COPIS Communication Protocol Documentation

1. Overview

COPIS (Computer-Operated Photogrammetric Imaging System) uses a distributed network of camera-controller boards. Each controller manages one camera and communicates using the following methods:

- UART serial text protocol between the host PC and controller
- I^2C bus communication between one designated as primary and one or more secondary controllers

A G-Code–derived command language for 5-axis movement with extensions for multi-controller addressing, camera shutter, autofocus and focus stacking controls.

2. System Architecture

2.1 Controller Network Layout

A COPIS system may contain one or more controllers with fixed addresses. Any controller may serve be configured as primary, but the current PC COPIS client software requires the primary controller to be assigned address 0 with secondary controllers in sequential order starting at 1. Controllers normally generate random addresses on first boot, but your system should have been preconfigured and will not be randomized. See list of available COPIS command if you need to change the address.

2.2 Host Interface

- Typically, only the Primary controller needs to connect to the host PC via USB.
- Secondary controllers only require USB for debugging or firmware flashing.
- UART communication is standard serial text at 115200 baud, 8-bit, no parity. Any serial terminal program can be used to communicate with a controller. YAT (Yet Another Terminal) is recommended. Alternatively, the COPIS Client application may be used for communication and supports multiple camera and pose orchestration.

2.3 I^2C Bus

- All controllers should be configured to share a common I^2C bus.
- The primary controller acts as the master.
- Commands for secondary controllers are forwarded via this I^2C network.

3. UART Status Line Format

Controllers report their status as one single, comma-delimited line, using this generalized format:

- id:<id>,ssf:<flags>,pos:<x>,<y>,<z>,<pan>,<tilt>

Example:

- id:0,ssf:128,pos:12.30,0.00,18.00,0.00,3.00

Field Definitions:

- id — Controller address (0–127)
- ssf — 8-bit system state flag (0–255)
- pos — Five comma-delimited values:
    - X position (mm)
    - Y position (mm)
    - Z position (mm)
    - Pan angle (degrees)
    - Tilt angle (degrees)

4. The System State Flags (SSF)

The System State Flag is an 8-bit integer representing the current status of the controller. An SSF of 0 indicates the controller is idle and ready to accept a command.

The bit flags are:

- bit 0 – Serial communications in progress
- bit 1 – I^2C communication in progress
- bit 2 – A command has been received and is awaiting execution
- bit 3 – A command is being executed
- bit 4 – A target pose has been queued
- bit 5 – The controller is move to a target pose
- bit 6 – The controller is homing it's camera
- bit 7 – The controller is locked

Controllers always start up in a locked state. Controllers may also lock if an error is encountered during operation. Until unlocked, no movement or camera commands will be accepted. To unlock a controller, issue the command:

- >[target id]M511

The COPIS client software performs this automatically; manual unlocking is only needed when using external terminal software.

5. Multi-Controller Command Routing

COPIS extends standard G-Code with a routing prefix:

- >[target_id]<command>

Example:

- >3G1X100P100

If no prefix is given, the command is interpreted by the controller directly connected to the host PC. Valid target IDs: 0–127

6. Command Language

6.1 Motion Commands

Motion commands use a G-Code–like format:

- G1X<mm>Y<mm>Z<mm>P<deg>T<deg>

Example:

- >3G1X100P100

6.2 Camera Control Commands

Camera shutter:

- C0S<duration_seconds>

Camera autofocus:

- C1S<duration_seconds>

Example (auto-focus then take picture for controller 1):

- >1C1S2
- >1C0S2

6.3. Example UART Session

On connection, the controller may report:

- id:0,ssf:128,pos:12.30,0.00,18.00,0.00,3.00

Unlock the connected controller:

- M511

Move connected controller's camera 50 mm along X:

- G1X50

Trigger shutter on connected controller's camera:

- C0S1

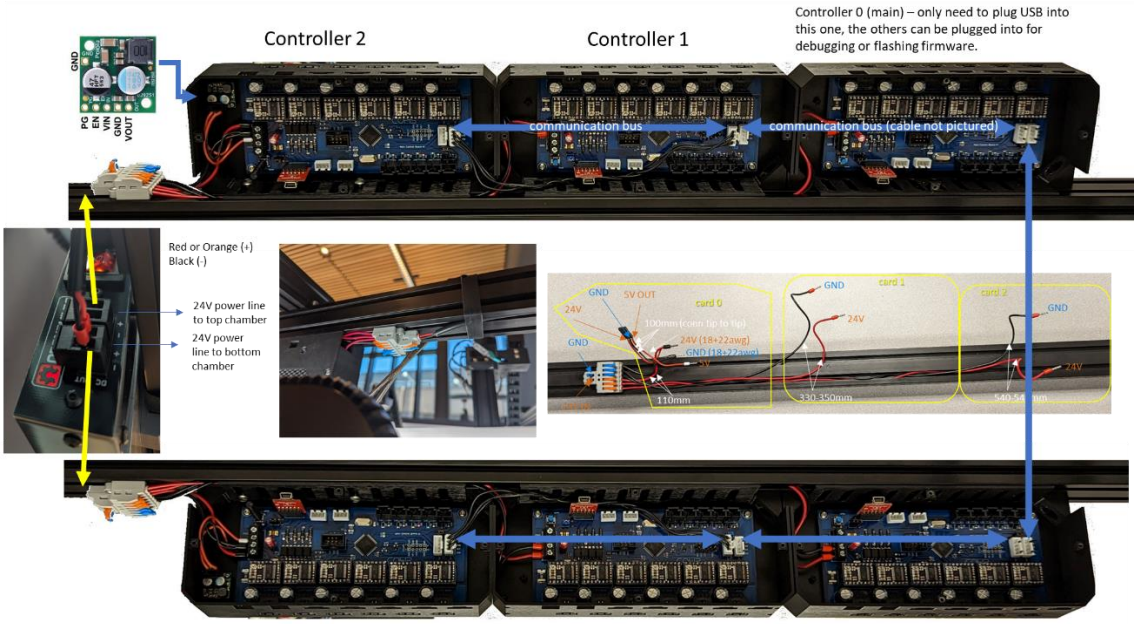
7. Command Execution Workflow

A single pose is most often comprised of a motion plus a camera action. A pose set is a group of poses that execute together and contains up to one pose per camera. All commands for a pose set can be sent to the primary controller at once. While each controller maintains a small internal command queue, it is best to wait until all controllers report ssf:0 (idle) before sending subsequent pose sets. The COPIS client application follows this workflow.

8. Physical Connections

Example 2-chamber, 6-camera setup:

- 24V power feeds top and bottom chambers.
- I^2C communication bus connects all controllers.
- Controller 0 is typically used for USB communication with the PC.



9. Command reference:

Desc	Code	Params	Version	Comments
Remote Shutter	C0	[P/S/X]##	101	P - milliseconds, S & X - Seconds
Remote AF	C1	[P/S/X]##	101	P - milliseconds, S & X - Seconds
Focus Stack	C10	Z##V##[P/S/X]##F##T	104,105	version 104 should not use this function (was still in dev.) As of version 105: V - num steps; Z - distance/step; P - shutter hold time in milliseconds; F-Feed rate; T - return to start; X pre - shutter delay in milliseconds, Y post shutter delay in milliseconds
Rapid Move	G0	X##Y##Z##P##T##	101	
Linear Move	G1	X##Y##Z##P##T##F##	101	
Homing Axis	G28	X##Y##Z##P##T##F##	101	
Pause	G4	[P/S/X]##	101	P - milliseconds, S & X - Seconds
Absolute Positioning	G90		101	
Relative Positioning	G91		101	
Set Position	G92	X##Y##Z##P##T##	101	
enable motor	M17		101	
disable motors	M18	[P/S/X]##	101,103	Parameter is optional. Time value P - milliseconds, S & X - seconds. If presents, sets the time motors will shutoff after period of inactivity
Set steps per unit dist (mm or dd)	M92	X##Y##Z##P##T##	101	
Set device ID	M101	V##	101,103	Must be done directly via serial if duplicates exist, starting in version 103, m101 without a parameter flips the role [primary/secondary]
Set motor idle lock time	M102	V##	101	V - milliseconds between 0 & 255, 255 keeps motors enabled. May change to 'P' variable instead of V in future update
Enable debug modes	M111	V##	101	Parameter can be used to enable/disable specific debug outputs 1=General, 2=Communications, 3=Motion Control, 4=Camera Control; no values enables/disables(flips) 1-4. 5 & 6 can be used to turn polling off(5) and on (6). 5 & 6 do not persist across reboots. To persist polling option (FW106) use M255 and set time to 0 (off) or other positive value (on).
Report limit switch states for all axis	M119		101	
Scan for connected cards	M120		101,103	Only applicable on main controllers, Starting in version 103 - optional param V queries specific id on bus. If V = id of card issuing command, then it

			will report its current pool info rather than querying the bus.
Reset status of connected cards	M121 V##	103	Resets the status of the connected card, optional param V queries specific id of card. If V = id of card issuing command, then it will report its current pool info rather than resetting.
Remove a previously detected card	M122 V##	103	Removes the connected card from pool, optional param V queries specific id of card. If V = id of card issuing command, then it will report its current pool info rather than removing.
Enable I2C settings cache	M123	103	Enables/disables use of I2C settings cache (if enabled, settings cache will be populated)
Refresh I2C settings cache	M124	103	Populate/refresh I2C settings cache - note cache can be repopoluated on a per card basis each time M503V## is called
Report I2C settings cache	M125 V##	103	Print out the cached settings for each card use optional V param to specify a card id
Enable/disable reporting via serial	M151	101	
Set Junction Deviation	M200 V##	101	
Set Acceleration	M201 V##	101	
Set Max_Speed	M203 X##Y##Z##P##T##	101	
Set Max Travel Distance	M208 X##Y##Z##P##T##	101	
Set Min Travel Distance	M209 X##Y##Z##P##T##	101	
Set internal poll interval	M255 [P/S/X]##V##	102,103	Time value P - milliseconds, S & X - seconds. No Value & 0 ignored. Max Value is 3000milliseconds. Anything higher will set to 3000ms. Starting on version 103 optional v param can be used to set role of card. 0 is secondary, >= 1 is primary; Starting with FW106 0 is acceptred and turns off the poll timer. Max value updated to 60000 in FW106
Enable Multi Turn	M360	101	
	M428 XYZPT	101	Sets current position to zero and defines a persistant offset from previous zero position (ie home). If Values are provided for the axis and optional param V is equal to 1, then provided values will define the offset rather than the current position relative to home.
Restore Machine defaults	M502	101	
Display Settings	M503 V##	101	Optional: V plus a random number to redirect secondary controller output from serial to i2C.
Unlock Device/Clear Status	M511	101	

Invert Selected Axis	M562 XYZPT	101	
Reboot	M998 V##	101	Parameter is optional. Any value greater than 0 causes allows any prior bufferred action to finish execution before reboot.