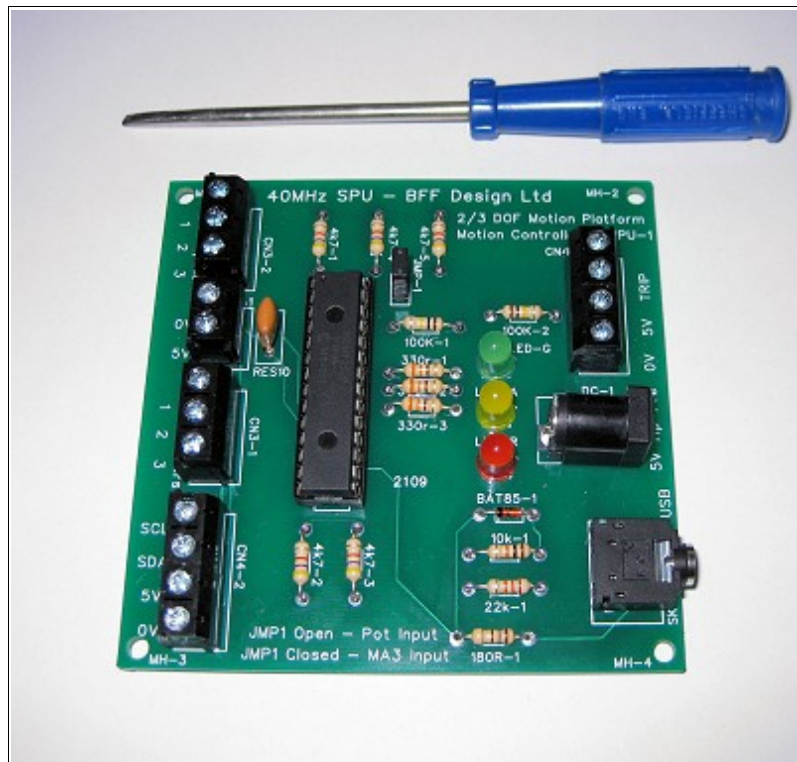# BFF Design Ltd - 40MHz Signal Processor Unit - 40SPU-1

The 40SPU-1 Signal Processor Unit is designed for use with the BFF PID Servo Controller software as part of a DIY motion platform closed loop position feedback PID servo control system. V2.5 or later of the PID Servo Controller and v2.4 or later of the BFF Motion Driver software are required. For details of a typical overall system arrangement see the illustrative System Wiring Diagram at the end of this document.

IMPORTANT – THE 40SPU-1 IS INTENDED FOR USE AS PART OF A PROPERLY PROTECTED CLOSED LOOP SERVO DRIVE. IF YOU USE THE 40SPU-1 YOU MUST ENSURE YOUR DRIVE IS FULLY PROTECTED AGAINST UNCONTROLLED MOTOR DRIVE IN THE EVENT OF WIRING, COMPONENT OR OTHER FAULTS OCCURRING IN YOUR SYSTEM. THIS IS ESPECIALLY IMPORTANT IN HOME-BUILT SYSTEMS. THE 40SPU-1 HAS A NUMBER OF BUILT IN SAFETY CUTOFF FEATURES, HOWEVER IT CAN NOT DETECT ALL FAULT EVENTS THAT MIGHT OCCUR IN A SYSTEM. YOU MUST FIT OVER-TRAVEL CUT-OFF SWITCHES TO CUT ELECTRICAL POWER TO THE MOTOR CONTROLLERS IN THE EVENT OF ACTUATOR OVER-TRAVEL. YOU MUST ALSO FIT ONE OR MORE EMERGENCY STOP SWITCHES IN OBVIOUS AND ACCESSIBLE POSITIONS WHICH ALSO CUT ELECTRICAL POWER TO THE MOTOR CONTROLLERS.

NEVER MAKE ANY WIRING OR CONNECTION ADJUSTMENTS WHEN THE SERVO DRIVE IS ACTIVE AND THE 40SPU-1 IS OPERATING. ALWAYS POWER DOWN THE SYSTEM BEFORE MAKING ANY ADJUSTMENTS.

1. 40SPU-1 Features

- I2C data output for use with Devantech MD03 motor speed controllers (I2C 400KHz Baud).

- 2 or 3 channel output for 2 or 3 DOF motion systems.

- Selectable Potentiometer (10 bit) or MA3 Digital Encoder (12 bit) position feedback.

- Built-in fast smoothing on the potentiometer feedback to reduce signal noise.

- Built-in "Pause Output" trip loop.

- 40MHz chip speed giving up to 50Hz control loop refresh speeds (PC and connection dependent).

- Direct connection to PC USB or Serial port (physical serial port recommended for fastest speeds). 115200 baud serial comms.

- LED status and error indicators.

2. Connections and Settings

Refer to photo -

A) CN3-2 - Feedback potentiometer wipers. Use good quality 10K linear pots. The +ve direction of the pots should match the +ve direction of rotation of the drive motors, otherwise the motor drive will be unstable.

B) 0V & 5V supply for the feedback pots or encoders – conveniently located beside the feedback signal connections. DO NOT drive other electrical equipment from the 5V connection on the 40SPU-1 board.

C) CN3-1 – Feedback signals from US Digital MA3 absolute position encoders. Only the 12bit PWM MA3 encoder types are supported – 10bit PWM and analogue types are NOT supported.

D) CN4-2 – I2C outputs to the Devantech MD03 motor speed controllers. The 0V and 5V connections can be used for the logic supply to the MD03's. Note the I2C bus wire lengths must be kept to less than approximately 300mm. The MD03 controllers must be set to the correct I2C addresses (Actuator 1 – 0xB0, Actuator 2 – 0xB2, Actuator 3 – 0xB4, see your MD03 documentation for the correct dip switch settings for this). Your normally closed actuator end-of-travel limit switches and an Emergency Stop switch MUST be wired in series in the 5V line to the MD03's to power-down the controllers if the actuators over-stroke or an emergency stop is required. To make your motion platform drive failsafe it is essential that the logic supply voltage to the motor controllers is cut when over travel conditions occur. Alternative emergency cut-of arrangements can be considered, however it is essential that if loss of motion control is suffered for whatever reason then the drive to the motors is cut. This is best achieved by limit switches that are physically triggered by the over travel.
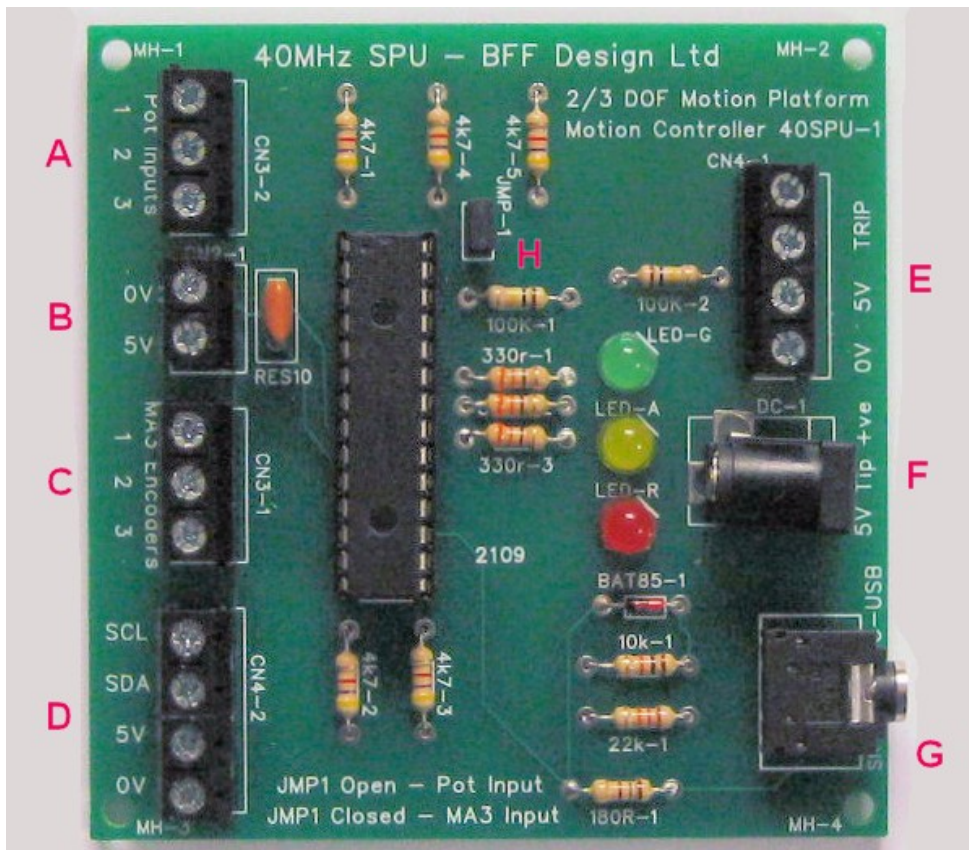
E) CN4-1 – Upper connection pair is a normally closed pause switch loop. If this loop goes open the drive to the motors is cut by the 40SPU-1 and the red and green LEDS flash together. A "Pause Output" switch can be wired in this loop. If you don't use a Pause switch then you must wire a short loop between the connectors to disable the trip detection.   CN4-1 – Lower connection pair provides alternative 0V and 5V power in connections for the board – see F) below for important comments on the logic power supply.

F) DC-1 – Power-in connector to suit 2.1mm power plugs – tip +ve. The board supply must be a REGULATED 5V DC supply of at least 500mA capacity. An unregulated voltage or inadequate current capacity may result in voltage dips which can cause the board's IC to drop out or the MD03's to mis-function. The board circuit includes a 100µF capacitor to stabilise the 5V lines however there is a limit to the level of protection this can give in the face of an irregular logic supply voltage. NOTE the board is not fitted with inverted polarity protection – not not reverse the polarity of the supply. It is recommended that the logic supply is separate from the main motor power

supply. Do not connect other electrical equipment to the 5V connections on the board as this might introduce disruptive voltage spikes or dips which can affect the 40SPU-1 function.

G) G – Stereo jack socket for PC connection. You MUST use either a PICAXE AXE027 USB download cable or a AXE026 Serial download cable. In my testing the AXE026 Serial cable results in noticeably faster refresh speeds than the USB cable connection however it requires a physical COM port installed on your PC – Serial PCI cards are not expensive. The USB download cable connects to a USB port to communicate through a "virtual" serial port installed by the cable drivers – these drivers should be provided with your AXE027 cable or downloaded from the PICAXE web site. NOTE neither cable is included with the 40SPU-1 purchase – you must supply your own.

H) JMP-1 – Input select jumper. OPEN for potentiometer feedback input to CN3-2 or CLOSED for MA3 encoder feedback to CN3-1. SUPPLIED CLOSED, SO REMOVE THE JUMPER LINK TO USE POTENTIOMETER FEEDBACK.

3. IMPORTANT - BFF PID Servo Controller Software Settings

Individual drive channels can enabled or disabled, and reads and writes to the I2C bus can be completely disabled through the settings in the PID Servo Controller's PID2.cfg configuration file.

Line 29 of the PID2.cfg file contains an 8bit binary entry and the enable/disable settings are made by altering the individual bits of the binary number.

EG Line 29 will look something like: 00111111   where bit7 is the leftmost or MSB and bit0 is the rightmost or LSB. The bit designations are:

Bit7 (MSB)   - I2C Write Disable, =0 enable, =1 disable

Bit6   - I2C Read Disable, =0 enable, =1 disable

Bit5   - Channel 1 enable, =1 enable, =0 disable

Bit4   - Channel 2 enable, =1 enable, =0 disable

Bit3   - Channel 3 enable, =1 enable, =0 disable

Bit2   - MA3 Encoder 1 Direction Reverse, =1 normal, =0 reverse

Bit1   - MA3 Encoder 2 Direction Reverse, =1 normal, =0 reverse

Bit0 (LSB)   - MA3 Encoder 3 Direction Reverse, =1 normal, =0 reverse

If you are using MD03 current and temperature monitoring and/or MA3 Encoder position feedback it is necessary to disable any channels that are not in use in your system. EG if you have a 2 DOF platform drive in which channel 1 is not used then set bit5=0 etc. Otherwise the encoder pulse-in measurement made by the board's IC on the channel 1 feedback will timeout and the control loop refresh speed will slow to a crawl. This setting will also disable any read attempts to a MD03 controller not present in the system which could also disrupt the 40SPU-1 operation.

Bit6 – If you are testing your comms with no MD03 controllers connected to the 40SPU-1 the I2C reads to those controllers should be disabled. Also a small speed performance gain may be obtained in full operation if the I2C reads are disabled completely. To do this set bit6=1. If you do this the MD03 controller current and temperature monitoring on the PID Servo software will be disabled.

Bit7 (MSB) – If required the I2C writes to the MD03 speed controllers can be completely disabled. This is particularly useful for testing purposes as it allows the full two-way comms between the 40SPU-1 and the PC to the checked without risk of activating the physical drives. To disable the I2C writes set bit7=1.

Bits0-2 – The direction of +ve feedback from MA3 encoders can be reversed by altering these bits, set =0 to reverse the MA3's default +ve direction. NOTE the +ve direction of MA3 output can not be altered by reversing the 0 and 5V supply as with a potentiometer.

BAUD Setting

Line 28 of the PID2.cfg file contains the baud rate setting for the serial comms to the 40SPU-1. This must be set to 115200 for the 40SPU-1 to operate.

For other BFF Servo Controller set up information (eg PID settings and system tuning) see the BFF Motion Driver User Manual.

4. Operation and LED Sequences

Make any settings required to the PID2.cfg config file – see section above.

Set the correct COM port number in the motion driver .bff configuration file you are using (parameter Port=COM?).

Ensure all connections are made and secure on the 40SPU-1 and the jumper setting is as required. Power-up the 40SPU-1 before starting the BFF PID Servo Controller software. When the 40SPU-1 powers-up the Amber LED will come on followed by 2 or 3 flashes of the Green LED. 2 Green flashes indicate potentiometer feedback is selected, 3 flashes indicate MA3 encoder feedback is enabled. The Amber LED will light and the 40SPU-1 will command zero speed from the MD03's and wait for data from the PC.

With the BFF Motion Driver v2.4 (or later) running on your PC start the PID Servo Controller software. If the comms are operational and the 40SPU-1 is receiving data it will flash the Amber LED once and then make three flashes to indicate the status of each channel – red for disabled, green for enabled. So for example Amber then Green – Green – Red indicates channels 1 and 2 are enabled and channel 3 is disabled. If all channels are disabled the Red and Green LED's will flash together to indicate an error.

Full comms between the PID Servo Controller and the 40SPU-1 should then commence and the Green LED should be seen flickering at the servo loop refresh speed – at the higher refresh speeds the flickering may be difficult to discern.

Subsequent Error Codes are:

Occasional Amber "blinks" – these indicate solitary serial-in timeouts detected by the 40SPU-1. The 40SPU-1 will react to sustained timeouts by closing the drive to the motors – see next item. However it is programmed to ignore single short timeouts and try again immediately to receive data from the PC. You may notice these solitary timeout events are more common when using the USB download cable, on my systems they are very rare when using a physical serial port connection. Comms timeouts of duration longer than 150 ms will cause the motor drive to be cut.

Red LED Flashing (with intervening green/ & amber flickers) – Sustained time-out (> 150 ms) on serial-in, the comms between the PC and 40SPU-1 have been interrupted. This is usually because the PID Servo Software has been closed or has stopped sending data. The green & amber flickers show the 40SPU-1's further attempts to receive data – the unit will try to re-establish comms and will pick-up normal operation when the PID Servo Controller software re-starts. The unit is programmed to be sensitive to loss of comms between it and the PC, this is to ensure as far as is possible that the drive to the motors is cut if communications with the controlling PC software is interrupted or lost.

The unit may have to be powered down & back up and the PID servo Controller software restarted if repeated successive comms interrupts occur.

Red and Amber LEDs Flashing – received serial data corrupted. Or more likely, an active feedback channel has gone to its high or low limit (eg for wiring disconnect). Drive will be cut and remain cut. Check the feedback device wiring and connections and trace the fault before reseting the 40SPU-1. NOTE the 40SPU-1 is not able to detect a disconnect in the potentiometer wiper lines but can detect loss of 0 or 5V supply to the pots and loss of signal pulse from MA3 encoders.
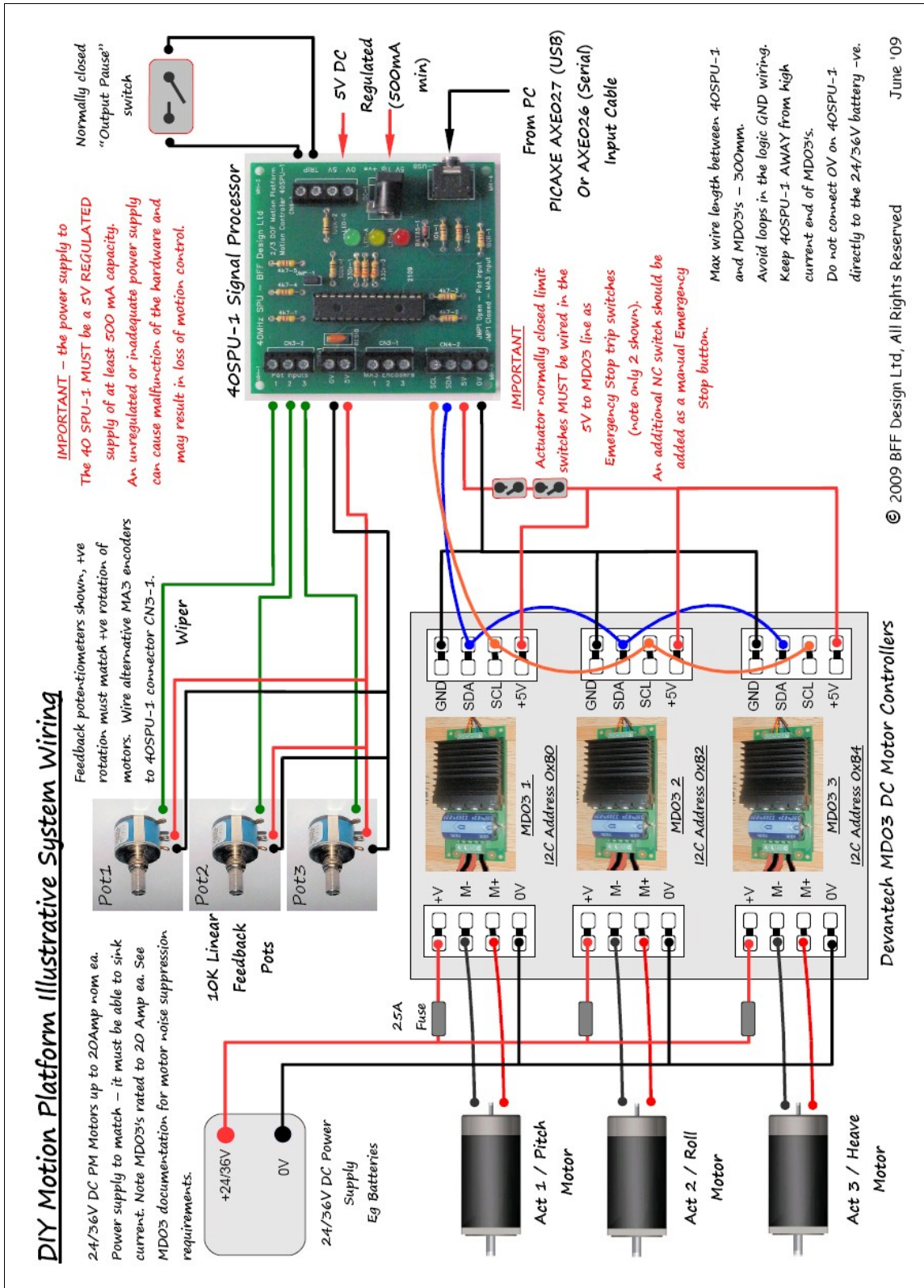

Red and Green LEDs Flashing (after the initialization sequences) – Trip loop has been opened. Normally due to a Pause Output switch being tripped (opened). If you are not using this trip loop then you may have forgotten to wire a short loop between the two trip connectors on CN4-1. Close the loop to return to normal operation.

5. Important Notes

Please read all of this data sheet thoroughly before using the 40SPU-1.

1. Note that v2.4 or later of the BFF Motion Driver software and v2.5 or later of the BFF Servo Controller Software are required for the 40SPU-1 to operate.

2. The safety of your motion platform drive system should be foremost in your mind as you build and operate your platform. Carefully consider the limit switch requirements discussed in section 2. D) above. Carefully consider the provision of prominent and accessible Emergency Stop buttons/switches.

3. Never make any wiring or connection adjustments when the servo drive is active and the 40SPU-1 is operating. Always power down the system before making any adjustments.

4. Carefully consider the 5V power supply requirements described in section 2. F) above. An inadequate or unregulated 5V power supply will cause problems with the 40SPU-1 function.

5. Do not power other electrical equipment from the 40SPU-1 power connections. Also, use a dedicated battery supply for the MD03 motor speed controllers driven by the 40SPU-1 card. If other equipment is also supplied by the battery supply and that equipment is connected to the same PC by its own USB or serial connection then a ground loop can be formed. This can induce large currents to flow through the 40SPU serial/USB cable which will disrupt the communcations and potentially damage the card.

6. Ensure all connections to the feedback potentiometers or encoders are absolutely secure. Erratic feedback signals can be caused by intermittent connections on any of the feedback device power or signal lines, and erratic feedback positions will cause the servo drive to react erratically. Loss of position feedback when the drive is in operation may result in fast drive to the actuator end stops. The 40SPU-1 includes some feedback signal loss detection on MA3 encoder input and due to loss of 0V or 5V connections to the potentiometers. However this will not protect from erratic feedback due to loose connections in the potentiometer wiper lines or from some types of intermittent wiring faults. Make sure all connections and wiring are secure.

7. During your initial system set up and testing set the I2C Write Disable bit (bit7) in the PID2.cfg to 1 to disable all writes to the MD03 speed controllers – as described in section 3 above. This will allow you to check your system wiring, position feedback function, comms etc without activation of the drive motors. Alternatively remove the main power fuses to ensure no power is available for the motors.

8. It is recommended that initial set up and testing of the servo drive hardware and system be undertaken with the drive actuators mechanically disconnected from the motion platform. This will allow the stability of the electric motor motion output to be assessed without risk of damage to the platform.

9. On testing I have found that the best servo drive performance is obtained using US Digital MA3 absolute position encoder input for position feedback and connection to a physical Serial "COM" port on the PC. The MA3 encoders exhibit lower noise levels than potentiometers and allow sharper gains to be used in the PID Servo Controller settings. The Physical COM port connection appears to allow faster servo loop refresh speeds than comms through the USB "virtual" COM port and these higher loop speeds also improve the motion quality. Note that only the 12bit PWM MA3 encoder types are supported and that they have a single turn 360 degree electrical travel – not the multi-turn capability of some potentiometers. This may affect the physical location of their fitment on the platform.

Typical Overall System Wiring

DIY Motion Platform Illustrative System Wiring

24/36V DC PM Motors up to 20Amp nom ea. Power supply to match – it must be able to sink current. Note MDO3's rated to 20 Amp ea. See MDO3 documentation for motor noise suppression requirements.

Feedback potentiometers shown, +ve rotation must match +ve rotation of motors. Wire alternative MA3 encoders to 4OSPU-1 connector CN3-1.

10K Linear Feedback Pots

Pot1 Pot2 Pot3

Wiper

40SPU-1 Signal Processor

Normally closed "Output Pause" switch

5V DC Regulated (500mA min)

From PC PICAXE AXEO27 (USB) Or AXEO26 (Serial) Input Cable

IMPORTANT – the power supply to The 4O SPU-1 MUST be a 5V REGULATED supply of at least 500 mA capacity. An unregulated or inadequate power supply can cause malfunction of the hardware and may result in loss of motion control.

IMPORTANT

Actuator normally closed limit switches MUST be wired in the 5V to MDO5 line as Emergency Stop trip switches (note only 2 shown). An additional NC switch should be added as a manual Emergency Stop button.

Max wire length between 4OSPU-1 and MDO3's – 300mm. Avoid loops in the logic GND wiring. Keep 4OSPU-1 AWAY from high current end of MDO3's. Do not connect 0V on 4OSPU-1 directly to the 24/36V battery -ve.

June '09

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GND SDA SCL +5V

MDO3 1
I2C Address OxBO

MDO3 2
I2C Address OxB2

MDO3 3
I2C Address OxB4

Devantech MDO3 DC Motor Controllers

+V M- M+ 0V

2.5A Fuse

+24/36V   0V

24/36V DC Power Supply Eg Batteries

Act 1 / Pitch Motor

Act 2 / Roll Motor

Act 3 / Heave Motor

Ian Hopper (BFF Design Ltd), Data Sheet Rev 1.1