

# PAQi User Manual

## PAQi



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# User Manual

## Camera in a Box (PAQi) with Poke

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Picture Acquisition and Inspection (PAQi) contains hardware to interface with your production system for acquiring and storing images from up to four DirectShow, Imaging Source, or NI Vision Acquisition compatible cameras on a Windows 10 Enterprise based PC. The PAQi unit includes LM3's patent-pending deep learning-based inspection server, optionally the PAQi can be setup to do vision analysis/inspection by licensing and setting up NI's Vision Builder AI. This document describes how to install and configure the PAQi in your production environment.

The PAQi system offers the following functionality:

- Windows based software for acquiring and storing images from USB and Gigabit cameras
- Communicates with assembly station via discrete IO or Industrial Communications for Allen Bradley PLCs
- Allows for part number acquisition using USB or triggered RS232 bar code scanners
- Stores results and images to MSSQL Server
- Based on the DirectShow media library developed by Microsoft, the program is capable of image scaling for a full featured user interface on a 1080p or 4k monitor. The monitor is required for initial setup however not required to run the system in normal production.
- Robust error handling ensures zero image loss for production use

## What You Need to Get Started

You will need the following to setup the system:

- LM3's PAQi with an external 19VDC@3A power supply
- Camera, lens, and cable
- Hardware to mount the cameras
- A keyboard, mouse, and monitor for the initial setup

### Optional Equipment

- A (24VDC) button with 8-pin female Eurostyle disconnect
- PNP LED only light stack for status indication
- A USB or RS232 bar code scanner with operating specifications
- Swivellink® or similar mounting hardware
- Monitor 1920x1080P Touch Screen
- USB Type-C to HDMI Adapter [Thunderbolt 3 Compatible]
- M12 PAQi to Machine interface cable in various lengths (3 Meter included)

### Related Documentation

The following documents should be referred to regarding the hardware which makes up the system:

- [https://msdn.microsoft.com/en-us/library/ms233763\(v=vs.100\).aspx](https://msdn.microsoft.com/en-us/library/ms233763(v=vs.100).aspx) – MSSQL Server Express setup notes in case you need to migrate the database to another location on your network.
- National Instruments VBAI manual - <http://www.ni.com/pdf/manuals/373379l.pdf>

## Safety Information



The following paragraphs contain important safety information you must follow when installing and operating the PAQi and all devices connecting to it. Do not operate the device in a manner not specified in the documentation. Misuse of the device may result in a hazard and may compromise the safety protection built into the device. If the device is damaged, turn it off and do not use it until service-trained personnel can check its safety. If necessary, return the device to LM3 Technologies, Inc. for repair. Keep away from live circuits. Do not remove equipment covers or shields unless you are trained to do so. If signal wires are connected to the device, hazardous voltages can exist even when the equipment is turned off. To avoid a shock hazard, do not perform procedures involving cover or shield removal unless you are qualified to do so. Disconnect all field power prior to removing covers or shields. If the device is rated for use with hazardous voltages (>30 Vrms, 42.4 Vpk, or 60 Vdc), it may require a safety earth-ground connection wire. Refer to the device specifications for maximum voltage ratings. Because of the danger of introducing additional hazards, do not install unauthorized parts or modify the device. Use the device only with the chassis, modules, accessories, and cables specified in the installation instructions. All covers and filler panels must be installed while operating the device. Do not operate the device in an explosive atmosphere or where flammable gases or fumes may be present. Operate the device only at or below the pollution degree stated in the specifications. Pollution consists of any foreign matter—solid, liquid, or gas—that may reduce dielectric strength or surface resistivity.

The following is a description of pollution degrees.

- Pollution Degree 1—No pollution or only dry, nonconductive pollution occurs. The pollution has no effect.
- Pollution Degree 2—Normally only nonconductive pollution occurs. Occasionally, nonconductive pollution becomes conductive because of condensation.
- Pollution Degree 3—Conductive pollution or dry, nonconductive pollution occurs. Nonconductive pollution becomes conductive because of condensation. Clean the device and accessories by brushing off light dust with a soft, nonmetallic brush. Remove other contaminants with a stiff, nonmetallic brush. The unit must be completely dry and free from contaminants before returning it to service. You must insulate signal connections for the maximum voltage for which the device is rated. Do not exceed the maximum ratings for the device. Remove power from signal lines before connection to or disconnection from the device.

Clean the device and accessories by brushing off light dust with a soft, nonmetallic brush. Remove other contaminants with a stiff, nonmetallic brush. The unit must be completely dry and free from contaminants before returning it to service. You must insulate signal connections for the maximum voltage for which the device is rated. Do not exceed the maximum ratings for the device. Remove power from signal lines before connection to or disconnection from the device.

## Installation Instructions

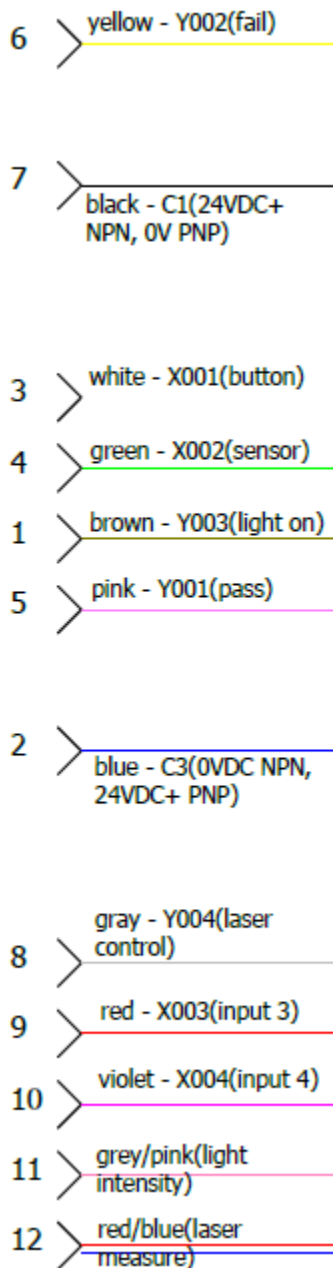
The PAQi is shipped pretested and ready for integration to your production station. To install:

1. Mount the PAQi to your assembly station or line using the DIN rail clips on the back side of the box. Optional mounting hardware is available with specification.
2. Mount the cameras in a position out of the way of production but pointing at the region of interest for the image you want to acquire. Connect the USB3 cameras to the USB3.0 or Camera ports on the box. It is recommended that the camera be mounted on a secure standalone mount to avoid vibration caused by the station.



3. Connect your keyboard, mouse, and monitor to the peripheral ports on the box.
4. Power for the PAQi unit is supplied by the Laptop type power supply included with the unit. Attach power to start unit.
5. Wire your sensors and indicator lights per the connection pin out diagram below keeping in mind the inputs are 24VDC PNP signals and the outputs relay the common voltage supplied on pin 3 of the output ports with a maximum voltage of 24VDC at 1A per channel. Note: Though the following pin assignments are absolute, the wire colors may vary based on the type of cable you use. Review your cable specifications for wire colors to ensure you use the correct pin out.

## PAQi IO Port Assignments



The M12 12-pin connector is used to power the IO and provide an interface for triggering the PAQi and receiving the pass/fail results when an inspection is completed where a PLC is not the master controller. For example, for molding operations where there is no station PLC, the M12 IO connector is used to interface the PAQi with the robot or press. The following signals are available on the M12 connector:

### Pin

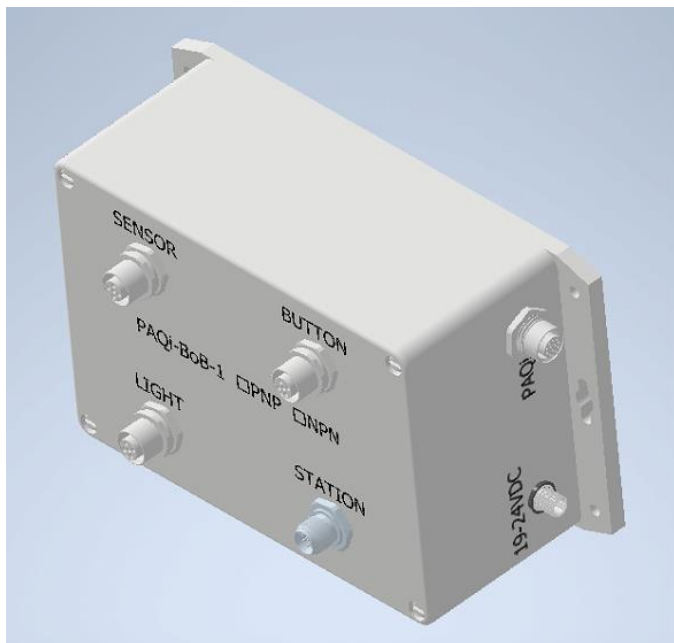
- 1 – output from PAQi to enable the LED ring or spotlight
- 2 – 24VDC+(PNIP)/0V(NPN) connection from external power supply to power the IO
- 3 – input to PAQi for button or a simple sensor
- 4 – input to PAQi for a sensor
- 5 – output from PAQi for inspection pass
- 6 – output from PAQi for inspection fail
- 7 – 0VDC(PNP)/24VDC+(NPN) connection from external source to feed common terminals for 24VDC sourcing inputs
- 8 – output from PAQi to enable a laser
- 9 – input to PAQi for inspection selection
- 10 – input to PAQi for inspection selection
- 11 – LED ring or spotlight intensity control
- 12 – 0-10v analog input

M12 Pin	Wire Color	PAQi IO	PAQi Signal	Machine Signal
1	Brown	O3	Light Activate	Spot or Ring Light Activate
2	Blue	C3	24VDC+ PNP, 0VDC NPN	Power for PLC
3	White	I1	Button Input	Trigger Button
4	Green	I2	Button or Reset Step Count Input	Reset Step Count Output
5	Pink	O1	Inspection Pass Output	Inspection Pass Input
6	Yellow	O2	Inspection Fail Output	Inspection Fail Input
7	Black	C1	0VDC PNP, 24VDC+ NPN	Power for PLC
8	Gray	Y4	Spare Output for Laser Control	Spare Input or Laser Activate
9	Red	I3	Spare Input for Selection	Output for inspect select
10	Violet	I4	Spare Input for Selection	Output for inspect select
11	Gray/Pin	DA1	0-10v Light Intensity Control	Spot or Ring Light Control
12	Red/Blue	AD1	0-10v Input	Analog sensor or control

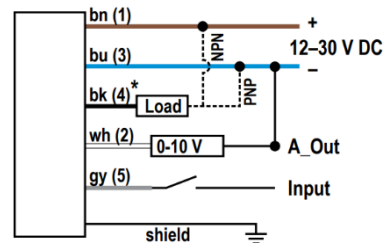
It is important to note the PAQi PLC can be programmed for machine control as communication with the PAQi software is not tied to the IO directly. More details on how to do this are included in the section below regarding triggering.

### PAQi BoB Port Configurations

The PAQi BoB (Breakout Box) is an accessory that can be purchased to allow for plug and play connection of sensor, lights, and buttons as well as a connection to the station PLC.



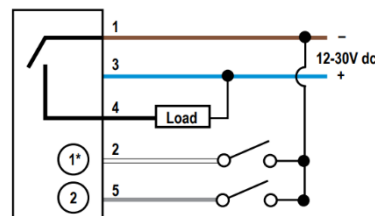
### Sensor Port Example Sensor Circuit (Banner Engineering (Q5X Series))



\* Push-Pull output. User-configurable PNP/NPN setting.

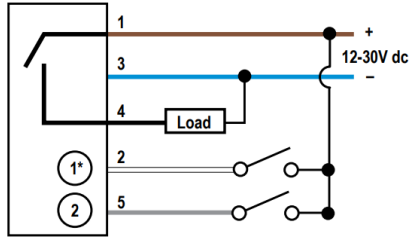
Engineering (Q5X Series)

### Button Port Example Circuit (NPN)



Banner Engineering (K50 Series)

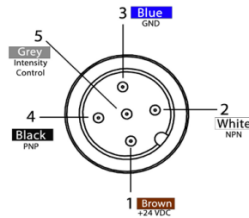
### Button Port Example Circuit (PNP)



Banner Engineering (K50 Series)

### Light Port Example Circuit

#### CONTINUOUS OPERATION MODE



Pins	Function	Signal
1	Power In	+24VDC
2	NPN	Sinking Signal
3	GND	Ground
4	PNP	Sourcing Signal
5	Intensity Control	1-10VDC

Smart Vision Light RM or SX30 Series

### M12 8-pin Station Port Connections

Pins	Function	NPN Signal	PNP Signal
1	Inspection Fail	Sinking Signal	Sourcing Signal
2	Power In	24VDC +	24VDC +
3	Trigger 2	Sinking Signal	Sourcing Signal
4	Trigger 1	Sinking Signal	Sourcing Signal
5	Trigger 3	Sinking Signal	Sourcing Signal
6	Inspection Pass	Sinking Signal	Sourcing Signal
7	GND	Ground	Ground
8	Inspection in Progress	Sinking Signal	Sourcing Signal

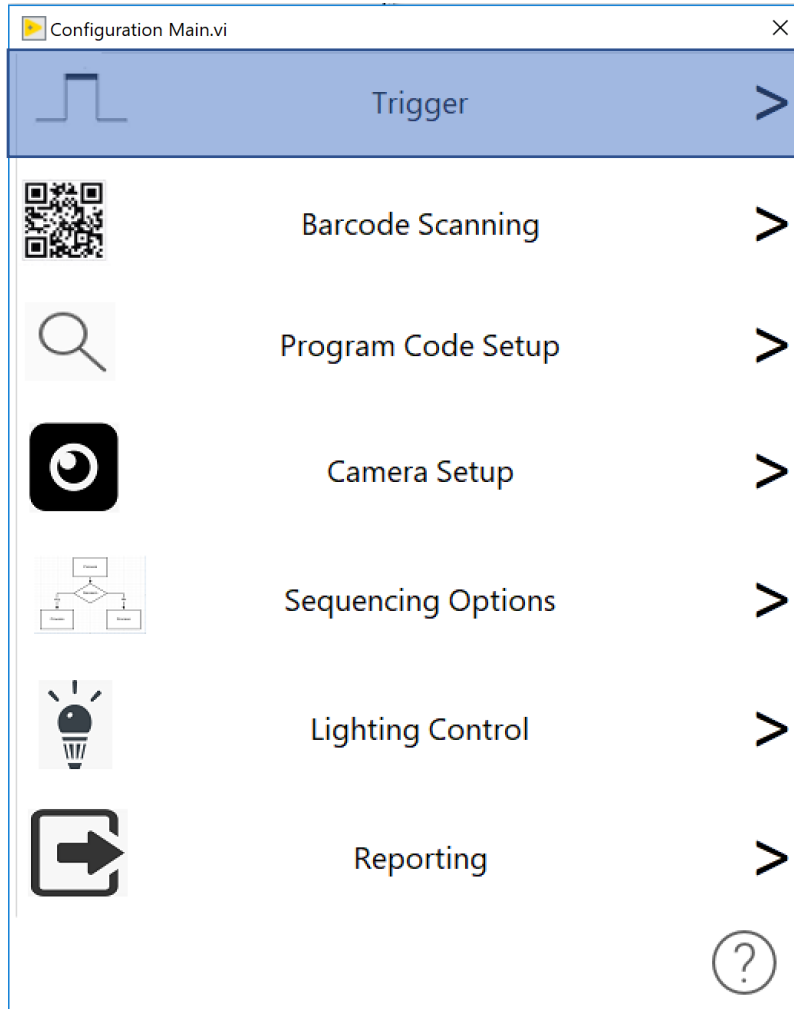


## Configuration Instructions

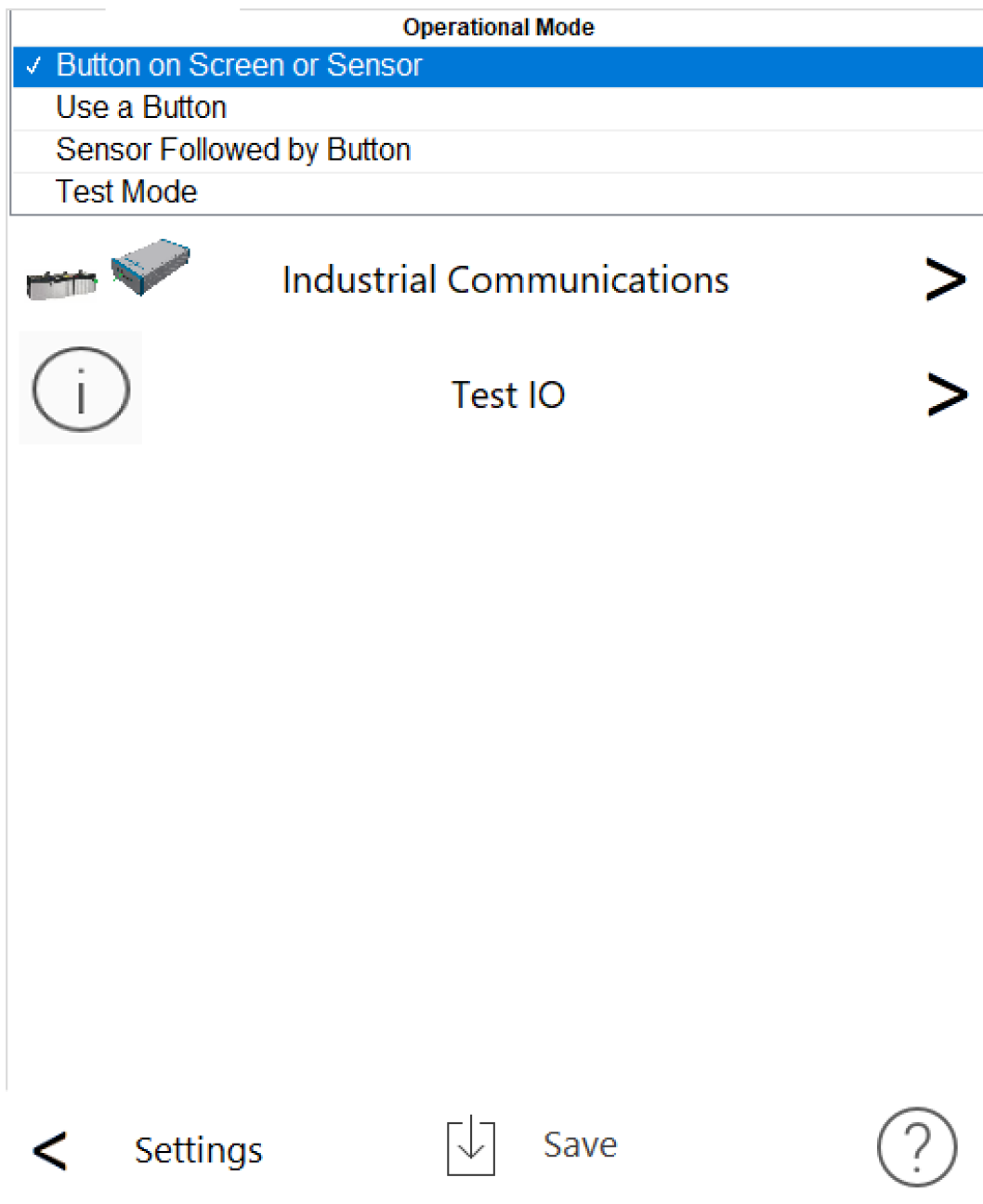
### System Configuration

The configuration program is structured in a logical order to lead you through the options for triggering the acquisition, changing camera settings based on program code, displaying images, storing images, running inspection where necessary, and controlling the sequence of operations.

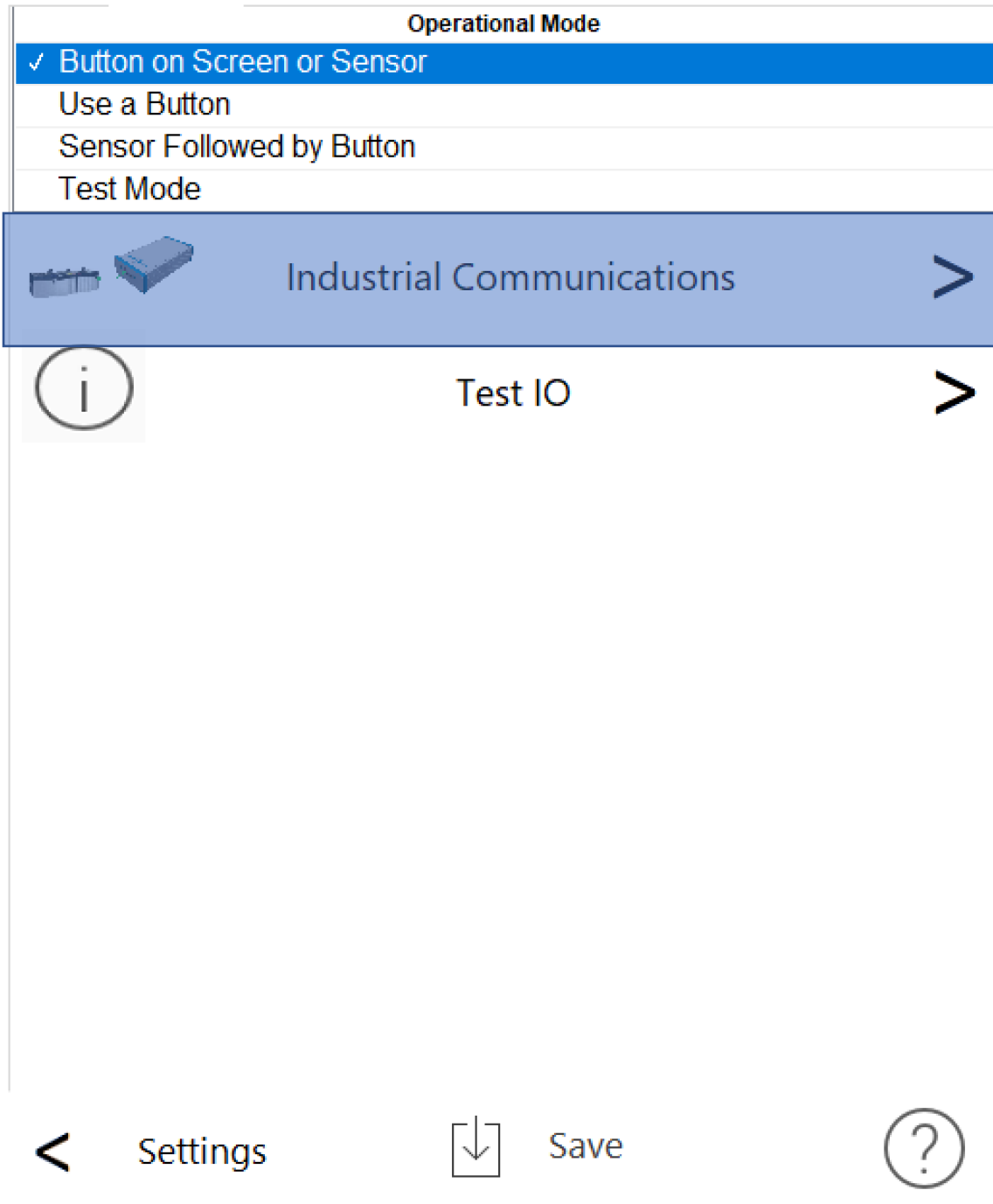
### Step 1 - Trigger Setup



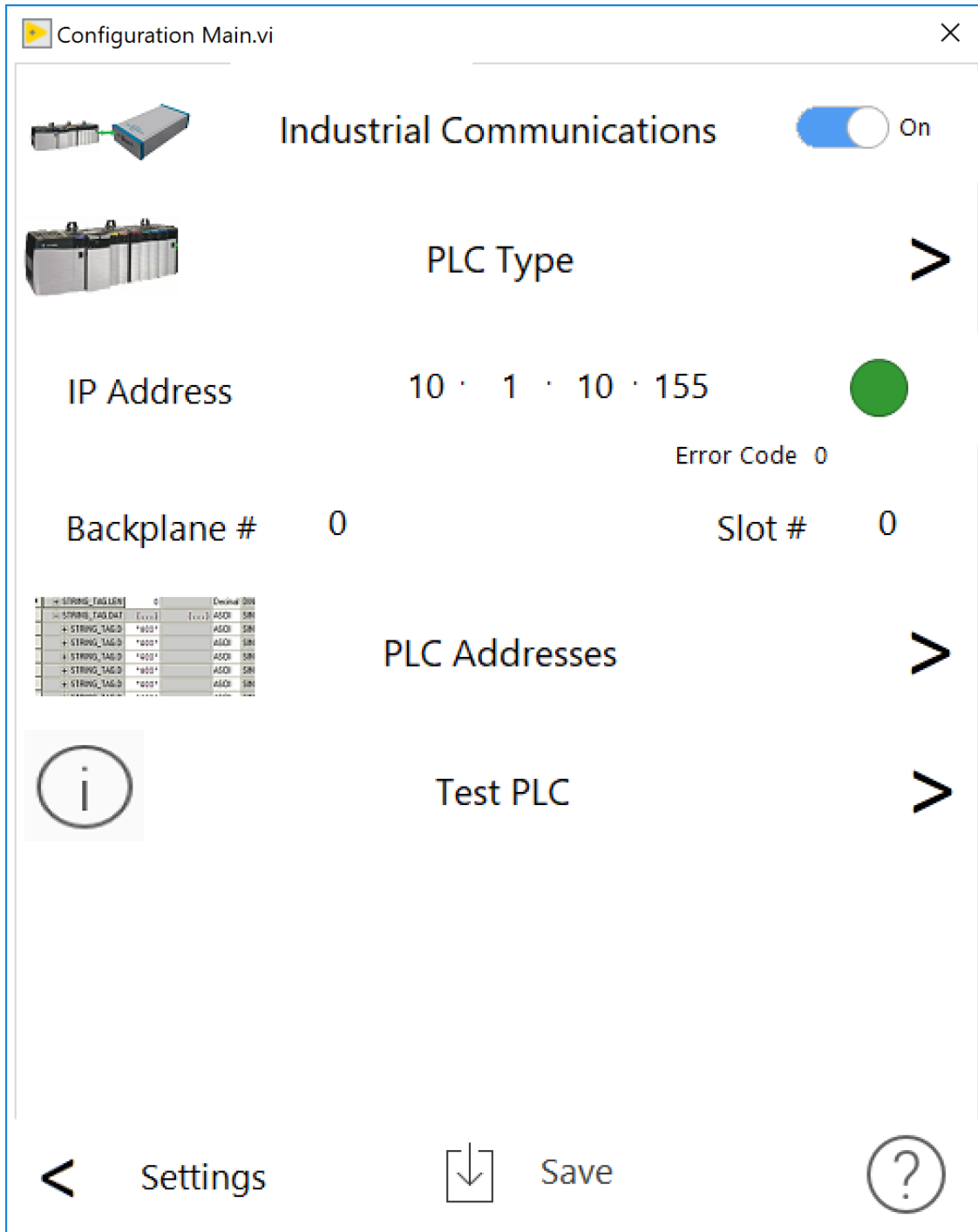
When the operational program is running, you can access the test configuration program by pressing the Options button between cycles and entering the master password. By default, the master password is empty and can be changed in the Reporting setup program.



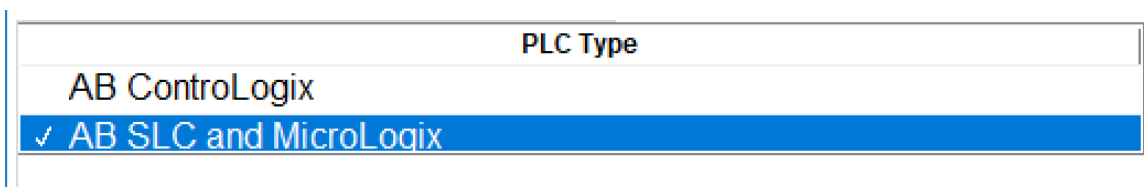
Triggering options include: Button on Screen or Sensor, Use a Button only, or use both. The test mode allows you to repetitively collect images. See the installation instructions section and schematics for wiring the IO. In all cases, the PAQi expects a high signal for all inputs. In order to save changes in all sub-programs, press the Save button at the bottom of the screen.



If you plan to use PLC communications to trigger the acquisition, press the industrial communications button to enable, set the PLC type, IP Address, Backplane # and Slot if PLC is a Contrologix version. If communications to the PLC is successful, the green light next to the IP Address will show green with an error code of 0. Error code can be looked up at [https://zone.ni.com/reference/en-XX/help/371361R-01/lverror/misc\\_lv\\_error\\_codes/](https://zone.ni.com/reference/en-XX/help/371361R-01/lverror/misc_lv_error_codes/).



The PAQi can communicate with two PLC types: Allen Bradley ControlLogix or SLC500(Micrologix Included).



Address	Symbol	Value	Comment
STRING_TAG_LEN	0	0	
STRING_TAG_LEN	0	0	
STRING_TAG_LEN	0	0	
STRING_TAG_LEN	0	0	
STRING_TAG_LEN	0	0	
STRING_TAG_LEN	0	0	
STRING_TAG_LEN	0	0	
STRING_TAG_LEN	0	0	
STRING_TAG_LEN	0	0	
STRING_TAG_LEN	0	0	

## PLC Addresses



Press the PLC Addresses button

to setup all relevant addresses for your application. Note that the ← arrow is for inputs to the PAQi and → are outputs from the PAQi.

- Barcode ← this is a string based address holding the complete barcode of the part being inspected including the serial number and program code which can also be called a part number. Parsing is used to separate the SN and program code – see barcode [section](#) below
- Trigger ← this is a bit based address for triggering the PAQi to run an inspection
- Button ← this is a bit based address for using a button in addition to the trigger to cause the PAQi to run an inspection. If you are running in step mode, this bit will also reset the step counter to start the cycle from the beginning.
- Pass → this is a bit based address for indicating the results of the inspection
- Fail → this is a bit based address for indicating the results of the inspection
- SN Out → this is a string based address the PAQi writes the parsed serial number to for validating the pass/fail results.
- On → this is a bit based address for indicating the PAQi is on
- In Progress → this is a bit based address for indicating the PAQi is running an inspection

In the least, the trigger and pass/fail bit based addresses should be configured if you are using a PLC to control the inspection. Depending on your MES, you can also manage the program code and serial number through the PLC communications or use a USB or RS232 scanner directly connected to the PAQi.

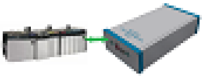
Finally, If you are communicating with a Contrologix PLC, you will enter Tag Addresses versus the native SLC PLC addresses in this example.


Configuration Main.vi ×

Barcode<--	ST20:0
Trigger<--	B3:1/0
Button <--	B3:1/1
Pass -->	B3:0/0
Fail -->	B3:0/1
SN Out -->	
On -->	B3:0/2
In Progress-->	B3:0/3

< Settings
 ↓ Save
 ?

Configuration Main.vi

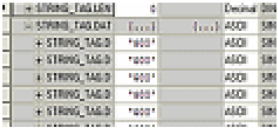
 **Industrial Communications**  On


 **PLC Type** >



**IP Address** 10 · 1 · 10 · 155

**Error Code** 0

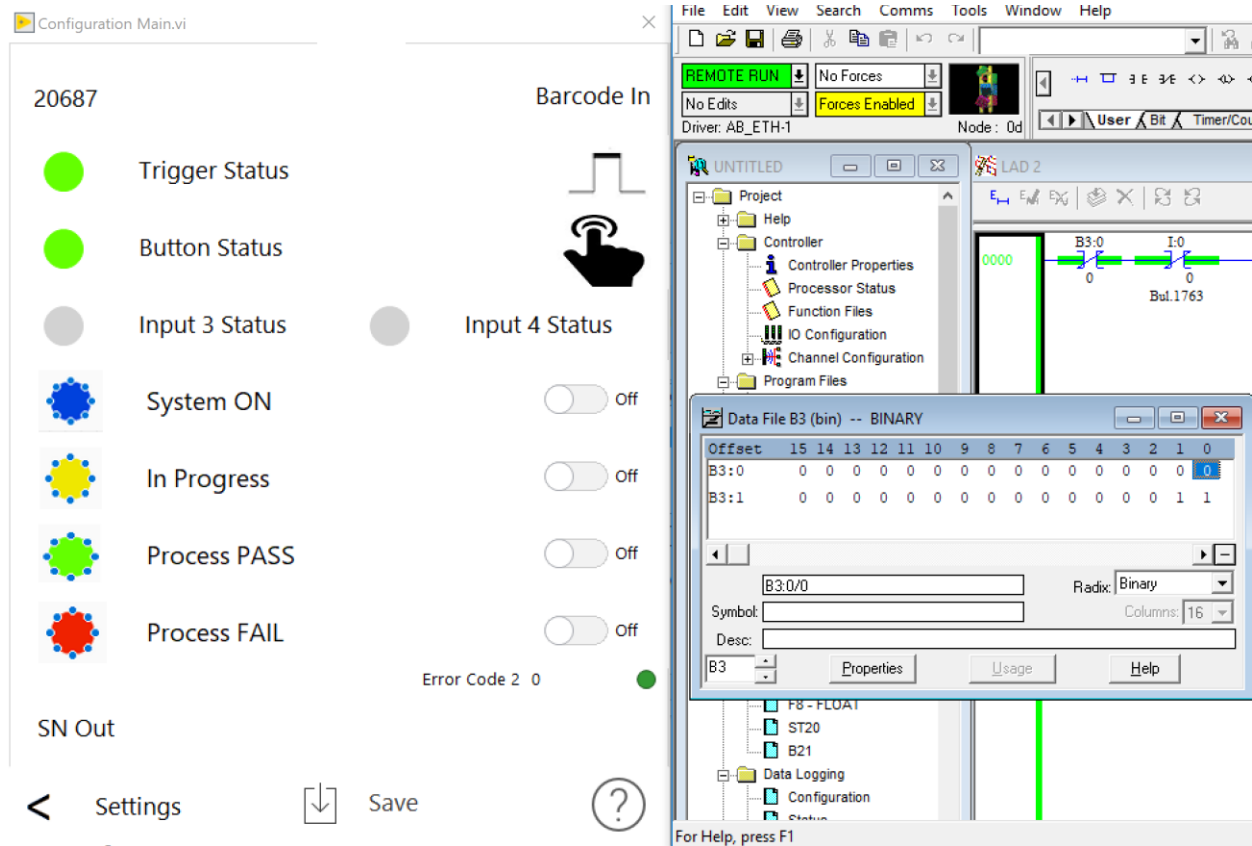
**Backplane #** 0 **Slot #** 0

 **PLC Addresses** >

 **Test PLC** >

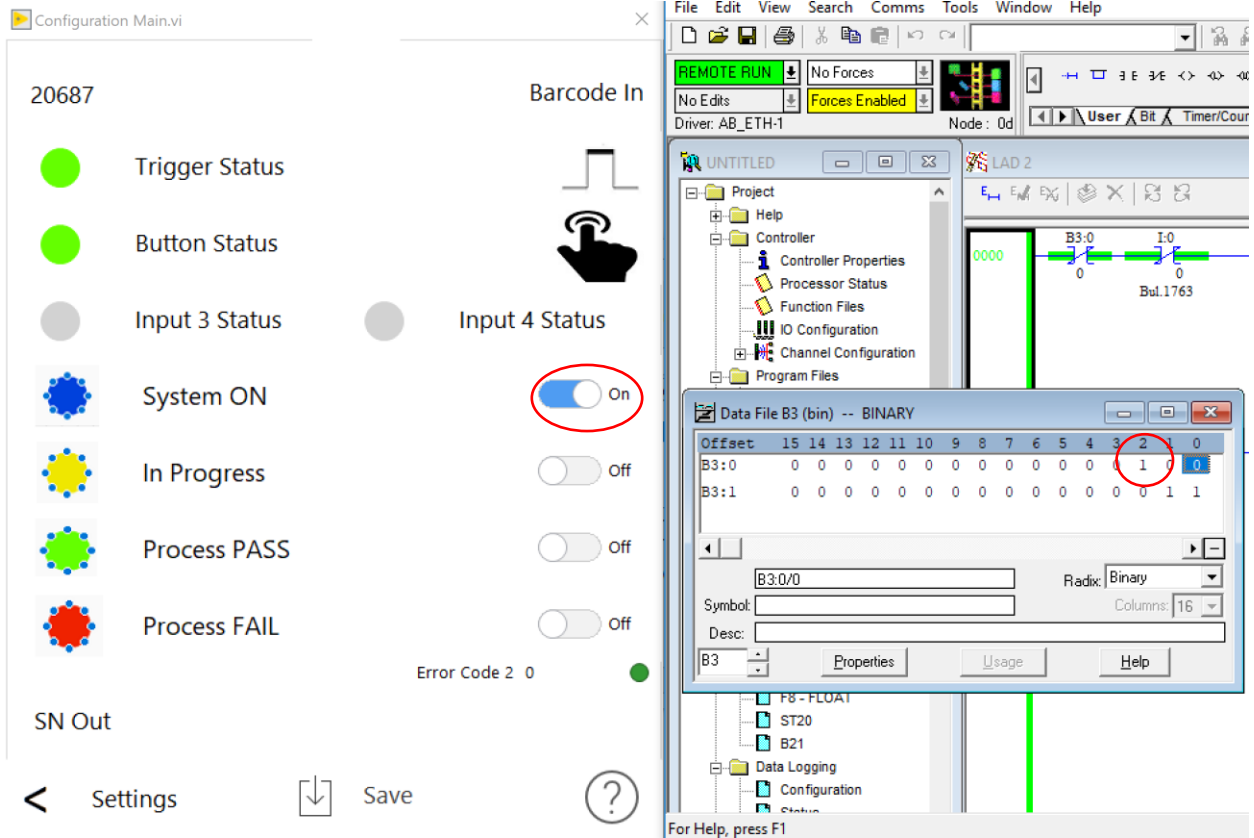
< **Settings**  **Save** 

The Test IO or Test PLC button gives access to the status of the IO whether you are using digital sensors or PLC communications. If you are using PLC communications, based on your address settings, you can test the communications using RSLogix and the program together for troubleshooting purposes.



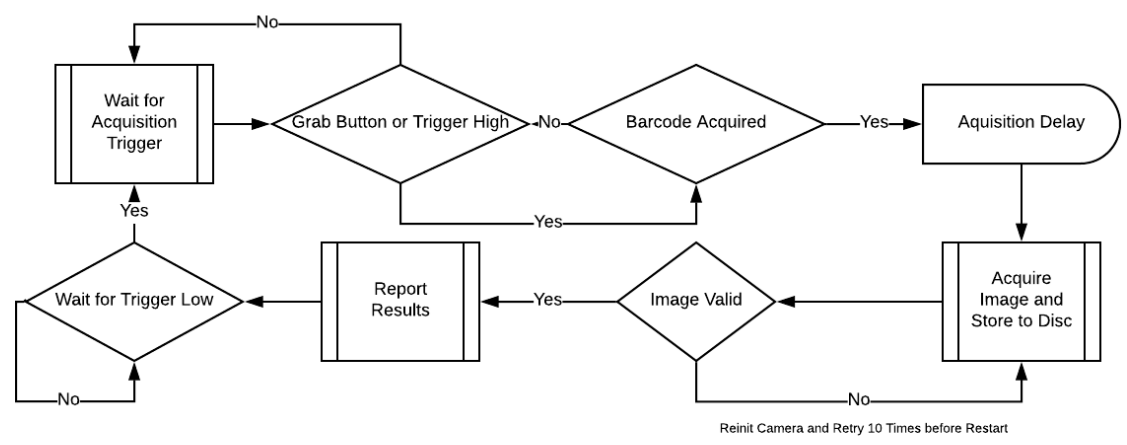
Using the addresses shown above, if you set B3:1/0 and B3:1/1 high, you will see the trigger and button status indicators light up if the communications is working. You will also notice the Barcode In value at the top of the screen. According to this example, the value of 20687 is in register ST20:0.





Notice in the above example, I set the System ON address to B3:0/2 so when I turn the output on, I see that bit go high in the PLC.

Acquisition Cycle Flow Basic

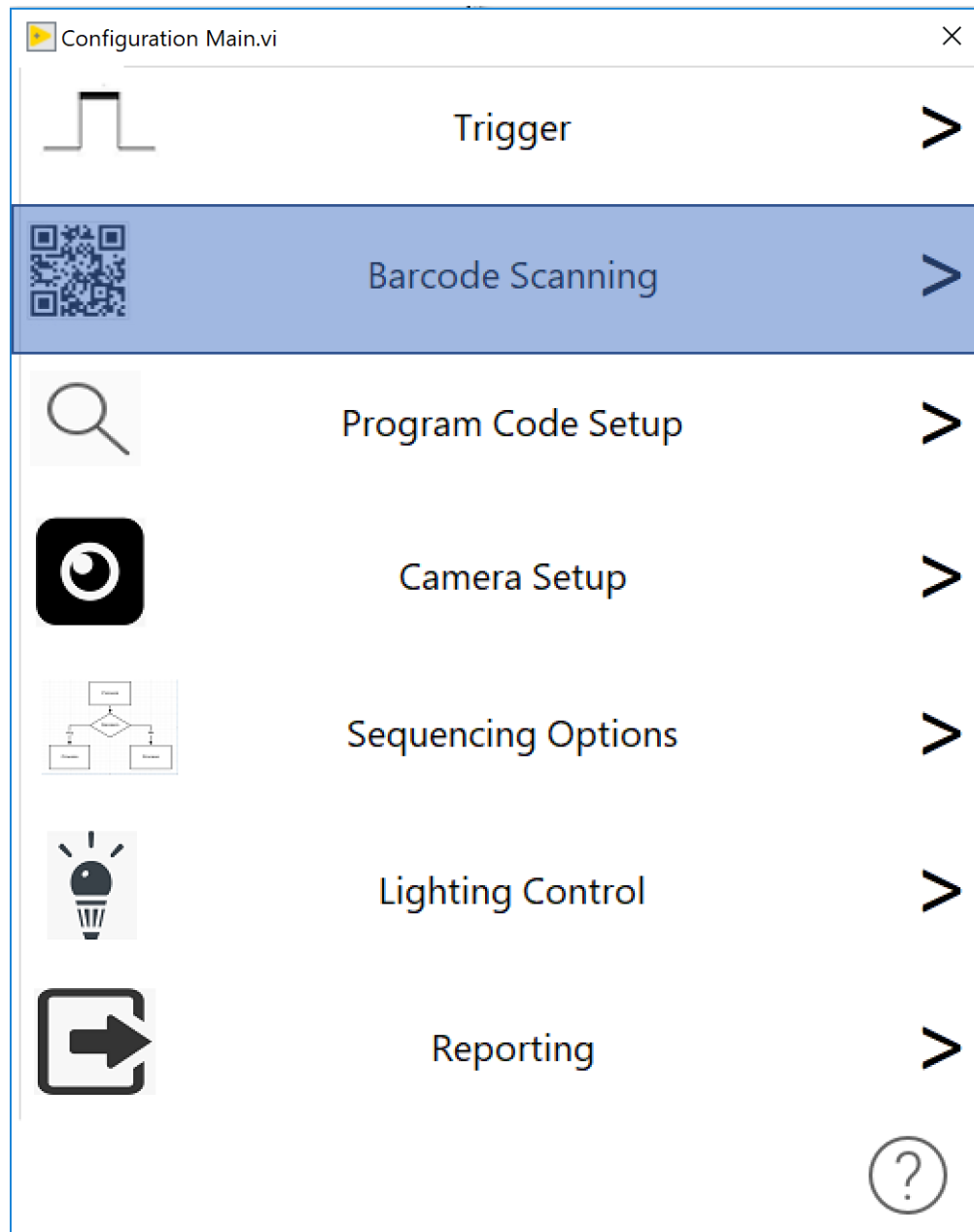


## Step2 - Barcode Setup Program

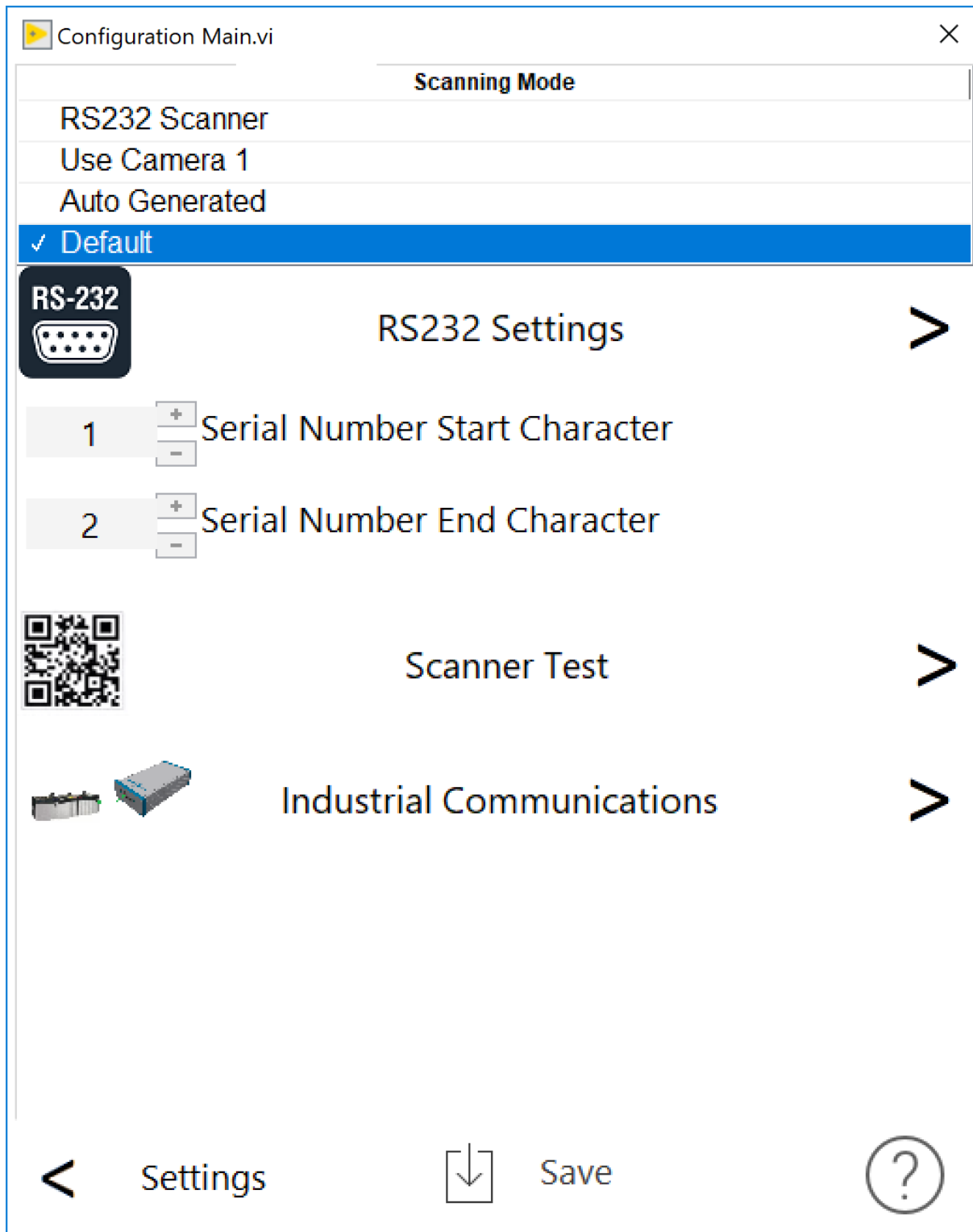
In order to store acquired images, the PAQi needs a serial number of the part under inspection. The serial number is used for naming the pictures using the format:

[Serial Number]-[Camera Name]-[Program Code]-[Step #]-[Timestamp].format.

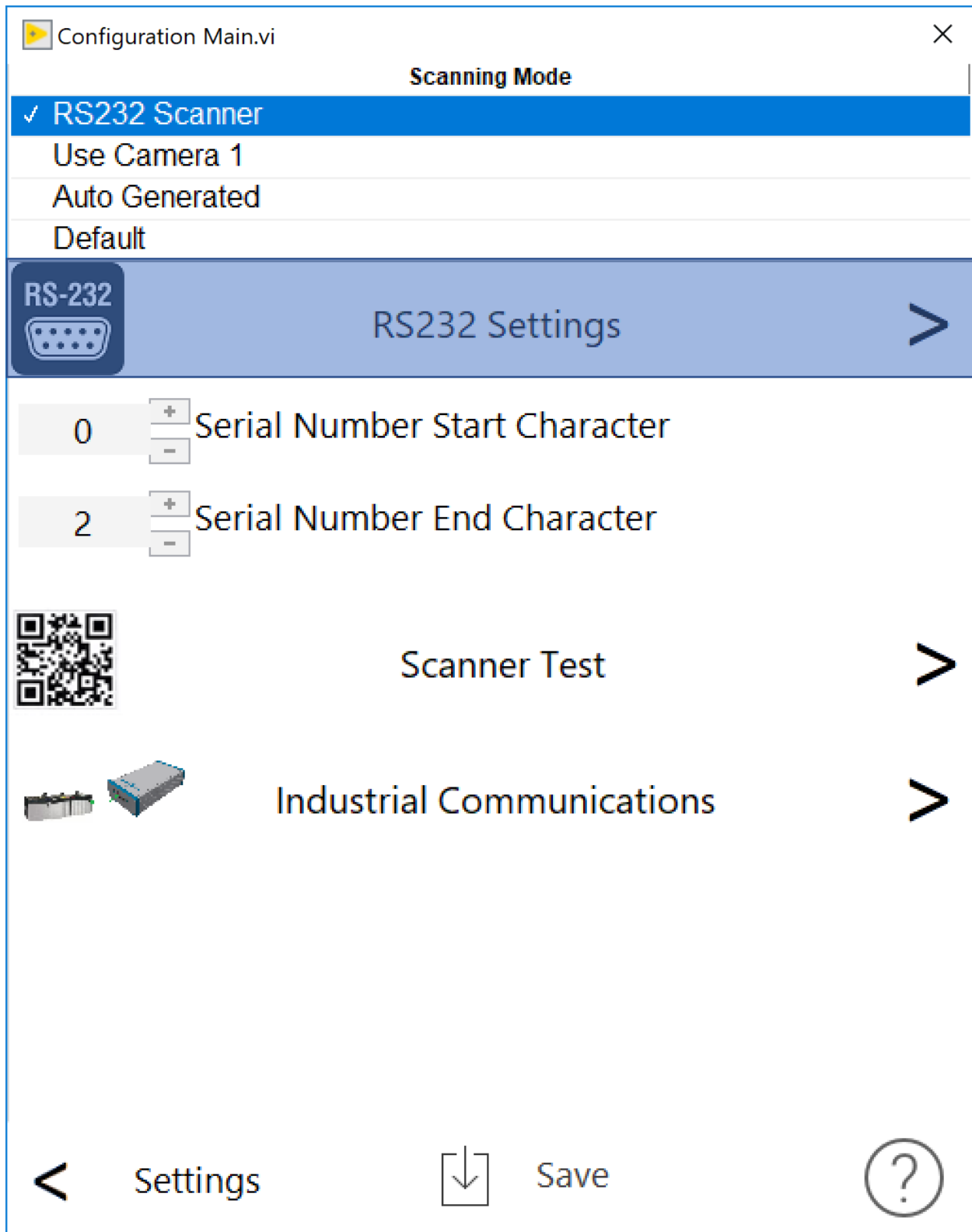
For example, if the SN=123456789, Camera Name=Left, Program Code=ABC, Step #=1 and the format is .jpg, the image name is 123456789-Left-ABC-1-10 11 10 AM.jpg



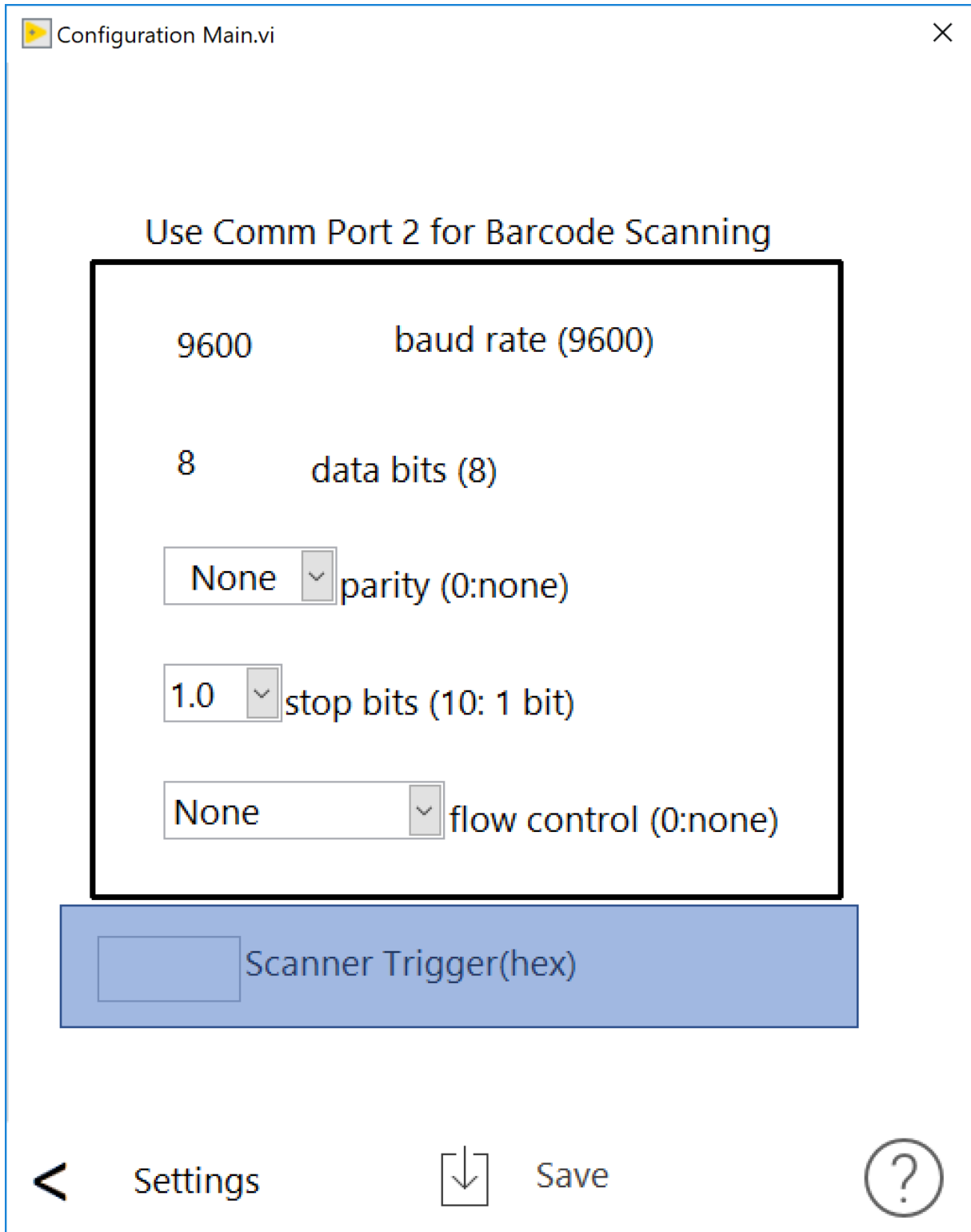
Press the Barcode Scanning button from the main configuration page



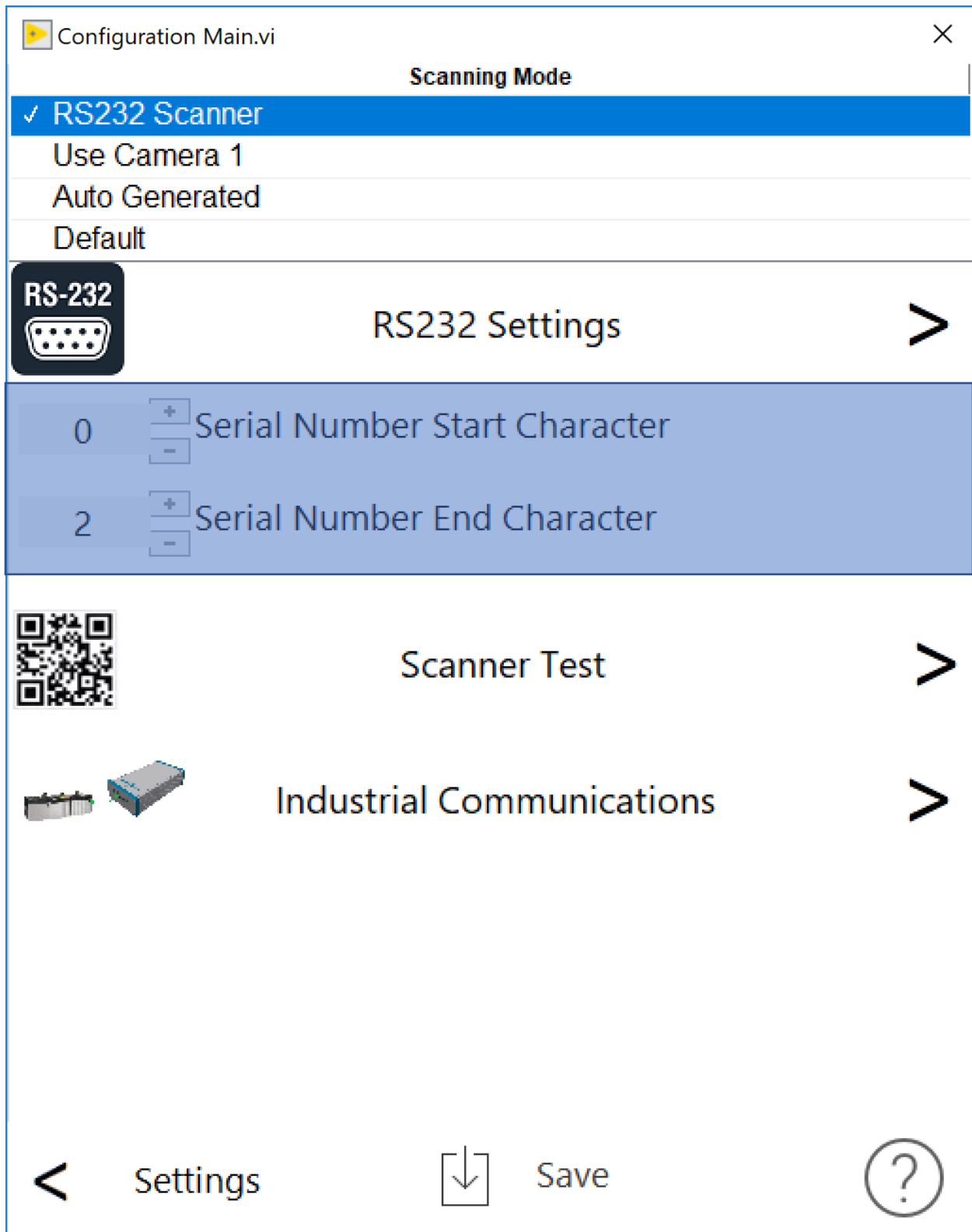
In the barcode setup program, set one scanning mode which can be using a default USB scanner, RS232 scanner, camera 1, or auto generated using a date/timestamp.



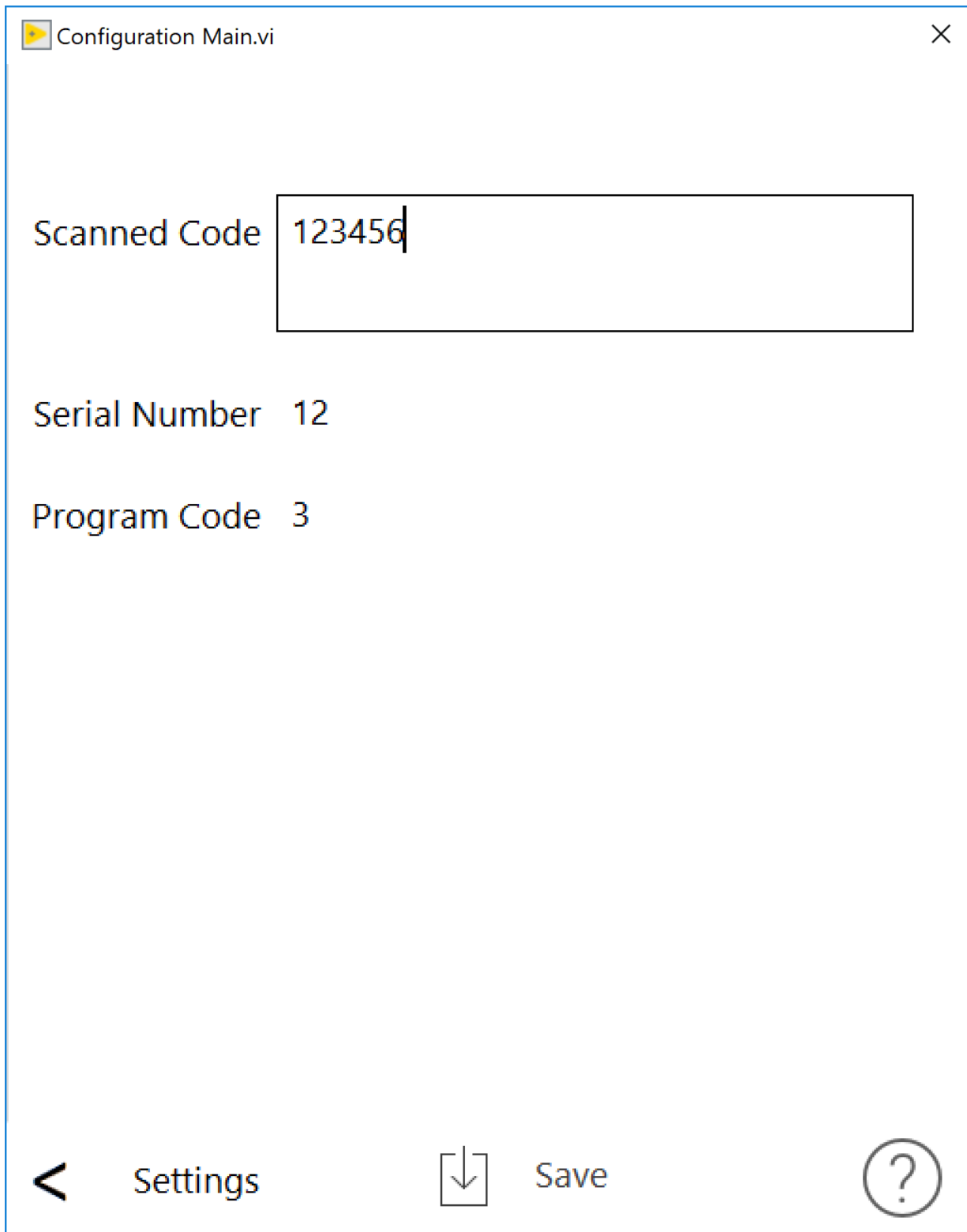
If you save the mode as RS232 Scanner, you will need to setup the RS232 settings by pressing the button. The barcode scanner must be setup to communicate on com port 2. Use Windows Device Manager to manage the com port used.



To use a RS232 scanner, you must match the serial settings of the scanner. See the scanner manual for defaults and information on how to change the scanner. You can automatically trigger the scanner by entering the hex-based trigger value in the Scanner Trigger control. For example, a Datalogix 4450 fixed scanner is triggered using hex value 02 by default.



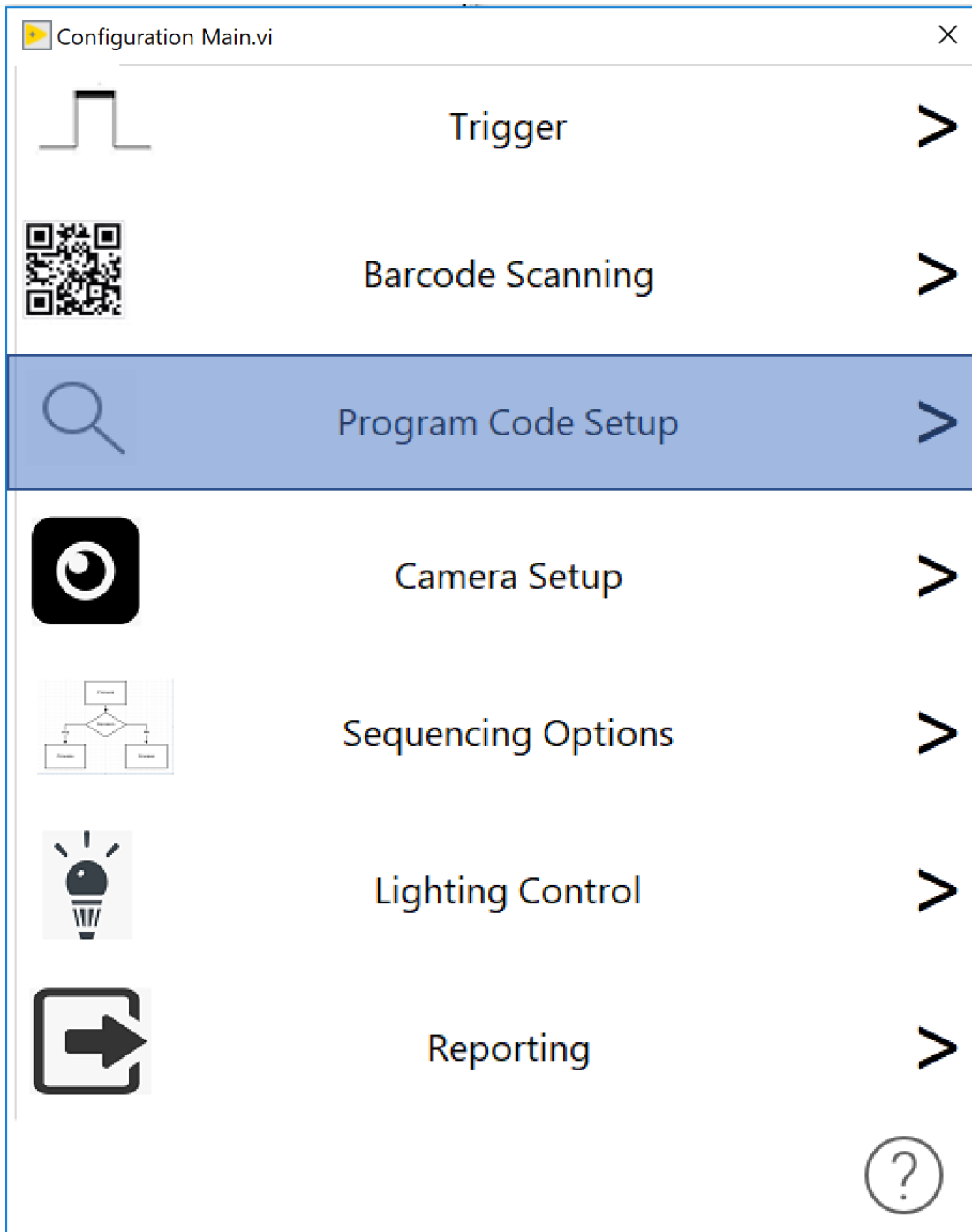
Return to the Barcode setup and enter the start and end characters for the serial number which will be used to label the acquired pictures in the format serial number-camera name-program code - step #-timestamp



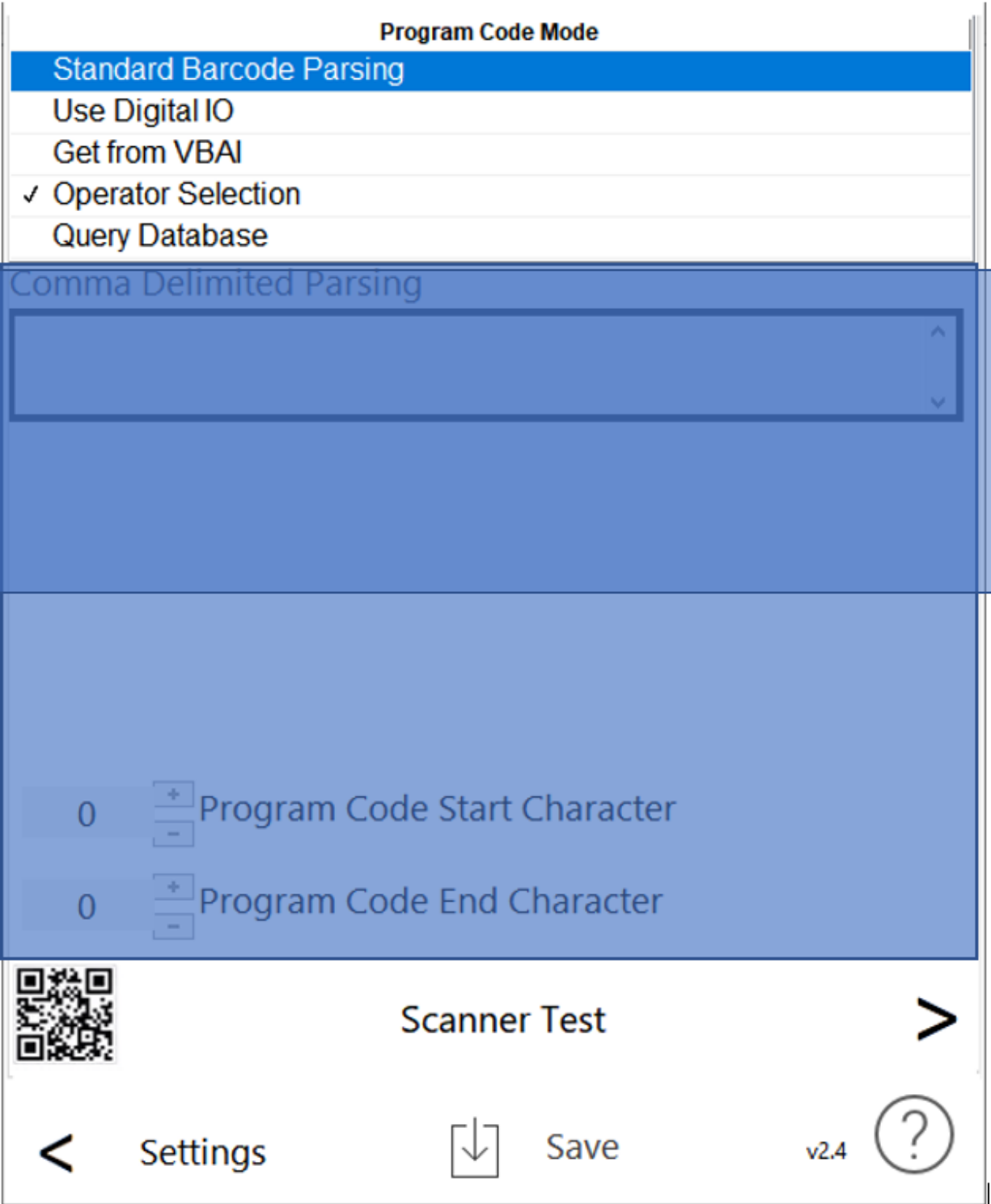
If you press the Scanner Test button, you will be able to test the bar code scanning and parsing so you know what to expect when you run the operational program.

### Step 3 - Program Code Setup Program

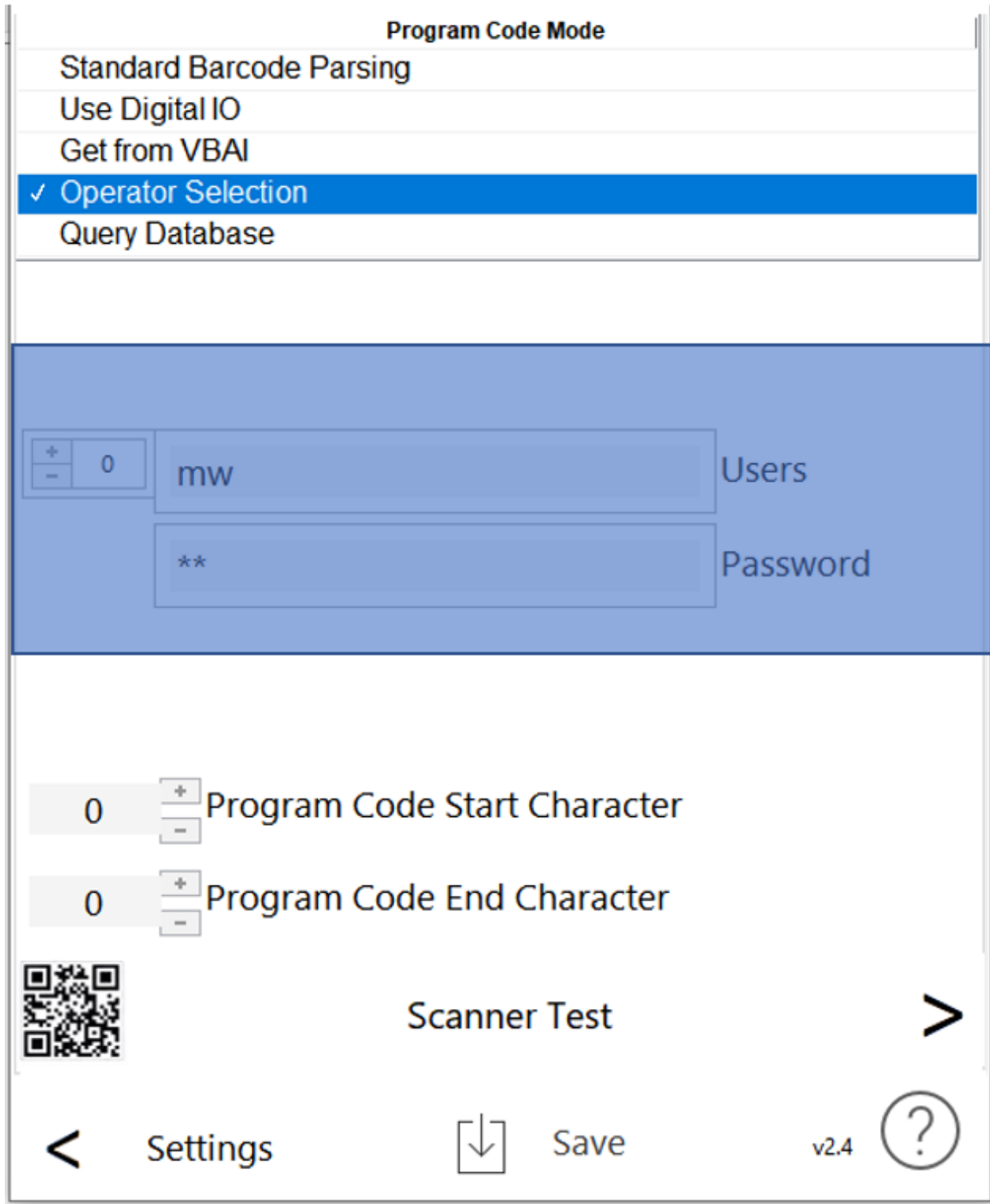
The program code equates to the part number or build code and is used for more advanced operations such as changing camera settings (exposure, gain, focus, ...) and running inspection based the part in the station. The program code is parsed from the overall bar code, retrieved from Vision Builder AI after an inspection is complete, is a number based on the digital inputs in a high state when the acquisition is triggered, or selected from a user accessible list. Program Code is a global variable and only one can be received per program cycle.



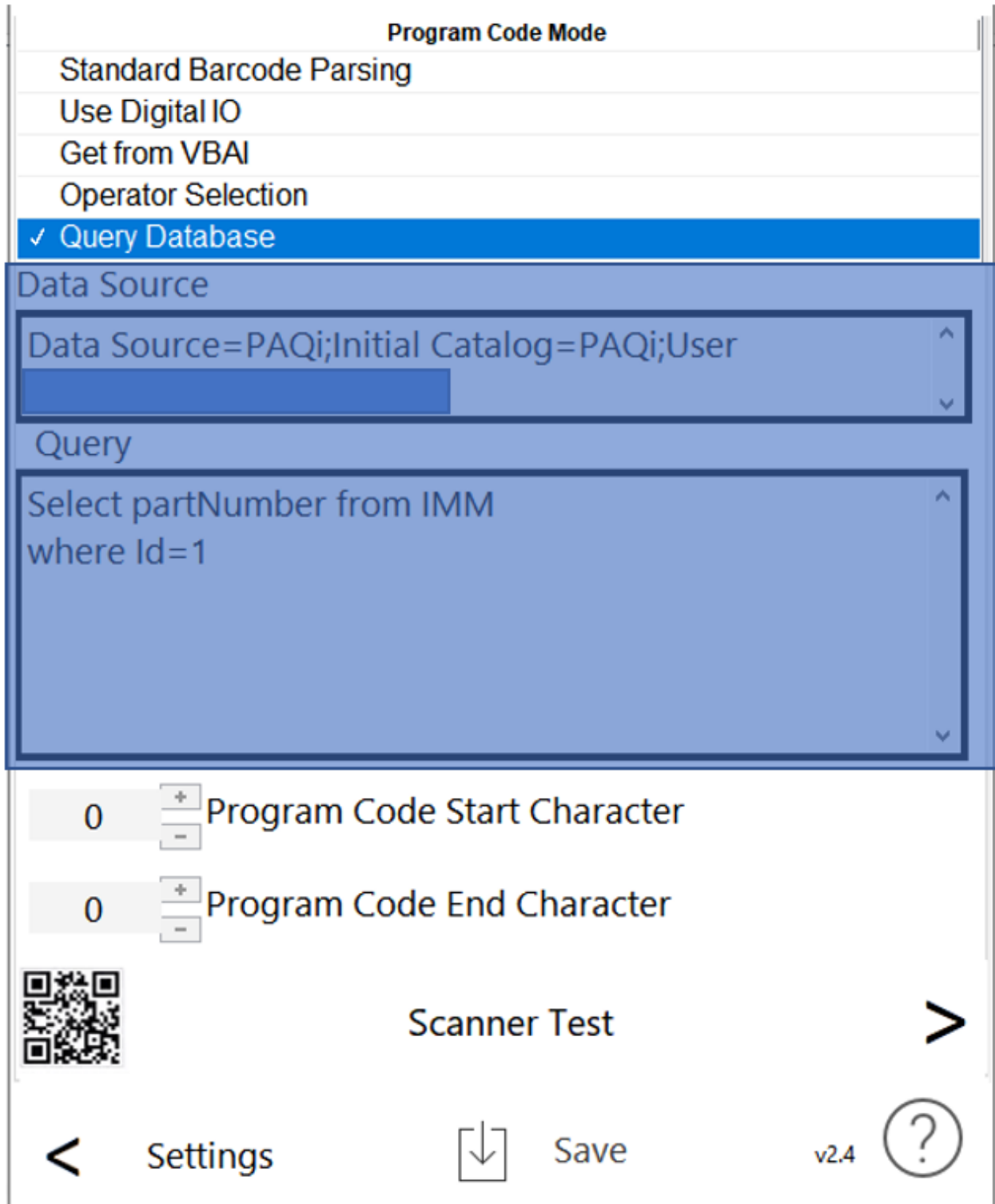




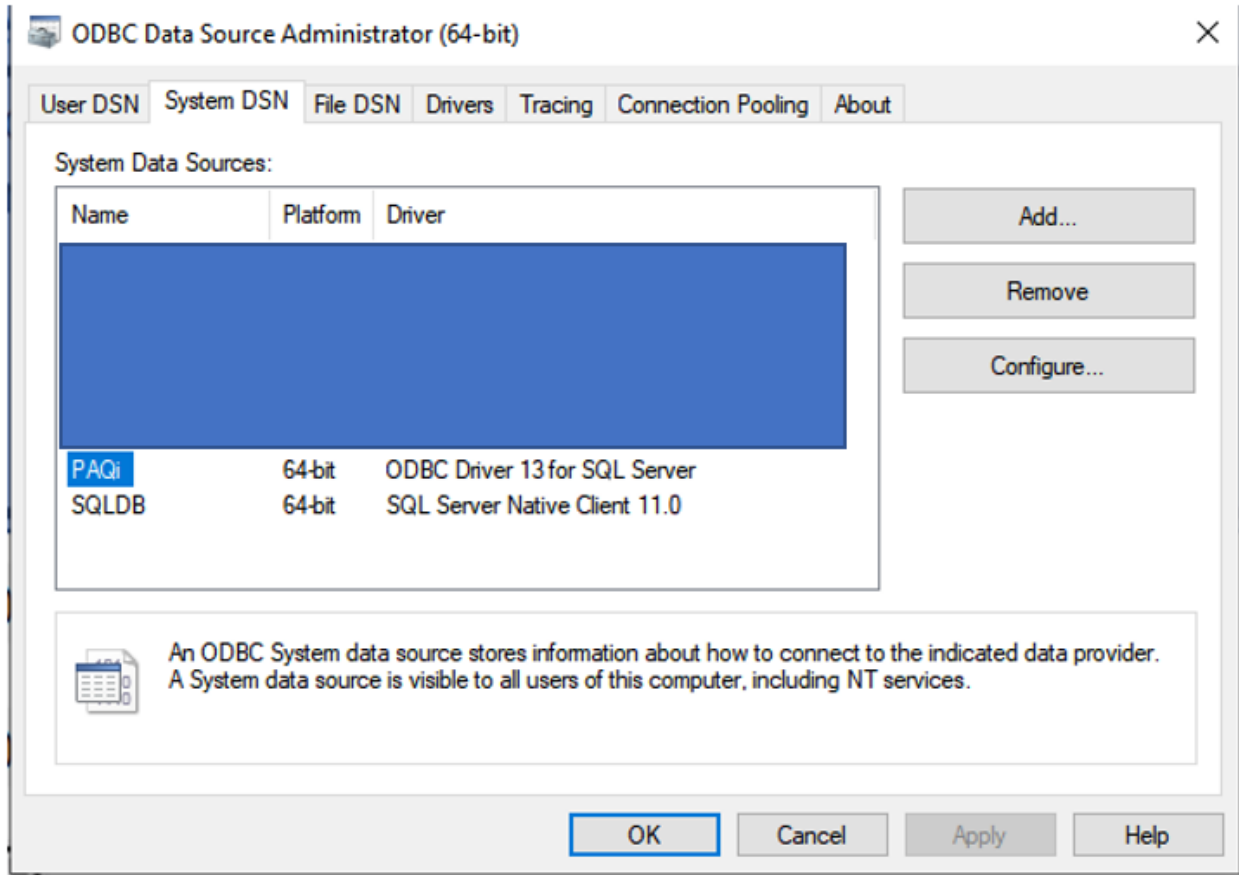
The program code can be parsed from the barcode using either a comma delimited string to parse from different locations or using a start and end location. If you enter a comma delimited parsing string, the program will only use it to obtain the program code. For example, if you use 0,1,2,4 for parsing and enter a barcode of 12345, the resulting barcode after parsing is 1235.



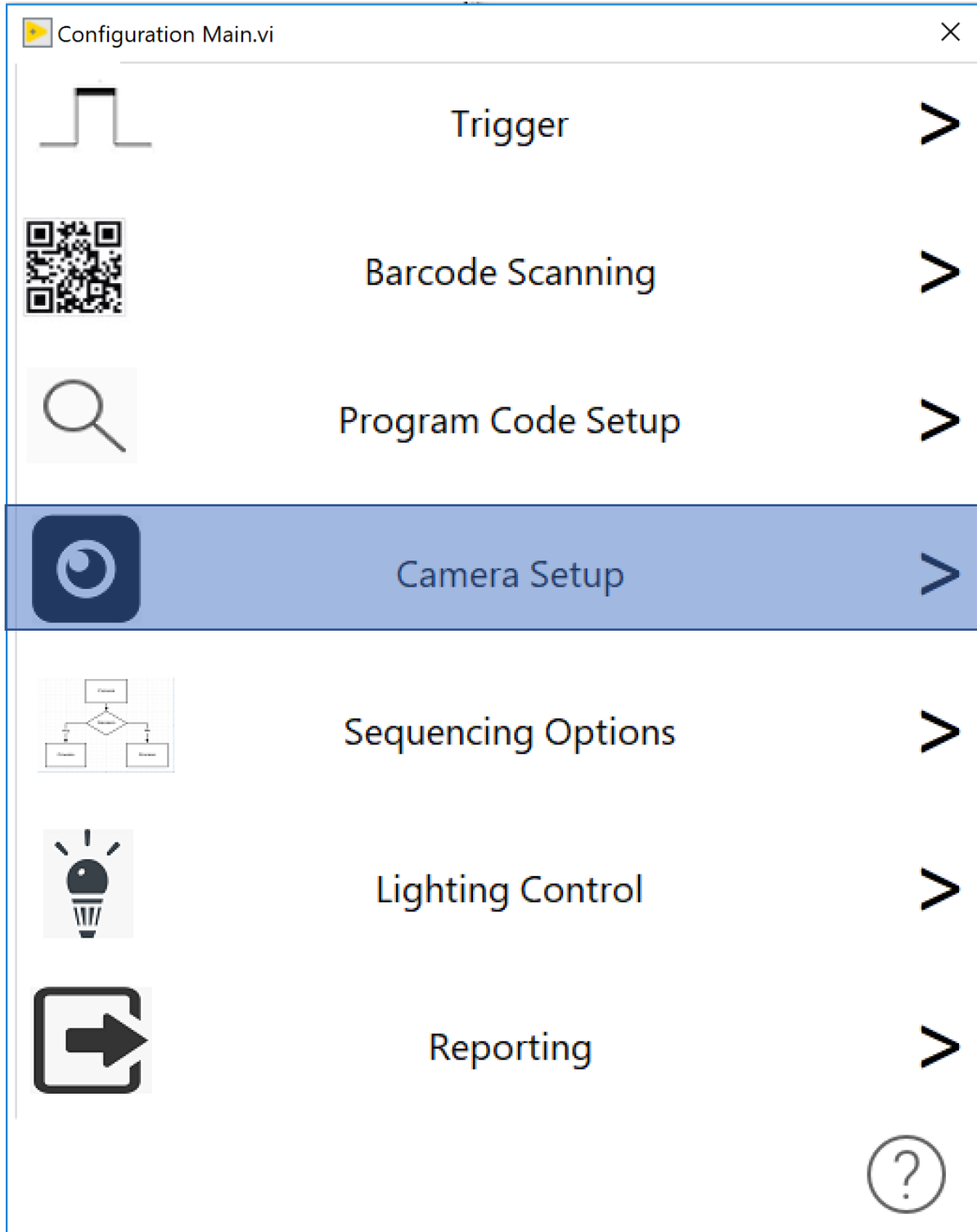
If you use the Operator Selection option, you must enter a set of user names and passwords for each authorized user. Under this mode of operations, no parsing is done on the barcode and the user can select from a list of configured program codes when the product being inspected changes.



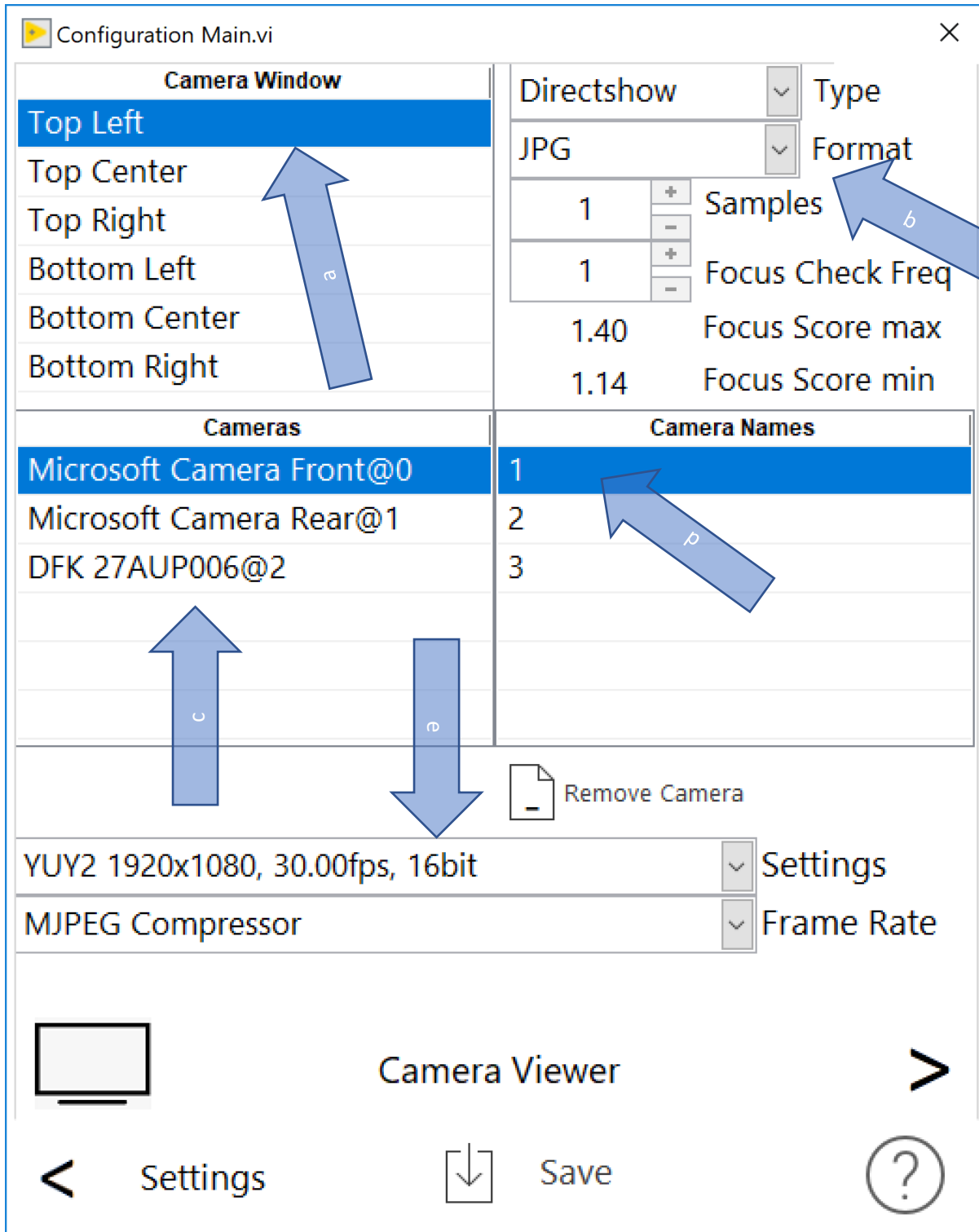
The final option for identifying the program code for determining the inspection routine to use is “Query Database” where you can setup a data source in ODBC Data Source and then run any query against a table within the database.



Step 4 - Camera Setup Program



The next step is to setup the cameras by connecting them to the PAQi via the USB3.0 and/or GigE Ports for acquiring from up to four cameras in total.



If using Direct Show type of Acquisition.

If you use the built in Direct Show drivers, you can connect any Direct Show compatible camera to the PAQi to acquire images. While direct show provides a general drive for webcams and all industrial cameras, it does not provide the ability to adjust image quality or the camera parameters such as exposure.

Step 4.a Start by selecting the Camera Window to configure starting from the top of the list.

Step 4.b

- Select the acquisition type - use Imaging Source where possible
- Number of samples - the higher the value the longer the cycle time but more stable images
- Focus check frequency – if zero, do not check focus value, if 1, check all.
- Focus check min and max – use the camera view to determine the nominal focus value/

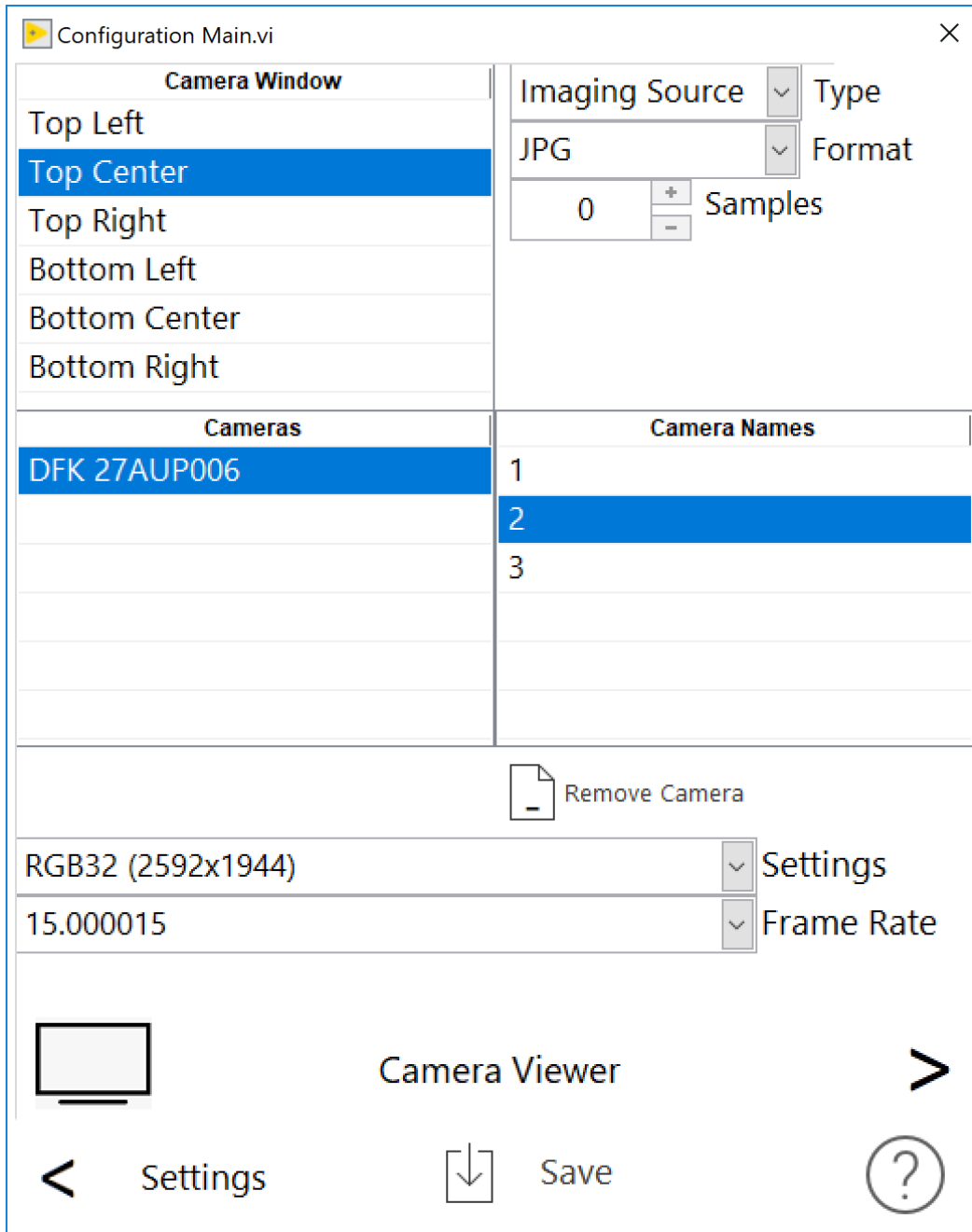
Step 4.c Select the camera from the list of connected cameras

Step 4.d Name the camera by clicking the first box in the list and enter a name.

Step 4.e Set the resolution and frame rate before saving.

*If a configuration already exists for a named camera, you will be prompted to overwrite it.*

If using VBAI to Acquire Images, there is no need to setup the cameras as that is all done in VBAI using NI's camera drivers with an additional license fee.

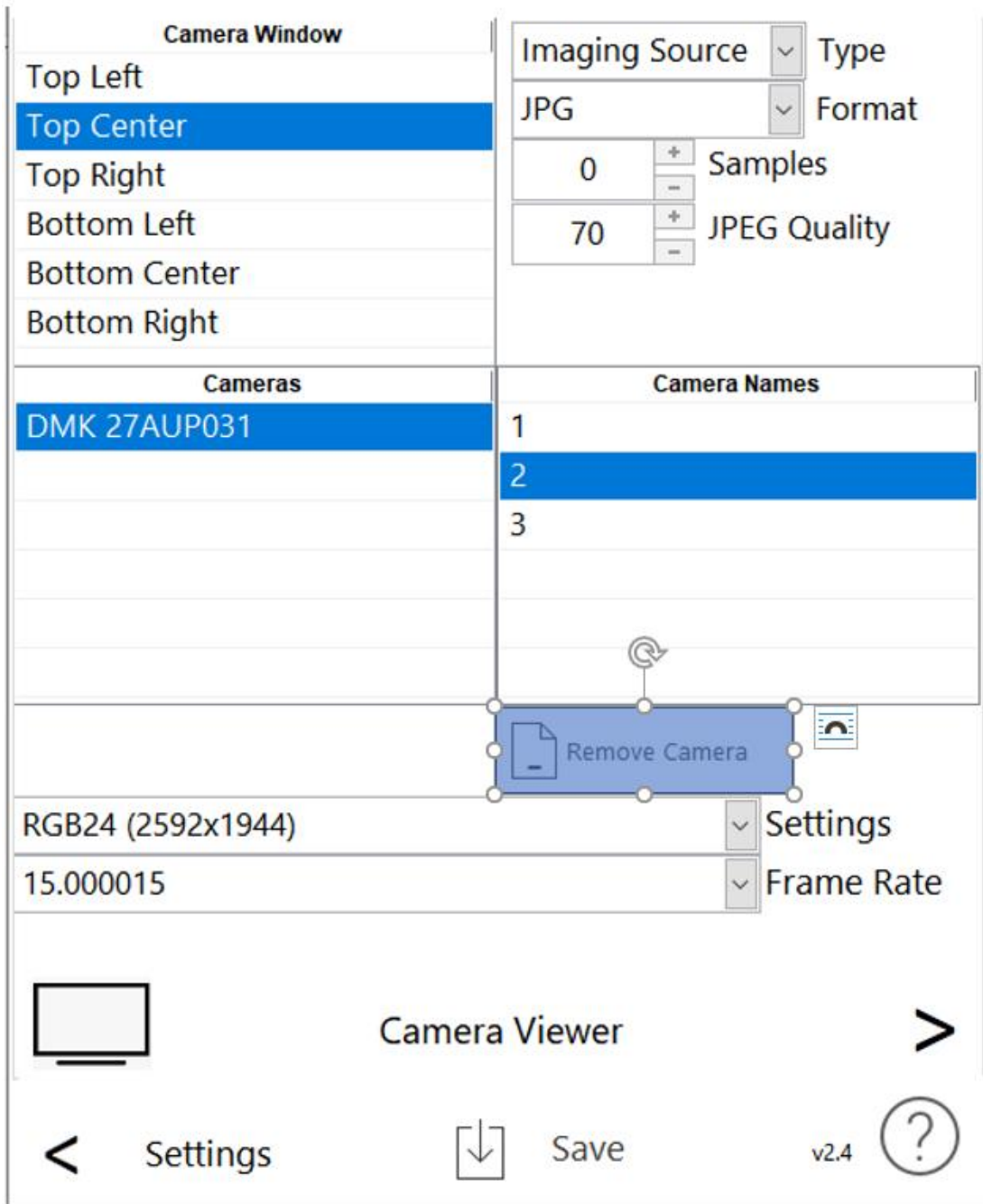


The above is an example of using the Imaging Source drivers.

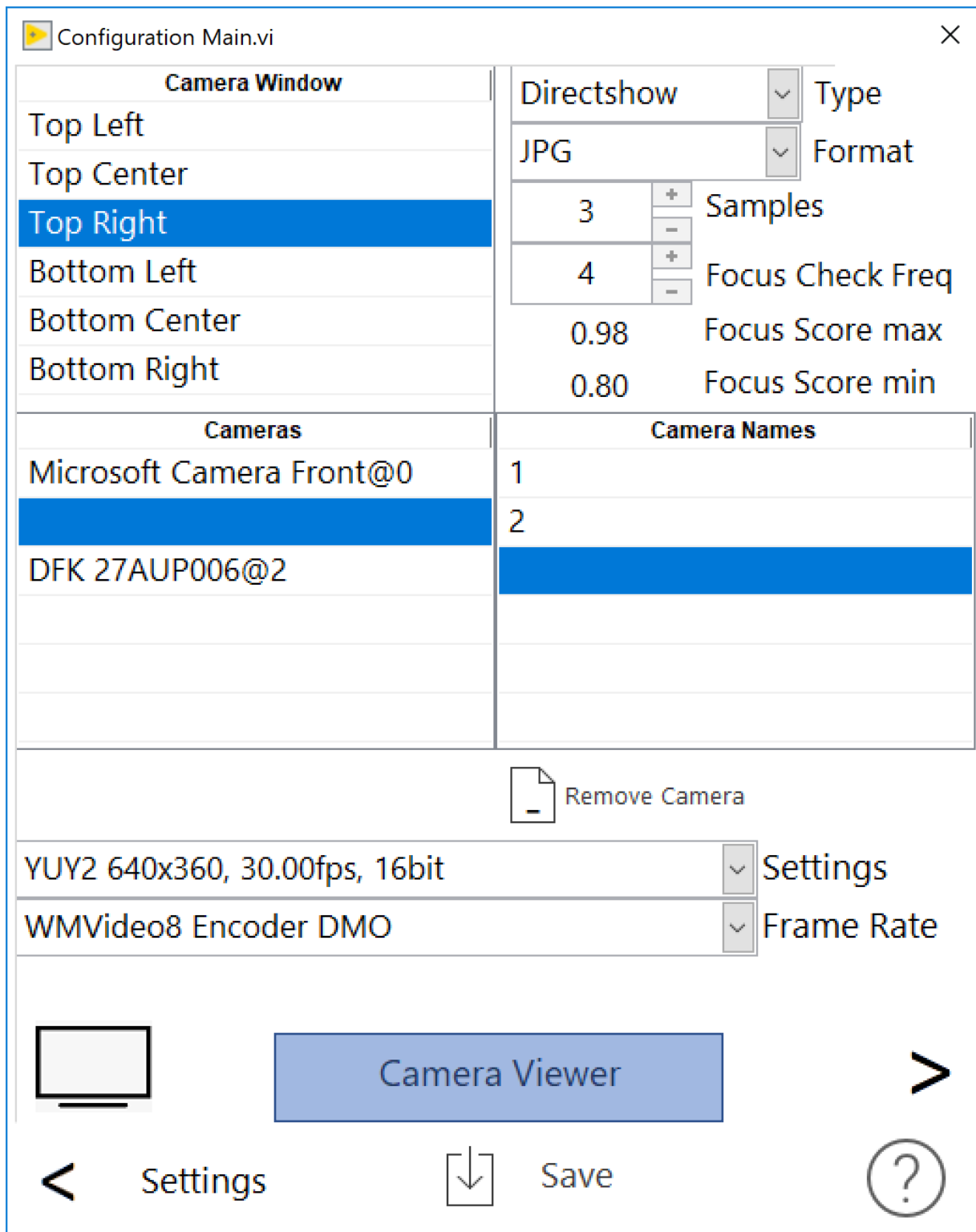


If you use imaging source acquisition type

The list of cameras will only be populated with imaging source cameras and there is no need for setting the focus frequency or limits but you will have the added option to set the quality of the JPEG images if the format is set to JPG. This provides a means for limiting disk space usage because images with a quality value of 90% for example are half the size of a 100% image with no noticeable difference in the image.



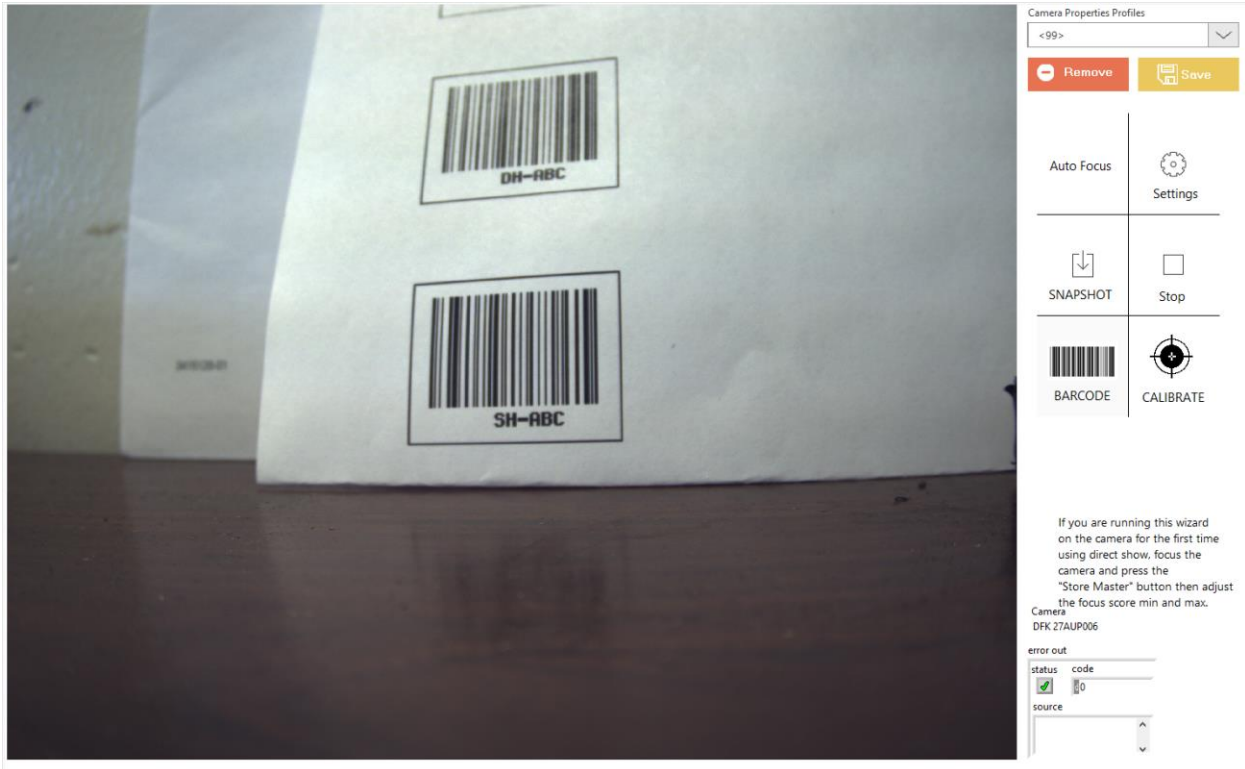
To remove a camera, select the camera window to remove and press the Remove Camera button and save. The result will be no acquisition for the selected window, so you may want to realign the cameras after removing a camera to maximize the picture size displayed on the operational program.



After selecting a camera, naming it, and setting the resolution and frame rate, press the Camera Viewer button to stream live video for use in focusing on the target.



## Camera Viewer

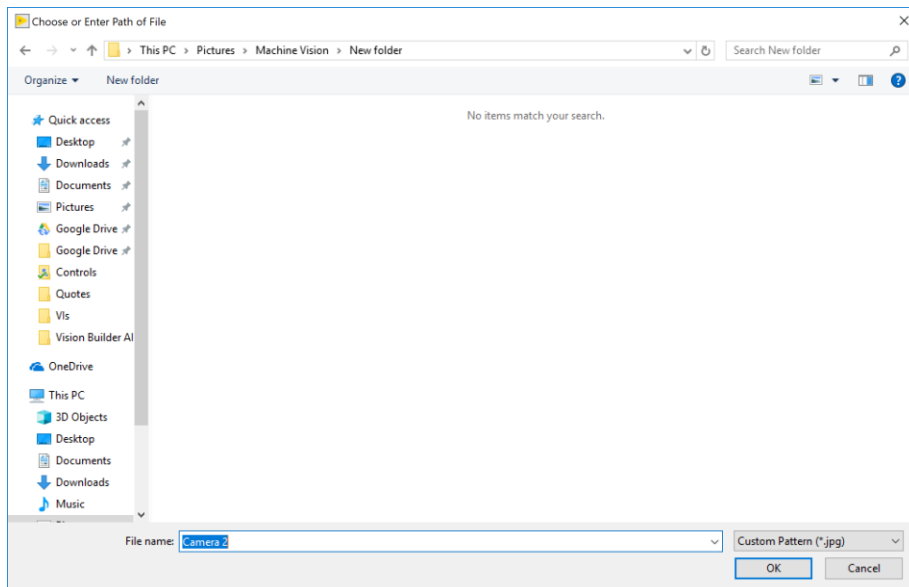


Depending on the type of acquisition selected, the buttons on the top right of the interface will allow you to do the following:

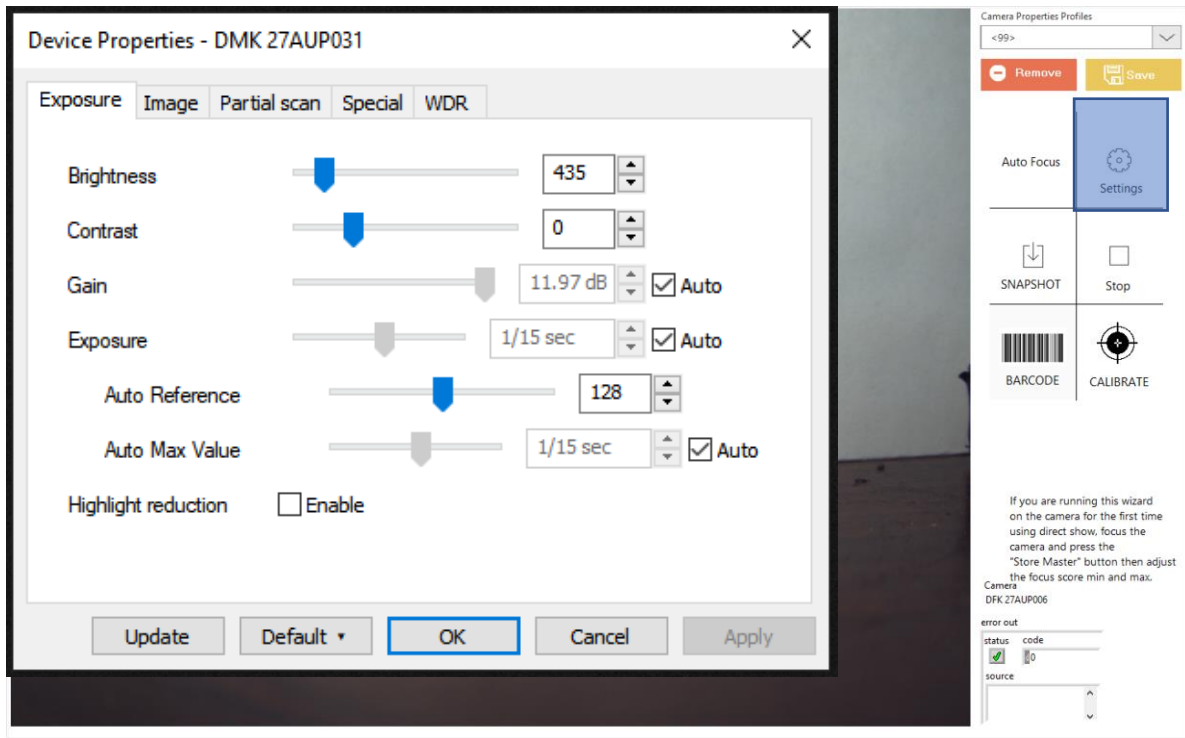
- Camera Properties Profile List – if using Imaging Source type, allows you to create new camera profiles which can be used to adjust the camera properties based on the program code. If you do not configure a profile but change the camera settings and save, the last settings applied to the camera will be used for all acquisition on that camera.
- Auto Focus – if using Imaging Source type and autofocus cameras, you can target a part and automatically focus on it. You will be asked to save the settings after making this change. Note this is a global configuration.
- Settings - if using Imaging Source type, you can change all camera properties using a separate interface. Note that if you have added and selected a camera profile, only its settings will change when changing settings and saving them.
- Snapshot – allows you to snap a picture from the live stream.
- Barcode – if you have VBAI enabled, you can test camera-based barcode scanning.
- Calibrate – allows you to setup a calibration routing in VBAI to assist in repositioning or focusing a camera.



By targeting a barcode and pressing the barcode button, the program will continuously call to VBAI in attempt to read the bar code. Depress the button to return to the live stream.



By pressing the snapshot button, you can store a single picture to disc. It is recommended that you save a “Golden Image” of the part to be validated in a specific location for future reference.



When you press the Settings button, the device properties interface is presented so you can adjust the camera properties. After adjusting, press apply and OK to return to the live stream.



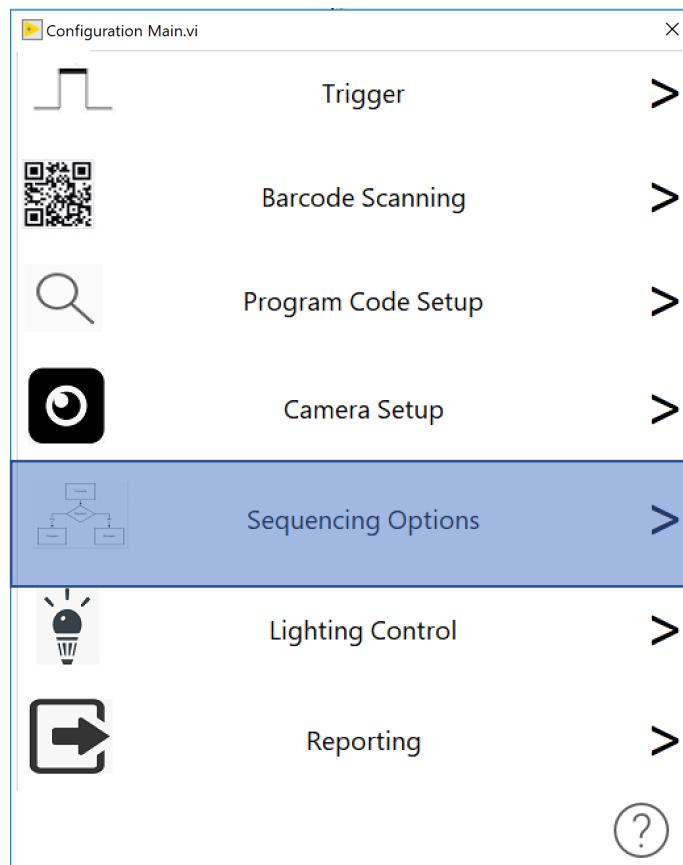
If you are using the Direct Show driver, use the Store Master button to save a master image of the part being inspected at which time the nominal focus score will be determined. Return to the Camera Setup window and press the save button.

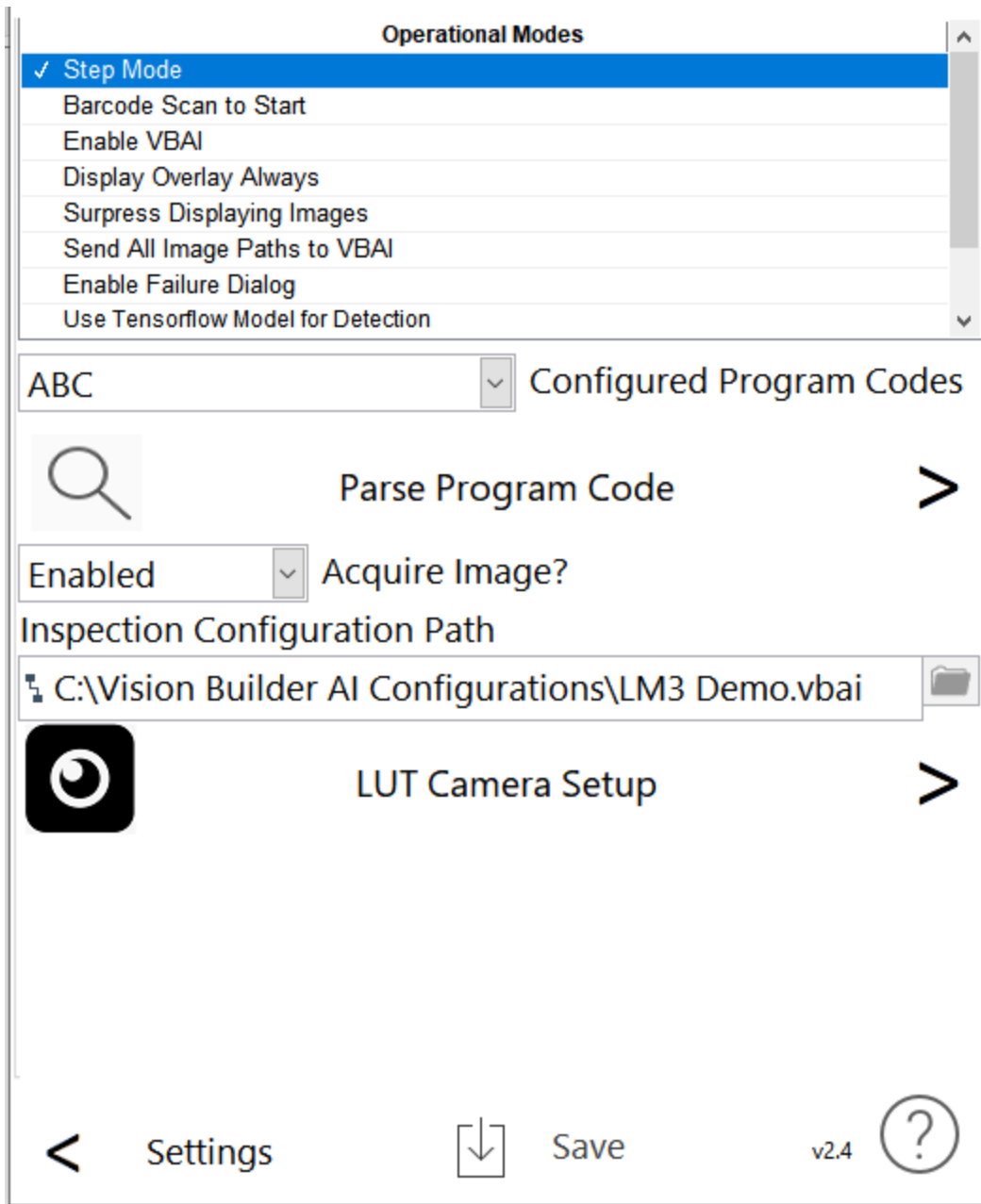
To exit the camera viewer, press the Stop button and wait for it to close. If you changed camera settings and want to save them for future acquisitions, acknowledge any popups requesting the changes to be saved.

## Step 5 - Sequencing Setup Program

Sequencing involves more advanced operations including:

- Running in Step Mode – this allows you to mount a camera on a robot and acquire several pictures of the same part or move the part and capture images of the part at different positions.
- Barcode Scan to Start – instead of using a sensor, you can trigger acquisition on a bar code scan.
- Enable VBAI – enable the analysis engine to run vision inspection or use a camera for barcode scanning.
- Display Overlay Always – if checked, the acquired image or analysis overlay will be displayed on the user interface. If uncheck, no images will be displayed and analyzed results will only be displayed on failure.
- Surpress Displaying Images – disables the image display to save processing time.
- Send All Image Paths to VBAI – if checked, the PACi software will send the path of all acquired images to VBAI for use in analyzing multiple images in once cycle. You must have the most recent VBAI template to use this option.
- Enable Failure Dialog – if analysis is enabled, this options will present a pop up window to override a failure.
- Use Tensorflow Model for Detection – when enabled, user is provided with a button for calibrating the analysis using AI based object detection.
- Enable Labeling Dialog – provides a means for labeling objects in an image as images are acquired.

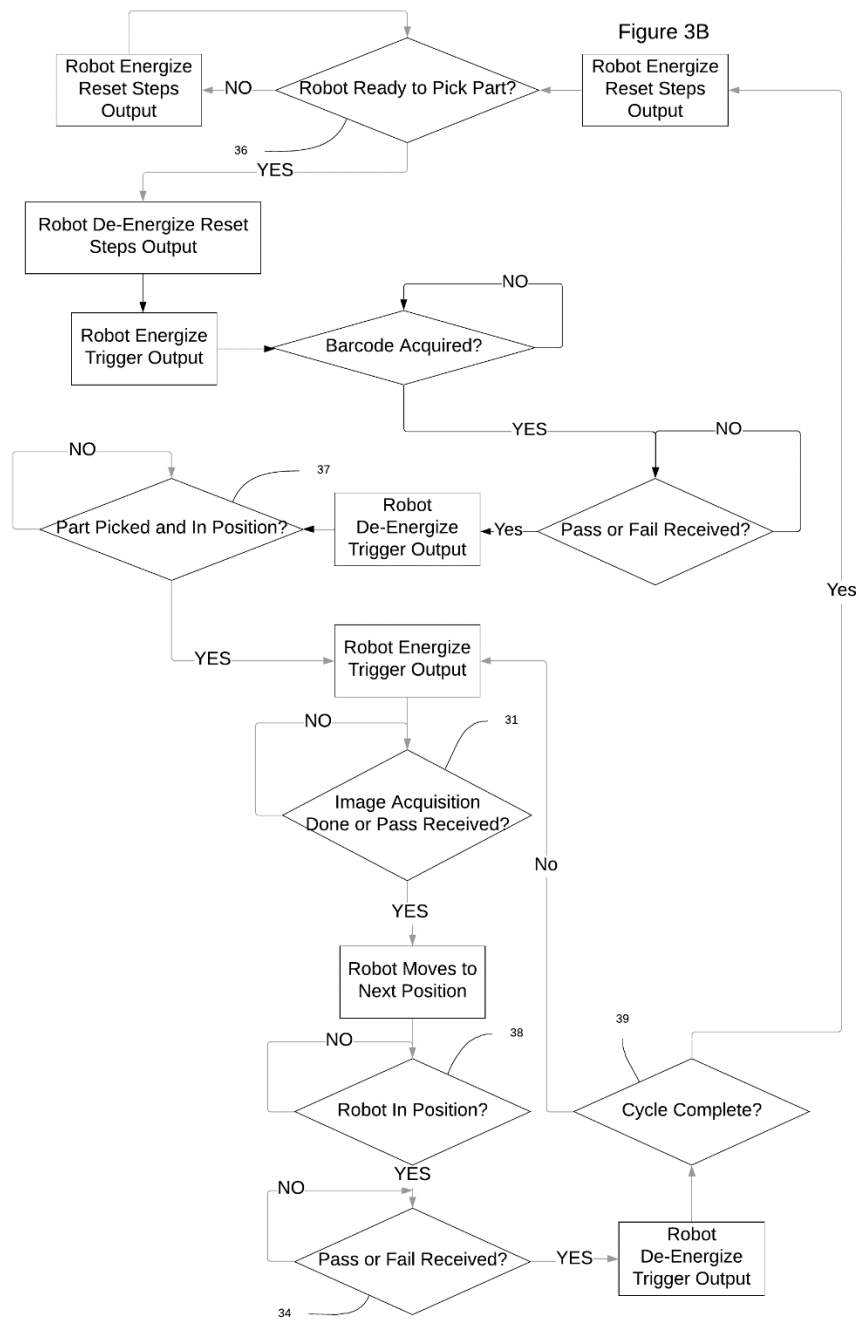




The operational modes list is a multi-select list where any of the provided options can be selected in parallel to the others. Hold the Ctrl button to select multiple options.

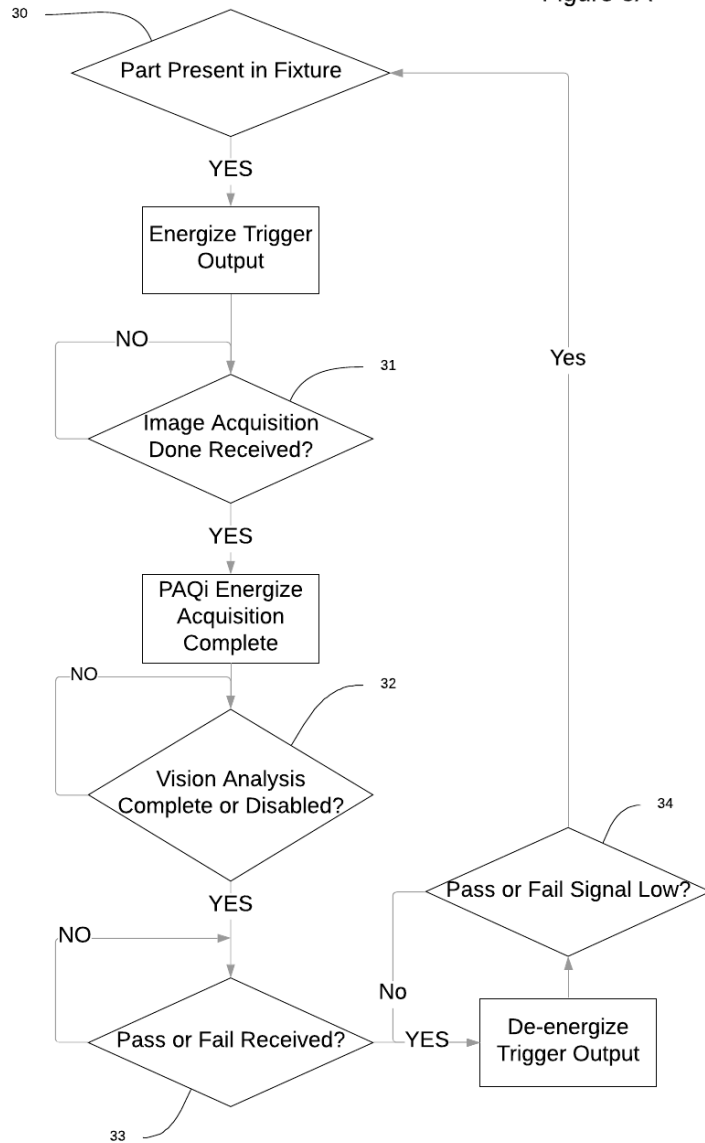
If you enable the Step Mode by highlighting it and pressing save, when the PAQi is triggered, it will first acquire the part program code and serial number as step 0. The PAQi will confirm step 0 and all subsequent steps are complete by returning a pass or fail via digital IO on the M12 connector or using EthernetIP communications to a PLC. The step mode is especially useful for robotic operations where one or more cameras are mounted to a robot and moved around the part being inspected to inspect multiple locations on the part. Conversely, the cameras could be in a fixed location and the part could be moved around relative to the camera position to complete inspection on multiple locations.



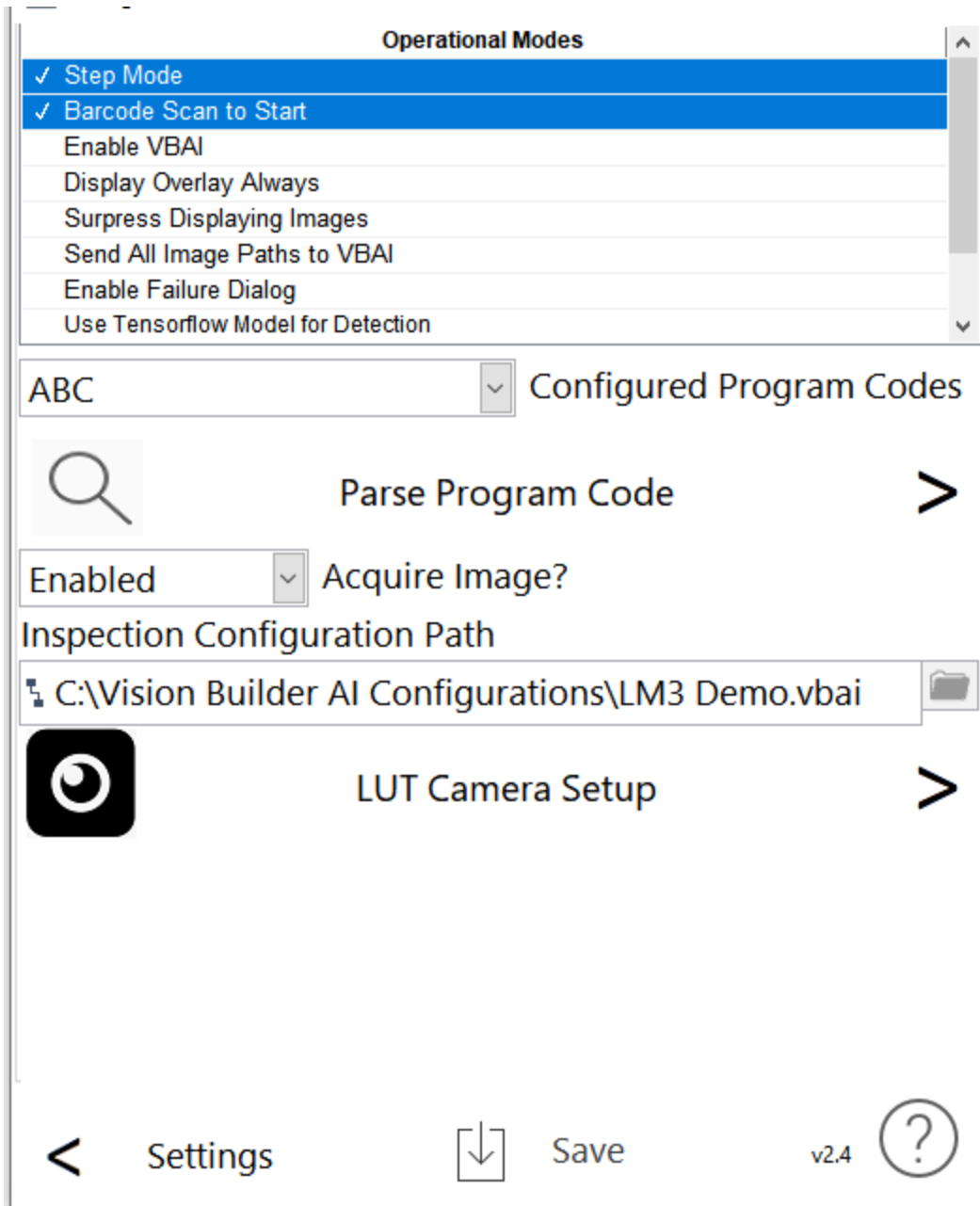


The above flow chart details a typical step mode operation where the robot triggers inspection after it moves the part or cameras and resets the sequence when done.

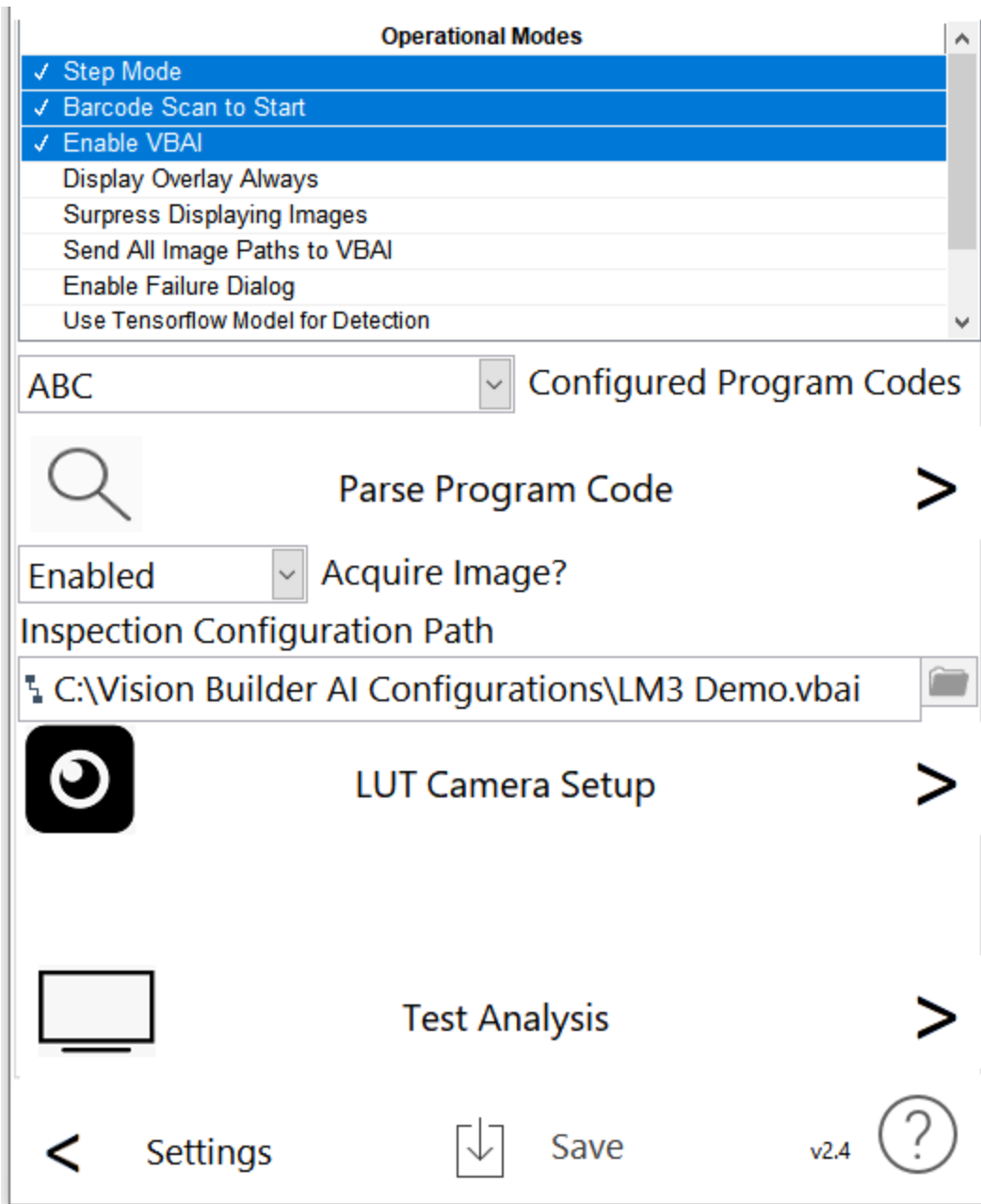
Figure 3A



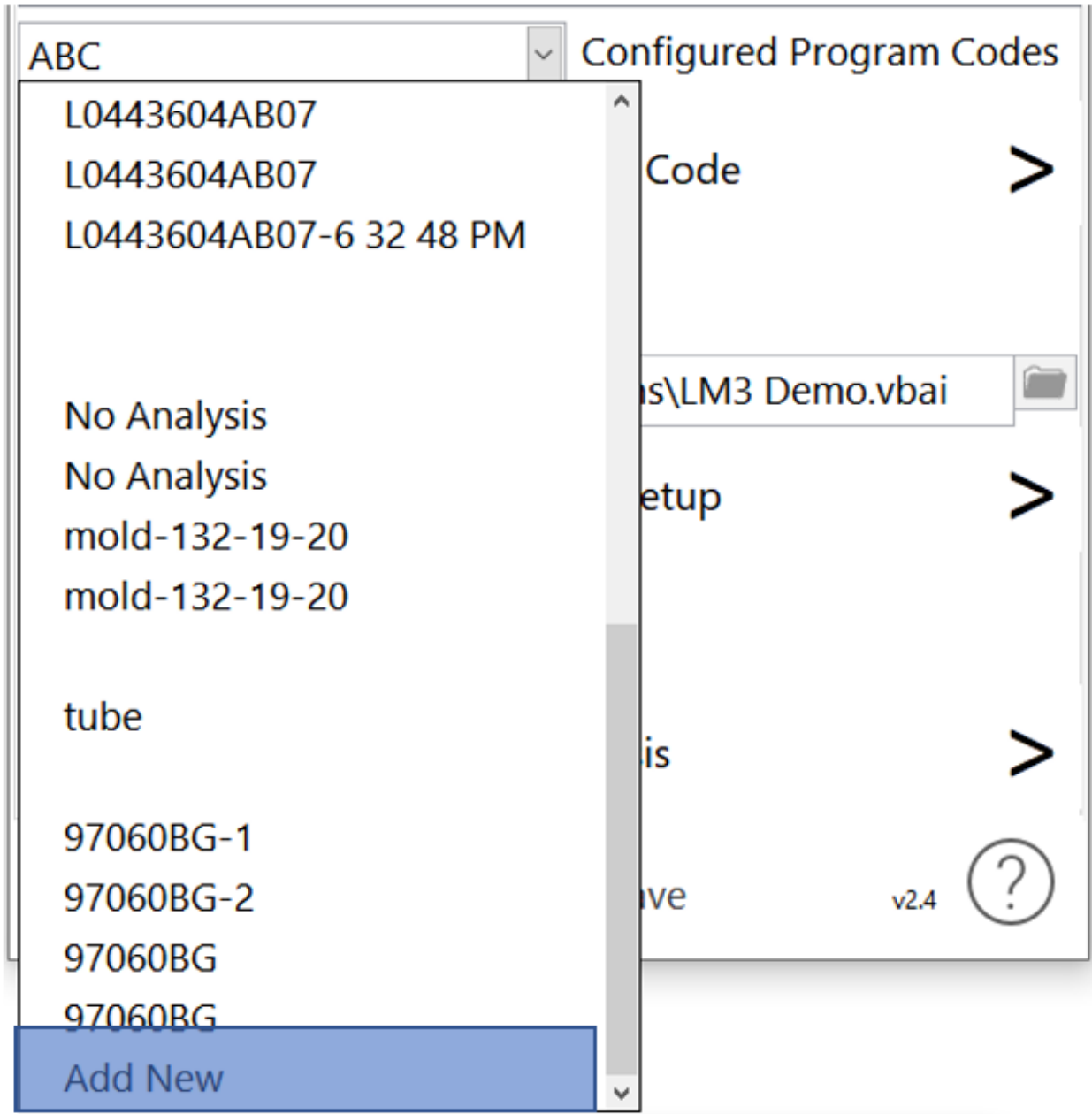
Conversely, when running in non-step mode, the handshake with the station is simpler and only requires handling of the trigger and pass/fail results



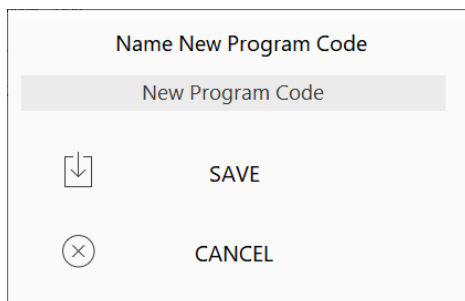
If you check the Barcode Scan to Start, the program will wait for the operator to scan the barcode to start acquiring images and doing inspection.



If you check the Enable VBAI option, you are provided with options for configuring the inspection routine to run per the configured program codes.

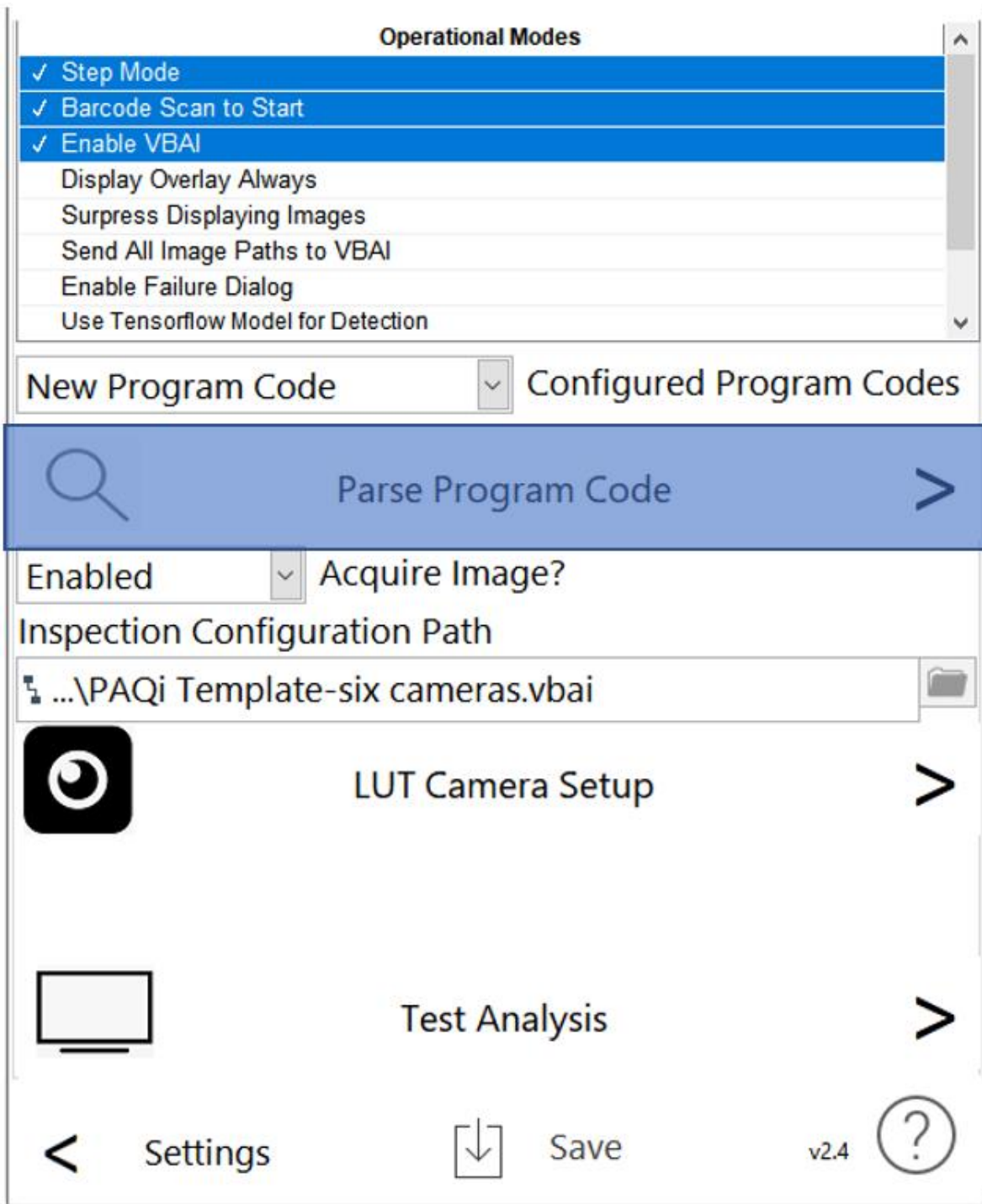


Program codes are a link between the program code acquired at the beginning of the acquisition cycle and the inspection process. To add a new program code, scroll to the end of the list and press the Add New item.



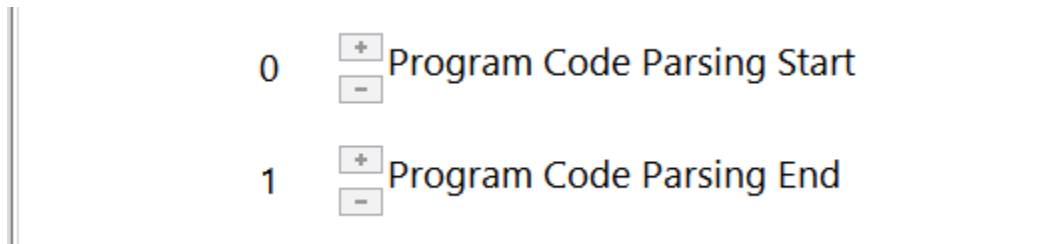
Enter the new program code and press Save to exit

Note it is normal to have empty or repetitive program codes in the LUT. If the program code is empty, the configuration associated with that program code will be executed for all parts processed. Duplicating a program code is done so you can associate the program code with different step values in step mode.

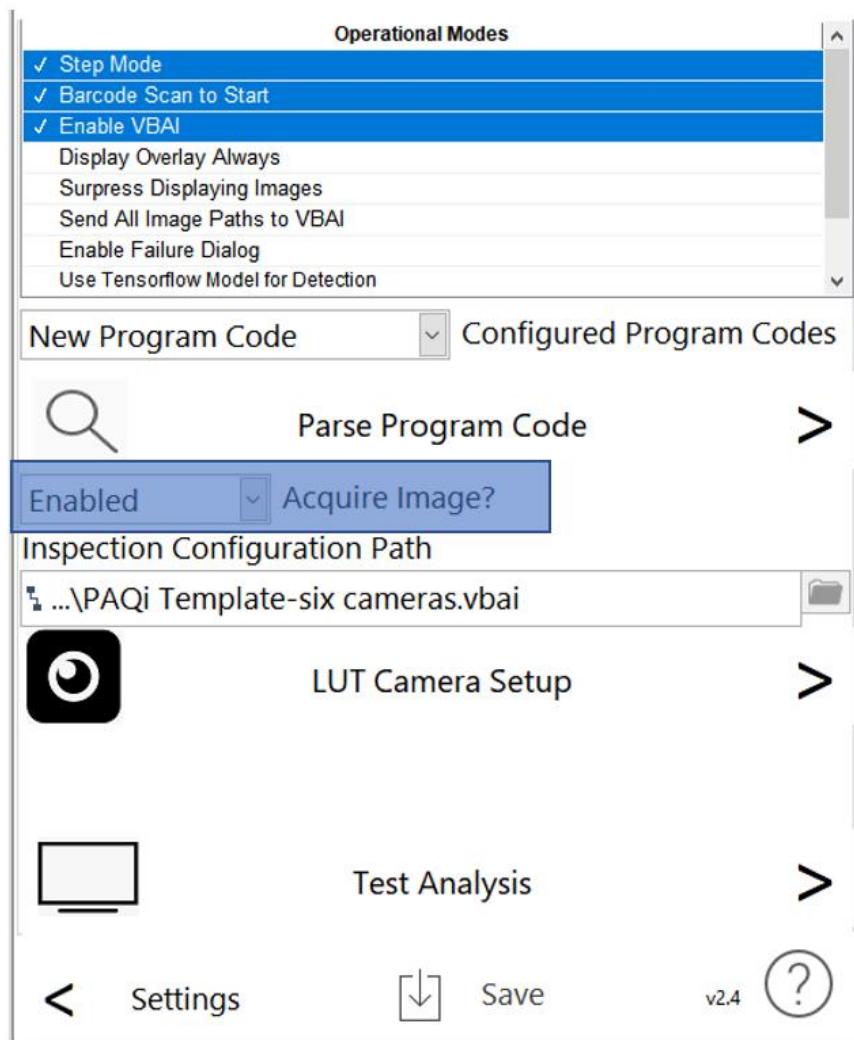


If you press the Parse Program Code button, you can choose to set up parsing on the overall acquired program code before determining how to inspect your parts. For example, assume we have an overall program code of xyz for a door panel where the first position sets the arm rest type, the 2<sup>nd</sup> sets the

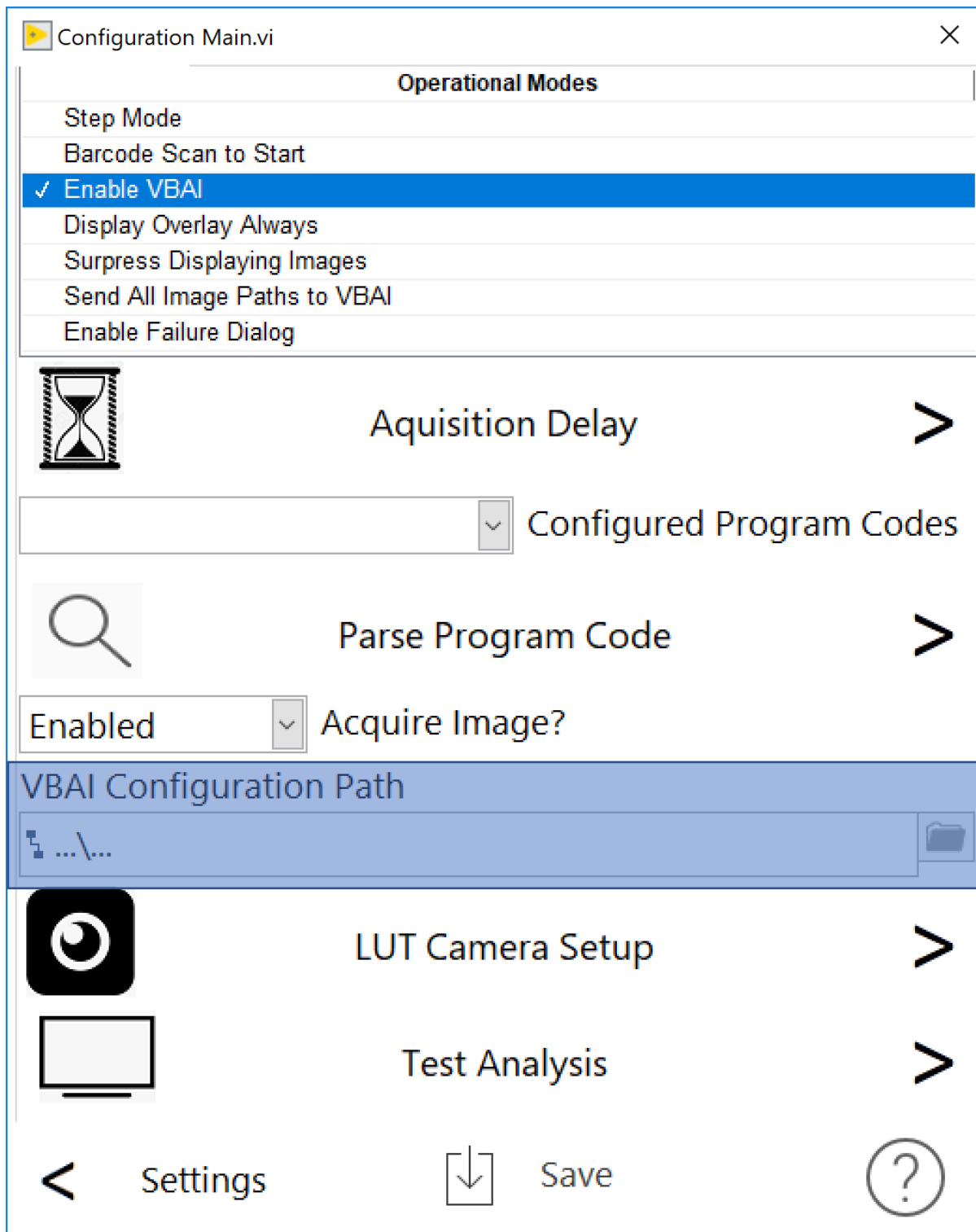
speaker grill type, and the 3<sup>rd</sup> specifies the upper handle type. Instead of programming all possible combinations for running inspection on that part, you can setup a configuration for the 1st position only, the 2<sup>nd</sup> position only, and the 3<sup>rd</sup> position only by setting parsing on the overall code.



By setting the program code parsing to 0 and 1, the x in xyz would be parsed before doing a lookup for the inspection configuration. Values of 1 and 2 would parse the y and so on.

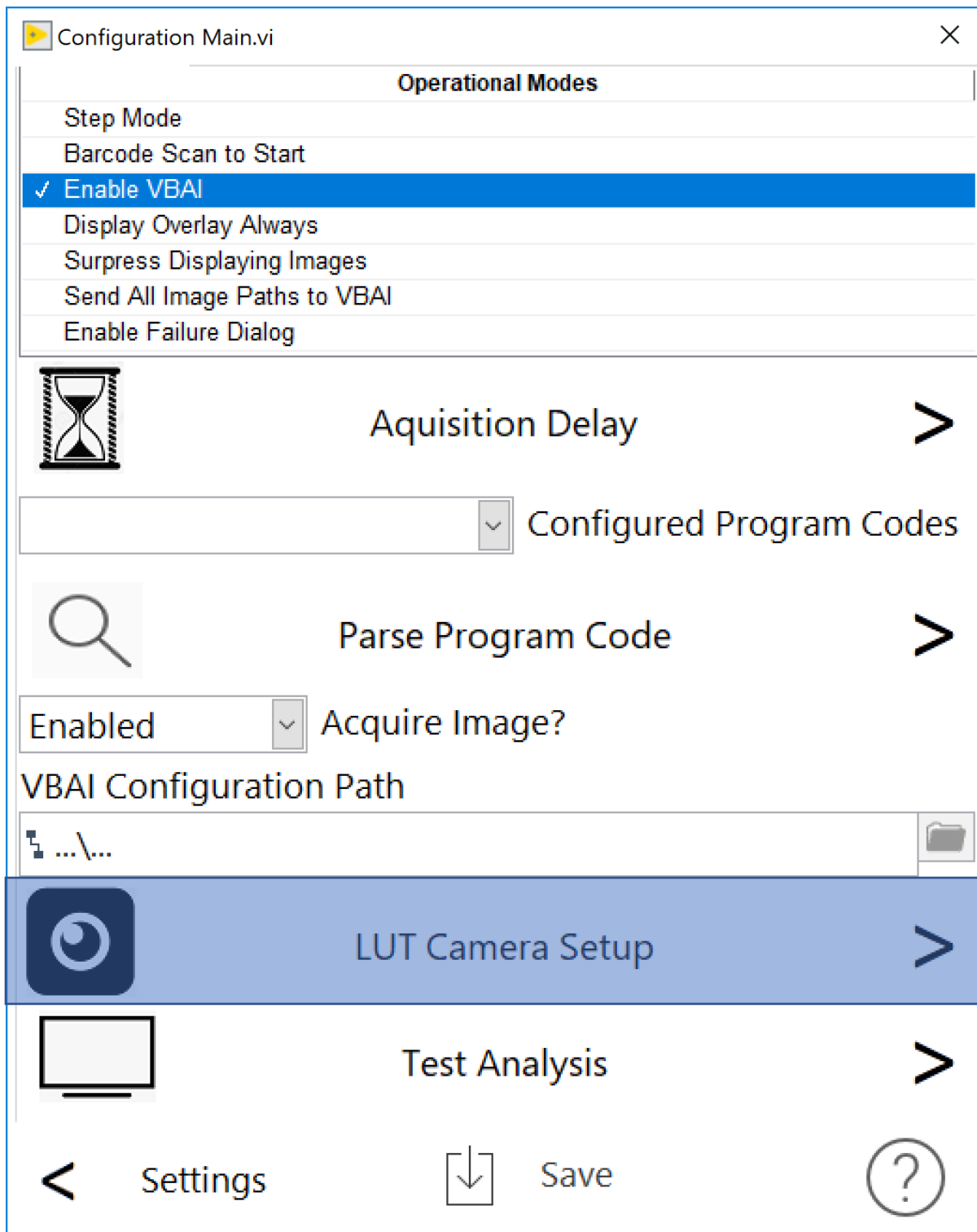


The Acquire Image selector is used to disable acquisition based on the program code configured so that you can inhibit image acquisition for certain program codes and steps. This is especially useful when you are running in step mode with multiple cameras and only need to acquire images from some cameras and not others at each step.

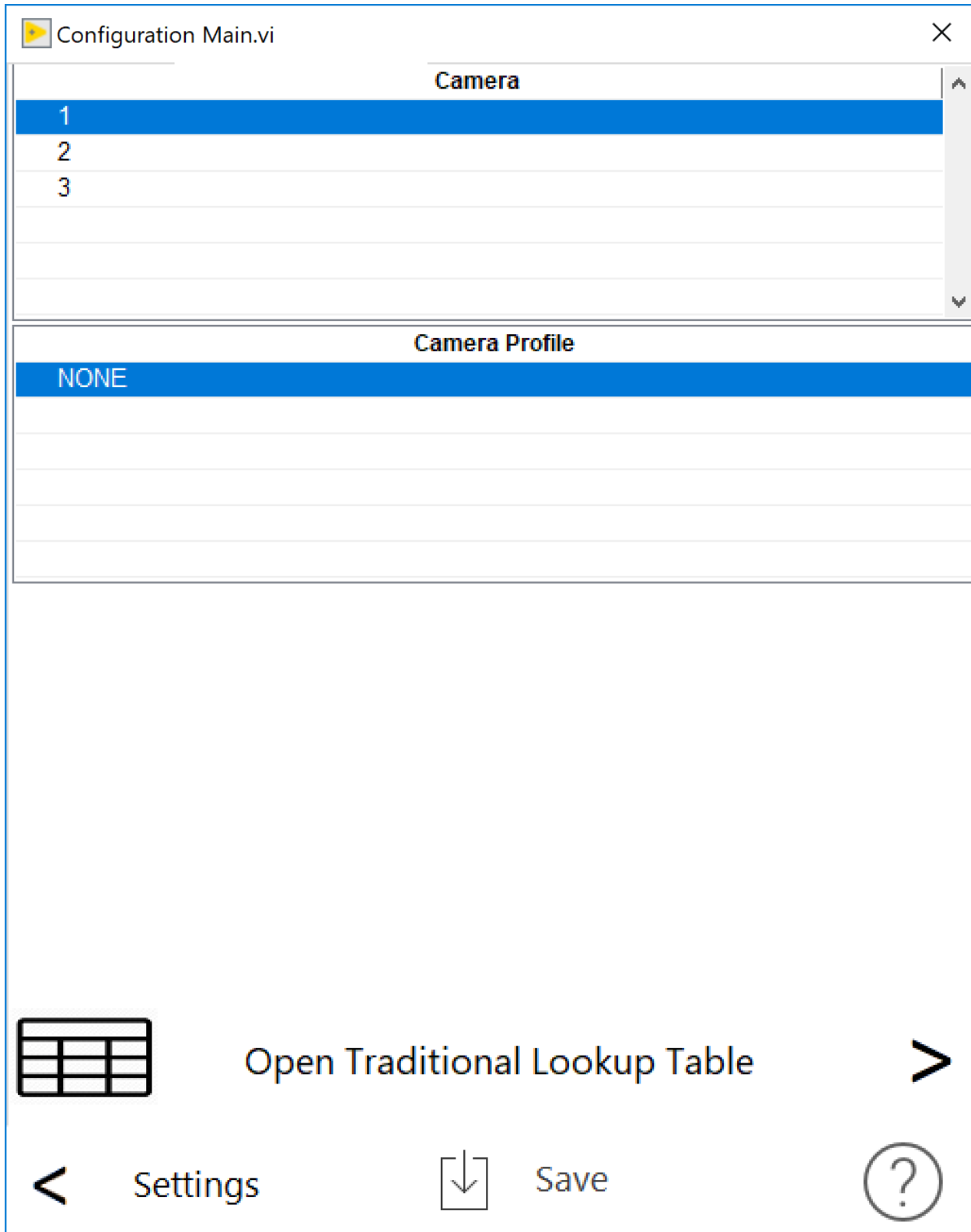


If you are doing inspection using traditional machine vision, select the VBAI configuration path (usually stored at C:\Vision Builder AI Configurations) to run for the selected program code. It is possible to switch the configuration used based on program code but it does take time to load the configuration and it is suggested you make decision points in the VBAI configuration so you can use one common configuration. This is explained in greater detail in the VBAI setup portion of this manual.

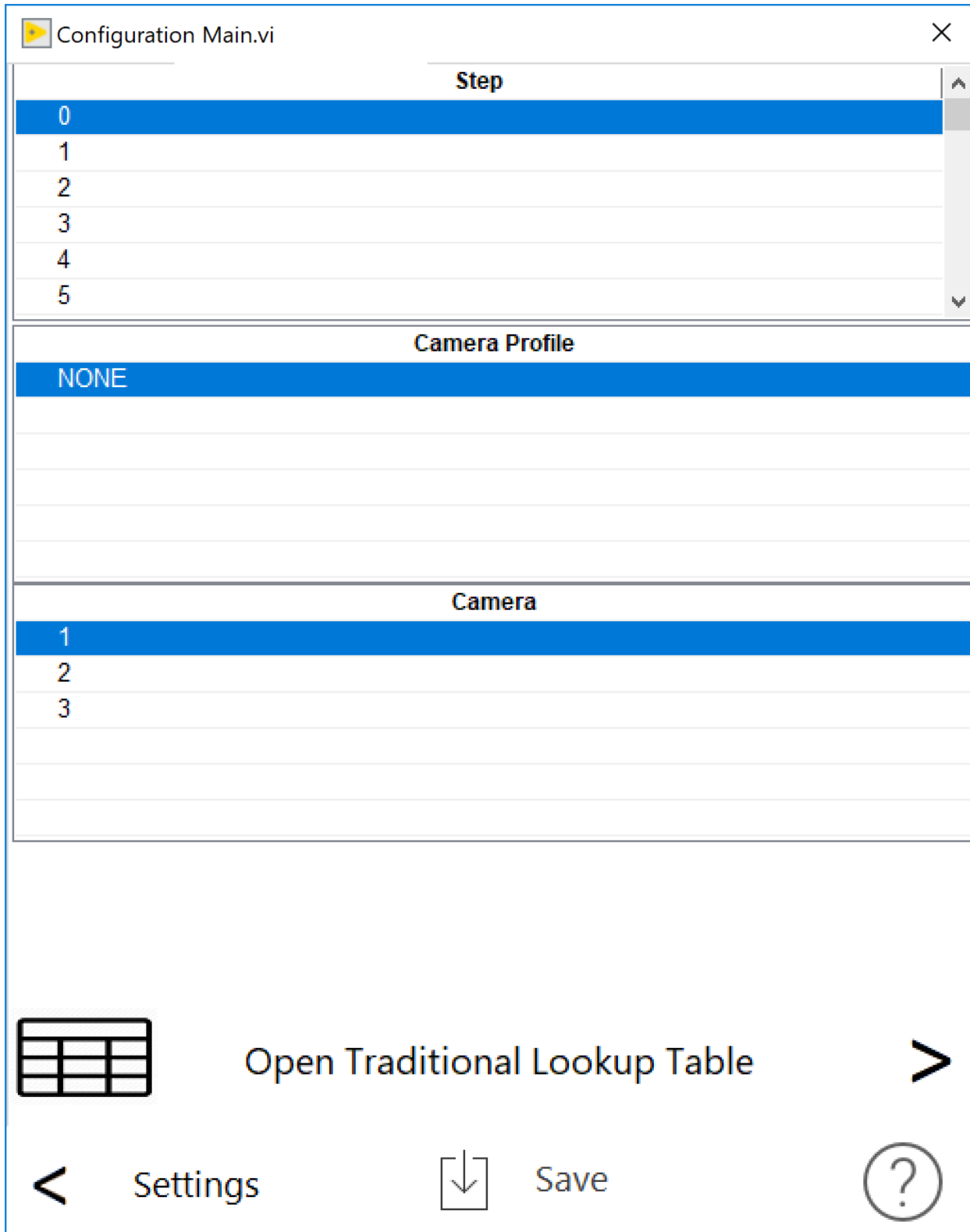




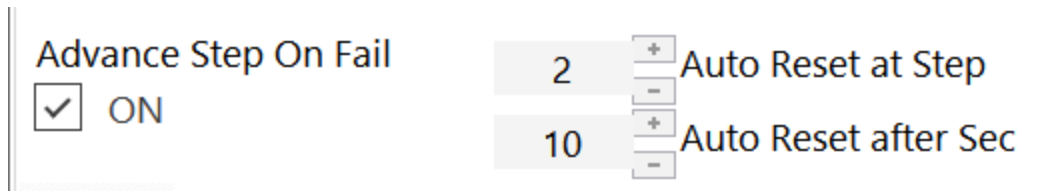
If you press the LUT Camera Setup you can associate a program code configuration with a camera, profile and step as described below.



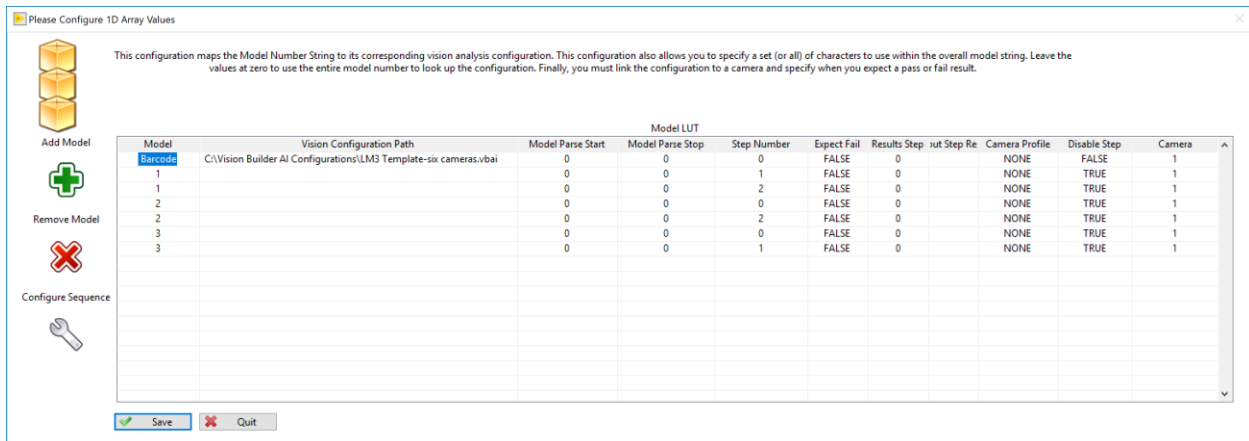
Select the camera associated with the selected program code configuration as well as the camera profile used to adjust the camera properties when the selected program code is detected. If running in step mode, you will need to also select the step to associate with the program code.



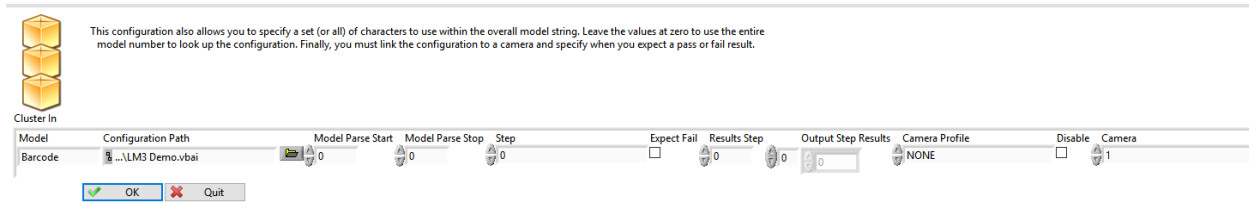
Optionally, you can configure all lookup table (LUT) at once by pressing the Open Traditional Lookup Table button.



If running in step mode, you can also configure the program to advance the step on failure so that the complete part or set of parts are inspected for each cycle. If you set the auto reset step, the PAQi program will handle resetting the steps. Auto Reset after Sec forces the cycle to reset to the beginning if idle the amount of time configured in seconds.



If you enter the Traditional Lookup Table, the buttons on the left of the interface provide a means for adding, removing, and configuring the options. Note, regardless of whether you plan to use camera barcode scanning, leave the first row set to barcode so that you do not have to set it up for use later. In any case, if a program code is parsed from the barcode or auto-generated, the Barcode LUT row will never be executed. The number of rows in the LUT does not affect cycle time so you do not need to worry about overloading it.

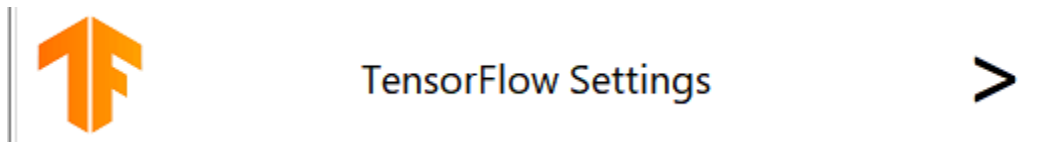


By pressing the configuration button, you can access the configuration for any given row including the following settings”

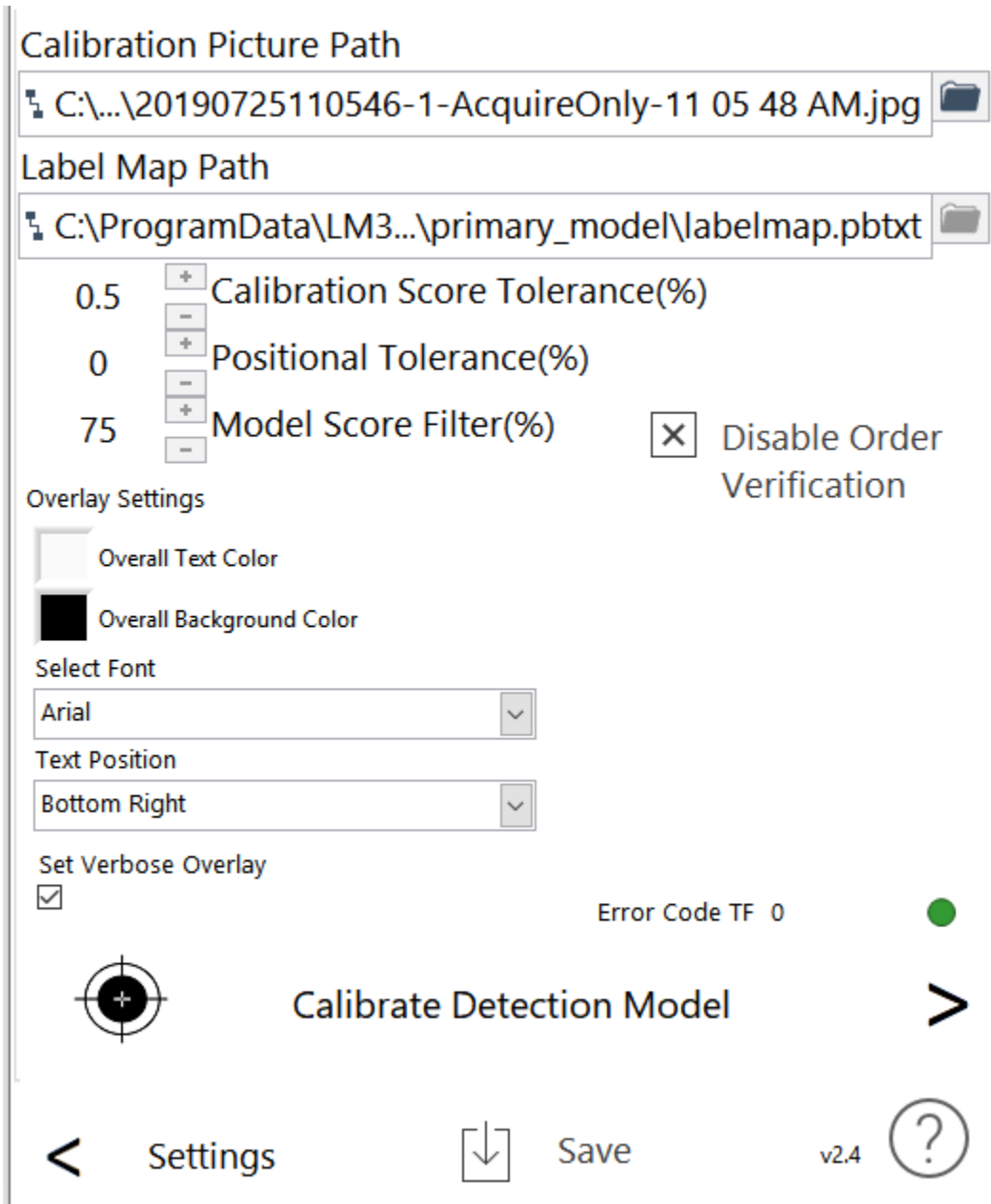
Model – this is a similar concept to the program code with the addition of parsing

- Configuration Path – path to VBAI configuration file or server path to run an inspection. LM3 provides two templates with the PAQi for configuring a multi-camera inspection routine in VBAI and servers for running AI based inspection.
- Model Parse Start – starting point of parsing of the overall program code to obtain the model.
- Model Parse Stop – starting point of parsing of the overall program code to obtain the model.
- Step Number – the step number associated with the LUT row

- Expect Fail – set if you have configured your VBAI inspection to find an object such as a scratch or a dent and expect it to not be found
- Results Step – which step from VBAI determines pass or fail. If set to zero, the PAQi uses the overall VBAI result.
- Output Step Results – the VBAI results steps can be written as bitmaps to 16-bit integers in the PLC to determine which step failed in the PLC.
- Camera Profile – if you select a camera profile setup in the Camera Setup and Camera Viewer, you can point to it in the LUT so the camera settings are changed whenever the model, step, and camera configured is executed.
- Disable – this causes acquisition and inspection to be masked whenever the model, step, and camera configured is executed.
- Camera – used to select which camera by name to associate with the LUT row



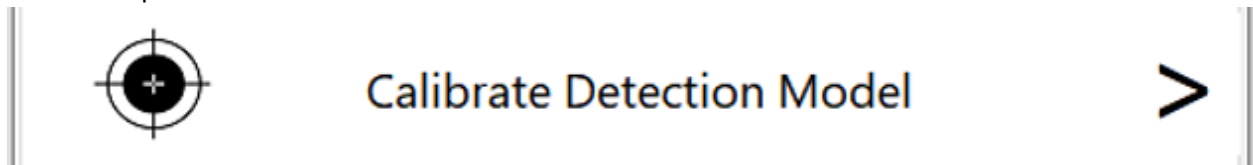
PAQi uses trained TensorFlow AI models to do object detection for use in inspection. To use these models, you will need to calibrate the model against a golden image for a particular program code, step, and camera.

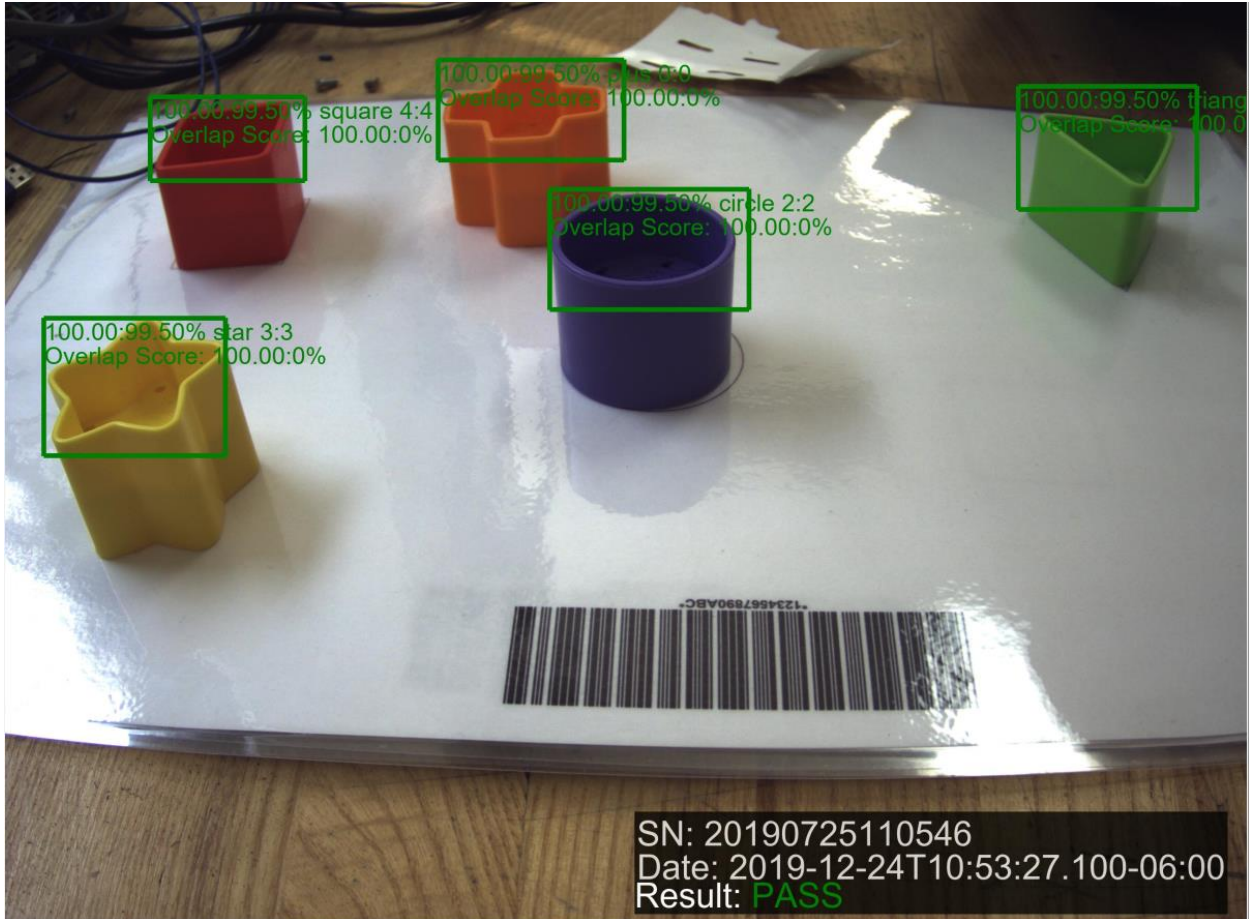


The TensorFlow Settings program provides a means for calibrating the AI model for relating the objects detected by it to the expected objects.

- Calibration Picture Path – point this path to an image taken of a good part with all detectable objects in view for the camera, step, and program code selected.
- Label Map Path – this by default is located at C:\ProgramData\LM3 Function Tester\custom\_server\primary\_model\labelmap.pbt.txt and contain the list of detectable objects used to train the model.
- Calibration Score Tolerance – this is used to set the threshold of the certainty score returned by the model. If you set this value to .5 for example and the objects in the image selected score at a 100% certainty, the threshold would be set to 95.5% certainty.
- Positional Tolerance – this value sets the threshold for the expected overlap in the calibrated objects versus the detected objects. The higher you set this value in a range from 0-100%, the more exact the system will expect the objects to be in a position relative to the calibration image.
- Model Score Filter – this is used to set the certainty threshold required to include detected objects in the pass/fail decision. When using TensorFlow serving, up to 300 objects can be returned by the model with scores as low as 0.001%. By setting this threshold to a higher value, less processing is required to analyze the results.
- Disable Order Verification – if checked on, the system does not expect the objects in any certain order. If checked off, the system will verify the order of the objects in a clockwise order from the top left corner of the image.
- Overlay Settings – these settings adjust the position, color, and font of the overall results overlay to avoid placing it over a detected object.
- Set Verbose Overlay – if checked, the detected objects are highlighted with the certainty score and object name displayed. If not checked, the program overlays the qc\_pass.png or qc\_fail.png images from the C:\ProgramData\LM3 Function Tester\results\_overlay\_generator\assets folder over the objects. You are always welcome to create your own icons and replace the default ones.

When you have set the above settings, press the Calibrate Detection Model button to initiate the calibration process.

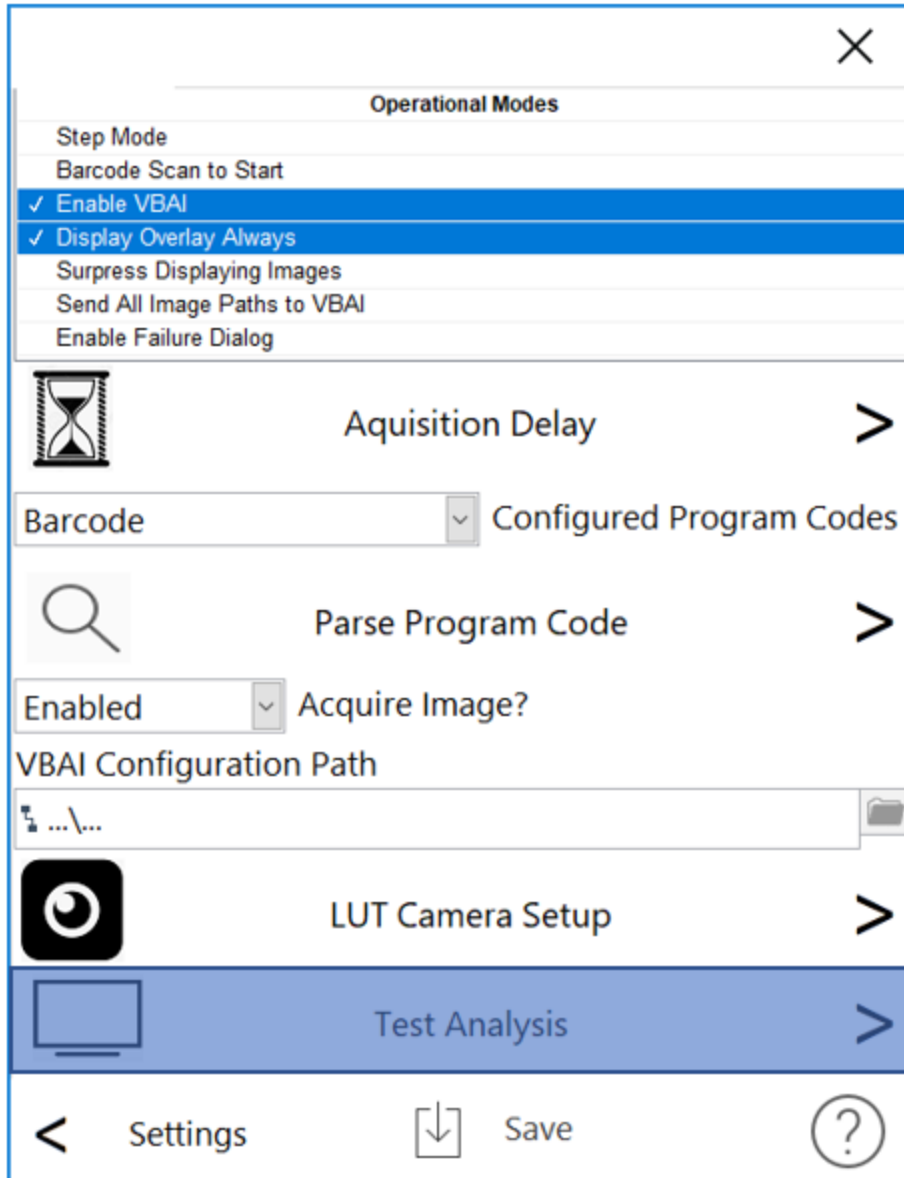




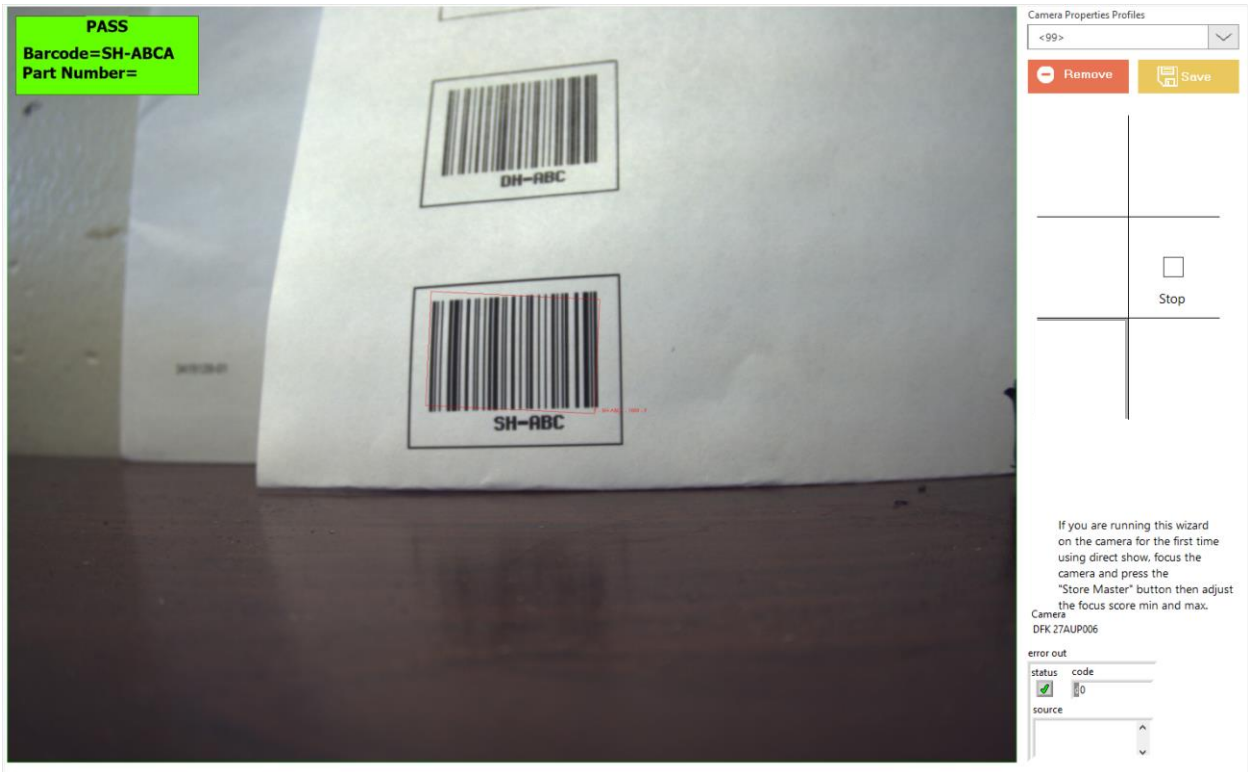
When the calibration is complete, the results will be displayed for your review. Make sure that the certainty scores are high for each object and all expected objects are detected.

Repeat the calibration process for all program codes you have configured to work with object detection.

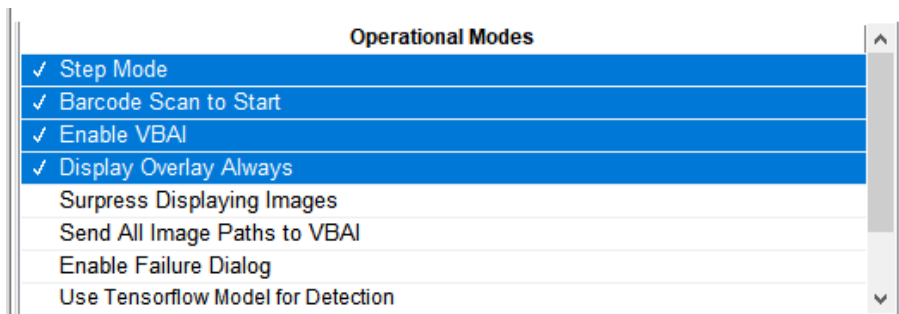




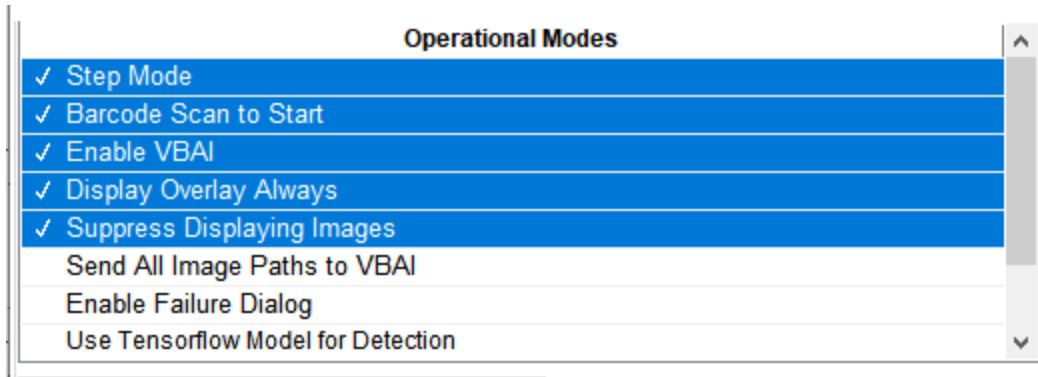
You can test a configured program code if you are using analysis (VBAI or TensorFlow) by pressing the Test Analysis button.



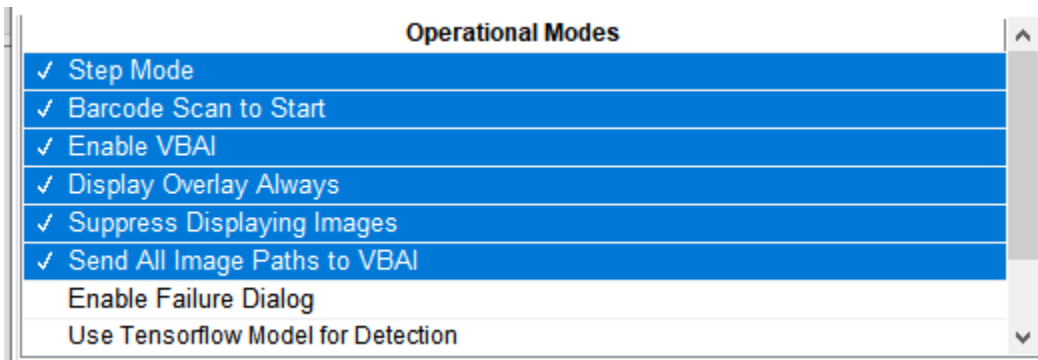
Depending on the program code configuration selected, the camera viewer is opened in a mode to continuously acquire an image from the associated camera and run the inspection for use in troubleshooting. Press Stop to quit the test inspection.



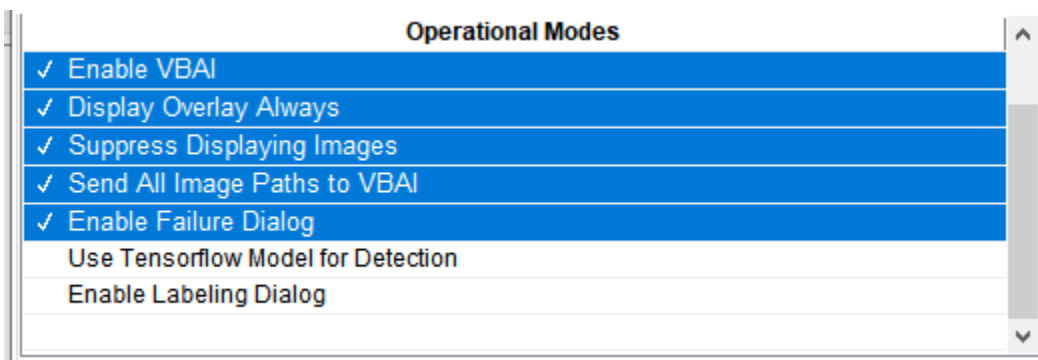
If you select the Display Overlay Always option from the Operational Modes, when analysis is done, the image with the results overlay will always be displayed. If unchecked, the overlay images will only be displayed if the analysis fails.



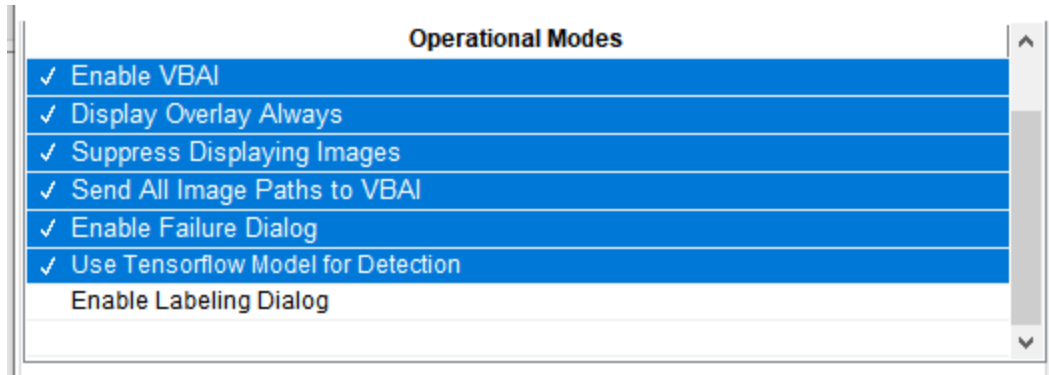
If you check the Suppress Display Images option, no images will be displayed on the user interface to save the time of loading images. Depending on the resolution of the camera, checking this option can save .5 seconds per camera.



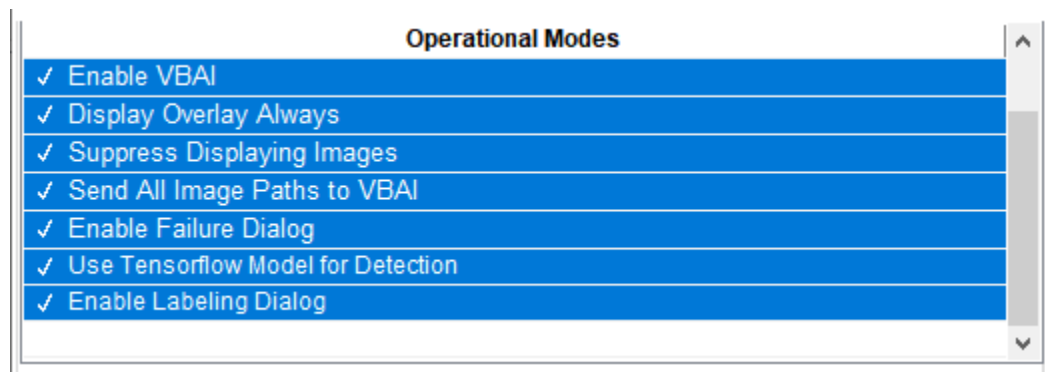
If you check the Send All Image Paths to VBAI option, an array of image paths for all images acquired will be sent to VBAI so you can use multiple images to do an inspection.



If you check the Enable Failure Dialog option and analysis is enabled, a pop up window will pop up in the operational program to override a failure.



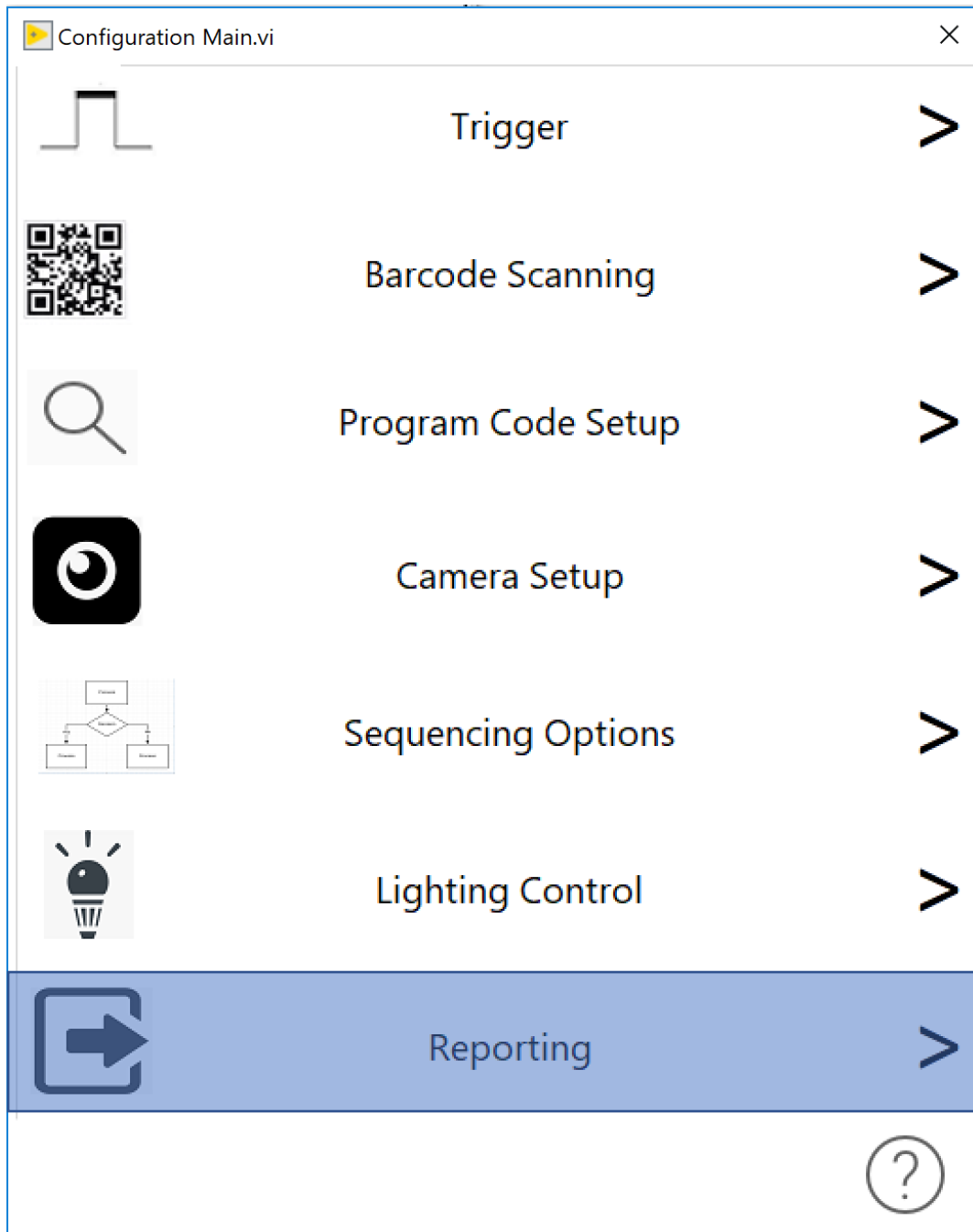
If you check the Use Tensorflow Model for Detection option, the user is provided with a button for calibrating the analysis using AI based object detection.

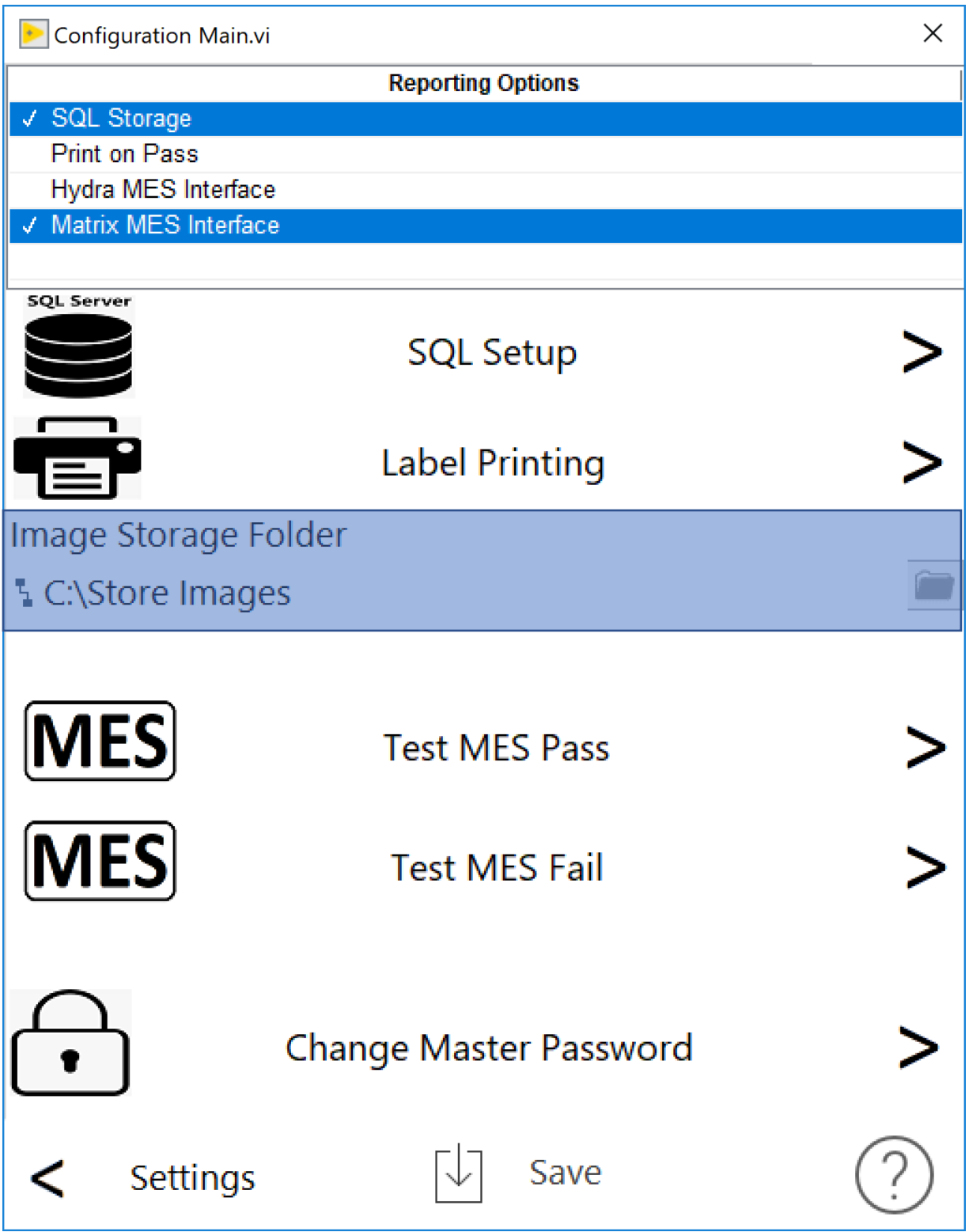


If you check the Enable Labeling Dialog option, a dialog will pop up to allow you to label objects in the images acquired.

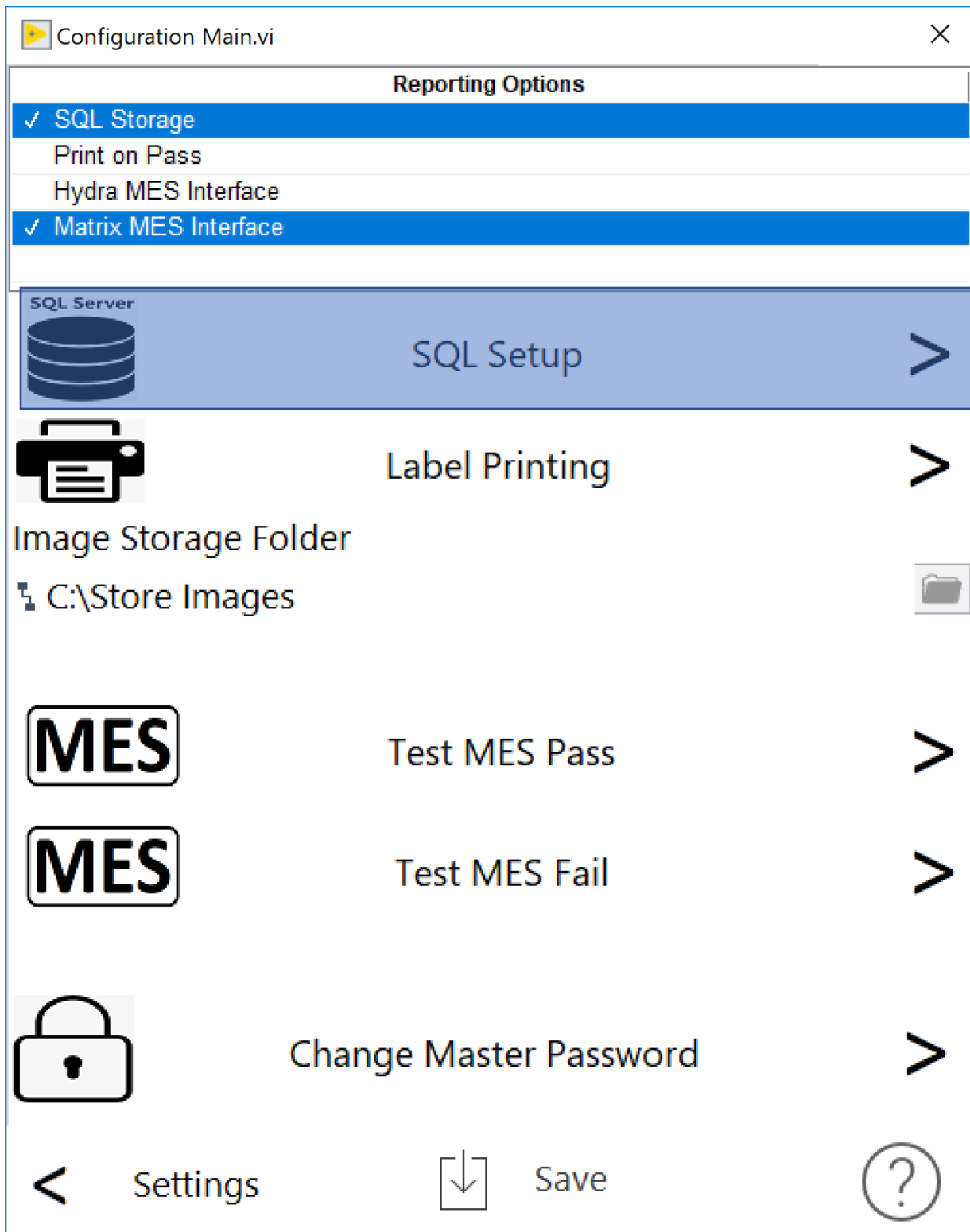
## Step 6 - Reporting Setup

The PAQi by default stores the acquired images to the configured drive on the box or on a connected network drive. In addition to image storage, the results of each acquisition can be logged to MSSQL or a flat file we named Matrix MES. Additionally, the PAQi is capable of providing a handshake via Modbus TCP communications and printing a barcode on a pass result.

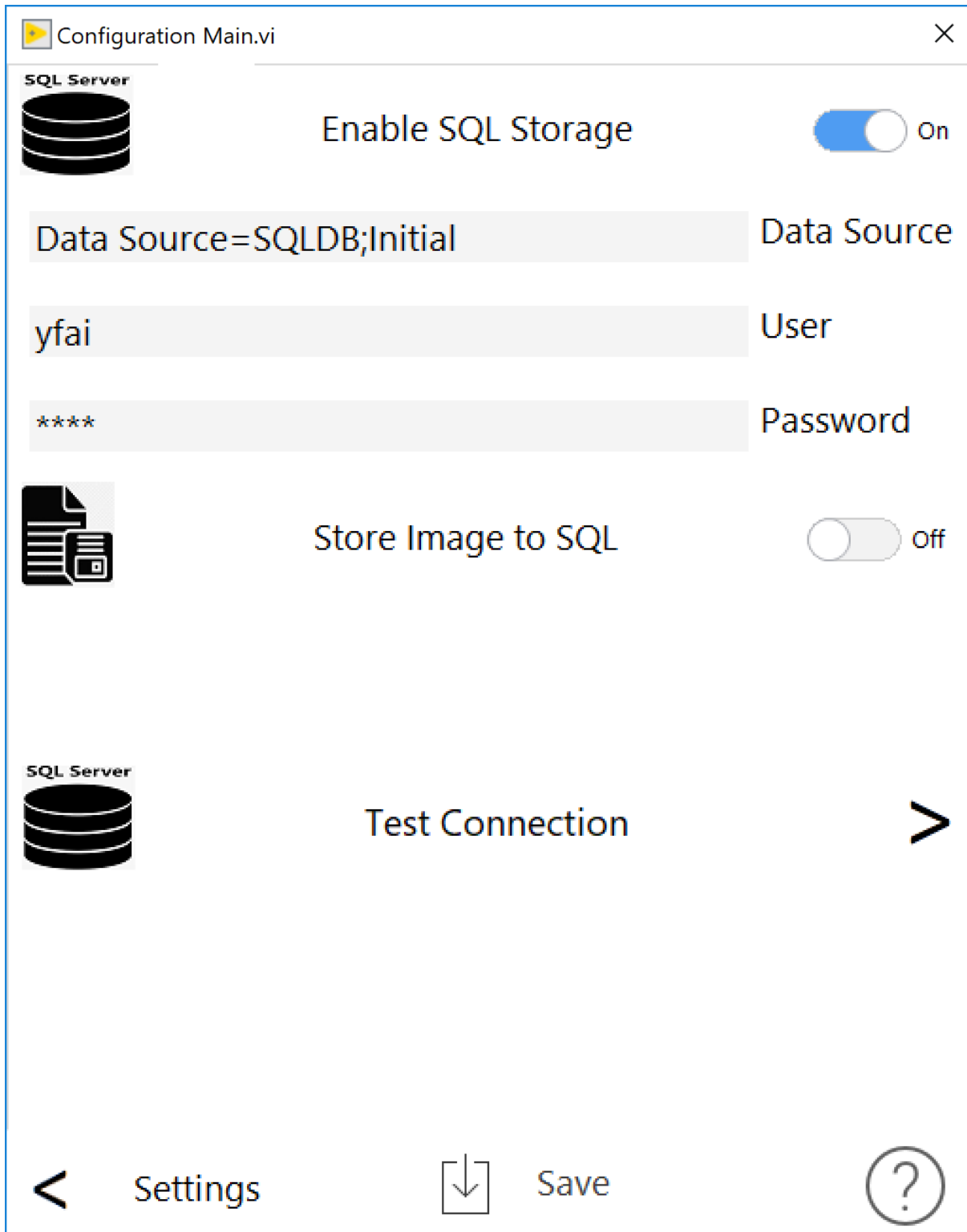




You can configure where the acquired images are stored by pressing the folder icon next to the Image Storage Folder control. You are welcome to store locally, on an external drive, or on a networked drive. Images are stored within the \MM-DD-YYYY\Images folder underneath the configured folder.

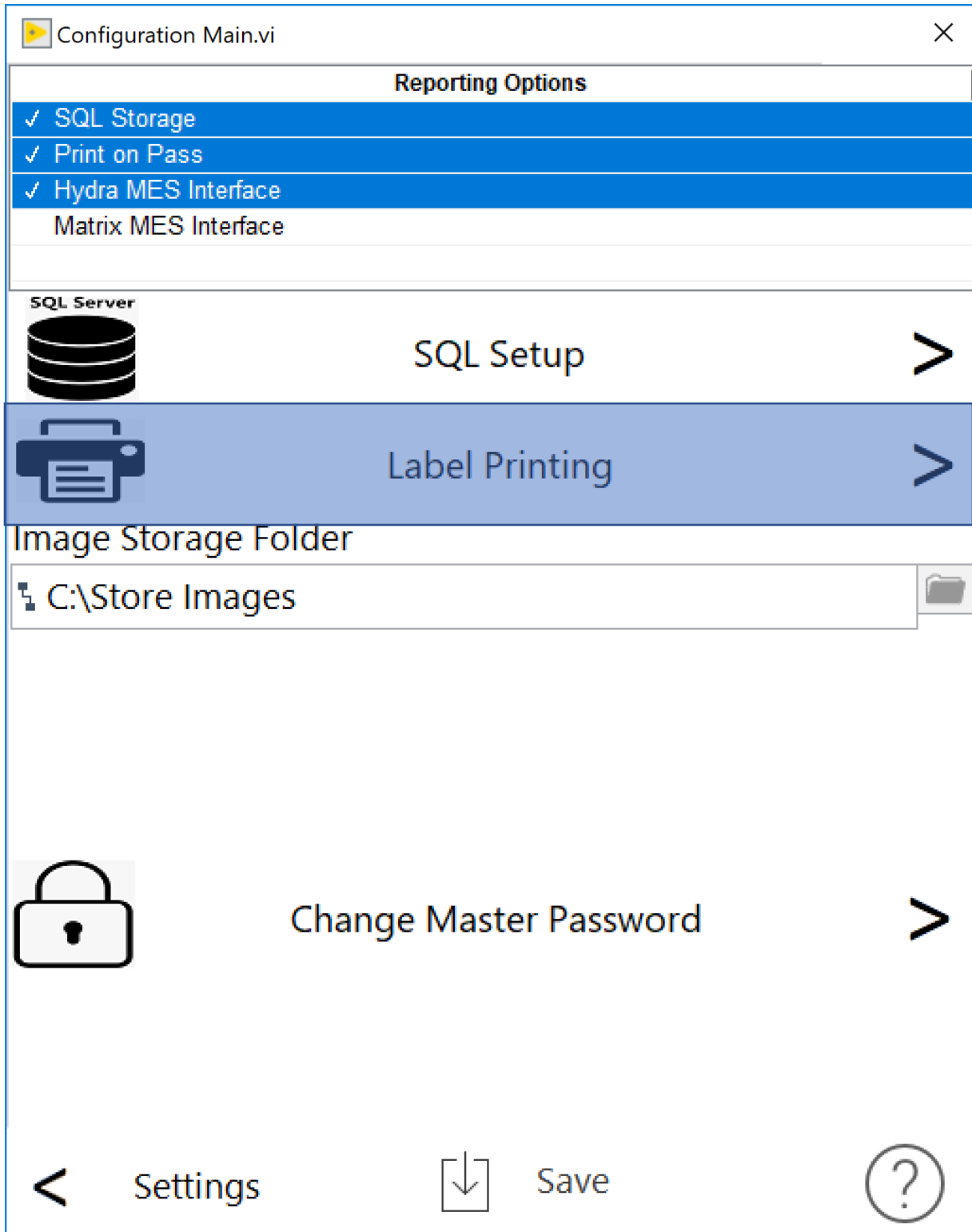


Start by selecting and saving the reporting options from the list. In order to enable SQL Storage, you must configure the connection to the database. Press the SQL Setup button to configure.

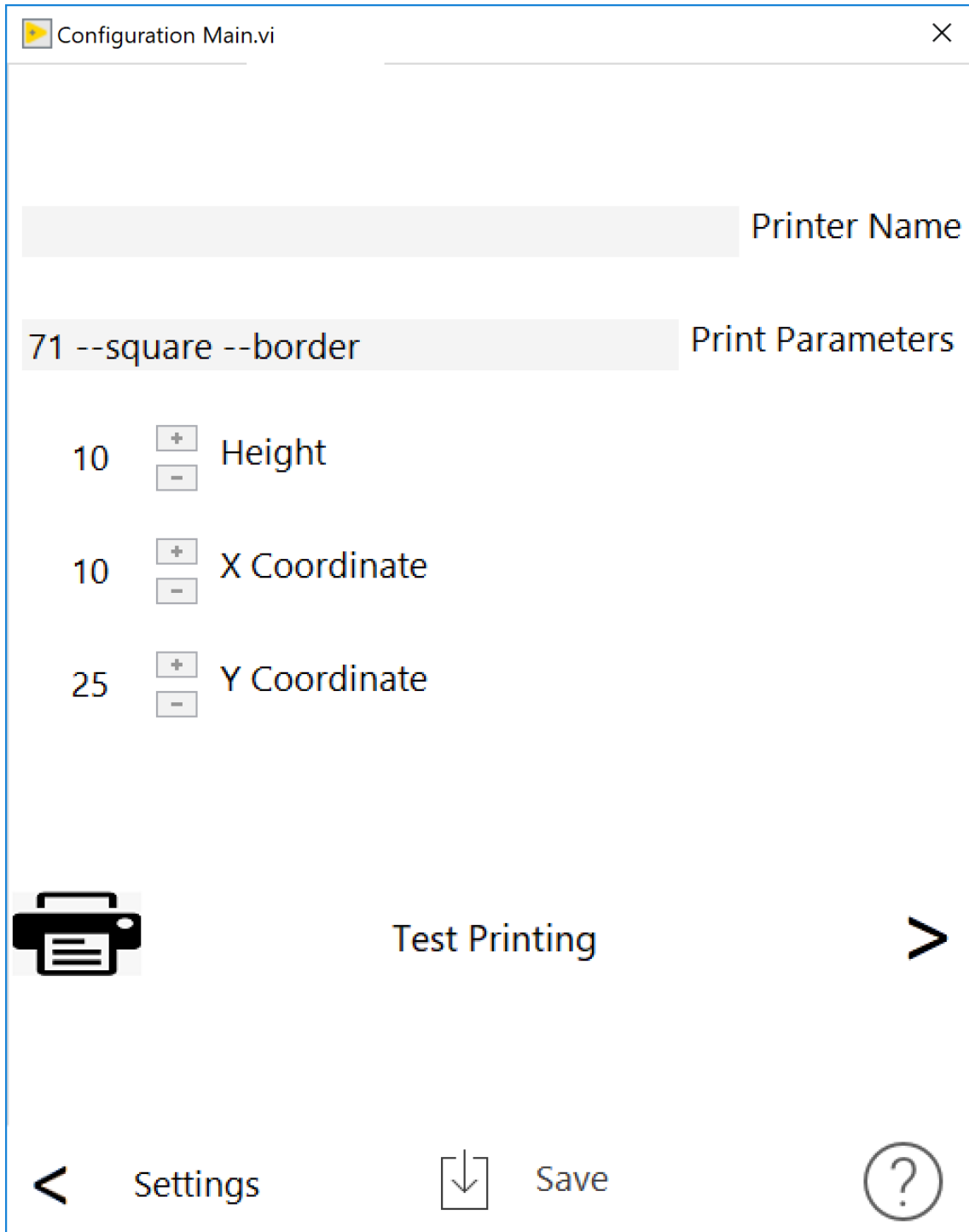


Once at the SQL configuration interface, configure the data source. A data source is typically setup in the Microsoft ODBC administration program under System DSN. Using a .NET naming convention, you then configure the data source as Data Source=SQLDB;Initial Catalog=PAQi; and assign the user name and password to access the DB. Save and test the connection after entering.

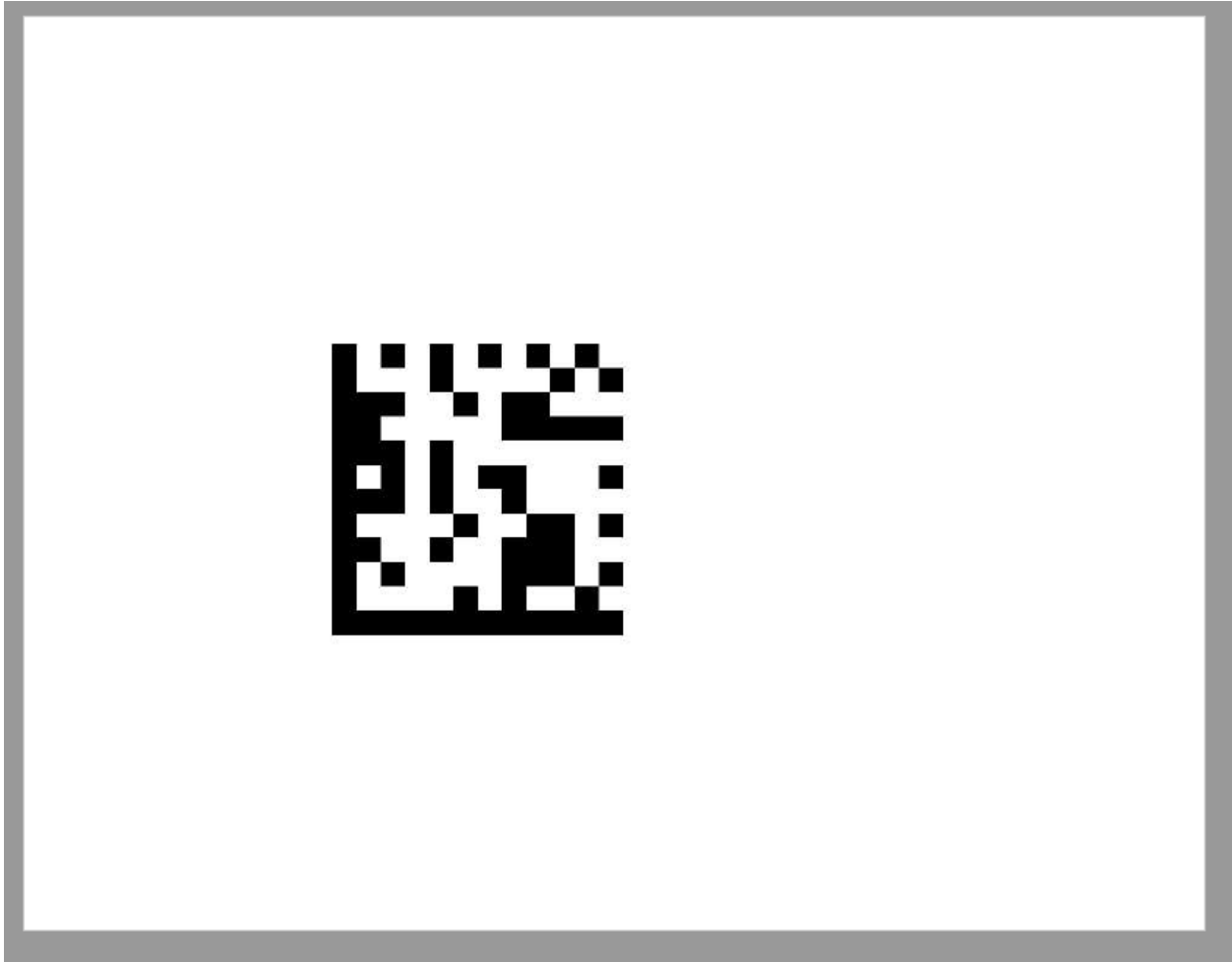




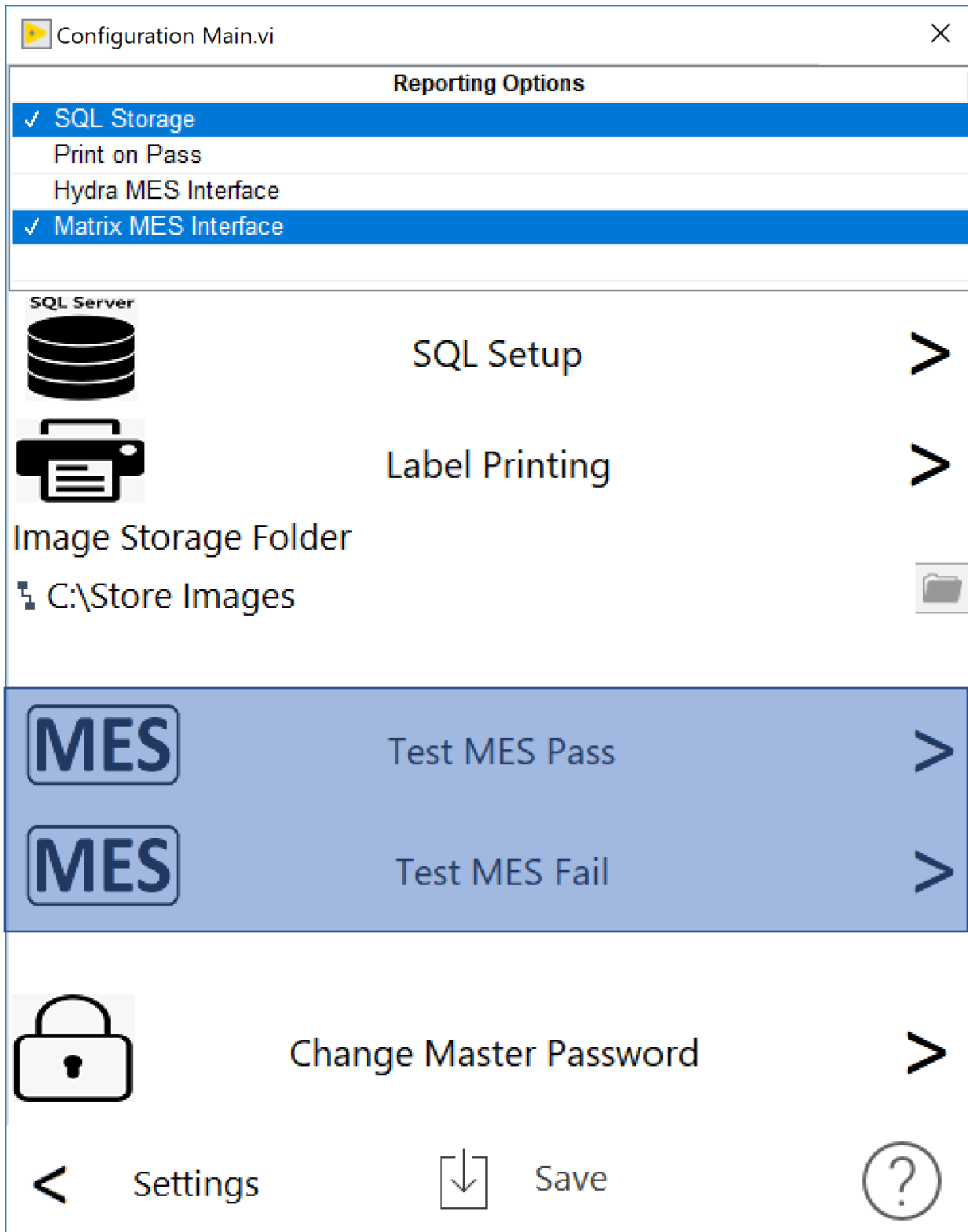
Configure label printing by pressing the button and entering the printing parameters.



The software uses Zint Barcode Generator© to generate the barcode over the image template stored at C:\Program Files\LM3 Technologies, Inc\PAQi\Data\printoutTemplate.png. Feel free to modify the template for the size of label you are using and include a log or a description of the label. See <http://zint.org.uk/Manual.aspx?type=p&page=4> for parameter syntax which includes the barcode type and additional settings.

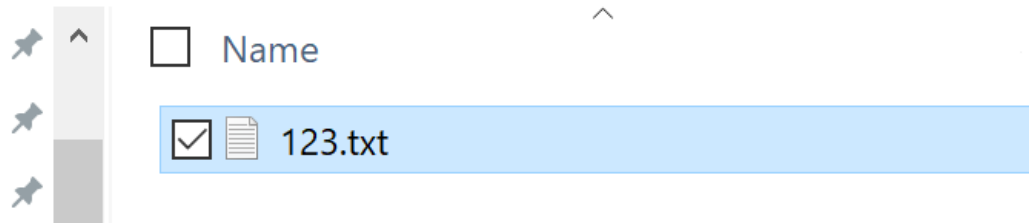


Example barcode matrix print out of 123ABC



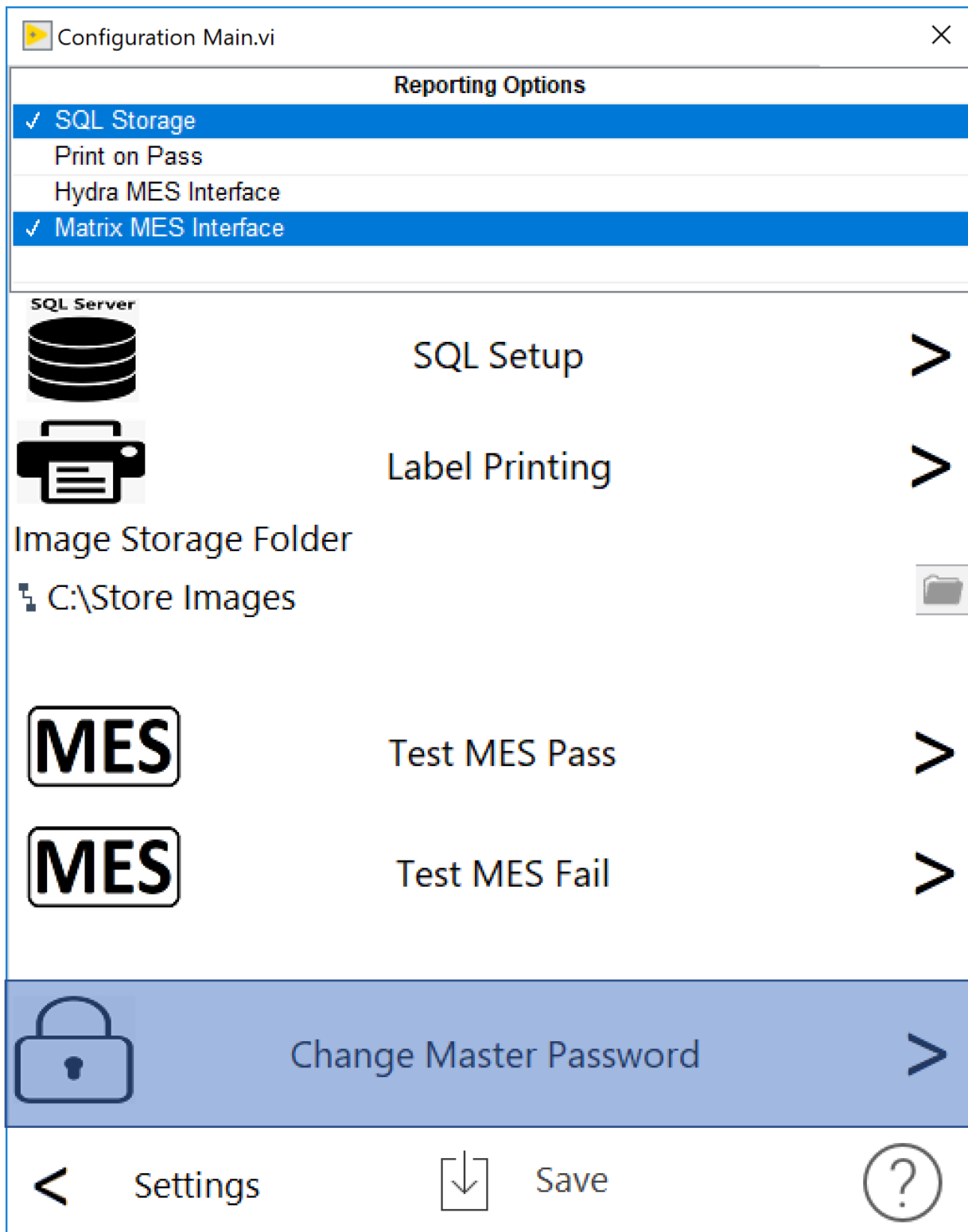
If you have enabled one of the MES interfaces, you can test them using the test MES pass or fail buttons. The program defaults the serial number for the test to 123

‣ Local Disk (C:) ‣ Store Images ‣ MES



The matrix type MES option stores a simple serial number named text file to the Image Storage Folder\MES. If using this option, the MES system should delete files as read to save disc space and manage the folder. Improper management of the folder can result in system slow down and crashes due to limitations in Windows regarding the number of files in a single directory.

Please consult with LM3 regarding the interface for Hydra MES or the need to add additional MES interfaces. The current program, copies the serial number acquired from the barcode to a Modbus register in the onboard PLC, sets the pass/fail result, and informs the MES that results are available. The handshake process is completed when the software sees the MES system set a process complete bit. All communication is done using Modbus TCP communications and the handshake can be customized in the onboard PLC program.



The final option for the reporting configuration is to change the master password used to control access to the options while running the operational program.

Configuration Main.vi

Enter Original Password

\*\*\*

Enter New Password

Enter New Password Again

Original Password Incorrect

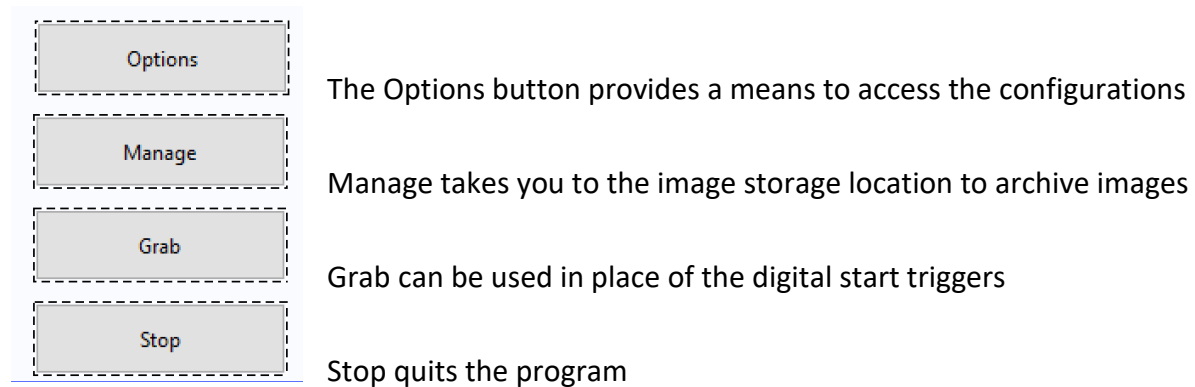
< Settings Save ?

To change the password, enter the original password and the new password twice.

## Operational Program Controls and Indicators



When the operational program is running, you can access the following controls:

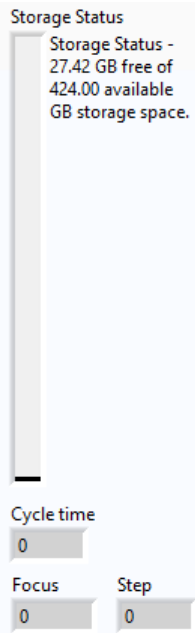


The footer displays the Program#(same as part number), Serial #, status indicators mimicking the digital outputs, cycle statistics, and the date and time.





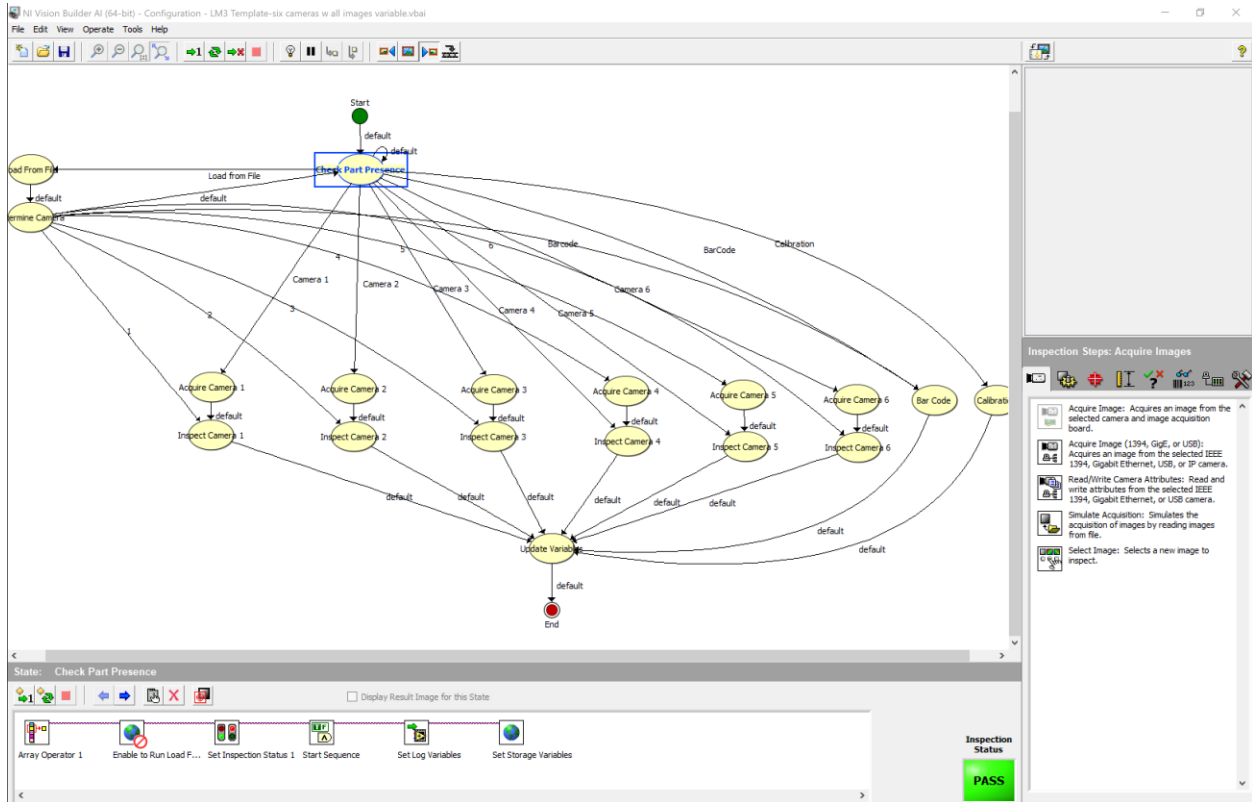
Other useful indicators include the running cycle time of each acquisition and the focus value for the camera being acquired from, the amount of storage space on the drive in which the images are being stored to, and the step in which the camera is on when in one camera on a robot mode.



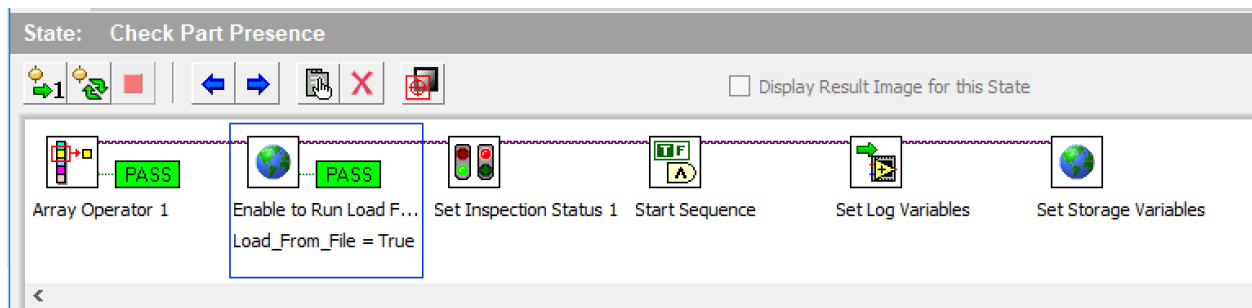
This indicator will show in yellow when there is less than 10% storage space available on the configured drive and show red if you drop below 5% at which time the software will start to FIFO the daily folders. If you require long term storage, make sure you move the images from the PAQi before you reach the 5% limit.

## Vision Builder AI Setup

We provide a VBAI template at C:\Vision Builder AI Configurations\LM3 Template-six cameras.vbai for use in setting up machine vision inspection. This template has the necessary logic in place to interface with the PAQi software and includes acquisition and inspection states for all six cameras so you can concentrate your efforts on the inspection setup and nothing else. We suggest you save the inspection as another name before modifying it.



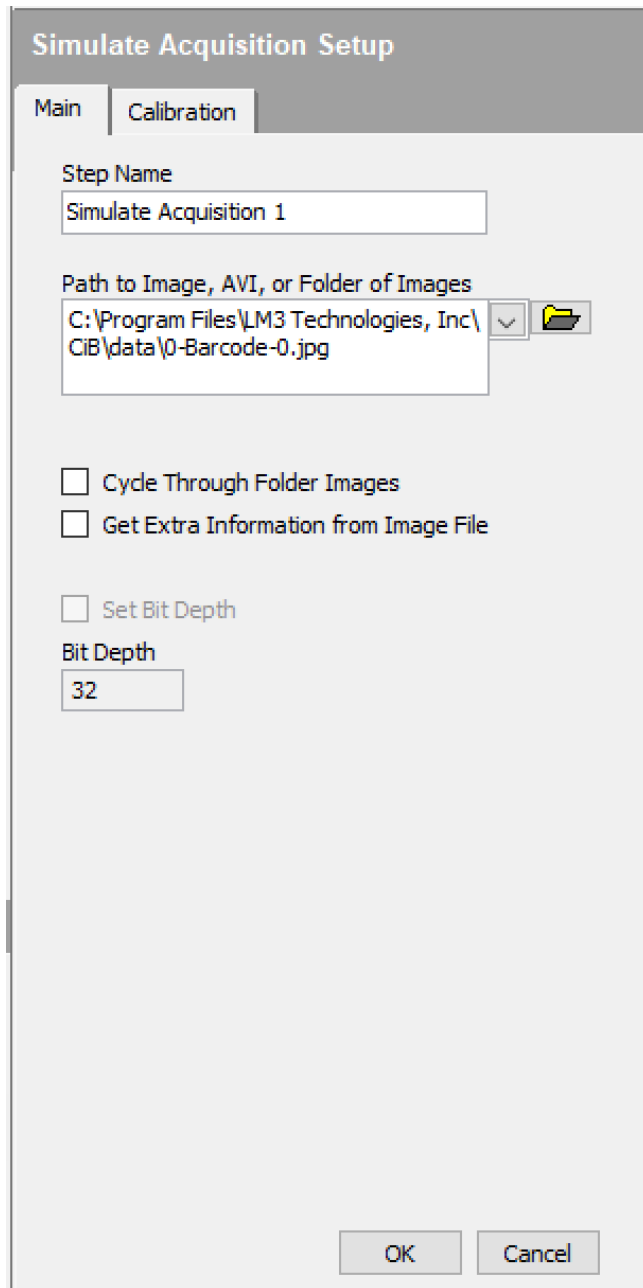
The template provides a means for testing your inspections by pointing to any image on the network.



To enable, go to the Check Part Presence state and enable the Enable to Run Load From File



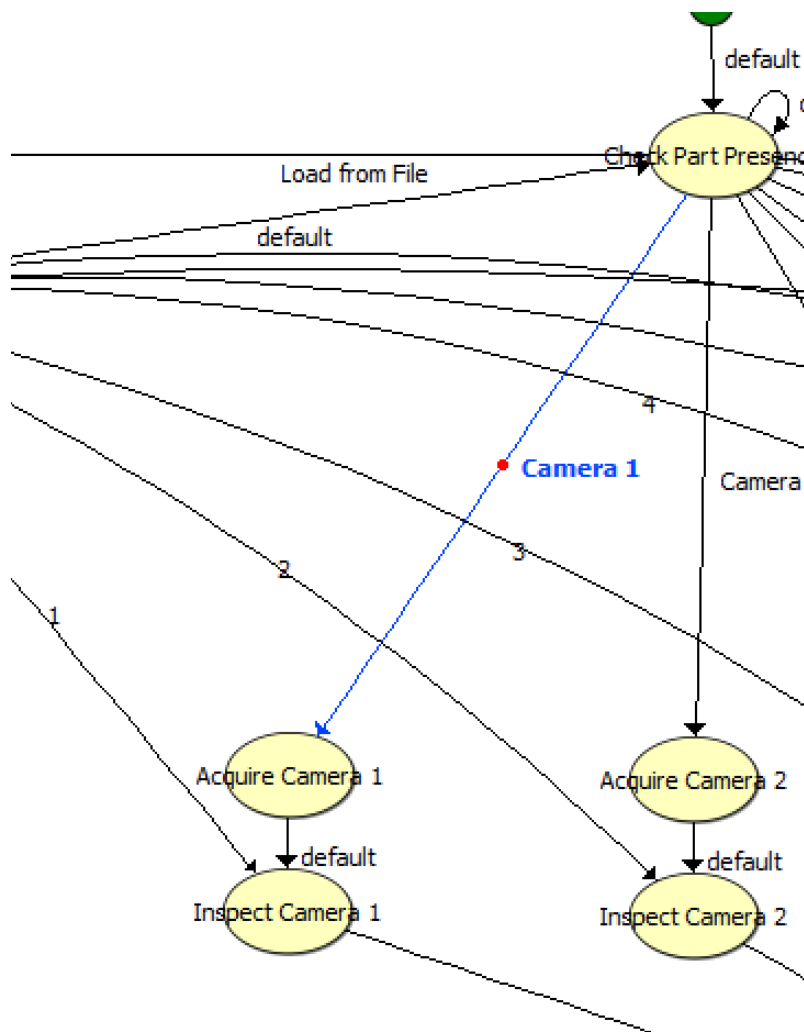
Next, go to the Load from File State and enable Simulate Acquisition 1

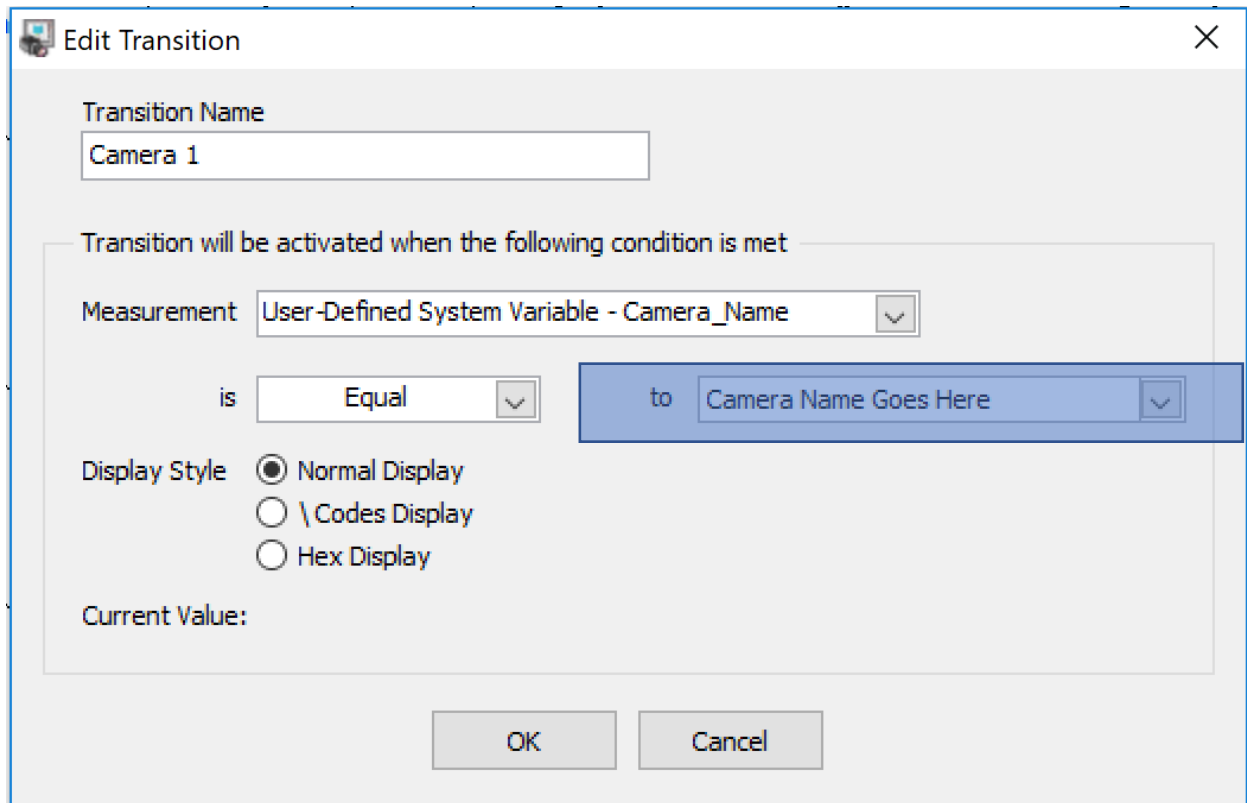


Double click on the steps to access the configuration shown to the right in the program interface.

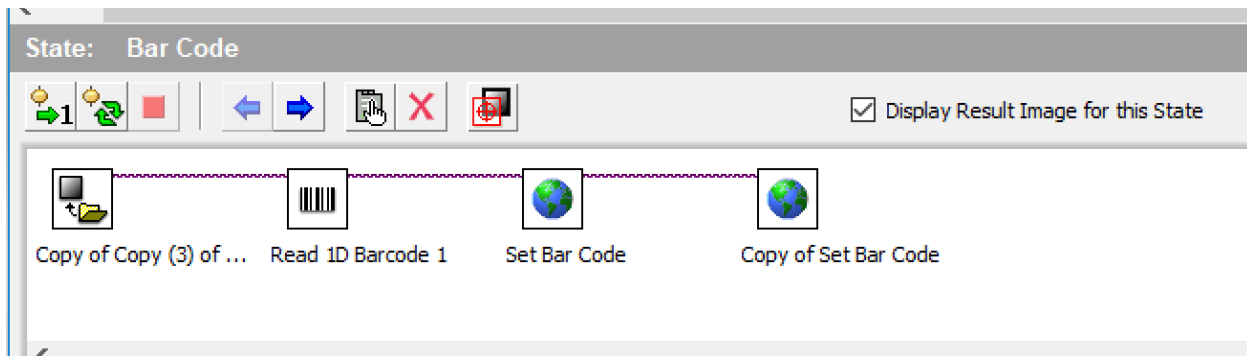
The VBAI template has steps in it for deconstructing the image file name into serial number, camera name, step number, and date based on the image naming convention [Serial Number]-[Camera Name-Step]-[Step #][Timestamp].format.

Transitioning from starting the inspection to acquiring and inspecting is based on the camera name and if you change the names from the defaults – 1,2,3,4,5,6, you will need to modify the transitions by double clicking on them.

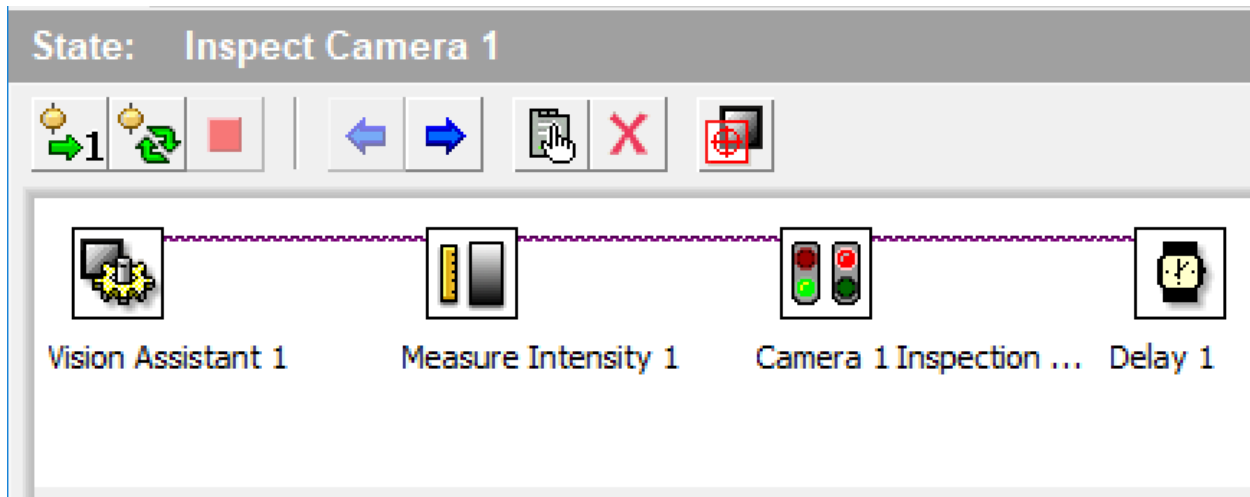




When inside the transition, rename the camera name variable value.

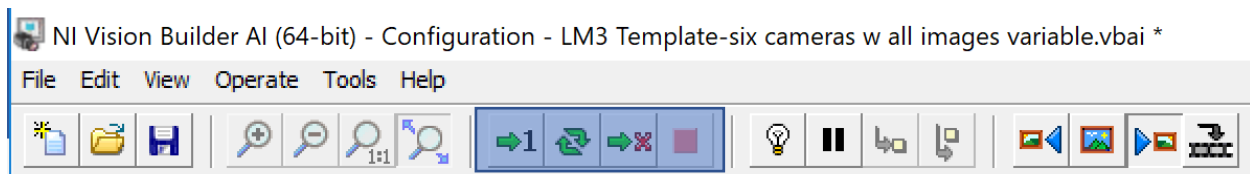


The Bar Code and Calibration states handle barcode scanning and calibration called by the Camera Viewer program. You can adjust those states based on your application.

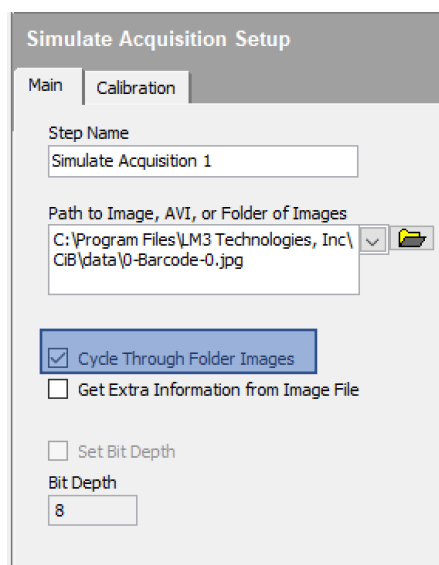


By default, the Inspect Camera 1 & 2 states contain a basic intensity measurement step as an example on how to configure an inspection. In many cases you will need to use the vision assistant step to transform color images to grayscale images prior to processing. The program will indicate this if you attempt to perform analysis steps on the wrong image type.

Use the program menu run buttons to test the modified configuration. The 1 arrow runs the configuration once, the loop continues to run it until stopped, and the arrow with the X runs the configuration until a failure is detected.



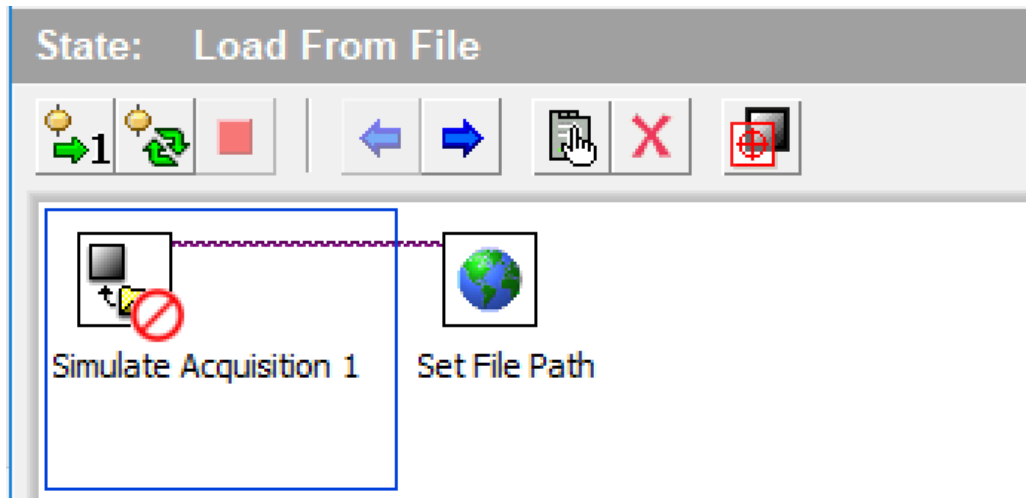
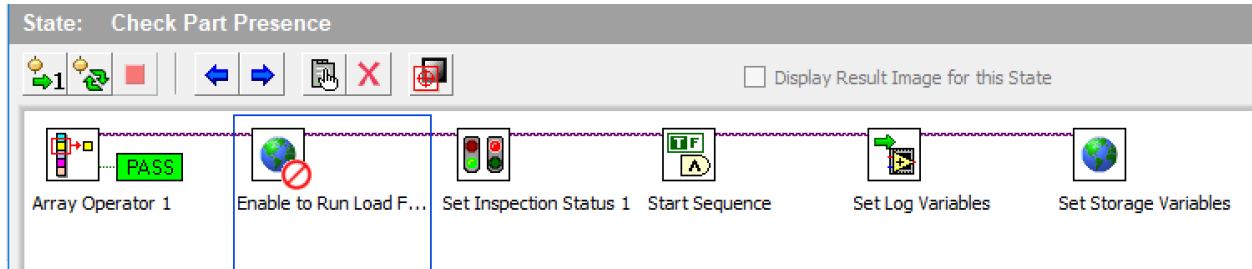
If you check the Cycle through Folder Images switch in the Simulate Acquisition Setup step,



You can use the program menu image arrows to step through the images or freeze on one only. This is useful in batch testing.



Before saving the modified inspection for use with the PAQi software, disable Enable to Run Load from File and Simulate Acquisition 1.



You can find many VBAI examples of all sorts at [C:\Users\Public\Documents\National Instruments\Vision Builder AI 2015\Examples](http://sine.ni.com/psp/app/doc/p/id/psp-741/lang/en). Additional information and tutorials can be found at <http://sine.ni.com/psp/app/doc/p/id/psp-741/lang/en>

## MSSQL Storage

By default, a DB called PAQi with default mixed mode credentials is installed on the PC to store the results shown below.

```

GO
DECLARE @return_value int
EXEC @return_value = [dbo].[sp_Get_Result]
@SN = N'12'

SELECT 'Return Value' = @return_value
GO
    
```

ID	SN	PN	Status	Path	ImageData	FocusValue	DateTime	Camera	Attempts	CycleTime	
14	20098	12	A	25	C:\Store Images\12-Camera 2.bmp	NULL	2017-04-06 09:16:50.000	1	1	NULL	
15	20127	12	A	25	C:\Store Images\12-Camera 1.bmp	NULL	2017-04-06 09:18:37.000	0	1	NULL	
16	20128	12	A	25	C:\Store Images\12-Camera 2.bmp	NULL	2017-04-06 09:18:37.000	0	1	NULL	
17	22062	12	A	25	C:\Store Images\12-Camera 1.bmp	NULL	2017-04-12 13:55:05.000	0	1	NULL	
18	22456	12	34	25	C:\Store Images\12-Camera1.jpg	NULL	2017-05-04 07:19:45.000	0	1	0	
19	22457	12	34	25	C:\Store Images\12-Camera2.jpg	NULL	-6858.61849242676	2017-05-04 07:19:45.000	1	1	0
20	22460	12	3	25	C:\Store Images\12-Camera1.jpg	NULL	38571.2984550213	2017-05-05 10:00:37.000	0	1	1
21	22461	12	3	25	C:\Store Images\12-Camera2.jpg	NULL	-6858.61849242676	2017-05-05 10:00:37.000	1	1	1
22	22462	12	3	25	C:\Store Images\12-Camera1.jpg	NULL	-9690.98124940693	2017-05-05 10:02:29.000	0	1	1
23	22467	12	34	25	C:\Store Images\12-Test1.jpg	0xFFD8...	-108732.584388088	2017-05-08 04:14:30.000	0	1	1.21163...

## Troubleshooting

The following troubleshooting table will assist in identifying the configuration or device at issue.

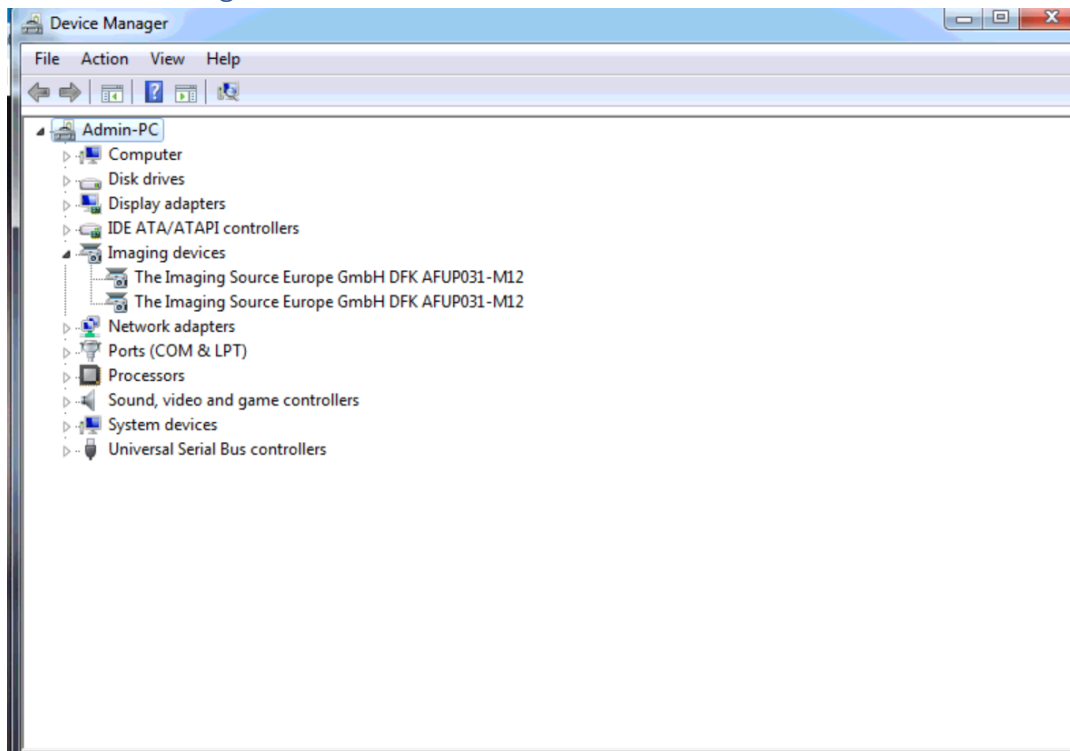
Issue	Possible Cause	Solution
Unable to open configuration file.	Corrupted or missing file.	Use configuration program to resave the vision, bar code, and logging parameters.
		Delete C:\ProgramData\LM3 Function Tester\VisionAcquisition.ini file and use wizard to reconfigure.
Program throws invalid configuration error on startup	Incorrectly configured camera	Use configuration program to select camera and settings.
	Missing camera	Reconnect the camera
	Malfunctioning camera	Replace camera
	Malfunctioning cable	Replace camera cable
Unable to trigger acquisition	Incorrectly wired part presence sensor	Refer to wire diagrams and correct.
	Malfunctioning digital input	Replace computer or IO device
	Wiring issue	Refer to wire diagrams and correct
		Verify the IP Address used to connect to the PLC is correct by pinging it



	EthernetIP based communications configuration error	Correct trigger and/or button input bit based address using the Industrial Communications configuration program. You can also test the communications in the configuration program.
Bar Code Scanning Failure	USB scanner not connected	Use notepad or WordPad to verify scanner can scan your codes. Once you can scan codes into WordPad, use the configuration program to test the parsing.
	Invalid configuration for RS232 scanner	Verify all RS232 settings using the bar code configuration program.
	RS232 scanner trigger incorrectly configured	Correct trigger string using the bar code configuration program.
	EthernetIP based communications configuration error	Verify the IP Address used to connect to the PLC is correct by pinging it
		Correct bar code input string address using the Industrial Communications configuration program. You can also test the communications in the configuration program.
Invalid parsing configuration	Correct parsing using the bar code configuration program.	
Program stalls at image acquisition	Incorrectly configured camera	Use configuration program to select camera an settings.
	Missing camera	Reconnect the camera
	Malfunctioning camera	Replace camera
	Malfunctioning cable	Replace camera cable
	Unable to store image	Check sufficient space available at storage path defined in logging parameters
Image acquisition is slow	Incorrectly configured camera	Use configuration program to select camera and adjust settings.
	External storage drive malfunction	Clean or replace storage drive
Program continuously waits for trigger off	Incorrectly wired part presence sensor	Refer to wire diagrams and correct.
	Malfunctioning digital input	Replace computer or IO device
		Verify the IP Address used to connect to the PLC is correct by pinging it

	EthernetIP based communications configuration error	Correct data output addresses using the Industrial Communications configuration program. You can also test the communications in the configuration program.
	Wiring issue	Refer to wire diagrams and correct
Program stalls and errors at Storing	Unable to connect to SQL database	View error log at [image storage path]\error log.txt and troubleshoot using details
	Inaccessible SQL server	Set write permissions
		Disable SQL storage by emptying UDL Filename control in logging parameters
Corrupted database	Reinstall software to reload the database	
Vision Analysis does not start using VBAI	Vision Builder AI does not start because wrong version	Make sure you have installed and licensed version 2015 f3 of Vision Builder AI
	TCP Server is not started on the Vision Builder AI	Use communications manager to enable the TCP server in Vision Builder AI
	The Lookup Table (LUT) is not configured correctly.	Modify the LUT configuration to use a valid configuration and model code.
	The .vbai configuration is missing components	Using the provided C:\Vision Builder AI Configurations\LM3 Template.vbai configuration, redo the vision analysis. If you accidentally modified the template file, a copy can be found at C:\Program Files\LM3 Technologies, Inc\PAQi\Data
Vision Analysis does not run when trying to calibrate for TensorFlow	TF Server not running	Start server at
Vision Analysis fails	The inspection state of the .vbai file is configured wrong.	Modify the .vbai configuration file related to the model code being tested.
	The Lookup Table (LUT) is not configured correctly.	Modify the LUT configuration to use a valid configuration and model code.

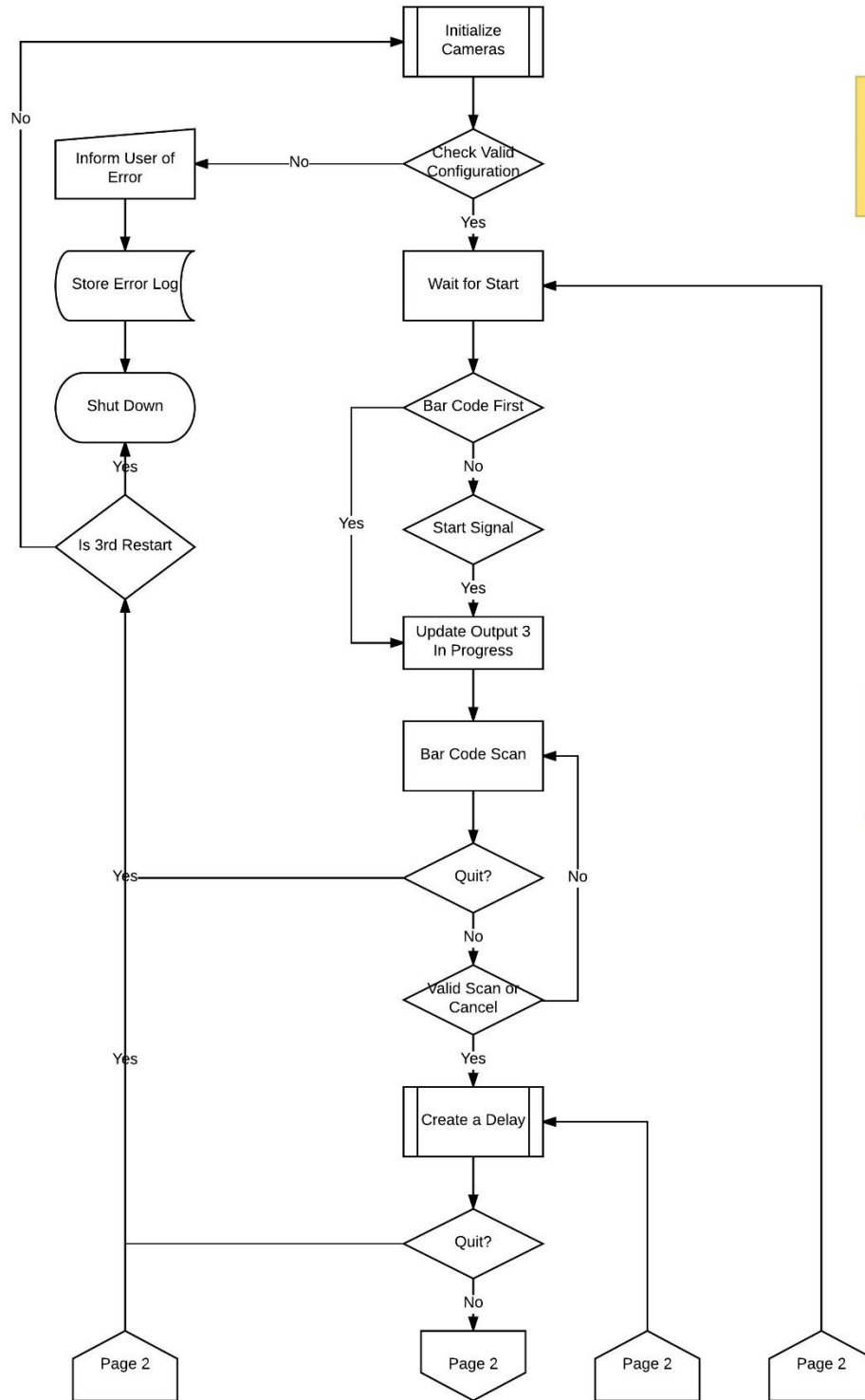
## Troubleshooting Camera Drivers



If you are unable to obtain an image from the camera, make sure the correct drivers are loaded. At the time of this manual, Imaging Source DFK cameras are being used and the above drivers should be installed. You can also use their program IC Control 2.4 to troubleshoot the camera. An installer is located at C:\Program Files\LM3 Technologies,inc\PAQi\Data\setup\_iccapture\_2.4.642.2631.en\_US.exe.

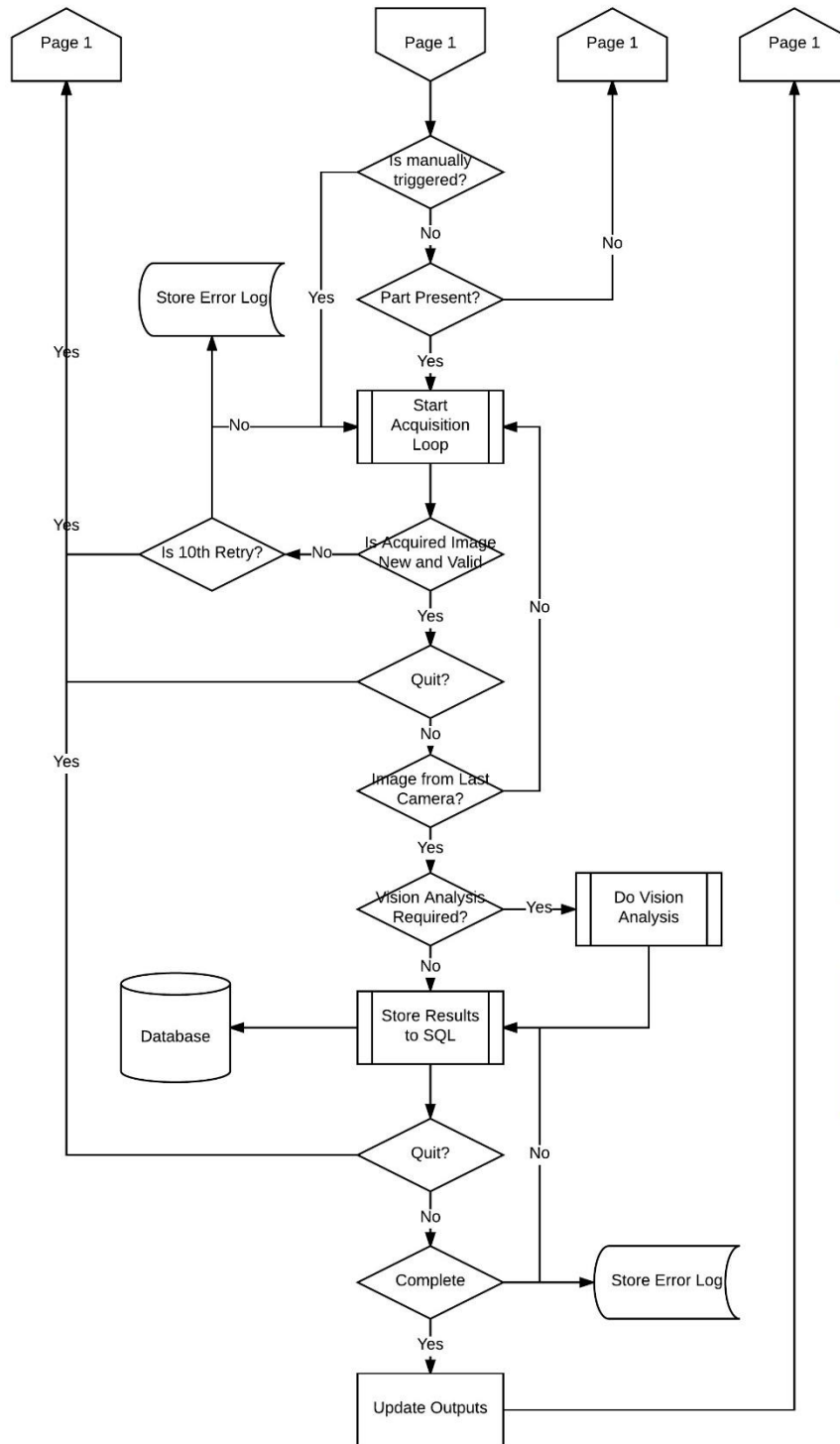
# Program Flow Chart

Stand Alone Image Acquisition SM Process Flow  
 Last Updated 6/13/2017 by Michael Walt



Invalid configuration include improper settings or a missing camera

If using a RS232 scanner, port 2 must be valid and properly configured



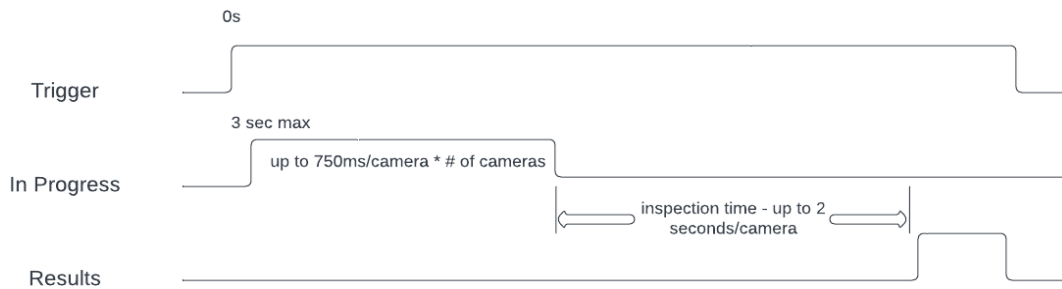
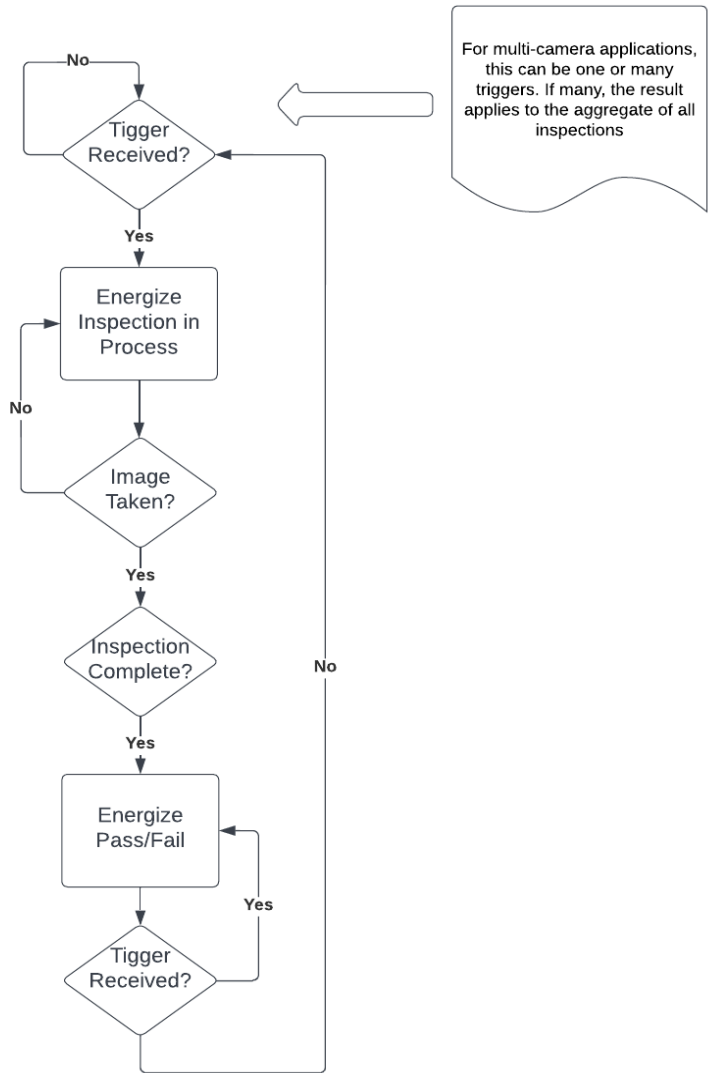
An inability to connect to a camera or out of focus image can cause an error. Additionally, if storage location is inaccessible, full, or delayed, errors can occur along with delays

The program does not error on a failed inspection but will error on these steps if the VBAI configuration is invalid or TCP communications fails

SQL has built in error detection and will inform of an inability to connect or write data

# Line Interface Flow Chart

## PAQi Line Interface

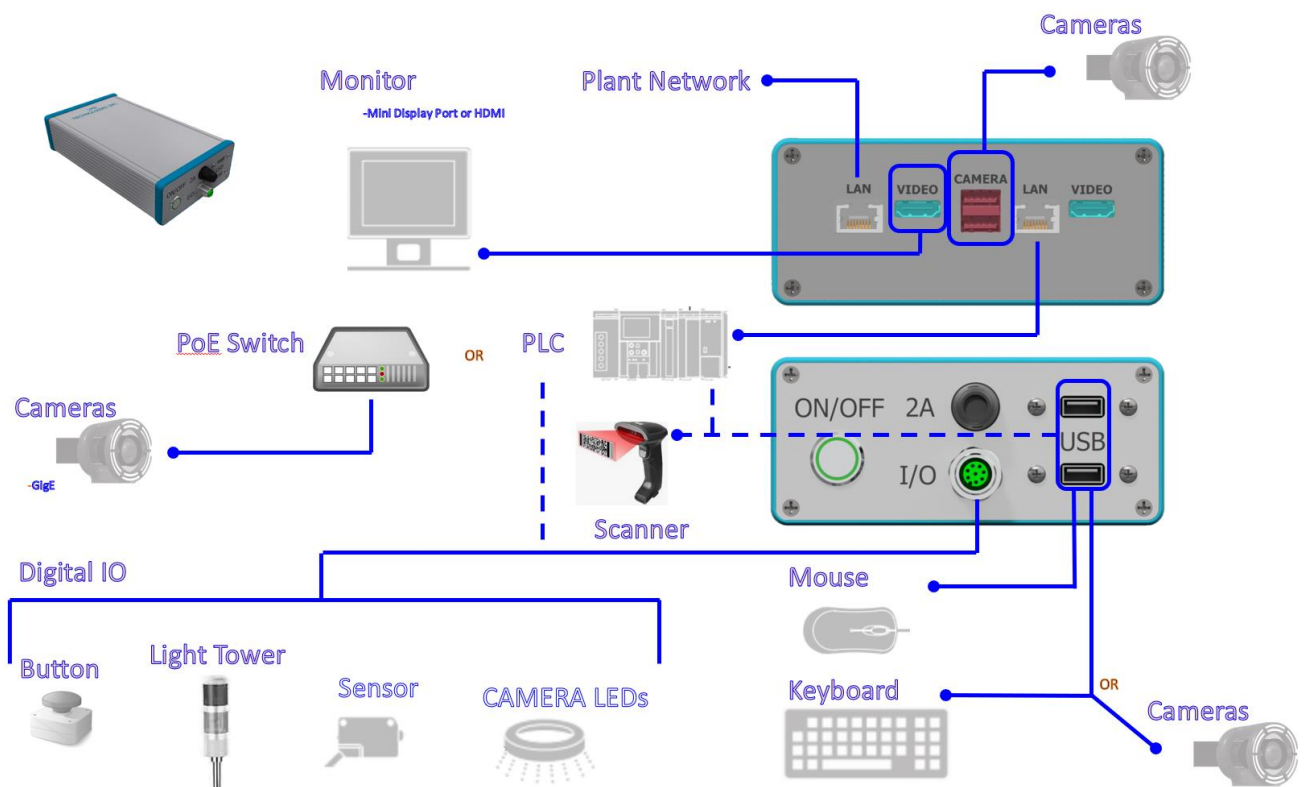


## Reference Materials

- [Imaging Source Camera and Lens Manufacture's Website](#)
- <http://sine.ni.com/psp/app/doc/p/id/psp-741/lang/en> - NI page for Vision Builder Automated Inspection
- [PAQi Video Manual](#)
- [Part 1 - General PAQi System Setup](#)
- [Part 2 - Operational Program No Step Mode](#)
- [Part 3- Step Mode Configuration](#)
- [Part 4 - Setting Up Inspection using AI](#)
- [Part 5 - Operational with Inspection](#)
- [Part 6 - SQL Results and Excel Macro](#)
- [QC Hero Online Training Website](#)

## System Layout Diagrams and Schematics

### PAQi Hardware Configuration Options



## Preventative Maintenance

The PAQi system requires very little maintenance once setup. The following is suggested:

- Daily – verify all cameras are in focus and the exposure setting is set properly to get good images.
- Monthly - Clean camera lenses using lens cleaner taking care not to scratch them.
- Yearly – review file storage requirements and archive old images.