DATASHEET

4D SYSTEMS

TURNING TECHNOLOGY INTO ART

Serial Camera Module

uCAM-II

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1. Description

The **uCAM-II** (microCAM-II) is a highly integrated serial camera module which can be attached to any host system that requires a video camera or a JPEG compressed still camera for embedded imaging applications.

The module uses a CMOS VGA colour sensor along with a JPEG compression chip that provides a low cost and low powered camera system. The module has an on-board serial interface (TTL) that is suitable for a direct connection to any host micro-controller UART or a PC system COM port.

The uCAM-II is capable of outputting both RAW format and JPEG format images.

User commands are sent using a simple serial protocol that can instruct the camera to send low resolution (80x60 to 160x120) single frame raw images for viewing or high resolution (160x128 to 640x480) JPEG images for storage or viewing.

The uCAM-II comes in a compact form factor with a built in lens and a 5-wire connector that provides easy access to both power and serial data.

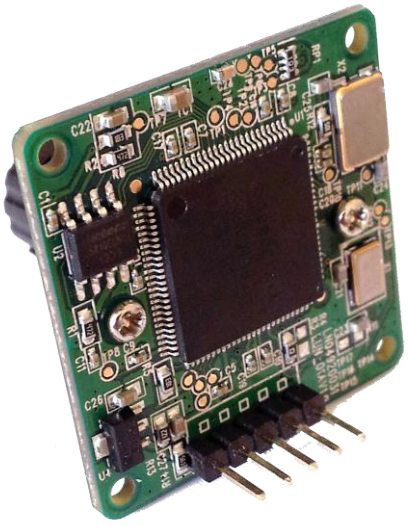
There are 3 lenses available for this camera from 4D Systems. A 56 degree (Standard), a 76 degree, and a 116 degree. These are available to purchase from 4D Systems separately if required. The uCAM-II ships with the 56 degree lens installed.

There is a locking nut on the barrel thread of the lens, which is used to lock the focus in place once set, to prevent it from inadvertently being changed.

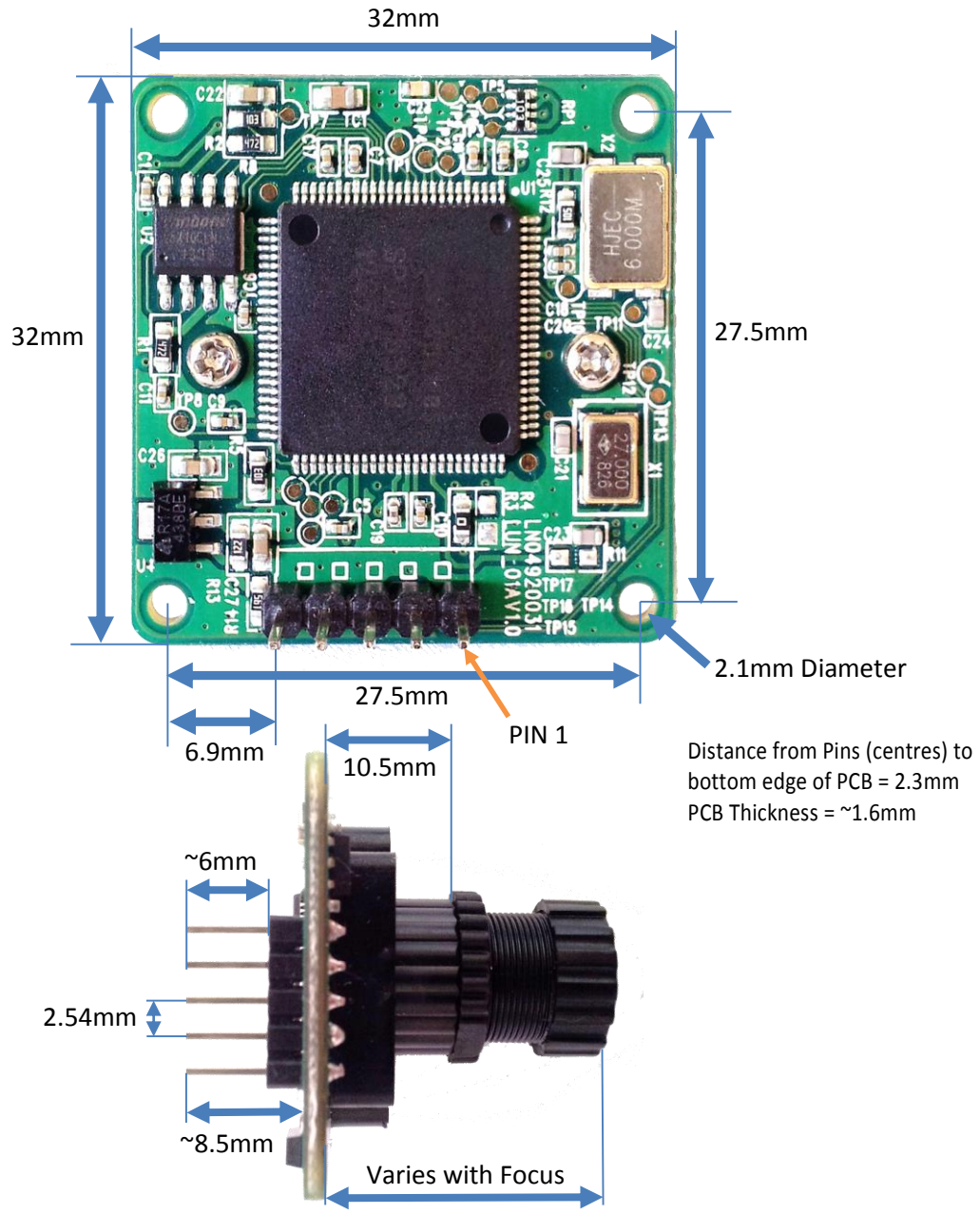


2. Features

- Small size, low cost and low powered camera module for embedded imaging applications.
- uCAM-II: 5V DC Supply nominal
- On-board EEPROM provides a command-based interface to external host via TTL serial link.
- UART: up to 3.68Mbps for transferring JPEG still pictures or raw images.
- On board VGA colour sensor and RAW / JPEG CODEC for different resolutions.
- Built-in down sampling, clamping and windowing circuits for VGA, QVGA or 160x120 image resolutions.
- Built-in colour conversion circuits for 16-bit CrYCbY, 8-bit gray, 16-bit RGB or standard JPEG images.
- No external DRAM required.
- Additions lenses available
- Locking nut for locking focus in place
- Weight ~6g.
- Dimensions: 32mm x 32mm x 21mm (without lens, including header)
- RoHS



3. Pin Configuration and Dimensions



uCAM-II Pin Outs			
Pin	**Symbol**	**I/O**	**Description**
1	5V	P	Main Voltage Supply +ve input pin. 4.5V to 9.0V DC range nominal 5V.
2	TX	O	Asynchronous Serial Transmit pin. Connect this pin to host controller Serial Receive (Rx) signal. The host receives data from uCAM-II via this pin. 3.3V Logic
3	RX	I	Asynchronous Serial Receive pin. Connect this pin to host controller Serial Transmit (Tx) signal. The host transmits commands to the uCAM-II via this pin. 3.3V Logic, however 5V Tolerant
4	GND	P	Supply Ground.
5	RES	--	Not Connected to anything – N/C.

I = Input, O = Output, P = Power

4. Pin Descriptions

5V pin 1 (uCAM-II Supply Voltage Input):
Module supply voltage input pin. This pin must be connected to a regulated supply voltage.
4.5V to 9.0V DC range, nominal 5.0V.

TX pin 2 (Serial Transmit):
Asynchronous Serial port Transmit pin, TX. Connect this pin to host Serial Receive (Rx) signal. The host receives data from the uCAM-II module via this pin. This pin outputs 3.3V logic.

RX pin 3 (Serial Receive):
Asynchronous Serial port Receive pin, RX. Connect this pin to host Serial Transmit (Tx) signal. The host transmits data to the uCAM-II via this pin. This pin is 3.3V Logic however is 5.0V tolerant.

GND pin 4 (uCAM-II Ground):
Module ground pin. This pin must be connected to ground.

5. Serial Interface - UART

The uCAM-II has a dedicated hardware UART that can communicate with a host via this serial port. This is the main interface used by the host to communicate with the module to send commands and receive back data. The primary features are:

- Full-Duplex 8 bit data transmission and reception through the TX and RX pins.
- Data format: 8 bits, No Parity, 1 Stop bit.
- Auto detect specific Baud rates from 9600 baud up to 921600 baud.
- Selectable Baud rates up to 3686400 bps.

The **uCAM-II** has low voltage serial TTL levels which can be directly interfaced to a micro-controller. The voltage levels could be converted to RS-232 through an external TTL to RS-232 converter to interface it to any RS-232 port such as the one on the PC.

Please note that while the baud rate can go up to 3686400 bps, not all RS232/RS485/TTL USB adaptors/cables can go this high. Please ensure your hardware can handle the rate you want to use. Please refer to sections 5.3 and 5.4 for more information.

5.1. Single Byte Timing

A single byte serial transmission consists of the start bit, 8-bits of data followed by the stop bit. The start bit is always 0, while a stop bit is always 1. The LSB (Least Significant Bit, Bit 0) is sent out first following the start bit. Figure 3.1 shows a single byte transmission timing diagram.

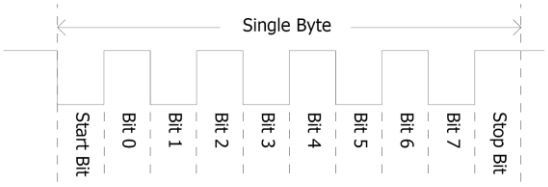


Figure 3.1: Single Byte Timing Diagram

5.2. Command Sequence Timing

A single command consists of 6 continuous single byte serial transmissions. The following Figure 3.2 shows an example of the SYNC (AA0D00000000h) command.

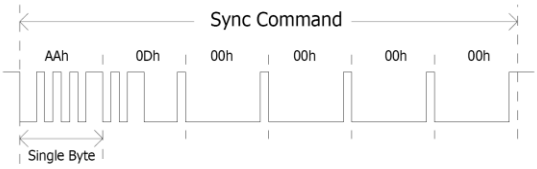


Figure 3.2: SYNC Command Timing Diagram

Please refer to section 7.1 for more information regarding synchronising the uCAM-II.

5.3. Auto-Baud Detect

The module can auto-detect the baud rate of the incoming command. The host should make connection with one of the following baud rates:

- 9600 bps
- 14400 bps
- 56000 bps
- 57600 bps
- 115200 bps
- 921600 bps

The module will keep using the last baud rate either autobauded or manually set until the next power cycle, or “full reset”.

Note: The baud rate can be set higher than the baud rated determined by the Auto-Baud detect function. Refer to Section 5.4

5.4. Setting the Baud Rates

You can set Baud rates using the Set Baud command, refer to the table in section 6.5

Note: Baud rate changes holds until “full reset” command is sent or Power cycle occurs. So, you can synchronise at any of the Auto-detect Baud rate.

5.5. Sleep mode

After the camera has been idle for 15 seconds it enters sleep (low power) mode. To wake up the camera in this state it is necessary to send the ‘Sync’ command. If the camera is required to stay awake, it is recommended to periodically end a ‘Sync’ command, such as every 10 seconds, to prevent the camera going to sleep if no other commands are being sent. If communications are occurring between the Host and the camera, the camera will not go to sleep until it has been idle for 15 seconds.

6. Command Set

Command	ID Number	Parameter1	Parameter2	Parameter3	Parameter4
INITIAL	AA01h	00h	Image Format	RAW Resolution (Still Image only)	JPEG Resolution
GET PICTURE	AA04h	Picture Type	00h	00h	00h
SNAPSHOT	AA05h	Snapshot Type	Skip Frame (Low Byte)	Skip Frame (High Byte)	00h
SET PACKAGE SIZE	AA06h	08h	Package Size (Low Byte)	Package Size (High Byte)	00h
Set Baud Rate	AA07h	1st Divider	2nd Divider	00h	00h
RESET	AA08h	Reset Type	00h	00h	XXh*
DATA	AA0Ah	Data Type	Length Byte 0	Length Byte 1	Length Byte 2
SYNC	AA0Dh	00h	00h	00h	00h
ACK	AA0Eh	Command ID	ACK Counter	00h / Package ID Byte 0	00h / Package ID Byte 1
NAK	AA0Fh	00h	NAK Counter	Error Number	00h
LIGHT	AA13h	Frequency Type	00h	00h	00h
*If the parameter is 0xFF, the command is a special Reset command and the module responds to it immediately.					

6.1. INITIAL (AA01h)

The host issues this command to configure the image size and Image Format. After receiving this command, the module will send out an ACK command to the host if the configuration was successful. Otherwise, a NAK command will be sent out.

6.1.1. Image Format

The uCAM-II can support 4 different image formats as follow:

8-bit Gray Scale (RAW, 8-bit for Y only)	03h
16-bit Colour (RAW, CrYCbY)	08h
16-bit Colour (RAW, 565(RGB))	06h
JPEG	07h

6.1.2. RAW Resolution

The uCAM-II can support 4 different image resolutions when in RAW mode:

80 x 60	01h
160 x 120	03h
128 x 128	09h
128 x 96	0Bh

6.1.3. JPEG Resolution

The uCAM-II embedded JPEG Code can support only multiples of 16 pixels, therefore the JPEG mode can only support following image sizes. It is different from the RAW mode.

160 x 128	03h
320 x 240	05h
640 x 480	07h

6.2. GET PICTURE (AA04h)

The host issues this command to request a picture from the uCAM-II.

6.2.1. Picture Type

Snapshot Picture Mode	01h
RAW Picture Mode	02h
JPEG Picture Mode	05h

6.3. SNAPSHOT (AA05h)

The uCAM-II will hold a single frame of still picture data in its buffer after receiving this command. This snapshot can then be retrieved from the buffer multiple times if required.

6.3.1. Snapshot Type

Compressed Picture (JPEG)	00h
Uncompressed Picture (RAW)	01h

6.3.2. Skip Frame Counter

The number of dropped frames can be defined before capture occurs. “0” keeps the current frame, “1” captures the next frame, and so on.

6.4. SET PACKAGE SIZE (AA06h)

The host issues this command to change the size of the data package which is used to transmit the compressed JPEG image data from the uCAM-II to the host. This command should be issued before sending SNAPSHOT or GET PICTURE commands to the uCAM-II.

Note: The size of the last package varies for different JPEG image sizes.

6.4.1. Package Size

The default size is 64 bytes and the maximum size is 512 bytes.



ID : Package ID, starts from zero for an image
Data Size : Size of image data in the package
Verify Code : Error detection code, equals to the lower byte of sum of the whole package data except the verify code field. The higher byte of this code is always zero. i.e. verify code = lowbyte(sum(byte[0] to byte[N-2]))

Note 1:
Once the host receives the image size from the uCAM-II, the following simple equation can be used to calculate the number of packages that will be received according to the package size set. The package settings only apply for compressed JPEG images.
Number of packages = Image size / (Package size – 6)

Note 2:
As the transmission of an uncompressed (RAW) image does not require the package mode, it is not necessary to set the package size for an uncompressed image. All of the pixel data for the RAW image will be sent continuously until completion.

6.5. SET BAUD RATE (AA07h)

The host can set the Baud rates using this command. Use the table below as a guide.

6.5.1. Baud Rates

Baud Rate	1st Divider	2nd Divider
2400	31 (0x1F)	47 (0x2F)
4800	31 (0x1F)	23 (0x17)
9600	31 (0x1F)	11 (0x0B)
19200	31 (0x1F)	5
38400	31 (0x1F)	2
57600	31 (0x1F)	1
115200	31 (0x1F)	0
153600	7	2
230400	7	1
460800	7	0
921600	1	1
1228800	2	0
1843200	1	0
3686400	0	0

Note: 3686400 baud is not achievable using the 4D programming cable or the PA5 due to the USB to Serial IC's used. To utilise this high speed baud rate, please check your serial port/device can handle this baud rate.

6.6. RESET (AA08h)

The host can reset the uCAM-II by issuing this command.

6.6.1. Reset Type

00h	Resets the whole system. The uCAM-II will reboot and reset all registers and state machines.
01h	Resets the state machines only.

6.7. DATA (AA0Ah)

The uCAM-II issues this command to inform the host the type and the size of the image data which is ready for transmitting to the host.

6.7.1. Data Type

Snapshot Picture	01h
RAW Picture	02h
JPEG Picture	05h

6.7.2. Length

These three bytes represent the length of data of the Picture that is ready for transmission back to the host.

6.8. SYNC (AA0Dh)

The host issues this command to make a connection. The ACK command must be received after sending this command. Refer to Section 5.2 for more details.

6.9. ACK (AA0Eh)

This command indicates the success of the last operation. After receiving any valid command, the ACK command must be sent out except when getting data. The host can issue this command to request image data package with the desired package ID after receiving the DATA command from the uCAM-II. The host should send this command with package ID F0F0h after receiving a package to end the package transfer.

Note: the field "command ID" should be 00h when request is for image data package.

6.9.1. Command ID

The command with that ID is acknowledged by this command.

6.9.2. ACK Counter

For debug only.

6.9.3. Package ID

For acknowledging the DATA command, these two bytes represent the requested package ID. For acknowledging other commands, these two bytes are set to 00h.

6.10. NAK (AA0Fh)

This command indicates corrupted transmission or unsupported features.

6.10.1. NAK Counter

For debug only

6.10.2. Error Number

Picture Type Error	01h	Parameter Error	0Bh
Picture Up Scale	02h	Send Register Timeout	0Ch
Picture Scale Error	03h	Command ID Error	0Dh
Unexpected Reply	04h	Picture Not Ready	0Fh
Send Picture Timeout	05h	Transfer Package Number Error	10h
Unexpected Command	06h	Set Transfer Package Size Wrong	11h
SRAM JPEG Type Error	07h	Command Header Error	F0h
SRAM JPEG Size Error	08h	Command Length Error	F1h
Picture Format Error	09h	Send Picture Error	F5h
Picture Size Error	0Ah	Send Command Error	FFh

6.11. LIGHT (AA13h)

The host issues this command to change the light frequency (hum) response of the uCAM-II.

6.11.1. Light Frequency Type

50Hz	00h
60Hz	01h

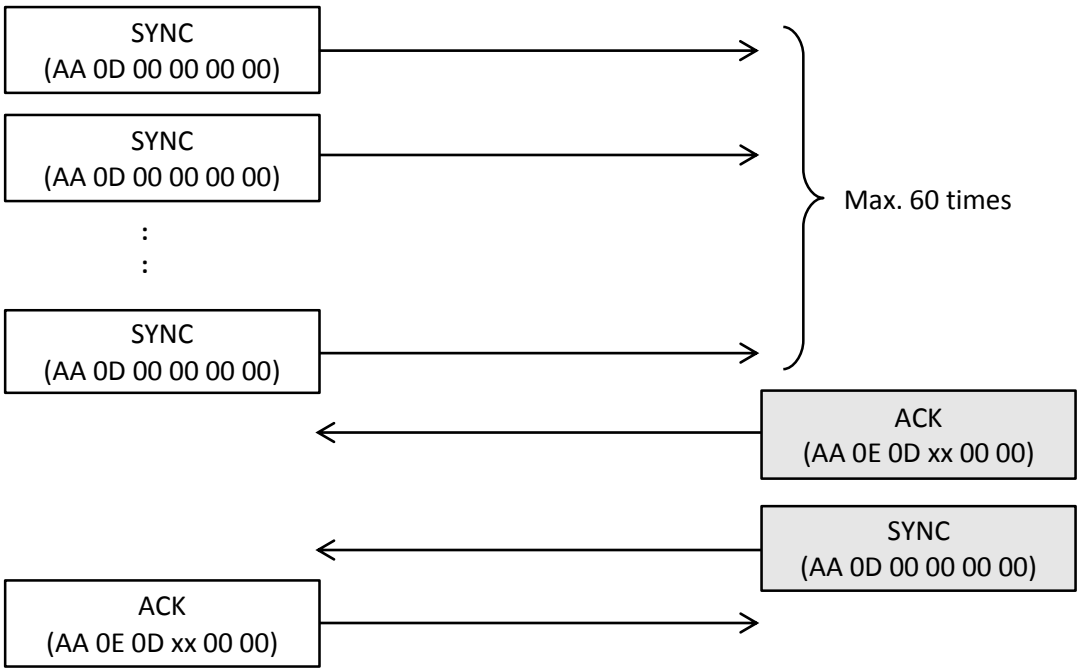
7. Command Protocol

This section outlines command usage and protocol transaction between the host and the uCAM-II module.

ACK and NAK responses are typical as replies from the Camera after sending a command, however silence is also possible if the camera has gone to sleep. Please refer to Section 6.9 and 6.10 for ACK/NAK information.

7.1. Synchronising the uCAM-II

Send the SYNC command until receiving the ACK command from uCAM-II (usually an ACK command is received after sending the SYNC command 25 times). This must be performed following a power-up.



Note 1:
The host should send the SYNC command one by one continuously until receiving the ACK and SYNC commands back from the uCAM-II module. Sometimes up to 25 to 60 SYNC commands maybe required before the module will respond. It is suggested that you start with a 5ms pause between retries and increase by 1ms for each additional retry. After receiving the response, the host should reply with the ACK command to finalise the synchronisation process.

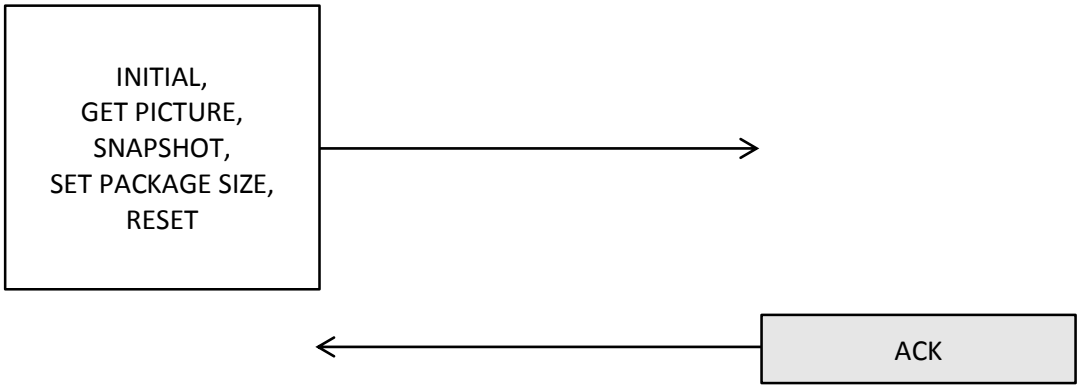
Note 2:
After synchronising and establishing a communications link with the uCAM-II, allow up to 1-2 seconds before capturing the first image. The uCAM-II needs this time to allow its AGC and AEC circuits to stabilise, otherwise the received image luminance maybe too high or too low.

Note 3:
The SYNC command is used to wake the camera up from Sleep (see Section 5.5), and is also used to keep the camera awake by periodically sending this command. Periodically sending commands is only required if no commands have been sent. If communications are occurring between the Host and the Camera, the camera will stay awake. When they stop for 15 seconds, the camera will go to sleep and will require waking with the SYNC command.

7.2. INITIAL, GET PICTURE, SNAPSHOT, SET PACKAGE SIZE, RESET Commands

When an INITIAL, GET PICTURE, SNAPSHOT, SET PACKAGE SIZE, or RESET command is sent to the camera, the camera will simply reply with an ACK if successful. Please refer to Section 6.9 and 6.10 for ACK/NAK information.

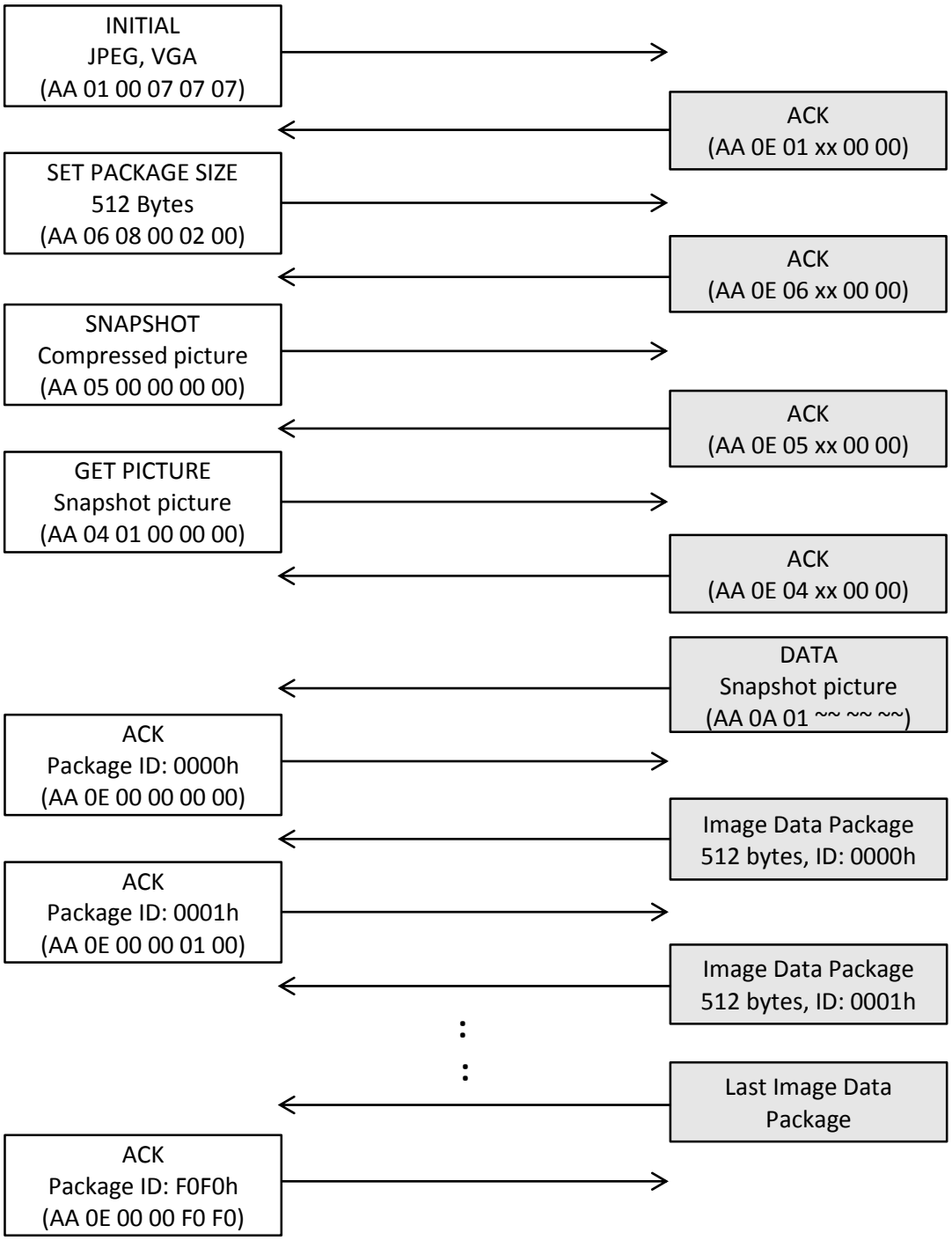
7.2.1. Example: Sending commands



7.3. Taking SNAPSHOT Pictures

Make sure a connection is established first (Section 8.2 Connecting to the uCAM-II) before using the following communications.

7.3.1. Example: JPEG Snapshot Picture (640 x 480 resolution)

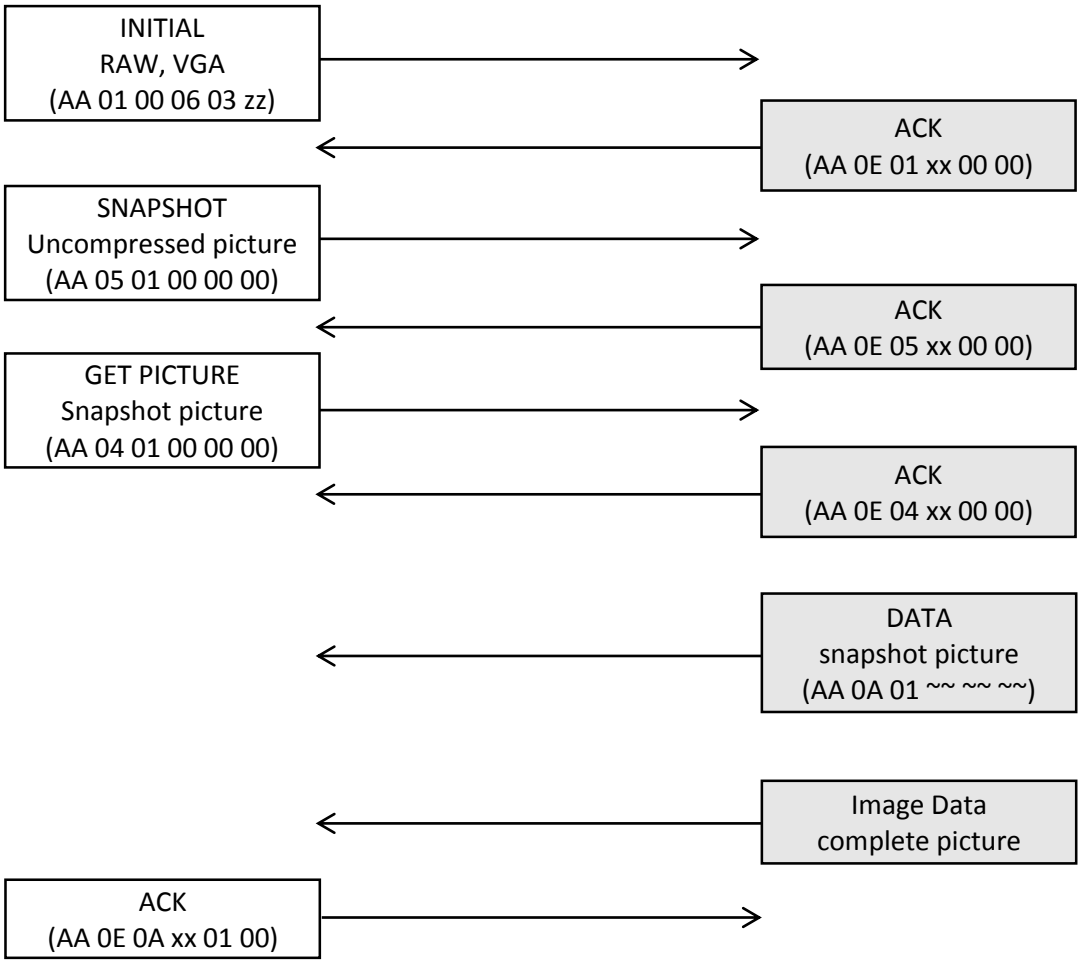


Note:

xx : Don't care

~~ : Image size returned by uCAM-II

7.3.2. Example: Snapshot Picture (160 x 120 resolution, 16bit colour, uncompressed/RAW picture)

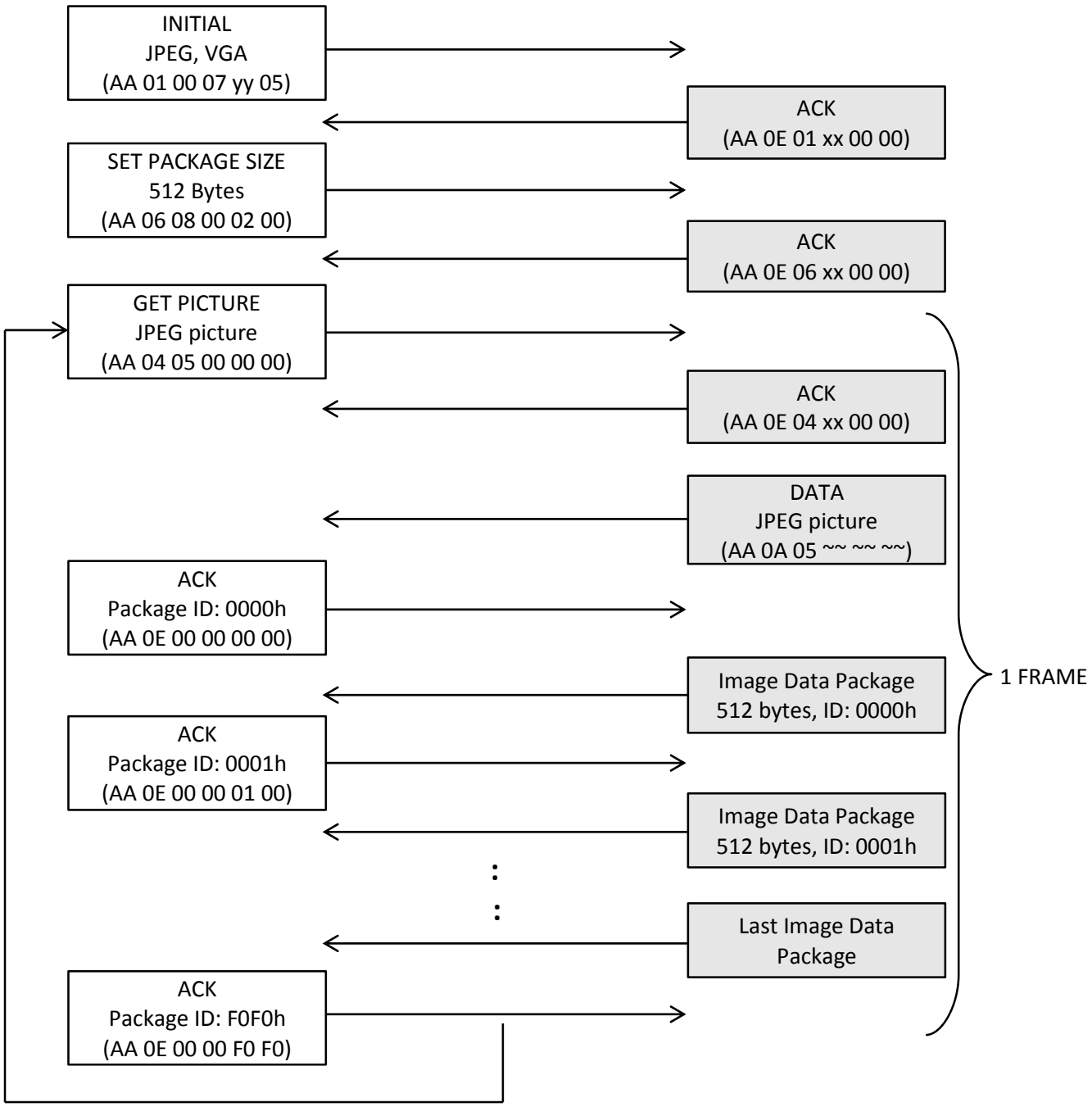


Note:
xx : Don't care
zz : 01, 03, 05 or 07. Don't care in RAW mode
~~ : Image size returned by uCAM-II

7.4. JPEG Pictures (Video)

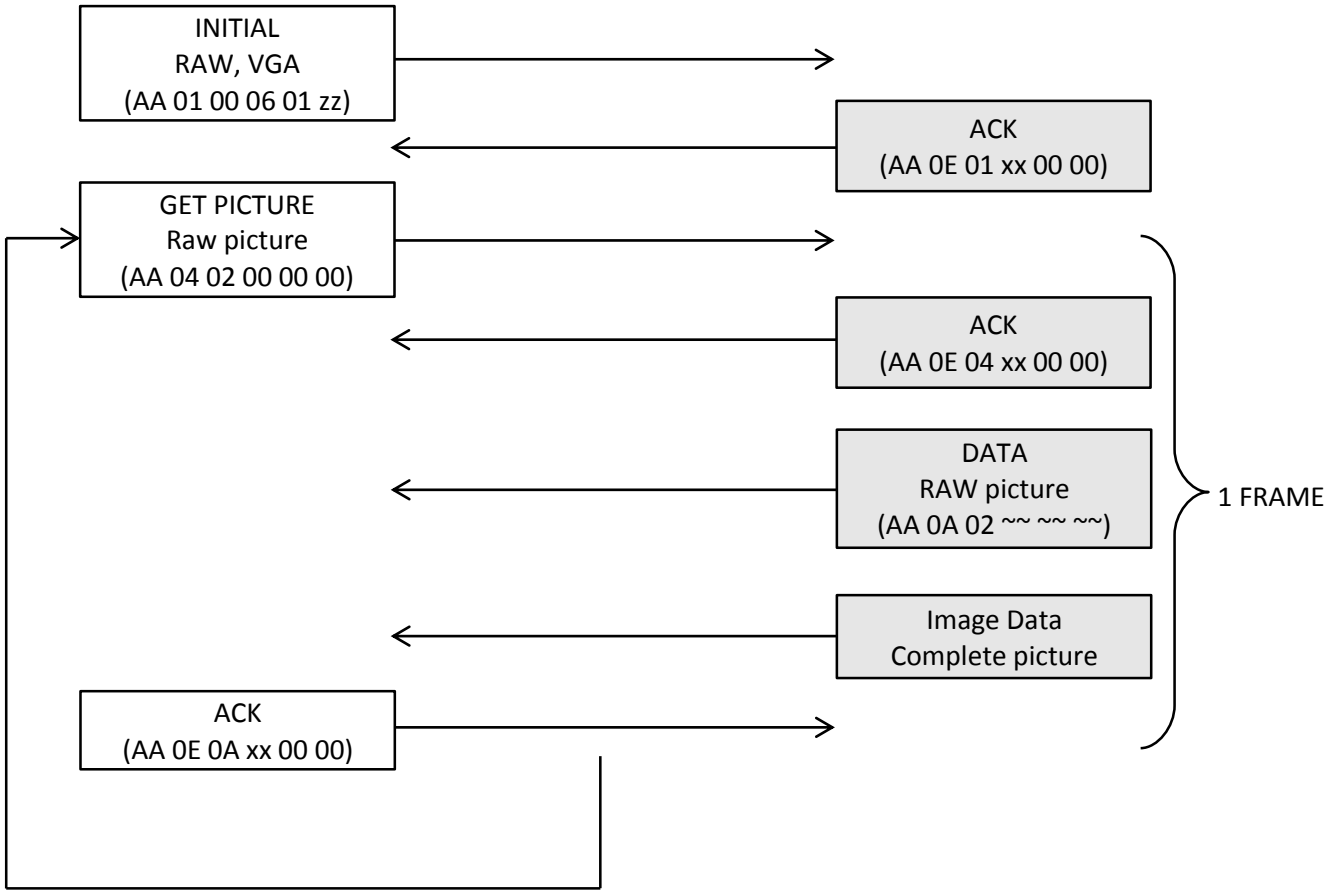
Make sure a connection is established first (Section 5.2 Connecting to the uCAM-II) before using the following communications.

7.4.1. Example: JPEG Picture (320 x 240 resolution)



Note:
xx : Don't care
yy : 01 or 03. Don't care in JPEG mode
~~ : Image size returned by uCAM-II

7.4.2. Example: Picture (80 x 60 resolution, 16bit colour, uncompressed/RAW picture)



Note:
xx : Don't care
zz : 01, 03, 05 or 07. Don't care in RAW mode
~~ : Image size returned by uCAM-II

8. Lens Information

	Lens Model	T		N1		W	
	View Angle	56°		76°		116°	
	F/No.	1.8		2.4		2.0	
	View Depth (meter)	From	To	From	To	From	To
Focused Object Distance (meter)	0.3	0.28	0.33	0.26	0.36	0.28	0.32
	0.5	0.44	0.59	0.39	0.69	0.44	0.57
	1	0.77	1.41	0.64	2.25	0.8	1.34
	1.5	1.04	2.67	0.82	9	1.09	2.41
	2.5	1.44	9.29	1.05	Infinity	1.54	6.72
	3	1.6	24.43			1.71	12.18
	5	2.03	Infinity	1.32	Infinity	2.22	Infinity

9. Troubleshooting

Q) Cannot connect to the camera, SYNC always fails
A) Unplug the camera and plug it in again, try to SYNC again. If this fails, then the power supply you are using may have a slow rise time. Testing of power supplies with a rise time of under 5uS resulted in correct operation. Power supplies with a rise time of greater than about 50uS resulted in trouble to SYNC. Change your power supply and try again.

Q) Was connected to camera but now it won't SYNC
A) Be sure you are doing the SYNC at the baud rate you were previously connected at. The uCAM-II will keep the baud rate which you had set until it is powered off. See section 5.4. If you still cannot connect, you may need to restart the camera with a power cycle.

Q) I am having trouble SYNC'ing with the uCAM-II
A) Please refer to Section 7.1 Note 1, and try this procedure to SYNC'ing.

Q) Cannot focus the camera on the target
A) Please refer to the table in section 8, and ensure you are using the correct lens for the distance to the object. Twist the lens in or out to adjust the focus, and secure using the lock nut.

Q) Camera no longer responding to Serial Commands
A) The uCAM-II will go to sleep after 15 seconds of sitting idle. Sending the SYNC Command will wake the camera from sleep, and will enable normal operation once again.

Q) Camera not responding to anything
A) In rare situations the uCAM-II may stop responding. Restarting the uCAM-II by powering off and on again should restore correct operation.

10. Embedded Display Modules

The following display modules, available from 4D Systems, are ideal for many embedded applications with the uCAM-II camera.

µOLED-96-G2



µOLED-128-G2



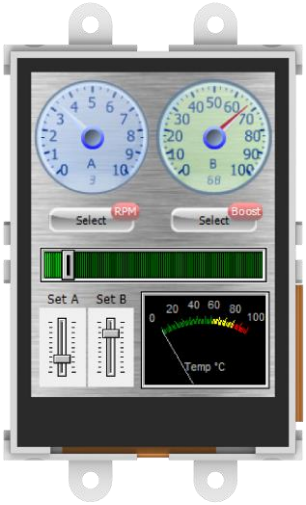
µLCD-144-G2



µOLED-160-G2



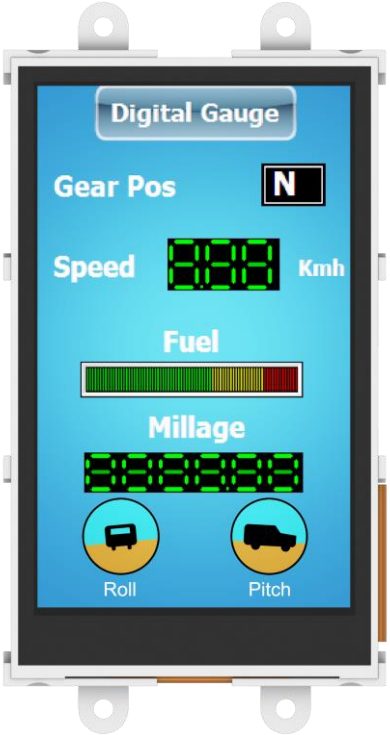
µLCD-24PTU



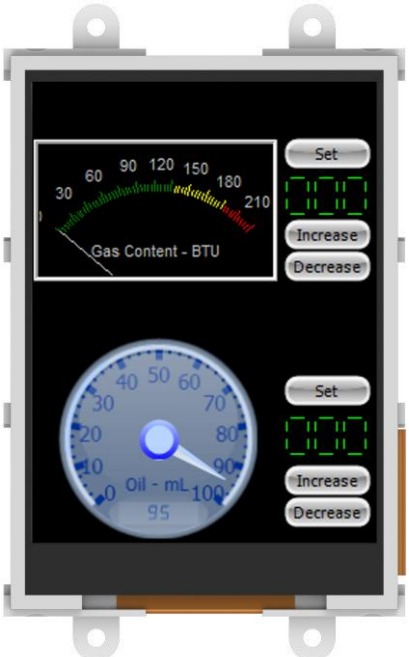
µLCD-28PTU



µLCD-32WPTU



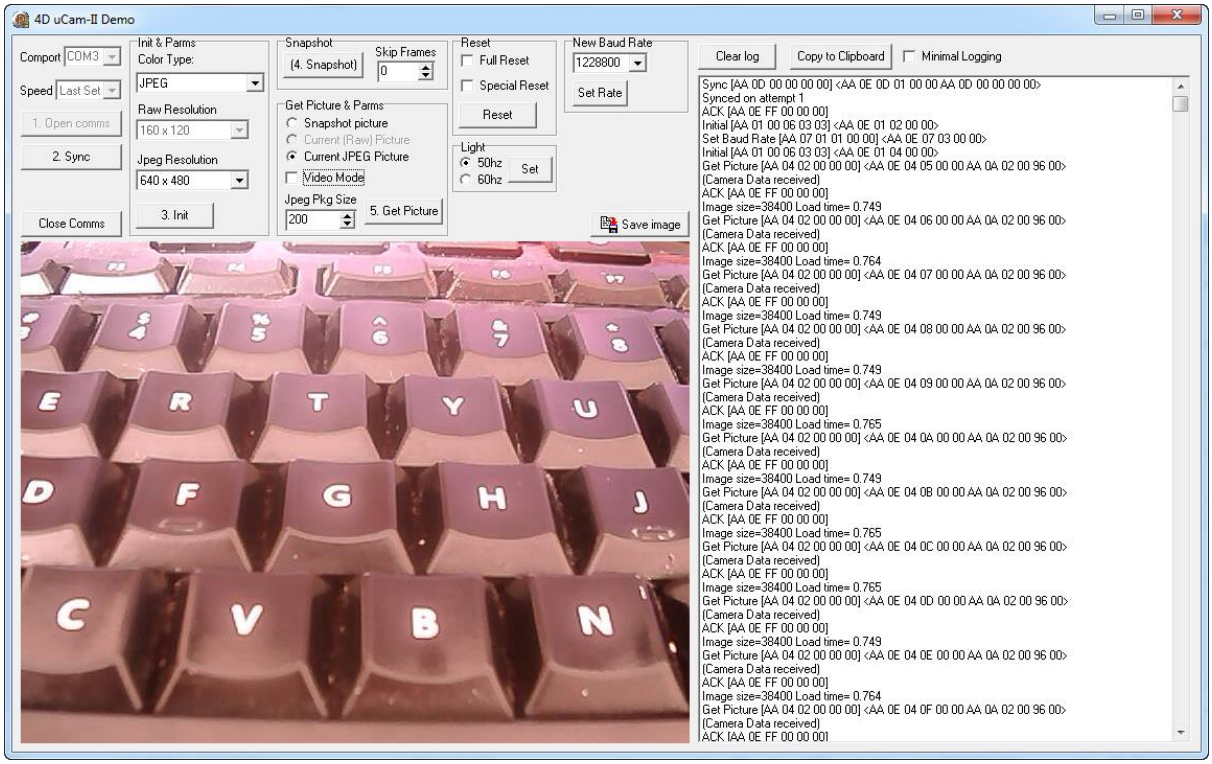
µLCD-32PTU



11. 4D Systems - Workshop 4 IDE

Workshop 4 is comprehensive software IDE that provides an integrated software development platform for all of the 4D family of processors and modules. The IDE combines the Editor, Compiler, Linker and Downloader to develop complete 4DGL application code for the relevant modules, and provides tools for modules which are not programmed.

When using the uCAM-II with Workshop 4, a test application called “4D uCAM-II Demo” will be available to test the camera.



The following image illustrates how to connect the uCAM-II to a PC to use when testing the module with Workshop 4, using the 4D Programming Cable.



12. Specifications and Ratings

RECOMMENDED OPERATING CONDITIONS					
Parameter	**Conditions**	**Min**	**Typ**	**Max**	**Units**
Supply Voltage (VCC)		4.5	5.0	9.0	V
Input Voltage Range	RX pin, 3.3V but 5V tolerant	--	3.3	5.0	V
'Shutter' delay.	Time after getpic starts to be sent before image begins.	--	150	200	ms
Operating Ambient Temperature		-30	--	+85	°C
Storage Temperature	RH 95% max.	-40	--	+105	°C

GLOBAL CHARACTERISTICS BASED ON OPERATING CONDITIONS					
Parameter	**Conditions**	**Min**	**Typ**	**Max**	**Units**
Supply Current (ICC)	VCC = 5.0V	--	75	90	mA
	Sleep / Standby	--	2	--	mA
Output Voltage Range	TX pin	2.4	3.3	--	V

OPTICAL CHARACTERISTICS	
Item	**Parameter**
Image Sensor	1/4" CMOS, 300K pixels
Pixel Size	5.55um x 5.55um
Effective Pixel Array	656 x 496
SNR	44.2dB @ 60 degree
Dynamic Range	51dB @ 60degree
White Balance	Automatic
Exposure	Automatic, self-regulating, 1/50(1/60) – 1/100,000(sec)
Lens viewing angle(3 options)	56 degrees, 76 degrees, 116 degrees
Focal Length	3.1mm
F/No.	2.6
Lens Construction	2P2G
Distortion	-2.1%
Dark Signal	25.2mV/sec
Sensitivity	2.93V/Lux.sec

ORDERING INFORMATION
Order Code: uCAM-II (Shipped with 56 degree angle lens) **Package:** 100mm x 150mm, Bubble wrapped in antistatic bag. **Note:** 76 degree and 176 degree lenses are provided additional on request.

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