Federal Communication Commission Interference Statement

This equipment has been tested and found to comply with the limits for a class B digital device, pursuant to part 15 of the FCC rules, these limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications, however, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one of the following measures:

- **Reorient or relocate the receiving antenna.**
- **Increase the separation between the equipment and receiver.**
- **Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.**
- **Consult the dealer or an experienced radio/TV technician for help.**

FCC Caution: Any changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate this equipment.

USER MANUAL

MCT8000/8100/8200 Series Motion Controllers: Hardware

Version 1.00

By Shenzhen Motion Control Technology Co., Ltd

Shenzhen Motion Control Technology Co., Ltd
1806Rm Highway Hub Management and Control Center
Zhuzilin, Shennan Rd, Futian District
Shenzhen 518040, P.R. China
Phone: (86)(755)3168525
Fax: (86)(755)3168521
URL: www.moxin.com

Using This Manual

This user manual provides information for proper operations of the MCT8000 series motion controllers.

A separate manual, ***MCT8000/8100/8200 Series Motion Controllers: Software Environment***, contains a description of the commands and functions available for use with these controllers.

Your motion controller has been designed to work with all the motor systems including DC servo, AC servo and stepper motor systems. To meet with your application requirements, appropriate software environments must be setup and configured. Please refer to ***MCT8000/8100/8200 Series Motion Controllers: Software Environment*** for details.

WARNING: Machinery in motion can be dangerous! It is the responsibility of the user to design effective error handling and safety protection as part of the machine system. MCT shall not be liable or responsible for any incidental or consequential damages.

Contents

Chapter 1 Overview

1.1 Introduction

The MCT8000/8100/8200 series motion control cards may be directly connected to PC-based computer using an ISA/PCI bus slot or a USB hub depending on the specific controller you selected. The MCT8000 series controller cards can be installed directly into an ISA bus slot, whereas the MCT8100 into a PCI bus slot. The MCT82000 series controller cards can be connected directly to an USB hub. Using newly developed DSP and FPGA technology, these controller series offers many enhanced features including high speed communications, faster encoder speeds, and improved cabling for EMI reduction. By specific design, all MCT8000/8100/8200 can run with or without host computer. And with the help of MCT8000 software package, the system can run in stand alone or internet mode. Please refer to a separate manual "*MCT8000/8100/8200 Series Motion Controllers: Software*

Environments" for details.

The MCT8000/8100/8200 series motion controllers provide two high speed dual-port rams communication channels with one for sending and receiving commands and another for data transmission between host and the controller. This gives instant access to status and parameters of the controller while the program is running. The controllers allow for high speed servo control up to 17 million encoder counts/sec and step motor control up to 3 million steps per second. Sample rates as low as 10us per axis are available.

A 2 meg Flash EEPROM provides non-volatile memory for storing application programs, parameters, arrays, and firmware. New firmware revisions are easily upgraded in the field without removing the controller from the host. As an option, the firmware may be stored into an one meg EPROM.

The MCT8000/8100/8200 is available with up to eight axes on a single ISA card. The MCT8000/2, MCT8000/4 two thru four axes controllers are on a single 7.6" x 3.9" card and the MCT8000/6, MCT8000 six thru eight axes controllers are on a single 8.7" x 3.9" card. The MCT32000, *motion controller with 32 axes on a single ISA/PCI card*, will also be available soon. Ask MCT Customer Service Center for details.

Designed to solve complex motion problems, the MCT8000/8100/8200 can be used for applications involving jogging, point-to-point positioning, vector positioning, electronic gearing, multiple move sequences, and contouring. The controller eliminates jerk by programmable acceleration and deceleration with profile smoothing. For smooth following of complex contours, the DMC8000/8100/8200 provides continuous vector feed of an infinite number of linear and arc segments. The controller also features electronic gearing with multiple master axes as well as gantry mode operation.

For synchronization with outside events, the MCT8000/8100/8200 provide uncommitted I/O, including 24 programmable digital inputs , 8 digital outputs, and 8 analog inputs for interface to sensors, and pressure transducers. Dedicated optoisolated inputs are provided on MCT8000 controllers for forward and reverse limits, abort, home, and definable input interrupts. Additional software is available to autotune, view trajectories on a PC screen, translate G-code files into motion, and create powerful, application-specific operator interfaces with JAVA. Drivers for Windows 95, 98, and NT are available.

1.2 Overview of Motor Types

The MCT8000/8100/8200 can provide the following types of motor control:

1. Standard servo motors (DC or AC) with +/- 10 volt command signals,
2. Standard servo motors (DC or AC) with step and direction signals,
3. Brushless servo motors with sinusoidal commutation,
4. Step motors with step and direction signals,
5. Other actuators such as hydraulics - For more information, contact MCT.

The user can program each axis for any combination of motor types, providing maximum flexibility.

1.2.1 Standard Servo Motor with +/- 10 Volt Command Signal

The MCT8000/8100/8200 achieves superior precision through use of 12-bit DACs and a sophisticated PID filter that features velocity and acceleration feedforward, an extra pole filter, and integration limits. The controller is configured by the factory for standard servo motor operations. In this configuration, the controller provides analog signal (+/- 10Volt) to connect to servo amplifiers.

1.2.2 Brushless Servo Motor with Sinusoidal Commutation

The difference between Standard Servo Motor and Brushless Servo Motor is that brushless servo motors need sinusoidal commutation. Many amplifiers, however, generate the sinusoidal commutation signals for the brushless servo motor. In this case, the brushless servo motor can be treated just like brush-type or standard servo motors.

1.2.3 Stepper Motor with Step and Direction Signals

The MCT8000/8100/8200 can control stepper motors. In this mode, the controller provides two signals to connect to the stepper motor: Step and Direction. For stepper motor operation, the controller does not require an encoder and operates the stepper motor in an open loop fashion. Appendix I describes the proper connection and procedure for using stepper motors.

1.3 System Elements

As shown in Figure 1.1, the MCT8000/8100/8200 is part of a motion control system which includes amplifiers, encoders and motors. In the following sections we will give you a rush description of these elements. There several application examples in Appendix I in this manual will also help you to understand these elements.

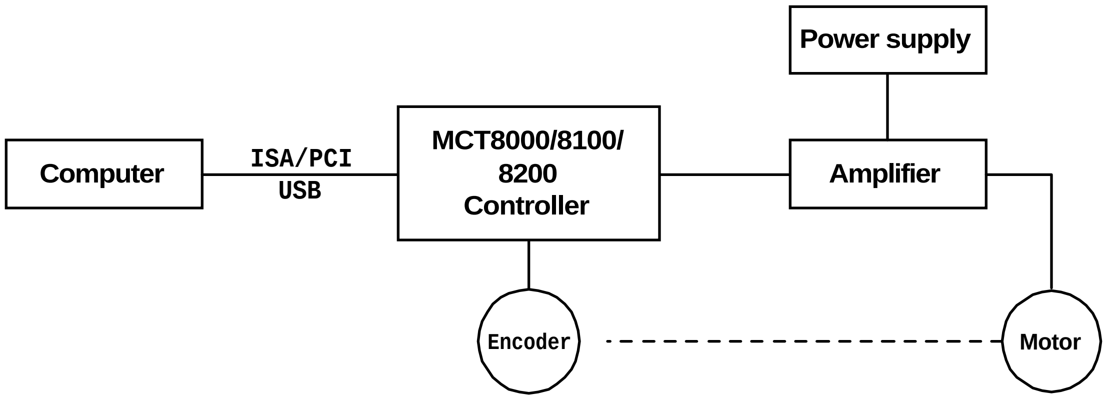


Figure 1.1 System Elements of a Typical Motion Control System

1.3.1 Motor

A motor converts current into torque which produces motion. Each axis of motion requires a motor sized properly to move the load at the required speed and acceleration. MCT's engineer can help you with motor sizing. Contact MCT Customer Service Center at 86-755-3168520 if you need technical support.

The motor may be a step or servo motor and can be brush-type or brushless, rotary or linear. For step motors, the controller can be operate full-step, half-step, or microstep drives. An encoder is not required when step motors are used.

1.3.2 Amplifier

For each axis, the power amplifier converts a +/-10 Volt signal from the controller into current to drive the motor. For stepper motors, the amplifier converts step and direction signals into current. The amplifier should be sized properly to meet the power requirements of the motor. For brushless motors, an amplifier that provides electronic commutation is required. The amplifiers may be either pulse-width-modulated (PWM) or linear.

They may also be configured for operation with or without a tachometer. For current amplifiers, the amplifier gain should be set such that a 10 Volt command generates the maximum required current. For example, if the motor peak current is 10A, the amplifier gain should be 1 A/V. For velocity mode amplifiers, 10 Volts should run the motor at the maximum speed.

1.3.3 Encoder

An encoder translates motion into electrical pulses which are fed back into the controller. The MCT8000/8100/8200 controller board accepts feedback from either a rotary or linear encoder. Typical encoders provide two channels in quadrate, known as CHA and CHB. This type of encoder is known as a quadrate encoder. Quadrate encoders may be either single-ended (CHA and CHB) or differential (CHA,CHA-,CHB,CHB-). The controller decodes either type into quadrate states or four times the number of cycles. Encoders may also have a third channel (or index) for synchronization.

There is no limit on encoder line density, however, the input frequency to the controller must not exceed 4250,000 full encoder cycles/second (17,000,000 quadrate counts/sec). For example, if the encoder line density is 10000 cycles per inch, the maximum speed is 425 inches/second, or, 648meters/minutes. If higher encoder frequency is required, please consult the MCT Customer Service

Center.

The standard voltage level is TTL (zero to five volts).

The MCT8000/8100/8200 can accept analog feedback (using ADC channel) instead of an encoder for any axis.

To interface with other types of position sensors such as resolvers or absolute encoders, MCT can customize the controller and command set. Please contact MCT to talk to one of our application engineers about your particular system requirements.

1.4 System Architecture Overview

The MCT8000/8100/8200 motherboard built around the Texas Instruments TMS320C31 floating-point Digital Signal Processor (DSP). It contains 128K Word memory fast enough to allow zero wait state operation. Several peripheral sub-systems are implemented to support a wide range of digital signal processing applications. Figure 1.2 shows a block diagram of the MCT8000/8100/8200 controller board.

The TMS320C31 supports a total memory space of 16M 32-bit words including program, data and I/O space. All off-chip memories and I/Os can be accessed by the host even while the DSP is running thus allowing easy system setup, on-line monitoring and controls.

The MCT8000/8100/8200 hardware is designed for flexible use at minimum program overhead by implementing functions in hardware otherwise often by software. The host interface of MCT8000 and MCT8100 contains a high speed bi-directional Dual Port Ram which can be accessed from both the DSP and the host computer. For the MCT8200, a Universal Serial Bus (USB) interface chip is added to the board to provide a more efficient and flexible communication between the host and the DSP. With the USB device, the MCT8200 controller can be plugged in anytime, even when the host computer is powered on.

By specific design, all MCT8000/8100/8200 can run with or without the host computer. And with the help of MCT8000 software package, the system can run in stand alone or internet mode. Please refer to a separate manual "*MCT8000/8100/8200 Series Motion Controllers: Software Environments*" for details.

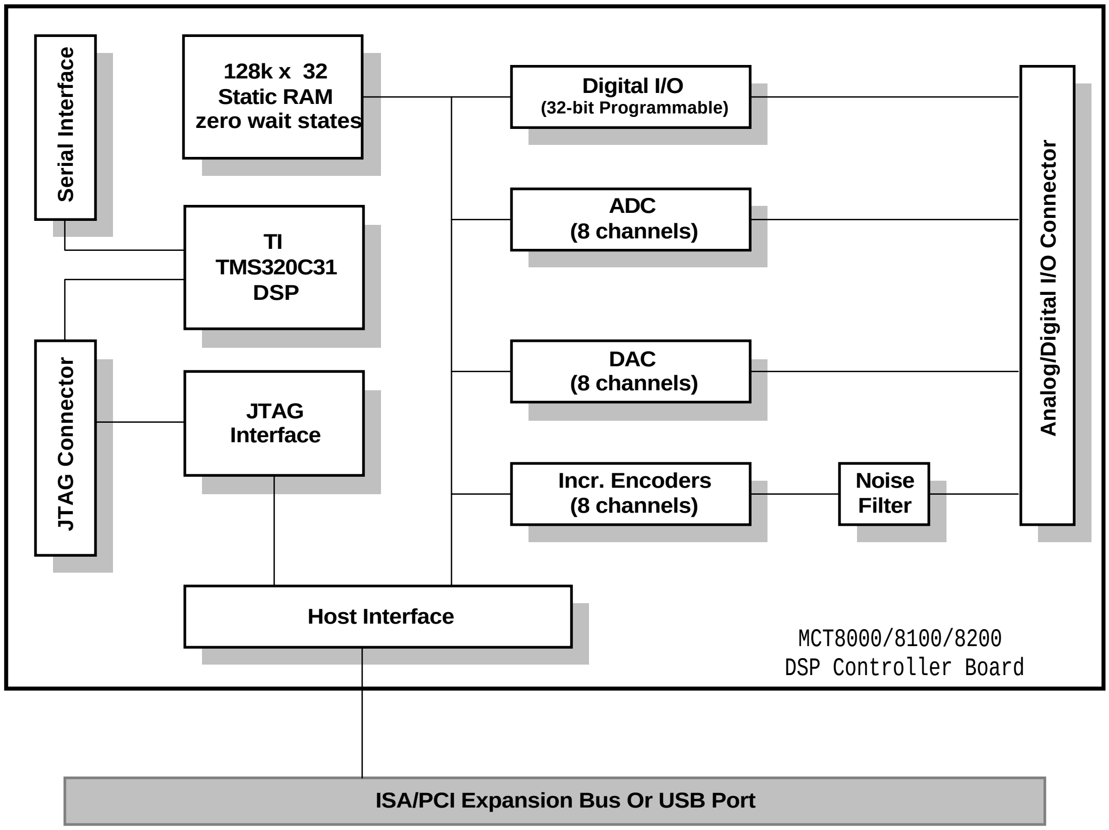


Figure 1.2 System Architecture Overview

1.5 Applications

The MCT8000/8100/8200 series motion controllers are specifically designed for development of high-speed multivariable digital controllers and real-time simulations in various fields as

- Electro-mechanical positioning systems,
- Electrical drive technology,
- Noise and vibration control,
- Demonstration systems, such as the inverted pendulum,
- Servo-hydraulics,
- Robotics,
- NC Machine Tools,
- AC and DC servo motors,
- Linear motors,
- Three-phase induction motors,
- Positioning systems and step motors,
- Active vibration control,

and is also well suited for general digital signal processing and related tasks. Integrated with MCT8000 software package, you could easily set up a web-based monitoring and control system which may used for many remote sensing, monitoring, and on-line control cases.

Chapter 2 Installation of MCT8000/8100 Controller Board

2.1 Handling Precautions

The MCT8000/8100 controller board contains devices sensitive to electrostatic discharge (ESD). Before unpacking the MCT8000 controller board precautions must be taken to avoid application of any high electrostatic voltage. Discharge yourself and all material the board comes in contact with by proper grounding. During storage or handling the board should be placed on conductive foam or in protective bag. Do not touch the gold connectors of the board and do not connect or disconnect any devices while power is applied. Remove power from the host before plugging or unplugging the MCT8000/8100 controller board.

2.2 Host Requirements

The MCT8000/8100/8200 controller board may be used in any IBM-PC/AT or compatible personal computers. For MCT8000 it takes up one Industry Standard Architecture (ISA) bus slot. The MCT8100 takes up one Peripheral Component Interconnect (PCI) bus slot. And MCT8200 needs only a free USB hub. For proper operation of the MCT8000/8100/8200 the following conditions must be met:

- The host computer power supply must deliver an additional 1.2 Amp. On the 5 Volt line and 100mA on the +12 Volt lines.
- The unused expansion 16-bit I/O ports must be available in the 1K host I/O space.

If you are not sure that your computer meets these requirements consult your computer technical reference manual or ask your dealer. If you are still in doubt contact MCT Customer Service Center before proceeding.

2.3 Settings on MCT8000 Controller Board

The MCT8000 controller Board will need to be installed in an available ISA bus slot after the base address has been selected and settings have been done on the board. The first order of business is to select an appropriate base address for the board by a 4-bit switch named K3. Table 2.1 indicates a memory map related to different settings of this 4-bit switch. The factory default setting is 0x300 as shown in Figure 2.1. You must use the current available I/O ports in your host system as your base address selection. If the system fails to start or your application program can not be downloaded with MCT program loader, simply pick a new I/O port location indicated in Table 2.1 and try again. This location can be manually changed without re-booting the computer system.

Next, the DSP external interrupt lines $\overline{\text{INT0}}$ through $\overline{\text{INT3}}$ need to be selected for system boot-loader by a 4-bit switch named K2. For technical reason, this switch must

Table 2.1 Base I/O Port Address Selections

K3-bit4	K3-bit3	K3-bit2	K3-bit1	Base Addr. Selected	Remark
ON	ON	ON	ON	0x200	
ON	ON	ON	OFF	0x220	
ON	ON	OFF	ON	0x240	
ON	ON	OFF	OFF	0x260	
ON	OFF	ON	ON	0x280	
ON	OFF	ON	OFF	0x2a0	
ON	OFF	OFF	ON	0x2c0	
ON	OFF	OFF	OFF	0x2e0	
OFF	ON	ON	ON	0x300	Factory Default Setting
OFF	ON	ON	OFF	0x320	
OFF	ON	OFF	ON	0x340	
OFF	ON	OFF	OFF	0x360	
OFF	OFF	ON	ON	0x380	
OFF	OFF	ON	OFF	0x3a0	
OFF	OFF	OFF	ON	0x3c0	
OFF	OFF	OFF	OFF	0x3e0	

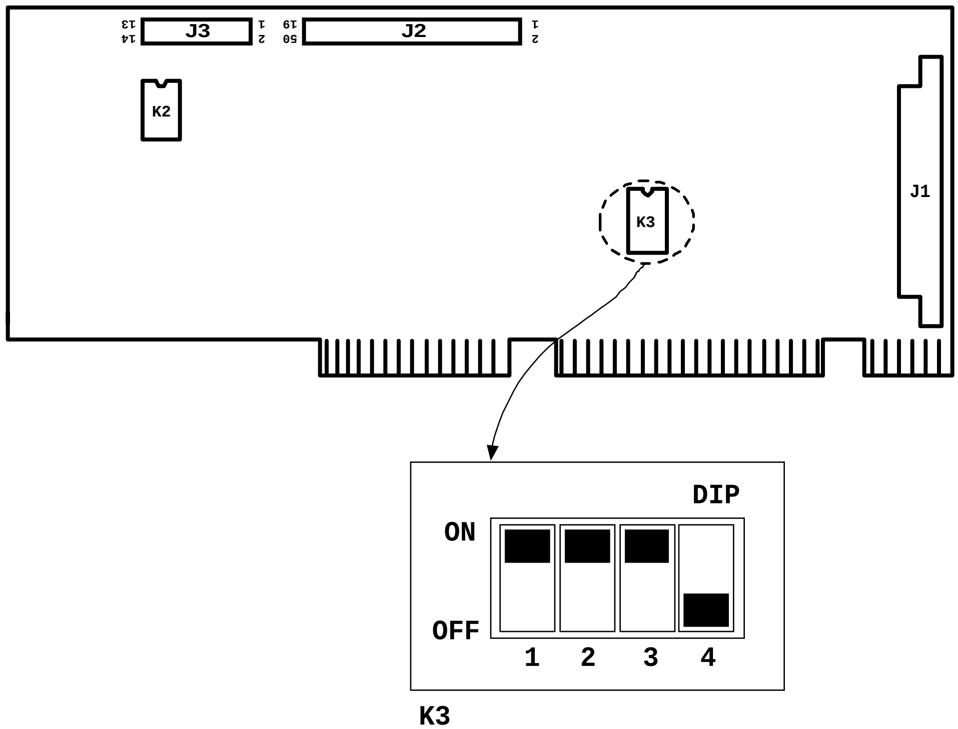


Figure 2.1 Setting of switch K3 for Host Base Address

be set as shown in Figure 2.2, with bit-2 in ON position and the rest in OFF positions. Before continuing, please fill in Table 2.2 with the settings you have chosen for future reference.

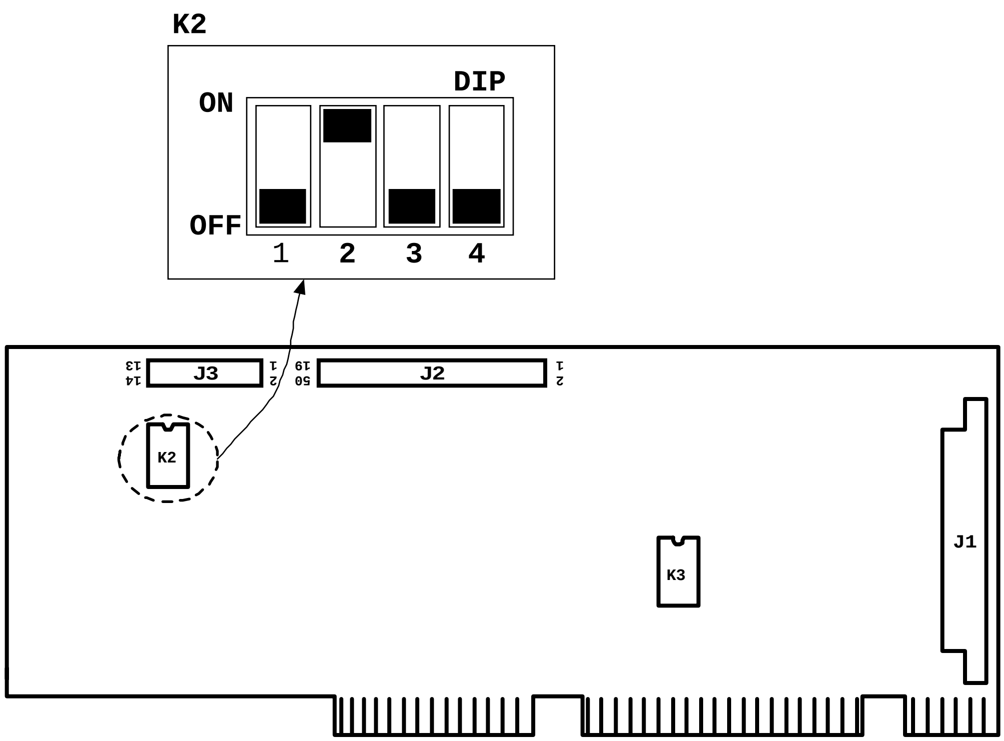


Figure 2.2 Switch K2 Setting for System Boot-loader

Table 2.2 Settings Recorder for Switches K2 and K3

K2-bit4	K2-bit3	K2-bit2	K2-bit1	K3-bit4	K3_bit3	K3-bit2	K3-bit1

OFF	OFF	ON	OFF	Your Selection	Your Selection	Your Selection	Your Selection

2.4 Inserting the MCT8000 Controller Board

After a proper I/O port base address is assigned and the DSP interrupt lines are selected, the MCT8000 is ready for use. To install the board first turn off the host power and open the case. Select an empty ISA bus slot and remove the bracket which covers the opening on the rear side of the case. Then insert the MCT8000. Ensure that both I/O connectors fit into their sockets, then press down the MCT8000 firmly. Screw on the board's bracket and close the cover. After turning on the host it should re-boot as usual. If it does not remove power immediately and check the I/O port base address and interrupt line selection of the MCT8000 and retry. If the host still does not come up try another I/O port base address. Check the host requirements (see section 2.2) if the MCT8000 is installed properly. If it still does not work, contact MCT engineer for instructions.

When the MCT8000 is inserted into the computer and the computer re-boot as usual, you can run the self-test program which comes with the MCT8000 software package. Please refer to a separate manual "*MCT8000/8100/8200 Series Motion Controllers: Software*" for details.

2.5 Running the Self-test Program

Before starting your own work with MCT8000/8100/8200, we strongly suggest that you run the self-test program which comes with the MCT8000 software package. This utility gives you a first look of how the system works. At the end of this program, a test report will let you know if the system functions OK. Please refer to a separate manual "*MCT8000/8100/8200 Series Motion Controllers: Software*" for more information

Chapter 3 Host Interface

The MCT8000 interfaces to the host by a block of sixteen 16-bit ports. The I/O interface is used to perform board setups, program download and runtime data transfers. The test bus controller setup and data transfer is also performed with the I/O interfaces.

To synchronize the execution of DSP and host programs two bi-directional dual-port rams has been included to allow the host interrupt the DSP and vice-versa.

The I/O interface between the host computer and the MCT8000 consists of block of 16 consecutive I/O ports. The on-board dip-switches are used to select the based address of this block within the 1K I/O address range of the PC/AT. Please refer to section 2.3 for details. *Note that only the available I/O addresses can be used for the host interface*. Table 3.1 shows typical I/O port allocations for your reference.

Table 3.1 I/O Port Address allocations for PC/AT

Address	Allocations
0x200—0x20f	Game control card
0x210—0x21f	reserved
0x220—0x2f7	reserved
0x2f8—0x2ff	Serial control adapter 2
0x300—0x31f	Prototype card
0x320—0x32f	reserved
0x330—0x36f	reserved
0x370—0x37f	Parallel control adapter 1
0x380—0x38f	Synchronized communication adapter 2
0x390—0x39f	reserved
0x3a0—0x3af	Synchronized communication adapter 1
0x3b0—0x3bf	Mono/printer control adapter
0x3c0—0x3cf	Color EGA/ VGA adapter
0x3d0—0x3df	Color CGA adapter
0x3e0—0x3ef	reserved
0x3f0—0x3f7	Floppy disk driver
0x3f8—0x3ff	Serial control adapter 1

The MCT8000 software package includes a series of functions into a Dynamic Linked Library (DLL) which can be used to communicate from the host to DSP.

Chapter 4 The TMS320C31 DSP

The TMS320C31 third generation floating-point DSP is a high performance member of Texas Instruments' TMS320 family of VLSI digital signal processor. It performs parallel multiply and ALU operations on integers or floating-point numbers in a single cycle. The TMS320C31 supports a large address space with various addressing modes allowing the use of high-level languages for application development. Some key features of the TMS320C31 are:

- 50 ns single cycle instruction execution time,
- object code compatible with the TMS320C30,
- Two 1K×32-bit dual access on-chip data RAM blocks,
- 64×32-bit instruction and data words, 24-bit address,
- 32-bit instruction and data words,24-bit address,
- 40-bit barrel shifter,
- Eight 40-bit accumulators,
- Two independent address arithmetic units,
- 2-and 3-operand instructions,
- Serial port,
- DMA control for concurrent DMA and CPU

Operation:

- Four external interrupts:
- Two 32-bit timers:

This section describes only those TMS320C31 features necessary for understanding the MCT8000's architecture and operation. For further information about the TMS320C31 refer to the Third Generation *TMS320C3x User's Guide* available from Texas Instruments.

The MCT8000/8100/8200 uses the TMS320C31's bus arbitration feature to make all off-chip DSP memory accessible to the host, allowing fast download operation without requiring a monitor program running on the DSP.

A high speed serial interface is include which may be used for communication between several processor boards to form a loosely couple multi processor system.

Four external user interrupt inputs(INT0 to INT3) are supported by the TMS320C31. INT3. INT1 is used for system boot loader. INT2 is driven by the Analog-to-Digital Converter. INT0 and INT3 buffered and available at the I/O connector.

The bus ready signal of the TMS320C31 (RDY) is used to adapt the TMS320C31 timing to the various on-board peripheral. The bus control register of the TMS320C31 is programmed for two wait states and external ready generation. The MCT8000 will then provide a proper ready signal for the external memory. The two wait states are required during accesses to the off-chip peripherals.

4.1 DSP Memory Map

The TMS320C31 supports a linear address spare of 16M 32-bit words. The MCT8000 contains 128K Words of zero wait states SRAM located at address 60000H, while the off-chip peripherals are mapped into address range 440000H-441000H. Figure 4.1 shows the complete TMS320C31 memory map. *As an option, MCT8000 reserved a memory block of 512K words of zero wait states and allocated at address 80000H which can be added to the off-chip memory space to fit customer's additional requirement*. Ask MCT Customer Service Center when you place your order.

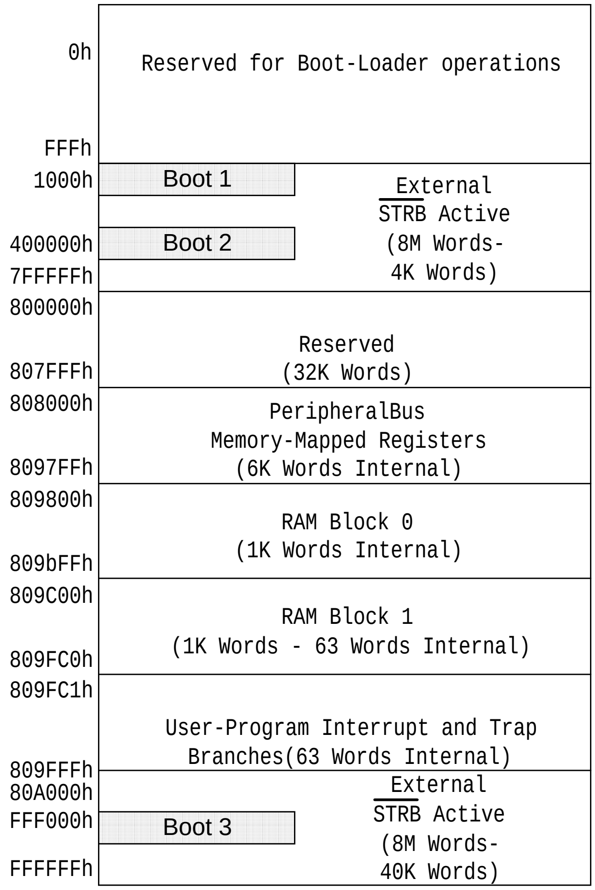


Figure 4.1 TMS320C31 memory map

The functions of the on-board peripherals are described in detail in the following chapters.

4.2Off-chip Memory

The TMS320C31 DSP provides two different modes of operation: microprocessor mode and microcomputer mode. Microcomputer mode minimizes external hardware requirements in final applications. The MCT8000 uses the microprocessor mode of the TMS320C31 to obtain full memory control by the host. User programs can be downloaded, monitored or altered at any time even while the DSP is running. The MCT8000's memory is fast enough to allow zero wait state operation at the full clock speed of 40MHz.

The base timing of the bus is controlled by the primary bus control register (PBCR) of the TMS320C31. The PBCR is memory mapped at address 808064H (refer to the TMS320C3x user's Guide). When the TMS320C31 is reset the slowest possible memory bus timing is selected. It must be reprogrammed by the application program to allow full speed operation of the MCT8000. The various fields of the PDCR should be programmed as follows:

BNKCMP The bank compare field allows the automatic insertion of wait states when crossing a memory bank boundary. This necessary if memories are used requiring several cycles to turn on. The memories installed on the MCT8000 do not require the insertion of wait states so BNKCMP is programmed to all zeros (00000B).

WTCNT The wait count field specifies the number of wait cycles to insert when software wait state generation is selected. For the MCT8000 the WTCNT is set to two wait states for accessing the on-board peripherals. An externally generated ready signal is used to perform zero wait states accesses to the on-board memory.

SWW The SWW field determines how the memory ready signal is generated. The MCT8000 contains a hardware ready generator activating the DSP's RDY input each time the external memory without wait states. The peripheral access ready signal is generated by the on-chip wait state counter (WTCNT). The SWW field must contain 10B to select the logical OR of the RDY input and the software ready generation.

HIZ Setting the HIZ bit forces the TMS320C31 into a hold state thus releasing the external bus. The bus access controller of the MCT8000 automatically generates external hold requests when the external bus is required so HIZ should be programmed to zero.

NOHOLD The NOHOLD bit controls whether the bus is released when an external hold is requested. If NOHOLD is set a deadlock occurs when the host tries to access the memory so NOHOLD should always be zero.

After a reset is applied to the TMS320C31 the instruction fetch cache system is turned off. To enable the cache system the cache enable bit (CE) in the DSP's status register must be set and the cache freeze bit (CF) must be cleared. When the cache system is enabled the host should not modify the DSP program while the DSP is running since it is not predictable whether the TMS320C31 will fetch the modified program code from memory or the unmodified instructions already residing in its internal cache memory. The TMS320C31's cache system only applies to instruction fetches while data transfers always bypass the cache. This allows to keep the cache enable when the host access DSP data at runtime. Correct programming of the cache control bits and the PBCR is mandatory of achieving the full performance of the MCT8000.

4.3Serial Interface

The TMS320C31 contains a serial port providing direct communication with various devices such as serial ADCs or other DSP's. Operation of the serial port is controlled by several TMS320C31 registers and mode bits and can be programmed for 8 to 32-bit data length in several synchronous and asynchronous operating modes. The transmit and receive data rate is determined by an internal programmable clock generator or an external clock source. Serial transfers can generate interrupts allowing to implement an event driven communication protocol in multi processor application. For further information about the DSP's serial interface refer to the TMS320C3x User's Guide.

4.4 External DSP Interrupts

Table 4.1 shows the corresponding DSP interrupt lines.

Source	Interrupt line
External interrupt input	INT0
System boot loader	INT1
ADC Chip	INT2
External interrupt input	INT3

Table 4.4.1 DSP interrupt sources.

The interrupt source sets the respective DSPINT flag in the IOCTL register and activates the DSP interrupt line. If the interrupt is enable in the TMS320C31's interrupt enable register (IE) and the global interrupt is enable bit (GIE) is set in the DSP's status register it performs an interrupt call to the address contained at the corresponding interrupt vector location. After the interrupt has been serviced the DSP has to set the DSPEOIx bit in the IOCYL register to reset the DSPINTx flag and to release the corresponding interrupt line. Then the respective interrupt flag in the DSP's interrupt flag register (IF) must be cleared. Refer to the TMS329C3x user's guide for further information about the interrupt system.

Chapter 5 Inputs and Outputs Sub-systems

To give maximum flexibility, MCT8000 motion controller contains many digital and analog inputs and outputs sub-systems. These sub-systems include 8 analog input ADC channels, 8 analog output DAC channels, 32-bit programmable digital I/O lines and 8 incremental quadrate encoder interfaces.

5.1 ADC Sub-system

MCT8000 controller board contains 8 ADC channel inputs. All ADCs have single ended bipolar with ±10V input span. All return lines are connected to system ground. To avoid ground loops separate return lines should be used for all connected sensors and the sensor grounds should be isolated from each other.

The system has an auto offset calibration function in order to eliminate the offset errors of the analog front end and the AD converter circuit. To do this refer to a separate manual "MCT8000/8100/8200 Motion Controller: Software" for further information.

All the ADCs can be connected to analog sensors for monitoring the target system status or collect data to form closed loop control systems.

5.2 DAC Sub-system

The MCT8000 controller board contains two quad 12-bit DACs with programmable output ranges. The DACs have single ended voltage outputs with ±10V span. To avoid ground loops separate signal return lines should be used for all connected actuators and the actuator grounds should be isolated from each other.

All the DACs can be used to generate control signals to the target system. And these DACs are always used with the corresponding encoder interfaces or ADCs to form closed-loop control systems.

5.3 DIO Sub-system

The MCT8000 controller contains 32-bit fully programmable digital I/Os. And those I/O bits, when programmed to outputs, can generate PWM pulses and interrupted signals. When programmed to inputs, these I/O bits could supply interrupted signals.

Among these 32-bit I/Os, sixteen bits are opto-isolated at MCT8000-IO interface board to make the controller be more safe and reliable.

5.4 Encoder Interface Sub-system

The MCT80000 contains eight incremental sensor interfaces to support optical incremental sensors commonly used in position control. Each interface contains line receives for input signals, a digital noise filter eliminating spikes on the phase lines, a quadrate decoder which converts the sensor's phase information to count-up and count-down pulse, a 24-bit counter which holds the current position of the sensor and 24-bit output latch.

The minimum encoder state width (i.e. the time the phi-lines must stay stable) is 60 ns resulting in a maximum count frequency of 17 MHz. Noise pulses shorter than 20 ns are eliminated by the digital noise pulse filter.

After power-up the position counters contain arbitrary data and must be synchronized to the absolute position of the connected plant. This is accomplished by moving the respective sensor until an index pulse is encountered. The system contains an auto initializing program to handle this task. Please refer to a separate manual "MCT8000/8100/8200 Motion controller: Software" for further information.

The 5V sensor supply voltage outputs are connected to the host's 5V power supply through MCT8000-IO interface board.

Chapter 6 JTAG Interface

The TMS320C31 features a superset of IEEE1149.1 JTAG stand emulation port. This emulation port can be used for hardware testing, in-circuit emulation and software debugging. The MCT8000 contains an emulator header allowing to connect to the Texas Instruments XDS510 emulator. Please refer to Texas Instruments document "TMS320C3x General Purpose Applications" for details. Please also note that the original XDS510 comes with a 12-pin Modular Port Scan Device (MPSD) connector. Some third party also produces XDS510 with a 14-pin connector in which pin 13 and 14 are grounded. The MCT8000 uses a 14-pin connector instead of the 12-pin connector. Figure 6.1 shows the detail connections.

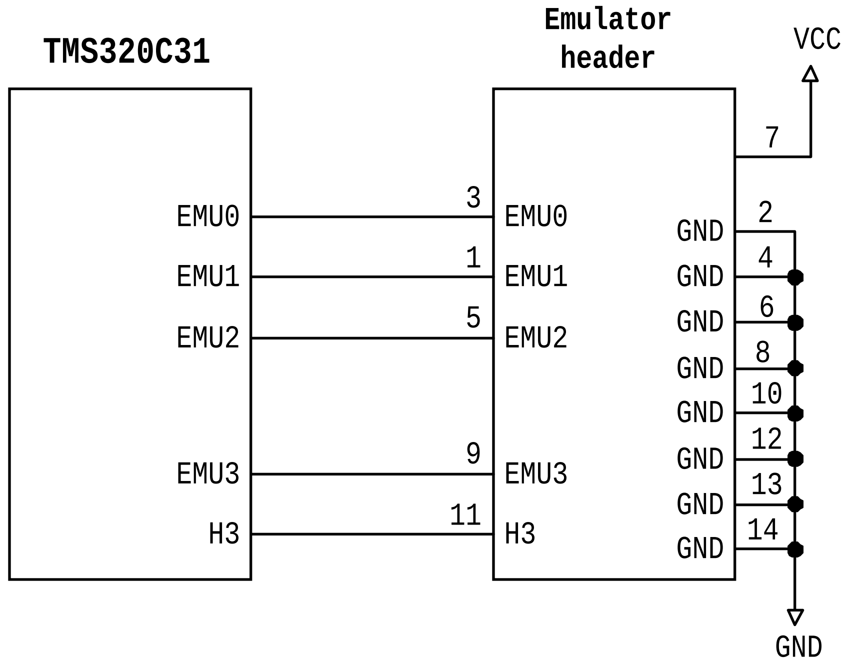


Figure 6.1 Connections Between the Emulator and the TMS320C31

Chapter 7 Connector Pin Arrangements

Figure 7.1 shows the connector layout of MCT8000 controller board. There three connectors, J1 through J3, on the board in which J3 is designed for JTAG interface, and J2 and J3 are for target system. These two connectors should be normally connected to MCT8000-IO interface board except that you develop your own interface board. Refer to Appendix I for further information.

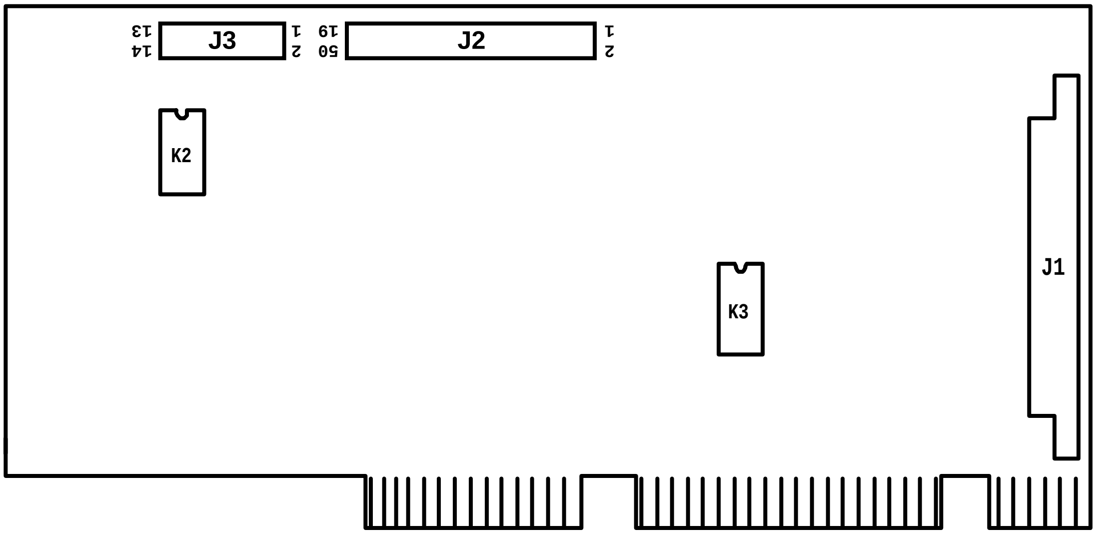


Figure 7.1 Connector Pin Arrangements of MCT8000 Controller Board

As shown in Figures 7.2 and 7.3, connector J1 is a 68-pin female high-density SUB-D connector and J2 is a 50-pin female high density SUB-D connector. Table 7.1 and Table 7.2 show their assignments respectively. Table 7.3 gives a further descriptions of these connector assignments.

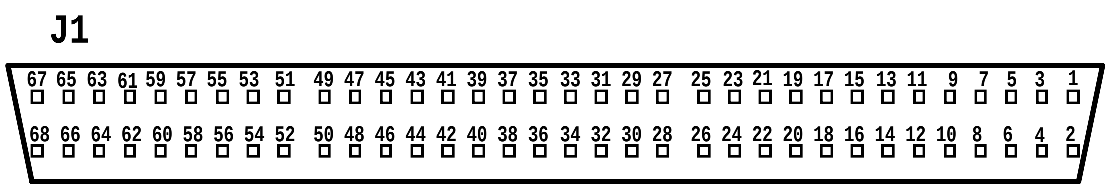


Figure 7.2 Closed look at Connector J1

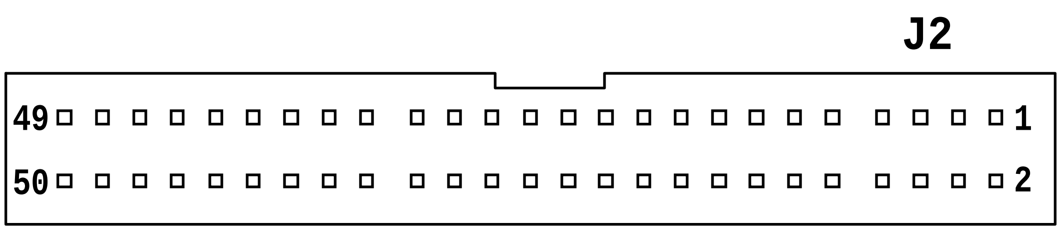


Figure 7.3 Closed look at Connector J2

Table 7.1 Connector J1 Pin-out Assignments

Pin	Signal	Pin	Signal	Pin	Signal	Pin	Signal
1	+12V	18	A5	35	ADC2	52	GND
2	GND	19	B4	36	ADC3	53	DIO0
3	+5V	20	B5	37	ADC4	54	DIO1
4	GND	21	C4	38	ADC5	55	DIO2
5	A0	22	C5	39	ADC6	56	DIO3
6	A1	23	A6	40	ADC7	57	DIO4
7	B0	24	A7	41	AGND	58	DIO5
8	B1	25	B6	42	AGND	59	DIO6
9	C0	26	B7	43	DAC0	60	DIO7
10	C1	27	C6	44	DAC1	61	+12V
11	A2	28	C7	45	DAC2	62	+12V
12	A3	29	+5v	46	DAC3	63	+5V
13	B2	30	GND	47	DAC4	64	+5V
14	B3	31	+12V	48	DAC5	65	GND

15	C2	32	GND	49	DAC6	66	GND
16	C3	33	ADC0	50	DAC7	67	-5V
17	A4	34	ADC1	51	-12V	68	GND

Table 7.2 Connector J2 Pin-out Assignments

Pin	Signal	Pin	Signal	Pin	Signal	Pin	Signal
1	-12V	14	DIO17	27	DIO30	39	GND
2	GND	15	DIO18	28	DIO31	40	FSX0
3	GND	16	DIO19	29	+5V	41	NC*
4	GND	17	DIO20	30	GND	42	CLKX0
5	DIO8	18	DIO21	31	+5V	43	NC
6	DIO8	19	DIO22	32	DR0	44	GND
7	DIO10	20	DIO23	33	TCLK0	45	NC
8	DIO11	21	DIO24	34	FSR0	46	GND
9	DIO12	22	DIO25	35	TCLK1	47	NC
10	DIO13	23	DIO26	36	CLKR0	48	INT0
11	DIO14	24	DIO27	37	DSP RESET	49	NC
12	DIO15	25	DIO28	38	DX0	50	INT3
13	DIO16	26	DIO29				

* NC = Not Connected.

Table 7.3 Pin-out Definitions of Connectors J1 and J2

Name	Function
ADC 0 – 7	Analog inputs, channel 0 through 7.
DAC 0 – 7	Analog outputs, channel 0 through 7.
A0-7	Quadrate encoded clock inputs, channel 0 through 7.
B0-7	Quadrate encoded clock inputs, channel 0 through 7.
C0-7	Index signal inputs, channel 0 through 7.
DIO0-31	Programmable digital I/O port.
AGND	Analog ground.
DGND	Digital ground.
DR0	Data-receive. Serial port 0 receives serial data on DR0.
TCLK0	Timer clock 0. As an input, TCLK0 is used by timer 0 to count external pulse. As an output, TCLK0 outputs pulses generated by timer0.
FSR0	Frame-synchronization pulse for receive. The FSR0 pulse initiates the data-receive process using DR0.
TCLK1	Timer clock 1. As an input, TCLK1 is used by timer 1 to count external pulse. As an output, TCLK1 outputs pulses generated by timer 1.
CLKR0	Serial port 0 receive clock. CLKR0 is the serial shift clock for the serial port0 receiver.
DSP RESET	Reset. When DSP RESET is a logic low, the device is in the reset condition. When DSP RESET becomes a logic high, execution begins from the location specified by the reset vector.
DX0	Data-transmit output. Serial port 0 transmits serial data on DX0.
FSX0	Frame-synchronization pulse for transmit. The FSX0 pulse initiates the data-transmit process using DX0.
CLKX0	Serial port 0 transmit clock . CLKX0 is the serial shift clock for the serial port 0 transmitter.
INT0	External interrupt
INT3	External interrupt

Chapter 8 MCT8000 Controller Data Sheet

Processor	Texas Instruments TMS320C31 floating-point DSP. Running at 40 MHz clock rate and 50ns cycle time. Two 32-bit on-chip timers/event counters On-chip bi-directional 8 M Baud serial link On-chip DMA. 4 external interrupt lines.
Memory	128K⋞32-bit zero wait state memory. Additional 512K⋞▤▤✍ ♌♓♦ ❍♏❍□❒⍓ ♓⬧ □□♦♓□■♋●✍ 2K⋞32-bit on-chip memory.
8 channel 12-bit ADCs	⌖📂🗀✞ ♓■□◆♦ ❒♋■♑♏✍ 📂✍⌛⬈⬧ ♍□■❖♏❒⬧♓□■ ♦♓❍♏✍ ⌖🗄❍✞ □⌁⌁⬧♏♦ ♏❒❒□❒✍
8 channel 12-bit DACs	⌖📂🗀✞ □◆♦□◆♦ ❒♋■♑♏✍ 📂🗀⬈⬧ ⬧♏♦♦●♓■♑ ♦♓❍♏✍ ⌖½☹💧✌ ☹♓■♏♋❒♓♦⍓✍
8 channel Incremental Encoder interface	Fourfold pulse multiplication. 17MHz maximum count frequency. Digital pulse filter. 24-bit position counter.
32-bit Digital inputs and outputs	Programmable. Opto-isolated.
Host-Interface	Sixteen 16-bit I/O ports in the 1K host I/O space. Memory and I/O are accessible by the host even while the DSP is running.
JTAG-Interface	14-pin emulator connector.
Physical size	8.7" x 3.9" for MCT8000 eight axes controller
Power supply	+5V⌖10%, 1.2A ⌖12V⌖5%, 100mA

Chapter 9 Troubleshooting

9.1 Overview

The following discussion may help you get your system to work.
Potential problems have been divided into groups as follows:

1. Installation
2. Communication
3. Stability and Compensation

The various symptoms along with the cause and the remedy are described in the following tables.

9.2 Installation

SYMPTOM	DIAGNOSIS	CAUSE	REMEDY
Motor runs away with no connections from controller to amplifier input.	Adjusting offset causes the motor to change speed.	1. Amplifier has an internal offset. 2. Damaged amplifier.	Adjust amplifier offset. Amplifier offset may also be compensated by use of the offset configuration on the controller. Replace amplifier.
Unable to read the encoders.	No encoder inputs are working	Encoder Cable is not connected	Connect Encoder cable
Encoder Position Drifts	Swapping cables fixes the problem	1. Poor connections/ intermittent cable	Review all terminal connections and connector contacts.
Encoder Position Drifts	Significant noise can be seen on CHA and / or CHB encoder signals	1. Noise	Shield encoder cables Avoid placing power cables near encoder cables Avoid ground Loops

9.3 Communication

SYMPTOM	DIAGNOSIS	CAUSE	REMEDY
Cannot communicate with controller	MCT software returns error message when communication is attempted.	1. Address conflict 2. Address selection does not agree with register information	Change address settings Using 4-bit dip switch From MCT software, edit environmental variable CNTL_PORT_BASE

9.4 Stability

SYMPTOM	DIAGNOSIS	CAUSE	REMEDY
Servo motor runs away when the loop is closed.	Reversed Motor Type corrects situation.	1. Wrong feedback polarity.	Reverse Motor or Encoder Wiring.
Motor Doesn’t Move		2. Too high gain or too little damping.	Decrease KI and KP. Increase KD.

For any problems you encountered, you could directly talk to MCT engineer at MCT Customer Service Center and he will always be there for you.

Product Warranty and Service

Seller warrants that equipment furnished will be free from defects in material and workmanship for a period of ***one year*** from the confirmed date of purchase of the original buyer. Upon written notice of any such defect, Seller will, at its option, repair or replace the defective item under the terms of this warranty, subject to the provisions and specific exclusions list herein.

This warranty shall not apply to equipment that has been previously repaired or altered outside our plant in any way as to, in the judgment of the manufacturer, affect its reliability. Nor will it apply if the equipment has been used in a manner exceeding its specifications or if the serial number has been removed.

Seller does not assume any liability for consequential damages as a result from our products uses, and in any event our liability shall not exceed the original selling price of the equipment.

The equipment warranty shall constitute the sole and exclusive remedy of any Buyer of Seller equipment and the sole and exclusive liability of the Seller, its successors or assigns, in connection with equipment purchased and in lieu of all other warranties expressed implied or statutory, including, but not limited to, any implied warranty of merchant ability or fitness and all other obligations or liabilities of seller, its successors or assigns.

The equipment must be return postage-prepaid. Package it securely and insure it. You will be charged for parts and labor if you lack proof of date of purchase, or if the warranty period is expired.

Appendix I MCT8000-I/O Board

Figure a.1 shows the layout of the MCT8000-I/O interface board. This part is the accessory of MCT8000/8100 eight axes controller board. This board is connected to MCT8000/8100 controller board trough a 68-pin socket J1, a 50-pin socket J2 and a 10-pin socket P5. The connector terminals P1, P2, P4, P6 are used for connections between the controller and the target system. Eight precision sockets P3-0 through P3-7 are connectors for position encoders. For detail descriptions of these connectors, please have a look at Table a.1 through a.5. The pin assignments for socket p3-0 through p3-7 are shown in Figure a.2.

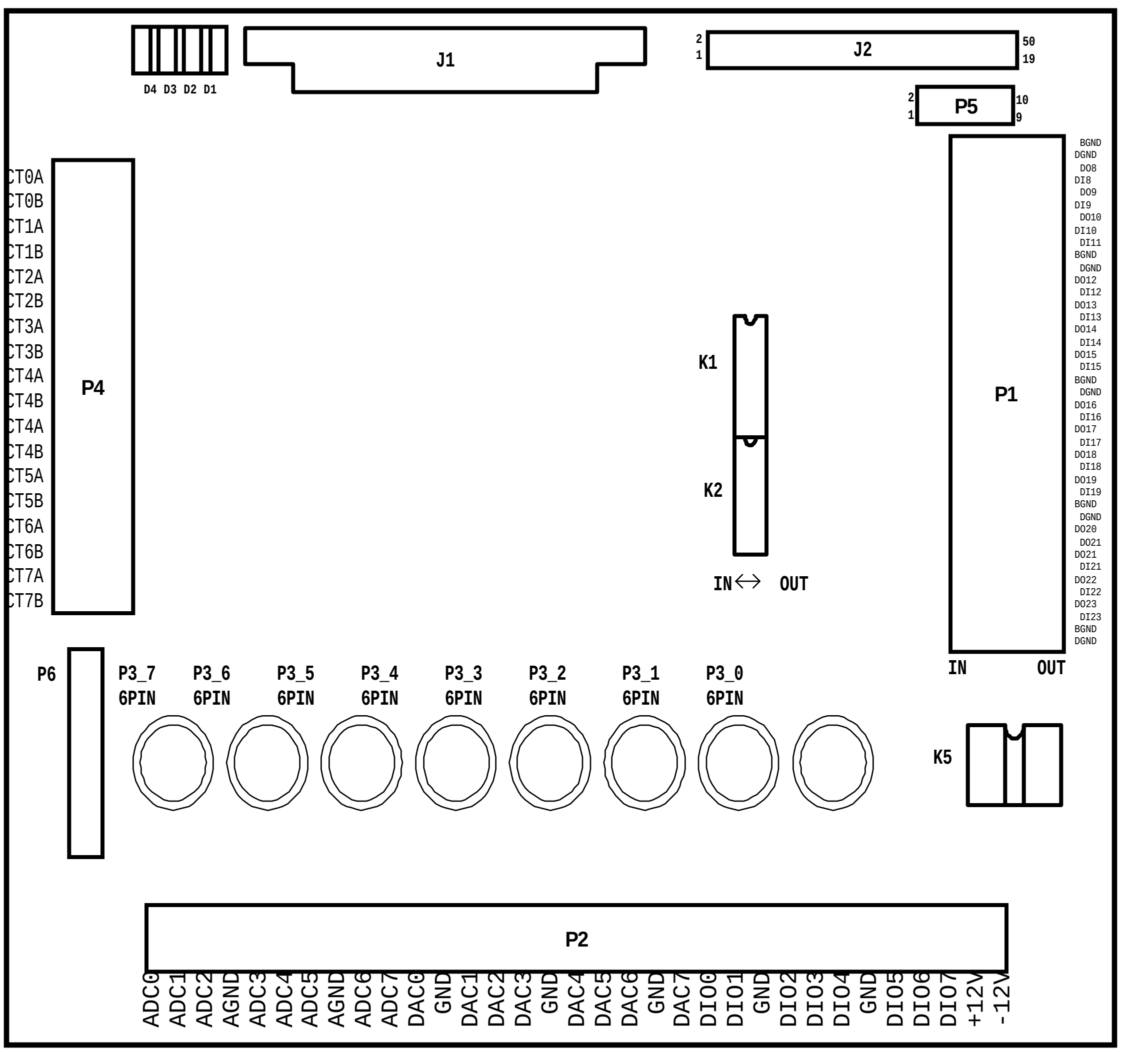


Figure a.1 Layout of MCT8000-I/O Interface Board

Table a.1 Pinout Arrangements of Connector P1

Pin (OUT)	Signal	Pin	Signal	Pin (IN)	Signal	Pin	Signal
1	BGND	23	DO16	2	DGND	24	DI16
3	DO8	25	DO17	4	DI8	26	DI17
5	DO9	27	DO18	6	DI9	28	DI18
7	DO10	29	DO19	8	DI10	30	DI19
9	DO11	31	BGND	10	DI11	32	DGND
11	BGND	33	DO20	12	DGND	34	DI20
13	DO12	35	DO21	14	DI12	36	DI21
15	DO13	37	DO22	16	DI13	38	DI22
17	DO14	39	DO23	18	DI14	40	DI23
19	DO15	41	BGND	20	DI15	42	DGND
21	BGND			22	DGND		

Table a.2 Pinout Arrangements of Connector P2

Pin	Signal	Pin	Signal	Pin	Signal	Pin	Signal
1	ADC0	10	ADC7	18	DAC5	26	DIO3
2	ADC1	11	DAC0	19	DAC6	27	DIO4
3	ADC2	12	GND	20	GND	28	GND
4	AGND	13	DAC1	21	DAC7	29	DIO5
5	ADC3	14	DAC2	22	DIO0	30	DIO6
6	ADC4	15	DAC3	23	DIO1	31	DIO7
7	ADC5	16	GND	24	GND	32	+12V
8	AGND	17	DAC4	25	DIO2	33	-12V
9	ADC6						

Table a.3 Pinout Arrangements of Connector P4

Pin	Signal	Pin	Signal	Pin	Signal	Pin	Signal
1	CAT0A	5	CAT2A	9	CAT4A	13	CAT6A
2	CAT0B	6	CAT2B	10	CAT4B	14	CAT6B
3	CAT1A	7	CAT3A	11	CAT5A	15	CAT7A
4	CAT1B	8	CAT3B	12	CAT5B	16	CAT7B

Table a.4 Pinout Arrangements of Socket P5

Pin	Signal	Pin	Signal
1	DR0	6	CLKX0
2	GND	7	DX0
3	FSR0	8	GND
4	GND	9	FSX0
5	CLKR0	10	GND

Table a.5 Pinout Arrangements of Connector P6

Pin	Signal
1	INT0
2	INT3
3	TCLK0
4	TCLK1
5	+5v
6	-5v

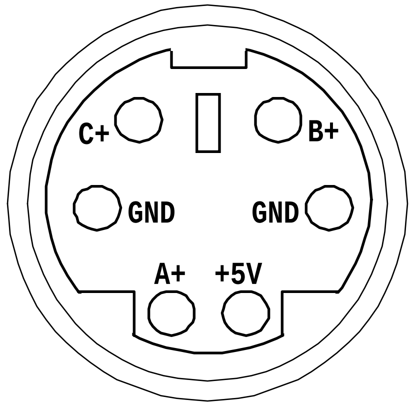


Figure a.2 Pin Assignment for Socket p3-0 through p3-7

Two 8-bit Dip Switches K1 and K2 are used to specify bit-8 through bit-23 as digital input pin or output pin depending on that this bit is programmed as input or output through software. If this bit is programmed as input then the corresponding bit in K1 or K2 must set to “OFF” position, otherwise let this bit be in “ON” position. Figure a.3 shows an example of that bit-8 through bit-15 are programmed as outputs whereas bit-16 through 23 programmed as inputs.

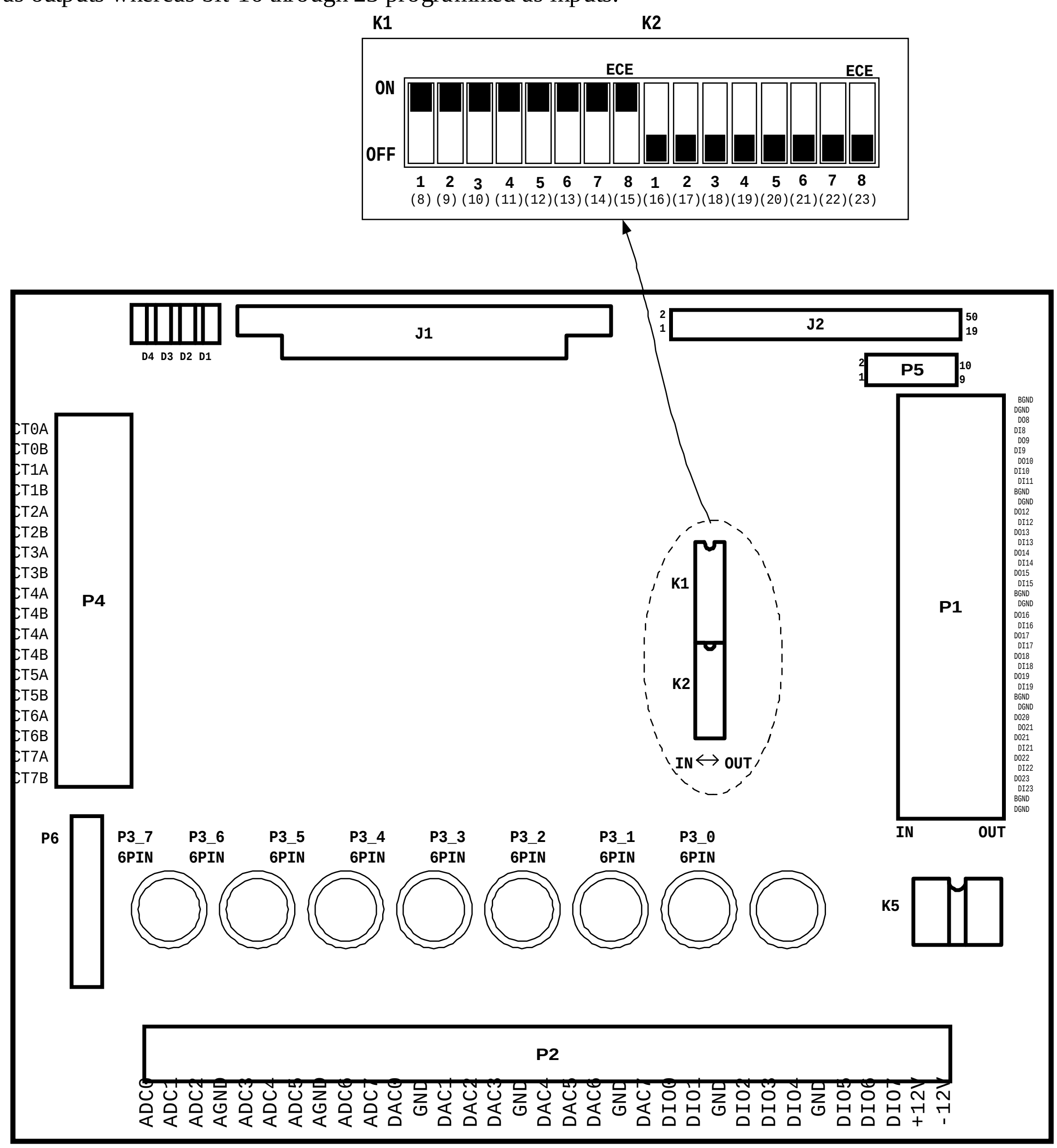


Figure a.3 Programming DIO bit 8 through 23

Appendix II Application Example

As mentioned in Chapter 1 in this manual, the MCT8000/8100/8200 series controllers can be used in many applications. Among those the basic applications are motion control ones. In this section we will give you several examples in motor control engineering. These examples could be easily extended to complex multi-axes motion control cases such as robot and NC machine tool controllers.

Example 1 Standard AC Servo Motor with +/- 10 Volt Command Signal

Figure b.1 shows an example using a MCT8000 controller to control a standard AC servo motor. In this example, a Panasonic MSD servo amplifier is used to drive the AC servo motor. A MCT8000 controller board and a MCT8000 I/O interface board are used to generate control signals to the amplifier. The encoder signal from the motor represents the current position of the motor and is feedback into the MCT8000. Compared this signal with the reference or command position MCT8000 controller generate a proper control signal for the motor and feed it into the amplifier through a DAC output terminal DAC0 to form a closed position loop scheme. Three digital outputs, DO8, DO9, DO10, are used to control the amplifier behavior. Two digital inputs, DI8 and DI9 are used to detect the status of the amplifier. A MCT8000 controller board can control up to 8 axes of this kind of motor at one time.

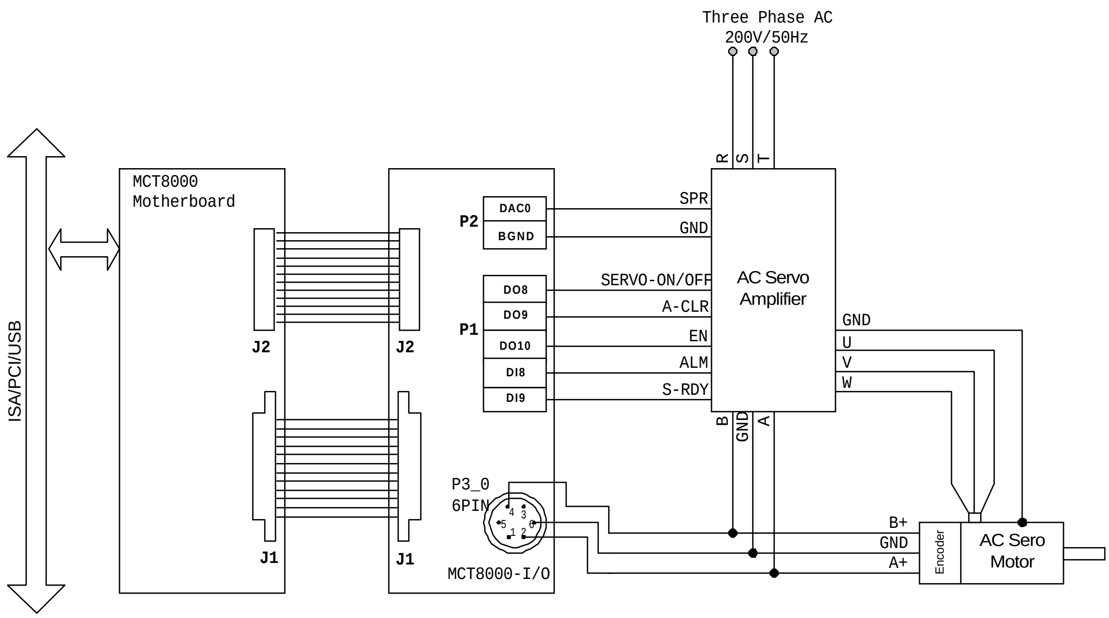


Figure b.1 Control of Standard AC Servo Motors

Example 2 Standard DC Brush Servo Motor with +/- 10 Volt Command Signal

Figure b.2 shows an example using a MCT8000 controller to control a standard DC brush servo motor. In this example, a servo amplifier is used to drive the DC servo motor. A MCT8000 controller board and a MCT8000 I/O interface board are used to generate control signals to the amplifier. The encoder signal from the motor represents the current position of the motor and is feedback into the MCT8000. Compared this signal with the reference or command position MCT8000 controller generate a proper control signal for the motor and feed it into the amplifier through a DAC output terminal DAC0 to form a closed position loop scheme. One digital output, DO8, is used to control the amplifier behavior. Another digital input DI8 and an analog input ADC0 are used to monitor the status of the amplifier. A MCT8000 controller board can control up to 8 axes of this kind of motor at one time.

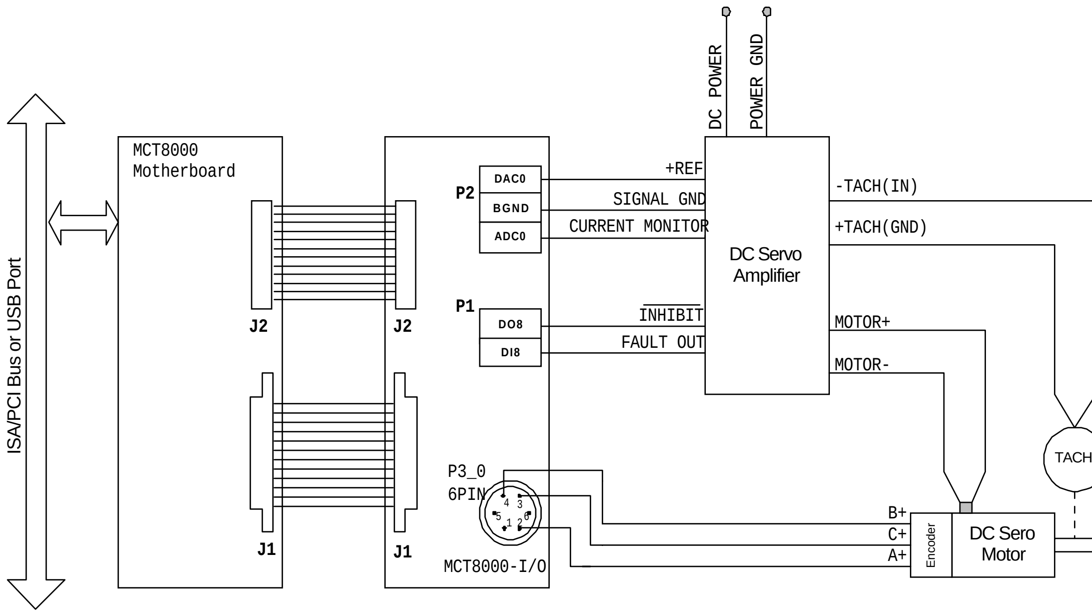
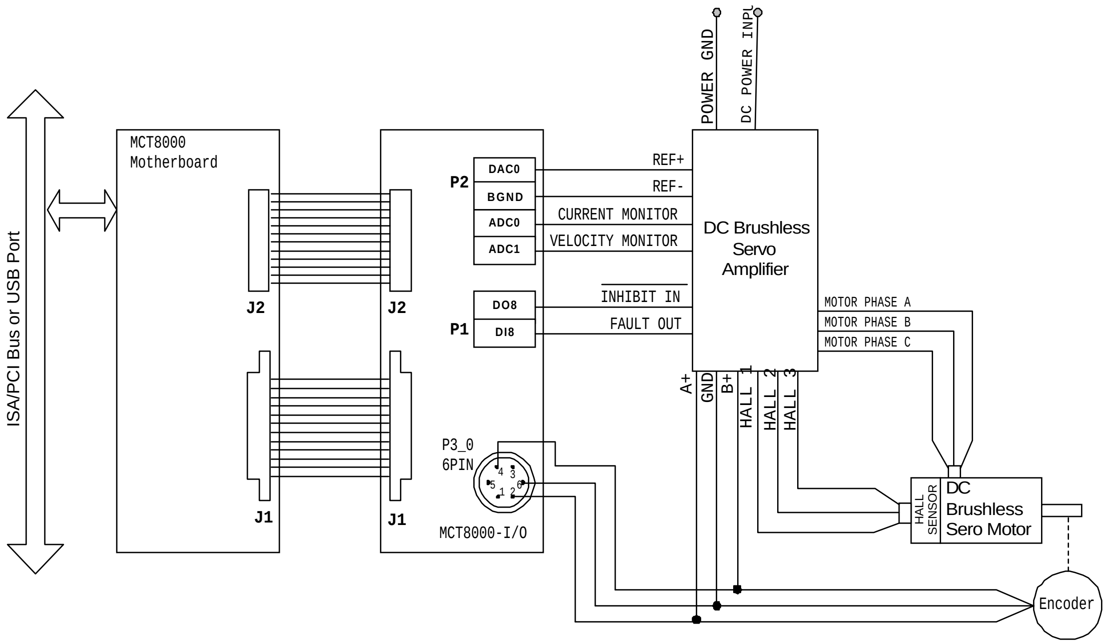


Figure b.2 Control of Standard DC Brush Servo Motors

Example 3 Standard DC Brushless Servo Motor with +/- 10 Volt Command Signal

Figure b.3 shows an example using a MCT8000 controller to control a standard DC brushless servo motor. In this example, a servo amplifier is used to drive the DC servo motor. A MCT8000 controller board and a MCT8000 I/O interface board are used to generate control signals to the amplifier. The encoder signal from the motor represents the current position of the motor and is feedback into the MCT8000. Compared this signal with the reference or command position MCT8000 controller generate a proper control signal for the motor and feed it into the amplifier through a DAC output terminal DAC0 to form a closed position loop scheme. One digital output, DO8, is used to control the amplifier behavior. Another digital input DI9 and two analog input ADC0 and ADC1 are used to monitor the status of the amplifier. A MCT8000 controller board can control up to 8 axes of this kind of motor at one time.



Figureb.3 Control of Standard DC Brushless Servo Motors

Example 4 Stepper motor with step and direction signals

Figure b.4 shows an example using a MCT8000 controller to control a stepper motor. In this example, a servo amplifier is used to drive the DC servo motor. A MCT8000 controller board and a MCT8000 I/O interface board are used to generate control signals to the amplifier. In this case, only three digital output bits DO8 through DO10 are used. A MCT8000 controller board can control up to 13 axes of this kind of motor at one time.

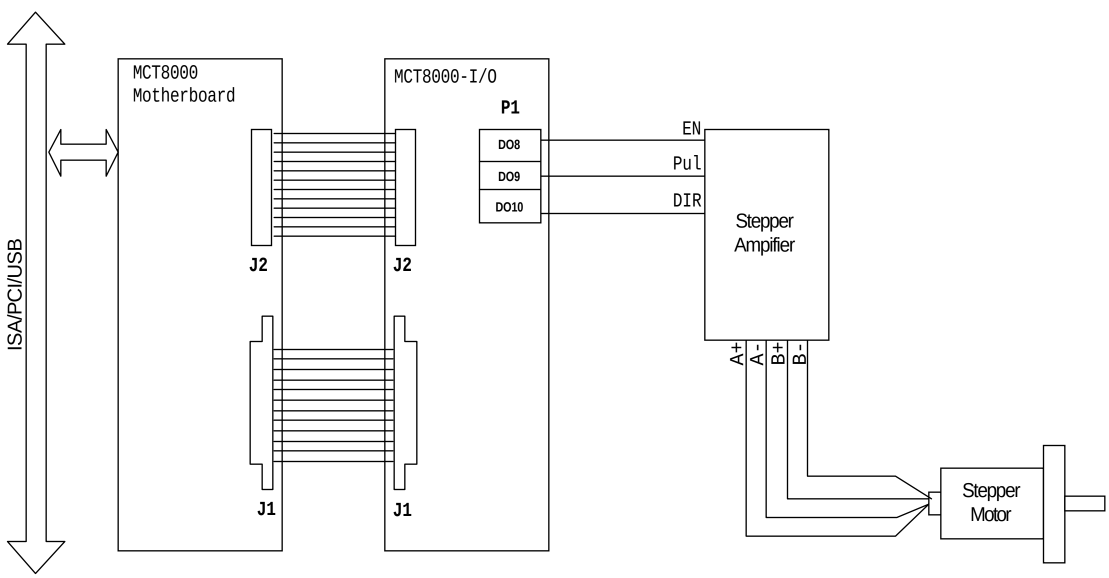


Figure b.4 Control of Stepper Motors

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