XD-M Datasheet

Xeryon Multi-axis Driver (XD-M)
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1. Introduction

The XD-M provides a complete solution for controlling multiple Xeryon stages, in particular Xeryon's XLS and XRT-U stages, and more in general ultrasonic stages. The controller reads the stage's integrated encoders, generates and amplifies the driving signals and communicates with a host controller or PC through a simple ASCII protocol. The driver comes with a user-friendly Windows interface and LabVIEW driver to steer the stage in open and closed loop. Important steering parameters can be tuned digitally via the user interface.

Specifications:

Size:	160 x 165 x 53 mm
Power supply:	15 V DC
Piezo signals:	0 – 48V (0 – 30 kHz)
Stages:	2 or more
Control:	Open and closed loop
Serial communication:	COM via micro-USB-B 2.0

The driver is delivered with a power adapter, USB cable and USB-stick with software to control the piezo stage.

2. Inputs & outputs

On the XD-M driver, following in- and outputs can be found on the front and back panel:

Front panel	
No IO	
Back panel	
Power supply	DC power jack 6-15 V DC
Multiple stage connectors	D-sub HD 15 (female) Contains power supply for the encoder, encoder signals and piezo signals.
Virtual COM-port	USB-B 2.0 port
Optional RS-232	D-Sub 9 (female)
Optional GPIO	D-sub 15 (female)

Each axis is provided with a D-sub HD15 connector comprising the piezo signals and encoder signals of a particular axis. The encoder supply voltage can be set individually for each axis, with choice between 3.3 and 5 V (internal jumper). The default voltage is 5 V.

The piezo drive signals have an amplitude of 30 Vpp and frequency range between 0 and 300 kHz, sufficient to drive Xeryon's ultrasonic linear and rotary stages.

- **Pin layout for the stage connectors (D-sub 15 HD female)**
  All stage connectors have identical pin layouts.

PIN #	SIGNAL	PIN #	SIGNAL
1	/	9	Encoder error *
2	Encoder power (5V)	10	Ground piezo 1 & 2
3	Encoder ground	11	Encoder index - *
4	Piezo 2	12	Encoder A - *
5	Piezo 1	13	Encoder B - *
6	Encoder index +	14	/
7	Encoder A +	15	/
8	Encoder B +		

* The encoder in the XRT-U rotary stage is single ended and has thus no I - / A - / B - signal. Neither has the XRT-U an encoder error signal.

Warning: Do not open the driver. In case of a damaged connector or cable, please contact Xeryon for repair or replacement.

3. Communication

A host computer or controller can communicate with the XD-M via the USB configured as a virtual COM port, or via dedicated UART pins on the headers (on the PCB). The baudrate is automatically detected by the driver and can be up to 230400 baud. The protocol uses 8 data bits, 1 stop bit, no parity bit, no handshaking.

Format

A command line consists of maximally 16 characters followed by a 'new line' character (ASCII code 10). The command has the following format:

X:DPOS=-12345678

- 1 character defining the axis, followed by a colon.
- 4 characters for the command.
- '=' sign separating the command from the corresponding value.
- Optional sign.
- Decimal value of 8 decimal places (9 if the sign is omitted).
- Maximum total of 16 characters.

The characters have to be sent from left to right, in the example above starting with 'X' and ending with '8'. The command tags are in upper case. The instruction should be terminated with a 'new line' character (ASCII code 10). The driver processes the instruction immediately after receiving this 'new line' character.

Some instructions such as 'ZERO' and 'RSET' require no value. In that case, it is sufficient to send only the command itself, e.g. 'ZERO' followed by the 'new line' character.

Addressing axes

To address an axis, put the axis name (1 letter followed by a colon) before the command. When no axis is specified, the command goes to the first axis (stage 1). In case of a single-axis system, no axis designation is required.

Multiple-axis system:

- Y:DPOS=-1000 -> positioning of the Y-axis only.
- DPOS=0 -> first axis is sent to its zero-coordinate.
- RSET -> reset the X-axis driver
- Y:RSET -> reset the Y-axis driver

Single-axis system:

- DPOS=-1000

Values

There are 9 characters reserved for the value including its sign. For signed values 8 decimal places are available, giving a range from -99 999 999 to +99 999 999. For positive numbers, the '+' sign can be

omitted, increasing the positive range to 999 999 999. No spaces, commas or periods should be added to the numbers. Only integers are allowed.

- X:DPOS=-99999999
- X:DPOS=+99999999
- X:DPOS=999999999

Units are as follows:

Type	Rotation stage	Translation stage	Resolution
Time, delays	ms		1 ms
Target position, step size	encoder units		1 encoder increment
Speed	deg/s (*)	µm/s	0.01 deg/s or 1 µm/s
Frequency	Hz		1 Hz

(*) Conversion factor of 100 required: e.g. enter SSPD=10000 for 100 deg/s.

Instruction set

Command	Range	Mode	Explanation
RSET	-	-	Reset the driver. All piezo signals go to zero and settings are set to their default value.
INDX	-	-	Find the index. After finding the index, go to the index position.
HOME	-	Closed loop	Go to the home position.
DPOS	24 bits	Closed loop	Set target position. Closed-loop control is used to reach and maintain the new position. The position is expressed in encoder units. Positive and negative values are allowed within the range of the stage.
STEP	24 bits	Closed loop	Move relative to the current position, over a specified distance. When already in closed loop, the current desired position is used as a reference. When in open loop, the actual position (encoder value) is used as a reference. The command value specifies the step size in encoder increments. Positive values send the stage towards higher encoder values, negative values send the stage towards lower encoder values. Closed-loop control is used to reach and maintain the new position.
MOVE	-1,0,1	Open loop	Continuously move in open loop. Phase and duty factor influence the speed, but speed is not controlled. A positive number sends the stage towards increasing encoder values, a negative number sends the stage towards decreasing encoder values. A zero value stops the stage.
SCAN	-1,0,1	Closed loop	Continuously move with fixed speed. The speed is maintained by closed-loop control. A positive number sends the stage towards increasing encoder values, a negative

			number sends the stage towards decreasing encoder values. A zero value stops the stage.
STOP	-	Open and closed loop	Stop the stage.
CONT	-	Open and closed loop	Continue movement after a stop command.
LLIM	24 bits	Open and closed loop	Set low-side soft end stop. Expressed in encoder units.
HLIM	24 bits	Open and closed loop	Set high-side soft end stop. Expressed in encoder units.
ZERO	-	Open & closed loop	Force the piezo signals to zero volt.
SSPD	24 bit	Closed loop	Set speed. Used as scanning speed (SCAN command) and as target speed towards the next target position (DPOS and STEP). Unit is 1 µm/s. Default: 10000 (10 mm/s).
PHAS	16 bit	Open loop	Set the phase offset between the excitation signals. Can be used to control the speed in open loop. Input values 0-65535 correspond to a phase shift of 0-360°. Below 32768 (180°) the phase corresponds with a MOVE=1 direction, above 32768 it corresponds to a MOVE=-1 direction.
DUTY	16 bit	Open loop	Set the duty factor of the excitation signals: width of the pulses. This instruction can be used to reduce the driving force and speed of the motor. Values 0-32767. 0: pulse width 50%, 32767: pulse width 0 %. Default: 0.
DUCO	1 bit	Closed loop	A duty factor is used in closed loop if set to 1. If set to 0, a fixed duty factor of 50% is used. Default: 1.
FREQ	24 bits	Open and closed loop	Set the frequency of the excitation signals. Unit is Hz. Default: 166000 (Hz).
PROP	16 bits	Closed loop	The phase and duty factor of the excitation signals are varied in proportion to this factor and the position error. Default: 7.
CFRQ	16 bits	Closed loop	Control frequency. Adapt this value to obtain stable closed-loop control. The optimal control frequency depends on the mass or inertia of the load. Default: 3000 (for zero load).
ELIM	20 bits	Closed loop	Limit on the position error used in closed-loop control. Expressed in encoder units. Default: 10000.
PTOL	16 bits	Closed loop	Position tolerance. Values are expressed in encoder units and should be in the range 0 – 32767. The range is applied symmetrically with respect to positive and negative position errors. e.g. PTOL=2 allows position errors between -2 and +2 encoder units. Small vibrations around the desired position can be suppressed by use of the position tolerance and timeout. Default: 5. See TOUT for more detail.

MTOL	16 bits	Closed loop	Maximum position tolerance. Values are expressed in encoder units and should be in the range 0 – 32767. See also PTOL and RTOL. Default: 10.
RTOL	16 bits	Closed loop	Growth rate of position tolerance. This is the rate at which the position tolerance grows. When a new target position is specified, the position tolerance starts with value PTOL. When the stage is within +/- PTOL range but has not yet settled, the position tolerance is steadily grown to make it easier for the stage to settle. The position tolerance grows until it reaches MTOL. RTOL is expressed in encoder units/s. RTOL and MTOL allow the use of smaller values for PTOL without the risk that the target position cannot be reached in a stable manner (stage keeps vibrating around the target). Default: 1 encoder unit/s.
TOUT	16 bits	Closed loop	Set timeout time. Small vibrations around the desired position can be suppressed by use of the position tolerance and timeout. When the stage is within +/- position tolerance of the desired position for a period set by timeout time, then the control is switched off. The time is expressed in milliseconds. The default value is 50 (50 ms). Also check PTOL.
DLAY	16 bit	Closed loop	Sets the delay between the moment the stage reaches its target position and the moment the 'position reached' flag is raised. Expressed in milliseconds. Default: 100 (100 ms).
ENCD	1 bit	Open and closed loop	Set the encoder direction. Set the counting direction with respect to the A/B signals of the incremental A-quad-B encoders. Flip this bit to swap left and right, or clockwise and counter-clockwise. Default value is 0.
ACTD	1 bit	Open and closed loop	Set the actuation direction. If not set correctly, the stage will move away from the desired position. Default value is 0.
PATH	1 bit	Closed loop	For rotation stages only. Selects whether the stage will follow the shortest path (PATH=1) to the target position or follow a linear approach, respecting high to low or low to high (PATH=0).
INFO	4 bits		Select type of info to be transmitted from the driver to the master (PC). 0: Stop broadcasting info 1: SRNO, SOFT, STAT, SYNC 2: SRNO, SOFT, STAT, SYNC, EPOS, DPOS, TIME 3: EPOS, DPOS, STAT 4: EPOS, DPOS, TIME 5: same as 2 6: same as 2 7: EPOS, STAT (default) e.g. INFO=7 will alternatingly send EPOS & STAT values.

Info sent back from the XD-M

Information is sent back from the XD-M to the master (PC) in ASCII format. The format is as follows:

1. One character identifying the axis, followed by a colon.
2. Four characters describing the type of information
3. '=' sign separating the command from the corresponding value
4. Signed value associated with that information (sign + 8 decimal places). The message is terminated with a 'new line' character (ASCII code 10).

e.g. X:EPOS=+12345678

The different types of information:

Command	Explanation
SRNO	Serial number of the driver (hardware)
SOFT	Software version installed on the driver. e.g. 20103 -> 2.1.3
STAT	Status (see below)
SYNC	Fixed value "12345678". Can be used for debugging communication issues.
EPOS	Encoder position.
DPOS	Desired position.
TIME	Time stamp
ROTS	Rotation counter.

The command INFO determines which information is sent back. First, all selected info is sent for the first axis, then all selected info for the second axis, and so on. After reporting the last axis, the driver switches automatically to the first axis.

The status word contains 24 bits:

Status bit	Name	Explanation
0	-	Always 1
1	-	Always 1
2	-	Always 0
3	-	Always 0
4	Force zero	Indicates whether the driving signals to the motor are currently forced to zero.
5	Motor on	Indicates whether the motor is on.
6	Closed loop	Indicates whether the motor is currently in closed loop control.
7	Encoder index	Indicates whether the stage is positioned exactly at the encoder indices.
8	Encoder valid	Indicates whether the encoder index has been passed and therefore the encoder value reflects the absolute position, not the relative position with respect to the startup position.
9	Searching index	Indicates whether the stage is currently searching the index position.
10	Position reached	Indicates whether the target position is reached (within tolerance limits).
11	-	Always 0
12	Encoder error	Indicates an error produced by the encoder.
13	Scanning	Indicates whether the stage is in a scanning mode.
14	Left end stop	Indicates that the left end stop is passed.

15	Right end stop	Indicates that the right end stop is passed.
16	Error limit	Indicates that the position error has reached the limit set by ELIM. This can indicate a collision or mechanical limit (end of stroke).
17-24	-	Not used

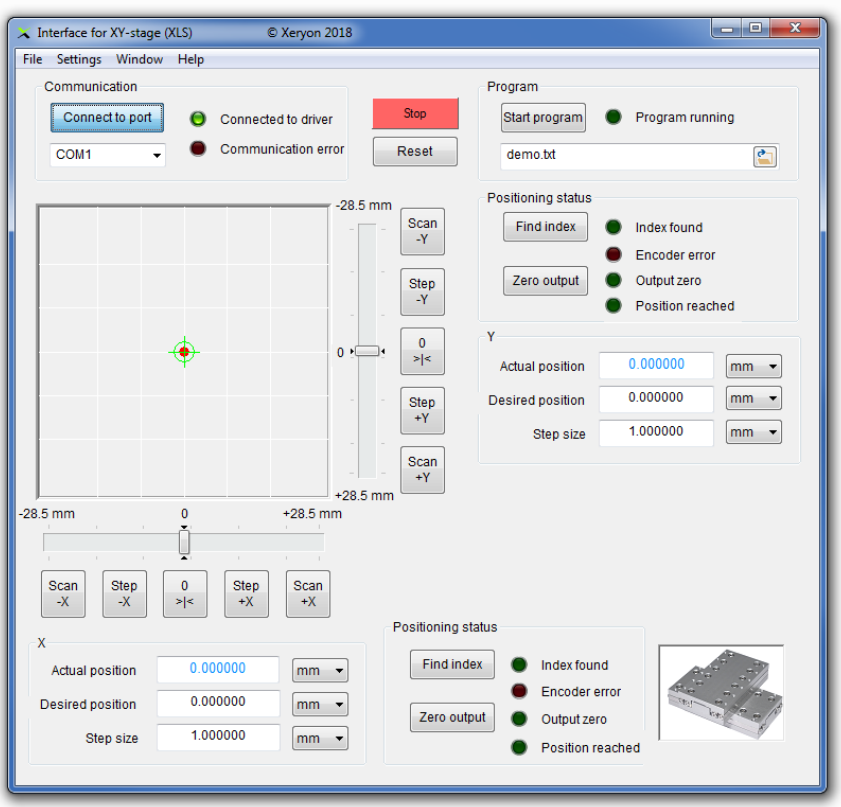
Visual feedback

The on-off button has integrated LEDs that light up when the driver is powered on.

4. User interface

To provide the user with a quick way to interact with the driver and the connected stage, a user interface is delivered with the XD-M. This interface comes in several variants depending on the type and number of axes. An example for an XY-stage is shown below. The use is simple and self-explanatory. It can be used for manual input and to run simple programs. More information regarding this user interface is given in the user manual of the stage.
This user interface is not intended for interaction with other programs written in C, Labview, Matlab, etc. These programs should directly interact with the driver via the protocol described above. On request, C++ or Labview code is provided to ease interfacing.

Remark: before one can use the user interface "Xeryon_Dialog.exe", one has to install the driver installation files. Copy the "xd-c.inf" and "xd_c_win.cat" files from the USB-stick to a folder on your hard disk, preferably in the same folder as the user interface "Xeryon_Dialog.exe" file. Don't install the driver installation files from a USB-stick or network disk. Then, when both driver installation files are copied to your hard disk, install the files by a right mouse click on "xd-c.inf" and choose "Install". The installation can take a while, please follow the next steps in the popup window. Reconnect the XD-M driver to your PC after installation of the driver installation files. Now, you are ready to open and use the user interface "Xeryon_Dialog.exe".



Files

The User Interface makes use of the following files:

- The executable of the User Interface: Xeryon_Dialog.exe
- A configuration file named “config.txt”. This file should not be edited by the user.
- A default settings file named “settings_default.txt”. The User Interface reads this file for initial settings at start up. Replace or modify this file to alter the default settings.
- A settings file named “settings_user.txt”. The user can save and load alternative settings files via the menu. The filename is free to choose, but the file dialog window presents “settings_user.txt” as default filename.
- Several program files for which the name and content can be freely chosen. The file dialog window presents “demo.txt” as default filename.

config.txt and settings_default.txt are required files and have to be in the same folder as Xeryon_Dialog.exe.

The settings file and program files are composed of the same commands that are used to directly talk to the XD-M (see paragraph 3). An important difference is that the User Interface uses position data in degrees, millimetre etc., while encoder units have to be used when talking directly to the XD-M. The conversion is automatically made by the User Interface. Similar conversions are made for speed (deg/s or mm/s). A few additional commands exist that affect the program flow and connection. With the exception of “MASS”, these are not axis specific.

Command	Explanation
BAUD	Set the baudrate for communication.
DPOL	Delay used when polling for a ‘position reached’ signal after a new target position is set. When DPOL is too small, the Windows Interface may trigger on the ‘position reached’ status flag of the previous target position due to communication delay. In that case, a succeeding WAIT command will start the timer at the start of the movement instead of after the target has been reached.
HELP	Switch help on or off. HELP=1 switches the info tips on. HELP=0 switches the info tips off.
HALT	Stop the program. (Not to be confused by the STOP command for the driver.)
LOG	Start or stop logging of data. LOG=1 switches logging on. LOG=0 switched logging off. Data is stored in datalog.csv. When datalog.csv already exists, new data is appended.
MASS	Specifies the mass/inertia of the load on the stage. The User Interface calculates the optimal control parameters to obtain stable operation.
PORT	Default port number to appear in the User Interface.
REPT	Repeat the above program a specified number of times. The program jumps to the first line.
WAIT	Wait a specified time before proceeding to the next command. Time expressed in milliseconds. When WAIT follows a STEP or DPOS command, the timer is started when reaching the target position.

Comment text should be preceded by a percentage sign.

Example settings file (settings_default.txt)

```
BAUD=115200  % Baudrate 115200
PORT=8       % Select COM-port 8 as default
INFO=2       % Select info, identical for all axes
X:ENCD=0     % Encoder direction for X-axis
Y:ENCD=1     % Encoder direction for Y-axis
X:FREQ=167000 % Piezo excitation frequency for X-axis
Y:FREQ=167000 % Piezo excitation frequency for Y-axis
X:SSPD=10    % Speed of X-axis
Y:SSPD=20    % Speed of Y-axis
X:PROP=3     % Proportional control factor for X-axis
Y:PROP=3     % Proportional control factor for Y-axis
X:LLIM=-28   % Lower position limit for X-axis
X:HLIM=28    % Upper position limit for X-axis
Y:LLIM=-28   % Lower position limit for Y-axis
Y:HLIM=28    % Upper position limit for Y-axis
X:MASS=100   % Load on X-axis
Y:MASS=50    % Load on Y-axis
X:PTOL=3     % Positioning tolerance in X-direction
Y:PTOL=5     % Positioning tolerance in Y-direction
```

Example program file (demo.txt)

```
Y:DPOS=-500  % Move to Y=-500
X:DPOS=-500  % Move to X=-500
WAIT=5000    % Wait 5 seconds
X:DPOS=0
WAIT=2000
X:DPOS=500
WAIT=2000

Y:DPOS=0
WAIT=2000
X:DPOS=0
WAIT=2000
X:DPOS=-500
WAIT=2000

Y:DPOS=500
WAIT=2000
X:DPOS=0
WAIT=2000
X:DPOS=500
WAIT=2000

REPT=3       % Repeat 3 times the code above
X:DPOS=0     % Finish in the centre
Y:DPOS=0     % Finish in the centre
```

5. Customer service

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