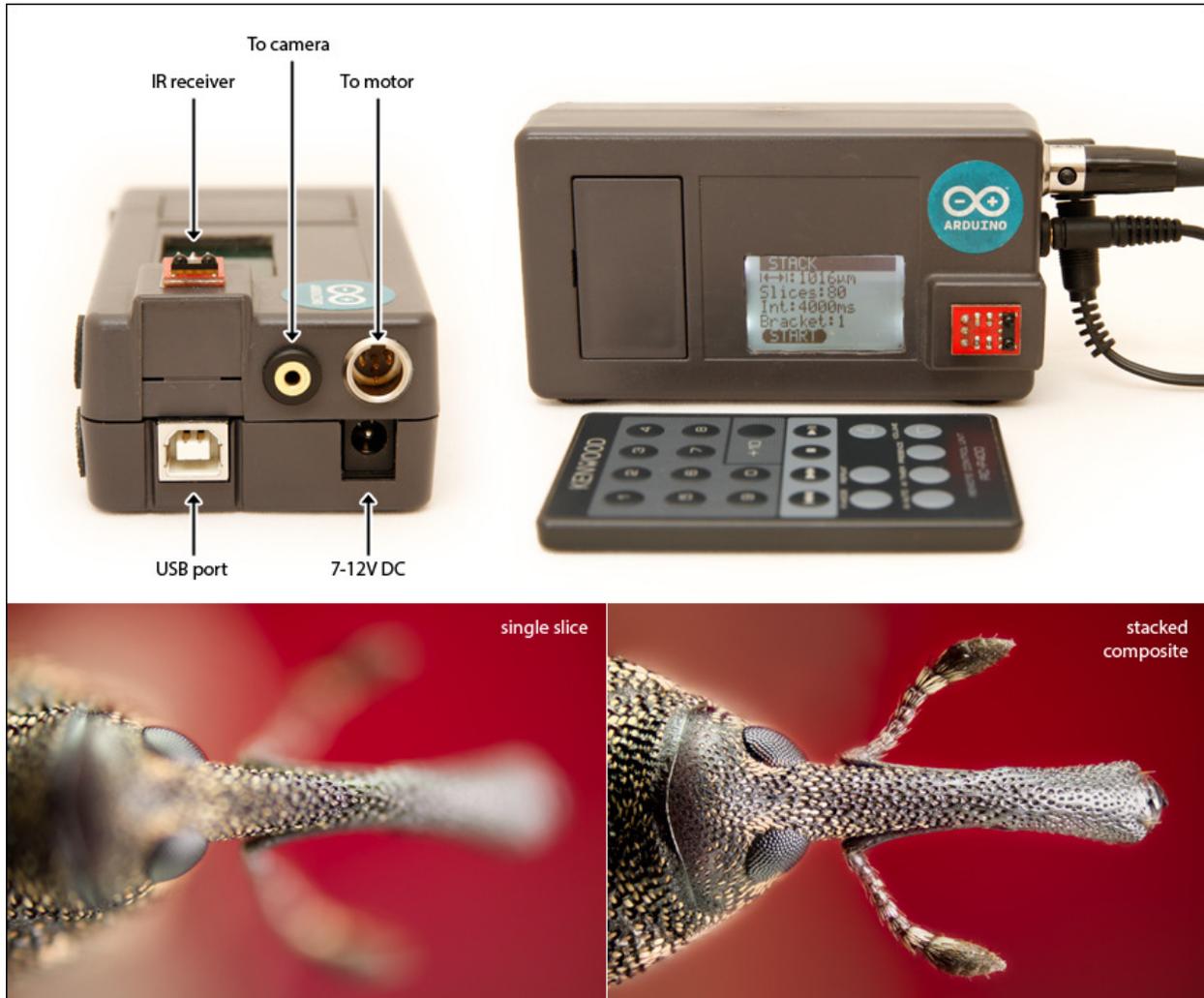


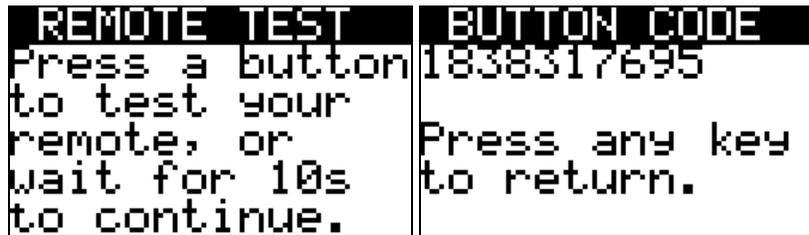
# Arduino Stacking Controller User Manual

Rev. Feb 14, 2016



For build instructions and the most recent software and manual, please visit <http://www.ryleeisitt.ca/articles/building-a-focus-stacking-controller/>

## Setting up Your Remote



The first screen appears when you power on your stacking controller and is intended to allow you to configure your remote. When at the “remote test” screen, press a button on your remote. If nothing happens, try a different remote protocol in the stacking software. The brand of your remote may give you a hint as to the protocol. Try the SIRC protocol for Sony remotes. NEC, SIRC, RC5, and RC6 protocols are the most common.

```
const lirrPulseFractionSettings_t REMOTE_PROTOCOL = PROTOCOL_NEC;
//const lirrPulseFractionSettings_t REMOTE_PROTOCOL = PROTOCOL_SIRC;
//const lirrBiPhaseSettings_t REMOTE_PROTOCOL = PROTOCOL_RC5;
//const lirrBiPhaseSettings_t REMOTE_PROTOCOL = PROTOCOL_RC6_MODE0;
//const lirrPulseFractionSettings_t REMOTE_PROTOCOL = PROTOCOL_JVC;
//const lirrPulseFractionSettings_t REMOTE_PROTOCOL = PROTOCOL_RCA;
//const lirrPulseFractionSettings_t REMOTE_PROTOCOL = PROTOCOL_SHARP;
//const lirrPulseFractionSettings_t REMOTE_PROTOCOL = PROTOCOL_SAMSUNG;
```

Once you’ve selected the correct remote protocol, a “button code” screen will appear when you press a remote button from the “remote test” screen. The number given on the first line should be inserted into `stacker.ino` in the appropriate spot to map that remote button to an action. Be sure to add the “ul” suffix. Once you have mapped buttons to each of the actions (make sure that each button code is unique), you will need to upload the modified stacking software to your microcontroller.

```
const uint32_t BT_1 = 1838317695ul; // Digit 1
const uint32_t BT_2 = 1838301375ul; // Digit 2
const uint32_t BT_3 = 1838334015ul; // Digit 3
const uint32_t BT_4 = 1838293215ul; // Digit 4
const uint32_t BT_5 = 1838325855ul; // Digit 5
const uint32_t BT_6 = 1838309535ul; // Digit 6
const uint32_t BT_7 = 1838342175ul; // Digit 7
const uint32_t BT_8 = 1838289135ul; // Digit 8
const uint32_t BT_9 = 1838321775ul; // Digit 9
const uint32_t BT_0 = 1838285055ul; // Digit 0
const uint32_t BT_ENTER = 1838305455ul; // Enter
const uint32_t BT_UP = 1838322285ul; // Up
const uint32_t BT_DOWN = 1838289645ul; // Down
const uint32_t BT_LEFT = 1838311575ul; // Left
const uint32_t BT_RIGHT = 1838344215ul; // Right
const uint32_t BT_BACK = 1838348295ul; // Back/Cancel
const uint32_t BT_HALFPRESS = 1838285820ul; // Trigger camera's half press (AF & metering)
const uint32_t BT_FULLPRESS = 1838302140ul; // Trigger camera's shutter
const uint32_t BT_BACKLIGHT = 1838318460ul; // Backlight toggle
```

Once you have mapped your remote and everything works, you can prevent the “remote test” screen from appearing at start-up by commenting out `#define remote_test` line in the stacking software.

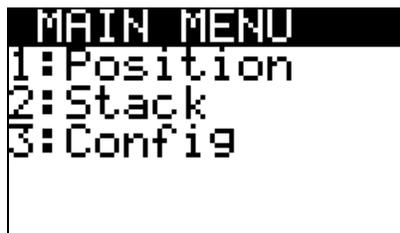
```
#define remote_test // comment this line out once you have configured your remote
```

## Universal Controls

From any screen, you can press the **backlight toggle** button to turn the LCD backlight on and off. You can also press the **exposure lock** (half-press) button to toggle your camera's exposure/AF lock mode. Finally, you can press the **shutter release** (full-press) button to trigger your camera's shutter. If your camera is in bulb mode, the shutter will remain open for as long as you hold the **shutter release** button down.

When your camera's exposure/AF lock mode is enabled, an "EL" symbol will appear in the upper right corner of the display. When your camera's shutter is open, a sun icon will appear in the upper right corner.

## Main Menu



At the main menu, press the digit that corresponds to the sub-menu you wish to go to. If you have not done so yet, go to the "Config" sub-menu to set up your stacking controller. You can press the **back/cancel** button in any sub-menu to return to the main menu.

## Configuration



The configuration menu allows you to adjust the behavior of the stacking controller.

Use the **up** and **down** buttons to move between parameters. Note that there are multiple pages of parameters that are accessed by repeatedly pressing **up** or **down**.

If a parameter has arrows on either side, this means that you must scroll through values using the **left** and **right** buttons on your remote.

If a parameter is followed by a checkbox, use the **enter** button to toggle parameters on and off.

Otherwise, if a parameter is a number, you can directly enter a new value using **digits 0-9** on your remote, then press **enter** to confirm the new number.

*Units*: this setting allows you to change the units of measurement used in the position and stack menus. The options are full steps (st), micrometers ( $\mu\text{m}$ ), millimeters (mm), centimeters (cm), and degrees ( $^\circ$ ).

*Contrast*: this setting allows you to change the contrast of the LCD. If the screen appears too light, increase this value by pressing **right**. If the screen appears too dark, decrease this value by pressing **left**.

*St/rev*: set this parameter to the number of full steps in one revolution of your stepper motor. To determine the proper value, divide  $360^\circ$  by your motor's rated  $^\circ/\text{step}$ . A  $1.8^\circ/\text{step}$  motor will give a value of 200.

*$\mu\text{m}/\text{rev}$ ,  $\text{mm}/\text{rev}$ ,  $\text{cm}/\text{rev}$* : set this parameter to the number of micrometers, millimeters, or centimeters that your stage advances over one revolution of the stepper motor. This value is used to calculate the measurements in the position and stack menus, but does not otherwise change the behavior of the stacking controller.

*Speed*: this parameter sets the maximum speed of the stepper motor in full steps/sec. Experiment with different speeds to determine what works best for you. 200 st/s should work well for many standard stepper motors. Higher speeds are more likely to cause missed steps, stalling, and reduced torque.

*Accel*: this parameter sets the rate of acceleration in full steps/sec<sup>2</sup>. Acceleration can prevent skipped steps and can allow the motor to ramp up to a higher speed than would otherwise be possible. If set to 0, the motor will start and stop suddenly (no acceleration or deceleration).

*Half-step (on/off)*: if on (recommended), the motor is driven in half-step mode, which is more precise, generates less vibration, uses less power, and produces less heat. The downside of half-stepping is that it has less torque, but this should not be a concern for most applications.

*Power save (on/off)*: If on (recommended), the motor is braked when not in use. This reduces heat and power consumption, but also reduces holding torque.

*Trigger (on/off)*: if on, the camera's shutter will be triggered repeatedly when stacking. Otherwise, it will not be triggered. Turning this setting off may be useful when shooting video.

*TV*: the duration (in milliseconds) that the camera's shutter will be triggered for while stacking if *trigger* is turned on.

## Calibrating Distance Readouts

The  $\mu\text{m}/\text{rev}$ ,  $\text{mm}/\text{rev}$ , or  $\text{cm}/\text{rev}$  value needs to be set correctly so that distance readouts are accurate. You can determine the correct value through calculation or experiment.

By calculation:

1. Determine your gearing ratio. If you have the motor directly coupled to your stage's adjustment knob, your gearing ratio is 1. Otherwise, the gearing ratio is equal to the number of teeth on the stepper motor gear/pulley divided by the number of teeth on the stage knob gear/pulley.

2. Obtain the specifications for your stage, which will hopefully tell you how many  $\mu\text{m}$ ,  $\text{mm}$ , or  $\text{cm}$  the adjustment knob advances through per revolution.
3. Multiply the stage's distance advanced per revolution by your gearing ratio and enter this value into the configuration.

Example: the timing pulley attached to my stepper motor has 18 teeth, and the pulley on my focus block's fine focus knob has 30 teeth, so my gearing ratio is 0.6. According to the specifications, the focus block advances 200  $\mu\text{m}$  per revolution of the fine focus knob. So, for each revolution of the stepper motor, my focus block will advance by 120  $\mu\text{m}$  (200  $\mu\text{m}$  x 0.6).

By experiment:

1. Set up your motorized stage and stacking controller as desired.
2. In the config menu, set *units* to "st" (full steps).
3. Using the focus stacking controller in the position menu, advance your stage through a fairly large distance that you can accurately measure. Measure the difference between the initial and final position using a ruler, caliper, depth micrometer, or other measuring device.
4. Look on the focus stacking controller's screen and note how many full steps of the stepper motor this distance corresponds to.
5. Divide the distance by the number of full steps taken. This gives you a distance/step measurement.
6. Multiply the distance/step by the number of full steps per revolution of your stepper motor. This gives you the distance/rev value.
7. Convert the distance/rev value, if necessary, to  $\mu\text{m}/\text{rev}$ ,  $\text{mm}/\text{rev}$ , or  $\text{cm}/\text{rev}$  – whichever gives you the resolution that you desire (keep in mind that only whole number distances are calculated).
8. Round the result to the nearest whole number. You may wish to do this procedure multiple times to determine an average.
9. In the config menu, change *units* to the desired setting and enter the value obtained above into the  $\mu\text{m}/\text{rev}$ ,  $\text{mm}/\text{rev}$ , or  $\text{cm}/\text{rev}$  field.

## Position Menu

```

POSITION
Pos: 1117µm
Beg: 133µm
End: 1117µm
←→: 984µm

```

Position mode allows you to move the motorized stage back and forth and set the beginning and end points of the stack. The **up** and **down** buttons allow you to select between the *pos*, *beg*, or *end* indexes. Stacks are done by starting at *beg* and ending at *end* and you need to set these position indexes from the position menu. If *pos* is selected, pressing **left** or **right** will move the motor back and forth without changing *beg* or *end*. To change *beg* or *end*, select one and press **left** or **right**. This will move the motor and adjust the value of *beg* or *end*.

You can send the motor to *beg* or *end* by selecting one and then pressing **enter**.

The last parameter displays the distance between *beg* and *end*.

## Stack Menu



In the stack menu, you tell the stacking controller how many positions (*slices*) to stop at for taking pictures throughout the stack, the time interval (*int*) between subsequent shots, and the number of shots (*bracket*) per position.

Use the **up** and **down** buttons on the remote to move between the parameters and modify the values using the **digits** on the remote.

The total number of photos that will be taken for a stack is determined by multiplying the number of slices by the bracket value. For normal use, leave bracket set to 1. Bracketing shots at each position can be useful if coupled with exposure bracketing on a camera to produce HDR stacks.

If you use flashes or strobes for illumination, consult the user manual for your light to determine the recommended time interval between shots to prevent overheating. If using continuous lighting, you can safely reduce the interval to the minimum necessary for reliable camera operation.

The number of slices should be set high enough to ensure that the resulting stack does not exhibit focus banding (alternating bands of in-focus and out-of-focus areas). Setting the number of slices too high, however, will contribute to increased wear on your camera's shutter mechanism, as well as require more storage space and time to process the stack.

Before you start the stacking process, you can enable the exposure lock mode (indicated by an EL symbol in the upper right of the display) by pressing the **exposure lock** button on the remote. This will keep the camera in a ready-to-shoot state during the entire stack which may decrease shutter lag and prevent the camera from entering a power saving mode. If exposure lock is not enabled, the controller will automatically enable and disable the exposure lock mode for each shot, which may be desired if you wish to see the results of each shot on the camera's LCD or video output.

When ready to begin the stack, select the *start* button and press **enter**.

During a stack, the motorized stage will automatically move between slices, and shots will automatically be taken at the desired time interval. The current progress will be updated on the LCD after every shot taken. While the stacking controller is operating and photos are being taken, avoid touching the camera, subject, table, or apparatus to prevent movement and vibrations.

You can cancel a stack at any time by pressing a button on your remote.

## Problems?

Although I run the hardware and software through a testing procedure prior to issuing software updates, bugs do slip through. If you have problems, please visit <http://www.ryleeisitt.ca> and use the contact form to get in touch with me. I can usually issue patched software fairly quickly once a problem has been identified.

Happy stacking!