UD Series DC Servo 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 complete installation to comply with the Low Voltage Directive or Machinery Directive. It is your responsibility as an installer 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.

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.

High voltages exist within enclosed units, on rack system backplanes (motherboards) and on transformer terminals. Keep clear of these areas when power is applied to the equipment.

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

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 1600.037.07, supersedes version 1600.037.06.

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.

Removal of the DC Series Servo Motor Data Appendix.

Alteration of the supply voltage for the UD Series of DC Servo Drives.

EMC and LVD Compliance Considerations

The UD Series of drives are sold as complex components to professional assemblers, as components they are not compliant with Electromagnetic Compatibility Directive 89/336/EEC.

The UD Series of drives are for use only at voltages under 75V DC, and are therefore outside the scope of current LVD requirements.

Note: Care must be taken particularly in transformer selection and wiring to ensure safety of the installation. The complete system may need to conform with either the Low Voltage Directive or the Machinery Directive.

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CHAPTER 1. GENERAL DESCRIPTION

Introduction

The UD2/5 is a high performance, low-loss pulse width modulated DC servo drive suitable for use with permanent-magnet servo motors.

The system comprises a 3U power sub-rack to which may be fitted up to three or eight axis cards, depending on the type. The UD5 is capable of delivering a continuous output power of over 1/2hp (375W) and the UD2 1/5hp (150W). Adjustable current limiting allows the drive to be matched to a wide range of motors. In addition, again depending on the type, the sub-rack may support one of the following options:

(a) A single DC motor supply rail, so that all motors are powered from the same DC supply.

(b) Two DC motor supply rails, so that motors may be run from different DC supply rails, thus allowing more accurate matching of a motor to its application (UR8 model only).

The drive is fully protected against damage caused by overheating and by short-circuits across motor connections or to earth. Additional protection circuitry monitors the voltage rails within the drive and disables the power switches if these fall outside the specification.

Inputs are provided for directional limit switches and each axis may be disabled independently.

The power supply card has a built-in power dump circuit which permits full four-quadrant operation.

Summary of Features

Protection Circuits

a) Adjustable current limit
b) Overcurrent
c) Overtemperature
d) Overvoltage
e) Output short circuit
f) Logic supply fault
g) Logic supply fuse
h) Motor supply fused on each axis

Function Indicators

a) Axis overcurrent
b) Axis overtemperature
c) Logic supply present
d) Motor supply high
e) Motor supply present
f) Supply failure

Adjustments

a) Signal gain
b) Tachometer gain
c) Balance
d) Time constant
e) Current limit

Outputs and Inputs

a) Reset
b) Axis disable
c) Programmable gain
d) Directional limit switches

Other Features

a) Power dump
b) Euro rack system

Options

a) Additional motor supply capacitor
b) High wattage dump resistor
c) Dual-voltage sub-rack
d) Three or eight axis sub-rack

NOTE: All options are factory set options, although (a) and (b) can be retro-fitted using kits available from the manufacturers.

Specification

Peak motor current (per axis)	+/- 5A (UD2), +/- 12A (UD5)
Max. continuous motor current (per axis)	+/- 2A (UD2), +/- 5A (UD5)
Typical motor supply voltage	70v DC
Absolute maximum motor supply voltage	75v DC
Minimum motor supply voltage	24v DC
Minimum recommended load inductance	0.5mH
Torque amplifier bandwidth	>2500Hz
Switching frequency	20kHz
Form factor	Better than 1.01
Pre-amp gain	0 - 2500 v/v
Power gain	1 A/v (UD2), 2.4 A./v (UD5)
Deadband	Zero
Gain linearity	+/- 4%
Typical input amplifier drift	10µV/°C
Current limit adjustment	Zero to peak motor current
Power dump current	6A at 100 volts
Power dump max. continuous power (standard) (with supplementary resistor)	 25W * 80W
AC supply inputs: (a) Motor supply (b) Logic supply	20 to 50v RMS 50-60Hz 18-0-18v RMS 50-60Hz
Auxiliary DC output	24v DC unregulated at 500mA
Ambient temperature range	0 - 50°C *
Dimensions: 3 Axis system (3U/42HP) 5 Axis system (3U/84HP)	269w x 133h x 252d mm (10.6 x 5.2 x 9.9ins), 483w x 133h x 252mm, (19.0 x 5.2 x 9.9ins)
Weights: UD2	0.3Kg (0.7 lbs)
UD5	0.4Kg (0.9 lbs)
UR3 + power supply	2.4Kg (5.3 lbs)
UR8 + power supply	4.0Kg (8.8 lbs)

* Fan cooling may be required

Note: A single voltage, 8-axis sub-rack can accept either a single or a three phase input. A dual voltage 8-axis sub-rack can only accept two single-phase inputs. The 3-axis sub-rack will only operate from a single-phase input.

Variant Information

There are two alternative sub-racks available for UD series drives.

The UR3 sub-rack can accommodate up to three drives together with a power supply card. All drives operate from the same motor supply voltage.

The UR8 sub-rack accommodates up to eight drives and a power supply card. This sub-rack can be supplied in either single or dual motor supply versions. A dual supply sub-rack can be identified by a break in the main HV1 rail and a track cut next to the HV1 pillar. The position of the breaks depends on the number of drives connected to the HV1 and HV2 supplies, and this is indicated by a number to be found adjacent to the HV1 rail break. 2/6 would indicate 2 drives at HV1 and 6 drives at HV2. Any combination of high and low voltage drives can be configured, the HV1 drives being located next to each other and closest to the power supply card.

Both the UR3 and UR8 sub-racks can be populated with any combination of UD2 and UD5 drives. The UD5 can be identified by the addition of a heatsink fitted with two metal-cased resistors.

IMPORTANT. A dual-voltage rack is intended to be operated with HV1 as the higher of the two supplies and HV2 as the lower. When connecting a dual-voltage system, always ensure that HV1 is greater than or equal to HV2 AT ALL TIMES, even in the event of a supply protection device operating. See 'Dual-voltage sub-rack - supply protection requirement' for further details.

CHAPTER 2. INSTALLATION

Installation

UD Series drives must be installed by competent personnel familiar with the installation, commissioning and operation of motion control equipment.

The drive system should be installed in an area where there is adequate ventilation above and below the sub-racks. The UR8 sub-rack can be mounted in a standard 19" cabinet. In some applications involving high duty cycles, ventilation fans and/or additional dump resistors may be required. Ensure the drive 0V and transformer screen are earthed. In the final application the equipment must be enclosed to prevent the operator coming into contact with any high voltages. This includes the transformer, drive and motor terminations.

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 should be provided in the final installation.

Connector Identification

The motherboard is fitted with two connectors behind each axis card for signal and motor connections. These are identified by a number such as PL2A or PL5B. The number refers to the axis position, and A or B indicates a motor or signal connector. References in this manual are general and do not relate to specific axis positions, so a typical reference would be "PLA pin 2".

Single-voltage Supply Connection

Figs. 1 & 2 show a typical connection scheme for a basic single-axis system using a single voltage sub-rack. Obviously additional control connections may be required.

Dual-voltage Supply Connection

Fig. 3 shows a similar scheme, but using a dual voltage sub-rack. As with the single voltage rack, additional control connections may be required.

Dual-voltage Sub-rack - Supply Protection Requirement

Note that when using a dual voltage sub-rack, the supply to the HV1 connections must ALWAYS be equal to or greater than the supply to the HV2 connections. Failure to comply with this requirement will result in damage to the unit. This applies at all times, even under fault conditions, therefore fuses should be arranged to ensure that the HV2 supply is removed in the event of operation of HV1 supply protection.

Motor AC Supply Connection

The motor supply will be derived from an isolating transformer and the voltage will depend on the application. The isolating transformer may be single phase or, in the case of a UR8 single-voltage chassis, either single phase or three phase. In either case the transformer should be rated for the total loading. This clearly depends on the duty cycle but would be typically 25-50VA per axis for the UD2 and 60-150VA per axis for the UD5. A fuse should be fitted in the primary circuit suitably rated for the AC supply and the transformer loading.

If an alternative transformer is used it must have an earthed screen between the primary and secondary windings and the insulation rating between primary and secondary should be adequate to ensure safety (minimum of 2300V AC rms).

For mains wiring, use approved mains cable of at least 0.75mm^2 CSA, taking care to keep all mains wiring away from all secondary and signal wiring. Ensure that the transformer terminations are suitably enclosed to prevent operator contact. either by fitting a suitable cover or enclosing the transformer within a housing. Note: low power secondaries must be separately fused with an in-line fuse in the wire close to the transformer. The fuse value should be approximately twice the current rating of the secondary winding being used (with a time delay characteristic).

Connections between the transformer secondary and the rack should not be made until the appropriate point in the setting-up procedure is reached.

The transformer secondary is connected to M5 screw terminals on the back of the sub-rack. In the case of a single-voltage 8-axis rack, both pairs of terminals are used in parallel for single-phase working, i.e. one side to L1/L3 and the other to L2/L4. Three terminals are used for three-phase working as shown in Fig. 4. In the case of the dual-voltage rack the connections are made to L1 and L2 (HV1), and to L3 and L4 (HV2) as indicated in Fig. 3.

Primary Fuse Ratings

Primary fuses need to be rated to protect the transformer and secondary wiring from short circuit faults whilst withstanding the primary in-rush current at power up.
The value of fuse required is given by:

$$\frac{15 \times VA}{\text{supply volts}} \quad \text{in amps}$$

Fuses need to be of the anti-surge high breaking capacity type, which have a limited range of values, consequently you may need to select the next highest standard value rather than the calculated value. For example, a 700VA transformer used with a supply of 240V will require a 4.4A fuse, consequently the next highest standard value of 5A will need to be selected. Note: If the live wire cannot be readily identified, fuse both phase conductors.

Disconnect Device

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.

Environmental Considerations

The drive system should be operated in the temperatures range 0 to 50C° (32 to 122°F) and at a relative humidity between 0 and 95% (non-condensing). Make sure the system is stored in temperatures from -40°C to 85°C (-40°F to 185°F).

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

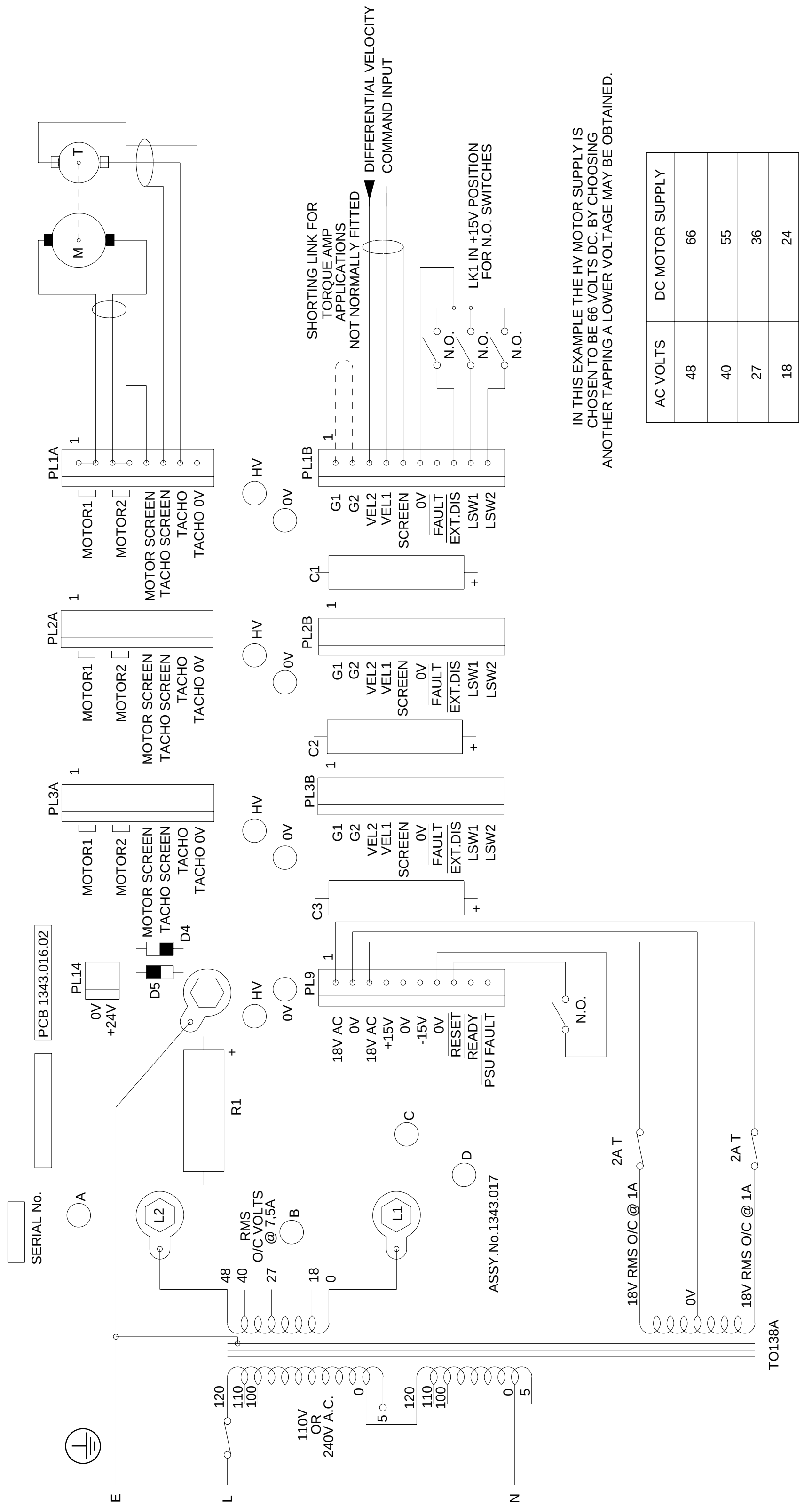

Figure 1. Customer Connections for UR3 DC Drive Rack (3-axis)

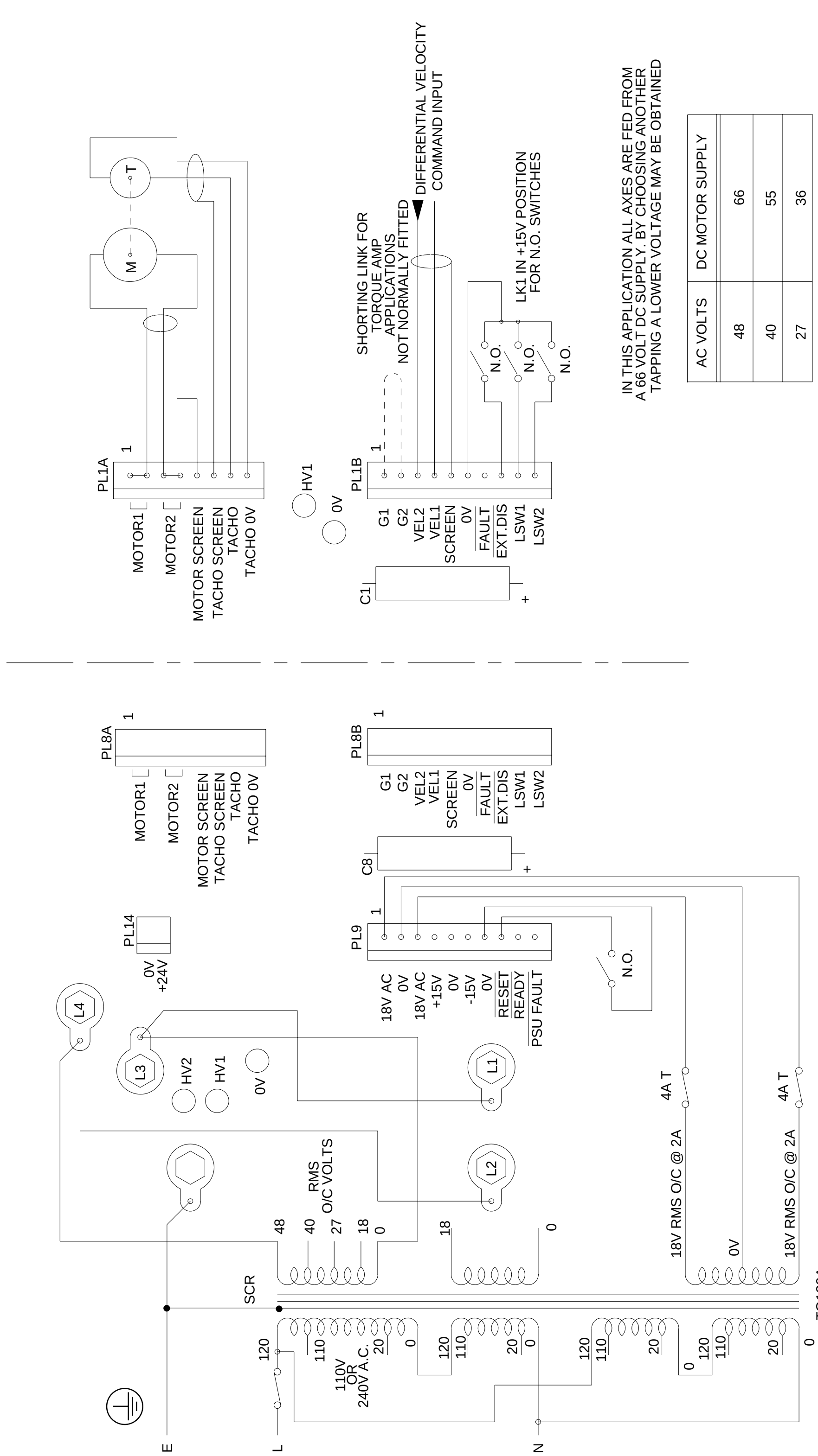

Figure 2. Customer Connections for UR8 DC Drive Rack Single Motor Supply & Single Phase

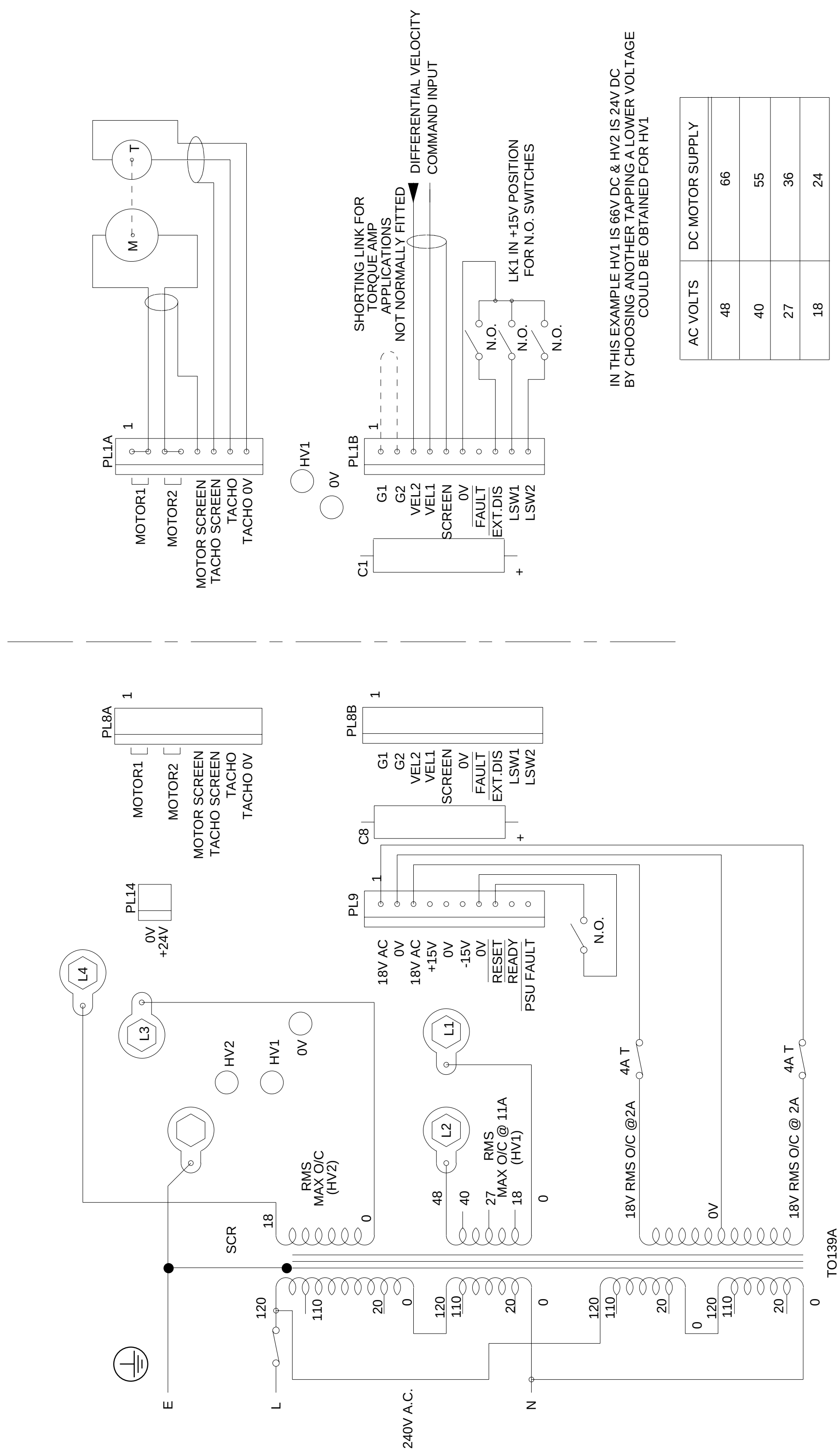

Figure 3. Customer Connections for UR8 DC Drive Rack Dual Motor Supply & Single Phase

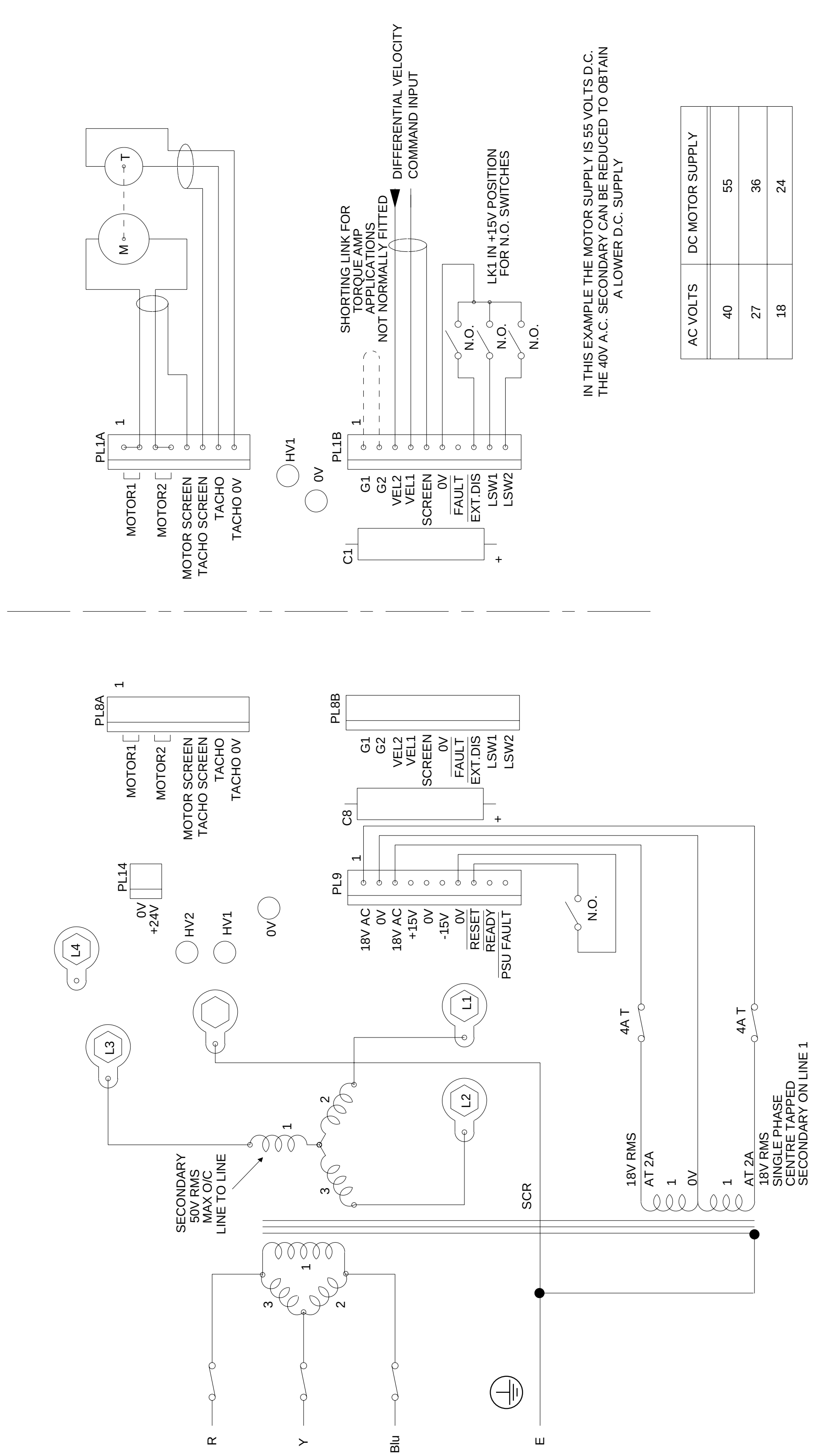

Figure 4. Customer Connections for UR8 DC Drive Rack Single Motor Supply & 3 Phase

When connecting up a dual-voltage chassis note that the utmost care must be taken to ensure that the HV1 supply is never lower than the HV2 supply. See 'Dual-voltage sub-rack - protection requirement'.

NOTE: When using one transformer to power more than one sub-rack, a separate secondary winding is required for each rack. Similarly when using one transformer to power both the HV1 and HV2 supplies of a dual-voltage system, a separate secondary winding should be used for each supply.

Logic Supply

Connect using a minimum wire size of 16/0.2mm (20 AWG).

An 18v-0-18v RMS AC Supply is required to power the logic circuitry. This should be an isolated secondary winding with a minimum rating of 50VA.

Connections are made to PL9 pins 1, 2 and 3 (18v-0-18v respectively).

Fuse Ratings

UR3:		
Drive fuses	FS1-3	5A QA HBC (UD2) 10A QA HBC (UD5)
HV fuses	FS4,5	16A TD HBC
18v fuses	FS6,7	2A TD LBC
UR8:		
Drive fuses	FS1-8	5A QA HBC (UD2) 10A QA HBC (UD5)
HV fuses	FS9,10,13,14	16A TD HBC
18v fuses	FS11,12	2A TD LBC
QA = quick-acting TD = time delay		
HBC = high breaking capacity LBC = low breaking capacity		

Motor Connections

Check motor inductance and if necessary add an additional series inductor to meet the minimum requirement of 0.5mH.

Connect using a wire size appropriate to the continuous rated motor current. Connections should be made to PLA MOTOR 1 and MOTOR 2. Each motor terminal has two pins, and both should be used where a UD5 is fitted.

To reduce the effect of radiated electrical noise it is suggested that the motor leads and the supply leads be run as twisted pairs, or as screened cable. It is also advisable to keep the motor and power leads away from the signal leads.

Check all connections carefully but DO NOT apply power to the drive before first reading the setting-up procedure.

Signal Connections

Signal connections should be made with a minimum wire size of 7/0.2mm (24 AWG), using the crimp terminals provided. A suitable tool is Molex part no. 11-01-0026 (HTR-2445-A).

Screened cable should be used for all signal inputs, and care should be taken to ensure that the screen is grounded at one end only.

Control Signals

Signal Input PLB Pins 3 and 4

The signal from the control source is connected to this input. Nominal signal range is +/- 10 volts, and the input impedance is 20K.

Tachometer Input PLA Pins 7 and 8

The input from the tachometer is connected to pin 7 with the return on pin 8.

Input impedance of this input is also 20K, and again the nominal signal range is +/- 10 volts. Maximum input signal is +/- 60 volts.

Limit Switch Inputs PLB Pins 9 and 10

These inputs are used to reduce the motor current to zero. They should be connected to mechanical switches having a low "on" resistance or to open-collector transistor outputs.

They can be used to avoid axis overtravel by preventing further motion in the inhibited direction.

Limit switch 1 is on PLB pin 9 and inhibits a positive voltage on PLA pins 1 and 2 with respect to PLA pins 3 and 4, this is equivalent to inhibiting a positive signal on VEL1 with respect to VEL2.

Limit switch 2 is on PLB pin 10 and inhibits a negative voltage on PLA pins 1 and 2 with respect to PLA pins 3 and 4, this is equivalent to inhibiting a negative signal on VEL1 with respect to VEL2.

External Disable PLB Pin 8

The relevant axis will be enabled when this input is high and disabled when the input is low. The input resistor is pulled high or low by the position of LK1 (see 'Limit polarity link'). With LK1 in the 0v. position, the input must be connected to +15v to enable the drive. The motor shaft will be free to rotate whilst the drive is disabled, but it should not be rotated at high speed as this may damage the power dump circuitry.

+/-15v Auxiliary Outputs PL9 Pins 4 and 6 (Pin 5 is 0v.)

Up to 40mA may be drawn from the UR8 or 400mA from the UR3 to power external circuitry.

24v DC Unregulated

A 24v DC unregulated output is made available to power customer circuits, and appears on connector PL14. Ensure that the maximum current taken from this supply does not exceed 500mA.

Velocity Amp Input PLB Pin 2

This input can be used to control the gain of the velocity amp by connecting a resistor between PLB pins 1 (G1) and 2 (G2). The internal gain is set to 6000 Amps/volt (UD5) and 2500 Amps/volt (UD2) with no resistor connected. The gain reduces to 6 Amps/volt (UD5) and 2.5 Amps/volt (UD2) with a short circuit.

The amplifier can be made to function as a torque amplifier by applying a short circuit between these two pins. The SIG GAIN potentiometer can now be used to control the gain so that a given signal voltage will cause a controlled amount of current (and therefore torque) to be produced.

Note that G1 and G2 are particularly susceptible to noise pickup, and great care should be taken if these are taken out to a control system.

Reset Input PL4 Pin 8 (Power Supply Card)

This input can be used either to reset the drive in the event of a fault, provided the fault has been located and rectified, or to disable all axes simultaneously.

However, it should be noted that it must be taken low for a minimum period of 0.5 second. Pin 7 on the same connector is 0v.

Limit Polarity Link

LK1 determines whether the Limit Inputs are normally pulled up or pulled down. If LK1 is fitted in the 0v. position then the inputs are pulled down 0v. requiring normally-closed limit switches returned to +15v. This method is "fail safe" because switch failure, or the breaking of the wire to the switches, will disable the drive.

If LK1 is fitted in the +15v position then the inputs are pulled up to +15v. Normally-open limit switches returned to 0v. are then required. This method is not "fail safe" but does allow the use of open collector outputs from a control device.

Protection Circuits

General

The drive is extensively protected against overloads, short circuits and other conditions likely to cause damage. Operation of the protection circuits is indicated by LEDs on the power supply and axis cards.

Faults detected on the power supply card result in all axes being disabled. A short circuit across a pair of motor terminals is detected on the relevant axis card and results only in that card being disabled.

All faults are latched and may be reset, once the cause of the fault has been corrected, either by temporarily disconnecting the mains supply or taking the Reset input low for at least 0.5 second. This input is on PL9 pin 8. Pin 7 of the same connector is 0v.

Power Supply Card LED 1 (Lowest Position)

Illumination of this LED indicates that the motor supply has reached a peak of above 100v DC. This condition is most likely to occur if excessive regeneration is taking place which may also cause the power dump fuse to fail. Should this be the case, it will usually be necessary to fit an alternative power dump resistor which is available from the manufacturers.

Power Supply LED 2

Illumination of this LED indicates a failure of the HV+7v rail which is internally generated on the power supply card.

Power Supply LED 3

Non-illumination of this LED indicates that either the +15v or the -15v supplies have fallen below 13.5v (typical). This may be because the auxiliary output is too heavily loaded by external circuitry, or can be the result of an internal failure.

Power Supply LED 4 (Top Position)

Illumination of this LED indicates that the motor supply is present, and above 30v (approx). It may remain illuminated after the motor supply has been switched off, but the intensity will decrease as the power supply capacitors are discharged.

Axis Card LED 1 (Top Position)

Illumination of this LED indicates a short circuit across the two motor terminals or a short to ground.

Axis Card LED 2

Illumination of this LED indicates overtemperature on that drive card.

CHAPTER 3. SETTING UP THE DRIVE

Initial Precautions

1. Try to ascertain polarity of motor and tachometer as this will remove the danger of runaway. If the polarity is known, the following information will enable the correct motor and tachometer connections to be made.

A positive input signal on VEL1 with respect to VEL2 will result in a positive voltage on MOTOR 1 with respect to MOTOR 2, and this should result in a negative tachometer voltage on PLA pin 7 with respect to PLA pin 8.

If this information is not available, then be prepared for the possibility of runaway.

2. Ensure that the motor mechanism is clear of obstructions. Ensure also that the motor is at the mid-position of its total travel (i.e. if there is a lead screw, check that it is at its mid-position).

3. BEFORE connecting the a.c. motor supply leads, measure the secondary voltage(s) from the isolating transformer. These should not exceed 50v AC at the nominal AC input voltage.

4. On multi-axis systems, work on only one axis at a time. To avoid confusion, disconnect axes that have not yet been set-up and disable axes that have been set-up. Connect a DC Ammeter in series with the motor, set to the correct range for the drive.

Setting-up Procedure

This procedure should be repeated for each axis, bearing in mind the comments in 'Initial precautions' number 4.

(a) Rotate the SIG GAIN control fully clockwise, and the other four controls fully anticlockwise. Then turn the TAC GAIN control approximately six turns clockwise.

(b) Apply zero velocity demand to input.

(c) Switch on the logic supply to the drive, and check that no fault LEDs are illuminated.

(d) Connect up the motor supply/supplies and switch on.

(e) SLOWLY rotate the I LIMIT control clockwise until the motor starts to rotate. If the motor starts to accelerate towards full speed, then switch off the motor supply and check that the TAC GAIN control has been rotated by at least six turns clockwise. If it has, reverse the tachometer connections. If, because of system earthing and screening criteria, it would be inconvenient to change the tachometer connections, then reverse the motor connections. Don't change the tachometer connections as well as the motor connections.

Switch on again and the motor should now rotate slowly.

(f) Adjust the balance control until the motor shaft rotates towards the positive limit. Check that the motor stops when the limit switch operates. If it fails to stop, remove power and reverse the limit switches. When power is re-applied, further movement should be prevented. Now rotate the BALANCE control in the opposite direction and check operation of the negative limit switch. Return the axis to the centre of travel, and stop motion using the balance control. Speed of return can be increased by reducing the TACHO gain.

(g) If the value of peak current is known, then this should be set up next by locking the motor shaft and rotating the I LIMIT control clockwise until the desired current is measured on the ammeter. This should be carried out as quickly as possible to avoid the motor and drive overheating. To assist in setting up if no ammeter is available, five turns clockwise gives approximately 50% peak current, 10 turns gives approximately 75% peak current. If the motor runs very hot in service it may be necessary to reduce the current limit setting.

(h) Rotate the TIME CON control clockwise until the motor shaft starts to oscillate, then turn back sufficiently to stop the oscillation. Failure of the system to break into oscillation is not a problem, it usually means that the system has a high mechanical resonant frequency.

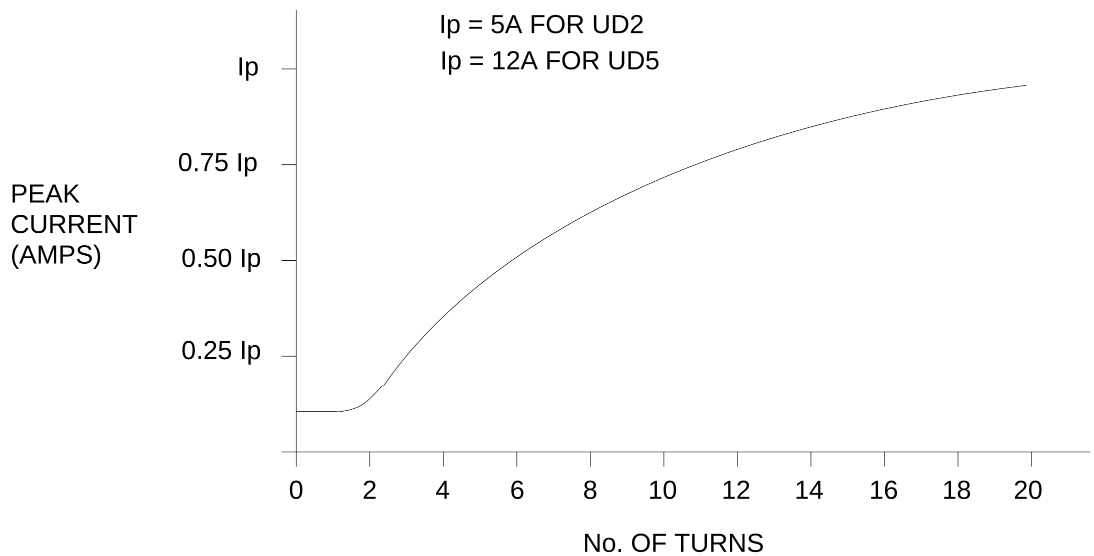

Figure 5. Relationship Between I LIMIT Control and Current

(i) Periodically apply and remove the input signal (i.e. apply a step signal to the input), noting the response of the system. Adjust the TAC GAIN control to give the shortest settling time without overshoot (ignore the fact that the final speed also changes). It may also be necessary to turn the TIME CON control a little further anticlockwise if oscillation can still be heard when the motor is moving, i.e. it sounds rough.

If the control system will not permit this method of control, remove the signal connections and use a separate DC power source, i.e. a battery or a DC power supply to provide the signal.

(j) Increase the signal gain or input signal to run the motor at high speed (not full speed) and check for smooth behaviour. If there are still signs of roughness try turning the TIME CON control anticlockwise or try reducing the TAC GAIN. To optimise the response it is necessary to connect an oscilloscope to the Tach signal input (PLA pin 7), the waveforms in Fig. 6 will help to indicate the required correction. Use a small input signal when observing these waveforms.

(k) Remove the input signal and readjust the balance control if necessary

(l) Finally set the SIG GAIN to give the correct speed for a given input signal.

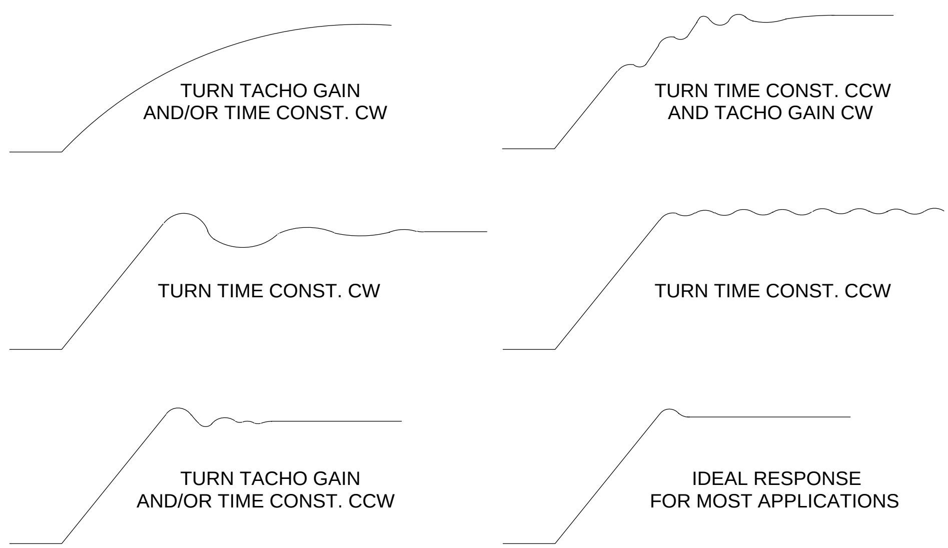

Figure 6. Tacho Signal Waveforms

CHAPTER 4. OPERATION

Theory of Operation - Axis Card

(Refer to schematic diagram Fig 7.)

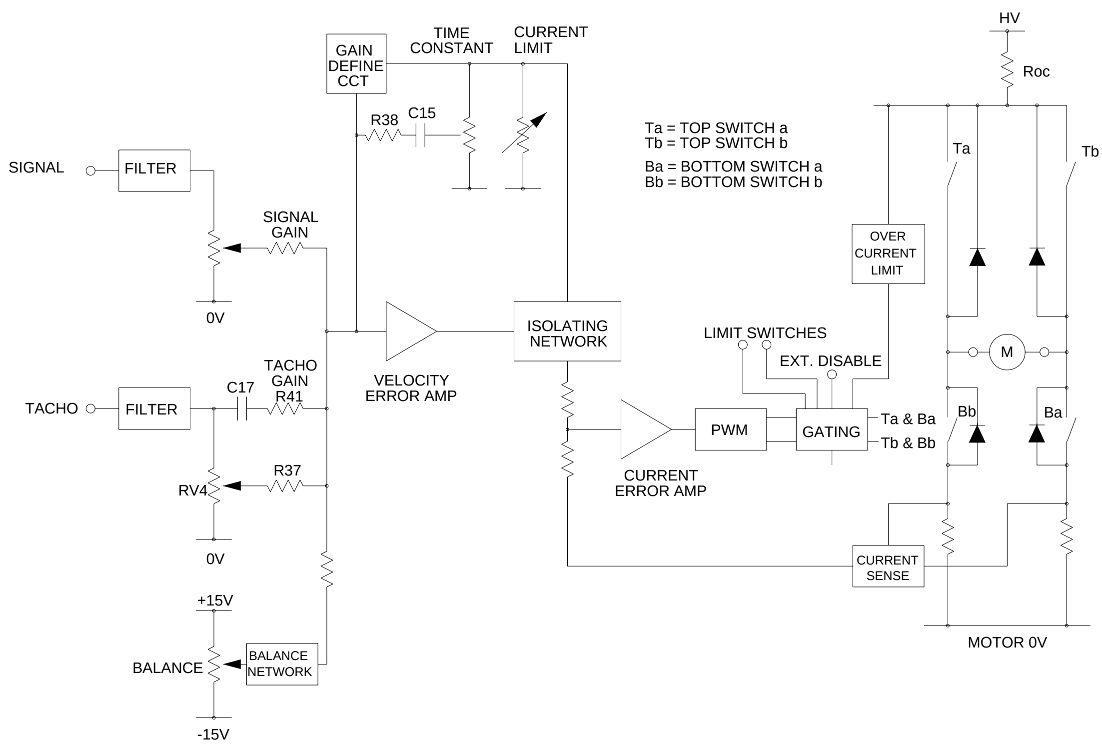

Figure 7. Axis Card Schematic

The axis card contains all the necessary circuitry to control a DC Servo Motor. It must be used in conjunction with a Power Supply card as this generates all the necessary voltages and includes the required monitoring circuitry.

It can be used with a simple analogue signal source (e.g. a potentiometer), a DC Servo Motor and a tachometer. Wherever possible the tachometer should be rigidly coupled to the motor, as flexible couplings will result in instability.

Output Stage

The output stage accepts the signals from the gating section (see 'Gating') and allows the flow of current in the required direction through the motor windings.

It consists of an H-bridge where the top and bottom switches are controlled in a diagonal formation i.e. the top right hand switch is turned on at the same time as the bottom left hand switch for current flow between MOTOR 1 and MOTOR 2, the converse being true for current flow in the opposite direction.

When the current has reached the desired level, the top switch will turn off, but the diagonal bottom switch will remain on. This provides a low-loss recirculative loop around the bottom half of the H-bridge, i.e. one bottom switch and one bottom recirculating diode conducting.

Both the top and bottom switches utilise active pull-off to minimise switching times. There is a certain amount of charge stored in the base of the transistor, and the switch cannot turn off completely until all this charge has gone. Using active pull-off extracts the charge quickly and this results in faster switching times.

Input Section and Velocity Error Amplifier

The velocity demand input consists of a filtered differential input amplifier with a gain of 0.5, which avoids saturation of the amplifier even with inputs up to 24v. The resultant signal is passed to the summing point of the velocity error amplifier.

The tachometer input also passes through a filter network to a potentiometer, then through an R-C network which provides a feed-forward function. This improves the system response to speed variations. Once again the resultant signal is passed to the summing point of the velocity error amplifier.

The velocity error amplifier then algebraically sums the signal input, the tachometer input and the balance control input, and produces at its output a velocity error signal.

The feedback network around this amplifier is in two parts. The TIME CON control and associated components (C15 and R38) form the a.c. feedback network and determine the response time of the velocity error amplifier. The gain defining network (RP3 and R35) determines the d.c. gain of the velocity error amplifier.

The I LIMIT control does not operate directly on the output of IC1, but via an isolating network which allows the I LIMIT control to clamp the velocity error signal anywhere between +5v and ˆ5v (approximately).

Current Error Amplifier

The clamped output of the velocity error amplifier is then algebraically summed with the current feedback signal to determine the current error. There is a bi-directional zener diode clamp around this amplifier to provide a fast slew rate by preventing the output stage of the amplifier from saturating.

Pulse Width Modulator

The current error is compared with a triangular waveform to determine the switching sequence for the output stage.

The output of the P.W.M. circuit comprises two signals defining which of the output transistors will be on, and for how long. This determines both the direction and rate of acceleration of the motor shaft.

Gating

This circuit combines the output of the P.W.M. circuit with the external disable signal, the enable/disable from the power supply card and the output of the overcurrent detector. This circuit therefore determines whether a request for current from the P.W.M. circuit can be allowed to proceed further.

Current Sense

The current sense circuit consists of two resistors in the current path, the voltage developed across the resistors being proportional to the current flowing.

The voltage across the two resistors is fed into a filtered differential amplifier to minimise the effects of noise and to allow calibration of the current feedback information.

If current is being injected into the load, or back into the motor supply rail (i.e. during regeneration), current will only be flowing in one sense resistor. When current is flowing in the recirculative mode around the bottom half of the H-bridge, it flows through two sense resistors. This leads to double the magnitude of the current feedback information being available. A 'half gain' circuit is introduced when this condition exists, thus providing correct current information.

The resulting waveform is fed to the current error amplifier.

Overcurrent Detector

All current supplied from the motor supply rail passes through a low-value sense resistor. The voltage developed across this resistor is referenced to the motor supply rail, so it is fed to a circuit that references it to 0v. This voltage is then compared to reference voltage and if it is greater, a latch is set, the axis is disabled and LED 1 is illuminated.

The latch may be reset either by temporarily removing the logic supply to the drive, or by taking the RESET input on PL4 pin 8 low for at least 0.5 second.

Theory of Operation - Power Supply Card

(Refer to schematic diagram Fig.8)

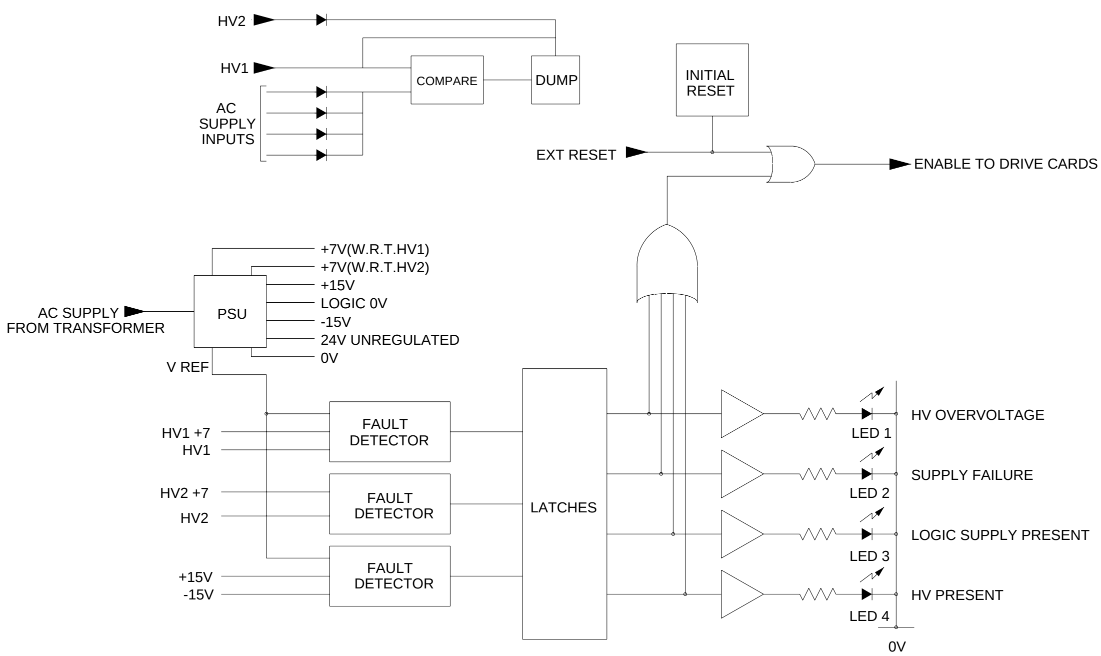

Figure 8. Power Supply Card Schematic

The same power supply card is used on both the single and dual voltage sub-racks.

This card comprises the power supply, fault logic and power dump circuitry. It generates all the voltages required to drive the axis cards, provides the supply rails for the active pull-off, monitors the power supply rails for faults and operates the power dump circuit in the event of excessive regeneration.

Logic Supply

The logic supplies are generated by taking the 18v-0-18v RMS supply, rectifying, smoothing, and regulating it via the two regulators. These supplies are used internally in the power supply card, and also made available on PL9 which is on the motherboard.

A 5.1 volt reference is also generated and this is used by the fault detection circuitry.

Active Pull-off Supply Generation

Two 7v DC (approx) supplies are also generated on this board. The negative of each supply is connected to one of the two HV rails, thus creating the HV1+7v and HV2+7v pull-off rails.

Fault Monitoring

The motor supply is monitored by comparing it (via a potential divider) with the 5.1v reference. If it exceeds a value determined by the potential divider then a latch will be set, LED 1 will be illuminated and the enable will be removed from all the axis cards.

The presence of the pull-off supply is also detected, since absence of these supplies during operation will seriously damage the unit. If they are not present then a latch is set, LED 2 is illuminated and the enable will be removed from the axis cards.

Both the positive and negative Logic Supply rails are monitored by comparing them (via a potential divider) with the 5.1v reference, and if either of them falls below predetermined values set by the potential dividers then a latch is set, LED 3 is extinguished and the enable is removed from the axis cards.

Enable/Reset Circuitry

The PSU FAULT (PL9 pin 10) is the result of OR-ing the fault latches on the Power Supply card, and is low when a fault occurs. It may be used to drive external circuitry, and can sink a maximum of 100mA.

The READY signal (PL9 pin 9) is itself the OR function of three signals, the RST signal from PL9 pin 8, an INTERNAL FAULT signal and the PSU fault signal which ensures that all fault latches are reset at power-on. The power-on reset signal also allows for all supply rails to be established before the axis cards are enabled.

Power Dump Circuit

This circuit is a standard feature on the UD system and ensures that the motor supply rail does not rise excessively during regeneration. It does this by comparing the actual supply rail value with a "calculated" value. This calculated value is obtained simply by rectifying the incoming AC Motor Supply rails. When the actual value exceeds the calculated value by a preset amount, then a dump resistor is switched into circuit to dissipate the excess energy. The circuit also discharges the HV capacitor at power-down.

As mentioned in 'Single-voltage supply connection', excessive regeneration may cause LED 1 to be illuminated or even cause the dump fuse to blow. Fitting an external alternative dump resistor provides for a greater power dissipation. In addition the manufacturers can supply a power supply card which has an increased dump capacity which must be used with the external dump resistor.

CHAPTER 5. TROUBLESHOOTING

General

In order to minimise field failures all UD drives are soak tested at elevated temperatures. In spite of this the occasional failure may still occur, and the following notes are intended as a brief guide to enable the cause of the fault to be located.

Module Removal and Replacement

Removal of axis cards and power supply cards from the sub-rack is easily achieved by removing the front panel and unplugging the module. Ensure that all supplies are switched off, and allow time for the supplies to collapse.

Power Supply Card

The majority of faults that can occur on this card will result in illumination of one or more of the LEDs, fault diagnosis on this card will therefore be listed under the relevant LED.

LED 1 (Red): Lowest Position

Failure of the dump circuit to cope with regeneration may result in this LED being on. Check if the fault occurs during a period of deceleration, if so then consult manufacturers regarding increasing the dump capability. Ensure that the supply rail normally has a value of less than 75V DC.

Check the dump fuse.

LED 2 (Red)

Check the drive fuses, FS1 to FS3 on UR3 racks and FS1 to FS8 on UR8 racks. These fuses are fitted on the inside of the motherboard and are accessible by removing the axis cards (see 'Module removal and replacement').

If the active pull off rail is missing then this LED will be on. Confirmation of this can be obtained by removing all the axis cards. Switch on the logic supply and the HV supply, if LED 2 is still illuminated then the power supply card is probably faulty. To confirm the cause, remove the power supply card and replace with another. If the fault is no longer apparent, then it is the power supply card that is at fault and it should be returned for repair.

LED 3 (Green)

Non-illumination of LED 3 indicates a logic supply fault, and checks should first be made that excessive current is not being drawn from the +/-15v auxiliary outputs (PL9 pins 4 and 6). The maximum permitted load is 400mA (UR3), or 40mA (UR8). Check also that the 18v-0-18v AC supply is not low due to the 24v unregulated supply being overloaded (maximum 500mA).

If neither of these is the cause of the fault indication, then the fault would appear to lie with either an axis card or with the power supply card itself. To eliminate the cards which are not responsible proceed as follows:

(a) Switch off all supplies and allow time for the supplies to collapse.

(b) Remove all axis cards.

(c) Switch on the logic supply ONLY.

(d) If LED 3 is still not illuminated then the fault lies with the power supply card.

(e) If it is, then the problem lies with one of the axis cards and the faulty card can be discovered by repeating the procedure, with each axis card connected in turn.

(f) It is possible that these tests will show that it is the number of axis cards connected that causes the fault, in which case the fault lies with the power supply card.

LED 4 (Green)

This LED indicates that HV is present. It will remain illuminated for a short time after HV has been switched off, because of the stored charge in the capacitors.

Axis Card

Faults associated with the axis card will either result in the illumination of the Overcurrent LED, or the Overtemperature LED.

Overcurrent LED Illumination

This LED will be illuminated in the event of a short circuit occurring between the motor terminals. It may also occur if either terminal is shorted to earth, either by arcing from the brushes or by a more direct connection.

If no external reason can be found then further tests will be necessary to establish the exact cause. Switch off all supplies, then remove the associated motor connections from the motherboard. Switch on the Logic Supply and then the Motor Supply. If the Overcurrent fault LED is now illuminated then the axis card is at fault and should be returned to the manufacturers for repair. It may be necessary to request motion in either direction to obtain the fault. If the LED does not come on then additional checks can be carried out with an ohmmeter.

Switch off all supplies and remove the suspect axis card. Using the ohmmeter check between each of the motor supply connections and each motor terminal (2a and c and 4a and c on the axis card edge connector). The reading should either be a high impedance or the equivalent of one diode voltage drop. Reversing the polarity of the ohmmeter leads should result in a similar set of readings, but if the first reading was high impedance then the reading with the polarity reversed will be a diode voltage drop. If this is not the case, i.e. either a short circuit, or a diode voltage drop is obtained in both cases, then one or more of the transistors in the H-Bridge is damaged and the axis card should be returned for repair.

If previous tests have not enabled the fault to be isolated then substitution of the cards should enable the fault to be narrowed down to one card which can then be returned for repair.

Overtemperature LED Illumination

This LED indicates an overtemperature fault. It may be the result of an axis card fault, which can of course be proved by substitution. If this does not identify the fault then checks should be made to ensure that the ambient temperature does not exceed 50°C, when all units in the vicinity of the drive have reached their normal operating temperature. A cooling fan may be necessary if high duty cycles are required.

Incorrect Operation

Noise from Motor or Unstable Motor Operation

This is usually caused by TAC GAIN or TIM CON controls being turned too far clockwise. Re-adjustment of either of these two controls should cure this, but if not then check that the motor-to-tachometer coupling is not defective. If none of these checks has isolated the problem then substitution of cards should be used to prove whether or not the axis card is at fault.

Motor Runaway

This can be caused either by the tachometer connections being broken, by them being reversed, or by the TAC GAIN control being turned too far anticlockwise. First turn the TAC GAIN control clockwise to ascertain whether this cures the fault. If not then check the leads for integrity and if the fault persists reverse the connections. If none of these steps cures the fault then substitution of modules can be used to prove if the axis card is faulty.

No Movement in One Direction

Check that there is no mechanical reason for the inability to move in one direction. Check also that the limit switch inputs (PLB pins 9 and 10) are not low as this will prevent movement in one direction.

If these checks do not locate the fault, then substitution of the module may prove if the axis card is faulty.

Motor Creep

This is usually caused by an incorrect setting of the BALANCE control, so first check this setting by turning the SIG GAIN control fully clockwise and confirming that there is zero velocity command on VEL1 and VEL2 inputs. Then adjust the BALANCE control until the motor shaft is stationary.

Ensure that any unused signal inputs are grounded to avoid pickup, and that all signals are supplied in twisted pairs or screened cables.

If none of these steps resolves the problem then, once again, try substitution of the axis card to prove if the module is at fault.

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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