

MBARI 4K ROV Camera

100221507-11-A-DOC

Electrical Design Description and Programming Notes

Rev. A 10JUL21 mrc

Drawing numbers

Mechanical design base assembly part number: 100221414-01-ASM

Electrical design base part number: 100221507-00-ASM

Camera system block diagram: 100221507-00-F-ASM_4kROVCameraBlockDiagram.pdf

Camera housing wiring diagram: 100221507-01-A-SCH_4kROVCameraInternalWiring.pdf

Camera controller PCB schematic: 100221507-03-A-SCH_4KROVCameraPCB.pdf

Lapbox wiring diagram: 100221507-02-A-SCH_4KROVCameraLapBoxWiring.pdf

Lapbox PCB schematic: 100221507-04-A-SCH_4KROVCameraLabBoxPCB.pdf

Rackbox wiring diagram: 100221507-05-A-SCH_4KROVRackBoxWiring.pdf

Processor I/O port assignments and descriptions: 100221507-10-B-DOC_ProcessorPortAssignments.pdf

(Revision letters may advance).

Specifications

Camera Input Voltage: 18-36 Volts DC, 65 Watts (note: if external lasers are powered from the camera housing, they may restrict the upper voltage limit).

Rackbox Input Voltage: 110 VAC, ground fault protected.

Design Description

The overall system design consists of three major components and are shown in the overall block diagram drawing **100221507-00-F-ASM_4kROVCameraBlockDiagram.pdf**. These are the **subsea camera assembly including chassis and housing**, the **topside rack interface box ("rackbox")** and the **user interface control box ("lapbox")**. The camera system has been built in a collaboration between MBARI (camera chassis, rack box and lapbox), and DeepSea Power and Light LCC (camera housing and adapter optics). The camera assembly includes mechanical and electrical components and they are all documented in the respective Solidworks and Orcad drawing sets and all drawings are contained in a "released PDF's" folder located in the project library here: \\atlas\ProjectLibrary\902001_4K_ROVCameraDevelopment\EngineeringDesignDocuments\ReleasedPDF's

The camera chassis and associated components are based around a commercial camera from the Sony Corporation, the 2/3" 3 CMOS array **HDC-P50**. This camera is designed to be used for applications such as steady-cam and boom shooting and is therefore compact and stripped down with no audio inputs, viewfinder,

etc. The camera lends itself well to repackaging for a compact underwater housing design with a minimum of very dense printed circuit cards. The system lens is the [Canon 15X4.3B](#), a state-of-the-art wide-angle zoom lens. The final important element is the [optical adapter system](#) for matching the camera lens optics to the optical dome port and seawater properties. The optical adapter was designed and fabricated by Paul Remijan of Fathom Imaging.

The camera chassis electrical design includes a printed circuit board with micro-processor for local control and monitoring functions as well as the optical telemetry system.

Programming Notes

Camera PCB microprocessor functions

The camera internal housing microprocessor (Microchip DSPIC33FJ256MC710A-H/PF) provides power control, lens control, lens position data and environmental conditions. Note that unused I/O pins are configured as outputs and driven low to minimize power consumption.

Detailed description of the I/O functions:

1. SPI bus 1 communications for the following peripherals.
 - a. Data out, two channels for driving the D/A converter for the zoom and focus lens servo commands. The DAC full scale range is 0-5V and analog circuitry scales to the appropriate lens drive signal range of around 2-8V.
 - b. Data in from the A/D converter for reading lens zoom and focus position feedback. The A/D converter full scale range is +/- 2.5V from the 2.5V reference, in two's complement binary, and analog circuitry scales the lens output of 2-7V to match this range.
2. SPI bus 2 communications for the following peripherals. Note that Brian Kieft has a C++ driver written for the LRAUV – which uses the same chipset - for handling these devices.
 - a. U6 a Honeywell humidity (and temp.) sensor. The humidity data is passed to the lapbox, the temperature data is used internally by the chip and is biased by local heat sources so is not used by the camera system.
 - b. U3 a pressure (and temp.) sensor. The pressure data is passed to the lapbox. Here too, the temperature data is used internally by the chip and is biased by local heat sources so is not used by the camera system.
 - c. U27 an external EEPROM memory chip.
3. Analog input CAMERA_TEMP. This analog voltage temperature input is the true measure of internal housing temperature. The sensor placement minimizes biasing by other local heat sources. The voltage to temperature conversion is 10mV per degree C + 500mV, i.e. 600mV = 10 degrees C.
4. Digital input /AFT_H2O_ALRM. This normally high input signal will go low when seawater is present at the rear or aft water alarm pins.
5. Digital input /FWD_H2O_ALRM. This normally high input signal will go low when seawater is present at the forward water alarm pins.
6. Digital output 2X_EXTENDER. This output signal drives the H-bridge circuit and actuator that moves the lens 2 times extender lever. A high level output places the camera lens in normal zoom operation. A low level output drives the zoom extender to the 2X zoom position. This signal should be configured to come up in the high level output state. I may need to add a pull-up resistor to hold

the state high as the system boots up to keep the actuator from moving every time the camera is powered up.

7. Digital output CAMERA_PWR. This output signal drives a relay that shorts the external power control I/O pins on the camera and provides a “soft” way to control camera power while leaving the 12V bus powered. High level output turns the camera on and low level output turns the camera off. Note that the camera controller PCB and micro are always on when ROV power to the camera is on.
8. Digital output /LASER_PWR. This output signal drives a smart switch that controls power to external lasers – if installed. High level output turns laser power on and low level output turns laser power off. The switch will automatically shut off and attempt restart if the current exceeds 2 Amps.
9. Digital input /OVERTEMP. This input signal flags that the hardware over-temperature circuitry has powered down the camera locally. Low level indicates the camera is in over-temperature of 47 degrees C or above and is powered down by hardware. High level indicates that the camera temperature is below the shutdown threshold. There is approximately 3 degrees of hysteresis so once an over temperature shutdown occurs, the camera will not power back up until the temperature drops below 44 degrees C. This hardware based over-temperature shutdown is completely independent of the software controlled camera power control. Note that one of the air circulating fans in the camera housing continues to operate during over temperature shutdown, helping to restore the temperature to the normal operating range.

Lapbox PCB microprocessor and user interface functions

The camera control lapbox uses the same microprocessor (Microchip DSPIC33FJ256MC710A-H/PF), and shares some of the same I/O configurations as the camera micro. The lapbox micro reads the user inputs for power and lens control and drives displays reflecting the state of the system. There are two separate control mechanisms. The lapbox functions that directly control and read back data from the camera micro are one standalone system. These functions are the camera and laser power control buttons, lens zoom and focus user controls and the environmental alarms. Design note, the functions for camera and laser power have no state feedback and the designer can decide to either illuminate the switch when detecting a switch input for these functions, or illuminate the switch when the bottomsides camera micro state change is acknowledged – if the architecture supports it.

Although the camera system is standalone, some data is passed over to NAVPROC or similar system for logging. This includes lens zoom and focus position and environmental data and optionally alarm status.

The second category are lapbox user functions that are implemented by the ROV control or other external system that are passed from the lapbox to another computer such as NAVPROC over an EIA 232 serial line. These functions include the pan & tilt controls for the camera and lights and associated selector switch functions. The architecture for these functions has been that the switch press state has been passed to NAVPROC. NAVPROC then sends a state acknowledgement and implements the function and the lapbox micro reflects the state on the switch indicator LED.

The user switch actuators are all momentary and switch inputs to the micro are conditioned using U1 and U4 MAX6818EAP+T switch debouncers. These I/O chips give the designer two options for reading switch inputs. In one mode, the switch state is latched when a user presses a switch, the chip outputs are continuously polled and after reading, the latches subsequently cleared by strobing the /SW_ENABLE. In the second mode, when a switch input detected, it is latched and /SW_CHANGE is used

to generate an interrupt. Subsequently the switch inputs are read and cleared with strobing the /SW_ENABLE line. See the chip data sheet for details. The maximum current through each switch is limited to 10mA., enough to keep the contacts low resistance but not create too much power dissipation.

The switch LED indicator lights are driven by a current buffer providing 12.5mA each when illuminated and there is no duty cycle limit or limit to the number of simultaneously illuminated LED's.

The camera lapbox design includes a piezo alarm that is driven from the microprocessor PIEZO_ALARM output signal. The implementation of this alarm is described as optional below, however the alarm functions of TEMP, WATER, and HUMIDITY are all serious alarms and the use of the piezo alarm is recommended.

Note that as in the camera micro, unused I/O pins must be configured as outputs and driven low to minimize microprocessor power consumption. The signals described below are received from or passed to the camera micro or NAVPROC and also are received and/or displayed on the lapbox lighted switch buttons.

Important design consideration: Mike Risi pointed out that it is very useful to have a human readable output from the lapbox for camera setup and debugging. For example on the lapbox there is no way to read the actual camera housing internal humidity or temperature values. If a terminal or laptop could be temporarily plugged into the lapbox serial port allocated for NAVPROC and these values presented in human readable form, then it would greatly aid the final camera checkout and housing closing process.

Power Control and Indicators

1. LASER_PWR_SW. High level switch input when lapbox **LASER** power switch is pressed. Function controls (toggles) the camera micro /LASER_PWR signal and the lapbox LASER_PWR_LED indicator driver.
2. CAMERA_PWR_SW. High level switch input when **CAMERA** power switch is pressed. Function controls (toggles) the camera micro CAMERA_PWR signal and the lapbox CAM_PWR_LED indicator driver. To prevent accidental turn-off of the camera, this switch state must be read and cleared for three sequential seconds before implementing the function. In both on and off?? When an over-temperature condition occurs on the camera and the hardware shuts the camera power off as seen with the /OVERTEMP flag (and indicator light) being set, the camera power CAMERA_PWR function should be turned off and blocked until the /OVERTEMP has cleared. The hardware will automatically turn the camera power back on, and clear the /OVERTEMP flag but it makes sense to have the user have to turn the power back on when the indicator flag (and light) show that the camera has cooled off sufficiently. For more detail, see the TEMP_ALARM_LED function below.

Actuator Functions

1. 2X_EXTENDER_SW. High level switch input when lapbox **2X EXTENDER** switch is pressed. Function controls (toggles) the camera micro 2X_EXTENDER signal and the lapbox 2X_EXTENDER_LED indicator driver.
2. SPI bus 2 communications for the following peripherals.
 - a. 2 channels of data in from the A/D converter for reading the analog signals from the focus position slide potentiometer and the zoom rate rocker potentiometer. The A/D converter full

scale range is +/- 2.5V from the 2.5V reference, in two's complement binary, and analog circuitry scales the potentiometer outputs to match this range.

Alarms

1. **TEMP.** This red indicator light is driven by the signal TEMP_ALARM_LED. The light should be flashed once per second when the camera housing internal temperature reading, CAMERA_TEMP, reaches 44 degrees C. If an /OVERTEMP flag is set, the light should be set to full on, CAMERA_PWR signal negated and blocked and the lapbox CAM_PWR_LED turned off. When the /OVERTEMP flag is cleared, the TEMP_ALARM_LED can be turned off (or blinked depending on the temperature reading) and the CAMERA_PWR signal unblocked. There is also the option of paralleling the light function with an installed piezo alarm buzzer turned on by a high level on the lapbox micro PIEZO_ALARM function. The goal here is to warn the user when the camera housing internal temperature reaches 44 deg. C to allow them to shut down the camera and allow it to cool (an internal fan keeps running). If an automatic shutdown occurs (at ~47 deg. C) then the TEMP alarm light goes on, the camera power indications will be switched off and the subsequent power-up of CAMERA_PWR and the lapbox CAM_PWR_LED blocked until the /OVERTEMP is cleared around 45 deg. C. (the camera will not power up anyway while the flag is set because of the independent hardware shutdown). This should present the simplest information to the operator, when an over-temperature occurs, the camera (and indicator light) power off and cannot be switched back on until the TEMP alarm light goes off or back to blinking.
2. **WATER.** This red indicator light is driven by WATER_ALARM_LED when either of the signals /AFT_H2O_ALARM or /FWD_H2O_ALARM are (low level) active. Optionally the piezo alarm buzzer can simultaneously also be turned on by a high level on the lapbox micro PIEZO_ALARM function.
3. **HUMIDITY.** This red indicator is driven by HUMIDITY_ALARM_LED. It should be flashed once per second if the housing humidity reaches 15% and turned solid on if the housing humidity reaches 30%. It may be prudent to have some mild digital averaging or other filtering on this signal. There is also the option of paralleling the HUMIDITY alarm function with the piezo alarm buzzer.

Pan & Tilt Functions (passed to NAVPROC)

Lapbox pan & tilt functions are not functionally coupled with the camera control functions but are

1. **JOYSTK_REV_SW.** High level switch input when lapbox **JOYSTICK REVERSAL** switch is pressed. Toggle function informs NAVPROC to reverse the lapbox pan & tilt joystick Y axis. LED function state confirmation indicator is driven by the lapbox micro signal JOYSTK_REV_LED.
2. **JOYSTK_SEN_SW.** High level switch input when lapbox **P & T FINE CONTROL** switch is pressed. Toggle function informs NAVPROC to divide pan & tilt X and Y inputs by 50%. LED function state confirmation indicator is driven by the lapbox micro signal JOYSTK_SEN_LED.
3. **PORT_LIGHT_SW.** High level switch input when lapbox **PORT LIGHT** switch is pressed. Toggle function informs NAVPROC to assign the lapbox pan & tilt joystick to the ROV port light pan & tilt. LED function state confirmation indicator is driven by the lapbox micro signal PORT_LIGHT_LED.
4. **PORT_CAM_SW.** High level switch input when lapbox **UPPER CAMERA** switch is pressed. Toggle function informs NAVPROC to assign the lapbox pan & tilt joystick to the ROV upper camera pan & tilt. LED function state confirmation indicator is driven by the lapbox micro signal PORT_CAM_LED.

5. STBD_CAM_SW. High level switch input when lapbox **MAIN CAMERA** switch is pressed. Toggle function informs NAVPROC to assign the lapbox pan & tilt joystick to the ROV main camera pan & tilt. LED function state confirmation indicator is driven by the lapbox micro signal STBD_CAM_LED.
6. STBD_LIGHT_SW. High level switch input when lapbox **STBD LIGHT** switch is pressed. Toggle function informs NAVPROC to assign the lapbox pan & tilt joystick to the ROV starboard light pan & tilt. LED function state confirmation indicator is driven by the lapbox micro signal STBD_LIGHT_LED.
7. Microprocessor A/D converter input AN10_JOYSTK_Y. Lapbox pan & tilt joystick Y axis full scale 0-3.3 Volt signal.
8. Microprocessor A/D converter input AN11_JOYSTK_X. Lapbox pan & tilt joystick X axis full scale 0-3.3 Volt signal.

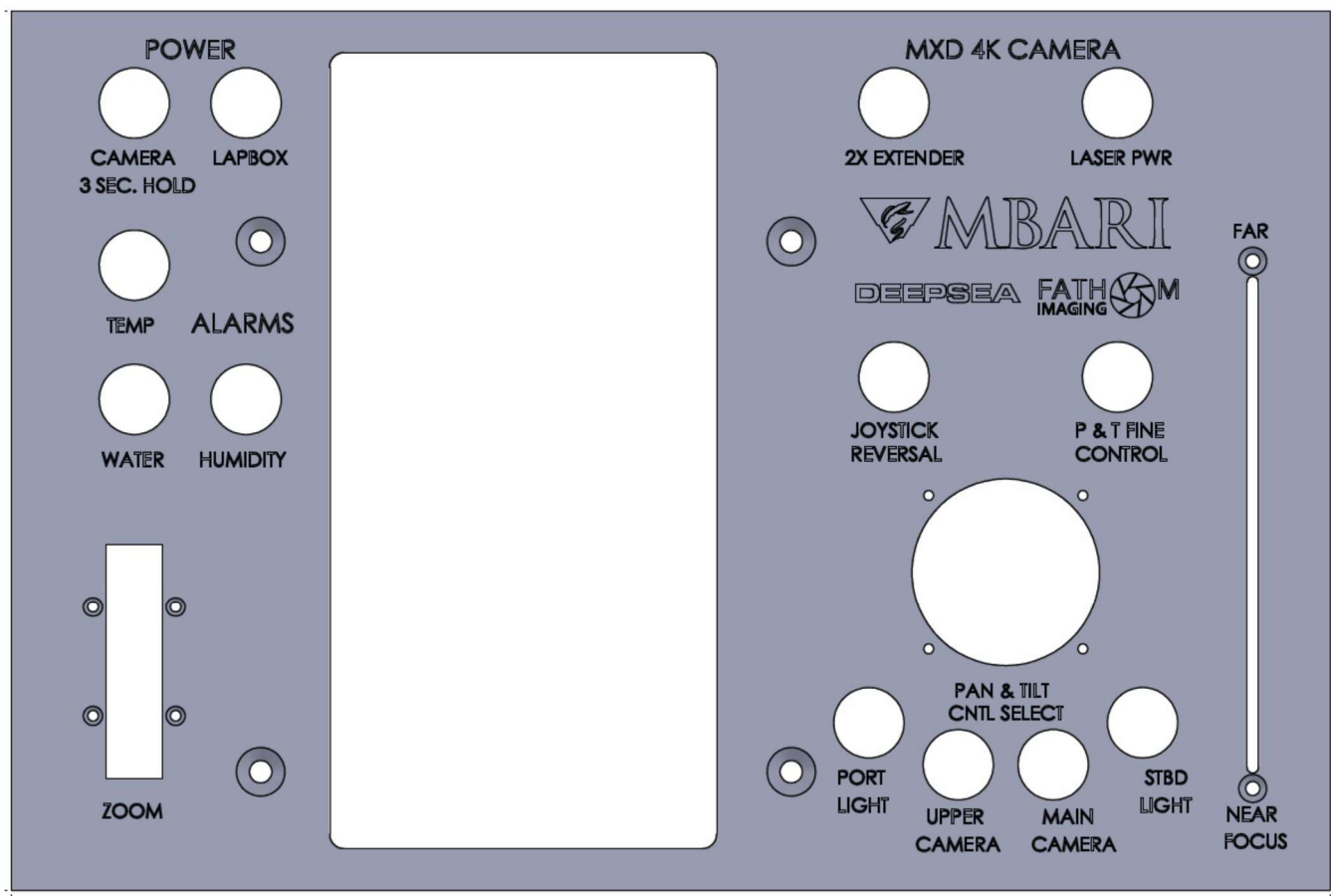


Figure 1. Camera control lapbox panel