

# NexStar Communication Protocol

This document describes the serial commands supported by the Celestron NexStar hand control. This information applies to the NexStar GPS, NexStar GPS-SA, NexStar iSeries, NexStar SE Series, NexStar GT, CPC, SLT, Advanced-GT, and CGE mounts.

Communication to the hand control is 9600 bits/sec, no parity and one stop bit via the RS-232 port on the base of the hand control.

Note: the GT hand control prior to version 104.0 should be treated as version 1.2 in the tables below. Version 104.0 should be treated as version 4.03.

## Get Position Commands

The following commands retrieve the position of the telescope in either RA/DEC or AZM-ALT coordinates.

The position is returned as a hexadecimal value that represents the fraction of a revolution around the axis. Two examples are given below:

- If the Get RA/DEC command returns 34AB,12CE then the DEC value is 12CE in hexadecimal. As a percentage of a revolution, this is  $4814/65536 = 0.07346$ . To calculate degrees, simply multiply by 360, giving a value of 26.4441 degrees.
- If the precise GET AZM-ALT command returns 12AB0500,40000500 then the AZM value is 12AB0500 in hexadecimal. As a percentage of a revolution, this is  $313197824/4294967296 = 0.0729$  or 26.252 degrees.

The standard commands offer a precision of  $1/65536 * 360 * 60 * 60 =$  about 19.8 arcseconds per unit while the precise commands offer a precision of  $1/16777216 * 360 * 60 * 60 =$  about 0.08 arcseconds per unit (only the upper 24 bits are used).

**Note:** if the telescope has not been aligned, the RA/DEC values will not be meaningful and the AZM-ALT values will be relative to where the telescope was powered on. After alignment, RA/DEC values will reflect the actual sky, azimuth will be indexed to North equals 0 and altitude will be indexed with 0 equal to the orientation where the optical tube is perpendicular to the azimuth axis.

Command Function	PC Command	Hand Control Response	Applies to Versions
Get RA/DEC	"E"	"34AB,12CE#"	1.2+
Get precise RA/DEC	"e"	"34AB0500,12CE0500#"	1.6+
Get AZM-ALT	"Z"	"12AB,4000#"	1.2+
Get precise AZM-ALT	"z"	"12AB0500,40000500#"	2.2+

## GOTO Commands

The following commands direct the telescope to GOTO a specified RA/DEC or AZM-ALT position. As with the Get Position commands, the values are in hexadecimal and represent the fraction of a rotation around the axis.

**Note:** GOTO RA/DEC commands will not work unless the telescope is aligned.

Command Function	PC Command	Hand Control Response	Applies to Versions
GOTO RA/DEC	"R34AB,12CE"	"#"	1.2+
GOTO precise RA/DEC	"r34AB0500,12CE0500"	"#"	1.6+
GOTO AZM-ALT	"B12AB,4000"	"#"	1.2+

GOTO precise AZM-ALT	"b12AB0500,40000500"	"#"	2.2+
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## Sync

To Sync to an object via serial commands, the user should center a known object in an eyepiece. Then the Sync serial command should be sent, using the celestial coordinates (RA and DEC) for that object. This causes future GOTO or Get Position commands to use coordinates relative to the Sync'd position, improving pointing accuracy to nearby objects. (we probably don't need to mention "from the planetarium package" since it also improves pointing accuracy if they GoTo objects via the hand control.) The format for the RA/DEC positions in the Sync command is identical to the GOTO RA/Dec command.

Command Function	PC Command	Hand Control Response	Applies to Versions
Sync RA/DEC	"S34AB,12CE"	"#"	4.10+
Sync precise RA/DEC	"s34AB0500,12CE0500"	"#"	4.10+

## Tracking Commands

The following commands retrieve or set the tracking mode.

Depending on the mount type, following tracking modes are available:

0 = Off

1 = Alt/Az

2 = EQ North

3 = EQ South

**Note:** On the CGE and Advanced GT hand control versions 3.01 through 3.04 the value for EQ North is 1 and EQ South is 2. This has been corrected to match the other models in current hand control versions.

Command Function	PC Command	Hand Control Response	Applies to Versions
Get Tracking Mode	"t"	chr(mode) & "#"	2.3+
Set Tracking Mode	"T" & chr(mode)	"#"	1.6+

## Slewing Commands

The following commands allow you to slew (move) the telescope at fixed or variable rates.

For **variable rates**, multiply the desired rate by 4 and then separate it into a high and low byte. For example if the desired tracking rate is 150 arcseconds/second, then:

trackRateHigh =  $(150 * 4) \backslash 256 = 2$ , and

trackRateLow =  $(150 * 4) \text{ mod } 256 = 88$

For **fixed rates**, simply use a value from 1-9 (or 0 to stop) to mimic the equivalent hand control rates.

**Note:** in most configurations, issuing the slew commands will override (or conflict with) the tracking mode of the mount. Hence it is always best to disable tracking first using the **Tracking Commands**, issue the slew command, then re-enable tracking. The main exception to this is when tracking equatorially - the **fixed rate** slews at 1 or 2 will not override tracking. This can be useful to simulate autoguiding.

**Note:** on GT models, the fixed rate slews at rate 9 move at 3 degrees per second instead of the maximum rate.

Command Function	PC Command	Hand Control Response	Applies to Versions
Variable rate Azm (or RA) slew in positive direction	"P" & chr(3) & chr(16) & chr(6) & chr(trackRateHigh) & chr(trackRateLow) & chr(0) & chr(0)	"#"	1.6+
Variable rate Azm (or RA) slew in negative direction	"P" & chr(3) & chr(16) & chr(7) & chr(trackRateHigh) & chr(trackRateLow) & chr(0) & chr(0)	"#"	1.6+
Variable rate Alt (or Dec) slew in positive direction	"P" & chr(3) & chr(17) & chr(6) & chr(trackRateHigh) & chr(trackRateLow) & chr(0) & chr(0)	"#"	1.6+
Variable rate Alt (or Dec) slew in negative direction	"P" & chr(3) & chr(17) & chr(7) & chr(trackRateHigh) & chr(trackRateLow) & chr(0) & chr(0)	"#"	1.6+
Fixed rate Azm (or RA) slew in positive direction	"P" & chr(2) & chr(16) & chr(36) & chr(rate) & chr(0) & chr(0) & chr(0)	"#"	1.6+
Fixed rate Azm (or RA) slew in negative direction	"P" & chr(2) & chr(16) & chr(37) & chr(rate) & chr(0) & chr(0) & chr(0)	"#"	1.6+
Fixed rate Alt (or DEC)	"P" &	"#"	1.6+

slew in positive direction	chr(2) & chr(17) & chr(36) & chr(rate) & chr(0) & chr(0) & chr(0)		
Fixed rate ALT (or DEC) slew in negative direction	"P" & chr(2) & chr(17) & chr(37) & chr(rate) & chr(0) & chr(0) & chr(0)	"#"	1.6+

### ***Time/Location Commands (Hand Control)***

The following commands set the time and location in the hand control.

The format of the location commands is: ABCDEFGH, where:

- A is the number of degrees of latitude.
- B is the number of minutes of latitude.
- C is the number of seconds of latitude.
- D is 0 for north and 1 for south.
- E is the number of degrees of longitude.
- F is the number of minutes of longitude.
- G is the number of seconds of longitude.
- H is 0 for east and 1 for west.

For example, to set the location to 118°20'17" W, 33°50'41" N, you would send (note that latitude is before longitude):  
 "W" & chr(33) & chr(50) & chr(41) & chr(0) & chr(118) & chr(20) & chr(17) & chr(1)

The format of the time commands is: QRSTUVWX, where:

- Q is the hour (24 hour clock).
- R is the minutes.
- S is the seconds.
- T is the month.
- U is the day.
- V is the year (century assumed as 20).
- W is the offset from GMT for the time zone. **Note:** if zone is negative, use 256-zone.
- X is 1 to enable Daylight Savings and 0 for Standard Time.

For example, to set the time to 3:26:00PM on April 6, 2005 in the Eastern time zone (-5 UTC: 256-5 = 251) you would send:

"H" & chr(15) & chr(26) & chr(0) & chr(4) & chr(6) & chr(5) & chr(251) & chr(1)

**Note:** All values are sent in binary format, not ASCII.

**Note:** The Get commands do **not** retrieve the time and location from the GPS unit (if one is present). The time and location are retrieved from the hand control. You must first enter the View Time/Site menu to update the hand control time if you want the time from the GPS or, use the GPS Commands in the next section.

Command Function	PC Command	Hand Control	Applies to Versions
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		<b>Response</b>	
Get Location	"w"	chr(A) & chr(B) & chr(C) & chr(D) & chr(E) & chr(F) & chr(G) & chr(H) & "#"	2.3+
Set Location	"W" & chr(A) & chr(B) & chr(C) & chr(D) & chr(E) & chr(F) & chr(G) & chr(H)	"#"	2.3+
Get Time	"h"	chr(Q) & chr(R) & chr(S) & chr(T) & chr(U) & chr(V) & chr(W) & chr(X) & "#"	2.3+
Set Time	"H" & chr(Q) & chr(R) & chr(S) & chr(T) & chr(U) & chr(V) & chr(W) & chr(X)	"#"	2.3+

### **GPS Commands**

The following table shows various commands that can be sent to a GPS unit. Note: all units of time are in UT.

<b>Command Function</b>	<b>PC Command</b>	<b>Hand Control Response</b>	<b>Applies to Versions</b>
Is GPS Linked? X > 0 if linked, 0 if not linked	"P" & chr(1) & chr(176) & chr(55) & chr(0) & chr(0) & chr(0) & chr(1)	chr(x) & "#"	1.6+
Get Latitude $((x*65536)+(y*256)+z)/(2$	"P" & chr(1) & chr(176) &	chr(x) & chr(y) & chr(z) &	1.6+

^24) is a fraction of a rotation. To convert to degrees, multiply by 360.	chr(1) & chr(0) & chr(0) & chr(0) & chr(3)	"#"	
Get Longitude  ((x*65536)+(y*256)+z)/(2^24) is a fraction of a rotation. To convert to degrees, multiply by 360.	"P" & chr(1) & chr(176) & chr(2) & chr(0) & chr(0) & chr(0) & chr(3)	chr(x) & chr(y) & chr(z) & "#"	1.6+
Get Date  x is month (1-12) y is day (1-31)	"P" & chr(1) & chr(176) & chr(3) & chr(0) & chr(0) & chr(0) & chr(2)	chr(x) & chr(y) & "#"	1.6+
Get Year  (x * 256) + y = year	"P" & chr(1) & chr(176) & chr(4) & chr(0) & chr(0) & chr(0) & chr(2)	chr(x) & chr(y) & "#"	1.6+
Get Time  x is the hours y is the minutes z is the seconds	"P" & chr(1) & chr(176) & chr(51) & chr(0) & chr(0) & chr(0) & chr(3)	chr(x) & chr(y) & chr(z) & "#"	1.6+

### **RTC Commands**

The following table shows various RTC commands on the CGE mount.

<b>Command Function</b>	<b>PC Command</b>	<b>Hand Control Response</b>	<b>Applies to Versions</b>
Get Date  x is month (1-12) y is day (1-31)	"P" & chr(1) & chr(178) & chr(3) & chr(0) & chr(0) & chr(0) &	chr(x) & chr(y) & "#"	1.6+

	chr(2)		
Get Year (x * 256) + y = year	"P" & chr(1) & chr(178) & chr(4) & chr(0) & chr(0) & chr(0) & chr(2)	chr(x) & chr(y) & "#"	1.6+
Get Time x is the hours y is the minutes z is the seconds	"P" & chr(1) & chr(178) & chr(51) & chr(0) & chr(0) & chr(0) & chr(3)	chr(x) & chr(y) & chr(z) & "#"	1.6+
Set Date x is month (1-12) y is day (1-31)	"P" & chr(3) & chr(178) & chr(131) & chr(x) & chr(y) & chr(0) & chr(0)	"#"	3.01+
Set Year (x * 256) + y = year	"P" & chr(3) & chr(178) & chr(132) & chr(x) & chr(y) & chr(0) & chr(0)	"#"	3.01+
Set Time x is the hours y is the minutes z is the seconds	"P" & chr(4) & chr(178) & chr(179) & chr(x) & chr(y) & chr(z) & chr(0)	"#"	3.01+

### **Miscellaneous Commands**

<b>Command Function</b>	<b>PC Command</b>	<b>Hand Control Response</b>	<b>Applies to Versions</b>
Get Version	"V"	chr(major) & chr(minor) & "#"	1.2+

Get Device Version  Devices include: 16 = AZM/RA Motor 17 = ALT/DEC Motor 176 = GPS Unit 178 = RTC (CGE only)	"P" & chr(1) & chr(dev) & chr(254) & chr(0) & chr(0) & chr(0) & chr(2)	chr(major) & chr(minor) & "#"	1.6+
Get Model 1 = GPS Series 3 = i-Series 4 = i-Series SE 5 = CGE 6 = Advanced GT 7 = SLT 9 = CPC 10 = GT 11 = 4/5 SE 12 = 6/8 SE	"m"	chr(model) & "#"	2.2+
Echo - useful to check communication	"K" & chr(x)	chr(x) & "#"	1.2+
Is Alignment Complete? - align=1 if aligned and 0 if not	"J"	chr(align) & #	1.2+
Is GOTO in Progress? - Response is <b>ASCII</b> "0" or "1"	"L"	prog & "#"	1.2+
Cancel GOTO	"M"	"#"	1.2+

## Developer Notes

### Timeouts

If the hand control is sent a command that requires it to communicate with another device, then the hand control will make multiple attempts to get the message through in the event of communications problems. Examples include "Get Position" commands, "GOTO in Progress" commands, etc.

Software drivers should be prepared to wait up to 3.5s (worst case scenario) for a hand control response. If serial commands are "blindly" sent without waiting for a response, then some commands may be dropped or the software driver could see responses that are for earlier commands.

### Pass-through Commands with No Response

Commands that start with 'P' are special pass-through commands that communicate with a specific telescope device. For instance, the Slew commands talk directly to the motor control. If a 'P' command is sent but no response is returned (because the device is not there or the command is unknown or there was a communication problem) then one extra data byte is returned before the '#' terminating character and any returned data is garbage. This is done to give software drivers a flag that something went wrong so appropriate action can be taken. It is particularly useful if you want to check for the existence of a device: for instance, check the time from the GPS unit, and look for an error response. Software drivers should check for the '#' termination character and if it is a different character then the next character (hopefully '#') should be consumed and any command-specific handling should be done.