Mount Command Protocol

Software version 2.15.1

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Introduction

This paper documents the Command Protocol used to remotely command and control the 10micron mounts, with software version 2.15.1.

The protocol is derived from the Meade LX200™ Serial Command Protocol in order to simplify operation with existing software. Many extensions are used to provide functionality not available with the standard LX200 protocol. Some commands are compatible with the Astro-Physics™ serial command protocol, and a few of them behave differently when used in different emulation modes (see the *Extended LX200 emulation and precision* paragraph).

Communication

The communication can be established using a serial connection or a TCP/IP connection.

Serial communication

The communication requires a serial line at 9600 bps, 8 bits per character, 1 stop bit and no parity. The device controlling the mount must initiate all communications, i.e. the mount will not send anything except as a response to a query.

TCP/IP communication

The mount must be configured with an IP address (see the user's manual). The device controlling the mount must connect to that IP address, port 3490 or 3492. Once the connection is established, the device controlling the mount must initiate all communications, i.e. the mount will not send anything except as a response to a query. Until software version 2.9.9, only one connection on each port at a given time is allowed and the mount will refuse further incoming connections. From 2.9.10 onwards, up to ten independent connections on each port are allowed.

Commands

All commands are case-sensitive. Each command is a string of characters beginning with ":" and ending with "#", with the only exception of the <ACK> command. A single "#" character clears the receiving buffer.

The commands evidenced in blue or green are extensions to the standard LX200 protocol. If part of a command's explanation is evidenced in blue or green, that part is an extension to the behaviour of the command with the standard LX200 protocol.

The characters evidenced in red should be replaced with the appropriate values to be communicated to the mount.

The meaning of the asterisk (*) character changes accordingly to the emulation and precision mode set:

Emulation and precision	Meaning of the asterisk (*) character
LX200 emulation, low or high precision	ascii code 223 (0xDF)
Extended emulation, low or high precision	ascii code 42 (0x2A) (ASCII asterisk "*")
Any emulation, ultra precision	Not used in communications from the mount to the controller, both 0xDF and 0x2A accepted in communications from the controller to the mount.

Except when stated otherwise, all equatorial coordinates used in the communication protocol are local topocentric coordinates.

Alignment Commands

In the LX200 protocol, the alignment commands are used to set or query the tracking mode of the mount; the so-called "Land" mode corresponds to no tracking, while "Polar" and "AltAz" mode correspond tracking in one or both axes.

Since the 10micron mounts do not support different mounting modes, these commands are used only to start and stop tracking.

<ACK> Query of alignment mounting mode, the command string is the single character "0x06".
Returns:
L If tracking is off
P If tracking is on

:AL#	Stops tracking. Returns: nothing
:AP#	Starts tracking. Returns: nothing

GPS commands

:gT#	Updates the clock, latitude, longitude and elevation data from the GPS. Until firmware version 2.12.5, this command may take several minutes to complete. During the process, the mount does not respond to other commands. From version 2.12.6 onwards, this command is asynchronous Returns: 0 if the user interrupts the process, or the GPS is unconnected, or some other error occurs 1 if the process has been completed successfully From firmware version 2.12.6 onwards, this command configures the mount to use data from a GPS module and returns immediately. Returns: 0 if the GPS module hasn't communicated all data yet 1 if the GPS module has communicated all data and the mount is synchronized
:gps#	Returns the last string from the GPS in standard NMEA format, if available, followed by a '#' character.
:gtg#	Checks if the mount clock is being kept synchronized to the clock of the connected GPS module. Returns: "0#" if the mount clock is not being kept synchronized to the GPS clock. "1#" if the mount clock is being kept synchronized to the GPS clock.

Sync Control and Model Building

:CMS#	Adds a alignment point to the current model, by synchronizing the position of the mount with the coordinates of the currently selected target and recalculating the alighment model. Returns: the string "V#" if successful the string "E#" if the model can't be refined Available from version 2.8.15.
:CM#	Synchronizes the position of the mount with the coordinates of the currently selected target. Starting with version 2.8.15, this command has two possible behaviours depending on the value passed to the last :CMCFGn# command. By default after startup, or after the :CMCFG0# command has been given, the synchronization works by offsetting the axis angles. If the :CMCFG1# command has been given, it works like the :CMS# command, but returning the strings below.

Returns:
the string “Coordinates matched #” if the coordinates have been synchronized
the string “Match fail: dist. too large#” if the coordinates have not been synchronized

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:CMR# The same as :CM#.

:CMCFGn#
Configures the behaviour of the :CM# and :CMR# commands depending on the value of n. If n=0, :the commands :CM# and :CMR# work in the default mode, i.e. they synchronize the position ot the mount with the coordinates of the currently selected target by correcting the axis offset values. If n=1, the commands :CM# and :CMR# work by using the synchronization position as an additional alignment star for refining the alignment model.
Returns:
the string "0#" if the value 0 has been passed
the string "1#" if the value 1 has been passed
Available from version 2.8.15.

:getalst# Gets the number of alignment stars used in the current alignment model.
Returns:
the number of alignment stars terminated by '#'.
Available from version 2.8.15.

:delalig# Deletes the current alignment model and stars.
Returns: an empty string terminated by '#'.
Available from version 2.8.15.

:getaliN# Gets the alignment information for star number N in the alignment model, where N goes from 1 to the number returned by :getalst#.
Returns:
the string "E#" if N is out of range
otherwise a string formatted as follows
"HH:MM:SS.SS,+dd*mm:ss.s,eeee.e#" where HH:MM:SS.SS is the hour angle of the alignment star in hours, minutes, seconds and hundredths of second, +dd*mm:ss.s is the declination of the alignment star in degrees, arcminutes, arcseconds and tenths of arcsecond, eeee.e is the error between the star and the alignment model in arcseconds.
Available from version 2.8.15.

:getain# Gets alignment information about the current alignment model.
Returns:
The string "E#" if there are less than two stars in the alignment; otherwiser, a string formatted as follows:
"ZZZ.ZZZZ,+AA.AAAA,EE.EEEE,PPP.PP,+OO.OOOO,+aa.aa,
+bb.bb,NN,RRRRR.R#" where ZZZ.ZZZZ and +AA.AAAA are the azimuth and altitude of the direction pointed at by the right ascension axis, EE.EEEE is the polar align error in degrees and decimals, PPP.PP is the position angle of the right ascension axis with respect to the celestial pole in degrees and decimals, +OO.OOOO is the orthogonality error between the optical axis of the telescope and the declination axis in degrees and decimals, +aa.aa is the number of turns of the azimuth adjustment knobs

(positive if the polar axis must be moved to the left), +bb.bb is the number of turns of the altitude adjustment knob (positive if the polar axis must be moved downwards), N is the number of terms used in the modeling, RRRRR.R is the expected RMS error in arcseconds.
Some values can be omitted and replaced with the string "E" if they aren't calculated: namely, the RMS and number of terms in case of less than 4 stars or QCI mounts, the orthogonality error in case of less than 3 stars, the polar align error and position angle in case of altazimuth mounts, the number of turns of the knobs in case of altazimuth mounts or latitude greater than 80 degrees.
Available form version 2.14.20.

:getalpN# Gets the alignment information for star number N in the alignment model, where N goes from 1 to the number returned by :getalst#, including the polar angle of the measured star coordinates with respect to the modeled star coordinates.
Returns:
the string "E#" if N is out of range
otherwise a string formatted as follows
"HH:MM:SS.SS,+dd*mm:ss.s,eeee.e,ppp#" where HH:MM:SS.SS is the hour angle of the alignment star in hours, minutes, seconds and hundredths of second (from 0h to 23h59m59.99s), +dd*mm:ss.s is the declination of the alignment star in degrees, arcminutes, arcseconds and tenths of arcsecond, eeee.e is the error between the star and the alignment model in arcseconds, ppp is the polar angle of the measured star with respect to the modeled star in the equatorial system in degrees from 0 to 359 (0 towards the north pole, 90 towards east).
Available from version 2.8.15.

:delalstN# Deletes the alignment star N, where N goes from 1 to the number returned by :getalst#, and recalculates the alignment model.
Returns:
the string "0#" if the procedure has failed (this can happen due to N being out of range, or if the model can't be recalculated correctly with the remaining stars).
the string "1#" if the procedure has succeeded.
Available from version 2.8.15.
Note that the first two stars cannot be deleted in firmware version < 2.10.6.

:newalig# Start creating a new alignment specification, that will be entered with the :newalpt command.
Returns:
the string "V#" (this is always successful).
See also the paragraph *Entering an alignment model*.
Available from version 2.8.15.

:newaltMRA,MDEC,MSIDE,PRA,PDEC,SIDTIME#
Add a new point to the alignment specification. The parameters are:
MRA – the mount-reported right ascension, expressed as HH:MM:SS.S
MDEC – the mount-reported declination, expressed as sDD:MM:SS
MSIDE – the mount-reported pier side (the letter 'E' or 'W', as reported by the :pS# command)

PRA – the plate-solved right ascension (i.e. the right ascension the telescope was effectively pointing to), expressed as HH:MM:SS.S
PDEC – the plate-solved declination (i.e. the declination the telescope was effectively pointing to), expressed as sDD:MM:SS
SIDTIME – the local sidereal time at the time of the measurement of the point, expressed as HH:MM:SS.S
Returns:
the string "nnn#" if the point is valid, where nnn is the current number of points in the alignment specification (including this one)
the string "E#" if the point is not valid
See also the paragraph *Entering an alignment model*.
Available from version 2.8.15.

:endalig# Completes the alignment specification and computes a new alignment from the given alignment points.
Returns:
the string "V#" if the alignment has been computed successfully
the string "E#" if the alignment couldn't be computed successfully with the current alignment specification. In this case the previous alignment is retained.
See also the paragraph *Entering an alignment model*.
Available from version 2.8.15.

:modelcnt# Returns the number of user alignment models saved in the mount.
Returns:
the string "nnn#", where nnn is the number of models available.
Available from version 2.13.3.

:modelnamN#
Returns the name of model N saved in the mount, from 1 to the number returned by command :modelcnt#.
Returns:
the string "#" if N is not valid;
the name of model N, terminated by the character "#".
The model names are escaped as explained at page 53. Model names are case-sensitive and have a maximum length of 15 characters. Spaces at the end are ignored.
Available from version 2.13.3.

:modelld0NAME#
Loads the model with the given NAME from the alignment models saved in the mount.
The model names are escaped as explained at page 53. Model names are case-sensitive and have a maximum length of 15 characters. Spaces at the end are ignored.
Returns:
the string "1#" if the model has been loaded correctly;
the string "0#" if there was an error.
Available from version 2.13.3.

:modelsv0NAME#
Saves in the mount the current model with the given NAME.

The model names are escaped as explained at page 53. Model names are case-sensitive and have a maximum length of 15 characters. Spaces at the end are ignored.
Returns:
the string "1#" if the model has been saved correctly;
the string "0#" if there was an error.
Available from version 2.13.3.

:modeldel0NAME#

Deletes the model with the given NAME from the alignment models saved in the mount.
The model names are escaped as explained at page 53. Model names are case-sensitive and have a maximum length of 15 characters. Spaces at the end are ignored.
Returns:
the string "1#" if the model has been deleted;
the string "0#" if there was an error.
Available from version 2.13.3.

Get Information

:GA# Get telescope altitude. Returns the current telescope altitude above the horizon formatted as follows:

Emulation and precision	Return value
Any emulation, low precision	sDD*MM# (degrees, arcminutes)
Any emulation, high precision	sDD*MM:SS# (degrees, arcminutes, arcseconds)
Any emulation, ultra precision	sDD:MM:SS.S# (degrees, arcminutes, arcseconds and tenths of arcsecond)

:Ga# Get current target altitude. Returns the target altitude above the horizon formatted as follows:

Emulation and precision	Return value
Any emulation, low precision	sDD*MM# (degrees, arcminutes)
Any emulation, high precision	sDD*MM:SS# (degrees, arcminutes, arcseconds)
Any emulation, ultra precision	sDD:MM:SS.S# (degrees, arcminutes, arcseconds and tenths of arcsecond)

If the target position has been set using the :Sr and :Sd commands, the return value is the altitude of the target computed from its equatorial coordinates at the time the :Ga command is received. Otherwise, it is the value set using the :Sa command. If neither an equatorial target position nor a target altitude has been set, the return value is undefined.
From version 2.12.14 onwards, when the mount is commanded to slew to a target from the keypad / virtual keypad interface, the target altitude is updated with the altitude of the target set by the keypad / virtual keypad interface.

:GC# Get current date. Returns the current date formatted as follows:

Emulation and precision	Return value
LX200 emulation, low and high precision	MM/DD/YY# (month, day, year)
Extended emulation, low and high precision	MM:DD:YY# (month, day, year) – note that the separator character is ':' instead of '/'.
Any emulation, ultra precision	YYYY-MM-DD# (year, month, day) – note that the separator character is '-' instead of '/'.

:GD# Get telescope declination. Returns the current telescope declination formatted as follows:

Emulation and precision	Return value
LX200 emulation, low and high precision	sDD*MM# (degrees, arcminutes)
Extended emulation, low and high precision	sDD*MM:SS# (degrees, arcminutes, arcseconds)
Any emulation, ultra precision	sDD:MM:SS.S# (degrees, arcminutes, arcseconds and tenths of arcsecond)

:Gd# Get current target declination. Returns the target declination formatted as follows:

Emulation and precision	Return value
LX200 emulation, low and high precision	sDD*MM# (degrees, arcminutes)
Extended emulation, low and high precision	sDD*MM:SS# (degrees, arcminutes, arcseconds)
Any emulation, ultra precision	sDD:MM:SS.S# (degrees, arcminutes, arcseconds and tenths of arcsecond)

If the target position has been set using the :Sa and :Sz commands, the return value is the declination of the target computed from its altazimuth coordinates at the time the :Gd command is received. Otherwise, it is the value set using the :Sd command. If neither an altazimuth target position nor a target declination has been set, the return value is undefined.
From version 2.12.14 onwards, when the mount is commanded to slew to a target from the keypad / virtual keypad interface, the target declination is updated with the declination of the target set by the keypad / virtual keypad interface.

:Gev# Gets the current site elevation.
Returns: sXXXX.X#
The current site elevation expressed in metres.
Available from version 2.9.9.

:GG# Get UTC offset time. Returns the number of hours to add to local time to convert it to UTC. The daylight savings setting in effect is factored into the returned value. The return value is formatted as follows:

Emulation and precision	Return value
LX200 emulation, low or high precision	sHH.H# (sign, hours and tenths of hours)
Extended emulation, low precision	sHH:MM.M# (sign, hours, minutes and tenths of minute)
Extended emulation, high precision	sHH:MM:SS.S# (sign, hours, minutes, seconds and tenths of second)
Any emulation, ultra precision	sHH:MM:SS.S# (sign, hours, minutes, seconds and tenths of second)

:Gg# Get current site longitude. **Note: East Longitudes are expressed as negative.** Returns the current site longitude formatted as follows:

Emulation and precision	Return value
Any emulation, low precision or LX200 emulation, high precision	sDDD*MM# (sign, degrees, arcminutes)
Extended emulation, high precision	sDDD*MM:SS# (sign, degrees, arcminutes, arcseconds)
Any emulation, ultra precision	sDDD:MM:SS.S# (sign, degrees, arcminutes, arcseconds, tenths of arcsecond)

:Gh# Get high limit. Returns the highest altitude above the horizon that the mount will be allowed to slew to without reporting an error message, formatted as follows:

Emulation and precision	Return value
Any emulation, low precision or high precision	sDD*# (sign, degrees)
Any emulation, ultra precision	sDD# (sign, degrees) (note the absence of '*')

:Ginfo# Get multiple information. Returns a string where multiple data are encoded, separated by commas ',', and terminated by '#'. Data are recognized by their position in the string. The data are the following:

Position	Datum
1	The telescope right ascension in hours and decimals (from 000.00000 to 23.99999), true equinox and equator of date of observation (i.e. Jnow).
2	The telescope declination in degrees and decimals (from –90.0000 to +90.0000), true equinox and equator of date of observation (i.e. Jnow).
3	A flag indicating the side of the pier on which the telescope is currently positioned ("E" or "W").
4	The telescope azimuth in degrees and decimals (from 000.0000 to 359.9999).
5	The telescope altitude in degrees and decimals (from -90.0000 to +90.0000).

6	The julian date (JJJJJJJ.JJJJJJJJ), UTC, with leap second flag (see command :GJD2# for the description of this datum).
7	A number encoding the status of the mount as in the :Gstat command.
8	A number returning the slew status (0 if :D# would return no slew, 1 otherwise).

The string is terminated by '#'. Other parameters may be added in future at the end of the string: do not assume that the number of parameters will stay the same.
Available from version 2.14.9 (previous versions may have this command but it was experimental and possibly with a different format).

:GINQ# Get the type of connection.
Returns:
0# if the connection is over a serial RS-232 port
1# if the connection is over a GPS or GPS/RS-232 port
2# if the connection is over a cabled LAN port
3# if the connection is over a wireless LAN
Available from version 2.10.

:GIP# Get the IP address of the mount.
Returns: nnn.nnn.nnn.nnn,mmm.mmm.mmm.mmm,ggg.ggg.ggg.ggg,c#
A string containing the IP address (nnn.nnn.nnn.nnn), the subnet mask (mmm.mmm.mmm.mmm), the gateway (ggg.ggg.ggg.ggg) and a character (c) that is set to “D” if the address is obtained from a DHCP server, or “M” if the address is configured manually.

:GIPW# Get the wireless IP address of the mount.
Returns: nnn.nnn.nnn.nnn,mmm.mmm.mmm.mmm,ggg.ggg.ggg.ggg,c#
A string containing the IP address (nnn.nnn.nnn.nnn), the subnet mask (mmm.mmm.mmm.mmm), the gateway (ggg.ggg.ggg.ggg) and a character (c) that is set to “D” if the address is obtained from a DHCP server, or “M” if the address is configured manually.
Available from version 2.9.8.

:GMAC# Returns the MAC address of the Ethernet interface.
Returns: a string
"NN:NN:NN:NN:NN:NN#" the MAC address (or the string "#" if no Ethernet interface is available).
Available from version 2.14.11.

:GMACW#
Returns the MAC address of the Wireless interface.
Returns: a string
"NN:NN:NN:NN:NN:NN#" the MAC address (or the string "#" if no wireless interface is available).
Available from version 2.14.11.

:GJD# Get the current Julian Date.
Returns: JJJJJJJ.JJJJJ#

The current Julian Date for the mount.

Note

The Julian Date is computed from the UTC time. During leap seconds, the value of the Julian Date should be considered invalid.

:GJD1# Get the current Julian Date with extended precision.
Returns: JJJJJJJ.JJJJJJJJ#
The current Julian Date for the mount in extended precision (8 decimal places).
Available from version 2.10.

Note

The Julian Date is computed from the UTC time. During leap seconds, the value of the Julian Date should be considered invalid.

:GJD2# Get the current Julian Date with extended precision and leap second flag.
Returns: JJJJJJJ.JJJJJJJJ# or JJJJJJJ.JJJJJJJJL#
The current Julian Date for the mount in extended precision (8 decimal places), with an optional "L" appended at the end to signal that we are in a leap second.
Available from version 2.13.2.

Note

The Julian Date is computed from the UTC time. During leap seconds, the value of the Julian Date continues to increase, with the "L" flag set. So, for example, you will have, around the time of the leap second of 2015 June 30:

Date	Time (UTC)	Result of :GJD2#
2015-06-30	23:59:59.0	2457204.49998843#
2015-06-30	23:59:59.5	2457204.49999421#
2015-06-30	23:59:60.0	2457204.50000000L#
2015-06-30	23:59:60.5	2457204.50000579L#
2015-07-01	00:00:00.0	2457204.50000000#
2015-07-01	00:00:00.5	2457204.50000579#

:GL# Get local time. Returns the local time in 24-hour format, formatted as follows:

Emulation and precision	**Return value**
LX200 emulation, low or high precision	HH:MM:SS# (hours, minutes, seconds)
Extended emulation, low precision	HH:MM.T# (hours, minutes and tenths of minutes)
Extended emulation, high precision	HH:MM:SS.S# (hours, minutes, seconds)
Any emulation, ultra precision	HH:MM:SS.SS# (hours, minutes, seconds, hundredths of second)

:GLDT# Get local date and time. Returns the local date and time formatted as follows:
<date>,<time>#
where <date> is formatted as in the :GC# command, and <time> is formatted as in the :GL# command.
Available from version 2.12.26.

:GUDT# Get UTC date and time. Returns the UTC date and time formatted as follows:
<date>,<time>#
where <date> is formatted as in the :GC# command, and <time> is formatted as in the :GL# command.
Available from version 2.12.26.

:GDUT# Get the current UTC – UT1 difference in seconds and decimals.
Returns:
XXX.XX# the UTC – UT1 difference in seconds and decimals (with sign).
Available from version 2.13.1.

:GDUTV# Gets the current status of the ΔT flag and the expiration date for the ΔT – UTC data.
Returns a string formatted as follows: "F,XXXX-XX-XX#", where:
XXXX-XX-XX the expiration date of the ΔT – UTC data (UTC);
F a flag which is "V" if data are valid, "E" if expired.
Available from version 2.15.

:GDGPS# Get the current GPS – UTC difference in seconds.
Returns:
XX# the current GPS – UTC difference in seconds.
Available from version 2.13.1.

:GULEAP#
Gets the date of the next leap second that will be accounted for.
Returns:
XXXX-XX-XX# the date (UTC) of the next leap second, if available;
E# if no leap second is due according to the data loaded in the mount.
Available from version 2.13.1.

:GMF# Get meridian side.
Returns: n#
A number with the following interpretation:
1 both sides of the meridian allowed;
2 only objects west of the meridian allowed;
3 only objects east of the meridian allowed.
Available from version 2.7.7.

:Go# Get lower limit. Returns the lowest altitude above the horizon that the mount will be allowed to slew to without reporting an error message, formatted as follows:

Emulation and precision	Return value
Any emulation, low precision or high precision	sDD*# (sign, degrees)
Any emulation, ultra precision	sDD# (sign, degrees) (note the absence of '*')

:Gpgc# Get guiding status.
Returns: n#
A number with the following interpretation:
0 the mount is not guiding;

1 the mount is guiding in right ascension / azimuth;
2 the mount is guiding in declination / altitude;
3 the mount is guiding in both axes.

Available from version 2.9.9.
Note: a bug prevents this command from working up to version 2.9.20. Use it only from version 2.9.21 upwards.

:GR# Get telescope right ascension. Returns the current telescope right ascension formatted as follows:

Emulation and precision	**Return value**
Any emulation, low precision	HH:MM.M# (hours, minutes and tenths of minutes)
LX200 emulation, high precision	HH:MM:SS# (hours, minutes, seconds)
Extended emulation, high precision	HH:MM:SS.S# (hours, minutes, seconds and tenths of seconds)
Any emulation, ultra precision	HH:MM:SS.SS# (hours, minutes, seconds and hundredths of seconds)

:Gr# Get current target RA. Returns the target right ascension formatted as follows:

Emulation and precision	**Return value**
Any emulation, low precision	HH:MM.M# (hours, minutes and tenths of minutes)
LX200 emulation, high precision	HH:MM:SS# (hours, minutes, seconds)
Extended emulation, high precision	HH:MM:SS.S# (hours, minutes, seconds and tenths of seconds)
Any emulation, ultra precision	HH:MM:SS.SS# (hours, minutes, seconds and hundredths of seconds)

If the target position has been set using the :Sa and :Sz commands, the return value is the right ascension of the target computed from its altazimuth coordinates at the time the :Gr command is received. Otherwise, it is the value set using the :Sr command. If neither an altazimuth target position nor a target right ascension has been set, the return value is undefined.
From version 2.12.14 onwards, when the mount is commanded to slew to a target from the keypad / virtual keypad interface, the target right ascension is updated with the right ascension of the target set by the keypad / virtual keypad interface.

:GRLYn# Get the status of relay n, where n is an ASCII digit (1...9) with the following interpretation:

1 User relay 1
2 User relay 2
3 User relay 3
4 User relay 4
5 User relay 5

6 User relay 6
7 Right Ascension/Azimuth motor heater
8 Declination/Altitude motor heater
Returns: 0 or 1 depending on the state of the relay, 1 means the relay is closed.
Available only for special purpose mounts with external relay control.

Note

The relays are in an undefined state during startup, then default at open (zero).

:GRPRS# Get the atmospheric pressure used in the refraction model. Note that this is the pressure at the location of the telescope, and not the pressure at sea level.
Returns: PPPP.P#
The required pressure in hPa.
Available from version 2.3.0.

:GRTMP# Get the temperature used in the refraction model
Returns: +TTT.T#
The required temperature in degrees Celsius (°C).
Available from version 2.3.0.

:GS# Get the sidereal time. Returns the local sidereal time formatted as follows:

Emulation and precision	**Return value**
Any emulation, low precision	HH:MM.M# (hours, minutes and tenths of minutes)
LX200 emulation, high precision	HH:MM:SS# (hours, minutes, seconds)
Extended emulation, high precision	HH:MM:SS.S# (hours, minutes, seconds and tenths of seconds)
Any emulation, ultra precision	HH:MM:SS.SS# (hours, minutes, seconds and hundredths of seconds)

Note

The result may be incorrect in firmware version <= 2.14.3.

:GREF# Gets the current status of the refraction correction.
Returns:
0 Refraction correction inactive
1 Refraction correction active
Available from version 2.10 (previous versions have refraction always active).

:GSC# Gets the current status of the speed correction flag
Returns:
0 Speed correction inactive
1 Speed correction active

Note

When the speed correction is active, the speed of any movement in the RA/azimuth axis is multiplied by cos (dec)$^{-1}$ or cos (altitude)$^{-1}$. In this way the angular speed on the sky is always constant. This is useful when autoguiding, since the relation between the duration of the correction pulses and the offsets in the focal plane of the telescope becomes independent from the declination (or altitude) of the mount.

:GSTAT# (deprecated, use :Gstat# instead) Gets the status of the mount.
Returns: a number depending on the current status of the mount. See :Gstat# for the list of codes.
Note: this command is deprecated because it has no '#' terminator.

:Gstat# Gets the status of the mount.
Returns: a number depending on the current status of the mount, terminated by a '#', with the following meaning:

0#	The mount is tracking.
1#	The mount is stopped after the pressing of the STOP key, receiving the :STOP# command or completing an homing sequence. Note that up to firmware version 2.12.21 included, the status will be returned as 1# just after the STOP key is pressed or the :STOP# command is received, even if the mount hasn't stopped yet. Since firmware version 2.12.22, this status will be returned only if the motors are actually stopped.
2#	The mount is slewing to the park position.
3#	The mount is unparking.
4#	The mount is slewing to the home position.
5#	The mount is parked.
6#	The mount is slewing, or the mount is going to stop (but still moving) after the STOP key has been pressed or the :STOP# command has been received.
7#	Tracking is off and the mount is not moving.
8#	The motors are inhibited because of low temperature (only for special-purpose mounts with temperature sensors) .
9#	Tracking is on but the mount is outside tracking limits.
10#	The mount is following a precalulated satellite trajectory.
11#	The mount needs an user intervention to authorize movement, due to a suspected inconsistency in data (see :USEROK# command); if this occurs, DO NOT assume anything about the correctness of the mount position or alignment data.
98#	Unknown status.
99#	Error.

Available from version 2.8.8.

Note

The slew settle time set by the :Sstm command does not affect the status returned by this command.

:Gstm# Returns the slew settle time. After a slew has been completed, the :D# and :GDW# commands will return a slewing status for the time duration set in this command.

Note: the :Gstat# command is not affected by this setting.
Returns: NNNNN.NNN#
The mount settle time in seconds.
Available from version 2.9.14.

:GDstm# Returns the dome settle time. After a slew has been completed, the :GDW# and :GDw# commands will return a slewing status for the time duration set in this command.
Returns: NNNNN.NNN#
The dome settle time in seconds.
Available from version 2.9.14.

:Glmt# Returns the meridian limit for tracking in degrees.
Returns: NN#
The meridian limit for tracking in degrees.
Available from version 2.11.

:Glms# Returns the meridian limit for slews in degrees.
Returns: NN#
The meridian limit for slews in degrees.
Available from version 2.11.

:Gmte# Returns the estimated time to tracking end due to horizon / flip limits reached.
Returns: NNNN#
The estimated time to tracking end in minutes of time.
Available from version 2.11.

:Guaf# Returns the unattended flip setting.
Returns:
0 disabled
1 enabled
Available from version 2.11.
Note: unattended flip didn't work properly in firmware versions up to 2.13.8 included.

:GT# Get tracking rate.
Returns: TT.T#
This value is computed in order to emulate the corresponding LX200 command. This corresponds to the equivalent frequency expressed in hertz assuming a synchronous motor design where a 60.0 Hz motor clock would produce 1 revolution of the mount in 24 hours. So, in order to obtain the tracking rate in arcseconds per second of time, this value should be divided by four.

:Gt# Get current site latitude. Returns the latitude of the current site formatted as follows:

Emulation and precision	Return value
Any emulation, low precision	sDD*MM# (sign, degrees, minutes)
LX200 emulation, high precision	sDD*MM# (sign, degrees, minutes)
Extended emulation, high precision	sDD*MM:SS# (sign, degrees, arcminutes, arcseconds)
Any emulation, ultra precision	sDD:MM:SS.S# (sign, degrees, arcminutes, arcseconds, tenths of arcsecond)

Positive implies north latitude.

:GTMPn# Get the temperature of element n, where n is an ASCII digit (1...9) with the following interpretation:
1 Right Ascension/Azimuth motor driver
2 Declination/Altitude motor driver
7 Right Ascension/Azimuth motor
8 Declination/Altitude motor
9 Electronics box temperature sensor
11 Keypad (v2) display sensor
12 Keypad (v2) PCB sensor
13 Keypad (v2) controller sensor
Returns: +TTT.T#
The required temperature in degrees Celsius (°C).
If the required temperature cannot be read, the string "Unavailable#" is returned.
If the electronics box temperature sensor is available, its readout can be used to monitor the electronics temperature to avoid overheating. The electronics box temperature should never go above +65°C. If the temperature goes above +65°C, immediate action should be taken in order to preserve the electronics – either cooling it or shutting it off. Higher temperatures would damage the electronics and the power supplies will automatically shut down at +70°C.
7, 8, 9 are available only for special-purpose mounts with temperature sensors.
11, 12, 13 are available only if a physical keypad version 2 is connected to the mount.
Available from version 2.3.0.

:GTMPLT#
Gets the status of the detection of low temperature conditions where the maximum slewing performance of the mount can be limited.
Returns:
0 no low temperature condition has been detected
1 a low temperature condition has been detected, the mount performance can be limited.
Available from version 2.14.8.

:GTMPOHn#
Gets the temperature overheat threshold for the motors, where n is an ASCII digit (1...9) with the following interpretation:
7 Right Ascension/Azimuth motor
8 Declination/Altitude motor

Returns: a string containing the overheat temperature threshold T_H in degrees Celsius (°C). When the temperature of the motor is above T_H, the motion is stopped and the heaters are turn off. The string is formatted as follows:
sTTT.T#
If the n parameter is invalid, the string "1" is returned.
Available only for special-purpose mounts with temperature sensors.
Available from version 2.7.8.

:GTMPTHn#
Gets the temperature thresholds for the motors, where n is an ASCII digit (1...9) with the following interpretation:
7 Right Ascension/Azimuth motor
8 Declination/Altitude motor
Returns: a string containing the three temperature thresholds T_0, T_1 and T_2, in this order and in degrees Celsius (°C). When the temperature of the motor is below T_0, the motion is stopped and the heaters are powered. When the temperature drops below T_1, the heaters are turned on, and when the temperature rises above T_2, the heaters are turned off. The string is formatted as follows:
sTTT.T,sTTT.T,sTTT.T#
If the n parameter is invalid, the string "1" is returned.
Available only for special-purpose mounts with temperature sensors.
Available from version 2.3.0.

:GTRK# Get the current tracking status of the mount
Returns:
0 the mount is not tracking
1 the mount is tracking
Available from version 2.3.0.

:GTTRK# Get the tracking status of the target object
Returns:
0 the target object is located in a position where tracking is not allowed (i.e. below the horizon, or above +89° if using an altazimuth mount)
1 the target object is located in a position where tracking is allowed
Available from version 2.3.0.

:GTsid# Get the destination side of the target object
Returns:
0 no target defined, or the target object is located in a position where it is not possible to go
2 the target is located in a position where the mount would slew to the west side
3 the target is located in a position where the mount would slew to the east side
Available from version 2.9.9.

Notes
See the :MSfs command.

:GVD# Get firmware date.
Returns: mmm dd yyyy# (month as a three-letter string among "Jan", "Feb", "Mar", "Apr", "May", "Jun", "Jul", "Aug", "Sep", "Oct", "Nov", "Dec"; day; year)

:GVN# Get firmware number.
Returns: <string>#
A string containing the firmware revision.

:GVP# Get product name.
Returns: <string>#
A string containing the product name:
"10micron GM1000HPS#" for a GM1000HPS mount
"10micron GM2000QCI#" for a GM2000QCI mount
"10micron GM2000HPS#" for a GM2000HPS mount
"10micron GM3000HPS#" for a GM3000HPS mount
"10micron GM4000QCI#" for a GM4000QCI mount
"10micron GM4000QCI 48V#" for a special GM4000QCI mount with 48V supply
"10micron GM4000HPS#" for a GM4000HPS mount
"10micron AZ2000#" for an altazimuth AZ2000 mount
"10micron AZ2000HPS#" for an altazimuth AZ2000HPS mount
"10micron AZ4000HPS#" for an altazimuth AZ4000HPS mount

:GVT# Get firmware time.
returns: HH:MM:SS# (hours, minutes, seconds)

:GVZ# Get control box hardware version.
Returns: <string#>
A string containing the control box version. Currently the string can be one of the following:
"Q-TYPE2012#" identifies a Q-TYPE 2012 control box
"PRE2012#" identifies a pre-2012 control box
"UNKNOWN#" identifies an unknown control box version
Available from version 2.9.9.

:GWAV# Query if wireless is available.
Returns:
the string "0#" if no wireless is available;
the string "1#" if a wireless adapter is available.
Available from version 2.10.

Note

Use this command to query for the existance of a wireless connection possibility. This doesn't mean that the wireless connection is active.

:GWRSC# Start scanning for wireless access points.
Returns:
the string "0#" if no wireless is available;
the string "1#" if a wireless adapter is available.
Available from version 2.10.

:GWRAP# Get the wireless access points available.
Returns:
the string "0#" if no wireless is available;

a string composed by the character "1" followed by a comma-separated list of access point names, terminated by the character "#".
The access points names are escaped as explained at page 53.
Available from version 2.9.8.

:GWID# Get the ESSID of the wireless network if available
Returns:
the string "#" if the wireless network is not connected
the string "<ESSID>#" where <ESSID> is the current access point name (escaped as explained at page 53).
Available from version 2.10.

:GWUP# Get the wireless network status.
Returns:
the string "E#" if the wireless network has not been configured;
the string "0#" if the wireless network has been configured correctly and is setup as a client;
the string "1#" if the wireless network has been configured correctly and is setup as an hotspot;
the string "2#" if the wireless network configuration is underway.
Available from version 2.12.25.

:GWRAP2#
Get the wireless access points available with encryption information.
Returns:
the string "0#" if no wireless is available;
a string, whose first character is:
"1" – the last wireless access point scan (started by :GWRSC#) is underway
"2" – the last wireless access point scan is ended
and then is followed by a comma-separated list of access point names, terminated by the character "#". Each access point name is preceded by a single letter with the following meaning:
'o' – Open access point (no security)
'w' – WEP security
'1' – WPA PSK security
'2' – WPA2 PSK security
'x' – unsupported security
So if the last access point scan is finished, there are two access points, one with ESSID "Office" and WEP security, and another with ESSID "Home" and WPA-PSK security, the return string will be:
"2wOffice,1Home#"
The access points names are escaped as explained at page 53.
Available from version 2.10.

:GZ# Get the telescope azimuth. Returns the current azimuth of the telescope formatted as follows:

Emulation and precision	Return value
Any emulation, low precision	DDD*MM# (degrees, arcminutes)
Any emulation, high precision	DDD*MM:SS# (degrees, arcminutes, arcseconds)
Any emulation, ultra precision	DDD:MM:SS.S# (degrees, arcminutes, arcseconds and tenths of arcsecond)

:Gz# Get the target azimuth. Returns the azimuth of the current target formatted as follows:

Emulation and precision	Return value
Any emulation, low precision	DDD*MM# (degrees, arcminutes)
Any emulation, high precision	DDD*MM:SS# (degrees, arcminutes, arcseconds)
Any emulation, ultra precision	DDD:MM:SS.S# (degrees, arcminutes, arcseconds and tenths of arcsecond)

If the target position has been set using the :Sr and :Sd commands, the return value is the azimuth of the target computed from its equatorial coordinates at the time the :Gz command is received. Otherwise, it is the value set using the :Sz command. If neither an equatorial target position nor a target azimuth has been set, the return value is undefined.
From version 2.12.14 onwards, when the mount is commanded to slew to a target from the keypad / virtual keypad interface, the target azimuth is updated with the azimuth of the target set by the keypad / virtual keypad interface.

:pS# Get the side of the pier on which the telescope is currently positioned.
Returns: the string “East#” or the string "West#".

:V# Get emulated firmware revision. This is implemented as some software needs it in order to function properly.
Returns: the string “G#”.

Home & Park Commands

:hS# Seeks the home position and stores the alignment information and the encoder values from the aligned mount at the home position in the nonvolatile memory of the mount. This command has effect only if the mount has homing sensors (GM4000QCI, AZ2000QCI).
Returns: nothing

:hF# Seeks the home position of the mount and sets/aligns the scope based on the encoder values and the alignment information stored in non-volatile memory.
This command has effect only if the mount has homing sensors (GM4000QCI, AZ2000QCI).
Returns: nothing

:hP#	Slew to park position Returns: nothing
:KA#	Slew to park position Returns: nothing
:PO#	Unpark Returns: nothing
:h?#	Query home status Returns: 0 home search failed 1 home search found 2 home search in progress

Notes

To detect the end of the park movement, the :D# command (see the next section) can be used.

The park position should be set with the hand controller or the virtual keypad software.

The alignment information and encoder values are saved when the mount is powered off even if it is not parked nor at the home position; as long as the mount is not moved manually, the position will be recovered at the next startup. The park command should be used in order to put the mount in a "safe" position, while the home commands are used when performing the initial alignment (in order to put the mount in a known position) and to recover the position information when the mount has been moved while unpowered. HPS and DDS mounts have absolute encoders, so the firmware always knows their position, even if the mount is moved manually when unpowered.

Movement Commands

:MA#	Slew to target altitude and azimuth. Returns: Returns: 0 no error if the target is below the lower limit: the string "1Object Below Horizon #" if the target is above the high limit: the string "2Object Below Higher #" if the slew cannot be performed due to another cause: the string "3Cannot Perform Slew #" if the mount is parked: the string "4Mount Parked #" if the mount is restricted to one side of the meridian and the object is on the other side: the string "5Object on the other side #"

Notes

The :MA# command will slew to the altazimuth coordinates defined by the commands :Sa (Set target altitude) and :Sz (Set target azimuth). After slewing to the target position, the mount will not track the object.

:Me#	Move east (for equatorial mounts) or left (for altazimuth mounts) at current rate. Returns: nothing If this command is given while moving at the guide rate, and the ultra precision mode is not active, turning off the mount while this command is in effect will make the mount to stay parked when turned on again.
:Mn#	Move north (for equatorial mounts) or up (for altazimuth mounts) at current rate. Returns: nothing
:Ms#	Move south (for equatorial mounts) or down (for altazimuth mounts) at current rate. Returns: nothing
:Mw#	Move west (for equatorial mounts) or right (for altazimuth mounts) at current rate. Returns: nothing
:MgeXXXX#	
:MeXXX#	Corrects the position of the mount to the east (for equatorial mounts) or left (for altazimuth mounts) by an amount equivalent to a motion of XXX milliseconds at the current autoguide speed. The maximum length of the correction is 1000 milliseconds up to firmware revision 2.9.20. From firmware revision 2.10, the maximum length of the correction is 9999 milliseconds.
:MgnXXXX#	
:MnXXX#	Corrects the position of the mount to the north (for equatorial mounts) or up (for altazimuth mounts) by an amount equivalent to a motion of XXX milliseconds at the current autoguide speed. The maximum length of the correction is 1000 milliseconds up to firmware revision 2.9.20. From firmware revision 2.10, the maximum length of the correction is 9999 milliseconds.
:MgsXXXX#	
:MsXXX#	Corrects the position of the mount to the south (for equatorial mounts) or down (for altazimuth mounts) by an amount equivalent to a motion of XXX milliseconds at the current autoguide speed. The maximum length of the correction is 1000 milliseconds up to firmware revision 2.9.20. From firmware revision 2.10, the maximum length of the correction is 9999 milliseconds.
:MgwXXXX#	

:MwXXX# Corrects the position of the mount to the west (for equatorial mounts) or right (for altazimuth mounts) by an amount equivalent to a motion of XXX milliseconds at the current autoguide speed. The maximum length of the correction is 1000 milliseconds up to firmware revision 2.9.20. From firmware revision 2.10, the maximum length of the correction is 9999 milliseconds.

Note

If the speed correction option is selected (with the hand controller or the virtual keypad software) the actual angular speed on the RA/azimuth axis is increased in order to achieve the same angular speed on the sky at the different angles of declination/altitude.

:MS# Slew to target object.
Returns:
0 no error
if the target is below the lower limit: the string
"1Object Below Horizon #"
if the target is above the high limit: the string
"2Object Below Higher #"
if the slew cannot be performed due to another cause: the string
"3Cannot Perform Slew #"
if the mount is parked: the string
"4Mount Parked #"
if the mount is restricted to one side of the meridian and the object is on the other side: the string
"5Object on the other side #"

Notes

The :MS# command will slew to the equatorial coordinates defined by the commands :Sr (Set target right ascension) and :Sd (Set target declination). It is assumed that the coordinates are apparent, topocentric and NOT corrected for refraction. After slewing to the target position, the mount will track the object.

:MSfsn# Slew to target object on the specified side, where n is 2 for west and 3 for east.
Returns:
0 no error
if the target is below the lower limit: the string
"1Object Below Horizon #"
if the target is above the high limit: the string
"2Object Below Higher #"
if the slew cannot be performed due to another cause: the string
"3Cannot Perform Slew #"
if the mount is parked: the string
"4Mount Parked #"
if the mount is restricted to one side of the meridian and the object is on the other side: the string
"5Object on the other side #"
Available from version 2.9.9.

Note

Use the :MSfs command in conjunction with the :GTsid command in order to check the destination side before slewing to an object. Using :GTsid followed by :MS would permit getting a side and then slewing successfully to the other side if betweeen the two commands the position of the object in the sky changes too much. Note that the behaviour obtained by using :GTsid for DestinationSideOfPier and :MS for slewing to the target (i.e. the possibility that the slew goes to the other side) is currently expected to happen within the ASCOM specification.

:MSnf# Slew to target object, disregarding the fine movement limit for slewing to the same meridian side.
Returns:
0 no error
if the target is below the lower limit: the string
"1Object Below Horizon #"
if the target is above the high limit: the string
"2Object Below Higher #"
if the slew cannot be performed due to another cause: the string
"3Cannot Perform Slew #"
if the mount is parked: the string
"4Mount Parked #"
if the mount is restricted to one side of the meridian and the object is on the other side: the string
"5Object on the other side #"
Available from version 2.11.

:EW# Swaps east and west directions.
Returns: nothing

:NS# Swaps north and south directions.
Returns: nothing

:Q# Halt all current slewing.
Returns: nothing

:Qe# Halt eastward (for equatorial mounts) or leftward (for altazimuth mounts) movements.
Returns: nothing

:Qn# Halt northward (for equatorial mounts) or upward (for altazimuth mounts) movements.
Returns: nothing

:Qs# Halt southward (for equatorial mounts) or downward (for altazimuth mounts) movements.
Returns: nothing

:Qw# Halt westward (for equatorial mounts) or rightward (for altazimuth mounts) movements.
Returns: nothing

:FLIP# This command acts in different ways on the AZ2000 and german equatorial (GM1000 – GM4000) mounts.
On an AZ2000 mount:
When observing an object near the lowest culmination, requests to make a 360° turn of the azimuth axis and point the object again.
On a german equatorial mount:
When observing an object near the meridian, requests to make a 180° turn of the RA axis and move the declination axis in order to point the object with the telescope on the other side of the mount.
Returns:
1 if successful
0 if the movement cannot be done

:D# Requests a string indicating the progress of the current slew operation.
Returns:
the string "■#", where the block character has ascii code 127 (0x7F), if a slew is in progress or a slew has ended from less than the settle time set in command :Sstm.
the string "#" if a slew has been completed or no slew is underway.

Note

If a dome is connected, check the :GDW# command, since it may be more appropriate for you.

:P# This command does nothing. It is included for compatibility with the LX200 command protocol, where it enables the high-precision pointing.

:NUDGEsXXXX,sYYYY#
This command cause the mount to move to a point which coordinates are offset from the current coordinates by sXXXX arcseconds in the RA/azimith axis and sYYYY arcseconds in the declination/altitude axis. This is the equivalent of computing new target coordinates and slewing to them. Do not use this command for autoguiding. The typical usage of this command is to center objects after a previous slew.
Returns:
0 no error
the string "1Object Below Horizon #" if the target is below the lower limit.
the string "2Object Below Higher #" if the target is above the high limit.
the string "3Cannot Perform Nudge #" if the nudge cannot be performed due to another cause.
Available from version 2.7.4.

Note

If the speed correction option is selected (with the hand controller or the virtual keypad software) the actual movement on the RA/azimuth axis is increased in order to achieve the same angular movement on the sky at the different angles of declination/altitude.

The nudge operation is equivalent to a slew; i.e. it is possible to check if the operation is completed using the :D# command. Trying to start a new nudge operation while the previous operation is incomplete (or if the telescope is still slewing to a target) will fail.

Rate Commands

:RC#	Set slew rate to Centering rate (2nd slowest) Returns: nothing
:RCn#	Sets the centering rate according to the value of n: 0 16x (0.067°/s) 1 64x (0.27°/s) 2 600x (2.5°/s) 3 1200x (5°/s) If the selected rate is greater than the current slew rate, the centering rate is made equal to the slew rate. For example, if the slew rate is set to 900x (3.75°/s), the command :RC3# will set the centering rate to 900x (3.75°/s). Returns: nothing
:RG#	Set slew rate to Guiding Rate (slowest) Returns: nothing
:RGn#	Sets the guiding rate according to the value of n: 0 0.25x (3.75”/s) 1 0.5x (7.5”/s) 2 1.0x (15”/s) Returns: nothing
:RM#	Set slew rate to Find Rate (2nd fastest) Returns: nothing
:RS#	Set slew rate to max (fastest) Returns: nothing
:RSn#	Sets the slew rate according to the value of n: 0 1200x (5°/s) 1 900x (3.75°/s) 2 600x (2.5°/s) If the selected rate is greater than the maximum slew rate, the slew rate is made equal to the maximum slew rate. For example, if the maximum slew rate is set to 3°/s, both the commands :RS0# and :RS1# will set the slew rate to 720x (3°/s). Returns: nothing
:RADD.D#	Set RA/azimuth slew rate to DD.D degrees per second (up to seven decimal places allowed). Returns: nothing
:REDD.D#	Set declination/altitude slew rate to DD.D degrees per second (up to seven decimal places allowed). Returns: nothing
:RgSS.S#	Set guiding rate to +/- SS.S to arc seconds per second.

When the guiding rate is selected (using the :RG# command), this rate is added or subtracted from the current tracking rates when the :Me# – :Mw# – :Mn# – :Ms# commands are issued, when the direction buttons are pressed on the keypad or the virtual keypad and also when guiding using the autoguide port. Rate shall not exceed sidereal speed (approx 15.0417”/sec).
Returns: nothing

:RcXXX# Set the centering rate to XXX times the sidereal speed, where XXX is comprised between 1 and 255.
Available from version 2.7.8.
Returns: nothing

:RsXXXX#Set the slew rate to XXXX times the sidereal speed, where XXXX is comprised between 1 and 1200.
Available from version 2.7.8.
Returns: nothing

:RMsXX# Set the slew rate (for automated moves) to XX degrees/s in the allowed range for the mount. Note: this does not select the slew rate for axis movements. In order to select the slew rate for axis movements, use the :RS command after this one.
Returns
0 valid
1 invalid
Available from version 2.9.9.

:GMs# Get the current slew rate in degrees/s.
Returns: XX#
the current slew rate in degrees/s.
Available from version 2.9.9.

:GMsa# Get the minimum slew rate that can be set in the mount in degrees/s.
Returns: XX#
the minimum slew rate in degrees/s.
Available from version 2.9.9.

:GMsb# Get the maximum slew rate that can be set in the mount in degrees/s.
Returns: XX#
the maximum slew rate in degrees/s.
Available from version 2.9.9.

:Ggui# Get current guide rate.
Returns: S.SS# (arcseconds/s)
The current guide rate.
Available from version 2.9.11.

Set Commands

:BdDD*MM:SS# or :BdHH:MM:SS# or :BdHH:MM:SS.S#

Sets declination/altitude backlash to DD*MM:SS (degrees, arcminutes, arcseconds) or HH:MM:SS(.S) (hours, minutes, seconds and optionally tenths of seconds).
Returns:
1 valid

:BrDD*MM:SS# or :BrHH:MM:SS# or :BrHH:MM:SS.S#
Sets RA/azimuth backlash to DD*MM:SS (degrees, arcminutes, arcseconds) or HH:MM:SS(.S) (hours, minutes, seconds and optionally tenths of seconds).
Returns:
1 valid

:SasDD*MM# or :SasDD*MM:SS# or :SasDD*MM:SS.S#
Set target object altitude to sDD*MM (sign, degrees, arcminutes), sDD*MM:SS (sign, degrees, arcminutes, arcseconds) or sDD*MM:SS.S (sign, degrees, arcminutes, arcseconds, tenths of arcsecond)
Returns:
0 object out of slew range
1 object within slew range

:SBn# Set baud rate n, where n is an ASCII digit (0...9) with the following interpertation:
0 115.2K
1 57.6K
2 38.4K
4 19.2K
6 9600
7 4800
8 2400
9 1200
Returns:
0 invalid rate
1 new baud rate accepted; this character is returned at the current baud rate and then changes to the new rate for further communication

Notes

This command has effect only on the RS-232 communication link.

:SCMM/DD/YY# or :SCMM/DD/YYYY# or :SCYYYY-MM-DD#
Set date to MM/DD/YY (month, day, year), MM/DD/YYYY (month, day, year) or YYYY-MM-DD (year, month, day). The date is expressed in local time.
Returns:
0 if the date is invalid
The string “1Updating Planetary Data. # #” if the date is valid.
The string "1<32 spaces>#<32 spaces>#" in extended LX200 emulation mode.
The character "1" without additional strings in ultra-precision mode (regardless of emulation).

:SdsDD*MM# or :SdsDD*MM:SS# or :Sd sDD*MM:SS.S#

Set target object declination to sDD*MM (sign, degrees, arcminutes), sDD*MM:SS (sign, degrees, arcminutes, arcseconds) or sDD*MM:SS.S (sign, degrees, arcminutes, arcseconds and tenths of arcsecond)
Returns:
0 invalid
1 valid

:SevsXXXX.X#
Set current site's elevation to sXXXX.X (sign, metres) in the range -1000.0 to 9999.9.
Returns:
0 invalid
1 valid
Available from version 2.9.9.

:SgsDDD*MM# or :SgsDDD*MM:SS# or :SgsDDD*MM:SS.S#
Set current site's longitude to sDDD*MM (sign, degrees, arcminutes), sDDD*MM:SS (sign, degrees, arcminutes, arcseconds) or sDDD*MM:SS.S (sign, degrees, arcminutes, arcseconds and tenths of arcsecond). **Note: East Longitudes are expressed as negative.**
Returns:
0 invalid
1 valid

:SGsHH.H# or :SGsHH:MM.M# or :SGsHH:MM:SS#
Set the number of hours added to local time to yield UTC (sign, hours and tenths of hour; sign, hours, minutes and tenths of minute; sign, hours, minutes and seconds)
Returns:
0 invalid
1 valid

Notes

The mount internally keeps UTC time. The :SG command operates only on the conversion between UTC time and the local time. In order to work with UTC, use :SG+00.0# before all time get/set commands. The UTC offset set by this command (and got by the :GG command) accounts for the DST set in the keypad: if the DST changes from off to on on the keypad, the UTC offset will decrease by an hour, and the time got from the :GL command will increase by an hour. If you are not using the keypad, you can ignore the DST setting.

:ShsDD# Set the highest altitude to which the telescope will slew to sDD degrees.
Returns:
0 invalid
1 valid

:SJDJJJJJJ.JJJJJ#
Set the Julian Date to the given value (up to eight decimal places).
Returns:
0 invalid
1 valid

Note

The Julian Date is computed from the UTC time. During leap seconds, there is no valid value for the Julian Date, so you cannot use this command to set time during leap seconds.

:SLHH:MM:SS#, :SLHH:MM:SS.S# or :SLHH:MM:SS.SS#

Set the local Time to HH:MM:SS (hours, minutes, seconds), HH:MM:SS.S (hours, minutes, seconds and tenths of second) or HH:MM:SS.SS (hours, minutes, seconds and hundredths of second).
Returns:
0 invalid
1 valid

Note

The UTC time (and the local time which derives from it) may contain leap seconds. This means that sometimes the seconds field may contain values from 60.00 to 60.59.

:SLDTYYYY-MM-DD,HH:MM:SS#

Set together the local date and time to HH:MM:SS (hours, minutes, seconds) and the local date to YYYY-MM-DD (year, month, day of month).
You may specify the date also with MM/DD/YY (month, day, year from 2000) or MM/DD/YYYY (month, day, year).
You may specify the time also with HH:MM:SS.S or HH:MM:SS.SS (adding decimal digits to the seconds).
Returns:
0 invalid
1 valid
Available from version 2.12.26.

Note

The UTC time (and the local time which derives from it) may contain leap seconds. This means that sometimes the seconds field may contain values from 60.00 to 60.59.

:SUDTYYYY-MM-DD,HH:MM:SS#

Set together the UTC date and time to HH:MM:SS (hours, minutes, seconds) and the local date to YYYY-MM-DD (year, month, day of month).
You may specify the date also with MM/DD/YY (month, day, year from 2000) or MM/DD/YYYY (month, day, year).
You may specify the time also with HH:MM:SS.S or HH:MM:SS.SS (adding decimal digits to the seconds).
Returns:
0 invalid
1 valid
Available from version 2.12.26.

Note

The UTC time (and the local time which derives from it) may contain leap seconds. This means that sometimes the seconds field may contain values from 60.00 to 60.59.

:SMFn# Set meridian side behaviour, where n is an ASCII digit (1..3) with the following interpretation:

1 both sides of the meridian allowed;
2 only objects west of the meridian allowed;
3 only objects east of the meridian allowed.
Returns:
0 invalid
1 valid
Available from version 2.7.7.

:SosDD# Set the minimum altitude above the horizon to which the telescope will slew to sDD degrees. Valid values are between –5 and +45 degrees.
Returns:
0 invalid
1 valid

:SrHH:MM.T# or :SrHH:MM:SS# or :SrHH:MM:SS.S# or :SrHH:MM:SS.SS#
Set target object RA to HH:MM.T (hours, minutes and tenths of minutes), HH:MM:SS (hours, minutes, seconds), HH:MM:SS.S (hours, minutes, seconds and tenths of second) or HH:MM:SS.SS (hours, minutes, seconds and hundredths of second).
Returns:
0 invalid
1 valid

:SRLYn,m#
Set the status of relay n, where n is an ASCII digit (1...9) with the following interpretation:
1 User relay 1
2 User relay 2
3 User relay 3
4 User relay 4
5 User relay 5
6 User relay 6
m is the new status of the relay, with 0 = open and 1 = closed.
Returns:
0 invalid
1 valid
Available only for special purpose mounts with external relay control.
Available from version 2.3.

:SREFn# Sets the current status of the refraction correction, where n has the following interpretation:
0 deactivate refraction correction
1 activate refraction correction
Returns:
0 invalid
1 valid
Available from version 2.10 (previous versions have refraction always active).

:SRPRSPPPP.P# Sets the atmospheric pressure used in the refraction model to PPPP.P hPa. Note that this is the pressure at the location of the telescope, and not the pressure at sea level.

Returns:
0 invalid
1 valid
Available from version 2.3.0.

:SRTMPsTTT.T# Sets the temperature used in the refraction model to sTTT.T degrees Celsius (°C).
Returns:
0 invalid
1 valid
Available from version 2.3.0.

:SSCn# Sets the current status of the speed correction flag (see the :GSC# command), where n has the following interpretation:
0 deactivate speed correction
1 activate speed correction
Returns:
0 invalid
1 valid

:SstmNNNNN.NNN #
Sets the slew settle time to NNNNN.NNN seconds (from 0 to 99999 s). After a slew of the mount has been completed, the :D# and :GDW# commands will return a slewing status for the time duration set in this command.
Note: the :Gstat# command is not affected by this setting.
Returns:
0 invalid
1 valid
Available from version 2.9.14.

:SDstmNNNNN.NNN #
Sets the dome settle time to NNNNN.NNN seconds (from 0 to 99999 s). After a dome slew has been completed, the :GDW# and :GDw# commands will return a slewing status for the time duration set in this command.
Returns:
0 invalid
1 valid
Available from version 2.9.14.

:SlmtNN# Sets the meridian limit for tracking in degrees. The minimum value is the same as the meridian limit for slews.
Returns:
0 invalid
1 valid
Available from version 2.11.

:SlmsNN# Sets the meridian limit for slews in degrees. Setting a meridian limit for slews greater than the meridian limit for tracking will increase the meridian limit for tracking to the same value.

Returns:
0 invalid
1 valid
Available from version 2.11.

:SuafN# Enables or disables the unattended flip. Use N=1 to enable, N=0 to disable. This is set always to 0 after power up.
Returns: nothing
Available from version 2.11.

Note

unattended flip didn't work properly in firmware versions up to 2.13.8 included.

:StsDD*MM# or :StsDD*MM:SS# or :StsDD*MM:SS.S#
Sets the current site latitude to sDD*MM (sign, degrees, arcminutes), sDD*MM:SS (sign, degrees, arcminutes, arcseconds), or sDD*MM:SS.S (sign, degrees, arcminutes, arcseconds and tenths of arcsecond)
Returns:
0 invalid
1 valid

:STMPTHn,sTTT.T,sTTT.T,sTTT.T#
Sets the temperature thresholds for the motors, where n is an ASCII digit (1...9) with the following interpretation:
7 Right Ascension/Azimuth motor
8 Declination/Altitude motor
sTTT.T are the three temperature thresholds T_0, T_1 and T_2, in this order and in degrees Celsius (°C) . They must obey the relation $T_0 < T_1 < T_2$ and must be in the range -100 / +40 °C. When the temperature of the motor is below T_0, the motion is stopped and the heaters are powered. When the temperature drops below T_1, the heaters are turned on, and when the temperature rises above T_2, the heaters are turned off.
Returns:
0 invalid
1 valid
Available only for special-purpose mounts with temperature sensors.
Available from version 2.3.

:STMPOHn,sTTT.T#
Sets the temperature overheat threshold for the motors, where n is an ASCII digit (1...9) with the following interpretation:
7 Right Ascension/Azimuth motor
8 Declination/Altitude motor
sTTT.T is the temperature threshold T_H in degrees Celsius (°C) . It be in the range 0 / +80 °C. When the temperature of the motor is above T_H, the motion is stopped and the heaters are turned off.
Returns:
0 invalid
1 valid
Available only for special-purpose mounts with temperature sensors.

Available from version 2.7.8.

:STOP# Halt all current movements, included tracking. If the mount is parked, parking or unparking it will be left in "parked" status. Otherwise, any movement command will return the mount to normal operation. Tracking can be restarted with the :AP# command.
Returns: nothing
Available from version 2.3.

:SwN# Set maximum slew rate to N degrees per second.
Returns:
0 invalid
1 valid

:SWRLstring#
Set the wireless interface configuration.
To configure an hotspot (other devices will connect to the network created by the mount), the string will be formatted as follows:
1,ssid,encryption,key,ip address,network mask
To configure a client (the mount will connect to an existing network), and get the IP address from a DHCP server on the network, the string will be formatted as follows:
0,ssid,encryption,key,DHCP
To configure a client (the mount will connect to an existing network), and set the IP address manually, the string will be formatted as follows:
0,ssid,encryption,key,ip address,network mask,gateway
ssid – the network SSID, escaped as explained at page 53.
encryption – the string WEP (for WEP encryption) or WPA (for WPA–PSK encryption); only WEP is supported in hotspot mode until version 2.10.4 included, WPA is supported in hotspot mode from version 2.10.5.
key – the WEP key or WPA passphrase, escaped as explained at page 53.
ip address – the IP address of the mount
network mask – the network mask for the subnet
gateway – the IP address of the gateway
Returns:
the string "1#" if the configuration has succeeded
the string "0#" if the configuration failed
Available from version 2.9.8, only for mounts with the wireless connection option installed.

Note

If the parameters of the current connection are changed, it may happen that the connection is lost afterwards.

:SWRLC#
Shut down the wireless interface.
Available from version 2.12.3, only for mounts with the wireless connection option installed.
Returns:
the string "1#"

:SIPstring#

Set the LAN interface configuration.
To configure the LAN interface to get the IP address from a DHCP server, the string will be "1"
To configure the LAN interface to a fixed IP address, the string will be "0,ip address,network mask,gateway"
Returns:
the string "1#" if the configuration has succeeded
the string "0#" if the configuration failed
Available from version 2.10

Note

If the parameters of the current connection are changed, it may happen that the connection is lost afterwards.

:SzDDD*MM# or :SzDDD*MM:SS# or :SzDDD*MM:SS.S#

Sets the target azimuth to DDD*MM (degrees, arcminutes), DDD*MM:SS (degrees, arcminutes, arcseconds), or DDD*MM:SS.S (degrees, arcminutes, arcseconds and tenths of arcsecond).
Returns:
0 invalid
1 valid

Tracking Commands

:$Q# Toggles the periodic error correction on and off. Has no effect if PEC training is active. Has no effect with the HPS mounts which don't feature PEC.
Returns: nothing

:p# Stops the periodic error correction. Has no effect with the HPS mounts which don't feature PEC.
Returns: nothing

:pP# Activates the periodic error correction. Has no effect with the HPS mounts which don't feature PEC.
Returns: nothing

:pR# Starts the periodic error correction training. Has no effect with the HPS mounts which don't feature PEC.
Returns: nothing

:pRX# Starts the periodic error correction training, where X has the following meaning:
0 short training (~15 minutes at sidereal speed)
1 medium training (~30 minutes at sidereal speed)
2 long training (~60 minutes at sidereal speed)
On an equatorial mount, only the R.A. axis is trained.
On an altazimuth mount, both axes are trained. The duration is proportionally longer due to the slower rates. Has no effect with the HPS mounts which don't feature PEC.

Returns: nothing

:pRaX# Starts the periodic error correction training of the altitude axis of an altazimuth mount, where X has the following meaning:
0 short training (~15 minutes at sidereal speed)
1 medium training (~30 minutes at sidereal speed)
2 long training (~60 minutes at sidereal speed)
The actual duration depends on the average rate on the altitude axis.
Has no effect with the HPS mounts which don't feature PEC.
Returns: nothing

:pRzX# Starts the periodic error correction training of the azimuth axis of an altazimuth mount, where X has the following meaning:
0 short training (~15 minutes at sidereal speed)
1 medium training (~30 minutes at sidereal speed)
2 long training (~60 minutes at sidereal speed)
The actual duration depends on the average rate on the azimuth axis.
Has no effect with the HPS mounts which don't feature PEC.
Returns: nothing

:T+# Increment custom tracking rate by 0.025 arcseconds per second of time.
Returns: nothing

:T-# Decrement custom tracking rate by 0.025 arcseconds per second of time.
Returns: nothing

:TL# Set lunar tracking rate
Returns: nothing

:TSOLAR# Set solar tracking rate
Returns: nothing

:TM# Set custom tracking rate
Returns: nothing

:TQ# Set default (sidereal) tracking rate
Returns: nothing

:TDDD.DDD#
Set custom tracking rate, where DDD.DDD is a decimal number which is four times the tracking rate expressed in arcseconds per second of time (see description of the :GT# command, Get tracking rate). This command should be issued before :TM#.

:STDDD.DDD#
Set the tracking rate to DDD.DDD, where DDD.DDD is a decimal number which is four times the tracking rate expressed in arcseconds per second of time.
Returns:
0 invalid
1 valid

:RT0# Set lunar tracking rate
Returns: nothing

:RT1# Set solar tracking rate
Returns: nothing

:RT2# Set default (sidereal) tracking rate
Returns: nothing

:RT9# Stop tracking
Returns: nothing

:RRsXXX.XXXX#
Set custom tracking rate in right ascension, where sXXX.XXXX is expressed in multiples of the sidereal speed. The rate is added to the standard sidereal tracking.
Returns:
1 valid
Available from version 2.7.8.

:RDsXXX.XXXX#
Set custom tracking rate in declination, where sXXX.XXXX is expressed in multiples of the sidereal speed.
Returns:
1 valid
Available from version 2.7.8.

:SdatN#
Configure the dual axis tracking setting. Use N=0 to disable the dual axis tracking, N=1 to enable the dual axis tracking. N=0 can be used only for equatorial mounts. This command does not start or stop tracking.
Returns:
1 valid
0 invalid
Available from version 2.13.9.

:Gdat#
Get the status of the dual axis tracking setting.
Returns:
0 dual axis tracking disabled (only for equatorial mounts)
1 dual axis tracking enabled
Available from version 2.13.9.

Precision Toggle

:U# Toggle between low and high precision modes. This controls the format of some values that are returned by the mount. In extened LX200 emulation mode, switches always to high precision (does not toggle).

Low precision: RA returned as HH:MM.T (hours, minutes and tenths of minutes), Dec/Az/Alt returned as sDD*MM (sign, degrees, arcminutes). Check the documentation of each command for details.
High precision: RA returned as HH:MM:SS (hours, minutes, seconds), Dec/Az/Alt returned as sDD*MM:SS (sign, degrees, arcminutes, arcseconds). Check the documentation of each command for details.
Returns: nothing

Note

From version 2.10, the 10micron mounts support also an ultra-precision mode that can set with :U2#. Using the :U# command in ultra-precision mode will switch back to high-precision mode.

:U0# Set low precision mode.
Returns: nothing

:U1# Set high precision mode.
Returns: nothing

:U2# Set ultra precision mode. In ultra precision mode, extra decimal digits are returned for some commands, and there is no more difference between different emulation modes.
Returns: nothing
Available from version 2.10.

Note

A Get Information command such as :GA# (Get altitude) can be used to detect the current precision setting, analysing the format of the response. See also the paragraph *Extended LX200 emulation and precision*.

Drive configuration

:SFAct.tt# Sets the final approach time constant to the given value t.tt (in seconds). The ammissible range is 0.25 … 5.00 seconds.
Returns:
E# function not supported
0# command failed (value out of range)
1# command successful
This function is supported only on the GM3000HPS and GM4000HPS mounts.
Available from version 2.14.21. From version 2.15 onwards, the value set with :SFAtc is used only if the final approach mode is 1, and it is required to set the final approach mode to 0 with the command :SFAmd0# to use the default value.

:GFAtc# Returns the final approach time constant used if the final approach mode is 1.
Returns:
E# function not supported
t.tt# the final approach time constant in seconds
This function is supported only on the GM3000HPS and GM4000HPS mounts.
Available from version 2.14.21. From version 2.15 onwards, this returns always the user-defined final approach time constant, and never 0.

:SFAlml.ll#
Sets the distance limit for the final approach to the given value l.ll in arcminutes, used if the final approach mode is 1. The ammissible range is 0 … 9.99 arcminutes. Use 0 to make always a final approach. The distance limit set with ::SFAlm is used only if the final approach mode is 1.
Returns:
E# function not supported
0# command failed (value out of range)
1# command successful
This function is supported only on the GM3000HPS and GM4000HPS mounts.
Available from version 2.15.

:GFAlm# Returns the final approach distance limit.
Returns:
l.ll# the user-defined final approach distance limit in arcminutes. This value is used by the mount only if the final approach mode is 1. This function is supported only on the GM3000HPS and GM4000HPS mounts.
Available from version 2.15.

:SFAmdN# Sets the final approach mode according to the following values of N:
N = 0 use the standard configuration for time constant and distance limit;
N = 1 use the user-defined parameters for time constant and distance limit.
Returns:
E# function not supported
0# command failed (value out of range)
1# command successful
This function is supported only on the GM3000HPS and GM4000HPS mounts.
Note: enabling the user-defined parameters may result in the mount not reaching a completely settled state after slews. This depends on the characteristics of the load on the mount.
Available from version 2.14.21. In version 2.14.21, the behaviour was different: with N = 2 the mount made always a final approach, with N = 1 the mount made a final approach only if the distance was less than 2 arcminutes. Furthermore, the user-defined time constant was used also if mode = 0. From version 2.15 onwards, the behaviour is the one described here.

:GFAmd# Returns the final approach mode (see command :SFAmd for the meaning of the different values).
Returns:
E# function not supported
0# The final approach mode is standard
1# The final approach mode is custom
This function is supported only on the GM3000HPS and GM4000HPS mounts.
Available from version 2.14.21. In version 2.14.21 the mode had a different meaning (see :SFAmd) than in later versions (from 2.15 onwards).

Dome Control

:GDA# Gets the dome azimuth, if a dome is connected.
Returns: XXXX#
The current azimuth of the dome in tenths of degree from 0 to 3599. In case of error, returns 9999#.
Available from version 1.6.4.
Note: due to an error, in versions < 2.9.11 the azimuth is given with a 180 degrees offset.

:GDF# Gets the flap status of the dome, if a dome is connected.
Returns:
0# no dome connected
1# flap closed
2# flap open
3# flap moving
4# flap not detected
Available from version 2.14.17.

:GDH# Gets the homing operation status on the dome.
Returns:
0# no homing operation
1# homing operation in progress
2# homing operation completed
Available from version 2.7.4.

:GDS# Gets the shutter status of the dome, if a dome is connected.
Returns:
0# no dome connected
1# shutter closed
2# shutter open
3# shutter moving
4# shutter not detected
Available from version 1.6.4. Answer "4#" added since version 2.14.17.

:GDW# Gets the status of the slew operation for the dome. Use this command in place of :D# if you want to check if both the telescope and the dome have arrived at target. The result is valid only if the dome is under the control of the internal mount logic.
Returns:
0# no slew in progress, dome at internally computed target
1# slew in progress or dome not at internally computed target
Available from version 2.7.4.

:GDw# Gets the status of the slew operation for the dome. The result is valid only if the dome is under external control via :SDA commands.
Returns:
0# no slew in progress, dome at manually set target
1# slew in progress, dome not at manually set target

Available from version 2.9.11.

:SDFn# Commands the dome flap, where n is an ASCII digit (1...2) with the following interpretation:
1 close flap
2 open flap
Returns:
0 failure
1 success (note: this means only that the command has been received, check the status of the flap with :GDF# for ensuring completion of the command)
Available from version 2.14.17.

:SDH# Starts homing on the dome. Note that this command succeeds even if no dome is connected. Please use :GDA# or :GDS# to check if a dome is connected.
Returns:
1 success – this does not mean that a dome is connected.
Available from version 2.7.4.

:SDMn# Sets the dome control, where n is an ASCII digit (0...2) with the following interpretation:
0 disconnect dome
1 dome on RS-232 port
2 dome on GPS port
Returns:
0 failure (if something else is connected to the selected port)
1 success – this does not mean that a dome is connected.
Available from version 1.6.4.

:SDSn# Commands the dome shutter, where n is an ASCII digit (1...2) with the following interpretation:
1 close shutter
2 open shutter
Returns:
0 failure
1 success (note: this means only that the command has been received, check the status of the flap with :GDF# for ensuring completion of the command)
Available from version 1.6.4.

:SDRXXXX#
Sets the dome radius to XXXX mm.
Returns: nothing
Available from version 1.6.4.

:SDTn# Sets the mount type for dome control, where n is an ASCII digit (1...2) with the following interpretation:
1 GM4000QCI/HPS with shoulders sticking out on the front side
2 GM4000QCI/HPS with shoulders sticking out on the back side
Returns: nothing
Available from version 1.6.4.

Note

This command has no effect on mounts other than the GM4000.

:SDUSS#

Sets the dome update interval to SS seconds (i.e. the dome is commanded to an updated position every SS seconds).
Returns: nothing
Available from version 1.6.4.

:SDXMsXXXX#

:SDYMsXXXX#

:SDZMsXXXX#

Set the mount position with respect to the centre of the dome, where sXXXX is the offset in mm towards North, East and the Zenith, respectively, measured from the centre of the base of the mount.
Returns: nothing
Available from version 1.6.4.

:SDXsXXXX#

:SDYsXXXX#

Set the position of the optical axis of the telescope relative to the declination mounting flange, where sXXXX is the measure in mm. :SDX specifies the distance from the flange to the optical axis (usually it is the radius of the optical tube), :SDY specifies the lateral displacement, measured from the centre of the mounting flange, positive towards right when looking from the back of the optical tube. Usually you will specify :SDY+0000# if the tube is not laterally displaced.
Returns: nothing
Available from version 1.6.4.

:SDAXXXX#

Slews the dome to the given azimuth (from 0 to 3600). This overrides the internal logic of the mount in order to give direct control of the dome azimuth to the controlling program. Setting any dome parameter from the keypad, or any of the following commands will give control again to the internal logic of the mount: :SDR, :SDT, :SDU, :SDXM, :SDYM, :SDZM, :SDX, :SDY, :SDAr.
Returns:
0 invalid (angle out of ammissible range)
1 valid
Available from version 2.9.11.

:SDAr#

Release dome control to the internal logic of the mount.
Returns: nothing
Available from version 2.9.11.

Axis angular position commands

:GaXa# Gets the angular position on r.a. axis (for equatorial mounts) or azimuth axis (for altazimuth mounts).
Returns: sXXX.XXXX#
The current angular position, with sign, in degrees and decimals.
Available from version 2.9.9.

:GaXb# Gets the angular position on dec. axis (for equatorial mounts) or altitude axis (for altazimuth mounts).
Returns: sXXX.XXXX#
The current angular position, with sign, in degrees and decimals.
Available from version 2.9.9.

:SaXasXXX.XXXX#
Sets the target angular position on r.a. axis (for equatorial mounts) or azimuth axis (for altazimuth mounts).
Returns
0 invalid (angle out of ammissible range)
1 valid
Available from version 2.9.9.

:SaXbsXXX.XXXX#
Sets the target angular position on dec. axis (for equatorial mounts) or altitude axis (for altazimuth mounts).
Returns
0 invalid (angle out of ammissible range)
1 valid
Available from version 2.9.9.

:QaXa# Gets the target angular position on r.a. axis (for equatorial mounts) or azimuth axis (for altazimuth mounts).
Returns: sXXX.XXXX#
The current target angular position, with sign, in degrees and decimals, as set by command :SaXa; if no target angular position has been set, returns the string "E#"
Available from version 2.9.9.

:QaXb# Gets the target angular position on dec. axis (for equatorial mounts) or altitude axis (for altazimuth mounts).
Returns: sXXX.XXXX#
The current target angular position, with sign, in degrees and decimals, as set by command :SaXb; if no target angular position has been set, returns the string "E#"
Available from version 2.9.9.

:MaX# Slews to the target angular positions sets with commands :SaXa and :SaXb and stops.
Returns:
0 no error

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if the target is below the lower limit: the string
"1Object Below Horizon #"
if the target is above the high limit: the string
"2Object Below Higher #"
if the slew cannot be performed due to another cause: the string
"3Cannot Perform Slew #"
if the mount is parked: the string
"4Mount Parked #"
Note: even if commands :SaXa and :SaXb have been successful, it is not guaranteed that :MaX succeeds, since the target angles can be both within range when taken one at time but the resulting target position can be still outside limits (such as limits defined by the altitude above the horizon).
Available from version 2.9.9.

:PaX# Slews to the target angular positions sets with commands :SaXa and :SaXb and parks.
Returns:
"0#" no error
"1#" the target is below the lower limit
"2#" the target is above the high limit
"3#" the slew cannot be performed due to another cause
"4#" the mount is already parked
Note: even if commands :SaXa and :SaXb have been successful, it is not guaranteed that :PaX succeeds, since the target angles can be both within range when taken one at time but the resulting target position can be still outside limits (such as limits defined by the altitude above the horizon).
Available from version 2.9.9.

:PiP# Parks the mount in the current position.
Returns:
"0#" error
"1#" mount parked
Available from version 2.9.9.

:PsX# Slews to the saved park angular position and parks.
Returns:
"0#" no error
"1#" the target is below the lower limit
"2#" the target is above the high limit
"3#" the slew cannot be performed due to another cause
"4#" the mount is already parked
Available from version 2.9.9.

:PyX# Saves the current angular position as parking position for the :PsX# commmand.
Returns:
0 no error
0 error
Available from version 2.9.9.

Dithering Commands

:SditMRR,DD#
Sets the dithering amount to RR arcseconds in right ascension and to DD arcseconds in declination. Allowed range is from 0 to 30 arcseconds.
Returns:
"0#" if the command failed
"1#" if the command succeeded.
Available from version 2.14.

:SditTD,E,I#
Sets the dithering timer. D is the delay in seconds (from 0 to 356400), E is the exposure in seconds (from 0 to 356400), I is the interval in seconds (from 5 to 356400).
Returns:
"0#" if the command failed
"1#" if the command succeeded.
Available from version 2.14.

:SditS# Starts dithering.
Returns:
"0#" if the command failed (the mount is in a state that doesn't allow dithering).
"1#" if the command succeeded.
Available from version 2.14.

:SditQ# Stops dithering.
Returns:
"0#" if the command failed
"1#" if the command succeeded.
Available from version 2.14.

:SditN# Execute dithering immediately. Dithering must be active.
Returns:
"0#" if the command failed (dithering isn't active).
"1#" if the command succeeded.
Available from version 2.14.

:GditP# Gets the dithering parameters.
Returns:
R,D,L,E,I# a string where R is the dithering amount in right ascension in arcseconds, D is the dithering amount in declination in arcseconds, L is the delay in seconds, E is the exposure in seconds, I is the interval in seconds.
Available from version 2.14.

:GditS# Gets status of dithering.
Returns:
"0#" if dithering isn't active
"1#" if dithering is active.
Available from version 2.14.

Satellite Orbital Elements Commands

:TLEDLn#

Loads orbital elements for a satellite from the TLE database in the mount. n is the index of the orbital elements in the database, starting from 1 to the number returned by the TLEDN command.
Returns:
E# the mount database doesn't contain a TLE with the given index.
<two line elements># an escaped string containing the TLE data from the mount database which has been loaded. Lines are terminated by ASCII newline (ASCII code 10).
Available from version 2.13.20.

:TLEDN# Gets the number of TLEs in the mount database.
Returns:
n# the number of TLEs in the mount database.
Available from version 2.13.20.

:TLEG# Returns the currently-loaded two line elements.
Returns:
<two line elements># a string containing the two line elements. Lines are terminated by the ASCII newline character (ASCII code 10), and the entire string is escaped with the mechanism described in the "escaped strings" section below.
If no TLE is currently loaded, returns the string E#.
Available from version 2.13.20.

:TLEL0<two line element>#

Loads satellite orbital elements in two-line format directly from the command protocol. <two line element> is a string containing the two line elements. Each lines can be terminated by escaped newline (ASCII code 10), carriage return (ASCII code 13) or a combination of both. The first line may contain the satellite name. The entire string is escaped with the mechanism described in the "escaped strings" section below.
The TLE format is described here:
https://www.celestrak.com/NORAD/documentation/tle-fmt.asp
For example, loading the NOAA 14 element set of that page can be accomplished with:

```
:TLEL0NOAA·14·····$0a
1·23455U·94089A···97320.90946019··.00000140··00000-0··10191-3·0··2621$0a
2·23455··99.0090·272.6745·0008546·223.1686·136.8816·14.11711747148495#
```

Returns:
E# invalid format
V# valid format
Available from version 2.13.20.

:TLEGAZJD#

Gets the apparent altazimuth coordinates of the satellite with the currently loaded orbital elements, computed for Julian Date JD (UTC).
Returns:
E# no TLE loaded

+AA.AAAA,ZZZ.ZZZZ# the apparent altazimuth coordinates, where +AA.AAAA is the altitude in degrees with decimals accounting for refraction, and ZZZ.ZZZZ is the azimuth in degrees with decimals.
Available from version 2.14.5.

:TLEGEQJD#
Gets the apparent equatorial coordinates of the satellite with the currently loaded orbital elements, computed for Julian Date JD (UTC).
Returns:
E# no TLE loaded
RR.RRRRR,+DD.DDDD# the apparent equatorial coordinates, where RR.RRRRR is the right ascension in hours with decimals, and +DD.DDDD is the declination in degrees with decimals.
Available from version 2.14.5.

:TLEPJD,min#
Precalulates the first transit of the satellite with the currently loaded orbital elements, starting from Julian Date JD and for a period of min minutes, where min is from 1 to 1440.
Two-line elements have to be loaded with the :TLEL command.
Returns:
E# no TLE loaded or invalid command
N# no passes in the given amount of time
JDstart,JDend,flags# data for the first pass in the given interval. JDstart and JDend mark the beginning and the end of the given transit. Flags is a string which can be empty or contain the letter F – meaning that mount will flip during the transit.
Available from version 2.13.20.

:TLES# Slews to the start of the satellite transit that has been precalculated with the :TLEP command.
Returns:
E# no transit has been precalculated
F# slew failed due to mount parked or other status blocking slews
V# slewing to the start of the transit, the mount will automatically start tracking the satellite.
S# the transit has already started, slewing to catch the satellite
Q# the transit has already ended, no slew occurs
Available from version 2.13.20.

:TLESCK# Gets the status of the slew to a precalculated satellite transit.
Returns:
V# slewing to the start of the transit
P# stopped at the start of the transit, waiting for the satellite
S# slewing to catch the satellite
T# tracking the satellite
Q# the transit has ended, not tracking
E# no slew to a satellite has been requested.
Available from version 2.14.22.

Other Commands

:EMUAP# Sets Astro-Physics compatible emulation mode.
Returns: nothing
Note: in ultra-precision mode, there is no difference between emulation modes.

:EMULX# Sets LX200 emulation mode.
Returns: nothing
Note: in ultra-precision mode, there is no difference between emulation modes.

:startlog# Starts a log of the commands received by the mount.
Returns: nothing

:stoplog# Ends the communication log.
Returns: nothing

:shutdown#Shuts down the mount. Available only with electronics model 2012 or above. Do NOT remove the power after receiving a successful answer.
Returns:
0 failure
1 success
Available from version 2.9.2.

:getlog# Gets the communication log.
Returns: a text containing the communication log (up to 256Kbytes).

:evlog# Gets the event log.
Returns: a text containing the communication log (up to 3Kbytes).
Available from version 2.7.8.

:USEROK#
Allow the mount to move, after an inconsistency has been signaled. See also the :Gstat# command.
Returns: nothing
Available from version 2.8.13.

:USERWAIT#
Stops the mount and waits the user to send the :USEROK# command or authorize movements again using the keypad. You can use this command to block the mount in case your system detects some inconsistency. See also the :Gstat# command.
Returns: nothing
Available from version 2.8.13.

:GETID#
Gets an unique hardware identifier for the mount. The identifier does not change (unless the mount is serviced, which could lead to a different identifier).
This command can be use to detect if different connections (i.e. a serial port and a LAN connection) are actually a connection to the same mount.
Returns: a 20-digit (64-bit) number terminated by # unique for each mount.

XXXXXXXXXXXXXXXXXXXX#
Available from version 2.9.11.

:NUtimsXXX#
Adjust the time of the mount of the given amount in milliseconds, from +999 to -999.
Returns:
"0#" if the command failed
"1#" if the command succeeded.
Available from version 2.10.

Extended LX200 emulation and precision

The mount can be configured to use an “Extended LX200 emulation" which modifies the return value of some commands, allowing operation with some software designed for Astro-Physics mounts, or to standard LX200 emulation in order to allow operation with some software designed for Meade LX200 mounts. These modes can be set using the :EMUAP# or :EMULX# commands. While the commands highlighted in green are always available, when the extended LX200 emulation mode is active the behaviour of some commands is modified. Furthermore, some commands will have different behaviour depending on the precision (low precision, high precision or ultra precision).

The precision setting pertains to the specific communication session. This means that each of the two serial ports and each single LAN connection begin with the default low-precision and can be independently configured with different precision settings. In this way, different programs with different precision requirements can be used at the same time.

When ultra-precision is set, all commands will behave in the same way regardless of the emulation chosen. The ultra precision has been added to firmware 2.10, so if you are writing software that will not be used with previous versions, our advice is to use the ultra-precision mode by sending the :U2# command (after checking the firmware version).

All differences in the command usage are described in each command.

Notes on pointing objects

The mount has a series of commands used to point objects. Usually you want to point a specific position in the sky with its equatorial coordinates (right ascension and declination). In this case, use the :Sr and :Sd commands to set the target coordinates. After doing that, you can use the :Ga and :Gz commands to get the current altitude and azimuth of the target (changing with time). You can also use the :GTTRK command to know if the target is located at a position where the mount will be able to track or not (the altazimuth mount cannot track objects above 89 degrees altitude).

The :MS command will slew the mount to the target coordinates.

If you use the :MA command, the scope will slew at the current altazimuth coordinates of the target and will remain there.

The situation is reversed if you use the :Sa and :Sz commands to set the target altazimuth coordinates. After doing that, the :Gr and :Gd commands return the current right ascension and declination of the target (changing with time). The :MA command will slew the mount to the target coordinates. The :MS command will calculate the current equatorial coordinates of the target and slew to them, and then tracking will be active.

The mount will not cope with different input coordinates from multiple sources, i.e. the keypad, virtual keypad, the serial connections and the network connection. Sending a command such as :Sr, :Sd, :Sa, :Sz to one of these interfaces will overwrite the coordinates set with the others.

Notes on building an alignment model

Starting with firmware version 2.8.15, the mounts have a series of commands used to make and manipulate the alignment model. The :CMS command works by matching the target set by the :Sr and :Sd commands to the current position of the mount as an alignment star.

Furthermore, the :CM/:CMR commmands can be set to have the same function of the :CMS command, by sending the command :CMCFG1# or activating the "Sync Refines" function with the keypad.

If you are starting with no alignment model (see the :getalst and :delalig commands), the first three position you match in this way act as a 3-Stars alignment. The following stars act as successive Refininig commmands given by the keypad.

These commands allows synchronizing the mount with a plate-solved position. You can then automate the aligment procedure by slewing to a sequence of target positions. In each position, take a picture and find the position of the centre of the field of view by plate solving. Send the position to the mount with the :Sr and :Sd commands, then give the :CMS command to add the point (also the :CM or :CMR command, if the "Sync Refines" function on the keypad is active).

You can also check the alignment model using the :getali/:getalp command, which gives you the position and error of each alignment star. You may also delete a star from the alingment model with the :delalst command.

It is important to check the possible error given by all these commands. In particular, the :delalst command may return an error due to the impossibility of calculating a new model after the star is removed. In this case, in order to delete the star from the model you will have to either delete the entire alignment model with the :delalig commmand, or add another star to the model before continuing.

All these commands are described in the "Sync Control" section.

Entering an alignment model

Starting from firmware 2.10.6, it is possible to enter into the mount an alignment model specification without the need of using the synchronization commands. In this case, instead of synchronizing the mount on each alignment point, you will send all the relevant data and compute the alignment model in one pass.

Each alignment point will be defined by a position in the sky (usually a well-known star, or the centre of an exposure that has been astrometrically plate-solved using a dedicated tool), and by the mount-reported coordinates.

The alignment specification is to be created as follows. First, you have to begin a new alignment specification by sending the command :newalig#. This will NOT clear the alignment model the mount is using, but *only* the alignment points for building the next model. Then you will add in sequence all the alignment points with the :newalpt command. For each point, you need the mount-

reported coordinates (right ascension, declination and pier side), the plate-solved coordinates (i.e. the "real" coordinates the telescope is pointing at), and the sidereal time of the match. When you have added all points, use the :endalig# command to compute a new alignment model.

Note that it is not necessary to clear the previously loaded alignment model before entering the new alignment points. Thus it is possible to create a new alignment model while still using an alignment model that was previously computed. On the other hand, it is extremely important that the alignment model is not *changed* between starting the measurement of the alignment points and computing the new model with :endalig#.

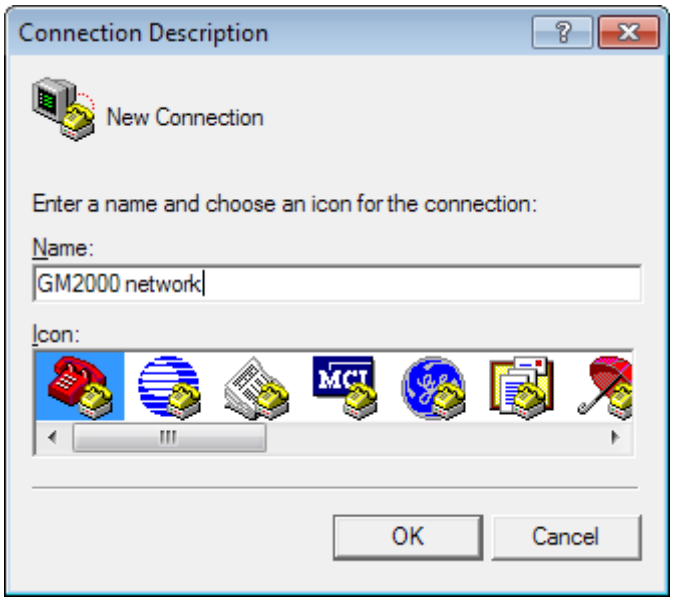
Escaped strings

Some strings are escaped in order to communicate with the mount. The escaping scheme is the following:

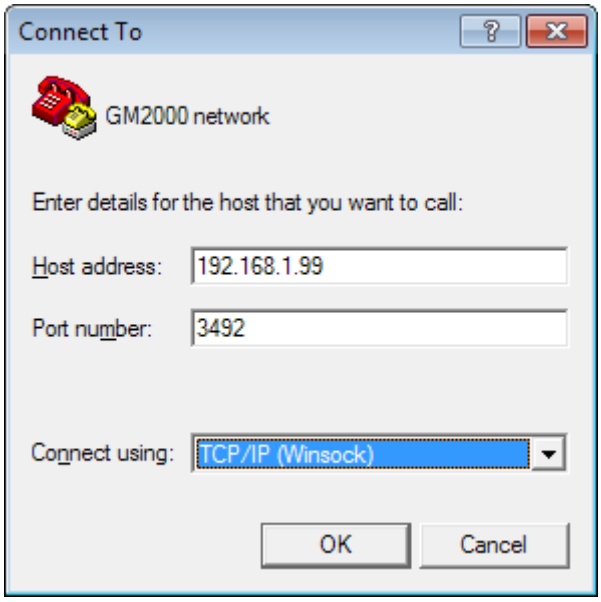
- the character '$' is escaped as the sequence "$$";
- the character '#' is escaped as the sequence "$23";
- the character ',' is escaped as the sequence "$2C";
- any character with ASCII code less than hexadecimal 20 or greater than hexadecimal 7E is escaped as '$XX' where XX is the hexadecimal ASCII code;
- any other character is passed unchanged.

Example of a HyperTerminal Session

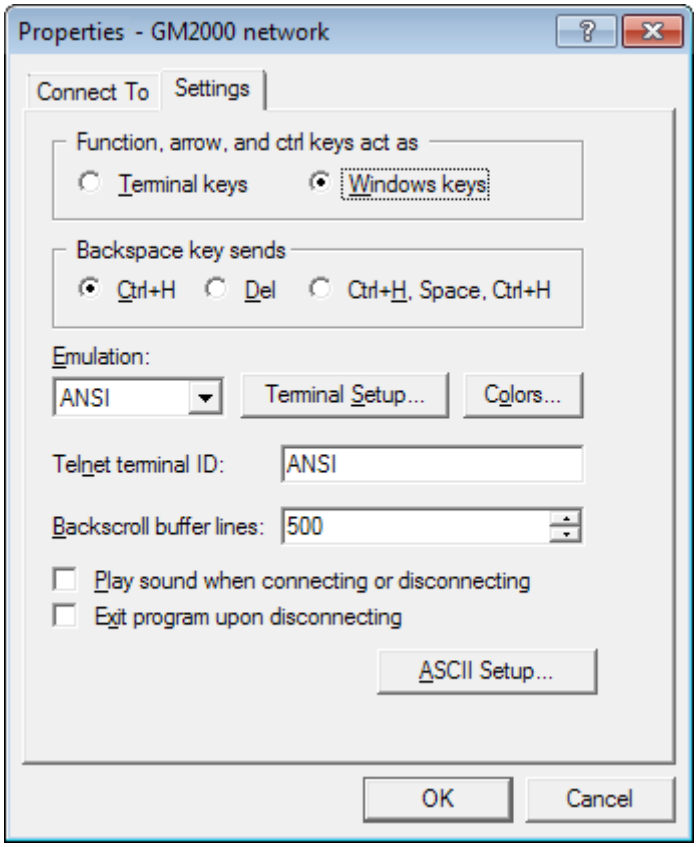
The following example shows how to connect to the mount through the Ethernet using HyperTerminal Private Edition version 6.3. Create a new connection, enter the connection name (such as "GM2000 network") and press OK.



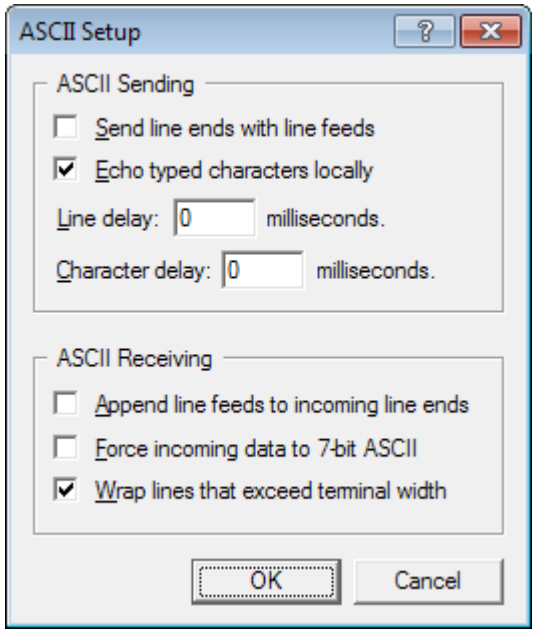
In the next window choose "TCP/IP (Winsock)", then enter the Host address (such as 192.168.1.99, depending on your mount configuration) and the port number (3490 or 3492).



The terminal will connect (look for "Connected" in the status bar). Now you should choose from the menu File → Properties, then the "Settings" tab. Choose "Function, arrow, and ctrl keys act as" "Windows keys" in order to enable copy and paste from the terminal window as shown in the figure.



Then click on "ASCII setup". Check "Echo typed characters locally" as shown in the next figure.



The terminal should now work as shown in the next figure.