airelectronics

UAV AUTOPILOTS

U-Camera Manual

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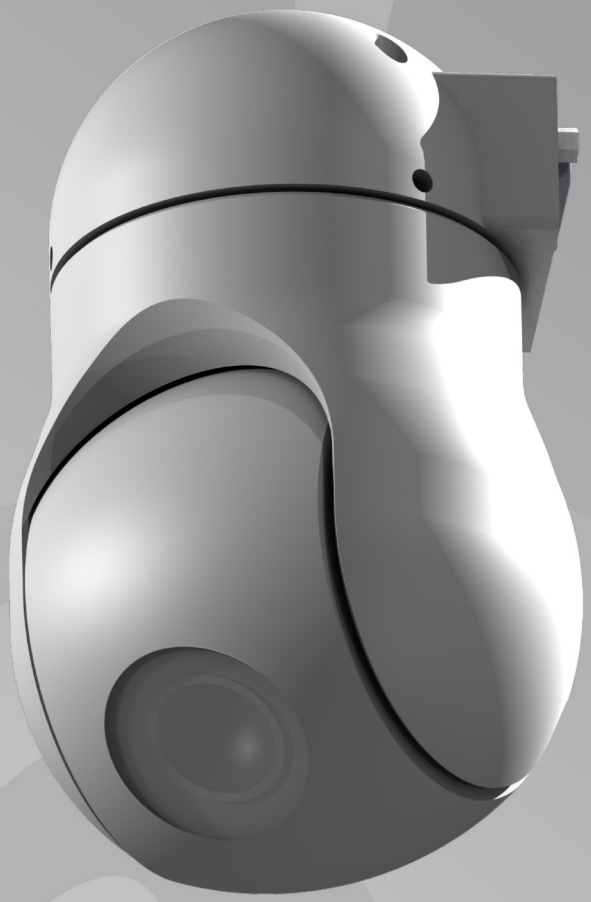

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1 General System Introduction

U-Camera is the Gimbal solution provided by Airelectronics, a state of the art, small form-factor Gimbal designed for small and medium sized UAVs. U-Camera can be mounted on fixed wing vehicles or rotary wing platforms such as multicopters or helicopters.

The system uses encoders, magnetometers and GPS information to calculate the pointing with high precision. Four different operation modes are available. Mounted camera provides a 10X optical zoom and an horizontal resolution of 530 TV Lines.

Based on the same FPGA technology as U-Pilot flight control system, U-Camera is capable of precise pointing even when mounted on vehicles with high dynamics. As its twin system U-Pilot, U-Camera is built using a two parallel microprocessor approach:

- One microprocessor takes care of the state estimation, pointing and control of the gimbal, using hardware acceleration to calculate high speed algorithms.
- Another processor handles secondary tasks as managing the camera modules or the communication with the UAV platform.

Due to the fact that those two processors are working in parallel and there is dedicated electronics taking care of all the serial ports, sensors, inputs and outputs, the system is capable of recalculating the gimbal position and control faster than any other system, providing an excellent video stabilization and pointing.

Using a standard RS-232 communication interface, U-Camera can be easily integrated with a wide range of systems available on the market.

1.1 U-Camera Elements

A U-Camera system is composed by the following elements:

- **U-Camera Board**: is the electronic board that computes the gimbal position and points and stabilizes it.
- **U-Camera Gimbal**: the proper gimbal, contains the video module, motors and sensors.
- **U-Camera Harness**: connects U-Camera Board and U-Camera Gimbal and provides the required connections such as power supply, command interface or video output.

Optionally, U-Camera system can include the following extra elements:

- **GPS Antenna**: if the embedded GPS chip is to be used, an external GPS antenna must be connected. Otherwise, GPS velocities can be externally provided.
- **Video transmitter**: in order to send the video feed from the vehicle to the ground station, a video transmitter and receiver is required.

1.2 Concept of system operation

The basic system operation concept is shown in Figure 1. When correctly placed, U-Camera Gimbal, Harness and Board act as a single element, U-Camera. The interface with other elements (FCS, Video transmitter) is done via U-Camera Harness.

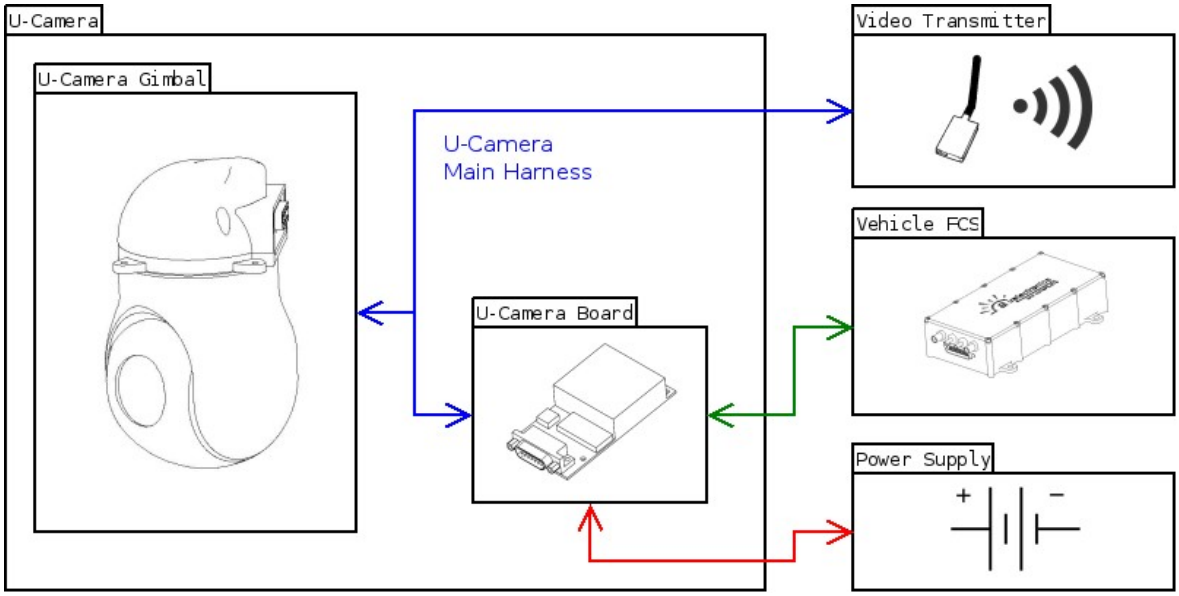


Figure 1: System concept

The vehicle Flight Control System (FCS) is in charge of managing the gimbal, commanding the required mode/angles/rates.

The power supply must be in the absolute range 9-28V, and U-Camera will internally regulate the tension level. In order to provide a power supply for the Video Transmitter, U-Camera has a 12V supply available for this purpose. For more information read the section 3.1.3.3

2 U-Camera Board

U-Camera Board is the electronic board that handles the gimbal pointing and control. It is designed as a separate item from the gimbal itself. This architecture allows the board to be placed anywhere inside the vehicle, allowing a more efficient distribution of masses when working with small vehicles.

U-Camera Board contains the following integrated elements.:

- Power regulators for video, electronics, and motors.
- Main FPGA containing the two processors along with multiple logic.
- GPS receiver
- ADC for voltage monitoring
- Thermal sensor
- Main DB-26 main connector

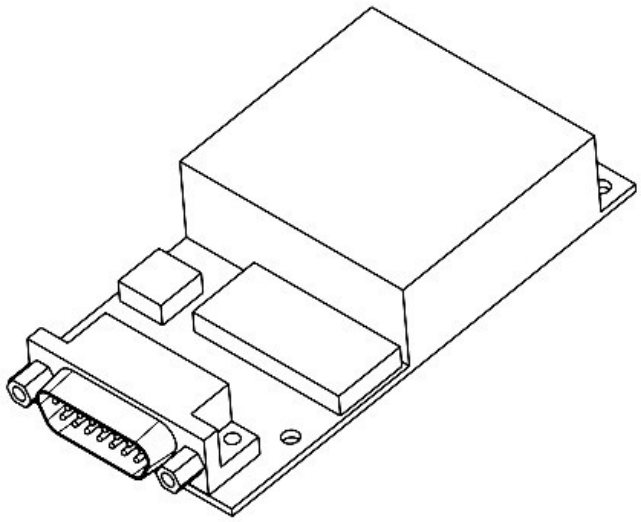


Figure 2: Mainboard schematic

This board must be placed on the vehicle. If the on-board GPS is to be used, receiver antenna should be located on the upper part of the vehicle to obtain the best view of the sky.

2.1 Manipulating U-Camera Board

The manipulation of U-Camera Board must always happen with the device disconnected from the power supply in order to avoid permanent damage.

To allow an easy fixation of U-Camera Board, it has four mounting holes described in Appendix A.

3 U-Camera Gimbal

The Gimbal of the U-Camera system contains the IMU sensors, motors and encoders along with the video module. U-Camera Gimbal is designed to have a small factor and low weight (<500grams), so its suitable for small vehicles.

The gimbal provides a DB-26 high density connector to interface with U-Camera Board and the rest of the system. A standard analog video output (PAL) is available on this connector along with a 12V supply for the video transmitter.

3.1 Mechanical Mounting

U-Camera can be easily mounted on multiple types of vehicles as described in the current section.

3.1.1 Vehicle considerations

U-Camera gimbal is designed to be mounted on both rotary and fixed wing vehicles. Although there is not a vehicle limitation, mounting position and orientation considerations are described in Section 3.1.2.

3.1.2 Mounting positions

U-Camera gimbal is designed to be mounted facing the ground from the airframe. An example of correct mounting position is shown in Figure 3. Other mounting options (Roll-Tilt configuration or upside down) will not work properly.

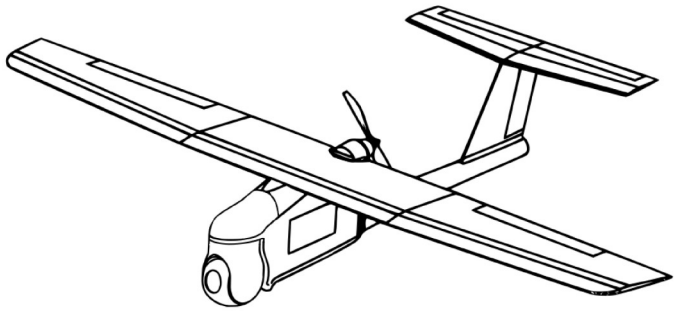


Figure 3: Example of correct mounting

The mounting scheme is referred to U-Camera gimbal, U-Camera Board can be mounted anywhere on the vehicle. The harness connecting U-Camera Board and Gimbal can be provided by Airelectronics or manufactured by the client following the guidelines described in the Section 6.

Mounting points are described in the Appendix A. Other mounting options are available upon request.

3.1.3 Vibration isolation

In order to obtain a satisfactory video experience, it is recommended to isolate the gimbal from the vibrations that may be present in the vehicle. This is specially important in vehicles powered by internal combustion engines or helicopters. Regarding vibration isolation, we can consider 3 types of vehicles:

- Combustion engine vehicles and all kind of helicopters
- Electrical multi-copters.
- Electrical fixed-wing vehicles.

3.1.3.1 Combustion engine vehicles / helicopters

If U-Camera is to be mounted on this type of vehicles, the use of silent blocks is mandatory. If the Gimbal is not isolated from the vibrations from the vehicle, the images provided by U-Camera may not be satisfactory and the gimbal may suffer permanent damage.

3.1.3.2 Electrical multicopters

When mounted on electrical vehicles, specially on multicopters, the use of silent blocks is highly recommended to obtain high quality images, although damaging the gimbal is less likely.

3.1.3.3 Electrical fixed wing vehicles

U-Camera can be mounted on electrical fixed vehicles without vibration isolation, although the use of silent blocks may improve quality of the images.

3.2 Video Transmitter

U-Camera Gimbal connector provide a power supply at 12V (1A max) for a video transmitter supply. The pins providing the 12V and ground are described in the main connection Section 6. Using this power supply the transmitter can be connected directly to the gimbal without external regulators, while maintaining the transmitter isolated from the rest of the system.

4 U-Camera Operation

4.1 Powering U-Camera

Before powering U-Camera, all the harness and wiring must be connected. U-Camera system is not ready for hot-plugging, and powerup without all the harness connected may damage the electronics.

U-Camera accepts input voltages from 9 to 28V. **IMPORTANT**: if the power supply is above 17V, active cooling of U-Camera Board is highly recommended to avoid permanent damage.

Upon power-up, the camera will point momentarily to Pan 0º and Tilt 0º and then will start to stabilize in Angles Mode (Defined in Section 4.2).

4.2 Pointing modes

U-Camera accepts different modes in order to satisfy various pointing operations:

- **Angles Mode**: Angles Mode will point the gimbal to the angles provided by Set Gimbal Angles Packet (Section 5.5.5). Note that the Gimbal will try to stabilize the camera while maintaining the Pan-Tilt angles. This will stabilize the image less accurately that the Rates Mode.
- **Rates Mode**: Rates Mode will completely stabilize the camera. The Gimbal will keep the camera pointing to a fixed direction in the space. The stabilization point can be modified using the Set Gimbal Rates Packet (Section 5.5.5.3).
- **STOW**: The mode will protect the camera lens pointing it to the angle tilt = +90° and pan = 0°.
- **Pilot**: The pilot mode will point the gimbal to tilt = 0° and pan = 0° to provide the front view from the vehicle. This mode has a soft stabilization.

4.3 GPS Configuration

U-Camera can work with and without GPS input. However, it is recommended to work with GPS input to provide the maximum pointing accuracy.

The GPS source can be selected according to the protocol description in section 5.5.5.4, being the following options available.

- **Internal GPS**: U-Camera will use the onboard GPS receiver to get the position and velocities. In this case, the GPS antenna must be placed correctly on the vehicle and connected to U-Camera Board.
- **External Feed**: U-Camera will use the position and velocities send from the controller as described in the communication protocol (Sections 5.5.5.1 and 5.5.5.2).

If no antenna is connected and no external feed is provided, U-Camera will continue working but pointing accuracy may decrease in high dynamics vehicles.

4.3.1 GPS Antenna position

In order to obtain the most accurate pointing, the GPS antenna position relative to the gimbal position should be provided to U-Camera. If this information is unaccurate, pointing

errors may appear. The packet that the GPS antenna position is described in the communication protocol (Section 5.5.5.7). The position is measured in millimeters and referred to the Gimbal fixed frame.

The gimbal fixed frame is defined:

- **X axis**: Camera pointing direction when Pan=Tilt=0
- **Y axis**: Tilt motor rotation axis when Pan=0
- **Z axis**: Pan Motor rotation axis directec to the video module.

4.4 Vehicle Angles and Velocities

In order to provide the best pointing accuracy, U-Camera accepts the Euler Angles of the vehicle (*Yaw*, *Pitch*, *Roll*) and angular velocities (*p*, *q*, *r*) as inputs. The packets providing these angles and velocities are described in the communication protocol (Section 5.5.5.5 and 5.5.5.6).

If this packet is received, U-Camera will use the provided angles as vehicle angles. If the packet is not being received U-Camera will calculate the vehicle angles from the GPS source.

Depending on the type of vehicle and Flight Control System used, externally provided vehicle angles will provide better performance.

4.5 Maximum Ratings

Input Characteristics		
	Minimum	**Maximum**
Input Voltage	9V	17V / 28V (with cooling)
Operating Temperature	-15 ºC	+70 ºC

4.6 Autoalign Sensors

U-Camera devices are precisely calibrated during manufacturing, but small perscusions may introduce bias into the sensor readings. To remove this bias, the user can command the autolignment of the sensors.

Autoalign can be commanded using two modes:

- **Gyro autoalign**: U-Camera will remove the bias from the gyroscopes.
- **Full autoalign**: U-Camera will remove the bias from the gyroscopes and acelerometers.

The gimbal should be positioned horizontally prior to the Autoalign command. Once the command is received, the camera will position itself with zero pan and tilt, and then it will monitorize the sensor reading for several seconds.

During the whole process U-Camera will report Gyro autoalign / Full autoalign mode. When the process finishes, the gimbal will switch to Angles mode.

IMPORTANT: during the autoalign process, the camera must be still. Any movement will result in a bad autoalign and bad stabilization performance.

4.7 FFC Calibration (IR only)

In order to the obtain the maximum image quality, thermal calibration is recommended.

To calibrate the infrared sensor, command the FFC Calibration mode using the command mode packet (Section 5.5.3.1). U-Camera will point itself to the Pan=0º, Tilt=90º and perform the calibration.

When the process finishes, the gimbal will switch to Angles mode.

IMPORTANT: this action may be commanded while flying althouth perform it on the ground is encouraged maximize the quality.

5 Communication Protocol

5.1 Protocol general description

U-Camera communicates using the U-Camera Serial Protocol, UCSP. UCSP is a serial protocol that allows the controller (indicated as CTRL in this document) to command U-Camera Gimbal (GMB in this document).

Source	Destination	Main Function
CTRL(Controller)	GMB(U-Camera)	Command and configuration
GMB(U-Camera)	CTRL(Controller)	Status Report and Answer

UCSP is a standard serial protocol at 115200 bps, 1 stop bit and no parity. The communication messages are based on a standard packet structure defined in the next Section 5.2.

UCSP Configuration	Serial Speed	Stop bit	Parity
	115200bps	1	None

The downstream flow (CTRL → GMB) is controlled by the master, which decides the packets to be sent and when to send them. Although not required, it is recommended to send periodically (~10Hz at least) packets regarding the command mode and desired angles/rates.

The upstream flow (GMB → CTRL) is handled by U-Camera sending periodically reports of its status. When CTRL sends a request, GMB replays to the request before sending more periodic reports. The periodic report packets are described in the Section 5.6.

5.2 Packet structure

The UCSP protocol is based on packets with variable length. The packet structure is described in the following tables.

0	1	2	3	4	...	N+3	N+4	N+5
SYNC BYTE	CATEGORY	ID	LENGTH	PAYLOAD1	...	PAYLOADN	CHK_A	CHK_B

Position	Name	Description
0	Synchronization Byte 0xCC	Synchronization Byte
1	Category number	Upcoming Packet Category
2	Id number	Upcoming Packet ID number
3	Packet Length(N)	Upcoming data Length
[4, N+3]	Payload	Payload Content
N+4	Checksum A	
N+5	Checksum B	

Note that the Packet Length Number is referred to Payload, meaning that the complete packet is composed by N + 6 bytes.

5.3 Checksum Calculation

As described in the previous section, the UCSP packets have two checksum bytes to determine the integrity of the packet.

This checksum is the 8-bit Fletcher algorithm, which is used in the TCP standard (RFC 1145).

Checksum A (CK_A) and Checksum B (CK_B) must be initialized to zero (0x00).

For each byte of the payload the byte is added to CK_A and then CK_B is the result of adding the previous CK_B value to CK_A.

When adding to CK_A and CK_B, values overflowing the 8 bits should be trimmed to 8 bit with a 0xFF mask if the data type is wider than 8 bits.

The checksum involves all the packet bytes except for the checksum bytes themselves. The packet is valid if the calculated CK_A and CK_B values are identical to the last two bytes of the packet.

A pseudo-code for checksum calculation is provided in the following figure:

```
unsigned char CK_A, CK_B
CK_A = 0,CK_B = 0
For ( I = 0; I<N; I++)
{
      CK_A = CK_A + Buffer[I]
      CK_B = CK_B + CK_A
}
```

Pseudo-code for check sum calculation

Figure 4: Pseudo-code for checksum calculation

For testing purposes, the following test packet is provided:

0	1	2	3	4	5	6	7	8	9	10	11	12	CK_A	CK_B
0xCC	0x01	0x02	0x09	0x01	0x02	0x03	0x04	0x05	0x06	0x07	0x08	0x09	0xFC	0x74

Figure 5:Example Packet

5.4 Data formats and structure

The data used in UCSP protocol is always sent using little endian scheme. The following table shows the order for the different data types used in the U-Camera protocol. The position indicates the order used for sending the bytes, meaning that Position 0 byte is sent before Position 1 byte and so on.

Type	Position 0	Position 1	Position 2	Position 3
Integer (int)	Int [7:0]	Int [15:8]	Int [23:16]	Int [31:24]
Unsigned Int (uint)	Uint [7:0]	Uint [15:8]	Uint [23:16]	Uint [31:24]
Float (float)	Float [7:0]	Float [15:8]	Float [23:16]	Float [31:24]
Short Int (int16)	Int16 [7:0]	Int16 [15:8]		
Unsigned Short Int (uint16)	Uint16 [7:0]	Uint16 [15:8]		
Byte/Char (byte)	Byte [7:0]			

5.5 Protocol Structure

As described in section 5.2, the protocol packets are defined by a category and Id byte. Categories are meant to group multiple commands related to the same element, the available categories in the protocol are listed in the following table.

Category Byte	Category Name	Brief
0x04	Non Volatile Memory	Commands related to the saving of the current configuration.
0x08	Device Information	Device Information
0x09	Gimbal	Gimbal Command and Report
0x0A	Camera	Camera Module Command and Report
0x0B	External Feed	External information provided to the gimbal
0x0C	IR Specific	Specific commands for the IR payload

5.5.1 Non Volatile Memory Category (Cat: 0x04)

This category allows to save the current configuration to the non-volatile memory using the “Save Configuration” packet.

Packet ID Byte	Packet Name	Source	Destination	Brief
0x01	Save Configuration	CTRL	GMB	Save configuration to Non Volatile Memory

5.5.1.1 Save configuration to NV memory (Cat: 0x04, ID: 0x01)

To save the current configuration ton the non volatile memory, just send this packet with no payload. During the process of saving the configuration, the gimbal will not send telemetry or respond to commands, although the stabilization and pointing will work normally. This process usually takes around one second.

Sync Byte	Category Byte	ID Byte	Length Byte	CK_A	CK_B
0xCC	0x04	0x01	0x00	0xD1	0x3E

DO NOT use this command during flight and remember to use a stable power supply. A loss of power during the saving process may cause permanent damage to the unit.

5.5.1.2 Save FFC to NV memory (Cat: 0x04, ID: 0x02, IR Only)

To save the FFC calibration to the non-volatile memory of the video module, just send this packet with no payload. Note that this command is only effective for IR cameras. More information about the FFC calibration is available in the section 4.7. The saving process may took up 10 seconds, and a power loss during the process may cause damage to the IR module.

Sync Byte	Category Byte	ID Byte	Length Byte	CK_A	CK_B
0xCC	0x04	0x02	0x00	0xD1	0x3E

5.5.2 Device Information Category (Cat: 0x08)

Device Information category contains the packets required to request and report the firmware version and the serial number of the unit.

Packet ID Byte	Packet Name	Source	Destination	Brief
0x01	Report Version	GMB	CTRL	Report Gimbal Software Version / Serial Number
0x02	Request Version	CTRL	GMB	Request Gimbal Software Version / Serial Number
0x03	Report Data Frequency	GMB	CTRL	Report Data Frequency for telemetry data
0x04	Request Data Frequency	CTRL	GMB	Request Data Frequency for telemetry data
0x05	Set Data Frequency	CTRL	GMB	Set Data Frequency for telemetry data

5.5.2.1 Report Gimbal Version (Cat: 0x08, ID: 0x01)

The payload of the gimbal version report uses the following structure:

Payload Position	Data Type	Data Description
0	int16	MB Serial Number
1	int16	SB Serial Number
2	int32	CPU0 Version
3	int32	CPU1 Version
4	int16	Non-Volatile Memory Version

5.5.2.2 Request Gimbal Version (Cat: 0x08, ID: 0x02)

To request the gimbal version information an empty packet is required.

Sync Byte	Category Byte	ID Byte	Length Byte	CK_A	CK_B
0xCC	0x08	0x02	0x00	0xD6	0x4C

5.5.2.3 Report Telemetry Data Frequency (Cat: 0x08, ID: 0x03)

This packet contains information about the frequency used to provide the telemetry data in Hertz. For example, 50Hz means that each one of the periodic packets will be transmited 50 times per second.

Payload Position	Data Type	Data Description
0	uint16	Data frequency in Hertzs

5.5.2.4 Request Telemetry Data Frequency (Cat: 0x08, ID: 0x04)

To request the gimbal version information an empty packet is required.

Sync Byte	Category Byte	ID Byte	Length Byte	CK_A	CK_B
0xCC	0x08	0x04	0x00	0xD8	0x50

5.5.2.5 Set Telemetry Data Frequency (Cat: 0x08, ID: 0x05)

The user can configure the data rate by sending this packet providing the desired data frequency.

Payload Position	Data Type	Data Description
0	uint16	Data frequency in Hertzs (1 to 200 Hz)

5.5.3 Gimbal Category (Cat: 0x09)

The Gimbal category refers to the control of the pointing system itself. This category contains the packets regarding mode selection/report and rates/angles command and report.

Packet ID Byte	Packet Name	Source	Destination	Brief
0x01	Set Mode	CTRL	GMB	Set Gimbal Mode
0x02	Report Mote	GMB	CTRL	Report Gimbal Mode
0x03	Set Gimbal Rates	CTRL	GMB	Set Gimbal Rates
0x04	Report Gimbal Rates	GMB	CTRL	Report Gimbal Rates
0x05	Set Gimbal Angles	CTRL	GMB	Set Gimbal Angles
0x06	Report Gimbal Angles	GMB	CTRL	Report Gimbal Angles

5.5.3.1 Set Mode Packet (Cat: 0x09, ID: 0x01)

The packet allows to set the pointing mode of the gimbal.

Data Position	Data Type	Data	Data Description
0	int16	Mode Number	Mode number described in the next table

Available Modes are:

Mode Number	Mode Name	Mode Description
0	Angles	Command Gimbal Angles
1	Rates	Command Pointing Rates
2	Safe Mode	Protect the Lens
3	PIlot	Front View
4	Init Mode	Initialization Mode
5	Gyro Autoalign	Performs Gyro Autoalign
6	Gull Autoalign	Performs Gyro and Accelerometers Autoalign
7	FFC Calibration	Performs FFC thermal calibration (IR only)

5.5.3.2 Report Mode Packet (Cat: 0x09, ID: 0x02)

This packet is reported periodically from the gimbal containing the operative mode number.

The packet structure is the following:

Data Position	Data Type	Data	Mode Description
0	int16	Mode Number	Mode number described in the previous table

The mode definition is the same described in the previous section.

5.5.3.3 Set gimbal Rates (Cat: 0x09, ID: 0x03)

The gimbal rates are the angular velocities commanded to the gimbal when the mode "Rates" is set. Note that unless this mode is active, the commands in this packet will take no effect.

The packet structure is:

Data Position	Data Type	Data	Data Description
0	int16	Pan Rate	degrees/Second * 100
1	int16	Tilt Rate	degrees/Second * 100
2	int16	Roll Rate	Not Implemented, fill with Zero

5.5.3.4 Report gimbal Rates (Cat: 0x09, ID: 0x04)

The reported gimbal rates are the actual angular velocities of the gimbal around its axis. Note that these values do not necessarily match the commanded rates.

The packet structure is:

Data Position	Data Type	Data	Data Description
0	int16	Pan Rate	degrees/Second * 100
1	int16	Tilt Rate	degrees/Second * 100
2	int16	Roll Rate	Not Implemented, report is always Zero

5.5.3.5 Set gimbal Angles (Cat: 0x09, ID: 0x05)

The gimbal angles are the position of the gimbal referred to its axis. Note that unless the mode angle is active, the commands in the packet will take no effect.

The packet structure is:

Data Position	Data Type	Data	Data Description
0	int16	Pan Angle	degrees * 100
1	int16	Tilt Angle	degrees * 100
2	int16	Roll Angle	Not Implemented, fill with Zero

5.5.3.6 Report gimbal Angles (Cat: 0x09, ID: 0x06)

The reported gimbal angles represent the current position of the gimbal referred to its axis. Note that these values do not necessarily match the commanded angles.

The packet structure is:

Data Position	Data Type	Data	Data Description
0	int16	Pan Angle	degrees * 100
1	int16	Tilt Angle	degrees * 100
2	int16	Roll Angle	Not Implemented, report is always Zero

5.5.4 Camera Category (Cat: 0x0A)

The camera category contains all the communications related to the video module and its configurations.

Packet ID Byte	Packet Name	Source	Destination	Brief
0x01	Set Zoom	CTRL	GMB	Set Camera Zoom
0x02	Report Zoom	GMB	CTRL	Report Camera Zoom

5.5.4.1 Set Camera Zoom Packet (Cat: 0x0A, ID: 0x01)

This packet allows to set the camera optical zoom level.

The packet structure is:

Data Position	Data Type	Data	Data Description
0	uint16	Zoom Value	Zoom Command (0 - 16383)

Where 0 is the minimum zoom (wide) and 16383 is the maximum (tele).

5.5.4.2 Report Camera Zoom Packet (Cat: 0x0A, ID: 0x02)

The reported zoom represents the current value of the camera optical zoom. In some situations the reported zoom may differ from the commanded zoom.

The packet structure is:

Data Position	Data Type	Data	Data Description
0	int16	Zoom Value	Zoom Report (0 - 16383)

5.5.4.3 Report Gimbal Type(Cat: 0x0A, ID: 0x03)

This packet reports the type of gimbal of the U-Camera device.

The packet structure is:

Data Position	Data Type	Data	Data Description
0	int16	Gimbal Type	Gimbal Type

The gimbal types are:

Gimbal Type Value	Gimbal Type Description
0x00	Invalid / Undefined
0x01	IR Gimbal
0x02	Daylight Gimbal

5.5.5 External Feed Category (Cat: 0x0B)

The External Feed category contains all the communications related to the use of the aircraft GPS instead of the gimbal one.

Packet ID Byte	Packet Name	Source	Destination	Brief
0x01	Send GPS Velocities	CTRL	GMB	Provides the GPS Velocities to be used in estimation
0x02	Send GPS Position and Velocities.	CTRL	GMB	Provides the GPS Position and Velocities to be used in estimation and pointing
0x03	System Position Report	GMB	CTRL	Reports current GPS Latitude, Longitude and Altitude
0x04	Configure GPS Feed	CTRL	GMB	Switch between onboard GPS and aircraft GPS
0x05	Send Vehicle Angles	CTRL	GMB	Provides the Vehicle Euler Angles to be used in estimation and pointing
0x06	Send Vehicle Angular Velocities	CTRL	GMB	Provides the Vehicle Angular velocities (p, q, r in the vehicle body frame).
0x07	Set GPS Antenna Position	CTRL	GMB	Set the GPS antenna position information
0x08	Request GPS Antenna Position	CTRL	GMB	Request the GPS antenna position information
0x09	GPS Antenna Position Report	GMB	CTRL	Reports the position of the GPS antenna

5.5.5.1 Send GPS Velocities (Cat: 0x0B, ID: 0x01)

Provides the GPS velocities for the gimbal calculations. This packet is ignored if on-board GPS is used.

The packet structure is:

Data Position	Data Type	Data	Data Description
0	int32	GPS Vel. North	meters/second * 1e2
1	int32	GPS Vel. Est	meters/second * 1e2
2	int32	GPS Vel. Down	meters/second * 1e2

5.5.5.2 Send GPS Position and Velocities (Cat: 0x0B, ID: 0x02)

Provides the GPS velocities and positions for the gimbal calculations. This packet is ignored if on-board GPS is used.

The packet structure is:

Data Position	Data Type	Data	Data Description
0	int32	GPS Pos Lat	degrees * 1e7
1	int32	GPS Pos Lon	degrees * 1e7
2	int32	GPS Pos Alt	meters * 1e5
3	int32	GPS Vel. North	meters/second * 1e2
4	int32	GPS Vel. Est	meters/second * 1e2
5	int32	GPS Vel. Down	meters/second * 1e2

5.5.5.3 System Position Report (Cat: 0x0B, ID: 0x03)

This packet reports the last system position calculated in the gimbal. Note that this position is not strictly the same as the GPS position.

The packet structure is:

Data Position	Data Type	Data	Data Description
0	int32	System Pos Lat	degrees * 1e7
1	int32	System Pos Lon	degrees * 1e7
2	int32	System Pos Alt	meters * 1e5

5.5.5.4 Configure GPS Feed (Cat: 0x0B, ID: 0x04)

This packet allows to configure the GPS source for the gimbal, which can be the internal GPS module or an external feed via serial port.

The packet structure is:

Data Position	Data Type	Data	Mode Description
0	byte	gps feed config	0: use internal GPS Module 1: use data from serial feed

5.5.5.5 Send Vehicle Angles (Cat: 0x0B, ID: 0x05)

Provides the vehicle Euler angles for the gimbal calculations.

The packet structure is:

Data Position	Data Type	Data	Data Description
0	int32	Yaw	degrees * 1e4

1	int32	Pitch	degrees * 1e4
2	int32	Roll	Degrees * 1e4

5.5.5.6 Send Vehicle Angular Velocities (Cat: 0x0B, ID: 0x06)

Provides the vehicle angular velocities in the host vehicle body frame (p, q, r) used to improve the attitude calculations.

Data Position	Data Type	Data	Data Description
0	int32	Yaw	Degrees / s * 1e4
1	int32	Pitch	Degrees / s * 1e4
2	int32	Roll	Degrees / s * 1e4

5.5.5.7 Set GPS Antenna Position(Cat: 0x0B, ID: 0x07)

This packet sets the GPS Antenna position. Note that if the configuration is not saved to the Non-Volatile memory after sending this packet, the GPS Antenna position will be lost upon system restart.

The packet structure is:

Data Position	Data Type	Data	Data Description
0	int16	X position	Meters * 1e3 (mm)
1	int16	Y position	Meters * 1e3 (mm)
2	int16	Z position	Meters * 1e3 (mm)

5.5.5.8 Request GPS Antenna Position (Cat: 0x0B, ID: 0x08)

Sending this packet with no payload causes U-Camera to report the GPS Antenna position on memory using packet described in 5.5.5.9.

5.5.5.9 GPS Antenna Position Report (Cat: 0x0B, ID: 0x09)

Reports current GPS Antenna position.

The packet structure is:

Data Position	Data Type	Data	Data Description
0	int16	X position	Meters * 1e3 (mm)
1	int16	Y position	Meters * 1e3 (mm)
2	int16	Z position	Meters * 1e3 (mm)

5.5.6 IR Specific Category (Cat: 0x0C)

The IR Specific category contains all the communications related to the IR camera.

Packet ID Byte	Packet Name	Source	Destination	Brief
0x01	Set IR Palette	CTRL	GMB	Sets the IR color scheme
0x02	Report IR Palette	GMB	CTRL	Reports the IR current color scheme

5.5.6.1 Set IR Palette Packet (Cat: 0x0C, ID: 0x01)

This packet sets the color scheme for the IR camera.

Data Position	Data Type	Data	Data Description
0	uint16	Color scheme	

5.5.6.2 Report IR Palette Packet (Cat: 0x0C, ID: 0x02)

This packet reports the color scheme for the IR camera.

Data Position	Data Type	Data	Data Description
0	uint16	Color scheme	

5.6 Periodic Reports Packets

U-Camera (GMB) periodically send report packets to inform the controller (CTRL) of the gimbal status. This periodic packet are listed in the following table.

Category	ID	Packet
0x08	0x01	U-Camera Version Packet
0x09	0x02	Mode Report
0x09	0x04	Rates Report
0x09	0x06	Angles Report
0x0A	0x02	Zoom Report
0x0A	0x03	Gimbal Type Report
0x0C	0x02	Report IR Palette

5.7 Protocol Summary

Packet	Sync Byte	Category Byte	Command ID Byte	Length Byte
Non Volatile Memory Category				
Save configuration to NV Memory	0xCC	0x04	0x01	0x00
Save FFC Calibration to NV Memory	0xCC	0x04	0x02	0x00
Device Information Category				
Report Gimbal Software Version	0xCC	0x08	0x01	0x0E
Request Gimbal Software Version	0xCC	0x08	0x02	0x00
Report Data Frequency	0xCC	0x08	0x03	0x02
Request Data Frequency	0xCC	0x08	0x04	0x00
Set Data Frequency	0xCC	0x08	0x05	0x02
Gimbal Category				
Set Mode	0xCC	0x09	0x01	0x02
Report Mode	0xCC	0x09	0x02	0x02
Set Gimbal Rates	0xCC	0x09	0x03	0x06
Report Gimbal Rates	0xCC	0x09	0x04	0x06
Set Gimbal Angles	0xCC	0x09	0x05	0x06
Report Gimbal Angles	0xCC	0x09	0x06	0x06
Camera Category				
Set Camera Zoom	0xCC	0x0A	0x01	0x04
Report Camera Zoom	0xCC	0x0A	0x02	0x04

Packet	Sync Byte	Category Byte	Command ID Byte	Length Byte
Report Gimbal Type	0xCC	0x0A	0x03	0x02
External Feed Category				
Report GPS Velocities	0xCC	0x0B	0x01	0x0C
Report GPS Position and Velocities	0xCC	0x0B	0x02	0x18
Report System Position	0xCC	0x0B	0x03	0x0C
Configure GPS Feed	0xCC	0x0B	0x04	0x01
Send Vehicle Angles	0xCC	0x0B	0x05	0x0C
Set GPS Antenna Position	0xCC	0x0B	0x06	0x06
Request GPS Antenna Position	0xCC	0x0B	0x07	0x00
Report GPS Antenna Position	0xCC	0x0B	0x08	0x06
IR Specific Category				
Set IR Palette	0xCC	0x0C	0x01	0x02
Report IR Palette	0xCC	0x0C	0x02	0x02

6 U-Camera electrical connections

6.1 U-Camera main connectors pin-out

As described in the previous sections U-Camera systems is composed by two main elements: U-Camera Gimbal and U-Camera Board. The main harness connects the two of them and provide the required external interfaces such as:

- Video Output and Video Transmitter supply(12V)
- Command Interface
- Main Power Supply: 9-28V (9-17V without active cooling).

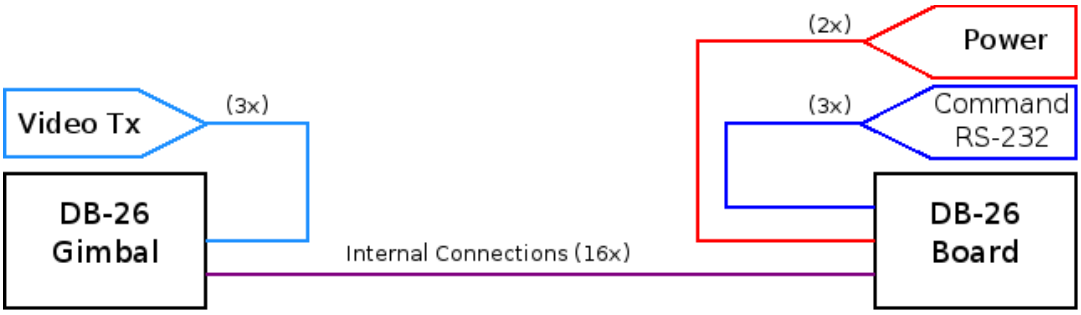


Figure 6: U-Camera Harness schematic

Both U-Camera Board and U-Camera Gimbal have DB-26 male conectors. To match this connectors, U-Camera Harness must end in two DB-26 female connectors.

The pinout of the DB-26 ends is presented in the Figure 7 and following table. In the table, harness internal connections are indicated with a green double arrow(<->) while external connections are represented with a single ended arrow (<- or →).

As indicated in section 4.1, the harness must be completely connected to all the elements before powering up the system. **IMPORTANT:** remember to connect each end to the proper element. Crossing the connectors of DB-26 Board and DB-26 Gimbal may result in permanent damage to the gimbal if powered.

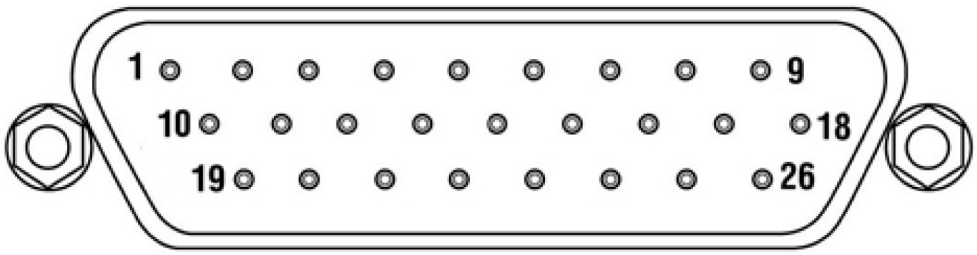


Figure 7: DB26 Male connector

Function	DB26 Gimbal	PIN	Main Harness	DB26 Board	Function
	Internal 01	01	<->	Internal 01	
	Internal 02	02	<->	Internal 02	
	Internal 03	03	<->	Internal 03	
	Internal 04	04	<->	Internal 04	
	Internal 05	05	<->	Internal 05	
	Internal 06	06	<->	Internal 06	
	Internal 07	07	<->	Internal 07	
	NC	08	X	0V	
	NC	09	X	0V	
	Internal 08	10	<->	Internal 08	
	Internal 09	11	<->	Internal 09	
	Internal 10	12	<->	Internal 10	
	Internal 11	13	<->	Internal 11	
	Internal 12	14	<->	Internal 12	
	NC	15	X	NC	
	NC	16	X	NC	
	NC	17	->	Serial 232 Rx	Command 232 Rx
	NC	18	->	Serial 232 Tx	Command 232 Tx
	Internal 13	19	<->	Internal 13	
	Internal 14	20	<->	Internal 14	
	Internal 15	21	<->	Internal 15	
	Internal 16	22	<->	Internal 16	
	NC	23	X	NC	
Video Out	Sig Video	24	<-	NC	
12V Video Tx	12V Video	25	<- / ->	DC_Input	Power +
0V Video Tx	0V Video	26	<- / ->	0V_Input	Power -

6.2 U-Camera Main Harness schematic

In the Figure 8 a pin-detailed schematic is presented. As for the direct connector-connector relations, no detail is required. The exernal connections are detailed in the following tables.

	Pin No.	Name	Function
Conn J3 Command	1	Rx	U-Camera Rx
	2	Tx	U-Camera Tx
	3	GND	Ground Reference

	Pin No.	Name	Function
Conn J4 P. Supply	1	NC	NC
	2	Vin	Input Voltage: 9-28V (9-17V without cooling)
	3	GND	Ground Reference

	Pin No.	Name	Function
Conn J5 Video Out	1	NC	Video PAL Output
	2	Vin	Video 12V(to Video Ground)
	3	GND	Video Ground

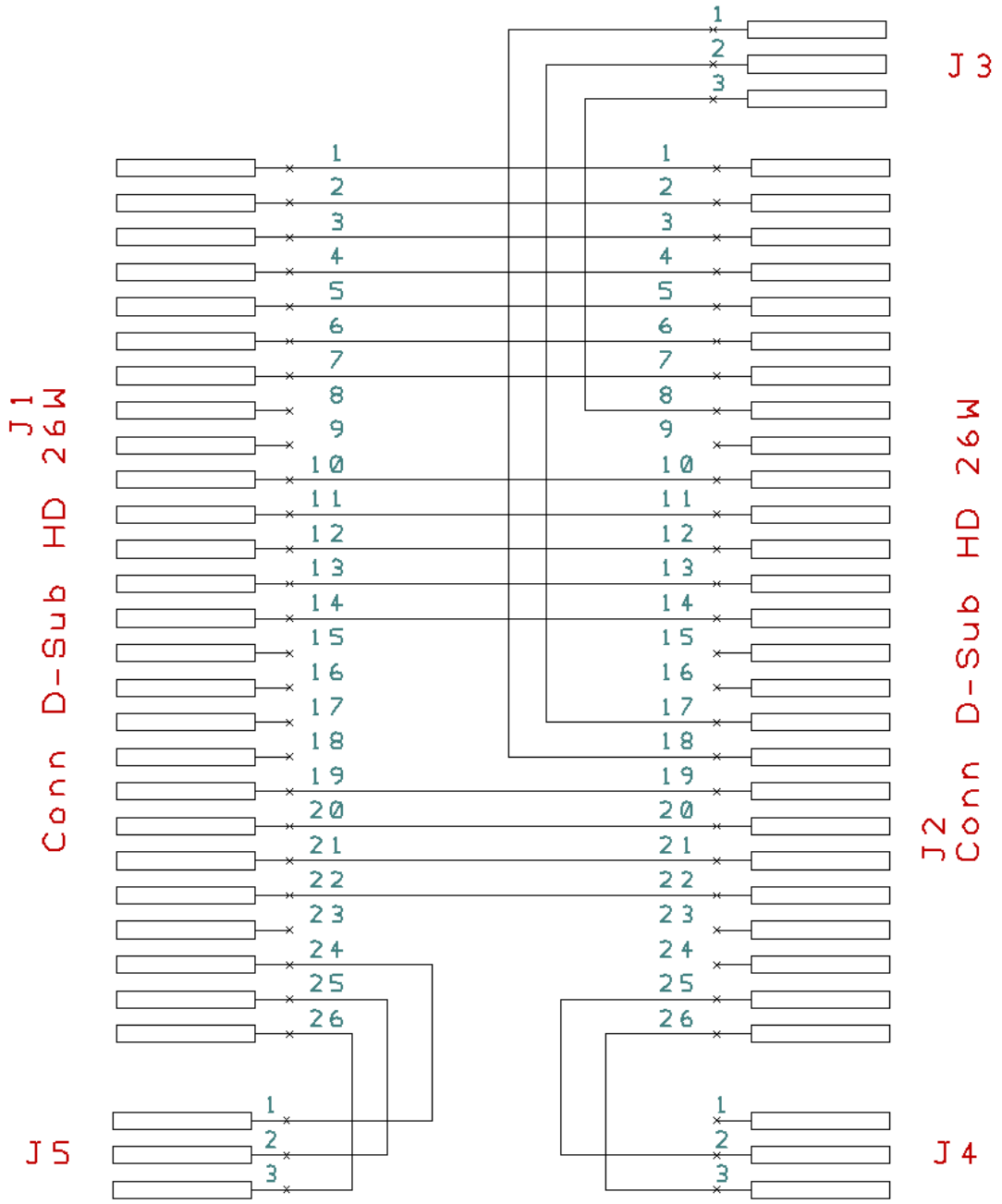
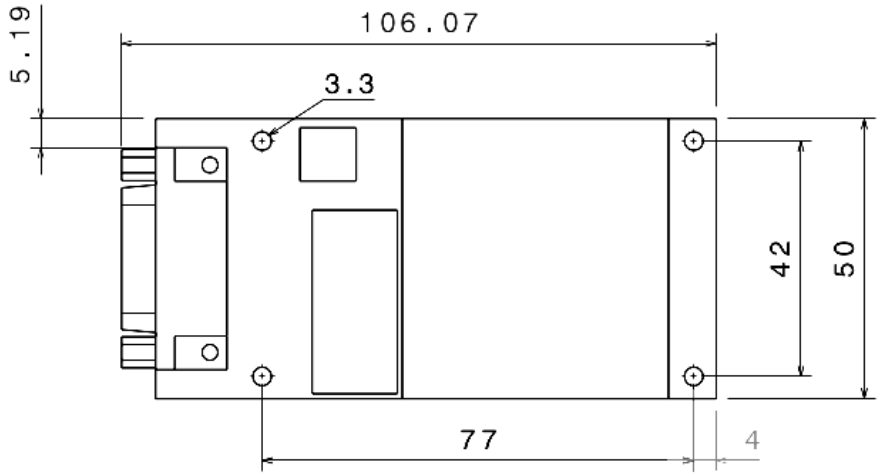
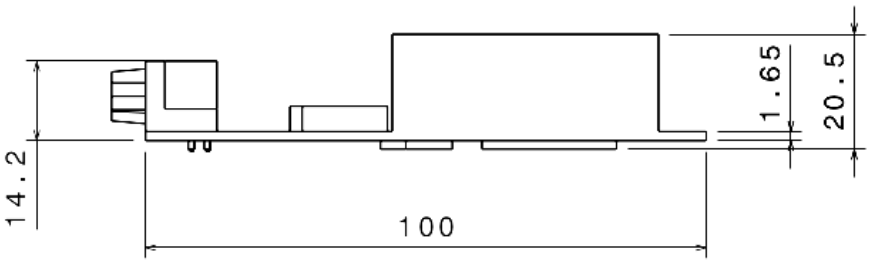


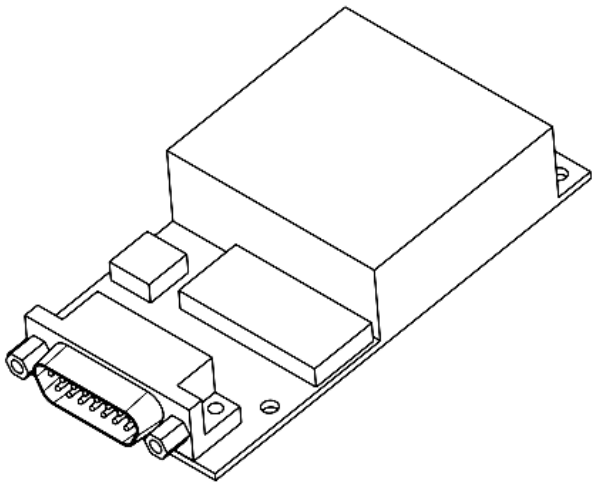
Figure 8: Main Harness Schematic

Appendix A Mechanical Drawings

MainBoard Dimensions

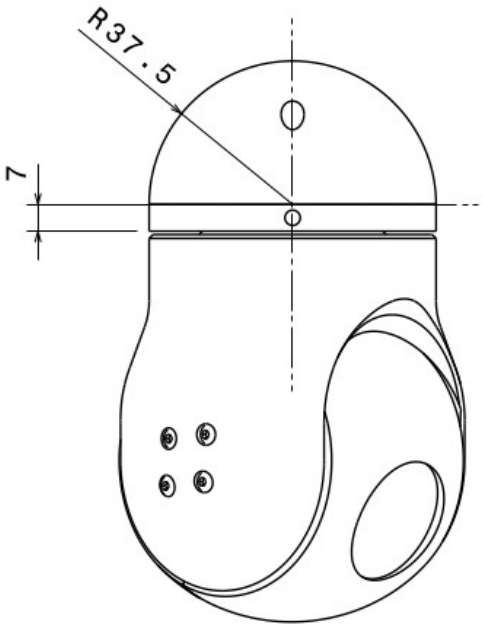




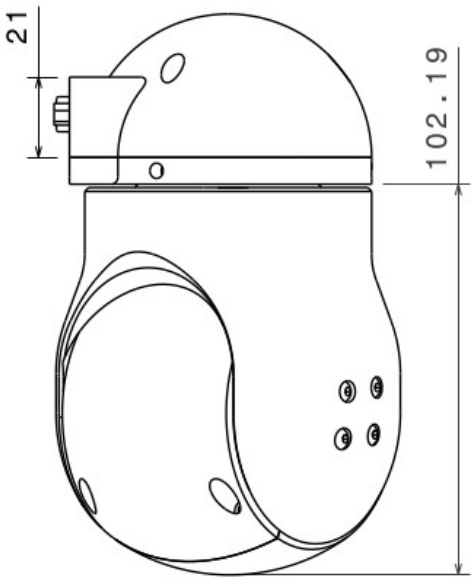


All distances and sizes are shown in mm

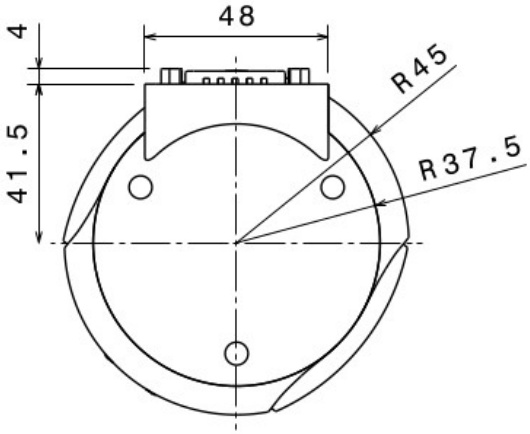
U-Camera External Size



Front view
Scale: 2:3



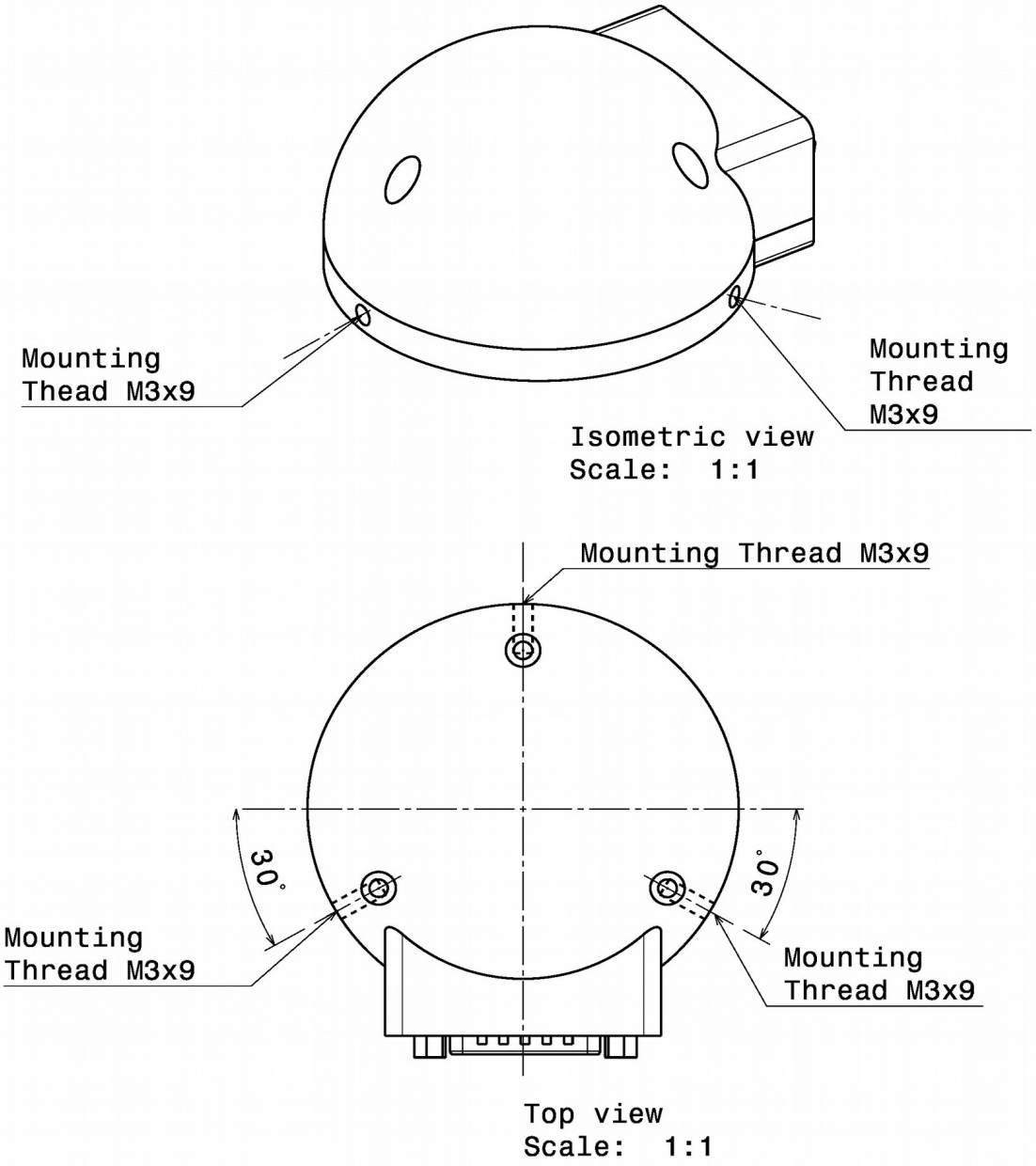
Left view
Scale: 2:3



Top view
Scale: 2:3

All distance and sizes
are in mm

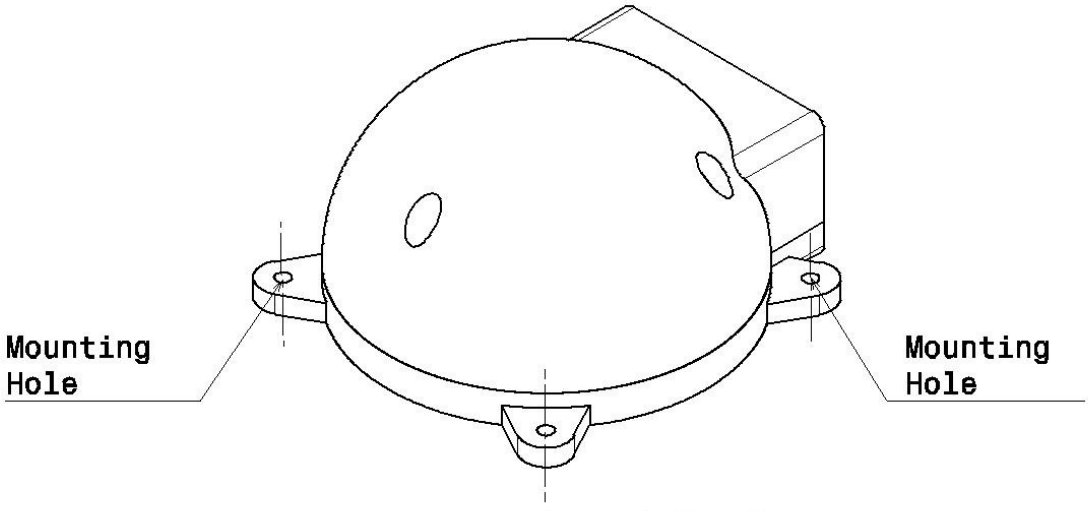
U-Camera Mounting system A



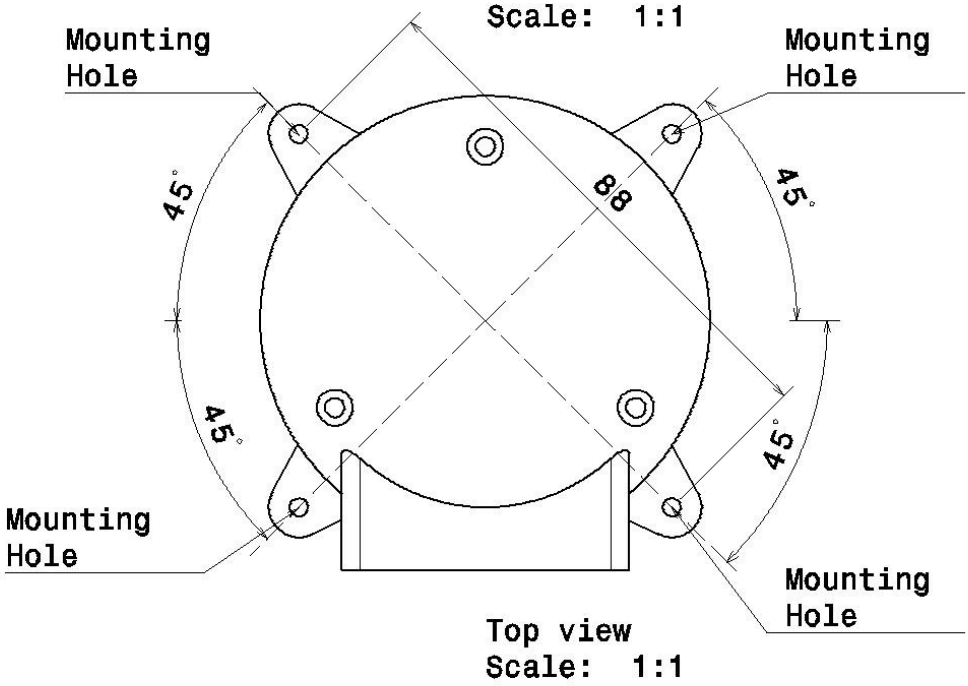
All distances and sizes are in mm

Note: other mounting options are available upon request.

U-Camera Mounting system B



Isometric view
Scale: 1:1



Top view
Scale: 1:1

All distances and sizes are in mm

Appendix B Change-log

This annex describes changes introduced to this document.

Date	Changes
2016/06/07	• Version up to 1.06 • Added IR palette periodic report packet • Added gimbal type report packet • Added missing IR packets to protocol brief
2016/05/17	• Version up to 1.05 • Added FFC Calibration Mode for IR Camera • Added Save FFC to NV memory for IR Camera • Added IR Palette command for IR Camera
2016/04/01	• Version up to 1.04 • Added Data Frequency Report and configuration • Removed position packet from periodic report
2016/02/15	• Version up to 1.03 • Added Autoalign modes • Added GPS antenna position packets
2015/11/19	• Added Mounting Type B
2015/11/18	• Updated some expressions • Corrected Save Configuration packet description
2015/11/03	• Version of document started 1.0 • Created Document

If you need a previous version of documentation, please, contact us at info@airelectronics.es