SKSCONTROL

ACN

MOTION CONTROL SYSTEM

User's Manual

5.5.2015 / SKS Control Oy

DECLARATION OF CONFORMITY

Manufacturer:	SKS Control Oy
Address:	SKS Control Oy Martinkyläntie 50 SF-01720 Vantaa Finland
Product:	ACN motion control system Conforms to the following directives and regulations:
EMC:	Directive 2004/108/EC
Generic Standards:	EN 50081-2 EN 50082-2

The purpose of this equipment is to be used as a part of the electrical system of an industrial machine. It is therefore essential that the installation and use of the product are executed according to manufacturer's instructions and specification. When installed as described in manufacturer's documentation, the equipment conforms to the requirements of the described standards. However, the final responsibility for the conformance of the complete installation and machinery where the equipment is being used is left with the manufacturer of such apparatus. In certain cases it is necessary to perform additional tests to confirm the EMC performance of the complete system.

Vantaa 5.5.2015 SKS Control Oy

A. Lindvall

GENERAL INFORMATION

The contents of this document are believed to be correct at the time of publishing. However, in case you find any errors or have suggestions concerning this information, please contact the manufacturer.

In the interest of continuous development and improvement, the manufacturer reserves the right to change the specification of the product or its performance, or the contents of this document, without notice.

The manufacturer gives a one (1) year limited warranty, starting from the date of delivery, covering any defects in materials or manufacture of the product. For warranty repair the product must be returned to the manufacturer or its authorized distributor. The manufacturer accepts no liability for any consequences resulting from inappropriate, negligent or incorrect installation or use of the product, any damage caused to equipment other than the product itself or any kind of indirect damage.

CONTENTS

1 Safety information

1.1 Warnings, caution and notes

WARNING

A warning contains information which is essential for avoiding a safety hazard or serious injury.

CAUTION

A caution contains information which is essential for avoiding damage to the product or other equipment.

NOTE A NOTE contains information which gives guidance to correct operation of the product.

Electrical safety – General warning

The supply and I/O voltage used in this product is 24V dc and is therefore safe to work with and cannot cause severe electric shock. In case of working with mains power supply or other high voltage equipment, adjacent to the product, extreme care is necessary at all times.

Mechanical installation

The ACN system is supplied with a metal base plate on which the modules are assembled. The base plate is equipped with flanges for installation on control cabinet back panels. Appropriate screws or bolts must be used to ensure the stability of the assembly. In case of vibrations, more care should be given to the assembly of the base plate as well as the module assembly. For more information on the mechanical installation, see section 4.

Environmental limits

Instructions within the supplied data and information within the ACN User's guide regarding transport, storage, installation and the use of the system must be complied with, including the specified environmental limits. The product must not be subjected to excessive physical force.

Fire protection

The ACN module enclosures are not classified as fire enclosures. A separate fire enclosure must be provided if necessary.

Compliance with regulations

The installer is responsible for complying with all relevant regulations, such as national wiring regulations, accident prevention regulations and electromagnetic compatibility (EMC) regulations. Particular attention must be given to the cross-sectional areas of conductors, the selection of fuses and other protection, and protective ground (earth) connections.

2 Product information

2.1 Introduction

Welcome to use the SKS Control ACN family of motion control products. The ACN system combines simple and compact system structure with powerful system software and programming tools.

The ACN system features continuous path servo control for up to 100 axes, expandable I/O connections and RS-232/422 serial and optional optical fiber communications as well as 10/100 base-T Ethernet communication. Additionally, the ACN system can be combined with a user terminal with an LCD graphics/text touch screen display.

This manual contains information on installing and using the ACN control system. Please study the following sections carefully before starting to work with your system. Also refer to the ARLACON McWay I/O system user's manual, the McDos user's manual and the McBasic programming environment reference manual where applicable.

In case you have questions or suggestions concerning this manual, the ACN system or other products supplied by SKS Control Oy, please contact the manufacturer:
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e-mail control@sks.fi

2.2 General overview

The complete ACN system combines a programmable control computer module (MPU) with axis connection modules (AXi or AXa), fieldbus I/O and/or other fieldbus connectable devices such as drives and HMI.

When using ACN axis connection modules, they are installed to a metal base plate with necessary connector boards for signal and power connections.

MPU modules are equipped with serial interfaces for communication with other devices, such as a PC or a display, Ethernet ports for networking and McWay I/O interfaces for connecting to ACN compatible I/O modules. ModBus fielbus protocol is available for use with both serial communications and Ethernet.

MPU3 controller module also includes an EtherCat fielbus master for use with real time i/o and motion control, and a futher optional fielbus slave connection.

MPU modules are also equipped with an SDHC memory card socket and a mini USB programming port. The MPU module and base plate circuit board contain additional connectors for expansion modules. For further information see sections 3.1 and 3.2.

The AXi/AXa axis connection modules each provide connections for one position controlled axis using the McWay I/O system. The position is controlled by using the information from a position encoder connected to the module. The module also includes 8+8 digital I/O terminals, limit switches, speed reference output and control relays. For further information see section 3.3.

The base plate equipped with connector boards is the chassis of the system on which the modules are assembled. The connection boards provide all electrical connections needed to the modules except for the Ethernet/fieldbus ports and the programming port located on the MPU module. The power supply is connected to the MPU connection board from which it provides power to all modules on the base plate. The base plate itself is usually fastened to the back plate of a control cabinet.

The ACN system uses a 24Vdc power, so it usually needs an external mains power supply with a suitable current rating, depending on the number of modules and I/O fitted. For further information on compatible power supplies see Table 1.

2.3 McWay I/O system

The McWay I/O system operates as a fast ring topology serial bus with down to 0,5 ms refresh rate. One loop (WAY 0) is as a default connected via the connection boards to the AXa/AXi-modules installed on the base plate. Another three optional McWay-loops can be connected to the base connector board of the MPU if necessary. See sections 3 and 4 for more details.

The 0,5ms refresh rate means that input information for the control unit (MPU) and data on the output modules (AXa/Axi) or other McWay compatible modules are never more than 0,5ms old. Thus, it is possible to perform closed loop servo control with the servo axis connection modules.

The ACN is available with either RS-422 or optical fiber McWay and serial interfaces. The RS-422 signal is preferably used with twisted pair cables whereas the optical fiber provides optimum EMC performance and fast communications for up to 50m distances. RS-232 is provided for short distance communication with a PC or other data equipment.

More details of the operation of McWay modules can also be found in the ARLACON McWay I/O system user's manual.

2.4 McBasic programming language

McBasic is a programming environment developed for use with ACN control systems. It combines the ease of the standard Basic programming language and interpreter type interactive programming and testing with a fast runtime compiler, multitasking capabilities and powerful logic and motion control commands.

The McBasic version in the ACN system runs under McDOS operating system allowing use of McDOS file and communication systems and utility programs. By using a WAKEUP.EX start-up batch file the system can be set to directly start at system power-up and automatically load and run an application program if desired.

The ACN system supports 32 logical axes as standard, expandable up to 128 logical axes using the appropriate McBasic firmware version. I/O and drives can be connected via the McWay I/O system or ModBus or Ethercat fieldbuses allowing large numbers of I/O and axes to be connected to one controller.

With its full floating point mathematics, strings, arrays, functions and structures, McBasic gives you tools for effective programming of work cycles, communications and data processing. Up to 30 simultaneous tasks can run in the ACN system. Tasks can also be created and killed at any time by the application program.

The McBasic programming language is described in detail in the McBasic programming environment reference manual.

2.5 **System hardware configuration**

When ordering a specified combination of ACN hardware, the system is installed and tested at factory with hardware and software set according to system configuration. After this, the system can also be expanded by installing various option modules and accessories within limitations set by supply and module combinations.

Section 4 of this manual provides information about the mechanical installation and section 5 about the electrical installation of the modules and system internal connections and settings of system options of your ACN control system.

To ensure the best system performance, ACN systems are factory equipped with latest version McDos and McBasic software. McBasic software is available in some different versions according to number of axes and options used. When shipping your ACN, the version applicable for the system configuration is stored in the internal SD card of the MPU module together with a WAKEUP file that automatically starts McBasic at power-up.

On the following page is a complete table of all ACN related products and spare parts along with order codes.

Table 1. Order codes of ACN system parts

ACN system modules and accessories	
Part	**Description**
Base plate	
Base plate 1-module	
Base plate 4-modules	
Base plate 6-modules	
Base plate 8-modules	
Base plate 10-modules	
Modules	
MPU2	Controller module
MPU3	Controller module
AXi	Axis connection module, increment encoder
AXa	Axis connection module, SSI absolute encoder
Connector PCB:s	
MPU-SCB	MPU connector module for base plate
AXE-SCB	Axi/Axa connector module for base plate
Serial and optical connection modules and cables	
MPU-OCB-F	Connection board for fiber McWAY or serial communication
MPU-OCB-C	Connection board for RS422 McWAY or serial communication
Mini USB cable	Programming cable/ PC connection cable
Mass memory	
SD-Card 2GB with USB adapter	
Accessories and spare parts	
Signal cable clamp	
Metal cable tie	
ACN feet	

3 Module overview and options

3.1 MPU2 controller module

The ACN MPU2 is a fast, Coldfire™ architecture based processor module for ACN motion control systems. It's an ideal choice for synchronization, position profiling and path control of electrical drives or hydraulics. The ACN MPU2 provides one of the most flexible concepts in motion control for automation of machinery and production lines on the market today by combining CNC, PLC and computer functions into a single, high-level programmable system. Modbus® fieldbus support further simplifies applications with compatible drives and HMI's.

The MPU2 module contains the CPU of the system, the 16MB RAM work memory and the FLASH storage memory available in the system. In addition the MPU2 module provides an USB serial port for programming and application use as well as an Ethernet port. The SD card flash drive is compatible with all standard SD and SDHC cards and accepts FAT12, FAT16 and FAT32 file formats for data exchange and compatibility.

The operating system on the MPU is the SKS Control McDOS platform designed for ACN control systems. Under McDOS runs the McBASIC machine control language and the necessary operating system services. McDOS also provides utilities for program development and maintenance work. For more information on McDOS refer to the Mc-DOS operation system user's manual. The McBench programming tools for Windows PC are shipped with the ACN MPU2 to provide an efficient environment for programming and working with your ACN system.

The ACN MPU2 module uses the SKS Control McWay distributed I/O system for communication with other products in the ACN motion control family, such as the AXi/AXa modules.

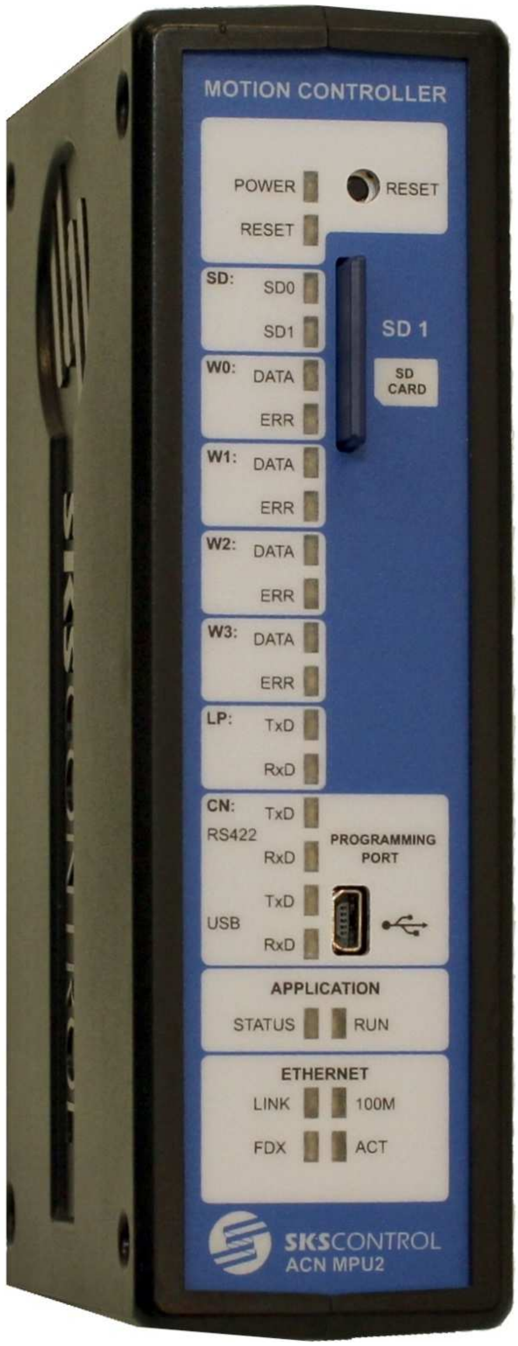


Figure 1, MPU2 module

3.1.1 Communications and options

The ACN system has up to four optional serial interfaces which are located on the MPU2 module connection board. The MPU2 module itself has one USB serial interface as standard, which is typically used for programming and as a PC interface. Three of the four McWay connections can be configured as serial ports by software if needed (W1, W2 and W3). W0 is always reserved internally for the AXi/AXa modules on the base plate and should not be used for any other purposes. To use the McWay connections 1,2 and 3 either as McWay loops or configured as serial ports, the MPU-OCB type option boards needs to be fitted providing either optical fiber or RS422 wire connections for the specific connections to be used.

An RJ45 standard Ethernet port for networking is located on the bottom of the module. It supports TCP/IP networking for connecting to programming tools, file services and various Modbus compatible devices as described in the McDOS and McBasic manuals.

On the MPU2-module front side there is a slot for an optional SDHC card, as well as a mini USB connector containing the CN signal configured as a serial port; see 0 for more information. A short overview of all interfaces and options is given in Table 2. For more detailed information on the electrical connections see section 5 of the manual.

Table 2. Summary of all MPU2 module interfaces

MPU2 module interfaces and options		
Connections, signals and slots	**Number of ports, signals or slots**	**Type and location**
Serial interfaces (CN, S1, S2, S3)	One as standard CN Expandable with additional 3 (S1, S2 and S3)	RS422 – Option on a connection board on the MPU base circuit board with CN, S0 and S1 signals. Fiber – Option on a connection board on the MPU base circuit board with CN, S0 and S1 signals.
McWay	4 (3 free of use) for external connections	RS422 – Option on connection board on the MPU base circuit board with W1, W2 and W3 signals. Fiber – Option on connection board on the MPU base circuit board with W1, W2 and W3 signals.
Ethernet	1	RJ45 – On the bottom of the MPU module.
SD card	1 slot	SD & SDHC – On the front panel of the MPU module.

3.1.2 MPU2 module side view and front panel

The short side of the MPU2 module, as shown in Figure 2, contains the Ethernet connector as well as a grounding terminal for the Ethernet cable shield.

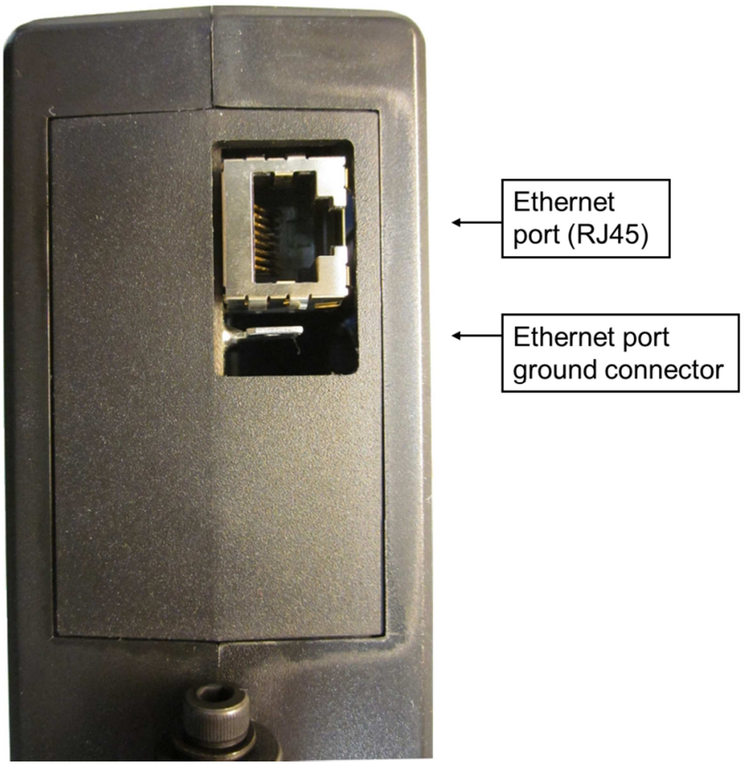


Figure 2, Side view of the MPU2 module.

The front panel of the module shown in 0 gives the user information of normal operation and possible errors. The panel is also equipped with an SD card slot and a mini USB connector for console serial port (CN). Information on the front panel LED:s and their function is also shown in Figure 3.

SD cards

LED	Function
SD0, SD1	SD card 0 (internal) and SD card 1 (external) read/write activity

W0 to W3

LED	Function
DATA	OFF = Bus inactive Brief Blink = Bus configured but not active Fast Blink = Bus configured but loop error occured Solid = Bus configured and active
ERR	Bus Packet Error

CN & LP

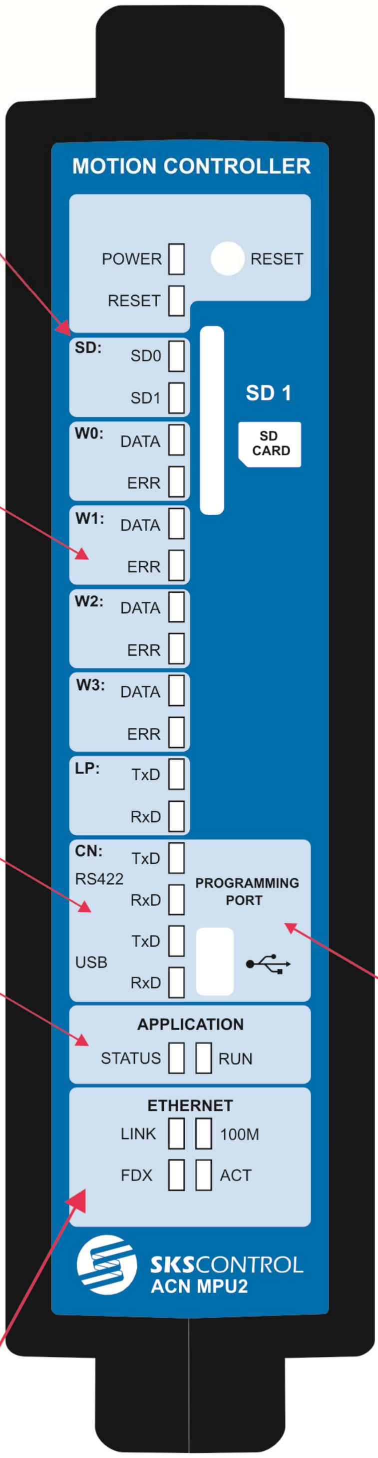
LED	Function
RxD	Data reception
TxD	Data transmission

APPLICATION

LED	Function
RUN	Solid = McBasic prompt Slow blink = Program running Fast blink = Program error
STATUS	Not implemented

Ethernet

LED	Function
LINK	Link established
100M	100M mode
FDX	Full Duplex
ACT	Ethernet Activity



USB 2.0 port for programming and monitoring

Figure 3, MPU2 module front panel

3.2 **MPU3 Module**

The ACN MPU3 is a fast, Coldfire™ architecture based processor module for ACN motion control systems. It's an ideal choice for synchronization, position profiling and path control of electrical drives or hydraulics. The ACN MPU3 provides one of the most flexible concepts in motion control for automation of machinery and production lines on the market today by combining CNC, PLC and computer functions into a single, high-level programmable system. Modbus® and Ethercat™ fieldbus support further simplifies applications with compatible drives and HMI's.

The MPU3 module contains the CPU of the system, the 64MB RAM work memory and the 2GB FLASH storage memory available in the system. In addition the MPU3 module provides a USB serial port for programming and application use as well as 2 Ethernet ports. The SD card flash drive is compatible with all standard SD and SDHC cards and accepts FAT12, FAT16 and FAT32 file-formats for data exchange and compatibility.

The operating system on the MPU3 is the SKS Control McDOS platform designed for ACN machine control systems. Under McDOS runs the McBASIC machine control language and the necessary operating system services. McDOS also provides utilities for program development and maintenance work. For more information on McDOS refer to the McDOS operating system user's manual. The McBench programming tools for Windows PC are shipped with the ACN MPU3 to provide an efficient environment for programming and working with your ACN system.

The ACN MPU3 module uses the SKS Control McWay distributed I/O system for communication with other products in the ACN motion control family, such as the AXi/AXa-modules. EtherCat master functionality is also available for use with compatible drives and real-time I/O equipment.

Figure 4, MPU3 module

3.2.1 Communications

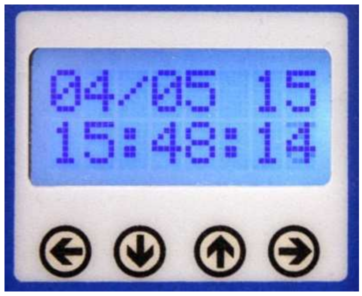
The MPU3 module has 2 10/100Mbit RJ-45 Ethernet ports on the front of the module, referred to as E1: (PORT 1) and E2: (PORT 2). Both ports can be used as standard TCP/IP network connection or as an Ethercat master.

Generally, PORT 1 is used for TCP/IP networking and PORT 2 for EtherCat™, althought other configurations can also be used. This configuration allows using PORT 1 for programming tools, connecting to file services and connecting to other devices such as HMI, remote I/O and drives using ModBus® master/slave functionality, while using port 2 for connecting to closed loop controlled drives and real-time I/O. For using ModBus® and EtherCat™ fieldbus protocols, please refer to the McBasic User's Manual.

The serial ports, USB and McWay I/O communications are similar to those in MPU2. (See section 3.1.1)

3.2.2 Front panel display and function keys

The front panel 2x8 character display and arrow keys allow observing some information on system status. When starting, the display shows briefly the boot device used for starting. Then date/time are shown as read from the system real time clock.



Using the ↑ and ↓ buttons data can be accessed in the following order: Date/Time → McDos version → Firmware version → Serial number → Ethernet 1 IP address → Ethernet 2 IP address → Ethernet 1 MAC → Ethernet 2 MAC.

The → button can be used to show a short explanation of the current data displayed.

The ← button returns the display to date/time.

The display and buttons can also be used from the application program.

Using the command OPEN #*n*, "FP:" opens the display/buttons for use from the program as device *n*. The display is organised as a 16 character row, so text can be displayed for example by printing a 16 character string with a ";" after it with the PRINT command:

```
PRINT #n, "  MPU3  RUNNING ";
```

The arrow buttons will produce characters A,B,C and D (ASCII 65,66,67 and 68) for ←,↓,↑,→ respectively, and can be read from device n for example with the BYTE(#) function:

From console with programming terminal, no button pushed:

```
PRINT BYTE(#n)
-1
```

After pushing the ← button:

```
PRINT BYTE(#n)
65
```

3.2.3 MPU3 front panel

The front panel of the module shown in Figure 5 gives the user information of normal operation and possible errors. The panel is also equipped with an SD card slot and a mini USB connector for console serial port (CN). Information on the front panel LEDs and their function is also shown in Figure 5.

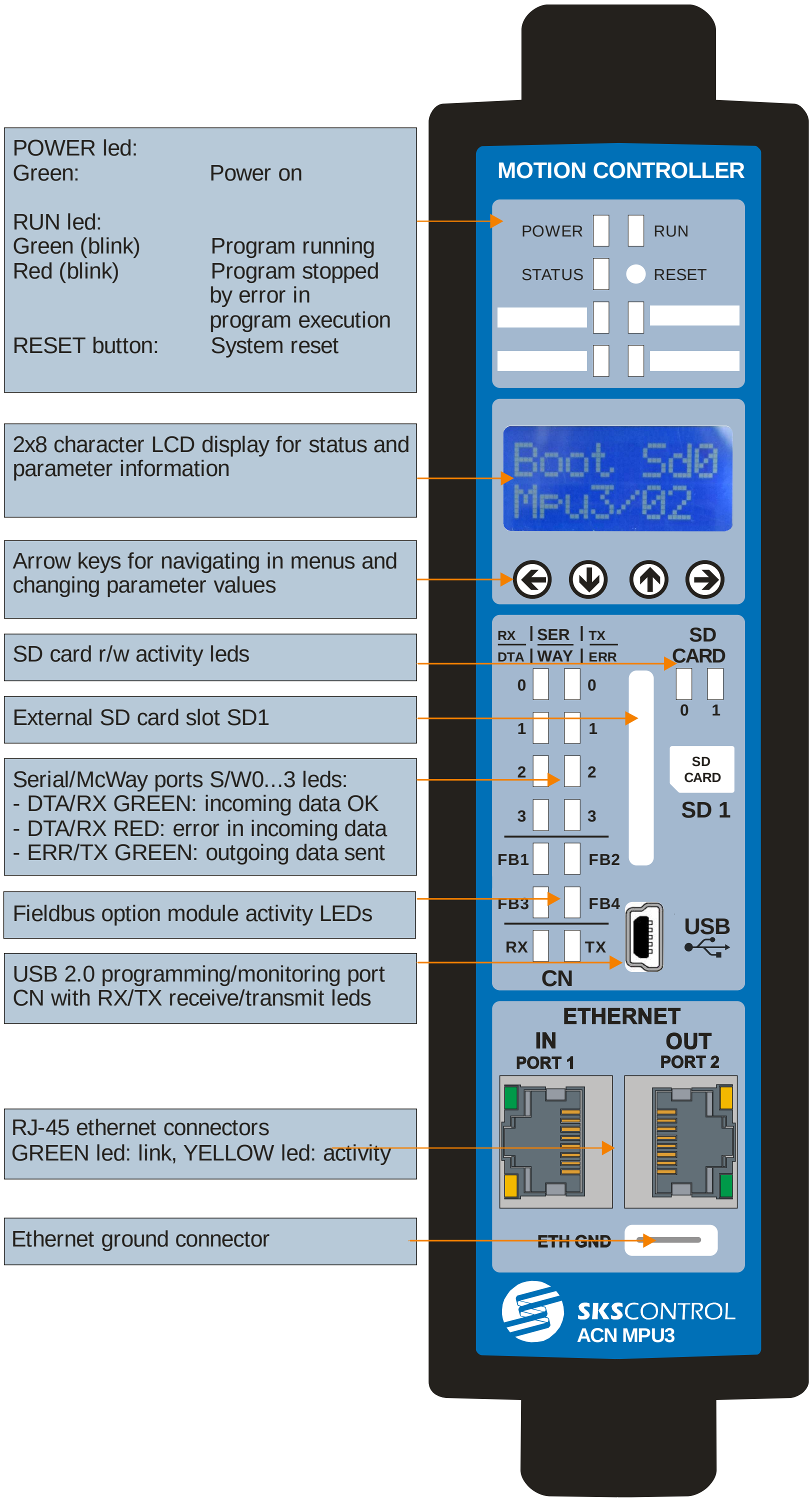


Figure 5, MPU3 module front panel

3.3 AXi/AXa Module

The ACN AXi/AXa axis connection units provide connections for one position controlled axis using the McWay I/O system. Position is controlled by the ACN control system using the position information from the absolute (AXa) or incremental (AXi) encoder connected to the module. Depending on the desired performance, servo, DC or inverter drives can be used for position and path control, synchronization and other types of motion. Servo and proportional hydraulics can also be controller using this module.

The AXa is an absolute encoder version of AXi. For most functionality, AXa is compatible with AXi. The main difference is in the operation of position transducer. Instead of a pulse encoder, an SSI (Synchronous Serial Interface) absolute encoder is used. The advantage of an absolute encoder is, that the system remembers its position information also when power is off thus eliminating need for home search after power up. Also, in case of interference to the position measurement system, the absolute encoder recovers its correct position value, thus improving system reliability. The default operational mode for AXa is 24bit frame SSI encoder. It is possible to mask bits with the McBasic ENCSIZEx command to use shorter position data. To ensure proper operation, use encoder types recommended by your ACN distributor. For other encoder types contact manufacturer.

After the module has been configured to the ACN control system McWay I/O loop, its connections can be operated using the McBasic motion control, and I/O commands and functions. Before operating the position loop, proper values must be given to McBasic position scale, regulator and kinematic parameters. Please refer to section 6.6 and 6.10 before commissioning and operating a position loop.

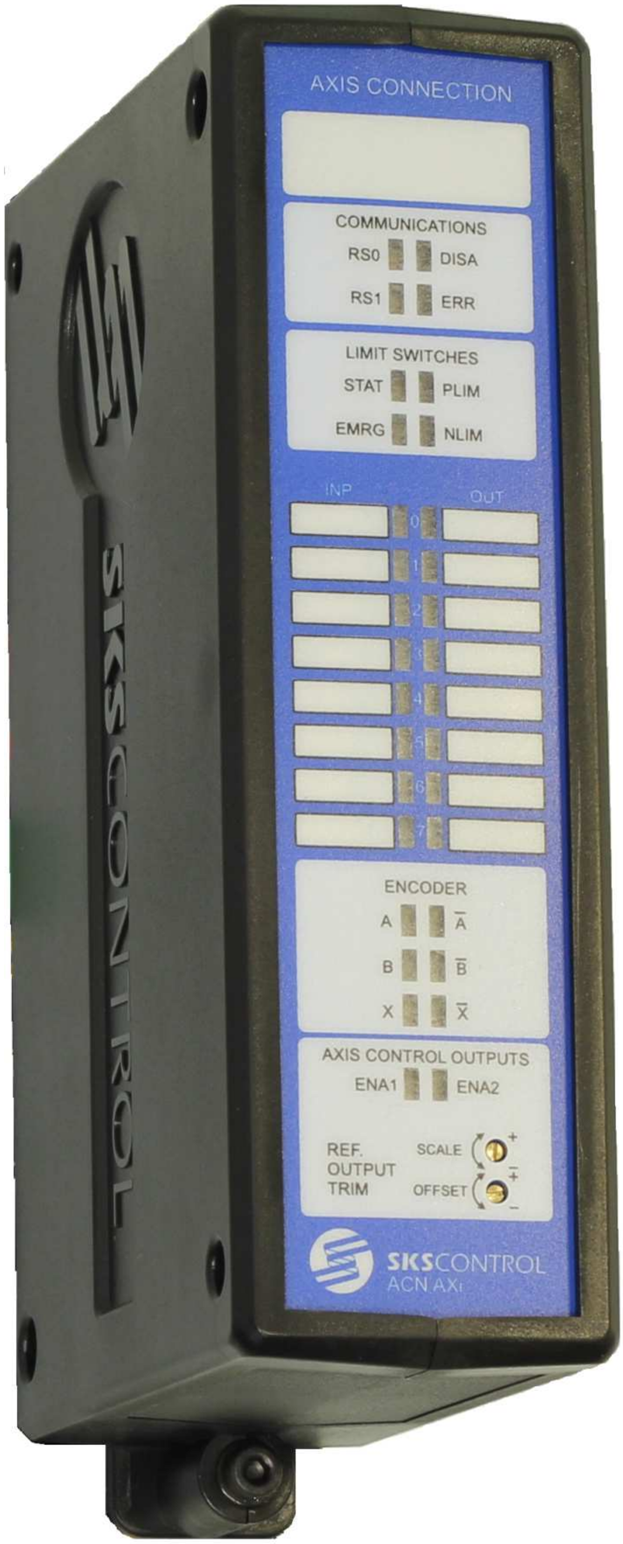


Figure 6, AXi/AXa module

3.3.1 AXi/AXa module front panel

The front panels of both versions of the module are equipped with indicator LED:s showing the normal operation of the module and possible errors. Figure 7 and Figure 8 give more detailed information of the front panels of both module types. The AXa module front panel differs from the AXi only by the encoder LED indicators.

AXi module front panel

Communications

LED	Function
RS0	Communications bus data
RS1	Communications bus data (inverted)
DISA	Indicates if bus data packet timeout has occurred
ERR	Bus packet error

Limit inputs

LED	Function
STAT	Status input ON/OFF
EMRG	Emergency input ON/OFF
PLIM	Positive limit input ON/OFF
NLIM	Negative limit input ON/OFF

Inputs 0 to 7
Outputs 0 to 7

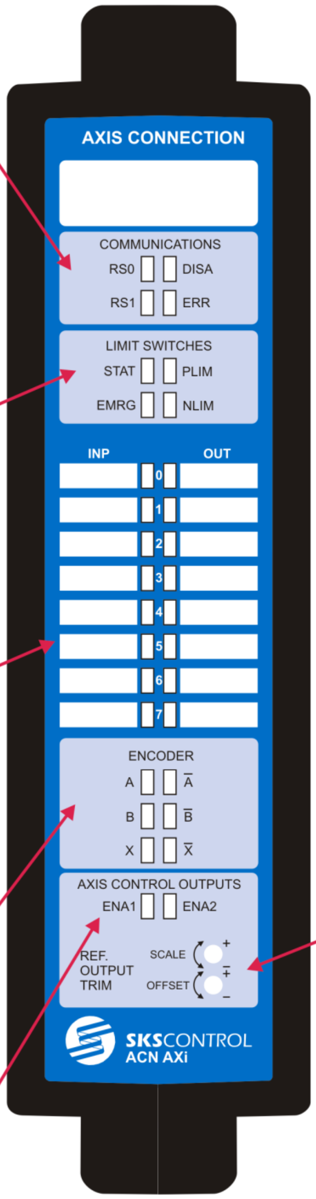
LED	Function
INP0-INP7	Input ON/OFF
OUT0-OUT7	Output ON/OFF

Encoder

LED	Function
A, Ā	Encoder channel A/Ā
B, B̄	Encoder channel B/B̄
X, X̄	Encoder Index X/X̄

Enable outputs

LED	Function
ENA1	Enable 1 ON/OFF
ENA2	Enable 2 ON/OFF



Reference voltage output adjust

Figure 7, AXi module front panel

AXa module front panel

Communications

LED	Function
RS0	Communications bus data
RS1	Communications bus data (inverted)
DISA	Bus disable indicator
ERR	Bus packet error

Limits

LED	Function
STAT	Status input ON/OFF
EMRG	Emergency input ON/OFF
PLIM	Positive limit input ON/OFF
NLIM	Negative limit input ON/OFF

Inputs 0 to 7
Outputs 0 to 7

LED	Function
INP0-INP7	Input ON/OFF
OUT0-OUT7	Output ON/OFF

Encoder

LED	Function
CLOCK, $\overline{\text{CLOCK}}$	SSI encoder Clock
DATA, $\overline{\text{DATA}}$	SSI encoder Data
X, $\overline{\text{X}}$	SSI encoder Index X/$\overline{\text{X}}$

Enable outputs

LED	Function
ENA1	Enable 1 ON/OFF
ENA2	Enable 2 ON/OFF

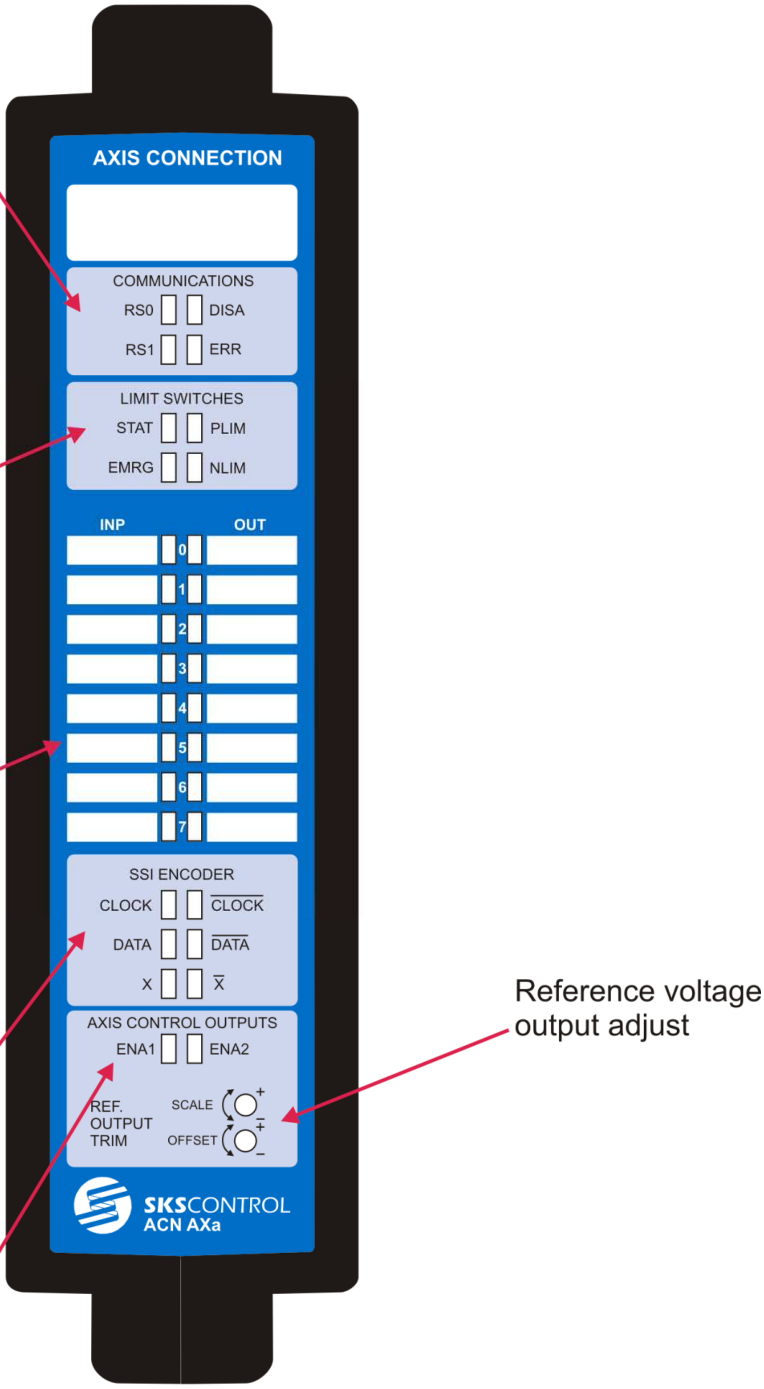


Figure 8, AXa module front panel

3.4 AXi/AXa module features

This section gives a description of the modules features. For a more detailed view of the electrical connections refer to section 5 of the manual.

3.4.1 Position capture

The AXi module is equipped with a fast position capture function that allows storing measured positions at exact input events. The function allows storing exact position value at rising or falling edge of either the index signal or input 0. To use the function with McBasic refer to McBasic Programming Environment Reference Manual for CAPTPOSx function.

NOTE CAPTPOSx function is also applicable to AXa absolute encoder axis connection module but since the module reads the encoder position only at each I/O cycle, it is not as accurate as for the AXi incremental module.

3.4.2 Encoder errors

In AXi it is possible to read, whether errors have occurred in encoding the quadrature signals coming from the encoder. The system can detect errors presenting themselves as simultaneous transitions in both A and B channels. The number of detected errors can be read with the ENCERRx function. For more details refer to McBasic Programming Environment Reference Manual.

The AXa logic can detect a range of problems in the SSI transfer. Reading ENCERRx is recommended for testing the correct operation of the encoder. In case of a large number of errors occurring constantly, check that the components are correctly connected and not broken. In case of occasional errors, check the cable type, earth and shield connections and use ferrite suppression for interference if necessary.

3.4.3 Limit switches

Limit switch logical addresses are specified together with the encoder logical axis as explained in McBasic documentation of the WAYMOD$= command.

Inputs are activated (1 or true, when read) by driving them to 24V. For more information see section 3.4.6 Inputs and outputs.

Driving the EMRG input to logical 0 always causes the drive connected to the module to be disabled. This operation is performed also as a hardware function of the module, so additional safety is achieved.

The STAT signal is an input electrically similar to limit switch inputs. It can be used for externally inducing an error condition for the axis. See LIMITTYPE and MOVEREADY for more details.

The operation of limit switch signals can be observed at corresponding LEDs. See Figure 7 or Figure 8.

3.4.4 Drive connections

Drive connections are supplied for interfacing with a motor speed regulator such as a servo amplifier. The logical axis of the signals is specified as explained in McBasic documentation of the WAYMOD$= command.

Two control relays with one change-over contact each are available. The relay connections are shown in section 5 in 0.

With McBasic DRIVETYPEx=1 the drive enable relay E2 is activated always when the respective axis position control is in operation. A position control error or PWR=0 command causes the relay to switch off. ENA1 can be controlled by software as OUT(a+2) where a is the number of axis *4 (0,4,8.....).

DRIVETYPEx=2 uses E1 as drive enable, E2 as direction control and REF output as unipolar speed reference 0...10V.

DRIVETYPEx=3 operates similarly to DRIVETYPE=1, except E1 follows the status of E2.

The enable relay is normally connected to a drive input that activates speed control (torque on). The relay can also be used to control a motor stand-by brake.

The status of the ENA relays is shown by LEDs ENA1 and ENA2.

The REF+ and REF- contacts are used to control the motor speed. They are normally connected to the drive speed reference input so that positive voltage at REF+. with respect to REF- causes the motor to turn to positive direction when measured from the position encoder.

The REF output is the output of the PID position regulator and provides speed reference voltages between -10 V and +10 V.

When the axis motion control is not active the REF output is 0V. The offset voltage of the REF output can be adjusted to 0 with potentiometer REF OFFSET and the scale of the output to nominal ±10V with potentiometer REF SCALE. Both potentiometers are 20r multiturn.

3.4.5 **Servo operation**

To be able to continuously control axis positions, the ACN systems use continuous path incremental motion control. This means that once started, the servo loop will control axis positions in motion and at standstill.

The McBasic motion commands (MOVE etc.) generate the specified movements by moving the internal set value registers as motion advances.

Position error is calculated as the difference between the set position and the actual position measured with the position encoder.

The position control algorithms calculate appropriate speed references out of the position error for each axis 50-2000 times per second according to controller settings thus maintaining the axes position errors as small as possible.

Most often the drive and motor controlled by the position controller are ac or dc servos or servo hydraulics. The performance of the motion control loop depends of the quality of the drives, motors and speed transducers forming a speed controlled drive system, the load and transmission dynamics and the accuracy of the position feedback encoder.

For high bandwidth position control, it is best to install the position encoder mechanically as near the motor as possible.

Before starting a position control loop, please check the operation of the speed control (tachogenerator + motor phasing) and the position encoder phasing (see controller documentation for commissioning procedures.).

3.4.6 Inputs and outputs

8 digital inputs and 8 outputs are available for free use by the application program.

Each I/O connector has terminals for four inputs or outputs and a common 24Vdc supply voltage and ground (0V).

The outputs of the AXi/AXa module are configured to operate as open collector PNP.

The inputs of the AXi/AXa module operate with a positive logic at a 24V voltage level.

The input logical threshold levels have been designed to provide maximum immunity for interference.

Table 3. Input signal levels

AXi/AXa input signal levels:	
V_{max}	30V
V_{on}	>14V
V_{off}	<10V
V_{min}	-10V

The 24V supply voltage output can be used to supply for example proximity switches, 0 in section 5.6 shows the electrical connections in the AXi/AXa inputs and outputs. The inputs at the Limit switches connector are also electrically similar.

The outputs of the AXi/AXa are open collector type with a protection diode connected to 24V. Output loads can be connected between 0V and OUTn.

Table 4. Output load levels

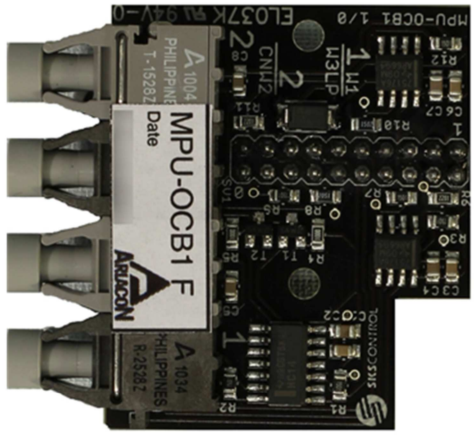
AXi/AXa output load levels	
V_{min}	0V
V_{max}	V_{supply}
I_{max}	200mA
I_{tot} from 24V	500mA

3.5 MPU module and base circuit board connection boards

The MPU-OCB F and MPU-OCB C connection boards are two optional cards that can be installed on either inside the MPU module itself or on the MPU connector board, providing interfaces for additional McWay I/O loops or serial communication if needed. Both versions of the card can be installed on all reserved places, providing RS422 (MPU-OCB-C) or fiber connections (MPU-OCB-F). The boards are installed using only two screws and there is no need for additional wiring or power connectors. For further information on mechanical installation see Section 4.4.2 and for electrical installation 5.7.

The MPU-OCB-F version provides high speed optical communications and should be used whenever possible for optimal immunity to electromagnetic interference. The board can be used with plastic fibers up to 30m with a speed of 1,25Mbit/s. Optical fiber segments are available in standard lengths and also in special lengths on request from your ACN distributor.

The MPU-OCB-C version provides for RS422 communication up to 200m with a twisted pair cable. This version is to be used where there is less danger of electromagnetic interference or the apparatus which it is connected to only accepts RS422 data.



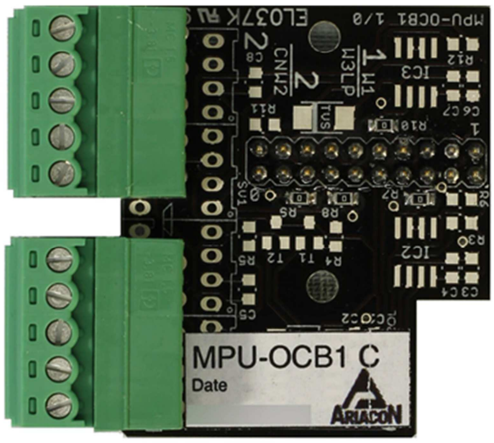


Figure 9, MPU-OCB versions F (top) and C (bottom)

4 Mechanical Installation

WARNING

Enclosure:

The product is intended to be mounted in an enclosure which prevents access except by trained and authorized personnel, and which prevents the ingress of contamination. It is designed for use in an environment classified as pollution degree 2 in accordance with IEC 60664-1. This means that only dry, non-conducting contamination is acceptable.

4.1 Environmental requirements

When storing, installing and operating the ACN system, appropriate care must be taken according to the environmental protection of the particular installation.

When installing, any dirt, particles, harmful gases or liquids must be prevented from entering any part of the system.

Although the ACN products are equipped with protection components and to avoid electrical interference in harsh industrial environments it is necessary to use good grounding practice and shielded cables in sensor signals and use adequate spike absorption (RC, diodes, varistors etc.) for inductive loads. Also cables generating high levels of electrical interference, such as power cables of modern servo amplifiers and inverters, must be shielded and grounded according to the manufacturers' specifications. The following limitations must be taken into account:

NOTE

	Storage	Operation
Temperature	-10...+65 °C	0...+40 °C
Humidity	< 95% RH non condensing	< 95% RH non condensing

4.2 Items supplied with the ACN product

The ACN system is delivered with all necessary mounting accessories for the modules and the base connector boards are factory assembled to the base plate. The only additional parts needed are the M6 flange head bolts (or similar) for assembling the ACN base plate to the assembly plate of the control cabinet. See 0 for a summary of parts supplied with the system and recommended additional parts. In the case of system expansion or spare part needs contact your ACN dealer.

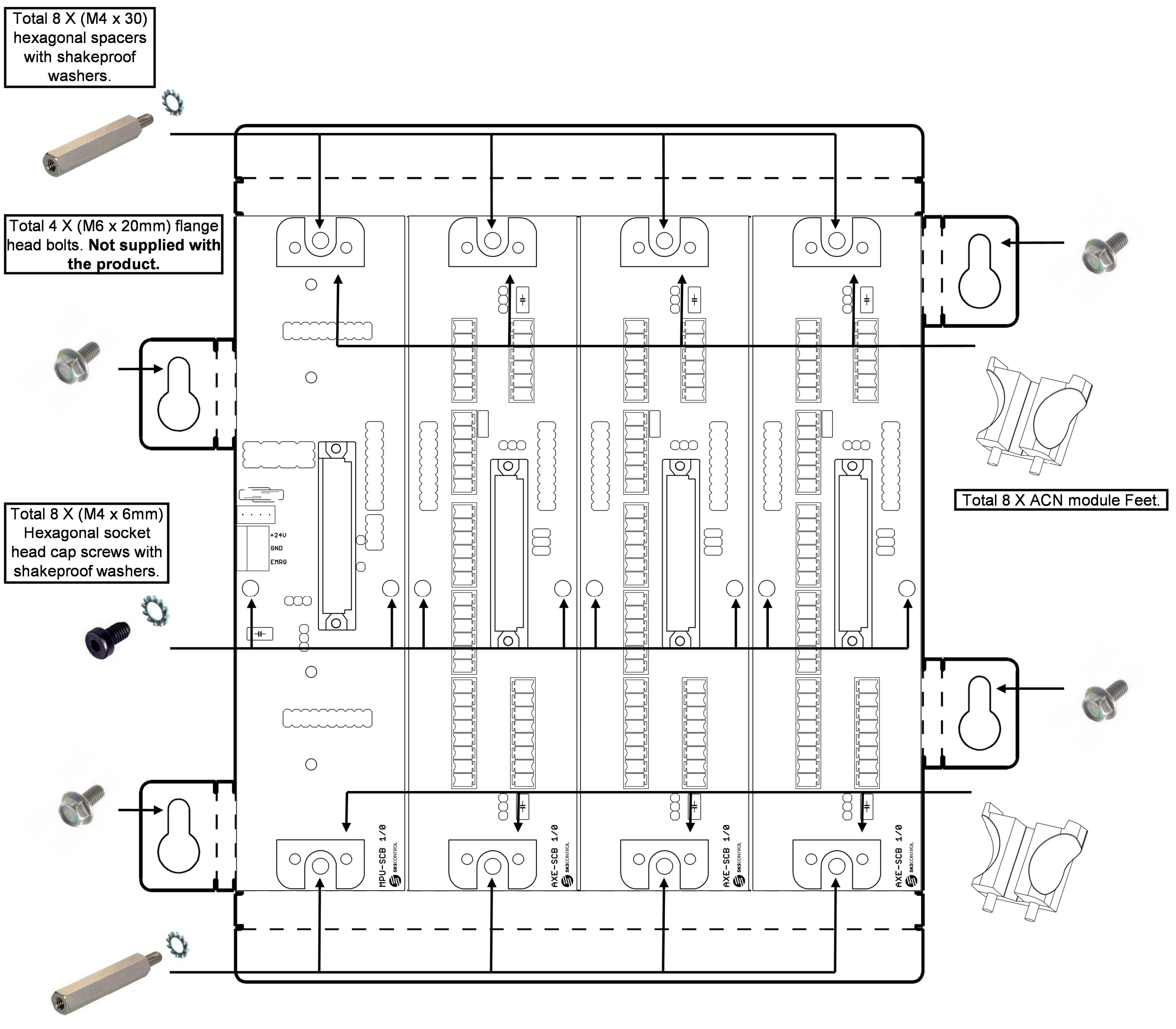


Figure 10, installation parts and accessories

4.3 Dimensions

0 shows the outer dimensions for mounting a four-module base plate. Free space is recommended to be left around the base plate to provide for adequate air flow and easy cable mounting.

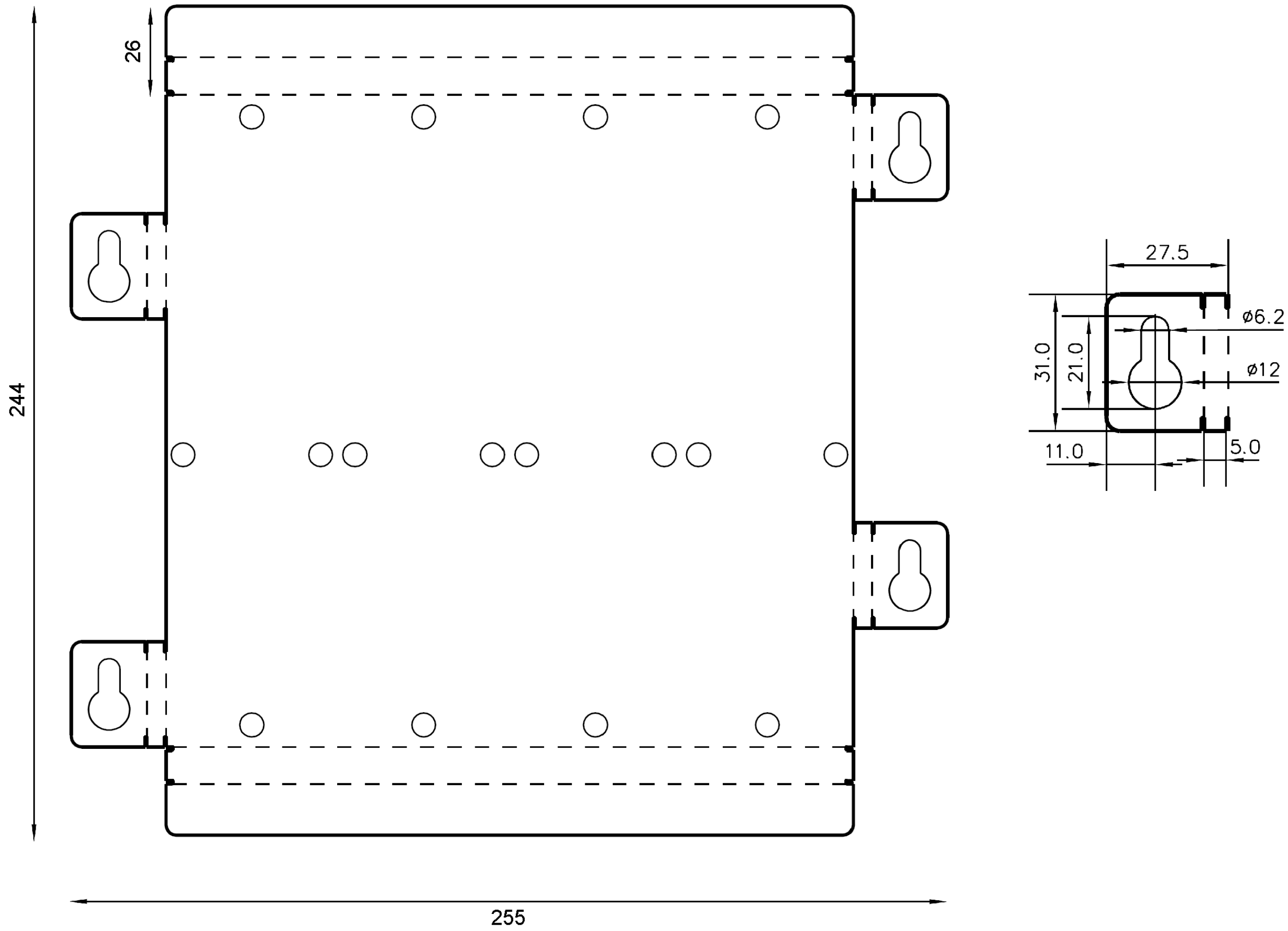


Figure 11, outer dimensions of the four-module base plate in mm.

4.4 Mounting

4.4.1 Base Plate

The base plate is to be mounted on the assembly plate inside a control cabinet using four M6-size flange head bolts or similar tightened to the mounting flanges showed in 0.

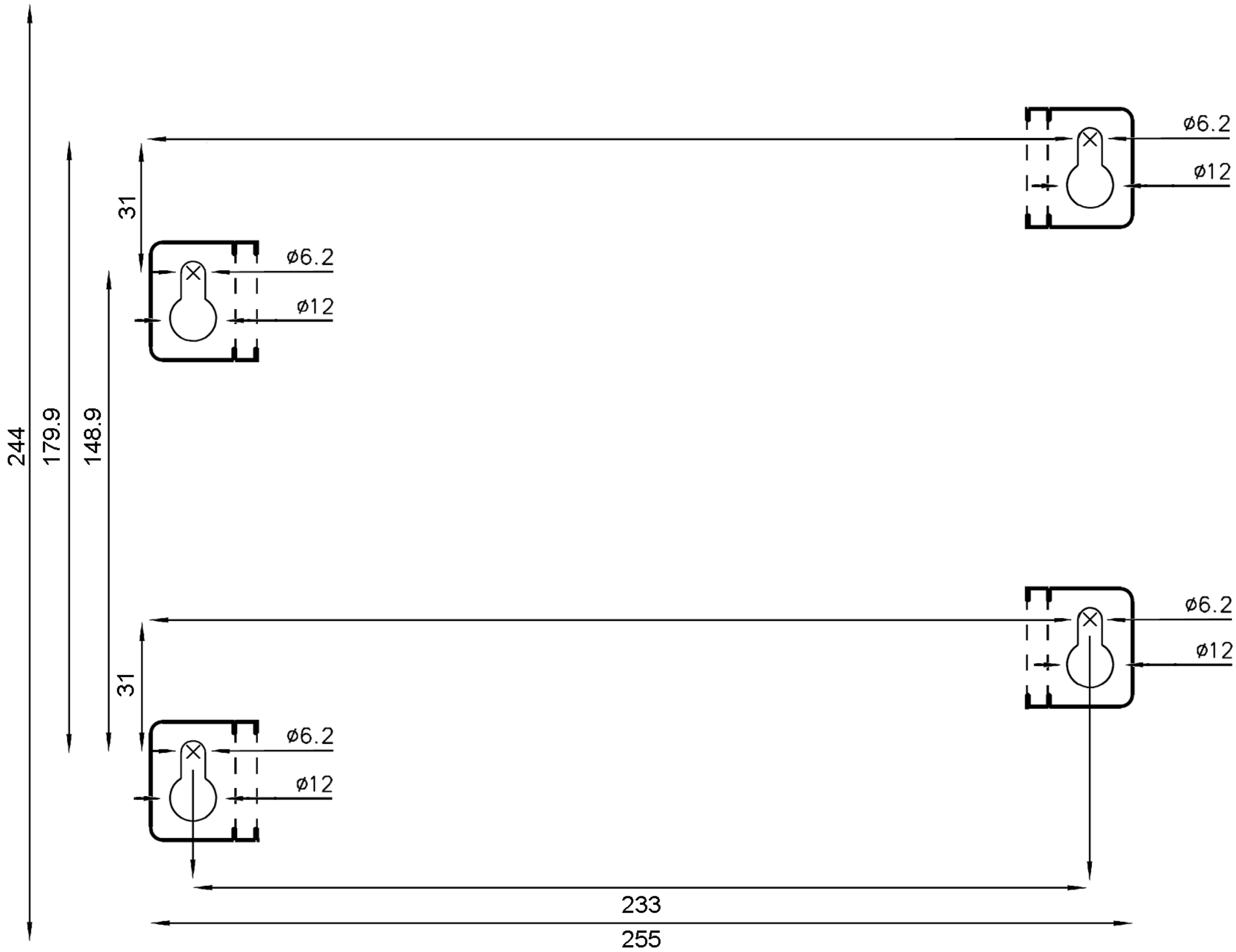


Figure 12, positions the four-module baseplate mounting holes.

The horizontal measurements will increase by 50 mm for one added module place. All vertical measurements are the same as for the four-module baseplate. For example, a baseplate with six module places will have the following horizontal measurements:

233mm (Four modules) → 333 (Six modules)

255mm (Four modules) → 355 (Six modules)

4.4.2 MPU Option boards' assembly instructions (MPU OCB-F and OCB-C)

Both available option cards for the MPU module (OCB-C and OCB-F) are placed on the pinstrip connector on the MPU base circuit board. The option board is fastened using two 3x6mm hexagonal screws as shown in Figure 13. For electrical installation and the location of the base circuit board pinstrip, see section 5.7.

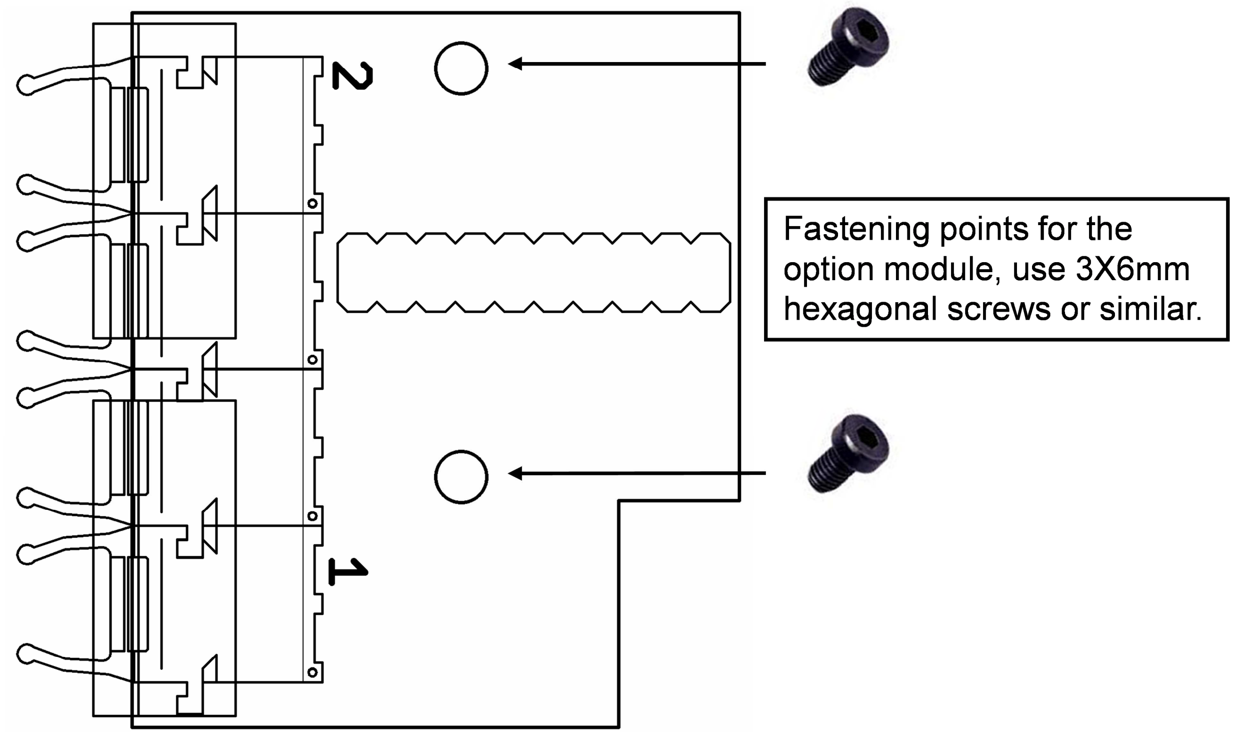


Figure 13, option modules MPU-OCB-C and MPU- OCB-F assembly

CAUTION

Use only screws supplied with the modules to ensure that the heads of the screws are small enough not to cover any conductors on the circuit board or else there will be a risk of damage due to short circuiting the board.

5 Electrical installation

5.1 Power supplies

Use a 24V power supply delivered by your ACN distributor. To comply with EN50081-2 requirements use twisted pair wire to feed the ACN unit. The base circuit board is by default equipped with a ferrite bead and a varistor to ensure maximum EMC-compatibility.

The minimum recommended power supply current capability is 5A for a complete system with four modules and increases by 1A per added module for bigger systems.

5.2 Ground and shields

For proper operation of an electrical system such as a machine control system with high power drives, it is essential to use good grounding practices and shielded cables.

The purpose for grounding and shielding is to

- Ensure the safety of the system.
- Prevent malfunction and breakdown of system components caused by electrical interference.
- Prevent interference from causing distortion in sensor and communication lines.
- Prevent the system from generating unacceptable interference levels.

To achieve this, the system must be carefully designed to keep the interference generating components apart from interference susceptible components. Physical distance minimizes the effects of magnetically coupled interference. When necessary, high noise level components should be installed in separate enclosure apart from control components and sensor signals.

Grounding arrangements must be based on a system ground operating as a common potential point for all grounds. Grounds for different electrical circuits are connected to the common ground with separate wires. The assembly plate of the cubicle where the control system is installed often offers a good point of common potential

For interference generating equipment such as drives and servo amplifiers, care must be taken to provide a short current path for interference currents back to the drive. Therefore in drives, the motor grounds and motor cable shields are connected to the drive ground rather than the system common ground. The drive grounds are then connected to the system common ground.

For sensitive signals such as encoder and communication lines suitable shielded cable types must be used and the shields must be connected to the system common ground.

0 shows some examples of ground connections and cabling in a control system with servo drives.

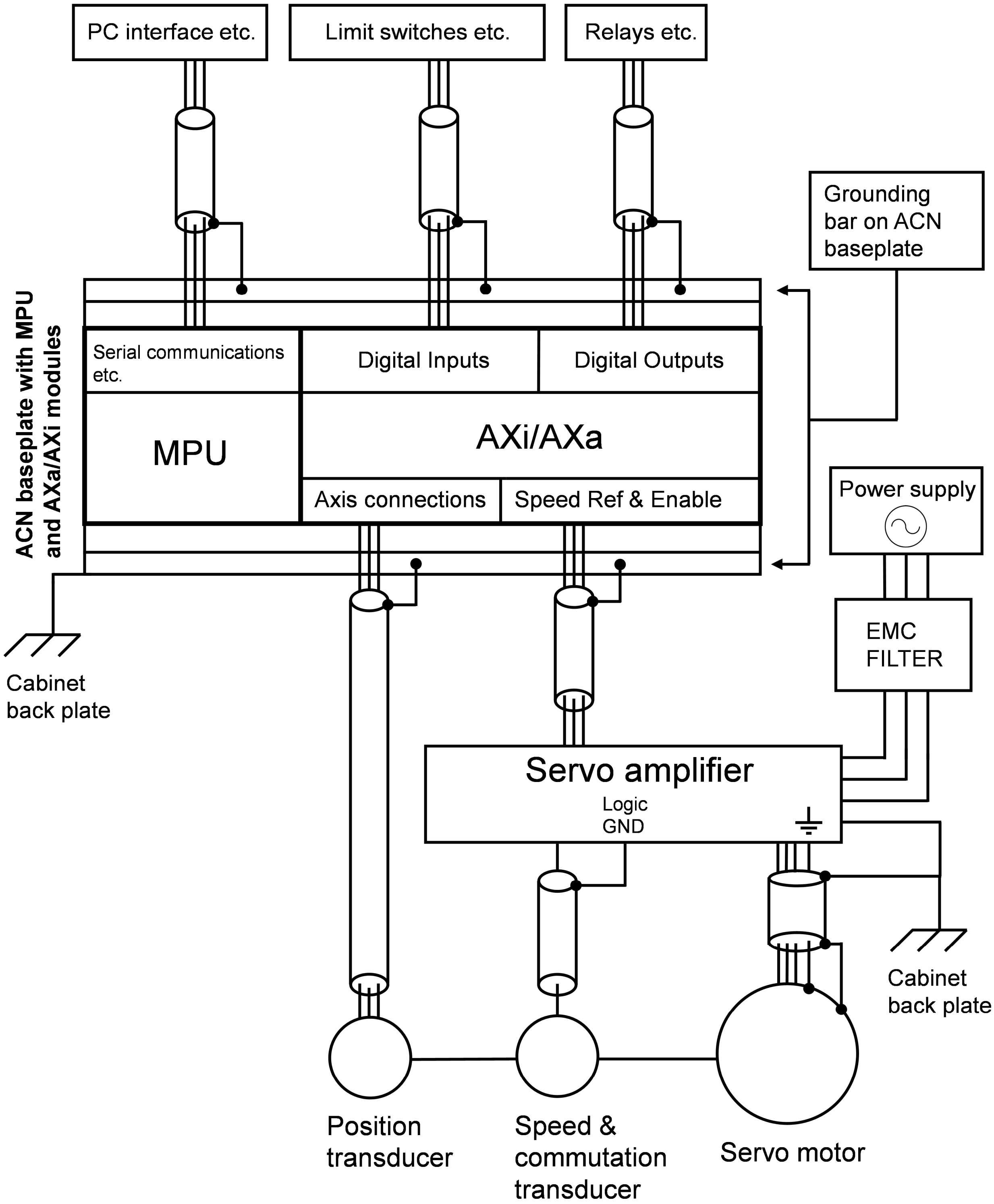


Figure 14, example of system grounding

The following considerations are useful when designing grounding and shielding in the system:

Encoder

To allow interference free operation the encoder cable must be of shielded type recommended by the encoder manufacturer and the shield must be connected to the ACN grounding bar using a metal cable tie or clamp as shown in 0. Do not connect the shield at the encoder end as this will probably cause a ground loop via the encoder chassis and the motor/machine chassis. Prefer twisted pair cables and encoders with line driver outputs.

Servo amplifier

The servo amplifier control cable must be shielded to avoid interference in the speed reference signal. The shield must be connected to ground at control system end only.

Motor and related transducers

The servo motor cable is a major interference generator in a switched mode servo or other type of drive system. To avoid high noise levels, the motor power cable should be of shielded type. A cable with an internal or external ground wire must be used to connect the motor chassis to the drive ground. Also the cable shield must be connected both to the drive chassis and to the motor chassis.

It is essential, that the motor grounds are all connected straight to the drive ground or to the cubicle back plate very near the drive. This way the currents caused by interference from the power wires flow back to the drive to form a loop as small as possible.

Usually there is a connection for the transducer (usually encoder or resolver) cable shield in conjunction with the related signal connections. Normally the signal cable shields are not connected in the transducer end if the shield in the transducer is connected to motor or machine chassis.

Communications cables

To ensure proper operation of data lines such as RS-232, RS-422 and RS-485, shielded cable types preferably with twisted pairs are recommended. Although the shields can be connected to the control system chassis (pin 1) in the ACN, the best noise immunity is achieved by using separate ground wires from shield to ground and connecting the shield to ACN ground bar.

I/O signal cables

In systems with high noise levels, such as plasma cutting or welding equipment (especially TIG) it may be necessary to used shielded cable types also for signals such as limit switches, valves and actuators. In this case the shields are connected to system ground at the control cabinet end only.

PE - TE grounding arrangement

In some installations it is possible to connect the protective earth (PE) and the technical earth (TE) to separate grounding arrangements in the electrical distribution system. For these cases the shields and grounds used for protective purposes or to prevent radiated noise are connected to PE (Cabinet, drive and motor ground, ACN chassis, actuator ground etc.).

Cable shields for signals susceptible to noise are connected to TE (encoders, sensors, communication lines). In some cases it may be useful to provide separate ground terminals for PE and TE in case further interference problems must be solved. Also it may help avoid interference to use separate ground wires for PE and TE from the nearest distribution panel. In this case the ACN base plate must be electrically isolated from the control cabinet back panel using insulators and a separate TE cable must be connected to the ACN base plate from the nearest distribution panel, see 0.

5.3 EMC

Electromagnetic compatibility (EMC) is an important design factor in industrial automation as well as in other electrical installations. The purpose of EMC is to ensure that electrical equipment emit electromagnetic energy (interference) less than what can cause malfunction of other equipment. The difference between the level of emissions and the level of susceptibility is called the EMC margin.

There are different standards and regulations specifying the test and measuring techniques and acceptable levels for conducted and radiated emissions and immunity.

5.3.1 The European EMC directive

The European Union requirements for EMC are stated in the EMC directive 2009/108/EC. The purpose of this directive is to ensure that all “Relevant Apparatus” marketed in the European Union have the same EMC margin in the same type of environment. Relevant apparatus is defined as a product or installation having an independent function and being delivered to the end user as such in the European Union. Such apparatus must also be marked with the CE mark to show the end user that the product complies with relevant parts of the regulations.

The Machine Directive containing regulations of machine safety and structure, demands that the machine complies with the requirements of the EMC directive. This means that emissions from the machine (conducted and radiated) must be under the levels stated in the appropriate basic standards and the immunity of the machine for interference must be on the levels stated in these standards. These basic standards are:

- EN50081-1 emissions, domestic and light industry
- EN50081-2 emissions, industrial
- EN50082-1 immunity, domestic and light industry
- EN50082-2 immunity, industrial

It is not necessary to maintain the same levels inside the application. Therefore the regulations do not apply to components and materials used in the machines as such. Also, the amount of emitted interference increases as the number of components increases. This increase varies according to the nature of the source.

While it is always necessary to maintain a suitable EMC margin inside the electrical system of a machine to ensure the proper operation of the machine, the cost effective way to build an EMC directive compliant machine is to design for the external connections and protection of the machine to comply with the necessary requirements.

Typical methods to achieve this are common filtering of power connections, appropriate housing structure for components and equipment and use of suitable screening and cable types together with correct grounding in the wiring of the system.

5.3.2 General installation guidelines

To help the machine manufacturer achieve compliance, SKS Control ACN products have been measured in test installation to pass the requirements of EN50081-2 and EN50082-2.

These installations are described in SKS Control ACN manuals. By following these installation practices the ACN components in the electrical system of the machine generally do not obstruct compliance. In complex cases, where it is difficult to install according to all instructions, and when the influence of other components must be considered, additional testing may be necessary to ensure compliance.

5.3.3 System grounding

The applicable regulations for protective earth of the system should be obeyed to ensure electrical safety.

Earth conductors used should be as short and large as possible and they must be able to carry the maximum short circuit current in a fault situation.

The control system, other electrical equipment and the machine must be interconnected to a common earth reference, the machine chassis earth.

Shields and earth wiring conducting emitted interference to earth, such as motor power cable shields and motor/drive earth should be connected to PE.

To ensure, that all earths are as free of interference as possible, all earth wiring must be connected in a tree fashion with branches routed to the central earth ground point, see 0 and 0).

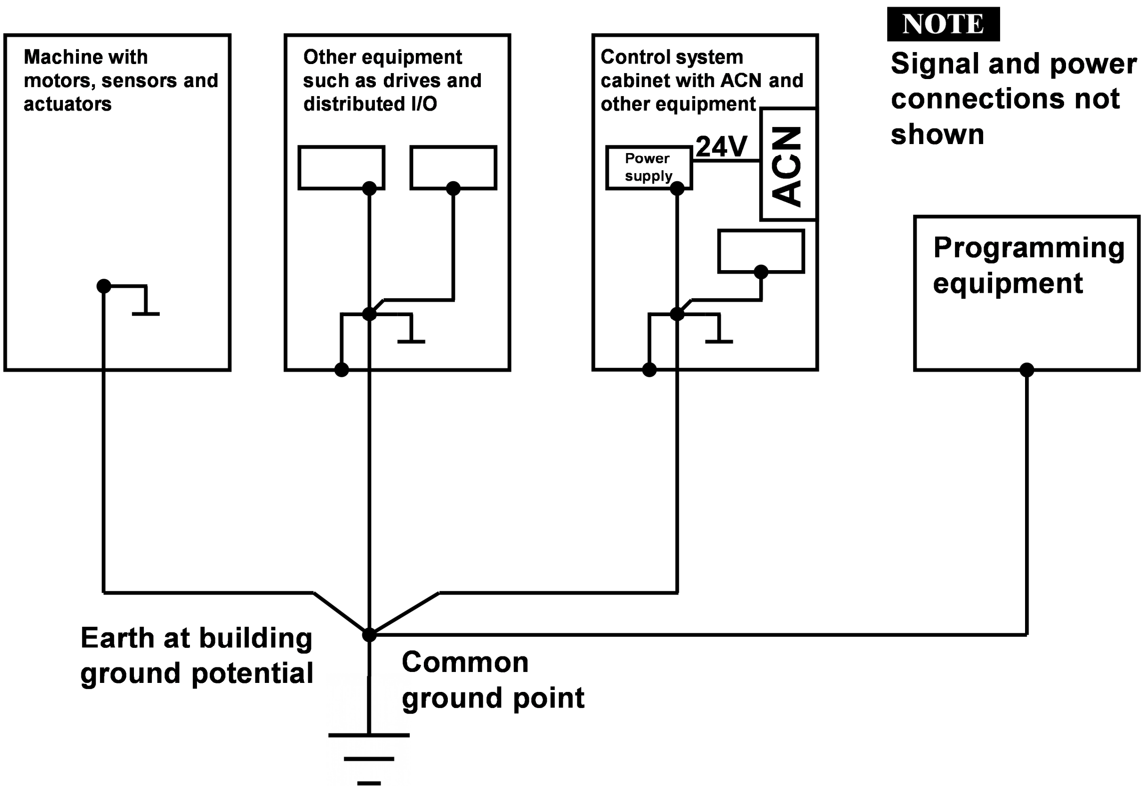


Figure 15, system ground tree arrangement

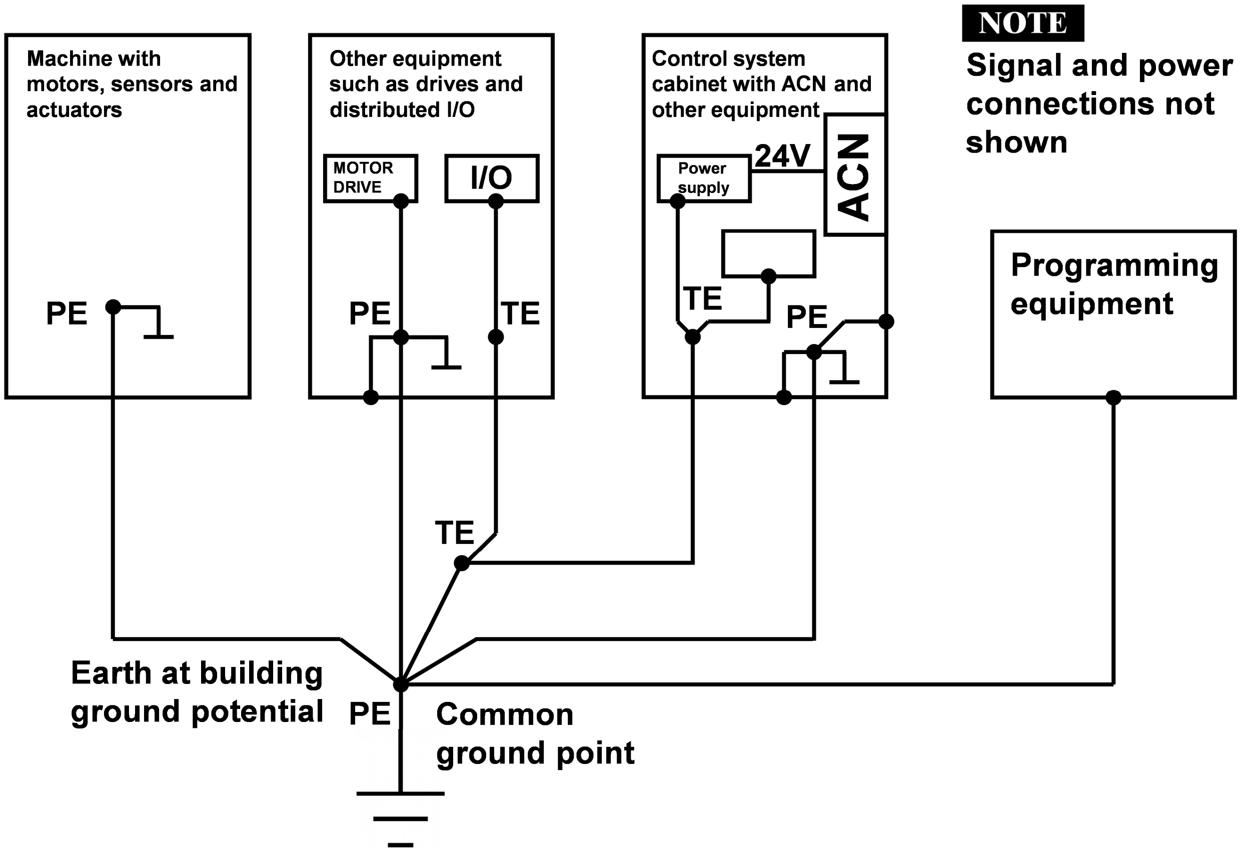


Figure 16, recommended ground arrangement with PE – TE

5.3.4 Enclosure

Install the equipment in a metal housing or equivalent. System wiring external to the enclosure must be routed in metal conduit or equivalent shielded cables must be used. For best results, use cables with double screen and connect the outer shield to the enclosure at entry and the inner shields to ground near the equipment.

Use ferrite rings with suitable permittivity, such as supplied by manufacturer, for external signal cables with shields wired to TE to reduce common mode interference and load to TE.

5.3.5 Signal Cables

To conduct signals such as communications or transducer signals use shielded cables with preferably twisted pair wires when applicable. The shields of the wiring must be connected to earth potential with minimum interference (generally ACN base plate ground bar). Signals using the shield for protecting themselves from outside interference must be connected to earth at the control cabinet. The other end of the shield must be left unconnected to avoid loops. When necessary, use ferrite rings on the cables to suppress common mode interference and keep it away from the system earth.

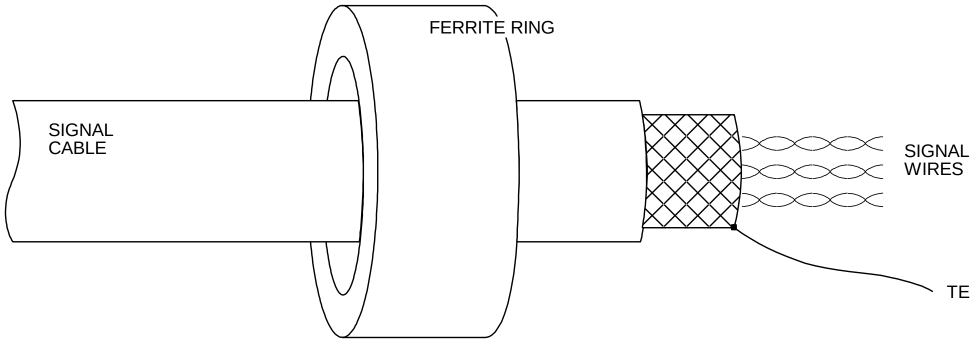


Figure 17, signal cable ferrite suppressor

5.4 Limit switches and emergency stop

Limit switch and emergency stop inputs are special inputs for motion control. These inputs are normally closed by default, so the system will operate normally when the inputs are connected to 24V.

Opening the emergency stop input, marked EMRG, immediately causes motion control operation for the axis concerned to be disabled. The drive enable output (ENA) will go off and reference signal (REF) will go to 0V. The operation is similar to cutting off servo control with McBasic PWR=0 command. The status of the EMRG input can be read as explained in McBasic manual.

The operation of the limit switch inputs NLIM (negative end limit) and PLIM (positive end limit) can be configured with the McBasic LIMITTYPE command. When operative, the limit switches cause motion control to go off if the switch for the current direction of motion is influenced. Stopping is performed as with EMRG. However, when the limit switch is influenced, servo control is not cut off, if the axis position set value is not moving towards the switch, so driving out of the switch area is possible with normal motion commands.

Signal names:

NLIM Negative (-) end limit switch. When used with default LIMITTYPE, the signal is connected to respective 24V by a normally closed limit switch. Opening the switch causes disabling and stopping of servo control during possible motion in negative direction. Typical use is limiting the operation range of a linear mechanism.

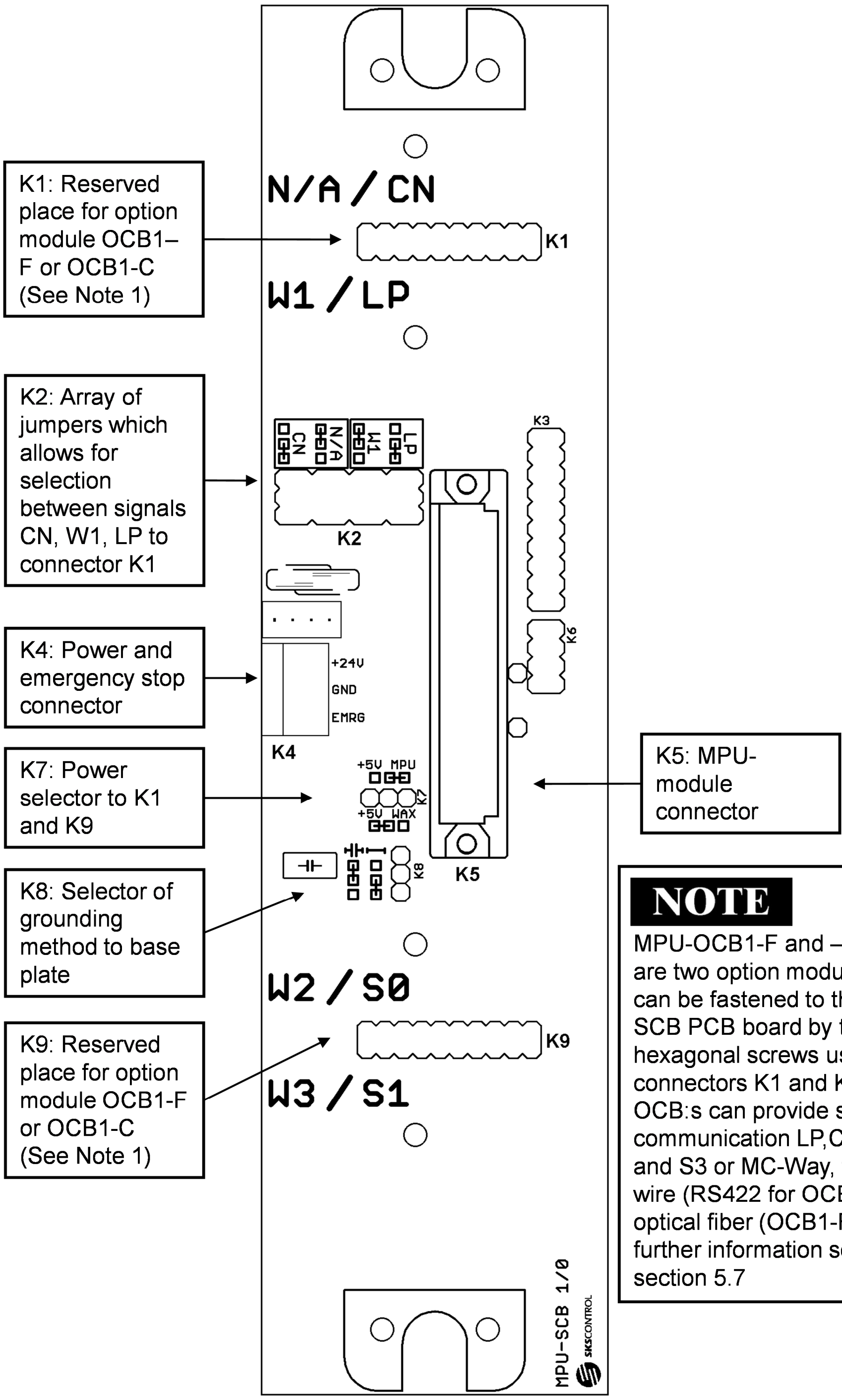
PLIM Positive (+) end limit switch. When used with default LIMITTYPE, the signal is connected to 24V by a normally closed limit switch. Opening the switch causes disabling and stopping of servo control during possible motion in positive direction. Typical use is limiting the operation range of a linear mechanism.

EMRG Emergency switch. During normal operation this signal is connected to +24V. Opening the switch causes motion and position control to be stopped and disabled. The ENA signal goes off and the reference output (REF) goes to 0V. This input is usually connected to the emergency switch arrangement of the electrical system of the installation.

For a safe emergency stop function, the emergency stop switches of the installation must first cut off servo and possibly other actuator power and as a result also the EMRG signals of the axes. If a controlled axis is powerful enough to cause damage in case of limit switch malfunction, it is also advisable to add switches connected to the emergency stop circuit at the ends of the motion area. Elastic or hydraulic bumpers may also be required to avoid damage when operating the emergency stop system.

5.5 MPU-module connector board electrical installation (MPU-SCB)

The MPU base circuit board contains the system power connector (K4), which includes the emergency stop signal, as well as two connectors for option board installation (K1 and K9). For more information see Figure 18. For more information on option board installation see section 5.7.



NOTE

MPU-OCB1-F and –OCB1-C are two option modules which can be fastened to the MPU-SCB PCB board by two M3 hexagonal screws using connectors K1 and K9. The OCB:s can provide serial communication LP,CN,S1,S2 and S3 or MC-Way, through wire (RS422 for OCB1-C) or optical fiber (OCB1-F). For further information see section 5.7

Figure 18, MPU base circuit board electrical installation.

5.5.1 MPU-SCB2 base board

The MPU-SCB2 connector board functions exactly the same as the previous version except that version 2 has LP port on an independent pin header and LP cannot be accessed using MPU-OCB type option modules. For more information, see Figure 19..

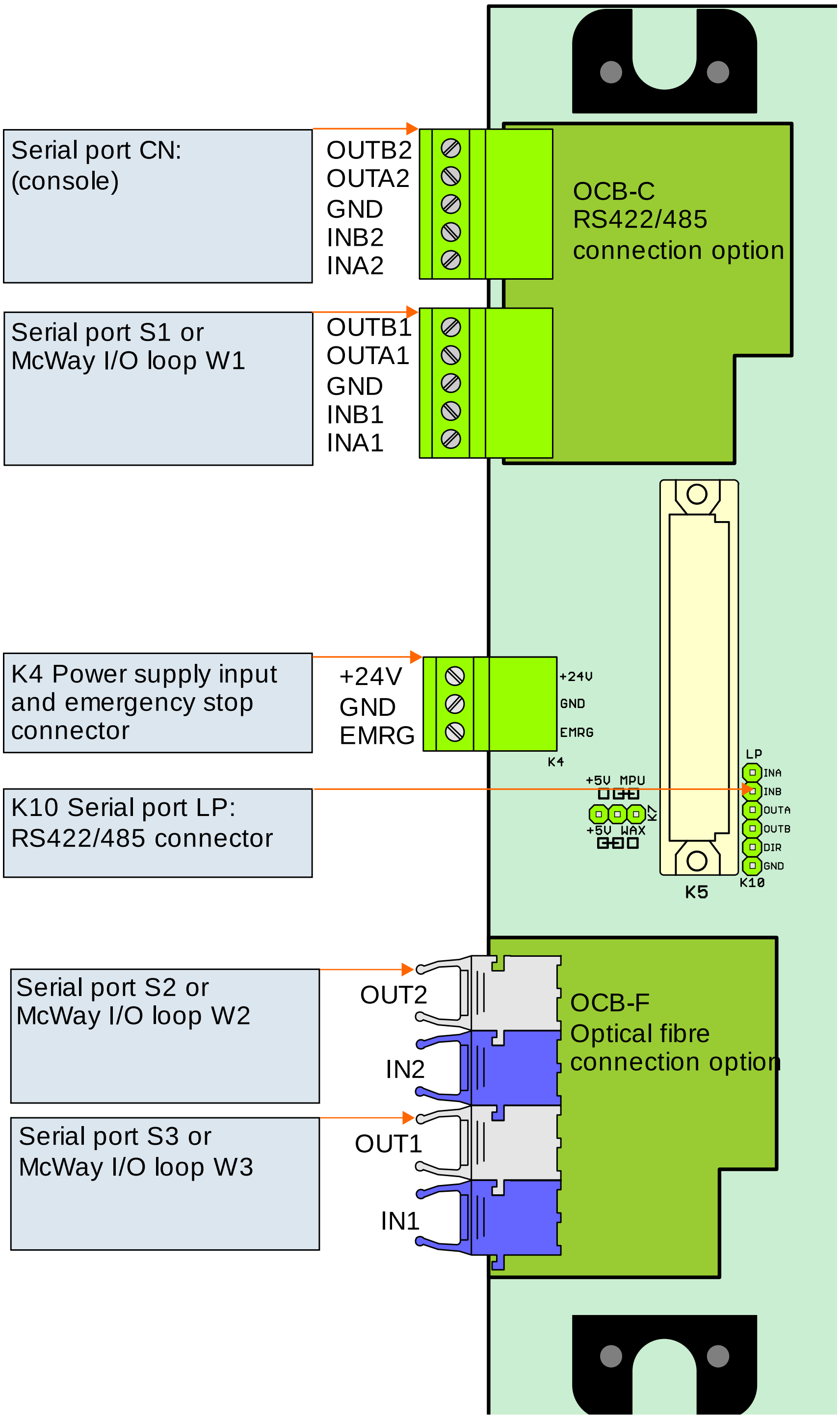


Figure 19, MPU module connector board version 2

5.6 **AXa/AXi base circuit board electrical installation (AXE-SCB)**

The AXi/Axa base circuit board contains all the necessary electrical connections to and from the Axi/Axa module. This includes all digital I/O, limits, encoder, relay etc. connections as well as the power feed and data transfer to the MPU module. Figure 20 shows an overview of the base circuit board with its options and connections.

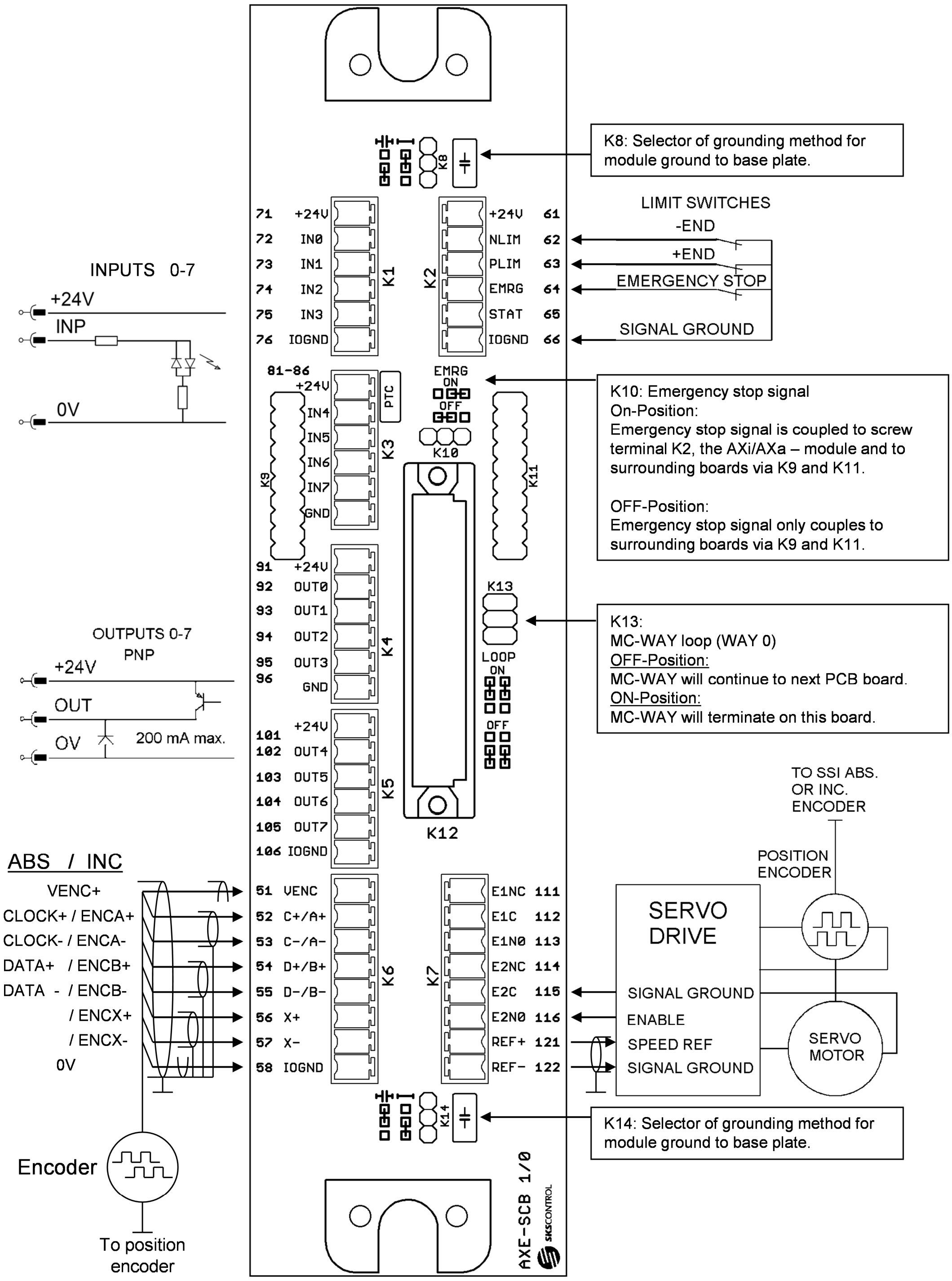


Figure 20, AXa/AXi base circuit board electrical installation.

Jumper K13 in Figure 20 configures the data transfer from and to the MPU module. When both jumpers are in their OFF position the data feed will be continued to the next board in the MC-WAY loop, physically to the right of the current one. When both jumpers are in their ON-position the data transfer will terminate on the current board and so the data loop will be complete and return to the MPU module. The ON-position is set on the last board in the MC-WAY loop. Always move both jumpers when changing the configuration.

Jumper K10 connects / disconnects the emergency stop signal from screw terminal K2 to the AXa/AXi module to be distributed to other modules and EMRG in MPU connection board’s K4 connector.

Jumpers K8 and K14 are by default set to the leftmost option which grounds the I/O- and module ground to the base plate through a capacitor, providing a high frequency ground for possible interference.

Figure 21 shows the drive speed reference and servo drive control relays connections and function. Some McBASIC commands to control the relays are also shown.

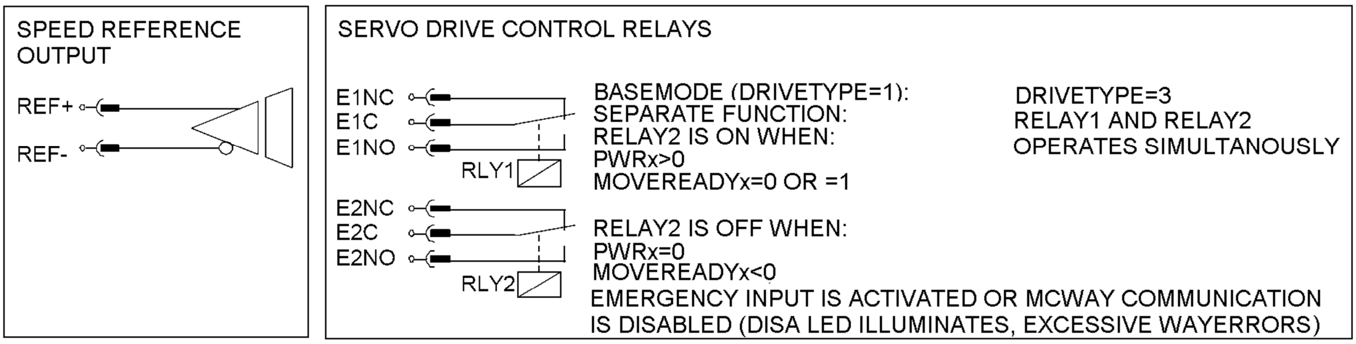


Figure 21, Reference output and control relay connections

5.6.1 Options

Both AXi/AXa modules have a DIP switch located inside the module and accessible from under the module. Using the switches, encoder voltage, communications baud rate and SSI encoder baud rate can be chosen. The following figure shows the location of the DIP switch along with its settings.

Switch	Function	ON	OFF (DEFAULT)
1	N/A	N/A	N/A
2	Encoder voltage (VENC)	12V	5V
3	Communications baudrate	78 kBaud	1.25 MBaud
4	SSI encoder baudrate (Only for AXa)	300 kBaud	1.25 MBaud

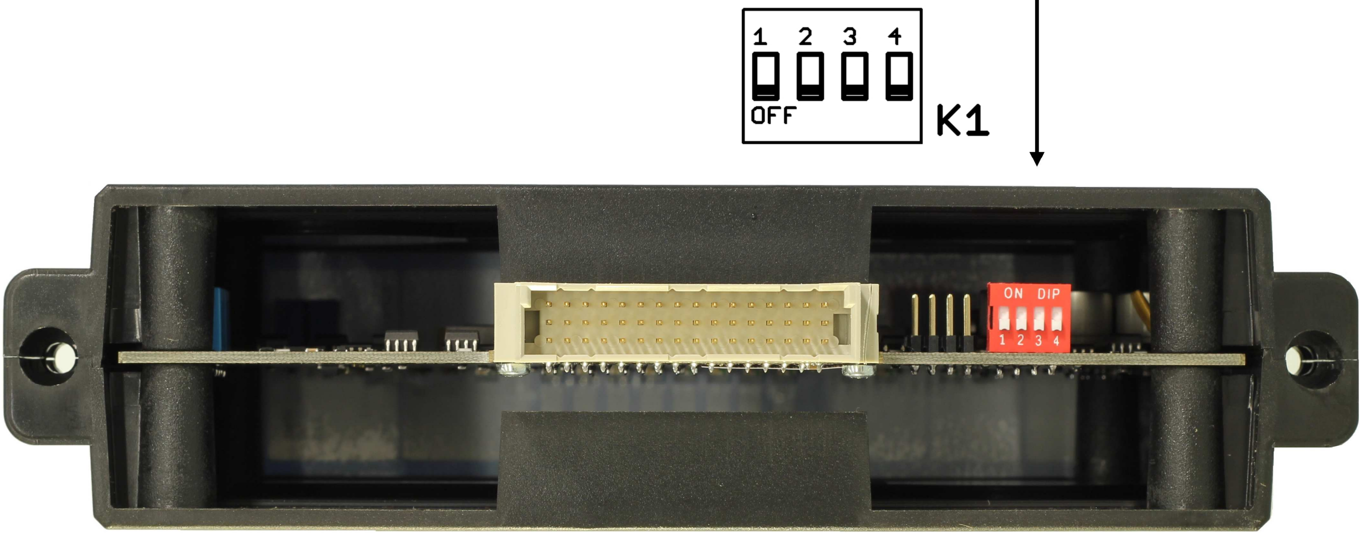


Figure 22, AXi/AXa module DIP switch

5.6.2 Position feedback for AXi module

The pulse encoder used for position feedback is connected to the K6 connector as shown in 0. The connection is shown for an encoder with line driver outputs. The inputs ENCA, ENCB and ENCX are used for the two pulse channels and the index channel of the encoder.

The supply voltage for the encoder is selectable by the DIP switch according to 0.

For details on selecting the logical motion axis for which the encoder is used please refer to McBasic documentation of the WAYMOD$= command.

It is possible to use also other types of encoder outputs by using suitable connections. Connection types for some signals are shown in 0. By interchanging channels A and B it is possible to change the direction of the pulse counter operation.

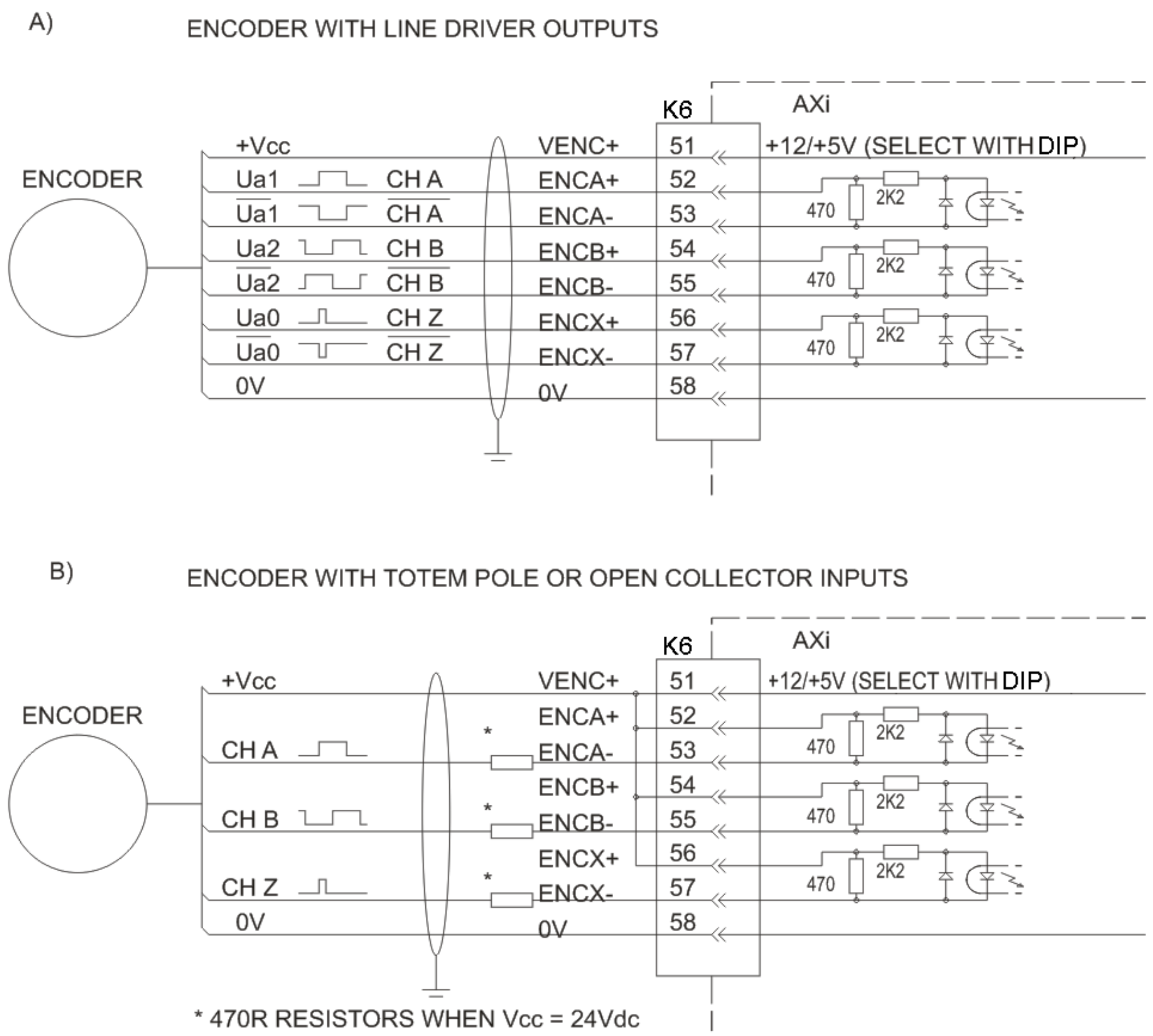


Figure 23, AXi encoder connections

With an encoder with line driver type outputs, each channel must have either it’s on or off led lit at all times (see Figure 7). The on led indicates that there is current flowing through the optocoupler and the signal is on. The off led indicates that the current is flowing in reverse direction and the signal is off. With totem pole or open collector signals only the "on" led will operate.

5.6.3 SSI encoder interface for AXa module

The SSI encoder interface is a standard synchronous serial interface type for connecting absolute encoders. The communication requires two wires (a twisted pair) to send the clock signal to the encoder and another pair of wires to send back the position data. The data frame holds 24 bits thus enabling the use of a maximum of 16.777.216 positions. Multiturn encoders are available for dividing this resolution for example over 4096 revolutions, 4096 positions each. Also other combinations can be used.

The SSI connector also provides 5/12 VDC selectable (See Figure 22) supply voltage for the encoder.

The index channel X in the encoder connector can also be used, but is mostly irrelevant for establishing coordinate origin since this is fixed in the encoder.

Two speeds are available for communications, 300kHz and 1,25MHz. The higher speed gives best performance but limits the usable encoder cable length. The lower speed requires some timing overhead in McWay loop because of longer position data access time. It is therefore recommended that when using the lower speed, AXa is not installed as the first module in the loop when there are other module types in the loop also. When installed as the first module in the loop, AXa will automatically reserve 40 I/O bits timing space from the loop, thus reducing the total loop capacity to 968 bits.

Note that the accuracy of the fast position capture function is limited by the SSI encoder read rate (=PIDFREQ) with the AXa module.

Table 5 sums up all the screw terminals on the AXi/AXa base circuit boards and gives a short description on all their functions and specifications.

Table 5. AXi and AXa base circuit board signals and description

Name	Number & connector	Signal	Description
Inputs 0-7	71-76 (K1) & 81-86 (K3)	Digital input	Eight 24V digital PNP type inputs with a current sink of maximum 10mA each. Minimum true value = 13Vdc
Limit switches	61-66 (K2)	Negative and positive limits, emergency stop, status	Negative and positive 24V/10mA PNP type limit switches. 24V/10mA PNP type emergency switch active low. Status input, mainly used for fast disabling of drives enables signals.
Outputs 0-7	91-96 (K4) & 101-106 (K5)	Digital output	Eight 24V digital PNP transistor outputs with a maximum current of 200mA each. All outputs are freely programmable in MC-BASIC.
Encoder	51-58 (K6)	Encoder, index	**For AXi:** 2 channel pulse encoder connector with index, isolated line receivers, interference detection and position latch functions. **For AXa:** One 24 bit SSI absolute encoder connection with selectable transfer rate (300kbaud & 1.25Mbaud). **Common for both:** Selectable encoder voltage 5V / 12V
Control relays and reference	111-116, 121-122 (K7)	Control relays, reference output	Two relay outputs with changeover contacts of maximum 24V/1A. 16bit isolated and fine tunable ±10V analog reference output with a maximum current of 10mA.

NOTE The input, output and limit switches connectors also have one +24V and one ground terminal for each terminal block.

5.7 Option board electrical installation

The uppermost option board on the MPU base circuit board can be configured with jumpers to use CN/LP/(W1 or S1) signals and the board on the lower connector K9 uses by default signals W2 and W3 and can be changed via McDOS to use S2 and S3 signals. The power selector K7 in Figure 24 is by default set to MPU-mode and needs to be changed only when the system consists of only AXi/Axa modules. For information on how to configure the uppermost board signals see Figure 25 and Table 6.

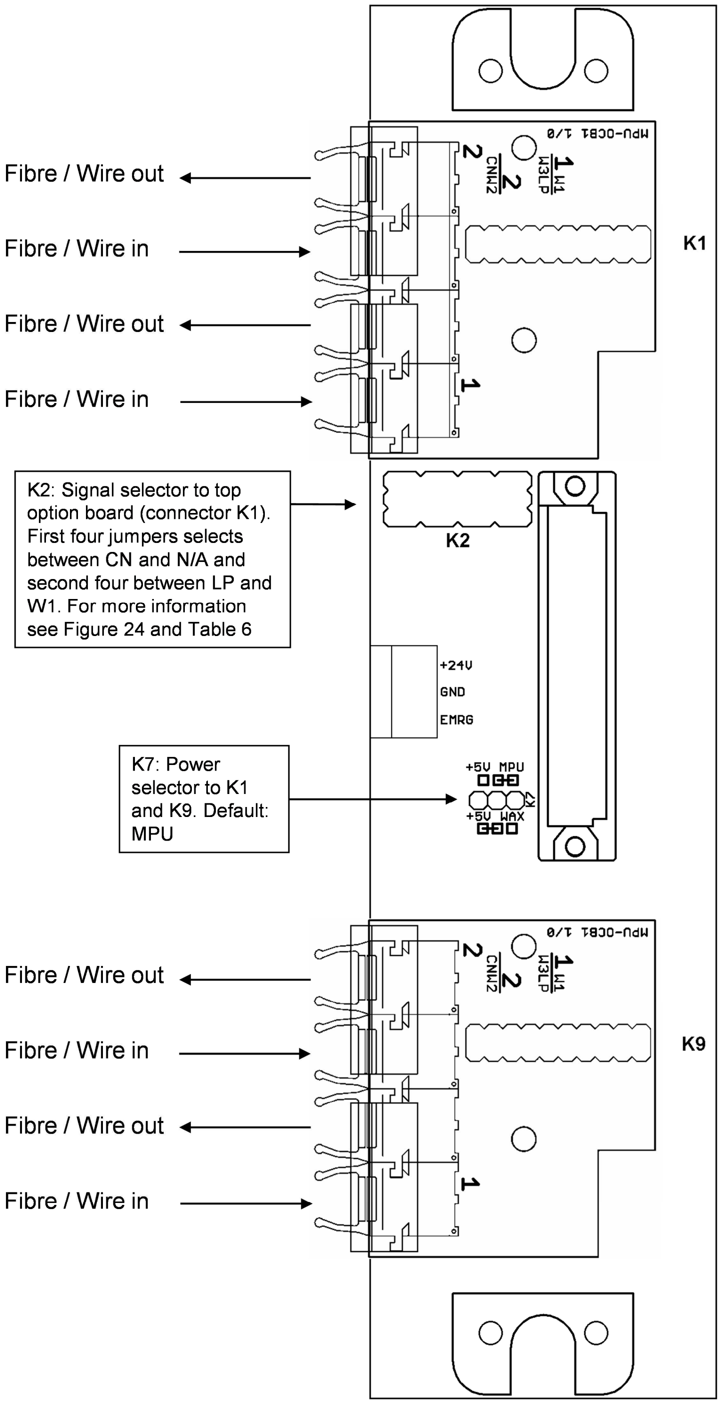


Figure 24, option board electrical installation on MPU-SCB

Figure 25 shows an overview of the jumpers that configures the signals to the uppermost option board on the MPU base circuit board. To change one of the signals, four jumpers must be moved at the same time according to Table 6.

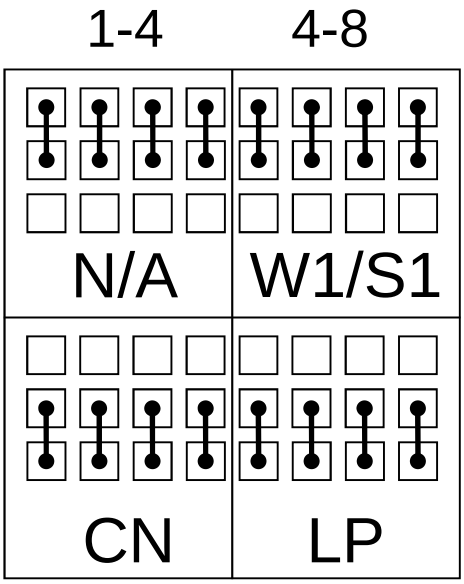


Figure 25, Signal selection to uppermost option board on MPU-SCB circuit board

Table 6. MPU-SCB option board signals' jumper configuration

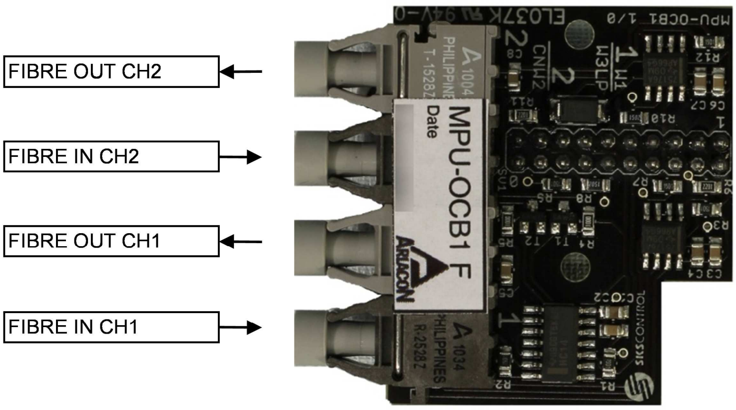
Jumper configuration				Respective signal connected to MPU option board (K1)	
First four jumpers up	First four jumpers down	Last four jumpers up	Last four jumpers down	Channel 1	Channel 2
X		X		W1 / S1	N/A
X			X	LP	N/A
	X	X		W1 / S1	CN
	X		X	LP	CN

CAUTION

Always switch of system power when installing any of the option boards or when changing the jumper configuration. Also shut down the power supply when connecting possible wires to or from the option boards. Violation of this can result in damage to the devices.

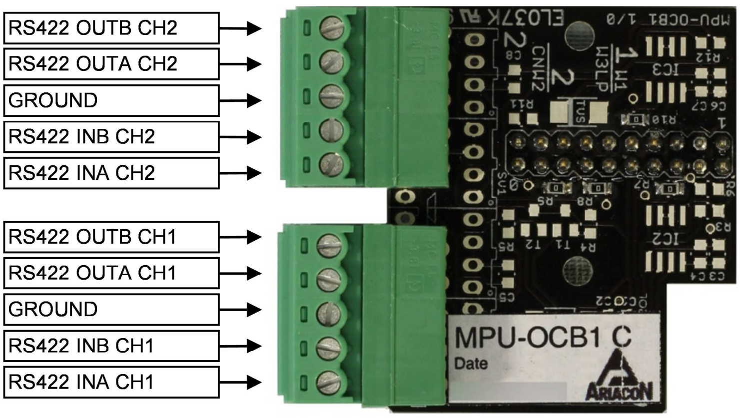
Figure 26 shows the detailed view of the signal connections to and from the two types of option boards available (MPU OCB-F and MPU OCB-C). The fiber version of the board is suitable for use with polymer fibers up to 30m and the copper wire version with twisted pair wires up to 200m.

MPU OCB1-F



The OCB-F version is equipped with model fibre receivers and transmitters compatible with HFBR-4500 connectors and 1mm plastic optical fibre.

MPU OCB1-C



The OCB-C version is equipped with two Phoenix contact MC-1.5/5-ST-3.81 screw terminal connectors which are compatible with 0.25mm^2 and 0.5mm^2 end sleeves.

Figure 26, overview of both versions of MPU option boards' electrical connections

5.8 System electrical installation

Figure 27 shows the complete overview of an example system containing one MPU and three AXa/Axi module base circuit boards with their respective external electrical connections and recommended grounding arrangements.

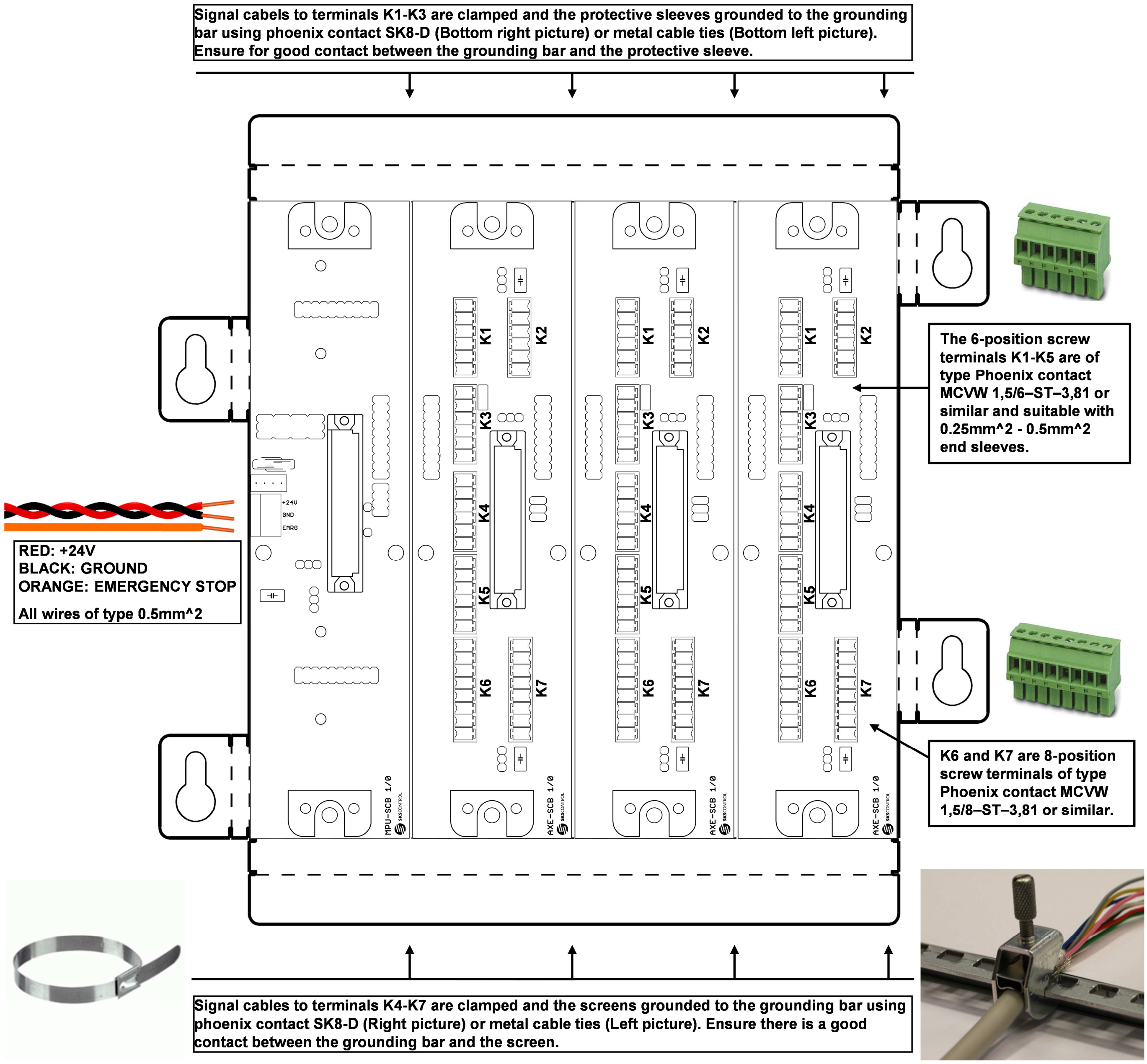


Figure 27, example system with electrical connections and grounding arrangements.

NOTE	It is important to ground the screens of the signal cables as shown in Figure 27 using either a metal cable tie or a screw clamp. The screens should always only be grounded in the ACN end to the grounding bar. For more information on system grounding see sections 5.2 and 5.3.

5.9 **Drive system**

An essential part of a position controlled motion system is the drive system. The drive system consists of the motor with related transmission and the electronic device that provides the motor with power and speed control, usually called the amplifier or the drive.

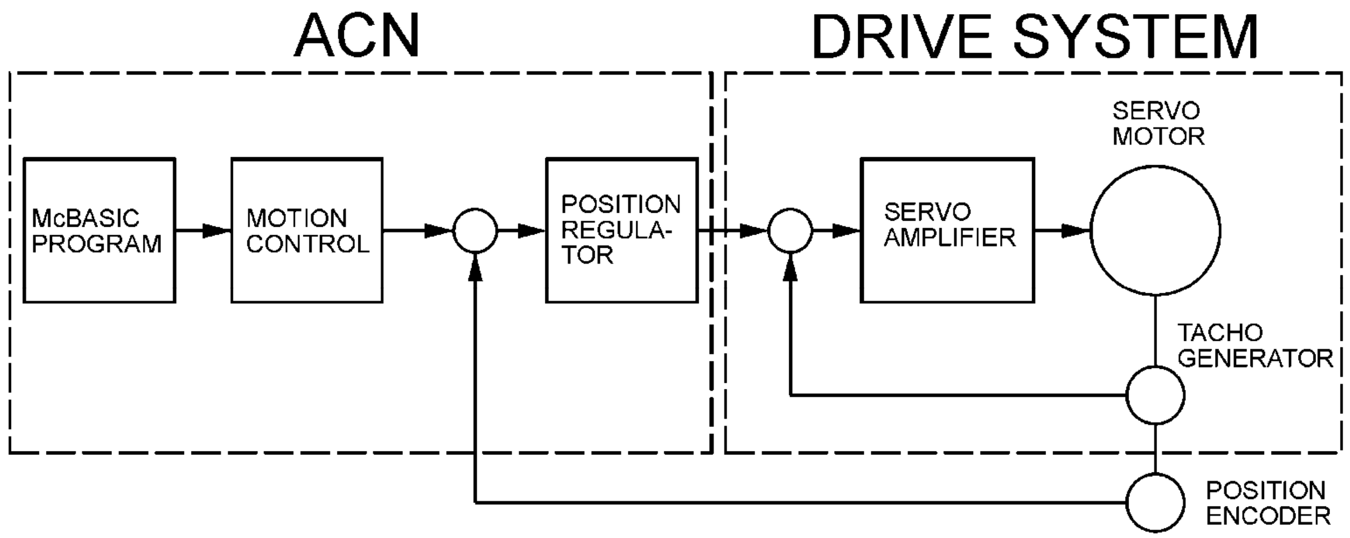


Figure 28, position control system structure.

The function of the drive system is usually to act as a speed control system for the mechanism concerned. Thus, the drive system can have a transducer such as the tacho generator to measure the actual speed of the motor. By regulating the current of the motor, the drive can carry out the set speed more or less accurately.

The position regulator uses a position encoder to keep track of the actual position of the mechanism. The position regulator compares this with the position set value to calculate the speed reference for the drive. In modern drive systems the speed and position information are often obtained from the same transducer installed in the motor.

The motion control function of the control system generates the position set value according to the motion type. For example a simple translation is performed by accelerating the position set value to the given speed using the given acceleration and decelerating again when approaching the end position.

When the motion is ready the position control remains active and holds the position until otherwise commanded.

5.9.1 **Dc servo systems**

The dc servo is a typical speed controlled drive system intended for accurate control and fast response. The word "servo" refers to a feedback controlled system with relatively high dynamic performance and linear characteristics making it suitable for following fast changing references.

A dc servo motor is normally a permanent magnet dc motor with low losses and smooth torque characteristics. The motor itself operates as a current-to-torque converter delivering a torque proportional to the current flowing through its rotor winding. A DC servo uses a commutator with brushes to connect the current to appropriate windings while the motor is rotating. A motor constant K_t [Nm/A] can be used to calculate the torque generated by a given current. The same value can also be used for calculating the voltage needed to rotate the motor at a given speed with no load, since K_t [Nm/A] = K_v [Vs/rad].

Usually the dc servo system uses a tachogenerator to measure the motor speed. The tacho is often installed on the motor axis as standard. The DC tacho delivers a voltage proportional to the motor speed. This voltage can be used by the servo amplifier electronics to control speed accurately.

Control ratios up to 1:20000 can be achieved with dc servos. The available speed loop bandwidth is limited mostly by motor inductance and amplifier electronics. Very fast response motors can be built using special designs.

The inertia of the rotating mass of the dc servo depends on the structure of the motor. A standard ceramic magnet dc servo is suitable for acceleration times from 0.1s to several seconds according to size of motor. Using rare earth magnets allows faster acceleration and smaller motor sizes. Special disk or cup armature motors with low inertia are also available for special purposes.

Conventional DC servo systems are well suited for ACN position control applications.

5.9.2 **Brushless servo systems**

To produce motors without the operational and lifetime limitations caused by the brushes and commutators of a dc servo, modern servos are often designed brushless.

There are two common types of brushless servos, the brushless DC and the synchronous AC servomotors.

Brushless DC servo

The brushless DC motor is based on reversing the construction of the common DC motor. Thus, the rotor contains a permanent magnet and the stator holds the windings. This way the brushes can be avoided and a lower rotor inertia is achieved. For commutation, the brushless DC motor must have sensors to determine the rotor commutating angles. These are generally hall-effect type sensors built inside the motor, often with a brushless tacho generator with the same operating principle as the motor.

Brushless DC motor requires an amplifier built for the motor type. Especially rare earth magnet types often have very low inertia and high acceleration capability. The inductance of this type of motor is quite high resulting in electrical time constants of about 10ms.

Brushless DC servos are popular in modern industrial applications in the 1-10kW range and they offer speed control ratios up to 1:20000 and are very suitable for ACN position control applications for demanding tasks requiring fast accelerations and maintenance free operation.

Syncronous AC servo

The synchronous AC servo motor has a construction very similar to that of the brushless DC servo motor. However, the voltage waveform required by the stator windings to rotate the motor is sinusoidal. Therefore this motor type requires a drive which can deliver continuous AC three phase current with phase according to rotor angle. Usually the AC synchronous servo motor is equipped with a resolver to provide the amplifier with data of rotor angle and speed.

The synchronous AC servo can produce a smooth torque over a wide speed range. Because of the characteristics of the resolver the AC servo has somewhat lower speed control accuracy than is achieved with tachos.

Because the resolver is a wirewound component with no other electrical parts and because many drive types can provide the control system position encoder signals based on the resolver data, the AC synchronous servo construction results in a very reliable motor assembly.

The AC synchronous servo especially together with digital drive constructions has become the most popular servo construction and is suitable for many application types as a standard servo in the 0.5-30 kW power range.

5.9.3 **Inverter drives**

The AC inverter drive is primarily designed for open loop control of standard asynchronous AC motors. To be used for position control applications it lacks the wide speed control range and the linear characteristics of a servo drive.

However, modern drive types have greatly improved in performance offering effective control ratios of more than 1:100 in open loop speed control. While the unlinearities and lack of torque at zero speed still affect position loop accuracy, moderate performance positioning, conveyor synchronization and other applications can be done with standard inverters.

The ACN PID control algorithm provides parameter settings to achieve system stability also with less ideal drive types. Additionally, the ACN system can produce signals for drives with unipolar speed reference and separate direction signal.

Modern drive technology has also made it possible to achieve near-servo performance with feedback controlled inverters. A vector inverter with a pulse encoder feedback from motor can control speed over a 1:1000 range and provide full torque at zero speed. These kinds of inverters are especially suitable for ACN position control applications.

Generally, inverter drives are suited also for high power range applications, for which servos may be higher cost and even not available.

5.9.4 **DC drives**

The thyristor DC drive with a wound field motor is a classical speed control drive system. With tacho generator feedback they can produce good speed control over a wide speed range. The bandwidth of the control is limited by the line frequency and some acoustic noise is generated especially at low speed. Since DC motors are more expensive than standard AC motors, the DC drive application area has diminished as inverter drives replace them. However the linear characteristics and the ability to drive braking current back to mains makes them still a possible choice for many applications including position control.

5.9.5 **Hydraulic systems**

Hydraulic servo systems can also be used in ACN position control applications. Depending on the accuracy and characteristics of the valve and the cylinder or hydraulic motor, different speed and accuracy needs can be met.

A hydraulic servo system is often suitable, where high forces must be produced. Also explosion hazardous areas or severe environments such as underwater can be suitable application areas.

5.9.6 Braking systems

When operating at rapidly decelerating speed or when lowering loads, a variable speed drive system often produces energy rather than consumes it. Because drives and amplifiers have limited energy storage, this energy must usually be consumed using braking resistors.

Servo amplifiers and inverter drives produce the motor currents by using an internal DC supply. Braking can cause the voltage of this supply to rise according to the amount of regenerated energy and available capacitance. Because drives are designed to operate under a specified maximum voltage level, heavy braking requires the drive system be equipped with a braking circuit to connect a braking resistor to the dc supply when it reaches a certain voltage level.

This braking system, sometimes called the dynamic braking system, must be powerful enough to handle the energies received during the application work cycles. Sometimes it can be more economical to add capacitance to the drive DC bus to allow storing more energy for reuse rather than use dissipation thru resistors.

5.10 Connecting to a PC

To program the ACN MPU module it is necessary to connect a display terminal, a PC or ARLACON program development system to the CN serial communications channel of the control unit. To communicate, the ACN only needs an USB-A to USB-mini cable.

For communications, please use the McBench programming environment or, a terminal program with xon/xoff handshake such as WINDOWS TERMINAL. Set the communication to 38400 baud, 8 bit, no parity, xon/xoff handshake.

Alternatively, you can connect to the ACN MPU through the Ethernet using Telnet protocol.

6 Programming and use

Once you have installed your ACN system and made the necessary connections described in section 5, you can start commissioning your system and testing programs.

6.1 Programming tools

To work with an ACN system you need to have a PC computer or a display terminal with asynchronous communications connected to the console port of the ACN MPU.

For interconnection, use a suitable cable supplied by your ACN distributor or refer to section 5.10 for connection data.

To use a PC for programming, the most convenient software tool is the McBench programming workbench supplied together with your ACN system. Other tools you can use to connect to the systems are terminal programs such as HyperTerminal supplied with Windows, PROCOMM, PCPLUS or other ANSI compatible terminal programs. McBench also offers tools for editing programs in a PC, loading programs to the ACN, copying files to and from the ACN and tools for commissioning and configuring the system.

Since McBasic program files are essentially text files, it is also possible to use other editor or word processing programs to write McBasic programs.

6.2 Getting started

Select communications parameters to match the default communications parameters of the ACN as follows.

ACN default transfer parameters

baud rate	38400baud
data bits	8
parity	no
stop bits	2
handshake	xon/xoff
mode	full duplex

Once you have your terminal operating, you can start your ACN by switching on power. The terminal should show the system starting and printing either the McDos version number or operating as defined in a possible WAKEUP.EX file. If the WAKUP.EX file loads a program and starts automatically McBasic, the program can be stopped with ctrl-X from the console after it has started to run. Please refer to McBasic programming manual and McDos user's manual for details.

6.3 Power up and testing

To start your ACN system, please follow the procedures in this section. Assume that the system is now connected to power supply and a programming terminal (PC) and the connections have been made for possible I/O system.

Start the terminal and possible communications program for full duplex on-line communication.

6.3.1 Switching on power

Start the control unit by turning on the 24V supply.

If a McWay I/O system is connected, some of the led lamps on the I/O modules will turn on.

If not otherwise programmed in a WAKEUP.EX file, the system will display a message:

```
McDos 3.xx              //McDOS version
hh:mm:ss dd/mm yyyy     //this is the real-time clock
D4:/>                   //Command prompt
```

starting the McDos operating system of the ACN. The prompt D4:/> shows that the current drive and path is D4:/. There are 3(4) memory devices in the ACN relevant for McDos all using a similar file and directory structure as found on MS-DOS or other popular operating systems. The default file system used in the ACN McDOS is McFs16, but the ACN is also FAT12, FAT16 or FAT32 compatible. The compatibility with FAT systems allows for flexible file operations and transfer with other devices, such as a PC.

The default drive system of the MPU module is as following:
D3: Sd 11 First partition of the external SD card (Application/portable)
D4: Sd 01 First partition of the Internal SD card (Application)
D7: Ram Ram-drive with configurable size (Volatile)
D8: Sd 02 Second partition of the Internal SD card (System)

The boot program will start McDos from the internal SD-Card hidden system area. If it is found, the respective MCDOS.CK is started. If no MCDOS.CK is found, the default McDos version included in the boot section of D4: is started. At this phase the drive where MCDOS.CK was found, or D4:, is set as the current drive (D0:, default drive for file operations).

The internal SD card is partitioned into two 512MB partitions. It uses the McFs16 file system, allowing copying files directly between the internal SD card and the optional external SD card (Drive D3) formatted either using FATxx or McFs file system.

The RAM drive D7: is a volatile drive, which means that its contents are erased every time the power is off, Thus it should only be used as temporary storage during program execution.

After start-up, McDos scans the memory devices, starting from the lowest number device present, for a file named WAKEUP.EX (the start-up batch file). When found, McDos executes the commands contained in the file. McDos leaves the drive where it finds WAKEUP.EX as the current drive (D0:) unless otherwise set by the commands in the file.

The default WAKEUP.EX is located at D4: containing the following commands:

SET CN:38K8N2	// This command sets the default speed of CN to 38kBaud.
PATH D0:,D4:/,D8:/	// This command set the search path for executable files (.CK and .EX) to include roots of all memory devices.
IP 192.168.0.20,255.255.255.0,192.168.0.1	// This command configures the device’s IP address, subnet mask and gateway address.
CNTO TELNET://	// This command sets the console to automatically move to Telnet when connected.
D4:BAS32	//This command starts the McBasic version for 32 logical axes stored in D4:.

McBasic can be started either without program file name

BAS32

or with one or more program file names

BAS32 PROG1[,PROG2,....,PROGn]

to load and start the specified programs.

After starting in command mode, McBasic operates as follows:

When started without program If the control unit program memory is empty, a message

McBasic (version.revision)

```
Program
System tables
Variables and compilations
Recycled
nnnnn  Free

B>
```

will appear on the terminal screen. This message is the status message of the McBasic programming environment with the McBasic command level prompt. At the prompt

B>

the user can always type McBasic commands, study system status and edit programs. With the RUN command the user can start program execution. With ctrl+X the user can stop the program at any time. For more details please study the McBasic manual.

6.4 **Editing in a PC**

To edit your application program in a PC you can create an ASCII file and edit it with a suitable editor or word processor program The recommended tool for this is the McBench programming tool program editor.

To load the program to the ACN control unit, use the McBench program loader or McFiles file transfer. If a syntax error is detected when loading a program, McBasic exits load mode and stops loading program.

Error messages are generated and sent to console respectively.

6.5 **System specific McBasic features**

The McBasic environment in the ACN operates under the McDos operating system, so you can enter the operating system level with DOS, SYSTEM or X command.

Following devices are as default available for OPEN command and thus input/output commands and functions.

CN:	console serial communications channel (default)
LP:	auxiliary serial communications channel
S1:	Optional serial communications channel (default WAY1)
S2:	Optional serial communications channel (default WAY2)
S3:	Optional serial communications channel (default WAY3)

If necessary, all device numbers D1: ... D8 can be configured using the McDos SET command as RAM and FLASH drives according to available RAM and application needs.

6.6 Servo system commissioning

1. To start a motion control system with feedback controlled position, first make sure to have installed the controllable axis connections and drive system according to the connection type used. Refer to drive manufacturer's documentation to install the drive system.

   If possible, do not couple your motor with the mechanism for preliminary testing. This prevents possible instability, transducer faults or signal phasing problems from breaking valuable mechanisms and reduces the risk for injuries especially with high power and/or high speed drives. In the following, the axis name x is used instead of the actual axis name used (X,Y,Z ...).

   The McBasic language used in ACN allows easy commissioning of position control systems by using the McBasic commands and functions directly from the McBasic command mode or by writing small test programs.

   If you use McWay axis modules (WAX) be sure to configure the i/o loop with McBasic WAYMOD$ command before commissioning.

2. First test the drive system without position loop. Check tacho phasing and equivalent for proper operation. Adjust the speed control loop of the drive to be undercritical (no oscillation). This open loop testing can be done without the ACN or using the ACN ENA and REF signals with the OPWRx= command (voltage at REF+/REF- is 10*OPWRx, where OPWRx can be from -1 to +1).

   To use the OPWRx command, the EMRG signal and the limit switches PLIM and NLIM (is configured active by LIMITTYPEx) must be connected to OV. The MAXERRx setting can be used to prevent motion from moving too far. If testing without motion area limitations, MAXERRx can be set to 0.

3. Test the phasing of motor and pulse encoder. The position read by the encoder (McBasic POSx function) should increase when driven with positive OPWR values.

   Set RESx according to mechanism used. Check the encoder operation for both directions.

4. Start position control. First use low GAINx, with INTGx, DERVx and SCOMPx=0. Start with GAINx=1. Use PWRx= command to enable position control without motion. PWRx=1 will allow full control range from REF (±10V) while a lower PWRx will limit the control range. Thus, for example using PWRx=.1 limits the speed to 1/10 of drive full speed. This can be used for safety when commissioning.

   Normally, if correctly connected, the motor will not move considerably after enabling control. If the motor accelerates and stops when reaching MAXERR limit or a limit switch, the encoder feedback is probably not operating correctly (wrong phasing). To reverse motor direction, interchange REF+ and REF-. To reverse encoder reading direction, interchange encoder channels A and B.

5. Set SPEEDx and ACCELx for the axis to suitable test values. Use a small motion like MOVERx 10 to test if the system is responding.

   Increase GAINx by doubling its value until the position control seems stiff enough. Too large values will cause oscillation.

6. Try adding some DERVx (1..4) to improve stability. Too high DERV can cause oscillation at high frequency or sluggish positioning. Higher DERV values require lower GAIN but can be useful with slow drives or high inertia.

   For high inertia load with elasticity in transmission it may be necessary to use lower gain and longer integration time or no integration in the speed loop.

7. To compensate for the position lag produced by proportional position control during motion, a feedforward factor, SCOMP, can be used. SCOMP adds voltage to REF output according to the theoretical speed during motion. By setting SCOMP to correspond to the maximum speed of the drive at 10V REF, SCOMP is set critical. A critical SCOMP will produce the theoretical image of the speed during the motion to REF thus allowing the feedback control to compensate only for system unidealities. The critical value for SCOMP can be found by testing with suitable speed (INTGx must be 0 when testing):

   ```
   SPEEDx=100 : ACCELx=200                        ' 0.5 second ramp
   MOVEx 500 : DELAY 1 : PRINT SPEEDx/OPWRx       '  delay longer than ramp
   ```

   The printed value will roughly be the theoretical maximum speed. By testing with POSERR function during motion the exact critical value for SCOMP can be found.

   A higher SCOMP value causes undercritical compensation. This may be used for partial compensation for position lag to adjust the positioning behaviour at the end of motion and to avoid too high POSERR during motion with low GAIN.

8. In some cases, especially with drives with no speed feedback, the INTG function can be used to improve position accuracy. Also with a very stiff and fast response mechanism with critically set SCOMP, INTG can be used to further improve accuracy. To find maximum accuracy, the LOG system of McBasic can be used to study the operation of the position control during motion.

9. Use the settings you have found for your application program.

6.7 **Application programming**

The aim of application programming is to write a program containing:

- system initialization and settings
- work cycle operation
- application control and communication with user interface
- diagnostics for application malfunction

Application programming can be done in three modes.

McBasic command mode

Using McBasic command mode program can be entered line by line as described in the McBasic programing manual. The program will be written into McBasic work memory where in can be run immediately any time. Syntax is checked after entering each command.

McDos editor (TX)

The McDos TX screen editor can be used together with a compatible terminal or PC for editing programs and saving them to disk. McBasic can load programs from disk for running and testing.

Offline editing with PC

Using a suitable editor such as the McBench program editor, ASCII files containing McBasic programs can be created and edited. ACN can receive a program sent by a suitable communications program in command mode or it can load a program file from an SD-Card.

6.8 **McWay configuration**

To use McWay modules in ACN their communication baud rate must be set to 1,25M.

Set the configuration of the installed I/O system using the McBasic WAYMOD$= command.

Command:	Set McWay configuration.
Syntax:	WAYMOD$(*n1*,*n2*)=*string*
n1	Number of McWay loop (0…3 for ACN).
n2	Number of McWay module in the loop (0 ...)
string	Type of module and settings

The number of McWay module n2 refers to the order number of the module starting from the module connected to ACN McWay out (module number 0) in the order they are connected in the McWay communications loop.

To determine the right settings for each I/O module type please refer to section 6.8.1.

The ACN has a McWay I/O loop with 1008 bits in and 1008 bits out. The number of bits used by different modules depends on the module type.

The module types available in ACN are:

Type	Function	bits out	bits in
EMPTY	empty module number	0	0
END	end of McWay loop	0	0
WOU	16 relay output module (WOU02000)	16	0
WOA	6 isolated analog outputs (WOA02004)	96	0
WIN	24 inputs isolated input module (WIN02001)	0	24
WIA2	2 isolated analog inputs (WIA02313 set for 2 inputs)	0	32
WIA4	4 isolated analog inputs (WIA02313 set for 4 inputs)	0	64
WIA6	6 isolated analog inputs (WIA02313 set for 6 inputs)	0	96
WIA	same as WIA6	0	96
WAX2	Servo axis connection module with I/O, incremental encoder	32	32
WAX2A	Servo axis connection module with I/O, SSI absolute encoder	40	40
AXi	Servo axis connection module with I/O, incremental encoder	32	32
AXa	Servo axis connection module with I/O, SSI absolute encoder	40	40

The last two lines are ACN format modules for installation on ACN base plates. The modules starting with a W are legacy format modules for DIN-rail installation, which can be inserted in all McWay I/O loops except Way 0. For more information, please contact your ACN dealer.

By configuring the McWay you set the sequence of modules in the McWay loop forming the I/O system. At the same time you set the logical addresses for the I/O connections available on the modules.

To use all loop capacity it is necessary to place modules using only output bits before modules using only input bits in the loop. The reason for this is that McWay modules can use the same bit positions in data frame for transferring input data to ACN after they have transferred output data to output modules.

Analog and digital output modules use only output bits and input modules only input bits. The axis connection modules use the same number of input and output bits, but it is most efficient to put them first in the loop as a different number of input and output bits before them consumes unused bits.

The logical axes with letter references in ACN are X,Y,Z,W,A,B,C,D,T and U. Axes can also be referenced by their numbers 0..31. The first ten axes have both letter names and numbers whereas axes 10…31 can only be referenced by their numbers (see Table 7). For information about command syntaxes see McBasic documentation.

Max. 100 physical axes can be connected to the system with axis connection modules. Axes not used as physical axes can be used as virtual axes in conjunction with commands like FOLLOW and MOVEPROF.

The default DRIVETYPE for the first four axes (X,Y,Z,W) in ACN is 1 (standard closed loop with ±10V reference) and 176 (virtual) for all other axes. Use the McBasic DRIVETYPE= command to set axes according to your needs. When configuring connection modules to the I/O system, following references are used for INP(a) (and OUT(a)) in configuration strings for axis connection modules.

Table 7. Axis references

Axis letter	Axis number	McWay address a
X	0	0
Y	1	4
Z	2	8
W	3	12
A	4	16
B	5	20
C	6	24
D	7	28
T	8	32
U	9	36
	10	40
	11	44
	12	48
	13	52
	.	.
	.	.
	.	.
	31	124

It is recommended that addresses 0 ... 63 not be used for i/o other than axes control as in many ACN configurations and other SKS Control MC control systems they are used for motion control purposes.'

6.8.1 AXi/AXa configuration

To configure the AXi/AXa module to a McWay loop, use the following configuration string:

Command AXi/Axa configuration to McWay loop

Syntax WAYMOD$(n,m)="AXi INP(a) [OUT(b)] IO(c)"

WAYMOD$(n,m)="AXa INP(a) [OUT(b)] IO(c)"

n Number of McWay loop (0...7).
m Module number in loop, 0 = first module.
a Address base for axis for inputs (position and limit switches),
where a is a multiple of 4. Typically:
a=0 X axis or axis 0
a=4 Y axis or axis 1
a=8 Z axis or axis 2
.
.
Check axis numbering for type of MC system and McBasic used.

Input addresses for axes:
a encoder index channel X
a+1 NLIM negative end limit switch
a+2 PLIM positive end limit switch
a+3 EMRG emergency stop input
b Address base for axis outputs (drive control relays and reference) as a. Default value b=a.

Output addresses for axes:
b not used
b+1 ENA1 relay output
b+2 ENA2 relay output
b+3 not used
c I/O address base for inputs 0...7 and outputs 0...7. The addresses of the inputs and output when used with INP() and OUT() functions will be c+input or output number. Must be a multiple of 4. The maximum value depends on controller type.

6.9 I/O usage

After configuration the inputs and outputs of the ACN are available for use with the INP( ) and OUT( ) functions of McBasic.

For example:

```
OUT(200)=1    'turn on OUT(200)

DO UNTIL INP(35)=1 : LOOP 'wait until INP(35) on
```

For more details refer to McBasic manual.

A special feature of the ACN McWay based I/O is the error values. In addition to the usual 0 and 1 the INP( ) and OUT( ) funtions can return negative values

-1 if there is a fatal communications error in McWay data transmission.

-2 if the module for which the I/O address is configured is not present in the McWay loop.

6.10 Starting the servo system

To use the ACN AXi/AXa servo control features, it is necessary to set some McBasic motion control parameters.

The ACN based motion control system consists of the drive system usually forming an inner speed control loop and the outer ACN position control loop.

When the McBasic command or application program activates the ACN motion control software, the position set value in the system starts to move as a function of time to form the image of the motion.

The position regulator continuously calculates the speed reference value for the drive to hold the actual position as close to the set value as possible, thus performing the actual motion according to the set value motion.

The operation of the position regulator can be adjusted with parameters:

GAINx	PID gain factor (0...65535)
INTGx	PID intergrating factor (0...255)
DERVx	PID derivating factor (0...255)
SCOMPx	Speed compensation (distance units/s)
ACOMPx	Acceleration compensation (speed units/s)
DCOMPx	Deceleration compensation (speed units/s)

Where x is the name of the axis involved (X, Y or Z). Alternately, syntaxes with number references for axes can be used. This also allows indirect referencing:

```
FOR n=0 TO 15
GAIN(n)=150 : INTG(n)=0 : DERV(n)=2
NEXT n
```

See McBasic manual for more information.

Figure 290 shows the principle of the servo control system for one axis.

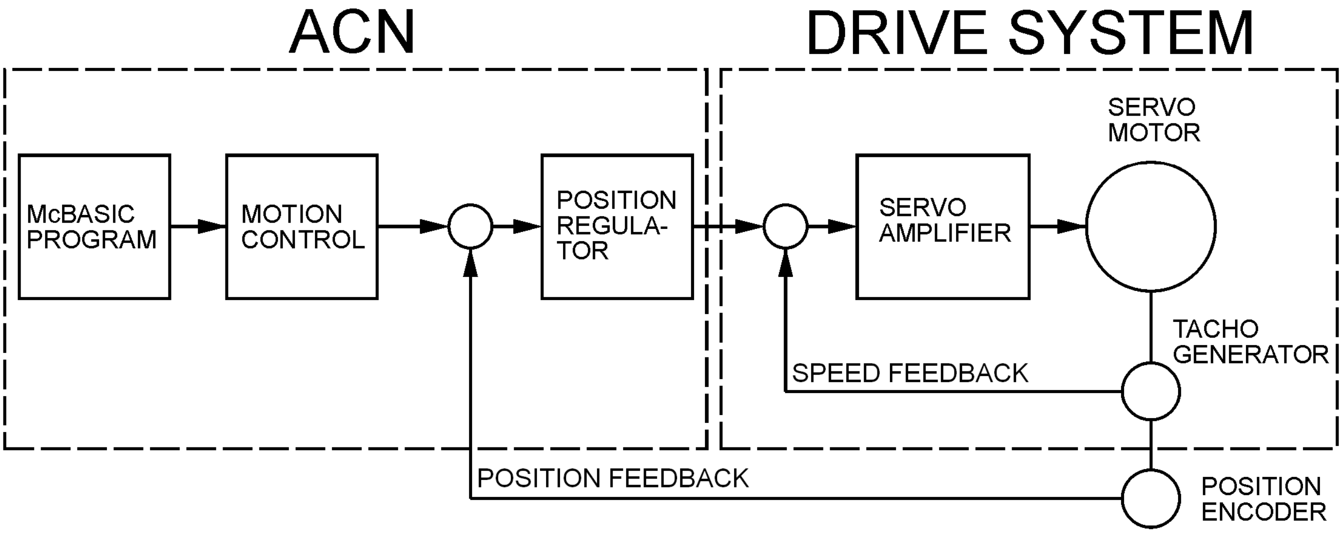


Figure 29, servo control architecture

Additional parameters that may have to be set before using servo control are:

PIDFREQ	Repeat rate of position control algorithm (50...2000), default 400 common for all axes
RESx	Position scale (pulse counts/programming unit usually mm)
MAXERRx	Maximum servo position error
LIMITTYPEx	Mode of operation for limit switches
DRIVETYPEx	Mode of operation for drive control (REF/ENA)
SPEEDx	The maximum speed used in motion
ACCELx	The acceleration used in motion
FILTERSIZEx	Position reference smoothing filter for generation of limited da/dt (S-ramp generation)

To study the operation of the parameters in more detail, please refer to the McBasic manual.

As an example of the servo parameter initialization a system might have the following X axis initialisation in the beginning of a program:

```
PIDFREQ=500
RESX=125   ' 125 pulse edges/mm
MAXERRX=10 ' poserr >10mm cuts off servo
GAINX=100  ' gain
INTGX=0 : DERVX=0 : SCOMPX=0 ' others off
SPEEDX=200 ' 200 mm/s
ACCELX=400 ' 0.5 s ramp (200/400=0.5)
FILTERSIZEX=20 ‘ 40ms filter (20/500 seconds)
```

To start moving the X axis, use the PWRX=1 command to start position control. The amplifier will go active and the position regulator will start holding the position.

To start a system with limited speed capability, use a lower value, like PWRX=0.2 to limit the regulator maximum output (max output = 10 x PWRX [volts]).

If the system is unstable, runs away from the set position and cuts off at MAXERR, check encoder phasing and speed loop phasing.

To operate the REF output without the speed regulator, use the OPWRX= command. (If necessary, MAXERR = ∞)

When the position regulator is running, use the MOVE or MOVER command to try moving the axis to new positions.

Adjust the GAIN, DERV, INTG and SCOMP parameters for stable operation. For many systems with tacho speed loop the parameters can be set by adjusting GAIN while leaving DERV, INTG and SCOMP to 0 and then adding DERV if necessary.

After the feedback parameters are set, SCOMP may be set at a value corresponding the speed of the axis when REF is 10V (this is called critical SCOMP). This will add a feed forward part in the REF signal compensating for the known part of the speed reference during motion and thus enabling accurate path control. Using a SCOMP value higher than the critical value causes undercritical SCOMP that compensates only partly for the position lag when in motion.

To disable speed compensation, leave SCOMP at 0. Critical SCOMP also provides the fastest point-to-point positioning. Undercritical or no SCOMP causes smoother operation at the end of the motion to avoid overshoot.

INTG can be used to integrate the position error for minimum error at constant or zero speed. The best INTG operation is achieved with high speed servo components and critical SCOMP.

6.11 Program storage and backup copies

After completing the application software, save the program to a non-volatile disk, usually one of the flash (SD card) drives. It is also possible to save the program to a RAM disk, but this is not recommended due to the volatility of the memory.