Causal Chamber™

Configuration `lt_mk2_camera_fast`

```
config version : 1.1
 chamber model : Light Tunnel Mk2

changelog
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  1.1: Increased measurement speed (see ch-chamber v0.2.0)
  1.0: Initial version
```
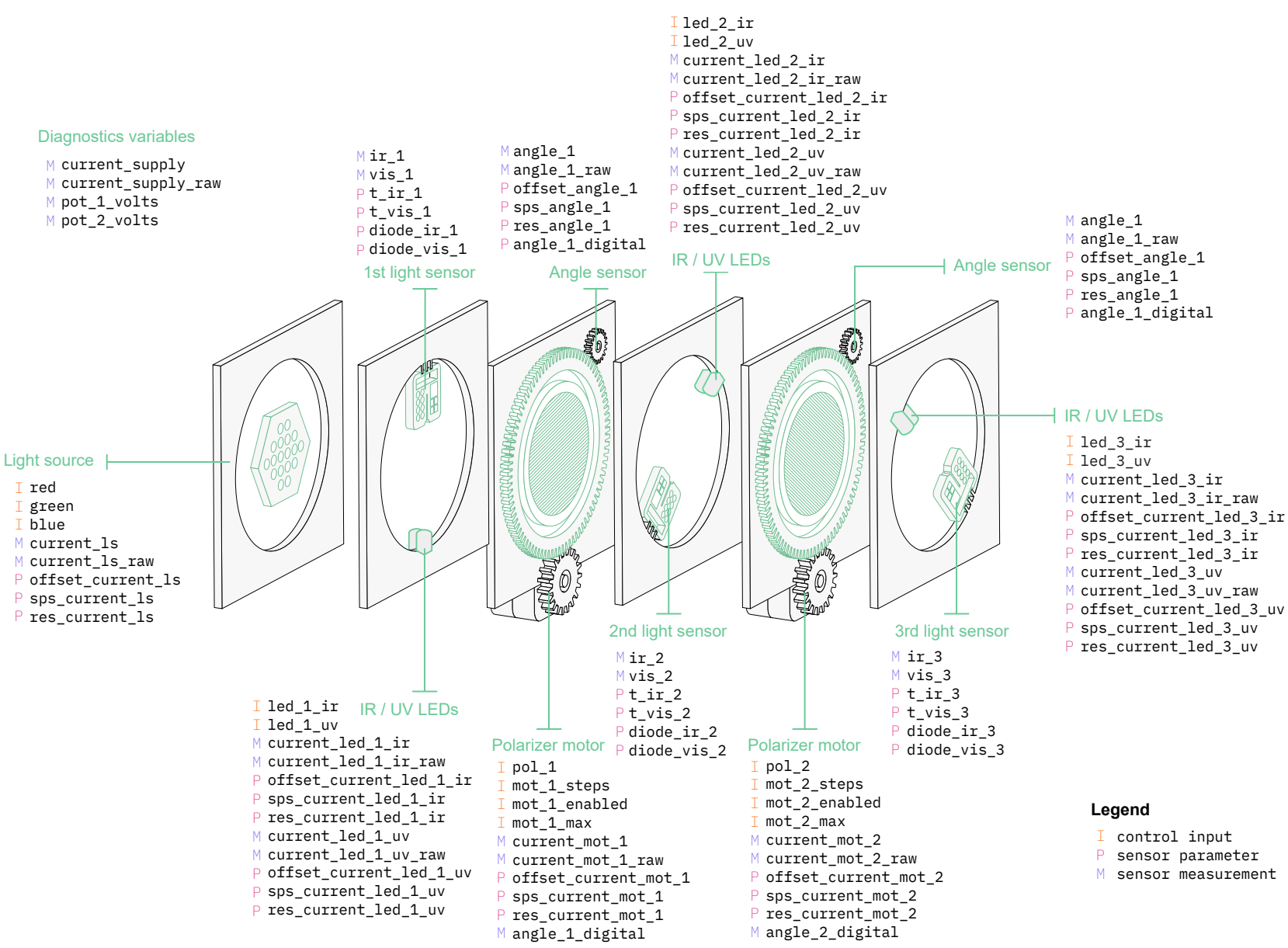

Description This configuration exposes the variables of the Light Tunnel Mk2. It allows setting the actuators of the tunnel (see table below) and capturing images using the camera. To ensure maximum resolution in the positioning of the polarizer frames, the motor parameters are kept fixed at the optimal levels. To increase the measurement speed, the light sensors are ignored and the parameters of all other sensors are kept fixed at the optimal settings.

Diagram

See the variable table below for a detailed description of each variable.



Basic operation

The chambers are operated through three basic instructions:

1. `set(target,value)` The chamber sets the variable `target` to the given `value`, and returns when the change has been made in the hardware, i.e., there is no need to introduce additional delays after this instruction. The list of valid targets (settable variables) and their values is given in the table below.

2. `measure(n,delay)`. The chamber takes `n` successive measurements of all variables, including images if it produces them. Setting `delay` (in milliseconds) adds an additional delay between measurements (if unset, `delay` defaults to 0).

3. `wait(milliseconds)` The chamber acts as a precise clock, and waits the given `milliseconds` before executing the next instruction. This is useful if we want to add a delay between a `set` and `measure` instruction.

Variables Table

Variable	Settable	Values	Default	Description
`timestamp`	No	float	–	The timestamp of the measurement, in seconds with respect to the system wall-clock.
`counter`	No	$\{i \in \mathbb{Z} : i \geq 0\}$	–	Measurement counter.
`flag`	Yes	float	0	User-defined flag.
`intervention`	No	{0,1}	–	Intervention flag. Has a value of 1 if this is the first measurement after a SET instruction, and 0 otherwise.
`image_size`	Yes	$\{1, \ldots, 1024\}$	1024	The size of the image produced by the camera, e.g., 100 corresponds to an image of 100×100 pixels.
`red`	Yes	$\{0, \ldots, 255\}$	0	The brightness setting of the red LEDs on the main light source. Higher values correspond to higher brightness.
`green`	Yes	$\{0, \ldots, 255\}$	0	The brightness setting of the green LEDs on the main light source. Higher values correspond to higher brightness.
`blue`	Yes	$\{0, \ldots, 255\}$	0	The brightness setting of the blue LEDs on the main light source. Higher values correspond to higher brightness.
`pol_1`	Yes	float $\in [-270, 270]$	0	The set position of the first polarizer, in degrees. The actual angle of the polarizer may slightly deviate from this setting due to the imperfect coupling of the mechanical pieces and the resolution of the motor (see `mot_1_steps`).
`pol_2`	Yes	float $\in [-270, 270]$	0	The set position of the second polarizer, in degrees. The actual angle of the polarizer may slightly deviate from this setting due to the imperfect coupling of the mechanical pieces and the resolution of the motor (see `mot_2_steps`).
`led_1_ir`	Yes	$\{0, \ldots, 4095\}$	0	The brightness setting of the infrared (IR) LED above the first light-intensity sensor. Higher values correspond to higher brightness.
`led_1_uv`	Yes	$\{0, \ldots, 4095\}$	0	The brightness setting of the ultraviolet (UV) LED above the first light-intensity sensor. Higher values correspond to higher brightness.
`led_2_ir`	Yes	$\{0, \ldots, 4095\}$	0	The brightness setting of the infrared (IR) LED above the second light-intensity sensor. Higher values correspond to higher brightness.
`led_2_uv`	Yes	$\{0, \ldots, 4095\}$	0	The brightness setting of the ultraviolet (UV) LED above the second light-intensity sensor. Higher values correspond to higher brightness.
`led_3_ir`	Yes	$\{0, \ldots, 4095\}$	0	The brightness setting of the infrared (IR) LED above the third light-intensity sensor. Higher values correspond to higher brightness.
`led_3_uv`	Yes	$\{0, \ldots, 4095\}$	0	The brightness setting of the ultraviolet (UV) LED above the third light-intensity sensor. Higher values correspond to higher brightness.
`current_ls`	No	float	–	The measurement of electric current drawn by the light source, in Amperes.
`current_ls_raw`	No	$\{-32768, \ldots, 32767\}$	–	The uncalibrated measurement, i.e., the raw ADC output, corresponding to the measurement `current_ls`.
`offset_current_ls`	No	$\{0, \ldots, 4095\}$	0	The reference voltage (offset) of the ADC producing the `current_ls` and `current_ls_raw` measurements. The actual reference voltage (in Volts) is given by $5 \times \frac{\texttt{offset\_current\_ls}}{4095}$. Because the signal from the current sensor is passed through an inverting amplifier, higher values of `offset_current_ls` result in lower values of `current_ls_raw`.
`sps_current_ls`	No	$\{0, \ldots, 7\}$	7	The data rate of the ADC producing the `current_ls` and `current_ls_raw` measurements. Lower values mean the ADC accumulates more readings to produce a single measurement, reducing noise but also lowering the measurement speed. The actual data rates are (respectively) $8, 16, 32, 64, 128, 250, 475$ and 860 samples per second.
`res_current_ls`	No	$\{0, \ldots, 5\}$	0	The resolution of the ADC producing the `current_ls` and `current_ls_raw` measurements. Higher values mean a higher resolution, where a smaller voltage range is mapped to the ADC output range $\{-32768, 32767\}$. The voltage ranges are, respectively, $\pm 6.144, \pm 4.096, \pm 2.048, \pm 1.024, \pm 0.512$ and ± 0.256 Volts. The reading will saturate, i.e., clamp at -32768 or 32767, if the input voltage exceeds the set range.

Table 1: Description of the variables produced by the chamber configuration `lt_mk2_camera_fast`. Settable variables can be manipulated by calling `.set(<variable>,<value>)`. "float" corresponds to a 32-bit float.

Variable	Settable	Values	Default	Description
`mot_1_steps`	No	{3200, 1600, 800, 400, 200}	3200	The steps-per-revolution of the stepper motor controlling the first polarizer. Higher values mean a higher motor resolution, i.e., more precise positioning. At low current levels `mot_1_max` and/or step values below 800, the motor may lose torque and start missing steps, resulting in a mismatch between the set position `pol_1` and the actual polarizer angle.
`mot_1_enabled`	No	{0,1}	1	Enables (1) or disables (0) the motor of the first polarizer. If the motor is disabled (0), setting `pol_1` will have no effect on the actual position of the polarizer.
`mot_1_max`	No	$\{0, \dots, 4095\}$	3000	Regulates the maximum current drawn by the motor controlling the first polarizer. At low current levels and/or `mot_1_steps` values below 800, the motor may lose torque and start missing steps, resulting in a mismatch between the set position `pol_1` and the actual polarizer angle.
`current_mot_1`	No	float	–	The measurement (in Amperes) of the electric current drawn by the motor controlling the first polarizer.
`current_mot_1_raw`	No	$\{-32768, \dots, 32767\}$	–	The uncalibrated measurement, i.e., the raw ADC output, corresponding to the measurement `current_mot_1`.
`offset_current_mot_1`	No	$\{0, \dots, 4095\}$	0	The reference voltage (offset) of the ADC producing the `current_mot_1` and `current_mot_1_raw` measurements. The actual reference voltage (in Volts) is given by $5 \times \frac{\texttt{offset\_current\_mot\_1}}{4095}$. Because the signal from the current sensor is passed through an inverting amplifier, higher values of `offset_current_mot_1` result in lower values of `current_mot_1_raw`.
`sps_current_mot_1`	No	$\{0, \dots, 7\}$	7	The data rate of the ADC producing the `current_mot_1` and `current_mot_1_raw` measurements. Lower values mean the ADC accumulates more readings to produce a single measurement, reducing noise but also lowering the measurement speed. The actual data rates are (respectively) $8, 16, 32, 64, 128, 250, 475$ and 860 samples per second.
`res_current_mot_1`	No	$\{0, \dots, 5\}$	0	The resolution of the ADC producing the `current_mot_1` and `current_mot_1_raw` measurements. Higher values mean a higher resolution, where a smaller voltage range is mapped to the ADC output range $\{-32768, 32767\}$. The voltage ranges are, respectively, $\pm 6.144, \pm 4.096, \pm 2.048, \pm 1.024, \pm 0.512$ and ± 0.256 Volts. The reading will saturate, i.e., clamp at -32768 or 32767, if the input voltage exceeds the set range.
`angle_1`	No	float	–	The position (in degrees) of the first polarizer as measured by the analog angle sensor.
`angle_1_raw`	No	$\{-32768, \dots, 32767\}$	–	The uncalibrated angle measurement for the first polarizer, i.e., the raw ADC output corresponding to `angle_1`.
`offset_angle_1`	No	$\{0, \dots, 4095\}$	0	The reference voltage (offset) of the ADC producing the `angle_1` and `angle_1_raw` measurements. The actual reference voltage (in Volts) is given by $5 \times \frac{\texttt{offset\_angle\_1}}{4095}$.
`sps_angle_1`	No	$\{0, \dots, 7\}$	7	The data rate of the ADC producing the `angle_1` and `angle_1_raw` measurements. Lower values mean the ADC accumulates more readings to produce a single measurement, reducing noise but also lowering the measurement speed. The actual data rates are (respectively) $8, 16, 32, 64, 128, 250, 475$ and 860 samples per second.
`res_angle_1`	No	$\{0, \dots, 5\}$	0	The resolution of the ADC producing the `angle_1` and `angle_1_raw` measurements. Higher values mean a higher resolution, where a smaller voltage range is mapped to the ADC output range $\{-32768, 32767\}$. The voltage ranges are, respectively, $\pm 6.144, \pm 4.096, \pm 2.048, \pm 1.024, \pm 0.512$ and ± 0.256 Volts. The reading will saturate, i.e., clamp at -32768 or 32767, if the input voltage exceeds the set range.
`angle_1_digital`	No	$\mathbb{Z}$	–	The position (in degrees) of the first polarizer as measured by the rotary encoder.

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Variable	Settable	Values	Default	Description
`mot_2_steps`	No	{3200, 1600, 800, 400, 200}	3200	The steps-per-revolution of the stepper motor controlling the second polarizer. Higher values mean a higher motor resolution, i.e., more precise positioning. At low current levels `mot_2_max` and/or step values below 800, the motor may lose torque and start missing steps, resulting in a mismatch between the set position `pol_2` and the actual polarizer angle.
`mot_2_enabled`	No	{0,1}	1	Enables (1) or disables (0) the motor of the second polarizer. If the motor is disabled (0), setting `pol_2` will have no effect on the actual position of the polarizer.
`mot_2_max`	No	$\{0, \dots, 4095\}$	3000	Regulates the maximum current drawn by the motor controlling the second polarizer. At low current levels and/or `mot_2_steps` values below 800, the motor may lose torque and start missing steps, resulting in a mismatch between the set position `pol_2` and the actual polarizer angle.
`current_mot_2`	No	float	–	The measurement (in Amperes) of the electric current drawn by the motor controlling the second polarizer.
`current_mot_2_raw`	No	$\{-32768, \dots, 32767\}$	–	The uncalibrated measurement, i.e., the raw ADC output, corresponding to the measurement `current_mot_2`.
`offset_current_mot_2`	No	$\{0, \dots, 4095\}$	0	The reference voltage (offset) of the ADC producing the `current_mot_2` and `current_mot_2_raw` measurements. The actual reference voltage (in Volts) is given by $5 \times \frac{\texttt{offset\_current\_mot\_2}}{4095}$. Because the signal from the current sensor is passed through an inverting amplifier, higher values of `offset_current_mot_2` result in lower values of `current_mot_2_raw`.
`sps_current_mot_2`	No	$\{0, \dots, 7\}$	7	The data rate of the ADC producing the `current_mot_2` and `current_mot_2_raw` measurements. Lower values mean the ADC accumulates more readings to produce a single measurement, reducing noise but also lowering the measurement speed. The actual data rates are (respectively) $8, 16, 32, 64, 128, 250, 475$ and 860 samples per second.
`res_current_mot_2`	No	$\{0, \dots, 5\}$	0	The resolution of the ADC producing the `current_mot_2` and `current_mot_2_raw` measurements. Higher values mean a higher resolution, where a smaller voltage range is mapped to the ADC output range $\{-32768, 32767\}$. The voltage ranges are, respectively, $\pm 6.144, \pm 4.096, \pm 2.048, \pm 1.024, \pm 0.512$ and ± 0.256 Volts. The reading will saturate, i.e., clamp at -32768 or 32767, if the input voltage exceeds the set range.
`angle_2`	No	float	–	The position (in degrees) of the second polarizer as measured by the analog angle sensor.
`angle_2_raw`	No	$\{-32768, \dots, 32767\}$	–	The uncalibrated angle measurement for the second polarizer, i.e., the raw ADC output corresponding to `angle_2`.
`offset_angle_2`	No	$\{0, \dots, 4095\}$	0	The reference voltage (offset) of the ADC producing the `angle_2` and `angle_2_raw` measurements. The actual reference voltage (in Volts) is given by $5 \times \frac{\texttt{offset\_angle\_2}}{4095}$.
`sps_angle_2`	No	$\{0, \dots, 7\}$	7	The data rate of the ADC producing the `angle_2` and `angle_2_raw` measurements. Lower values mean the ADC accumulates more readings to produce a single measurement, reducing noise but also lowering the measurement speed. The actual data rates are (respectively) $8, 16, 32, 64, 128, 250, 475$ and 860 samples per second.
`res_angle_2`	No	$\{0, \dots, 5\}$	0	The resolution of the ADC producing the `angle_2` and `angle_2_raw` measurements. Higher values mean a higher resolution, where a smaller voltage range is mapped to the ADC output range $\{-32768, 32767\}$. The voltage ranges are, respectively, $\pm 6.144, \pm 4.096, \pm 2.048, \pm 1.024, \pm 0.512$ and ± 0.256 Volts. The reading will saturate, i.e., clamp at -32768 or 32767, if the input voltage exceeds the set range.
`angle_2_digital`	No	$\mathbb{Z}$	–	The position (in degrees) of the second polarizer as measured by the rotary encoder.
`current_led_1_ir`	No	float	–	Measurement (in Amperes) of the current drawn by the IR LED above the first sensor.
`current_led_1_ir_raw`	No	$\{-32768, \dots, 32767\}$	–	The uncalibrated measurement, i.e., the raw ADC output, corresponding to the measurement `current_led_1_ir`.

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Variable	Settable	Values	Default	Description
offset_current_led_1_ir	No	$\{0, \dots, 4095\}$	0	The reference voltage (offset) of the ADC producing the current_led_1_ir and current_led_1_ir_raw measurements. The actual reference voltage (in Volts) is given by $5 \times \frac{\texttt{offset\_current\_led\_1\_ir}}{4095}$. Because the signal from the current sensor is passed through an inverting amplifier, higher values of offset_current_led_1_ir result in lower values of current_led_1_ir_raw.
sps_current_led_1_ir	No	$\{0, \dots, 7\}$	7	The data rate of the ADC producing the current_led_1_ir and current_led_1_ir_raw measurements. Lower values mean the ADC accumulates more readings to produce a single measurement, reducing noise but also lowering the measurement speed. The actual data rates are (respectively) $8, 16, 32, 64, 128, 250, 475$ and 860 samples per second.
res_current_led_1_ir	No	$\{0, \dots, 5\}$	0	The resolution of the ADC producing the current_led_1_ir and current_led_1_ir_raw measurements. Higher values mean a higher resolution, where a smaller voltage range is mapped to the ADC output range $\{-32768, 32767\}$. The voltage ranges are, respectively, $\pm 6.144, \pm 4.096, \pm 2.048, \pm 1.024, \pm 0.512$ and ± 0.256 Volts. The reading will saturate, i.e., clamp at -32768 or 32767, if the input voltage exceeds the set range.
current_led_1_uv	No	float	–	Measurement (in Amperes) of the current drawn by the UV LED above the first sensor.
current_led_1_uv_raw	No	$\{-32768, \dots, 32767\}$	–	The uncalibrated measurement, i.e., the raw ADC output, corresponding to the measurement current_led_1_uv.
offset_current_led_1_uv	No	$\{0, \dots, 4095\}$	0	The reference voltage (offset) of the ADC producing the current_led_1_uv and current_led_1_uv_raw measurements. The actual reference voltage (in Volts) is given by $5 \times \frac{\texttt{offset\_current\_led\_1\_uv}}{4095}$. Because the signal from the current sensor is passed through an inverting amplifier, higher values of offset_current_led_1_uv result in lower values of current_led_1_uv_raw.
sps_current_led_1_uv	No	$\{0, \dots, 7\}$	7	The data rate of the ADC producing the current_led_1_uv and current_led_1_uv_raw measurements. Lower values mean the ADC accumulates more readings to produce a single measurement, reducing noise but also lowering the measurement speed. The actual data rates are (respectively) $8, 16, 32, 64, 128, 250, 475$ and 860 samples per second.
res_current_led_1_uv	No	$\{0, \dots, 5\}$	0	The resolution of the ADC producing the current_led_1_uv and current_led_1_uv_raw measurements. Higher values mean a higher resolution, where a smaller voltage range is mapped to the ADC output range $\{-32768, 32767\}$. The voltage ranges are, respectively, $\pm 6.144, \pm 4.096, \pm 2.048, \pm 1.024, \pm 0.512$ and ± 0.256 Volts. The reading will saturate, i.e., clamp at -32768 or 32767, if the input voltage exceeds the set range.
current_led_2_ir	No	float	–	Measurement (in Amperes) of the current drawn by the IR LED above the second sensor.
current_led_2_ir_raw	No	$\{-32768, \dots, 32767\}$	–	The uncalibrated measurement, i.e., the raw ADC output, corresponding to the measurement current_led_2_ir.
offset_current_led_2_ir	No	$\{0, \dots, 4095\}$	0	The reference voltage (offset) of the ADC producing the current_led_2_ir and current_led_2_ir_raw measurements. The actual reference voltage (in Volts) is given by $5 \times \frac{\texttt{offset\_current\_led\_2\_ir}}{4095}$.Because the signal from the current sensor is passed through an inverting amplifier, higher values of offset_current_led_2_ir result in lower values of current_led_2_ir_raw.
sps_current_led_2_ir	No	$\{0, \dots, 7\}$	7	The data rate of the ADC producing the current_led_2_ir and current_led_2_ir_raw measurements. Lower values mean the ADC accumulates more readings to produce a single measurement, reducing noise but also lowering the measurement speed. The actual data rates are (respectively) $8, 16, 32, 64, 128, 250, 475$ and 860 samples per second.

Table 1: Description of the variables produced by the chamber configuration lt_mk2_camera_fast. Settable variables can be manipulated by calling .set(<variable>,<value>). "float" corresponds to a 32-bit float.

Variable	Settable	Values	Default	Description
res_current_led_2_ir	No	$\{0,\dots,5\}$	0	The resolution of the ADC producing the current_led_2_ir and current_led_2_ir_raw measurements. Higher values mean a higher resolution, where a smaller voltage range is mapped to the ADC output range $\{-32768, 32767\}$. The voltage ranges are, respectively, $\pm 6.144, \pm 4.096, \pm 2.048, \pm 1.024, \pm 0.512$ and ± 0.256 Volts. The reading will saturate, i.e., clamp at -32768 or 32767, if the input voltage exceeds the set range.
current_led_2_uv	No	float	–	Measurement (in Amperes) of the current drawn by the UV LED above the second sensor.
current_led_2_uv_raw	No	$\{-32768,\dots,32767\}$	–	The uncalibrated measurement, i.e., the raw ADC output, corresponding to the measurement current_led_2_uv.
offset_current_led_2_uv	No	$\{0,\dots,4095\}$	0	The reference voltage (offset) of the ADC producing the current_led_2_uv and current_led_2_uv_raw measurements. The actual reference voltage (in Volts) is given by $5 \times \frac{\texttt{offset\_current\_led\_2\_uv}}{4095}$. Because the signal from the current sensor is passed through an inverting amplifier, higher values of offset_current_led_2_uv result in lower values of current_led_2_uv_raw.
sps_current_led_2_uv	No	$\{0,\dots,7\}$	7	The data rate of the ADC producing the current_led_2_uv and current_led_2_uv_raw measurements. Lower values mean the ADC accumulates more readings to produce a single measurement, reducing noise but also lowering the measurement speed. The actual data rates are (respectively) $8, 16, 32, 64, 128, 250, 475$ and 860 samples per second.
res_current_led_2_uv	No	$\{0,\dots,5\}$	0	The resolution of the ADC producing the current_led_2_uv and current_led_2_uv_raw measurements. Higher values mean a higher resolution, where a smaller voltage range is mapped to the ADC output range $\{-32768, 32767\}$. The voltage ranges are, respectively, $\pm 6.144, \pm 4.096, \pm 2.048, \pm 1.024, \pm 0.512$ and ± 0.256 Volts. The reading will saturate, i.e., clamp at -32768 or 32767, if the input voltage exceeds the set range.
current_led_3_ir	No	float	–	Measurement (in Amperes) of the current drawn by the IR LED above the third sensor.
current_led_3_ir_raw	No	$\{-32768,\dots,32767\}$	–	The uncalibrated measurement, i.e., the raw ADC output, corresponding to the measurement current_led_3_ir.
offset_current_led_3_ir	No	$\{0,\dots,4095\}$	0	The reference voltage (offset) of the ADC producing the current_led_3_ir and current_led_3_ir_raw measurements. The actual reference voltage (in Volts) is given by $5 \times \frac{\texttt{offset\_current\_led\_3\_ir}}{4095}$. Because the signal from the current sensor is passed through an inverting amplifier, higher values of offset_current_led_3_ir result in lower values of current_led_3_ir_raw.
sps_current_led_3_ir	No	$\{0,\dots,7\}$	7	The data rate of the ADC producing the current_led_3_ir and current_led_3_ir_raw measurements. Lower values mean the ADC accumulates more readings to produce a single measurement, reducing noise but also lowering the measurement speed. The actual data rates are (respectively) $8, 16, 32, 64, 128, 250, 475$ and 860 samples per second.
res_current_led_3_ir	No	$\{0,\dots,5\}$	0	The resolution of the ADC producing the current_led_3_ir and current_led_3_ir_raw measurements. Higher values mean a higher resolution, where a smaller voltage range is mapped to the ADC output range $\{-32768, 32767\}$. The voltage ranges are, respectively, $\pm 6.144, \pm 4.096, \pm 2.048, \pm 1.024, \pm 0.512$ and ± 0.256 Volts. The reading will saturate, i.e., clamp at -32768 or 32767, if the input voltage exceeds the set range.
current_led_3_uv	No	float	–	Measurement (in Amperes) of the current drawn by the UV LED above the third sensor.
current_led_3_uv_raw	No	$\{-32768,\dots,32767\}$	–	The uncalibrated measurement, i.e., the raw ADC output, corresponding to the measurement current_led_3_uv.

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Variable	Settable	Values	Default	Description
`offset_current_led_3_uv`	No	$\{0, \ldots, 4095\}$	0	The reference voltage (offset) of the ADC producing the `current_led_3_uv` and `current_led_3_uv_raw` measurements. The actual reference voltage (in Volts) is given by $5 \times \frac{\texttt{offset\_current\_led\_3\_uv}}{4095}$.Because the signal from the current sensor is passed through an inverting amplifier, higher values of `offset_current_led_3_uv` result in lower values of `current_led_3_uv_raw`.
`sps_current_led_3_uv`	No	$\{0, \ldots, 7\}$	7	The data rate of the ADC producing the `current_led_3_uv` and `current_led_3_uv_raw` measurements. Lower values mean the ADC accumulates more readings to produce a single measurement, reducing noise but also lowering the measurement speed. The actual data rates are (respectively) $8, 16, 32, 64, 128, 250, 475$ and 860 samples per second.
`res_current_led_3_uv`	No	$\{0, \ldots, 5\}$	0	The resolution of the ADC producing the `current_led_3_uv` and `current_led_3_uv_raw` measurements. Higher values mean a higher resolution, where a smaller voltage range is mapped to the ADC output range $\{-32768, 32767\}$. The voltage ranges are, respectively, $\pm 6.144, \pm 4.096, \pm 2.048, \pm 1.024, \pm 0.512$ and ± 0.256 Volts. The reading will saturate, i.e., clamp at -32768 or 32767, if the input voltage exceeds the set range.
`current_supply`	No	float	–	The current drawn by the chamber and all its components, including the onboard computer and server. Used for diagnosis.
`current_supply_raw`	No	$\{0, \ldots, 1023\}$	–	The uncalibrated measurement, i.e., the raw ADC output, corresponding to the measurement `current_supply`.
`pot_1_volts`	No	float	–	The raw voltage (in volts) of the first angle sensor. Used for diagnosis.
`pot_2_volts`	No	float	–	The raw voltage (in volts) of the second angle sensor. Used for diagnosis.

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