MX Driver Reference Manual

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June 2, 2011

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Contents

Chapter 1

Introduction

MX is a portable beamline control and data acquisition toolkit currently in use at a number of synchrotron beamlines and laboratory X-ray generator systems. The purpose of this manual is to explain how to set up the configuration files that control how MX works.

The most important step in configuring a new MX system is the building of the MX configuration files which are generally found in the directory *$MXDIR/etc* where *MXDIR* is an environment variable that points to the top of the MX directory tree. If you use the standard definition that *MXDIR = /opt/mx*, then the configuration files will be found in */opt/mx/etc*. The most important configuration files are:

/opt/mx/etc/motor.dat	- The primary MX client-side database file.
/opt/mx/etc/mxserver.acl	- An access control list for the MX server.
/opt/mx/etc/mxserver.dat	- The MX server-side database file.
/opt/mx/etc/mxupdate.dat	- The *mxupdate* process's configuration file.

We will cover *mxserver.acl* and *mxupdate.dat* first since they are simple and relatively easy to explain.

1.1 *mxserver.acl*

mxserver.acl is an access control list file that describes what computers are allowed to connect to the local MX server. It is a simple text file with one entry per line. The entries are either IP addresses or Internet domain names. I recommend the use of IP addresses since then the MX server does not need to perform potentially time consuming DNS lookups to find the IP address from the domain name, but it is your choice. Here is an example *mxserver.acl* file:

```
127.0.0.1
192.168.17.5
192.168.17.27
192.168.22.*
myhost.example.com
*.example.net
```

This configuration files says that the individual IP addresses 127.0.0.1, 192.168.17.5 and 192.168.17.27 are allowed, that any host on the subnet 192.168.22.* is allowed, that *myhost.example.com* is allowed, and that any host in

the domain **.example.net* is allowed. You will note that * wildcards are allowed. In addition, the *?* wildcard, which stands for a single character, is also allowed although it is not as easy to use.

At present, MX only does access control on a host level basis and allows any username from a given machine to connect. Although MX clients do transmit their username to the remote MX server, this information is not used for access control since it is trivially spoofed. Support for user level access control will be added once something along the lines of an SSL/TLS certificate infrastructure has been added to MX.

1.2 *mxupdate.dat*

The *mxupdate* process exists to save and restore MX database variables so that their values can be preserved when the MX server is stopped and restarted. It is another simple text file that contains the name of one record field per line. An example *mxupdate.dat* file looks like:

```
edge_energy.value     1 0
d_spacing.value       1 0
beam_offset.value     1 0
shutter_policy.value  1 0
xafs_header1.value    1 0
xafs_header2.value    1 0
xafs_header3.value    1 0
sff_header1.value     1 0
sff_header2.value     1 0
sff_header_fmt.value  1 0
theta_enabled.value   1 0
momega_enabled.value  1 0
normpoly_enable.value 1 0
normal_enabled.value  1 0
id_ev_enabled.value   1 0
momega_params.value   1 0
normpoly_params.value 1 0
id_ev_harmonic.value  1 0
id_ev_offset.value    1 0
id_ev_params.value    1 0
```

The first field on each line is the name of an MX record field. For example, *edge_energy.value* refers to the record called *edge_energy* and the field within it called *value*. Any record field listed here will have its value saved twice a minute and will have its value restored the next time the MX server is started from the *mxupdate* state files called */opt/mx/state/mxsave.1* and */opt/mx/state/mxsave.2*. When *mxupdate* restores the values the next time the MX server is started, *mxupdate* will choose whichever of the two state files which is both complete and most recent.

For the present, you should set the second and third fields on each line above to 1 and 0 respectively. These fields are not currently documented, since they are scheduled to be changed in the future.

1.3 The MX Record Database Files *motor.dat* and *mxserver.dat*

The most important configuration files in MX are the client-side *motor.dat* file and the server-side *mxserver.dat* file. These files describe the set of objects called *MX records* which are used to represent the motors, counter, MCAs, serial ports, and so forth that an MX client or server will manage.

The first thing you will note if you compare *motor.dat* and *mxserver.dat* is that they have exactly the same format. This is due to the fact that MX servers and clients actually use exactly the same set of device drivers. In fact, the only thing that marks a process as being an MX client is the use of one of the device drivers that send command requests across the network to a remote server rather than to a device directly attached to the client process.

For example, suppose you have a Compumotor 6K motor controller that is managed by an MX server and a remote MX client wants to move a motor belonging to the 6K. The MX server will have in its database a record for the motor of type *compumotor* which communicates via a directly attached RS-232 port, while the MX client will have a record of type *network_motor* which sends the request across the network via a socket. But other than the fact that the server or client are using different low level drivers, they treat the motor moves the same.

To make the example more concrete, let us display some example MX configuration files. First, here is an *mxserver.dat* file for an MX server managing a 4-axis Compumotor 6K motor controller:

```
6k_rs232  interface rs232 tty "" "" 9600 8 N 1 S 0x0d0a 0x0d0a /dev/ttyS1
6k interface controller compumotor_int "" "" 6k_rs232 0x0 1 1 4
m1 device motor compumotor "" "" 0  0 -1000000 1000000 0 -1 -1 0.04 0 urad 6k 1 1 1
m2 device motor compumotor "" "" 0  0 -1000000 1000000 0 -1 -1 0.04 0 urad 6k 1 2 1
m3 device motor compumotor "" "" 0  0 -1000000 1000000 0 -1 -1 .0188 0 um 6k 1 3 1
m4 device motor compumotor "" "" 0  0 -200000 200000 0 -1 -1 0.25 0 urad 6k 1 4 1
```

For the moment, we will not go too deeply into the details of the format of the lines. The first thing to note here is that each line of the database file corresponds to one MX record, whose name is the first item on the line. Thus, there are six MX records in this database named *6k_rs232*, *6k*, *m1*, *m2*, *m3*, *m4*. There is nothing special about these record names. All that MX expects is that they be unique, be ordinary printing ASCII characters, and be 15 characters long or less.

Going to a little lower level of detail, the second, third, and fourth fields on each line describe the MX device driver that will be used to control the underlying hardware. The second field is called the *mx_superclass* field, the third field is the *mx_class* field, and the fourth field is the *mx_type* field. Typically the MX driver as a whole will be referred to by the name of the *mx_type* field. For the example database above, this breaks down as follows:

Record Name	Superclass	Class	Type	Explanation
6k_rs232	interface	rs232	tty	This record uses the *tty* driver for Posix serial ports.
6k	interface	controller	compumotor_int	This record manages the 6K controller as a whole.
m1	device	motor	compumotor	This record manages axis 1 of the 6K controller.
m2	device	motor	compumotor	This record manages axis 2 of the 6K controller.
m3	device	motor	compumotor	This record manages axis 3 of the 6K controller.
m4	device	motor	compumotor	This record manages axis 4 of the 6K controller.

To finish the example, we now show the client side *motor.dat* file that matches the MX server database shown above:

```
serv server network tcpip_server "" "" 0x0 192.168.17.10 9727
m1 device motor network_motor "" "" 0 0 -1e+06 1e+06 0 -1 -1 1 0 urad serv m1
m2 device motor network_motor "" "" 0 0 -1e+06 1e+06 0 -1 -1 1 0 urad serv m2
omega device motor network_motor "" "" 0 0 -1e+06 1e+06 0 -1 -1 1 0 urad serv m3
chi   device motor network_motor "" "" 0 0 -1e+06 1e+06 0 -1 -1 1 0 urad serv m4
```

In more verbose language, this breaks down as:

Record Name	Superclass	Class	Type	Explanation
serv	server	network	tcpip_server	This record manages the connection to an MX server running on port 9727 of host 192.168.17.10.
m1	device	motor	network_motor	This record requests server *serv* to perform actions on its behalf on the server's record *m1*.
m2	device	motor	network_motor	This record requests server *serv* to perform actions on its behalf on the server's record *m2*.
omega	device	motor	network_motor	This record requests server *serv* to perform actions on its behalf on the server's record *m3*.
chi	device	motor	network_motor	This record requests server *serv* to perform actions on its behalf on the server's record *m4*.

An important detail to notice here is that the name of the client's record does not have to be the same as the name the server knows it by. For example, client record *omega* sends requests to the server for server record *m3*. However, it is common and convenient to give the records the same name in the clients and in the servers.

One last detail to note is that an MX client is not restricted to only one server connection. If you had an MX client database that started with the following

```
serv1 server network tcpip_server "" "" 0x0 192.168.17.11 9727
serv2 server network tcpip_server "" "" 0x0 192.168.17.12 9727
serv3 server network tcpip_server "" "" 0x0 192.168.17.13 9727
```

then the client would have three simultaneous connections to three different MX servers.

1.4 Records and Record Fields

So what is a record, actually? On a technical level, it is a C data structure of type *MX_RECORD* that is declared in the MX source code in the header file *mx/libMx/mx_record.h*. But most of you probably did not want to know that.

On a more practical level, it is a repository for most of the information that MX program needs to know about a given object. The reason I say "most" is that MX records often have pointers to other MX records in the database. Thus, the *6k* record from the example in the previous section does not itself contain the information about the RS-232 settings of the port used to communicate with the Compumotor controller. Instead it uses the pointer *6k_rs232* in its own record description so that it can find that information in the record *6k_rs232*.

MX records are the primary "objects" of MX. They encapsulate both data values such as motor position, scaler counts, etc. and tables of functions ("methods") that operate on that data. Many of the data fields will be the same for all records of a given class. For example, all motor drivers need to have a place to store the current position of the motor. However, each record type will have type specific information in it. For example, a Pontech *stp100* record contains a field for the digital I/O pin number used to implement a home switch, a concept which many motor drivers would have no need for.

Internally, the data belonging to a record is contained in a variety of C data structures with names like *MX_MOTOR*, *MX_COMPUMOTOR*, *MX_PMAC_MOTOR*, and so forth. However, when it comes time to read data from a disk file or send it across the network, we can't really use the binary C structures or pointers to them for this. Theoretically you could, but it would be a really bad idea to do so. Instead, we use the concept of a *record field*.

An MX record field contains a pointer to a piece of data and also a description of its datatype and size. The record field also has a name that we can use to refer to it by. For example, if we look at an MX motor record called *theta*,

its position will be found in the record field *theta.position*. Thus, the record field name has two parts, namely, the record name *theta* and the field name *position*. Information read from MX database files and sent across MX network connections is identified by it record field name.

We said earlier in this chapter that each horizontal line in an MX database corresponds to one MX record. Within a given database line, the data is organized by field name. As we saw earlier, the first four fields are called *name*, *mx_superclass*, *mx_class*, and *mx_type*. These four fields are always found at the start of an MX database line. They are followed by two more fields called *label* and *acl_description* which are also common to all record types. These record fields can be summarized by the following table:

Field Name	**Field Type**	**Number of Dimensions**	**Sizes**	**Description**
name	string	1	16	The name of the record
mx_superclass	recordtype	0	0	The string “device”
mx_class	recordtype	0	0	The string “motor”
mx_type	recordtype	0	0	The name of the motor driver for this motor.
label	string	1	40	A verbose description of the record.
acl_description	string	1	40	Placeholder for an access control list *(not yet implemented)*.

You will see tables like the above throughout the rest of this manual, so we will try to explain it further here.

First of all, the **Field Name** column is just what it says, the name of the field. The **Field Type** column tells you what datatype the field contains. At present, MX supports the following datatypes, which are mostly modeled on the C datatypes:

Internal Name	Common Name	Description
MXFT_STRING	string	Null terminated C string
MXFT_CHAR	char	C char
MXFT_UCHAR	uchar	C unsigned char
MXFT_SHORT	short	C short
MXFT_USHORT	ushort	C unsigned short
MXFT_INT	int	C int
MXFT_UINT	uint	C unsigned int
MXFT_LONG	long	C long
MXFT_ULONG	ulong	C unsigned long
MXFT_FLOAT	float	C float
MXFT_DOUBLE	double	C double
MXFT_HEX	hex	A C unsigned long, usually represented in hexadecimal notation, such as 0x27a5.
MXFT_RECORD	record	A pointer to another MX record, represented by the name of the record in the database file.
MXFT_RECORDTYPE	recordtype	Used to point to device driver structures. Represented by the name of the driver type.
MXFT_INTERFACE	interface	A generalization of the MX_RECORD type which includes an optional address field. Typically used for devices that can be controlled by both RS-232 and GPIB. An example would be *gpib0:4* which refers to GPIB address 4 for GPIB interface record *gpib0*.

The **Number of Dimensions** column refers, of course, to the dimensions of the array containing the data. The case "0" stands for a single scalar value. The **Sizes** column contains a list of the sizes of each dimension.

Chapter 2

Amplifiers

2.1 APS ADCMOD2

2.2 APS QuadEM

2.3 Keithley 428

2.4 Keithley 2000

2.5 Keithley 2400

2.6 Keithley 2700

2.7 Network Amplifier

2.8 Oxford Danfysik IC PLUS

2.9 SCIPE Amplifier

2.10 Soft Amplifier

2.11 SRS SR-570

2.12 UDT Tramp

Chapter 3

Analog I/O

3.1 APS ADCMOD2 Analog I/O

3.2 Data Track Tracker Analog I/O

3.3 Kinetic Systems 3112 Analog Output

3.4 Kinetic Systems 3512 Analog Input

3.5 MODBUS Analog I/O

3.6 Multichannel Analog Input Function

3.7 Network Analog I/O

3.8 Newport Electronics Iseries Analog I/O

3.9 Prairie Digital Model 45 Analog I/O

3.10 Soft Analog I/O

3.11 Spellman DF3/FF3 Series High Voltage Power Supplies

The Spellman DF3/FF3 series *(http://www.spellmanhv.com/tech/pdf/DF3FF3MAN.pdf)* of high voltage power supplies for X-ray generator systems. MX communicates with the power supply via an RS-232 link.

The available drivers include:

spellman_df3 - Communicates with the power supply via RS-232.
spellman_df3_ain - Reports the value of the voltage, current, or filament current.
spellman_df3_aout - Controls the setpoint for the voltage, current, power limit, or filament current limit.
spellman_df3_din - Turns the X-ray generator on/off or resets a power supply fault.
spellman_df3_dout - Reports the X-ray on status or any of the fault conditions.

The record fields for the *spellman_df3* driver are:

Field Name	Field Type	Number of Dimensions	Sizes	Description
See *Common record field definitions*				
rs232_record	string	1	0	Name of the RS-232 port used to communicate with the Spellman power supply.
query_interval	double	0	0	Minimum time interval between hardware queries.
default_power_limit	hex	0	0	Default value for the power limit specified as a hexadecimal integer.
default_filament_current_limit	hex	0	0	Default value for the filament current limit specified as a hexadecimal integer.

The RS-232 command language for the Spellman power supply only supports a single 'Q' command that reports all of the analog and digital input values at once. Since there are 12 of these values, reading out all of them can lead to a lot of redundant polling. The purpose of the *query_interval* field is to specify a minimum time in seconds between 'Q' commands. If a client asks for an input value before the minimum time has elapsed, the values cached from a previous call to 'Q' are returned instead.

The record fields for the *spellman_df3_ain* driver are:

Field Name	Field Type	Number of Dimensions	Sizes	Description
See *Common analog input field definitions*				
spellman_df3_record	record	0	0	The Spellman power supply record.
input_type	double	0	0	The type of input used for this record.

The *input_type* field can have any of the following values:

0 - Voltage (0 to 0x3FF, 60 kV max)

1 - Current (0 to 0x3FF, 80 mA max)

2 - Filament current (0 to 0x3FF, 5 amps max)

The record fields for the *spellman_df3_aout* driver are:

Field Name	Field Type	Number of Dimensions	Sizes	Description
See *Common analog output field definitions*				
spellman_df3_record	record	0	0	The Spellman power supply record.
output_type	double	0	0	The type of output used for this record.

The *output_type* field can have any of the following values:

0 - Voltage setpoint (0 to 0xFFF, 60 kV max)

1 - Current setpoint (0 to 0xFFF, 80 mA max)

2 - Power limit (0 to 0xFFF, 4 kW max)

3 - Filament current limit (0 to 0xFFF, 5 amps max)

The record fields for the *spellman_df3_din* driver are:

Field Name	Field Type	Number of Dimensions	Sizes	Description
See *Common digital input field definitions*				
spellman_df3_record	record	0	0	The Spellman power supply record.
input_type	unsigned long	0	0	The type of input used for this record.

The *input_type* field can have any of the following values:

0 - kV minimum fault

1 - overcurrent fault

2 - overpower fault

3 - overvoltage fault

4 - filament current limit fault

5 - power supply fault

6 - X-ray on indicator

7 - interlock status

8 - control mode indicator

The record fields for the *spellman_df3_dout* driver are:

Field Name	Field Type	Number of Dimensions	Sizes	Description
See *Common digital output field definitions*				
spellman_df3_record	record	0	0	The Spellman power supply record.
output_type	unsigned long	0	0	The type of output used for this record.

The *output_type* field can have any of the following values:

0 - X-rays on (Writing 1 turns them on; 0 turns them off)

1 - X-rays off (Writing 1 turns them off; 0 turns them on)

1 - Power supply reset

The following is an example database for the Spellman DF3/FF3 power supply:

```
spellman_rs232 interface rs232 tty "" "" 9600 8 N 1 N 0x0d 0x0d 1 0x0 /dev/ttyS0
spellman interface controller spellman_df3 "" "" spellman_rs232 1 0x1ff 0x1ff
#
voltage_cmd     device analog_output spellman_df3_aout "" "" 0 0.0146520 0 kV 0x0 spellman 0
current_cmd     device analog_output spellman_df3_aout "" "" 0 0.0195360 0 mA 0x0 spellman 1
#
xrayson_cmd     device digital_output spellman_df3_dout "" "" 0 spellman 0
xraysoff_cmd    device digital_output spellman_df3_dout "" "" 0 spellman 1
power_reset     device digital_output spellman_df3_dout "" "" 0 spellman 2
#
voltage         device analog_input spellman_df3_ain "" "" 0 0.0586510 0 kV 0x0 0 "" spellman 0
current         device analog_input spellman_df3_ain "" "" 0 0.0782014 0 mA 0x0 0 "" spellman 1
filament        device analog_input spellman_df3_ain "" "" 0 0.0782014 0 A 0x0 0 "" spellman 2
#
kv_min_fault    device digital_input spellman_df3_din "" "" 0 spellman 0
ovcurrent_fault device digital_input spellman_df3_din "" "" 0 spellman 1
ovpower_fault   device digital_input spellman_df3_din "" "" 0 spellman 2
ovvoltage_fault device digital_input spellman_df3_din "" "" 0 spellman 3
fil_curr_fault  device digital_input spellman_df3_din "" "" 0 spellman 4
power_sup_fault device digital_input spellman_df3_din "" "" 0 spellman 5
xrays_on        device digital_input spellman_df3_din "" "" 0 spellman 6
interlock_state device digital_input spellman_df3_din "" "" 0 spellman 7
remote_mode     device digital_input spellman_df3_din "" "" 0 spellman 8
```

3.12 Stanford Research Systems SR-630

The SR-630 is a 16-channel thermocouple readout controller.

An example database for the SR-630 looks like:

```
sr630_rs232 interface rs232 tty "" "" 9600 8 N 1 N 0x0a 0x0a 10 0x0 /dev/ttyS7
sr630 interface controller sr630 "" "" sr630_rs232
```

```
temp1  device analog_input sr630_ainput "" "" 0 1 0 C 0x0 0 "" sr630 1
temp2  device analog_input sr630_ainput "" "" 0 1 0 C 0x0 0 "" sr630 2
temp3  device analog_input sr630_ainput "" "" 0 1 0 C 0x0 0 "" sr630 3
temp4  device analog_input sr630_ainput "" "" 0 1 0 C 0x0 0 "" sr630 4
temp5  device analog_input sr630_ainput "" "" 0 1 0 C 0x0 0 "" sr630 5
temp6  device analog_input sr630_ainput "" "" 0 1 0 C 0x0 0 "" sr630 6
temp7  device analog_input sr630_ainput "" "" 0 1 0 C 0x0 0 "" sr630 7
temp8  device analog_input sr630_ainput "" "" 0 1 0 C 0x0 0 "" sr630 8
temp9  device analog_input sr630_ainput "" "" 0 1 0 C 0x0 0 "" sr630 9
temp10 device analog_input sr630_ainput "" "" 0 1 0 C 0x0 0 "" sr630 10
temp11 device analog_input sr630_ainput "" "" 0 1 0 C 0x0 0 "" sr630 11
temp12 device analog_input sr630_ainput "" "" 0 1 0 C 0x0 0 "" sr630 12
temp13 device analog_input sr630_ainput "" "" 0 1 0 C 0x0 0 "" sr630 13
temp14 device analog_input sr630_ainput "" "" 0 1 0 C 0x0 0 "" sr630 14
temp15 device analog_input sr630_ainput "" "" 0 1 0 C 0x0 0 "" sr630 15
temp16 device analog_input sr630_ainput "" "" 0 1 0 C 0x0 0 "" sr630 16
```

3.13 Wago 750 Series MODBUS Analog Output

3.14 Motor Controller Analog I/O

3.15 Other Controller Type Analog I/O

Chapter 4

Area Detector

4.1 Aviex PCCD-170170

4.2 Network Area Detector

4.3 Soft Area Detector

Chapter 5

Autoscale Devices

5.1 Autoscale Amplifier

5.2 Autoscale Filter

5.3 Autoscale Filter and Amplifier

5.4 Related Devices

5.4.1 Autoscale Scaler

5.4.2 Gain Tracking Scaler

MX scaler driver to control MX gain tracking scalers. Gain tracking scalers are pseudoscalers that rescale their reported number of counts to go up and down when an associated amplifier changes its gain.

For example, suppose that the real scaler was reading 1745 counts, the amplifier was set to 10^8 gain and the gain tracking scale factor was 10^{10}. Then, the gain tracking scaler would report a value of 174500 counts. If the amplifier gain was changed to 10^9, then the gain tracking scaler would report a value of 17450 counts.

Gain tracking scalers are intended to be used in combination with autoscaling scalers, so that when the autoscaling scaler changes the gain of the amplifier, the values reported by gain tracking scalers will change to match.

Chapter 6

Counter/Timers

6.1 Am9513

The following is an example database for the IIT BCPS setup for Am9513 boards:

```
ports   interface portio linux_portio "" "" /dev/portio
am9513  interface controller am9513 "" "" ports 0x284 0x1b0
i8255   interface controller i8255 "" "" ports 0x280
#
# Motor 1 uses Am9513 counters 1 & 2 to generate the motor step pulses while
# 8255 output bit 2 of port C is used to generate the direction signal.
#
motor1  device motor am9513_motor "" "" 0 0 -1000000 1000000 0 -1 -1 0.005 0 um 2 am9513:1 am9513:2 p
portc   device digital_output i8255_out "" ""  0 i8255 C
#
# Scaler 1 is a 32 bit scaler created using Am9513 counters 4 & 5.  The
# counter is gated by the gate input for its low order counter (GATE4),
# while external pulses to be counted are fed to the source input for
# its low order counter (SRC4).
#
scaler1 device scaler am9513_scaler "" "" 0 0 0 2 am9513:4 am9513:5 0x4 0x4
#
# Timer 1 is a 16 bit timer created using Am9513 counter 3.  It is using
# a 5 MHz clock signal.
#
timer1  device timer am9513_timer "" "" 1  am9513:3 5000000
```

Warning: The *am9513* interface driver has only been fully implemented and tested for Am9513-based systems using 8-bit bus access.

At present, MX Am9513 timers can only use one 16-bit counter. Also note that the timer driver relies on the output for the timer's counter being connected to its own gate input. That is, OUT(n) must be connected to GATE(n) for the timer to work. Of course, OUT(n) is also connected to the GATE inputs of the scalers that this timer is gating.

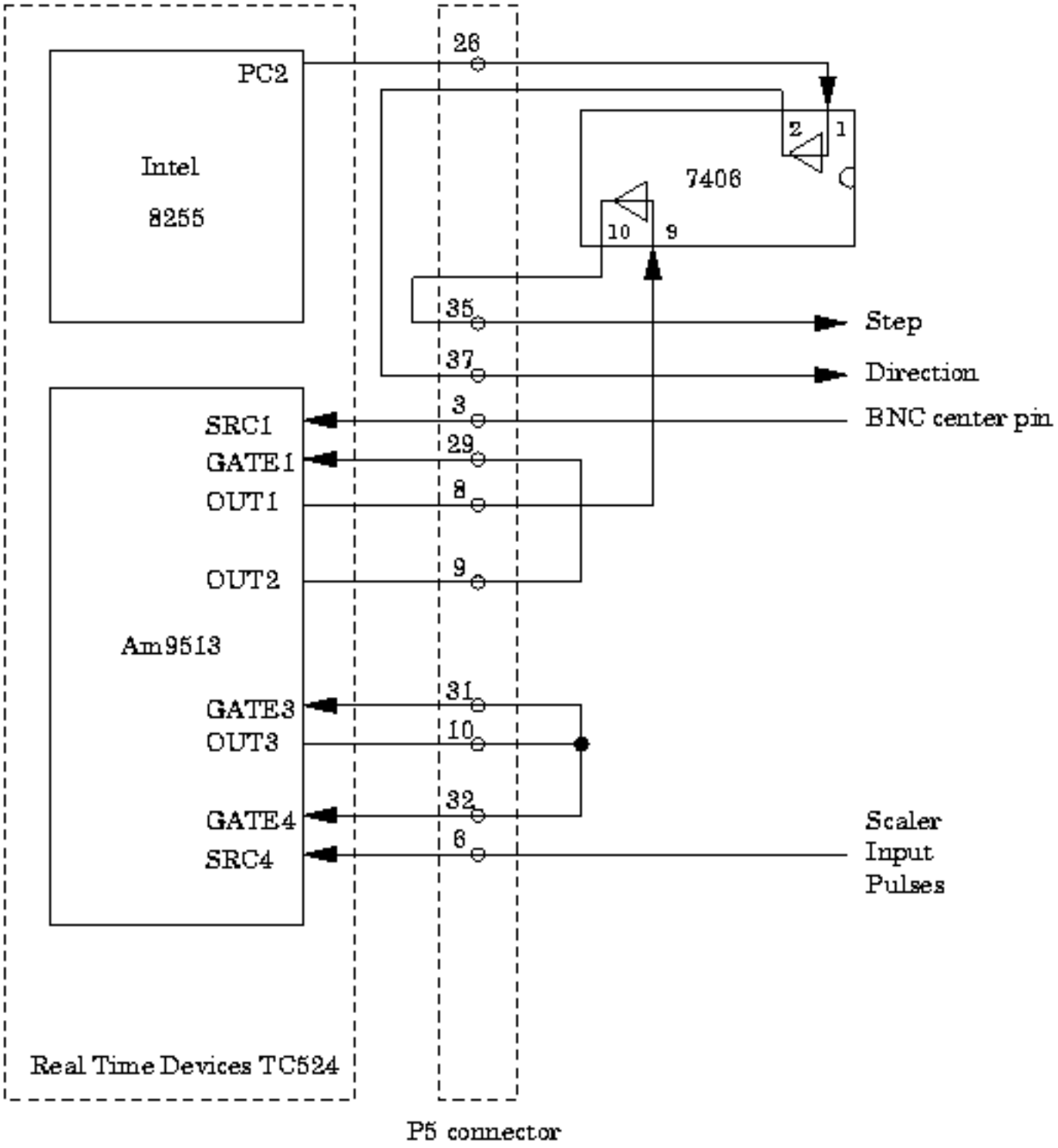


Figure 6.1: Wiring diagram used by the IIT BCPS department

6.2 Black Cat Systems GM-xx

6.3 Blu-Ice Timer

6.4 DSP QS450 or Kinetic Systems 3610

6.5 EPICS Scaler

The MX EPICS scaler support optionally can make use of globally visible dark current values. This is done by loading an additional EPICS database file in "st.cmd" that can be found in the MX base distribution in the file *mx/driver_info/epics_scaler/Jscaler_dark.db*. This EPICS database implements two additional records per EPICS scaler channel. For example, for scaler channel 2 the records are

- (P)(S)_Dark2.VAL - Dark current per second for scaler channel 2.

- (P)(S)_SD2.VAL - The dark current subtracted value for scaler 2.

where $(P) and $(S) are defined to have the same values as in the standard Jscaler.db database. The database is loaded into the EPICS VME crate by adding a line to the 'st.cmd' startup script that looks like

```
dbLoadRecords("iocBoot/ioc1/Jscaler_dark.db","P=s10id:,S=scaler1,C=0", top)
```

Please note that this database contains a definition for the scaler record $(P) and $(S) itself and thus is not immediately compatible with the standard *Jscaler.db* database. This is due to the fact that EPICS does not supply any way for an add-on database to add forward links to existing records. If you wish to combine *Jscaler.db* and *Jscaler_dark.db*, the simplest way is to merely move the FLNK field whose value is "(P)(S)_cts1.PROC" in Jscaler.db to the LNK4 field of Fanout record "(P)(S)_fan0" defined in *Jscaler_dark.db*.

Hopefully, something equivalent to the dark current fields in *Jscaler_dark.db* will be added to some future version of *Jscaler.db*.

6.6 EPICS Timer

6.7 Interval Timer

6.8 Joerger VSC8/16

6.9 MCA Timer

6.10 MCS Timer

6.11 Network Scaler

6.12 Network Timer

6.13 Ortec 974

6.14 Prairie Digital Model 45

6.15 PFCU Shutter Timer

6.16 Radix Databox Scaler/Timer

6.17 RTC-018

6.18 SCIPE Scaler

6.19 SCIPE Timer

6.20 Soft Scaler

6.21 Soft Timer

6.22 Spec Scaler

6.23 Spec Timer

6.24 XIA DXP Timer

6.25 XIA Handel Timer

6.26 Pseudoscalers

6.26.1 Autoscale Related Pseudoscalers

6.26.2 MCA Related Pseudoscalers

6.26.3 MCS Scaler

6.26.4 Scaler Function

WARNING WARNING WARNING WARNING WARNING WARNING WARNING WARNING WARNING

This driver does **NOT** attempt to ensure that all of the timers start at exactly the same time. This means that devices gated by different timers may not be gated on for exactly the same timer interval, although the lengths of time they are gated on for should be the same. The result is that you may get **SYSTEMATIC ERRORS** if you do not use this driver intelligently. It is up to you to decide whether or not this makes a difference to the experiment you are performing. The *best* solution is to make sure that all of your measuring devices are gated by the same hardware timer, but if that is not possible, then this driver may be useful as a stopgap.

Caveat emptor.

Chapter 7

Digital I/O

Chapter 8

Encoder

8.1 Kinetic Systems 3640

Chapter 9

Goniostat/Diffractometer Tables

9.1 IMCA-CAT ADC Table at APS Sector 17

The ADC table is designed to support a standard crystallography goniostat. At present, it is the support for an ADSC Quantum 105 detector system. The geometry of the table is shown by the figure below: The geometry is described further in a technical note in PDF format. The note is also available in Postscript if you prefer.

The MX table support for ADC tables uses two different kinds of records, namely, an ADC specific table record described here and the generic table motor record described in the motor section.

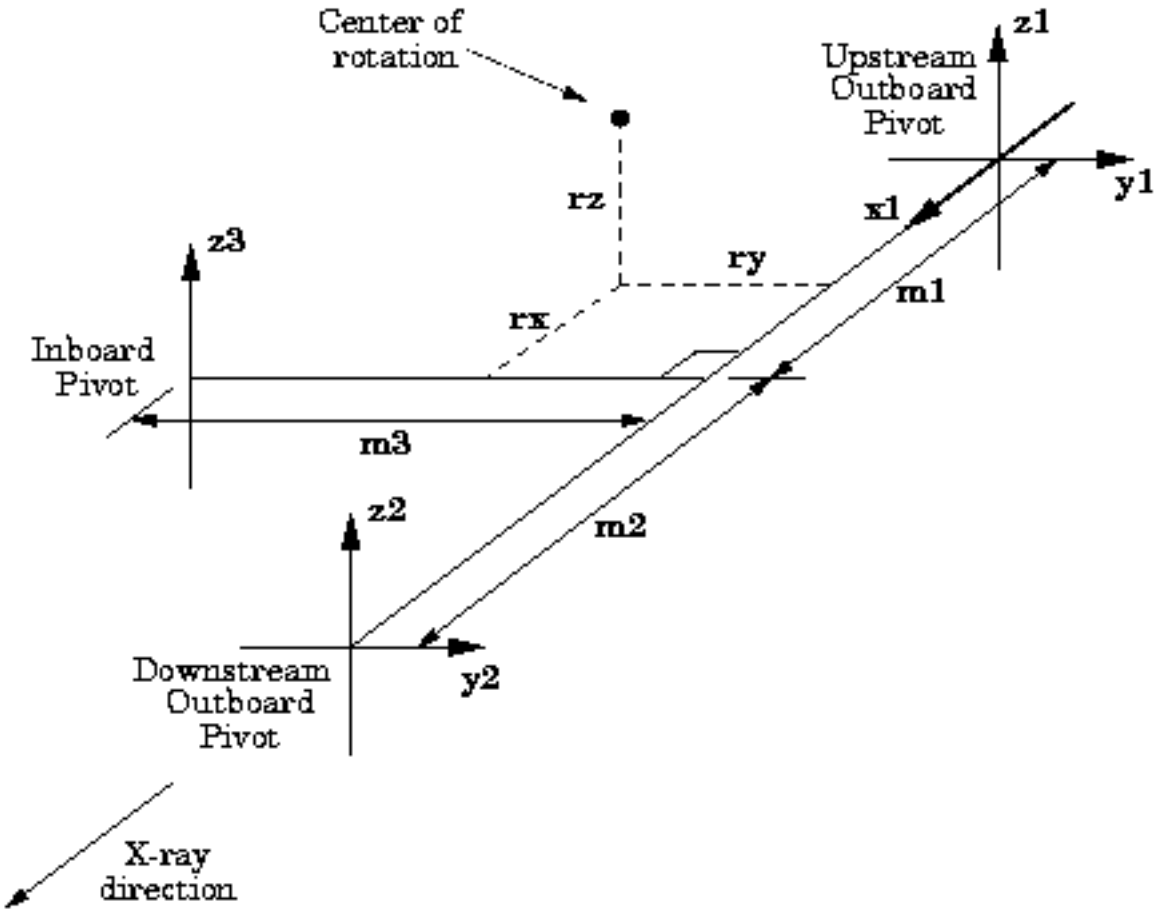


Figure 9.1: IMCA-CAT ADC table geometry

9.1.1 Record Fields in the Record Description

Field Name	Field Type	Number of Dimensions	Sizes	Description
name	string	1	16	The name of the record
mx_superclass	recordtype	0	0	The string "device"
mx_class	recordtype	0	0	The string "table"
mx_type	recordtype	0	0	The string "adc_table"
label	string	1	40	A verbose description of the record.
acl_description	string	1	40	Placeholder for an access control list *(not yet implemented)*.
motor_record_array	record	1	6	The names of the raw motor records used by this table record listed in the order X1, Y1, Y2, Z1, Z2, and Z3.
m1	double	0	0	Distance from the table zero point to the Z1 pivot point.
m2	double	0	0	Distance from the table zero point to the Z2 pivot point.
m3	double	0	0	Distance from the table zero point to the Z3 pivot point.
rx	double	0	0	X component of the distance from the table zero point to the rotation center.
ry	double	0	0	Y component of the distance from the table zero point to the rotation center.
rz	double	0	0	Z component of the distance from the table zero point to the rotation center.

An example database for this table type would look like:

```
adsc_table device table adc_table "" ""  x1 y1 y2 z1 z2 z3 0.4 0.6 0.75 0.25 0.25 0.5
x1         device motor soft_motor "" "" 0 0 -20000000 20000000 0 -1 -1 0.001 0 um
y1         device motor soft_motor "" "" 0 0 -20000000 20000000 0 -1 -1 0.001 0 um
y2         device motor soft_motor "" "" 0 0 -20000000 20000000 0 -1 -1 0.001 0 um
z1         device motor soft_motor "" "" 0 0 -20000000 20000000 0 -1 -1 0.001 0 um
z2         device motor soft_motor "" "" 0 0 -20000000 20000000 0 -1 -1 0.001 0 um
z3         device motor soft_motor "" "" 0 0 -20000000 20000000 0 -1 -1 0.001 0 um
tx         device motor table_motor "" "" 0 0 -20000000 20000000 0 -1 -1 1 0 um adsc_table 1
ty         device motor table_motor "" "" 0 0 -20000000 20000000 0 -1 -1 1 0 um adsc_table 2
tz         device motor table_motor "" "" 0 0 -20000000 20000000 0 -1 -1 1 0 um adsc_table 3
troll      device motor table_motor "" "" 0 0 -20000000 20000000 0 -1 -1 1 0 urad adsc_table 4
tpitch     device motor table_motor "" "" 0 0 -20000000 20000000 0 -1 -1 1 0 urad adsc_table 5
tyaw       device motor table_motor "" "" 0 0 -20000000 20000000 0 -1 -1 1 0 urad adsc_table 6
```

In this example, the *adsc_table* record is the actual table record itself. It is configured to use soft motors *x1*, *y1*, *y2*, *z1*, *z2*, and *z3* as the raw motors. The table parameters for the example are set to *m1 = 0.4*, *m2 = 0.6*, *m3 = 0.75*, *rx = 0.25*, *ry = 0.25*, and *rz = 0.5*.

Chapter 10

Motors

All motor records in MX support a common set of operations that are described in this chapter. We describe first the set of record fields found in the record description string in an MX database file for a motor.

Motor records are divided into two subclasses, namely, *stepper* and *analog* motors. The two classes are distinguished by the format of the numbers used to communicate with the underlying controller. Motor controllers for which positions, speeds, etc. are specified in integer units (*steps or encoder ticks*) are called *stepper* motors by MX motor support. Motor controllers for which positions, speeds, etc. are specified in floating point units are called *analog* motors by MX motor support.

10.1 Record Fields in the Record Description

The following fields must be included in the record description for a record in an MX database file. They must appear in the order presented below.

Field Name	Field Type	Number of Dimensions	Sizes	Description
name	string	1	16	The name of the record
mx_superclass	recordtype	0	0	The string "device"
mx_class	recordtype	0	0	The string "motor"
mx_type	recordtype	0	0	The name of the motor driver for this motor.
label	string	1	40	A verbose description of the record.
acl_description	string	1	40	Placeholder for an access control list *(not yet implemented)*.
raw_position	long *for stepper*, double *for analog*	0	0	The motor position in raw units. Generally this value will be overwritten by the position read from the motor controller.
raw_backlash_correction	long *for stepper*, double *for analog*	0	0	The MX backlash correction in raw units.
raw_negative_limit	long *for stepper*, double *for analog*	0	0	The software negative limit in raw units.
raw_positive_limit	long *for stepper*, double *for analog*	0	0	The software positive limit in raw units.
raw_move_deadband	long *for stepper*, double *for analog*	0	0	The motion deadband in raw units. A requested move is not performed unless the difference between the requested and the current positions is bigger than the deadband distance.
raw_minimum_speed_limit	long *for stepper*, double *for analog*	0	0	The slowest raw speed that can be requested for this motor. Negative values have special meanings. -1 means there are no restrictions on the requested raw speed. -2 means that the speed cannot be changed.
raw_maximum_speed_limit	long *for stepper*, double *for analog*	0	0	The fastest raw speed that can be requested for this motor. Negative values have the same meaning as for "raw_minimum_speed_limit".
scale	double	0	0	The "scale" field is used together with the "offset" field to compute positions in user units using the formula: *user_units = scale * raw_units + offset*.
offset	double	0	0	See the description of the "scale" field.
units	string	1	16	User units for the motor, such as *um*, or *deg*.

An example motor record description for a "disabled motor" is shown below.

```
theta device motor disabled_motor "" "" 0 0 -20000000 20000000 0 -1 -1 5e-05 0 deg
```

The disabled motor record was chosen for this example since it has no type-specific fields.

10.2 Motor Controllers

MX currently supports a wide variety of motor controllers. Motor controllers typically have a lot of additional I/O devices that are associated with the controller, such as digital and analog I/O. For convenience, we describe all of the MX drivers for a given motor controller here in one place.

10.2.1 Advanced Control Systems MCU-2

Platforms: All

The *mcu2* driver is for the MCU-2 stepping motor driver/controller from Advanced Control Systems. Vendor information for the MCU-2 can be found at http://www.acsmotion.com/ACS MCU-2 Product Page.htm

The individual axes for this controller can be accessed independently of each other, so this motor driver directly speaks to the serial port, instead of going through an intermediate *interface* record.

Field Name	Field Type	Number of Dimensions	Sizes	Description
See *Common Motor Field Definitions*				
rs232_record	record	0	0	Name of the serial port record that is connected to the MCS2 unit.
axis_address	long	0	0	Axis number of this particular MCU2 controlled motor.
mcu2_flags	hex	0	0	Flag bits used to modify the behavior of the *mcu2* driver.

The valid flag bits for the *mcu2_flags* field are as follows:

0x1 - This bit tells the driver that home searches should home to a limit switch rather than looking for a home switch.

0x2 - If this bit is set, commands to the MCU-2 will not be prefixed with a '#' character.

10.2.2 Aerotech Unidex 500

Platforms: Win32

This set of drivers is for the Unidex 500 family of motor controllers from Aerotech. The Unidex 500 is no longer for sale.

The available drivers include:

u500 Interface driver for controlling one or more Unidex 500 motor controllers.

u500_motor Motor driver for an individual axis of a Unidex 500 motor controller.

The MX drivers are only supported on Microsoft Windows since they depend on the binary WAPI Windows DLLs distributed by Aerotech.

***u500* Record Fields**

Field Name	Field Type	Number of Dimensions	Sizes	Description
See *Common record field definitions*				
num_boards	long	0	0	The number of Unidex 500 boards attached to the computer.
firmware_filename	string	2	(*num_boards*, *mxu_filename_length*)	An array of firmware file names.
parameter_filename	string	2	(*num_boards*, *mxu_filename_length*)	An array of parameter file names.
calibration_filename	string	2	(*num_boards*, *mxu_filename_length*)	An array of calibration file names. This field is optional. Set it to an empty string "" if not needed.
pso_firmware_filename	string	2	(*num_boards*, *mxu_filename_length*)	An array of PSO firmware file names. This field is optional. Set it to an empty string "" if not needed.

In the table above, *mxu_filename_length* is a platform specific maximum filename length.

***u500_motor* Record Fields**

Field Name	Field Type	Number of Dimensions	Sizes	Description
See *Common motor field definitions*				
u500_record	record	0	0	The name of the U500 controller record for this motor.
board_number	int	0	0	The number of the U500 board used to control this motor.
axis_name	char	0	0	The single character U500 axis name for this motor.
default_speed	double	0	0	The default speed for the motor.

10.2.3 Am9513-based Motor

Platforms: All

It is possible to configure an Am9513 chip to act as a very basic motor controller which only knows how to run at the base speed. See the **Am9513** subsection in the **Counter/Timer** section.

10.2.4 Animatics SmartMotor

Platforms: All

This set of drivers is for the SmartMotor integrated motor/controller units from Animatics *(http://www.animatics.com/)*.

Vendor information about the SmartMotor can be found here http://www.animatics.com/web/motors.html

The available drivers for this type of controller include:
smartmotor - A motor driver for the Animatics SmartMotor.
smartmotor_ain - An analog input driver for the Animatics SmartMotor.
smartmotor_aout - An analog output driver for the Animatics SmartMotor.
smartmotor_din - An digital input driver for the Animatics SmartMotor.
smartmotor_dout - An digital output driver for the Animatics SmartMotor.

***smartmotor* record fields**

Field Name	Field Type	Number of Dimensions	Sizes	Description
See *Common Motor Field Definitions*				
rs232_record	record	0	0	Name of the serial port record used to communicate with a daisy chained set of SmartMotors.
motor_address	long	0	0	The numerical address of the SmartMotor on the daisy chain.
smartmotor_flags	hex	0	0	Flag bits used to modify the behavior of the *smartmotor* driver.

The valid flag bits for the *smartmotor_flags* field are as follows:

0x1 - This tells the MX driver to command a daisy chained set of SmartMotors to automatically assign addresses to themselves at startup time.
0x2 - This tells the MX driver to assume that the SmartMotors echo all commands sent to them.
0x1000 - This enables limit switches during home searches.

***smartmotor_ain* record fields**

Field Name	Field Type	Number of Dimensions	Sizes	Description
See *Common Analog Input Field Definitions*				
smartmotor_record	record	0	0	Name of the SmartMotor record that this port belongs to.
port_name	string	1	5	Smartmotor port name. See below for a list.

***smartmotor_aout* record fields**

Field Name	Field Type	Number of Dimensions	Sizes	Description
See *Common Analog Output Field Definitions*				
smartmotor_record	record	0	0	Name of the SmartMotor record that this port belongs to.
port_name	string	1	5	Smartmotor port name. See below for a list.

***smartmotor_din* record fields**

Field Name	Field Type	Number of Dimensions	Sizes	Description
See *Common Digital Input Field Definitions*				
smartmotor_record	record	0	0	Name of the SmartMotor record that this port belongs to.
port_name	string	1	5	Smartmotor port name. See below for a list.

smartmotor_dout **record fields**

Field Name	Field Type	Number of Dimensions	Sizes	Description
See *Common Digital Output Field Definitions*				
smartmotor_record	record	0	0	Name of the SmartMotor record that this port belongs to.
port_name	string	1	5	Smartmotor port name. See below for a list.

Allowed Port Names The allowed port names for SmartMotor I/O ports fall into several categories:

- *Onboard I/O ports* - The allowed names for onboard I/O ports are *UA, UB, UC, UD, UE, UF, UG, UI,* and *UJ.*
- *Anilink analog input ports* - Analog input port names are two characters long. The first character is a letter in the range from *A* to *H*. The second character is a number in the range from *1* to *4*. Some examples are: *A3, D1,* and *G4*.
- *Anilink analog output ports* - Analog output port names are one character long in the range from *A* to *H*.
- *Anilink digital I/O ports* - These are either two or three characters long. The first character is a letter in the range from *A* to *H*. The remaining characters are a number in the range from *0* to *63*.
- *Temperature* - The name of the temperature sensor port is *TEMP*.

10.2.5 APS Insertion Device

Platforms: Requires EPICS 3.14 support.

This driver is used to control either the gap or the harmonic energy of an undulator/wiggler insertion device at the Advanced Photon Source *(http://www.aps.anl.gov/)*. These driver make use of the information found at the APS ID Controls Information (http://www.aps.anl.gov/aod/blops/IDINFO/ID_Controls.html) web page.

The only driver supported is:
aps_gap - Controls either the gap or energy of the insertion device.

The record fields for this driver are:

Field Name	Field Type	Number of Dimensions	Sizes	Description
See *Common Motor Field Definitions*				
sector_number	long	0	0	The number of the APS sector that the insertion device belongs to. For example, at APS Sector 10-ID, the sector number would be 10.
motor_subtype	long	0	0	This field has four possible values: 1 - for gap control in millimeters. 2 - for ID energy control in keV. 3 - for taper control in millimeters. 4 - for taper control in keV.

10.2.6 Blu-Ice Motor

Platforms: All

This driver controls a motor controlled by a Blu-Ice DHS or DCSS. See the Blu-Ice section for more information.

10.2.7 Bruker D8

Platforms: All

This driver is for the D8 motor controller made by Bruker AXS and distributed with goniostat systems from them.

Warning: This driver was only tested with a prerelease version of the D8.

***d8* record fields**

Field Name	Field Type	Number of Dimensions	Sizes	Description
See *Common Record Field Definitions*				
rs232_record	record	0	0	Record name of the serial port that is connected to this D8 controller.

***d8_motor* record fields**

Field Name	Field Type	Number of Dimensions	Sizes	Description
See *Common Motor Field Definitions*				
d8_record	record	0	0	Record name of the D8 controller that this motor belongs to.
drive_number	long	0	0	Drive number of this axis.
d8_speed	double	0	0	Initial speed of this D8 motor.

10.2.8 Compumotor 6K and 6000 Series Motor Controllers

Platforms: All

This set of drivers supports both the Compumotor 6000 and 6K series of controllers from the Compumotor division of Parker Hannifin *(http://www.compumotor.com/)*. Vendor information about the 6K series can be found at http://www.compumotor.com/literature/pg023_6k.htm

Several different MX drivers are associated with this type of controller. They are:

- *compumotor_int* - An interface driver that manages all of the Compumotor controllers attached to a particular serial port or Ethernet connection. There will be one of these records for each controller.

- *compumotor* - The basic motor driver for Compumotor controllers. Each axis will use its own separate instance of this driver.

- *compumotor_lin* - Designed for performing linear interpolation moves with multiple axes. **Warning:** currently somewhat broken.

- *compumotor_din* - Used to read the digital input pins on a Compumotor 6K controller.

- *compumotor_dout* - Used to control the digital output pins on a Compumotor 6K controller.

So far these drivers have been tested with both the 6K and Zeta 6104 controllers.

An example database for a 4-axis Compumotor 6K controller would look like this

```
6k_rs232 interface rs232 tty "" "" 9600 8 N 1 S 0x0d0a 0x0d0a 10 0x0 /dev/ttyS5
6k interface controller compumotor_int "" "" 6k_rs232 0x0 1 1 4
m1 device motor compumotor "" "" 0  0 -1000000 1000000 0 -1 -1 1 0 um 6k_test 1 1 1
m2 device motor compumotor "" "" 0  0 -1000000 1000000 0 -1 -1 1 0 um 6k_test 1 2 1
m3 device motor compumotor "" "" 0  0 -1000000 1000000 0 -1 -1 1 0 um 6k_test 1 3 1
m4 device motor compumotor "" "" 0  0 -1000000 1000000 0 -1 -1 1 0 um 6k_test 1 4 1
```

compumotor_int

This interface driver manages information about the Compumotor controller as a whole that is not specific to a particular axis.

Field Name	Field Type	Number of Dimensions	Sizes	Description
See *Common Record Field Definitions*				
rs232_record	record	0	0	The name of the *rs232_record* interface that the controller is plugged into. In general, the *rs232_record* can either correspond to a real RS-232 device such as the *tty* or *win32_com* driver or to a device connected via Ethernet, which will use the *tcp232* driver.
interface_flags	hex	0	0	Flags to select optional features. They are described in more detail below.
num_controllers	long	0	0	For a multidrop system such as the Zeta 6104, this record will control all of the real controllers attached to the multidrop cable. You must specify the number of controllers here. For a 6K controller, this value will always be 1.
controller_number	long	1	*num_controllers*	This varying length array lists the controller address for each controller as set by the Compumotor `ADDR` command. For a 6K controller, there will only be one value here.
num_axes	long	1	*num_controllers*	This varying length array lists the maximum number of motor axes for each controller on the multidrop cable. For a 6K controller, there will only be one value here. The allowed range of values for this field are from 1 to 8.

The *interface_flags* field will be the logical OR of the option bits selected from the following list:

0x1 - If this flag is selected, the MX driver will send a Compumotor `ADDR` command at startup, which will cause the controllers on a multidrop to automatically configure their addresses from 1 to N. In general, we recommend not use this option. Instead, you should configure the address in the startup program of each controller.

0x2 - If this flag is selected, the MX driver expects the Compumotor controller to echo all commands sent to it. This option is not normally recommended since it adds extra RS-232 I/O for reading and discarding the echoed command strings. It is just here in case you are alternating operation of the controller between MX and some other package that expects the commands to be echoed.

compumotor

The *compumotor* driver handles one particular axis in a Compumotor controller. Since Compumotor interface records support multiple controllers and axes, both the controller number and the axis number must be specified.

Go to the MX Motor Driver Support page for the common motor record description fields. For the *compumotor* driver, the following driver specific fields are present:

Field Name	Field Type	Number of Dimensions	Sizes	Description
See *Common Motor Field Definitions*				
compumotor_interface_record	record	0	0	The name of the Compumotor controller record for this motor.
controller_number	long	0	0	The controller number for this particular motor.
axis_number	long	0	0	The axis number for this particular motor in the specified controller.
flags	hex	0	0	Setting particular bits in the flags variable can modify the behavior of the driver. The individual bit values are specified below.

Flag bits for the *flags* field:

0x1 - This flag tells the driver to get the motor position using the TPE (Transfer Position of Encoder) command rather than the TPM (Transfer Position of Motor) command.

0x2 - This flag tells the driver to round raw motor positions to the nearest integer when setting motor destinations using the D command or redefining the position using the PSET command.

0x1000 - This flag tells the driver to disable hardware limits for this axis using the LH0 command.

compumotor_din

Field Name	Field Type	Number of Dimensions	Sizes	Description
See *Common Digital Input Field Definitions*				
compumotor_interface_record	record	0	0	The name of the Compumotor controller record for this motor.
controller_number	long	0	0	The controller number for this particular device.
brick_number	long	0	0	The brick number for this particular device.
first_bit	long	0	0	The bit number of the first bit controlled by this record.
num_bits	long	0	0	The number of bits controlled by this record.

compumotor_dout

Field Name	Field Type	Number of Dimensions	Sizes	Description
See *Common Digital Output Field Definitions*				
compumotor_interface_record	record	0	0	The name of the Compumotor controller record for this motor.
controller_number	long	0	0	The controller number for this particular device.
brick_number	long	0	0	The brick number for this particular device.
first_bit	long	0	0	The bit number of the first bit controlled by this record.
num_bits	long	0	0	The number of bits controlled by this record.

compumotor_lin

Warning: The *compumotor_lin* driver is partially obsolete and partially broken. If you merely want to have the motor perform a simultaneous start, then you should use the *linear_function* pseudomotor instead. If you want blended moves, then you will need to fix the part of the driver that is supposed to do that.

Field Name	Field Type	Number of Dimensions	Sizes	Description
See *Common Motor Field Definitions*				
flags	hex	0	0	Setting particular bits in the flags variable can modify the behavior of this pseudomotor. The individual bit values are specified below.
num_motors	long	0	0	The number of motors used by this pseudomotor.
motor_record_array	record	1	*num_motors*	This array lists all of the motor records used by this pseudomotor.
real_motor_scale	double	1	*num_motors*	The real motor position is multiplied by this scale when computing the raw pseudomotor position.
real_motor_offset	double	1	*num_motors*	This offset is added to the scaled real motor position when computing the raw pseudomotor position.
motor_move_fraction	double	1	*num_motors*	When a move is commanded, this value specifies what fraction of the total raw pseudomotor move is to be performed by this motor.

The *interface_flags* field will be the logical OR of the option bits selected from the following list:

0x1 - If this flag is selected, the pseudomotor will perform a simultaneous start rather than a blended move. **Warning:** If you do *not* set this bit, the driver attempts to perform a blended move. However, the driver currently does not correctly implement the blended move.

General Notes

- The MX drivers assume that daisy-chained controllers are numbered from 1 to N where N is the number of controllers. This may be done via the **ADDR** command as described in the 6000 and 6K Command Reference manuals. For more information look at the sections named *RS-232C Daisy-Chaining* and *RS-485 Multi-Drop* in the Compumotor 6000 or 6K Programmer's Guide.
- If you use the ethernet port on a 6K controller, you will need to use the 'tcp232' RS-232 interface type and specify the port number to connect to as 5002.

  Warning: Very old 6K controllers used port 502. If there is a problem, using a packet sniffer while the vendor supplied code for Windows is running should be able to determine the correct port number.
- The MX Compumotor drivers make certain assumptions about the internal configuration of Compumotor controllers. Figure 10.1 shows an example startup script for Compmotor controllers that is compatible with MX. The MX drivers will not operate correctly if the variables **ERRLVL**, **EOT**, and **MA** are not set as shown. Also

```
; This command script is to be downloaded into a Compumotor 6000 or 6K
; controller in order to set up the controller to be compatible with MX.
; The script sets up a startup command program to be executed by the
; Compumotor controller at power-on.  The commands for ERRLVL, EOT, and MA
; _must_ be set as shown below or else the MX driver will not work.
; If you need other commands to set motor parameters, network addresses,
; and so forth, add them to the commands listed below.
;
; Please note that if you use ECHO1, you must add the 0x2 echo on flag to
; the compumotor_int record that defines the connection to the interface.
; This lets the driver know that it needs to discard echoed characters.
;
; For a single controller, it is better to set ECHO0 since that will
; eliminate the overhead of discarding the characters.  However, in a
; multidrop daisy chain configuration, ECHO1 _must_ _be_ _set_ since the
; controllers rely on the echoing to send the command on to the next
; controller in the daisy chain.  If ECHO0 is set in a daisy chain
; configuration, the configuration will mostly work but will randomly
; lock up from time to time, so don't do it.
;
; William Lavender -- Last modified April 27, 2002
;
DEF mstart
ERRLVL1          ; Have the controller generate a minimum amount of output.
EOT13,10,0       ; Want all output lines to have the same line terminators.
MA1              ; Use absolute mode for positioning.
LH0              ; Disable limits (for testing only!)
ENC0             ; Use motor step mode ( or set ENC1 for encoder step mode ).
ECHO1            ; Enable command echoing.
END
```

Figure 10.1: Recommended STARTP program for MX controlled Compumotor motors.

note that the setting shown for **EOT** means that the 'rs232' driver must be configured with the read and write terminators set to 0x0d0a. In addition, the setting **ECHO1** is required in order for multi-drop installations to function correctly. For a single controller, you may use **ECHO0** which will reduce the amount of serial I/O required.

Bugs

At present, Zeta 6104s occasionally stop communicating with the MX driver. The exact circumstances under which this occurs is not entirely clear. However, since most of our Compumotor usage is migrating towards the 6K series, the need to fix this issue may become less important.

10.2.9 DAC Motor

Platforms: All

This driver is used to control an MX analog output device as if it were a motor. The type of control supported here is fairly basic. When a move is commanded, all that happens is that the DAC output voltage is changed to the value corresponding to the new position.

There is only one driver specific specific field for the *dac_motor* driver. Here is the description of it:

Field Name	Field Type	Number of Dimensions	Sizes	Description
See *Common Motor Field Definitions*				
dac_record	record	0	0	The name of the MX analog output record used by this motor record.

10.2.10 Delta Tau PMAC

Platform: All

The PMAC series of motor controllers is manufactured by Delta Tau Data Systems of Chatsworth, CA. PMAC motor controllers are definitely the most powerful motor controllers supported by MX. However, they are also the most complicated to setup and program of all the controllers supported by MX, so they may not be the best choice for simple applications.

The MX PMAC drivers are designed to be easily adaptable to any model of PMAC motor controller. However, the drivers have been tested mainly with the Turbo PMAC series of controllers. There is also limited support for the Power PMAC series and lightly tested support for the original legacy PMAC 1 series.

Note: If you are using a Power PMAC controller, you will be better off using the MX *powerpmac* series of drivers described in the next section of this manual. The *powerpmac* drivers support a much larger amount of the total functionality of a Power PMAC.

The drivers listed below currently all operate via PMAC ASCII communication interfaces of various types.

MX has a large number of drivers for interacting with PMAC motor controllers:

pmac	Interface driver for controlling one or more PMAC motor controllers connected to an ASCII serial interface.
pmac_motor	Motor driver for controlling a single motor of a PMAC controller.
pmac_cs_axis	Motor driver for controlling a coordinate system axis belonging to a PMAC motor controller.
pmac_mce	Multichannel encoder (MCE) driver for reading out any motor belonging to a given PMAC motor controller.
pmac_ainput	Analog input driver for reading a floating point value from a PMAC variable.
pmac_aoutput	Analog output driver for writing a floating point value to a PMAC variable.
pmac_dinput	Digital input driver for reading an integer value from a PMAC variable.
pmac_doutput	Digital output driver for writing an integer value to a PMAC variable.
pmac_long	Variable driver for reading and writing signed integer values to and from a PMAC variable.
pmac_ulong	Variable driver for reading and writing unsigned integer values to and from a PMAC variable.
pmac_double	Variable driver for reading and writing floating point values to and from a PMAC variable.

MX PMAC drivers

pmac driver

Pmac interface records are used to control one or more PMAC motor controllers attached to a given external interface. An example *pmac* record looks like

```
pmac1 interface controller pmac "" "" rs232 pmac1_rs232 1
```

which describes a single PMAC motor controller attached to MX RS-232 record **pmac1_rs232**.

The driver-specific record fields are

Field Name	Field Type	Number of Dimensions	Sizes	Description
See *Common Record Field Definitions*				
port_type_name	string	1	32	A string such as *rs232* that describes the type of PMAC interface this is. See below for more information.
port_args	string	1	80	This contains port type specific information such as the name of an RS-232 port record. See below for more information.
num_cards	long	0	0	The number of individual PMAC controllers attached to this interface. In most cases this will be 1. However, for a controller attached to a multidrop connection such as RS-485, this will be the number of controllers attached to the multidrop.

PMAC ASCII command interfaces are accessible via a variety of different mechanisms such as RS-422, Ethernet, USB, VME, etc. Since the information needed to describe the interface can vary widely from interface type to

interface type, the information needed to the interface is specified in a string called *port_args*. The currently defined port types are:

port_type_name	*port_args*
rs232	The name of the MX RS-232/422/485 record that this PMAC interface is attached to, such as *pmac1_rs232* in the example below.
tcp	The network hostname of the PMAC. The network protocol for this port type is described in the "PMAC ETHERNET PROTOCOL" section of the manual for the Delta Tau Acc-54E UMAC board. The TCP port number is not specified since the protocol requires it to always be 1025. **Note:** Only TCP connections are supported. Currently USB and UDP connections are **not** supported.
gpascii	This case is for a Power PMAC that is being controlled over a Telnet connection using Delta Tau's **gpascii** command. The port_args string for this case looks like `"pmac1_socket root deltatau"`. The first field in this string is the name of the MX RS-232 record used to communicate with the Power PMAC. This record **must** be of type *telnet*, since the Power PMAC will perform Telnet negotiation with the MX client. Records of type *tcp232* will **not** work since the *tcp232* driver does not know how to handle Telnet negotiation. The second field is the name of the account used to login to the Power PMAC. The default is *root*. The *gpascii* interface has not been tested with non-root accounts. The third field is the password of the account used to login to the Power PMAC. The default is *deltatau*.
gplib	This is for the special case of an MX server that is running on the Power PMAC itself with the MX library linked to the Delta Tau provided libraries. For this case, the *port_args* string is empty. **Warning:** It is **strongly** recommended that you use the MX *powerpmac* series of drivers rather than the MX *pmac* drivers, since the *powerpmac* drivers exports a much larger fraction of the total functionality of a Power PMAC.
epics_ect	This port type uses the string command and response interfaces provided with the EPICS PMAC software written by Tom Coleman of the Argonne National Laboratory ECT group. This port type uses EPICS process variable names that are constructed by appending "StrCmd" or "StrRsp" to the names. Thus, if the port args were "S18ID", then the EPICS process variables used by this interface would be *S18IDStrCmd.VAL* and *S18IDStrRsp.VAL*. Note: There is an alternate set of MX EPICS drivers called *pmac_tc_motor* and *pmac_bio_motor* that is described elsewhere in this manual.

Here are some examples of MX database records for each port type:

Port type *rs232*:

Via a Linux tty port:

```
pmac1_rs232 interface rs232 tty "" "" 38400 8 N 1 H 0xd 0xd -1 0x0 /dev/ttyS5
pmac1 interface controller pmac "" "" rs232 pmac1_rs232 1
```

Via a network socket:

```
pmac1_rs232 interface rs232 tcp232 "" "" 38400 8 N 1 H 0xd 0xd -1 0x0 w11 3001 0x0
pmac1 interface controller pmac "" "" rs232 pmac1_rs232 1
```

Port type *tcp*:

```
pmac1 interface controller pmac "" "" tcp 192.168.0.1 1
```

Port type *gpascii*:

```
pmac1_socket interface rs232 telnet "" "" 38400 8 N 1 H 0x0d0a 0x0d0a -1 0x0 powerpmac 23 0x0
pmac1 interface controller pmac "" "" gpascii "pmac1_socket root deltatau" 1
```

Port type *gplib*:

```
pmac1 interface controller pmac "" "" gplib "" 1
```

pmac_motor driver

A *pmac_motor* record refers to one particular motor in a PMAC motor controller. The motor is controlled mostly via PMAC "jog" mode commands except for certain features not available via jog commands.

An example *pmac_motor* record looks like

```
x1 device motor pmac_motor "" "" 0 0 -10000000 10000000 0 -1 -1   0.05 0 um pmac1 0 4
```

which describes a motor called **x1** which belongs to controller 0, axis 4 of PMAC interface **pmac1**. The example motor uses a scale factor of 0.05 μ-meters per step and raw motion limits of $\pm$ 10000000 steps.

Field Name	Field Type	Number of Dimensions	Sizes	Description
See *Common Motor Field Definitions*				
pmac_record	record	0	0	Name of the PMAC interface record that controls this motor.
card_number	long	0	0	Card number of the PMAC card that controls this motor. For PMACs that are not in a multi-drop configuration, the card number will normally be 0.
motor_number	long	0	0	The PMAC motor number for this specific motor.

pmac_cs_axis driver

Note: This driver does not support Power PMAC controllers at all. For Power PMAC controllers, use the powerpmac_cs_axis driver instead.

A *pmac_cs_axis* record makes use of a specified coordinate system axis for a coordinate system defined in a PMAC controller. PMAC coordinate systems can be thought of as a way of defining "pseudomotors" inside a PMAC controller in a manner that is analogous to the way MX defines pseudomotors. However, PMAC coordinate system axes are more powerful than MX pseudomotors, since for a coordinate system, the PMAC controller is able to ensure that all of the raw motors are able to maintain their correct relative relationship even while the motors are moving. Ordinary MX pseudomotors make sure that the real motors are at the correct positions at the beginning and end of motor moves, but they cannot do this while a move is in progress.

Pmac_cs_axis motor records require that some preliminary setup be done in the PMAC before they may be used. There are three primary steps in this process:

- The coordinate system that this axis is to be part of must be set up before this record may be used.

- You must write a motion program that will be run every time a move of this axis is commanded. The motion program **must** define the move destination, the feedrate (*reciprocal of the speed*), the acceleration time, and the S curve acceleration times in terms of PMAC motion variables so that the *pmac_cs_axis* driver can set them. I recommend that you use Q-variables so that variables used by this coordinate system will not interfer with other coordinate systems used by your PMAC.
- You must arrange for the current position of the coordinate system axis to be continuously updated to a PMAC variable that you specify. The most obvious way to do this is with a constantly running PMAC PLC program which is set up to calculate the coordinate system axis position from the real motor positions at all times. I would recommend that you use a Q-variable for this too. Of course, the kinematic calculation logic of the PLC program must match the logic of the PMAC motion program mentioned above.

An example *pmac_cs_axis* record looks like

```
det_distance motor pmac_cs_axis "" "" 0 0 200 1000 0 -1 -1 1 0 mm pmac1 0 2 Z 3 Q50 Q51 Q52 Q53 Q54
```

This describes a motor called **det_distance** which corresponds to axis Z of coordinate system 2 running in card 0 of PMAC interface **pmac1**. The axis performs moves using motion program 3 with position, destination, feedrate, acceleration time, and S-curve acceleration time managed by PMAC coordinate system variables Q50 through Q54.

Field Name	Field Type	Number of Dimensions	Sizes	Description
See *Common Motor Field Definitions*				
pmac_record	record	0	0	Name of the interface record for the PMAC that runs this coordinate system.
card_number	long	0	0	Card number of the PMAC card that controls this axis. For PMACs that are not in a multi-drop configuration, the card number will normally be 0.
coordinate_system	long	0	0	The PMAC coordinate system number.
axis_name	char	0	0	The name of the coordinate system axis used by this motor. The possible names are X, Y, Z, A, B, and C.
move_program_number	long	0	0	The number of the motion program that is used to move this axis as part of the coordinate system.
position_variable	string	1	8	Name of the PMAC variable that the MX driver uses to read the current position of the axis from.
destination_variable	string	1	8	The MX driver writes the new axis destination to this PMAC variable before starting the motion program to perform the move.
feedrate_variable	string	1	8	The MX driver sets the axis speed by writing to the specified PMAC feedrate variable.
acceleration_time_variable	string	1	8	The MX driver sets the axis acceleration time by writing to this variable.
s_curve_acceleration_time_var	string	1	8	The MX driver sets the axis acceleration time by writing to this variable.

Note: If all you want is basic control of the individual motors belonging to a PMAC controller, then it is not necessary to create MX *pmac_cs_axis* motor records or coordinate systems in the PMAC. You can get basic control of the motors with just the *pmac_motor* records, with much less setup required. You only need *pmac_cs_axis* records if you want to make use of the special abilities of PMAC coordinate systems.

pmac_mce driver

A *pmac_mce* record is used to save the positions of the moving PMAC motor during an MX quick scan, so that they can be read out at the end of the scan. *MCE* stands for multichannel encoder; a term that is thought to have been originated by the author. This feature is implemented by permanently assigning one of the motors in the PMAC to be a slave motor, not connected to a real motor axis. Instead, it is slaved at run time to the primary real motor axis of the move. The slave motor is programmed to always generate step and direction output, which is converted by a small amount of electronic login into clockwise (CW) and counterclockwise (CCW) pulse trains which can be fed into two channels of a multichannel scaler.

**** A figure here might help. ****

For more information, read the section on Multichannel encoders further on in this document and also read the chapter about MX scans.

Field Name	Field Type	Number of Dimensions	Sizes	Description
See *Common MCE Field Definitions*				
pmac_record	record	0	0	This field specifies the name of the PMAC controller that contains the slave axis for this particular PMAC.
card_number	long	0	0	Card number of the PMAC controller that contains the slave axis for this particular PMAC.
mcs_record	record	0	0	Name of the multichannel scaler (MCS) record that the clockwise (CW) and counterclockwise (CCW) pulse trains are sent to.
down_channel	ulong	0	0	Number of the MCS channel that receives the counterclockwise pulses.
up_channel	ulong	0	0	Number of the MCS channel that receives the clockwise pulses.
plc_program_number	long	0	0	Number of the PMAC PLC program that is run when the assignment of the slave axis to a master is changed. If you specify a negative number for this field, the driver uses the absolute value of it as the slave motor axis number and does not use a PLC program.

PMAC Analog and Digital I/O Drivers

pmac_ainput driver

This is an MX analog input driver that reads a floating point value from a PMAC variable.

Field Name	Field Type	Number of Dimensions	Sizes	Description
See *Common Analog Input Field Definitions*				
pmac_record	record	0	0	The name of the PMAC that contains this PMAC variable.
card_number	long	0	0	The card number of the PMAC that contains this PMAC variable.
pmac_variable_name	string	1	8	The name of the PMAC variable.

pmac_aoutput driver

This is an MX analog output driver that writes a floating point value to a PMAC variable.

Field Name	Field Type	Number of Dimensions	Sizes	Description
See *Common Analog Output Field Definitions*				
pmac_record	record	0	0	The name of the PMAC that contains this PMAC variable.
card_number	long	0	0	The card number of the PMAC that contains this PMAC variable.
pmac_variable_name	string	1	8	The name of the PMAC variable.

pmac_dinput driver

This is an MX digital input driver that reads an integer value from a PMAC variable.

Field Name	Field Type	Number of Dimensions	Sizes	Description
See *Common Digital Input Field Definitions*				
pmac_record	record	0	0	The name of the PMAC that contains this PMAC variable.
card_number	long	0	0	The card number of the PMAC that contains this PMAC variable.
pmac_variable_name	string	1	8	The name of the PMAC variable.

pmac_doutput driver

This is an MX analog output driver that writes an integer value to a PMAC variable.

Field Name	Field Type	Number of Dimensions	Sizes	Description
See *Common Digital Output Field Definitions*				
pmac_record	record	0	0	The name of the PMAC that contains this PMAC variable.
card_number	long	0	0	The card number of the PMAC that contains this PMAC variable.
pmac_variable_name	string	1	8	The name of the PMAC variable.

PMAC Variable Drivers

pmac_long driver

This is an MX variable driver for reading and writing signed integer values to and from a PMAC variable.

Field Name	Field Type	Number of Dimensions	Sizes	Description
See *Common PMAC Variable Field Definitions*				
pmac_record	record	0	0	The name of the PMAC that contains this PMAC variable.
card_number	long	0	0	The card number of the PMAC that contains this PMAC variable.
pmac_variable_name	string	1	8	The name of the PMAC variable.

pmac_ulong driver

This is an MX variable driver for reading and writing unsigned integer values to and from a PMAC variable.

Field Name	Field Type	Number of Dimensions	Sizes	Description
See *Common PMAC Variable Field Definitions*				
pmac_record	record	0	0	The name of the PMAC that contains this PMAC variable.
card_number	long	0	0	The card number of the PMAC that contains this PMAC variable.
pmac_variable_name	string	1	8	The name of the PMAC variable.

pmac_double driver

This is an MX variable driver for reading and writing unsigned integer values to and from a PMAC variable.

Field Name	Field Type	Number of Dimensions	Sizes	Description
See *Common PMAC Variable Field Definitions*				
pmac_record	record	0	0	The name of the PMAC that contains this PMAC variable.
card_number	long	0	0	The card number of the PMAC that contains this PMAC variable.
pmac_variable_name	string	1	8	The name of the PMAC variable.

10.2.11 Delta Tau Power PMAC

Platform: Power PMAC controllers running PowerPC Linux

The Power PMAC series of motor controllers from Delta Tau Data Systems of Chatsworth, California is their newest series of motor controllers. The special feature of this series of controllers is that they are implemented using a PowerPC based system using Linux together with Xenomai extensions for real-time control. Fortunately, they are using a fairly standard version of the Debian 5.0 (Lenny) distribution for **powerpc**. Although they provide a Cygwin-based cross compiler system for Windows, the Debian Linux installation on the Power PMAC itself comes complete with development tools like GCC, GDB, and Make. Thus, it is possible to do Power PMAC software development directly on the Power PMAC itself.

The MX *powerpmac* series of drivers is designed to run under Linux on the Power PMAC's CPU. Instead of using **gpascii**, the MX drivers use the Delta Tau-provided *gplib.h* include file and directly link to Delta Tau's /opt/ppmac/libppmac.so library. This provides direct access to features like the Power PMAC shared memory interface.

So far all of the software development has been done directly on the Power PMAC itself. However, we do all of our work on an SD card installed in the Power PMAC's SD slot to avoid unnecessary changes to the Power PMAC root partition and to avoid unnecessary wear on the Power PMAC's flash memory.

At present, the following MX drivers are available:

powerpmac	Interface driver for controlling the Power PMAC controller.
powerpmac_motor	Motor driver for controlling a single motor of a Power PMAC controller.

Analog and digital I/O drivers, coordinate system drivers, multichannel encoder drivers, multichannel scaler drivers, and variable drivers are planned but not yet implemented.

MX Power PMAC drivers

powerpmac driver

Powerpmac interface records are used to control one or more PMAC motor controllers attached to a given external interface. An example *powerpmac* record looks like

```
ppmac1 interface controller powerpmac "" ""
```

Note that the *powerpmac* does not have *any* driver specific fields. This is because the driver is able to autoconfigure itself by directly querying the Power PMAC libraries.

powerpmac_motor driver

A *pmac_motor* record refers to one particular motor in a PMAC motor controller. The motor is controlled mostly via PMAC "jog" mode commands except for certain features not available via jog commands.

An example *pmac_motor* record looks like

```
x1 device motor powerpmac_motor "" "" 0 0 -10000000 10000000 0 -1 -1 0.05 0 um ppmac1 4
```

which describes a motor called **x1** which belongs to controller 0, axis 4 of PMAC interface **pmac1**. The example motor uses a scale factor of 0.05 μ-meters per step and raw motion limits of $\pm$ 10000000 steps.

Field Name	Field Type	Number of Dimensions	Sizes	Description
See *Common Motor Field Definitions*				
powerpmac_record	record	0	0	Name of the Power PMAC interface record that controls this motor.
motor_number	long	0	0	The Power PMAC motor number for this specific motor.

Here is an example database for the Power PMAC:

```
ppmac1 interface controller powerpmac "" ""
m1     device motor powerpmac_motor "" "" 0 0 -10000000 10000000 0 -1 -1 0.0001 0 um ppmac1 1
m2     device motor powerpmac_motor "" "" 0 0 -10000000 10000000 0 -1 -1 0.0001 0 um ppmac1 2
m3     device motor powerpmac_motor "" "" 0 0 -10000000 10000000 0 -1 -1 0.0001 0 um ppmac1 3
m4     device motor powerpmac_motor "" "" 0 0 -10000000 10000000 0 -1 -1 0.0001 0 um ppmac1 4
```

10.2.12 Disabled Motor

Platforms: All

This driver type was added to make it easier to quickly disable a particular motor in the MX database. The *disabled_motor* driver has no extra fields beyond the default motor fields. This makes it easy to just change the *mx_type* field in the record description to *disabled_motor* and have the record description still be a valid record description, albeit with ignored, trailing text.

The *disabled_motor* driver makes no attempt to accurately simulate the behavior of a real motor. If you want a more accurate simulation, select the *soft_motor* driver described further on in this chapter.

10.2.13 DSP E500

Platforms: All

The DSP E500 was a CAMAC-based stepper motor controller from DSP Technology, Inc. that is no longer available. In the 1980's, this controller was one of the most popular motor controllers in use in the synchrotron radiation field, and there are still many in use at installations around the world.

e500 driver

Field Name	Field Type	Number of Dimensions	Sizes	Description
See *Common Motor Field Definitions*				
camac_record	record	0	0	The MX record for the CAMAC crate that the E500 controller is installed in.
slot	long	0	0	The CAMAC slot number that the E500 controller is installed in.
subaddress	long	0	0	The CAMAC subaddress for the motor channel used by this motor.
e500_base_speed	ushort	0	0	The initial base speed for this motor.
e500_slew_speed	ulong	0	0	The initial slew speed for this motor.
acceleration_time	ushort	0	0	The initial acceleration time for this motor.
correction_limit	ushort	0	0	The initial correction limit for this motor.
lam_mask	long	0	0	The initial LAM mask for this motor.

Notes:

- The E500 does not have any non-volatile memory, so all of its parameters must be programmed from scratch each time the MX driver starts.
- This driver dates from the mid-1990s and should not be regarded as a good example of how to write an MX motor driver.

10.2.14 EPICS Motor

Platforms: Requires EPICS 3.14 support.

The MX *epics_motor* driver uses EPICS Channel Access to communicate as an EPICS client with the Advanced Photon Source's EPICS motor driver *(http://www.aps.anl.gov/upd/people/sluiter/epics/motor/)* in an EPICS IOC.

There is only one driver specific specific field for the *epics_motor* driver. Here it is:

Field Name	Field Type	Number of Dimensions	Sizes	Description
See *Common Motor Field Definitions*				
epics_record_name	string	1	100	The name of the EPICS motor record used by this MX record.

10.2.15 IMS MDrive

Platforms: All

The IMS MDrive is an integrated motor/controller combination with microstepping that is housed as one unit. The MDrive is produced by Intelligent Motion Systems *(http://www.imshome.com/)*.

mdrive record

Field Name	Field Type	Number of Dimensions	Sizes	Description
See *Common Motor Field Definitions*				
rs232_record	record	0	0	The name of the RS-232 record that this MDrive is connected to.
axis_name	char	0	0	The MDrive axis name

The MDrive also has a few analog input and digital I/O ports as part of the module.

mdrive_ain record

There is only one analog input port.

Field Name	Field Type	Number of Dimensions	Sizes	Description
See *Common Analog Input Field Definitions*				
mdrive_record	record	0	0	The record name of the MDrive that this I/O port is connected to.

mdrive_din record

Field Name	Field Type	Number of Dimensions	Sizes	Description
See *Common Digital Input Field Definitions*				
mdrive_record	record	0	0	The record name of the MDrive that this I/O port is connected to.
port_number	long	0	0	

mdrive_dout record

Field Name	Field Type	Number of Dimensions	Sizes	Description
See *Common Digital Output Field Definitions*				
mdrive_record	record	0	0	The record name of the MDrive that this I/O port is connected to.
port_number	long	0	0	

10.2.16 IMS Panther and IM483

Platforms: All

This driver is for the Panther HI/HE microstepping driver/controllers as well as the IM483I and IM483IE controllers as well. These controllers are manufactured by Intelligent Motion Systems *(http://www.imshome.com/)*. The controllers all support multi-drop serial connections which are called "Party Line" mode by the manual. This driver probably also works for the Panther LI, Panther LE, IM1007I, and IM1007IE controllers, but this has not been tested.

Warning: The IM483I and IM483IE are both motor controllers. However, the similar sounding IM483 is *not* a motor controller. Instead the IM483 is only a microstepping driver. Don't get them confused.

These controllers do not have any non-volatile storage, so all of their parameters must be reprogrammed from scratch each time that the MX driver starts. The *axis_name* parameter can be any ASCII upper case or lower case letter as well as a subset of ASCII punctuation marks. Read the manual for more information.

panther_hi driver
The Panther HI does not have any support for encoders.

Field Name	Field Type	Number of Dimensions	Sizes	Description
See *Common Motor Field Definitions*				
rs232_record	record	0	0	The RS-232 record name for this motor.
axis_name	char	0	0	The axis name for this motor.
default_speed	long	0	0	This value is used at startup by the *V* command.
default_base_speed	long	0	0	This value is used at startup by the *I* command.
acceleration_slope	long	0	0	This value, together with the *deceleration_slope* is used at startup by the *K* command.
deceleration_slope	long	0	0	This value, together with the *acceleration_slope* is used at startup by the *K* command.
microstep_divide_factor	long	0	0	This value is used at startup by the *D* command.
step_resolution_mode	char	0	0	This value is used at startup by the *H* command.
hold_current	long	0	0	This value, together with the *run_current* is used at startup by the *Y* command.
run_current	long	0	0	This value, together with the *hold_current* is used at startup by the *Y* command.
settling_time_delay	long	0	0	This value is used at startup by the *E* command.
limit_polarity	long	0	0	This value is used at startup by the *l* command. Please note that the character is a lower-case L.

panther_he driver

The Panther HE *does* have support for encoders.

Field Name	Field Type	Number of Dimensions	Sizes	Description
See *Common Motor Field Definitions*				
rs232_record	record	0	0	The RS-232 record name for this motor.
axis_name	char	0	0	The axis name for this motor.
default_speed	long	0	0	This value is used at startup by the *V* command.
default_base_speed	long	0	0	This value is used at startup by the *I* command.
acceleration_slope	long	0	0	This value, together with the *deceleration_slope* is used at startup by the *K* command.
deceleration_slope	long	0	0	This value, together with the *acceleration_slope* is used at startup by the *K* command.
microstep_divide_factor	long	0	0	This value is used at startup by the *D* command.
step_resolution_mode	char	0	0	This value is used at startup by the *H* command.
hold_current	long	0	0	This value, together with the *run_current* is used at startup by the *Y* command.
run_current	long	0	0	This value, together with the *hold_current* is used at startup by the *Y* command.
settling_time_delay	long	0	0	This value is used at startup by the *E* command.
limit_polarity	long	0	0	This value is used at startup by the *l* command. Please note that the character is a lower-case L.
encoder_resolution	long	0	0	This value is used at startup by the *e* command.
deadband_size	long	0	0	This value is used at startup by the *d* command.
hunt_velocity	long	0	0	This value is used at startup by the *v* command.
hunt_resolution	long	0	0	This value is used at startup by the *h* command.
stall_factor	long	0	0	This value is used at startup by the *s* command.
stall_sample_rate	long	0	0	This value is used at startup by the *t* command.
max_stall_retries	long	0	0	This value is used at startup by the *r* command.

10.2.17 Joerger SMC24

Platforms: All

This is an MX motor driver for the Joerger SMC24 CAMAC stepping motor controller from Joerger Enterprises, Inc. As of June 2011, this controller is still available as a “legacy” product.

Field Name	Field Type	Number of Dimensions	Sizes	Description
See *Common Motor Field Definitions*				
crate_record	record	0	0	The MX record name for the CAMAC crate.
slot	long	0	0	The CAMAC slot number 'N'.
encoder_record	record	0	0	The MX record name for the encoder used to store motor positions.
motor_steps_per_encoder_tick	double	0	0	It means what it says. The motor steps to encoder ticks ratio may be a non-integer number.
flags	hex	0	0	These flags can change the behavior of the driver and are described below.

The allowed values for the *flags* field are:
0x1 - The driver assumes that the encoder uses a 32-bit counter.
0x2 - Clockwise and counterclockwise encoder pulses will be used.

Warning: As far as I know, this driver has not been tested in a long time. However, if broken, I expect that it would take less than a day to get the MX driver working again.

The Joerger SMC24 controller does not have an internal register to record its current position, so it needs the assistance of an external device to keep track of the motor's absolute position. Traditionally, a Kinetic Systems 3640 CAMAC up/down counter is used as the external device, but any device capable of acting as an encoder-like device may be used as long as there is an MX encoder driver for it.

Also, traditionally the Kinetic Systems 3640 up/down counter was modified in the field to connect pairs of 16-bit up/down counters to form 32-bit up/down counters. However, if this has not been done, the driver can also emulate in software a 32-bit step counter using a 16-bit hardware encoder by setting the bit in the "flags" variable called MXF_SMC24_USE_32BIT_SOFTWARE_COUNTER (0x1) .

10.2.18 Kohzu SC-200, SC-400, and SC-800

Platforms: All

This driver is for the SC series of stepping motor controllers from Kohzu (http://www.kohzu.com/). Both RS-232 and GPIB support has been implemented in the MX drivers, but only the RS-232 support has actually been tested.

The MX drivers for this controller are
kohzu_sc Interface driver for controlling the Kohzu SC controller.
kohzu_sc_motor Motor driver for controlling a single motor of the controller.

kohzu_sc driver

Field Name	Field Type	Number of Dimensions	Sizes	Description
See *Common Record Field Definitions*				
port_interface	interface	0	0	For RS-232 connections, this will be the name of the MX RS-232 record, such as *kohzu_com1*. For GPIB connections, this will be the name of the MX GPIB record together with the GPIB address of the Kohzu controller, such as *kohzu_gpib:4* for a controller at GPIB address 4.

kohzu_sc_motor driver

Field Name	Field Type	Number of Dimensions	Sizes	Description
See *Common Motor Field Definitions*				
kohzu_sc_record	record	0	0	The name of the MX record for the Kohzu controller above.
axis_number	long	0	0	The number of the motor axis.
kohzu_sc_flags	hex	0	0	Flag bits described below that affect the behavior of the driver.

The valid flag bits for the *kohzu_sc_flags* field are:

0x1 - This tells the controller to report the position for this motor returned by an attached encoder rather than the commanded step position.

0x1000 - This tells the controller to ignore hardware limits for this motor.

Here is an example MX database for the Kohzu SC series:

```
kohzu_com1 interface rs232 win32_com "" "" 38400 8 N 1 N 0x0d0a 0x0d0a -1 0x0 com1
kohzu_sc interface controller kohzu_sc "" "" kohzu_com1
k1 device motor kohzu_sc_motor "" "" 0 0 -10000000 10000000 0 -1 -1 1.0 0 steps kohzu_sc 1 0x0
k2 device motor kohzu_sc_motor "" "" 0 0 -10000000 10000000 0 -1 -1 1.0 0 steps kohzu_sc 2 0x0
```

10.2.19 Lakeshore 330 Temperature Controller

Platforms: All

The *ls330_motor* driver is for the LakeShore 330 temperature controller from LakeShore Cryotronics, Inc. (http://www.lakeshore.com/). Since temperature controllers generally have PID loops, MX usually treats temperature controllers as if they were motor controllers. This allows the temperature setpoint to be step scanned. Both RS-232 and GPIB support has been implemented in the MX driver.

The fields for the *ls330_motor* driver are:

Field Name	Field Type	Number of Dimensions	Sizes	Description
See *Common Motor Field Definitions*				
port_interface	interface	0	0	For RS-232 connections, this will be the name of the MX RS-232 record, such as *lakeshore_tty1*. For GPIB connections, this will be the name of the MX GPIB record together with the GPIB address of the Kohzu controller, such as *k500s:12* for a controller at GPIB address 12.
busy_deadband	double	0	0	The LakeShore controller does not provide a command to ask for whether or not the setpoint has been reached. Instead, we must decide that for ourselves by computing the difference between the current temperature and the temperature setpoint. If the absolute value of the difference is less than the *busy_deadband* value set by this field, then the "motor" move is declared to be complete.

Here is an example MX database for the Lakeshore 330:

```
keithley_rs232 interface rs232 tty "" "" 9600 8 N 1 N 0xd 0xd -1 0x0 /dev/ttya
k500s          interface gpib k500serial "" "" 13 0 0xa 0xa 0x0 keithley_rs232
lakeshore      device motor ls330_motor "" "" 296.1 0 0 1000000 0 -1 -1 1 0 K k500s:12 0
```

The above example uses a Keithley 500-SERIAL module as an RS-232 to GPIB converter.

10.2.20 Mar Desktop Beamline

Platforms: All

The MarDTB DeskTop Beamline is an advanced goniostat for computer-controlled data collection from Rayonix (formerly MarUSA). Their web site can be found at http://www.rayonix.com/.

The MarDTB system contains a variety of computer-controlled motors, ion chamber readouts, and a shutter. They are intended to be used only by Rayonix-supplied software, so the interfaces for talking to them are almost completely undocumented. However, by leveraging what limited documentation exists and by reverse engineering some information, I have been able to figure out how to talk to them anyway.

Before continuing, I want to say one thing:

DO NOT ASK RAYONIX ANY QUESTIONS ABOUT THESE MX DRIVERS.

If you have questions, contact the author (William Lavender) for help.

Since these interfaces are undocumented, it is possible that changes to the Rayonix software can break these MX drivers. In fact, there have been occasions in the past where Rayonix changes ***have*** broken these MX drivers. Furthermore, I have not had a chance to test the correctness of these drivers since 2007, so it is quite possible, indeed likely, that the drivers do not work correctly with current versions of Rayonix firmware. **In fact, it is possible that using these drivers can break your MarDTB system.** If it does, then I doubt that Rayonix will regard this as covered by their warranty. So, if you have any qualms or doubts, do not use these drivers.

Having said all of that, here are the drivers that are available.

mardtb	An interface driver for the MarDTB controller as a whole.
mardtb_motor	A motor driver for controlling individual MarDTB motors.
mardtb_status	Used for reading out various bits of status information from the MarDTB.
mardtb_shutter	Controls the MarDTB shutter.

mardtb driver

The *mardtb* driver communicates with the MarDTB control computer via a TCP socket using the *tcp232* driver. Although the port number is the Telnet port number (23), it appears that the MarDTB operating system does not send any Telnet negotiation sequences, so using the *tcp232* driver worked. If this no longer works, then using the *telnet* MX driver may help.

The driver specific fields are

Field Name	Field Type	Number of Dimensions	Sizes	Description
See *Common Record Field Definitions*				
rs232_record	record	0	0	This is the name of the *tcp232* record used to communicate with the MarDTB.
username	string	1	8	This is the username used to login to the MarDTB. As far as I know, this must always be *esd*.
mardtb_flags	hex	0	0	The flag values are described below.

Flag values for the *mardtb_flags* field.

0x1000 - Three parameter status dump. Needed by very old MarDTB systems, as in, long before 2005. Probably you will not need this.

Other flag values exist, but are not documented since they *do not work!* Don't try them.

mardtb_motor driver

The *mardtb_motor* driver moves one of the motors on the MarDTB system. It may not be safe to move some of these motors, so be really careful with this one!

The driver specific fields are

Field Name	Field Type	Number of Dimensions	Sizes	Description
See *Common Motor Field Definitions*				
mardtb_record	record	0	0	This is the name of the controller record for the MarDTB.
motor_number	long	0	0	The MarDTB motor number for this motor.
default_speed	ulong	0	0	The default speed for this motor. Reasonable values for this speed are not documented by Rayonix.
default_acceleration	ulong	0	0	The default acceleration for this motor. Reasonable values for this acceleration are not documented by Rayonix.

mardtb_status driver

This driver reads one of the internal status values from the MarDTB.

The driver specific fields are:

Field Name	Field Type	Number of Dimensions	Sizes	Description
See *Common Analog Input Field Definitions*				
mardtb_record	record	0	0	This is the name of the controller record for the MarDTB.
parameter_number	long	0	0	The MarDTB parameter number for this status variable.

The meaning of most of the status values is unknown. However, it is known that 136 and 137 return the values from the two ion chambers of the MarDTB, while 138 returns the value from an internal MarDTB clock.

mardtb_shutter driver

This driver controls the MarDTB shutter.

The driver specific fields are:

Field Name	Field Type	Number of Dimensions	Sizes	Description
See *Common Relay Field Definitions*				
mardtb_record	record	0	0	This is the name of the controller record for the MarDTB.

Here is an example database for the MarDTB:

```
mardtb_rs232 interface rs232 tcp232 "" "" 38400 8 N 1 H 0x0d0a 0x0d0a -1 0x0 192.0.2.3 23 0x0
mardtb  interface controller mardtb "" "" mardtb_rs232 esd 0x0
phi device motor mardtb_motor "" "" 0 0 -1000000 1000000 0 -1 -1 -0.00125 0 deg mardtb 6 10000 1000
p136  device analog_input mardtb_status "" "" 0 1 0 units 0x0 0 "" mardtb 136
p137  device analog_input mardtb_status "" "" 0 1 0 units 0x0 0 "" mardtb 137
clock device analog_input mardtb_status "" "" 0 1 0 units 0x0 0 "" mardtb 138
shutter device relay mardtb_shutter "" "" mardtb
```

10.2.21 Mclennan

Platforms: All

This set of drivers is for the Mclennan PM-600 from Mclennan Servo Supplies (http://www.mclennan.co.uk/). It contains code for several other models of Mclennan controller, but it has only actually been tested with the PM-600.

The MX drivers and their fields include

mclennan driver

Field Name	Field Type	Number of Dimensions	Sizes	Description
See *Common Motor Field Definitions*				
rs232_record	record	0	0	The name of the MX record for the RS-232 port that the controller is plugged into.
axis_number	long	0	0	The axis number for this encoder.
axis_encoder_number	long	0	0	If a PM368 encoder display is installed, specify the axis encoder number for it here. If a PM368 is **not** installed, then specify -1 here.

mclennan_ain driver

Field Name	Field Type	Number of Dimensions	Sizes	Description
See *Common Analog Input Field Definitions*				
mclennan_record	record	0	0	The name of the MX motor record that this analog input belongs to.
port_number	long	0	0	The port number for this analog input.

mclennan_aout driver

Field Name	Field Type	Number of Dimensions	Sizes	Description
See *Common Analog Output Field Definitions*				
mclennan_record	record	0	0	The name of the MX motor record that this analog output belongs to.
port_number	long	0	0	The port number for this analog output.

mclennan_din driver

Field Name	Field Type	Number of Dimensions	Sizes	Description
See *Common Digital Input Field Definitions*				
mclennan_record	record	0	0	The name of the MX motor record that this digital input belongs to.
port_number	long	0	0	The port number for this digital input.

mclennan_dout driver

Field Name	Field Type	Number of Dimensions	Sizes	Description
See *Common Digital Output Field Definitions*				
mclennan_record	record	0	0	The name of the MX motor record that this digital output belongs to.
port_number	long	0	0	The port number for this digital output.

Here is an example database for the *mclennan* driver:

```
mr interface rs232 tty "" "" 9600 7 E 1 N 0x0d0a 0x0d -1 0x0 /dev/ttyS0
m1 device motor mclennan "" "" 0 0 -1000000000 1000000000 0 -1 -1 1 0 steps mr 1 -1
din1  device digital_input mclennan_din "" "" 0 m1 1
dout1 device digital_output mclennan_dout "" "" 0 m1 1
ain1  device analog_input mclennan_ain "" "" 0 1 0 units 0x0 0 "" m1 1
aout3 device analog_output mclennan_aout "" "" 0 1 0 units 0x0 m1 3
```

10.2.22 Mclennan PM-304

Platforms: All

The Mclennan PM-304 controller is a single-axis servo controller from Mclennan (www.mclennan.co.uk) that is no longer manufactured.

Field Name	Field Type	Number of Dimensions	Sizes	Description
See *Common Motor Field Definitions*				
rs232_record	record	0	0	The name of the MX record for the RS-232 port that this controller is plugged into.
axis_number	long	0	0	The axis number for this encoder.
axis_encoder_number	long	0	0	If a PM368 encoder display is installed, specify the axis encoder number for it here. If a PM368 is **not** installed, then specify -1 here.
minimum_event_interval	double	0	0	It is possible for MX to send commands faster than the PM-304 can cope with. This field sets a minimum time in seconds between commands sent to the PM-304. A typical value for this field is 0.1 seconds.

An example database for the PM-304 looks like this:

```
theta_rs232 interface rs232 tty "" "" 9600 7 E 1 N 0xd0a 0xd0a 1 0 /dev/ttyS3
theta  device motor pm304 "" "" 0 0 -5400000 200000 0 0 20000 -5e-05 0 deg theta_rs232 1 201 0.1
```

The MX driver for the PM304 requires that responses from the controller include an address prefix. By default, the PM304 has this feature turned off. You may turn it on by sending the string

```
1AD
```

to the PM304, assuming that it is configured for address 1. Please note that the AD command is a toggle, so if address prefixes are already turned on, the AD command will turn them off.

10.2.23 National Instruments PC-STEP

Platform: Linux or Windows

National Instruments PC-STEP cards were ISA-bus motion controllers originally made by nuLogic. This is an MX port I/O driver for communicating with a PC-STEP card. If you are running on Windows, then you may have better luck using the MX drivers for the National Instruments ValueMotion series of motor controllers, since they are currently supported by National Instruments.

The PC-STEP family of drivers has two drivers:

pcstep driver

Field Name	Field Type	Number of Dimensions	Sizes	Description
See *Common Record Field Definitions*				
portio_record	record	0	0	This is the name of the MX port I/O record used to communicate with the PC-STEP card.
base_address	hex	0	0	The hexadecimal base address of the I/O ports used by the card.
limit_switch_polarity	hex	0	0	This sets the polarity of the limit switches used by all of the motors.
enable_limit_switches	hex	0	0	If this is set to 1, the limit switches are enabled. If it is set to 0, then the limit switches are not enabled.

pcstep_motor driver

The PC-STEP card does not have non-volatile memory for storing motor parameters, so they must be set directly in the MX database.

Field Name	Field Type	Number of Dimensions	Sizes	Description
See *Common Motor Field Definitions*				
controller_record	record	0	0	The name of the MX record that controls this PC-STEP card.
axis_id	long	0	0	The axis number for this motor.
default_speed	ulong	0	0	The default speed for the motor.
default_base_speed	ulong	0	0	The default base speed for the motor.
default_acceleration	ulong	0	0	The default acceleration for the motor.
default_acceleration_factor	ulong	0	0	The default acceleration factor for the motor.
lines_per_revolution	ushort	0	0	Specifies the resolution of the encoder readout.
steps_per_revolution	ushort	0	0	Specifies the number of steps per revolution for the motor.

Here is an example database for the PC-STEP:

```
portio  interface portio linux_portio "" "" /dev/portio
nulogic interface generic pcstep "" "" portio 0x210 0xc0 0xc0
m1      device motor pcstep_motor "" "" 0 0 -20000000 20000000 0 -1 -1 0.0001 0 um nulogic 1 20000 5
m2      device motor pcstep_motor "" "" 0 0 -20000000 20000000 0 -1 -1 0.0001 0 um nulogic 2 20000 5
```

10.2.24 National Instruments ValueMotion

Platform: Windows

The National Instruments ValueMotion series of motor controllers uses the MX *pcmotion32* series of drivers. The *pcmotion32* family of MX drivers has two drivers:

pcmotion32 driver

This driver communicates with the PCMOTION32.DLL library provided by National Instruments.

pcmotion32_motor driver

Here is an example database for the *pcmotion32* family of MX drivers.

```
nulogic interface controller pcmotion32 "" "" 1  0  0
m1      device motor pcmotion32_motor "" "" 0 0 -20000000 20000000 0 -1 -1 0.0001 0 um nulogic 1 200
m2      device motor pcmotion32_motor "" "" 0 0 -20000000 20000000 0 -1 -1 0.0001 0 um nulogic 2 200
```

10.2.25 Network Motor

Platform: All

The *network_motor* driver is used by MX clients to communicate with motors controlled by a remote MX server. Here are the fields used by that driver.

Field Name	Field Type	Number of Dimensions	Sizes	Description
See *Common Motor Field Definitions*				
server_record	record	0	0	The name of the MX server record used by this motor.
remote_record_name	string	1	16	The name of the matching motor record in the MX server's own database.

Here is an example database for the *network_motor* driver.

```
10id   server network tcpip_server "" "" 0x20000000 127.0.0.1 9827
theta  device motor network_motor "" "" 10 0 -100000 100000 0 -1 -1 1 0 deg 10id theta
omega  device motor network_motor "" "" 0 0 -50000 50000 0 -1 -1 1 0 um 10id omega
chi    device motor network_motor "" "" 0 -20 -50000 50000 0 -1 -1 1 0 um 10id chi
pivot  device motor network_motor "" "" 0 -20 -50000 50000 0 -1 -1 1 0 um 10id pivot
```

10.2.26 Newport MM3000

Platforms: All

The MM3000 is an old motor controller formerly available from Newport Corporation (http://www.newport.com/). It has not been for sale since sometime in the early 1990s.

mm3000 driver

Field Name	Field Type	Number of Dimensions	Sizes	Description
See *Common Record Field Definitions*				
controller_interface	interface	0	0	The interface description for the MM3000 controller. See below for more information.

The *controller_interface* field works as follows. For RS-232, the name of the MX RS-232 record used to communicate with the controller. For GPIB, the name of the MX GPIB record followed by a colon ':' and then the GPIB address. For example, *mono_gpib:4* would be found at GPIB address 4 on the GPIB bus reached through MX record *mono_gpib*.

mm3000_motor driver

Field Name	Field Type	Number of Dimensions	Sizes	Description
See *Common Motor Field Definitions*				
newport_record	record	0	0	The name of the MX record for the Newport controller.
axis_number	long	0	0	The axis number for this motor axis. The allowed values are 1 through 4.

10.2.27 Newport MM4000

Platforms: All

These drivers are for the MM4000 series of motion controllers from Newport Corporation (http://www.newport.com/). The drivers have been tested with the MM4000 and MM4005 controllers, but not the MM4006 controller. None of these controllers are still available for sale.

Note: If you are using an MM4000 series controller with RS-232, the driver **requires** that you go into the front panel setup menus and change the value of the field "Terminator" under "General Setup" for the controller to CR/LF. For GPIB connections, this should not matter.

mm4000 driver

Field Name	Field Type	Number of Dimensions	Sizes	Description
See *Common Record Field Definitions*				
controller_interface	interface	0	0	The interface description for the MM4000 controller. See below for more information.

The *controller_interface* field works as follows. For RS-232, the name of the MX RS-232 record used to communicate with the controller. For GPIB, the name of the MX GPIB record followed by a colon ':' and then the GPIB address. For example, *mono_gpib:4* would be found at GPIB address 4 on the GPIB bus reached through MX record *mono_gpib*.

mm4000_motor driver

Field Name	Field Type	Number of Dimensions	Sizes	Description
See *Common Motor Field Definitions*				
newport_record	record	0	0	The name of the MX record for the Newport controller.
axis_number	long	0	0	The axis number for this motor axis. The allowed values are 1 through 4.

10.2.28 Newport ESP series

Platforms: All

These drivers are for the ESP series of motion controllers from Newport Corporation (http://www.newport.com/). The drivers have been tested with the ESP300 and ESP301 controllers. The drivers *may* work with the ESP100 or the ESP7000, but this has not been tested. The drivers **will not** work with the ESP6000 since that is a PC ISA bus card which uses a completely different software architecture.

Only the ESP301 controller is currently available for sale (June 2011).

esp driver

Field Name	Field Type	Number of Dimensions	Sizes	Description
See *Common Record Field Definitions*				
controller_interface	interface	0	0	The interface description for the ESP controller. See below for more information.

The *controller_interface* field works as follows. For RS-232, the name of the MX RS-232 record used to communicate with the controller. For GPIB, the name of the MX GPIB record followed by a colon ':' and then the GPIB address. For example, *mono_gpib:4* would be found at GPIB address 4 on the GPIB bus reached through MX record *mono_gpib*.

esp_motor driver

Field Name	Field Type	Number of Dimensions	Sizes	Description
See *Common Motor Field Definitions*				
newport_record	record	0	0	The name of the MX record for the Newport controller.
axis_number	long	0	0	The axis number for this motor axis. The allowed values are 1 through 3 for the ESP300 and ESP301.

10.2.29 Newport Picomotor

Platforms: All

The Picomotor 875x series of actuators from Newport (formerly New Focus) are used for fine positioning of motors and stages in cold or vacuum environments.

picomotor_controller driver

Field Name	Field Type	Number of Dimensions	Sizes	Description
See *Common Record Field Definitions*				
rs232_record	record	0	0	The name of the MX RS-232 record used to communicate with the controller.

picomotor_ainput driver

Field Name	Field Type	Number of Dimensions	Sizes	Description
See *Common Analog Input Field Definitions*				
picomotor_controller_record	record	0	0	MX record name for the Picomotor controller.
driver_name	string	1	4	A1 to A31 for 8751-C drivers; I0 to I31 for I/O devices; 0 for joystick
channel_number	long	0	0	0, 1, or 2.

picomotor_dinput driver

Field Name	Field Type	Number of Dimensions	Sizes	Description
See *Common Digital Input Field Definitions*				
picomotor_controller_record	record	0	0	MX record name for the Picomotor controller.
driver_name	string	1	4	I0 to I31
channel_number	long	0	0	0 to 9 for I/O module; 8 to 11 for joystick.

picomotor_doutput driver

Field Name	Field Type	Number of Dimensions	Sizes	Description
See *Common Digital Output Field Definitions*				
picomotor_controller_record	record	0	0	MX record name for the Picomotor controller.
driver_name	string	1	4	I0 to I31
channel_number	long	0	0	0 to 6 for I/O module; 0 to 7 for joystick.

picomotor motor driver

Field Name	Field Type	Number of Dimensions	Sizes	Description
See *Common Motor Field Definitions*				
picomotor_controller_record	record	0	0	MX record name for the Picomotor controller.
driver_name	string	1	4	Allowed driver names run from A1 to A31.
motor_number	long	0	0	For the 8753, the valid values are 0, 1, or 2.
flags	hex	0	0	Option flag bits for the *picomotor* driver.

Currently, the only option flag bit defined is:

0x1 - This bit tells the motor driver to perform home searches to a limit switch using the FLI or RLI commands. If this bit is not set, then the driver will use the FIN or RIN commands.

10.2.30 NSLS MMC32

Platforms: All

The NSLS MMC32 was a GPIB-based motor controller formerly made at the National Synchrotron Light Source. There is no separate controller record for this driver. Instead, each connected motor axis has a separate record.

mmc32 driver

Field Name	Field Type	Number of Dimensions	Sizes	Description
See *Common Motor Field Definitions*				
gpib_interface	interface	0	0	The name of the GPIB record that this MMC32 is connected to, followed by a colon ':' and then the GPIB address. For example, *mono_gpib:4*.
motor_number	long	0	0	The motor number of the individual axis.
multiplication_factor	double	0	0	The velocity multiplication factor.
start_velocity	long	0	0	The start velocity (base speed) for the motor.
peak_velocity	long	0	0	The peak velocity (slew speed) for the motor.
acceleration_steps	long	0	0	The acceleration distance in steps.

10.2.31 OSS μ-GLIDE

Platforms: All

These drivers are for the BCW μ-GLIDE motors from Oceaneering Space Systems.

uglide driver

Field Name	Field Type	Number of Dimensions	Sizes	Description
See *Common Record Field Definitions*				
rs232_record	record	0	0	The MX RS-232 record used to communicate with the μ-GLIDE controller.
uglide_flags	hex	0	0	The meaning of these flag bits is described below.

0x1 - Tells the μ-GLIDE controller to treat absolute move requests as relative move requests.

0x2 - Bypass home search on boot. Normally, if the controller does not respond to a command at driver startup time, the driver attempts to initialize it by requesting a home search. Setting this flag disables that feature.

uglide_motor driver

Field Name	Field Type	Number of Dimensions	Sizes	Description
See *Common Motor Field Definitions*				
uglide_record	record	0	0	The MX controller record for the μ-GLIDE controller.
axis_name	char	0	0	The name of this motor axis.

10.2.32 Oxford Cryosystems Cryostream 600 Temperature Controller

Platforms: All

These drivers are for the Cryostream 600 temperature controller from Oxford Cryosystems.

cryostream600_motor driver
This driver allows you to control the temperature setpoint as if it were a motor position.

Field Name	Field Type	Number of Dimensions	Sizes	Description
See *Common Motor Field Definitions*				
rs232_record	record	0	0	The MX RS-232 record used to communicate with the controller.
ramp_rate	double	0	0	The initial ramp rate (speed) in Kelvin per hour.
busy_deadband	double	0	0	The busy deadband in Kelvin.

The Cryostream 600 controller does not provide a direct way to determine that a "move" is complete. Instead the MX driver checks to see if the difference between the measured temperature and the setpoint is less than the *busy_deadband* value defined above. If it is, the driver declares the "move" to be complete and tells the controller to hold at the current temperature.

cryostream600_status driver
This driver can be used to report various pieces of the internal status of the controller.

Field Name	Field Type	Number of Dimensions	Sizes	Description
See *Common Analog Input Field Definitions*				
cryostream600_motor_record	record	0	0	The MX motor record for this controller.
parameter_type	long	0	0	The parameter type for this record as described below.

The possible values for *parameter_type* are:

1 - Current measured temperature in Kelvin.
2 - Temperature setpoint in Kelvin.
3 - The difference between the measured temperature and the temperature setpoint in Kelvin.
4 - Final temperature in Kelvin.
5 - The current ramp rate in Kelvin per hour.
6 - Evaporator temperature in Kelvin.
7 - Ice block detection. If this field is non-zero, the controller thinks that an ice block is present

10.2.33 Oxford Instruments ITC503 Temperature Controller

itc503_control

The value of 'parameter_type' is the letter that starts the ITC503 command that will be sent. The currently supported values are:

- A - Set auto/manual for heater and gas
- C - Set local/remote/lock status
- G - Set gas flow (in manual only)
- O - Set heater output volts (in manual only)

There are several other ITC503 control commands, but only the ones likely to be used in routine operation are supported.

itc503_motor

The two lowest order bits in 'itc503_motor_flags' are used to construct a 'Cn' control command. The 'Cn' determines whether or not the controller is in LOCAL or REMOTE mode and also whether or not the LOC/REM button is locked or active. The possible values for the 'Cn' command are:

- C0 - Local and locked (default state)
- C1 - Remote and locked (front panel disabled)
- C2 - Local and unlocked
- C3 - Remote and unlocked (front panel disabled)

itc503_status

The value of 'parameter_type' is used to construct an ITC503 'R' command. Thus, the values of the parameters are as listed in the Oxford manual:

- 0 - Set temperature
- 1 - Sensor 1 temperature
- 2 - Sensor 2 temperature
- 3 - Sensor 3 temperature
- 4 - Temperature error
- 5 - Heater O/P (as
- 6 - Heater O/P (as Volts, approx.)
- 7 - Gas flow O/P (arbitrary units)
- 8 - Proportional band

- 9 - Integral action time
- 10 - Derivative action time
- 11 - Channel 1 freq/4
- 12 - Channel 2 freq/4
- 13 - Channel 3 freq/4

10.2.34 Pan-Tilt-Zoom Motor

10.2.35 Phidget Stepper (old version)

10.2.36 Physik Instrumente E662 Piezo Controller

10.2.37 Pontech STP100

The permitted board numbers are from 1 to 255.

The permitted values for digital I/O pins are:

0	-	Disable the pin.
3, 5, 6, 8	-	The pin is active closed.
-3, -5, -6, -8	-	The pin is active open.

Pins 5 and 6 are normally used for limit switches while either pin 3 or pin 8 is used for the home switch. This is because pins 5 and 6 already have pullup resistors.

The output of the RP command is 0 = closed and 1 = open.

10.2.38 Prairie Digital Model 40

10.2.39 Precision MicroControl MCAPI-based Motor Controllers

10.2.40 Pro-Dex VME58

Platforms: All

The VME58 motor controller from Pro-Dex (formerly Oregon Microsystems) is a 4 or 8 axis motor controller capable of supporting both servo and stepper applications. It is no longer for sale.

This set of drivers controls the VME58 by sending raw ASCII commands to the controller through an MX VME record.

vme58 driver

Field Name	Field Type	Number of Dimensions	Sizes	Description
See *Common Record Field Definitions*				
vme_record	record	0	0	The name of the MX VME record used to communicate with the VME58.
crate_number	ulong	0	0	The VME crate number for this motor controller.
base_address	hex	0	0	The base address in hexadecimal of the motor controller.

vme58_motor driver

Field Name	Field Type	Number of Dimensions	Sizes	Description
See *Common Motor Field Definitions*				
vme58_record	record	0	0	The MX controller record for this motor axis.
axis_number	long	0	0	The axis number for this motor axis. This can range from 1 to 4 for models with encoder feedback and from 1 to 8 for models with no encoder feedback.
flags	hex	0	0	The meaning of the flag bits in this field are described below.
default_speed	long	0	0	The initial slew speed for the axis.
default_base_speed	long	0	0	The initial base speed for the axis. This is not used for servo axes.
default_acceleration	long	0	0	The initial acceleration for this axis.

The meaning of the bits in the *flags* field above are as follows:

0x1 - Ignore database settings. This option tells the driver not to reprogram the speeds and accelerations for the axis at startup time.
0x2 - Use encoder. *Not actually implemented in the driver at this time.*
0x10 - Disable hardware limits for this axis.
0x20 - Set the home switch to active high. This allows the use of normally closed home switches.

10.2.41 Radix Databox

10.2.42 Scientific Instruments 9650 Temperature Controller

10.2.43 SCIPE Motor

10.2.44 Soft Motor

10.2.45 Spec Motor

10.2.46 SRC Monochromator

This driver is used to change the energy of a monochromator at the Aladdin storage ring of the Synchrotron Radiation Center (SRC) *(http://www.src.wisc.edu/)* at the University of Wisconsin-Madison. MX communicates over an RS-232 link with the SRC computer that actually controls the monochromator.

The supported driver is:

src_mono - Changes the monochromator energy for the beamline.

The record fields for this driver are:

Field Name	Field Type	Number of Dimensions	Sizes	Description
See *Common motor field definitions*				
rs232_record	string	1	0	The name of the RS-232 port used to communicate with the SRC control computer.

The following is an example database for the SRC monochromator:

```
src_computer interface rs232 tty "" "" 9600 8 N 1 N 0x0d0a 0x0d 1 0x0 /dev/ttyS0
energy       device motor src_mono "" "" 0 0 210 800 0 -2 -2 1 0 eV src_computer
```

10.2.47 Velmex VP9000

10.2.48 XIA HSC-1 Huber Slit Controller

By default, the HSC-1 Huber Slit Controllers are delivered with default values that do not allow the slit blades to be moved to anywhere the blades can physically reach. The default values for parameters 1 and 2 are:

Parameter	Name	Default Value	Default in um
1	Outer Motion Limit	4400	11000 um
2	Origin Position	400	1000 um

The MX drivers for the HSC-1 assume that these two parameters have been redefined to have the following values:

Parameter	Name	Default Value	Default in um
1	Outer Motion Limit	10400	26000 um
2	Origin Position	5200	13000 um

The reprogramming must be done using a terminal program like Kermit or Minicom. Suppose you have an HSC-1 controller with a serial number of XIAHSC-B-0001. Then the appropriate commands to send to the HSC-1 would be:

```
!XIAHSC-B-0001 W 1 10400
!XIAHSC-B-0001 W 2 5200
```

Next, in the MX config file, specify the limits, scales and offsets of the various axes as follows:

XIA motor name	negative limit (raw units)	positive limit (raw units)	scale	offset
A	-65535	65535	2.5	-13000
B	-65535	65535	2.5	-13000
C	-65535	65535	2.5	0
S	0	131071	2.5	-26000

Then, you will be able to move the A, B, and C motors from -13000 um to +13000 um and the S motor from 0 um to 26000 um.

Please note that the HSC-1 motor positions can only be set to the value 0. A “set motor ... position” command to any other value than zero will fail. The “set motor ... position 0” command itself will cause the HSC-1 to execute an “Immediate Calibration” or “0 I” command. Also note that the slit size motor S cannot be moved to a negative value, so if S is at zero and there is a visible gap between the blades, then you will have to manually close the slit by hand.

Here is an example database for two HSC-1 controllers attached to the same serial port:

```
hsc1_rs232 interface rs232 tty "" "" 9600 8 N 1 N 0xd0a 0xd /dev/ttyS0
hsc1_1     interface controller hsc1 "" "" hsc1_rs232 2 XIAHSC-B-0067 XIAHSC-B-0069
hsc67a     device motor hsc1_motor "" "" 0 0 -65535  65535 0 -1 -1 2.5 -13000 um hsc1_1 0 A
hsc67b     device motor hsc1_motor "" "" 0 0 -65535  65535 0 -1 -1 2.5 -13000 um hsc1_1 0 B
hsc67c     device motor hsc1_motor "" "" 0 0 -65535  65535 0 -1 -1 2.5      0 um hsc1_1 0 C
hsc67s     device motor hsc1_motor "" "" 0 0      0 131071 0 -1 -1 2.5 -26000 um hsc1_1 0 S
```

```
hsc69a     device motor hsc1_motor "" "" 0 0 -65535  65535 0 -1 -1 2.5 -13000 um hsc1_1 1 A
hsc69b     device motor hsc1_motor "" "" 0 0 -65535  65535 0 -1 -1 2.5 -13000 um hsc1_1 1 B
hsc69c     device motor hsc1_motor "" "" 0 0 -65535  65535 0 -1 -1 2.5      0 um hsc1_1 1 C
hsc69s     device motor hsc1_motor "" "" 0 0      0 131071 0 -1 -1 2.5 -26000 um hsc1_1 1 S
```

10.3 Pseudomotors

Pseudomotor support goes here.

10.3.1 ADSC Two Theta

10.3.2 A-Frame Detector Motor

This is an MX motor driver for the pseudomotors used by Gerd Rosenbaum's A-frame CCD detector mount. The geometry of this detector mount is shown in the following figure:

The pseudomotors available are:

- *detector_distance* - This is the length of the line perpendicular to the plane containing the front face of the detector which passed through the center of rotation of the goniometer head.
- *detector_horizontal_angle* - This is the angle between the line used by the detector distance and the horizonal plane.
- *detector_offset* - This is the distance between the centerline of the detector and the line used to define the detector distance above.

There are three constants that describe the system:

- *A* - This is the perpendicular distance between the two vertical supports that hold up the detector.
- *B* - This is the distance along the centerline of the detector from the front face of the detector to the point where a perpendicular from the downstream detector pivot intersects this line.
- *C* - This is the separation between the centerline of the detector and the line defining the detector distance above.

The pseudomotors depend on the positions of three real motors. These are:

- *dv_upstream* - This motor controls the height of the upstream vertical detector support.
- *dv_downstream* - This motor controls the height of the downstream vertical detector support.
- *dh* - This motor controls the horizontal position of the vertical detector supports.

Confused? I am planning to write a short document that describes the definitions of these parameters in more detail and derives the formulas describing them. If you are reading this text and I have not yet written that document, then pester me until I do write it.

Warning: The detector horizonal angle is expressed internally in radians. If you want to display the angle in degrees, use the scale field of the angle pseudomotor to do the conversion.

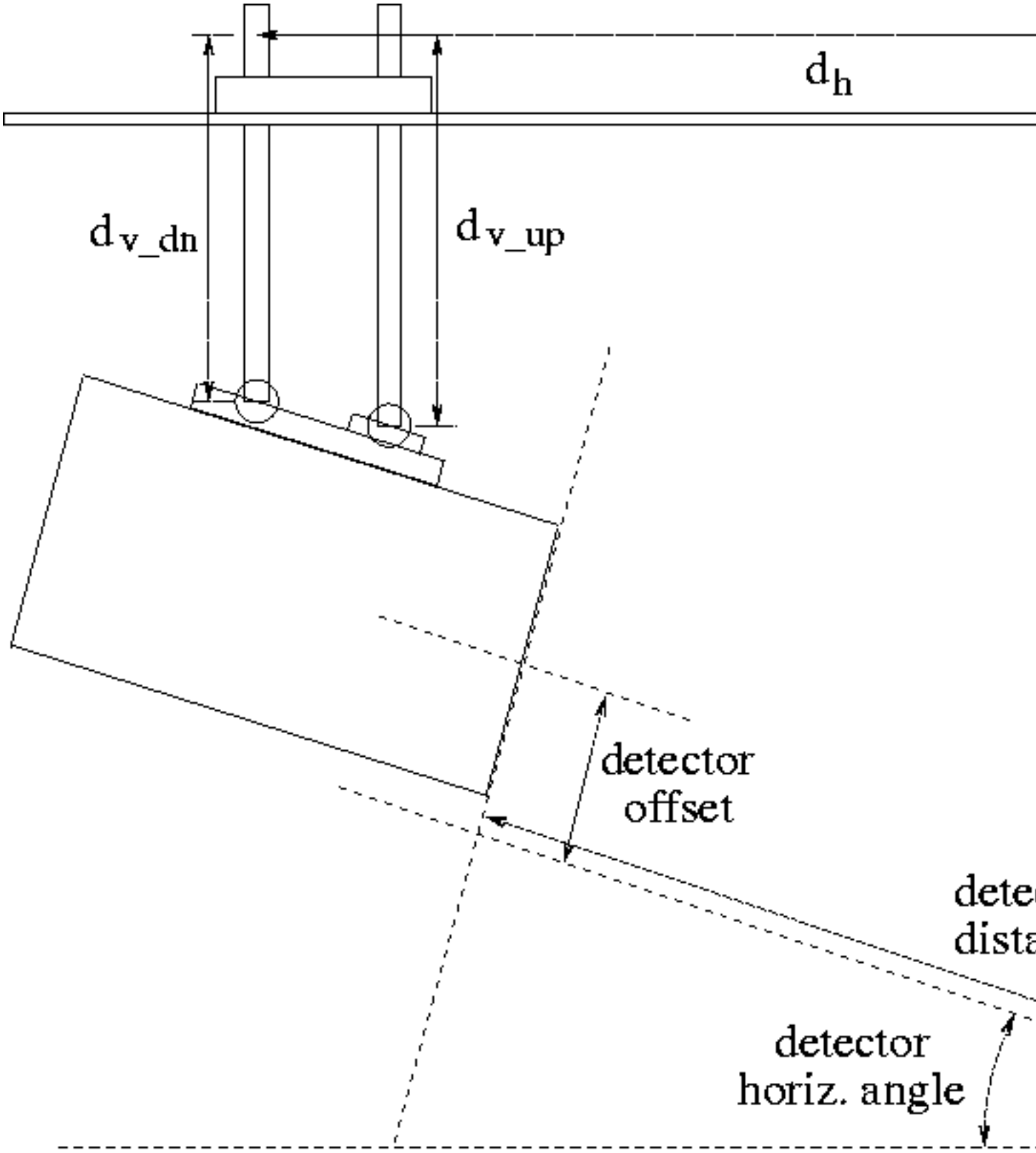


Figure 10.2: A-frame CCD detector mount designed by Gerd Rosenbaum

10.3.3 ALS Dewar Positioner

10.3.4 APS 18-ID

10.3.5 Delta

10.3.6 Elapsed Time

10.3.7 Energy

10.3.8 Linear Function

An example database for the *linear_function* pseudomotor looks like:

```
cmirror_us   device motor compumotor "" "" 0  0 -1000000 1000000 0 -1 -1 1 0 um 6k_coll 1 3 1
cmirror_ds   device motor compumotor "" "" 0  0 -1000000 1000000 0 -1 -1 1 0 um 6k_coll 1 2 1
cmirror_bend device motor linear_function "" "" 0  0 -1000000 1000000 0 -1 -1
1 0 um 0x1 2 cmirror_us cmirror_ds 0.5 0.5 0 0 0.5 0.5
```

10.3.9 Monochromator

The monochromator pseudomotor is implemented using a large collection of MX records. These records can be categorized into several groups:

- The monochromator record with *N* dependencies.
- *N* dependency list records.
- *N* dependency enable records.
- *N* dependency parameter records.
- *N* dependency record list records.
- *N* dependency type records.

where the value of *N* above is set by the value of the *num_dependencies* field in the monochromator record.

Monochromator Record

The MX Motor Driver Support page describes the common motor record description fields. For the *monochromator* driver, the following driver specific fields are present:

Field Name	Field Type	Number of Dimensions	Sizes	Description
See *Common motor field definitions*				
num_dependencies	long	0	0	The number of dependencies for this monochromator pseudomotor.
list_array	record	1	*num_dependencies*	The list of depencency list records.

Example:

```
theta device motor monochromator "" "" 0 0 -10 270 0 -1 -1 1 0 deg 4 theta_list momega_list id_ev_li
```

The monochromator record is a pseudomotor record which contains a list of the dependencies used by the pseudomotor. In general, one of the dependencies will be a *primary* dependency which describes the primary axis used by the monochromator pseudomotor *(usually theta)*. The rest of the dependencies will be *secondary* dependencies that describe motors that are to be moved to positions that depend on the position of the primary dependency motor. There should only be one primary dependency.

In the example above, the dependencies specified are:

- *theta_list* - This is the primary dependency and describes the dependence of the monochromator pseudomotor on the real theta axis of the monochromator.
- *momega_list* - A secondary dependency that controls the angle between the first and second monochromator crystal.
- *id_ev_list* - A secondary dependency that controls the energy of the peak of the undulator spectrum for this beamline.
- *normal_list* - A secondary dependency that controls the perpendicular spacing between the first and second monochromator crystals.

This example does not include all of the available dependency types which are described in more detail below. In addition, the primary dependency does not have to be the first record listed, but it is customary to do so.

Dependency List Records

An example dependency list record looks like

```
momega_list  variable inline record "" "" 1  4  momega_enabled momega_type momega_params momega_recor
```

Dependency list records must be four element 1-dimensional arrays of type MXFT_RECORD. The individual elements of this array must be in the following order:

- *Dependency enable record* - used to enable or disable the dependency. (*momega_enabled* in the example above.)
- *Dependency type record* - describes what type of dependency this is. (*momega_type* in the example above.)
- *Dependency parameters record* - describes the parameters used by this dependency. (*momega_params* in the example above.)
- *Dependency record list* - describes the records used by this dependency. (*momega_records* in the example above.)

The individual elements of the array are described in more detail below.

Dependency Enable Records

An example dependency enable record looks like

```
momega_enabled variable net_variable net_int "" "" localhost momega_enabled.value 1  1  0
```

The dependency enable record must be a variable record of type MXFT_INT. It has two legal values:

- *1* - The dependency is enabled and the dependent motor(s) will be moved to positions that correspond to the position of the primary dependency.
- *0* - The dependency is disabled and the dependent motor(s) will not be moved.

Dependency Parameter Records

An example dependency parameters record looks like

```
momega_params variable net_variable net_double "" "" localhost momega_params.value 1 4 0 0 0 0
```

The dependency parameters record will be a 1-dimensional variable record of some kind. The particular variable type used will depend on the dependency type as described below. In the example above, the parameters record is a 1-dimensional array of integers that are all initialized to 0.

Dependency Record List Records

An example dependency record list looks like

```
momega_records variable inline record "" "" 1 1 momega
```

The dependency record list record will be a 1-dimensional variable record of type MXFT_RECORD. The number and identity of the listed records will depend on the dependency type as described below. In the example above, the record list array contains only the record *momega*.

Dependency Type Records

An example dependency type record looks like

```
momega_type variable inline int "" "" 1 1 2
```

The dependency type record will be 1-dimensional variable record of type MXFT_INT with only one element, namely, the dependency type. In the example above, the dependency type is 2.

At present, nine different dependency types are available. Dependency types 0 and 1 are *primary* dependency types, while types 2 through 8 are *secondary* dependency types.

Type 0 - Theta dependency

The theta dependency is used to control the position of the primary theta axis. This dependency is normally the *primary* dependency for the monochromator pseudomotor. If this dependency does not exist or is disabled, the real theta axis will not be moved at all.

- **Record list record** - This is a 1-dimensional array with only one element, specifically, the name of the *real* theta motor record.
- **Parameters record** - This record must be present, but its contents are not used by this dependency. Typically, a dummy variable will be used here as in the example below.

An example set of records for the theta dependency looks like

```
theta_list    variable inline record "" "" 1  4  theta_enabled theta_type dummy_params theta_records
theta_type    variable inline int    "" "" 1  1  0
theta_enabled variable inline int    "" "" 1  1  1
theta_records variable inline record "" "" 1  1  theta_real
dummy_params  variable inline double "" "" 1  1  0
```

Normally, there is no reason for the users to disable this dependency, so it is standard to hard code it to 1 as in the example above.

Type 1 - Energy dependency

The energy dependency is a *primary* dependency that computes the monochromator theta angle from a monochromator energy provided by a foreign beamline control system. Use of this dependency is **not recommended**, unless the underlying beamline control software/hardware does not provide a direct way of querying and controlling the theta angle. Use of this dependency is **incompatible** with the type 0 theta dependency specified above. Do not specify both of them in the same MX database.

If you are looking for a way to control a *dependent* motor as a polynomial function of energy, you should be using the type 8 *energy polynomial* dependency described below.

- **Record list record** - This is a 1-dimensional array of type MXFT_RECORD containing two elements:
  - *energy record* - This motor record queries and controls the monochromator energy.
  - *monochromator d spacing record* - This is a variable record that contains the d spacing of the monochromator crystal in angstroms.
- **Parameters record** - This record must be present, but its contents are not used by this dependency. Typically, a dummy variable will be used here as in the example below.

An example set of records for the energy dependency looks like

```
energy_list    variable inline record        "" "" 1  4  energy_enabled energy_type dummy_params ener
energy_type    variable inline int           "" "" 1  1  1
energy_enabled variable net_variable net_int "" "" 1  1  1
energy_records variable inline record        "" "" 1  2  energy d_spacing
dummy_params   variable inline double        "" "" 1  1  0
```

A corresponding d spacing variable would look like

```
d_spacing variable net_variable net_double "" "" localhost d_spacing.value 1  1  3.1355
```

The monochromator theta angle is computed using the standard Bragg equation

theta = asin(12398.5 / (2.0 * d_spacing * energy))

Normally, there is no reason for the users to disable this dependency, so it is standard to hard code it to 1 as in the example above.

Type 2 - Polynomial dependency

This dependency type is a *secondary* dependency that allows a dependent motor to be moved to positions that are a polynomial function of the theta position of the monochromator. The computed position will be of the form

dependent_position = c0 + c1 * theta + c2 * (theta**2) + c3 * (theta**3) + ...

Beamline staff may configure this polynomial to have as few or as many terms in it as they want by changing the number of elements in the parameters array below. For example, a parameters array record with only two array elements will describe a dependent position that has a linear dependence on theta, while a parameters array record with four array elements describes a cubic dependence on theta. It is generally not useful to use a polynomial of higher order than cubic, although there is no limit in the record as to how high the order may be.

- **Record list record** - This is a 1-dimensional array with only one element, specifically, the name of the dependent motor record.

- **Parameters record** - This is a 1-dimensional array of type MXFT_DOUBLE which contains the coefficients of the polynomial. The coefficients are specified in order starting with the constant term and continuing up to the coefficient of the highest order term.

An example set of records for the polynomial dependency looks like

```
momega_list    variable inline record           "" "" 1  4  momega_enabled momega_type momega_params
momega_type    variable inline int              "" "" 1  1  2
momega_enabled variable net_variable net_int    "" "" localhost momega_enabled.value 1  1  0
momega_records variable inline record           "" "" 1  1  momega
momega_params  variable net_variable net_double "" "" localhost momega_params.value  1  4  0 0 0 0
```

In the example above, *momega_params* is a cubic polynomial. If the value of *momega_params* at some particular time was set to something like (0.32, 0.41, -0.02, 0.015), the computed polynomial would have the form

momega = 0.32 + 0.41 * theta - 0.02 * (theta**2) + 0.015 * (theta**3)

Typically, the values of these coefficients will be determined by measuring the location of the peak X-ray intensity as a function of the dependent motor position for several values of theta Then a curve will be fitted to the measurements.

Type 3 - Insertion device energy dependency

This dependency type is a *secondary* dependency that changes the energy of the undulator peak such that the maximum of the undulator spectrum is at the same energy as the monochromator.

- **Record list record** - This is a 1-dimensional array of type MXFT_RECORD containing two elements:
  - *insertion device motor record* - This is a motor record that controls the position of the undulator peak in units of eV.
  - *monochromator d spacing record* - This is a variable record that contains the d spacing of the monochromator crystal in angstroms.
- **Parameters record** - This is a 1-dimensional array of type MXFT_DOUBLE which contains two elements:
  - *gap harmonic* - This is the requested undulator harmonic number and should be a positive odd integer such as 1, 3, 5, etc. This is usually set to 1.
  - *gap offset* - This is an offset to be added to the computed gap energy.

For a given monochromator *theta* position in degrees, the undulator energy is computed as follows:

mono_energy = 12398.5 / (2.0 * d_spacing * sin(theta))

undulator_energy = (mono_energy + gap_offset) / gap_harmonic

Please note that if the undulator controls provided by your storage ring *also* have a way of setting the gap harmonic in addition to the method provided by MX, then you should only set one of them to the harmonic number and set the other to 1. For example, at the APS, if you set both EPICS's variable for the gap harmonic to 3 *and* MX's variable for the gap harmonic to 3, you would actually end up with the ninth harmonic.

An example set of records for the insertion device energy dependency looks like

```
id_ev_list    variable inline record           "" "" 1  4  id_ev_enabled id_ev_type id_ev_params id_
id_ev_type    variable inline int              "" "" 1  1  3
id_ev_enabled variable net_variable net_int    "" "" localhost id_ev_enabled.value 1  1  0
id_ev_records variable inline record           "" "" 1  2  id_ev d_spacing
id_ev_params  variable net_variable net_double "" "" localhost id_ev_params.value 1  2  1 100
```

Type 4 - Constant exit Bragg normal dependency

This dependency type is a *secondary* dependency that changes the perpendicular spacing between the first and second monochromator crystals so that the X-ray beam exiting the monochromator stays at a constant height.

- **Record list record** - This is a 1-dimensional array of type MXFT_RECORD containing two elements:
  - *normal record* - This motor record controls the perpendicular spacing between the two monochromators crystals.
  - *beam offset record* - This is a variable record of type MXFT_DOUBLE that contains the desired fixed offset distance of the beam expressed in the same units as the *normal* motor.
- **Parameters record** - This record must be present, but its contents are not used by this dependency. Typically, a dummy variable will be used here as in the example below.

An example set of records for the Bragg normal dependency looks like

```
normal_list    variable inline record        "" "" 1  4  normal_enabled normal_type dummy_params norm
normal_type    variable inline int           "" "" 1  1  4
normal_enabled variable net_variable net_int "" "" localhost normal_enabled.value 1  1  0
normal_records variable inline record        "" "" 1  2  normal beam_offset
dummy_params   variable inline double        "" "" 1  1  0
```

A corresponding beam offset variable would look like

```
beam_offset variable net_variable net_double "" "" localhost beam_offset.value 1  1  -35000
```

The Bragg normal position is computed from the beam offset and the monochromator theta angle via the equation

bragg_normal = beam_offset / (2.0 * cos(theta))

If a positive move of the normal motor at theta = 0 is in the opposite direction from the desired beam offset, then the value of the beam offset must be set to a negative number. For example, this is true of the MX installations at APS sectors 10 and 17 where beam_offset = -35000 um.

Type 5 - Constant exit Bragg parallel dependency dependency

This dependency type is a *secondary* dependency that translates the second crystal parallel to its surface. This dependency should normally be used in combination with the Bragg normal dependency listed above. It is used to ensure that the X-ray beam does not fall off the end of the second crystal.

- **Record list record** - This is a 1-dimensional array of type MXFT_RECORD containing two elements:
  - *parallel record* - This motor record controls the translated position of the second crystal.
  - *beam offset record* - This is a variable record of type MXFT_DOUBLE that contains the desired fixed offset distance of the beam expressed in the same units as the *normal* motor.
- **Parameters record** - This record must be present, but its contents are not used by this dependency. Typically, a dummy variable will be used here as in the example below.

An example set of records for the Bragg parallel dependency looks like

```
parallel_list    variable inline record        "" "" 1  4  parallel_enabled parallel_type dummy_para
parallel_type    variable inline int           "" "" 1  1  5
parallel_enabled variable net_variable net_int "" "" localhost parallel_enabled.value 1  1  0
parallel_records variable inline record        "" "" 1  2  parallel beam_offset
dummy_params     variable inline double        "" "" 1  1  0
```

A corresponding beam offset variable would look like

```
beam_offset variable net_variable net_double "" "" localhost beam_offset.value 1  1  -35000
```

If used in combination with a Bragg normal dependency, the two dependencies should use the same MX variable to control the beam offset.

The Bragg parallel position is computed from the beam offset and the monochromator theta angle via the equation
bragg_parallel = beam_offset / (2.0 * sin(theta))

Type 6 - Experiment table height dependency

If a given monochromator does not support fixed exit beam operation, an alternate way to ensure that the X-ray beam hits the desired target is to put the experiment on a table that can be vertically translated to track the beam.

- **Record list record** - This is a 1-dimensional array of type MXFT_RECORD containing three elements:
  - *table height record* - This motor record controls the vertical height of the experiment table.
  - *table offset record* - This is a variable record of type MXFT_DOUBLE that provides a way of adding a constant offset to the computed table height.
  - *crystal separation record* - This is a variable record of type MXFT_DOUBLE that contains the perpendicular crystal separation distance expressed in the same units as the *table height* motor.
- **Parameters record** - This record must be present, but its contents are not used by this dependency. Typically, a dummy variable will be used here as in the example below.

An example set of records for the experiment table height dependency looks like

```
theight_list    variable inline record        "" "" 1  4  theight_enabled theight_type dummy_params
theight_type    variable inline int           "" "" 1  1  6
theight_enabled variable net_variable net_int "" "" localhost theight_enabled.value 1  1  0
theight_records variable inline record        "" "" 1  3  theight toffset crystal_sep
dummy_params    variable inline double        "" "" 1  1  0
```

A corresponding pair of variables would look like

```
toffset     variable net_variable net_double "" "" localhost toffset.value 1  1  0
crystal_sep variable net_variable net_double "" "" localhost crystal_sep.value 1  1  5000
```

The experiment table height position is computed via the equation
table_height = table_offset + 2.0 * crystal_separation * cos(theta)

Type 7 - Diffractometer theta dependency

The diffractometer theta dependency is used to control the Bragg angle of a diffractometer or goniostat in the experimental hutch so that it is set to the correct angle to diffract the X-ray beam coming from the monochromator. This dependency assumes that, in general, the crystal on the diffractometer will have a different d spacing than that of the monochromator crystal.

If the diffractometer angle is called *htheta* and the diffractometer d spacing is called *hd_spacing*, the diffractometer angle is computed by the equation

sin(htheta) = d_spacing * sin(theta) / hd_spacing

The raw value of *htheta* is adjusted using a linear equation of the form

htheta_adjusted = diffractometer_scale * htheta + diffractometer_offset

- **Record list record** - This is a 1-dimensional array of type MXFT_RECORD containing three elements:
  - *diffractometer theta motor record* - This the a motor record that controls the diffractometer theta angle.
  - *monochromator d spacing record* - This is a variable record that contains the d spacing of the monochromator crystal in angstroms.
  - *diffractometer d spacing record* - This is a variable record that contains the d spacing of the diffractometer crystal in angstroms.
- **Parameters record** - This is a 1-dimensional array of type MXFT_DOUBLE which contains two elements which are used to compute the adjusted diffractometer angle:
  - *diffractometer scale*
  - *diffractometer offset*

An example set of records for the diffractometer theta dependency looks like

```
htheta_list     variable inline record           "" "" 1 4 htheta_enabled htheta_type htheta_params h
htheta_type     variable inline int              "" "" 1 1 7
htheta_enabled  variable net_variable net_int    "" "" localhost htheta_enabled.value 1  1  0
htheta_records  variable inline record           "" "" 1 3 htheta d_spacing hd_spacing
htheta_params   variable net_variable net_double "" "" localhost htheta_params.value 1  2  0 0
```

Type 8 - Energy polynomial dependency

The energy polynomial dependency is similar to the type 2 polynomial dependency described above, except the dependent motor position is a polynomial function of the monochromator X-ray energy. Thus, the dependent position will have the form

dependent_position = c0 + c1 * energy + c2 * (energy**2) + c3 * (energy**3) + ...

This dependency assumes that the energy is expressed in eV.

- **Record list record** - This is a 1-dimensional array containing two elements:
  - *dependent motor record* - This motor record controls the dependent motor whose position is determined by the energy polynomial.
  - *monochromator d spacing record* - This is a variable record that contains the d spacing of the monochromator crystal in angstroms. This record is used to convert the theta angle in degrees to energy in eV.

- **Parameters record** - This is a 1-dimensional array of type MXFT_DOUBLE which contains the coefficients of the polynomial. The coefficients are specified in order starting with the constant term and continuing up to the coefficient of the highest order term.

An example set of records for the energy polynomial dependency looks like

```
focus_list     variable inline record           "" "" 1 4 focus_enabled focus_type focus_params focu
focus_type     variable inline int              "" "" 1 1 8
focus_enabled  variable net_variable net_int    "" "" localhost focus_enabled.value 1  1  0
focus_records  variable inline record           "" "" 1 2 focus d_spacing
focus_params   variable net_variable net_double "" "" localhost focus_params.value 1  4  0 0 0 0
```

Type 9 - Option selector dependency

The option selector dependency is used together with a "position_select" calculation record to switch an external value between multiple settings depending on the current value of the monochromator theta position. The "position_select" variable has an integer value from 1 to N. For example, this could be used to automatically switch between mirror stripes at certain X-ray energies.

- **Record list record** - This is a 1-dimensional array of type MXFT_RECORD containing two elements:
  - *option selector record* - This should be a calculation variable record of type "position_select" that controls the external value and contains a list of allowed values for the external value.
  - *option range record* - This is the name of the parameters record below.
- **Parameters record** - This is a 2-dimensional Nx2 array of type MXFT_DOUBLE which contains pairs of elements that describe the limits for each allowed theta range. The two values for each theta range are
  - *theta range lower limit*
  - *theta range upper limit*

  The number N is the number of theta ranges.

An example set of records for the option selector dependency looks like

```
stripe_list    variable inline record "" "" 1  4  stripe_enabled stripe_type dummy_params stripe_rec
stripe_type    variable inline int "" "" 1  1  9
stripe_enabled variable inline int "" "" 1  1  1
stripe_records variable inline record "" "" 1  2  stripe_select stripe_params
stripe_params  variable inline double "" "" 2  4  2  0 5  4.5 8.5  8 11  10.5 15
stripe_select  variable calc position_select "" "" stripe 4 300 600 900 1200 1 1 -1
stripe         device motor soft_motor "" "" 0 0 -1000000000 1000000000 0 -1 -1 0.01 0 um 100000 0 5
```

The example above is for an X-ray mirror whose transverse position is determined by a motor record called *stripe*. There are 4 allowed positions for *stripe*, namely, 300, 600, 900, and 1200. The allowed *theta* ranges corresponding to the allowed positions are 0 to 5 degrees, 4.5 to 8.5 degrees, 8 to 11 degrees, and 10.5 to 15 degrees. The *stripe* position to be selected is determined by comparing the current position of *theta* to the parameter ranges in the variable *stripe_params*. According to *stripe_params*, the *stripe* motor is allowed to be at 300 if *theta* is between 0 and 5, or it is allowed to be at 600 if *theta* is between 4.5 and 8.5, and so forth. If *theta* moves outside the allowed range of positions for the current selection, the option selector will switch to the next selection.

Notice that the allowed ranges for *theta* overlap. This is to provide a deadband for switches between option selector ranges. As an example, suppose *theta* is currently at 7 degrees. This means that *theta* is within the second option selector range of 4.5 to 8.5 degrees and that the *stripe* motor should currently be at 600. However, if *theta* is moved to 9 degrees, this is outside the current option selector range, so *stripe* will be moved to the next allowed position of 900. However, the lower end of the new range, namely, 8 degrees, is below the upper end of the original range, namely, 8.5 degrees. This means that *theta* must be moved below 8 degrees before the *stripe* position will be moved back to the previous value of 600.

Note that if *theta* is below 0 degrees, the *stripe* motor will be sent to 300, while if *theta* is above 15 degrees, the *stripe* motor will be moved to 1200.

Bugs

The MX database for the monochromator pseudomotor system has turned out to be much more complex to set up than I had originally wanted. It is my intention to revise this pseudomotor to be easier to configure, but I have no time estimate as to when that will happen.

Some of the dependencies are user configurable via the parameters record while others are configured via additional records added to the record list.

10.3.10 Q Motor

This is an MX pseudomotor driver for the momentum transfer parameter q, which is defined as

$$q = \frac{4\pi \sin(\theta)}{\lambda} = \frac{2\pi}{d}$$

where λ is the wavelength of the incident X-ray, θ is the Bragg angle for the analyzer arm and d is the effective crystal d-spacing that is currently being probed.

Warning: θ above must not be set to the angle of the analyzer arm. Instead, it must be set to half of that angle which is the nominal Bragg angle.

10.3.11 Record Field Motor

10.3.12 Segmented Move

10.3.13 Slit Motor

slit_type field - This integer field select the type of slit pseudomotor that this record represents. There are four possible values for the *slit_type* field, which come in two groups of two, namely, the SAME case and the OPPOSITE case. The allowed values are:

- 1 - *(MXF_SLIT_CENTER_SAME)*
- 2 - *(MXF_SLIT_WIDTH_SAME)*
- 3 - *(MXF_SLIT_CENTER_OPPOSITE)*
- 4 - *(MXF_SLIT_WIDTH_OPPOSITE)*

The SAME cases above are for slit blade pairs that move in the same physical direction when they are both commanded to perform moves of the same sign. The OPPOSITE cases are for slit blade pairs that move in the opposite direction from each other when they are both commanded to perform moves of the same sign.

As an example, for a top and bottom slit blade pair, if a positive move of each causes both blades to go up, you use the SAME case. On the other hand, if a positive move of each causes the top slit blade to go up and the bottom slit blade to go down, you use the OPPOSITE case.

10.3.14 Table Motor

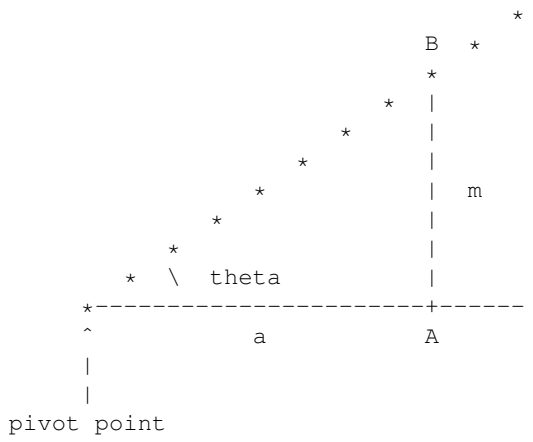
10.3.15 Tangent Arm/Sine Arm

This is an MX motor driver to move a tangent arm or sine arm pseudomotor.

IMPORTANT: The moving motor position and the arm length must both be specified using the *same* user units, while the angle offset must be specified in radians. Thus, if the moving motor position is specified in micrometers, then the arm length must be specified in micrometers as well.

If you want to specify the angle offset in degrees rather than in radians, the simplest way is to create a 'translation_mtr' record containing only the raw angle offset motor. Then, set a scale factor in the translation motor record that converts from radians to degrees.

A tangent arm consists of two arms that are connected at a pivot point as follows:

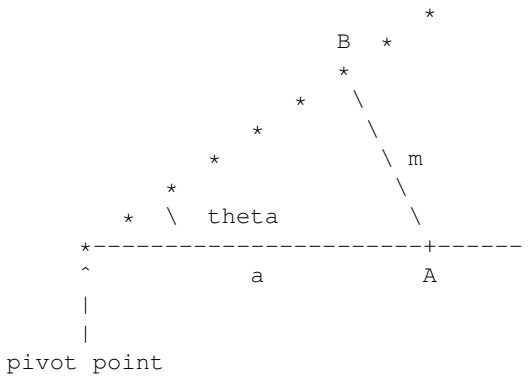


A linear motor is attached to the fixed arm at point A and then moves a push rod that pushes the moving arm at point B. In this geometry, the position of the moving motor, m, is related to the angle theta by the relationship

$$\tan(\theta) = \frac{m}{a}$$

where a is the distance of the motor on the arm it is attached to from the pivot point. The important consideration here is that the linear motion is perpendicular to the fixed arm.

A sine arm is similar except that the linear motion is now perpendicular to the moving arm:



This changes the equation to the form

$$\sin(\theta) = \frac{m}{a}$$

hence the name "sine arm".

Note: The 'tangent_arm' and 'sine_arm' drivers share the same code and distinguished in the driver code by their different driver types, namely, MXT_MTR_TANGENT_ARM and MXT_MTR_SINE_ARM.

10.3.16 Theta-Two Theta

10.3.17 Translation

10.3.18 Wavelength

10.3.19 Wavenumber

10.3.20 XAFS Wavenumber

This MX pseudomotor driver controls another MX motor in units of XAFS electron wavenumber.

The XAFS electron wavenumber k is computed using the equation:

$$E_{photon} = E_{edge} + \frac{\hbar^2 k^2}{2m_{electron}}$$

Chapter 11

Multichannel Analog Input

11.1 Keithley 2700

11.2 Oxford Danfysik QBPM

Chapter 12

Multichannel Analyzers

12.1 EPICS MCA

12.2 Network MCA

12.3 Ortec UMCBI (Trump)

12.4 Röntec RCL-22 MCA

12.5 Soft MCA

12.6 X-Ray Instrumentation Associates (XIA)

12.7 MCA Associated Records

12.7.1 MCA Alternate Time

12.7.2 MCA Channel

12.7.3 MCA Region of Interest Integral

12.7.4 MCA Value

Chapter 13

Multichannel Encoders

Chapter 14

Multichannel Scalers

14.1 EPICS MCS

The MX EPICS MCS support optionally can make use of globally visible dark current values. This is done by loading an additional EPICS analog output record per MCS channel which is used to store the dark current value. This is most easily described by giving an example.

Suppose you have a set of MCS records loaded in the EPICS "st.cmd" script that look like

```
dbLoadRecords("mcaApp/Db/mca.db","P=s10id:,M=mcs1,CARD=0,SIGNAL=0,DTYPE=Struck STR7201 MCS,NCHAN=2000
dbLoadRecords("mcaApp/Db/mca.db","P=s10id:,M=mcs2,CARD=0,SIGNAL=1,DTYPE=Struck STR7201 MCS,NCHAN=2000
dbLoadRecords("mcaApp/Db/mca.db","P=s10id:,M=mcs3,CARD=0,SIGNAL=2,DTYPE=Struck STR7201 MCS,NCHAN=2000
dbLoadRecords("mcaApp/Db/mca.db","P=s10id:,M=mcs4,CARD=0,SIGNAL=3,DTYPE=Struck STR7201 MCS,NCHAN=2000
```

Then, all that you need to add to support dark currents for these channels is to add something like the following lines to "st.cmd".

```
dbLoadRecords("iocBoot/ioc1/mcs_dark.db","P=s10id:,M=mcs1", top)
dbLoadRecords("iocBoot/ioc1/mcs_dark.db","P=s10id:,M=mcs2", top)
dbLoadRecords("iocBoot/ioc1/mcs_dark.db","P=s10id:,M=mcs3", top)
dbLoadRecords("iocBoot/ioc1/mcs_dark.db","P=s10id:,M=mcs4", top)
```

The *mcs_dark.db* database file is extremely simple. The entire contents of the file is:

```
grecord(ao,"$(P)$(M)_Dark") {
        field(PREC,"3")
}
```

A copy of this file may be found in the MX base source distribution in the file *mx/driver_info/epics_mcs/mcs_dark.db*.

14.2 Network MCS

14.3 Radix Databox MCS

14.4 Scaler Function MCS

14.5 SIS3801

14.6 Soft MCS

14.7 X-ray Instrumentation Associates MCS

Chapter 15

Pan-Tilt-Zoom Controllers

Chapter 16

Pulse Generator

16.1 Network Pulse Generator

16.2 Prairie Digital Model 45 Pulse Generator

16.3 Struck SIS3801

16.4 Struck SIS3807

Chapter 17

Relays

Chapter 18

Sample Changers

18.1 Network

18.2 Sercat ALS Robot

Chapter 19

Single Channel Analyzers

19.1 Network SCA

19.2 Oxford Danfysik Cyberstar X1000

19.3 Soft SCA

Chapter 20

Video Input Devices

20.1 EPIX XCLIB

20.2 Network Video Input

20.3 Soft Video Input

20.4 Video4Linux 2

Chapter 21

CAMAC

21.1 DSP6001

21.2 ESONE

21.3 Soft CAMAC

Chapter 22

Camera Link

22.1 Camera Link API

22.2 EPIX Camera Link

22.3 Soft Camera Link

Chapter 23

GPIB

23.1 EPICS GPIB

23.2 Iotech Micro488EX GPIB

23.3 Keithley 500-SERIAL

23.4 Linux GPIB

23.5 Linux Lab Project GPIB

Warning: This MX driver was originally developed for the Linux 2.0.x device driver provided by the Linux Lab Project, but that project seems to have stalled. Fortunately, the code seems to have been picked up by the Linux GPIB Package Homepage *(http://linux-gpib.sourceforge.net/)* which supports Linux 2.4.x. However, this MX driver has not yet been tested with the new Linux 2.4.x version of the device driver.

The Linux Lab Project GPIB driver does not provide an equivalent to the ibdev() function that finds a GPIB device by address. That makes the Linux Lab Project driver the only one that does not provide such an interface, so it is easier just to provide one for it. This is handled by adding to */etc/gpib.conf* the contents of the file *mx/driver_info/llp_gpib/gpib.conf_addon* from the MX base source distribution, so that there is a way to find a given GPIB device by its primary address. The contents of the file *gpib.conf_addon* is shown in the following figure:

23.6 National Instruments GPIB

23.7 Network GPIB

```
/* Devices for use with the MX Linux GPIB driver. */

device { name = gpib0.1     pad=1    sad=0 }
device { name = gpib0.2     pad=2    sad=0 }
device { name = gpib0.3     pad=3    sad=0 }
device { name = gpib0.4     pad=4    sad=0 }
device { name = gpib0.5     pad=5    sad=0 }
device { name = gpib0.6     pad=6    sad=0 }
device { name = gpib0.7     pad=7    sad=0 }
device { name = gpib0.8     pad=8    sad=0 }
device { name = gpib0.9     pad=9    sad=0 }
device { name = gpib0.10    pad=10   sad=0 }
device { name = gpib0.11    pad=11   sad=0 }
device { name = gpib0.12    pad=12   sad=0 }
device { name = gpib0.13    pad=13   sad=0 }
device { name = gpib0.14    pad=14   sad=0 }
device { name = gpib0.15    pad=15   sad=0 }
device { name = gpib0.16    pad=16   sad=0 }
device { name = gpib0.17    pad=17   sad=0 }
device { name = gpib0.18    pad=18   sad=0 }
device { name = gpib0.19    pad=19   sad=0 }
device { name = gpib0.20    pad=20   sad=0 }
device { name = gpib0.21    pad=21   sad=0 }
device { name = gpib0.22    pad=22   sad=0 }
device { name = gpib0.23    pad=23   sad=0 }
device { name = gpib0.24    pad=24   sad=0 }
device { name = gpib0.25    pad=25   sad=0 }
device { name = gpib0.26    pad=26   sad=0 }
device { name = gpib0.27    pad=27   sad=0 }
device { name = gpib0.28    pad=28   sad=0 }
device { name = gpib0.29    pad=29   sad=0 }
device { name = gpib0.30    pad=30   sad=0 }
device { name = gpib0.31    pad=31   sad=0 }
```

Figure 23.1: *gpib.conf_addon* for the MX Linux Lab Project GPIB driver

Chapter 24

MODBUS

24.1 MODBUS Serial RTU

24.2 MODBUS/TCP

Chapter 25

Port I/O

25.1 DriverLINX Port I/O

This MX driver is an interface to the DriverLINX port I/O driver for Windows NT/98/95 written by Scientific Software Tools, Inc. The DriverLINX package may be downloaded from http://www.sstnet.com/dnload/dnload.htm. This driver is primarily intended for use under Windows NT, since the 'dos_portio' driver already handles Windows 98/95, but it should work on all three operating systems.

Warning: These drivers have not yet been tested with Windows 2000 or Windows XP.

25.2 MSDOS Port I/O

25.3 Linux iopl() and ioperm() drivers

25.4 Linux portio driver

25.5 VxWorks Port I/O

Chapter 26

RS-232

Chapter 27

USB

27.1 Libusb

Chapter 28

VME

Chapter 29

Variables

29.1 EPICS Variables

29.2 Inline Variables

29.3 Network Variables

29.4 PMAC Variables

29.5 Spec Variables

29.6 Calculation Variables

29.6.1 APS Topup Time to Inject

29.6.2 APS Topup Interlock

29.6.3 Mathop Variables

29.6.4 Polynomial

29.6.5 Position Select

Chapter 30

Servers

30.1 TCP/IP Servers

30.2 Unix Domain Socket Servers

Chapter 31

Scans

31.1 Linear Scans

31.1.1 Input Scans

31.1.2 Motor Scans

31.1.3 Pseudomotor Scans

31.1.4 Slit Scans

31.1.5 Theta-Two Theta Scans

31.2 List Scans

31.2.1 File List Scans

31.3 XAFS Scans

31.4 Quick Scans *(also known as Fast or Slew Scans)*

31.4.1 Joerger Quick Scans

31.4.2 MCS Quick Scans

Chapter 32

Interfaces to Other Control Systems