IntelliPaper Scanning System Manual

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6/13/13

Introduction

The purpose of this machine is to automatically sort between good and bad intelliPaper cards. The general procedure uses a Motoman MH5L robot arm equipped with a suction grabber to move cards from an input stack to either a good or bad pile. The cards are scanned with a probe mounted on a roller carriage to test them while the robot is moving the previous card.

Figure 1 Motoman Robot

Parts

1) Rolling Carriage. The frame that holds the USB scanner probe rolls by means of bearings on the two vertical supports. The correct pressure is maintained on the probe by adjusting the counterweight.

2) Paper Holding Bracket. This is a bracket defining the corner into which cards are set in order to be aligned properly for scanning.

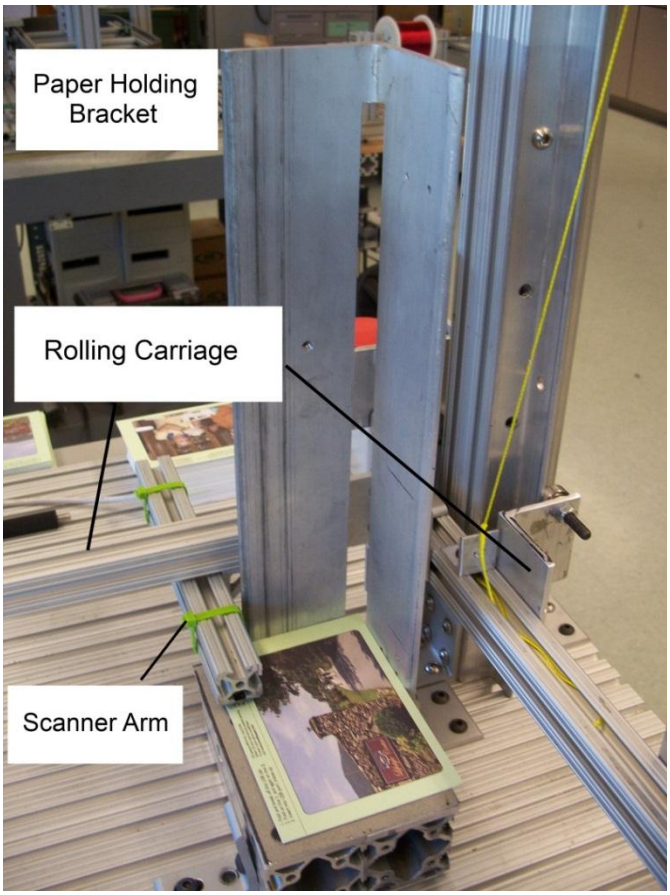


Figure 2 Scanning System

3) USB scanner probe. The USB scanner probe is mounted on the end of an arm extending from the rolling carriage. The position of the probe can be easily adjusted by loosening the bolts that hold the arm in place. The wires that connect the scanner probe to the testing circuit board are run through the scanner probe arm.

Figure 3 Scanning Probe

4) Motoman Robot (MH5L). The Motoman Robot is used for moving the intelliPaper from the scanning pile to either the good or bad pile. The top piece of intelliPaper is moved by four suction cups mounted on the end of the robot.
5) Programmable Logic Controller. The Automation Direct DL06 PLC is used in this system, but any similarly capable PLC will suffice.
6) Other utilities: compressed air for the suction tool mounted on the robot. 24V DC power supply.

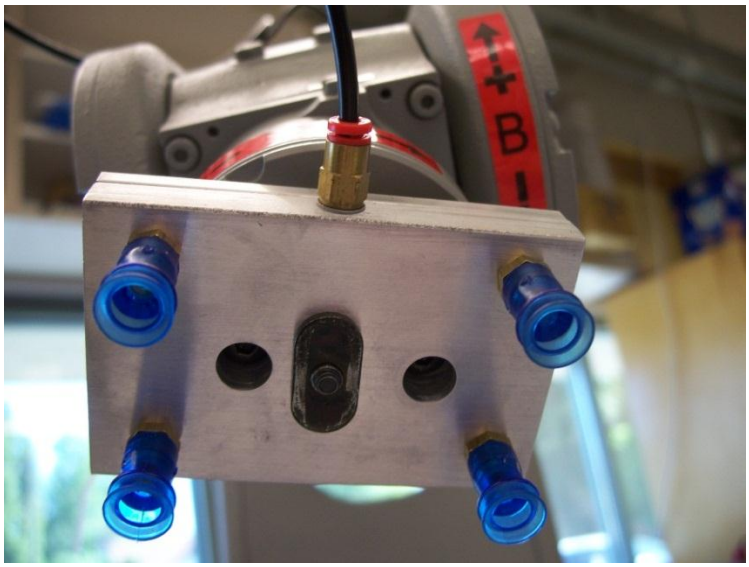


Figure 4 Suction Tool

7) Friction Roller (Not pictured). A means for singulating sheets of intelliPaper. Attaches to the rolling carriage and applies friction to the stack of cards preventing the robot from removing more than one at a time.

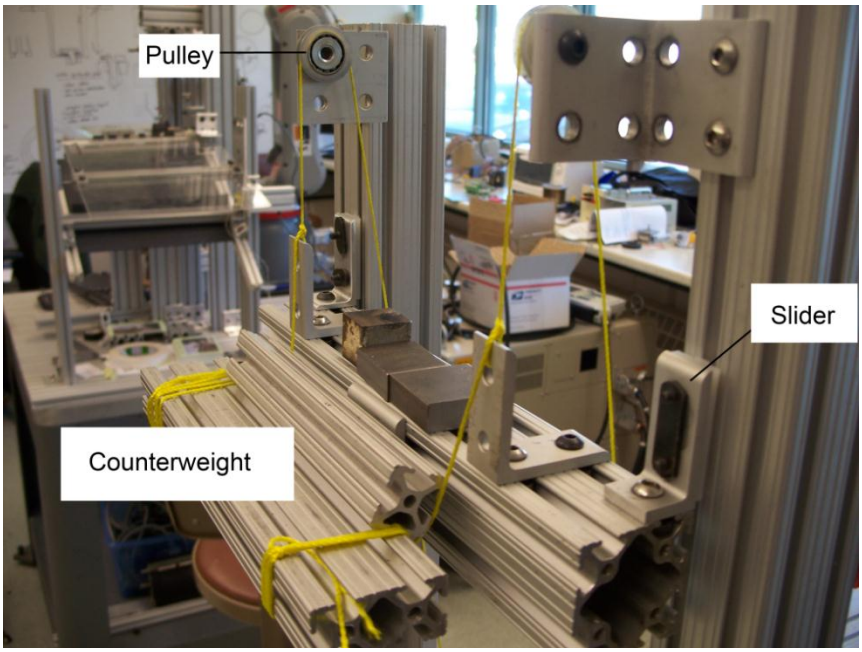


Figure 5 Adjustable Counterweight System

Initial Setup

This setup process must occur when a new paper size is loaded into the machine for the first time. For each paper size there must be a separate robot program. The program variables must be reset to specify the locations for card pickup, the drop piles, and other intermediate locations. When the new program is created, it may be saved and reloaded onto the robot the next time the same paper size is used without having to reset all the program variables. A sample table showing each position variable is shown below (Table 1), followed by an explanation of each variable and when it needs to be set. All the highlighted spots must be set when a new program is created for a new paper size. The spots highlighted in blue must be reset with each new stack of cards placed into the machine.

Positions for 3 X 5 paper size robot program						
Position Variable	X (mm)	Y (mm)	Z (mm)	RX (deg)	RY (deg)	RZ (deg)
P001	258	-46	496	.3	0	-48
P007	544.9	-32.1	-115.5	-0.35	-1.04	42.85
P008	544.9	-32.1	-125.5	-0.35	-1.04	42.85
P009	0	0	0.58	0	0	0
P010	414	-262	-294	-0.35	-1.04	42.85
P011	246	-262	-294	-0.35	-1.04	42.85
P012	544.9	-227	-125.5	-0.35	-1.04	42.85

Table 1. Robot program position variables

P001: Home. This is the robot home position, intentionally quite distant from the rest of the machine to be out of the way for other machine setup procedures. It goes to this position at the start and end of a program. This position is constant and never needs to be reset.

P007: Initial Above Stack. This is where the robot goes to first before coming down to suck up a card to make sure that it does not jam up the stack of cards or suction cups. The X and Y spots of this position need to be set every time a program is created for a new card size in order to pick up sheets off of the stack efficiently. The Z spot must be reset every time a new stack of paper is put into the machine or when paper is added or taken away from the stack.

P008: Initial Stack Surface. This is where the robot goes to actually pick up the sheet. Set this variable at the same times as P007.

P009: Height Increment: This is a position variable that holds the value for the paper thickness in its Z spot. It should never need to be reset unless a different thickness of paper is used.

P010: Initial Good Drop. This is where the robot goes to drop good cards in a pile. This position needs to be set every time a program is created for a new card size. Only the X and Y spots should have to be adjusted.

P011: Initial Bad Drop. This is where the robot goes to drop bad cards in a pile. Set this variable at the same times as P010.

P012: Initial Clear of Stack. This is where the robot goes as it slides the top sheet off of the pile. Set this variable at the same times as P007.

Before Starting a Job

1. Place the correct table in the corner of the paper holding bracket.
2. Raise the rolling carriage and then place the stack of cards into the corner of the paper holding bracket. (Ensure that the USB contacts are accessible).
3. Adjust the USB scanner probe location so that it will contact the intelliPaper USB contacts. This is done simply by loosening the bolts on the scanner arm, adjusting the position, and then retightening the bolts.
4. Ensure that the USB testing circuit board is powered.
5. Measure the height of the paper from the table top surface. Use this measurement to update the position variables in the robot program that are highlighted in blue in Table 1*.
6. Set the number of cards that you wish to scan into the robot program. This is set towards the end of the program and appears as follows to allow for 50 cards to be scanned:

```
IFTHEN I000>50
```

7. Turn on the PLC and set it to RUN mode. As it is currently configured, the red button associated with input X4 must be released and toggle switch X100 must be turned on.
8. Turn the robot control to “Play”, push the “Servos on” button, and then push the green start button.

* It is recommended to always start each program with the paper loaded up to a specific height so that this variable does not need to be adjusted. This will reduce the time spent loading new stacks of paper.

Continuing Work

1) Tighten up tolerances to take the play out of the pulley system.
2) Solve the problem of multiple cards sliding out at once.
    a. Friction roller on the side
    b. Guard plate that blocks all but the top sheet
    c. Air bursts under top card
3) Provide a faster means of adjusting the bottom surface table for new sizes.
    a. Have the paper corner slide along a flat surface so the scanning location and robot positions do not have to be adjusted very much with new paper sizes.
4) Optimize robot program to move most efficiently for each paper size.
5) With each new paper size and for taller paper stacks (more than 200 cards) robot position variables must be adjusted and set so that the robot movements will not interfere with card stacks.

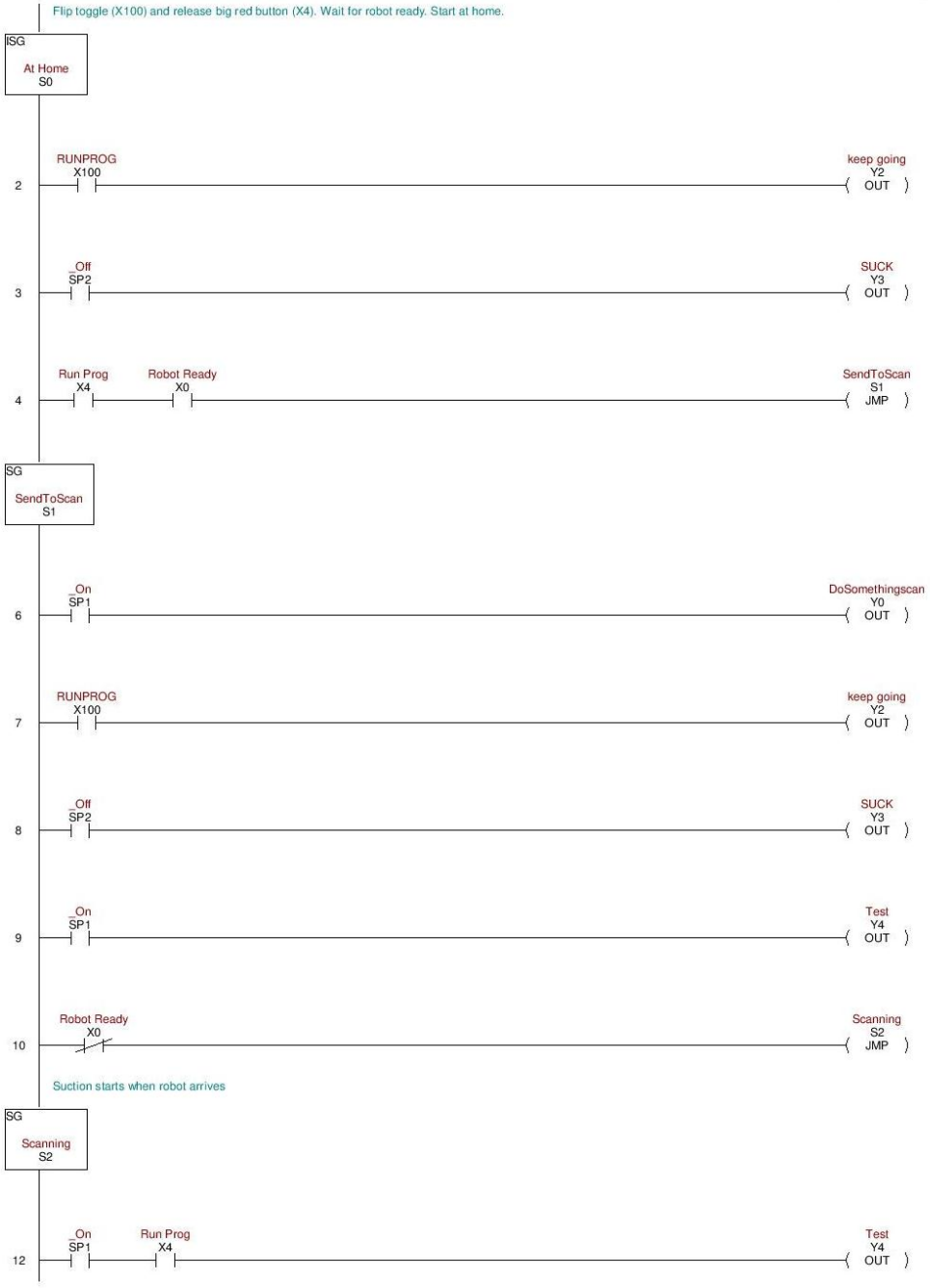
6) Fine tune PLC logic to ensure error states are safeguarded against.

Long-Term Maintenance

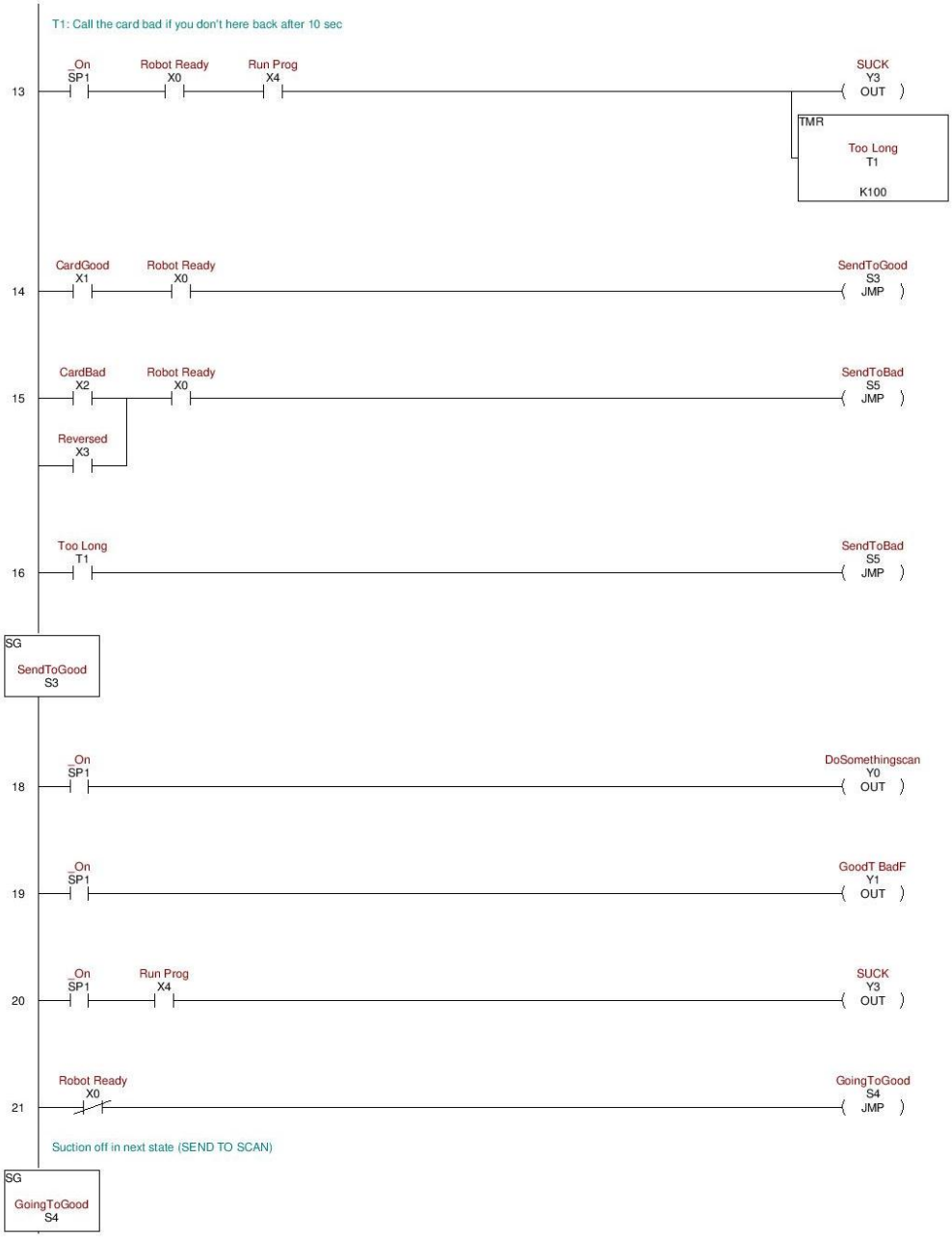
For the framework of the machine, the bearings need to be inspected once a month and changed once every one to three years depending on the amount of use. For maintenance on the Motoman robot, see the attached maintenance manual for the DX 100 Motoman robot. The spring connectors on the USB scanner probe must be inspected every 10,000 cards for wear and tear. If the just one of the spring contacts fails to make a good contact the USB scanner probe must be replaced.

PLC Ladder Diagram

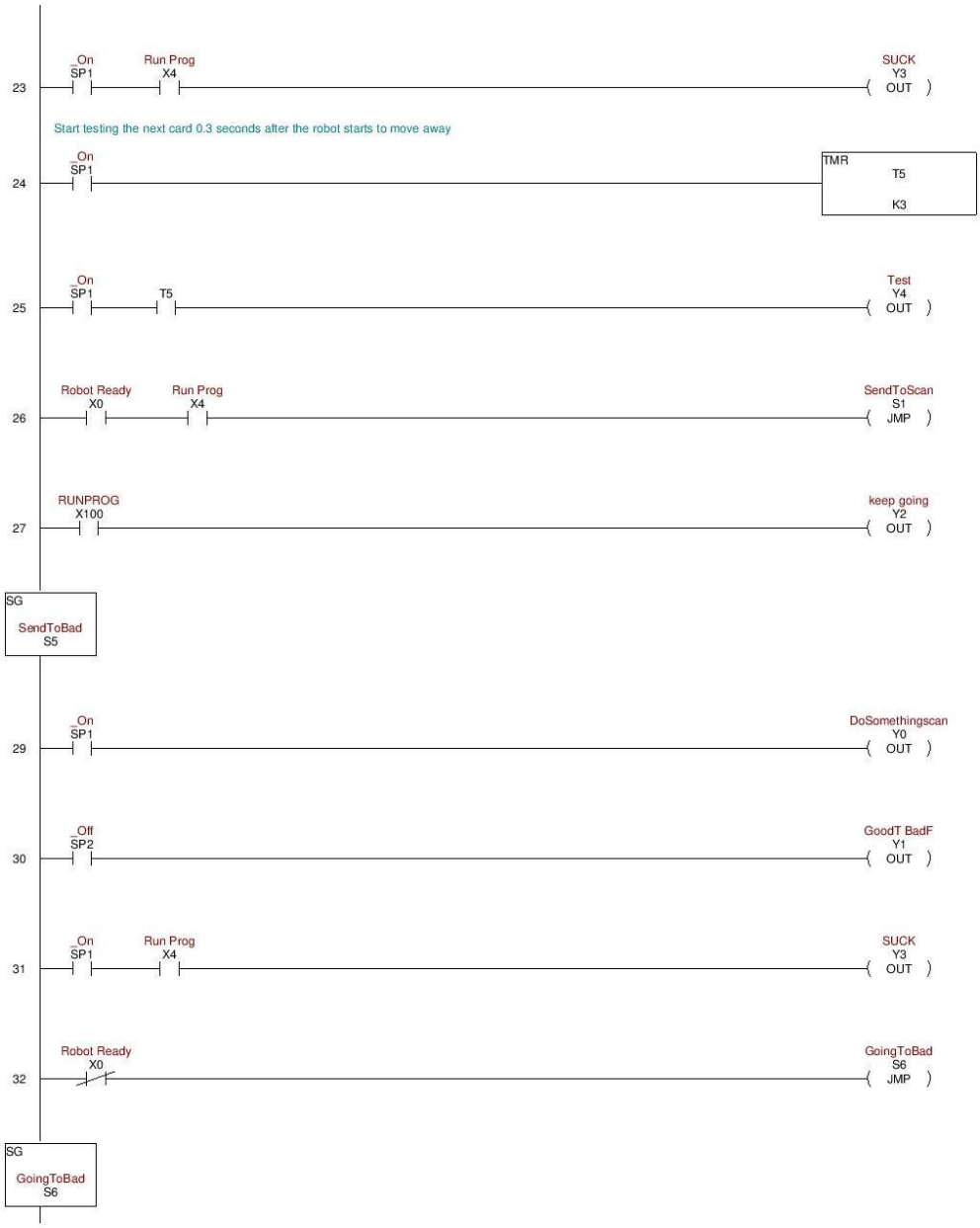
Below is the ladder diagram that should be written to the Programmable Logic Controller.



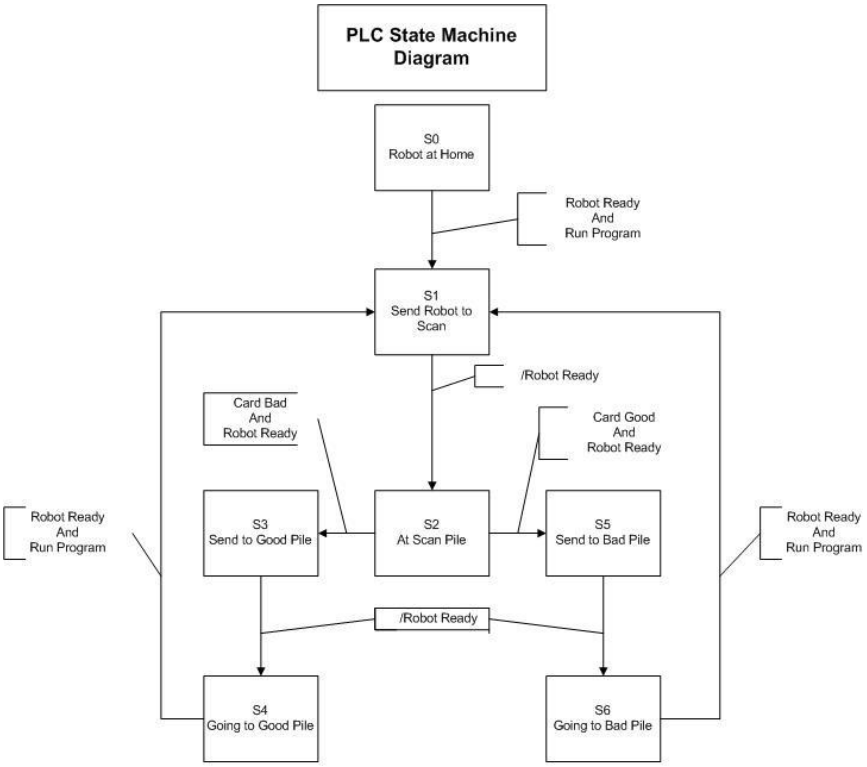
IntelliPaper USB testing machine



IntelliPaper USB testing machine



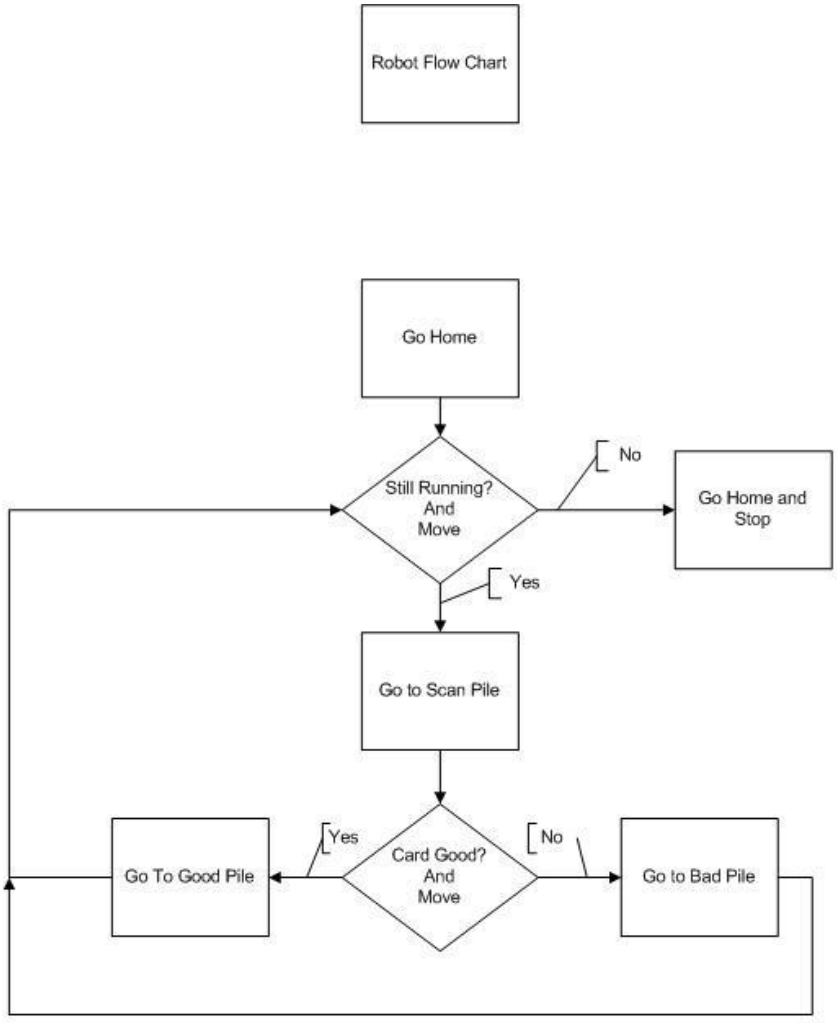
IntelliPaper USB testing machine



Inputs

X0	Robot Ready
X1	Card Good
X2	Card Bad
X100	Run Program

Robot Flow Chart



Inputs	
DIN1 (Y#)	Move
DIN2 (Y#)	Good Card (True)
DIN3 (Y#)	Still Running

Robot Program

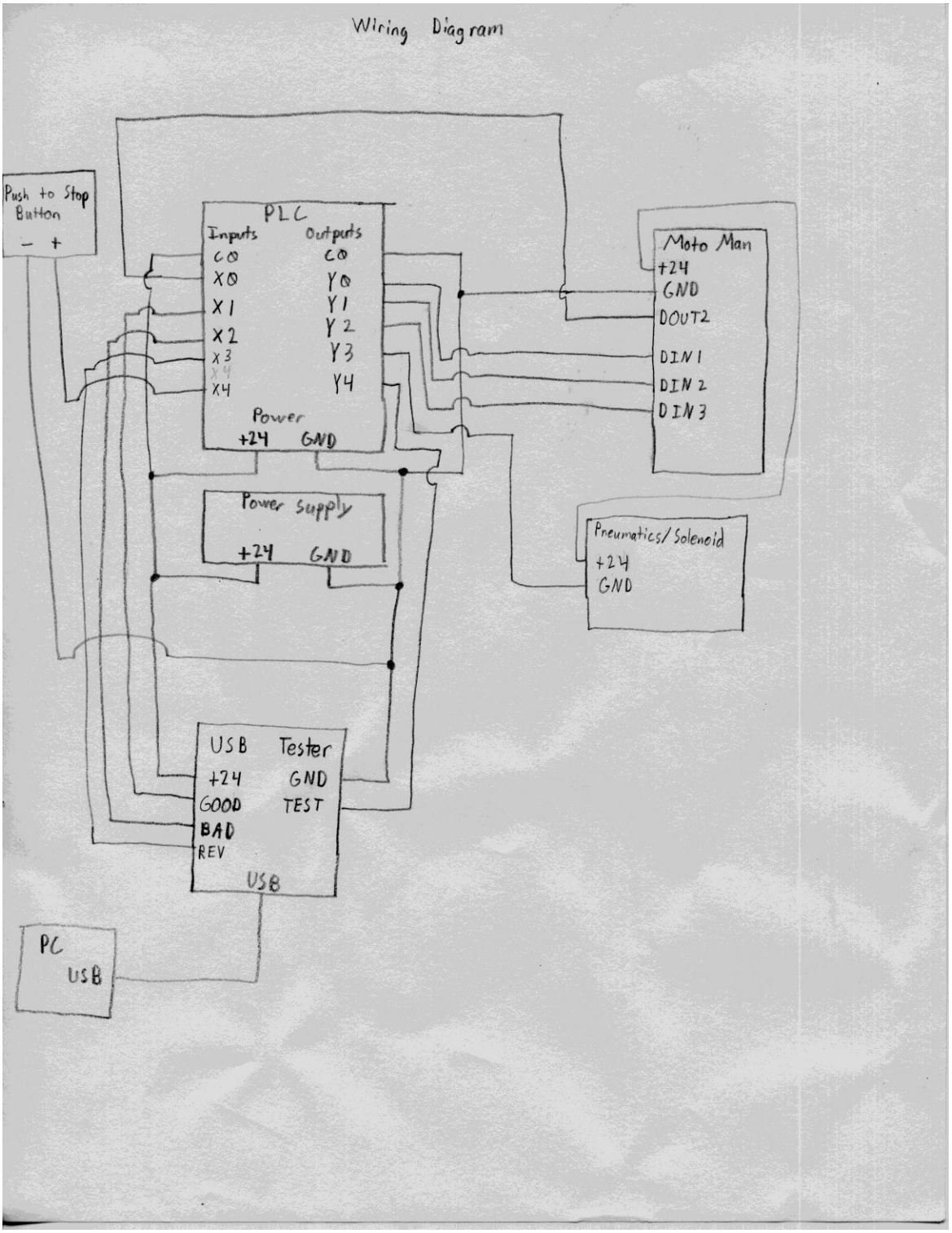
A sample program is given below for testing a 3x5 paper size. This program can be edited as a text document, saved as a JBI file, and loaded directly into the Motoman controller. The name of the file must match the second line of the program. For example, this program must be saved as “3X5TESTPROG.JBI” in order to successfully load the program onto the controller.

The program works by first going home, and then setting the variables to the correct values and starting a counter. Then the robot and the PLC communicate back and forth using input and output signals, and the robot follows a specified path between the position variables. As long as the robot continues to receive the signal telling it that the program is on (the toggle switch X100 on the PLC), then the positions and counter will increment and keep track of stack height and number of cards. After it done the pre-specified number of cycles (number of cards) the robot will stop and go home.

```
/JOB
//NAME 3X5TESTPROG
//POS
///NPOS 0,0,0,12,0,0
///TOOL 0
///POSTYPE BASE
///RECTAN
///RCONF 0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0
P00001=258.000,-46.000,496.000,-3.0000,0.0000,-48.0000
P00002=544.900,-32.100,-144.500,-0.3500,-1.0400,42.8500
P00003=544.900,-32.100,-154.500,-0.3500,-1.0400,42.8500
P00004=544.900,-227.000,-154.500,-0.3500,-1.0400,42.8500
P00005=414.000,-262.000,-265.000,-0.3500,-1.0400,42.8500
P00006=246.000,-262.000,-265.000,-0.3500,-1.0400,42.8500
P00007=544.900,-32.100,-115.500,-0.3500,-1.0400,42.8500
P00008=544.900,-32.100,-125.500,-0.3500,-1.0400,42.8500
P00009=0.000,0.000,0.580,0.0000,0.0000,0.0000
P00010=414.000,-262.000,-294.000,-0.3500,-1.0400,42.8500
P00011=246.000,-262.000,-294.000,-0.3500,-1.0400,42.8500
P00012=544.900,-227.000,-125.500,-0.3500,-1.0400,42.8500
//INST
///DATE 2013/06/12 23:07
///ATTR SC,RW
///GROUP1 RB1
NOP
DOUT OT#(2) OFF
SET P002 P007
SET P003 P008
SET P004 P012
SET P005 P010
SET P006 P011
SET I000 1
MOVL P001 V=300.0
WHILE IN#(3)=ON
        DOUT OT#(2) ON
        WAIT IN#(1)=ON
        DOUT OT#(2) OFF
        TIMER T=0.10
        MOVL P004 V=500.0
        MOVL P002 V=500.0
        MOVL P003 V=300.0
```

```
        DOUT OT#(2) ON
        WAIT IN#(1)=ON
        IFTHEN IN#(2)=ON
               DOUT OT#(2) OFF
               MOVL P004 V=150.0
               MOVJ P005 VJ=100.00
        ELSEIF IN#(2)=OFF
               DOUT OT#(2) OFF
               MOVL P004 V=150.0
               MOVJ P006 VJ=100.00
        ENDIF
        SUB P002 P009
        SUB P003 P009
        SUB P004 P009
        ADD P005 P009
        ADD P006 P009
        INC I000
        IFTHEN I000>50
               JUMP *STOP
        ENDIF
ENDWHILE
*STOP
DOUT OT#(2) ON
MOVL P001 V=300.0
END
```

Wiring Diagram



Performance

Properly configured and calibrated, the machine can read and sort cards at a rate of one card every three seconds. The machine is capable of sorting a stack of paper two feet in height. The machine is capable of sorting to multiple stacks (not just good or bad) but this requires more involved programing of the robot. When the robot is moving, it is a good idea to stay clear of the robot work area, serious injury or severe death could ensue in case of a human/robot accident.

Maintenance

For the framework of the machine, the bearings need to be inspected once a month and changed once every one to three years depending on the amount of use. For maintenance on the Motoman robot, see the attached maintenance manual for the DX 100 Motoman robot. The spring connectors on the USB scanner probe must be inspected every 10,000 cards for wear and tear. If the just one of the spring contacts fails to make a good contact the USB scanner probe must be replaced.