X3 RS232 Communication User Guide

Version 1.2

1.1 General

This document describes how to talk to the X3 MEMS Digital inclinometer using the RS232 serial interface. It explains the X3 RS232 command set so that a serial device such as a PLC or microcontroller can talk to the X3 using the RS232 serial bus. In addition to the ability to talk to the X3 directly, US Digital provides a DLL, demo, and user configuration utility software to run on a PC using Windows. The DLL allows the user to talk to the X3 using higher level functions to save development time. See the **X3 DLL User** Guide and the **X3 datasheet** for other related documents.

The following section describes the low level RS232 communication between an X3 and the host computer.

- The RS-232 serial port has a configurable baud rate, 8 data bits, and no parity.
- The X3 does not initiate transmission.
- The X3 simply responds to host commands.
- The X3 responds within 1.6 milliseconds for all “Get” or “Read” commands and within 23 milliseconds for all “Set” or “Write” commands. At 115200 baud rate, the total transaction time for all “Get” or “Read” commands is approximately 4 milliseconds and 25 milliseconds for “Set” or “Write” commands.
- Each command sent by the host must be completed within 500 milliseconds; otherwise, the X3 will discard the partial command.
- Byte order is Big Endian (most significant byte first).
- Serial communication uses binary mode, not ASCII.
- Unless otherwise specified, all values use 2’s complement numbers.
- Each command includes an address byte to provide the ability to address multiple devices in the future. For the present, even though the current version of the X3 ignores the value of the address byte, it should be set to zero to reserve the addressing ability in the future.
- All “Set” commands return a status byte along with a checksum.
- Checksum
    - A single byte checksum is appended to all responses from the X3. The user can use or ignore the checksum.
    - The checksum is the lowest byte of the 2’s complement of the sum of all bytes in the message except the checksum. That means that the sum of all bytes in the message plus the checksum is zero.
    - To verify data integrity, simply sum all the response bytes including the checksum and verify that the sum is equal to zero.
    - “Get” commands (commands that read values from the X3) do not use a checksum. However, to ensure that X3 configuration parameters cannot be changed by accident, all “Set” commands (commands that change X3 parameters) require a check sum to be sent from the host as the last byte.

1.2 User commands - Overview

Angles are reported in degrees multiplied by 1000 since the user provides the decimal point. Example: 89999 means 89.999 degrees.

Temperatures are reported in degrees C multiplied by 100 since the user provides the decimal point. Example: 2499 means 24.99 degrees C.

X3 axes are numbered 0, 1, 2 (relative zero).

Accelerometer values are reported in Gs multiplied by 102,300 since the user provides the decimal point. Example: 51,150 means 0.5 Gs.

All commands in this document are sent from the host to the X3.

All "Set" commands except for Set Output change the X3 modes or parameters. The X3 saves them in non-volatile memory before responding with a successful status. The possible status byte values are as follows:

Status Value	Description
0x00	Success
0x01	Invalid command
0x02	Reserved
0x03	Invalid parameter
0x04	X3 received invalid checksum
0x05	Reserved
0x06	Reserved
0x07	Flash erase error
0x08	Flash program error

1.3 Get and Set Angles

There are three commands in this group.

1.3.1 Get All Angles

	Parameter	# bytes	Units	Notes
Command	address	1		0
	E1 (hex)	1		
Response	angle0	4	deg * 1000	* see angle range
	angle1	4		
	angle2	4		
	temperature	2	deg C * 100	-5000 to 19000
	checksum	1		

*angle range:
-180.000 to +179.999 if angle output mode = 0 (bidirectional)
0 to +359.999 if angle output mode = 1 (unidirectional)

Example:

```
Command:  (     00,      E1)
Notes:    (address, command)
Response: (00, 02, 7D, B2, FF, FF, 4E, F8, 00, 00, 4E, DE,    09, 6F,       E7)
Notes:    (angle0--------, angle1--------, angle2--------, degrees C, checksum)
```

Meaning:
angle0 value = 00027DB2 (hex) which equates to 163.250 degrees
angle1 value = FFFF4EF8 (hex) which equates to -45.320 degrees
angle2 value = 00004EDE (hex) which equates to 20.190 degrees
temperature = 096F (hex) which equates to 24.15 degrees
checksum = E7

Refer to X3User.dll function **X3_GetAllAngles** in the X3 DLL User Guide.

1.3.2 Get One Angle

	Parameter	# bytes	Units	Notes
Command	address	1		0
	E0 (hex)	1		
	axis	1		0,1,2
Response	angle	4	deg * 1000	* see angle range
	checksum	1		

*angle range:
-180.000 to +179.999 if angle output mode = 0 (bidirectional)
0 to +359.999 if angle output mode = 1 (unidirectional)

Example:

```
Command:   (     00,      E0,   01)
Notes:     (address, command, axis)
Response:  (00, 02, 37, 4e,       79)
Notes:     (angle1--------, checksum)
```

Meaning:
angle1 value = 0002374E (hex) which equates to 145.230 degrees
checksum = 79 (hex)

Refer to X3User.dll function **X3_GetAngle** in the X3 DLL User Guide.

1.3.3 Set One Angle

This command will calculate and save an angle offset so that the current position is reported as the specified angle. Be sure to wait the number milliseconds specified in the Set Damping command for the angle to stabilize.

	Parameter	# bytes	Units	Notes
Command	address	1		0
	C1 (hex)	1		
	axis	1		0, 1 or 2
	angle	4	deg * 1000	* see angle range (-360,000 to 359,999)
	checksum	1		
Response	status	1		0 = pass
	checksum	1		

*angle range:
-180.000 to +179.999 if angle output mode = 0 (bidirectional)
0 to +359.999 if angle output mode = 1 (unidirectional)

Example:

```
Command:   (     00,      C1,   01, 00, 00, 29, 04,       11)
Notes:     (address, command, axis, angle---------, checksum)
Response:  (    00,       00)
Notes:     (status, checksum)
```

Meaning:
angle value = 00002904 (hex) which equates to 10.500 degrees.
The current angle of axis 1 will be reported as 10.500 degrees.

Refer to X3User.dll function **X3_SetAngle** in the X3 DLL User Guide.

1.4 Angle Offsets

The user can specify an angle offset that the X3 will internally add to the angle before it gets reported it to the host.

reported angle = absolute angle + angle offset

The X3 will keep the reported angle within the valid range set by the Set Angle Output Range command.

The following two commands can be used to get or set offset values to the desired axis:

1.4.1 Get All Angle Offsets

	Parameter	# bytes	Units	Notes
Command	address	1		0
	EF (hex)	1		
Response	angle0 offset	4	deg * 1000	* see angle range The factory defaults are set to 0.
	angle1 offset	4		
	angle2 offset	4		
	checksum	1		

*angle range:
-180.000 to +179.999 if angle output mode = 0 (bidirectional)
0 to +359.999 if angle output mode = 1 (unidirectional)

Example:

```
Command:   (     00,      EF)
Notes:     (address, command)
Response:  (00, 00, 28, 0A, FF, FF, E4, 76, 00, 00, AF, C8,       FF)
Notes:     ( angle0 offset,  angle1 offset,  angle2 offset, checksum)
```

Meaning:
angle0 offset = 0000280A (hex) which equates to 10.250 degrees
angle1 offset = FFFFE476 (hex) which equates to -7.050 degrees
angle2 offset = 0000AFC8 (hex) which equates to 45.000 degrees

Refer to X3User.dll function **X3_GetAllAngleOffsets** in the X3 DLL User Guide.

1.4.2 Set One Angle Offset

The user can specify an angle offset that the X3 will internally add to the angle before it gets reported it to the host.

reported angle = absolute angle + angle offset

The X3 will keep the reported angle within the valid range set by the Set Angle Output Range command.

	Parameter	# bytes	Units	Notes
Command	address	1		0
	CF (hex)	1		
	axis	1		0, 1 or 2
	offset	4	deg * 1000	* see angle range (-360,000 to 359,999)
	checksum	1		
Response	status	1		0 = pass
	checksum	1		

*angle range:
-180.000 to +179.999 if angle output mode = 0 (bidirectional)
0 to +359.999 if angle output mode = 1 (unidirectional)

Example:

```
Command:   (     00,      CF,   01, FF, FF, CE, FA,       6A)
Notes:     (address, command, axis, offset--------, checksum)
Response:  (    00,       00)
Notes:     (status, checksum)
```

Meaning:
angle offset = FFFFCEFA (hex) which equates to -12.550 degrees.
Set angle offset of axis 1 to -12.550 degrees.

Refer to X3User.dll function **X3_SetAngleOffset** in the X3 DLL User Guide.

1.5 Read All Data

	Parameter	# bytes	Units	Range
Command	address	1		0
	0xA0	1		
Response	angle0	4	deg*1000	*see angle range
	angle1	4		
	angle2	4		
	temperature	2	deg C * 100	-4000 to 15000
	accel0	4	g * 102,300	±204,700 (averaged, uncalibrated)
	accel1	4		
	accel2	4		
	serial number	4		Unsigned number
	checksum	1		

*angle range:

-180,000 to 179,999 if angle output mode = 0 (signed)

0 to 360,000 if angle output mode = 1 (unsigned)

This is similar to the Read All Angles user command but adds the accelerometer outputs.

Note that the X3 will report raw un-calibrated averaged accelerometer values based on the damping time set in the Set Damping command.

Example:

```
Command:   (     00,      A0)
Notes:     (address, command)
Response:  (FF, FF, F9, 89, FF, FF, F8, 01, FF, FD, 73, 66,      0D, C1,
           00, 00, 02, 5C, 00, 00, 04, 28, FF, FE, 82, 25, 00, 00, 00, 01,
                 B7)
Notes:     (angle0--------, angle1--------, angle2--------, Temperature,
           accel0--------, accel1--------, accel2--------,  serial number,
           checksum)
```

Meaning:
angle0 value = FFFFF989 (hex) which equates to -1.655 degrees
angle1 value = FFFF4EF8 (hex) which equates to -2.047 degrees
angle2 value = FFFD7366 (hex) which equates to -167.066 degrees
temperature = 0DC1 (hex) which equates to 35.21 degrees
accel0 value = 0000025C (hex) which equates to 0.00590g.
accel1 value = 00000428 (hex) which equates to 0.01040g.
accel2 value = FFFE8225 (hex) which equates to -0.95557g.
serial number = 00000001 (hex) which equates to 1.

Refer to X3User.dll function **X3_GetAllData** in the X3 DLL User Guide.

1.6 Directions

Each X3 axis can be configured as normal or reversed direction. The following two commands can be used to get or set direction parameters of the desired axis (axes).

1.6.1 Get All Directions

	Parameter	# bytes	Units	Notes
Command	address	1		0
	E4 (hex)	1		
Response	direction0	1		0 = normal 1 = reversed The factory defaults are set to 0.
	direction1	1		
	direction2	1		
	checksum	1		

Example:

```
Command:   (     00,      E4)
Notes:     (address, command)
Response:  (        00,         01,         00,       FF)
Notes:     (direction0, direction1, direction2, checksum)
```

Meaning: The direction of axis 0 is normal, axis 1 is reversed, and axis 2 is normal.

Refer to X3User.dll function **X3_GetAllDirections** in the X3 DLL User Guide.

1.6.2 Set One Direction

	Parameter	# bytes	Units	Notes
Command	address	1		0
	C4 (hex)	1		
	axis	1		0, 1 or 2
	direction	1		0 = normal 1 = reversed
	checksum	1		
Response	status	1		0 = pass
	checksum	1		

Example:

```
Command:   (     00,      C4,   00,        01,       3B)
Notes:     (address, command, axis, direction, checksum)
Response:  (    00,       00)
Notes:     (Status, checksum)
```

Meaning: Set axis 0 to reversed direction.

Refer to X3User.dll function **X3_SetDirection** in the X3 DLL User Guide.

1.7 Damping

Electronic damping is achieved by averaging multiple samples together to improve accuracy and reduce noise. The longer the damping, the more positions are averaged together (more smoothing), the slower the response time, and the more stable the reported position. The number of samples per reported position can be calculated by the damping time divided by 1.56 milliseconds.

1.7.1 Get Damping

	Parameter	# bytes	Units	Notes
Command	address	1		0
	E6 (hex)	1		
Response	time	2	milliseconds	2 to 5,000. 0 = will report invalid parameter 1 = will cause all angles to report -90000 (-90 deg.) The factory default is set to 500.
	checksum	1		

Example:

```
Command:   (     00,      E6)
Notes:     (address, command)
Response:  (01, F4,       0B)
Notes:     (time--, checksum)
```

Meaning:
time = 01F4 (hex) which equates to 500 milliseconds.
The damping time is 500 milliseconds.

Refer to X3User.dll function **X3_GetDamping** in the X3 DLL User Guide.

1.7.2 Set Damping

	Parameter	# bytes	Units	Notes
Command	address	1		0
	C6 (hex)	1		
	time	2	milliseconds	2 to 5,000. 0 and 1 are reserved.
	checksum	1		
Response	status	1		0 = pass
	checksum	1		

Example:

```
Command:   (     00,      C6, 00, C8,       72)
Notes:     (address, command, time--, checksum)
Response:  (    00,       00)
Notes:     (status, checksum)
```

Meaning:
time = 00C8 (hex) which equates to 200 milliseconds.
Set the damping time to 200 milliseconds.

Refer to X3User.dll function **X3_SetDamping** in the X3 DLL User Guide.

1.8 Angle Output Range Setup

There are two commands in this group.

1.8.1 Get Angle Output Range

	Parameter	# bytes	Units	Notes
Command	address	1		0
	BD (hex)	1		
Response	angle range *	1		0 = range is -180.000 to 179.999 1 = range is 0.000 to 359.999 The factory default is set to 0.
	checksum	1		

*angle range:
-180.000 to +179.999 if angle output mode = 0 (bidirectional)
0 to +359.999 if angle output mode = 1 (unidirectional)

Example:

```
Command:   (     00,      BD)
Notes:     (address, command)
Response:  (         01,       FF)
Notes:     (angle range, checksum)
```

Meaning: The angle output range is set to = 1 (0 to +359.999).

Refer to X3User.dll function **X3_GetAngleOutputRange** in the X3 DLL User Guide.

1.8.2 Set Angle Output Range

	Parameter	# bytes	Units	Notes
Command	address	1		0
	AB (hex)	1		
	angle range *	1		0 = range is -180.000 to 179.999 1 = range is 0.000 to 359.999
	checksum	1		
Response	status	1		0 = pass
	checksum	1		

*angle range:
-180.000 to +179.999 if angle output mode = 0 (bidirectional)
0 to +359.999 if angle output mode = 1 (unidirectional)

Example:

```
Command:   (     00,      AB,          01,       54)
Notes:     (address, command, angle range, checksum)
Response:  (    00,       00)
Notes:     (status, checksum)
```

Meaning: Set the angle range to angle range = 1 (0.000 to 359.999).

Refer to X3User.dll function **X3_SetAngleOutputRange** in the X3 DLL User Guide.

1.9 Device Information

This function provides factory defined settings.

1.9.1 Get Device Information

	Parameter	# bytes	Units	Notes
Command	address	1		0
	E9 (hex)	1		
Response	serial number	4		Unsigned number
	firmware version	6		ASCII characters padded with spaces (not null terminated).
	product type	6		ASCII characters padded with spaces (not null terminated).
	calibration status	2		See table below
	checksum	1		

Calibration status description:

Bit	Description
0	set if axis 0 is calibrated
1	set if axis 1 is calibrated
2	set if axis 2 is calibrated
3	set if calibration is temperature compensated
4-15	reserved

Example:

```
Command:   (     00,      E9)
Notes:     (address, command)
Response: (00, 00, 30, 39, 31, 2E, 34, 32, 20, 20, 58, 33, 20, 20, 20, 20,
                 00,          0F,       78)
Notes:    (serial#-------, firmware version------, product type----------,
           reserved, cal. status, checksum)
```

Meaning: The current device has the following information
Serial number = 12345
Firmware version = 1.47
Product type = X3
Reserved (shown as 00)

Refer to X3User.dll function **X3_GetDeviceInfo** in the X3 DLL User Guide.

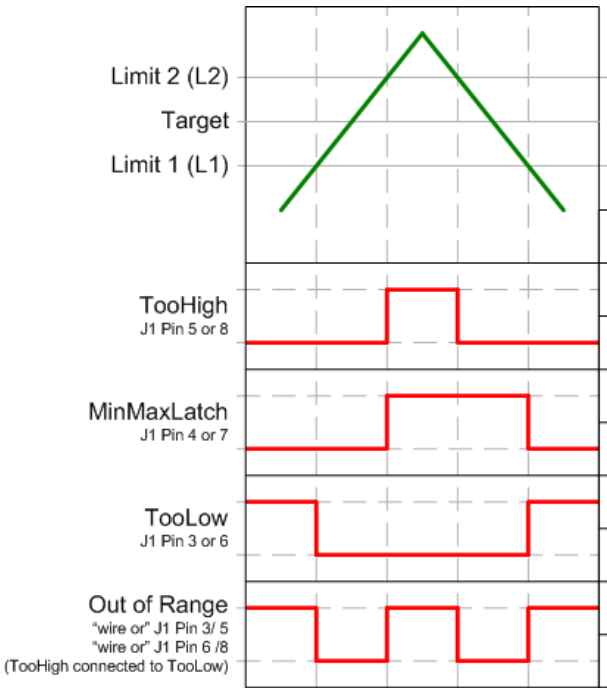
1.10 Output Configuration

The six output pins on the X3's J1 8-pin connector are divided into two groups of three pins (Group 0 – pins 3/4/5 and Group 1 – pins 6/7/8). Each group can be configured to function in four different modes (manual, quadrature, tilt, and PWM). Note that both output Groups do not have to be set to the same output mode. For example, Group 0 can be a tilt switch for axis 0 while Group 1 can be configured as a quadrature output for axis 1. It is also possible to have Group 0 and Group 1 set to the same axis, but with PWM output on one group and Quadrature output on another.

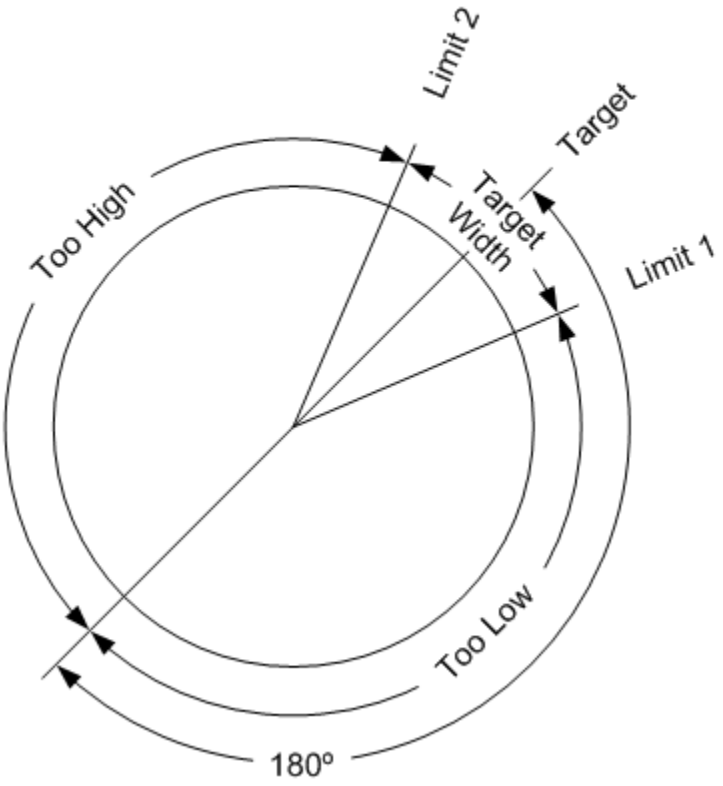
The "manual" mode allows the user to use the 6 output pins as an output port (see Get Output Bits and Set Output Bits commands).

The "quadrature" mode causes quadrature signals to be generated for a selected axis (each 3 bit group outputs A, B, index). Note that if both groups are in quadrature mode, the same CPR is used for both. The last CPR setting is used for both groups. The angle output range must be set to -180.000 to +179.999 (bidirectional) in this mode.

In "tilt switch" mode, each 3 bit group becomes an indicator for angles that are "Too High", "MinMaxLatch" or "Too Low". The angle output range must be set to -180.000 to +179.999 (bidirectional) in this mode.



LED	Output Voltage	MOSFET	Condition	Latched
ON	LOW	ON	> L2	No
OFF	HIGH	OFF	≤ L2	No
ON	LOW	ON	set by > L2	Yes
OFF	HIGH	OFF	reset by < L1	Yes
ON	LOW	ON	< L1	No
OFF	HIGH	OFF	≥ L1	No
-	LOW	ON	< L1 or > L2	No
-	HIGH	OFF	≥ L1 and ≤ L2	No



The tilt switch uses 2 parameters for each Group: target angle, and target width. Both angles are in increments of .001 degrees and in the range -180.000 to +179.999 degrees. The target width is the full angle range centered on the target angle. The behavior of each output is shown in the table below where:

Limit2 = Target + TargetWidth /2
Limit1 = Target - TargetWidth /2

Output Pin	Behavior of Output MOSFET
Too High	= ON if Current Angle is > Limit2 = OFF otherwise
Too Low	= ON if Current Angle is < Limit1 = OFF otherwise
MinMaxLatch	= ON if Current Angle is > Limit2. "MinMaxLatch" will remain ON until Current Angle < Limit1. = OFF if Current Angle is < Limit1. "MinMaxLatch" will remain OFF until Current Angle > Limit2.

Note that the tilt switch outputs will change whenever the above conditions are met. If the user writes a new offset to the angle without changing the Limit1/2 values, the tilt switch output may change unless the Target Angle and Target Width are also changed to match.
Consider an example where the Target angle = 45 deg, and the Target Width = 10 deg. This means that Limit2 = 45 deg + 5 deg = 50 deg and Limit1 = 45 deg – 5 deg. = 40 deg. As the X3 is rotated, the “Too Low” MOSFET will turn ON when the current angle is < 40 deg. The ”Too High” MOSFET will turn ON when the current angle is > 50 deg. The “MinMaxLatch” MOSFET will turn ON if the current angle is > 50 deg. It will remain ON until the current angle is < 40 deg. The “MinMaxLatch” MOSFET will turn OFF if the current angle is < 40 deg. It will remain OFF until the current angle is > 50 deg.

The PWM mode will output a PWM signal corresponding to the measured angle. The PWM frequency is specified by the mode byte. The angle output range must be set to -180.000 to +179.999 (bidirectional) in this mode. The duty cycle ranges from 12.5% (-180.00 deg) to 87.5% (+ 179.99). 50% duty corresponds to 0 deg. There are 36000 possible duty cycle values from 12.5% to 87.5%, so the PWM resolution is 0.01 deg. If both groups are in PWM mode, both groups will use the last PWM frequency setting.

J1 Pin-out (8-pin):

J1 is the male programmable output connector. The 6 signal pins are divided into two groups of 3 pins each. Each group can be independently set to be manual, quadrature, tilt switch, or PWM output.

		Output Configuration			
J1 Pin	Group	User Ouput	Quadrature	Tilt Switch	PWM
1		GND			
2		+Vin (Power supply input)			
3	0	Output 0	A Quadrature	Too Low	0
4	0	Output 1	B Quadrature	MinMaxLatch	PWM
5	0	Output 2	Index	Too High	0
6	1	Output 3	A Quadrature	Too Low	PWM
7	1	Output 4	B Quadrature	MinMaxLatch	0
8	1	Output 5	Index	Too High	0

Be sure that the output range is set to -180.000 to 179.999 when these modes are being used.

There are four functions in this group.

1.10.1 Get Output Configuration

	Parameter	# bytes	Units	Range
Command	address	1		0
	0xE3	1		
	Group	1		0 = outputs 0-2 1 = outputs 3-5
Response	mode	1		0 = manual 1 = quadrature 2 = tilt 3 = PWM 500 Hz 4 = PWM 250 Hz 5 = PWM 125 Hz 6 = PWM 62.5 Hz 7 = PWM 31.3 Hz 8 = PWM 15.6 Hz 9 = PWM 7.8 Hz 10 = PWM 3.9 Hz The factory default is set to 1.
	axis	1		0, 1 or 2
	resolution	2	CPR	1 – 9,000 (4-36,000 codes / revolution) when mode = 1. Ignore otherwise. The factory default is set to 9000.
	target angle	4	deg * 1000	-180,000 to 179,999 when mode = 2. Ignore otherwise. The factory default is set to 0.
	target width	4	deg * 1000	0 to 359,999 when mode = 2. Ignore otherwise. The factory default is set to 10000 (10 deg).
	checksum	1		

target angle – This is the target angle for tilt mode.
target width – This is the angle width from low to high limits around the target.

Example:

```
Command:   (     00,      E3,    00)
Notes:     (address, command, group)
Response:  (  01,   00,     23, 28, 00, 00, 00, 00, 00, 00, 00, 00, 92      )
Notes:     (mode, axis, resolution, target--------, target width--, checksum)
```

Meaning: The current device has the following information
mode = quadrature, axis = 0
resolution = 9000 CPR (36,000 codes / revolution)
target = 0, target width = 0

Refer to X3User.dll function **X3_GetOutputConfig** in the X3 DLL User Guide.

1.10.2 Set Output Configuration

	Parameter	# bytes	Units	Range
Command	address	1		0
	0xC3	1		
	group	1		0 = outputs 0-2 1 = outputs 3-5
	mode	1		0 = manual 1 = quadrature 2 = tilt 3 = PWM 500 Hz 4 = PWM 250 Hz 5 = PWM 125 Hz 6 = PWM 62.5 Hz 7 = PWM 31.3 Hz 8 = PWM 15.6 Hz 9 = PWM 7.8 Hz 10 = PWM 3.9 Hz
	axis	1		0, 1 or 2
	resolution	2	CPR	1 – 9,000 when mode = 1. Ignored otherwise.
	target angle	4	deg * 1000	-180,000 to 179,999 when mode=2. Ignored otherwise.
	target width	4	deg * 1000	0 to 359,999 when mode = 2. Ignored otherwise.
	checksum	1		
Response	status	1		0 = pass
	checksum	1		

If mode = 0 (manual), then the 3 output pins for the specified group are set to general purpose output port. Use the **Set Output** command to write the 6 bit port data.
Note: the angle range must be set to -180.000 to 179.999 for all modes except 0. Refer to **Set Angle Output Range**.

Example:

```
Command:   (     00,      C3,    00,   01,   01,     23, 28, 00, 00, 00, 00,
           00, 00, 00, 00,       F0)
Notes:     (address, command, group, mode, axis, resolution, target angle--,
           target width -, checksum)
Response:  (00    , 00      )
Notes:     (status, checksum)
```

Meaning: The current device has the following information
mode = quadrature, axis = 1
resolution = 9000 CPR (36,000 codes / revolution)
target = 0, target width = 0

Refer to X3User.dll function **X3_SetOutputConfig** in the X3 DLL User Guide.

1.10.3 Get Output Update Rate

	Parameter	# bytes	Units	Range
Command	address	1		0
	0xBC	1		
Response	update rate	1		0x01 (fastest) to 0xff (slowest) The factory default is set to 0x01.
	checksum	1		

This function reads the output update rate setting. See **Set Output Update Rate** for a full description.

Examples:

```
Read output update rate
Command:    (     00,      BC)
Notes:      (address, command)
Response:   (         01,       FF)
Notes:      (update rate, checksum)
```

Meaning: The output update rate = 0x01 (fastest)

Refer to X3User.dll function **X3_GetOutputUpdateRate** in the X3 DLL User Guide.

1.10.4 Set Output Update Rate

	Parameter	# bytes	Units	Range
Command	address	1		0
	0xBB	1		
	update rate	1		0x01 (fastest) to 0xff (slowest) The factory default is set to 0x01.
	checksum	1		
Response	status	1		0 = pass
	checksum	1		

This function allows the output update rate of all 6 output pins on J1 to be changed. This setting only affects all signals on J1. It does not affect the angle measurement rate or the serial interface data rate.

The majority of users should leave the output update rate in its default (fastest) setting. A slower rate can be programmed for users that need a slower update in quadrature mode. The slower update rate will affect the manual, tilt and PWM modes by introducing a delay in the response time for these output modes. There is usually no reason to use a slower update rate in manual/tilt/PWM modes.

When the update rate is set to 0x01, the minimum quadrature state time is approximately 35µs and the average quadrature state time is about 145µs (6.9 kHz). Each increment in the update rate value adds ~ 2.7µs to the minimum quadrature state time and ~ 4.6µs to the average quadrature state time.

When the update rate is set to 0xFF or 0x00, the minimum quadrature state time is approximately 720µs and the average quadrature state time is ~ 1.3 millisec. (.77 kHz).

Examples:

```
Change to fastest output update rate
Command:   (     00,      BB,          01,       44)
Notes:     (address, command, update rate, checksum)
Response:  (    00,       00)
Notes:     (status, checksum)

Change to slower output update rate
Command:   (     00,      BB,          20,       25)
Notes:     (address, command, update rate, checksum)
Response:  (    00,       00)
Notes:     (status, checksum)
```

Refer to X3User.dll function **X3_SetOutputUpdateRate** in the X3 DLL User Guide.

1.10.5 Get Startup Delay

	Parameter	# bytes	Units	Range
Command	address	1		0
	0xBF	1		
Response	startup delay	2		1 (fastest) to 65534 (slowest) The factory default is set to 320
	checksum	1		

This function reads the startup delay. The startup delay in seconds is approximately (startup delay)/640. The factory default of 320 gives a startup delay of 0.5 seconds. See **Set Startup Delay** for a full description. Each increment adds 1.5625 mSec.

Example:

```
Command:   (     00,      BF)
Notes:     (address, command)
Response:  (    03,    C0,       3D)
Notes:     (delay--------, checksum)
```

Meaning: The current startup delay is 0x03C0 (960 decimal) which is 1.5 seconds since 960 / 640 and 960 x 1.5625 mSec = 1.5 seconds.
Refer to X3User.dll function **X3_GetStartupDelay** in the X3 DLL User Guide

1.10.6 Set Startup Delay

	Parameter	# bytes	Units	Range
Command	address	1		0
	0xBE	1		
	startup delay	2		1 (fastest) to 65534 (slowest) Reserved values = 0, 65535 The factory default is set to 320
	checksum	1		
Response	status	1		0 = pass
	checksum	1		

This function allows the "startup delay" to be adjusted. This delay allows time for an external microcontroller or PLC to get ready to receive quadrature inputs after power up. During this time, the X3 will set the index output high and A and B low to reset an external quadrature counter. After this delay time expires, the **X3** will send a stream of quadrature cycles to update the external quadrature counter so that it holds the absolute X3 angle. (See the **X3 Datasheet** for details). The **X3** will then send quadrature cycles as necessary to follow real-time angle changes.

In manual/tilt/PWM modes, the outputs are deasserted (MOSFETs are off, outputs are high, and associated LEDs are off) until the startup delay expires.

The startup delay in seconds is approximately (startup delay)/640. The factory default of 320 gives a startup delay of 0.5 seconds. Each increment adds 1.5625 mSec. 65534 will provide a maximum delay of 102.4 seconds.

Example:

```
Set 1.5 second startup delay
Command:   (     00,      BE,        03,       C0,       7F)
Notes:     (address, command, startup delay -----, checksum)
Response:  (    00,       00)
Notes:     (status, checksum)
```

Refer to X3User.dll function **X3_SetStartupDelay** in the X3 DLL User Guide

1.10.7 Get Output Bits

	Parameter	# bytes	Units	Range
Command	address	1		0
	0xF8	1		
Response	output port data	1		0x00 to 0x3f (6 bits)
	checksum	1		

This command reads the data currently output on the 6 bit output port. This command can be issued even when in Tilt or Quadrature modes.

Example:

```
Command:   (     00,      f8)
Notes:     (address, command)
Response:  (       3f,       c1)
Notes:     (port data, checksum)
```

If response is (3f, c1), then all outputs are high.
If response is (00, 00), then all outputs are low.

Refer to X3User.dll function **X3_GetOutput** in the X3 DLL User Guide.

1.10.8 Set Output Bits

	Parameter	# bytes	Units	Range
Command	address	1		0
	0xA6	1		
	bit data	1		0x00-0x3f (6 bits)
	checksum	1		
Response	status	1		0 = pass
	checksum	1		

This command is to write any bit pattern to the 6 output bits. The pin connected to LED D1 is the lsb. The corresponding LED's will also be set to match the output. This command is ignored unless the Output Configuration is in Mode 0 (manual). If a group is not enabled for output, the corresponding 3 bits in the data byte are ignored. These values are not saved to non-volatile memory. Each time the X3 is powered up, these bits are turned off.

The output voltage is high (MOSFET turned off) when the corresponding output bit is set to 1.

Examples:
Set all output bits high

```
Command:   (     00,      a6,       3f,       1b)
Notes:     (address, command, bit data, checksum)
Response:  (    00,       00)
Notes:     (status, checksum)
```

00 a6 3f 1b – set all 6 bits high
00 a6 00 5a - set all 6 bits low
00 a6 15 45 – 0x15 to output bits
00 a6 2a 30 – 0x2a to output bits

Refer to X3User.dll function **X3_SetOutput** in the X3 DLL User Guide.

1.11 Set Baud Rate

	Parameter	# bytes	Units	Range
Command	address	1		0
	0xBA	1		
	baud rate index	1		0x00: 115.2 kbps 0x01: 57.6 kbps 0x02: 38.4 kbps 0x03: 19.2 kbps 0x04: 9.6 kbps The factory default is set to 0x00.
	checksum	1		
Response	status	1		0 = pass
	checksum	1		

This command changes the serial port baud rate used by the X3. The response is sent using the previous baud rate. The baud rate is changed about 10 milliseconds after a successful response is sent.

Examples:

Change baud rate to 115.2 kbps

```
Command:   (     00,      BA,              00,       46)
Notes:     (address, command, baud rate index, checksum)
Response:  (     00,      00)
Notes:     (status, checksum)
```

Change baud rate to 9.6 kbps

```
Command:   (00, ba, 04, 42)
Notes:     (address, command, baud rate index, checksum)
Response:  (     00,      00)
Notes:     (status, checksum)
```

Refer to X3User.dll function **X3_InitComm** and **X3_SetBaudRate** in the X3 DLL User Guide.