User Manual for Manual Mode Control

Multi-Axis Positioning System for Water Blaster Testing

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1 - Summary of Manual Mode

Manual Mode is one of the two options available for controlling the testing rig made by the Fort Lewis College senior seminar team. This option is the faster and easier option, as no computer or path is needed to make the motors run. Only the buttons and switches on the electrical box are needed to move the testing rig. The downside to this mode is that the accuracy and consistency is lower due to being an open feedback system.

The manual mode also does not have any soft limit capabilities, meaning the system will not know the boundaries that the motors can move and relies on the torque sensors within the motor to stop them from crashing into the sides. This means extra precaution is required when working near the limits of the mechanical system.

2 – Controlling the Testing Rig

This section details what the manual system can do and how to access and control the testing rig

2.1 - Buttons and Layout

On the electrical box there is 10 different components that allow the operator to change or control the testing rig. The name of each component is:

Fig 1: Top-down view of the electrical box showing the different components that the operator can use to control the system

Going from left to right top to bottom the following components are found:

Power switch:

This controls the power to the entire electrical box. flicking this switch on allows power to reach the microcontrollers within, allowing the ability for signals to be sent to the motors.

LEDs:

The four colored LEDs are used to diagnose what state the manual system is in. More is discussed in the LED diagnostics section.

Emergency Stop:

When this button is pressed, all signals will cease, causing the motors to no longer be able to move. A signal to the dump valve is also sent. This signal must be set up during implementation to allow for the dump valve functionality to work.

Mode switch:

This switch controls which mode the system is in, either automatic or manual.

- **LCD screen:** Displays information and allows the operator to change settings when in manual mode.
- **Motor enable buttons:** Two buttons that work as a secondary on functionality to make sure the motors are enabled when wanted. More is discussed in the “Turning System on” section.
- **X and Z rotary encoders:** Controls multiple different functions with the rotational and press features these components bring.
- **X and Z Momentary switches:** When pushed and everything else is enabled correctly, these will move the motor in the corresponding direction.

2.2 - Turning the System on

To turn the manual mode system on, make sure the power is plugged in, and the power switch is turned on. Then set the mode switch to manual. If everything is working correctly, the LCD screen should display positional and velocity data of the motors.

To enable the motors so they can move you have to hold the rightmost motor enable button then to press the leftmost motor enable button. If done correctly, the yellow LED should be turned on, and the text on the info screen should be in all caps instead of camel cased. Pressing the leftmost motor enables button will disable the motors.

2.3 - Moving the Motors

Once the manual mode is turned on and is enabled, the motors can be moved. The speed shown on the LCD is the set max velocity of the motor. To change this, rotate the corresponding rotary encoder clockwise to increase the velocity or counterclockwise to decrease the velocity. The set velocity has a limit based on the motors. This value can be changed in the code if necessary.

Once the max set velocity is set, the motors can move by simply pushing the momentary switch in the direction the operator wants the motors to move. The X momentary can move left or right, so the operator can move the carriage left or right using the X momentary switch. The Z momentary switch can move up or down, so the operator can move the carriage up or down using the Z momentary switch.

2.4 - LED Diagnostice

Each LED is programmed to indicate a state that the manual system is in.

- Red LED: Emergency Stop is pressed; all operations have been cancelled
- Yellow LED: Motors are enabled and ready to be controlled
- Green LED: X axis is being sent signals to move
- Blue LED: Z axis is being sent signals to move

2.5 Changing Settings

Pressing either of the rotary encoders changes the LCD screen to display the options menu of that axis. To move around the options menu, the operator can rotate the rotary encoder clockwise to go down and counterclockwise to go up. Pressing the rotary encoder selects where the cursor is. The cursor is represented by a blinking line. Pressing the back symbol located at the top of any screen changes the LCD screen to display the previous screen. Moving the cursor onto either the downwards facing arrow or the upwards facing arrow will move the screen to show more settings.

Pressing the other rotary encoder switches the settings menu to the other axis. Rotating the other rotary encoder does nothing. With the options menu a few parameters can be changed to the fourth decimal. This includes the max set velocity and the velocity step (the amount the velocity changes when rotating the rotary encoder).

The linear regression model is the system used to roughly determine the velocity and position of the motor based on information from the operator. These values are defaulted to the values found by the senior seminar team. If you notice the velocities or positions being off, check the troubleshooting section to figure out how to calculate a new linear regression model.

Pressing the emergency stop or setting the system into automatic mode will cause the LCD to display if these features are turned on. Turning these features off will make the LCD screen be on the info screen.

3 – Accessing Code

All of the code and manuals will be provided on the GitHub the senior seminar team made. It is recommended to use the STM32 Cube IDE to upload any code to the STM32 microcontroller. The microcontroller can be programmed with a USB mini A adapter cable. Make sure everything is unpowered before uploading code. The IDE will not recognize the microcontroller unless the JP5 jumper is moved to jump the middle and right pin. This will set the microcontroller to be only powered by the USB. Once uploading is done, the JP5 jumper has to be switched back in order to be powered externally again. Below is a picture of the board with the JP5 jumper set to be powered externally by jumping the middle and left pin:

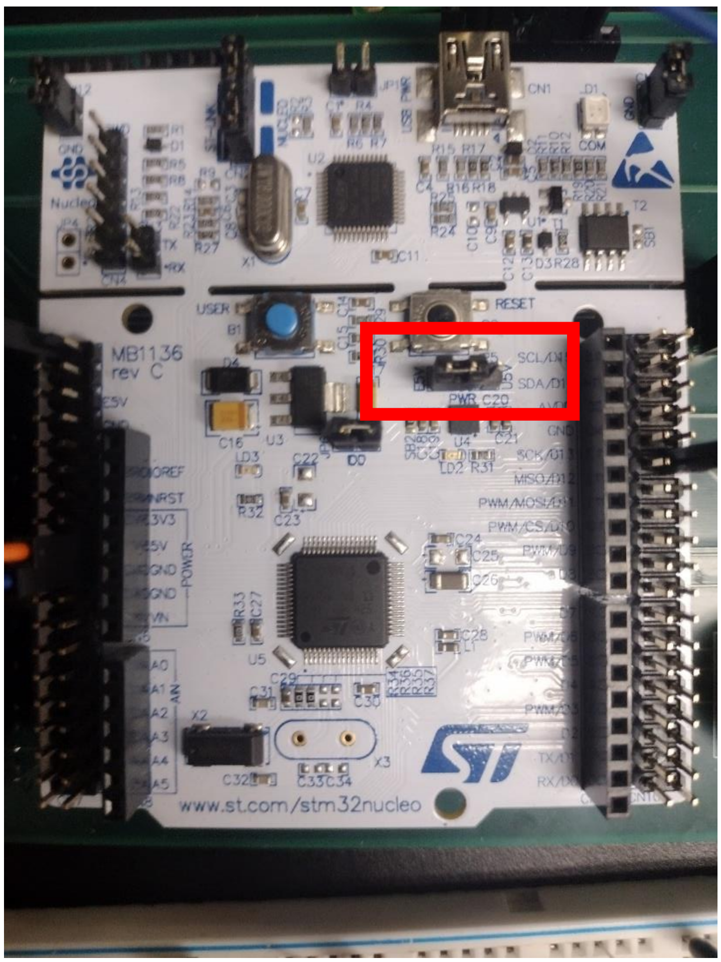

Fig 1: Top down view of the microcontroller. The JP5 jumper is highlighted and set to be powered externally instead of being powered via USB.

4 – Troubleshooting

4.1 - Calibration

The testing rig was calibrated before being implemented, but the system can go out of sync. If the gears were changed to a different size or the motors settings were changed using an IR sensor and ClearPath, the calibration will be off. This can be seen as the velocities not matching what the motors are outputting.

To calibrate an axis, the current linear regression for the axis must be known, and two runs of different velocities must be done. It is recommended to do one slow run (0.1-3 in/s) and one fast run (>3 in/s). the actual velocities of each run must be measured. The measured velocities should be as accurate as possible to allow the manual system to be as close as possible to what is being outputted. Once the current linear regression is known, the input velocities, and the measured velocities are found, inputting the variables into the following formula will give the calibrated linear regression:

$$M_{calibrated} = M_{current} \frac{V_{fast\ input} - V_{slow\ input}}{V_{fast\ measured} - V_{slow\ measured}}$$

$$b_{calibrated} = V_{slow\ input} - M_{calibrated} \frac{V_{slow\ measured} - b_{current}}{M_{current}}$$

Upload this calibrated linear regression to the STM32F411RET6 microcontroller that is directly on the green PCB and not the one within the 3D printed casing.

4.2 - Flickering

If the LCD is flickering or numbers are changing when they are not supposed to be, then there is an electrical disconnection causing an input to be floating. Check every electrical connection in the box that would interact with the LCD in the way that is flicking. If the velocity of an axis is flickering, check the momentary switch of that axis.

4.3 - Incorrect text in settings

Sometimes in the settings multiple rows get switched out with the same string or underscores. This happens when the rotary encoder is spun too fast, or the timers of the microcontroller happen to signal during a row transition. This bug is purely visual and will not affect the performance of the manual mode. If you need to read what was changed, simply move the rotary encoder until that row is selected. The row will display the correct string after it blinks.