

CE
**PKC Series Packaged
Stepper Drives
User Guide**

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IMPORTANT INFORMATION FOR USERS

Installation and Operation of Digiplan Equipment

It is important that Digiplan motion control equipment is installed and operated in such a way that all applicable safety requirements are met. Note that it may be necessary for the completed installation to comply with the Low Voltage Directive or Machinery Directive. It is your responsibility as a user to ensure that you identify the relevant safety standards and comply with them; failure to do so may result in damage to equipment and personal injury. In particular, you should study the contents of this user guide carefully before installing or operating the equipment.

The installation, set-up, test and maintenance procedures given in this User Guide should only be carried out by competent personnel trained in the installation of electronic equipment. Such personnel should be aware of the potential electrical and mechanical hazards associated with mains-powered motion control equipment - please see the safety warning below. The individual or group having overall responsibility for this equipment must ensure that operators are adequately trained.

Under no circumstances will the suppliers of the equipment be liable for any incidental, consequential or special damages of any kind whatsoever, including but not limited to lost profits arising from or in any way connected with the use of the equipment or this user guide.



SAFETY WARNING

High-performance motion control equipment is capable of producing rapid movement and very high forces. Unexpected motion may occur especially during the development of controller programs. **KEEP WELL CLEAR** of any machinery driven by stepper or servo motors. Never touch any part of the equipment while it is in operation.

This product is sold as a motion control component to be installed in a complete system using good engineering practice. Care must be taken to ensure that the product is installed and used in a safe manner according to local safety laws and regulations. In particular, the product must be enclosed such that no part is accessible while power may be applied.

If the equipment is used in any manner that does not conform to the instructions given in this User Guide, then the protection provided by the equipment may be impaired.

The information in this user guide, including any apparatus, methods, techniques, and concepts described herein, are the proprietary property of Parker Digiplan or its licensors, and may not be copied, disclosed, or used for any purpose not expressly authorised by the owner thereof.

Since Digiplan constantly strives to improve all of its products, we reserve the right to modify equipment and user guides without prior notice. No part of this user guide may be reproduced in any form without the prior consent of Digiplan.

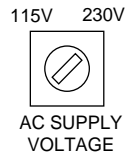
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IMPORTANT INFORMATION FOR USERS

Power Connections

Supply Voltage Selection

The PKC60M/80M Packaged Drive is supplied with its supply voltage selector set to 230V, as shown below.



115V AC operation can be set by adjustment of the supply selector, which is positioned by the supply input connector (see **Mains Supply** in **Installation**).

Note: No change of fuse is required between 230V and 115V operation.

Supply Cable

The drive is supplied with two mains supply cables:

IEC connector to an American style 3-pin plug - for use at 115V

IEC connector to flying leads - for use at 230V or 115V.

Factory Jumper Link Settings

The PKC Series uses CD60M/CD80M drives which are configured by jumper link settings. As supplied from the factory, the link settings will give the following drive performance:

Standby current reduction 50% of full load
Drive resolution 400 steps/rev
Energise permanently enabled
Motor current set to a minimum

To alter any of these settings refer to **Chapter 3 Setting Up The CD60/80M Drive**.

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User Guide Change Summary

The following is a summary of the primary changes to this user guide since the last version was released. This user guide, version 1600.047.05, supersedes version 1600.047.04.

When a user guide is updated, the new or changed text is differentiated with a change bar in the outside margin (this paragraph is an example). If an entire chapter is changed, the change bar is located on the outside margin of the chapter title.

Major changes introduced at revision 05 are:

- LVD compliance
- Factory default jumper link settings have changed

Warning symbols used on Digiplan drives have the following meanings:



Refer to the accompanying documentation



Protective conductor terminal



Risk of electric shock



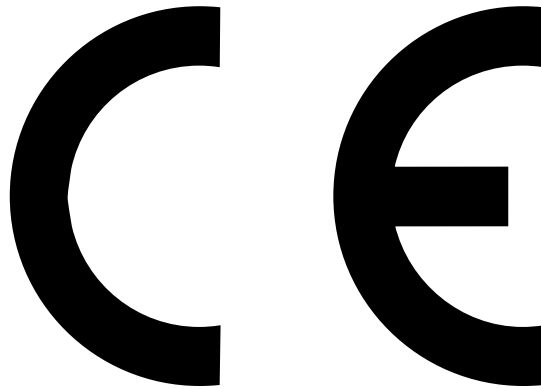
Alternating current



Hot surface



Frame or chassis terminal



Product Type: PKC 60M/80M Packaged Stepper Drive

The above product is in compliance with the requirements of directives

- **73/23/EEC** Low Voltage Directive
- **93/68/EEC** CE Marking Directive

The PKC drive is sold as a complex component to professional assemblers, as a component it is not compliant with Electromagnetic Compatibility Directive 89/336/EEC.

Chapter 1. GENERAL DESCRIPTION

Introduction

The PKC series drives are packaged versions of the CD60/80M models designed to operate directly from either 115v or 230v AC mains supplies*. The built-in toroidal transformer will deliver a motor supply voltage of either 85v or 55v DC, the lower voltage being preferable in low-speed applications in order to minimise dissipation in both motor and drive. A power dump circuit is incorporated which dissipates regenerated power during deceleration of the motor. Other features include full short-circuit and thermal protection, programmable motor current fold-back at standstill, and ministepping. Resolutions of 4000, 2000, 1000 or 400 steps/rev are available.

A simple ramped oscillator is incorporated in the drive and this has two speed ranges with preset speed controls. External speed controls may be fitted if required. The slow speed may be set between 400 and 10,000 steps/sec., and the fast speed between 4,000 and 100,000 steps/sec. The fast range is ramped with an approximate acceleration time of 120mS and a deceleration time of 60mS. These times may be extended by the addition of a capacitor.

The PKC drives have provision for a BC7 buffered clock or RC9 ramped clock card to be fitted, and this will operate entirely independently of the built-in oscillator. The drives can also be used in conjunction with Digiplan or Compumotor packaged indexers; in this case an OPT2 opto card will be required to provide isolation between the control system and the drive.

The PKC drive may also be fitted with an IFX indexer card. This version is covered by a separate user guide.

There are six drives in the range and are numbered according to the corresponding CD drive module and the options that are fitted. The drive types are:

PKC60M	PKC80M
PKC60M/RC9	PKC80M/RC9
PKC60M/BC7	PKC80M/BC7

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Note: Previous versions of the PKC used to incorporate CD20/25/25M/30/35/35M drives. CD60/80M drives offer ministepping as standard, and the CD80M offers higher current. The former boost input is now external reset. The mains input to the PKC is now via an IEC connector, and a mains voltage selector is provided.

* The drive is ordered as a 115V or 230V model, but can be changed to suit local requirements by altering the voltage selector.

Specification

	PKC60M	PKC80M
Nominal output current (RMS)	6A	7.8A
Suitable motor current range	4-8A	5-10A
Motor supply voltage	+55v or +85v	
Logic supply voltage	+24v	
Auxiliary DC output	+24v at 250mA (500mA with external capacitor)	
Standby current reduction	50% or 80% of full current	
Minimum motor inductance	0.5mH	
Nominal chopping frequency (kHz)	18	18
Maximum stepping rates	200kHz at 4000 steps/rev	
Suitable motor type	4,6 or 8 lead (5 lead not suitable)	
Input logic levels	Low 0 to +2v or short-circuit to 0v. High +10v to +12v or open-circuit	
Input impedance	4K7 pull-up to +12v	
Logic outputs	Open-collector NPN transistors, low level +1v max at 15mA max; high level +24v max.	
AC supply voltage	115V or 230V	
Frequency	47-63Hz	
Supply voltage tolerance	+/- 10%	
Power peak	600VA	
continuous	300VA	
Operating temperature range	0° - 40°C	
Maximum heatsink temperature	85°C	
Humidity	0 - 95% non-condensing	
Weight	7.25Kg	
Dimensions in mm (ins)	292mm x 152mm, 188mm high	

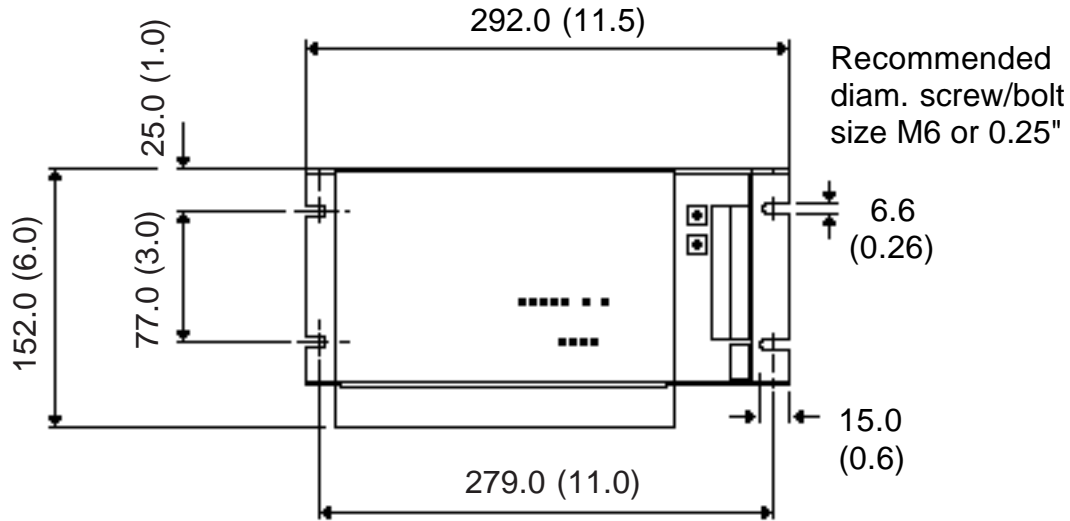


Figure 1-1. Mounting Dimensions - mm (ins)

Fuse Ratings

Four fuses are fitted to the drive power supply circuits. These are located on the motherboard, and are accessible by removing the drive cover (refer to Chapter 5 "Removal and Replacement of Drive Module"). The fuses are rated as follows:

Fuse Number	Function
FS1	HV drive fuse, 10A 6.3 x 32mm. Use a quick-blow, high breaking capacity type.
FS2	Power dump fuse, 1A time-delay 6.3 x 32mm
FS3	24v fuse, 2A time-delay 6.3 x 32mm
Mains fuse for 115V and 230V AC	Mains input fuse, 6.3A time-delay, high breaking capacity, 5 x 20mm, incorporated within the mains connector.

Table 1-1. Fuse Ratings

LED Functions

There are four LEDs which indicate the drive operating conditions. These are located behind the terminal blocks, and their functions are as follows:

LED Number	Function
LED1	indicates that the drive is on zero phase.
LED2	indicates a drive fault. The nature of the fault may be confirmed by checking the LEDs on the drive module which are visible through holes in the cover.
LED3	indicates that the +24v supply is present.
LED4	indicates that the high-voltage supply is present. It also shows that the HV capacitor is charged up, so do not attempt to work on the unit until this LED is fully extinguished.

Table 1-2. LED Functions

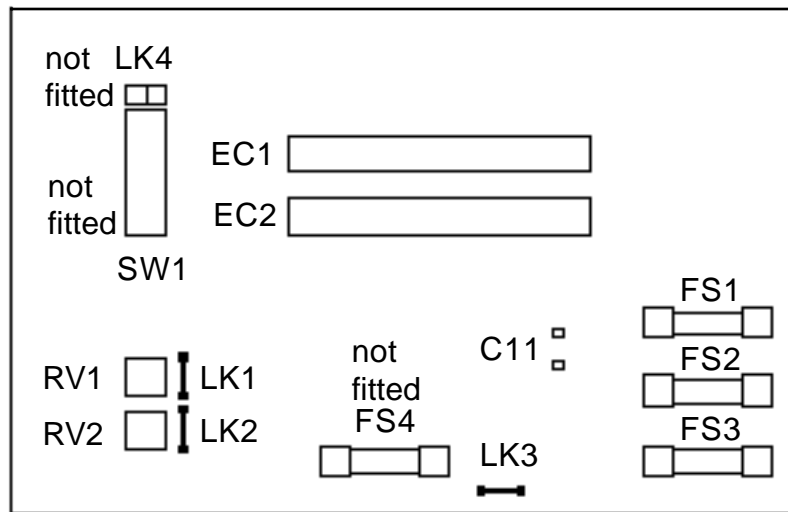


Figure 1-2. PKC Motherboard Showing Pot, Fuse and Link Positions

Chapter 2. INSTALLATION

The drive module has been designed to be mounted with the mounting flanges on a vertical surface. In this position, optimum cooling is guaranteed.

Motor and signal connections are made to three terminal blocks on one end of the drive. The control signals are taken to TB1 and TB2, the motor connections to TB3. The mains input is via an IEC mains connector on the top of the drive. A voltage selector is provided to select between 115V and 230V.

Mounting

PKC drives must be installed by competent personnel familiar with the installation, commissioning and operation of motion control equipment. In the final application the equipment must be enclosed to prevent the operator coming into contact with any high voltages. This includes the motor terminations.

The PKC drives are not EMC compliant, they are sold as a complex component for use by professional assemblers of motion control systems.

Metal equipment cabinets offer the most advantages for siting the equipment since they can provide operator protection, EMC screening and can be readily fitted with interlocks arranged to remove all AC power when the cabinet door is opened. This form of installation also allows the fitting of metal trays beneath the equipment to act as a flame barrier which must be provided in the final installation, in accordance with LVD requirements.

General Wiring and Earthing Recommendations

Input/output signal connections longer than about 500mm should use wires having a collective or individual screen. Route signal connections separately from power and motor connections. If the motor leads run in the same trunking as signal leads, then either the motor or signal leads should be screened. Connect the screen to the earth stud at one end, and insulate it at the remote end.

Where signal connections pass between units mounted in different enclosures and separately energised from the mains, optical isolation of all communication lines is recommended. It is still desirable that all such isolated systems have their 0v rails directly connected to earth.

Motor leads should be collectively screened if they run close to power switching lines, particularly those driving unsuppressed inductive loads. In general it is preferable to keep power connections, motor leads and control signal connections separate as far as possible. Where it is unavoidable to run motor leads in the same trunking as control signal leads, either the motor leads or signal leads should be screened. Connect the screen to earth at one end, and insulate it at the remote end. In any event, control signal connections longer than about 500mm (20") are best made using wires having a collective or individual screen.

Contactors and relays feeding inductive loads should be adequately suppressed.

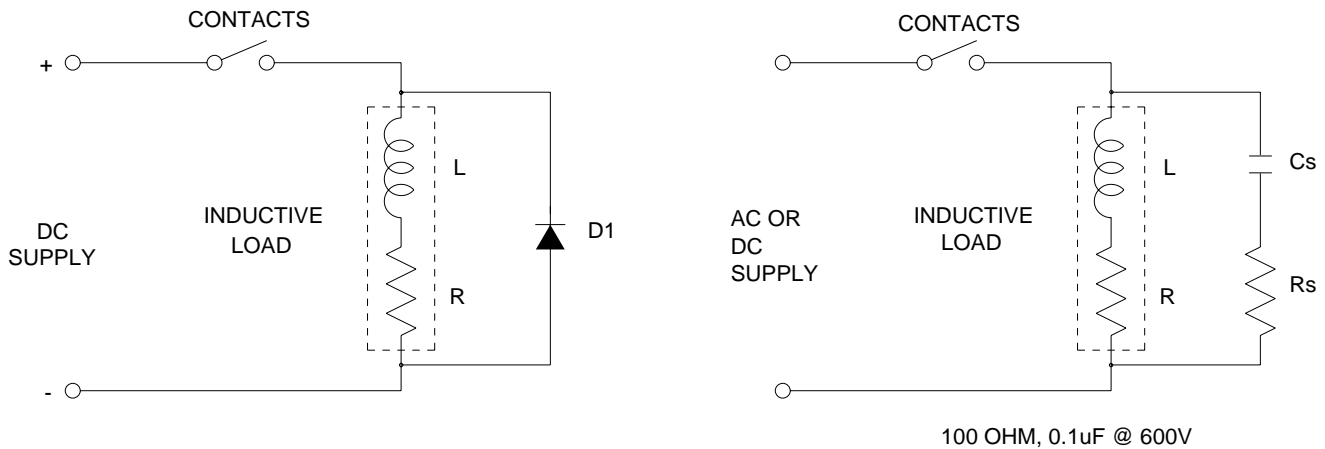


Figure 2-1. Typical Suppression Circuits

Mains Supply

The AC mains supply is connected via the IEC mains connector at the top of the unit (see Figure 2-2). The voltage is set to either 115V or 230V using the mains selector positioned by the IEC inlet.

The input is protected by a 6.3A time-lag, high-breaking-capacity fuse (5 x 20mm) incorporated in the mains connector. Peak power is 600VA; continuous power drawn from the supply must not exceed 300VA.

CAUTION

Do not adjust the power selection switch while power is applied to the drive.

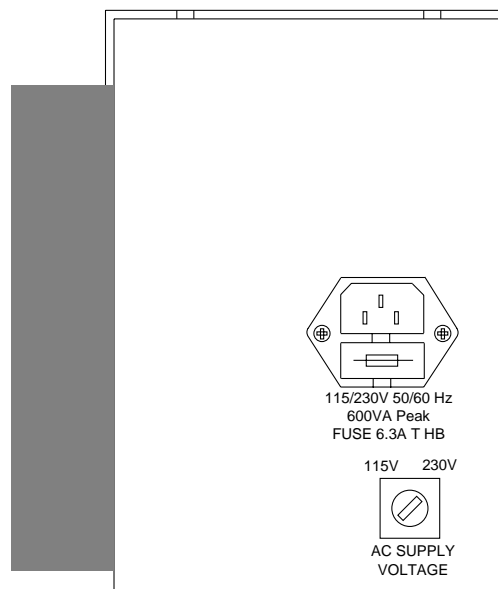


Figure 2-2. Power Connector and Voltage Selector

Mains AC Power Connections

The drive is supplied with an AC mains supply cable having an IEC drive compatible plug at one end and an American style 3-pin plug at the other. If you do not wish to use the American style 3-pin plug (for example the drive is to be used at 230v AC) you may cut it off and use an alternative supply connection. But, **TAKE CARE** the supply cable uses European colour coding:

- Line (Live) - Brown
- Neutral - Blue
- Ground (Earth) - Green/yellow

Mains wiring should use an approved cable type (minimum CSA 0.75mm²). The mains wiring should be routed away from signal wiring and the motor cable.

It is important that the equipment is earthed.

Motor Connections

A disconnect device must be provided which isolates all mains supply current-carrying conductors. If the mains supply is permanently connected, a switch or circuit breaker must be included in the wiring. It must be placed close to the equipment (less than 1 metre) and marked as the disconnecting device for the equipment.

Connect the motor leads to TB3 using the connection data on the following pages. Connect one phase of the motor to terminals 1A and 1B, and the other phase to terminals 2A and 2B. To reverse the direction of rotation relative to the direction control input, interchange the connections to 1A and 1B (see Figure 2-3).

Do not use as drive current setting which exceeds the motor rating.

NOTE: If the PKC was sold with a QM or RM motor (sold in the USA) refer to the "Digiplan Motor User Guide" supplied with the motor, or call Digiplan USA. This motor user guide contains complete wiring and current information for these motors.

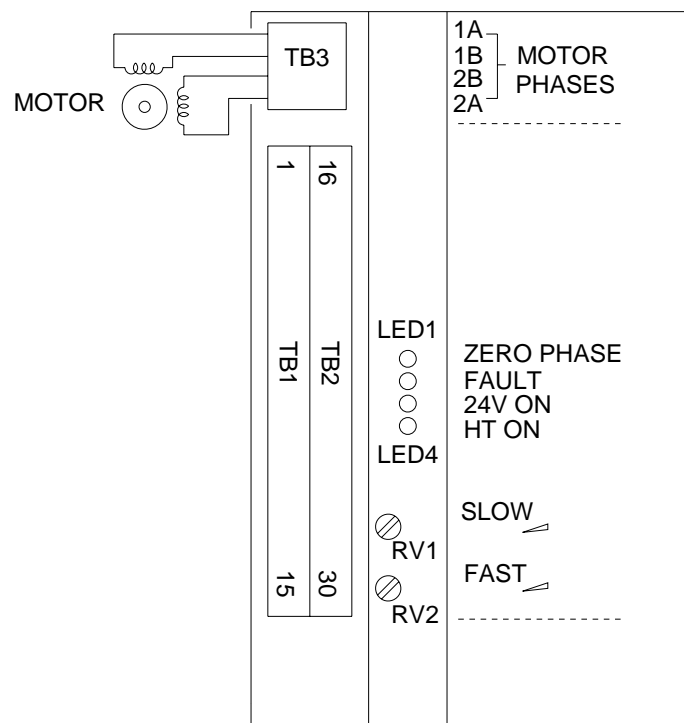


Figure 2-3. Signal and Motor Connections

Motor Cable	The recommended gauge for PKC drives is 1.5mm ² . Use a cable containing four conductors plus the braided screen. The temperature rating of the cable must be greater than or equal to the motor case temperature and should be at least 80°C. The insulation rating should be at least 350V.
Motor Earth	The motor body must be reliably earthed (less than 0.1Ω resistance).
Motor Insulation	Motor insulation must be rated to withstand at least 500V rms.

WARNING

**The case of a motor can become very hot.
Precautions may need to be taken to prevent operator contact.**

Important note: The toroidal transformer is rated for 300VA continuous. This level of power demand will only be required when attempting to operate a 42-size motor continuously close to its full rated torque. In practice, a typical stepper application operating at 70% of the rated torque will not overload the drive's power supply. In general, stepper motors are not suitable for continuous operation at high speed.

Environmental Considerations

The operational temperature range for the drive system is:

- Operating Temperature: 0° to 40°C (32° to 104°F)
- Relative Humidity: 0% to 95% (non-condensing)
- Storage Temperature: -40° to 85°C (-40° to 185°F)

Refer to the manufacturer's environmental specifications for the maximum motor case temperature when it is in operation. This may be a hazard to system operators.

The mains input to the drive must be Installation Category II maximum.

PKC drives can be used in a Pollution Degree 2 environment i.e., one in which only non-conductive pollution occurs.

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N.C. - no connection.

MAKE	TYPE	A+	A-	B-	B+	NOTES
Pacific Scientific	6-lead	Black	Orange	Red	Yellow	White/Blk/Org, White/Red/Yel N.C.
	8-lead	Black	Orange	Red	Yellow	Link Wh/Blk & Wh/Org Link Wh/Red & Wh/Yel
	T.box	1	3	2	4	Link 5 & 6, link 7 & 8
Astrosyn, Rapidsyn, Slo-syn	6-lead	Red	Red/Wh	Grn	Grn/Wh	White & Black N.C.
	T.box (x6)	1	3	4	5	2 & 6 N.C.
Slo-syn	8-lead	Red	Red/Wh	Grn	Grn/Wh	Link Black & White, link Org & Blk/Wh
	T.box (x8)	1	3	5	4	Link 2 & 6, link 7 & 8
Stebon, Digiplan SM	8-lead	Red	Yel	Pink	Blk	Link Blue & violet, link White & Grey
	T.box	1	2	3	4	Link 5 & 6, link 7 & 8
M.A.E.	6-lead	Grn/Wh	Grn	Red	Red/Wh	White & Black N.C.
	8-lead	Black	Orange	Red	Yellow	Link Wh/Blk & Wh/Org, Link Wh/Red & Wh/Yel
	T.box	6	5	8	7	Link 1 & 3, link 2 & 4
Zebotronics	T.box	1	4	5	8	Link 2 & 3, link 6 & 7
Oriental	6-lead	Black	Green	Red	Blue	Yellow & White N.C.
Sonceboz	8-lead	Green	Grn/Wh	Red	Red/Wh	Link Org & Blk/Wh, link Black & White
Japan Servo	6-lead	Red	Blue	Green	Yellow	2 x White N.C.
Escap	8-lead	Brown	Org/Wh	Red	Yel/Wh	Link Brn/Wh & Org, Link Red/Wh & Yellow.
Bodine	8-lead	Brown	Orange	Yellow	Red	Link Wh/Brn & Wh/Org, link Wh/Yel & Wh/Red.
	T.box	1	3	4	2	Link 5 & 7, link 6 & 8
Digiplan/Compumotor OEM Series	4-lead	-	-	-	-	Internally wired in parallel
	8-lead	Red	Black	Green	White	Link blue & yellow Link orange & brown
Digiplan/Compumotor QM & S Motors	8-lead	Red	Black	White	Green	Link Yel & Blue Link Org & Brown
Digiplan/Compumotor QM & S Motors (except 106-205)	T.box	1	3	4	5	Link 2 & 6 Link 7 & 8
Digiplan/Compumotor QM & S106-205	T.box	1	3	7	8	Link 5 & 6 Link 2 & 4

Table 2-1. Motor Connection Data - Windings in Series

N.C. - no connection.

For 6-lead motors, connections shown are for one half-winding.

MAKE	TYPE	A+	A-	B-	B+	NOTES
Pacific Scientific	6-lead	Black	Wh/Blk/ Orange	Red	Wh/Red/ Yellow	Or & Yellow N.C.
	8-lead	Black & Wh/Or	Or & Wh/Blk	Red/ Wh/Yel	Yel & Wh/Red	
	T.box	1 & 5	3 & 6	2 & 7	4 & 8	
Astrosyn, Rapidsyn, Slo-syn	6-lead	Red	Black	Green	White	Red/Wh & Grn/Wh N.C. 3 & 5 N.C.
	T.box(x6)	1	6	4	2	
Slo-syn	8-lead	Red & White	Blk & Red/Wh	Grn & Blk/Wh	Org & Grn/Wh	
	T.box(x8)	1 & 2	3 & 6	4 & 7	5 & 8	
Stebon, Digiplan SM	8-lead	Rd & Blue	Yel & Violet	Wh & Pink	Black & Grey	
	T.box	1 & 6	2 & 5	3 & 8	4 & 7	
M.A.E.	6-lead	Grn/Wh	White	Red	Black	Grn & Red N.C
	8-lead	Black & Wh/Or	Or & Wh/Blk	Red & Wh/Yel	Yel & Wh/Red	
	T.box	3 & 6	1 & 5	4 & 8	2 & 7	
Zebotronics	T.box	1 & 2	3 & 4	5 & 6	7 & 8	
Oriental	6-lead	Black	Yellow	Red	White	Grn & Blue N.C.
Sonceboz	8-lead	Grn & Blk/Wh	Or & Grn/Wh	Red & White	Blk & Red/Wh	
Japan Servo	6-lead	Red	White*	Green	White*	
Escap	8-lead	Brn & Orange	Brn/Wh & Org/Wh	Red & Yellow	Red/Wh & Yel/Wh	
Bodine	8-lead	Brn & Wh/Or	Wh/Brn & Orange	Yel & Wh/Red	Wh/Yel & Red	
	T.box	1 & 7	3 & 5	4 & 6	2 & 8	
Digiplan/Compumotor OEM Series†	4-lead	Red	Black	Green	White	
	8-lead	Red & Blue	Yellow & Black	Green & Orange	Brown & White	
Digiplan/Compumotor QM & S Motors	8-lead	Red & Blue	Blk & Yellow	Wh & Brn	Green & Org.	
Digiplan/Compumotor QM & S Motors (except 106-205)	T.box	1 & 2	3 & 6	4 & 7	5 & 8	
Digiplan/Compumotor QM & S 106-205	T.box	1 & 5	3 & 6	2 & 7	4 & 8	

* Use correct White for each phase.

† Size 34 only. Size 23 can only be operated in series.

Table 2-2. Motor Connection Data - Windings in Parallel

Motor Supply Voltage Setting

As supplied the drive will operate at a motor supply voltage of 85v DC. This is necessary in order to obtain the optimum high-speed performance, but in low-speed applications it may be preferable to use a lower supply voltage. In this way the power dissipation in both motor and drive is minimised. The supply voltage may be changed by removing the drive cover as outlined in Chapter 5 "Removal and Replacement of Drive Module", and rearranging the transformer leads as follows:

85v DC supply

White lead to tab 9

Red lead to tab 1

55v DC supply

White lead to tab 1

Red lead to tab 9

Control Signal Connections

All control signals are taken to terminals TB1 and TB2, these terminals being arranged on two levels. TB1 is the lower terminal and is numbered 1 to 15, TB2 is the upper terminal and is numbered 16 to 30. The terminal functions are as follows:

Term No.	Terminal Function	Term No.	Terminal Function
1	+24v out	16	Positive motion limit input
2	Fault output	17	Negative motion limit input
3	Zero phase output	18	Direction request input
4	Ext. reset input	19	Allow clock input
5	Motor direction (in or out)	20	Motion /deceleration complete out
6	Motor clock (in or out)	21	Fast 2 input
7	Energise input	22	Slow 2 input
8	0v.	23	Slow adjust 2 (a)
9	Slow adjust 1	24	Slow adjust 2 (b)
10	Fast adjust 1	25	Fast adjust 2 (a)
11	Speed adjust 1 common	26	Fast adjust 2 (b)
12	Fast 1 input	27	Ramped or buffered clock output
13	Slow 1 input	28	Motion requested+in motion out
14	Not used	29	Internal clock out/home speed in
15	Not used	30	Buffered clock in/fast modify in

Table 2-3. Control Connector Terminal Functions

The built-in oscillator is referred to as clock 1 and the optional BC7 or RC9 card as clock 2. Terminals 16 - 30 are only used when the optional clock card is fitted.

Description of Terminal Functions

1. *+24v OUT*: This is an auxiliary output which may be used to power external circuitry, maximum current 500mA. It is advisable to use an external decoupling capacitor (2200uF 40v) if the current to be drawn exceeds 250mA.
2. *FAULT*: This is a composite output signal which goes high in the event of an overload, supply failure or overtemperature fault. It is driven by an open-collector transistor and should therefore be pulled up by an external resistor when the signal is required. The resistor should be returned to a voltage no higher than 24v and should not allow more than 15mA to flow when the output is low.
3. *ZERO PHASE*: The zero phase output is low when the translator is in its primary state. This occurs every 8 steps in the half step mode, and the signal will therefore go low 50 times per rev. with a 200-step motor. It corresponds with current flowing from A to B in each motor phase. At switch-on the translator is always reset to the zero phase state. The signal is used when establishing a mechanical reference or "datum" position.
4. *EXTERNAL RESET*: Connect to 0V for 1 second to reset a fault condition.

This terminal was formerly *BOOST*

5. *DIRECTION*: Taking this input low will reverse the direction of motor rotation. The direction should only be changed when the motor is stationary or running within the start/stop speed range. Do not change the direction signal within 5uS of the low-going edge of a clock pulse. This terminal is also the direction output from the BC7 or RC9 when fitted.
6. *CLOCK*: An external ramped clock signal is fed in via this terminal. The clock pulses should be low-going with a minimum pulse width of 1μS. When the drive is being run from the internal oscillator, the clock pulses may be monitored at this point.

7. $\overline{\text{ENERGISE}}$: This input enables the motor to be de-energised so that it may be rotated slowly by hand (if it is safe to do so) without switching the system off. To remotely de-energise the motor, drive LK3 must be in position I. The input should then be connected to 0v in order to energise the motor. DO NOT turn the motor at high speed with the drive de-energised as this may overload the power dump circuit. Similarly the drive should not be de-energised whilst the motor is running.

8. 0v: Use this terminal as the common return point for the control signals.

9. *SLOW ADJUST 1*: Connection for external speed control of the internal oscillator slow rate. Connect an external 100K potentiometer between terminals 9 and 11, and turn RV1 on the drive fully anticlockwise. If the minimum speed is too high, disconnect RV1 by cutting link 1 (see Figure 1-2).

10. *FAST ADJUST 1*: Connection for external speed control of the internal oscillator fast rate. Connect an external 10K potentiometer between terminals 10 and 11, and turn RV2 on the drive fully anticlockwise. If necessary, RV2 may be disconnected by cutting link 2 (see Figure 1-2).

11. *RATE ADJUST COMMON*: Common return for external speed controls.

12. $\overline{\text{FAST 1}}$: Connect to 0v to run the internal oscillator at the fast rate.

13. $\overline{\text{SLOW 1}}$: Connect to 0v to run the internal oscillator at the slow rate.

14. Not used

15. Not used

NOTE: the following terminals (16-30) are used only when the optional BC7 or RC9 clock card is fitted.

16. $\overline{+LIMIT}$: This is a directional limit switch input which inhibits motion in one direction only. It should be connected to a normally-open pair of switch contacts, the second contact being taken to 0v. When the input is shorted to ground it disables the clock and a normal deceleration to stop will occur. The Direction Request must then be changed before the motor can be re-started. This limit input is operative when the Direction Request is low, and it is therefore necessary to ensure that direction "0" causes motion towards the positive limit switch.

17. $\overline{-LIMIT}$: This is a complementary input to terminal 16 - it operates in the same way but only when the Direction Request is at logic 1.

18. *DIRECTION REQUEST*: This is the direction input signal to the clock card which is used to call up the required direction of travel; it determines the direction of the next motor step provided motion is not present (i.e. is at logic 1). If it is changed when motion is present, it will initiate deceleration to stop before the motor is reversed. The buffered clock will ignore any clock pulses fed in during deceleration; following a direction change the incoming clock should therefore be stopped until motion is not present.

19. $\overline{ALLOW\ CLOCK}$: Connect this terminal to 0v to run the oscillator. If it is taken high when the motor is running on the internal oscillator, a normal deceleration to stop will occur. If a positioning system has a table clamp feedback signal available it may be conveniently applied to this input to inhibit motor operation whilst the clamp is operative. This input may be held permanently low by fitting link 1 on the BC7 and link 2 on the RC9 (Figures 2-10 and 2-14 show the link positions).

20. $\overline{MOTION/DEC.COMP}$: This output signal goes high when there are no pulses stored within the buffered clock and the motor is stationary. It is intended to indicate to the control system that the motor has come to rest and can be driven in the reverse direction if required. A 50mS delay is included in the signal path to prevent loss of synchronism as a result of the motor being reversed too quickly. This terminal becomes the DECELERATION COMPLETE output if an RC9 is used, and it is high when the motor is stationary or running at either the HOME or SLOW speed.

21. FAST 2: When this input is taken low it calls up the Fast Rate of the oscillator. The oscillator generates a fixed-frequency waveform and the required acceleration and deceleration is performed by the buffered clock. In the case of the ramped clock, taking this input low will cause the motor to start at the HOME speed and accelerate up to the preset FAST speed.

22. SLOW 2: The preset Slow Rate of the oscillator is called up when this input goes low. Since the oscillator output is connected into the buffered clock it is not necessary for the slow rate to lie within the start/stop range of the motor. Note that when the input is removed there may still be pulses stored in the buffer which will cause the motor to continue to step. If an RC9 ramped clock is used no acceleration will be used, and therefore the Slow speed must be set within the start/stop range of the motor. This input is only operative when deceleration is complete and the Home speed input is high.

23 & 24 SLOW ADJUST 2: The Slow speed may be remotely controlled by connecting an external variable resistor across these terminals, typically 100K. The maximum recommended resistor value is 2 Megohms. Note that the BC7 oscillator will not respond to the "slow" input unless there is a resistor across these terminals whereas the RC9 has a preset control on the card.

25 & 26 FAST ADJUST 2: An external variable resistor may be connected across these terminals to provide remote adjustment of the Fast speed. A 20K potentiometer will give a range of adjustment of about 40:1. Note that the BC7 oscillator will not respond to the "fast" input unless there is a resistor across these terminals. FAST MODIFY (terminal 30) should be used for remote control of the fast rate on the RC9.

27. RAMPED OR BUFFERED CLOCK OUT: This is the clock output signal and should be wired across to terminal 6 for normal operation.

28. MOTION REQUESTED + IN MOTION: When the motor is actually moving or has been commanded to do so, this output signal goes low. When it returns to the high state it denotes that no further pulses will be given to the motor, i.e. all input pulses have been delivered and the buffer is empty. In a positioning system this signal may be used to drive a table clamp.

29. *INT. CK OUT/HOME SPEED IN*: This is the output from the BC7 internal oscillator. It is normally linked internally to the buffer input via link 6 on the buffered clock card. This same terminal becomes the HOME SPEED input if an RC9 ramped clock is used in place of the BC7.

30. *BUFF. CK IN/FAST MOD*: The clock input to the buffer which may be driven by an external pulse source. The low-going input pulses should remain low for at least $10\mu\text{S}$ and the maximum permitted frequency is 20kHz. It becomes the FAST MODIFY input if an RC9 is used. When the motor is operating in the slew region the Fast speed may be varied by means of this input. To make use of this facility it is necessary to remove link 1 on the clock card.

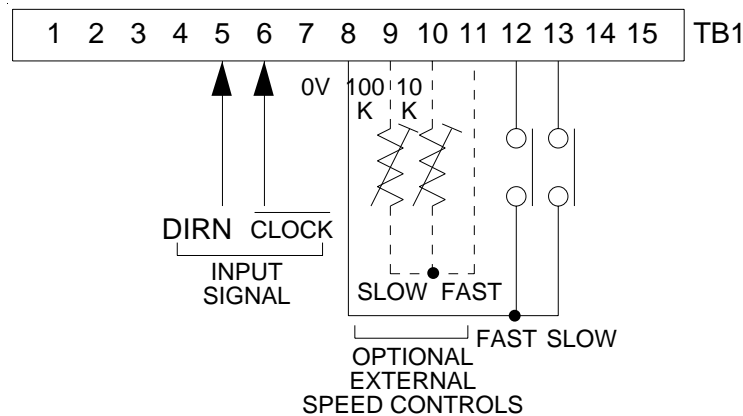


Figure 2-4. Control Connections for Standard Drive Module

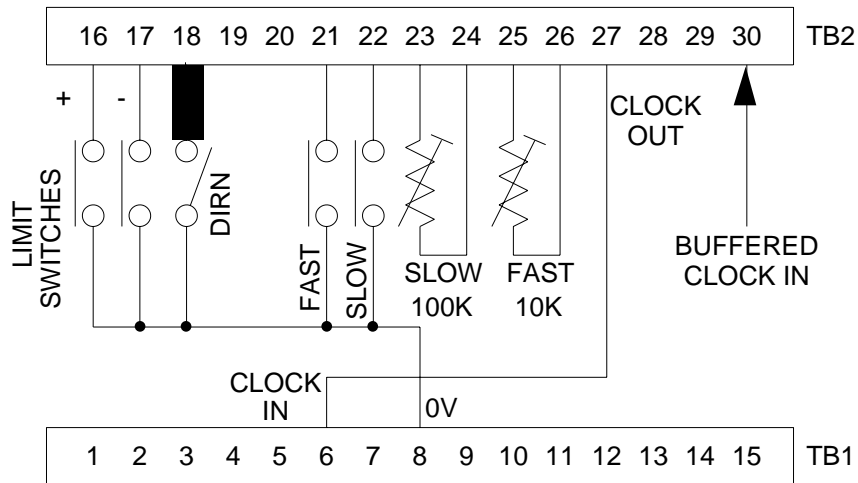


Figure 2-5. Control Connections for Drive Fitted with BC7 Buffered Clock

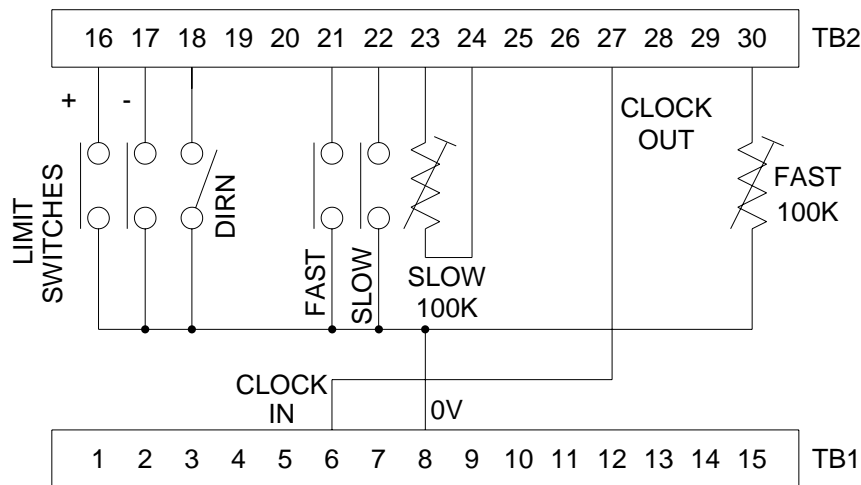


Figure 2-6. Control Connections for Drive Fitted with RC9 Ramped Clock

Internal Oscillator

As well as providing for an optional BC7 or RC9 clock card (described later in this chapter), the motherboard incorporates as standard an internal oscillator having two speed ranges. The speed in each range is adjusted using preset controls RV1 and RV2 (see Figure 1-2), with provision for external controls if required. The slow speed may be set between 400 and 10,000 steps/sec, and the fast speed between 4,000 and 100,000 steps/sec. Signals from an external control system, or from the optional clock cards, will be unaffected by this oscillator if it is not being used.

The fast speed range is ramped with an approximate acceleration time of 120mS and a deceleration time of 60mS. These times may be extended by the addition of capacitor C11, a value of 22 μ F will give approximately double the preset times. Use a dipped tantalum capacitor rated at 25 volts and observe the correct polarity. The location for C11 is near the centre of the board close to C6 (see Chapter 5 "Removal and Replacement of Drive Module").

Link Functions

Link Number	Function
LK1	cut to disconnect the slow rate preset RV1 on the internal oscillator.
LK2	cut to disconnect the fast rate preset RV2 on the internal oscillator.
LK3	cut to remove the internal connection between the drive 0v rail and earth. This link should only be cut if the 0v rail is earthed elsewhere in the system (via TB1 pin 8). It is important that the drive 0V is reliably earthed.
LK4	Not used

Table 2-4. Motherboard Link Functions

The Optional RC9 Ramped Clock

The ramped clock is basically a wide-range, remotely-programmable oscillator. It incorporates acceleration and deceleration circuits which enable the motor to be operated at full speed without loss of synchronism. In addition, the motor may be run at preset speeds either in the start/stop range or in the slew region, and an interlock circuit allows protection against exceeding the limits of mechanical travel.

The facilities offered by the ramped clock are summarised below.

- (1) The motor may be run at a preset or remotely-adjustable speed within the start/stop range. This is referred to as the SLOW speed.
- (2) The motor may be run at high speed, up to the maximum obtainable from the system, without loss of synchronism. This is achieved by starting off at a speed within the start/stop range, called the HOME speed, and then accelerating up to the required speed in a controlled manner. When stopping, the motor is decelerated at a controlled rate down to the Home speed before being brought to rest. The preset FAST speed is also remotely adjustable, and may be varied whilst the motor is running by using the FAST MODIFY facility which operates through the acceleration and deceleration circuits. In this way the speed may be adjusted manually without any risk of missed steps or stalling.
- (3) The direction of rotation may be reversed, even when running at full speed, without loss of synchronism. The motor will be decelerated down to Home speed, reversed and accelerated back up to speed in the opposite direction.
- (4) The system will accept Motion Limit signals without missing steps - the motor will slow down to Home speed and stop, and can then only be restarted in the opposite direction.
- (5) The acceleration and deceleration rates, as well as the preset speeds, are adjustable on the oscillator card to optimise the system performance.
- (6) Output signals are provided which enable an external control system to monitor the status of the oscillator.

Specification

Speed ranges	Home 60 - 1600 steps/sec. Slow 60 - 1600 steps/sec. Fast 1000 - 21,000 steps/sec. (with Home speed set to 60 s/s).
Fast modify	Adjusts Fast speed from 100% preset rate down to 3% above Home speed
Acceleration time	0.1 to 3 secs.

Deceleration time	0.1 to 5 secs.
Clock output	Low-going pulse 12 μ S wide.
Input circuits	4K7 min. impedance to +12V. Logic 1 level +11V to +30V or open-circuit. Logic 0 level less than +1V at 3mA or short-circuit to 0V.
Output circuits	Open-collector transistors referenced to 0V and capable of switching up to +30V at 15mA maximum.
Power requirements	+24V +/-15% at 135mA max.

**Functional
Description**

Figure 2-7 shows a sequence of operations which illustrate most aspects of the system behaviour. The uppermost waveform is the "motion profile" which shows how the speed and direction of the motor vary with time, and underneath are the various control waveforms. By considering the motion profile in stages the operation of the oscillator should become clear.

The system starts off at rest, and at point A the Slow speed is called up by the Slow speed input going to logic 0. The motor is able to start immediately at the slow speed since this is set within its start/stop range. At B the input command is removed so the motor stops.

At C both the Home and Fast inputs are taken low, causing the motor to start at the Home speed and immediately accelerate up to the Fast speed which is reached at D. At E the Fast input is removed but the Home input remains, so the motor decelerates until it reaches the Home speed at F and then continues to run at this speed until the Home input is removed at G. The portion between C and G would be a typical motion profile for a positioning system; most of the travel is covered at high speed, and shortly before the target position is reached the motor slows to a speed within the start/stop range. The motor then stops when the correct number of steps have been performed.

At point H only the Fast input is applied, and again the motor will start off at the Home speed and accelerate to full speed. At J the limit switch operates, causing the motor to decelerate to the Home speed and stop at K. It remains stationary until the Direction Request input is changed at L, and since the Fast input is still applied the motor now accelerates to full speed in the opposite direction. At point M the direction request input is changed whilst the motor is still running at full speed - the motor decelerates to Home speed at N, immediately reverses and accelerates again to full speed in the forward direction. Note that the Motor Direction signal only changes over at the point where the motor actually reverses, so this signal should be used where an indication of true direction is required, for instance when using a counter to monitor position.

At P the Fast Modify input has been used to reduce the speed, and the normal deceleration curve is followed. The Fast input is removed at R, the motor slows to Home speed at S and stops.

The circuit elements which perform these functions are shown schematically in Figure 2-8. The oscillator itself is a current-controlled device which generates a pulse waveform at a frequency proportional to input current. Therefore at any given time the stepping rate is represented by the magnitude of the input current to the oscillator. To run the motor at either the Slow or Home speed, it is necessary only to feed the appropriate current into the oscillator since these speeds are within the start/stop range of the motor and no acceleration or deceleration is required. The Slow and Home Speed inputs are each taken to a current generator which feeds a preset current into the oscillator to generate the required frequency. The Home Speed input overrides the Slow Speed input, and both inputs are inhibited by the detection of a limit condition.

When the motor is required to run at high speed the ramping circuit comes into operation. The Fast input turns on the Home Speed current generator so that the motor starts off at the Home Speed. At the same time the CR charging circuit is switched on and this generates the acceleration waveform, the value of the charging resistor determining the acceleration rate. The acceleration characteristic may be varied between exponential and linear by means of a preset resistor. The acceleration voltage is converted to a current and fed into the oscillator, causing the output frequency to rise in a controlled fashion. When the acceleration voltage reaches a preset level corresponding to maximum motor speed, this is detected by the comparator and the charging circuit is turned off. The comparator reference level may be altered by the Fast Modify Input, thus changing the maximum speed attained by the motor.

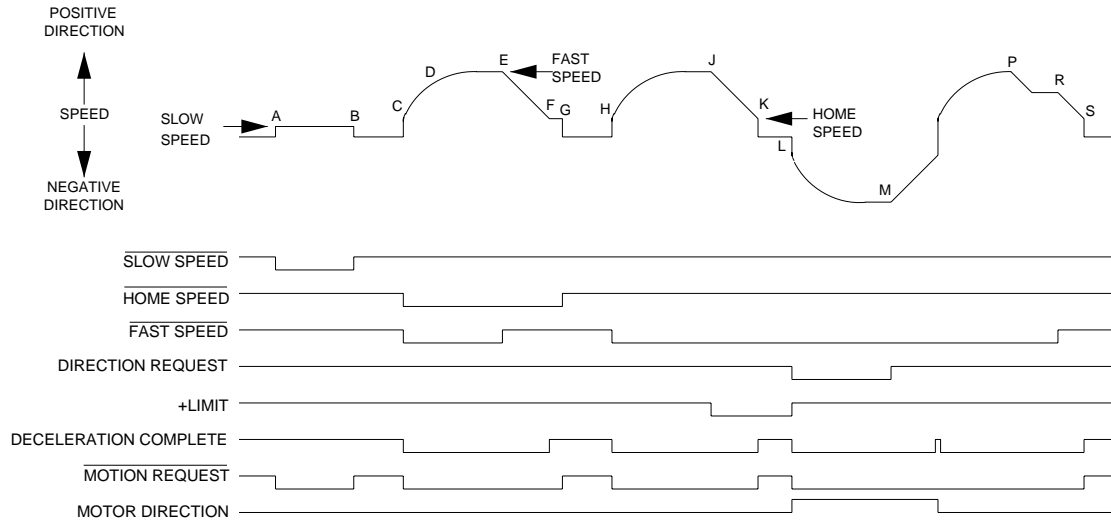


Figure 2-7. Ramped Clock Waveforms

When the Fast input is removed, the deceleration current generator is turned on and this discharges the capacitor at a controlled linear rate. There will be a corresponding fall in the output frequency from the oscillator until the capacitor voltage reaches a preset clamp level, at which point the motor will be running at Home Speed since the only remaining input current to the oscillator is that from the Home Speed current generator. This current generator is now switched off and the motor stops.

The remaining circuitry on the board is for controlling motor direction in conjunction with the limit interlock circuit. The Direction Request input is taken to the direction latch which is only permitted to change its state when deceleration is complete, in other words when the ramping circuit is in its quiescent state. Under these conditions the motor is either stationary or running within the start/stop range and so can be instantly reversed. If the direction request is changed whilst the ramping circuit is in operation (i.e. motor running in the slow region) the Fast input is removed so that the motor decelerates to Home Speed before reversing. The Fast input is then reconnected so that the motor accelerates back up to speed in the opposite direction.

When a limit condition is detected the interlock circuit disconnects all inputs so that the motor decelerates to a halt. To re-start the motor it is necessary to change the Direction Request, when the input conditions will be restored allowing the motor to move off in the opposite direction. Grounding the positive limit input inhibits motion when the Direction Request is at "0"; the negative limit input inhibits motion when the Direction Request is at "1".

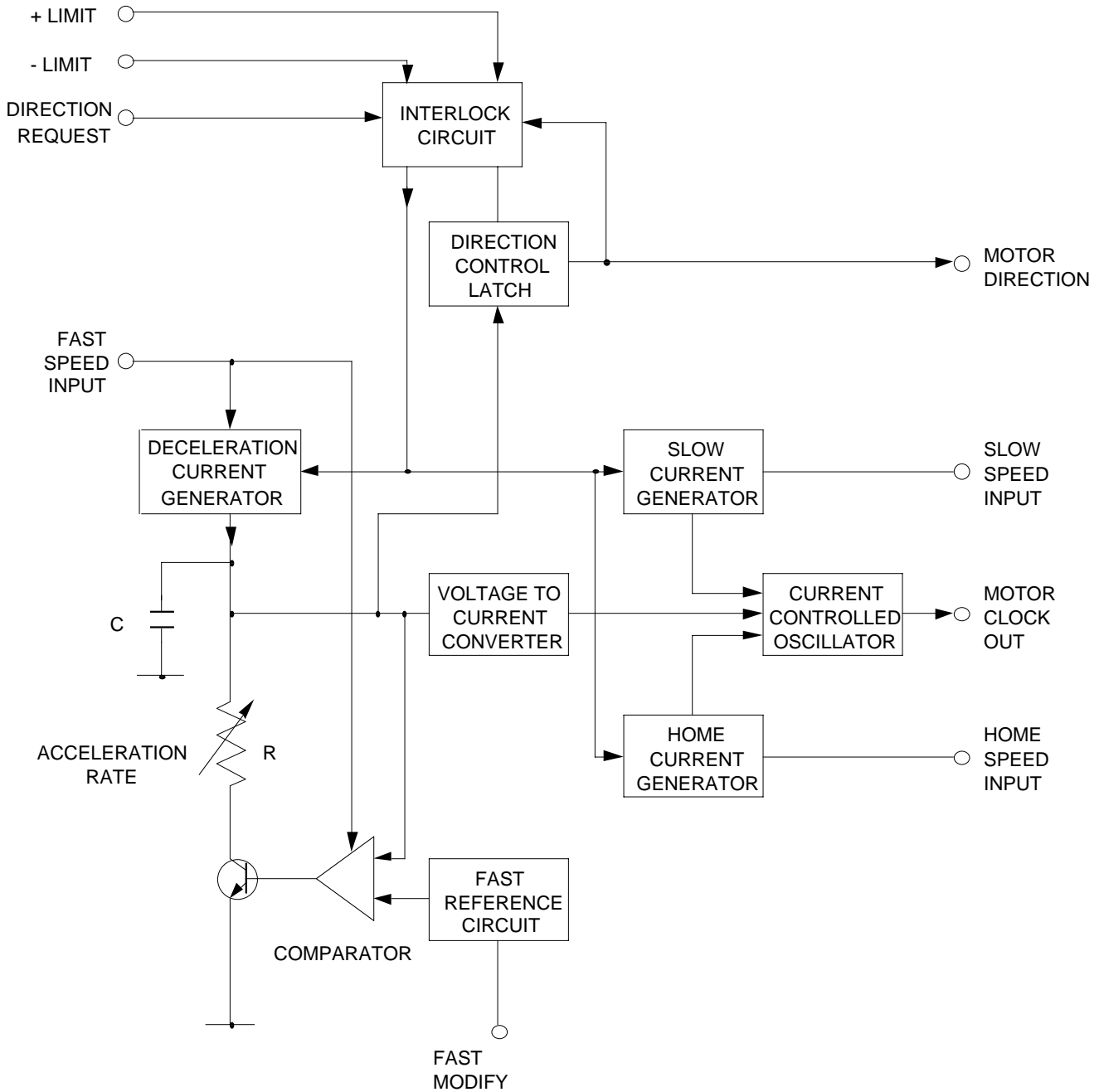


Figure 2-8. Ramped Clock Block Schematic

RC9 Ramped Clock Limit Switch Connections

The limit interlock circuits are brought into operation by shorting the appropriate limit input to 0V. This method of connection is shown in Figure 2-9(a) and is satisfactory when small microswitches, reedswitches or proximity switches are used. However, if industrial machine-tool type switches are used the current drawn by the limit input may be insufficient to ensure good contact wetting and the operation may be unreliable. In this case a preferred connection arrangement is shown in Figure 2-9(b) in which a normally-closed contact is used in conjunction with a pull-down resistor. This configuration is virtually fail-safe since the limit circuit is activated by the switch contacts becoming open-circuit.

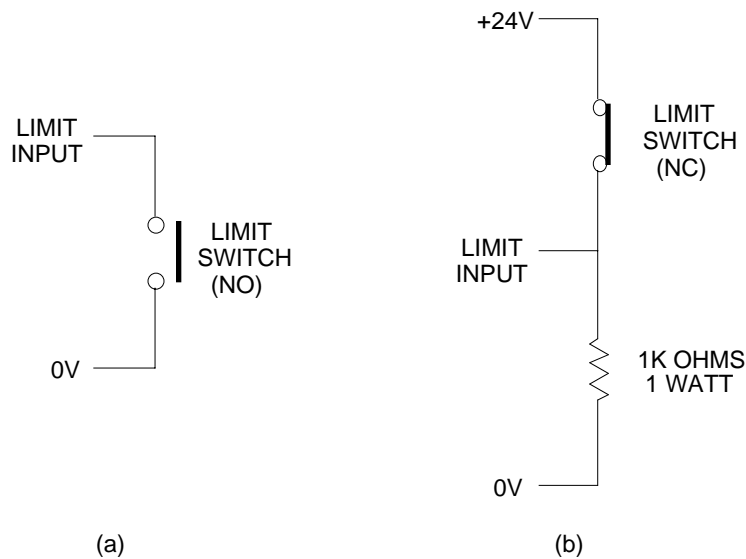


Figure 2-9. Limit Switch Configurations

RC9 Ramped Clock: Setting Up

The most suitable method of setting up the Ramped Clock will depend on the application. If defined stepping rates are required and it is known that these are well within the capability of the motor, the adjustments may be made using a suitable counter or frequency meter. If on the other hand the system is required to move to a new position in the shortest possible time the adjustments should be made experimentally on the complete system. In either case it will normally be necessary to set up the acceleration and deceleration rates experimentally. If wide variations of load are expected, the adjustments should be checked at both maximum and minimum load. This is necessary because a large frictional load aids deceleration and a permissible deceleration rate at full load may be unacceptable when the load is reduced.

The ideal method of setting up the clock for optimum performance is to use the control system as an indexer so that the number of step pulses fed to the motor is controlled. If this is not possible or if the system is to be manually controlled, refer to the following sections which explains the procedure to adopt when no indexer is available.

Adjustment Using an Indexer

Attach a light pointer to the motor shaft and align it with a reference mark. Turn preset controls RV1, RV2 & RV3 fully anticlockwise, RV4 & RV5 fully clockwise (see Figure 2-10).

Arrange to index through one revolution of the motor, i.e. 400 steps in the 400 step/rev. mode, using only the Home speed. (If the control system wants to call up Fast speed, detach the lead from the Fast input). Index the motor and check that the pointer is aligned when the motor stops. Repeat the indexing operation and slowly turn the Home speed preset RV2 clockwise until stalling occurs when the motor starts or stops. This will be indicated either by the motor failing to run at all or by the pointer being misaligned when the motor stops.

The point where stalling is about to occur represents the upper limit of the Home speed, so to allow a safety margin the control should be turned back about 1 turn. The speed setting obtained by this method should be reduced by about 50% if instantaneous reversal is required without loss of synchronism. If the Fast input lead was detached, reconnect it and arrange to run the motor continuously at the Fast speed. If this is not possible, set up the indexer to perform a large number of steps. When the motor has run up to speed, slowly rotate the Fast speed preset RV3 clockwise until the motor stalls. Turn the control back by not less than 1 turn to give a working margin.

Now arrange to index the motor through a whole number of revolutions by generating say 4000 steps, giving 10 revolutions in the 400 step/rev. mode. Ensure that the indexer initiates deceleration (by removing the Fast input) well before the finish of the index. Start with the pointer aligned with the reference mark, index the motor and check that the pointer is once again aligned when the motor stops. Repeat the indexing operation and slowly rotate the Acceleration Rate preset RV4 anticlockwise until the motor stalls on acceleration. When this happens the motor will usually stop, but under exceptional circumstances it may result only in missed steps which will be indicated by the pointer stopping short when the motor comes to rest. Turn RV4 back about 1 turn from the point where stalling occurs. Continue to index the motor and slowly rotate the Deceleration Rate preset RV5 anticlockwise until the motor stalls on deceleration. This will be shown by the pointer over-shooting when the motor comes to rest. Turn RV5 back about 1 turn from this point.

Change over the Direction Request and confirm that the motor behaves correctly when indexed in the reverse direction.

If the Slow speed is to be used, arrange to call up the Slow input and adjust the rate by means of RV1. The setting will clearly depend on the purpose for which the slow speed is required, but it must be slower than the Home speed assuming that the latter has been set up as suggested near the top of the start/stop range.

**Adjustment Without
an Indexer**

Turn preset controls RV1, RV2 & RV3 fully anticlockwise, RV4 & RV5 fully clockwise. Arrange to run the motor at the Home speed in a periodic fashion so that the behaviour both starting and stopping may be observed. Slowly turn the Home speed preset RV2 clockwise until stalling occurs either on starting or stopping, indicated by the motor failing to start or skidding on after stopping. The latter condition is accompanied by a change in the sound from the motor when it comes to rest.

The point where stalling is about to occur represents the upper limit of the Home speed, so to allow a safety margin the control should be turned back about 1 turn. Reduce this speed by about 50% if instantaneous reversal is required without loss of synchronism.

Arrange to run the motor continuously at the Fast speed. Slowly rotate the Fast speed preset RV3 clockwise until the motor stalls. Turn the control back by not less than 1 turn to give a working margin.

Periodically apply the Fast speed input and slowly rotate the Acceleration Rate preset RV4 anticlockwise until the motor stalls during acceleration. Turn the control back about 1 turn. Continue to apply the Fast speed input periodically and slowly rotate the Deceleration Rate preset RV5 anticlockwise until the motor skids on during deceleration. Turn the control back about 1 turn from this point.

If the Slow speed is to be used, arrange to call up the Slow input and adjust the rate by means of RV1. The setting should be slower than the Home speed to ensure that stalling does not occur.

Change over the Direction Request and test the motor at all speeds in the reverse direction.

**RC9 Ramped Clock
Adjustment of
Acceleration
Characteristic**

The ramped clock is normally set up to have an acceleration characteristic which is almost exponential. Such a characteristic is suitable for most applications since at high speeds the available accelerating torque is less than at low speed. This is a result of both

the inherent torque/speed characteristics of the motor and also the increase of viscous drag loading with speed. In certain cases where there is abundant torque available and a brisk acceleration is required, some improvement may be effected by making the acceleration characteristic more linear. This is achieved by changing the value of R5 on the clock card. The resistor is normally 1K8 but this value may be increased or removed altogether. The effect of such a change must be determined experimentally on the complete system.

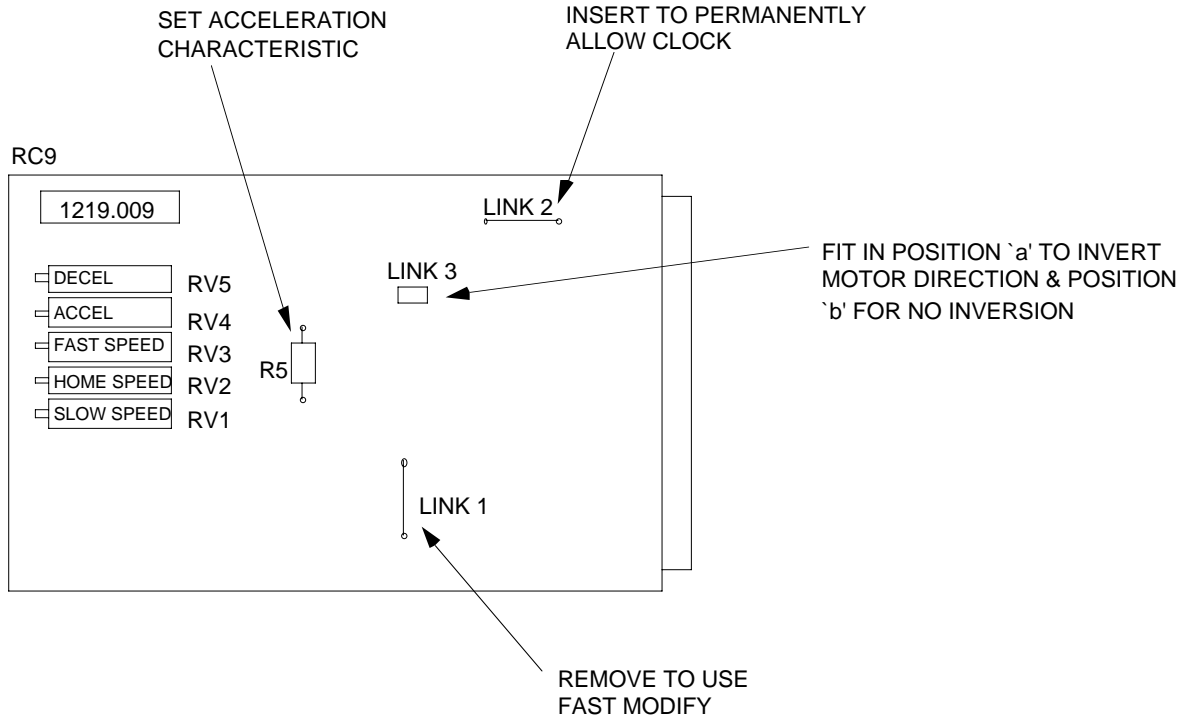


Figure 2-10. Links and Preset Controls on the RC9 Ramped Clock

The Optional BC7 Buffered Clock

The BC7 Buffered Clock is designed for use with control systems which generate a sequence of clock pulses at a rate corresponding to the desired motor speed. These pulses may be delivered as a burst giving an index amount, at a fixed frequency for constant-speed operation, or in a random fashion with a varying period. The buffered clock will store the incoming pulses and deliver a re-timed pulse sequence to the drive, incorporating the necessary acceleration and deceleration to avoid loss of synchronism. The maximum input frequency to the buffer should not exceed the maximum stepping rate of the motor - the clock is not intended to be used as a buffer for very high frequency pulses.

A separate oscillator is included on the card and this permits operation at preset speeds from DC logic inputs or manual switches. The card can therefore be used as the clock source in an indexing system. Directional limit switch inputs are also included.

The card is available in three versions - the BC7/1 has a maximum following error of 4500 at 20kHz and suits the majority of applications, whereas the BC7/4 operates at speeds up to 50kHz with a maximum following error of 50,000. This allows it to be used with high-resolution drives and also permits long acceleration times necessary in high-inertia systems. The BC7/8 operates at up to 80kHz for use with 2000 step/rev microstepping drives, and also permits a maximum following error of 50,000.

	BC7/1	BC7/4	BC7/8
Maximum following error	4,500	50,000	50,000
Maximum speed	20,000s/s	50,000s/s	80,000s/s
Base speed	200-2600s/s	300-2000s/s	600-4000s/s
Acceleration time to 95%	0.1-1.2sec.	0.45-3.0sec.	0.4-2.5sec.
Deceleration time	0.15-0.7sec.	0.40-3.0sec.	0.2-1.3sec.
Int. oscillator slow range	25-800s/s	70-2000s/s	140-4000s/s
Int. oscillator fast range	400-20Ks/s	1K-50Ks/s	2K-80Ks/s
Power requirements	+24v @ 135mA		

Operating Principles

The buffered clock is based on an up-down counter which stores the incoming pulses (see Figure 2-12). The output from the counter drives a D-to-A converter which in turn feeds a voltage-controlled oscillator. This oscillator generates motor clock pulses and these are fed back to the buffer counter in the opposite sense to the incoming pulses. Clock pulses fed into the buffer will accumulate and generate an increasing output from the D-to-A converter. This causes the VCO to accelerate until it is generating motor pulses at the same rate as the incoming pulse stream. When the input pulses stop, the VCO slows down and finally stops when it has emptied the buffer. Thus the fixed-frequency input pulse train is converted to a variable-frequency output incorporating acceleration and deceleration. The output frequency will be the same as the input frequency at the end of acceleration, and the total number of output pulses will equal the number of input pulses.

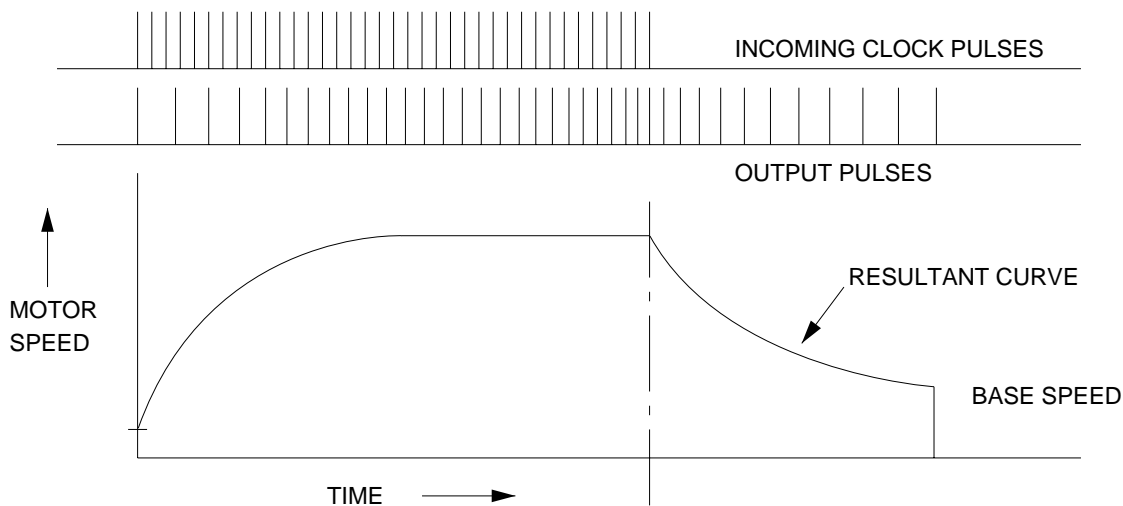


Figure 2-11. Buffered Clock Characteristics

Between the D-to-A converter and the VCO is a gain control which sets the acceleration time. If the gain is reduced, more input pulses will be required to produce a given output speed and these will take longer to accumulate, giving a longer acceleration time. Since there are now more pulses to be emptied from the buffer, the deceleration time will also be longer. A separate "Base speed" control allows adjustment of the VCO speed at the end of deceleration. This minimises deceleration time by stopping the motor once it has re-entered its start/stop range.

The number of pulses stored in the buffer is referred to as the following error. This increases to a maximum at the end of acceleration, and reduces to zero when the motor stops. The maximum following error depends both on speed and the setting of the gain control.

When a limit condition is detected, no further clock pulses are allowed into the buffer. This causes the motor to decelerate to rest, and it can only be re-started by changing the direction request input so that the system is brought off the limit. Note that if the direction request is changed whilst the motor is running, further input pulses are ignored until the motor stops. The motor direction output then changes and the motor accelerates back up to speed in the opposite direction.

The independent internal oscillator enables the buffered clock to serve as a self-contained pulse source. The oscillator has fast and slow speed ranges, though both speeds may be set outside the start/stop range of the motor since the necessary ramping is performed by the buffer. The speed in each range is determined by an external resistor, and suitable preset controls are incorporated in the indexer motherboard. External resistors or potentiometers are required when using the standard clock card motherboard. The oscillator has an "allow clock" input which overrides the Fast and slow inputs, allowing the clock to be disabled.

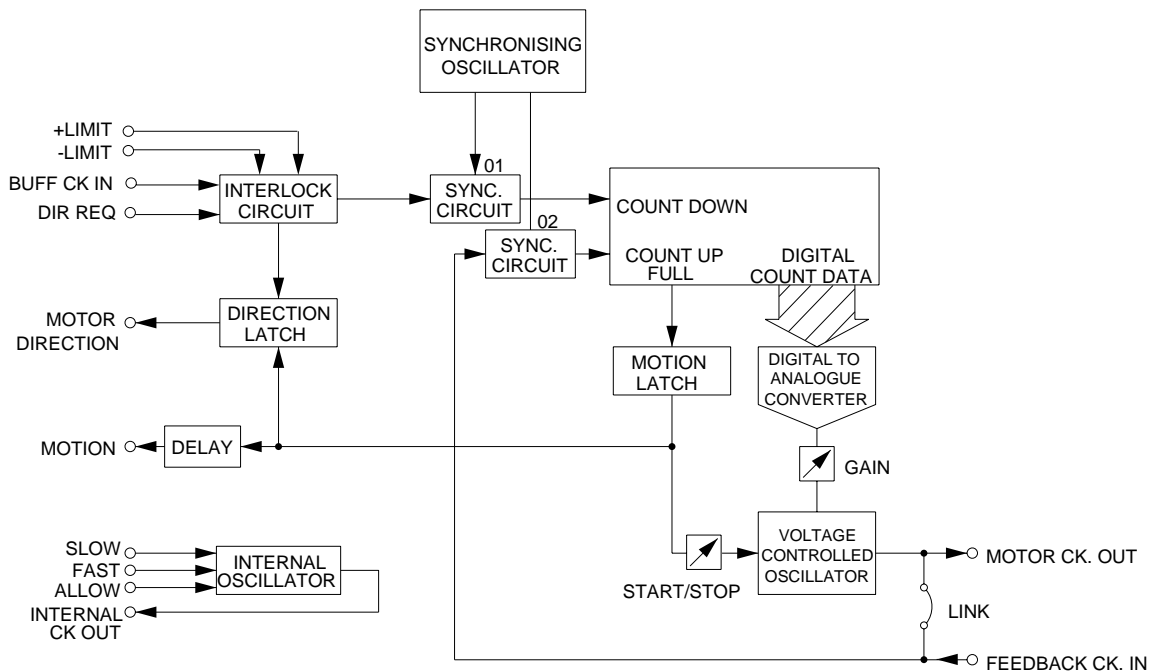


Figure 2-12. Simplified Buffered Clock Schematic

**Buffered Clock
Link Functions
on the BC7**

Link Number	Function
Link 3	Factory set offset link (do not remove).
Link 6	Links the output from the internal oscillator directly to the buffered clock. Remove this link if the oscillator output is to be used independently (available on "internal clock out" terminal).
Link 7	Connects the "allow clock" input permanently to 0v, avoiding the need for an external connection. Remove this link if the "allow clock" function is required.
Link 8	Insert this link to obtain a preset slow speed on the internal oscillator, approximately 800Hz.
Link 9	Insert this link to obtain a preset fast speed on the internal oscillator, approximately 20kHz.
Link 10	This link connects the VCO output back into the buffer. If the link is removed, clock pulses fed into the buffer will cause the VCO to run continuously. This can be used to set up the buffer by feeding in a known number of pulses and then adjusting the gain control for a specific speed.
Links 11 & 12	These determine the phase of the "motor direction" output relative to the "direction request" input. With link 12 fitted, motor direction will be high when direction request is high. Remove link 12 and fit link 11 to invert the phase of the motor direction output.

Table 2-5. Buffered Clock Link Functions**BC7 Buffered
Clock: Limit Switch
Connections**

The limit circuits are activated by taking the appropriate limit input to 0v. This method of connection is shown in Figure 2-13(a) and is satisfactory when small microswitches or proximity switches are used. However, if industrial or machine-tool type switches are used the current drawn by the limit input may be insufficient to ensure good contact wetting and may lead to unreliable operation. In this case a preferred arrangement is as shown in Figure 2-13(b) in which a normally-closed contact is used in conjunction with a pull-down resistor.

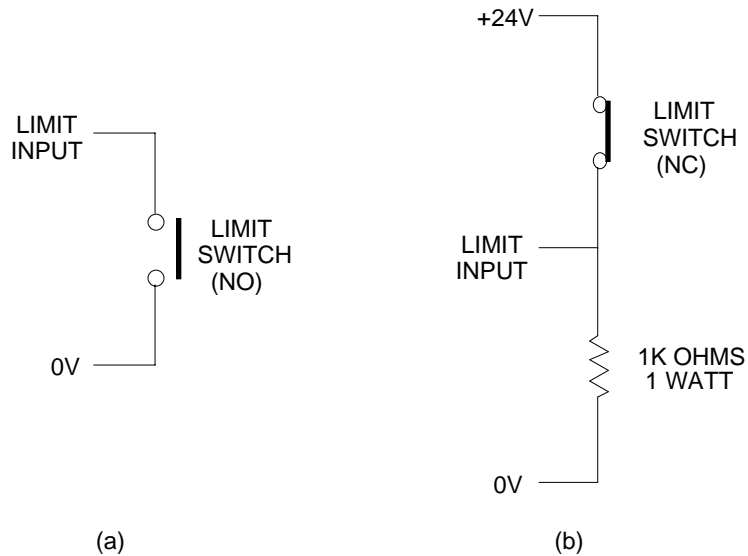


Figure 2-13. Limit Switch Configurations

**BC7 Buffered
Clock: Setting Up
the Buffered Clock**

There are two adjustments to be made on the card, and these should be carried out with the motor fully loaded. If wide variations of load are expected, the adjustment should be checked at both maximum and minimum load. This is necessary because a large frictional load aids deceleration and a permissible deceleration rate at full load may be unacceptable when the load is reduced.

In most applications, the procedure outlined below will prove satisfactory provided that the input frequency can be raised above the maximum required speed. If this is not possible then the alternative procedure given in "Adjustment Using an Indexer" may be followed.

**Adjustment
Using a Variable-
Frequency Source**

Set the input frequency to the buffered clock 20% higher than the maximum required stepping rate. Turn gain control fully clockwise and base speed control fully anticlockwise (see Figure 2-14). Periodically start and stop the motor by interrupting the input to the buffered clock, and slowly rotate the gain control anticlockwise until the motor stalls on acceleration or runs on during deceleration (there is an audible change in the motor behaviour when this occurs). Back off the gain control until the motor just runs without stalling, and check the setting with the motor running in the reverse direction. The following error in the buffered clock will now incorporate an adequate margin when running at the normal maximum rate. Continue to start and stop the motor, this time rotating the base speed control clockwise until the motor just starts to run on during deceleration. Back off the base speed control approximately one full turn. Once again check the operation in the reverse direction.

Adjustment Using an Indexer

Set up the Indexer so that its output rate corresponds to the maximum required motor speed. Arrange to index through a whole number of motor revolutions, e.g. 4000 steps giving 10 revolutions at 400 steps/rev. Mark the motor shaft or attach a light pointer and align it with a reference mark so that deviations from the indexed amount can be easily detected.

Turn gain control fully clockwise and base speed control fully anticlockwise (see Figure 2-14). Index the motor and check that the pointer is aligned with the reference mark when the motor stops. Repeat the indexing operation and slowly increase the gain by rotating the control anticlockwise until the motor stalls on acceleration or deceleration. Stalling on acceleration will usually cause the motor to stop altogether but can result purely in missed steps which will be shown by the pointer stopping short of the reference mark. Stalling on deceleration will be indicated by the pointer overshooting the reference mark. Back off the gain control until the motor just indexes without stalling. The system is now set up with the absolute minimum following error, and the next stage is to increase this by 20% to ensure reliable operation.

Switch the unit off and break the feedback connection by removing link 10 or external connection (see Figure 2-14). Switch on and use the Indexer to feed a known quantity of pulses into the buffer until the motor reaches the required maximum speed - since the feedback connection is removed the buffer will not be emptied and the motor will run continuously. If the required speed is exceeded, the system should be switched off and on again to reset the buffer. When the correct speed is reached the number of pulses in the buffer is equal to the following error. Use the Indexer to add extra pulses into the buffer to increase this number by 20%, e.g. if 1200 pulses are required to reach maximum speed, add another 240 pulses. Turn back RV1 until the motor returns to the required maximum speed. (If the motor stalls when the extra pulses are added, switch off to reset the buffer, turn the gain control fully clockwise and switch on again. Add the required number of pulses into the buffer including the extra 20%; and then turn the gain control anticlockwise until the motor runs

at the required maximum speed). The following error at full speed will now incorporate a 20% margin which is adequate for most applications. Switch off and remake the feedback connection.

Repeat the indexing operation through a whole number of motor revolutions and slowly rotate the Base speed preset clockwise until the motor runs on after decelerating, shown by the pointer overshooting the reference mark. Turn the Base speed preset back one complete turn. Check that the motor now indexes correctly; change over the Direction Request and check the operation in the opposite direction.

Internal Oscillator Speed Adjustment

With links 8 and 9 inserted on the board, the Slow and Fast Rates of the internal oscillator are preset. As mentioned in Chapter 2, external control of the rates may be achieved by connecting variable resistors across the appropriate terminals. Typical values are 100K for the slow control and 10K for the fast control. Alternatively, fixed resistors may be substituted for the links in order to change the preset speeds. The simplest way of achieving this is to use variable resistors to set up the required rates and then substitute the equivalent fixed resistors.

Connect a variable resistor up to 2 Megohms across the Slow Rate (a) and (b) terminals. Call up the Slow speed and adjust the resistor to obtain the required rate. Switch off and disconnect the resistor, measure its value and fit the equivalent fixed resistor in place of link 8. Repeat the procedure for the Fast speed by connecting a variable resistor up to 20K across the Fast Rate (a) and (b) terminals, and after adjustment fit the equivalent fixed resistor in place of link 9.

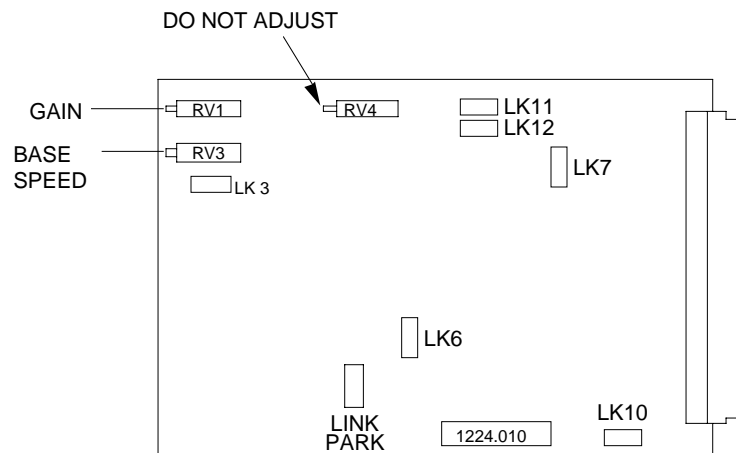


Figure 2-14. BC7 PCB Showing Pot and Link Positions

Chapter 3. SETTING UP THE CD60/80M DRIVE

The drive, as supplied, operates in the 400 step/rev mode and will deliver the minimum rated current to the motor. It is possible to change the operating conditions by means of links on the translator. Refer to Chapter 5 for drive module removal and replacement procedure.

Drive Link Settings

You can adjust the performance of a particular drive by altering the setting of links mounted upon the PSU and Translator card. The layout of the links, as fitted in the factory, is shown in Figure 3-1.



Figure 3-1. CD60M/CD80M Link Layout

CAUTION - risk of electric shock

**Do not remove drive modules while power is applied to them.
Remove power and wait for capacitors to discharge.**

The 4 links allow the adjustment of standby current reduction, resolution, the selection of a permanent or selectable energise function and motor current. The range of options available is shown in Table 3-1.

Link No.	Option	Link Position	Value	
LK1	Standby current reduction	A	80% of full load	
		B*	50% of full load	
		C	Permanent (50%) standby	
LK2	Resolution	D	4,000 steps/rev	
		E	2,000 steps/rev	
		F	1,000 steps/rev	
		G*	400 steps/rev	
LK3	Energise	H*	Permanently energised	
		I	Energise externally controllable	
LK4	Motor current		CD60M	CD80M
		J	6A	7.8A
		K	5.5A	7A
		L	4.4A	5.6A
		M*	3.8A	4.9A

*Factory settings

Note: LK2 can occupy positions D, E, F or G - there is an unused position between E and F.

Table 3-1. Link Setting Options

Standby Current Reduction

The standby current reduction links allow you to reduce the motor current by a percentage of the programmed current when the motor is stationary. Permanent standby reduces the motor current by 50% of its programmed value and may be used in combination with motor current link settings to achieve half the value of the load currents given in Table 3-1, although no standby current reduction is possible when used in this manner.

Resolution

The CD60M and CD80M drives offer ministepping as standard, enabling a maximum resolution of 4,000 steps/rev. Ministepping operation results in both higher resolution positioning and smooth low speed rotation.

Energise The energise edge connector signal allows a drive to be remotely selected, depending upon the logic state of the controlling signal.

When a drive is shutdown or de-energised the motor may be turned slowly by hand (if it is safe to do so) to allow the re-positioning of mechanical components.

If you wish to use the $\overline{\text{energise}}$ input (TB1 pin 7) to energise the drive, link setting 'I' must be made.

Motor Current Motor current may be link adjusted to the values given in Table 3-1 depending upon your application requirements. The motor currents quoted in Table 3-1 are RMS values and the chosen setting must not exceed the current rating of the motor. Peak currents are approximately 40% higher than the RMS values - the peak current from the CD80M is therefore 11A.

Chapter 4. OPT2 INTERFACE CARD

The OPT2 interface card plugs into terminal TB2 on the drive motherboard when the PKC series drive is being driven from a Compumotor control system. The OPT2 card provides isolation between the drive and control system. Power for the opto-isolators is derived from the drive motherboard. The unit has been designed in such a way that the Step, Direction and Shut-down inputs may all be driven differentially from 5v levels.

Input logic levels: On - 3v to 5v
 Off - < 1v

Note that the unit can also be driven from a single ended source, and in this case the negative input must be connected to the common 0v terminal 29 (TB2).

The fault output, terminal 30 (TB2) is an open-collector output and should be pulled-up via a 4K7 resistor to an external supply not exceeding +24v.

The following terminal functions refer to the PKC series drive when used in conjunction with the OPT2 interface card:

PKC (TB2) 30-Way Connector	Compumotor Control System 25-Way D Connector	
Terminal No.	Terminal No.	Function
16	16	Shut-down +
17	17	Shut-down -
18	1	Step +
19	14	Step -
28	2	Direction +
27	15	Direction -

Table 6-1. Drive Terminal Functions with OPT2 Card Fitted

Note that when an OPT2 card is fitted on the drive, the PKC internal oscillator is inhibited and Direction can only be controlled from the external control system.

Chapter 5. TROUBLESHOOTING

Fault Conditions

There are three protection systems built into the drive, any of which may cause it to shut down. The reason for shutdown is shown by LED indicators.

Overcurrent

An excessive current flowing in the motor leads causes the overcurrent circuit to shut down the drive. This may be caused by incorrect motor connections or short circuits, and can also occur if a very low inductance motor is desynchronised during deceleration.

Supply Failure

The supply protection circuit shuts down the drive if either the motor supply falls below about 40 volts, the motor supply rises above 170 volts or the internally derived voltage rails fail.

Overtemperature

This mode of shutdown occurs if the heatsink temperature reaches 85°C, which will generally be the result of inadequate cooling.

The Fault output will go high whatever the reason for shutdown, and the fault circuit can be reset by temporarily removing power from the drive or by taking the external reset pin (TB1 pin 4) low for 1 second. If the fault is due to overtemperature, it will also be necessary to allow time for the drive to cool down.

Fault Finding Guide

Check that the motor shaft is free to rotate with the drive switched off. If not, check for tight spots, misalignment etc. When satisfied switch on the drive and go through the following checklist.

1. Is there audible noise from the motor, or is the shaft locked?
YES - go to 6. NO - continue.
2. Which LEDs on the drive are illuminated?

ZERO PHASE -	Check for open-circuit motor connections. If these are O.K., drive is probably faulty.
OVERCURRENT -	Go to 3.
SUPPLY FAILURE -	Go to 4.
OVERTEMPERATURE -	The drive has overheated and should be switched off and left to cool. If it was previously operating satisfactorily, more cooling is required.
MORE THAN ONE -	The drive is almost certainly faulty.
NONE AT ALL -	Continue.

3. Disconnect the motor and switch on again. If the overcurrent LED comes on, the drive has been damaged. If not, check for shorts or crossed connections on the motor leads. Occasionally a very low inductance motor may cause the drive to fault out.
4. Check the fuses on the motherboard. If these are correct, there is probably an internal supply failure within the drive. Note that if initial checks are carried out by winding the supply up slowly with a variable transformer, this will invariably give a false supply failure condition.
5. When clock pulses are applied, does the motor shaft rotate at all? YES - go to 7. NO - continue.
6. Does the motor sound as if it is trying to run? YES - check for continuity on both motor phases at the edge connector. If OK, try reducing the acceleration rate and/or start speed. NO - check that there are adequate clock pulses into the drive on terminal 6. The pulse should stay below +1v for at least $1\mu\text{S}$ and the level between the pulses should be greater than +11v. If the clock pulses are OK, the drive is probably faulty.
7. Does the motor stall during acceleration? YES - try reducing the acceleration rate and/or top speed, and try using boost. If this fails, the load is probably too great for the motor. NO - the problem is outside the scope of this quiz. A few suggestions follow which may be useful.

Sometimes a motor will perform in an odd fashion due to resonance effects, particularly when lightly loaded. The cure may be to change the start speed, change the acceleration rate (it could be too slow) or to reduce the motor current. If the motor is connected in series, try changing to parallel (see Tables 2-1 and 2-2).

An excessive deceleration rate will cause the motor to overshoot when coming to rest, with the result that it performs too many steps. This effect is usually accompanied by a screeching sound during deceleration.

If the motor runs excessively hot, check the motor rating against the drive output. If the motor is hot after a long period at standstill, check the standby current with a meter in series with one motor phase. If the motor is mis-indexing, the number of steps in error may give a clue to the cause. Desynchronisation will give a multiple of 4 full steps (8 half steps), whereas odd numbers of steps suggest noise on the clock line and optical isolation should be considered.

Removal and Replacement of Drive Module

The removal of the drive module is easily achieved in the following manner:

- (a) Ensure that all supplies have been switched off and capacitors have time to discharge (wait for 2 minutes).
- (b) Position the drive with the terminal blocks towards you as shown in Figure 5-1 and remove the four M3 x 10mm screws marked A. The screws at the back of the unit are holding the two sections of the cover together - only remove the part of the cover with the LED holes, leaving the part with the mains connector in place.
- (c) Remove the two M3 x 10mm screws marked B which hold the cover to the heatsink as shown in Figure 5-2. The drive cover can now be gently pulled upwards from the unit.
- (d) Remove the four M3 x 10mm screws marked C which secure the drive module to the heatsink (see Figure 5-2). The drive module can now be removed from the heatsink.
- (e) Removal of the top cover with mains connector may be required to reach fuses or change the HV voltage. There is no need to remove any wires from the connector or the voltage selector. Four M3 screws can be removed to swing the cover to one side. Two screws hold the top cover to the chassis and two more hold it to the heatsink.

- (f) Replacement is the reversal of removal, but great care should be taken when replacing the cover, to relocate the LEDs correctly in the cover. Note that when replacing the drive, silicone grease is used on the mating surfaces of the heat shunt. This guarantees good thermal contact between the heatsink and heat shunt.

Ensure that the single-coil lock washers are replaced on each screw.

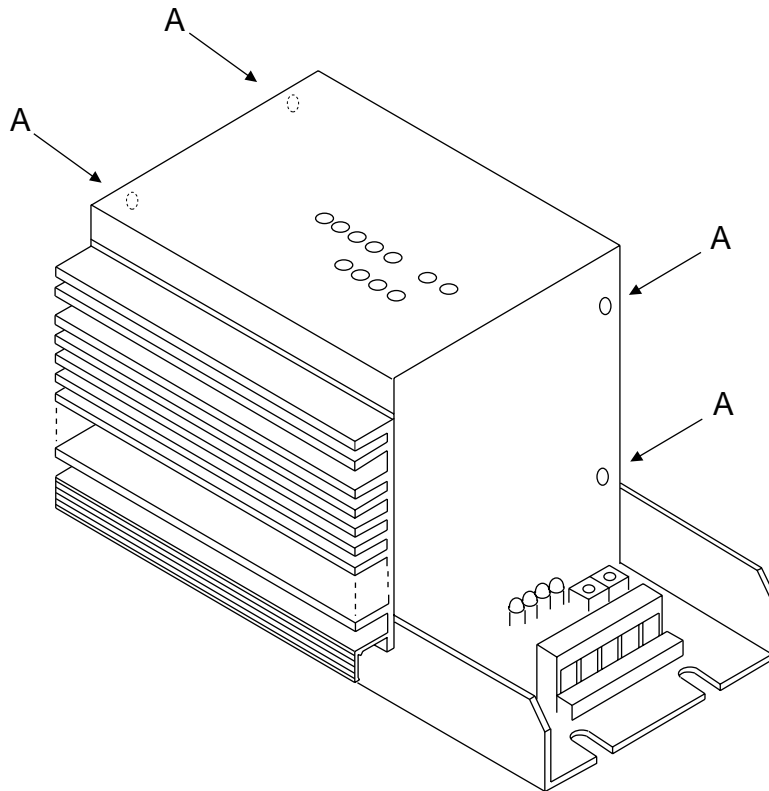


Figure 5-1. PKC Drive Schematic

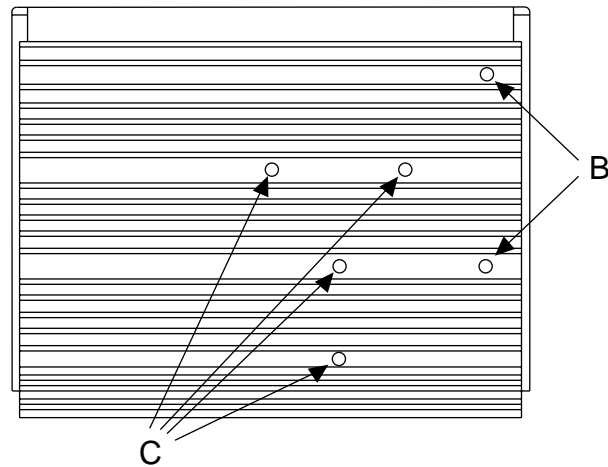


Figure 5-2. Cover and Drive Module Fixing Locations

Returning the System

Contact the Parker Automation Technology Centre or the machinery manufacturer who supplied the product. Equipment for repair should NOT be returned directly to Digiplan without prior authorisation. Repairs will be carried out by Digiplan but will be processed via your supplier.

Digiplan may at their discretion authorise direct shipment to and from Poole or Rohnert Park, but only by prior arrangement with your supplier. Existing UK and USA customers who purchase equipment directly from Digiplan should contact Poole or Rohnert Park for further information (contact numbers are at the front of this User Guide).

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