Franklin MCI

Franklin Mechanical & Control Inc

Wafer Handler

Software Manual

Franklin Mechanical Handler Control Software

This manual covers the SMM-EX-8.

Table of Contents

Franklin Mechanical Handler Control Software 2
First Time Setup 2
Handler Control 3
Basic Operation 3
EPO Recovery 4
Recipes 5
Interlocks 5
Warnings/Issues 5
Basic Description of How to Setup the Loader 6
Detailed Descriptions of Button Functions 7
Setup Screen Buttons 7
Main GUI buttons 17

First Time Setup

It is recommended that the handler be powered up before starting the software. Remember to turn on the main system power at the back of the unit before pressing the power on button near the front of the unit (on the left side). This will eliminate a "Cannot Communicate" error which occurs when the handler is not powered up.

When the software first starts it will show the words "Please Log In" near the top. After a few seconds the log in screen will appear. The default password for Administrator is "\\\\\". The default password for User is "password". For first time setup, log in as Administrator. The default COM port is probably wrong, so you will probably get a "Can't talk to handler!" error. To fix the error, open the setup panel and select the correct COM port on the Settings tab. Make sure to save the settings. You will need to restart the software for the change to take effect.

Once you have the COM port configured correctly, a prompt will appear asking if you want to home the loader; it is recommended that you do so. Once the loader has homed, open the setup panel. Check all of the positions to make sure they are correctly aligned. Also, check the cassette settings – the elevator first wafer height, spacing, and stroke. The best way to check the elevator settings is to move to the first wafer position on the setup panel, disable the end effector motor, and manually move the end effector into the cassette to make sure it does not crash and that it picks up the wafer when it is

moved into the "put" position. Finally, check the mapper settings on the "Other Settings" tab – test run the mapper and then adjust the first wafer Z, starting height, and ending height until the mapper detects all of the wafers and also detects cross slotted wafers. Each time the mapper is tested the new test results appear at the bottom of the results text box.

Once you have everything configured correctly, close the setup panel. The size of the currently loaded cassette should appear next to the wafer selection buttons at the lower left part of the screen. The system is now ready to use.

Handler Control

The primary purpose of the handler is to load wafers to an inspection stage, wait for them to be inspected, and return them to the cassette. It also includes a module which allows the wafer to be lifted for topside and backside macro inspection. The system operates only on 200 MM wafers and touches only a small exclusion area at the edge of each wafer.

Basic Operation

1. Select the wafers you wish to be inspected.

Left click on a slot number button to select a wafer. Clicking multiple times toggles between several different operations, including no operation. Right clicking on a button displays a menu from which any operation can be enabled or disabled.

2. Place the cassette on the handler.

The cassette size (200MM) will be reported to the right of the slot number buttons. If it does not appear, the cassette is not properly loaded. If it is incorrect, the cassette may be improperly loaded or the system may be improperly configured.

3. Press "Start Cassette".

If the "Auto-Map Cassette" check box is checked, the system will map the cassette before loading any wafers. If the cassette is already mapped it will not be re-mapped until it is removed and replaced. If any slots are vacant, the corresponding number button will become blank. If any slots are cross-slotted the system displays an error message and will not attempt to remove wafers from the cassette.

4. If topside or backside macro are enabled, these will be performed first. Click the "Manual Control" button or check the "Always Do Manual Macro" check box to enable the joystick. If the joystick is enabled, press the button to finish; if it is not enabled, the duration of macro inspection is set in the setup panel. Macro inspection can also be terminated by clicking the "Next Macro Inspection Stage" button on the GUI.
5. When a wafer is loaded on the stage, move the stage from the home position. Perform inspection. Backside stage inspection will be performed first.
6. Return the stage to the home/load position. Wait for the handler to return the sample to the cassette (or flip it over and return it to the stage).

7. Repeat for each wafer to be inspected. The slot number buttons will change color as each wafer is inspected.
8. Remove the cassette.

Inspection may be paused or canceled at any time. If inspection is paused the system may not stop moving right away. To cancel inspection, press the "Reset Cassette" button. The loader will attempt to replace all wafers in the cassette and will not perform additional inspection until "Start Cassette" is clicked again. The wafers will be returned to their starting orientation (meaning that a wafer currently on the stage doing backside inspection will be placed on the macro and flipped before returning to the cassette.)

EPO Recovery

If the system is running a cassette cycle when an EPO event occurs, the wafers may move slightly as the end effector will lose vacuum during the EPO. Thus, the system requires that all wafers be removed before homing the system to resume operation. Under certain circumstances, it may not be physically possible or practical to remove the wafers. If this is the case, then the operator will need to enter the Setup panel to re-home the system. The operator must be logged in as Administrator to enter the setup panel.

1. Restore power to the handler.
2. Open the setup panel.
3. Initialize all IOs (button near lower left corner of Diagnostics tab)
4. Verify system can safely retract end effector. If there is a wafer on the end effector, it is usually safe to retract the end effector if the vacuum is turned on and the system senses vacuum. If the system was in the process of picking up or putting down a wafer (if the robot up/down drive was in motion) then the robot moves to the Down position when the handler loses power, which should place the wafer on the stage/macro and allow the end effector to be safely retracted. If it is not safe for the system to retract the end effector, the end effector must be retracted by hand. Disable the end effector motor from the Positions tab of the setup panel, remove the Plexiglas cover, and retract the end effector.
5. Initialize and home the end effector drive.
6. Initialize the flip arm. If there is a wafer in the flip arm, it is safe to initialize the arm as long as the wafer is not partially protruding. If it is coming out of the arm, the wafer will need to be removed with a vacuum wand to ensure safe handling.
7. Initialize and home the macro spin drive. This will send the flip arm up.
8. At this point, it should be safe to home the robot rotation.
9. Initialize and home the robot up/down drive.
10. Initialize and home the elevator. This completes homing the system.
11. Use the get/put wafer buttons on the Diagnostics tab of the setup panel to return any wafers present on the system to the cassette.
12. Exit the setup panel. The system should return to normal operation.

Recipes

A recipe is a set of wafers to be inspected. To create a recipe, select the wafers you wish to inspect. Make sure that the correct operations are selected, e.g. topside macro inspection vs. backside macro inspection or both. Click the "Add..." button. A window will appear which will ask you to name the recipe. If you enter a name and select "OK", the name will appear in the list of recipes above the slot number buttons. Selecting that recipe will change the current wafer selection to whatever was selected when the "Add..." button was clicked.

Interlocks

An interlock is a sensor which prevents (or permits) loading to a specific position. By default, each loader comes with a single stage position sensor, which is configured to use a single interlock. Standard options for the loader include a rotatable stage with a rotation position verification switch and a wafer protrusion sensor for the cassette, so there could potentially be three interlocks on a system. Custom configurations are also possible.

At the core, what an interlock does is quite simple. Just before the loader picks up or places a wafer, it checks for defined interlocks for that position (cassette, macro, and/or stage). If there is a defined interlock, it MUST be active, or the loader will not pick/place from/to that position. (The polarity can be changed in the software.) If the interlock sensor is not active, then an error message is displayed to the user.

The stage is a slightly special case: In order to signal that the stage inspection has begun, the system waits for an interlock on the stage to go inactive. Then the system waits for all stage interlocks to go active again, at which point it picks the wafer up from the stage.

The polarity of all interlocks can be edited in the Setup panel. The interlocks are configured by Franklin at the factory and are not intended to be edited.

Warnings/Issues

Do not let the computer running the handler go into "sleep mode". Windows does not properly re-open the COM ports when the computer goes to sleep, and the only way to fix it is to either restart the computer or unplug the USB-Serial adapter and plug it back in.

Basic Description of How to Setup the Loader

The loaders are set up and configured at the factory. The following is an overview of the setup process – for details of the functions of specific settings or buttons, check the detailed description.

Adjust the cassette position until the center of the end effector is over the center of the elevator. Then retract the end effector and place the cassette on the elevator. Move to the first wafer and disable the end effector motor, then move the end effector over to the cassette and verify that the end effector does not hit the wafer as it goes into the cassette (also that it does not hit the wafer below it). The end effector should be quite close to the bottom of the wafer. Make sure that the cassette is leveled to the end effector (i.e. all four vacuum cups on the end effector should be the same distance from the bottom of the wafer.) Then put the elevator into the "put" position and verify that the wafer can be removed from the cassette without touching the cassette. Re-enable the end effector motor, set the end effector cassette position to something much too small (for example, 180.0), and move to the cassette position. Adjust the cassette position upwards until the white wafer pusher bar is just barely touching the edge of the wafer. Verify that the wafer can be picked up using the Get Cassette button on the setup panel. Then repeat this process for wafer 25 - the cassette may need to be tilted to make sure that the wafers are leveled to the end effector, and this may result in a different end effector cassette position. If the numbers are different for wafers 25 and 1, use the interpolation feature to ensure that the wafer is always picked up correctly and does not violate the exclusion zone.

Once wafers can be safely picked out of the cassette, pick a wafer and move the wafer over to the macro inspection station. Verify that the wafer can be inserted into the macro inspection station without contacting the flip arm of the macro inspection station. Also verify that the pickup position is correct - when dropping off, the system checks a sensor to make sure it doesn't drive the wafer into the flip arm, but when picking up it uses a fixed position, so make sure that this position is correct so that the exclusion zone will not be violated. The stage alignment will need to be checked as well; also make sure that the stage sensor is active when, and only when, the stage is in the correct position.

Attempt to map the cassette. The mapper results will appear on the setup panel with the "target" wafer ranges on the left and the "detected" wafer ranges on the right (possibly below if the wafer was detected as a cross-slotted wafer). Usually only the first wafer position needs to be reconfigured, but the mapper start and end height may need to change if the wafer can't see slot 1 or 25 or if the wafer is detecting the H-bar or the top of the cassette. Sometimes the elevator platform will need to be adjusted to make the cassette easier to map; the platform has 2 screws on each corner which can be used to adjust the cassette so that the wafers are level. Also, sometimes you may need to adjust the sensitivity of the wafer mapper sensor mounted on the side of the robot. To adjust the sensitivity, move the robot to the aligner position. Flip up the clear plastic cover covering the top of the mapper sensor amplifier, mounted on the side of the robot. Use the gray right and left arrows to adjust the sensitivity – typical values for the sensitivity range between 7000 and 9000, depending on the thickness of the wafers and how level the wafers are when they are in the cassette. (Thicker wafers require smaller numbers or they may be falsely detected as cross slotted wafers, and thinner wafers require larger numbers or the mapper may miss some wafers.)

All of these setup operations are performed at the factory, so user setup should be a simple verification. However, if a module needs to be removed and replaced for maintenance purposes, the alignment

should be re-verified before production wafers are used.

Detailed Descriptions of Button Functions

Setup Screen Buttons

On the right side of the setup panel we have four buttons, a drop down list, and a group of labels. Most of the setup panel is occupied by a tabbed dialog with 6 tabs. Starting from the top, the controls on the right side are labeled:

1. "Stop" button - This button is disabled unless the user has issued a movement command from the setup panel. Clicking this button cancels the current movement command and issues a hard stop command to all motors on the handler. The system should be re-homed as the hard stop usually creates position errors. However, the setup panel will not force you to re-home the system.
2. "Save Settings" button - Saves the current settings to the .ini file. If changes have been made and have not been saved they will be lost if the software is exited.
3. "Exit Setup" button - Closes the setup panel
4. "Enable Tooltips" check box - Enables or disables the tooltips for the controls on the setup panel.
5. "Check Cassette Switches" check box - This causes the system to check for the cassette being removed or changed. Normally this is not checked because the cassette is frequently removed and replaced when verifying cassette positions.
6. "Current Cassette Size" combo box – This selects the current set of settings for this size wafers. Elevator positions, alternate cassette drop off positions, and mapper settings are all dependent on the current wafer settings and may change when the selected wafer settings change.
7. "Adv. Cassette Settings" button – Opens a new window which allows for changes to advanced cassette configurations. This includes allowing or disabling a wafer size, setting up alternate configurations for the same cassette, changing the displayed label for the cassette size, and enabling or disabling specific slot numbers for a given cassette size.
8. "Status of Last Action" labels – These display information about the last action taken by the setup panel. Simple actions such as turning the end effector vacuum on and off do not cause a report; the reports are typically generated for actions that require the handler to physically move. The display shows if the action was canceled before it completed (e.g. if the Stop button was pressed), if there were any errors, and the error message if there was an error.

These controls are always visible. The rest of the buttons in the setup panel are only visible when a certain tab is selected. Each tab will be described from left to right.

The first tab is labeled "Diagnostics" and contains commands related to homing and initializing the system, testing vacuum, and testing loading/unloading of wafers. It is divided into 8 groups of buttons arranged into 3 columns. There are also 2 more buttons which are not in a group and are found at the lower left-hand corner, labeled "Initialize System" and "Initialize IOs". I will describe each group of

buttons by column from left to right.

The first group of buttons is labeled "Vacuum Control". It contains 2 buttons and 2 labels.

1. "Stage Vac Now On" / "Stage Vac Now Off" - Controls the vacuum to the stage. Clicking the button when it says Stage Vac Now On will turn off the stage vacuum. Clicking the button when it says Stage Vac Now Off will turn on the stage vacuum. Below this button is a label which says "Sensor Reports: On" when the stage vacuum sensor senses vacuum and "Sensor Reports: Off" when the stage vacuum sensor does not sense vacuum. The sensor is only checked when the button is clicked, and the system waits for the Stage Vacuum Delay to elapse before checking the sensor.
2. "End Effector Vac Now On" / " End Effector Vac Now Off" - Controls the vacuum to the end effector. Clicking the button when it says End Effector Vac Now On will turn off the end effector vacuum. Clicking the button when it says End Effector Vac Now Off will turn on the end effector vacuum. Below this button is a label which says "Sensor Reports: On" when the end effector vacuum sensor senses vacuum and "Sensor Reports: Off" when the end effector vacuum sensor does not sense vacuum. The sensor is only checked when the button is clicked, and the system waits for the End Effector Vacuum Delay to elapse before checking the sensor.

The second group of buttons is labeled "Load/Unload Test". It contains 8 buttons and 1 drop down list. A large label on top warns the user that these buttons subvert some of the collision prevention systems of the handler and should be used responsibly. The drop down list is labeled as a list of cassette slot numbers which are used when testing loading or unloading to the cassette.

The buttons in this group are:

1. "Get Stage" - Attempts to pick up a wafer from the stage. The wafer will be on the end effector when this finishes.
2. "Put Stage" - Attempts to place a wafer on the stage. Will fail if there is no wafer on the end effector.
3. "Get Inverter (topside)" - Attempts to pick up a wafer from the macro inspection station. The wafer will be on the end effector when this finishes. The top of the wafer should be up.
4. "Put Inverter (topside)" - Attempts to place a wafer on the macro inspection station. Will fail if there is no wafer on the end effector. The top of the wafer should be up.
5. "Get Inverter (backside)" - Attempts to pick up a wafer from the macro inspection station. The wafer will be on the end effector when this finishes. The back of the wafer should be up.
6. "Put Inverter (backside)" - Attempts to place a wafer on the macro inspection station. Will fail if there is no wafer on the end effector. The back of the wafer should be up.
7. "Get Cassette" - Attempts to pick up a wafer from the currently selected slot number of the cassette. Beware: Make sure the correct cassette size is currently selected on the "Positions" tab, make sure the cassette is properly loaded, and make sure the wafer is properly loaded in the cassette. The wafer will be in the end effector when this finishes.
8. "Put Cassette" - Attempts to place a wafer in the currently selected slot number of the cassette. Beware: Make sure the correct cassette size is currently selected in the "Positions" tab, make sure the cassette is properly loaded, make sure the selected cassette slot is empty, and make sure the wafer is properly aligned (e.g. A wafer that was manually placed on the end effector will collide with the cassette if it is placed in the cassette.). Will fail if there is no wafer on the end effector.

And the last two buttons in the column:

1. "Initialize System". This button runs the homing routine performed by the software on start-up. All IOs will be initialized, and all drives will be homed.
2. "Initialize IOs" - This button initializes all of the IOs in the system, but does not home any drives. This is the first step for re-homing the loader. This must be performed for the cassette sensors and stage switch to work properly.

Moving to the top of the second column, the first group of buttons in the second column is labeled "Robot Rotation Control". It allows for homing and testing the robot rotation drive. The 6 buttons in this group are:

1. "Initialize and Home Rotation" - Initializes and homes the rotation drive.
2. "Inverter" - Rotates the robot so that it is pointing to the macro inspection station.
3. "Stage" - Rotates the robot so that it is pointing to the stage.
4. "Start" - Starts a continuous robot rotation cycle. The robot will move to each position in a regular pattern until the cycle is stopped.
5. "Elevator" - Rotates the robot so that it is pointing to the cassette elevator.
6. "Stop" - Cancels a continuous robot rotation cycle.

The second group of buttons in the second column is labeled "Robot Up/Down Control". It allows for homing and testing of the robot up/down drive. The three buttons in this group are:

1. "Initialize and Home Up/Down" - Initializes and homes the robot up/down drive.
2. "Up" - Moves the robot to the Up position.
3. "Down" - Moves the robot to the "Down" position.

The third group of buttons in the second column is labeled "End Effector" and has only one button, "Initialize and Home End Effector". This button initializes and homes the end effector.

The fourth group of buttons in the second column is labeled "Elevator Control". It allows for homing and testing of the elevator drive. It is particularly useful for testing if the elevator will stall at a given speed with a given load. It contains 5 buttons, one drop down list and one text box. The text box is labeled "Speed:" and sets a motor speed override (VM, or Maximum Velocity from the Motors tab) which is used for the movement commands issued by the buttons in this group and only for the movement commands issued by the buttons in this group. The buttons are:

1. "Initialize and Home Elevator" - Initializes and homes the elevator.
2. "Elevator Up" - Moves the elevator up until it hits the limit switch or the "Elevator Stop" button is pressed.
3. "Elevator Stop" - Issues a soft stop command to the elevator.
4. "Elevator Down" - Moves the elevator down until it hits the limit switch or the "Elevator Stop" button is pressed.
5. "Limit Cycle" - Re-homes the elevator, then moves it up and down the number of times that is currently shown in the drop down list, which contains numbers from 1 to 15.

Moving to the third column, the first group in the third column is labeled "Inverter Flip Up/Down Control". It allows for homing and testing of the flip arm drive. The four buttons in this group are:

1. "Initialize Flip (does not home)" - Initializes the macro flip arm drive. This drive does not home; the movements of this arm are controlled by position sensors.
2. "Up" - Moves the flip arm up, allowing the wafer to be viewed and the inverter to be rotated.
3. "Down (top of wafer up)" - Moves the flip arm down. First rotates the inverter so that the top of the wafer will be facing up. If the flip arm is currently down but the bottom of the wafer is up, the flip arm will come up, rotate, and then go back down.
4. "Down (top of wafer down)" - Moves the flip arm down. First rotates the inverter so that the top of the wafer will be facing down. If the flip arm is currently down but the top of the wafer is up, the flip arm will come up, rotate, and then go back down.

The second group in the third column is labeled "Inverter Spin Control". It allows for homing and testing the rotation of the macro inspection station. The three buttons in this group are:

1. "Initialize and Home Inverter Spin" - Initializes and homes the spinning axis of the wafer inverter. The flip arm will also be initialized, and it will be moved into the Up position.
2. "View Top" - Moves the flip arm up, then rotates the inverter so that the top of the wafer is facing the front of the handler. This is rotated 180 degrees from the home position.
3. "View Bottom" - Moves the flip arm up, then rotates the inverter so that the bottom of the wafer is facing the front of the handler.

The second tab is labeled "Positions". This tab allows for configuring the positions of the robot and the elevator. The positions for each motor are included in a separate box. The boxes for the three robot motion axes are on the left, and the elevator configuration box is on the right.

Starting at the top left, we have the "Rotation (R)" group. The four positions for the rotation are:

1. Stage. "Move to Stage" moves to this position, which is indicated by the number in the box labeled "Stage Position (Degrees):" and should be facing towards the stage, directly away from the cassette. Adjusting this number while the robot is in the stage position will automatically rotate the robot to the newly configured position.
2. Cassette. "Move to Cassette" moves to this position, which is indicated by the number in the box labeled "Cassette Position (Degrees):" and should be facing towards the cassette elevator. Proper alignment can be verified with the white wafer pusher bar. Adjusting this number while the robot is in the cassette position will automatically rotate the robot to the newly configured position.
3. Inverter. "Move to Invert" moves to this position, which is indicated by the number in the box labeled "Invert Position (Degrees):" and should be facing towards the macro inspection station. Adjusting this number while the robot is in the inverter position will automatically rotate the robot to the newly configured position.
4. Mapping. "Move to Map" moves to this position, which is indicated by the number in the box labeled "Map Position (Degrees):" and should be facing away from the cassette so that the wafer mapper sensor laser is centered on the reflector – frequently the same position as the stage position. Adjusting this number while the robot is in the mapping position will automatically rotate the robot to the newly configured position.

The next group is the "End Effector (T)" group. There are four end effector positions. A check box at

the bottom, labeled "Motor Enabled", can be used to remove holding current from the end effector motor. This is useful for preventing crashes while attempting to verify rotation position alignment and cassette size elevator height alignment. Checking the check box re-homes the end effector and turns on the hold current; un-checking the check box turns off the hold current.
The end effector positions are:

1. Stage. "Move to Stage" moves to this position, which is indicated by the number in the box labeled "Stage Position (mm):". The button is disabled unless the rotation drive is in the stage position. Adjusting this number while the end effector is in the stage position will automatically move the end effector to the newly configured position.
2. Cassette. "Move to Cassette" moves to this position, which is indicated by the number in the box labeled "Cassette Position (mm):". The button is disabled unless the rotation drive is in the cassette position. Adjusting this number while the end effector is in the cassette position will automatically move the end effector to the newly configured position.
3. Inverter. "Move to Invert" moves to this position, which is indicated by the number in the box labeled "Invert Position (mm):". The button is disabled unless the rotation drive is in the inverter position. Adjusting this number while the end effector is in the inverter position will automatically move the end effector to the newly configured position.
4. Retracted. "Retract" moves to this position, which is indicated by the number in the box labeled "Retract Position (mm):". The end effector should be completely retracted while in this position to prevent collisions when rotating – this will be true if the configured number is negative. Adjusting this number while the end effector is in the retracted position will automatically move the end effector to the newly configured position.

The last group in the column, the last group of robot positions, is labeled "Up Down (U)". The three positions for the robot up/down are:

1. Up. "Move Up" moves to this position, which is indicated by the number in the box labeled "Up Position (mm):" and should be at the peak of the robot's vertical travel. Adjusting this number while the robot is in the up position will automatically move the robot to the newly configured position. The robot is in this position to pick or place wafers in the cassette.
2. Down. "Move Down" moves to this position, which is indicated by the number in the box labeled "Down Position (mm):" and should be at the bottom of the robot's vertical travel Adjusting this number while the robot is in the down position will automatically move the robot to the newly configured position.
3. Macro. "Move Macro" moves to this position, which is indicated by the number in the box labeled "Macro Position (mm):" and should be near the middle of the robot's vertical travel - just below the height at which the wafer is held in the Down position on the macro inspection station. Adjusting this number while the robot is in the macro position will automatically move the robot to the newly configured position. This position is used only when picking up a wafer from the macro inspection station.

At the bottom of the column but outside of a group is a text box labeled "Increment:". The text box controls the increment for the up/down arrows. Clicking an up/down arrow (or pressing the up or down arrow keys while the cursor is on one of these boxes) will adjust the displayed number by the number shown in this text box.

The group on the right-hand side is labeled "Elevator Positions (Cassette Size Specific)" and contains controls for configuring elevator settings for different cassette sizes, as well as alternate drop off positions. The controls for moving the elevator are near the bottom in a box labeled "Move to Wafer". From top to bottom, the controls in this group are:

1. "Cassette Size Label" - this text box controls the displayed label on the main GUI for the selected cassette size.
2. "Wafer Spacing (mm):" - this box controls the space between each wafer for the selected cassette size. A standard 6 inch cassette is 4.75 mm, and a standard 8 inch cassette is 6.35 mm.
3. "Stroke (mm):" - this box controls the distance the elevator moves to pick up or place a wafer in the cassette. It should be around half of the distance between the wafers.
4. "Wafer #1 Z (mm):" - this text box controls the position of the elevator when preparing to pick up the first (bottom) wafer in a cassette of the given size.

Within the "Move to Wafer" group, we have a button, two selector buttons, a drop down menu, and a text box. The drop down menu is labeled "Wafer #" and has a list of the numbers 1 to 25. These correspond to slot numbers in the cassette. When one of these numbers is selected, the system computes the final position number for that slot based on the current settings and displays it in the text box. This is either the number for when the system is not holding a wafer or the number for when the system is holding a wafer. The position where the system is not holding a wafer is the "Get Position" and is selected when the select button labeled "Get Position" is marked. The position where the system is holding a wafer is the "Put Position" and is selected when the select button labeled "Put Position" is marked. To actually move to the position indicated by the text box, click the "Move to Wafer" button.

At the bottom of the right side we have a group of controls labeled "Cassette Position Interpolation". This is used when the cassette platform must be leveled such that the wafers in the cassette are level but the cassette itself is not; this results in the pickup/drop-off position being slightly different for each wafer in the cassette. The controls in this group are:

1. "Enable Interpolation" check box - When this is checked, the cassette position for the R and T drives is controlled by the interpolation settings and the slot number. The cassette position is not used.
2. Start Slot number box - This is the first wafer used to define the interpolation; typically wafer 1 but if slot 1 is not available another slot can be used.
3. End Slot number box - This is the last wafer used to define the interpolation; it must be higher in the cassette than the start slot for interpolation to work properly. Typically slot 25 but could be another slot number, particularly for a cassette with more or less than 25 slots.
4. Rotation (R) Start text box - This stores the rotation cassette position at the start slot.
5. Rotation (R) End text box - This stores the rotation cassette position at the end slot. Rotation positions for other slots will be calculated based on the positions for the start and end slots.
6. End Effector (T) Start text box - This stores the end effector cassette position at the start slot.
7. End Effector (T) End text box - This stores the end effector cassette position at the end slot. End effector positions for other slots will be calculated based on the positions for the start and end slots.
8. Move to Cassette Start Button - Moves to the cassette position used for the starting slot. Will first retract the end effector, then move the elevator to the start wafer position, then rotate and extend.
9. Move to Cassette End Button - Moves to the cassette position used for the ending slot. Will first

retract the end effector, then move the elevator to the end wafer position, then rotate and extend.

The next tab is labeled "Wafer Inverter Settings". This tab allows for configuring the positions of the wafer inverter and settings related to performing topside and backside macro inspection, both automatic and manual. It contains 3 groups of controls. Two of the groups allow testing and configuration of the wafer inverter drives. The remaining group allows for configuring the actions taken during macro inspection. This group is on the left and will be described first. The controls in this group, from top to bottom, are:

1. "Flip Arm Fast Slew Speed (deg/sec):" text box – This controls the speed at which the flip arm moves up and down. The fast speed is used when moving up, and used to move about 85% of the way down.
2. "Flip Arm Slow Slew Speed (deg/sec):" text box – This controls the speed at which the flip arm moves when it is almost finished moving and is looking for the position verification sensor.
3. "End Effector Slow Slew Speed (mm/sec):" text box – This box controls the speed at which the end effector moves when it is near the end of its travel either placing a wafer in the inverter (because it is looking for the switch) or getting a wafer from the cassette (in case the wafer is protruding slightly).
4. "Flip Arm Joystick Center (1-1023):" text box – This controls the center position for the F (Y) axis on the joystick. If the system moves up or down when the joystick is centered, adjusting this should correct the problem.
5. "Flip Arm Joystick Deadband (0-500):" text box – This box controls the deadband on the F (Y) axis on the joystick.
6. "Flip Arm Joystick Range (deg):" text box – This controls the distance from center that the joystick is allowed to move the wafer in the F (Y) axis during manual macro inspection.
7. "Flip Arm Joystick Speed (deg/sec):" text box – This controls the speed at which the F (Y) axis moves during manual macro inspection.
8. "Macro Rotation Joystick Center (1-1023):" text box – This controls the center position for the S (X) axis on the joystick. If the system moves left or right when the joystick is centered, adjusting this should correct the problem.
9. "Macro Rotation Joystick Deadband (0-500)" text box – This box controls the deadband on the S (X) axis on the joystick.
10. "Macro Rotation Joystick Speed (deg/sec):" text box – This controls the speed at which the S (X) axis moves during manual macro inspection.
11. "Macro Rotation Joystick Range (deg):" text box – This controls the distance from center that the joystick is allowed to move the wafer in the S (X) axis during manual macro inspection.
12. "Test Joystick (Topside)" button – This button rotates the wafer so that the top of the wafer is facing the operator and enables the joystick. The joystick button must be pressed before the setup panel will respond to other commands.
13. "Test Joystick (Backside)" button – This button rotates the wafer so that the bottom of the wafer is facing the operator and enables the joystick. The joystick button must be pressed before the setup panel will respond to other commands.

The "Increment" text box at the bottom of the left column controls the amount positions change when their up/down arrows are clicked; changing the number shown in this text box will change the amount

incremented or decremented when any of the up/down arrows on the text boxes which have up/down arrows are clicked.

Moving to the right column, the first group of controls is labeled "Rotation (S)" and contains controls for configuring and testing the positions for the rotation of the macro inspection station. The two positions are:

1. Topside. "Move Topside" moves to this position, which is indicated by the number in the box labeled "Topside Position (Degrees):". This should be rotated 180 degrees from the home position. Adjusting this number while the inverter is rotated to the topside position will automatically rotate the inverter to the newly configured position.
2. Backside. "Move Backside" moves to this position, which is indicated by the number in the box labeled "Backside Position (Degrees):". Adjusting this number while the inverter is rotated to the backside position will automatically rotate the inverter to the newly configured position.

The second group of controls in the right hand column is labeled "Flip (F)" and allows for testing the positions of the flipper arm. These positions cannot be configured. The three buttons in this group are:

1. "Flip Up" - Moves the flip arm up, allowing the wafer to be viewed and the inverter to be rotated.
2. "Flip Down (with backside up)" - Moves the flip arm down. First rotates the inverter so that the top of the wafer will be facing down. If the flip arm is currently down but the top of the wafer is up, the flip arm will come up, rotate, and then go back down.
3. "Flip Down (with topside up)" - Moves the flip arm down. First rotates the inverter so that the top of the wafer will be facing up. If the flip arm is currently down but the bottom of the wafer is up, the flip arm will come up, rotate, and then go back down.

The next tab is labeled "Settings". This tab contains many options which affect the appearance of the GUI and the workflow of the system, as well as the COM port and some vacuum settings. Starting on the left side, there are a number of check boxes near the top; they are:

1. "Pause on Empty Cassette Slots" - Used primarily when mapping is disabled. Causes the handler to treat a failure to grab a wafer from the cassette as an error – normally it is considered to be an empty slot and will be skipped.
2. "Require Selected Wafers to be Present" - If this is checked, then all the wafers selected by the current recipe must be present when the mapper runs. If any wafers are missing, the system will throw an error and the cassette must be replaced and remapped to continue.
3. "Load Wafers from Top (25) to Bottom (1)" - If checked, wafers are run starting with 25 and with 1 as the last wafer to run. This prevents delays when the mapper runs, as after the mapper finishes it is near the position to load wafer 25. Defaults to on.
4. "Enable Continuous Operation" - Used for testing. Causes the system to simulate stage inspection lasting between 20 and 50 seconds. Also causes the system to restart a cassette cycle without waiting for the cassette to be removed if the "Auto Restart" check box (on the main GUI) is checked. When this is active, "Continuous Operation Enabled" will be displayed in red on the main GUI near the bottom right corner, just above the Franklin logo.

Underneath these checkboxes is a group labeled "Slot Colors." The group contains 10 buttons. Each button controls one of the colors used for wafers in a particular stage of running (or configured to perform certain operations). Each button opens a small dialog which allows you to select a new color.

At the top of the right side are five text boxes and a number box, they are:

1. "End Effector Vacuum Delay (ms):" - This controls the delay between when the end effector vacuum solenoid is turned on or off and when the sensor is checked. This delay gives the system time for the vacuum pressure to change. It is measured in milliseconds.
2. "Stage Vacuum Delay (ms):" - This controls the delay between when the stage vacuum solenoid is turned on or off and when the sensor is checked. This delay gives the system time for the vacuum pressure to change. It is measured in milliseconds.
3. "Base Font Size" - Controls the size of the main GUI. 8.25 is the default. Values larger than 16 are not permitted.
4. "Check Cassette Interval (milliseconds)" - Controls how often the cassette sensors are checked. Checking too fast can cause the handler to respond more slowly to other commands. Checking too slowly can cause the handler to fail to detect a cassette being rapidly removed and replaced.
5. "Log Message Display Interval (milliseconds)" - Controls how fast the messages on the main GUI cycle between different messages when there is more than one status message to display.
6. "Auto Rehome Loader Every Hours" number box - If this is set to a positive number, causes the handler to request that it be re-homed after this many hours have passed. Setting to -1 or 0 disables this feature. The user will have the chance to wait for 1 hour to rehome if they desire, and the system will not attempt to rehome if a cassette cycle is running.

Underneath these text boxes is a combo box labeled "COM Port" which controls which COM port is used to communicate with the handler. It is pre-populated with all of the valid COM port numbers on the computer. Changes to this setting require a software restart to take effect.
The two buttons below this combo box are:

1. "Change User Password" - Opens a new window which changes the user password. The user password must be entered to change the password. Setting the password to nothing (leaving the box blank) disables the password and causes the system to automatically log in as User when the software first starts.
2. "Change Admin Password" - Opens a new window which changes the administrator password. The administrator password must be entered to change the password.

The next tab is labeled "Motors" and contains settings which control the movement of all the axes in the system. For each of the motors, there is a small group of controls. The controls are the same for all of the motors and I will only describe them once. The largest control shows the values of all configurable drive variables. The commonly used variables are:

1. "VM:" - (Maximum Velocity) – The highest speed the motor moves.
2. "A:" - (Acceleration) – Acceleration for the motor in steps/second.
3. "D:" - (Deceleration) – Deceleration for the motor in steps/second.
4. "HC:" - (Holding Current) – Controls the amount of force used to keep a motor from moving.
5. "RC:" - (Run Current) – Controls the amount of current that goes to the motor. Too little current can stall a motor, and too much current can damage the handler.

The other controls include two combo boxes and a check box. The combo boxes control the IO port used for the positive and negative limit switch. Not all drives have both of these switches; for drives that do not have one of these switches this setting has no effect. These settings are not meant to be edited by the user and are displayed for information purposes only. The "Active High" check box inverts the polarity of the limit switches. Changes to motor settings do not take effect until the motor is re-initialized, typically by re homing the handler.

The next tab is labeled "I/O Configuration" and allows for viewing the state of all the inputs in the system. For each of the general purpose inputs and limit switch inputs, the current state can be viewed. The button labeled "Check Input Values" located at the bottom of the list of IOs and above the limit switch inputs updates the displayed values for all IOs as well as all limit switches and the stage switch.

Also on this tab is a control which allows for the polarity of the stage switch to be changed. If the system is equipped with a stage rotation sensor or cassette protrusion sensor, the polarities of these sensors can also be adjusted. Checking the checkbox next to the given sensor inverts the polarity for that sensor.

The last tab is labeled "Cassette Specific Settings" and contains controls which allow for configuring the mapper and the prealign settings. The first group of controls is labeled "Mapper Settings" and allows for configuring and testing the mapper. The controls in this group are:

1. "Starting Height:" box – This box controls the height at which the mapper sensor turns on when mapping the cassette. This height should be well below the height of the first wafer, but not so far below that the mapper sensor's laser hits the H-Bar of the cassette.
2. "Ending Height:" box – This box controls the height at which the mapper sensor turns off when mapping the cassette. This height should be well above the last wafer, but not so far above the last wafer that the mapper sensor's laser hits the top of the cassette or the cassette elevator hits the bottom limit switch.
3. "First Wafer Location:" box – This box indicates the height at which the first wafer is located.
4. "Margin of Error:" box – This box controls the margin of error for detecting a wafer, which is the number of millimeters above or below the wafer's position the sensor is 'allowed' to detect the wafer without marking it as cross-slotted or double-stacked. The minimum value depends on the thickness of the wafers, and the maximum value depends on the spacing of the wafers – if the value is larger than the Wafer Spacing (configured on the Positions tab) the mapper will not be able to detect cross slotted wafers, and if the value is more than double the thickness of the wafers the system may not be able to detect double stacked wafers.
5. "Mapping Speed:" text box – This text box controls the speed at which the elevator moves during a mapping operation.
6. "Test Mapper" button – This button runs the mapper using the current settings.
7. "Laser On" button – This button turns on the mapper laser (useful for verifying that the laser is aligned correctly to hit the reflector.)
8. "Laser Off" button – This button turns off the mapper laser.
9. "Mapper Test Results:" text box – This text box shows the results of the mapper runs started by clicking the Test Mapper button. The results list the cross slotted wafers first, the detected wafers second, and the positions at which a wafer was sensed (listed as start – finish) last. The results show only the most recent run of the mapper.

Main GUI buttons

Many of the buttons on the main GUI are only visible in certain situations. For example in the center of the screen are 5 buttons used for error handling that are only visible when an error has occurred and have different labels and functions depending on the error. Just below them are two larger buttons only visible when a wafer has been loaded onto the macro inspection station; the "Next Macro Inspection Stage" causes the macro operation currently being performed to finish and the next stage of macro inspection (back macro, or replacing the wafer in the cassette, or loading it on the stage) to take place. The "Manual Control" button enables the joystick which allows for manual control of topside macro inspection operations. Near the bottom of the column of buttons on the right side of the GUI is a button which is visible if logged in as Administrator and not visible if logged in as User. Clicking this button shows the Setup panel. When continuous operation mode is enabled, another message appears below this button which reads "Continuous Operation Enabled" in red.

Most of the controls on the main GUI are divided into two columns, one on the right and the other on the left. The controls on the left are in a group labeled "Cassette Slot Selection". At the top of this group is a list of available recipes. These can be created by the user. Clicking the "Add..." button will open a dialog allowing you to set the name for a new recipe. Setting the name to the same name as an existing recipe will cause the existing recipe to be overwritten; the user will be prompted to continue and has the option to cancel. The recipe created will be whatever the wafer selection is when the Add button is clicked. Clicking the "Save" button causes the current settings to be saved as the current selected recipe. Clicking the "Delete" button will cause the currently selected recipe to be removed. Deleting all recipes will cause a set of default recipes to appear if the software is restarted without creating any recipes. "Save" and "Delete" are only visible if the user is logged in as Administrator. Underneath these buttons is a color code for the wafer selection colors. This cannot be edited from the main GUI but the colors can be changed in the Setup screen. Underneath this color code are 25 buttons numbered 1 through 25. These correspond to the 25 wafers in a standard cassette. Each wafer can be selected for Stage and Macro inspection, Stage Inspection Only, Macro inspection Only, or nothing (Don't Run). Clicking on one of the wafer slot buttons cycles through these options as long as the wafer has not started running in the current cassette cycle. Right clicking on one of these buttons shows a smaller menu where individual operations can be enabled or disabled without having to click through all four options; this also allows the user to enable only topside or backside inspection. If the wafer has run or is running, clicking on the cassette slot button toggles between the normal status display and a black button with a red "XX" indicating that the wafer is a reject. When the mapper runs, any cassette slot button that corresponds to an empty cassette slot is disabled and cannot be edited; the slot displays the requested operations based on the recipe, but the system will skip the wafer.
Several controls are located in the lower middle of the GUI. I will now describe the controls which are always visible; they are:

1. "View as Checkbox Grid" button – This button opens a new window with a large number of check boxes, one for each wafer for each operation. This allows for complicated recipes to be edited more easily.
2. "Auto-Map Cassette" check box – If this check box is checked, the mapper will automatically run at the start of each cassette cycle, as long as it has not already been run. Also, if the cassette is removed during a cassette cycle, the mapper will run again when it is replaced. If this option

is disabled, the mapper will only run when the Map Cassette button is pressed.

3. "Current Alternate Settings" combo box – This allows selecting different settings for the same size cassette (meaning a cassette which hits the same cassette size sensor switches). For example, it could be used to have different pick up points for thick or thin wafers. Cannot be edited while a cassette cycle is running.
4. "Always Do Manual Macro" check box – If this check box is checked, the system will always open the manual macro control dialog when a topside macro inspection operation is performed.

The rest of the controls on the main GUI are in a column on the right side of the GUI. The first seven of these are in a group labeled "Loader Control" and allow for starting, stopping, pausing, and canceling a cassette cycle. They are:

1. "Start Cassette" button – This button starts a cassette cycle.
2. "Reset Cassette" button – Terminates the current cassette cycle and returns all wafers to the cassette. Also resets the mapper data.
3. "Release Stage Vac" button – This button releases the stage vacuum. The wafer on the stage must be removed to continue. Does nothing if the stage vacuum is currently disabled.
4. "Pause" button – This button causes the system to temporarily stop until the Pause button is pressed again. While paused, this button will read "Resume". The movement commands in progress when this button is pressed will be allowed to finish, which prevents position errors.
5. "Map Cassette" button – This button runs the mapper. The results will be indicated on the cassette slot buttons. This button is only enabled if there is no cassette cycle currently running.
6. "Auto Restart" check box – If this check box is checked, the system will automatically start a new cassette cycle a few seconds after the current cassette cycle finishes. Clicking Reset Cassette clears this check box. If this option is disabled the system will not start another cassette cycle until Start Cassette is clicked.

The next group of three buttons is labeled "Misc" and contains three buttons. They are:

1. "Re-home Handler" - Causes the handler to re-home itself. Usually not needed unless the Halt Operation button was clicked or the power to the handler was interrupted.
2. "Exit Program" - Causes the program to exit. Disabled unless there is no cassette cycle running.
3. "Help" - Opens a .pdf file with help information.

The last button is labeled "Log Out" and causes the log in screen to reappear so that the user can log in as administrator (or vice versa).