REDLAKE

2.6

MotionXtra™

HG-100K

Command Protocol

REDLAKE

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1. Introduction

Redlake HG cameras work in environments containing a mix of HG models (HG-100K, HG-LE, HG-TH, and HG-XR) and legacy cameras. The HG camera command protocol described in this document builds on the command protocol for Redlake's legacy cameras. This approach minimizes the effort to convert existing customer and third-party control software to support the HG cameras.

Modifications to existing commands have been made only when the meaning of the command would not be substantially altered. Where minor modifications to legacy commands would not suffice, new commands have been created to access HG functionality. All new commands have been created in the "spirit" of the legacy commands.

Legacy commands having no relevance to HG cameras have not been implemented and will return an error indicating the use of an unsupported command.

Unlike legacy cameras, HG cameras support the notion of multiple hosts simultaneously communicating with any and all HG cameras. Not all commands are available when another host has taken control of a camera. The legacy notion of "Attach" has been extended to handle such situations.

This document describes the Legacy camera commands inherited by HG cameras, and the new HG camera commands. Commands are defined in terms of how they are issued, when they are valid, the actions they perform, and the messages they return.

Glossary

For this document, the following terms and abbreviations apply:

Term	Definition
Camera	A component of the HG system that contains the sensor and captures and stores the images.
Camera Control Unit	The Camera Control Unit (CCU) is the computer that the customer uses for running the application program software. It is used to set up and control cameras, and to download the event images.
CCM	The acronym for color correction matrix.
CCU	The acronym for Camera Control Unit.
DCU	The acronym for Display Control Unit.
Display Control Unit	The Display Control Unit (DCU) is a portable commercial device used locally to run a limited version of the application program software. It is used to set up and focus a camera, and to perform emergency downloads.
FPS	The acronym for Frames Per Second.
HG-100K	Integrated HG camera, with 1504 X 1128 sensor
HG-LE	Integrated HG camera, with 752 X 1128 sensor
HG-TH	Tethered-head HG camera; includes a console unit that supports one to four camera heads, each with 752 X 564 sensor.
HG-XR	Integrated HG camera, with 1504 X 1128 sensor, next generation
HSU	Acronym for "Hub/Sync Unit; same as "hub"
Hub	The component of the HG system that collects camera image data and transmits it towards the CCU and fans out commands and sync/timing signals to the cameras connected to it. Hubs as well as legacy devices may be connected to a hub.
IRIG/GPS Time	Inter-Range Instrumentation Group/Global Positioning System Time. Time code signals of various formats defined by the IRIG 200-98 standard/Time derived from GPS satellites. Both require an optional receiver/decoder/generator module.
Legacy	Refers to the older cameras currently in use. Specifically HG-2000, HG-TX, and CR-2000.
Root Hub	The hub connected to/closest to the CCU.

2. Interface Protocol

Command Syntax

HG cameras receive commands and transmit replies on one of two Ethernet LAN interfaces. On the Ethernet, UDP/IP (User Datagram Protocol/Internet Protocol) datagrams carry commands and replies. Each camera command or reply occupies a single UDP/IP datagram, which in turn fits within a single Ethernet packet. HG cameras transmit image data in a series of UDP/IP datagrams. Appendix A describes the HG camera image transmission protocol. This discussion refers only to the content of command and reply traffic between the camera and the controlling host.

All command and reply messages for HG cameras are strings of ASCII characters. Commands are always terminated with an ASCII CR-LF pair. Replies may include several lines of data, formatted as strings of ASCII characters, each terminated by a CR-LF pair.

Legacy cameras possess two command formats: a textual mnemonic format, and a more concise textual numeric format. HG cameras support only the numeric format.

Both Legacy and HG cameras listen for host commands on a selectable IP port (port number 1027 for HG cameras, by default). Control software may use broadcast datagrams to send the same command to all cameras, or may unicast commands to individual cameras. When this is done in a system containing only Legacy cameras and hubs, each camera hears all traffic sent by the controlling application. Therefore, Legacy systems require a means of addressing a single camera among many. Each camera is assigned a unique ID number, so that a command prefaced with a pound sign (#) and an ID number (a two-digit hexadecimal number) will only be heard by the specified camera. A camera will add a prefix its response to an individual command with its ID number.

This addressing scheme is supported by HG cameras. The disadvantage of this addressing scheme is that it can lead to significant problems when multiple Legacy cameras are assigned the same ID number. This limitation has been removed in HG cameras implementation, though it still applies to Legacy cameras present in a mixed environment with HG cameras.

Unlike Legacy hubs, HG hubs contain an Ethernet switch fabric that permits commands to be targeted to individual cameras by directing messages to the individual camera's IP address, rather than to a broadcast address. HG cameras support both methods of targeting commands to individual cameras. Other than for a few specific global operations, it is expected that message broadcasts are relatively rare, and that both individual and group commands will normally be issued by targeting individual cameras.

Numeric commands not preceded by `#id` are global commands. Different forms of the Stop command are shown below to illustrate the differences between global and local command structure.

Format of Command Descriptions

This document includes a section describing each command to which HG cameras will respond, and the possible replies the camera will generate in response. Each section includes a description of the command's function, followed by a table of Command Prerequisites, and tables showing the specific formats for command and reply strings (see example tables below).

In the tables, bold type indicates command and argument text sent to the Camera. Each command is terminated with an ASCII CR-LF (carriage return, line feed) pair.

Command Prerequisites					
Camera State	☒ Standby	☒ Live	☒ Ready	☒ Recording	☒ Recording Done
Attach State	☐ Required	☒ Ignored	☐ Required only when modifying values		
Command Modes	☒ Individual	☒ Group	☐ Supports Simulation		
Intended Use	☒ Operator	☒ Supervisor	☐ **Factory Only** (OMIT FROM USER DOCS)		

Table 1: Example Command Prerequisites Table

If a camera must be in a particular state to successfully execute a command, this is shown in the first line of the prerequisites table. For example, a Trigger command only makes sense if a camera is in the Ready state. HG cameras will only carry out some commands when the transmitting host has Attached to the camera. This is indicated in the second line of the prerequisites table. Cameras will reply with error messages if they receive a command for which they are in the wrong state, or from an un-attached host.

The last two lines in the table are suggested uses. The Command Modes represent how the command may be sent to the camera. “Individual” corresponds to a normal unicast network transmission. Group is multicast, and though the camera does not actually join any multicast groups, the host will likely simulate such behavior by a burst of unicast messages. Supports Simulation indicates the command may be passed to the Try (command simulation) command.

The Intended Use line hints at the usefulness of the command, especially to an operator at the camera adjusting frame, focus and exposure. Commands not expected to be needed by the operator of the camera will have the Operator block unchecked.

The Command Prerequisites tables for all commands are summarized in the Command Prerequisites Matrix in section 0.

The command send and response syntax tables look like this:

	Syntax	**Description**
Stop Command	**19**	This command will stop every camera receiving it.
Response	*No response*	There is no response to global commands.

Table 2: Example of Global Command (STOP)

	Syntax	**Description**
Stop Command	**#0519**	This command stops only the camera with ID=05.
Successful Response	#050119	The command completed successfully.
Failure Response	#05ee19	The command failed, where *‘ee’* is the explanation code.

Table 3: Example of Local Command (STOP)

Command	Description
#*id*91	Query a camera for its serial number.

Table 4: Example Command Table

Response	Description
#*id*0191*nnnnnnnn*	Command succeeded where *nnnnnnnn* is the camera serial number.
#*idee*91	Command failed, and *ee* is the explanation code.

Table 5: Example Response Table

In the command table, `#id` represents the pound-sign followed by a two-digit camera hexadecimal ID. When present between square brackets as `[#id]`, the use of the camera ID is optional, meaning the command may be used in both the global and individual forms.

Camera Announcements

The camera will normally generate network traffic only in response to commands. In specific situations it will be necessary for the camera to autonomously send a message called an Announcement, which will normally be multicast to the selected multicast group (**225.1.1.201** by default) and the selected network port number (**10505** by default). Announcements will have the format of a reply to a successful query command (values may be returned).

Announcement Name	Name	Code	Description
Detach	**DIS**	A0	A different DCU/CCU now controls the camera (an Attach command has been received from another DCU/CCU). This announcement is unicast only to the prior controller, to inform it that control has been taken away from it. This announcement is not multicast.
Hello	**HLO**	A1	The camera has just established network connectivity. The announcement will contain the current camera ID, formatted per the Identify command. This announcement will be multicast on both network interfaces every ***7*** seconds until traffic is received on any network interface. The host response should be an Attach command, a status request, or a query.
Over/Under Temperature	**HOT**	A2	The camera internal temperature has exceeded normal (max/min) operational limits. The announcement will contain the current temperature, formatted per the Get Temperature command. This announcement does not affect camera operation in any way: The camera will continue to run. It is up to the user to select an appropriate physical action in response to this announcement (such as stopping recording or removing power).
Primary Power Lost	**POW**	A3	The camera is losing external power and will be entering battery backup mode (only image memory refresh and a single LED is powered). Exiting this mode will be indicated by the "Hello" announcement. ***Note****: This announcement is sent only on a "best effort" basis: It will not be sent if the camera power supply hold-up time is insufficient to transmit the packet, which may be the case if recording is in progress when power is lost.*
State Change	**STC**	A4	The camera has changed states. The announcement will contain the current system state, formatted per the Get Camera State command.
Root Hub Absent	**SYN**	A5	A root hub has not been detected on the Sync/Trigger bus. The announcement may also indicate the loss of the Sync/Trigger bus itself, in which case the camera will continue to operate using its internal timing source.
Fault Text Message	**FTM**	A6	The camera has detected an error or fault condition. The Announcement will contain a text description of the error/fault. The first FTM announcement from a camera will be accompanied by a State Change announcement if a fault has occurred.
Configuration Update Complete	**CUC**	A7	The camera has completed a configuration update process begun with a Configuration Execute command.

Table 6: Announcements from Camera

Parameter Interdependencies (Side Effects)

Changing the value of some camera parameters directly affects the valid value ranges (soft limits) of other camera parameters. The major dependencies for HG cameras are shown below. Minor dependencies and side effects are documented with the associated commands.

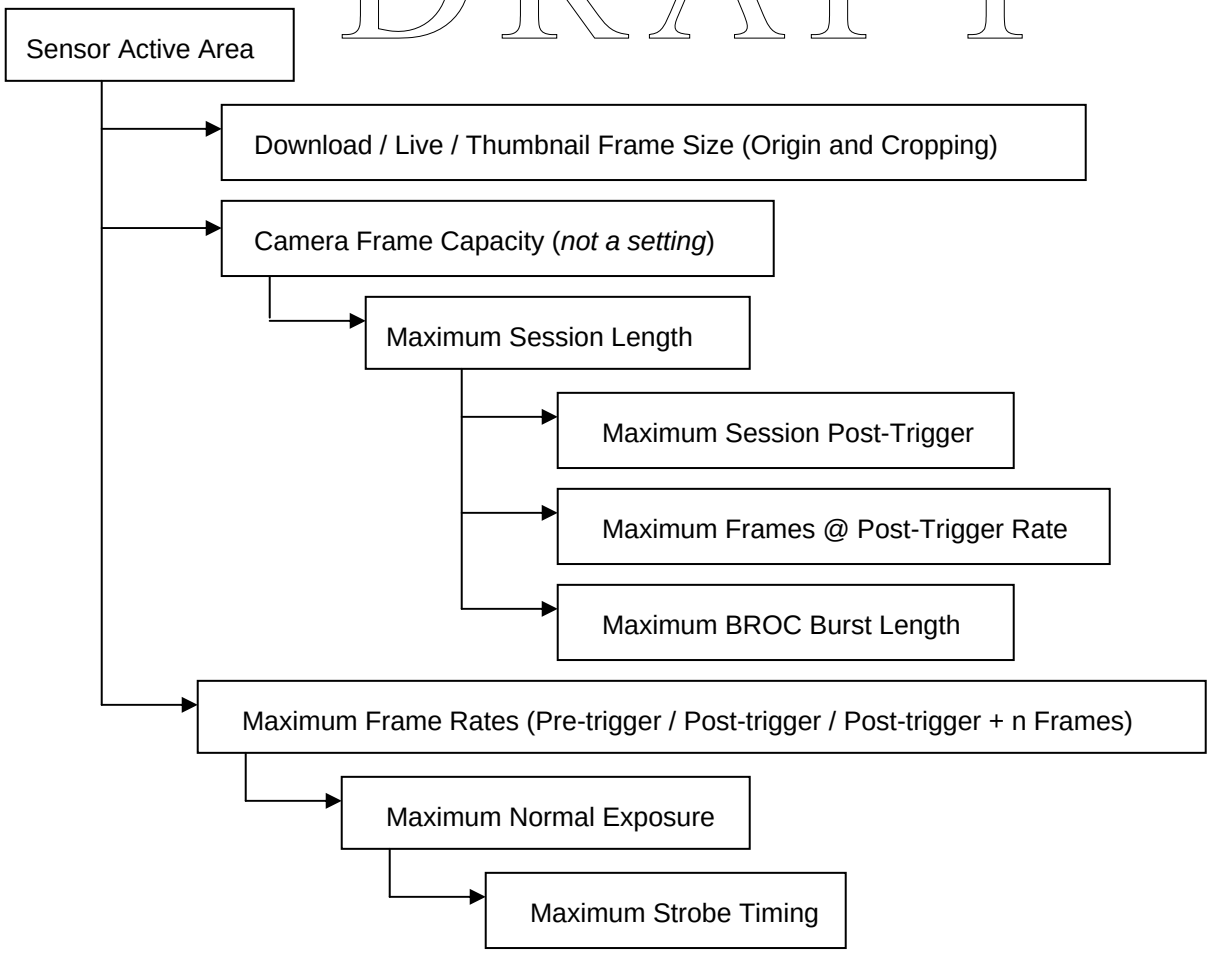


Figure 1: Side Effects

When a parameter in the hierarchy is changed, all parameters dependent on it (below it in the tree) will be checked. If any checked parameter would be made invalid by the new high-level value, then the value of the checked parameter will be automatically adjusted to a suitable value. The updated dependent value is included as part of the command reply. Specific interdependencies and side effects are documented with the affected commands.

When issuing multiple commands to the camera, it is recommended they be ordered according to a top-down traversal of the above tree. This will ensure all commands will succeed. Issuing the same commands in reverse order may cause some of the commands to fail, and the camera will likely not be in the desired configuration after the command sequence completes.

For example, changing the Sensor Active Area will cause all other items in the tree to be checked, and then adjusted if needed. Changing the Normal Exposure will cause only the Strobe Timing to be checked.
Changes are not permitted to propagate up the tree. For example, if the camera were configured to take 800 x 600 images, an attempt to set the Live Frame Size to 1504 x 1128 will not cause the Sensor Active Area to be changed. In this case, the command would fail, and an error would be returned.

To assist camera management, and to avoid the need for external systems to replicate the logic of the above dependency tree, the Try (command simulation) command has been created to permit commands to be performed via simulation, and expected side-effects returned, without affecting the actual camera state. Refer to the discussion of the Try command for details.

Fault Management

Definitions:

Fault: Any condition detected by the camera that reduces camera functionality below full factory specifications.

Fault Text Message: A Fault Text Message (FTM) Announcement accompanies every fault. A State Change Announcement will also accompany the first FTM.

Fault State: A restricted state of camera operation that disallows recording initiation (unless overridden), but is otherwise functional to the greatest extent possible. If the Fault State is entered while a recording is in progress (the camera is in the Ready or Recording states), the recording will be allowed to complete if possible. Recording initiation is prevented in the Fault State by disabling the Ready command and the Configurable and Trigger hardware inputs.

Latched Fault: A fault due to internal failures that immediately causes the camera to enter the Fault State. The Memory and Mode LEDs blink together to indicate Latched Faults.

Transient Fault: A fault due to external conditions that, when corrected and after the camera has been reset, will permit the camera to return to full normal operation. A Transient Fault does not cause the camera to enter the Fault State, so the camera state will not change. There is no visible indication of a Transient Fault, but Fault Text Messages will be sent.

Hardware Fault: A fault that prevents the application from executing normally. The camera is non-functional. The Memory and Mode LEDs blink alternately to indicate Hardware Faults.

An example of a Transient fault is the absence of a DHCP server on the Fast interface when the camera has been configured for DHCP operation on the Fast interface (Fast IP address is all zeros). In this case, the Fast interface is not usable, and the Slow interface will provide the only means of camera control until a DHCP server is seen on the Fast interface.

HG cameras are expected to be extremely rugged, robust and reliable. Thus, the occurrence of any internal (Latched) fault must be treated as an extraordinary event. The camera retains information describing the fault environment and sequence. To permit this information to be recovered and analyzed (for the purpose of camera repair and product improvement), only a Redlake Technical Support Engineer may clear a Latched Fault.

The Reset command (with the Fault Override parameter) may be used to permit a camera with a Latched Fault to initiate a single recording. This command must be issued prior to all subsequent recordings until the cause of the Latched Fault has been repaired.

3. Status Query Commands

Get Camera Status

This command returns a comprehensive status dump of the camera's configuration. The Attach command calls this command internally when an Attach with Status Dump is requested.

Status returned includes all the values returned by all commands that support the query request syntax (a command without parameters that returns status information). Each status item is on its own line, separated by CRLF character pairs.

> ***Note:*** *Imperative commands (such as Live, Stop, Ready, Record, Delete Recording, and Live / Thumbnail / Download Frame Requests) do not support the query syntax. The state of the functionality for some of these command controls is obtained via separate status request commands.*

The Get Camera Status command is intended to be used by any host that either does not require camera control or has had camera control taken away from it, so it may more easily stay in sync with the detailed camera status.

Command Prerequisites					
Camera State	☒ Standby	☒ Live	☒ Ready	☒ Recording	☒ Recording Done
Attach State	☐ Required	☒ Ignored	☐ Required only when modifying values		
Command Modes	☒ Individual	☐ Group	☐ Supports Simulation		
Intended Use	☒ Operator	☒ Supervisor	☐ **Factory Only** (OMIT FROM USER DOCS)		

Table 7: Get Camera Status Command Prerequisites

Command	**Description**
***#id*95**	Query status of a camera, where *id* is the camera's ID number, a hexadecimal number between 00h and FFh.

Table 8: Get Camera Status Command

Response	**Description**
*#idee*95	Command failed, and *'ee'* is the explanation code.
*#id*0195 *info*	Command succeeded. The data represented by *info* consists of approximately 45 lines of data.

Table 9: Get Camera Status Reply

Get Camera State

This command returns the camera's current state, current fault state, and current fault override state. The State Change announcement contains state data in the same format.

The effects of the fault state are:

1. The Mode and Memory LEDs on the camera rear panel will blink in unison.
2. The camera will not enter the Ready state. This may be overridden via the Reset command.

If a recording is in progress (camera state equals READY or RECORDING) when a fault occurs, the recording will continue to completion, if possible.

Command Prerequisites					
Camera State	☒ Standby	☒ Live	☒ Ready	☒ Recording	☒ Recording Done
Attach State	☐ Required	☒ Ignored	☐ Required only when modifying values		
Command Modes	☒ Individual	☒ Group	☐ Supports Simulation		
Intended Use	☒ Operator	☒ Supervisor	☐ **Factory Only** (OMIT FROM USER DOCS)		

Table 10: Get Camera State Command Prerequisites

Command	**Description**
#*id*40	Get camera state.

Table 11: Get Camera State Command

Response	**Description**
#*idee*40	Command not completed where *'ee'* is an explanation code.

#*id*0140*xxyyzz*	Command completed successfully where *xx* is the camera state, *yy* is the camera fault state, and *zz* is the camera fault override state as follows: ***xx*** **Camera State** 00 UNKNOWN 01 STANDBY 02 LIVE 03 READY (pre-trigger recording) 04 RECORDING (post-trigger recording) 05 RECORD DONE 06 DOWNLOAD 0B OFFLINE 0E RECONFIGURING HEADS 11 RECORD DONE WITH ERROR 12 STANDBY (NO HEAD) 13 STANDBY (BAD HEAD) 14 STANDBY (UNCONFIGURED HEAD) ***yy*** **Fault State** 00 No Fault FF The camera is in the FAULT state. ***zz*** **Override State** 00 No override. FF The fault has been overridden

Table 12: Get Camera State Reply

Some of the states are specific to the HG-TH console and provide more detailed information about head attachment states.

The RECONFIGURING HEADS state is entered briefly while configuring a new head. In this state, commands are rejected with a BAD STATE error. This state can only be entered when all “cameras” on the console (i.e. all heads) are in the LIVE or STANDBY state.

The RECORD DONE WITH ERROR state reports that the current recording in memory did not complete normally.

The STANDBY (NO HEAD) state is reported by a “camera” that has memory allocated but currently has no head attached on its port and no recording in memory.

The STANDBY (BAD HEAD) state is reported by a “camera” that has memory allocated for a head and detects a tether attached, but was not able to communicate with a head on the tether. This state is reported if the tether is attached at the console but no head is attached to the tether. The only way to exit this state is to reboot or to unplug the tether at the console. This state does not occur if there is a recording in memory for this port; the RECORD DONE, DOWNLOAD, or RECORD DONE WITH ERROR state takes priority.

The STANDBY (UNCONFIGURED HEAD) state is reported by a “camera” that has memory allocated for a head and detects a tether or head attached, but has not yet been able to configure the head. The head will be configured at the first opportunity. This state occurs when a head attachment changes while a recording is present in memory on the console. If you detach a head and reattach the same head while a recording is present in memory for a different port, the “camera” for the newly-attached head will report this state until the recording is deleted. This state also occurs briefly after head attachment with no recordings in memory and persists until reconfiguration begins.

Get Camera Type

This command queries the camera to determine if it has a color or monochrome sensor installed. Commands specific to color functionality (including White Balance Values and Light Source Select) are disabled on cameras with monochrome sensors.

In the HG-TH console, if a recording is present for this "camera" or port, the camera type reported is for the head that made the recording, which is not necessarily the same as the currently-connected head.

Command Prerequisites					
Camera State	☒ Standby	☒ Live	☒ Ready	☒ Recording	☒ Recording Done
Attach State	☐ Required	☒ Ignored	☐ Required only when modifying values		
Command Modes	☒ Individual	☒ Group	☐ Supports Simulation		
Intended Use	☒ Operator	☒ Supervisor	☐ **Factory Only** (OMIT FROM USER DOCS)		

Table 13: Get Camera Type Command Prerequisites

Command	**Description**
***#id*48**	Return the camera sensor type.

Table 14: Get Camera Type Command

Response	**Description**
*#id*014801	Camera is a color camera.
*#id*014802	Camera is a monochrome camera.
*#idee*48	Command failed, and *'ee'* is the explanation code.

Table 15: Get Camera Type Reply

Get Camera Info

This command returns two data items: the camera model formatted in 2 hexadecimal digits, and the camera application software version number formatted in 8 hexadecimal digits (32 bits). Table 16 below shows the codes assigned to each HG camera model.

Code	Camera Model
07	HG-100K
08	HG-LE
09	HG-TH, 752 X 562
10	HG-XR
12	HG-CH
13	HG-XR without IRIG

Table 16: Camera Model Codes

Command Prerequisites					
Camera State	☒ Standby	☒ Live	☒ Ready	☒ Recording	☒ Recording Done
Attach State	☐ Required	☒ Ignored	☐ Required only when modifying values		
Command Modes	☒ Individual	☒ Group	☐ Supports Simulation		
Intended Use	☒ Operator	☒ Supervisor	☐ **Factory Only** (OMIT FROM USER DOCS)		

Table 17: Get Camera Info Command Prerequisites

Command	Description
#*id*97	Query a camera for its model and firmware version.

Table 18: Get Camera Info Command

Response	Description
#*id*0197*mmvvvvvvvv*	Command succeeded where *mm* is the Camera model (as shown in Table 16) and *vvvvvvvv* is the firmware version.
#*idee*97	Command failed, and *ee* is the explanation code.

Table 19: Get Camera Info Reply

Get Temperature

This command returns the camera's internal temperature as a signed eight-bit number. Readable temperature range is from -55º C to 125º C in 1º increments. For HG-TH cameras, temeratures are returned for both console and camera head.

Command Prerequisites					
Camera State	☒ Standby	☒ Live	☒ Ready	☒ Recording	☒ Recording Done
Attach State	☐ Required	☒ Ignored	☐ Required only when modifying values		
Command Modes	☒ Individual	☒ Group	☐ Supports Simulation		
Intended Use	☒ Operator	☒ Supervisor	☐ **Factory Only** (OMIT FROM USER DOCS)		

Table 20: Get Temperature Command Prerequisites

Command	Description
#*id*50	Request camera internal temperature.

Table 21: Get Temperature Command

Response	Description
#*id*0150tt	Command succeeded where *tt* is the temperature as a signed eight-bit hexadecimal number.
#*id*0150*ttTT*	(HG-TH only) Command succeeded where *tt* is the HG-TH console temperature, and *TT* is the HG-TH camera head temperature.
#*id*ee50	Command failed, and *'ee'* is the explanation code.

Table 22: Get Temperature Reply

Get Session Length

This command returns the Session Length value. It is a redundant command retained for backwards compatibility.

Command Prerequisites					
Camera State	☒ Standby	☒ Live	☒ Ready	☒ Recording	☒ Recording Done
Attach State	☐ Required	☒ Ignored	☐ Required only when modifying values		
Command Modes	☒ Individual	☒ Group	☐ Supports Simulation		
Intended Use	☒ Operator	☒ Supervisor	☐ **Factory Only** (OMIT FROM USER DOCS)		

Table 23: Get Session Length Command Prerequisites

Command	Description
#*id*51	Returns the current Session Length.

Table 24: Get Session Length Command

Response	Description
#*id*0151*nnnnnnnn*	Command completed successfully where *nnnnnnnn* is a 32-bit hexadecimal number representing the Session Length.
#*idee*51	Command failed, and *'ee'* is the explanation code.

Table 25: Get Session Length Reply

Get Frame Length

This command returns the best estimate for the sizes of the next Live, Thumbnail and Download frame transfers. The values include all headers, footers and padding that may be present in addition to the image data. The sizes returned will be exact unless JPEG encoding is used, in which case the size will be the maximum limit.

Command Prerequisites					
Camera State	☒ Standby	☒ Live	☒ Ready	☒ Recording	☒ Recording Done
Attach State	☐ Required	☒ Ignored	☐ Required only when modifying values		
Command Modes	☒ Individual	☒ Group	☐ Supports Simulation		
Intended Use	☒ Operator	☒ Supervisor	☐ **Factory Only** (OMIT FROM USER DOCS)		

Table 26: Get Frame Length Command Prerequisites

Command	Description
#*id*9A	Returns the sizes for the next frame transfers.

Table 27: Get Frame Length Command

Response	Description
#*id*019A*llllllltttttttddddddd*	Command completed successfully where *lllllll* is a 32-bit hexadecimal number representing the size in bytes of the next Live frame, *ttttttt* is the size of the next Thumbnail frame, and *ddddddd* is the size of the next Download frame.
#*idee*51	Command failed, and *'ee'* is the explanation code.

Table 28: Get Frame Length Reply

Get Sensor Size

This command returns the sensor geometry for the camera (physical height and width in pixels), which defines the maximum allowed sensor active area. It also returns restrictions on the active area height and width settings (e.g., height and width must be even multiples of these numbers). Finally, it returns a variable-length list of suggested sensor active area settings. Control software can present these to users in camera setup menus.

Command Prerequisites					
Camera State	☒ Standby	☒ Live	☒ Ready	☒ Recording	☒ Recording Done
Attach State	☐ Required	☒ Ignored	☐ Required only when modifying values		
Command Modes	☒ Individual	☒ Group	☐ Supports Simulation		
Intended Use	☒ Operator	☒ Supervisor	☐ **Factory Only** (OMIT FROM USER DOCS)		

Table 29: Get Sensor Size Command Prerequisites

Command	**Description**
#*id*9F	Query a camera for its sensor geometry.

Table 30: Get Sensor Size Command

Response	**Description**
#*id*019F01*WWWWHHHH wwwwhhhhiijj*	Command succeeded (first line of response). *WWWW* and *HHHH* give the physical sensor width and height (respectively) in pixels. This is also the maximum allowed sensor active area. *wwww* and *hhhh* give the minimum allowed active area. *ii* gives the restriction on values for the active area height (active area height must be an even multiple of *ii*). *jj* gives a similar restriction for active area widths.
#*id*019F02*hhhhwwww*	The reply can include several lines of this form. Each *hhhh* and *wwww* pair gives a suggested sensor active area height and width that control software can present to the user (e.g., in a drop-down menu) as a convenience in configuring the camera.
#*id*019F03	The reply always includes a line of this form, as an indicator that the reply is complete and no more lines follow.
#*idee*9F	Command failed, and *ee* is the explanation code.

Table 31: Get Sensor Size Reply

Get Frame Rate Info

This command returns the range of frame rates allowed for the currently set sensor active area. It also supplies a list of suggested "standard" frame rates that the control software can present to the user (e.g., in a drop-down menu) for convenience in configuring the camera.

Command Prerequisites					
Camera State	☒ Standby	☒ Live	☒ Ready	☒ Recording	☒ Recording Done
Attach State	☐ Required	☒ Ignored	☐ Required only when modifying values		
Command Modes	☒ Individual	☒ Group	☐ Supports Simulation		
Intended Use	☒ Operator	☒ Supervisor	☐ **Factory Only** (OMIT FROM USER DOCS)		

Table 32: Get Frame Rate Info Command Prerequisites

Command	Description
#*id*05	Query a camera for frame rate info.

Table 33: Get Frame Rate Info Command

Response	Description
#*id*010501*RRRRRRRRrrrrrrrrii*	Command succeeded (first line of response). *RRRRRRRR* gives the maximum allowed frame rate for the current sensor active area. *rrrrrrrr* gives the minimum allowed frame rate. *ii* gives the greatest common divisor required for valid frame rates (i.e., *ii* evenly divides all valid frame rates).
#*id*010502*rrrrrrrr*	The reply can include several lines of this form. Each *rrrrrrrr* gives a suggested frame rate that control software can present to the user (e.g., in a drop-down menu) as a convenience in configuring the camera.
#*id*010503	The reply always includes a line of this form, as an indicator that the reply is complete and no more lines follow.
#*idee*05	Command failed, and *ee* is the explanation code.

Table 34: Get Frame Rate Info Reply

Get IRIG Lock State

This command returns the current IRIG (or GPS) timing "lock" state. "Locked" indicates that the camera is receiving and successfully decoding an incoming time signal (either IRIG or GPS), and that the camera's internal timebase is phase-locked to the incoming signal.

Note: *This command is only valid on camera models that support IRIG or GPS input. Other models will return an "Unsupported command" error (code 0x11).*

Command Prerequisites					
Camera State	☒ Standby	☒ Live	☒ Ready	☒ Recording	☒ Recording Done
Attach State	☐ Required	☒ Ignored	☐ Required only when modifying values		
Command Modes	☒ Individual	☒ Group	☐ Supports Simulation		
Intended Use	☒ Operator	☒ Supervisor	☐ **Factory Only** (OMIT FROM USER DOCS)		

Table 35: Get IRIG Lock State Command Prerequisites

Command	**Description**
***#id*64**	Query a camera for lock state.

Table 36: Get IRIG Lock State Command

Response	**Description**
*#id*0164nn	Command succeeded. "nn" gives the lock state, as follows: 00: Camera has not locked to IRIG or GPS timebase 01: Camera has locked to IRIG or GPS timebase.
*#idee*64	Command failed, and *ee* is the explanation code.

Table 37: Get IRIG Lock State Reply

Try (Command Simulation)

The Try command takes another camera command as a parameter, and causes the passed command to be performed in simulation. The results returned indicate what ***would*** happen were the passed command to be directly executed (with the camera in precisely the current state), though the camera status is ***not*** affected in any way.

The simulation is extremely faithful. While the Try command may be used in any camera state that state must be valid for the command passed as its parameter, or the simulation result will contain an expected error for the passed command.

Not all camera commands may be simulated. An attempt to simulate an unsupported command will cause the Try command to return a “Command Rejected” error. The following commands support simulation:

Code	Command Title
90	Sensor Active Area
0E	Session Length
06	Frame Rate
04	Trigger Position
07	Exposure
82	Configure Configurable Input
83	Configure Strobe Output
9C/8D/8E	Download/Live/Thumbnail Frame Size

Table 38: Commands Supporting Simulation

These commands are the same commands that cause or are affected by side-effects as described in the Parameter Interdependencies (Side Effects) section of chapter 2. The Try command permits side-effects to be predicted.

As an example, let’s say camera #01 was configured to acquire a massive number of tiny frames at some enormous frame rate. We now want to capture full-size images (1504x1128). The command to do this, Sensor Active Area, would be sent as **#019005E00468**, so the Try version would be **#01DD9005E00468**. Sending this command could produce the following output:

```
#0101DD90
#01019005E00468
#01010E000004F0000004F0
#0101040000004EF
#0101060B0B0B04EF
#01019B04F0
#0101060606060001
```

The first line of the output (#0101DD90) is the reply to the Try command itself, which states that the simulation of command 90 (Sensor Active Area) was successful, and its output follows. Note that this does ***not*** mean the command being simulated returned a successful reply! It means only that the requested command was simulated.

The second line (#01019005E00468) is the start of the output of the ***simulated*** execution of the Sensor Active Area command, which states that the command performed successfully. The remaining lines are part of the ***simulated*** Sensor Active Area command reply, and represent the ***simulated*** output of commands affected by side-effects caused by the Sensor Active Area command. The actual camera configuration is ***unchanged***.

Command Prerequisites					
Camera State	☒ Standby	☒ Live	☒ Ready	☒ Recording	☒ Recording Done
Attach State	☒ Required	☐ Ignored	☐ Required only when modifying values		
Command Modes	☒ Individual	☐ Group	☐ Supports Simulation		
Intended Use	☒ Operator	☒ Supervisor	☐ **Factory Only** (OMIT FROM USER DOCS)		

Table 39: Try Command Prerequisites

Command	Description
#id*DD*ccccc…	Perform the passed command *ccccc…* under simulation.

Table 40: Try Command

Response	Description
*#id*01DD*cc* *… (other command output)*	Command completed successfully, and the simulated output for command *cc* is appended.
*#idee*51	Command failed, and *'ee'* is the explanation code.

Table 41: Try Reply

Update (Load new software, etc.)

The configuration update process loads new software and/or FPGA programs into the camera. The complete configuration update process includes loading files onto the camera via FTP sessions, sending the Update command shown here, and later receiving notification that the camera has completed the configuration update. Appendix E describes this process more fully.

Command Prerequisites					
Camera State	☒ Standby	☐ Live	☐ Ready	☐ Recording	☐ Recording Done
Attach State	☒ Required	☐ Ignored	☐ Required only when modifying values		
Command Modes	☒ Individual	☐ Group	☐ Supports Simulation		
Intended Use	☐ Operator	☒ Supervisor	☒ **Factory Only** (OMIT FROM USER DOCS)		

Table 42: Update Command Prerequisites

Command	Description
#*id*D0	Initiate update process. Update files must previously be loaded into the camera's RAM file system. See Appendix E for details.

Table 43: Update Command

Response	Description
#*id*01D0	Update initiated successfully.
#*idee*D0	Command failed, and *'ee'* is the explanation code.

Table 44: Update Replay

4. Platform Control/Configuration Commands

Attach to Camera

The Attach command provides host access to those commands capable of modifying the camera status. That is, the Attach command is used to establish control over a camera.

The Attach command returns a status flag and the IP address of the ***previously*** attached host. The status flag values are defined in the table below. The value of the IP address will fall into one of three categories:

1. If the value of the IP address is all zeros, then no host has attached since the camera was started.
2. If the IP address matches that of the requestor, then the requestor was already attached.
3. Otherwise, the IP address is that of the host last controlling the camera. The first Attach command sent to a camera that has just been powered up will return an IP of all zeros.

The Attach response may optionally include the same status information returned by the Get Camera Status command, to enable rapid host program synchronization with the current camera configuration.

Side Effects: *When a successful Attach is performed when a different host was previously attached, the previous host will be detached and will be sent a Detach announcement.*

Flag values	Meaning
0x02	Attach performed (requestor has control of the camera).
0x01	Camera status dump appended.
0x03	Attach performed, and camera status dump appended.
0x00	No attach performed, no status dump appended (a query was performed).

Table 45: Attach Reply Status Flag Values

Command Prerequisites					
Camera State	☒ Standby	☒ Live	☒ Ready	☒ Recording	☒ Recording Done
Attach State	☐ Required	☒ Ignored	☐ Required only when modifying values		
Command Modes	☒ Individual	☒ Group	☐ Supports Simulation		
Intended Use	☒ Operator	☒ Supervisor	☐ **Factory Only** (OMIT FROM USER DOCS)		

Table 46: Attach Command Prerequisites

Command	Description
0102	Attach to camera silently (no reply).
#*id*01	Query attach status of a camera, where *id* is the camera's ID number, a hexadecimal number between 00h and FFh.
#*id*0101	Attach to a camera without returning a status dump.
#*id*0102	Attach to a camera and return a status dump.

Table 47: Attach Command

Response	Description
#*idee*01	Command failed, and *'ee'* is the explanation code.
#*id*0101*ssnnnnnnnn [info]*	Command succeeded, where *id* is the Camera ID number, *ss* is the reply status flag, and *nnnnnnnn* is the IP address of the ***previously*** connected host. The data represented by *info* will be present only if an attach was performed and the requestor was not previously attached.
#*id*010102*nnnnnnnn*	Requestor is attached, and was previously attached. No status appended.
#*id*010100*nnnnnnnn*	No attach performed, no status appended (normal query reply when the requestor is ***not*** attached).
#*id*010101*nnnnnnnn*	No attach performed, no status appended (normal query reply when the requestor is attached).
#*id*010103*nnnnnnnn info*	Attach performed, status appended (requestor was not previously attached).

Table 48: Attach Reply

Identify

When broadcast, this command causes every camera connected to the host computer to reply with its assigned Camera ID. A host normally broadcasts this command when it first connects to the camera system (such as after starting the CCU application).

If the entire camera network was just powered up, then it is likely that all connected cameras will be sending “Hello” announcements before the host finishes booting. The host must allow for the arrival of one or more “Hello” announcements after Identify is sent, and before the reply arrives.

Command Prerequisites					
Camera State	☒ Standby	☒ Live	☒ Ready	☒ Recording	☒ Recording Done
Attach State	☐ Required	☒ Ignored	☐ Required only when modifying values		
Command Modes	☒ Individual	☒ Group	☐ Supports Simulation		
Intended Use	☒ Operator	☒ Supervisor	☐ **Factory Only** (OMIT FROM USER DOCS)		

Table 49: Identify Command Prerequisites

Command	**Description**
54	Query each camera for its ID number and Model number.
#*id*54	Verify the ID of a specific camera.

Table 50: Identify Command

Response	**Description**
#*id*0154*idmm*	Command succeeded where *id* is the Camera ID number and *mm* is the camera Model number (formatted per the Get Camera Info command).
#*idee*54	Command failed, and *‘ee’* is the explanation code.

Table 51: Identify Reply

Get Serial Number

This command returns the factory-assigned 32-bit camera serial number, formatted as eight hexadecimal digits. After conversion to decimal, the value returned must match the serial number marked on the camera rear panel.

In the HG-TH console, if a recording is present for this "camera" or port, the serial number reported is for the head that made the recording, which is not necessarily the same as the currently-connected head.

Command Prerequisites					
Camera State	☒ Standby	☒ Live	☒ Ready	☒ Recording	☒ Recording Done
Attach State	☐ Required	☒ Ignored	☐ Required only when modifying values		
Command Modes	☒ Individual	☒ Group	☐ Supports Simulation		
Intended Use	☒ Operator	☒ Supervisor	☐ **Factory Only** (OMIT FROM USER DOCS)		

Table 52: Get Camera Serial Number Command Prerequisites

Command	**Description**
#*id*91	Query a camera for its serial number.

Table 53: Get Camera Serial Number Command

Response	**Description**
#*id*0191*nnnnnnnn*	Command succeeded where *nnnnnnnn* is the camera serial number.
#*idee*91	Command failed, and *ee* is the explanation code.

Table 54: Get Camera Serial Number Reply

Get Connected Head Serial Number

This command is for HG-TH only. It returns the factory-assigned 32-bit camera serial number of the currently-connected head, formatted as eight hexadecimal digits. The serial number reported by this command could be different from the one reported by the Get Serial Number command. If a recording is present for a port or "camera" on the HG-TH console, the serial number and other characteristics such as whether it is monochrome are reported for the camera that made the recording. For convenience, this command also reports the serial number for the "camera" or recording.

Command Prerequisites					
Camera State	☒ Standby	☒ Live	☒ Ready	☒ Recording	☒ Recording Done
Attach State	☐ Required	☒ Ignored	☐ Required only when modifying values		
Command Modes	☒ Individual	☒ Group	☐ Supports Simulation		
Intended Use	☒ Operator	☒ Supervisor	☐ **Factory Only** (OMIT FROM USER DOCS)		

Table 55: Get Camera Serial Number Command Prerequisites

Command	**Description**
***#id*77**	Query a camera for the serial number of the currently connected head.

Table 56: Get Camera Serial Number Command

Response	**Description**
*#id*0177*nnnnnnnnmmmmmmmm*	Command succeeded where *nnnnnnnn* is the connected head's serial number and mmmmmmmm is the serial number that would be reported by Get Serial Number.
*#idee*77	Command failed, and *ee* is the explanation code.

Table 57: Get Camera Serial Number Reply

IP Address

Set the IP addresses for the camera's Ethernet communication links. The IP address must be legal, or an error will be returned. For example, an IP address with a value of 255 in the last octet (such as 100.2.1.255) is illegal (it is a subnet broadcast address), and will cause the command to fail. By default, only the Fast interface is affected. The use of the trailing parameter "SLOW" is required to affect the Slow interface.

If the IP address of the Fast interface is 0.0.0.0 with a Subnet Mask of 0.0.0.0, it indicates that the camera is ready and able to accept an IP address assigned by the DHCP server. Assigning the Fast interface an IP address other than 0.0.0.0 will cause the camera's DHCP **client** to be disabled, and the configured IP address will be used instead.

> ***Note:*** *Since the presence of a host DHCP server cannot be guaranteed, the default Fast IP address is set to 192.168.0.2 with a Subnet Mask of 255.255.255.0 before leaving the factory.*

The default IP address of the Slow interface is 90.0.0.1. The camera provides a DHCP **server** for the Slow interface, and the Slow interface IP address is also used to configure the block of nine IP addresses that may be issued by the DHCP server. This block occupies the nine addresses immediately following the Slow interface IP address. For the default Slow interface IP address of 90.0.0.1, the default DHCP server will issue addresses ranging from 90.0.0.2 through 90.0.0.10. When a DCU is connected directly to a camera, and its network interface is configured to use DHCP, it will be issued an IP address within the above block.

An IP address of 0.0.0.0 may not be used on the Slow interface and will cause an error to be returned, since the Slow interface provides a DHCP server, and may not be a DHCP client.

> ***Note:*** *The values set by this command **will not take effect** until either camera power is cycled or the Reset command is issued to restart the camera.*
>
> *The final byte of the Slow interface IP address must not exceed 244 to ensure only valid IP addresses will be issued by the DHCP server.*
>
> *When the DCU is connected to a hub, it **will not** have access to the DHCP server in each camera. In this case, either the DCU will obtain an IP address from the same source as do the cameras: If there is no DHCP server on the camera LAN, then the DCU's IP address will need to be assigned **manually**.*

Command Prerequisites					
Camera State	☒ Standby	☒ Live	☒ Ready	☒ Recording	☒ Recording Done
Attach State	☐ Required	☐ Ignored	☒ Required only when modifying values		
Command Modes	☒ Individual	☐ Group	☐ Supports Simulation		
Intended Use	☐ Operator	☒ Supervisor	☐ **Factory Only** (OMIT FROM USER DOCS)		

Table 58: IP Address Command Prerequisites

Command	Description
#*id*4D	Return the current Fast and Slow IP addresses.
#*id*4DSLOW	Return the current Slow IP address.
[#id]4D*xxxxxxxx*	Set the Fast IP address to *xxxxxxxx* (hexadecimal)
[#id]4D*xxxxxxxx*SLOW	Set the Slow IP address to *xxxxxxxx* (hexadecimal)

Table 59: IP Address Command

Response	Description
#*id*014D*xxxxxxxx*	Command completed successfully, where *xxxxxxxx* is the camera's Fast IP address expressed as a hexadecimal value.
#*id*014D*xxxxxxxx*SLOW	Command completed successfully, where *xxxxxxxx* is the camera's Slow IP address expressed as a hexadecimal value.
#*id*014D*ffffffffssssssss*	Command completed successfully, where *ffffffff* is the camera's Fast IP address, and *ssssssss* is the Slow IP address.
#*idee*4D	Command failed, and *'ee'* is the explanation code.

Table 60: IP Address Reply

Example	
#*id*4D64000001	Set the camera's Fast IP address to 100.0.0.1

Table 61: IP Address Example

Subnet Mask

Set the subnet masks for the Ethernet communication interfaces. By default, only the Fast interface is affected. The use of the trailing parameter "SLOW" is required to affect the Slow interface.

The default mask for the both the Fast and Slow interface is 255.255.255.0. If DHCP is used on the Fast interface, the default mask is 0.0.0.0, which allows the Fast interface to accept the mask assigned by the DHCP Server. As a general practice, using the most restrictive subnet mask (most bits set) that is consistent with proper system operation is recommended, since this will allow the camera to ignore other traffic that may be present on the network.

If a non-zero mask is used, it must match the class of the IP address assigned via the IP Address command. Class A IP addresses require masks starting with 255.*.*.*., Class B requires 255.255.*.*, and Class C requires 255.255.255.*. An IP address must not have all bits set (255.255.255.255 is illegal).

Note: *The values set by this command **will not take effect** until the camera power is cycled, the camera's Reset button is pressed, or the Reset command is issued to restart the camera.*

Command Prerequisites					
Camera State	☒ Standby	☒ Live	☒ Ready	☒ Recording	☒ Recording Done
Attach State	☐ Required	☐ Ignored	☒ Required only when modifying values		
Command Modes	☒ Individual	☐ Group	☐ Supports Simulation		
Intended Use	☐ Operator	☒ Supervisor	☐ **Factory Only** (OMIT FROM USER DOCS)		

Table 62: Subnet Mask Command Prerequisites

Command	**Description**
#*id*4E	Return the current Fast and Slow subnet masks.
#*id*4ESLOW	Return the current Slow subnet mask.
[#id]4E*xxxxxxxx*	Set the camera's Fast subnet mask to *xxxxxxxx* (hexadecimal).
[#id]4E*xxxxxxxx*SLOW	Set the camera's Slow subnet mask to *xxxxxxxx* (hexadecimal).

Table 63: Subnet Mask Command

Response	**Description**
#*id*014E*xxxxxxxx*	Command succeeded where *xxxxxxxx* is the Fast subnet mask.
#*id*014E*xxxxxxxx*SLOW	Command succeeded where *xxxxxxxx* is the Slow subnet mask.
#*id*014E*ffffffffssssssss*	Command succeeded where *ffffffff* is the Fast subnet mask, and *ssssssss* is the Slow subnet mask.
#*idee*4E	Command failed, and *'ee'* is the explanation code.

Table 64: Subnet Mask Reply

Example	
#*id*4EFF000000	Set the camera's Fast subnet mask to 255.0.0.0

Table 65: Subnet Mask Example

Datagram Size

Set the IP datagram size (***not*** Ethernet packet size) in bytes. The datagram size is the maximum size of the UDP/IP packets exchanged between the camera and the host computer via the network connection.

Datagrams are transported using one or more Ethernet packets. If there are problems maintaining reliable Ethernet communications (which may be due to a slow host computer), using smaller datagrams may improve reliability, at the cost of slightly slowed communication.

By default, only the Fast interface is affected. The use of the trailing parameter "SLOW" is required to affect only the Slow interface.

The following datagram sizes are supported:

Parameter Value	Datagram Size
0C00	0C00h (3072) bytes
1800	1800h (6144) bytes
2000	2000h (8192) bytes
3000	3000h (12288) bytes
6000	6000h (24576) bytes (**default**)
8000	8000h (32768) bytes

Table 66: Supported Datagram Sizes

Command Prerequisites					
Camera State	☒ Standby	☒ Live	☒ Ready	☒ Recording	☒ Recording Done
Attach State	☐ Required	☐ Ignored	☒ Required only when modifying values		
Command Modes	☒ Individual	☒ Group	☐ Supports Simulation		
Intended Use	☐ Operator	☒ Supervisor	☐ **Factory Only** (OMIT FROM USER DOCS)		

Table 67: Datagram Size Command Prerequisites

Command	Description
#*id*53	Return the Fast and Slow datagram sizes.
#*id*53SLOW	Return the Slow datagram size.
[#id]53*nnnn*	Set the datagram size on the Fast network to *nnnn*, per the table above.
[#id]53*nnnn*SLOW	Set the datagram size on the Slow network to *nnnn*, per the table above.

Table 68: Datagram Size Command

Response	Description
#*id*0153*nnnn*	Command succeeded where *nnnn* is the Fast datagram size.
#*id*0153*nnnn*SLOW	Command succeeded where *nnnn* is the Slow datagram size.
#*id*0153*ffffssss*	Command succeeded, where *ffff* is the Fast datagram size and *ssss* is the Slow datagram size.
#*idee*53	Command failed, and *'ee'* is the explanation code.

Table 69: Datagram Size Reply

Command Port Number

Select the IP port the camera listens to for the host commands. The selected port number must be an unsigned 16-bit value greater than 1025. This command affects both the Fast and Slow interfaces. The default port number for commands is **1027**, and should not be changed unless absolutely necessary.

Note: *This command is intended for factory use only.*

Note: *The value set by this command **will not take effect** until either the power is cycled or the Reset command is issued to restart the camera.*

Command Prerequisites					
Camera State	☒ Standby	☒ Live	☒ Ready	☒ Recording	☒ Recording Done
Attach State	☐ Required	☐ Ignored	☒ Required only when modifying values		
Command Modes	☒ Individual	☒ Group	☐ Supports Simulation		
Intended Use	☐ Operator	☒ Supervisor	☒ **Factory Only** (OMIT FROM USER DOCS)		

Table 70: Command Port Number Command Prerequisites

Command	**Description**
#id80	Return the Command Port number.
[#id]80*pppp*	Set the command port number to *pppp*.

Table 71: Command Port Number Command

Response	**Description**
#*id*0180*pppp*	Command succeeded, where *pppp* is the Command Port number.
#*idee*80	Command failed, and *'ee'* is the explanation code.

Table 72: Command Port Number Reply

Announcement Setup

Select the IP port and address to which the camera sends Announcements.

The selected port number must be an unsigned 16-bit value greater than 1025. The default Announcement port is **10505** (0x2909).

The selected address should be either a multicast group (224.0.0.0 through 239.255.255.255) or a broadcast address (*.*.*.255). The default Announcement address is the multicast address **225.1.1.201**.

Note: *This command is intended for factory use only.*
Note: *The value set by this command **will not take effect** until either the power is cycled or the Reset command is issued to restart the camera.*

Command Prerequisites					
Camera State	☒ Standby	☒ Live	☒ Ready	☒ Recording	☒ Recording Done
Attach State	☐ Required	☐ Ignored	☒ Required only when modifying values		
Command Modes	☒ Individual	☒ Group	☐ Supports Simulation		
Intended Use	☐ Operator	☒ Supervisor	☒ **Factory Only** (OMIT FROM USER DOCS)		

Table 73: Announcement Port Number Command Prerequisites

Command	**Description**
#id9D	Return the Announcement Port number and Address.
[#id]9D*pppp*	Set the Announcement port number to *pppp*.
[#id]9D*ppppaaaaaaaa*	Set the Announcement port number to *pppp*, and the Announcement address to *aaaaaaaa*.

Table 74: Announcement Port Number Command

Response	**Description**
#*id*019D*ppppaaaaaaaa*	Command succeeded, where *pppp* is the Announcement Port number and *aaaaaaaa* is the Announcement Address.
#*idee*9D	Command failed, and *'ee'* is the explanation code.

Table 75: Announcement Port Number Reply

Reset (Reboot or Fault Override) Camera

When used ***without*** a parameter, this command will reinitialize the camera without affecting images that may be present in memory. This is equivalent to powering up from the battery backup state, where the FPGAs are reprogrammed, camera software is copied to SRAM, the RTOS and all applications are restarted, and saved camera logical states and parameter values are restored. Any images in memory are identified and preserved.
The reply is sent before the restart is performed. The host should expect to receive a Hello announcement from the camera after the restart is completed.

If images are present in memory, the camera will be in the Recording Done state when this command completes. Otherwise, it will be in the Standby state.

When used ***with*** a parameter, this command may be used to override the Fault state, in order to permit the camera to initiate recording once. This does not remove the Fault state (the LEDs will continue to blink, and the camera status will still report the Fault state).

> ***Note:*** *There is no guarantee that any frames will be acquired by any recording made after overriding the Fault state.*

Command Prerequisites					
Camera State	☒ Standby	☒ Live	☒ Ready	☒ Recording	☒ Recording Done
Attach State	☒ Required	☐ Ignored	☐ Required only when modifying values		
Command Modes	☒ Individual	☐ Group	☐ Supports Simulation		
Intended Use	☐ Operator	☒ Supervisor	☐ **Factory Only** (OMIT FROM USER DOCS)		

Table 76: Reset Command Prerequisites

Command	**Description**	
#*id*5F	Reset camera *id*.	
#*id*5FFF	Override the Fault state. (No other parameter value is valid.)	
#*id*5FBE	Create a **B**ack-door test **E**rror message	**FACTORY ONLY**
#*id*5FBF	Create a **B**ack-door test **F**ault message	**FACTORY ONLY**
#*id*5FBC	**B**ack-door **C**lear of Fault state and delete all logs.	**FACTORY ONLY**
#*id*5FBD	**B**ack-door **D**elete of Data Dictionary NV data.	**FACTORY ONLY**

Table 77: Reset Command

Response	**Description**
#*id*015F	Command succeeded, camera reset initiated.
#*id*015FFF	Command succeeded, fault state overridden.
#*idee*5F	Command failed, and *'ee'* is the explanation code.

Table 78: Reset Reply

Battery Level

Report the battery charge level as an integer percentage ranging from 0% to 100%.

Command Prerequisites					
Camera State	☒ Standby	☒ Live	☒ Ready	☒ Recording	☒ Recording Done
Attach State	☐ Required	☒ Ignored	☐ Required only when modifying values		
Command Modes	☒ Individual	☒ Group	☐ Supports Simulation		
Intended Use	☒ Operator	☒ Supervisor	☐ **Factory Only** (OMIT FROM USER DOCS)		

Table 79: Battery Level Command Prerequisites

Command	Description
#*id*81	Report battery level for camera *id*.

Table 80: Battery Level Command

Response	Description
#*id*0181*bb*	Command succeeded, battery level at *bb* percent.
#*idee*81	Command failed, and *'ee'* is the explanation code.

Table 81: Battery Level Reply

Time

Use this command to set the software Time of Day clock in the camera. Since the HG cameras do not possess a battery-backed hardware real time clock, this command should be issued to each camera as part of the normal CCU/DCU initialization process. This command is best sent to all cameras simultaneously.

Command Prerequisites					
Camera State	☒ Standby	☒ Live	☒ Ready	☒ Recording	☒ Recording Done
Attach State	☐ Required	☐ Ignored	☒ Required only when modifying values		
Command Modes	☒ Individual	☒ Group	☐ Supports Simulation		
Intended Use	☐ Operator	☒ Supervisor	☐ **Factory Only** (OMIT FROM USER DOCS)		

Table 82: Time Command Prerequisites

Command	Description
#*id*08	Return the current time of day as *hh*:*mm*:*ss* in ***Decimal*** format. *Note: Only commands related to date/time use decimal notation – all other notation is hexadecimal.*
[#*id*]08*hhmmss*	Set the camera's time. *hh* range is from 00 to 23, *mm* and *ss* are 00 to 59.

Table 83: Time Command

Response	Description
#*id*0108*hhmmss*	Command succeeded where *hhmmss* is the current *decimal* time.
#*idee*08	Command failed, and *'ee'* is the explanation code.

Table 84: Time Reply

Example	
08011050	Set the system time to 01:10:50 am.

Table 85: Time Command Example

Date

Use this command to set the date in the camera. Since the HG cameras do not possess a battery-backed real time clock, this command should be issued to each camera as part of the normal CCU/DCU initialization process. This command is best sent to all cameras simultaneously.

Command Prerequisites					
Camera State	☒ Standby	☒ Live	☒ Ready	☒ Recording	☒ Recording Done
Attach State	☐ Required	☐ Ignored	☒ Required only when modifying values		
Command Modes	☒ Individual	☒ Group	☐ Supports Simulation		
Intended Use	☐ Operator	☒ Supervisor	☐ **Factory Only** (OMIT FROM USER DOCS)		

Table 86: Date Command Prerequisites

Command	Description
#*id*09	Return the current date in BCD format.
[#*id*]09*mmddyy*	Set the camera's date. The date format is *mmddyy* in Decimal format, where *mm* is 1-12, *dd* is 1-31, and *yy* is 02-99 (years past 2000).

Table 87: Date Command

Response	Description
#*id*0109*mmddyy*	Command succeeded where *mmddyy* is the current *decimal* date.
#*idee*09	Command failed, and *'ee'* is the explanation code.

Table 88: Date Reply

Example	
09083103	Set the system date to 08/31/03.

Table 89: Date Command Example

Timestamp Reference

This command establishes the reference for image timestamps. The camera can reference timestamps to the Trigger time or to the start-of-exposure for Frame 0. Timestamp values can also include an optional offset from the reference time; these offsets can range from 0x80000000 (-2,147 seconds) to 0x7FFFFFFF (+2,147 seconds).

Command Prerequisites					
Camera State	☒ Standby	☒ Live	☒ Ready	☒ Recording	☒ Recording Done
Attach State	☐ Required	☐ Ignored	☒ Required only when modifying values		
Command Modes	☒ Individual	☒ Group	☐ Supports Simulation		
Intended Use	☒ Operator	☒ Supervisor	☐ **Factory Only** (OMIT FROM USER DOCS)		

Table 90: Timestamp Reference Command Prerequisites

Command	Description
#*id*0D	Query a camera for its timestamp reference setting.
#id0D*cctttttttt*	Set timestamp reference. *cc* establishes either the Trigger time (01) or Frame 0 time (02) as the reference for image timestamps. *ttttttt* gives an additional offset, positive or negative, to be applied to each frame's timestamp. The offset time is given in microseconds. Negative values are expressed in two's-complement notation: 00000000 No offset from reference time 0000000A Add 10 microseconds to timestamps, as shown in border data FFFFFFFF Subtract one microsecond from timestamps FFFFFF9C Subtract 100 microseconds from timestamps

Table 91: Timestamp Reference Command

Response	Description
#*id*010D*cctttttttt*	Command succeeded. "cc" and "ttttttt" are the current timestamp reference settings, as described above.
#*idee*0D	Command failed, and *ee* is the explanation code.

Table 92: Timestamp Reference Reply

Ancillary Data

This command sets and returns the arbitrary 32-byte ancillary data for a recording. The user is allowed to set any 32-byte sequence as ancillary data.

Command Prerequisites					
Camera State	☐ ~~Standby~~	☐ ~~Live~~	☐ ~~Ready~~	☐ ~~Recording~~	☒ Recording Done
Attach State	☐ Required	☐ Ignored	☒ Required only when modifying values		
Command Modes	☒ Individual	☒ Group	☐ Supports Simulation		
Intended Use	☒ Operator	☒ Supervisor	☐ **Factory Only** (OMIT FROM USER DOCS)		

Table 93: Ancillary Data Command Prerequisites

Command	Description
#*id*0F*dddd…dd*	Set ancillary data for recording. *dddd…dd* specifies arbitrary binary data of exactly 32 bytes (64 hexadecimal characters).
#*id*0F	Query a camera for ancillary data.

Table 94: Ancillary Data Command

Response	Description
#*id*010F*dddd…dd*	Command succeeded, where *dddd…dd* is the 32-byte ancillary data.
#*idee*0F	Command failed, and *ee* is the explanation code.

Table 95: Ancillary Data Reply

Fast Network Port

Normally, the camera's fast network port will operate at 100Mbps. The port switches to 1000Mbps (Gigabit Ethernet) during TIFF or Type 2 download operations. After downloads have finished, or when a recording has been deleted, the camera will switch back to 100Mbps. This strategy conserves power consumption in the camera.

This command gives control software explicit control over the interface. When commanded to 100Mbps mode, the fast port will remain at 100Mbps even during TIFF and Type 2 download operations. This command disables the automatic speed switch.

When commanded to 1000Mbps, the fast port will switch to 1000Mbps and remain at that speed. (If the camera is connected to a 100Mbps-only device, this command will have no effect.) In this mode, the camera will consume more power and generate additional heat. Control software should always return the camera to 100Mbps or "auto" mode before placing the camera into the LIVE, READY, or RECORD states.
At startup, the camera always reverts to "auto" mode. The camera does not maintain the fast port mode setting in its non-volatile memory.

Value	Description
00	Automatic speed switching (default mode)
01	Disable automatic speed switching; force 100Mbps operation
02	Disable automatic speed switching; force 1000Mbps operation

Table 96: Fast Network Port Parameter Values

Command Prerequisites					
Camera State	☒ Standby	☒ Live	☒ Ready	☒ Recording	☒ Recording Done
Attach State	☒ Required	☐ Ignored	☐ Required only when modifying values		
Command Modes	☒ Individual	☐ Group	☐ Supports Simulation		
Intended Use	☐ Operator	☒ Supervisor	☐ **Factory Only** (OMIT FROM USER DOCS)		

Table 97: Fast Network Port Command Prerequisites

Command	Description
#*id*9E	Return current Fast Port mode setting.
#*id*9E*mm*	Set Fast Port mode to *'mm'* as shown in Table 96

Table 98: Fast Network Port Command

Response	Description
#*id*019E*mm*	Command success. Fast port mode now '*mm*'.
#*idee*9E	Command failed, and *'ee'* is the explanation code.

Table 99: Fast Network Port Reply

Auto-Ready Mode

This command sets and returns the value of the Auto-Ready option. When the Auto-Ready option is 1, the camera will immediately enter the Ready state after a power-up or reset. When the Auto-Ready option is 0, the camera will go into Standby when it powers up or reboots. The Auto-Ready option is ignored if the camera boots with a recording in memory already. Since it only affects boot-time behavior, there is no other immediately effect of the command; camera state does not change until the next boot.

Command Prerequisites					
Camera State	☒ Standby	☒ Live	☒ Ready	☒ Recording	☒ Recording Done
Attach State	☒ Required	☐ Ignored	☒ Required only when modifying values		
Command Modes	☒ Individual	☒ Group	☐ Supports Simulation		
Intended Use	☒ Operator	☒ Supervisor	☐ **Factory Only** (OMIT FROM USER DOCS)		

Table 100: Auto-Ready Command Prerequisites

Command	**Description**
#*id*75*dd*	Set Auto-Ready option. *dd* is 00 to disable the Auto-Ready mode, 01 to enable it.
#*id*75	Query a camera for its current Auto-Ready option setting.

Table 101: Auto-Ready Command

Response	**Description**
#*id*0175*dd*	Command succeeded, where *dd* is 00 if the Auto-Ready option is not in effect, 01 if the Auto-Ready option is active.
#*idee*75	Command failed, and *ee* is the explanation code.

Table 102: Auto-Ready Reply

Lens Control

This command allows text commands to be sent to an auxiliary lens controller. It also allows controlling power to the lens controller and obtaining the current power status. The command code of 76 is immediately followed by an option 00, 01, 02, or 03. If the option value is 00, the text that follows is a command to the lens controller; in this case, the response includes the text returned from the lens controller. If the option is 01, the lens controller is powered up. If the option is 02, the lens controller is powered down. If the option is 03, the current power status of the lens control is returned.

Command Prerequisites					
Camera State	☒ Standby	☒ Live	☒ Ready	☒ Recording	☒ Recording Done
Attach State	☒ Required	☐ Ignored	☐ Required only when modifying values		
Command Modes	☒ Individual	☒ Group	☐ Supports Simulation		
Intended Use	☒ Operator	☒ Supervisor	☐ **Factory Only** (OMIT FROM USER DOCS)		

Table 103: Lens Control Command Prerequisites

Command	Description
#*id*7600*text*	Handle lens control command or status as described above, where *text* is a text string of up to 15 characters.
#*id*7601	Power up the lens controller
#*id*7602	Remove power from the lens controller.
#*id*7603	Return the power status of the lens controller.

Table 104: Lens Control Command

Response	Description
#*id*017600*text*	Transmission of the lens command to the lens controller succeeded. Text is the response from the lens controller.
#id017601a0 OK Lens On	The command to power the lens controller succeeded.
#id017601a0 OK ERR11	The command to power the lens controller failed.
#id017602af OK Lens On	The command to remove power from the lens controller succeeded.
#id017602af OK ERR10	The command to remove power from the lens controller failed.
#id017603as OK Lens On	The command to obtain lens controller power status succeeded and the power is currently on.
#id017603as OK Lens Off	The command to obtain lens controller power status succeeded and the power is currently off.
#*idee*76	Command failed, and *ee* is the explanation code.

Table 105: Lens Control Reply

Intensifier Power

This command allows control over the Intensifier Interface power and the intensifier tube power. The interface power is a 13V supply from the sensor IO board, turning this power off will disable all intensifier functions. The Tube power is supplied by an external power supply and can be switched on or off at the interface board. This command is only supported on the Intensified camera.

Command Prerequisites					
Camera State	☒ Standby	☒ Live	☒ Ready	☒ Recording	☒ Recording Done
Attach State	☒ Required	☐ Ignored	☐ Required only when modifying values		
Command Modes	☒ Individual	☒ Group	☐ Supports Simulation		
Intended Use	☒ Operator	☒ Supervisor	☐ **Factory Only** (OMIT FROM USER DOCS)		

Table 106: Lens and Intensifier power Command Prerequisites

Command	Description
#***id***78	Query the Current power state.
#***id***78***iitt***	Set the power state. Values in field ii control the 13V to the interface and values in tt control the tube power supply. Values are 00 – Power off. 01 – Power on
#***id***7801	Power on the lens and intensifier ports.

Table 107: Lens and Intensifier power Command

Response	Description
#***id***0178*0000*	Intensifier Interface and tube are powered off.
#***id***01780100	Intensifier Interface is powered, the tube is not powered
#***id***01780101	Intensifier Interface and Tube are powered.
#***idee***78	Command failed, and *ee* is the explanation code.

Table 108: Lens and Intensifier power Reply

Intensifier gate control

This command allows the intensifier gate pulse provided on pin 1 of the intensifier connector to be changed. The delay after Frame sync and the pulse duration can be specified. Both the delay and duration are specified in nano-seconds. The minimum and maximum values are dependant upon the system clock. At 60Mhz the minimum pulse width is 17nSeconds and the maximum values for both fields are 4250nS. For this command to execute the Intensifier port must be powered. If this command is executed without, first power being applied error code 30 will occur.
See the detailed design document for further information.

Command Prerequisites					
Camera State	☒ Standby	☒ Live	☒ Ready	☒ Recording	☒ Recording Done
Attach State	☒ Required	☐ Ignored	☐ Required only when modifying values		
Command Modes	☒ Individual	☒ Group	☐ Supports Simulation		
Intended Use	☒ Operator	☒ Supervisor	☐ **Factory Only** (OMIT FROM USER DOCS)		

Table 109: Intensifier Gate control Prerequisites

Command	**Description**
#*id*7A	Query the Current gate settings.
#*id*7Awwwwdddd	wwww is the gate pulse width specified as a decimal in NanoSeconds. dddd is the delay from frame sync to the pulse start as a decimal specified in Nono-seconds.

Table 110: Intensifier Gate control Command

Response	**Description**
#*id*017A*wwwwdddd*	The current intensifier Gate settings are returned. wwww is the gate pulse width specified as a decimal in NanoSeconds. dddd is the delay from frame sync to the pulse start as a decimal specified in Nono-seconds.
#*idee*7A	Command failed, and *ee* is the explanation code.

Table 111: Intensifier Gate control Reply

Intensifier analog gain control

This command sets the level of the analog gain signal on the intensifier port, pin 3. For this command to have any effect the intensifier port must first be powered. The gain is set as a percentage, where 0% gives the minimum output of 240mV and 100% gives the maximum output of 5.36V. The ramp up of power is a linear function for all voltages between these values.

Command Prerequisites					
Camera State	☒ Standby	☒ Live	☒ Ready	☒ Recording	☒ Recording Done
Attach State	☒ Required	☐ Ignored	☐ Required only when modifying values		
Command Modes	☒ Individual	☒ Group	☐ Supports Simulation		
Intended Use	☒ Operator	☒ Supervisor	☐ **Factory Only** (OMIT FROM USER DOCS)		

Table 112: Intensifier analog gain control Prerequisites

Command	Description
#*id*7B	Query the Current gain settings.
#*id*7Bgg	Set the analog gain as a percentage. 0% - 240mV to 100% - 5.36V gg is the gain in percent specified as a hexadecimal 100% = 64

Table 113: Intensifier analog gain control Command

Response	Description
#*id*017B*gg*	The current intensifier analog gain setting. gg is the current gain as a percentage, given in HexaDecimal format.
#*idee*7B	Command failed, and *ee* is the explanation code.

Table 114: Intensifier analog gain control Reply

Intensifier Cooling Control

This command Allows control of the intensifier cooling hardware.

Command Prerequisites					
Camera State	☒ Standby	☒ Live	☒ Ready	☒ Recording	☒ Recording Done
Attach State	☒ Required	☐ Ignored	☐ Required only when modifying values		
Command Modes	☒ Individual	☒ Group	☐ Supports Simulation		
Intended Use	☒ Operator	☒ Supervisor	☐ **Factory Only** (OMIT FROM USER DOCS)		

Table 115: Intensifier Cooling control Prerequisites

Command	Description
#*id*7C	Query.
#*id*7C*aabb*	Set The cooling controls. aa – sets the fan state. where: 00 – Turns the fan off 01 – Turns the fan on 02 – Places the fan in Auto mode. Firmware will decide when the fan should come on or off. bb – Sets the TEC state. where: 00 – Turns the TEC off 01 – Turns the TEC on 02 – Places the TEC in Auto mode. Firmware will decide when the TEC should come on or off.

Table 116: Intensifier cooling control Command

Response	Description
#*id*017C***aabbcccc***	Returns the current cooling and temperature status. aa – Is the fan state. where. 00 – The Fan is set permanently off 01 – The fan is set permanently on 03 – The Fan is in auto mode and is currently ON 04 – The Fan is in auto mode and is currently OFF 05 – The Fan is in an overcurrent condition. bb – Is the TEC state. where 00 – The TEC is set permanently OFF 01 – The TEC is set permanently ON 03 – The TEC is in auto mode and is currently ON. 04 – The TEC is in auto mode and is currently OFF cccc – Is the current intensifier temperature in $1/10^{th}$ of a degrees C
#*idee*7C	Command failed, and *ee* is the explanation code.

Table 117: Intensifier cooling control Reply

Intensifier Status Query

This command returns the critical status of the intensifier. This is a query only command and returns the state of the Intensifier shutdown signal, The fan over current signal and the over/under voltage signal. This command is only valid on the Intensified camera.

Command Prerequisites					
Camera State	☒ Standby	☒ Live	☒ Ready	☒ Recording	☒ Recording Done
Attach State	☒ Required	☐ Ignored	☐ Required only when modifying values		
Command Modes	☒ Individual	☒ Group	☐ Supports Simulation		
Intended Use	☒ Operator	☒ Supervisor	☐ **Factory Only** (OMIT FROM USER DOCS)		

Table 118: Intensifier status query Prerequisites

Command	Description
#*id*7D	Query.

Table 119: Intensifier status query Command

Response	Description
#*id*017D***ss***	Returns the current intensifier status bits. bit [0] – is the TUBE over or under voltage flag. Set to '1' if the condition is true. bit[1] – is the shutdown signal flag. Set to '1' if the condition is true. The shutdown signal is asserted by hardware if the average light intensity is too high. bit[2] – is the Fan over current flag and is set to '1' if the condition is true. bit[3] – Is the Override flag and is set to '1' if the camera has been placed in override mode. bit[4] – is the POWER SUPPLY over or under voltage flag and is set to '1' if the condition is true. bit[5] – is the HOT flag and is set to '1' if the intensifier has reached a temperature where cooling is recommended. bit[6] – is the over temperature flag and is set to '1' if the intensifier has reached a temperature where continued use may cause damage. Eg. a value of 0x05 in the ss field denotes that the fan is over current and a over / under voltage condition is true. A value of 0x00 in the ss field denotes that the intensifier is working correctly.
#*idee*7D	Command failed, and *ee* is the explanation code.

Table 120: Intensifier status query Reply

Intensifier Shutdown Override

This command allows an override of the automatic shutdown features implemented in Hardware. If the Intensifier average light level becomes too high then the shutdown signal is asserted and the intensifier will power off. If the shutdown override flag is set using this command, then the shutdown signal will be asserted, however the automatic shutdown of the intensifier will not be carried out.
This command is implemented in the Protocol only, motion Central and the SDK do not expose methods to set this flag

Command Prerequisites					
Camera State	☒ Standby	☒ Live	☒ Ready	☒ Recording	☒ Recording Done
Attach State	☒ Required	☐ Ignored	☐ Required only when modifying values		
Command Modes	☒ Individual	☒ Group	☐ Supports Simulation		
Intended Use	☐ Operator	☐ Supervisor	☒ **Factory Only** (OMIT FROM USER DOCS)		

Table 121: Intensifier shutdown override Prerequisites

Command	**Description**
#*id*7E	Query
#id7E00	Turn the override OFF – Normal operation
#*id*7E01	Turn the override ON.

Table 122: Intensifier shutdown override Command

Response	**Description**
#*id*017E***00***	Override is currently OFF.
#*id*017E***01***	Override is currently ON.
#*idee*7E	Command failed, and *ee* is the explanation code.

Table 123: Intensifier shutdown override Reply

5. Pre-Record Commands

Camera ID

This command sets the ID code for a camera. When communicating with multiple cameras, each camera should be assigned a unique ID number so that downloaded recordings may be more easily distinguished (the Camera ID is included in the Border Data embedded within each downloaded image).

For HG cameras, the Camera Name may be passed as an optional double-quoted string. Camera Name strings longer than 50 characters will be silently truncated to a length of 50. When no Camera Name string is provided, it will be set to the textual three-digit decimal equivalent of the Camera ID number.

The reply to this command will be prefaced with the Camera ID to which the command was issued, not the Camera ID value updated as a result of performing the command (which is included in the body of the reply).

Command Prerequisites					
Camera State	☒ Standby	☒ Live	☒ Ready	☒ Recording	☒ Recording Done
Attach State	☐ Required	☐ Ignored	☒ Required only when modifying values		
Command Modes	☒ Individual	☐ Group	☐ Supports Simulation		
Intended Use	☐ Operator	☒ Supervisor	☐ **Factory Only** (OMIT FROM USER DOCS)		

Table 124: Camera ID Command Prerequisites

Command	**Description**
#***id*52***xx***[*"ttt"*]	Changes the camera's ID number from *id* to *xx*, an 8-bit number, between 00h and FFh hexadecimal. The quoted Camera Name string "*ttt*" is optional.

Table 125: Camera ID Command

Response	**Description**
#*id*0152*nn"ttt"*	Command succeeded, where *id* is the ***previous*** ID number (the ID of the reply matches the ID the command was sent to), *nn* is the ***new*** ID number, and "*ttt*" is the ***new*** camera Name.
#*idee*52	Command failed, and *'ee'* is the explanation code.

Table 126: Camera ID Reply

Examples	
#01522D	Change the camera ID of camera number 1 to 45_{10}.
#01522D"Outside Profile View"	Change the camera ID of camera number 1 to 45_{10}, with a camera name of "Outside Profile View".

Table 127: Camera ID Command Examples

Session ID

The Session ID is an 8-bit number between 0 and 255_{10} used to identify the purpose of the recording. This command sets the recording ID, and is normally issued to all cameras simultaneously any time prior to download.

The Session Name is an optional double-quoted string. Session Name strings longer than 50 characters will be silently truncated to a length of 50. When no Session Name string is provided, it will be set to the textual three-digit decimal equivalent of the Session ID number.

Command Prerequisites					
Camera State	☒ Standby	☒ Live	☒ Ready	☒ Recording	☒ Recording Done
Attach State	☐ Required	☐ Ignored	☒ Required only when modifying values		
Command Modes	☒ Individual	☒ Group	☐ Supports Simulation		
Intended Use	☐ Operator	☒ Supervisor	☐ **Factory Only** (OMIT FROM USER DOCS)		

Table 128: Session ID Command Prerequisites

Command	**Description**
#*id*0C	Return the session ID for the next recording.
#*id*0C*ii*[“*ttt***”]	Set the session ID for the next recording where *ii* is a number between 00h and FFh. The quoted Session Name string *“ttt”* is optional.

Table 129: Session ID Command

Response	**Description**
#*id*010C*ii*“*ttt*”	Command succeeded where *ii* is the current session ID, and *“ttt”* is the session Name.
#*idee*0C	Command failed, and *‘ee’* is the explanation code.

Table 130: Session ID Reply

Example	
#010C2D	Set the session ID number of camera One to 45.
#010C2D“Test 1A, Step 17”	Set the session ID number of camera One to 45, with a session name of “Test 1A, Step 17”.

Table 131: Session ID Command Example

Sensor Active Area

Configure the size of the acquired image. Sensor areas allowed and the maximum frame rates achievable with different sensor areas vary among cameramodels. The Get Sensor Size and Get Frame Rate Info commands return information on allowed sensor areas and maximum frame rates. Control software should use the information returned by these commands to qualify user selections for the Sensor Active Area command.

All HG cameras can acquire full-size images at rates up to 1000 frames per second. At higher frame rates, the sensor active area must be reduced (with this command), to allow sufficient time to read out all sensor pixels between exposures.

Side Effects: *Changing the Sensor Active Area will affect the maximum or minimum values for Frame Rate (and Number of Frames at Post-Trigger Rate), Exposure, Strobe Timing, Session Length, Trigger Position and the Live/Thumbnail/Download Frame Sizes.*

Please Refer to Appendix E for documentation on determining legal Frame Rates/Resolutions.

Command Prerequisites					
Camera State	☒ Standby	☒ Live	☐ Ready	☐ Recording	☒ Recording Done
Attach State	☐ Required	☐ Ignored	☒ Required only when modifying values		
Command Modes	☒ Individual	☒ Group	☒ Supports Simulation		
Intended Use	☒ Operator	☒ Supervisor	☐ **Factory Only** (OMIT FROM USER DOCS)		

Table 132: Sensor Active Area Command Prerequisites

Command	**Description**
#*id*90	Query the current Sensor Active Area.
[#*id*]90*wwwwhhhh*	Set the Sensor Active Area to *wwww* pixels wide by *hhhh* pixels high.

Table 133: Sensor Active Area Command

Response	**Description**
#*id*90*wwwwhhhh*	Command succeeded where *www* is the active width, and *hhhh* is the active height.
#*idee*90	Command failed, and *'ee'* is the explanation code.

Table 134: Sensor Active Area Reply

Session Length

Set the maximum number of frames to be acquired during the next recording. The Session Length must be greater than zero, and must not exceed the camera frame capacity. The camera frame capacity, which is dependent on the Sensor Active Area and the amount of installed memory, is part of the command reply.

HG cameras support session lengths greater than 65535 frames. Use the 32-bit version of the Session Length command in such cases. (Legacy cameras support only the 16-bit format, and will generate errors in response ot the 32-bit format.)

Note: *Recording only a single frame (Session Length of 1) may not be possible.*

Side Effects: *Changing the Session Length will affect the maximum values for Trigger Position, Number of Frames exposed at Post-Trigger Rate (part of the Frame Rate command), and BROC Burst Length.*

Please Refer to Appendix E for documentation on how to calculate maximum session length.

Command Prerequisites					
Camera State	☒ Standby	☒ Live	☐ Ready	☐ Recording	☐ Recording Done
Attach State	☐ Required	☐ Ignored	☒ Required only when modifying values		
Command Modes	☒ Individual	☒ Group	☒ Supports Simulation		
Intended Use	☒ Operator	☒ Supervisor	☐ **Factory Only** (OMIT FROM USER DOCS)		

Table 135: Session Length Command Prerequisites

Command	Description
#*id*0E	Return the current session length and the maximum number of frames available in memory for recording.
[#*id*]0E*nnnn* *or* **[#*id*]0E*nnnnnnnn***	Set the session length to *nnnn*, where *nnnn* is either a 4-digit or 8-digit hexadecimal number.

Table 136: Session Length Command

Response	Description
#*id*0E*nnnnnnncccccccc*	Command completed successfully where *nnnnnnnn* is a 32-bit hexadecimal number representing the current session length, and *cccccccc* is a 32-bit number representing the camera frame capacity.
#idee0E	Command failed, and *'ee'* is the explanation code.

Table 137: Session Length Reply

Configure Configurable Input

HG cameras include an external input (labeled "SYNC" on the camera or console) that may be configured for several different uses. This command establishes the operating mode of the "SYNC" (or "configurable") input.

Purpose	Parameter Value	Description
Disabled	**00**	The Configurable Input has no affect on camera operation. The camera Frame Sync is from the Sync/Trigger bus, as is the Trigger Source (unless the Record command is used to initiate a manual trigger). The camera may only enter the Ready state manually, via the Ready command.
External Frame Sync	**01**	The Configurable Input is used as the frame clock when in the Ready and Recording states. Trigger and Trigger Delay operate normally, but the Strobe Output Timing value is restricted to positive values. If the input signal frequency drops below a minimum value of 30 Hz, the camera hardware continues to expose frames at a minimum rate of 30 Hz, or at a rate it estimates based on measurements of the incoming External Frame Sync signal. This places an upper bound on the time it will take (post-trigger) to fill the image memory. When using the Configurable Input for External Frame Sync, acquisition will always finish (the camera will always enter the "Recording Done" state) within a bounded period of time.
Record On Command (ROC)	**02**	Once in the Recording state, the camera internal Frame Rate Generator runs normally. However, the Trigger input and its associated parameters (Trigger Delay, pre- post-, etc.) are not used. The Configurable Input in ROC mode acts as a "frame store qualifier." Only video frames exposed during times when the input is active are stored in the image memory. When image memory fills, recording stops and the camera enters the Recording Done state. The Session Length parameter controls the total number of frames stored. Frames are numbered from zero (first frame recorded after active edge on input) up. If external software can arrange to capture an IRIG time on the same edge, the user would have a way to correlate time of day with frame zero. Frame zero is always the first one saved in image memory. In this mode, the camera may remain in the Recording state for an indefinite period of time if the ROC input is inactive.
Burst Record on Command (BROC)	**03**	Operates as described for ROC, except only the pre-trigger frame rate is used, and the configurable input now becomes an edge sensitive input. On each active edge, the hardware enables frame storage for a programmable number of frames, determined by the BROC Burst Length command. When image memory fills (again based on Session Length parameter), recording stops and the camera enters the Recording Done state. Frames are numbered as in ROC mode; frame zero is the first one captured in the first burst. Like ROC, the camera may remain in the Recording state for an indefinite period of time, if the input is held at the inactive logic level.

Purpose	Parameter Value	Description
Ready	**04**	On the first active edge, place the camera into the Ready state. It is equivalent to issuing the Ready command, but has the added benefit of tighter timing uniformity across multiple cameras, since the command parser is bypassed.

Table 138: Configurable Input Configurations

Concerning frame timestamp wrapping in ROC and BROC modes: Once started, the user must guarantee that the configurable input "off" time will not exceed the timestamp counter wrap-around time. The timestamp will roll over every 143.1655765 seconds (2 minutes, 23 seconds and 165,576.5 microseconds). Failure to ensure this will result in incorrect frame times being reported.

When active, the polarity of the Configurable Input may be configured as Positive (01), Negative (02) or Disabled (00). The polarity parameter is ignored when the Configurable Input is inactive.

Note: ***Live While Record*** *is not available in ROC and BROC modes.*
Note: *When the camera enters the Fault State, the Configurable Input will be disabled unless it was configured for External Frame Sync.*

Command Prerequisites					
Camera State	☒ Standby	☒ Live	☐ Ready	☐ Recording	☒ Recording Done
Attach State	☐ Required	☐ Ignored	☒ Required only when modifying values		
Command Modes	☒ Individual	☒ Group	☒ Supports Simulation		
Intended Use	☒ Operator	☒ Supervisor	☐ **Factory Only** (OMIT FROM USER DOCS)		

Table 139: Configurable Input Command Prerequisites

Command	Description
#*id*82	Return the configuration of the Configurable Input (CI).
[#*id*]82*nnpp*	Set the CI to the mode indicated by *nn* (per the above table) with polarity *pp*.
[#*id*]820000	Disable the CI. This is the preferred form.
[#*id*]82*nn*00	Disable the CI, where *nn* is ignored and is forced to 00.
[#*id*]820101 *or* **[#*id*]820102**	Configure the CI to be the External Frame Sync input with Positive or Negative polarity.
[#*id*]820201 *or* **[#*id*]820202**	Configure the CI to be the ROC input with Positive or Negative polarity.
[#*id*]820301 *or* **[#*id*]820302**	Configure the CI to be the BROC input with Positive or Negative polarity.
[#*id*]820401 *or* **[#*id*]820402**	Configure the CI to be the Ready input with Positive or Negative polarity.

Table 140: Configurable Input Command

Response	Description
#*id*0182*nnpp*	Command completed successfully, where *nn* is the mode of the Configurable Input and *pp* is the polarity.
#*idee*82	Command failed, and *'ee'* is the explanation code.

Table 141: Configurable Input Reply

BROC Burst Length

Set the number of frames to be acquired during each BROC event. The number of frames specified must be strictly less than the Session Length. In normal use, it is recommended that the BROC Burst Length be set to a value less than or equal to the Session Length divided by the anticipated number of BROC events.

Side Effects: *If any command causes the Session Length to be set to a value less than the BROC Burst Length, the BROC Burst Length will be automatically reduced.*

Frame acquisition will halt when the total number of frames acquired during a sequence of BROC events reaches the Session Length. Should this occur, the final BROC event may contain fewer frames than the BROC Burst Length.

Note: *Precise timing information may be lost if the time between BROC events permits the timestamp value to wrap (143.1655765 seconds).*

Command Prerequisites					
Camera State	☒ Standby	☒ Live	☐ Ready	☐ Recording	☒ Recording Done
Attach State	☐ Required	☐ Ignored	☒ Required only when modifying values		
Command Modes	☒ Individual	☒ Group	☐ Supports Simulation		
Intended Use	☒ Operator	☒ Supervisor	☐ **Factory Only** (OMIT FROM USER DOCS)		

Table 142: BROC Burst Length Command Prerequisites

Command	**Description**
#*id*9B	Return the current BROC burst length.
[#*id*]9B*nnnn*	Set the BROC burst length to *nnnn*, where *nnnn* is a 4-digit hexadecimal number.

Table 143: BROC Burst Length Command

Response	**Description**
#*id*09B*nnnn*	Command completed successfully where *nnnn* is a 16-bit hexadecimal number representing the current BROC burst length.
#*idee*9B	Command failed, and *'ee'* is the explanation code.

Table 144: BROC Burst Length Reply

Configure Strobe Output

The camera Strobe Output is used to synchronize external systems with the start of each frame acquisition. The camera strobe output may be configured as follows:

1. Enable/Disable.
2. Polarity (frame integration active while positive or negative).
3. Timing (phasing) relative to frame integration. Valid range is from **100 µs** before the start of frame integration to **5 µs** before the end of frame integration, in **5 µs** steps.

The first parameter to this command may have the following values:

Value	Description
00	Disable Strobe Output.
01	Strobe Output Enabled with Positive polarity.
02	Strobe Output Enabled with Negative polarity.

Table 145: Strobe Output Configuration

The second parameter indicates when the Strobe Output will change state. It is a four-digit ***signed*** hexadecimal value indicating the number of microseconds relative to the start of frame integration. Negative values occur prior to the start of frame integration, and Positive values occur after.

Note: *1) The **maximum** valid range of the Strobe Output time value is -100 (FF9C) to +32765 (7FFD). The Strobe Timing value must be a multiple of 5. If the passed value is not a multiple of 5, it will be rounded toward zero to the next multiple of 5. Any rounding performed will be reflected in the command reply.*
2) When positive, the Strobe Output timing value interacts with the Exposure value. The value must be at least 5 µs less than the current Exposure value. Be sure to set the Exposure before issuing this command. If the timing value is not at least 5 µs less than the Exposure value, it will be set to a value that is the next lower multiple of 5 µs that is also at least 5 µs less than the Exposure value. The resulting Strobe Output timing value may be up to 9 µs less than the Exposure value.
3) The width of the Strobe Output pulse may range from 5 µs to (100 µs + Exposure) or 32767 µs, whichever is less.
*4) When External Frame Sync is selected, the Strobe Output timing value must be positive (negative values will be rejected), and the output signal **may not be stable**.*

Side Effects: *The valid range of the Strobe Output timing value depends on the current values of Frame Rate and Exposure and the configuration of the Configurable Input. If changes to these values would invalidate the Strobe Output timing value, the Strobe Output timing will be adjusted automatically.*

Command Prerequisites					
Camera State	☒ Standby	☒ Live	☐ Ready	☐ Recording	☐ Recording Done
Attach State	☐ Required	☐ Ignored	☒ Required only when modifying values		
Command Modes	☒ Individual	☐ Group	☒ Supports Simulation		
Intended Use	☒ Operator	☒ Supervisor	☐ **Factory Only** (OMIT FROM USER DOCS)		

Table 146: Strobe Output Command Prerequisites

Command	Description
#*id*83	Return the configuration of the Strobe output.
[#*id*]83*nnvvvv*	Set the Strobe Output to the mode indicated by *nn* (per the above table), with a ***signed*** time value of *vvvv*.

Table 147: Strobe Output Command

Response	Description
#*id*0183*nnvvvv*	~~Command completed successfully where *nn* is the mode of~~ the Strobe Output, and *vvvv* is the ***signed*** time value.
#*id*0183*nnvvvvmmmm*	As above, with optional maximum soft limit value *mmmm* appended.
#*idee*83	Command failed, and *'ee'* is the explanation code.

Table 148: Strobe Output Reply

Configure External Trigger Input

Configure the camera external trigger input. This input is used to propagate a locally supplied trigger signal to the Sync/Trigger bus. If the Sync/Trigger bus is absent, the External Trigger input triggers the camera locally.

The camera's external Trigger input can be configured "active high" or "active low." When configured active high, the camera recognizes the input as "active" when the input rises above 3.9 volts. When configured active low, the camera recognizes the input as "active" when the input is held below 0.9 volts.

The camera enforces a minimum time that the Trigger input must remain continuously at its active level before it recognizes a valid trigger event. This "debounce" time is adjustable, and can be used to reject noise pulses on the Trigger input, or to debounce mechanical contacts used as trigger sources.

The camera's debounce delay is used only when no Hub/Sync Unit (HSU) is present. When the camera has a connection to an HSU, it propagates its Trigger input directly to the HSU without any debounce delay.

The debounce delay can be set from 0 microseconds (0x00000000) to a maximum of 500,000 microseconds (0x0007A120).

This command accepts a single parameter with the following values:

Value	Description
00	External Trigger Input disabled (default).
01	Positive-going edge causes Trigger code to be sent on Sync/Trigger bus.
02	Negative-going edge causes Trigger code to be sent on Sync/Trigger bus.

Table 149: Configure External Trigger Input Parameter Values

Command Prerequisites					
Camera State	☒ Standby	☒ Live	☐ Ready	☐ Recording	☒ Recording Done
Attach State	☐ Required	☐ Ignored	☒ Required only when modifying values		
Command Modes	☒ Individual	☒ Group	☐ Supports Simulation		
Intended Use	☒ Operator	☒ Supervisor	☐ **Factory Only** (OMIT FROM USER DOCS)		

Table 150: Configure External Trigger Input Command Prerequisites

Command	Description
#*id*84	Return the configuration of the External Trigger Input.
[#*id*]84*nndddddddd*	Set the External Trigger Input to the mode indicated by *nn* (per the above table), and the debounce delay to *dddddddd* microseconds (0–500,000).

Table 151: Configure External Trigger Input Command

Response	Description
#*id*0184*nndddddddd*	Command completed successfully where *nn* is the configuration of the External Trigger Input, and *dddddddd* is the current debounce delay setting.
#*idee*84	Command failed, and *'ee'* is the explanation code.

Table 152: Configure External Trigger Input Reply

Frame Rate

This command selects the frame rates for the next recording. The HG-100K and HG-LE cameras record at rates ranging from 25 to 100,000 fps. When power is applied to the camera, the frame rates are restored to the last values set. The values set using this command are ignored when external frame synchronization is used (see the Configure Configurable Input command).

Control software can specify frames in either of two formats. Table 153 defines a set of codes for pre-defined frame rates. Control software can use these codes in the short command formats described below (the #id06 commands). Likewise, when all the frame rates currently set in a camera fall within the set of pre-defined rates shown in Table 153, the camera uses these codes in its replies.

Value	Description
01	Set the frame rate to 30 fps.
02	Set the frame rate to 60 fps.
03	Set the frame rate to 125 fps.
04	Set the frame rate to 250 fps.
05	Set the frame rate to 500 fps.
06	Set the frame rate to 1000 fps.
07	Set the frame rate to 2000 fps. (Valid with partial frames only)
08	Set the frame rate to 3000 fps. (Valid with partial frames only)
09	Set the frame rate to 5000 fps. (Valid with partial frames only)
0A	Set the frame rate to 10,000 fps. (Valid with partial frames only)
0B	Set the frame rate to 20,000 fps. (Valid with partial frames only)
0C	Set the frame rate to 30,000 fps. (Valid with partial frames only)
0D	Set the frame rate to 50,000 fps. (Valid with partial frames only)
0E	Set the frame rate to 100,000 fps. (Valid with partial frames only)

Table 153: Frame Rate Command Parameters

Control software can use an extended format command (the #id0600 commands) to specify frame rates other than those shown in Table 153. The extended format commands allow control software to configure arbitrary frame rates, within the constraints allowed by the camera (see the Get Frame Rate Info command). The camera likewise uses extended format replies to specify frame rates whenever any frame rate set in the camera does not fall in the set of pre-defined frame rates described in Table 153.

The frame rate set by this command does not affect the Live frame rate (fixed at **30** fps, maximum).

The camera can be configured to use up to three frame rates in a single recording: Pre-trigger, post-trigger, and post-(trigger + *n* frames). If only a single rate is passed, then all three rates use that value. If two rates are passed, then the second value is used for both post-trigger rates.

If a third frame rate parameter is passed to this command, a fourth parameter is also required to indicate the number of post-trigger frames that must pass before the third frame rate value applies. The minimum value for the number of frames at the post-trigger rate is one (1). This value has meaning only if the Frame Position specifies the acquisition of at least two post-trigger frames.

Note: *1) The value specified for the number of frames at the post-trigger frame rate must be less than the number of post-trigger frames as set via the Trigger Position command.*

2) At least one frame will always be captured at the post-trigger rate, even if the number of frames at the post-trigger frame rate is set to zero.

Side Effects:

1) *Should an increase to the frame geometry (Sensor Active Area) cause the current Frame Rate(s) to become invalid, the Frame Rate(s) are automatically reduced to valid values. Similarly, an increase in the frame geometry also affect the camera frame capacity, which can affect the Session Length, which can in turn affect the Trigger Position, which in turn can affect the Number of Frames at the Post Trigger Rate, which is automatically reduced to a valid value.*
2) *Should changes to the Trigger position cause the number of frames being captured at the post-trigger rate to become zero, the post-trigger frame rate is set equal to the pre-trigger frame rate. Should changes to the Trigger Position or the number of frames being captured at the post-trigger rate cause the number of frames being captured at the final frame rate to become zero, the final frame rate is set equal to the post-trigger frame rate.*
3) *If the Trigger Position is increased from zero, then the number of frames at the post-trigger rate is set to one (1), and all other frames are allocated to the final frame rate.*

Command Prerequisites					
Camera State	☒ Standby	☒ Live	☐ Ready	☐ Recording	☐ Recording Done
Attach State	☐ Required	☐ Ignored	☒ Required only when modifying values		
Command Modes	☒ Individual	☒ Group	☒ Supports Simulation		
Intended Use	☐ Operator	☒ Supervisor	☐ **Factory Only** (OMIT FROM USER DOCS)		

Table 154: Frame Rate Command Prerequisites

Command	Description
#*id*06	Return the current frame rate.
[#*id*]06*aabbccxxxx*	Set the frame rate to *aa* prior to trigger, to *bb* immediately after trigger, and to *cc* after *xxxx* post-trigger frames. *aa*, *bb*, and *cc* are codes from Table 153.
[#*id*]06*aa*	Set all frame rates to *aa*.
[#*id*]06*aabb*	Set the pre-trigger frame rate to *aa*, and both post-trigger frame rates to *bb*.
[#*id*]0600*aaaaaaaabbbb bbbbccccccccxxxxxxxx*	Set pre-trigger (*aaa…*), post-trigger (*bbb…*), and final (*ccc…*) frame rates. Use the final frame rate after *xxx…* post-trigger frames have been captured. Frame rates are given in frames per second.
[#*id*]0600*aaaaaaaabbbb bbbb*	Set pre-trigger (*aaa…*) and post-trigger (*bbb…*) frame rates.
[#*id*]0600*aaaaaaaa*	Set all frame rates to *aaa.…*

Table 155: Frame Rate Command

Response	Description
#*id*0106*aabbccxxxxmm*	Command succeeded, where *aa*, *bb*, and *cc* are the frame rates, *xxxx* is the post trigger frame count at which frame rate *cc* is applied, and *mm* is the maximum allowed frame rate. If *bb* and *cc* are the same, then *xxxx* is zero.
[#*id*]010600*aaaaaaaabbbbbbbbccccccccxxxxxxxx*	Command succeeded, where *aaa…*, *bbb…*, and *ccc…* are the frame rates, and *xxx…* is the post-trigger frame count at which frame rate *ccc…* is applied.
[#*id*]010600*aaaaaaaabbbbbbbbccccccccxxxxxxxxmmmmmmmm*	Command succeeded, where *aaa…*, *bbb…*, and *ccc…* are the frame rates, *xxx…* is the post-trigger frame count at which frame rate *ccc…* is applied, and *mmm…* is the maximum allowed frame rate.
#*idee*06	Command failed, and *'ee'* is the explanation code.

Table 156: Frame Rate Reply

Trigger Position (Post-Trigger Session Length)

Set the number of frames to be recorded after a trigger has occurred. The number of post-trigger frames may range from 0 to the session length minus one. One frame is reserved for the trigger frame.

The HG -100Ks support partial frame configurations that permit more frames to be recorded than can be described with a 16-bit value, so 32-bit parameters are also supported. The 16-bit version of the command must be used when both Legacy and HG cameras are in the same group. Sending the 32-bit version of this command to a Legacy camera will generate an error.

Note: *1) The recording will not contain the expected number of pre-trigger frames if there is insufficient time to record all pre-trigger frames to be acquired before the trigger occurs. The configured number of post-trigger frames is guaranteed to be present if the recording runs to completion.*
2) The Trigger Position is ignored when ROC or BROC are active (see the Configure Configurable Input command).

Side Effects: *If the Session Length is reduced to a value that invalidates the Trigger Position value, the Trigger Position will be automatically adjusted to the nearest valid value.*

Command Prerequisites					
Camera State	☒ Standby	☒ Live	☐ Ready	☐ Recording	☐ Recording Done
Attach State	☐ Required	☐ Ignored	☒ Required only when modifying values		
Command Modes	☒ Individual	☒ Group	☒ Supports Simulation		
Intended Use	☒ Operator	☒ Supervisor	☐ **Factory Only** (OMIT FROM USER DOCS)		

Table 157: Post-Trigger Position Command Prerequisites

Command	**Description**
#*id*04	Return the current post-trigger frame count.
[#*id*]04*xxxx* *or* **[#*id*]04*xxxxxxxx***	Set the number of post-trigger frames to *xxxx*, a hexadecimal 16-bit number (*xxxxxxxx* is 32-bit) that specifies the number of frames to be recorded after the trigger.

Table 158: Post-Trigger Position Commands

Response	**Description**
#*id*0104*xxxx* *or* #*id*0104*xxxxxxxx*	Command succeeded, where *xxxx*[*xxxx*] is the current 16 [32] bit post-trigger frame count setting.
#*idee*04	Command failed, and *'ee'* is the explanation code.

Table 159: Post-Trigger Position Reply

Trigger Delay

When the camera is in the Ready state (recording to memory is in progress), frame 0 will be marked and post-trigger recording will start after a trigger is received. This command will delay the start of post-trigger recording by an amount ranging from 0 to 65535 milliseconds (65.535 seconds).

Command Prerequisites					
Camera State	☒ Standby	☒ Live	☐ Ready	☐ Recording	☐ Recording Done
Attach State	☐ Required	☐ Ignored	☒ Required only when modifying values		
Command Modes	☒ Individual	☒ Group	☐ Supports Simulation		
Intended Use	☒ Operator	☒ Supervisor	☐ **Factory Only** (OMIT FROM USER DOCS)		

Table 160: Trigger Delay Command Prerequisites

Command	Description
#*id*5D	*Query* the current trigger delay.
[#*id*]5D*xxxx*	Where *xxxx* is the trigger delay measured in milliseconds, with a range of 0000h through FFFFh. Accuracy is +0, -1 ms.

Table 161: Trigger Delay Command

Response	Description
#*id*015D*xxxx*	Command completed successfully where *xxxx* is the current setting.
#*id*ee5D	Command failed, and *'ee'* is the explanation code.

Table 162: Trigger Delay Reply

Exposure

This command sets the exposure duration. The minimum exposure is 5 microseconds. The longest exposure permitted for each frame is **3** µs less than the value of one divided by the frame rate. Given a minimum frame rate of 30 fps, the exposure value must always be no more than 1/3 s - 3 µs = 33330 µs. The exposure duration is changed in 1 µs steps. The camera automatically corrects any requested exposure that is not in range and returns the corrected value in the response string. When power is applied to the camera, the exposure time will return to the value in effect when power was removed.

Note: *If the exposure time is invalid after a frame rate change, the camera will set the exposure to a value equal to [(1/frame rate) - 3 µs]. Increasing the Sensor Active Area may also cause frame rate changes that in turn may cause the exposure value to change.*

Two Exposure values are provided: Ambient (low lighting) and Normal (event lighting). The Normal exposure value is always used during recording. When not recording, the Exposure Select command determines which exposure value is used when acquiring Live and Thumbnail frames.

Command Prerequisites					
Camera State	☒ Standby	☒ Live	☐ Ready	☐ Recording	☒ Recording Done
Attach State	☐ Required	☐ Ignored	☒ Required only when modifying values		
Command Modes	☒ Individual	☐ Group	☒ Supports Simulation		
Intended Use	☒ Operator	☒ Supervisor	☐ **Factory Only** (OMIT FROM USER DOCS)		

Table 163: Exposure Command Prerequisites

Command	Description
#*id*0701	Return the current Ambient (low lighting) exposure setting.
#*id*0702	Return the current Normal (event lighting) exposure setting.
#*id*07	Return both the Ambient and Normal exposure settings.
[#*id*]0701*tttt*	Set the Ambient exposure to *tttt* µs, where *tttt* is a 16-bit hexadecimal number that can have values from 0017h to 8224h for a frame rate of 30 fps.
[#*id*]0702*tttt*	Set the Normal exposure to *tttt* µs, where *tttt* is a 16-bit hexadecimal number with values from 0001h to 4E0Fh.

Table 164: Exposure Command

Response	Description
#*id*010701*tttt*	Command succeeded where *tttt* is the Ambient exposure setting.
#*id*010702*tttt*	Command succeeded where *tttt* is the Normal exposure setting.
#*id*0107*nntttttmmmm*	As above, where *mmmm* is the Normal/Ambient maximum exposure limit value.
#*id*010703*llllnnnn*	Command succeeded, where *llll* is the Ambient exposure setting, and *nnnn* is the Normal exposure setting.
#*id*010703*llllnnnnmmmm*	As above, where *mmmm* is the optional maximum Normal exposure limit value.
#*id*ee07	Command failed, and *'ee'* is the explanation code.

Table 165: Exposure Reply

Exposure Select

Select the Exposure setting (Normal or Ambient) to be used by all subsequent commands when the camera is in the Standby or Live states.

Command Prerequisites			
Camera State	☒ Standby	☒ Live	☐ Ready ☐ Recording ☐ Recording Done
Attach State	☐ Required	☒ Ignored	☐ Required only when modifying values
Command Modes	☒ Individual	☒ Group	☐ Supports Simulation
Intended Use	☒ Operator	☒ Supervisor	☐ **Factory Only** (OMIT FROM USER DOCS)

Table 166: Exposure Select Command Prerequisites

Command	Description
[#*id*]9801	Select Ambient Exposure.
[#*id*]9802	Select Normal Exposure.
#*id*98	Query the selected exposure.

Table 167: Exposure Select Command

Response	Description
#*id*0198*xx*	Command succeeded where *xx* is the current exposure selection.
#*idee*98	Command failed, and *'ee'* is the explanation code.

Table 168: Exposure Select Reply

Exposure Shift

The camera will normally synchronize its exposure times to an external IRIG or GPS timebase such that an exposure always starts on even 1-second intervals. This command may be used to shift frame timing ahead or behind even 1-second intervals.

Note: *This command applies only to models that support IRIG/GPS inputs.*
Note: *This command has no effect on frame timing in External Sync mode.*

Command Prerequisites			
Camera State	☒ Standby	☒ Live	☐ Ready ☐ Recording ☐ Recording Done
Attach State	☒ Required	☒ Ignored	☐ Required only when modifying values
Command Modes	☒ Individual	☒ Group	☐ Supports Simulation
Intended Use	☒ Operator	☒ Supervisor	☐ **Factory Only** (OMIT FROM USER DOCS)

Table 169: Exposure Shift Command Prerequisites

Command	**Description**
[#*id*]10*nnnnnnnn*	Set exposure shift *nnnnnnnn* microseconds off even 1-second time. "*nnnnnnnn*" is a signed, twos-compliment time, in microseconds. Negative values will advance exposure times; positive values will delay exposure times. The exposure shift must be less than $\frac{1}{FrameRate}$, where *Frame Rate* is given in frames per second.
#*id*10	Query the current exposure shift setting.

Table 170: Exposure Shift Command

Response	**Description**
#*id*0110*nnnnnnnn*	Command succeeded where *nnnnnnnn* is the current exposure shift.
#*idee*10	Command failed, and *'ee'* is the explanation code.

Table 171: Exposure Shift Reply

White Balance Values

Set the User White Balance coefficients. The User White Balance coefficients are a set of three channel gain multiplier values used to ensure the Red, Green and Blue channel signals will have identical levels for gray (black to white) pixels. These values are normally determined by the CCU/DCU using the following calculation:

1. Obtain the pixel values for an area of the field of view that is known to contain grayscale (between black and white) pixels. The pixel values may be acquired by sampling data from a suitable Live or Download image. An area of at least 16x16 pixels should be sampled to avoid possible JPEG artifacts.
2. Sum the values for all pixels in each of the Red, Green and Blue channel sample sets.
3. The maximum of the above sums is assigned a gain multiplier of 1.0. Calculate the gain multipliers needed to increase each of the other two sums to match the value of the maximum channel. These gain values will normally be between 1.0 and 3.0.
4. Convert the gain multipliers obtained above to unsigned 32-bit fixed-point hexadecimal values having the form xxxx.xxxx (16-bit whole part, 16-bit fractional part). These are the values to pass to the White Balance Values command. The maximum valid value is 3.9990234375 (0x0003FFC0).

Note: *Each color correction matrix (CCM, selected via the Light Source Select command) has an associated set of default White Balance Values that are loaded whenever the CCM selection changes. It will usually be necessary to recalculate the User White Balance values whenever the Light Source Selection changes.*

Note: *White Balance is meaningful ONLY for cameras containing color sensors. The command is available on cameras with monochrome sensors, but in that case is only used as a gain adjustment.*

Command Prerequisites					
Camera State	☒ Standby	☒ Live	☒ Ready	☒ Recording	☒ Recording Done
Attach State	☐ Required	☐ Ignored	☒ Required only when modifying values		
Command Modes	☒ Individual	☐ Group	☐ Supports Simulation		
Intended Use	☒ Operator	☒ Supervisor	☐ **Factory Only** (OMIT FROM USER DOCS)		

Table 172: White Patch Values Command Prerequisites

Command	Description
#*id*12	Return the current set of white balance values.
[#*id*]12*rrrrrrrrggggggggbbbbbbbb*	Set the white balance coefficients to the passed values. The values are 16.16 bit fixed-point values.

Table 173: White Patch Values Command

Response	Description
#*id*0112*rrrrrrrrggggggggbbbbbbbb*	Command succeeded, *rrrrrrrr*, *gggggggg*, and *bbbbbbbb* are the current red, green, and blue white balance coefficients.
#*id*ee12	Command failed, *'ee'* is the explanation code.

Table 174: White Patch Values Reply

Ready (Initiate Pre-trigger Recording)

Ready Mode Initiates the storage of acquired image data in the camera memory. Frames are stored as pre-trigger frames until the camera is triggered, after which frames are stored as post-trigger frames. The trigger may be generated either by the receipt of a hardware trigger signal (from the Sync/Trigger bus or from the Configurable Input), or by the host issuing the Record command.

Command Prerequisites					
Camera State	☒ Standby	☒ Live	☐ Ready	☐ Recording	☐ Recording Done
Attach State	☒ Required	☐ Ignored	☐ Required only when modifying values		
Command Modes	☒ Individual	☒ Group	☐ Supports Simulation		
Intended Use	☐ Operator	☒ Supervisor	☐ **Factory Only** (OMIT FROM USER DOCS)		

Table 175: Ready Command Prerequisites

Command	**Description**
[#*id*]1B	Start pre-trigger recording.

Table 176: Ready Command

Response	**Description**
#*id*011B	Ready command completed successfully.
#*id*ee1B	Command failed, and *'ee'* is the explanation code.

Table 177: Ready Reply

Record (Manual Trigger)

The Record command is a manual trigger command, causing the next frame to be identified as Frame 0 and starting the post-trigger recording process, in lieu of an external hardware trigger signal. If the camera is not in the Ready state, an error will be returned.

This command affects **only** the camera receiving it, and does not propagate to other cameras via the Sync/Trigger bus. To use this command to trigger multiple cameras, it must either be sent to each camera individually (asynchronous trigger) or broadcast to all cameras (semi-synchronous trigger). The only way to obtain a truly synchronous trigger is to use a hardware trigger that is propagated to all cameras.

Command Prerequisites					
Camera State	☐ Standby	☐ Live	☒ Ready	☐ Recording	☐ Recording Done
Attach State	☒ Required	☐ Ignored	☐ Required only when modifying values		
Command Modes	☒ Individual	☒ Group	☐ Supports Simulation		
Intended Use	☐ Operator	☒ Supervisor	☐ **Factory Only** (OMIT FROM USER DOCS)		

Table 178: Record Command Prerequisites

Command	Description
[*#id*]74	Issue a manual trigger, flag Frame 0, start post-trigger recording.

Table 179: Record Command

Response	Description
#*id*0174	Record command completed successfully.
#*id*ee74	Command failed, and *'ee'* is the explanation code.

Table 180: Record Reply

Frame Sync Source

This command is for the HG-XR only. It sets or returns the source of frame synchronization. The command accepts a single parameter with the following values:

Value	Description
00	Use internal timing, which could be an HSU or an external frame sync source.
01	Use the IRIG source attached through a BNC on the camera's rear panel.
02	Use GPS, which requires attaching a GPS antenna to the camera's rear panel.

Table 181: Frame Sync Source Parameter Values

Command Prerequisites					
Camera State	☒ Standby	☒ Live	☐ Ready	☐ Recording	☐ Recording Done
Attach State	☒ Required	☐ Ignored	☐ Required only when modifying values		
Command Modes	☒ Individual	☒ Group	☐ Supports Simulation		
Intended Use	☒ Operator	☒ Supervisor	☐ **Factory Only** (OMIT FROM USER DOCS)		

Table 182: Frame Sync Source Command Prerequisites

Command	Description
#*id*66*dd*	Sets the frame synchronization source to 00=internal, 01=IRIG, 02=GPS
#*id*66	Returns the current choice of frame synchronization source.

Table 183: Frame Sync Source Command

Response	Description
#*id*0166*dd*	Frame Sync Source command completed successfully and dd is the current frame synchronization source.
#*id*ee66	Command failed, and *'ee'* is the explanation code.

Table 184: Frame Sync Source Reply

6. Post-Record Commands

IRIG Time

Set the IRIG reference time for frame zero (the trigger frame of a recording). The camera computes IRIG time for all other frames based on the frame timestamp and the IRIG time entered for frame zero of the recording. The IRIG time always defaults to 0 at startup.

The IRIG time may be set any time prior to downloading recorded images: The IRIG value is used only to compute the IRIG time value in each image's Border Data as part of the download process. The IRIG time reported in the Border Data for Live and Thumbnail frames may be inaccurate.

Note: *There is a short delay between the receipt of the trigger input and the actual start of Frame 0. The HG cameras account for this, automatically adjusting the timestamp to compensate.*

Command Prerequisites					
Camera State	☒ Standby	☒ Live	☒ Ready	☒ Recording	☒ Recording Done
Attach State	☐ Required	☐ Ignored	☒ Required only when modifying values		
Command Modes	☒ Individual	☒ Group	☐ Supports Simulation		
Intended Use	☐ Operator	☒ Supervisor	☐ **Factory Only** (OMIT FROM USER DOCS)		

Table 185: IRIG Time Command Prerequisites

Command	**Description**
#*id*47	Return the current IRIG time.
[#*id*]47*ddddhhmmssxxxx*	Set the camera IRIG time. The format for time is *ddddhhmmssxxxx* in hexadecimal format, where days (*dddd)* ranges from 0000h to 016Eh (366), hours (*hh)* ranges from 00h to 17h (23), and minutes (*mm)* and seconds (*ss)* range from 00h to 3Bh (59). Microseconds (*xxxx)* ranges from 0000h to 270Fh, and is considered to be a fixed point value having the form xxx.x. (270Fh equates to 999.9 milliseconds).

Table 186: IRIG Time Command

Response	**Description**
#*id*0147*ddddhhmmssxxxx*	Command succeeded where *ddddhhmmssxxxx* is the IRIG time.
#*idee*47	Command failed, *'ee'* is the explanation code.

Table 187: IRIG Time Reply

Example	
470064010A32270F	Set the IRIG time to 100: 01:10:50.9999

Table 188: IRIG Time Command Example

IRIG Time Reference

Camera models that support IRIG (or GPS) time will include IRIG (or GPS) timestamps in each image's border data. The camera may be configured to mark the IRIG timestamp at the beginning, middle, or end of the frame's exposure.

Command Prerequisites			
Camera State	☒ ~~Standby~~	☒ ~~Live~~	☒ ~~Ready~~ ☒ ~~Recording~~ ☒ ~~Recording Done~~
Attach State	☐ Required	☐ Ignored	☒ Required only when modifying values
Command Modes	☒ Individual	☒ Group	☐ Supports Simulation
Intended Use	☐ Operator	☒ Supervisor	☐ **Factory Only** (OMIT FROM USER DOCS)

Table 189: Set IRIG Time Reference Command Prerequisites

Command	Description
#*id*11	Return the current IRIG Time Reference
[#*id*]11*nn*	Set the IRIG Time Reference: 01 – IRIG timestamps apply to start of exposure 02 – IRIG timestamps apply to middle of exposure 03 – IRIG timestamps apply to the end of exposure

Table 190: Set IRIG Time Reference Command

Response	Description
#*id*0111*nn*	Command succeeded. "nn" gives the current setting as shown above.
#*idee*11	Command failed, *'ee'* is the explanation code.

Table 191: Set IRIG Time Reference Reply

Get Frame Number Range

Query the camera for the lowest and highest recorded frame number currently stored in memory. It provides the limit values to be used with the Download Frame Request command.

Negative numbers represent pre-trigger frames, and positive numbers represent post-trigger frames. The start frame number will always be less than or equal to zero (non-positive), and the end frame number will always be greater than or equal to zero (non-negative). If both values are zero, then only a single frame was acquired, Frame 0, the Trigger Frame.

The HG-100K cameras support variable frame sizes that allow recording more frames than can be described with a signed 16-bit value. The Get Frame Number Range command also supports signed 32-bit frame numbers.

Command Prerequisites					
Camera State	☐ Standby	☐ Live	☐ Ready	☐ Recording	☒ Recording Done
Attach State	☐ Required	☒ Ignored	☐ Required only when modifying values		
Command Modes	☒ Individual	☒ Group	☐ Supports Simulation		
Intended Use	☐ Operator	☒ Supervisor	☐ **Factory Only** (OMIT FROM USER DOCS)		

Table 192: Get Frame Number Range Command Prerequisites

Command	**Description**
[*#id*]45	Return lowest and highest frame number.

Table 193: Get Frame Number Range Command

Response	**Description**
*#id*0145*nnnnhhhh* *or* *#id*0145*nnnnnnnnhhhhhhhh*	Command succeeded, *nnnn* is the lowest frame number, and *hhhh* is the highest frame number stored in memory. Both *nnnn* and *hhhh* are 16- or 32-bit hexadecimal numbers using twos complement for negative values.
*#idee*45	Command failed, and *'ee'* is the explanation code.

Table 194: Get Frame Number Range Reply

7. View/Download Commands

Light Source Select

The camera contains predefined color correction matrices (CCMs) for three light sources: Tungsten, HMI and Daylight. The CCM allows the camera to compensate the sensor response for the spectrum of the light illuminating the scene. Select the color correction matrix that best matches the lighting on the subject.

Each CCM has an associated set of default White Balance values that overwrite the current User White Balance values. After selecting a light source, the color rendition may be improved by adjusting the White Balance values.

Note: *This command is valid ONLY for cameras containing color sensors.*

Command Prerequisites					
Camera State	☒ Standby	☒ Live	☒ Ready	☒ Recording	☒ Recording Done
Attach State	☐ Required	☐ Ignored	☒ Required only when modifying values		
Command Modes	☒ Individual	☒ Group	☐ Supports Simulation		
Intended Use	☒ Operator	☒ Supervisor	☐ **Factory Only** (OMIT FROM USER DOCS)		

Table 195: Light Source Select Command Prerequisites

Command	**Description**
#*id*71	Returns the current light source selection.
[#*id*]7100	Select daylight.
[#*id*]7101	Select Tungsten lighting.
[#*id*]7102	Select HMI lamps.
[#*id*]7103	Select User CCM. **[Factory Only]**
[#*id*]7104	Select Unity CCM (no color correction, forced for monochrome sensors).

Table 196: Light Source Select Command

Response	**Description**
#*id*0171*ss*	Command succeeded, where *ss* is the current selection.
#*id*ee71	Command failed, where *'ee'* is an explanation code.

Table 197: Light Source Select Reply

Color Correction Matrix

Get the 9 values for any CCM, or Set the User CCM values.

Note: *This is a factory-only command.*

Note: *This command is valid ONLY for cameras containing color sensors.*

Command Prerequisites					
Camera State	☒ Standby	☒ Live	☒ Ready	☒ Recording	☒ Recording Done
Attach State	☐ Required	☐ Ignored	☒ Required only when modifying values		
Command Modes	☒ Individual	☒ Group	☐ Supports Simulation		
Intended Use	☐ Operator	☐ Supervisor	☒ **Factory Only** (OMIT FROM USER DOCS)		

Table 198: Color Correction Matrix Command Prerequisites

Command	**Description**
#*id*93	Returns the values for the currently selected CCM.
#*id*93*nn*	Returns the selected CCM values. The values for nn are the same as those for the Light Source Select command.
[#*id*]9303*aaaaaaaabbbbbbbbcccccccddddddddeeeeeeeeffffffffgggggggghhhhhhhhiiiiiiii*	Set the nine User CCM values. Each is a nn.nn (16.16) fixed point value. *Note: Pre-defined CCMs have an associated default White Balance value set. The User CCM has no default associated White Balance value set.*

Table 199: Color Correction Matrix Command

Response	**Description**
#*id*0193*nnaaaaaaaabbbbbbbbcccccccddddddddeeeeeeeeffffffffgggggggghhhhhhhhiiiiiiii*	Command succeeded, where *nn* is the current selection, and *aaaaaaaa* through *iiiiiiii* are the 9 values.
#*id*ee93	Command failed, where *'ee'* is an explanation code.

Table 200: Color Correction Matrix Reply

Camera Orientation

This command records an "orientation" setting in the camera' s non-volatile settings database. Each image downloaded from the camera includes a copy of this setting in its border data. Control software can use this setting to properly rotate images for user display. Note that the camera itself does not rotate images based on this setting.

Command Prerequisites					
Camera State	☒ Standby	☒ Live	☒ Ready	☒ Recording	☒ Recording Done
Attach State	☐ Required	☐ Ignored	☒ Required only when modifying values		
Command Modes	☒ Individual	☒ Group	☐ Supports Simulation		
Intended Use	☒ Operator	☒ Supervisor	☐ **Factory Only** (OMIT FROM USER DOCS)		

Table 201: Camera Orientation Command Prerequisites

Command	Description
#*id*0A	Query a camera for its orientation setting.
#id0A*aaaa*	Set orientation. *aaaa* gives camera rotation in degrees, and must be one of four values: 0000 0°, camera upright, no rotation required for image display 005A 90°, camera lying on right side, rotate 90° left for display 00B4 180°, camera upside down, rotate 180° for display 010E 270°, camera lying on left side, rotate 90° right for display

Table 202: Camera Orientation Command

Response	Description
#*id*010A*aaaa*	Command succeeded. *aaaa* is the current orientation setting, as described above.
#*idee*0A	Command failed, and *ee* is the explanation code.

Table 203: Camera Orientation Reply

Sharpening Gain

Select an edge data gain of 0 (disabled), 0.5, 1.0 (default), 1.5 or 2.0. The edge data is the result of an unsharp masking operation, the value of which is scaled by this factor prior to being fed to the Sharpening LUT.

Note: *This is a factory-only command.*

Command Prerequisites					
Camera State	☒ Standby	☒ Live	☒ Ready	☒ Recording	☒ Recording Done
Attach State	☐ Required	☐ Ignored	☒ Required only when modifying values		
Command Modes	☒ Individual	☒ Group	☐ Supports Simulation		
Intended Use	☐ Operator	☐ Supervisor	☒ **Factory Only** (OMIT FROM USER DOCS)		

Table 204: Sharpening Gain Command Prerequisites

Command	**Description**
#*id*70	Returns the current Sharpening Gain selection.
[#*id*]7000	Disable Sharpening Gain (no edge enhancement occurs).
[#*id*]7001	Sharpening Gain is 0.5.
[#*id*]7002	Sharpening Gain is 1.0 (default).
[#*id*]7003	Sharpening Gain is 1.5.
[#*id*]7004	Sharpening Gain is 2.0.

Table 205: Sharpening Gain Command

Response	**Description**
#*id*0170*vv*	Command succeeded, where *vv* is the current selection.
#*idee*70	Command failed, where *'ee'* is an explanation code.

Table 206: Sharpening Gain Reply

Sharpening LUT

Select the LUT used mix edge data into the image. The LUT filters the edge information to control specific effects: "Clip" filtering prevents large edges from having too great an effect on the final image (reduces undesired saturation). "Core" filtering prevents small edges (likely representing noise) from affecting the image (keeping smooth areas smooth).

Note: *This is a factory-only command.*

Command Prerequisites					
Camera State	☒ Standby	☒ Live	☒ Ready	☒ Recording	☒ Recording Done
Attach State	☐ Required	☐ Ignored	☒ Required only when modifying values		
Command Modes	☒ Individual	☒ Group	☐ Supports Simulation		
Intended Use	☐ Operator	☐ Supervisor	☒ **Factory Only** (OMIT FROM USER DOCS)		

Table 207: Sharpening LUT Command Prerequisites

Command	**Description**
#*id*94	Returns the current sharpening LUT selection.
[#*id*]9400	Select Linear LUT (no Clip or Core filtering)
[#*id*]9401	Select "Clip" LUT
[#*id*]9402	Select "Core" LUT
[#*id*]9403	Select "Clip & Core" LUT (default)

Table 208: Sharpening LUT Command

Response	**Description**
#*id*0194*vv*	Command succeeded, where *vv* is the current selection.
#*idee*94	Command failed, where *'ee'* is an explanation code.

Table 209: Sharpening LUT Reply

Live

Places the system in the LIVE mode for 30 seconds, which ensures the sensor and analog circuitry is fully powered. This mode avoids power cycling that would otherwise occur with each frame request serviced while the camera is in STANDBY mode.

The same net effect may be obtained by requesting a Thumbnail or Live frame at least once every 30 seconds. Using the Live command allows full power to be maintained without needing to transfer any frames.

Note: *The camera image dynamic thermal compensation system is not operational when the camera is in STANDBY. It is recommended the camera be placed in LIVE mode at least one second prior to initiating a recording, so the thermal compensation system may stabilize, and optimal image quality be ensured.*

Command Prerequisites					
Camera State	☒ Standby	☒ Live	☐ Ready	☐ Recording	☐ Recording Done
Attach State	☒ Required	☐ Ignored	☐ Required only when modifying values		
Command Modes	☒ Individual	☐ Group	☐ Supports Simulation		
Intended Use	☒ Operator	☒ Supervisor	☐ **Factory Only** (OMIT FROM USER DOCS)		

Table 210: Live Command Prerequisites

Command	**Description**
[*#id*]1A	Place the camera in Live mode.

Table 211: Live Command

Response	**Description**
*#id*011A	Command succeeded.
*#idee*1A	Command failed, and *'ee'* is the explanation code.

Table 212: Live Reply

Stop

Halt any Live or Ready (pre-trigger recording) operation in progress, and place the camera in the STANDBY (reduced power consumption) state. The Stop command does ***not*** affect any post-trigger recording in progress, and will return an error if issued while a camera is in the Recording or Recording Done states.

Command Prerequisites					
Camera State	☒ Standby	☒ Live	☒ Ready	☐ Recording	☐ Recording Done
Attach State	☒ Required	☐ Ignored	☐ Required only when modifying values		
Command Modes	☒ Individual	☒ Group	☐ Supports Simulation		
Intended Use	☐ Operator	☒ Supervisor	☐ **Factory Only** (OMIT FROM USER DOCS)		

Table 213: Stop Command Prerequisites

Command	**Description**
[*#id*]19	Places the camera in the Stop state.

Table 214: Stop Command

Response	**Description**
*#id*0119	Command succeeded.
*#idee*19	Command failed, and *'ee'* is the explanation code.

Table 215: Stop Reply

Download Frame Format

Select Type2, RGB, or JPEG frame formats. The image transmission process is explained in detail in Appendix A.

Type2 images consist of a single plane of data, where each pixel represents a fully corrected version of the corresponding sensor pixel. The pixel values may be spaced non-linearly to minimize the impact of noise and maximize the use of the available dynamic range. The linear value may be obtained using the LUT provided in the Border Data (described in Appendix B). For cameras containing color sensors, the full RGB image may be reconstructed by applying the Redlake HG color interpolation algorithm.

RGB images consist of either three (color) or one (monochrome) planes of fully corrected linear data.

JPEG images are the JPEG encoding of the corresponding RGB image. JPEG images are compressed by discarding image details that are normally not apparent to a human observer, though on rare occasions extremely complex images may contain visible artifacts. For this reason, do ***not*** use JPEG as the sole archival storage format. *Note: Monochrome images do not compress as well as color images, and may be expected to be about twice as large.*

Command Prerequisites					
Camera State	☒ Standby	☒ Live	☒ Ready	☒ Recording	☒ Recording Done
Attach State	☐ Required	☐ Ignored	☒ Required only when modifying values		
Command Modes	☒ Individual	☒ Group	☐ Supports Simulation		
Intended Use	☐ Operator	☒ Supervisor	☐ **Factory Only** (OMIT FROM USER DOCS)		

Table 216: Download Frame Format Command Prerequisites

Value	Description
00	Type2 with non-linear pixel encoding
01	RGB with linear pixels
04	JPEG with linear pixels

Table 217: Download Frame Format Parameter Values

Note: *Several values in the range* **10** *through* **3F** *are reserved for Factory Use Only. They will not return an error, though they may cause unexpected camera behavior.*

Command	Description
#*id*87	Returns current format setting.
[#*id*]87*nn*	Set frame format to *nn* per above table.

Table 218: Download Frame Format Command

Response	Description
#*id*0187*nn*	Command succeeded. Frame format is *nn*.
#*id*ee87	Command failed, and *'ee'* is the explanation.

Table 219: Download Frame Format Reply

Download Rate Limit

Set the inter-packet delay inserted after each packet of image data during download. Use of this command should be necessary only when the receiver is unable to keep up with frame packet transmission. The actual packet sequence involved in transmitting an image is fairly intricate, and is explained in detail in Appendix A.
A different delay is specified for each download type (RGB, Type2 and JPEG). Each delay is an unsigned 16-bit value (0 to 65535) in units of "network clocks", where the network clock for the Fast interface is 125 MHz (8 ns), and the network clock for the Slow (DCU) interface is 12.5 MHz (80 ns).

The default value for all inter-packet delays is 0 ns. The maximum value, 65535, corresponds to an inter-packet delay of 524 us for the Fast interface, and 5.24 ms for the Slow (DCU) interface.

Command Prerequisites					
Camera State	☒ Standby	☒ Live	☒ Ready	☒ Recording	☒ Recording Done
Attach State	☐ Required	☐ Ignored	☒ Required only when modifying values		
Command Modes	☒ Individual	☒ Group	☐ Supports Simulation		
Intended Use	☐ Operator	☒ Supervisor	☐ **Factory Only** (OMIT FROM USER DOCS)		

Table 220: Download Rate Limit Command Prerequisites

Command	Description
#*id*89	Return the current download rate (interpacket gap) settings.
[#*id*]89*rrrrttttjjjj*	Set the download rate (interpacket gap) to *rrrr* for RGB data, *tttt* for Type2 data, and *jjjj* for JPEG data.

Table 221: Download Rate Command

Response	Description
#*id*0189*rrrrttttjjjj*	Command succeeded. Interpacket gaps are *rrrr*, *tttt*, *and jjjj* for RGB, Type2 and JPEG image data, respectively.
#*id*ee89	Command failed, and *'ee'* is the explanation.

Table 222: Download Rate Reply

Download Frame Request

Request transmission of a previously recorded frame to the specified IP port. The frame will be formatted per the current File Format and Download Frame Format settings. This command may be reissued before previously requested frames have been sent. Additional requests are queued up to a maximum of 255 queued requests.

The actual packet sequence involved in transmitting an image is fairly intricate, and is explained in detail in Appendix A.

Note: *There is no query form of this command.*

Command Prerequisites					
Camera State	☐ Standby	☐ Live	☐ Ready	☐ Recording	☒ Recording Done
Attach State	☒ Required	☐ Ignored	☐ Required only when modifying values		
Command Modes	☒ Individual	☐ Group	☐ Supports Simulation		
Intended Use	☐ Operator	☒ Supervisor	☐ **Factory Only** (OMIT FROM USER DOCS)		

Table 223: Download Frame Request Command Prerequisites

Command	**Description**
[#*id*]88*kkkkpppp* *or* **[#*id*]88*kkkkkkkkpppp***	Download the specified frame to the specified port. *kkkk* is a ***signed*** 16-bit number, and *kkkkkkkk* is a ***signed*** 32-bit number. *pppp* is an ***unsigned*** 16-bit number.

Table 224: Download Frame Request Command

Response	**Description**
#*id*0188	Command succeeded. Frame(s) are on their way.
#*id*ee88	Command failed, and *'ee'* is the explanation.

Table 225: Download Frame Request Reply

Abort Download

Delete any queued Download Frame requests. Any frame transmission in progress may be terminated with extreme prejudice. If no download is in progress, this command succeeds.

Command Prerequisites			
Camera State	☐ Standby	☐ Live	☐ Ready ☐ Recording ☒ Recording Done
Attach State	☒ Required	☐ Ignored	☐ Required only when modifying values
Command Modes	☒ Individual	☐ Group	☐ Supports Simulation
Intended Use	☐ Operator	☒ Supervisor	☐ **Factory Only** (OMIT FROM USER DOCS)

Table 226: Abort Download Command Prerequisites

Command	Description
[*#id*]86	Halt any download in progress.

Table 227: Abort Download Command

Response	Description
*#id*0186	Command succeeded.
*#id*ee86	Command failed, and *'ee'* is the explanation.

Table 228: Abort Download Reply

Live Frame Format

Select Type2, RGB, or JPEG frame formats for LiveView requests. The image transmission process is explained in detail in Appendix A.

See *Download Frame Format* above for descriptions of available frame formats.

Command Prerequisites					
Camera State	☒ Standby	☒ Live	☒ Ready	☒ Recording	☒ Recording Done
Attach State	☐ Required	☐ Ignored	☒ Required only when modifying values		
Command Modes	☒ Individual	☒ Group	☐ Supports Simulation		
Intended Use	☐ Operator	☒ Supervisor	☐ **Factory Only** (OMIT FROM USER DOCS)		

Table 229: Live Frame Format Command Prerequisites

Value	Description
00	Type2 with non-linear pixel encoding
01	RGB with linear pixels
04	JPEG with linear pixels

Table 230: Live Frame Format Parameter Values

Note: *Several values in the range* **10** *through* **3F** *are reserved for Factory Use Only. They will not return an error, though they may cause unexpected camera behavior.*

Command	Description
#*id*8A	Returns current format setting.
[#*id*]8A*nn*	Set frame format to *nn* per above table.

Table 231: Live Frame Format Command

Response	Description
#*id*018A*nn*	Command succeeded. Frame format is *nn*.
#*id*ee8A	Command failed, and *'ee'* is the explanation.

Table 232: Live Frame Format Reply

Live Frame Size

Select how the acquired live frame is to be subsampled prior to transmission. Both cropping and/or ¼ decimation (2:1 zoom, dropping every other line and column) may be applied. Parameters: Pixel Origin (top-left corner, X_0, Y_0), Crop Area (width, height), and Decimate (T/F). Live frame size may not exceed 752 x 564.
The pixel origin and area values must fit within the current Sensor Active Area. All ordinates are expressed as 16-bit (4 character) hexadecimal values. The decimation parameter has a value of 00 for disabled, and 01 for enabled.

The Pixel Origin coordinates must be even values. The Crop Area width must be a positive multiple of 32 pixels, and the Crop Area height must be a positive multiple of 8 pixels.

All Live frames sent after this command succeeds will be satisfied using the passed settings.

Command Prerequisites					
Camera State	☒ Standby	☒ Live	☒ Ready	☒ Recording	☒ Recording Done
Attach State	☐ Required	☐ Ignored	☒ Required only when modifying values		
Command Modes	☒ Individual	☒ Group	☒ Supports Simulation		
Intended Use	☒ Operator	☒ Supervisor	☐ **Factory Only** (OMIT FROM USER DOCS)		

Table 233: Live Frame Size Command Prerequisites

Command	**Description**
#*id*8D	Returns the previous Live frame size settings.
[#*id*]8D*xxxxyyyywwwwhhhhdd*	Configure the Live settings to sample the image from the top-left corner at (*xxxx*,*yyyy*) for a size that is *wwww* by *hhhh* pixels. Pass this through the decimator if *dd* is **01**, and do not decimate if *dd* is **00**.

Table 234: Live Frame Size Command

Response	**Description**
#*id*018D*xxxxyyyywwwwhhhhdd*	Command succeeded. Future Live frame requests will be satisfied using these values.
#*idee*8D	Command failed, *'ee'* is the explanation code.

Table 235: Live Frame Size Reply

Thumbnail Frame Size

Select how the acquired thumbnail frame is to be subsampled prior to transmission. Parameters: Pixel Origin (top-left corner, X_0, Y_0), Crop Area (width, height), and ¼ Decimation (on/off).

The pixel origin and area values are relative to (must fit within) the current Sensor Active Area. All ordinates are expressed as 16-bit (4 character) hexadecimal values. The decimator parameter has a value of 00 for disabled, and 01 for enabled.

The Pixel Origin coordinates must be even values. The Crop Area width must be a positive multiple of 32 pixels, and the Crop Area height must be a positive multiple of 8 pixels.

All Thumbnail frames sent after this command succeeds will be satisfied using the passed settings.

Note: *When the full sensor area is used, the smallest full-frame image that can be created is 752 x 564. The host must subsample the image if a smaller displayed size is desired. When using the JPEG format, image size reductions of up to 8:1 (1/64 size) are readily obtained via subsampling during the JPEG decoding process. Thus, a full-frame image easily may be viewed as small as 94x70.*

Command Prerequisites					
Camera State	☒ Standby	☒ Live	☒ Ready	☒ Recording	☒ Recording Done
Attach State	☐ Required	☐ Ignored	☒ Required only when modifying values		
Command Modes	☒ Individual	☒ Group	☒ Supports Simulation		
Intended Use	☒ Operator	☒ Supervisor	☐ **Factory Only** (OMIT FROM USER DOCS)		

Table 236: Thumbnail Frame Size Command Prerequisites

Command	**Description**
#*id*8E	Returns the previous Thumbnail frame size settings.
[#*id*]8E*xxxxyyyywwwwhhhhdd*	Configure the Thumbnail settings to sample the image from the top-left corner at (*xxxx*,*yyyy*) for a size that is *wwww* by *hhhh* pixels. Pass this through the decimator if *dd* is **01**, and do not decimate if *dd* is **00**.

Table 237: Thumbnail Frame Size Command

Response	**Description**
#*id*018E*xxxxyyyywwwwhhhhdd*	Command succeeded. Future Thumbnail frame requests will be satisfied using these values.
#*idee*8E	Command failed, *'ee'* is the explanation code.

Table 238: Thumbnail Frame Size Reply

Download Frame Size

Select how previously recorded frames to be downloaded are to be subsampled prior to transmission. Parameters: Pixel Origin (top-left corner, X_0, Y_0), Crop Area (width, height), and ¼ Decimation (on/off).

The pixel origin and area values are relative to (must fit within) the current Sensor Active Area. All ordinates are expressed as 16-bit (4 character) hexadecimal values. The decimator parameter has a value of 00 for disabled, and 01 for enabled.

The Pixel Origin coordinates must be even values. The Crop Area width must be a positive multiple of 32 pixels, and the Crop Area height must be a positive multiple of 8 pixels.

All Download frames sent after this command succeeds will be satisfied using the passed settings.

WARNING: *Frames downloaded using less than the entire recorded frame resolution should* ***not*** *be used for archival purposes. Perform a separate full-sized download for images being archived.*

Command Prerequisites					
Camera State	☒ Standby	☒ Live	☒ Ready	☒ Recording	☒ Recording Done
Attach State	☐ Required	☐ Ignored	☒ Required only when modifying values		
Command Modes	☒ Individual	☒ Group	☒ Supports Simulation		
Intended Use	☒ Operator	☒ Supervisor	☐ **Factory Only** (OMIT FROM USER DOCS)		

Table 239: Download Frame Size Command Prerequisites

Command	Description
#*id*9C	Returns the previous Download frame size settings.
[#*id*]9C*xxxxyyyywwwwhhhhdd*	Configure the Download settings to sample the image from the top-left corner at (*xxxx*,*yyyy*) for a size that is *wwww* by *hhhh* pixels. Pass this through the decimator if *dd* is **01**, and do not decimate if *dd* is **00**.

Table 240: Download Frame Size Command

Response	Description
#*id*019C*xxxxyyyywwwwhhhhdd*	Command succeeded. Future Download frame requests will be satisfied using these values.
#*idee*9C	Command failed, *'ee'* is the explanation code.

Table 241: Download Frame Size Reply

Live Frame Rate Limit

Set a maximum Live frame rate. Frame requests arriving faster than this rate will be queued (refer to the Live Frame Request command). Requests arriving at a slower rate will be serviced as they arrive. The frame rate may range from a minimum of 1 to a maximum of 30 (1Eh) frames per second. The default value is 30 fps.

Command Prerequisites					
Camera State	☒ Standby	☒ Live	☒ Ready	☒ Recording	☒ Recording Done
Attach State	☐ Required	☐ Ignored	☒ Required only when modifying values		
Command Modes	☒ Individual	☒ Group	☐ Supports Simulation		
Intended Use	☐ Operator	☒ Supervisor	☐ **Factory Only** (OMIT FROM USER DOCS)		

Table 242: Live Frame Rate Command Prerequisites

Command	**Description**
#*id*8F	*Returns* current frame rate setting.
[#*id*]8F*nn*	Set frame rate to *nn* (01 – 1E fps).

Table 243: Live Frame Rate Command

Response	**Description**
#*id*018F*nn*	Command succeeded. Frame rate is *nn*.
#*id*ee8F	Command failed, and *'ee'* is the explanation.

Table 244: Live Frame Rate Reply

Live Frame Request

Request transmission of *n* live frames formatted per the previously configured Live Frame Format settings. The number of frames requested must be no more than 255. If additional requests are made while frames are being sent, the additional requests will be queued up to a maximum of 255 queued requests.

The actual packet sequence involved in transmitting an image is fairly intricate, and is explained in detail in Appendix A.

Note: *There is no query form of this command.*

Command Prerequisites					
Camera State	☒ Standby	☒ Live	☒ Ready	☒ Recording	☐ Recording Done
Attach State	☒ Required	☐ Ignored	☐ Required only when modifying values		
Command Modes	☒ Individual	☐ Group	☐ Supports Simulation		
Intended Use	☒ Operator	☒ Supervisor	☐ **Factory Only** (OMIT FROM USER DOCS)		

Table 245: Live Frame Request Command Prerequisites

Command	**Description**
[*#id*]8C*nnpppp*	Download *nn* live frames to IP port *pppp*.

Table 246: Live Frame Request Command

Response	**Description**
*#id*018C	Command succeeded. Frames are on their way.
*#id*ee8C	Command failed, and *'ee'* is the explanation.

Table 247: Live Frame Request Reply

Live Quick Look

This command is a synonym for a Single Frame Live Frame Request, and is provided to enhance Legacy integration. If frames are requested faster than they can be delivered, up to **255** frame requests will be queued.
The actual packet sequence involved in transmitting an image is fairly intricate, and is explained in detail in Appendix A.

Note: *There is no query form of this command.*

Command Prerequisites					
Camera State	☐ Standby	☒ Live	☒ Ready	☒ Recording	☐ Recording Done
Attach State	☒ Required	☐ Ignored	☐ Required only when modifying values		
Command Modes	☒ Individual	☐ Group	☐ Supports Simulation		
Intended Use	☒ Operator	☒ Supervisor	☐ **Factory Only** (OMIT FROM USER DOCS)		

Table 248: Live Quick Look Command Prerequisites

Command	Description
[#*id*]72*pppp*	Request a single live frame be sent to port *pppp*.

Table 249: Live Quick Look Command

Response	Description
#*id*0172	Command succeeded. A frame is on its way.
#*id*ee72	Command failed, and *'ee'* is the explanation.

Table 250: Live Quick Look Reply

Abort Live

Delete any queued Live Frame requests. Any frame transmission in progress will continue to completion. If no live transmission is in progress, this command trivially succeeds.

Note: *There is no query form of this command.*

Command Prerequisites					
Camera State	☒ Standby	☒ Live	☒ Ready	☒ Recording	☒ Recording Done
Attach State	☒ Required	☐ Ignored	☐ Required only when modifying values		
Command Modes	☒ Individual	☐ Group	☐ Supports Simulation		
Intended Use	☐ Operator	☒ Supervisor	☐ **Factory Only** (OMIT FROM USER DOCS)		

Table 251: Abort Live Command Prerequisites

Command	**Description**
[*#id*]99	Any live transfers in progress or pending have been halted.

Table 252: Abort Live Command

Response	**Description**
*#id*0199	Command succeeded.
*#id*ee99	Command failed, and *'ee'* is the explanation.

Table 253: Abort Live Reply

Set Video Mode

This command applies only to HG cameras (e.g. the HG-TH) that support a composite video output. This command will return an error if used with cameras that do not have a composite video output.

This command establishes the operating mode of the composite video output. The output may be disabled, or set to operate in either NTSC or PAL mode. Table 254 shows the encoding used to specify video output modes.

The command will set the operating mode for all cameras if several cameras share a single composite video output (for example, the HG-TH console's video output),

Value	Description
00	Video output Off
01	Use NTSC fomat
02	Use PAL format

Table 254: Composite Video Output Mode Encoding

Command Prerequisites					
Camera State	☒ Standby	☒ Live	☒ Ready	☒ Recording	☒ Recording Done
Attach State	☒ Required	☐ Ignored	☐ Required only when modifying values		
Command Modes	☒ Individual	☐ Group	☐ Supports Simulation		
Intended Use	☐ Operator	☒ Supervisor	☐ **Factory Only** (OMIT FROM USER DOCS)		

Table 255: Set Composite Video Output Mode Command Prerequisites

Command	Description
[#*id*]68	Return current composite video output mode
[#*id*]68mm	Set video output mode to "mm".

Table 256: Set Composite Video Output Mode Command

Response	Description
#*id*0168mm	Command succeeded. Current video output mode is "mm",
#*id*ee68	Command failed, and *'ee'* is the explanation.

Table 257: Set Composite Video Output Mode Reply

Select Camera for Video Output

This command applies only to HG cameras (e.g. the HG-TH) that support a composite video output. This command will return an error if used with cameras that do not have a composite video output.

This command enables composite video output for a camera. If another camera was previously sending output to the composite video output, that camera's output will be disabled. This command is a "channel selector" for a shared video output.

Command Prerequisites					
Camera State	☒ Standby	☒ Live	☒ Ready	☒ Recording	☒ Recording Done
Attach State	☒ Required	☐ Ignored	☐ Required only when modifying values		
Command Modes	☒ Individual	☐ Group	☐ Supports Simulation		
Intended Use	☐ Operator	☒ Supervisor	☐ **Factory Only** (OMIT FROM USER DOCS)		

Table 258: Select Camera for Video Output Command Prerequisites

Command	**Description**
[#*id*]6E	Return current video status
[#*id*]6E00	Turn off a camera's composite video output
[#*id*]6E01	Turn on a camera's composite video output

Table 259: Select Camera for Video Output Command

Response	**Description**
#*id*016E00	Command succeeded. Camera's video output is off
#*id*016E01	Command succeeded. Camera's video output is on
#*id*ee6E	Command failed, and *'ee'* is the explanation.

Table 260: Select Camera for Video Output Reply

Set On-Screen Display (OSD) Mode

This command applies only to HG cameras (e.g. the HG-TH) that support a composite video output. This command will return an error if used with cameras that do not have a composite video output.

This command establishes the operating mode for the on-screen display (OSD) superimposed on the composite video output. The OSD may be turned off completely, or it may show time-of-day information, camera ID information, or both. Table 261 shows the encoding used for each mode.

For the HG-XR model, the OSD may include the camera state ("recording," "record done," etc.), or the IRIG/GPS time. The time displayed is determined by the Frame Sync Source. If the current Frame Sync Source is Internal, the time displayed is the camera's internal time-of-day clock; otherwise it is the IRIG or GPS time.

Value	Description
00	OSD Off
01	Display time-of-day
02	Display camera ID (HG-TH only)
03	Display both time-of-day and camera ID (HG-TH only)
04	Display camera state (HG-XR only)
05	Display camera state and IRIG/GPS time (HG-XR only)

Table 261: OSD Mode Encoding

Command Prerequisites					
Camera State	☒ Standby	☒ Live	☒ Ready	☒ Recording	☒ Recording Done
Attach State	☒ Required	☐ Ignored	☐ Required only when modifying values		
Command Modes	☒ Individual	☐ Group	☐ Supports Simulation		
Intended Use	☐ Operator	☒ Supervisor	☐ **Factory Only** (OMIT FROM USER DOCS)		

Table 262: OSD Mode Command Prerequisites

Command	Description
[#*id*]69	Return the current OSD mode
[#*id*]69mm	Set OSD mode to "mm", as encoded in Table 261.

Table 263: OSD Mode Command

Response	Description
#*id*0169mm	Command succeeded. Current OSD mode is "mm".
#*id*ee69	Command failed, and *'ee'* is the explanation.

Table 264: OSD Mode Reply

Thumbnail Frame Request

Request transmission of a freshly acquired frame formatted per the Thumbnail Frame Size settings. The actual packet sequence involved in transmitting an image is fairly intricate, and is explained in detail in Appendix A.

Note: *1) There is no query form of this command.*
2) Thumbnail requests do not queue.

Command Prerequisites					
Camera State	☒ Standby	☒ Live	☐ Ready	☐ Recording	☐ Recording Done
Attach State	☐ Required	☒ Ignored	☐ Required only when modifying values		
Command Modes	☒ Individual	☐ Group	☐ Supports Simulation		
Intended Use	☒ Operator	☒ Supervisor	☐ **Factory Only** (OMIT FROM USER DOCS)		

Table 265: Thumbnail Frame Request Command Prerequisites

Command	**Description**
[*#id*]92*pppp*	Request a single thumbnail frame be transmitted to port *pppp*.

Table 266: Thumbnail Frame Request Command

Response	**Description**
*#id*0192	Command succeeded. A frame is on its way.
*#id*ee92	Command failed, and *'ee'* is the explanation.

Table 267: Thumbnail Frame Request Reply

Delete Recording

This command erases all recorded images in memory.

***Caution**: This command permanently erases all information recorded in memory. Be sure you download the frames you wish to preserve before issuing this command.*

***WARNING**: Playback of recorded images from the camera is not the same as downloading them to an archival storage system. Be sure to save your images!*

***Note:** There is no query form of this command.*

Command Prerequisites					
Camera State	☐ Standby	☐ Live	☐ Ready	☐ Recording	☒ Recording Done
Attach State	☒ Required	☐ Ignored	☐ Required only when modifying values		
Command Modes	☒ Individual	☐ Group	☐ Supports Simulation		
Intended Use	☐ Operator	☒ Supervisor	☐ **Factory Only** (OMIT FROM USER DOCS)		

Table 268: Delete Recording Command Prerequisites

Command	**Description**
[*#id*]96	Erase image memory.

Table 269: Delete Recording Command

Response	**Description**
*#id*0196	Command accepted for processing.
*#idee*96	Command failed, and *'ee'* is the explanation code.

Table 270: Delete Recording Reply

8. Command Summary

Explanation Codes

The following codes are returned as the part of the reply to each command. The expected explanation code is always '01', representing success. All other codes represent errors.

Hexadecimal Code	Explanation
01	Success
03	Command in progress
10	Invalid command string
11	Unsupported command
12	Invalid command
13	Access denied
14	Parameter out of range
15	Invalid number of parameters
16	Invalid camera state
18	No recording in memory
20	Operation aborted
26	Time out
27	Temperature out of range
28	Disk or file error (not used)
29	File not found (not used)
30	Unable to execute command
40	Command Rejected: another user is Attached, or the command may not be performed under the current camera state

Table 271: Explanation Codes

Common Commands

The commands below are Legacy commands that have been adopted by and adapted to the HG cameras without significant *functional* change. Some have new options. For example, the Frame Rate command has more rate choices and supports multiple sequential frame rates. Other commands, such as those using frame numbers, are enhanced to support 32-bit parameters.

Command	Name	Code	Enhancements / Changes
Attach	ATT	01	Same concept, different implementation
Trigger position	TRG	04	32-bit values accepted
Frame rate	RTE	06	100K fps max, supports 3 sequential frame rates, can set pre-defined rates or arbitrary frame rates (within camera's constraints)
Exposure	EXE	07	
Time	TIM	08	
Date	DAT	09	
Session ID	SID	0C	50 character name string added
Session length	SSL	0E	
White Balance Values	WBL	12	Values can be passed in
Stop	STP	19	Standby power mode
Live	LIV	1A	Full power mode
Ready	RDY	1B	Record/Ready split into separate commands
Get camera state	STA	40	Some states obsolete
Get Frame Number Range	MMF	45	32-bit values accepted
IRIG time	IRG	47	IRIG time for frame zero
Get camera type	TYP	48	
IP Address	IPA	4D	Used for both Fast and Slow interfaces.
Subnet mask	SNM	4E	Used for both Fast and Slow interfaces.
Get temperature	TMP	50	
Get session length	SLN	51	32-bit values accepted
Camera ID	PID	52	50 character name string added
Datagram size	DGS	53	Used for both Fast and Slow interfaces.
Identify	IDN	54	
Trigger delay	TDY	5D	Adapted to HG architecture
Reset	RST	5F	Does not affect HG image memory.
File Format	FFT	6F	Download file format. JPEG
Edge Enhancement	EDG	70	Still Factory Only
Light Source Select	LSR	71	Fewer illuminant choices
Live Quick Look	LQL	72	Synonym to new Live Frame Request command
Sharpening Gain	SHP	73	Used to be Factory Only
Record	REC	74	Record/Ready are separate commands

Table 272: Inherited Commands

Unique Commands

The following HG camera commands have no exact counterpart in Legacy camera systems.

Command	Code	Description / Comments
Get Frame Rate Info	05	Return the range of frame rates allowed for the currently set sensor active area.
Camera Orientation	0A	Record an orientation setting in the camera's non-volatile settings database.
Timestamp Reference	0D	Establish Trigger time or Frame 0 time as the reference for image timestamps.
Ancillary Data	0F	Set and return the arbitrary 32-byte ancillary data.
Set OSD Mode	69	Select operating mode for composite video on-screen display.
Command Port Number	80	Select the IP port the camera listens to for host commands.
Battery Level	81	Read battery charge level.
Configure Configurable Input	82	Set up configurable input, including polarity.
Configure Strobe Output	83	Configure strobe timing relationship and polarity.
Configure External Trigger Input	84	The polarity of the Trigger Input signal can be specified independently of the Trigger Source, since it will be propagated to the Sync/Trigger system ***only*** if it has an external connection. This command can also be used to set the debounce delay.
Abort Download	86	Stop sending previously requested frames. Lets the CCU stop transmission in case of error or dropped frame. Transmission of any current frame halts immediately.
Download Frame Format	87	Similar to LFF/TFF below.
Download Frame Request	88	Transmit recorded frame #*n*. Continuous download is achieved by making another request before all previous frames have been sent. Requests are queued.
Download Rate	89	Adjusts inter-packet gap to avoid packet loss during download.
Live Frame Format Thumbnail Frame Format	8A 8B	JPEG by default, but Type2 and RGB may also be selected, as can linear or second-order encoding. **NOTE: Default is JPEG: This command is Factory-Only.**
Live Frame Request	8C	Send *n* live frames to the requestor. If requestor is not attached, then the command will fail. Use this in Live mode to avoid excessive power state cycling. May be used in any mode other than Recording Done.
Live Frame Size Thumbnail Size	8D 8E	Set reduced frame size for transmission. Specifies (x, y) position and (width, height) cropping. The decimator may also be enabled or bypassed. All requested portions of the image must lie entirely within the image area defined by the Active Sensor Area.
Live Frame Rate	8F	Set maximum frame transmission rate (to aid request queuing). Default is 30 fps.
Sensor Active Area	90	Frame size for recording. This is the size of the image to be read from the sensor and stored in camera memory. The image is taken from the center of the sensor; only height and width are specified.
Get Serial Number	91	Get camera serial number.

Command	Code	Description / Comments
Thumbnail Frame Request	92	Send a single thumbnail frame to the requestor.
Color Correction Matrix	93	Get/Set all 9 matrix values. Factory-only command.
Sharpening LUT	94	Configure/select sharpening LUT to use.
Get Camera Status	95	Full status dump, also used by Attach command.
Delete Recording	96	Valid only in Recording Done state. Camera is left in Standby state.
Get Camera Info	97	Get camera Model and Firmware version.
Exposure Select	98	Select Normal / Ambient exposure value.
Abort Live	99	Abort any requested or active Live transfer.
Get Frame Sizes	9A	Return current transfer sizes for Download, Thumbnail and Live frames.
BROC Burst Length	9B	Set the number of frames to be acquired for each BROC event.
Download Frame Size	9C	Set reduced frame size for transmission.
Announcement Setup	9D	Configure IP port and address to which Announcements are sent.
Get Sensor Size	9F	Return sensor geometry for the camera.
Try	DD	Command simulation command.

Table 273: New HG Commands

Commands Sorted Numerically

Code	Command	Code	Command
01	Attach	72	Live Quick Look
04	Trigger position	73	Sharpening Gain
05	Get Frame Rate Info	74	Record
06	Frame rate	75	Auto Ready
07	Exposure	76	Lens Control
08	Time	80	Command Port Number
09	Date	81	Battery Level
0A	Camera Orientation	82	Configure Configurable Output
0C	Session ID	83	Configure Strobe Output
0D	Timestamp Reference	84	Configure External Trigger Input
0E	Session length	86	Abort Download
0F	Ancillary Data	87	Download Frame Format
10	Exposure Shift	88	Download Frame Request
11	Set IRIG Time Reference	89	Download Rate
12	White Balance Values	8A	Live Frame Format
19	Stop	8B	Thumbnail Frame Format
1A	Live	8C	Live Frame Request
1B	Ready	8D	Live Frame Size
40	Get camera state	8E	Thumbnail Size
45	Get Frame Number Range	8F	Live Frame Rate
47	IRIG time	90	Sensor Active Area
48	Get camera type	91	Get Serial Number
4D	IP Address	92	Thumbnail Frame Request
4E	Subnet mask	93	Color Correction Matrix
50	Get temperature	94	Sharpening LUT
51	Get session length	95	Get Camera Status
52	Camera ID	96	Delete Recording
53	Datagram size	97	Get Camera Info
54	Identify	98	Exposure Select
5D	Trigger delay	99	Abort Live
5F	Reset	9A	Get Frame Sizes
64	Get IRIG Lock State	9B	BROC Burst Length
66	Frame Sync Source	9C	Download Frame Size
68	Set Video Output Mode	9D	Announcement Setup
69	Set On-Screen Display Mode	9F	Get Sensor Size
6E	Select Video Output	DD	Try (command simulation)
6F	File Format		
70	Edge Enhancement		
71	Light Source Select		

Table 274: Commands Sorted Numerically

Command Summary Sheet

The following table summarizes frequently used camera commands, in order of common use.

Command Name	Code	Abbreviated Usage
Attach	01	**#*id*0102**
Sensor Active Area	90	**#*id*90*wwwwhhhh***
Session Length	0E	**#*id*0E*nnnn* or #*id*0E*nnnnnnnn***
Frame Rate	06	**#*id*06*aa*** *or* **#*id*06*aabb*** *or* **#*id*06*aabbccxxxx*** aa/bb/cc: 01=30fps, 02=60, 03=125, 04=250, 05=500, 06=1000, 07=2K, 08=3K, 09=5K, 0A=10K, 0B=50K, 0C=100K xxxx = # post-trigger frames for cc Also **#*id*0600*aaaaaaaa*** or **#*id*0600*aaaaaaaabbbbbbbb*** or **#*id*0600*aaaaaaaabbbbbbbbccccccccxxxxxxxx***
Trigger Position	04	**#id04*nnnn*** or **#*id*04*nnnnnnnn***
Exposure	07	#***id*0701*nnnn*** ambient #***id*0702*nnnn*** normal
Exposure Select	98	#***id*9801** ambient #***id*9802** normal
White Balance	12	#***id*12*rrrrrrrrggggggggbbbbbbbb*** (16.16)
Ready	1B	#***id*1B**
Record	74	#***id*74**
Get Frame Number Range	45	#***id*45**
Light Source Select	71	#***id*71*nn*** 00=daylight, 01=tungsten, 02=HMI, 03=user
Live	1A	#***id*1A**
Stop	19	#***id*19**
Download Frame Format	87	#***id*87*nn*** 00=Type2 2nd order, 01=RGB linear, 04=JPEG linear, 21=Type2 linear
Download Frame Request	88	#***id*88*kkkkpppp*** or #***id*88*kkkkkkkkpppp*** kkkk = frame number, pppp = port
Live Frame Size	8D	#***id*8D*xxxxyyyywwwwhhhhdd*** dd = 01 decimate, 00 full size
Thumbnail Frame Size	8E	#***id*8E*xxxxyyyywwwwhhhhdd*** dd = 01 decimate, 00 full size
Live Frame Rate	8F	#***id*8F**
Live Frame Request	8C	#***id*8C*nnpppp*** nn = count, pppp = port
Abort Live	99	#***id*99**
Set Video Output Mode	68	#***id*87*mm*** 00=Off, 01=NTSC, 02=PAL
Set On-Screen Display Mode	69	#***id*87*mm*** 00=OSD Off, 01=Time, 02=Camera ID, 03=both
Select Video Output	6E	#***id*87*nn*** 00=Off, 01=Select
Thumbnail Frame Request	92	#***id*92*pppp*** pppp = port

Command Name	Code	Abbreviated Usage
Delete Recording	96	#***id*96**
Download Frame Size	9C	#***id*9C*xxxxyyyywwwwhhhdd*** *dd* = 01 decimate, 00 full size
Configure Configurable Input	82	#***id*82*nnpp*** *nn* = 00=disabled, 01=ext frame sync, 02=ROC, 03=BROC, 04=Ready, *pp* = 00 disable, 01 positive, 02 negative
Strobe Timing	83	#***id*83*nnvvvv*** *nn* = 00=disable, 01=positive, 02=negative, *vvvv* = signed –100 to 32765
Try *(Command Simulation)*	DD	#***id*DD*[Followed By Any Simulatable Command]***

Table 275: Command Summary Sheet

Command Prerequisite Matrix

Command Name	Camera State					Attach State			Modes			Intended Use		
	Standby	Live	Ready	Recording	Recording Done	Required	Ignored	Required for Modify	Individual	Group	Supports Simulation	Operator	Supervisor	Factory Only
Get Camera Status	X	X	X	X	X		X		X			X	X	
Get Camera State	X	X	X	X	X		X		X	X		X	X	
Get Camera Type	X	X	X	X	X		X		X	X		X	X	
Get Camera Info	X	X	X	X	X		X		X	X		X	X	
Get Temperature	X	X	X	X	X		X		X	X		X	X	
Get IRIG Lock State	X	X	X	X	X		X		X	X		X	X	
Get Session Length	X	X	X	X	X		X		X	X		X	X	
Get Frame Length	X	X	X	X	X		X		X	X		X	X	
Get Sensor Size	X	X	X	X	X		X		X	X		X	X	
Get Frame Rate Info	X	X	X	X	X		X		X	X		X	X	
Attach to Camera	X	X	X	X	X		X		X	X		X	X	
Identify	X	X	X	X	X		X		X	X		X	X	

Command Name	Camera State					Attach State			Modes			Intended Use		
	Standby	Live	Ready	Recording	Recording Done	Required	Ignored	Required for Modify	Individual	Group	Supports Simulation	Operator	Supervisor	Factory Only
Get Serial Number This command returns the factory-assigned 32-bit camera serial number, formatted as eight hexadecimal digits. After conversion to decimal, the value returned must match the serial number marked on the camera rear panel. **In the HG-TH console, if a recording is present for this "camera" or port, the serial number reported is for the head that made the recording, which is not necessarily the same as the currently-connected head.**	X	X	X	X	X		X		X	X		X	X	

Command Prerequisites				
Camera State	Standby	Live	Ready	Recording / Recording Done
Attach State	Required	Ignored	Required only when modifying values	
Command Modes	Individual	Group	Supports Simulation	
Intended Use	Operator	Supervisor	**Factory Only** (OMIT FROM USER DOCS)	

Table 52: Get Camera Serial Number Command Prerequisites

Command	Description
#id91	Query a camera for its serial number.

Table 53: Get Camera Serial Number Command

Response	Description
#id0191nnnnnnnn	Command succeeded where *nnnnnnnn* is the camera serial number.
#idee91	Command failed, and *ee* is the explanation code.

Table 54: Get Camera Serial Number Reply

Get Connected Head Serial Number														
IP Address	X	X	X	X	X			X	X				X	
Subnet Mask	X	X	X	X	X			X	X				X	

Command Name	Camera State					Attach State			Modes			Intended Use		
	Standby	Live	Ready	Recording	Recording Done	Required	Ignored	Required for Modify	Individual	Group	Supports Simulation	Operator	Supervisor	Factory Only
Datagram Size	X	X	X	X	X			X	X	X			X	
Command Port Number	X	X	X	X	X			X	X	X			X	X
Announcement Setup	X	X	X	X	X			X	X	X			X	X
Reset (Reboot or Fault Override) Camera	X	X	X	X	X			X	X	X			X	
Battery Level	X	X	X	X	X		X		X	X		X	X	
Time	X	X	X	X	X			X	X				X	
Date	X	X	X	X	X			X	X				X	
Timestamp Reference	X	X	X	X	X			X	X	X		X	X	
Ancillary Data					X			X	X	X		X	X	
Auto-Ready Mode	X	X	X	X	X			X	X	X		X	X	
Lens Control	X	X	X	X	X	X			X	X		X	X	
Camera ID	X	X	X	X	X			X	X				X	
Session ID	X	X	X	X	X			X	X	X			X	
Sensor Active Area	X	X			X			X	X	X	X	X	X	
Session Length	X	X						X	X	X	X	X	X	
Configure Configurable Input	X	X			X			X	X	X	X	X	X	
BROC Burst Length	X	X			X			X	X	X		X	X	
Configure Strobe Output	X	X						X	X	X	X	X	X	
Configure External Trigger Input	X	X			X			X	X	X		X	X	
Frame Rate	X	X						X	X	X	X		X	
Trigger Position (Post-Trigger Session Length)	X	X						X	X	X	X		X	
Trigger Delay	X	X						X	X	X		X	X	
Exposure	X	X						X	X		X	X	X	
Exposure Select	X	X					X		X	X		X	X	
Exposure Shift	X	X						X	X			X	X	
Ready (Initiate Pre-trigger Recording)	X	X				X			X	X			X	
Record (Manual Trigger)			X			X			X	X			X	
IRIG Time	X	X	X	X	X			X	X	X			X	
IRIG Time Reference	X	X	X	X	X			X	X	X			X	
Light Source Select	X	X	X	X	X			X	X	X		X	X	
Color Correction Matrix	X	X	X	X	X			X	X	X				X
Camera Orientation	X	X	X	X	X			X	X	X		X	X	
Sharpening Gain	X	X	X	X	X			X	X	X				X
Sharpening LUT	X	X	X	X	X			X	X	X				X
Live	X	X				X			X			X	X	
Stop	X	X	X			X			X	X			X	
Download Frame Format	X	X	X	X	X			X	X	X			X	
Download Rate Limit	X	X	X	X	X			X	X	X			X	
Download Frame Request					X	X			X				X	

Command Name	Camera State					Attach State			Modes			Intended Use		
	Standby	Live	Ready	Recording	Recording Done	Required	Ignored	Required for Modify	Individual	Group	Supports Simulation	Operator	Supervisor	Factory Only
Abort Download					X	X			X				X	
Thumbnail Frame Size	X	X	X	X	X			X	X	X	X	X	X	
Download Frame Size	X	X	X	X	X			X	X	X	X	X	X	
Live Frame Rate Limit	X	X	X	X	X			X	X	X			X	
Live Frame Request	X	X	X	X		X			X			X	X	
Live Quick Look		X	X	X		X			X			X	X	
Abort Live	X	X	X	X	X	X			X				X	
Set Video Mode	X	X	X	X	X	X			X				X	
Select Camera for Video Output	X	X	X	X	X	X			X				X	
Set On-Screen Display (OSD) Mode	X	X	X	X	X	X			X				X	
Thumbnail Frame Request	X	X					X		X			X	X	
Delete Recording					X	X			X				X	

Table 276: Command Prerequisite Matrix

Legacy Commands [Factory Use Only]

The table below lists commands present in Legacy cameras. This table is for reference only, and may be incomplete (it does not track the current state of the Legacy camera firmware). The information for the Key field is incomplete. The value codes for the Key field are:

- **P** Password-protected command
- **I** Internal Redlake command (usually for calibration)
- **L** Local-only (non-global) command
- ***** Not Documented in HG-TX User Manual

Legacy commands have both text and numeric formats, where the text format was normally used over serial connections (where it may be entered manually), and the numeric format over network connections (entered via software).

Legacy Commands				
Text Command	**Binary Code**	**Key**	**Description**	**Remarks (Relevance to HG cameras)**
	0103		Attach Global (opt. password)	N/A
	0105		Attach Local (opt. password)	N/A
ADJ		**PI**	Adjust Channel Gain or Offset	N/A
AEX	**55**		Auto expose	Feature not supported
AGN		*****	Average Green Pixels	N/A
ASV	**14**		Automatic save	New method
BPB	**1E**		Block play back	No video output on camera
BRT	**30**		Baud rate	No RS485 interface
CD	**57**		Change directory	No local storage
CLP		*****	Clip Mode	
COC		**PI**	Column Offset	N/A
DAT	**09**		Date	
DDY	**5C**		Download start delay	New method
DEL	**5A**		Delete file(s)	No local storage
DGS	**53**		UDP datagram size	Adopted
DIR	**56**		Directory listing	No local storage
DLF		*****	Download Frames #2	
DTD		*****	Detect Drive	No local storage
DWN	**28**		Download	New method, bigger frame numbers
EDG		*****	Edge Enhancement	Adopted
ETM		*****	Elapsed Time Meter	N/A
EXE	**07**		Exposure	Adopted
FFT	**6F**		File format type	Adopted
GTO	**23**		Go to frame	No video output on camera
IDN	**54**		Identify	Adopted
IMG		**PI**	Go To Camera Control Mode	N/A
IPA	**4D**	**L**	IP address	Adopted
IRG	**47**		IRIG time	Adopted
LIV	**1A**		Set Live mode	Adopted

Legacy Commands				
Text Command	**Binary Code**	**Key**	**Description**	**Remarks (Relevance to HG cameras)**
LSR		**I**	Light Source Select	Adopted
LQL		**I**	Live Quick Look	Adopted, Synonym for LFR
MD	**58**		Make directory	No local storage
MDC		**PI**	Mode Control (blue gain, etc.)	Adopted
MMF	**45**		Get frame number range	Adopted
OBR	**6C**		One button record	Feature not supported
OUT		**I**	Toucan Output Mode	Normal or Edge Gradient
PID	**52**		Camera ID	Adopted
PLY	**1C**		Play	No video output on camera
PRT	**1D**		Play rate	No video output on camera
RD	**59**		Remove directory	No local storage
RDY	**1B01**		Ready	Adopted
REC	**1BFF**		Record	Adopted
RET	**0B**		Reticle	No video output on camera
RGB		*****	Return Reticle Box RGB values	Not needed
RPL	**6B**		Disable rear panel buttons	No rear panel buttons on camera
RST	**5F**		Reset	Adopted
RTE	**06**		Frame rate	Adopted
SDF	**4B**		Set download frames	New method, bigger frame numbers
SHP		*****	Sharpening Gain	Adopted
SID	**0C**		Session ID	Adopted
SLN	**51**		Get session length	Adopted
SLT	**65**		Split frame	Use new sensor setup command
SNM			IP subnet mask	Adopted
SPA	**4C**	**PI**	Set MAC address	Set at factory
SSL			Session length	
STA			Get camera state	Adopted
STP			Stop	Adopted
SYN			Frame sync mode on/off	Adopted
TDY			Trigger delay	Adopted
TIM			Time of day	Adopted
TMP			Get camera temperature	Adopted
TRG			Trigger position	Adopted
TYP			Get camera type	Adopted
VID	**6E**		Output video switch	Adopted
VOM	**68**		Video output mode	Adopted
WBL			White balance	Adopted
WCH		*****	White Patch Cross Hair on/off	No video output on camera
WPB		**(P)**	White patch box	Adopted

Table 277: Legacy Commands

Unsupported Legacy Commands [Factory Use Only]

The Legacy commands below are not supported by HG cameras, and will return an error whenever sent to the camera.

Mnemonic	Code	Description
AEX	55	Auto exposure
ASV	14	Automatic Save
BPB*	1E	Block Playback
BRT	30	Baud rate
CLP		Clip Mode
CD	57	Change directory
DDY	5C	Download start delay
DEL	5A	Delete file(s)
DIR	56	Directory listing
DWN	28	Download
GTO	23	Go to Frame
SPA	4C	MAC Address
MD	58	Make directory
OBR	6C	Auto Acquire Record Mode
PLY	1C	Play
PRT	1D	Play rate
RD	59	Remove directory
RET	0B	Reticle
RGB		Return Reticle Box RGB values
RPL	6B	Disable Rear panel buttons
SDF	4B	Set download frames
SLT	65	Split frame select
VID	6E	Output video Switch
VOM	68	Select video output mode

Table 278 Unsupported Legacy Commands

Appendix A: Image Transmission

HG cameras do not create fully formatted image files as such, and the host (the recipient of the frame data, such as the CCU/DCU) performs all image file creation and management functions. When presented with a request for a frame of video data, the camera will generate a reply containing the frame image data and an instance of the Border Data (Appendix B) describing the frame content. It is the responsibility of the host to use the data as needed, such as displaying it, formatting it for storage, analyzing it, or discarding it.

Images sent by HG cameras via the Live/Thumbnail/Download Frame Request commands are sent as a series of UDP/IP datagrams, each of which may in turn be composed of multiple Ethernet packets. The following discussion describes the UDP/IP datagram stream.

A.1 Pixel Types

Images may be requested in any permutation of the following “flavors”:

Type	Description
Size	Images may be decimated (zoomed down) from their native size.
Number of 8-Bit Image Planes	Images may be single-plane (Type2) or triple-plane (RGB, JPEG).
Encoding	8-bit pixels may be encoded linearly (truncated from 12 bits), with non-linear encoding (optimizing the placement of the 256 available codes across the entire dynamic range, accounting for noise). Additionally, entire images may be encoded with JPEG encoding.

Table 279: Image Format Permutations

While the camera supports the full set of the above permutations, many of them are superfluous. The formats typically used by host applications include:

Type	Description
Download Type2	Full size, single plane, 8 bits, non-linear encoding
Download TIFF	Full size, triple-plane, 8 bits, linear encoding
Playback	1/2 size (1/4 the pixels), JPEG encoding
View “Live”	1/2 size (1/4 the pixels), JPEG encoding
View “Thumbnail”	1/2 size (1/4 the pixels), JPEG encoding

Table 280: Typical Image Formats

For color cameras, Type2 data consists of a single plane of data sampled from a triple-plane RGB image. Each pixel location contains either the Red, Green or Blue color component value from the corresponding RGB pixel. The color component selected maps directly to the Bayer CFA (Color Filter Array) overlaying the sensor, the first pixel of which is identified in the Border Data “Hg100k.FirstPixelType” field (see Appendix B). The data may be stored in a non-linear format, and may be expanded to 16-bit linear data via the Border Data “Hg100k.ExpandPixels” lookup table. The full RGB image may then be reconstructed by interpolation using a proprietary Redlake Inc. algorithm.

For monochrome cameras, the Type2 data and “RGB” both consist of a single plane of pixels, with no mapping to the color domain. The only difference is that monochrome “RGB” data will always have linear pixels, and Type2 data may have non-linear pixels.

The JPEG data emitted by the camera originates from a JPEG compression engine.

A.2 Frame Request Protocol

A host can request thumbnail frames, live frames, or recorded frames. A thumbnail frame request is a request for a single recently captured frame. A request for a live frame is a "keep-going token" used for flow control during live viewing; this mechanism is described in detail below. A request for a recorded frame identifies a specific frame number; these requests can be queued ahead so that the Camera starts sending another frame immediately after the previous one is sent.

The Camera does not distinguish a download for playing a recorded image from a download for storing data. It is the responsibility of the host to ensure that it receives data as reliably as it requires. The host can issue retry requests as needed; it might choose to ignore dropped frames during fast play and only retry when saving or playing very slowly.

To retry, the host repeats the request for a frame; there is no provision for retrying smaller units such as UDP packets. Before issuing a retry, the host should send a "Transmit Abort" command to stop the Camera's transmission of any previously requested frames.

Each command requesting a frame receives the typical short response indicating that the command was received and the parameters to the command were valid (or an error response). Image transmission begins immediately with image packets sent to the port specified in the frame request command. There is no guarantee that the response to the frame request command will arrive before the first image packet, but operating system buffering generally permits the receiver to wait for the command acknowledgment before receiving from the socket that was created for image reception.

Up to two requests for recorded frames can be outstanding concurrently. This allows the data movement to avoid lag time between frames; the Camera can start sending the next frame immediately. For download it is not necessary that the host use this facility; it can choose to simply request a frame, then wait for the entire frame to arrive, then request the next frame. However, it is unlikely that the host can achieve a play rate of 30 frames per second without requesting one frame ahead.

The host controls the pacing of display for recorded frames. It can play the frames at a regular rate determined by its own local clock. It need only request data far enough in advance to ensure that each frame is available in its local memory when the time comes to display it. But by controlling the timing at the host, there is an intentional delay between the arrival of a frame and its display; the host will not display the frame until its time. Although this is acceptable when playing recorded frames, live frame transmission is handled differently to achieve both minimal latency and desired frame rate.

The same mechanism used for playing recorded frames is used for downloading recorded frames for archival. Again the host completely controls the timing. In this case, the host's delays come from disk access rather than from sleeping until the next frame display time. But from the Camera's viewpoint, play and download are the same.

For live frame transmission, it is important to minimize the time between capture of a frame and its display. The host must not insert any artificial delays; it must begin decode and display of data received, as soon as possible. Therefore, for live frame transmission the Camera controls the pacing.

The Camera sends live frames at a regular rate, which defaults to 30 frames per second. The host can reduce the rate with a rate-control command. There is a second mechanism to help the host avoid exhausting system buffers when the Application Program is unable to maintain the current rate. The host must send a live-frame request for each frame to be sent; these can be queued well ahead based on the hosts buffering availability. If time comes to transmit a frame and no "live frame request token" is available, the Camera stops sending until another request is received.

A.3 Frame Segmentation

Each video frame is sent as a series of segments, each segment filling one UDP packet (datagram). A trailer (not a header!) within each UDP packet provides the frame number and segment's sequence number. Figure 2 illustrates the segmentation of image data into UDP packets and the segmentation of UDP packets into Ethernet packets.

The first UDP packet is designated the "frame header packet" and is constructed by firmware; this packet has a length appropriate for the content to be sent and is probably about 1 KB.

Successive UDP packets containing image data are all of one size. (That size was given in the header packet.) The last image data UDP packet includes padding if necessary to fill it out to the same size as the others. Image data packets are constructed by hardware.

The final UDP packet for a frame is designated the "frame trailer packet" and is constructed by firmware. The frame trailer contains the actual length of the image so the receiver will know how to remove any added padding.

The "Maximum Image Data" value provided in the frame header is the worst-case count of image data bytes. It does not include possible padding in the last UDP packet. For RGB and Type 2 images, the maximum size is equal to the image data size; for JPEG, the maximum size is generally much larger than the actual length.

Each UDP packet, whether firmware-generated or hardware-generated, includes a segment trailer for the receiver's use in reassembling the frame. Table 281 illustrates the format of the per-segment trailer, which is placed at the end of the UDP packet. The header packet is always Segment 0 and the first image data packet is Segment 1. The "Last Segment" flag is set for the last segment containing image data. The "Frame Trailer" flag is set in the frame trailer packet. Negative offsets in the "Byte Offset" column are from the end of the packet.

Byte Offset	Bits	Size (bits)	Field	Comment
–8	31-0	32	Frame Number	A signed (twos complement) 32-bit numeric value.
–4	31	1	Is Last Image Segment	1 if this is the last segment of image data, 0 otherwise.
–4	30	1	Is Frame Trailer	1 if this is the frame trailer packet, 0 otherwise. Always 0 in image data packets sent by FPGA.
–4	29-0	30	Segment Number	The segment number within this frame. Segment 0 is the firmware-generated header. The first image data segment is 1.

Table 281: Segment Trailer

Segments containing image data are transmitted in order, but the header packet and trailer packet are transmitted asynchronously with respect to the image data. The frame header packet is transmitted either before or soon after the first image data segment; the trailer packet is always transmitted after the header packet but could be sent either before or after all image data is sent.

In the Segment Trailer, shown in Table 281, the fields marked with boldface are written by the FPGA for each segment. When sending image data, the FPGA always clears bit 30, "Is Frame Trailer."

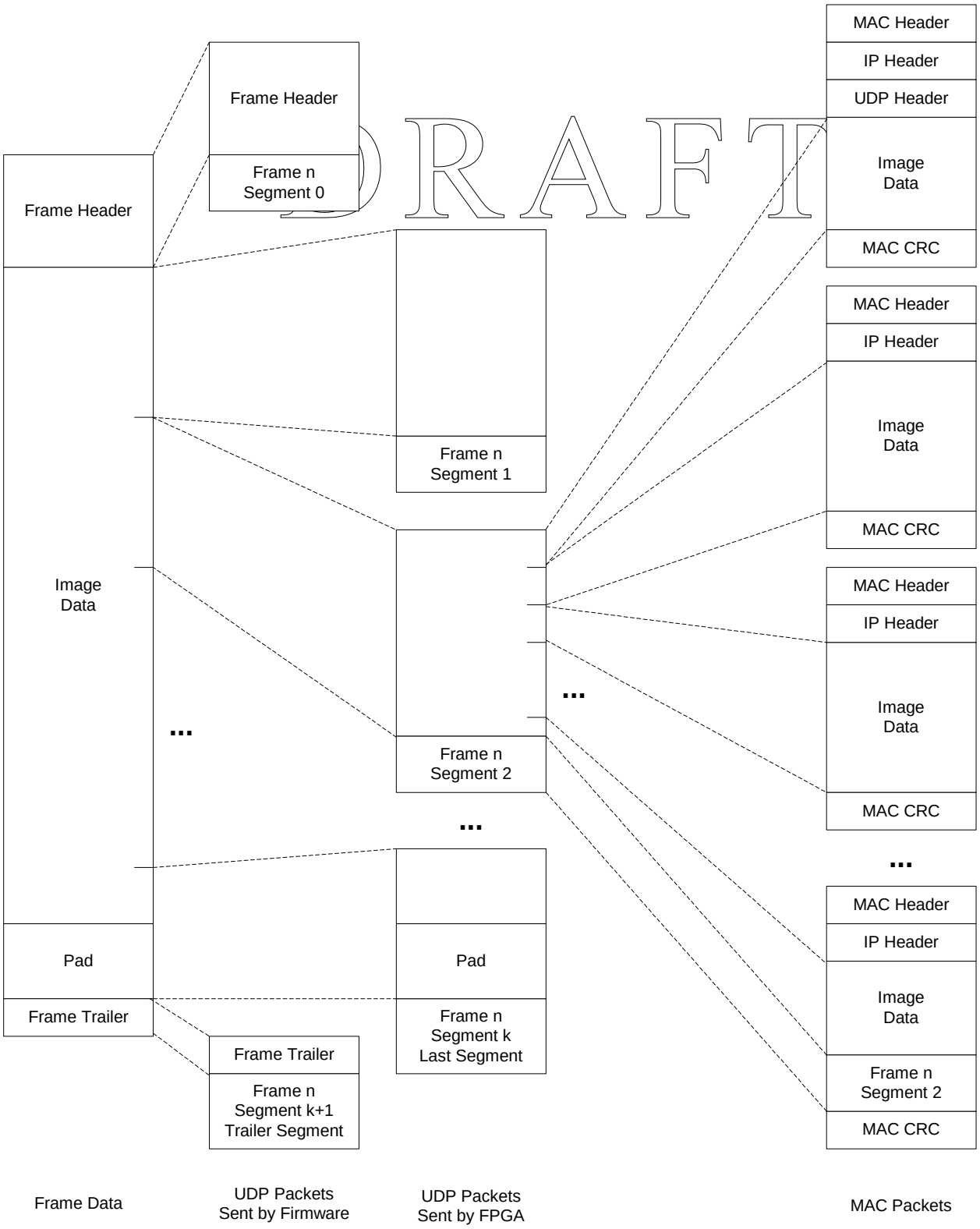


Figure 2: Image Packets

A.4 Trailers vs. Headers

There are several reasons to use a trailer on each UDP packet instead of a header. One reason is that it allows hardware to compute a UDP checksum. The UDP checksum is a field of the UDP header. When the first Ethernet packet containing the initial data is transmitted, not all data is available so the checksum cannot be computed. If checksums are to be used, an artificial value for the checksum must be inserted in that UDP header. With a trailer at the end of the UDP packet, the last word of the packet can contain the value that causes that artificial checksum to be correct. The current implementation does not use UDP checksums, but this mechanism allows for a possible future enhancement by increasing the trailer size and modifying the hardware to compute checksums.

A second reason for using trailers is ease of buffer management in the receiving software. The software can receive UDP packets into a large buffer without having to juggle headers. Each UDP packet must typically be retrieved from the operating system in a single “recv()” call that writes data into a buffer provided by the application. *By placing per-packet information at the end, the beginning of the packet is the actual image data that immediately follows the previously received image data.* Each packet can be written to the next buffer location, overwriting the trailer information of the previous packet.

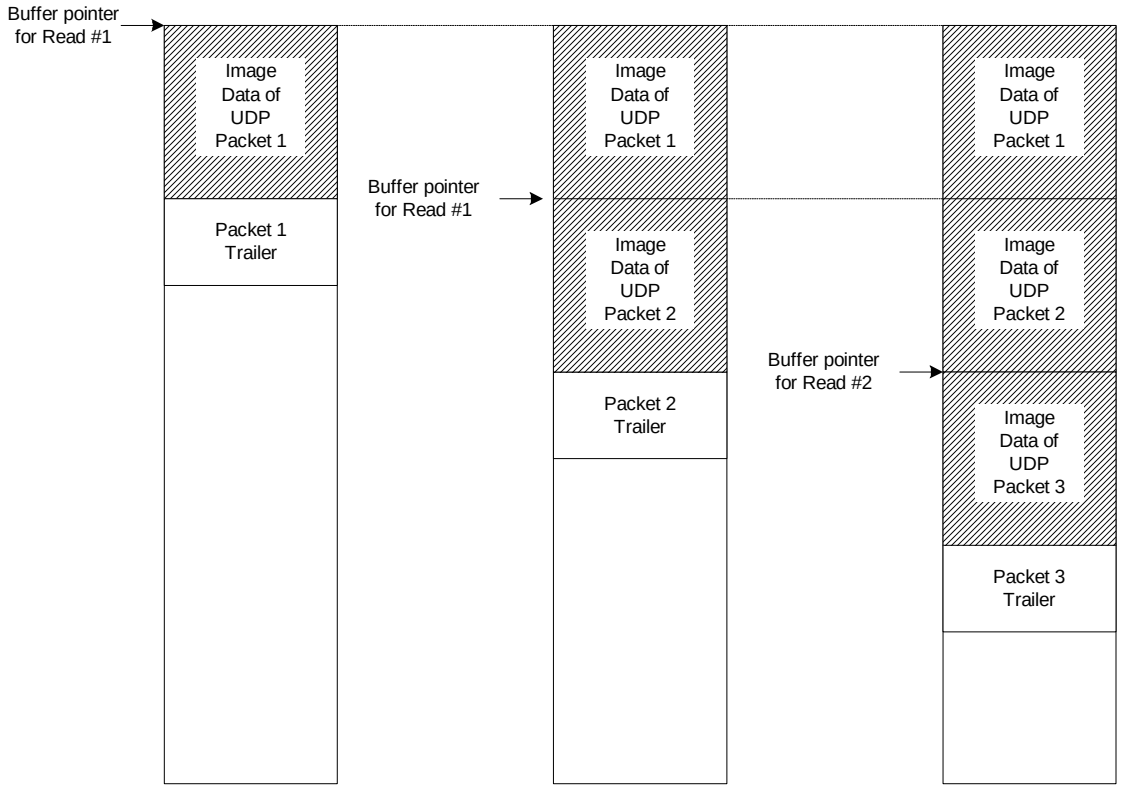


Figure 3: Trailers in Image Buffers

A.5 Frame Data Headers

A Type2 file has its Border Data structure (Appendix B) at the end of the file. For transmission of Type2 data, however, the header is sent first so that the per-frame border information can be available early. Having image dimensions and other details available when the first packet is received may provide some advantages to the receiver for buffer management or performance optimization.

To construct a Type2 file, host software should retain the Border Data from the header packet in memory, then receive the image data and write it to a file or memory buffer as it is received, then append the Border Data so it will land at the end of the file.

A TIFF file contains a header defined by the TIFF specification. Rather than constructing actual TIFF headers, the Camera sends sufficient information for the receiver to construct a TIFF file if it chooses. As in Type2 transmissions, the first UDP packet includes the Border Data.

The transmission formats for JPEG data are similar to the other formats. However, because the size of a JPEG image is not known when the header packet is constructed, the receiver cannot discover the size until the trailer packet is received. To create a JPEG file, the receiver must construct a JPEG header and prefix it to the image data transmitted from the camera. The information required to create this header is in the Border Data.

For live play, some of the Border Data structure is not required or even meaningful, but headers for live play still include the Border Data structure. Some Border Data fields contain artificial values when sending live frames. Although frames for live views do not have formal frame numbers, the transmitted frames are sequentially numbered so receiving software can distinguish segments of different frames. Thumbnail frames also contain artificial frame numbers.

When recorded data is sent, the frame numbers conform to the “Trigger Frame Zero” conventions. Frame numbers before the trigger frame have negative numbers, those after have positive numbers, and the trigger frame is numbered zero.

The Frame Header is shown in Table 282.

Byte Offset	Bits	Size (bits)	Field	Comment
0	7-0	8	Image Type	JPEG, Type2, RGB
1	7	1	Is Live Image	1 if live, 0 if recorded
1	6	1	Is Thumbnail Quality	1 if lesser quality for thumbnail
1	5-0	6	Reserved	
2	15-0	16	UDP Size	Size of UDP packets containing image data, in bytes
4	31-0	32	Maximum Image Data	Maximum amount of image data to be sent, in bytes
8	-	-	Border Data	See Border Data definition

Table 282: Frame Header

The Frame Trailer is shown in Table 283.

Byte Offset	Bits	Size (bits)	Field	Comment
0	31-0	32	Actual Image Size	The actual amount of valid image data that was sent, pad excluded

Table 283: Frame Trailer

A.6 IP Fragmentation

A UDP packet (datagram) can be larger than a single Ethernet packet. By using these larger UDP packets, the receiving Application Program does not need to retrieve data one Ethernet packet at time. A lower level of the operating system assembles fragments without application intervention.

The image transmission hardware segments each UDP packet into multiple Ethernet packets by emulating the activity of an IP protocol stack. The fragmentation is illustrated in Figure 2. Each frame is broken into multiple UDP packets. Each UDP packet is broken into multiple Ethernet packets. The MAC and IP headers appear in each packet. The first Ethernet packet of the UDP packet contains a UDP header.

The MAC header is shown in Figure 4. It contains a 48-bit destination address, a 48-bit source address, and a 16-bit “DIX Ethernet 2” protocol type field, which is always set to hexadecimal 0800 to indicate “Internet Protocol” or IP as the next layer.

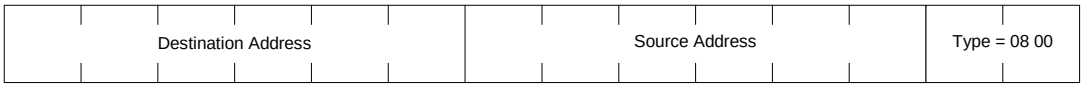


Figure 4: MAC Header

The next layer is the IP protocol, which provides fragmentation. The IP protocol header is illustrated in Table 284. Most of the fields are ignored by the hardware and their definitions in the table below are subject to change. Firmware fills in a template at the start of transmission of a frame; the state machine then updates certain fields for each packet.

IP Protocol Header					
Byte Offset	**Bits**	**Size (in bits)**	**Field**	**Content**	**Comment**
0	7-4	4	Version	4h	
0	3-0	4	Internet Header Length in 32-bit words	5h	
1	7-5	8	Type of Service: Precedence	000b	Routine
1	4	1	Type of Service: Delay	0b	Normal Delay
1	3	1	Type of Service: Throughput	1b	High Throughput
1	2	1	Type of Service: Reliability	0b	Normal Reliability
1	1-0	2	Type of Service: Reserved	00b	
2	15-0	16	Total Length	(compute)	1500 except in last fragment
4	15	1	Identification Constant	1	Always 1 to distinguish from software-generated IP packets
4	14-0	15	Identification	*From counter in FPGA*	Increment at the start of each UDP packet
6	7	1	Flags: Reserved	0b	
6	6	1	Flags: Don’t Fragment	0b	May Fragment

IP Protocol Header					
Byte Offset	**Bits**	**Size (in bits)**	**Field**	**Content**	**Comment**
6	5	1	Flags: More Fragments	*0b or 1b*	1 on all fragments except the last
6	4-0	5	Fragment Offset High Bits	*Offset*	Offset is a multiple of 185
7	7-0	8	Fragment Offset Low Bits	*Offset*	Offset is a multiple of 185
8	7-0	8	Time To Live	01h	Don't propagate through routers?
9	7-0	8	Protocol	11h	UDP = 17d
10	15-0	16	Header Checksum	*Checksum*	
12	31-0	32	Source Address	sw	Provided by software
16	31-0	32	Destination Address	sw	Provided by software

Table 284: IP Header

The image transmission state machine fills in the IP header fields listed below:

IP Identification	This field aids reassembly of datagrams. The actual value does not matter, but it must change each time a new datagram (UDP packet) is started. All fragments of one datagram have the same IP Identification. The high bit of the IP Identification field is always 1 in the image data IP fragments.
More Fragments Flag	The flag is set if there are more fragments, clear otherwise. Therefore, the More Fragments Flag bit is 1 on all fragments except the last.
Fragment Offset	A multiple of 185, which is the maximum Ethernet IP content size divided by eight. The content size is the Ethernet frame size less the size of the MAC and IP headers and MAC CRC field. Each time a fragment is sent, 185 are added to the fragment offset.
Header Checksum	The 16-bit ones complement of the ones complement sum of all 16-bit words in the header. For purposes of computing the checksum, the value of the checksum field itself is zero.

The first IP/Ethernet packet of a datagram contains the UDP header, defined below. The UDP Length field is set by software to the correct value for all but the last packet. The image transmission state machine modifies the Length field for the last packet based on the Segment Size and the Frame Length.

Byte Offset	**Bits**	**Size (in bits)**	**Field**	**Content**	**Comment**
0	15-0	16	Source Port	sw	
2	15-0	16	Destination Port	sw	
4	15-0	16	Length	SW/FPGA	Set by software for initial packets, set by hardware for last packet
6	15-0	16	Checksum	0000h	Not using UDP checksums.

Table 285: UDP Header

The last IP/Ethernet packet of a datagram finishes with the segment trailer as defined in Table 281. Because of the UDP packet header in the first packet and the segment trailer in the last packet, those MAC packets can contain different amounts of image data than the intermediate packets. Intermediate packets contain 1480 bytes of image data. Because of the 8-byte UDP header and the 8-byte segment

trailers, the first and last packet of a segment contains at most 1472 bytes of image data. The last MAC packet could contain less than 1472 bytes. The UDP packet size can be any multiple of 4 bytes.

A.7 Fragmentation Example

Suppose the frame length is 1,696,512 = 1504 x 1128 and the software datagram size is 16,384. Then the FPGA Segment Size register will be set to 16,392 (software's datagram size plus UDP header size). This results in 104 UDP packets. Each of the first 103 UDP packets contains 16,376 bytes of image data plus 8 bytes of trailer; the UDP Length field is 16,392. The 104th UDP packet contains 9784 bytes of image data, 6592 bytes of padding, and 8 bytes of trailer; the UDP Length field is 16,392.

When sending the UDP packets, each is fragmented into 12 IP fragments, each of which corresponds to one MAC packet. The first of those 12 MAC packets contains 14 bytes of MAC header, 20 bytes of IP header, 8 bytes of UDP header, 1472 bytes of image data, and 4 bytes of CRC; the IP Total Length field is 1500. The 2nd through 11th of those MAC packets each contains 14 bytes of MAC header, 20 bytes of IP header, 1480 bytes of image data or padding, and 4 bytes of CRC; the IP Total Length field is 1500. The 12th packet contains 14 bytes of MAC header, 20 bytes of IP header, 104 bytes of padding, 8 bytes of trailer, and 4 bytes of CRC; the IP Total Length field is 132.

First Pkt	Intermediate Pkts (× 10)	Final Pkt	Content
14	14	14	MAC Header
20	20	20	IP Header
8			UDP Header (UDP Length=9800)
1472	1480	104	Image Data or padding
		8	Segment Trailer
4	4	4	MAC CRC
1518	1518	150	Total Bytes in MAC Packet
1500	1500	132	IP Header "Total Length" Field

Table 286: Initial Packet Content Summary

When all the smoke has cleared, the total image data sent is

```
(104 × (1472 + (10 × 1480) + 104)) - 6592 = 1,696,512 bytes
```

Appendix B: Border Data

HG cameras send an instance of the 1024 byte Border Data block with each image transmitted by the camera. This block is not directly compatible with either the content or format of the Legacy Border Data, but has many close similarities. Those items in the "Common" portion have corresponding entries in the Legacy Border Data, and items in the "Hg100k" portion are unique to the HG system. Fields marked "RESERVED" are initialized to zero.

The following HG Border Data Format description employs a language-independent offset / size / type / content description format. All numeric multi-byte fields are in ***network byte order*** (big-endian).

Name	Offset	Size	Type	Description
Common.FileSignature	0	8	char[8]	"HG-100K" + trailing NULL
Common.VideoType	8	1	enum	Color = 1, Mono = 2, Unknown = 0
Common.SessionID	9	1	uint8	0 thru 255
Common.CameraID	10	1	uint8	0 thru 255 (default = 1)
Common.RecordRate	11	1	enum	0 = Unknown, 1 = 30 fps, 2 = 60 fps, 3 = 125 fps, 4 = 250 fps, 5 = 500 fps, 6 = 1 K fps, 7 = 2 K fps, 8 = 3 K fps, 9 = 5 K fps, 10 = 10 K fps, 11 = 50 K fps, 12 = 100 K fps
RESERVED	12	1	N/A	RESERVED
Common.RecordMode	13	1	enum	0 = Record, 1 = Stop, 2 = Trigger, 3 = Trigger2
Common.WhiteBalance	14	1	enum	0 = Daylight, 1 = Tungsten, 2 = HMI, 3 = User, 4 = Unity (all ones)
Common.LightSource	15	1	enum	0 = Daylight, 1 = Tungsten, 2 = HMI, 3 = User, 4 = Unity
Common.McdlPresent	16	1	enum	0 = Absent, 1 = Present
Common.IrigPresent	17	1	enum	0 = Absent, 1 = Present
Common.WhiteBalanceCoefs.Red	18	4	float	IEEE-768, in network byte order
Common.WhiteBalanceCoefs.Green	22	4	float	IEEE-768, in network byte order
Common.WhiteBalanceCoefs.Blue	26	4	float	IEEE-768, in network byte order
Common.FrameNumber	30	2	int16	Signed, relative to trigger frame (16-bit version of Hg100k.FrameNumber)
Common.IsTriggerFrame	32	1	enum	0 = NOT trigger frame, 1 = IS trigger frame
Common.RealTimeDate.Seconds	33	1	BCD	Upper nibble is 10s, lower is 1s
Common.RealTimeDate.Minutes	34	1	BCD	Upper nibble is 10s, lower is 1s
Common.RealTimeDate.Hours	35	1	BCD	Upper nibble is 10s, lower is 1s
Common.RealTimeDate.Day	36	1	BCD	Upper nibble is 10s, lower is 1s
Common.RealTimeDate.Month	37	1	BCD	Upper nibble is 10s, lower is 1s
Common.RealTimeDate.Year	38	1	BCD	Upper nibble is 10s, lower is 1s
Common.IrigTime.Day100s	39	1	uint8	0 thru 3
Common.IrigTime.Day10s	40	1	uint8	0 thru 9
Common.IrigTime.Day1s	41	1	uint8	0 thru 9 (0 thru 366 with above)

Name	Offset	Size	Type	Description
Common.IrigTime.Hour10s	42	1	uint8	0 thru 2
Common.IrigTime.Hour1s	43	1	uint8	0 thru 9 (0 thru 59 with above)
Common.IrigTime.Minute10s	44	1	uint8	0 thru 5
Common.IrigTime.Minute1s	45	1	uint8	0 thru 9 (0 thru 59 with above)
Common.IrigTime.Second10s	46	1	uint8	0 thru 5
Common.IrigTime.Second1s	47	1	uint8	0 thru 9 (0 thru 59 with above)
Common.IrigTime.Microseconds	48	4	uint32	0 thru 999,999
Common.ElapsedTime.Minutes	52	2	int16	Signed, relative to trigger time.
Common.ElapsedTime.Microseconds	54	4	int32	Signed, relative to trigger time.
Common.MdclData	58	60	uint16[30]	UNUSED
RESERVED	118	1	N/A	RESERVED
Common.Exposure	119	4	uint32	23 thru 33330 microseconds
Hg100k.InterfaceZone	123	4	uint32	***Always zero***
Hg100k.BorderDataFormat	127	1	enum	0 = HG/CR/TX, 100 = HG-100K
Hg100k.CameraName	128	51	char[51]	A null-terminated ASCII text string
Hg100k.SessionName	179	51	char[51]	A null-terminated ASCII text string
Hg100k.FirstPixelType	230	1	enum	0 = Red, 1 = Blue, 2 = Green on a Red Row, 3 = Green on a Blue Row
Hg100k.SerialNumber	231	4	uint32	Must match camera label
Hg100k.SensorActiveArea.x	235	2	uint16	32 thru 1504 by steps of 32
Hg100k.SensorActiveArea.y	237	2	uint16	8 thru 1128 by steps of 8
Hg100k.PipelineState	239	4	uint32 (bit vector)	Root Hub Absent = 0x00008000 All other bits are RESERVED, and may have arbitrary values.
Hg100k.EdgeEnhancement	243	1	enum	0 = None, 1 = 0.5, 2 = 1.0, 3 = 1.5, 4 = 2.0
Hg100k.ColorCorrectionMatrix.R0C0	244	4	Radix16	16.16 fixed point (/ 65536.0)
Hg100k.ColorCorrectionMatrix.R0C1	248	4	Radix16	16.16 fixed point (/ 65536.0)
Hg100k.ColorCorrectionMatrix.R0C2	252	4	Radix16	16.16 fixed point (/ 65536.0)
Hg100k.ColorCorrectionMatrix.R1C0	256	4	Radix16	16.16 fixed point (/ 65536.0)
Hg100k.ColorCorrectionMatrix.R1C1	260	4	Radix16	16.16 fixed point (/ 65536.0)
Hg100k.ColorCorrectionMatrix.R1C2	264	4	Radix16	16.16 fixed point (/ 65536.0)
Hg100k.ColorCorrectionMatrix.R2C0	268	4	Radix16	16.16 fixed point (/ 65536.0)
Hg100k.ColorCorrectionMatrix.R2C1	272	4	Radix16	16.16 fixed point (/ 65536.0)
Hg100k.ColorCorrectionMatrix.R2C2	276	4	Radix16	16.16 fixed point (/ 65536.0)
Hg100k.FrameNumber	280	4	int32	-1,864,134 thru 1,864,134 (approx.)
Hg100k.TimeSincePriorFrame	284	4	uint32	Microseconds
Hg100k.FrameFormat	288	1	enum	0 = RGB, 1 = Type2, 2 = JPEG
Hg100k.ImageSize.x	289	2	uint16	Post crop/decimate
Hg100k.ImageSize.y	291	2	uint16	Post crop/decimate
Hg100k.MaxPixelValue	293	2	uint16	Always 255
Hg100k.BlackOffset	295	2	uint16	Always 0
Hg100k.PixelEncoding	297	1	enum	0 = 2^{nd} order, 1 = linear

Name	Offset	Size	Type	Description
Hg100k.Gamma	298	1	fp8	4.4 fixed point (divide by 16.0)
Hg100k.JpegRestartInterval	299	2	uint16	See PM-36 Data Sheet
Hg100k.JpegQualityFactor	301	2	uint16	See PM-36 Data Sheet
Hg100k.ExpandPixels	303	512	uint16[256]	8-to-16-bit LUT, reverses PixelEncoding to generate 16-bit linear pixels. N/A for JPEG, use three times for RGB.
Hg100k.ExtendedFrameRate	815	4	uint32	Frame Rate, in frames per second.
Hg100k.AncillaryData	819	32	uint8[32]	User-supplied data. See the Ancillary Data command.
Hg100k.CameraOrientation	851	2	uint16	User-supplied camera orientation setting. See the Camera Orientation command.
Hg100k.TimeZeroReference	853	1	uint8	01=Timestamps referenced to Trigger time. 02=Timestamps referenced to Frame Zero start of exposure.
Hg100k.TimestampOffset	854	4	int32	Signed offset added to frame's timestamp.
Hg100k.TriggerDebounceTime	858	4	uint32	Trigger debounce delay.
Hg100k.FrameSyncSource	862	1	uint8	Frame timing synchronized to 0=Internal, 1=IRIG, 2=GPS
Hg100k.IrigReference	863	1	uint8	IRIG/GPS timestamp for this frame is referenced to Start of Exposure=1, Middle=2, or End=3
Hg100k.ExposureShift	864	4	uint32	
Hg100k.TimeBaseLocked	868	1	uint8	True if the camera's clock is locked to the currently-selected timebase, identified in FrameSyncSource
RESERVED AREA	869	150	uint8[158]	***Always zero***
Hg100k.BorderDataFormatVersion	1019	1	uint8	1=version 1 format; has corrected ExpandPixels table for Type 2 downloads. 2=version 2 format, has fields at 862-868 which were added for HG-XR.
EndOfBorderData	1020	4	char[4]	4 ASCII chars = "EoBD" (***E***nd ***o***f ***B***order ***D***ata) = 0x456F4244 integer

Table 287: Border Data Format

Appendix E: Definitions and Formulas

E.1 Definitions

INT	Integer function: round down to nearest integer (i.e., truncate fractional part)
Width	Sensor active area width, in pixels. Width must always be an integral multiple of 32, greater than or equal to 32.
Height	Sensor active area height, in pixels. Height must always be an integral multiple of 8, greater than or equal to 16.
SessionLength	Number of frames than the camera can hold in its image memory.
Rate	Maximum record frame rate allowed by camera, expressed in frames per second.
FPS	Frames Per Second
ExposureSetting	The nominal exposure, in microseconds, set in the camera (e.g. via the "Set Exposure" command).
ExposureTime	Actual light integration time for the camera's CMOS sensor, in microseconds.
ExposureStartDelay	The time, in microseconds, between an active edge on **SYNC IN** and camera shutter open.
StrobeDelaySetting	The nominal strobe delay, in microseconds, set in the camera.
StrobeDelay	Difference between the active edge at the camera's **STROBE** output and the actual start of integration time at the camera's CMOS sensor, in nanoseconds.
TriggerDelaySetting	The nominal Trigger Delay, in microseconds, set in the camera.
TriggerDelay	Difference between the detection of an active **TRIGGER** input (camera or hub) and the recognition of the trigger event by cameras, in microseconds.

E.2 Session Length

The camera's report of maximum session length provides the most accurate information, but an approximation of the number of frames that will fit into capture is given by:

$$SessionLength_{Min} = 1$$

HG-100K with 2 GB of memory

$$SessionLength_{Max} = 2 \times INT\left(\frac{268{,}435{,}424}{\frac{Width \times Height}{4} + 32}\right)$$

HG-100K with 4 GB of memory

$$SessionLength_{Max} = 4 \times INT\left(\frac{268{,}435{,}424}{\frac{Width \times Height}{4} + 32}\right)$$

HG-LE with 1 GB of memory

$$SessionLength_{Max} = 1 \times INT\left(\frac{268{,}435{,}424}{\frac{Width \times Height}{4} + 32}\right)$$

HG-LE with 2 GB of memory

$$SessionLength_{Max} = 2 \times INT\left(\frac{268{,}435{,}424}{\frac{Width \times Height}{4} + 32}\right)$$

HG-TH with 2 GB of memory

$$SessionLength_{Max} = \frac{2}{\#ofheads} \times INT\left(\frac{268{,}435{,}424}{\frac{Width \times Height}{4} + 32}\right)$$

HG-TH with 4 GB of memory

$$SessionLength_{Max} = \frac{4}{\#ofheads} \times INT\left(\frac{268{,}435{,}424}{\frac{Width \times Height}{4} + 32}\right)$$

HG-TH with 8 GB of memory

$$SessionLength_{Max} = \frac{8}{\#ofheads} \times INT\left(\frac{268{,}435{,}424}{\frac{Width \times Height}{4} + 32}\right)$$

E.3 Frame Rates

Running in Normal mode, the camera uses its internal frame rate generator. The internal frame rate generator supports a set of specific frame rates (60, 125, 250, etc.), as described in the Command Protocol document. The camera will only accept frame rate settings that do not exceed $Rate_{Max}$, as given below. For example, at 1504 × 1128, $Rate_{Max}$ is 1034.6 frames per second. The fastest rate available from the internal frame rate generator that does not exceed this value is 1000 frames per second.

When using the camera's **SYNC IN** input, the camera is not limited to the specific frame rates generated by the internal frame rate generator. In this mode, the camera will run at any frame rate, provided $Rate_{Max}$ is not exceeded. Frame rates are forced to the next lower multiple of 5 and must be no more than 113195.

$$Rate_{Min} = 30$$

HG-100K

$$Rate_{Max} = \min\left\{ \begin{array}{l} \dfrac{10^9}{7{,}467 + \dfrac{Height}{4}\left(267 + 16.67\dfrac{Width}{8}\right)} \\ \\ \dfrac{10^6}{ExposureSetting + 3} \end{array} \right.$$

HG-LE

$$Rate_{Max} = \min\left\{ \begin{array}{l} \dfrac{10^9}{7{,}467 + \dfrac{Height}{4}\left(267 + 16.67\dfrac{Width}{4}\right)} \\ \\ \dfrac{10^6}{ExposureSetting + 3} \end{array} \right.$$

HG-TH

$$Rate_{Max} = \min\left\{ \begin{array}{l} \dfrac{10^9}{7{,}467 + \dfrac{Height}{2}\left(267 + 16.67\dfrac{Width}{8}\right)} \\ \\ \dfrac{10^6}{ExposureSetting + 3} \end{array} \right.$$

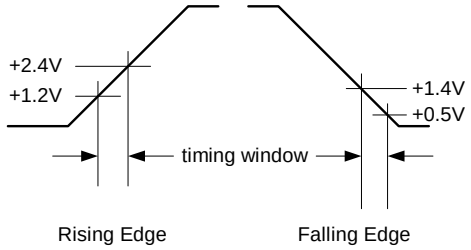
Note that the maximum frame rate is limited by both the sensor resolution and by the exposure setting, whichever is most restrictive.

Rates lower than 30FPS may be applied at the camera's **SYNC IN** input when the camera is running in External Sync mode. At frame rates lower than 30FPS, the camera's temperature compensation system may not operate correctly, and picture quality may degrade.

Rates greater than $Rate_{Max}$ may be applied at the camera's **SYNC IN** input when the camera is running in External Sync mode. However, the camera will only recognize a request to start a new exposure (active edge on **SYNC IN**) after $1/Rate_{Max}$ seconds have passed since the last exposure was started. That is, the camera will not expose frames at a rate greater than that allowed by the current sensor area (resolution) and exposure settings.

E.4 External Sync Exposure Timing

With the camera in External Sync mode, the user may configure the **SYNC IN** input to recognize either rising or falling edges as requests to begin an exposure. The camera will recognize a rising edge as the input level rises through the +1.2V to +2.1V range. The camera will recognize a falling edge as the input level falls through the +1.4V to +0.5V range. Long transition times on **SYNC IN** will introduce greater uncertainty in the precise time that the camera starts an exposure, as shown below. To minimize the uncertainty in exposure timing, keep transitions times on **SYNC IN** short.



Each time the camera completes an exposure, it begins a readout process that moves captured image data from the sensor's photodiodes to the camera's image memory. The sensor's pixels are read out row by row. The sensor requires a brief pause between each row read out. The sensor's shutter is only allowed to open during these pauses, or after the read out process for the previous frame has completed. This means that the camera may not be able to open the shutter with precisely on the active edge of **SYNC IN**, or even with a consistent delay after the active edge. There is some variation in when the shutter will actually open, based on when the active edge arrives relative to the read out of the previous frame.

The minimum delay from **SYNC IN** to start of exposure (*ExposureStartDelay*$_{Min}$) will occur when the sensor readout process has completed by the time the **SYNC IN** edge arrives at the camera. In this case, there is no additional delay required for the exposure process to synchronize with the sensor readout process.

$$ExposureStartDelay_{Min} = 4.3$$

HG-100K

$$ExposureStartDelay_{Max} = 6.5 + 0.01667\left(\frac{Width}{8}\right)$$

HG-LE/TH

$$ExposureStartDelay_{Max} = 2.3 + 0.01667\left(\frac{Width}{4}\right)$$

In order to be recognized as a valid exposure request, an input pulse on **SYNC IN** must be at least 4μSec wide.

E.5 Exposure Time

The actual time that the sensor's shutter is open is longer than the nominal exposure time set through the camera's command interface. Also, for reasons similar to those described above for the variations in exposure start times, there is some variation in actual exposure times that depends on the arrival time of an exposure request relative to the sensor readout process.

For exposure settings of 1 or 2 microseconds:

$$ExposureTime = ExposureSetting + 4.2 \pm 0.1$$

The camera (FW rev 20030226_01) generates Frame Sync pulses that are exactly the same length as the Exposure setting. However, there are delays in the sensor timing associated with both the start of exposure and end of exposure. The start of exposure occurs when the sensor FPGA de-asserts sensor Reset. This happens (shortest case) five 60MHz clocks after the active edge of Frame Sync, or 83.333… microseconds late. The end of exposure occurs on the falling edge of the sensor Sample signal. The sensor FPGA generates this signal after several delays: 2 or 3 state machine transition delays, TsuPCH, TwPCH, ThoPCH, and TwSMP. This all adds up to 255 clocks (worst-case) or 4.25 microseconds. Since the start of exposure is delayed by 83 microseconds, the actual exposure time is 4.16 microseconds (longest) or 4.15 (shortest). Scope measurements show actual times as long as 4.3 microseconds. It's not clear whether this is measurement error or additional delays not accounted for. In any event, we add some tolerance to allow for this.

For exposure settings 3 microseconds and longer:

HG-100K

$$ExposureTime_{Min} = ExposureSetting + 2.1 - 0.01667\left(\frac{Width}{8}\right)$$

$$ExposureTime_{Max} = ExposureSetting + 4.3$$

HG-LE/TH

$$ExposureTime_{Min} = ExposureSetting - \left(2.1 + 0.01667\left(\frac{Width}{4}\right)\right)$$

$$ExposureTime_{Max} = ExposureSetting + 0.1 \quad \text{(for all models)}$$

E.6 Strobe Output Timing (with internal Frame Rate Generator)

When the Strobe Delay setting in the camera is less than or equal to zero, the **STROBE** output will lead the actual start of exposure. The minimum lead time is given by:

$$StrobeDelay_{Min} = -StrobeDelaySetting$$

The maximum lead time is given by:

HG-100K

$$StrobeDelay_{Max} = \begin{cases} -StrobeDelaySetting + 0.10, & ExposureSetting < 3 \\ -StrobeDelaySetting + 2.2 + 0.01667\left(\frac{Width}{8}\right), & ExposureSetting \geq 3 \end{cases}$$

HG-LE/TH

$$StrobeDelay_{Max} = \begin{cases} -StrobeDelaySetting + 0.10, & ExposureSetting < 7 \\ -StrobeDelaySetting + 2.2 + 0.01667\left(\frac{Width}{4}\right), & ExposureSetting \geq 7 \end{cases}$$

When the Strobe Delay setting in the camera is greater than zero, the **STROBE** output will be delayed from the actual start of exposure. The delay time, in microseconds, is given by:

HG-100K

$$StrobeDelay_{Min} = \begin{cases} StrobeDelaySetting - 0.10, & ExposureSetting < 3 \\ StrobeDelaySetting - \left(2.2 + 0.01667\left(\frac{Width}{8}\right)\right), & ExposureSetting \geq 3 \end{cases}$$

$$StrobeDelay_{Max} = StrobeDelaySetting$$

HG-LE/TH

$$StrobeDelay_{Min} = \begin{cases} StrobeDelaySetting - 0.10, & ExposureSetting < 7 \\ StrobeDelaySetting - \left(2.2 + 0.01667\left(\frac{Width}{4}\right)\right), & ExposureSetting \geq 7 \end{cases}$$

$$StrobeDelay_{Max} = StrobeDelaySetting$$

E.7 Hardware Trigger Delay through Hubs

The camera will designate one frame in its image memory as "Frame 0." Frames recorded after Frame 0 are numbered 1, 2, 3…. Those recorded prior to Frame 0 are numbered –1, –2, –3…. Frame 0 is the frame whose exposure started most recently at the time the camera recognized the Trigger event. That is, the time that the camera recognizes the Trigger event is always prior to the time frame 1's exposure started, but after (or at) the time Frame 0's exposure started.

There is always a delay from the time the Trigger signal enters the system (at a Hub or Camera **TRIGGER** input), until the cameras recognize the Trigger event. The minimum and maximum delays are expressed here in microseconds:

$$TriggerDelay_{Min} = TriggerDelaySetting + 650$$

$$TriggerDelay_{Max} = TriggerDelaySetting + 750$$

The variation between minimum and maximum trigger delays, as shown above, apply from one recording to the next. For one recording, the variation in the trigger delay among cameras in a system is limited to ±1μSec.

E.8 Cable Lengths and Timing

The Sync/Trigger/Power (STP) cables that connect cameras to hubs, and hub to hubs, carry the signals that cameras use to synchronize themselves to one another. Differences in total STP cable length between the root hub and various cameras will introduce small skews in the timing among cameras. The equations shown above do not include these skews.

The STP cables add about 6 nanoseconds per meter of propagation time to the trigger and synchronization signals. Thus, in a five-hub, two-camera system, one camera could be connected with a short (5 Meter) STP cable, while the other could have a total of 500 Meters of cable in the path to the root hub, for a cable length difference of 496 Meters. The downstream camera's timing would be skewed almost 3 microseconds behind the upstream camera. This skew would affect the frame synchronization between the two cameras. In addition, this delay would be added to the Trigger Delay time, if the trigger signal were applied at the downstream camera.