Conestoga College Institute of Technology and Advanced Learning

Electrical Engineering Technology

PB1803 reflow oven

EECE3330

Term: Winter 2015

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Date: Friday, April 10

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# Abstract

A common problem in industry today is that for smaller operations, assembled PCB based products have to be moved from the pick and place machine to the solder reflow oven by hand. Production by hand, even with skilled workers, will contribute to losses in production output and profit, when compared to a fully automated production process.

The PB1803 Reflow Oven from RBM Solutions is designed for small and medium sized enterprises (SMEs) who are interested in automating their entire manufacturing process to meet increasing demand. With an easy to use design, backed by powerful SCADA (Supervisory Control and Data Acquisition) management tools, the PB1803 from RBM Solutions will be an important addition to any production line.

# Acknowledgements

RBM Solutions would like to acknowledge José Delgado and Terry Walker for their contributions in leading the team to the current design with many helpful comments and suggestions. The team would also like acknowledge Dana Xu for her help in finding the parts and components used in this design. A special acknowledgement to BDL Consulting, who graciously donated their SLC5/05 processor. The SCADA and wireless connectivity components of this project would not have been possible without their contribution. Another special acknowledgement to Neal Palmer of ME Industries for his help in leading the team to a solution for the pneumatic gripper.

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# Introduction

The PB1803 Reflow Oven from RBM Solutions is designed to work in conjunction with the RBM Solutions PM1800 line of pick and place machines for a seamless, fully automated manufacturing operation. Capable of handling assembled products up to 76.2 millimeters in width, And equipped with industry leading safety features, The PB1803 is the perfect fit for any small to medium sized businesses.

# Purpose

The purpose of this report is to detail the design and specifications of the PB1803 Baking Station so that the end-user can operate the machine for its intended purpose and in a safe manner. The design detailed in this report is final, but can be subject to change, when necessary.

# Background

The solder reflow ovens commonly found in the market today, employ infrared heaters to heat up the pre-applied solder paste past its melting point by means of radiation. The liquid solder will then flow freely around electrical connection points. For some larger machines, the last step of the process involves moving the product through one or more cooling zones. When the solder material is sufficiently cooled, the solder joint creates a solid electrical and mechanical connection between the component and the PCB. Due to specific thermal profiles of the product, temperature control and monitoring is achieved through statistical process control (SPC). Typical machines range from small desktop units similar to a toaster oven to large standalone units equipped with conveyors and capable of producing dozens of boards at a time.

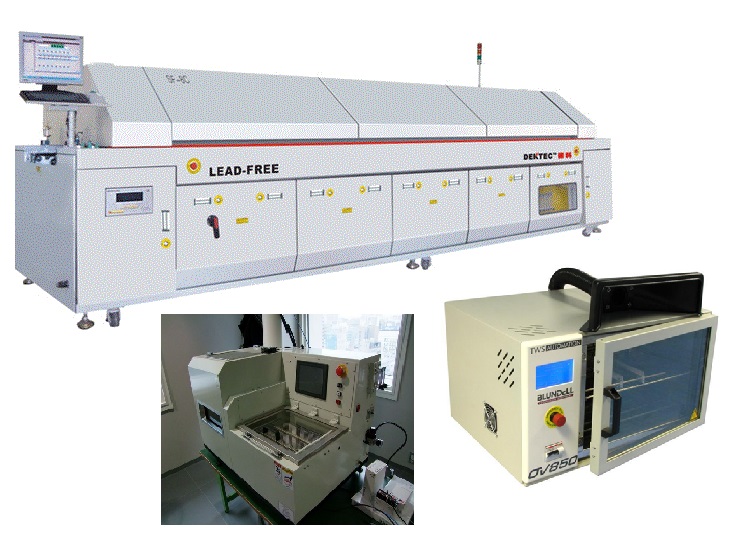


Figure : Typical reflow ovens. Units range from desktop ovens to large stand-alone machines.

# Equipment

The PB1803 will use the SLC500 series of PLCs from Allen Bradley. A single SLC500 seven-slot chassis will house all the input and output cards, along with the processor. In slot zero, there will a SLC 5/05 processor. Slots one and two will be used by a 16-point DC input card and a 16-point DC output card, respectively. A 4-point 1756-NIO4V analog input/output card will occupy slot three. In slot four, an HSTP1 stepper motor driver card will provide a PWM signal to drive all the stepper motors in the machine.

Motion on both axes are provided by SMC LXSH2SA-125 linear actuators. These linear actuators are driven by DC stepper motors. A stepper motor driver board drives each stepper motor with a PWM signal from the HSTP1. The PB1803 is equipped with a vacuum gripper, allowing the machine to pick up products of a variety of sizes. The vacuum gripper also prevents any electrostatic discharge, which may cause damage to an electronic component. The rest of the pneumatic system consists of a small SMC pressure regulator, a 5/3 way solenoid valve, and a vacuum pump.

Products will be transported by two small conveyors, both driven by a small single phase motor. A halogen bulb will simulate the heater element for the oven. Temperature measurement will be provided by a T-type thermocouple. The thermocouple signal is amplified by a thermocouple transmitter, whose output is fed as a 4 to 20 milliamp signal to the 1746-NIO4V analog card. Photo-eye sensors are used to detect the position of the product along the conveyor.

An HMI panel will provide the operator with a simple user interface. The HMI is a Panelview Plus 700 from Allen Bradley. The 24 volts DC used by the Panelview and other devices are provided by a 1606-XLS from AB. To increase visibility inside the machine, two LED light strips will be used. The LED strips requires 12 volts DC, which is supplied from a 1606-XLP 12 volt power supply, also from Allen Bradley. Aside from simulated buttons on the HMI, the PB1803 is equipped with physical start and stop pushbuttons. The Allen Bradley 800H series of pushbuttons are used. Wireless connectivity to the machine is provided by a Linksys E2500 dual band router, using the wireless N protocol (IEEE 802.11n-2009). The router also acts as a switch, allowing for Ethernet connection to the machine. The wireless connection is configured for MAC address filtering, only allowing access to authorized machines.

Incorporated into the design, are an array of safety features. Access to the machine is restricted by a pair of STI TL5012 guard locks on the doors. There are also emergency stop push buttons located on the front and rear sides of the machine. Pilot lights and a stack light will indicate to the operator that the machine is either running in auto mode, manual mode, or in emergency (off) mode, through the amber, green, and red lights. There will be 3 panels. One 40cm by 30cm panels will house all the power supplies and the terminal blocks for the 120 volt line-in. Another 40cm by 30cm panel will house the SLC500 rack and the DC terminal blocks. A 15cm by 30cm panel will contain the master safety relay. The power electrical panel will be protected with a safety disconnect, only allowing access to the panel by first removing power to the entire system. Finally, a master safety relay will be used to implement a dual-channel, control reliable safety circuit.

T-slotted aluminum framing will make up the structure on which the machine is built around. Plexiglas will enclose the working surface of the machine. Painted plywood will cover the rest of the machine, and will also be used for the build surface. The PB1803 is placed on top of four, 4” locking castors.

For the specific model numbers of each component, please refer to Appendix A: Parts List.

# Procedure

The process begins with the indicator light on green, signaling to the operator that the machine is on automatic operation mode. This signifies that the previous job is done, and the machine is ready for the next product. The operator will load a unfinished product onto the conveyor. When the part is in place, the operator will be prompted to press the start pushbutton. Either the physical start pushbutton or start button icon on the HMI can be pressed. The machine will now begin to move the product down the conveyor to the pick-up location. The vacuum gripper will then pick up the product from the infeed conveyor to the bake conveyor. The bake conveyor will move the product to the baking location, and the heating element will turn on until the pre-set temperature is reached. After the product has been processed, the bake conveyor will move the product to the drop-off bin. For the duration of the building process, the indicator light will be on yellow. If any one of the safety devices is triggered during the building process, the machine will remove power to all motion and the indicator light will turn red and the HMI will also display a warning message.

# Power Requirements

The machine is designed to operate on standard 120V AC. The total current required is estimated to be around 7.46 amps. Under the Ontario Electrical Safety Code guidelines, the full load current of a machine should be no more than 80% of the rating of a fuse. A 15 amp circuit breaker will be more than adequate in providing overcurrent protection. For more detailed information about the estimated maximum power requirements of the individual components, please refer to Table 1: Power Requirements shown below. The PB1803 is measured to draw about 0.45 amps when idle, and about a maximum of 0.82 amps during the baking process. The maximum current draw occurs when the bake conveyor and the y-axis are moving simultaneously. The measurements are taken by a clamp-on multi-meter.

**Table 1: Power Requirements**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Item** | **Voltage** | **Current (A)** | **Quantity** | **Total Current (A)** |
| *PLC* | 120 VAC | 0.96 | 1 | 0.96 |
| *HMI* | 24 VDC | 1.6 | 1 | 1.6 |
| *Sanyo Denki Stepper Motor (linear actuator)* | 3.1 VDC | 1 | 2 | 2 |
| *Linksys Router* | 9 VDC | 1 | 1 | 1 |
| *800L Pilot Light* | 24 VDC | 0.015 | 3 | negligible |
| *Stack light* | 24 VDC | 0.015 | 3 | negligible |
| *Single Phase Induction Motor (conveyor)* | 115 VAC | 0.2 | 2 | 0.4 |
| *LED Light Strip* | 12 VDC | 0.5 | 2 | 1 |
| Halogen Bulb | 120 VAC | 0.5 | 1 | 0.5 |
| **Estimated Total Max Current:** | | | | **7.46 Amps** |

# Conclusions

The PB1803 reflow oven is designed to handle medium sized components. In replacing the need to move assembled components from the pick and place machine to the reflow oven by hand, production rates are increased. The ease of use and the small physical footprint of the PB1803 allows the end user to place the production line anywhere.

# Appendix A: Parts List

|  |  |  |  |
| --- | --- | --- | --- |
| **Item** | **Manufacturer** | **Model** | **Quantity** |
| SLC 5/05 | AB | 1747-L552 | 1 |
| DC Input Card | AB | 1746-IB16 | 1 |
| DC Output Card | AB | 1746-OB16 | 1 |
| Analog Input Output Card | AB | 1746-NIO4V | 1 |
| Stepper Module | AB | 1746-HSTP1 | 1 |
| 7-Slot Chassis | AB | 1746-A7 | 1 |
| SLC500 Power Supply | AB | 1746-P2 | 1 |
| Panelview Plus 700 | AB | 2711P-RP7 | 1 |
| Linear Actuator | SMC | LXSH2SA-125 | 2 |
| 19.75” Conveyor | ATS | Unknown | 1 |
| 14” Conveyor | ATS | Unknown | 1 |
| 115V Single Phase Motor | Oriental Motor | VH1206A-GV | 2 |
| Vacuum gripper | Unknown | Unknown | 1 |
| 5/3 solenoid valve | SMC | Unknown | 1 |
| Vacuum pump | Festo | Unknown | 1 |
| Air pressure regulator | SMC | AR20-N02EH-Z | 1 |
| Thermocouple | Omega | T-type | 1 |
| Thermocouple transmitter | Watlow | 96B1-CAAM-00RG | 1 |
| Red Pilot Light | AB | 800T-QBH2R | 1 |
| Green Pilot light | AB | 800T-QBH2G | 1 |
| Amber Pilot Light | AB | 800T-QBH2A | 1 |
| Stack light | AB | 855D-T00SC20B24Y6y5y6y7 | 1 |
| Photo-eye sensors | Banner | Q12AP6FF50Q3 | 5 |
| Start Push Button | AB | 800H-AR1 | 1 |
| Stop Push Button | AB | 800H-AR6 | 1 |
| Safety relay | AB | MSR127T | 1 |
| Guardlock | STI | TL5012 | 2 |
| E-stop | AB | 800T-FX6D4 | 2 |
| 24VDC Power Supply | AB | 1606-XLS | 1 |
| 12 VDC Power Supply | AB | 1606-XLP | 1 |
| Dual-Band Wireless N Router | Cisco Linksys | E2500 | 1 |
| Halogen Bulb | Phillips | 60 Watt | 1 |
| LED Light Strip | Unknown | Unknown | 2 |
| 40cm x 30cm Panel | AB | Unknown | 2 |
| 15cm x 30cm Panel | Unknown | Unknown | 1 |
| T-slotted Aluminum Frame |  |  | ~19.65m |
| Plexiglas | Generic |  | 1.89 m2 |
| Plywood |  |  | ~1.342m2 |
| 4” Locking Castors | Unknown | Unknown | 4 |

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