

**SG-4 Autonomous Guider
and
AllSky-340/340C All-Sky Camera
Serial Interface Specification**

Santa Barbara Instrument Group

April, 28, 2009

Version 1.00

**Santa Barbara Instrument Group
147A Castilian Drive
Santa Barbara, CA 93117
Phone: (805) 571-7244 Fax: (805) 571-1147
Web: <www.sbig.com> EMail: sbig@sbig.com**

Table of Contents

Introduction.....	1
Setup	1
Camera Defaults.....	1
Factory Reset	1
Establishing Communication	1
Serial Commands	1
Checksum.....	1
Checksum Example	2
Testing Commands	2
Communications Test	2
Open Shutter	2
Close Shutter.....	2
De-energize Shutter Motor	2
Setup Commands	3
Get Firmware Version Number	3
Change Baud Rate.....	3
Activate Guide Relays	4
Force Guide Relays.....	4
Set Max Move.....	4
Get Max Move	5
Set Min Move	5
Get Min Move.....	5
Set Y Aggressiveness.....	5
Get Y Aggressiveness	6
Set X Aggressiveness.....	6
Get X Aggressiveness	6
Get Serial Number	6
Imaging Commands	7
Define Sub-Frame.....	7
Take Image.....	8
Abort Image	8
Transfer Image	9
Autonomous Guiding Commands.....	10
Calibrate Guider.....	10
Autonomous Guide	10

Introduction

The All-Sky Camera and Autonomous Guider Serial Interface is a simple command/response interface using a mix of standard ASCII commands and some binary data. The use of standard ASCII commands facilitates testing of the simpler commands and provides better program readability, while the binary data simplifies programming the more complex commands.

Setup

Camera Defaults

On initial power-up of a new camera, the camera serial port defaults to 9600 baud, no parity, 8 data bits, and 1 stop bit.

Factory Reset

Through use, the power-up baud rate can be changed to allow use in fixed baud rate systems. It may be necessary to reset the power-up baud rate back to 9600 baud. To do this, first turn off the camera. Depress the push-button and hold it in while turning on the camera. Leave the push-button depressed for at least 2 seconds. This will reset the power-up baud rate back to 9600 baud.

Establishing Communication

When it is known what baud rate the camera is currently set to it is a simple matter of establishing communication. However, when the camera's baud rate is unknown it can be a little harder. Fortunately there are only 6 different baud rates that the camera could possibly be set to. I've found that it is a simple matter to cycle through all the baud rates until one is found that works.

This is not difficult and can be quite quick. I've found that a serial port timeout of 100ms is more than sufficient to get a response from the camera when the correct baud rate is selected. This means that all 6 baud rates can be tested in less than one second.

So, to initially establish communication with a camera, start with 9600 baud and use the *Communications Test* command. If no response is received within 100ms, change to the next baud rate and repeat. When the proper response is received, the camera baud rate has been found!

Serial Commands

Commands given here are broken down into three categories: Testing, Setup, Imaging, and Autonomous Guiding. Case does matter for all commands. While all the current commands are upper case, lower case commands may be added in the future.

Checksum

All commands must be followed by a checksum value.

Prior to every serial command, the checksum value should be cleared to 0.

During the serial transfer, each byte transferred should be inverted and then exclusive ored to the current checksum value. The most significant bit of the checksum should always be cleared.

When the command is sent, send the checksum value to the camera.

Prior to any command related response, the camera will send the checksum value it computed back to the controller. If the camera matched the received and computed checksum, it will execute the command. If the values do not match, no further action will be taken.

Checksum Example

Single Byte Command

Command: "E" = 45h

Inverse of 45h = BAh

Checksum = 3Ah = ":"

Successful Transaction:

Sent: "E:"

Received: "O"

Failed Transaction due to bit error during "E" transfer:

Sent: "E:"

Received: ">"

Failed Transaction due to bit error during checksum transfer:

Sent: "E:"

Received: "t:"

Multi Byte Command

Command: "B6" = 42h, 36h

Inverse of 42h = BDh

Checksum = 3Dh

Inverse of 36h = C9h

3Dh xor C9h = F4h

Checksum = 74h = "t"

Successful Transaction:

Send: "B6t"

Received: "t", then "S" at new baud rate

Testing Commands

Communications Test

Command: "E"

Response: "O"

Description: This command is used as a basic test of communication. Nothing is done in the camera other than sending the response.

Open Shutter

Command: "O"

Response: *none*

Description: This command will energize the shutter motor and move the shutter to the open position. The motor will remain energized to facilitate shutter alignment.

Close Shutter

Command: "C"

Response: *none*

Description: This command will energize the shutter motor and move the shutter to the closed position. The motor will remain energized to facilitate shutter alignment.

De-energize Shutter Motor

Command: "K"

Response: *none*

Description: This command will de-energize the shutter motor. The shutter will not be moved.

Setup Commands

Get Firmware Version Number

Command: "V"
Response: 2 bytes
Byte 1 – Version Number Upper Byte
Byte 2 – Version Number Lower Byte
Description: This command gets the current Version Number of the firmware running in the camera. The Version Number is a 2-byte integer and is parsed as follows:
D15: 0 = Released version, 1 = "Test" version
D14-D8 = Major version number
D7-D0 = Minor version number

So, a returned value of 0x0110 represents a version number of V1.16. A returned value of 0x820f represents a version number of T2.15.

Change Baud Rate

Command: "B0", "B1", "B2", "B3", "B4", "B5", "B6"
Response: *multiple*
Description: This command is used to change the baud rate. Depending on which command is sent, the baud rate will change to:
B0 = 9600 baud
B1 = 19200 baud
B2 = 38400 baud
B3 = 57600 baud
B4 = 115200 baud
B5 = 230400 baud
B6 = 460800 baud

Upon receipt of one of the above commands, the camera will immediately change its baud rate and send a response *at the new baud rate*. The response will be an "S". After receipt of the "S" response, the computer must send the characters (in exactly this case), "Test". If the transmission is successful and the camera receives this text, it will reply with "TestOk". Finally the computer must reply with "k".

If this process is either not followed, or one of the transmissions fails, the camera will revert back to its previous baud rate setting and will resume waiting for a command. If the process is successful, the camera will retain the new baud rate and store it into non-volatile storage. This new baud rate will then be in use until it is explicitly changed again.

If communication is lost and cannot be recovered at the current baud rate, the camera can be reset to the default 9600 baud. See the section above labeled *Factory Reset*.

Activate Guide Relays

Command: "G" + 3 bytes

Byte 1 - Relay Bit Map:

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0	0	0	0	Y-	Y+	X-	X+

Byte 2 - Relay Activation Time:

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Relay Activation Time in milliseconds (upper byte)							

Byte 3 - Relay Activation Time:

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Relay Activation Time in milliseconds (lower byte)							

Response: "K"

Description: This command will activate the selected relays for the specified time. When the relay activation is complete, the response will be sent.

Force Guide Relays

Command: "g" + 1 byte

Byte 1 - Relay Bit Map:

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0	0	0	0	Y-	Y+	X-	X+

Response: *none*

Description: This command will activate or deactivate the selected relays until explicitly disabled with another "g" or "G" command.

Set Max Move

Command: "M" + 2 bytes

Byte 1 – Max Move Time:

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Max Move Time in milliseconds (upper byte)							

Byte 2 – Max Move Time:

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Max Move Time in milliseconds (lower byte)							

Response: "K"

Description: This command sets the maximum move time used during the autonomous guiding operation.

Get Max Move

Command: "m"

Response: 2 bytes

Byte 1 – Max Move Time:

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Max Move Time in milliseconds (upper byte)							

Byte 2 – Max Move Time:

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Max Move Time in milliseconds (lower byte)							

Description: This command gets the maximum move time used during the autonomous guiding operation.

Set Min Move

Command: "N" + 2 bytes

Byte 1 – Min Move Time:

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Min Move Time in milliseconds (upper byte)							

Byte 2 – Min Move Time:

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Min Move Time in milliseconds (lower byte)							

Response: "K"

Description: This command sets the minimum move time used during the autonomous guiding operation.

Get Min Move

Command: "n"

Response: 2 bytes

Byte 1 – Min Move Time:

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Min Move Time in milliseconds (upper byte)							

Byte 2 – Min Move Time:

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Min Move Time in milliseconds (lower byte)							

Description: This command gets the minimum move time used during the autonomous guiding operation.

Set Y Aggressiveness

Command: "Y" + 1 byte

Byte 1 – Y Aggressiveness:

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Aggressiveness % = Value/255*100							

Response: "K"

Description: This command sets the Y Aggressiveness used during the autonomous guiding operation.

Get Y Aggressiveness

Command: "y"

Response: 1 byte

Byte 1 – Y Aggressiveness:

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Aggressiveness % = Value/255*100							

Description: This command gets the Y Aggressiveness used during the autonomous guiding operation.

Set X Aggressiveness

Command: "Z" + 1 byte

Byte 1 – X Aggressiveness:

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Aggressiveness % = Value/255*100							

Response: "K"

Description: This command sets the X Aggressiveness used during the autonomous guiding operation.

Get X Aggressiveness

Command: "z"

Response: 1 byte

Byte 1 – X Aggressiveness:

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Aggressiveness % = Value/255*100							

Description: This command gets the X Aggressiveness used during the autonomous guiding operation.

Get Serial Number

Command: "r"

Response: 9 byte string

Description: This command gets the camera serial number.

Imaging Commands

Define Sub-Frame

Command: "S" + 5 bytes

Byte 1 - Sub-Frame X Start:

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
X coordinate for the start of the sub-frame (upper byte)							

Byte 2 - Sub-Frame X Start:

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
X coordinate for the start of the sub-frame (lower byte)							

Byte 3 - Sub-Frame Y Start:

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Y coordinate for the start of the sub-frame (upper byte)							

Byte 4 - Sub-Frame Y Start:

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Y coordinate for the start of the sub-frame (lower byte)							

Byte 5 - Sub-Frame Size:

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0	Sub-frame size in pixels for both axis (sub-frame is always square)						

Response: *none*

Description: This command defines the location and size of the sub-frame. The maximum size of the sub-frame is 127 pixels. This command does not cause a sub-frame to be exposed; it only defines the size of the sub-frame when selected in the *Take Image* command.

Take Image

Command: "T" + 4 bytes

Byte 1 - Exposure Time:

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Exposure time in 10ms units (upper byte)							

Byte 2 - Exposure Time:

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Exposure time in 10ms units (lower byte)							

Byte 3 - Binning/Sub-Frame:

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0xff=Sub-frame, 0x02=Bin 2x2, 0x01=Bin 1x1 (cropped), 0x00=Bin 1x1 (full)							

Byte 4 - Exposure Type:

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0x02=Light - Auto Dark, 0x01=Light Only, 0x00=Dark Only							

Response: *multiple*

Description: This command is used to start an exposure. While an exposure is in process, the camera will send commands over the serial port indicating the progress of the exposure.

"E" = Exposure in progress. This is sent approximately every 150ms.

"R" = Readout in progress. This is sent at the beginning of the CCD readout.

"D" = Exposure done. This is sent after readout is complete.

Once the Exposure done response is sent, the camera is now ready to respond to new serial commands.

Special Note: The Bin 1x1 (full) setting does not support Auto Dark mode. When Byte 3 is set to 0x00, Byte 4 *must* be either 0x00 (Light Only) or 0x01 (Dark Only).

Abort Image

Command: "A"

Response: *none*

Description: This command will abort an exposure in progress. If no exposure is in progress, the command is ignored. No response is sent acknowledging the abort.

After receipt of this command when an exposure is in progress, the camera will stop the exposure and read out the image into the frame buffer. Thus the accumulated image data is not lost.

Transfer Image

Command: "X"

Response: *multiple*

Description: This command will begin an image transfer. The total number of bytes to be transferred depends on the bin/sub-frame parameter of the *Take Image* command. The following indicates the number of pixels that will be transferred:

Bin 1x1 (full): $640 \times 480 = 307200$ pixels

Bin 1x1 (cropped): $512 \times 480 = 245760$ pixels

Bin 2x2: $320 \times 240 = 76800$ pixels

Sub-Frame: Sub-Frame Size^2 pixels

The computer should expect the above number of pixels to be transferred.

Pixels are two-bytes long and are transmitted over the serial port least significant byte first.

The camera transmits 4096 pixels at a time in bin 1x1, 1024 pixels at a time in bin 2x2 mode or one line (sub-frame size pixels) in sub-frame mode. Multiply these values by 2 to determine the number of bytes.

After this transfer the camera sends a check-sum byte. The check-sum byte is computed by XORing all the previous bytes (8192, 2048, or sub-frame size * 2) together. After receipt of the check-sum byte, the computer should compare a locally computed check-sum byte with that sent by the camera. After this comparison, a new byte must be sent back to the camera depending on the result.

"K" = Check-sum okay, continue transfer.

"R" = Check-sum not okay, resend previous pixels (4096, 1024, or sub-frame size)

"S" = Stop transfer

When the "R" command is received the same block of data will be resent along with the check-sum byte.

After receipt of the "K" command, the camera will continue transferring the next block of pixels and the new check-sum byte.

If the computer sends the "S" command, the camera will send no other image data and will immediately begin waiting for a new command.

This process (pixels, check-sum, wait for confirmation) will continue until the entire image is transferred. No indication of the end of the transfer exists - the computer must keep track of the number of bytes successfully transmitted and stop when the proper count is reached.

The camera does support an interleaved download and exposure. If a download is in progress when an exposure finishes, the camera will transfer the accumulated charge to the readout pixels and then leave them there until the download finishes. The readout pixels have larger dark current than the light-sensitive pixels, so exposures should only be interleaved when the download time is known to be shorter than the exposure.

Autonomous Guiding Commands

Autonomous guiding serial port commands are available to mimic pushing the button on the rear of the SG-4. After sending a command, the SG-4 will send text-based status information over the serial port (e.g. Calibration results, guide star position, relay activation times, etc.). The exact text is beyond the scope of this document. Expect an unlimited amount of received text after sending one of these commands. When any process is done (either through normal completion, or after aborting), the camera will send a Ctrl-Z character (0x1a). The Ctrl-Z will not be sent at any other time, so this can be used to determine that the process is complete.

While these processes are running, sending any byte to the SG-4 will abort the process.

Calibrate Guider

Command: "H"

Response: *see above*

Description: This command will begin the automatic guider calibration process.

Autonomous Guide

Command: "I"

Response: *see above*

Description: This command will begin the autonomous guiding process.