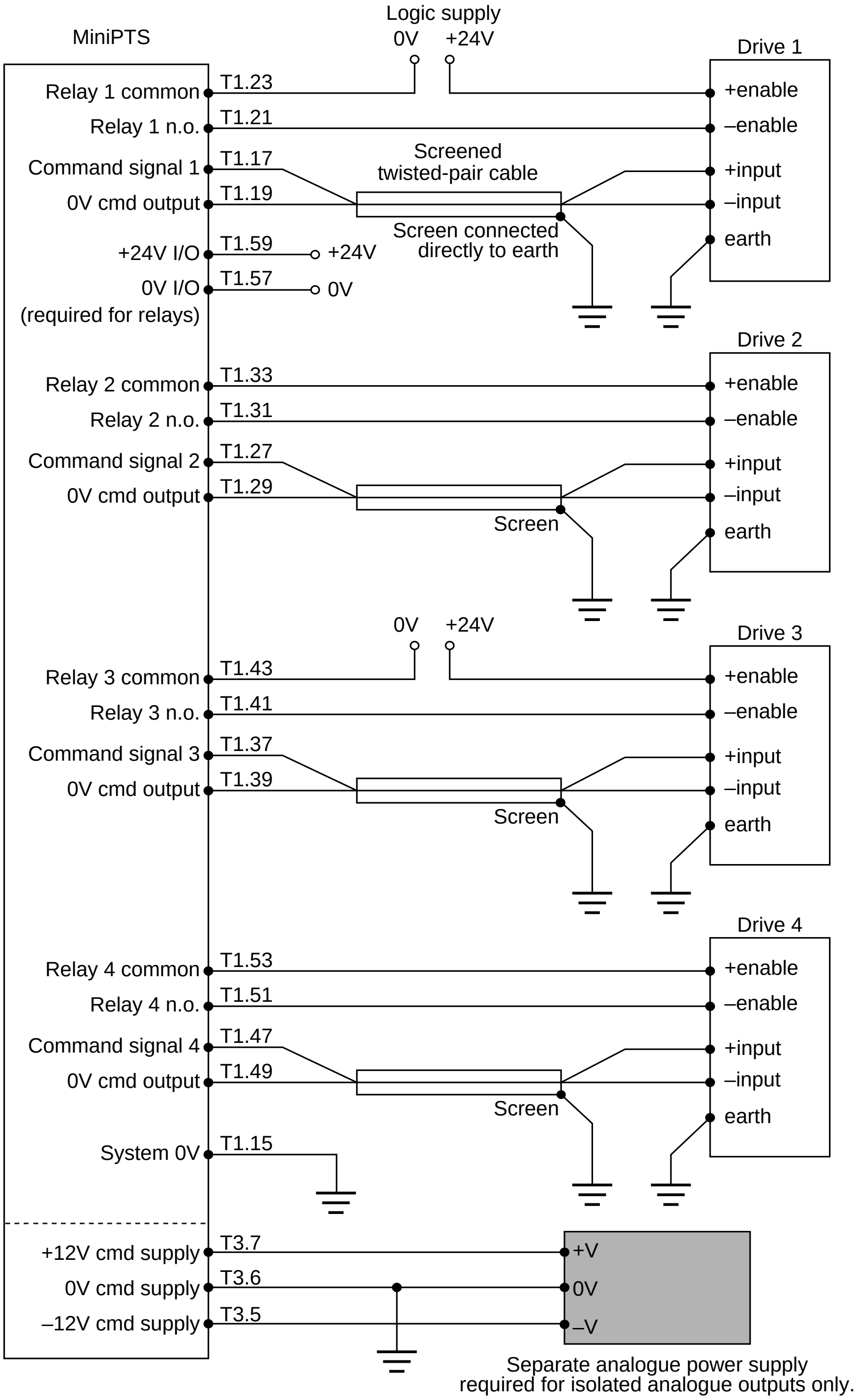


Figure 10. Typical analogue output connections.

6.7 Digital inputs and outputs

The MiniPTS 4 provides sixteen digital inputs and eight digital outputs, all fully isolated. These may be used for several functions, such as monitoring pushbuttons or guards, controlling external solenoids or relays, or signalling to a programmable logic controller. The isolated interface allows +24V logic signals to be used.

This diagram shows typical input and output circuits, with any protection components and indicator LEDs on the MiniPTS backplane shown as well.

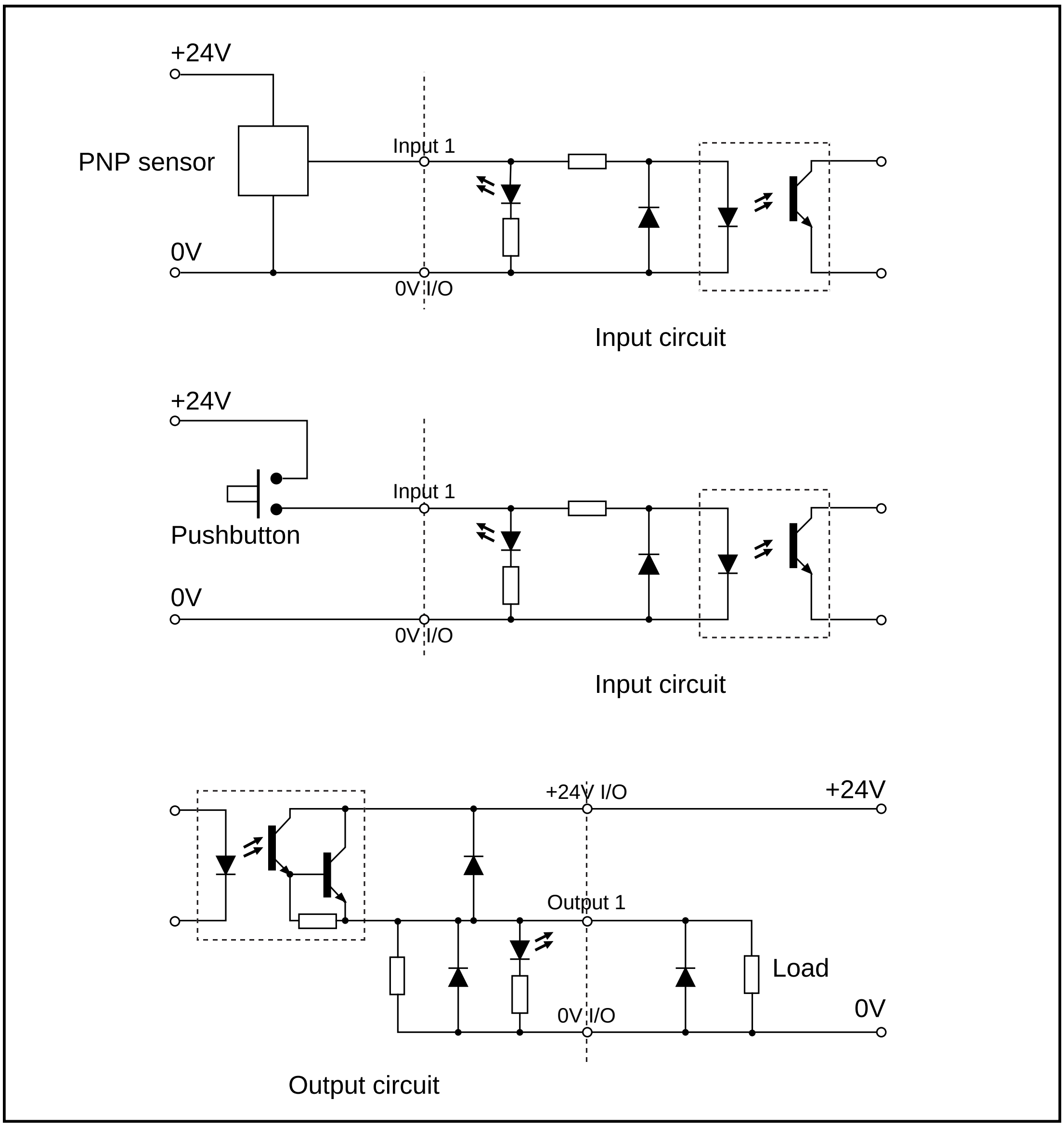


Figure 11. Input and output circuits

7. Safety - Using Guards and Limits

All machines should include comprehensive safety features. This is essential both for normal safety considerations, and to comply with Health and Safety requirements. It can also prevent any unwanted interference with the machine while it is running.

All moving machinery must be guarded so that it cannot be reached by anybody while in motion. The guards should be fitted with guard switches or sensors, connected so as to immediately cut power from the motors when any guard is opened. On some machines, it may be useful to lock the guards closed by means of a solenoid to prevent them from being opened while the machine is running. This allows the machine to detect any attempt to open a guard and shut down the machine cleanly before unlocking the guard and allowing it to open.

Motors which have constraints or limits on their range of motion should be fitted with hard wired limit switches. These should cut power from the motors if any motor goes outside its limits of travel. The machine must also have one or more locking emergency stop pushbutton switches, accessible from several positions around the machine. Anyone operating or working on the machine must be able to instantly stop the machine at any time by hitting an emergency stop switch.

Guards, emergency stop and limit switches may be connected into the PTS motor control systems, by using the digital input lines. However, the programmable input functions on the PTS unit should only be used in addition to the conventional hard wired guard and limit switches, not to replace them. The digital inputs can be used to trigger a smooth shutdown sequence, or to generate a limit switch error and shut down immediately. The control system can then remove power from the motors and drives if required, under software control, by using a digital output line to switch the motor supply contactors. **In all installations the limit switches and guard switches MUST remove all electrical power from the motors and drives, independently of any action of the control system.** If power is removed from the control system, then again all power must be removed from the motors. This is easily done by connecting the onboard relay on each axis controller into the drive enable function, or into the control circuit for the motor and drive main contactors.

Note that in most cases, it is not necessary to remove power from the control system, only from all the high power equipment. If power to the control system and encoders can be maintained even when the motors and drives are shut down, then the system does not lose any position information. This can allow the machine to start up again much more quickly than if the control system is powered off as well, since the machine does not need to execute a complete initialization before it can be restarted.

For more information on programming the MiniPTS 4 for limit switch inputs and user defined functions, please refer to the descriptions of the DL and DI commands in the Input/Output Configuration section of the MiniPTS 4 Reference Manual.

8. Encoders

8.1 What is an encoder ?

An encoder used in a position or speed control system is simply a device to measure the position of some moving part of the machine. Often it is used to measure the shaft position of a motor, but it may equally well be used to read the position of, for example, a linear slide driven by a leadscrew mechanism. In all cases, the encoder measures position (or speed) and converts it to some electrical signal. In the discussions below, rotary encoders are described, but most of the information applies equally well to linear encoders.

8.2 Types of encoders

Encoders come in various types. All of them have the same basic design. They have a device to measure positions or angles, and one or more detectors which give signals when the measuring device is moved. In optical encoders, the measuring device is a glass or plastic disc with a graticule or diffraction grating pattern on it. Filament lamps or light emitting diodes (LEDs) shine light through the disc, passing through the pattern and into light sensitive detectors such as phototransistors. When the disc is moved, the motion of the grating causes the light falling on the photodetectors to vary. The resulting electrical signals from the photodetectors are amplified to produce a usable output signal, either TTL, open collector or line driver. Some of the basic encoder types are described below.

8.2.1 Single phase encoders

These have a single photodetector and a single track on the optical grating. They provide a pulse output which indicates the motion of the shaft and the distance travelled, but does not distinguish the direction of motion. They are used in speed controllers for some unidirectional motor systems. Very coarse single phase encoders are available, consisting of a disc with a number of slots cut into the rim, say ten or twenty slots, and a slotted optical switch or magnetic sensor. These can be used for coarse control or measurement of speed in some systems.

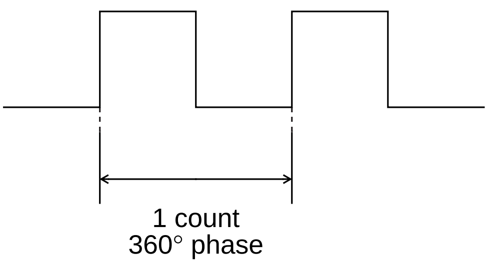


Figure 12. Single phase encoder signal.

8.2.2 Incremental or quadrature encoders

These have two photodetectors, but usually still only one track on the encoder disc. The two pulse signals are usually denoted by the names A and B. To use an incremental encoder to measure position, it is simply necessary to count the pulse cycles on the A and B tracks produced when the shaft is moved. By distinguishing the positive and negative directions, and counting either up or down appropriately, the count value represents the signed distance from the starting position to the current position.

In order to determine the direction of rotation of the shaft, the two detectors are aligned such that the signals from the one track on the disc appear phase shifted on one detector relative to the other by nominally 90°, a quarter of a cycle. When two signals have this 90° phase relationship, they are described as being in quadrature. This phase shift between the two signals allows the direction of motion to be distinguished, as well as the distance travelled. In one direction the track A signal will lead the track B signal, while in the opposite direction they are reversed, and the track B signal will lead the track A signal. This allows incremental encoders to be used for position feedback in servo motor control systems. In addition, it is possible to detect every transition on each signal track, to increase the available resolution of the encoder by a factor of four.

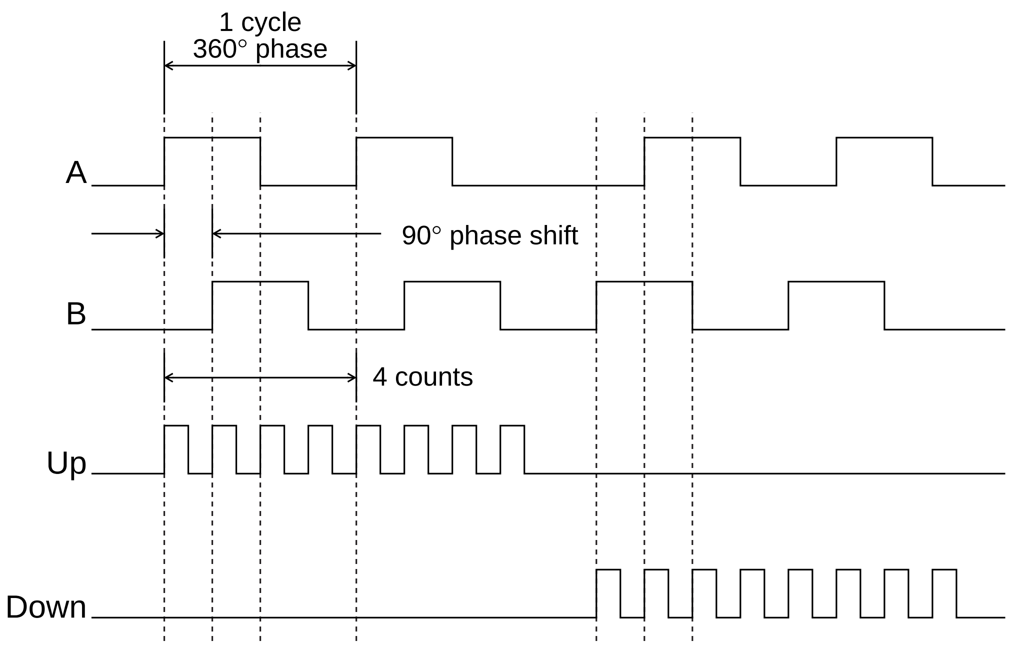


Figure 13. Incremental encoder signals and multiplication.

The major drawback of incremental encoders is that when a system is first turned on, there is no information about the current motor position. The encoder indicates only how far and in what direction the motor moves from this starting position. To provide a datum point, many incremental encoders have an extra track on their optical disc and a third photodetector. This third track, known as the marker or reference track, gives only one pulse per complete revolution of the encoder shaft. It is used to define an absolute zero position for the shaft, by moving until the marker signal is detected and setting the position counters to zero at that point. The marker signal is typically only one half or one quarter of an encoder cycle, and so provides an accurate datum position.

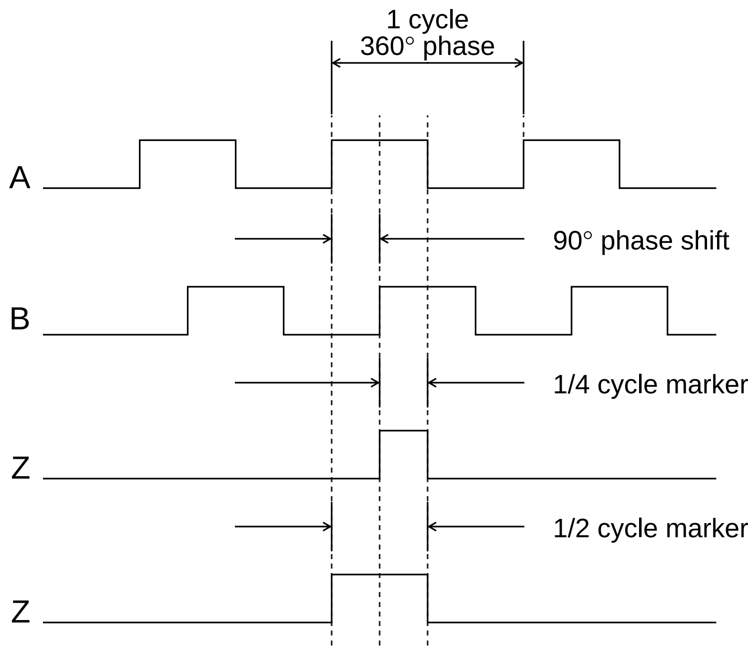


Figure 14. Incremental encoder marker signals.

Incremental encoders are readily available from 100 to 2500 counts per turn, and hardware multiplication of the encoder signals increases this by four times to 10,000 counts per turn. There are also now available incremental encoders using semiconductor lasers and interferometric techniques that give 81,000 counts per turn as standard, and up to 16 times this with hardware interpolation (1,296,000 counts per turn).

8.2.3 Absolute encoders

Absolute encoders have several tracks on the optical disc, and several photodetectors. The transitions between dark and light portions of the tracks on the encoder disc are arranged such that the parallel data available from the photodetectors represents the absolute position of the shaft. Absolute encoders are available from 8 bits to 14 bits wide, or even more, and with either binary, BCD or Gray code outputs. Gray code is often used to avoid possible problems when sampling the data while it is changing. With Gray code, only one bit of the data changes at any one encoder line transition, so that even if the data output changes while it is sampled, the error can only be ±1 bit.

Absolute encoders overcome the problem with incremental encoders of finding the zero position when the system is first started, since the absolute position value is always available. However, they are much more expensive than incremental encoders, they have to be physically larger to get the increased number of tracks onto the disc, and they require as many wires in the connecting cable as they have data bits. They also have the limitation that the position values are defined for only one revolution of the shaft, and then they cycle through the same values again. In contrast, incremental encoders with their counters may be used over any range of position values, limited only by the size of the counters used. In addition, absolute encoders of greater than 12 bits resolution (4096 counts per turn) are less commonly available and very expensive.

8.2.4 Hybrid encoders

Hybrid encoders are a combination of incremental and absolute encoders, in an attempt to work around the drawbacks of the two types. They have both incremental and absolute data signals, but usually only at low to medium resolution. They use a low resolution absolute encoder disc of, say, 8 bits precision, in conjunction with a higher resolution incremental encoder track. This gives some absolute position information at all times, and the incremental track allows finer position control than just the absolute data.

8.2.5 SSI encoders

The MiniPTS 4 has provision for position feedback using SSI encoders. These are absolute encoders with a synchronous serial interface. They have typically 12 bits of position data per turn (4096 counts), and often have up to 12 bits of turns count data (4096 turns) available as well. The data from the encoder is returned in a serial format, 1 bit at a time, when requested by the axis card. This avoids the cabling problems of parallel absolute encoders, while giving absolute position information at all times.

For information on configuring the MiniPTS 4 for use with SSI encoders, refer to figure 13 on page 51 onwards.

8.3 Choosing an encoder

The MiniPTS 4 is designed to use incremental encoders with complementary line driver outputs. These are used for increased signal integrity and noise rejection as compared with cheaper encoders having only single ended output signals. The main criterion for selecting a particular encoder are the number of counts or resolution of the encoder, its mechanical specification for vibration, sealing etc., and its physical size.

The mechanical and size requirements for the encoder are dictated by the machine design, and do not affect the control system. The choice of encoder resolution does affect the setup of the control system, but the MiniPTS 4 is more flexible than most in its facilities for accommodating different encoders.

8.3.1 Maximum count rate

The maximum encoder cycle rate for the MiniPTS 4 is 1.2 MHz, giving an absolute maximum count rate of 4.8 MHz after the hardware $\times 4$ multiplication. This sets a maximum limit on the shaft speed for a given resolution encoder, or alternatively sets a maximum encoder resolution at a given shaft speed. For example, a 2,500 line encoder (giving 10,000 counts) reaches the count rate limit at

$$\omega = 4800000 \div 10000 \times 60 = 28800(\text{r.p.m.})$$

Conversely, for a system with a maximum shaft speed of 6,000 r.p.m., the maximum encoder resolution that can be used is

$$R = (4800000 \div 6000) \times 60 = 48000(\text{counts})$$

Note that when using the normal move facilities on the MiniPTS 4, the set speed value is limited to a maximum of 4,000,000 counts per second, giving some headroom for speed variations around the nominal speed.

8.3.2 Machine cycle length

It is often convenient to choose an encoder such the machine cycle length is either a nice round number of encoder counts or at least a whole number of encoder counts, although this is not necessary with the MiniPTS 4. It makes setting up the system simpler because the parameter values are more easily related both to the machine geometry and its operation. The MiniPTS 4 can be programmed for any encoder cycle length, using the SB set bounds command.

If it is not possible to choose an encoder such that there is a whole number of encoder counts per machine cycle, then the system must use some technique for handling the fractional counts at end of each cycle. Otherwise, the odd part of a count will be lost on every machine cycle, and the motor position will drift relative to the rest of the machine. Using the auto-referencing facilities of the MiniPTS 4, it is possible to allow for this by checking the measured motor position every cycle against the zero marker signal. It is even possible to set up the system to check on only one of several possible marker positions, once the system is correctly initialised.

For more information on using the bounds and auto-referencing commands please refer to the PTS Reference Manual.

8.4 Encoder installation

Optical encoders with their glass or plastic disc are precision devices, and are relatively fragile. It is important that the encoder is mounted correctly so as to avoid any damage or excessive wear that could reduce its working life. The following points should be considered when installing an encoder.

- The encoder shaft should not be subject to any end or side thrust, and there should be no misalignment of the shaft. All of these will cause excessive wear of the encoder bearings, and will give rise to additional friction in the system. The encoder shaft should be connected by means of a suitable flexible coupling. These are available specifically for use with shaft encoders, designed for minimum backlash. The data sheet for any particular encoder includes the maximum permissible limits for the shaft loading.

- If possible, do not mount the encoder in an exposed protruding position, where it may be easily damaged.

- When using an encoder with a standard housing, avoid contact with oil or water as this may damage the internal electronics. Where the application requires a higher degree of environmental protection for the encoder, use one with an IP sealing rating or heavy duty housing.

- If the encoder is driven by a pulley which itself is chain or belt driven, the pulley should be mounted in its own bearings, and a coupling used to connect the encoder to the pulley. This is to avoid excessive side loads on the encoder shaft due to the sideways forces acting on the pulley.

- Do not pull the encoder cable. Make sure that the cable can not be caught up in any moving parts of the machine.

- Keep the encoder cable length as short as possible. If the cable is too long, it will be more susceptible to electrical noise. It is also necessary to ensure that the encoder supply voltage is still correct at the encoder end of the cable, as a long cable can produce a significant drop in the supply voltage. Check the resistance of the cable, and the supply current requirements of the encoder. If necessary, adjust the local power supply to compensate for the losses, but be careful not to exceed the supply voltage rating of the encoder or it will be damaged. Alternatively, either use several wires in the cable for the supply connections, or use a remote sense connection so that the power supply can regulate for the correct voltage at the far end of the cable.

9. Motors

9.1 Types of motor

There are many different types of electric motor, including d.c. servo motors, a.c. motors, and brushless servo motors. Each type has quite different performance characteristics, and is suitable for different applications.

Normal brushed d.c. servo motors are widely used. They develop full torque over a wide speed range, and are easily controlled. However, the torque does fall off at speeds near the maximum speed limit for the motor, and they have only a limited intermittent overdrive capability. The maximum torque available at a given speed is limited by the commutation of the motor brushes. The brushes are also subject to wear, and must be inspected and replaced at regular intervals. The diagram below shows a typical torque-speed plot for a d.c. servo motor.

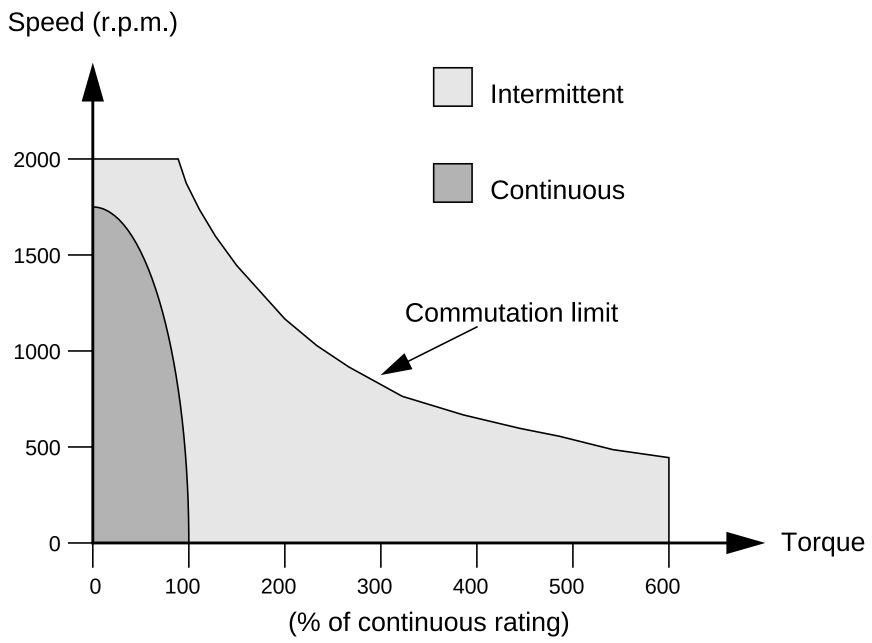


Figure 15. Torque-speed curve for a d.c. motor.

In contrast, a.c. motors are normally used with inverter drives in applications where the motor speed is constant or nearly so. They are designed for continuous near-synchronous operation, but they can be controlled with variable frequency inverter drives. They have poor low speed torque, and do not particularly have any intermittent high torque capability. However, since they do not require brushes, they have lower maintenance requirements than brushed d.c. motors. The diagram below shows a typical torque-speed curve for an a.c. motor.

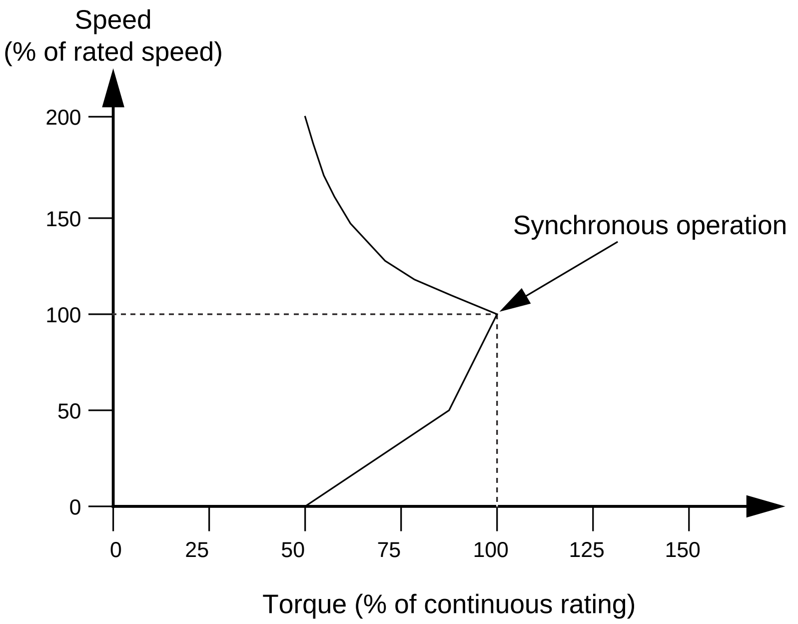


Figure 16. Torque-speed curve for an a.c. motor.

Brushless motors combine the best features of both d.c. and a.c. motors. They have high torque at all speeds, in some cases right up to the maximum speed of the motor. They have no brushes, giving improved reliability and lower maintenance than a brushed d.c. motor, and they do not suffer from the commutation limiting effects at high speeds and torques. They have a very high intermittent overdrive capability, up to as much as ten times the continuous rating for short periods. This is very useful in applications such as indexing, where the motor starts and stops very rapidly, but is not running continuously. They dissipate excess heat very quickly, because the motor windings are in the static outer case of the motor, not on the armature. This means they can run continuously at high power levels without overheating internally. All these factors combine to make brushless motors ideally suited for use in servo control systems. The diagram below shows a typical torque-speed curve for a brushless motor.

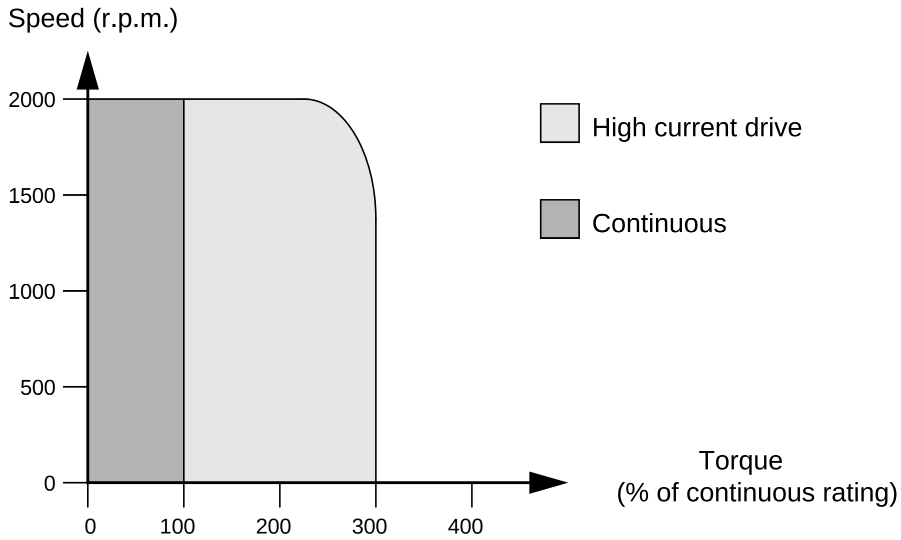


Figure 17. Torque-speed curve for a brushless motor.

9.2 Choosing a motor

The choice of motor for a particular application depends on several factors. Some of these are given below.

- Maximum torque required.
- Continuous torque required (r.m.s.).
- Maximum motor shaft speed.
- Maximum acceleration rate.

The torque is the turning effort required from the motor in order to accelerate the mechanical load or system at the desired rate. It is usually measured in Newton metres (Nm), gramme centimetres (gcm), pound feet (lb ft) or ounce inches (oz in). In order to calculate the torque required from the motor, it is necessary to find out the following information about the mechanical system.

- The reflected total inertia of the system or load, at the motor shaft.
- The reflected total friction of the load.
- The internal motor inertia and friction.
- The maximum acceleration rate of the motor.
- Any gear or pulley ratios in the mechanical system.

For example, consider a motor driving a load via a belt and pulleys. The total torque required from the motor is given by :

$$T = \left(\left(\frac{D_1}{D_2}\right)^2 I_L + I_M\right)\frac{d^2\theta}{dt^2} + \frac{D_1}{D_2}F_L + F_M$$

where T = total motor torque required
D_1 = diameter of motor pulley
D_2 = diameter of load pulley
I_L = inertia of load
I_M = inertia of motor
$\frac{d^2\theta}{dt^2}$ = acceleration at motor shaft
F_L = friction torque of load
F_M = friction of motor.

In most cases, the inertia and friction can be assumed constant, unless the system has a changing load. In this case the maximum possible load should be used in the calculations. The required velocity profile of the motor should be sketched out by plotting motor velocity against time. The slope of this gives the motor acceleration, and thus the maximum required acceleration can be found from the steepest slope on the graph. This acceleration value can then be substituted in the torque equation for a given motor to see if the motor is powerful enough to do the job.

This can be repeated along the velocity-time plot for all accelerations to give a graph of torque against time. This can be used to find the average or r.m.s. continuous torque required by the system. Servo motors are often specified with both a continuous and a peak torque rating, and they should be chosen such that the torque requirement of the machine is well within the capacity of the motor. Care must also be taken to ensure that the maximum speed of the motor is not exceeded.

Note that if too large a motor is selected, the motor inertia is higher than for a smaller motor. This affects the maximum acceleration that the motor produces. It is not always the largest or most powerful motor that accelerates the load at the quickest rate. Also note that maximum power transfer from the motor into the load is obtained if the motor inertia and load inertia are similar.

The ideal motor should have as high a torque to inertia ratio as possible. Pancake or printed armature motors are often used because they have low rotor inertias. This is also another advantage of brushless motors, in that they have low rotor inertias. This is because the rotor often does not have any electrical windings but consists simply of a permanent magnet on a shaft.

9.3 Mounting the motor

The motor must be mounted rigidly to the structure of the machine or to a solid floor. If it is not mounted securely, it may vibrate or oscillate when the motor is powered up and the position or velocity control loops closed. The motor exerts as much torque on its mountings as it does on the load. If the mountings are flexible, they may form a resonant system, with the motor supplying plenty of power to sustain severe oscillations.

9.4 Connecting the motor to the load

The motor shaft must be connected securely to the load. This may be by means of a drive shaft, a toothed belt and pulleys, or by a gearbox. In all cases the coupling between the motor and the load must be as stiff as possible, and must have minimum backlash. At the same time, care must be taken to avoid adding any unnecessary friction into the system, as this reduces the performance of the servo system.

A common problem when connecting the motor to its load is backlash. This is usually found in gearboxes, where the input gear is allowed to move by a small amount between the teeth of the output gear, while the output gear is stationary. A similar effect is seen if the motor mountings are loose or sloppy, or if the coupling between motor and load is too flexible. The effect of backlash is not just a loss of position accuracy, but may in extreme cases result in a highly unstable system. All possible precautions must be taken to minimise or eliminate backlash in the system.

10. Tuning the Position Control Loop

10.1 General

Tuning the position loop is the process of adjusting the various gain terms in the controller to get the best response from the motor and drive. The dynamic behaviour of the system depends on these gain constants, and on the mechanical characteristics of the system being controlled. The easiest way to choose suitable gain constants is by experiment, using the real motor and load. It is possible to calculate the required parameters, but this requires detailed knowledge of the motor and load transfer functions, which are not always available and are difficult to measure. In practice, with a software controlled system such as the MiniPTS 4 it is very simple and much quicker just to experiment with gain settings. The MiniPTS 4 allows the gain values for any motor to be changed at any time, even while the motor is moving, just by sending simple commands to the system via a standard computer terminal. In addition, there are several diagnostic aids on the system to provide information about the performance of the system.

10.2 Control algorithm

The motor control system operates by sampling the position of the motor at regular intervals, and calculating a motor demand signal according to some control algorithm. The algorithm used is of the following form.

$$V_{out} = KPe_i + KI\sum e_i + KD(e_i - e_{i-1}) - KV(p_i - p_{i-1}) + KF(d_i - d_{i-1})$$

where KP = proportional gain constant
KI = integral gain constant
KD = differential gain constant
KV = velocity feedback gain constant
KF = velocity feed-forward gain constant
e_i = position error (= demand position – measured position)
d_i = demand position
p_i = measured position

The actual scaling between position error and output voltage, for proportional gain only, is as follows:

$$V_{out} = \text{Error} \times \frac{KP}{256} \times \frac{10}{2048}\text{Volts}$$

where KP is the proportional gain term, and Error is the position error, measured in encoder counts. The other control terms have similar scalings.

10.3 Monitoring the performance

There are two main facilities provided in the MiniPTS 4 to help to monitor the performance of the motors.

- Continuous display mode.
  The continuous display mode, accessed by the DM command, prints via the serial port a continuous display of the demand position, measured position, and position error on the current channel.

- Monitor function.
  Any unused analogue output may be programmed for use as a monitor output signal. The monitor output can be programmed to output a signal proportional to one of a wide range of measured values. This signal may be viewed on an oscilloscope or a chart recorder. This is particularly useful for seeing the effects of changes in the gain terms when used in conjunction with a storage oscilloscope, as the results can be seen immediately on the display trace.

- PTS Toolkit tuning display.
  The PTS Toolkit PC based front end software includes a simple tuning display. It allows the demand and measured speeds of any one axis to be plotted on the screen, together with the position error. It uses the serial port to upload the information from the PTS unit. It can operate in continuous mode with some limitations in sample rate, or in historical mode, where data is stored and buffered at the full system sample rate and every sample is uploaded to the PC.

These facilities are described fully in the MiniPTS 4 Reference Manual.

10.4 A simple tuning procedure

Tuning a control system is never easy, especially if it is necessary to wring the last ounce of performance out of a motor. However, in most cases this simple outline procedure is a useful starting point for a fuller tuning exercise on a system.

NOTE : This procedure involves trying to set the system into oscillation in order to find an upper limit on the gain parameters. If this is likely to cause any problems or damage to the system, or it is impractical for any reason, then this procedure should not be followed.

- Firstly, the motor and drive must themselves be correctly set up. On most drive systems, the drive unit operates a velocity control loop to control the speed of the motor according to the speed demand signal it receives. This inner control loop should be set up according to the drive and motor manufacturer’s instructions. This should be done with the servo controller either disconnected or in the motor off state, so that it is not trying to control the position at the same time.

- Check that the control system is correctly connected to the drive and to the position encoder.

- Either :
  Connect an oscilloscope or chart recorder to the analogue monitor output, select the desired monitor function with the SF command, and set the monitor gain to some non-zero value with the KM command, say 400. For example, setting SF to 2 selects the measured velocity as the monitor function, so that the output voltage represents the measured change in motor position at each sample. Set up the auxiliary output channel number with the AO command.
  Or :
  Use the PTS Toolkit tuning display on a PC connected to the serial port to display the motor demand speed, measured speed and position error.

- Set the proportional gain to some low value, say 50, and set all other gain terms to zero. The default settings for the gain parameters are 256 for KP and KF, and zero for all other gain values. Set the velocity and acceleration with the SV and SA commands to some suitable low values, depending on the resolution of the encoder.

- Enable the position control action with the PC command. If the motor immediately runs at high speed in one direction and then stops, giving a “motor position error” error message, then the sense of the encoder is reversed. Correct this by swapping one pair of encoder wires, or by setting the appropriate flag bit in the control word for the channel using the CW command. The following stages assume that the system is now correctly controlling the motor position.

- Try executing some simple move commands, such as MR1000. The motor should move as instructed. If at any time it starts to run at high speed in one direction and stops, as described above, then check the encoder connections again. If it moves as requested but starts to vibrate or oscillate, then the gain is already too high. Reduce it by halves until the vibration stops. The monitor output should show something approximating a trapezoidal or triangular velocity profile for the move.

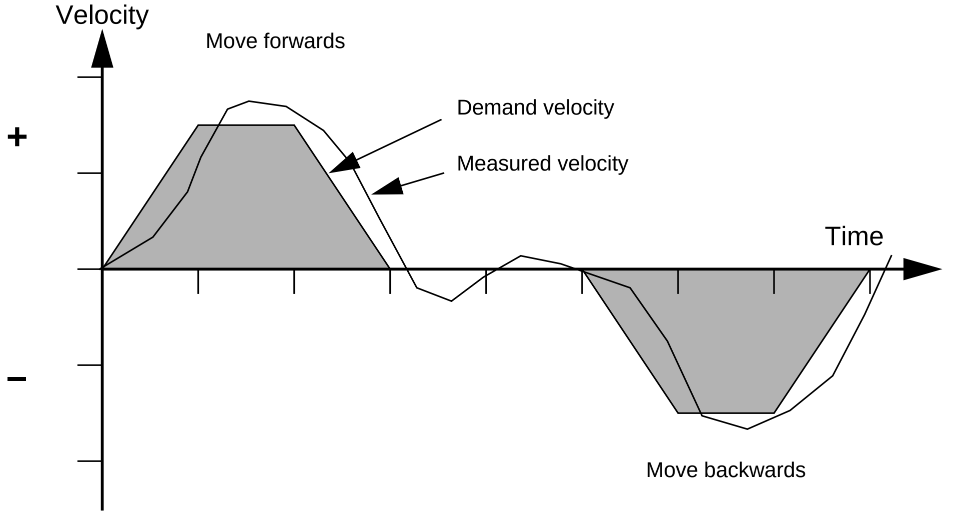


Figure 18. Motor performance for detuned system.

- When the motor is following some simple slow move commands correctly, the next stage is to try some fast moves. This is like giving the system a step function. Increase the speed and acceleration to larger values, and try some move commands again. Repeat this until the motor is making a very sudden motion.

- Set the system to repeatedly execute this sudden move, with a pause between each move to allow the system to settle. An example command string is :

  ```
  MR1000/WT128/MR-1000/WT128/RP
  ```

  This command string sets up a loop where the motor moves 1000 counts positive, pauses for half a second, moves back 1000 counts negative to its start position, and waits another half second. This repeats until stopped by using the AX abort execution or ER end repeat commands.

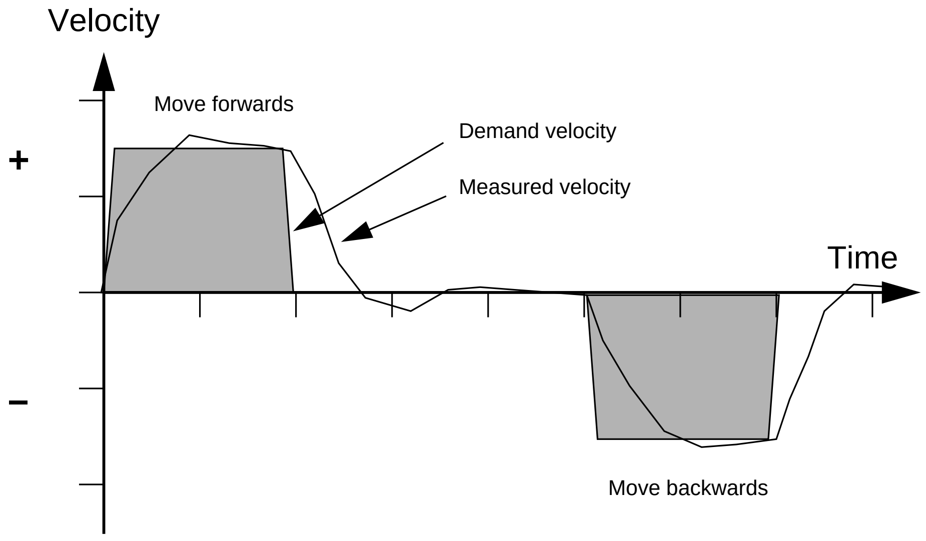


Figure 19. Motor performance for faster moves.

- While the system is executing this move command loop, slowly increase the proportional gain with the KP command until overshoot or ringing occurs at the end of each move. This is an indication that the system is beginning to become unstable. It should be possible to increase the gain to the point where the oscillation is sustained indefinitely, or decays away slowly. This is the highest usable value of KP without making the system completely unstable, although it is of no practical use because of the oscillations.

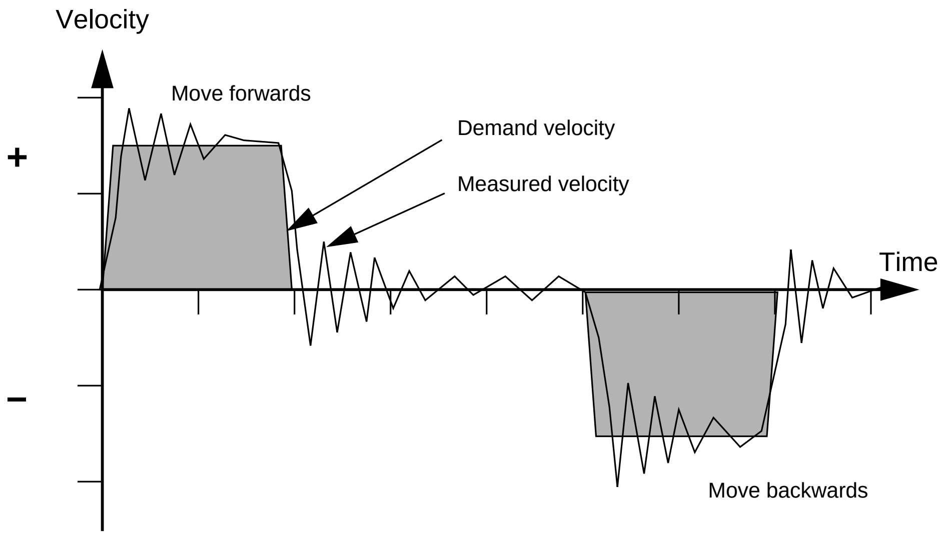


Figure 20. Motor performance with oscillation.

- Now increase the velocity feedback gain with the KV command. Velocity feedback adds damping into the system, and should begin to reduce the amplitude of the oscillations. This should be visible on the monitor signal. Continue to increase the value of KV until the oscillations stop, and there is little or no ringing at the end of each move. The KV term usually can be increased to a much larger value than the KP term. On many systems, it is possible to increase KV to the point where no oscillations or ringing occurs, and the time taken to reach the target position is a minimum. This is called critical damping.

  NOTE : On some very low inertia motors with small loads, the KV term may prove ineffective in damping the oscillations, and may make them worse. In this case, an additional external source of damping such as a tachogenerator must be fitted to the motor. This provides instant velocity feedback to the motor drive and is not subject to the sample time constraints of a digital system. Tachogenerators may of course be used with any systems, not just low inertia systems.

- Stop the move command loop with the AX or ER command. If it is possible to run the machine at constant speed in one direction, then the KF feed-forward gain may be set up at this point as well. If not, it will have to be set up during more normal operation of the system. Set the speed to the desired operating speed of the motor. Turn on the continuous position display with the DM command, and start the motor at constant velocity with the VC command. The third column in the DM display shows the position error. Increase the value of KF and note that the position error values should decrease. KF may be increased until the position is approximately zero, at which point the feed-forward gain is compensating for the velocity lag present in the system with proportional gain only. The KF value may be increased further to the point where the motor position is ahead of the demand position, if required, without any problems.

This procedure, although it only describes setting up some of the gain terms, is sufficient in many cases to give acceptable performance from the motor system. However, an acceptable setup for any particular operation may not be ideal for a different operation, so it is useful to experiment with many different moves and profiles to find the best compromise. Clearly, the most important operation for the purpose of tuning the motors is the normal operation cycle of the machine. Note that by using the command sequence facilities on the system, it is quite feasible to change gain settings automatically, in response to an input signal or according to a set programme. This would be used, for example, on a robot arm, where the ideal setup depends on the load carried by the arm.

Tuning any control system is not a simple process, particularly a servo control system with a very fast response time. Most literature on control systems and tuning describes the application of controllers to large process plant, where the plant response time to a change is very long compared to the sample time of the controller. The situation is often quite different when dealing with high speed electric motors, which now can have mechanical time constants down to about 10 ms with no external load.

11. Testing the System

11.1 General

This section describes some simple test procedures for some parts of the PTS systems. These do not comprise a full system test, but may be useful to verify the basic operation of the system, the motor and the encoder.

All these tests require the use of a computer terminal or VDU with an RS-232 serial port. A simple portable terminal is sufficient for most tests. Some tests require additional test equipment, as given below.

11.2 Serial port

The system prints characters via the RS-232 serial port when it is powered up. These may be detected by using the terminal, or with a serial data analyser. The system normally prints a version and copyright message, followed by the '`>`' or '`:`' prompt character. An example for a MiniPTS 4 is shown here.

```
Mini-PTS Version 1.9.1.1
Copyright 1995 Quin Systems Ltd

Motor1 found
Motor2 found
Motor3 found
Motor4 found
Motor5 found

1:
Restoring parameters | Done
Checking sequence 1
1:
```

If there is no response from the unit, or the messages are garbled, then check the connections between the terminal and the system, and also check that the serial data format on the terminal is set to eight data bits, one stop bit, no parity and 9600 baud. If there is still no response from the system on power-up, the serial data signals should be checked with a data analyser or an oscilloscope, to verify whether the system is actually sending any characters out.

Once the startup message is received, try sending characters to the system by typing them on the terminal keyboard. Each character should be echoed (printed on the terminal screen) as it is typed on the keyboard. Press the `Return` or `Enter` key. This sends the characters to the system as a command string. The system should respond, probably with an error message, followed by the command prompt character as before.

Once communications with the system are established via the serial port, it is possible to use the normal command set to test most other features of the system.

11.3 Encoder

Ensure that the shaft encoder is connected to the inputs of the MiniPTS 4, and that the motor power is switched off. Type “DM” on the keyboard, and press Return. The system should start displaying data continuously, giving the demand position, measured position, and position error information.

The measured position data in the second column of data gives the current position, in encoder counts, of the encoder shaft. Turn the shaft by hand, and the displayed position data should change, showing that the system has measured the change in position of the shaft. Note that the three bicolour LEDs next to the 9 way encoder socket should be switching rapidly between red and green as the encoder is turned. The LEDs show red for the “on” polarity and green for the “off” polarity of each encoder signal.

If the encoder position counts up and down by only one count, then one of the two phases of the encoder signals is not being detected. If the encoder position value does not change at all, then either both phase signals are missing, the encoder power supply is missing or off, or the light source in the encoder is faulty. If the position tends to count either up or down whichever direction the shaft is turned, then the track A and B signals are mixed up with their complementary signals, such that instead of the system receiving two signals in quadrature, it always receives two signals in opposite phase regardless of the shaft direction. These problems can be confirmed by monitoring the encoder signals with an oscilloscope, or by observing the indicator LEDs.

If the encoder marker signal is used as the position reference signal, then this should also be checked. Type “DZ1/RM1” to enable referencing on the encoder marker pulse. Then type “WF/DF/RP”. The system should respond with the ‘W’ prompt to indicate that it is waiting for the reference signal. Turn the encoder shaft so that it passes through the marker position, and the system should display the value of the reference position error, measured on the desired transition of the reference input signal. Continue to turn the encoder shaft to verify the operation of the reference input and marker signal as required. If the system does not display the value of the reference error, but stays in the waiting state with the ‘W’ prompt, then check that the marker input signal is present with an oscilloscope. If the encoder marker signal is not detected, there may be some problem with the encoder or the connections to it. Type “AX/WE” followed by Return when finished, to stop the wait command loop.

11.4 Motor enable relay

Equipment required :

Multimeter or DVM with resistance or continuity measurement facilities.

Set the multimeter to its resistance or continuity test range. To check the function of the motor enable relay, the meter should be connected between the *relay common* signal and either the *relay n.o.* or *relay n.c.* signals as required. Note that the MiniPTS 4 requires the 24V i/o supply to be connected for correct operation of the enable relays.

Type “`MO<Return>`” to set the system into the motor off state. Check that the relay normally open contacts are open circuit, and that the normally closed contacts are short circuit. Type “`PC<Return>`” to go to the position control state. Check that the normally open contacts are now closed, and the normally closed contacts are open.

11.5 Command signal

Equipment required :

Multimeter or DVM, or an oscilloscope.

Make sure that power is still not connected to the motors and drives. Set the multimeter to the 10V range. Connect the meter between the *command signal* output and *0V cmd*. If the system has the analogue isolation option fitted to the command signal, ensure that the external power supply for the isolation amplifier output stage is connected and turned on.

Press Return to get the current prompt character. If the prompt is neither of the normal idle state prompt characters ‘>’ or ‘:’, then type “ST<Return>” to return to idle. If the idle prompt is the ‘:’ motor off prompt, type “PC<Return>” to put the system into position control mode. Type “ZC<Return>” to ensure that the current encoder position is defined as zero. Set the maximum following error and timeout parameters to large values by typing “SE10000/TO2000<Return>” to stop the error checks from interrupting the tests.

Check that the voltage on the command signal output is close to 0V. Type in a simple move command, such as “MA1000<Return>”. Check that the command signal voltage increases gradually towards +10V. Type “MA-1000<Return>” and check that the command signal voltage decreases gradually towards –10V. Type “MA0<Return>” and check that the command signal returns to 0V.

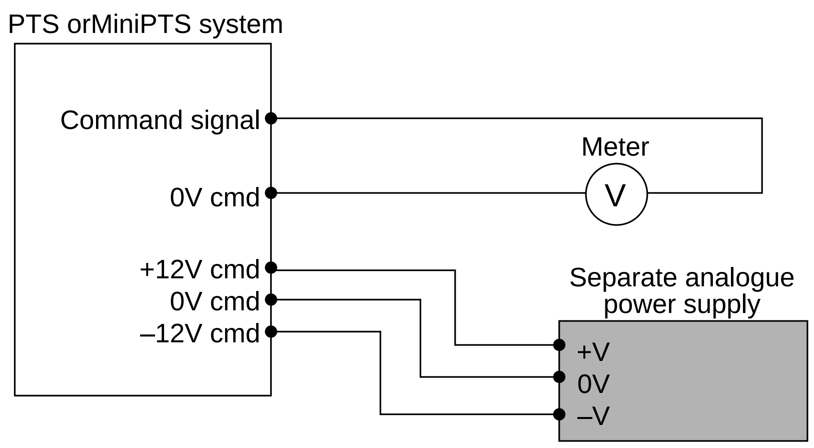


Figure 21. Testing the analogue outputs.

11.6 Digital signals

Equipment required :

Multimeter or DVM.
Connecting wire or pushbutton switch.
External power supply.

The digital signals may be checked using the multimeter in conjunction with the manual input and output commands. Set the external power supply to the voltage required by the digital inputs, usually +24V. Begin with all input and output lines disconnected from the external system. Type “`RI<Return>`” and check that all inputs are shown with a ‘0’. Connect the external power supply to each input line in turn, and use the RI command to verify the operation of each line.

Connect the external power supply to the +24V and 0V I/O connections. Connect the multimeter in turn to each output line, and using the SO set output and CO clear output commands, check the operation of the line. The SO command turns on the output optical isolator, pulling the output signal up to +24V, and the CO command turns the output isolator off.

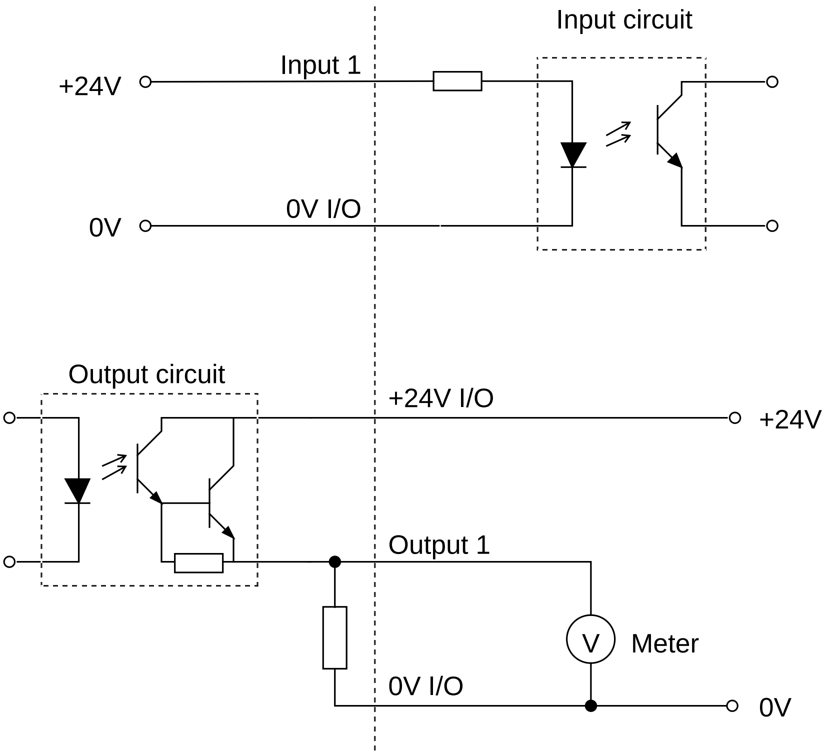


Figure 22. Testing the digital signals.

12. Electrical Details

12.1 Signal names

The signal names in this document follow certain conventions for simplicity.

A ‘/’ prefix is used on the encoder signals to denote a complementary or inverted signal. Thus the /A signal is the complement of the A signal.

A ‘+’ or ‘–’ suffix is used to denote the high or low side of the plant connections. Connections with a ‘+’ suffix are the high side of a signal, and those with a ‘–’ suffix are the low side. For example, the analogue input+ and analogue input– connections are the high and low plant connections respectively for the analogue input signal.

NOTE: It is important that the polarity of the plant connections is correct. If these are reversed, the optical isolator devices on the MiniPTS 4 may be damaged.

12.2 Encoder input circuits

The encoder input circuit is shown in the diagram below. The MiniPTS backplane provides the buffers and LED indicators, while the isolation and termination components are on the SRV-4 four axis controller board. Note that the three bicolour LEDs next to the 9 way encoder sockets show red for the “on” polarity and green for the “off” polarity of the encoder signals.

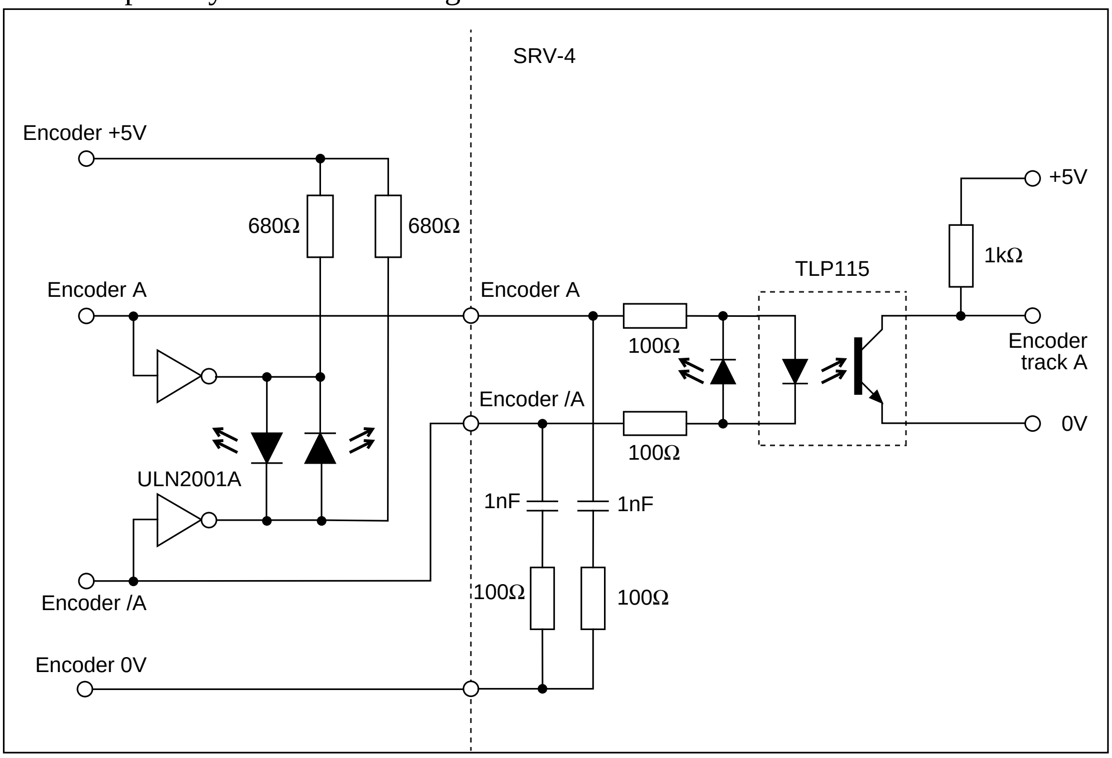


Figure 23. Encoder input circuits.

12.3 Isolated input and output circuits

Circuit diagrams for the isolated digital inputs and outputs are shown in the diagram below.

The MiniPTS 4 includes extra protection components, as shown. The reversed diode on the input lines and the diodes on the output lines provide reverse voltage protection. An indicator LED is also fitted on inputs and outputs to show the state of the line.

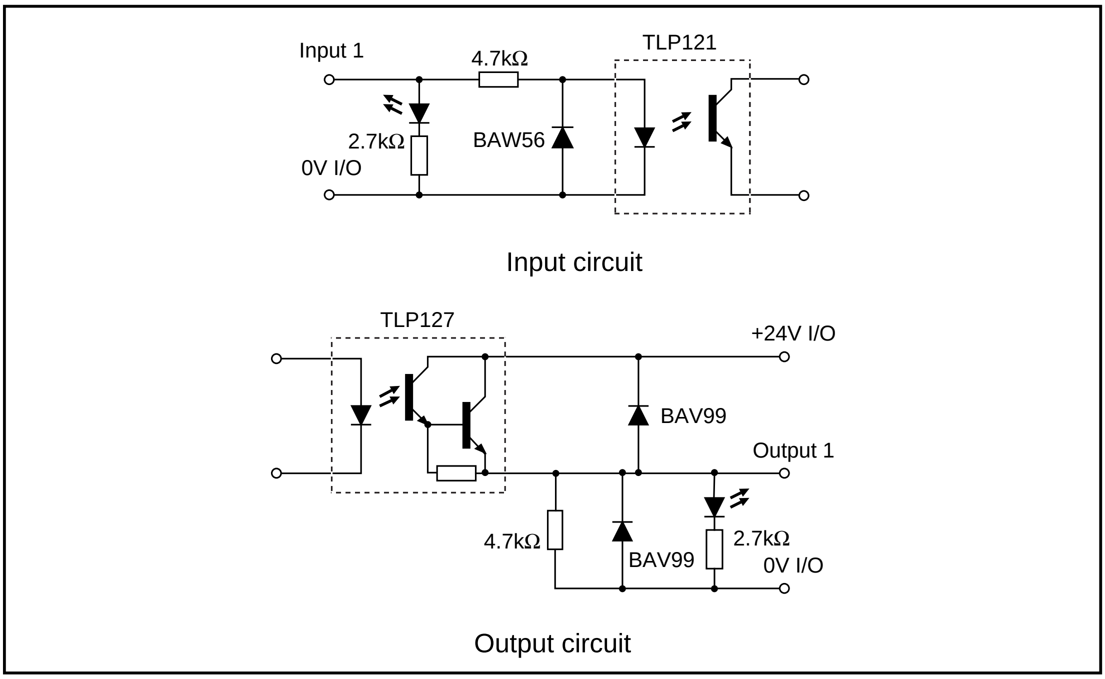


Figure 24. Isolated input and output circuits.

If the outputs are overloaded by switching too high a current, the output optocoupler devices may be damaged. Care should be taken to avoid shorting the switched outputs to the 24V i/o supply rails.

12.4 Electrical characteristics

External power supplies :

Encoder supply	+5V
Digital i/o supply	+24V
Analogue isolation supply	±12-15V (Acceptable range ±7 to ±18V)

Encoder inputs :

Input signal levels	+5V nominal
Isolation voltage	250V a.c. peak or d.c.
Frequency (count rate)	1.2 MHz maximum (4.8×10^6 counts per second)

Track A input leads track B input for positive direction

Analogue input :

Input range	±10V (differential)
Resolution	12 bits

Analogue outputs :

Direct output range	±10V
Isolated output range	±10V at nominal supply voltage
Isolation voltage	250V a.c. peak or d.c.
Resolution	12 bits
Output impedance	100 Ω

Digital inputs :

Voltage rating		+24V nominal
Input current	typical:	10–20 mA
	maximum:	50 mA
Threshold voltage		10–16V
Reverse voltage		+5V maximum
Isolation voltage		250V a.c. peak or d.c.

Digital outputs :

Saturation voltage (output on)	1.9V maximum (at full load current)
Load current	100 mA maximum
Reverse voltage	+5V maximum
Isolation voltage	250V a.c. peak or d.c.

Relay contacts :

Rated load	0.5A 60V a.c. peak or d.c.
Switch power maximum	30W 30VA
Contact resistance	50 mΩ maximum
Operate/release time	5 ms maximum
Service life	10^7 operations (24V 0.2A d.c. resistive load)

13. Board Configurations

13.1 General

This section gives details of the configuration options on all the boards used in the MiniPTS 4. They are described here for completeness, although the settings are not normally changed. The boards are set up as described below when shipped.

13.2 SRV-4 four axis servo controller board

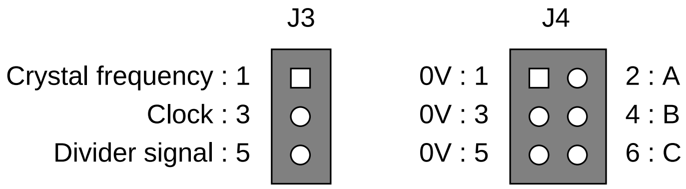
The SRV-4 board is used in the MiniPTS 4 system.

J1: Processor options
Jumper J1 is provided for use with some processor test facilities. No links should be fitted to J1 in normal operation.

J2: G64 bus cycle type
If no link is fitted to jumper J2, then all G64 bus accesses to the SRV-4 are asynchronous, and the module provides the /DTACK signal to the host processor to indicate the end of a bus cycle. If a link is fitted, then all G64 bus accesses are synchronous with the E clock signal from the host processor. When the module is configured for synchronous bus cycles, it uses the MRDY signal to delay host processor accesses, if required for internal bus arbitration.

J3,4: External clock frequency

Jumpers J3 and J4 set the clock frequency for the local 68331 processor on the SRV-4, when an external clock oscillator is fitted. Jumper J3 selects either the base oscillator frequency or a divider output frequency. Jumper J4 selects the output frequency from the divider as a power of 2 division of the clock oscillator frequency. Note that the external clock oscillator is not normally fitted, as the processor's internal clock oscillator is used.

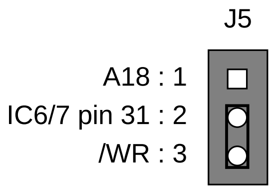


A link fitted connects the clock select line to 0V. The table below shows the clock division ratio for all link settings, and the selected clock speed, for a 16 MHz oscillator.

J3	J4 A	J4 B	J4 C	Clock Speed	Divisor
1-2	any	any	any	16 Mhz	1
2-3	in	in	in	8 MHz	2
2-3	out	in	in	4 MHz	4
2-3	in	out	in	2 MHz	8
2-3	out	out	in	1 MHz	16
2-3	in	in	out	500 kHz	32
2-3	out	in	out	250 kHz	64
2-3	in	out	out	125 kHz	128
2-3	out	out	out	62.5 kHz	256

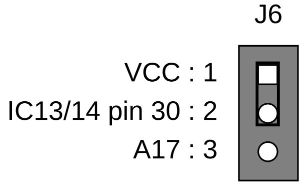
J5: EPROM device select

Jumper J5 selects the signal connected to pin 31 of the EPROM or flash memory devices IC6 and IC7. It allows either the write strobe or address line A18 to be connected as required. For 27C040 or larger EPROM devices (512k×8) fit a link between pins 1 and 2. For smaller eproms and flash memory devices fit a link between pins 2 and 3.



J6: RAM device select

Jumper J6 selects the signal connected to pin 30 of the SRAM memory devices IC13 and IC14. It allows pin 30 to be connected to either the +ve supply or address line A17 as required. For 128k×8 devices fit a link between pins 1 and 2. For 256k×8 or larger devices fit a link between pins 2 and 3.

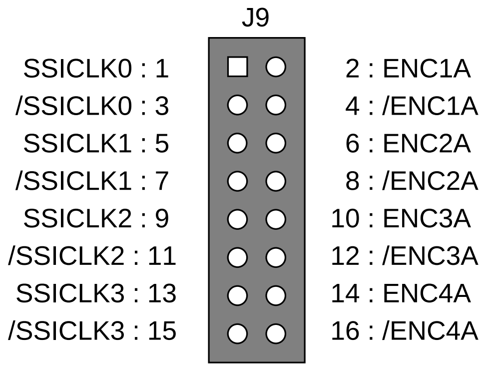


J7, 8: G64 bus interrupt configuration

Jumpers J7 and J8 are used to select the G64 bus interrupt line(s) that the SRV-4 uses to interrupt the host processor when writing to the dual port memory. These interrupts are not used in the MiniPTS 4.

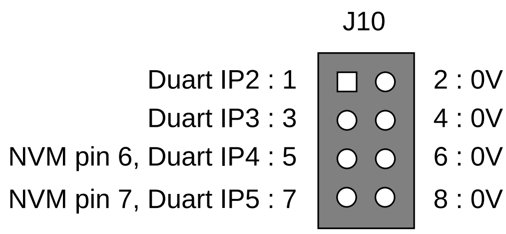
J9: SSI encoder clock signals

Jumper J9 connects the clock signals for the SSI absolute encoder option to the external A and /A encoder connections on each channel. When an absolute SSI encoder is used on a channel, two links are fitted to jumper J9 for that channel. Each channel may be configured separately. The serial data output signals from each SSI encoder are received on the B and /B encoder input connections.



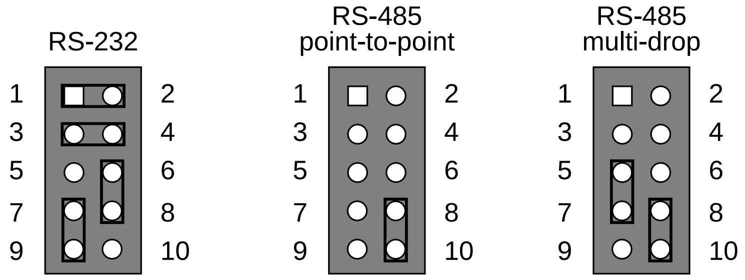
J10: Spare duart inputs

Jumper J10 allows the unused inputs on the duart serial port device to be tied high or low. The duart input pins are connected to a pull-up resistor network, and the jumper pad allows them to be connected to 0V. Two of these lines are also connected to pins 6 and 7 of the serial EEPROM device IC27, for configuration of device-dependent options.



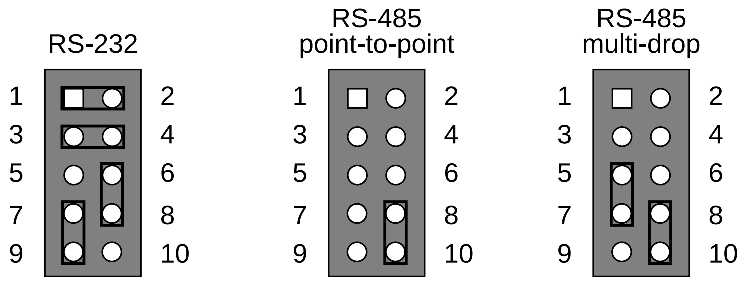
J11: Serial port A

Jumper J11 allows serial port A to be configured for RS-232 or RS-485 signals, and also determines the driver enable function for RS-485. The figure below shows the different configurations.



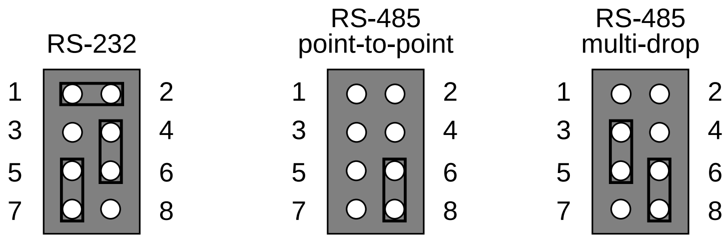
J12: Serial port B

Jumper J12 allows serial port B to be configured for RS-232 or RS-485 signals, and also determines the driver enable function for RS-485. The figure below shows the different configurations.



J13: Serial port C

Jumper J13 allows serial port C to be configured for RS-232 or RS-485 signals, and also determines the driver enable function for RS-485. The figure below shows the different configurations.



The normal configuration for the serial ports is with port A set for RS-232 as the main programming port, and port B set for RS-485 point-to-point for use with the Operator’s Panel.

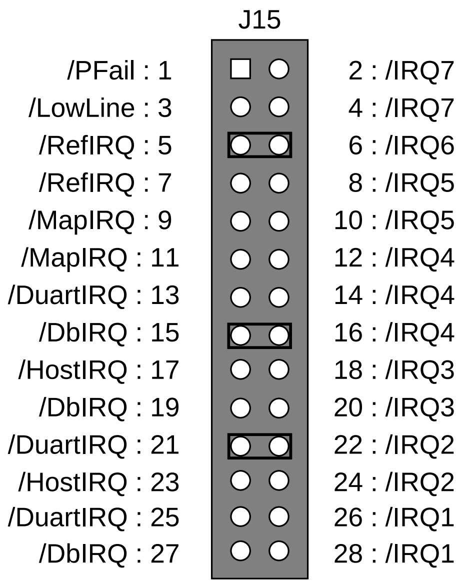
J14: Watchdog enable

If a link is fitted to jumper J14, then the hardware watchdog is enabled. If no link is fitted, then the hardware watchdog is disabled. The hardware watchdog timeout period is fixed at about 100ms. Note that the hardware watchdog is not currently supported by the standard firmware.

The hardware watchdog signal is latched when a watchdog timeout occurs. This allows the SRV-4 processor to test the signal and distinguish between a normal power-up reset and a watchdog reset, and to report an error to the host processor if required.

J15: Interrupt configuration

Jumper J15 is used to connect the various external interrupt sources to the seven local processor interrupt inputs.



The normal configuration is with the duart interrupt connected to /IRQ2, the daughter board interrupt connected to /IRQ4, and the reference interrupt connected to /IRQ6. The standard MiniPTS 4 firmware fitted to the SRV-4 uses these interrupt levels.

The /DbIRQ daughter board interrupt signal is available for use with any special purpose daughter boards that may require the use of interrupts. Note that the SRVX-248E expansion board requires a link to /IRQ4 to support marker pulse referencing on the extra encoder input.

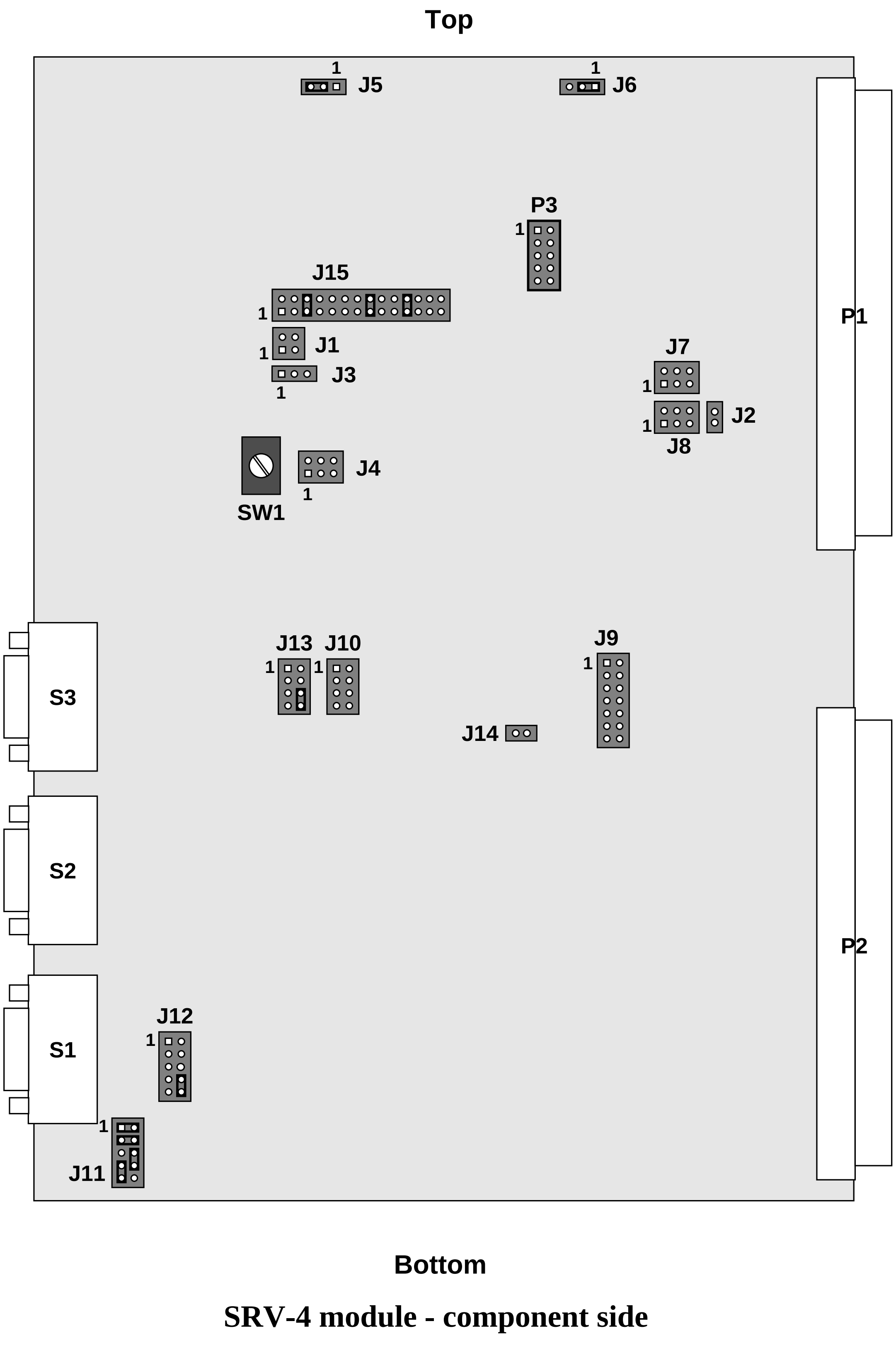


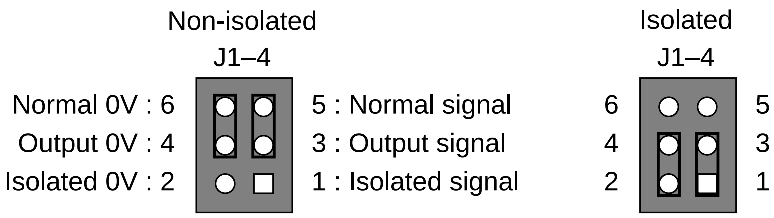
Figure 25. SRV-4 switch and jumper locations

13.3 MPTS-BP1 MiniPTS backplane

This board provides all the external connections for the MiniPTS system.

J1–4: Analogue output isolation

Jumpers J1–J4 are used to select either the isolated or non-isolated analogue output signals. When isolated outputs are selected, an external analogue supply of ±12–15V must be connected to the MiniPTS on terminal block T3. This provides the power supply for the isolated output amplifiers. The isolation amplifiers themselves must also be fitted into sockets IC5–8 as required. These are Burr-Brown ISO122P devices.



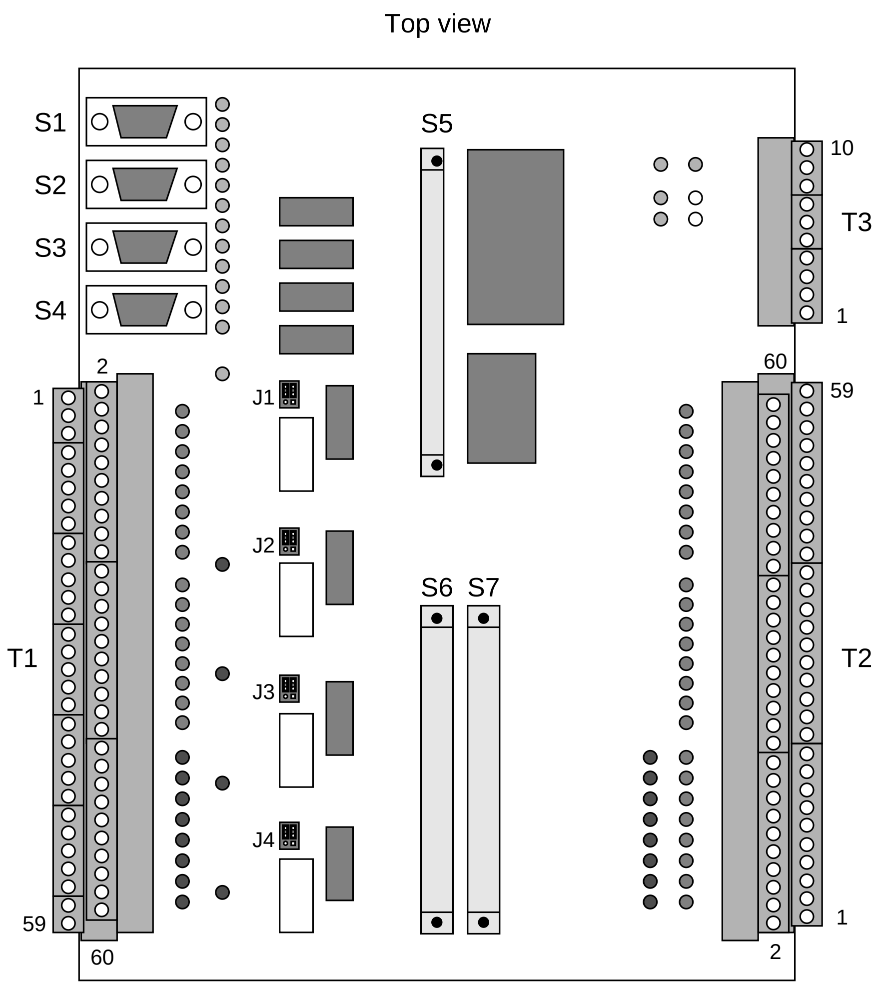


Figure 26. MiniPTS backplane layout

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