KissCAM Pro Datasheet and User Manual

Features

- **1280 x 960 Resolution (1.2MP)**
- **Global Shutter**
- **Dual SD Card Slots**
- **Colour or mono with filter options**
- **S-mount lens holder for 2.1 to 16mm lenses**
- **Miniature size (46 x 36 x 17mm)**
- **Low mass (20g)**
- **3.3 - 5V Supply at 90mA**
- **UART command and telemetry interface**
- **Tested from -20 to +60°C**

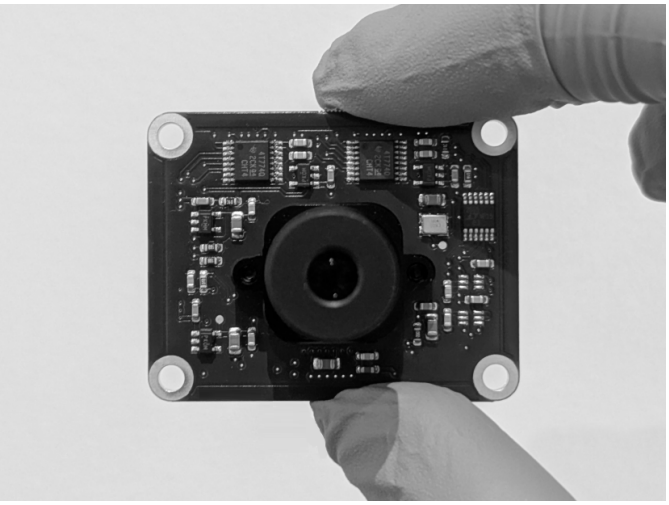


Figure 1: KissCAM Pro miniature still camera.

Applications

- Engineering/Inspection camera for small satellites
- Earth observation payload for CubeSats
- Context camera for high-resolution imagers

1. General Description

The MVP KissCAM Pro is a miniature, low-cost, imager for satellites. It is designed for small size, ease of use and rapid integration, making it ideal for use as an engineering inspection camera or simple CubeSat payload.

KissCAM is designed around the Microsemi AR0135 automotive CMOS image sensor. Onboard power regulation allows KissCAM to be powered from either 3.3 or 5V. Communication with KissCAM is via a logic-level or RS422 UART interface, which is readily compatible with most microcontrollers.

The command and telemetry interface is simple to understand and implement. Essential functions, such as setting the exposure and capturing images can be accessed through single telecommands. Direct access to image sensor registers is also available for advanced users.

KissCAM takes monochrome or bayer-colour filter images in standard (640 x 480 pixels) or high definition (1280 x 960 pixels). Redundant micro-SD card slots provide ample image storage. An image preview mode at 80 x 60 pixels is also available.

Despite its small size (38 x 20 x 18mm) and mass (10g), KissCAM Pro features all glass and metal optics. A low-profile, wide-angle lens is fitted as stock, but the aluminium s-mount lens holder allows compatibility with a wide variety of commercial M12 lenses and optical filters.

Reliability is considered through conservative PCB layout, automotive-grade components, and IPC Class 3 manufacture.

2. Absolute Maximum Ratings

Table 1: Absolute Maximum Ratings of KissCAM

Parameter	Rating	Unit	Notes
Supply Voltage	−0.3 to +6	V	
RS422 Interface Input	−60 to +60	V	±15kV ESD protected
Storage Temperature	−20 to +85	°C	

Note: Stresses above those listed under Absolute Maximum Ratings can cause permanent damage to the device.

3. Electrical Specifications

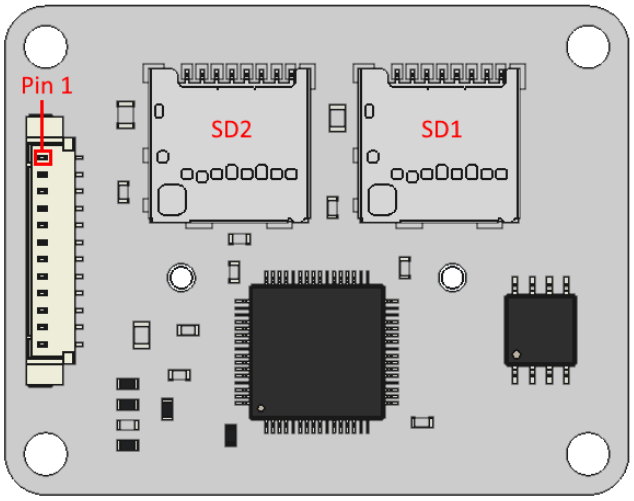
Table 2: Electrical Specifications and standard operating conditions.

Parameter	Symbol	Min.	Typ.	Max.	Unit	Conditions
Supply Voltage	V_{dd}	3.2	3.3	5.5	V	3.3V Recommended.
Current Consumption	I_{dd}	60	90	150	mA	Min: Standby. Max: SD card ops
UART Interface Baud	b	115200	921600	921600	baud	8 data bits, 1 stop bit, no parity.

4. Pinout

Electrical interfacing to KissCAM is via a single 12-way Molex Picoblade connector (53261-0671).

Table 3: Electrical Pinout

Pin	Name	Description	Connector Location
1	TX+	RS422 Interface	
2	TX-	RS422 Interface	
3	RX-	RS422 Interface	
4	RX+	RS422 Interface	
5	RS422 GND	RS422 Interface	
6	+1V8	Do not use	
7	SIG GND	Do not use	
8	AUX	Do not use	
9	TTL RX	Do not use	
10	TTL TX	Do not use	
11	V_{dd}	Power 3.3V to 5V	
12	GND	Power Ground	

5. Mechanical Specifications

KissCAM was designed from the ground up to be compatible with even the smallest CubeSats, while still offering the flexibility of a standard M12 lens mount. MVP Aerospace offers a wide-angle lens as standard, but customers can order KissCAM without a lens if they wish to fit their own.

KissCAM is designed to be mounted using four M3 cap-head screws. It is light enough to be mounted as a daughter board on standard 1.6mm thickness PC104 cards, as are common in CubeSats. In this way, KissCAM can easily be added as a primary or auxiliary payload on the Z+/Z- end of the PC104 card stack. Alternatively, KissCAM can be mounted to the X or Y panels using standoffs.

All KissCAM materials have been carefully chosen to be low-outgassing. The Molex Picoblade connector has extensive flight heritage, the lens mount is anodised aluminium, and the stock lens is all metal and glass construction. The PCB material is FR4 Tg 155. All staking is performed with flight heritage epoxy.

The customer is responsible for staking the connector and mounting screws.

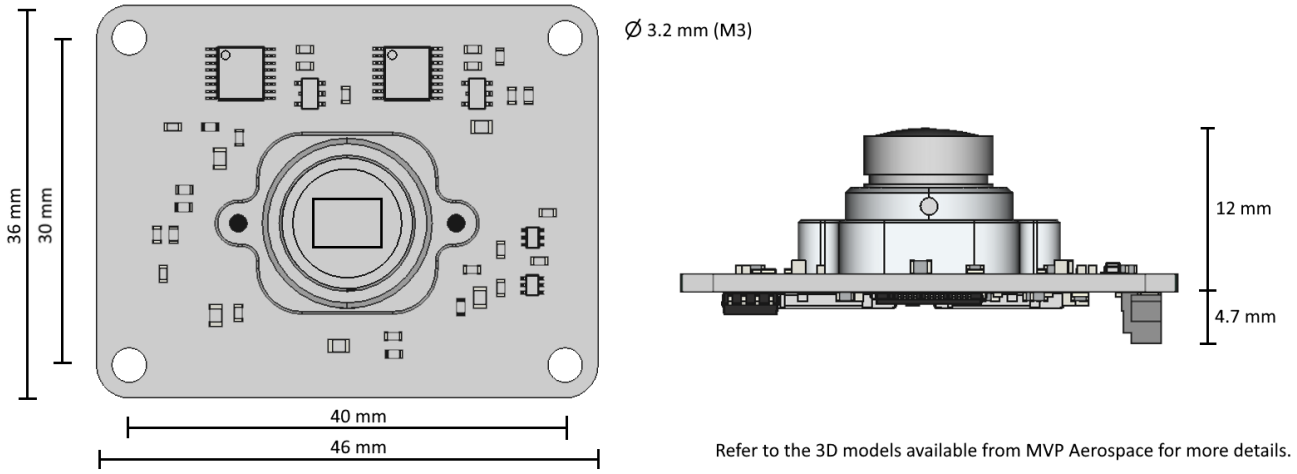


Figure 2: KissCAM primary dimensions. Refer to the CAD model for more detailed information.

Table 4: Mechanical and Optical properties

Parameter	Value	Unit	Notes
L x W x H	46 x 36 x 17	mm	1 mm tolerance
Sensor Alignment	0	Degrees	Image length aligned to KissCAM length
Weight without lens	7	g	
Weight of stock lens	3	g	All metal and glass lens
Stock Field of View	97 x 81	Degrees	1/3” sensor, 2.1 mm FL lens
Mounting holes	4 x 3.2mm		
Mounting hardware	4 x M3 screws		Use aerospace standard torquing

6. Camera Operation

6.1 Architecture

KissCAM's architecture is based on a 1.2MP Onsemi AR0135CS CMOS image sensor connected to an ARM Cortex M microcontroller via its 8-bit parallel camera interface. Non-volatile image storage is provided by 16Mb of QSPI-connected MRAM memory. Data is transferred from the image sensor to the MCU, and from the MCU to the non-volatile memory using the MCU's DMA (Direct Memory Access) peripheral.

KissCAM is powered by 3.3V to 5V (VDD). Onboard voltage regulators generate local supplies of 1.8V and 2.5V for the MCU and image sensor. The command and telemetry interface is provided by the MCU's UART peripheral via an RS422 driver, or VDD-level logic buffer.

6.2 Image Capture and Download

KissCAM has four operating modes: Sleep, Standard definition (SD), Zoom, and High definition (HD). Transitioning between modes is possible at any time using the ***Set Mode*** command. Transitioning modes resets all image sensor registers, such as exposure, to default.

In sleep mode the image sensor is held in reset, resulting in minimum power consumption. KissCAM still responds to TTC which is not related to the image sensor, such ***Ping*** (Section 7.4.2). Image downloads are also possible.

In SD Mode, KissCAM captures full FOV images with a resolution of 640 x 480 pixels (VGA resolution). This is a quarter of the image sensor's full resolution. Digital binning, performed in the image sensor, takes the average of four pixels at a time to produce the reduced-resolution output. SD images can be saved in any of four non-volatile memory slots, and downloaded individually.

Zoom mode is similar to SD mode, except images are taken from the center 640 x 480 pixels of the image sensor.

In HD mode, KissCAM captures full FOV images with a resolution of 1280 x 960 pixels (1.2 MP). Due to the limited non-volatile memory, pnly a single HD image can be stored at a time. The image is stored across all four memory slots as shown in Figure 3, and is downloaded as four individual SD images. Any existing SD images will be overwritten when an HD image is captured.

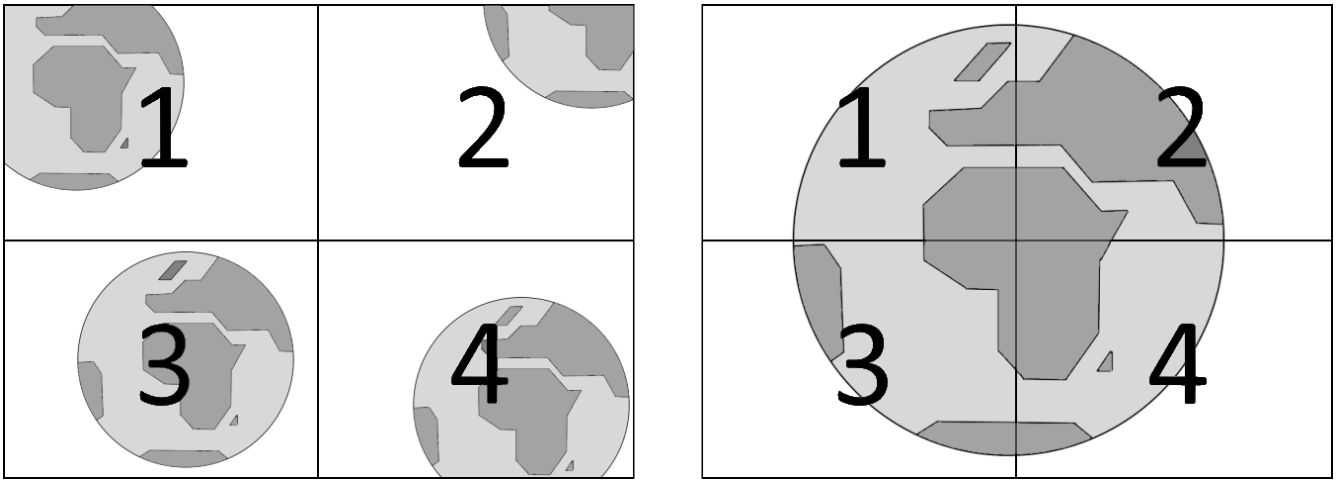


Figure 3: SD image capture (left) allows 4 VGA images to be captured into 4 memory slots, while HD image capture (right) captures a single 1.2MP image across all 4 memory slots.

6.3 Global Shutter

Modern CMOS image sensors largely fall into two categories: Global shutter and rolling shutter. Global shutter designs expose all pixels simultaneously when taking an image, while rolling shutters expose rows of pixels sequentially. Rolling shutter designs have become the most common solution in consumer-grade imagers, but can cause artifacts when capturing rapidly moving scenes.

KissCAM's automotive grade AR0135CS image sensor features a global shutter, allowing rapidly moving scenes to be captured accurately. This is useful on tumbling or slewing satellite platforms, or to capture deployables in action. Note that potential motion blur caused by long exposure times should be considered separately.

A downside to global shutter image sensors is a greater predisposition to "'hot/dead"' pixels. These are pixels that are stuck at full white or full black, or suffer from lower sensitivity. Hot/dead pixels can exist from start of life, or may appear over the sensor's lifetime. A small number of hot/dead pixels should not be considered a defect and should be post-processed out on the host platform, if required.

6.4 Bayer Colour Filter

KissCAM Pro is avaiable in monochrome or colour versions. The colour image sensor has a bayer colour pattern overlaid. This is a common technique for achieving colour images. The bayer pattern follows the sequence shown in Figure 4. If the raw data is plotted as an 8-bit greyscale image, a checkerboard pattern is typically visible. MVP Aerospace provides a utility for converting the raw images into colour. This utility is based on the Python OpenCV *cvtColor(im, cv2.COLOR_BayerGR2RGB)* function. Alternatively, commercial photo editing software capable of handling RAW images can perform the conversion.

After conversion to colour, most images will require white-balancing. This is a common process in photo editing and can be performed in most photo editing software. For more advice on raw image data processing, please contact MVP Aerospace.

Figure 4: Left - The image sensor's bayer pattern. Centre - Raw image data displayed in 8-bit greyscale displays a subtle checkerboard pattern. Right - a zoomed-in view of the checkerboard pattern caused by the bayer filter.

6.5 SD Cards

KissCAM Pro has redundant Micro-SD cards for mass, non-volatile image storage. Only one SD card can be powered on and accessed at a time, with all SD card commands operating on the currently-powered card. The SD cards operate as an extension of the standard KissCAM functionality and are not integral to the processes of capturing or downloading images.

The SD cards are accessed in SPI mode. This interface allows full-resolution images to be written to the SD card in approximately two seconds. Note that not all SD cards support SPI mode (although most reputable brands do). Please contact MVP Aerospace for a list of tested cards.

KissCAM Pro offers basic SD card file action and navigation commands. Action commands include saving, opening, or deleting an image from the SD card. Each image has a four letter name, which must be specified for action commands. File system navigation commands include iterating through images on the card, as well as returning to the first image on the card. File navigation commands only update a file pointer and return the image name, and are typically followed by an action command, such as save, open, or delete.

All cards should be formatted with FAT32 on a standard computer before use in a KissCAM Pro, and should be staked in place before vibration testing (or launch) as described in Section 8. On orbit, MVP Aerospace recommends that customers only power the SD cards when required. Individual images can still be captured and downloaded without the use of the SD cards (Section 6.2).

See Section 3 for the location and naming of the card slots.

7. Command and Telemetry

The command and telemetry interface, which operates over UART (RS422 or logic-level) at 115200 baud, is designed for simplicity and ease of integration. Commands, in the form of byte sequences (packets), are sent to the KissCAM from a host system and telemetry packets are returned. All commands have the same format and length, and all result in a telemetry or error response. Most commands simply return an acknowledge telemetry packet, while others return image or other data. KissCAM sends no unsolicited telemetry.

It is mandatory to wait for a response to a command before sending the next one. A 2000 ms timeout may be used to detect stalled or broken communication, in which case the command can be retried or KissCAM power cycled.

7.1 Command Format

Command Format						
0x40 '@'	Command	Param 1	Param 2	Param 3	Param 4	0x0D '\r'

Every command has the same format and is composed of seven bytes. The first byte is a start byte of 0x40 '@'. Next comes a command byte. As KissCAM is designed for simplicity, there are only eight unique commands. The command bytes typically have easy to remember ASCII representations, such as 'C' for capture, and 'D' for download. See Section 7.3 for an overview of available commands, and Section 7.4 for details.

After the command byte there are four parameter bytes. How these bytes are utilised is command dependent. For example, some commands utilise 8-bit parameters, while others use 16-bit parameters (MSB transmitted first). Not all parameter bytes are used by every command. If a parameter is not used by a command it must still be transmitted (keeping the total command length at 7 bytes), but its value is ignored by KissCAM. It is recommended to transmit 0x00 for unused parameters.

Finally, every command must be terminated with a carriage return character: 0x0D '\r'.

7.2 Telemetry Format

Telemetry Format								
0x40 '@'	ACK/Err	Mode	len MSB	len LSB	Tlm 0	...	Tlm n	0x0D '\r'

All received KissCAM commands result in a telemetry or error response packet. All response packets have the same format, but may include different numbers of telemetry data points. Data length is coded into the packet to simplify host software.

The first byte of every response packet is the start character 0x40 '@', followed by an ACK byte flag. KissCAM acknowledges a successful command with a copy of the command byte in the ACK field. If a command cannot be interpreted or executed correctly an Error flag of 0xFF is returned in the ACK field instead.

The third byte represents KissCAM's current mode (Section 6.2). After the Mode byte comes a 16-bit number (MSB first) representing the number of telemetry bytes to follow (excluding the final 0x0D '\r'). The content of these telemetry bytes depends on the command, as detailed in Section 7.5. Error responses have telemetry bytes, too, giving details of the error cause. See Section 7.4.9 for details on error responses.

Finally, every response packet is terminated with a carriage return character: 0x0D '\r'.

7.3 Command and Telemetry Summary

The table below gives a summary of the available commands and their responses. It is strongly recommended that all available commands be made available at system telecommand level. The ***Read Register*** and ***Write Register*** commands should only be used with guidance from MVP Aerospace, as incorrect use can cause permanent damage to KissCAM. Details on the commands and responses are given in Section 7.4.

Table 5: Command and Telemetry Summary

Command Name	Command	Description	Response	Section
Ping	0x50 'P'	Basic health check	Uptime (s)	7.4.1
Set Baudrate	0x42 'B'	Change communication baudrate	Ack	7.4.2
Set Mode	0x4D 'M'	Set mode: Sleep, SD, HD	Ack	7.4.3
Set Exposure	0x45 'E'	Set image exposure time.	Ack	7.4.4
Capture	0x43 'C'	Capture a new image	Ack	7.4.5
Download	0x44 'D'	Download a a row of image data	Image Data	7.4.6
Read Register	0x52 'R'	Read an image sensor register directly	Register Contents	7.4.7
Write Register	0x57 'W'	Write an image sensor register directly	Ack	7.4.8
SD Card Power	0x4B 'K'	Turn SD cards on or off	Ack	7.4.9
SD Card Save	0x53 'S'	Save image to SD card	Ack	7.4.10
SD Card Open	0x4F 'O'	Open image from SD card	Ack	7.4.10
SD Card Delete	0x4E 'N'	Delete image from SD Card	Ack	7.4.10
SD Card First	0x46 'F'	Navigate to first image on SD card	File Name	7.4.11
SD Card Next	0x58 'X'	Jump to next image on SD card	File Name	7.4.11
-	0xFF	Possible response to any command	Error	7.4.12

7.4 Command and Telemetry Details

7.4.1 Ping

The ***Ping*** command checks communication and basic health status of KissCAM. It takes a single parameter which selects between an MCU-only (0x00), or MCU and image sensor (0x01), communication check. An MCU-only check tests the command-reply behaviour of KissCAM. An MCU and image sensor check also attempts to read the image sensor ID register over I2C. Both test types, if successful, return a fixed-length ACK with four telemetry bytes indicating successful and invalid command counts, and a 16-bit uptime in seconds. Failed communication results in no response or an Error response (Section 7.5.9).

Ping Command						
0x40 '@'	0x50 'P'	**PN**	0x00	0x00	0x00	0x0D '\r'

[PN] Ping Type. 0x00 MCU only, 0x01 MCU and Image Sensor.

Ping Response									
0x40 '@'	0x50 'P'	**MD**	0x00	0x04	**RXV**	**RXF**	**TM1**	**TM2**	0x0D '\r'

[MD] Mode. b[7:4] SD cards power status. b[3:0] Current KissCAM mode.
[RXV] Number of valid received commands. Rolls over at 256.
[RXF] Number of invalid received commands. Rolls over at 256.
[TM1] KissCAM uptime in seconds MSB.
[TM2] KissCAM uptime in seconds LSB.

7.4.2 Set Comms Baudrate

KissCAM Pro defaults to a UART baudrate of 921600 after boot. A switch to a lower baudrate can be commanded.

A successful ***Set Baudrate*** command will return a standard ACK, ***at the new baudrate***, with no additional telemetry bytes.

Set Baudrate Command						
0x40 '@'	0x42 'B'	**BAUD**	0x00	0x00	0x00	0x0D '\r'

[BAUD] 0x00: 115200. 0x01: 230400. 0x02: 460800. 0x03: 921600

Set Baud Response					
0x40 '@'	0x42 'B'	**MD**	0x00	0x00	0x0D '\r'

[MD] Mode. b[7:4] SD cards power status. b[3:0] Current KissCAM mode.

7.4.3 Set Mode

KissCAM has four operating modes: Sleep, Standard definition (SD), Zoom, and High definition (HD). Transitioning between the modes is possible at any time using the ***Set Mode*** command. ***Note that mode changes take up to 3 seconds to complete.***

Sleep Mode keeps the image sensor in reset, saving power. To start capturing images, KissCAM must be put into SD, Zoom, or HD mode with a ***Set Mode*** command. This brings the sensor out of reset, followed by a check of I2C communication with the sensor and setting up default image sensor register settings. A successful mode change will result in a standard ACK with no additional telemetry bytes. Mode changes reset sensor registers, such as exposure, to their KissCAM defaults.

Set Mode Command						
0x40 '@'	0x4D 'M'	**MD**	0x00	0x00	0x00	0x0D '\r'

[MD] Mode: 0 Sleep, 1 SD, 2 Zoom, 3 HD

Set Mode Response					
0x40 '@'	0x4D 'M'	**MD**	0x00	0x00	0x0D '\r'

[MD] Mode. b[7:4] SD cards power status. b[3:0] Current KissCAM mode.

7.4.4 Set Exposure

The exposure of KissCAM images can be changed with the persistent ***Set Exposure*** command. Auto-exposure algorithms can struggle with the extreme contrast between the blackness of space and the sunlit Earth, especially if the satellite is rotating, so manual exposure is preferred. The command ***Set Exposure*** takes a single parameter specifying the exposure in steps of 89.5 microseconds, and can range from 2 to 960. Therefore, the default setting of 672 gives an exposure time of: 672 x 89.5 = 60.144 ms.

The default exposure time is typically good for taking indoor images in a lab environment. Much lower exposure settings are required for images taken outdoors or from space. As a starting point, MVP Aerospace recommends an exposure setting of 10 for in-orbit images. More advanced exposure settings can be applied with guidance from MVP Aerospace.

A successful ***Set Exposure*** command will return a standard ACK with no additional telemetry bytes.

Set Exposure Command						
0x40 '@'	0x45 'E'	**EX1**	**EX2**	0x00	0x00	0x0D '\r'

[EX1] Exposure MSB.
[EX2] Exposure LSB.

Set Exposure Response					
0x40 '@'	0x45 'E'	**MD**	0x00	0x00	0x0D '\r'

[MD] Mode. b[7:4] SD cards power status. b[3:0] Current KissCAM mode.

7.4.5 Capture

Capturing an image with KissCAM is simple. The ***Capture*** command will capture a new image to memory and return an acknowledge response if successful. Thereafter, the image can be downloaded using the ***Download*** command (Section 7.4.6). KissCAM images are taken at either 640 x 480 or 1280 x 960 pixels resolution, depending on the current mode (Section 6.2). Each pixel is represented by a single data byte. Therefore, images are 300kB or 1200kB in size.

The ***Capture*** command takes two parameters: Memory Slot and Test Pattern Enable. In SD and Zoom modes there is a choice of four memory slots (1-4) to save to. In HD mode all four memory slots are used to save the four quadrants of the image, so the Memory Slot parameter is ignored.

The Test Pattern Enable parameter allows a test pattern to be saved into memory rather than a real camera image. This is useful for verifying the datapath from KissCAM to the host platform. The test pattern includes all pixel values (0-255) in a repeating pattern, as shown in Figure 5.

A successful ***Capture*** command will return an ACK with two telemetry bytes indicating the exposure used.

Capture Command						
0x40 '@'	0x43 'C'	**MEM**	**TST**	0x00	0x00	0x0D '\r'

[MEM] Memory Slot: 0-3
[TST] Enable Test Pattern. 0x00 is off. 0x01 is on.

Capture Response					
0x40 '@'	0x43 'C'	**MD**	0x00	0x00	0x0D '\r'

[MD] Mode. b[7:4] SD cards power status. b[3:0] Current KissCAM mode.

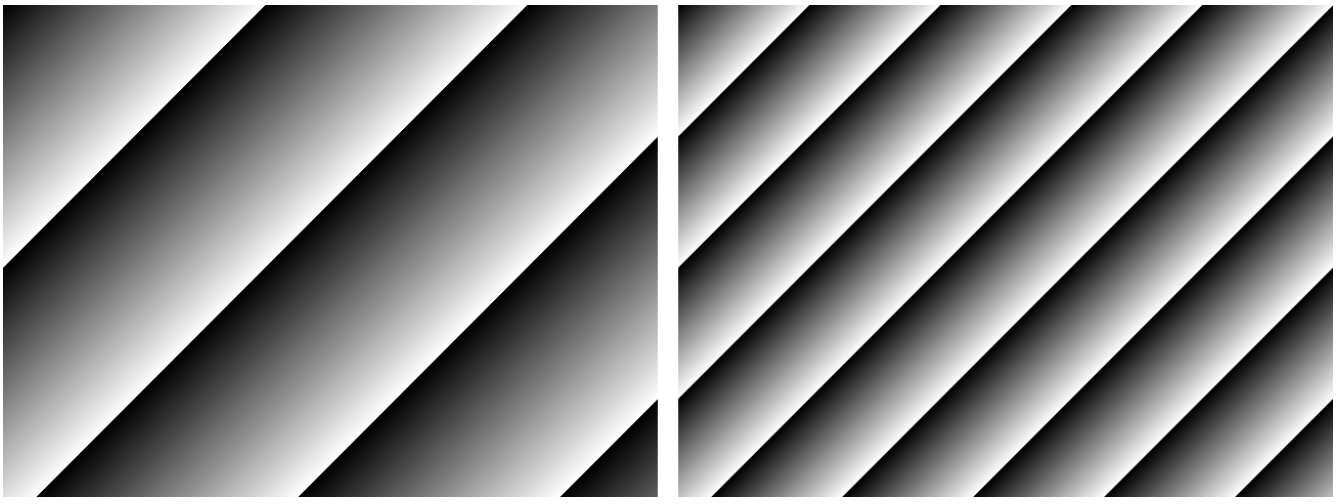


Figure 5: Test pattern in SD (640 x 480) on the left, and in HD (1280 x 640) on the right.

7.4.6 Download

Once an image has been captured with the ***Capture*** command (Section 6.4.5) it can be downloaded. Images are downloaded one image line at a time, simplifying the process of packetising the data for ground-station downlink.

The ***Download*** command takes three parameters: Memory Slot, Preview Flag, and Line Number. The memory slot (1-4) matches the same parameter in the ***Capture*** command and specifies which image slot to download. The current mode does not affect the behaviour of the download process. However, it is important to remember that images captured while in HD mode will occupy all four memory slots and will have to be downloaded as four SD images.

The preview flag parameter can be set to 0x00 or 0x01. This specifies whether a full resolution (640 x 480) or preview resolution (80 x 60) image should be downloaded. Since CubeSats typically have limited downlink bandwidth, the preview resolution images are useful for checking the usefulness of a captured image. For example, the preview resolution should be sufficient for confirming that the Earth is in the field of view and exposed correctly. The same image can be downloaded in both preview and full resolution as many times as desired.

The line number parameter specifies which line of image data to download, starting at line zero. Lines can be downloaded as many times as desired, allowing missed data to be re-downloaded. Not all lines need to be downloaded. A new image can be captured after downloading all, some, or none of the lines.

Every valid ***Download*** command will result in a KissCAM response containing a line of image data. The format of the ***Download*** response is fixed (Section 7.2), but its length depends on the line length (full resolution vs preview). Two bytes for line number are added to the start of each image line. Therefore, the data length encoded in the length bytes is equal to line length plus two.

To download an image from a memory slot the ***Download*** command should be sent 480 times with the row parameter incrementing from 0 to 479. Alternatively, to download a preview resolution image, the ***Download*** command should be sent 60 times with the preview flag set and with the row parameter incrementing from 0 to 59.

Download Command						
0x40 '@'	0x44 'D'	**MEM**	**PRE**	**LN1**	**LN2**	0x0D '\r'

[MEM] Memory Slot: 1-4
[PRE] Image Preview. 0x00 is full resolution. 0x01 is thumbnail.
[LN1] Image line number MSB.
[LN2] Image line number LSB.

Download Response								
0x40 '@'	0x44 'D'	**MD**	0x02/0x00	0x82/0x52	**LN1**	**LN2**	**IMG**	0x0D '\r'

[MD] Mode. b[7:4] SD cards power status. b[3:0] Current KissCAM mode.
[LN1] Image line number MSB.
[LN2] Image line number LSB.
[IMG] One line of image data. Either 640 or 80 bytes long.

7.4.7 Read Register

The ***Read Register*** command reads a specified 16-bit register directly from the image sensor over I2C. It exposes advanced functionality beyond the basic KissCAM telecommands. Its use should be limited to the specific test cases below, or after consultation with MVP Aerospace.

To test the system-level implementation of this telecommand, the exposure time register can be read at address 0x3012. The value of this register is 0x02A0 after power-up, or as set by the *Set Exposure* command.

Read Register Command						
0x40 '@'	0x52 'R'	**AD1**	**AD2**	0x00	0x00	0x0D '\r'

[AD1] 16-bit Register Address MSB.
[AD2] 16-bit Register Address LSB.

Read Register Response									
0x40 '@'	0x52 'R'	**MD**	0x00	0x04	**AD1**	**AD2**	**RG1**	**RG2**	0x0D '\r'

[MD] Mode. b[7:4] SD cards power status. b[3:0] Current KissCAM mode.
[AD1] 16-bit Register Address MSB.
[AD2] 16-bit Register Address LSB.
[RG1] 16-bit Register Data MSB.
[RG2] 16-bit Register Data LSB.

7.4.8 Write Register

The ***Write Register*** command writes a specified 16-bit value to a specified 16-bit image sensor register over I2C. It exposes advanced functionality beyond the basic KissCAM telecommands. Its use should be limited to the specific test cases below, or after consultation with MVP Aerospace. **Writing incorrect register settings can cause permanent damage to the device.**

To test the system-level implementation of this telecommand, the exposure time register can be written at address 0x3012. After a write, the new register value can be verified with the ***Read Register*** command (Section 7.4.6).

Write Register Command						
0x40 '@'	0x57 'W'	**AD1**	**AD2**	**RG1**	**RG2**	0x0D '\r'

[AD1] 16-bit Register Address MSB.
[AD2] 16-bit Register Address LSB.
[RG1] 16-bit Register Data MSB.
[RG2] 16-bit Register Data LSB.

Write Register Response					
0x40 '@'	0x57 'W'	**MD**	0x00	0x00	0x0D '\r'

[MD] Mode. b[7:4] SD cards power status. b[3:0] Current KissCAM mode.

7.4.9 SD Card Power

The ***SD Card Power*** command controls power to the SD cards. The SD cards can be off, or one SD card can be powered at a time. All other SD card commands described in this document apply to the currently powered card.

KissCAM polls the SD card to ensure it is not busy before allowing the card to be powered off. However, it is recommended that an additional safety delay of about three seconds is applied between SD card operations and card or unit power-off.

SD Card Power Command						
0x40 '@'	0x4B 'K'	**SD**	0x00	0x00	0x00	0x0D '\r'

[SD] 0x00 cards off. 0x01 only Card1 on. 0x02 only Card2 on.

SD Card Power Response					
0x40 '@'	0x4B 'K'	**MD**	0x00	0x00	0x0D '\r'

[MD] Mode. b[7:4] SD cards power status. b[3:0] Current KissCAM mode.

7.4.10 SD Card Actions

The SD card ***Save, Open and Delete*** action commands all take a four character file name as parameter and act on the currently-powered SD card. ***Save*** copies the data of internal memory slots 1-4 to the currently-powered SD card as a single 1280x960 image (Refer to Section 6.2 for more information on internal memory and image formats). Saving an image to SD card takes approximately 2 seconds, after which the command response will be given. It is the hosts responsibility to assign unique file names.

The ***Open*** command copies a 1280x960 image, identified by the four character filename, from SD card to internal memory slots 1-4. From there, the image[s] can be downloaded over serial following the standard process (Section 6.2). To find the filenames of images existing on the card, the KissCAM Pro file navigation commands can be utilised (Section 7.4.10). Opening an image from SD card takes approximately 2 seconds, after which the command response will be given and the image will exist in internal memory. Only files generated by KissCAM Pro should be opened.

The ***Delete*** command deletes a file on the SD card, as identified by the four character filename.

For development and debugging purposes, the KissCAM Pro SD cards can be read by a personal computer with a memory card reader. The images that KissCAM Pro saves are in binary format, with each file byte representing a single pixel. As such, the images will not appear as thumbnails or directly viewable images. MVP Aerospace recommends using their own tools, or the third-party software ImageJ, to import and view these images as raw.

SD Card Action Command						
0x40 '@'	0x53 'S' / 0x4F 'O' / 0x58 'X'	**N**	**A**	**M**	**E**	0x0D '\r'

[NAME] Four character filename.

SD Card Action Response									
0x40 '@'	0x53 'S' / 0x4F 'O' / 0x58 'X'	**MD**	0x00	0x04	**N**	**A**	**M**	**E**	0x0D '\r'

[MD] Mode. b[7:4] SD cards power status. b[3:0] Current KissCAM mode.
[NAME] Four character filename.

7.4.11 SD Card Navigation

The ***SD Card Next and First*** navigation commands do not modify the SD card contents. Instead, the are used to navigate the images already on the SD card. The ***Next*** command can be used to iterate through the image files on the card. The ***First*** command returns to the first image file on the card. Both commands generate a response with the four letter filename.

The ***First*** command returns the filename NULL if there are no files on the card. The ***Next*** command returns an Error Response (Section 7.4.11) if iterating beyond the last file.

SD Card Navigation Command						
0x40 '@'	0x4E 'N' / 0x46 'F'	**N**	**A**	**M**	**E**	0x0D '\r'

NAME Four character filename.

SD Card Navigation Response									
0x40 '@'	0x4E 'N' / 0x46 'F'	**MD**	0x00	0x04	**N**	**A**	**M**	**E**	0x0D '\r'

MD Mode. b[7:4] SD cards power status. b[3:0] Current KissCAM mode.
NAME Four character filename.

7.4.12 Error Response

Commands which can not be recognised, have invalid parameters, or encounter errors during execution, will result in an Error Response Telemetry packet. Error response telemetry packets have the same format as other telemetry packets, but the command byte copy is replaced with the error code 0xFF (See Section 6.2). Error response telemetry packets have three telemetry bytes: a copy of the command byte which caused the error, an error type code indicating the reason for the error, and an error count since boot.

The error type codes are:
0x00 - Unknown
0x01 - Unrecognised command
0x02 - Invalid parameter
0x03 - KissCAM is in the wrong mode
0x04 - Image sensor problem
0x05 - SD card problem

Error Response								
0x40 '@'	0xFF	**MD**	0x00	0x03	**CMD**	**ERR**	**RXF**	0x0D '\r'

MD Current Sensor Mode.
CMD Copy of the command which caused the error.
ERR Error Type.
RXF Number of invalid received commands. Rolls over at 256.

8. Flight Preparation

8.1 SD Cards

The SD card slots are not latching or spring loaded and rely on a friction hold. Take care when inserting or removing the cards.

SD cards should be formatted with FAT32 on a desktop computer before insertion into KissCAM. There is no ability to format the cards while in KissCAM. Not all makes of SD cards are supported. KissCAM Pros are typically supplied with SD cards, but if spares or replacements are required, contact MVP Aerospace for a list of tested cards.

8.2 Lens Focus

KissCAM may need its lens focussed before use. This allows customers to adjust the lens for close or infinity focus.

Focusing the lens is a manual process. Gently twist the lens by hand a few degrees between taking and downloading preview images. Once the image looks focused in a preview image, switch to ZOOM mode images. Be very careful not to screw the lens so deep into the lens holder that the lens hits the image sensor. Refer to Figure 7 for the approximate depth of the stock lens when focused at infinity.

8.3 Staking

Before subjecting KissCAM to vibration testing, or flight, the lens, lens holder andd SD cards need to be staked (glued). MVP Aerospace recommends using 3M 2216 epoxy, but similar space-rated alternatives are suitable, too. Before following the steps below, inspect your KissCAM as some models come pre-staked.

1. Torque the lens mount screws (Figure 6) to 0.2Nm using a T6 Torx driver.
2. Stake the lens mount screws as per Figure 6. **Ensure no epoxy touches any electrical components**.
3. Stake the lens mount as per Figure 7.
4. Once the lens is focused, place **three** blobs of epoxy around the perimeter of the lens to secure the focus (Figure 7). **Do not place epoxy around the full perimeter of the lens!**
5. Stake the SD cards in place.

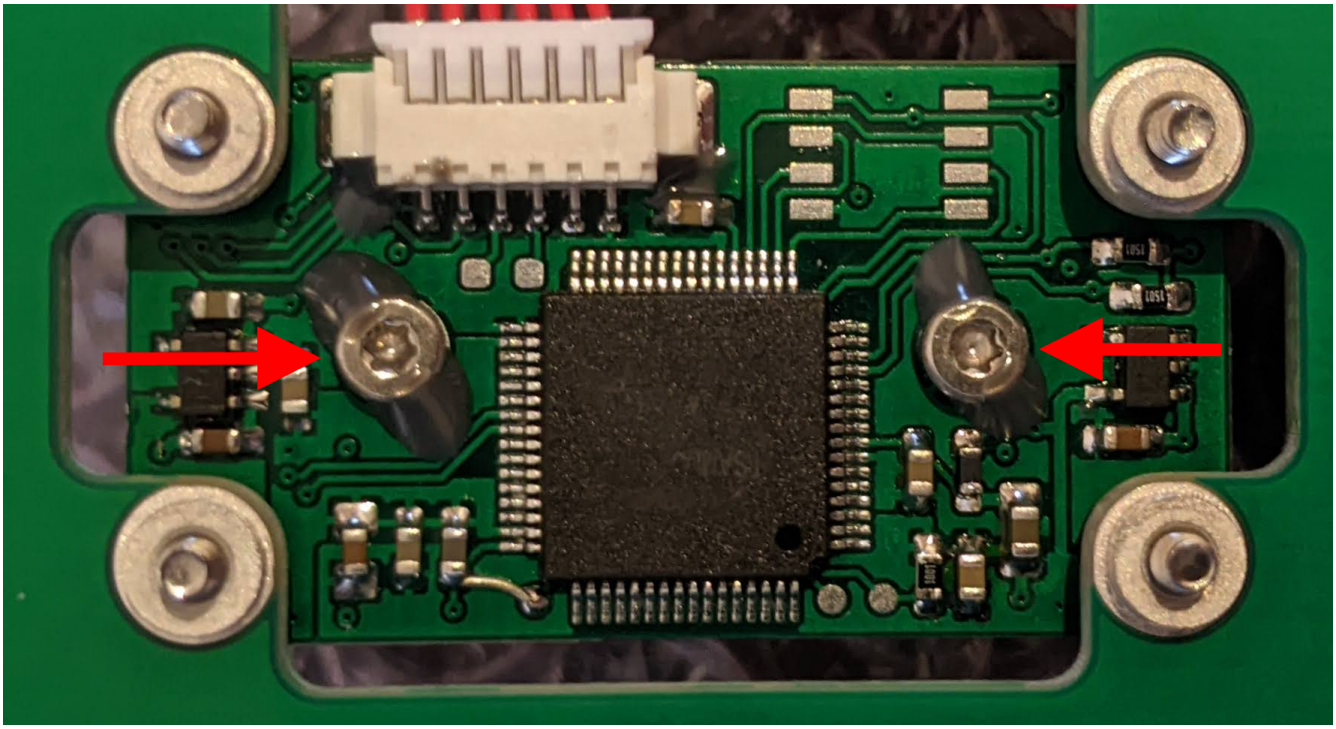


Figure 6: Staking of the lens holder screws.

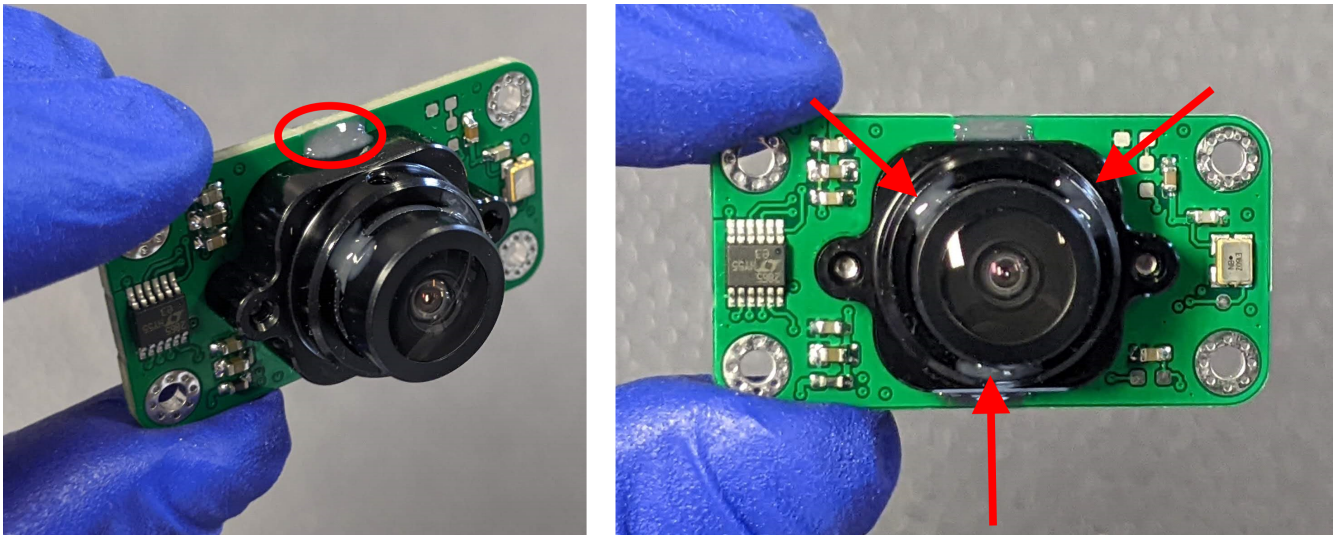


Figure 7: Staking of the lens and lens holder.

9. Quick Start Guide

Please contact MVP Aerospace for the KissCAM Pro Quick Start Guide.