FLEXIBLE MANUFACTURING SYSTEMS (FMS)

A Closer Look

What Will Be Covered

- Definition
- History of FMS
- FMS equipment
- Types of FMS
- Applications of FMS
- FSM different approaches
- Advantages
- Disadvantage
- Development of FMS
- Nuts and Bolts
- How FMS works
- A real world example
- Summary

Definition

A Flexible Manufacturing System (FMS) is a production system consisting of a set of identical and/or complementary numerically controlled machine which are connected through an automated transportation system.

each process in FMS is controlled by a dedicated computer (FMS cell computer).

(Learn more…)

History of FMS

At the turn of the century FMS did not exist. There was not a big enough need for efficiency because the markets were national and there was no foreign competition. Manufacturers could tell the consumers what to buy. Henry Ford is quoted as saying people can order any color of car as long as it is black. This was the thinking of many big manufacturers of the time. After the Second World War a new era in manufacturing was to come. The discovery of new materials and production techniques increased quality and productivity. The wars end open foreign markets and new competition. Now the market focused on consumer and not the manufacturer. The first FMS was patent in 1965 by Theo Williamson who made numerically controlled equipment. Examples of numerically controlled equipment are like a CNC lathes or mills which is called varying types of FMS. In the 70 s manufacturers could not stay to date with the ever-growing technological knowledge manufacturers competitors have, so FMS became mainstream in manufacturing.

In the 80 s for the first time manufacturers had to take in consideration efficiency, quality, and flexibility to stay in business.

Equipment of FMS

- Primary equipment

  work centers
  - Universal machining centers (prismatic FMSs)
  - Turning centers (rotational FMSs)
  - Grinding machines
  - Nibbling machines

  Process centers
  - Wash machines
  - Coordinate measuring machines
  - Robotic work stations
  - Manual workstations

Equipment of FMS

- Secondary equipment

  Support stations

  - Pallet/fixture load/unload stations
  - Tool commissioning/setting area

  Support equipment

  - Robots
  - Pallet/fixture/stillage stores
  - Pallet buffer stations
  - Tools stores
  - Raw material stores
  - Transport system(AGVs,RGVs,robots)
  - Transport units(pallets/stillages)

Types of FMS

- Sequential FMS
- Random FMS
- Dedicated FMS
- Engineered FMS
- Modular FMS

Application of FMS

- Metal-cutting machining
- Metal forming
- Assembly
- Joining-welding (arc , spot), glueing
- Surface treatment
- Inspection
- Testing

FMS different approaches

- The capability of producing different parts without major retooling

- A measure of how fast the company converts its process/es from making an old line of products to produce a new product

- The ability to change a production schedule, to modify a part, or to handle multiple parts

Advantages of using FMS

- To reduce set up and queue times
- Improve efficiency
- Reduce time for product completion
- Utilize human workers better
- Improve product routing
- Produce a variety of Items under one roof
- Improve product quality
- Serve a variety of vendors simultaneously
- Produce more product more quickly

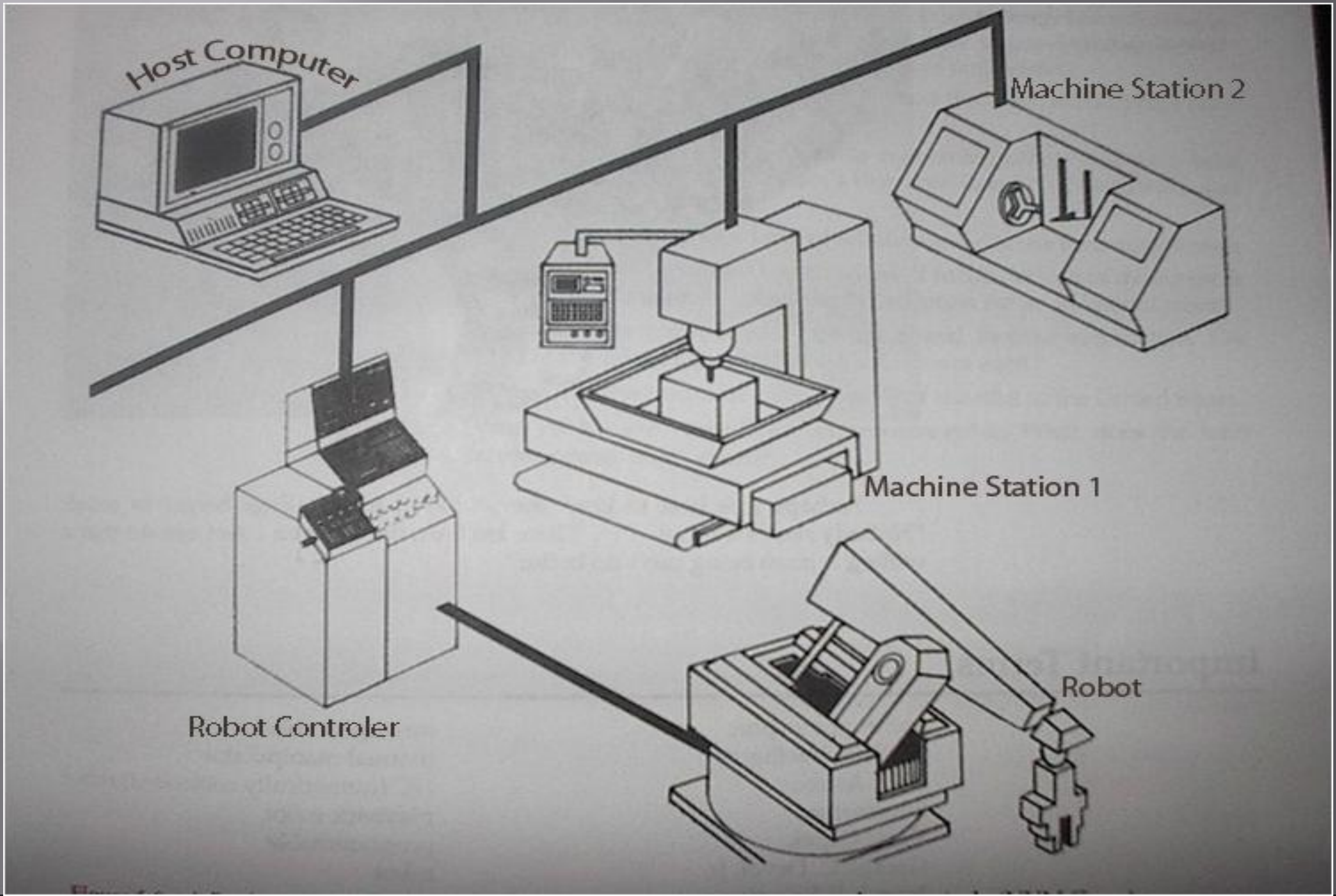
Disadvantage of using FMS

- Limited ability to adapt to changes in product or product mix (ex:machines are of limited capacity and the tooling necessary for products, even of the same family, is not always feasible in a given FMS)
- Substantial pre-planning activity
- Expensive, costing millions of dollars
- Technological problems of exact component positioning and precise timing necessary to process a component
- Sophisticated manufacturing systems

Development of FMS

- Several actions must be decided on before you can have a have a FMS. These actions include.
- Selecting operations needed to make the product.
- Putting the operations in a logical order.
- Selecting equipment to make the product.
- Arranging the equipment for efficient use.
- Designing special devices to help build the product.
- Developing ways to control product quality.
- Testing the manufacturing system.

Illustration example of a FMS



Nuts and Bolts of FMS

FMS Layouts

- Progressive Layout:
  - Best for producing a variety of parts
- Closed Loop Layout:
  - Parts can skip stations for flexibility
  - Used for large part sizes
  - Best for long process times

FMS Layouts Continued

- Ladder Layout:
  - Parts can be sent to any machine in any sequence
  - Parts not limited to particular part families

- Open Field Layout:
  - Most complex FMS layout
  - Includes several support stations

Flexible Automation

- Ability to adapt to engineering changes in parts
- Increase in number of similar parts produced on the system
- Ability to accommodate routing changes
- Ability to rapidly change production set up

Challenges with FMS

- Determining if FMS the best production system for your company (economically and socially)
- Possible expansion costs associated with implementing FMS
- Day to day maintenance of FMS operations

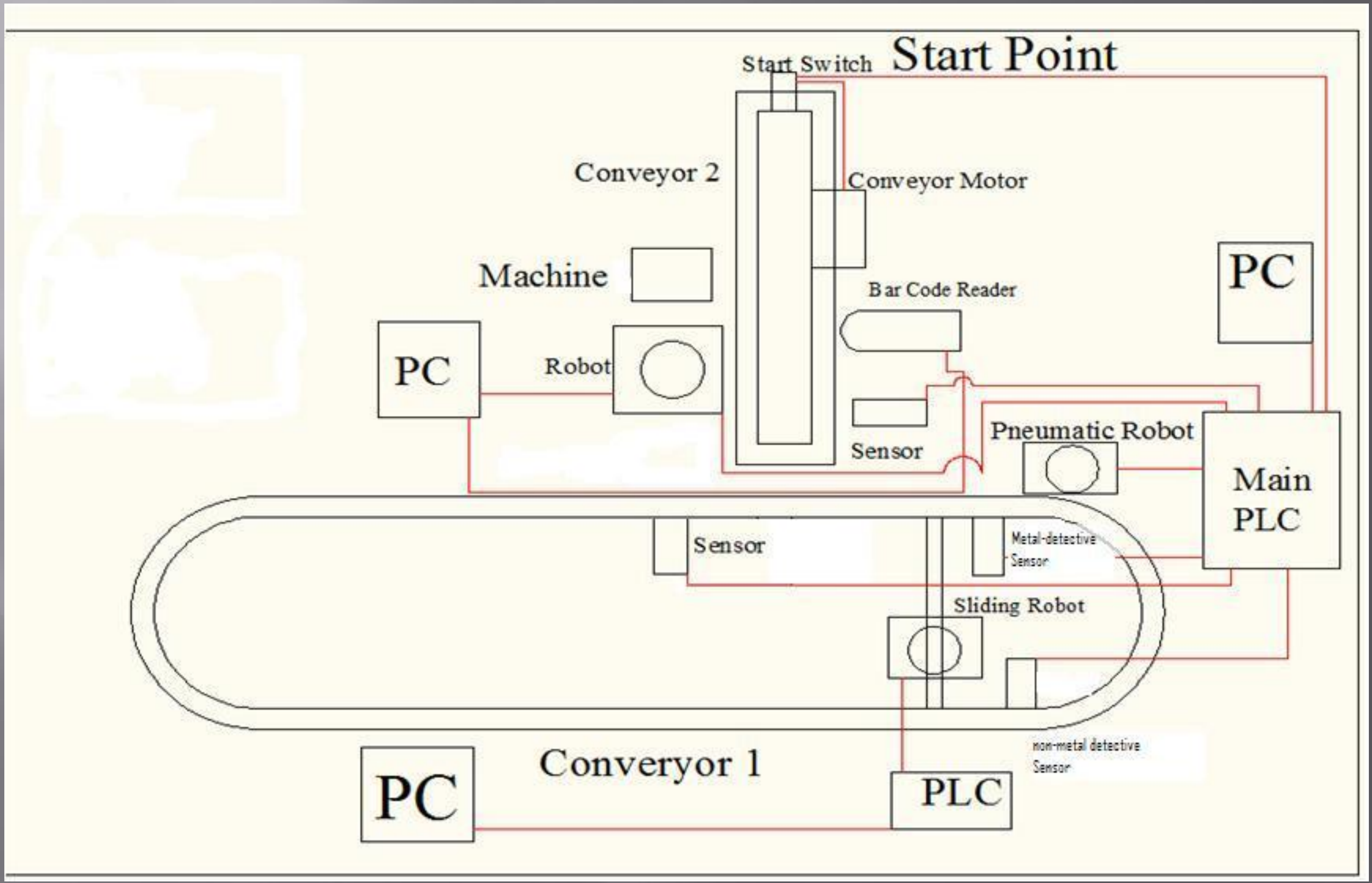
FLEXIBLE MANUFACTURING SYSTEM

How Does It Work ?

Making FMS Work

- By implementing the components of robotics, manufacturing technology and computer integrated manufacturing in a correct order one can achieve a successful Flexible Manufacturing System

An outline for Mechanical Engineering CAD/CAM laboratory Integrated System



Introduction

Location: CAD/CAM Laboratory in Mechanical Engineering Department
Concept : A flexible manufacturing system including different cells
Components:

Name of Device	*Quantity and description*
5 Axis Robot	2
Personal Compute	3
Universal belt Conveyor	1
Flexible Conveyor	1
PLC device	2
Sensors	9(4 Contact Sensors,3 Optical sensors,1 Metal detector and 1 Non-Metal Detector)
Motors	3(1 Emergency stop and run push button)
Other	

How does it work?

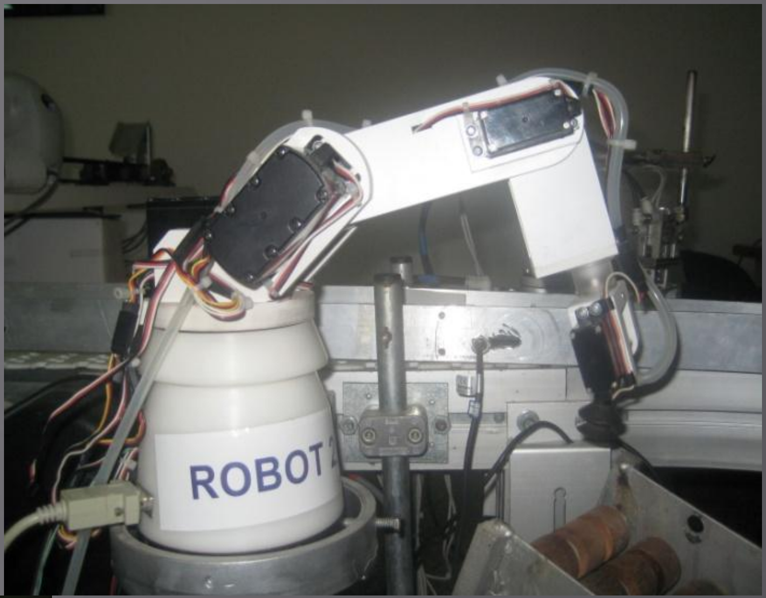
ROBOTS

First 5 axis robot is in charge of picking and placing parts which are scanned by the barcode reader, and transfer them to the left side for machining or throw it to the conveyor for the other operations.
This robot utilizes a vacuum gripper to pick the parts.

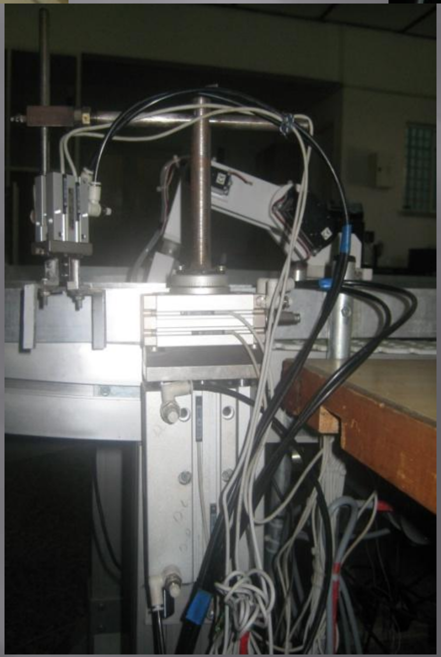
Pneumatic Robot which contained a few reed sensors, used to set the limits for the pneumatic cylinder motion. This robot is using a general griper which can be close or open in each time.
This robot just picks the parts which are detected by the Metal Detector sensor, placed before it.
Hence, the duty of this robot is to pick the Metal-Coated parts, chosen by the sensor placed near it.

Second Five axis robot which has the same specifications as the former one, used to pick the Non-Metal parts (which are detected by non-metal detector sensor on the big conveyor) from the flexible conveyor and place them into a rail way for the next defined operations.
This robot placed on a special Nut and Screw system which is connected to a Motor using to turning the screw in case of moving the robot across the Big conveyor .

First robot



second robot



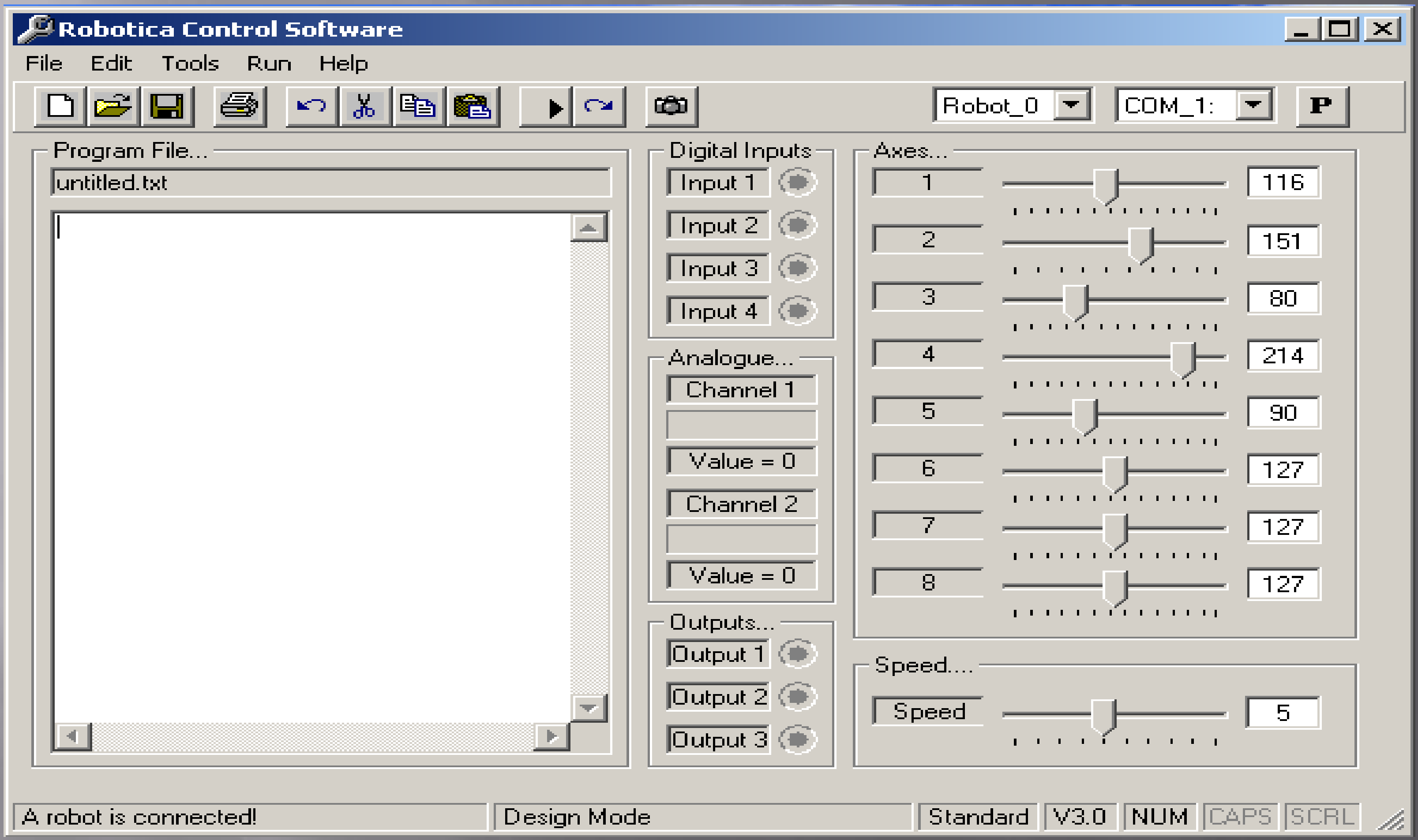
pneumatic robot

COMPUTERS AND SOFTWARES

First Robot is controlled by a General PC, using a visual basic program to read the barcodes and also control the robot’s motion. For each part the program decide Where to be placed according to the parts’ barcode

The second 5-axis robot is controlled by a PC using special software which is named “Robotica”. Generally, this software has a GIU (Graphical User Interface) which can be used for programming the robot remotely. After writing the program, by pressing the Run Button on the program screen, each line transferred to the robot using a general RS-232 cable.

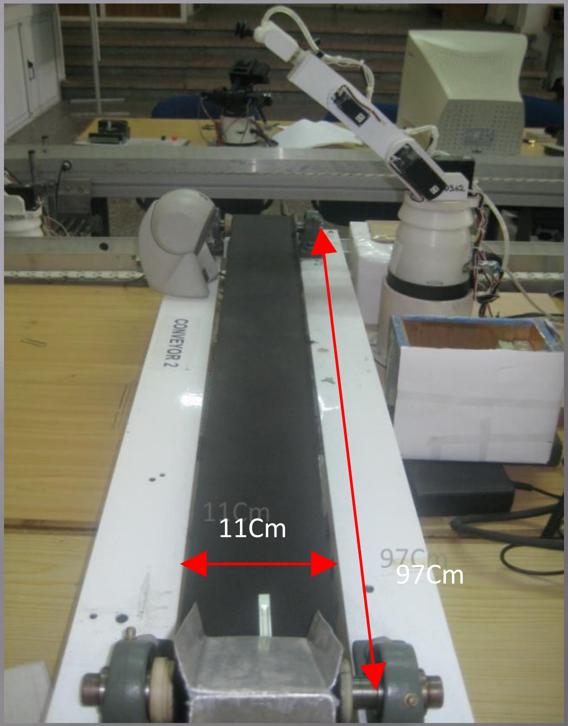
Also we have another PC which is used to monitor the Main PlC , placed in an anti dust cabin for safety.

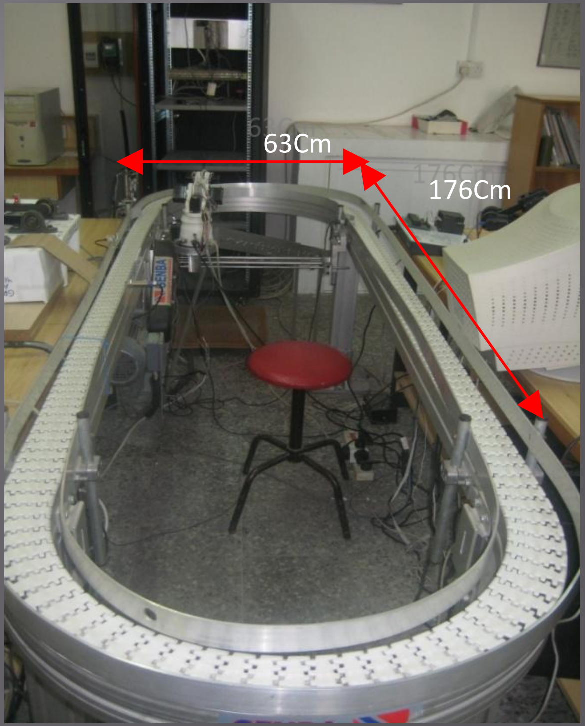


Screen shot from Robotica Software

CONVEYORS

We have 2 Conveyors, one general belt conveyor and one big flexible conveyor which are driven by two different Motors . The specifications of these two conveyors are as below:



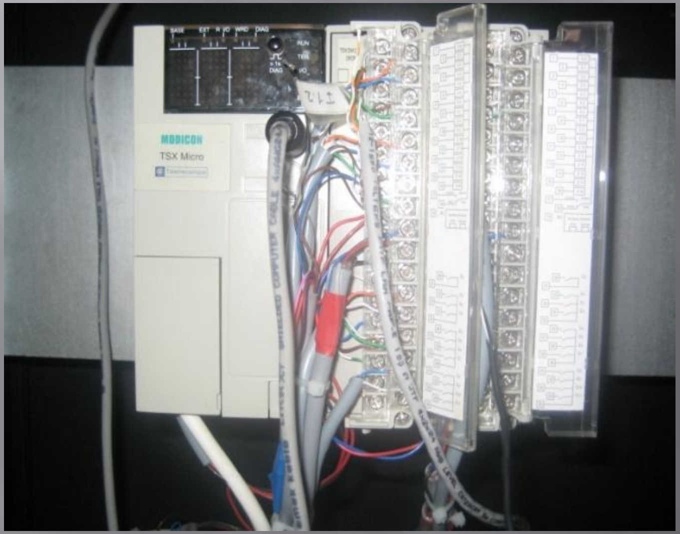


PLCs

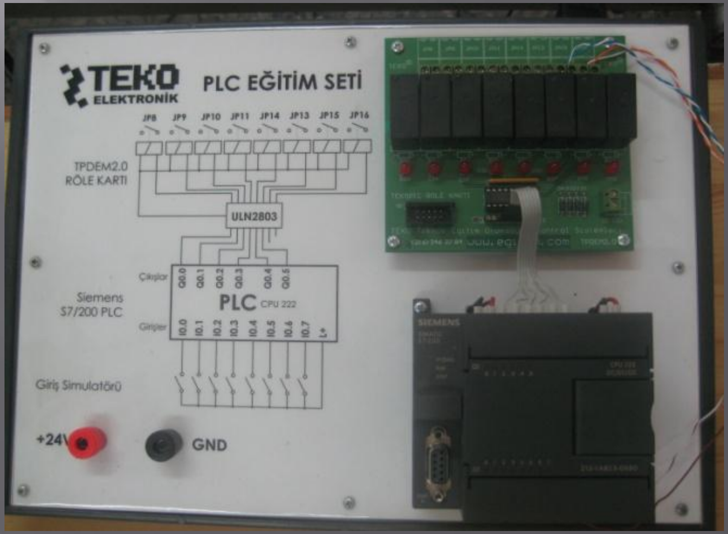
We have two different PLC devices :

A Siemens S7-200 PLC with 5 inputs and 5 outputs , which is used as secondary plc device , just to transfer the fire signal to the second five axis robot.

A Telemeqanic PLC with inputs and output , used as main PLC device for controlling the motors, conveyors, sensors and all other feedback signals.



Telemeqanic Micro TSX PLC



SIEMENS S7-200 PLC

REVIEWING THE SCENARIO

To run the system three parts are designed for three different operations. At the first cell the scenario is collaboration of the barcode reader and the first robot. After inserting the part in the input place , the small conveyor start switch pushed down and the small conveyor runs. After this the parts moves across the barcode reader for reading the parts' barcode, after that the conveyor stopped when the part reached the optical sensor on the belt conveyor.

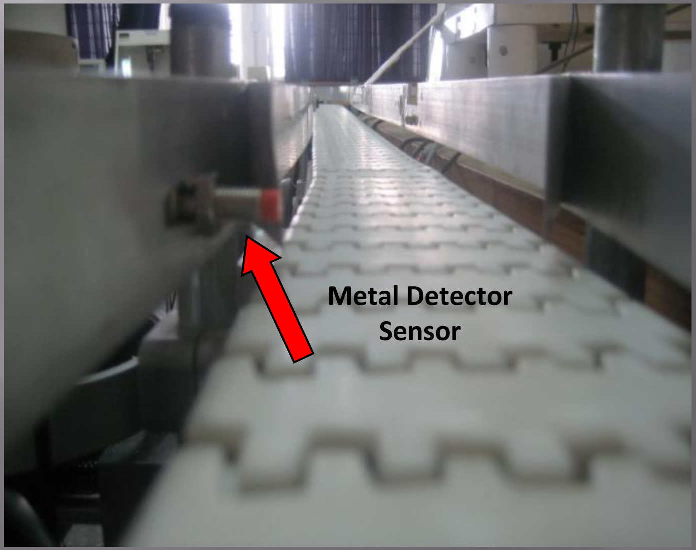
The Barcode reader Device

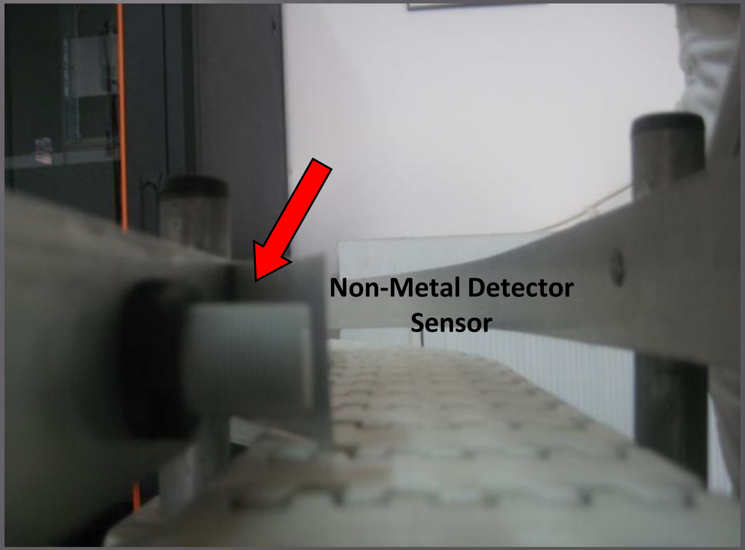
3 parts(1 Metal and 2 Non-metal with different barcodes)

Regarding to the parts' barcode, two different operations may have done. Parts with barcode going to the box 1, other parts must thrown to the second flexible conveyors , these parts including metal and non-metal parts. Throwing parts into the flexible conveyor, they switch the optical sensor on which caused the big conveyor to turn on.

After a while the parts reach the metal detector sensor, in this case if the part was non-metal, it passes the sensor and continue it rout, otherwise the metal detector sensor send a signal to the main PLC and main PLC send signal to the pneumatic robot to catch the metal part.

The non-metal parts continue their route until they reach the non-metal sensor, at this time, the sensor send a signal to the main PLC and the main PLC send the required signal to the robot and also to the screw motion control, so the screw starts turning and the robot get close to the part which is in the conveyor waiting to be caught by the robot. During this operation, the PC which is used to control the second robot must be run and ready to send the program to the robot. The robot catches the part and after that the signal from the non-metal sensor goes off, so the screw starts in reverse direction by receiving a signal from the main PLC , and the robot throws the parts into a special rail at the end of the rout.



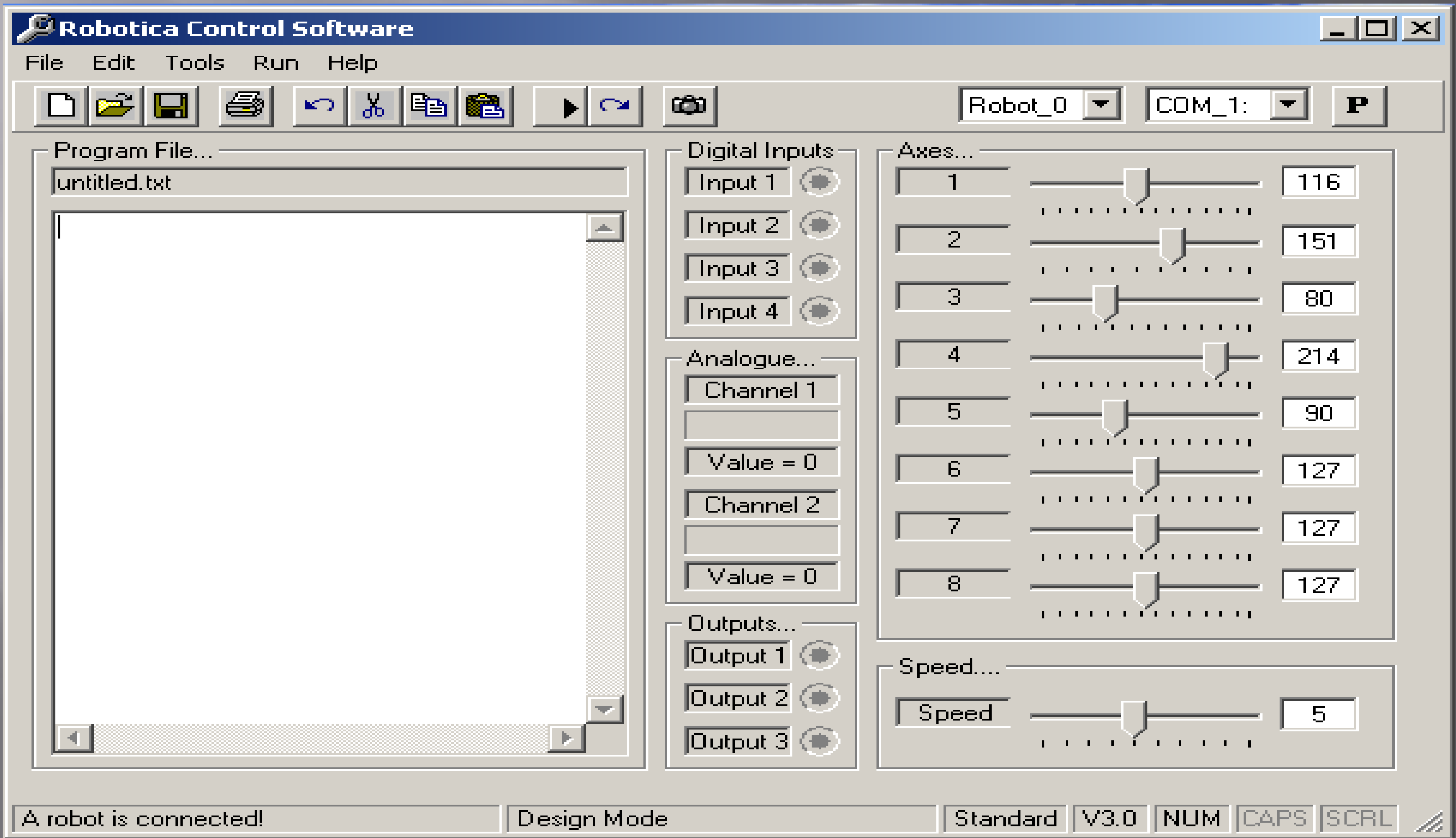


It must be considered that by detection of any part (metal or non-metal) by the special sensors the big conveyor stopped and waiting for part-received signal from the first sensor of big conveyor.

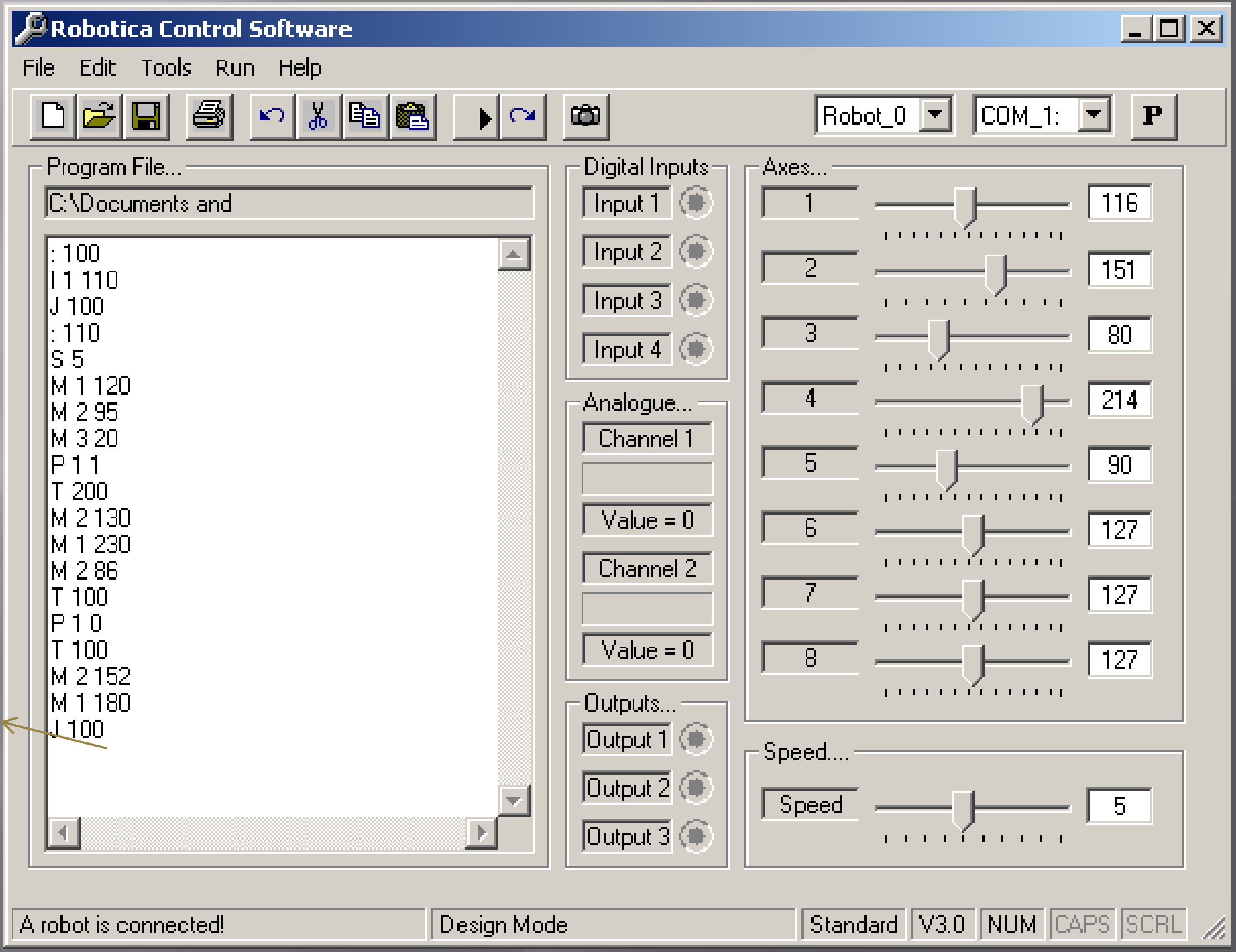
Beside this an alarm system designed to warn the operator if the part is going to reach the sensor in improper position (if it stands vertically) . When the alarm optical sensor detected the part which stood vertically the alarm beep starts and warn the operator to correct the part situation(it must lays on the width of the part) and after that push start button for resuming the conveyor cycle.

How are the Robots Programmed

In this integrated system robots are programmed with visual basics. But first coordinates are defined with the help of ROBOTICA. ROBOTICA is a program to define the coordinates for a robot. Each robot has several axes which are controlled with this program.



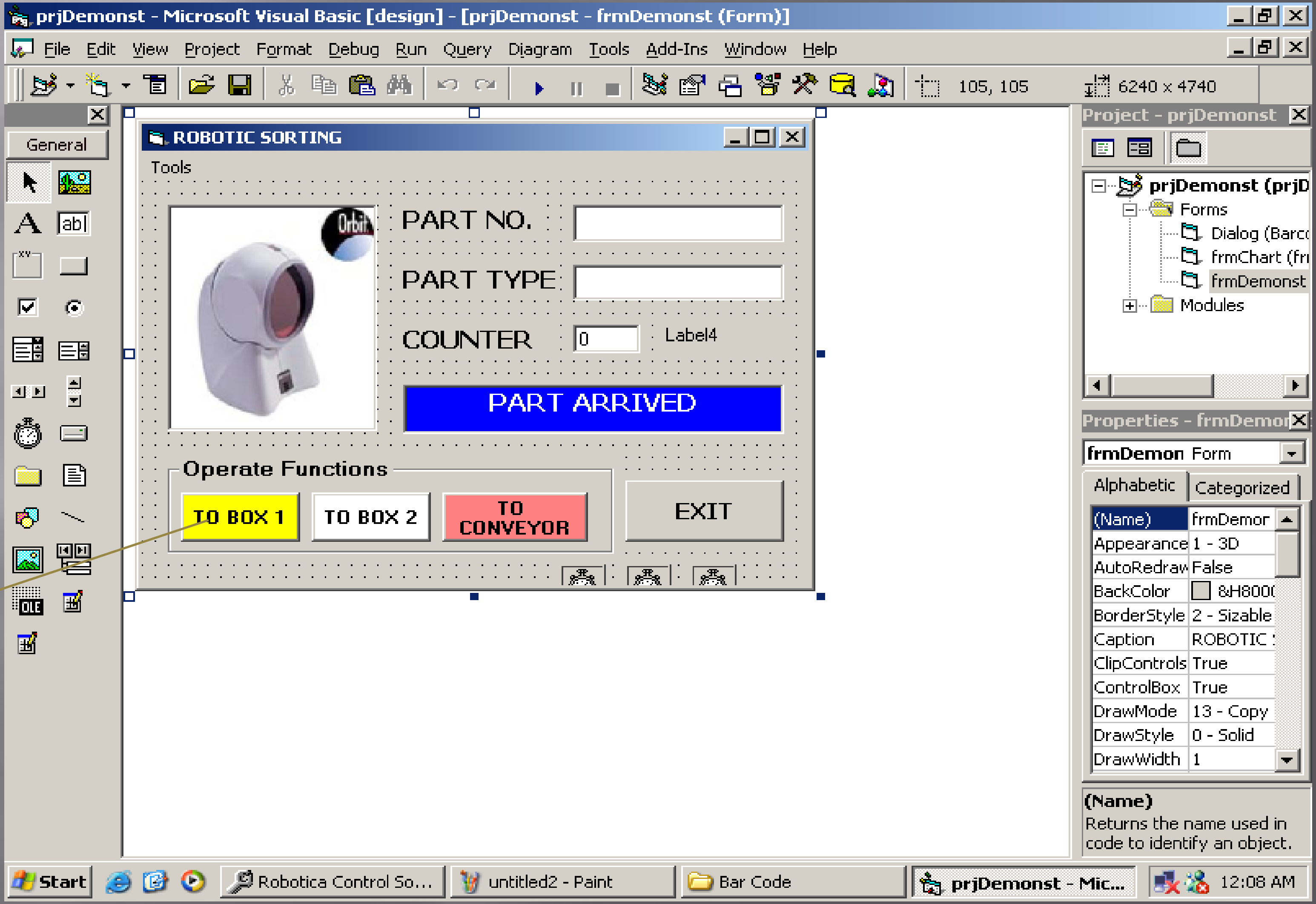
For example here 3 programmers are written for the robot next to conveyor 2 to take the part to machine 1 or machine 2 or conveyor 1



This command jumps to line one

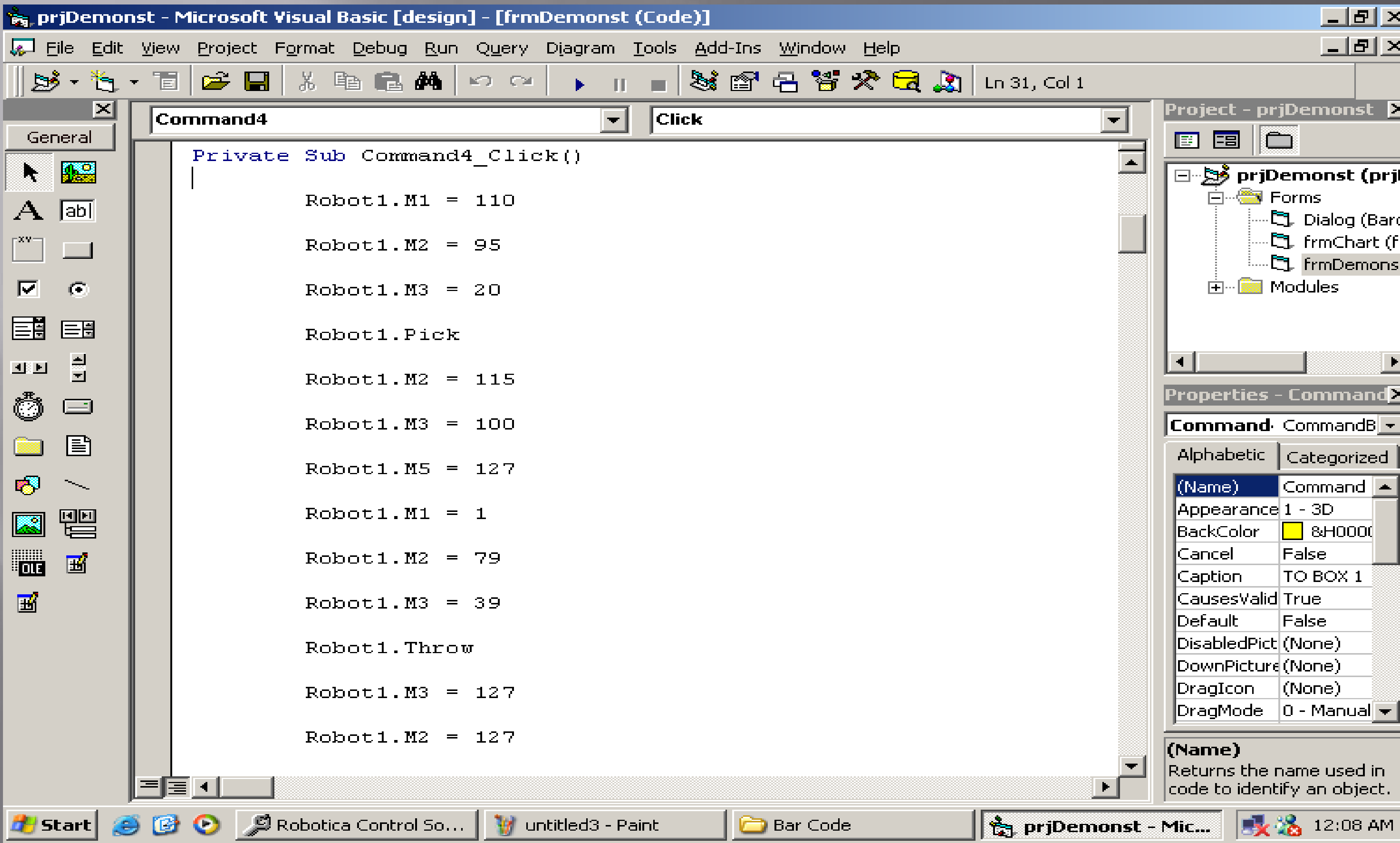
In the previous slide J stands for jump, M 1,2,.. Are for different axes of the robot and the coordinated for each axis is defined. In order to have a loop in this system J 100 is used to jump the last line to the first line. T stand for time. The robot will wait in a position for a small time interval defined by T 100,200,.. . S and P are used to get a part and release it at specified position.

With the help of these coordinates the visual basic program is written. It is defined in this program for example for a part with a specific bar code, take the part and place it in machine one. Here an outline of the program is given.



By selecting any bottom one can change the program

Now three positions are defined for the robot to move to that position, take the part and place it in a machine or conveyor one. Here the codes to place the part in machine one are shown. These codes can be accessed easily by double clicking on box 1 in the program and change the coordinates according to the coordinates that were set in ROBOTICA.


prjDemonst - Microsoft Visual Basic [design] - [frmDemonst (Code)]
File Edit View Project Format Debug Run Query Diagram Tools Add-Ins Window Help
Ln 31, Col 1
General
Command4
Click
Private Sub Command4_Click()
Robot1.M1 = 110
Robot1.M2 = 95
Robot1.M3 = 20
Robot1.Pick
Robot1.M2 = 115
Robot1.M3 = 100
Robot1.M5 = 127
Robot1.M1 = 1
Robot1.M2 = 79
Robot1.M3 = 39
Robot1.Throw
Robot1.M3 = 127
Robot1.M2 = 127
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Cancel False
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CausesValid True
Default False
DisabledPict (None)
DownPicture (None)
DragIcon (None)
DragMode 0 - Manual
(Name)
Returns the name used in code to identify an object.
Start
Robotica Control So...
untitled3 - Paint
Bar Code
prjDemonst - Mic...
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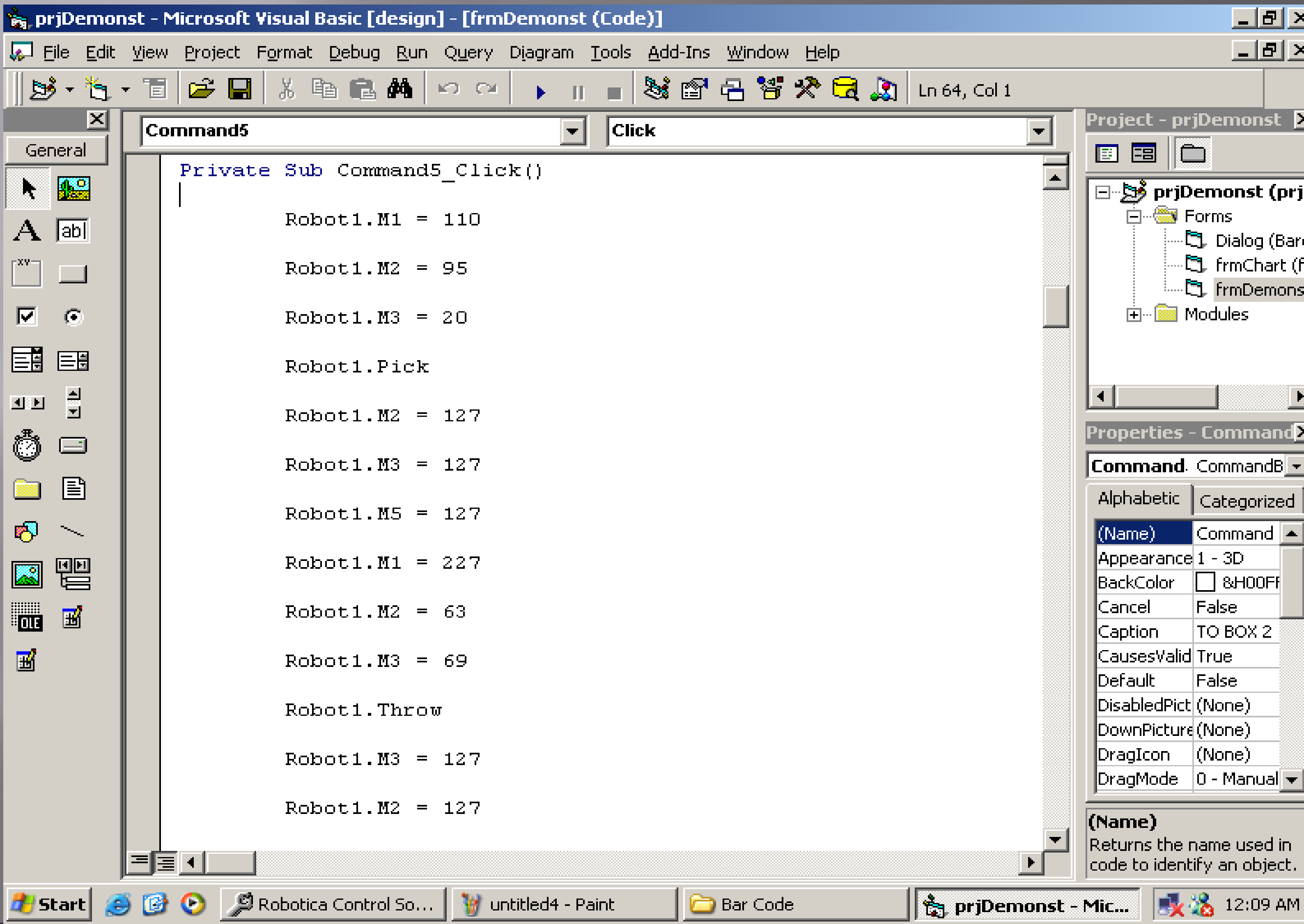
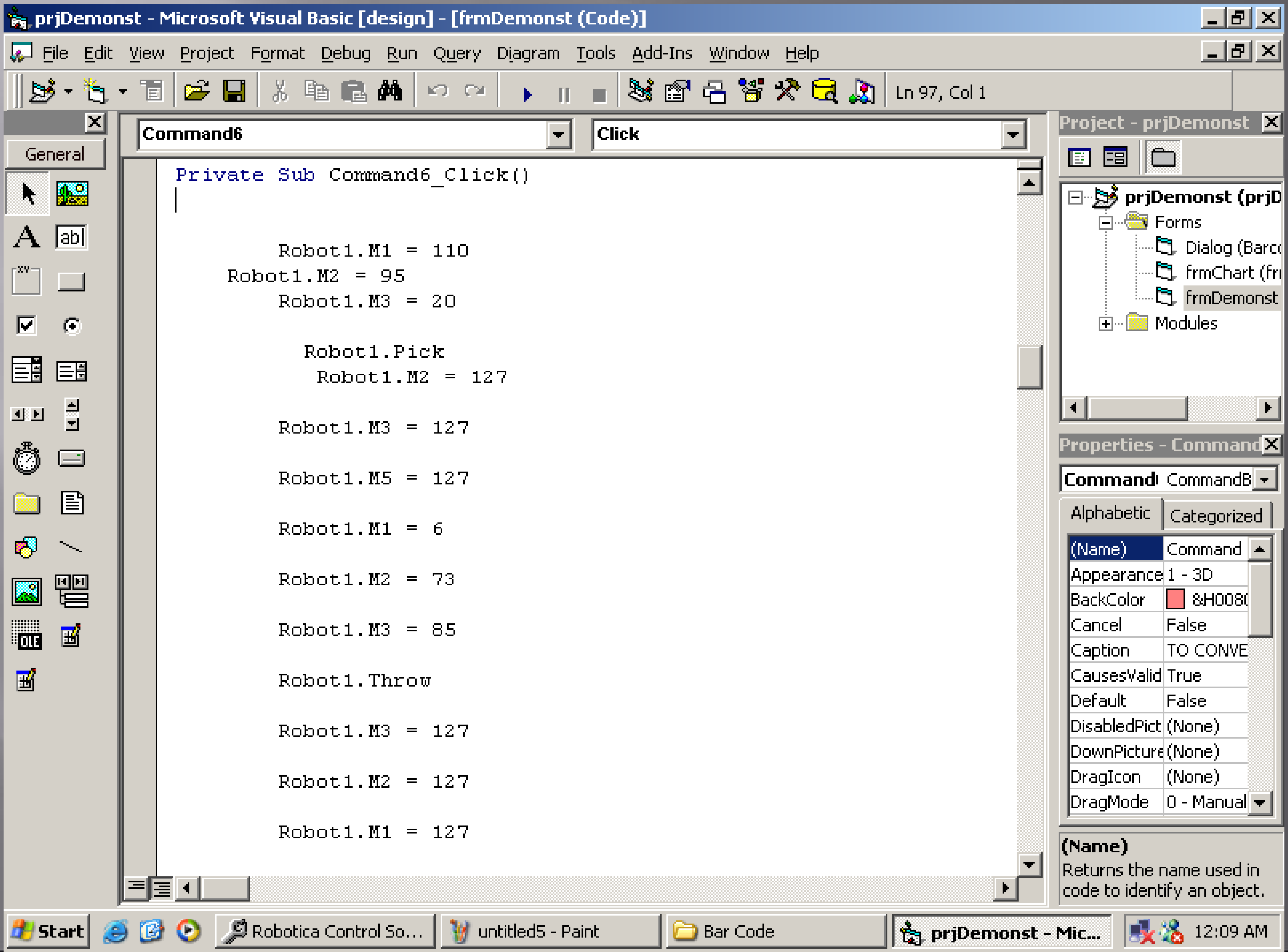
Here are the coordinates for box 2 or machine 2 are shown. One can simply define his/her coordinates according to those he/she defined in ROBOTICA.

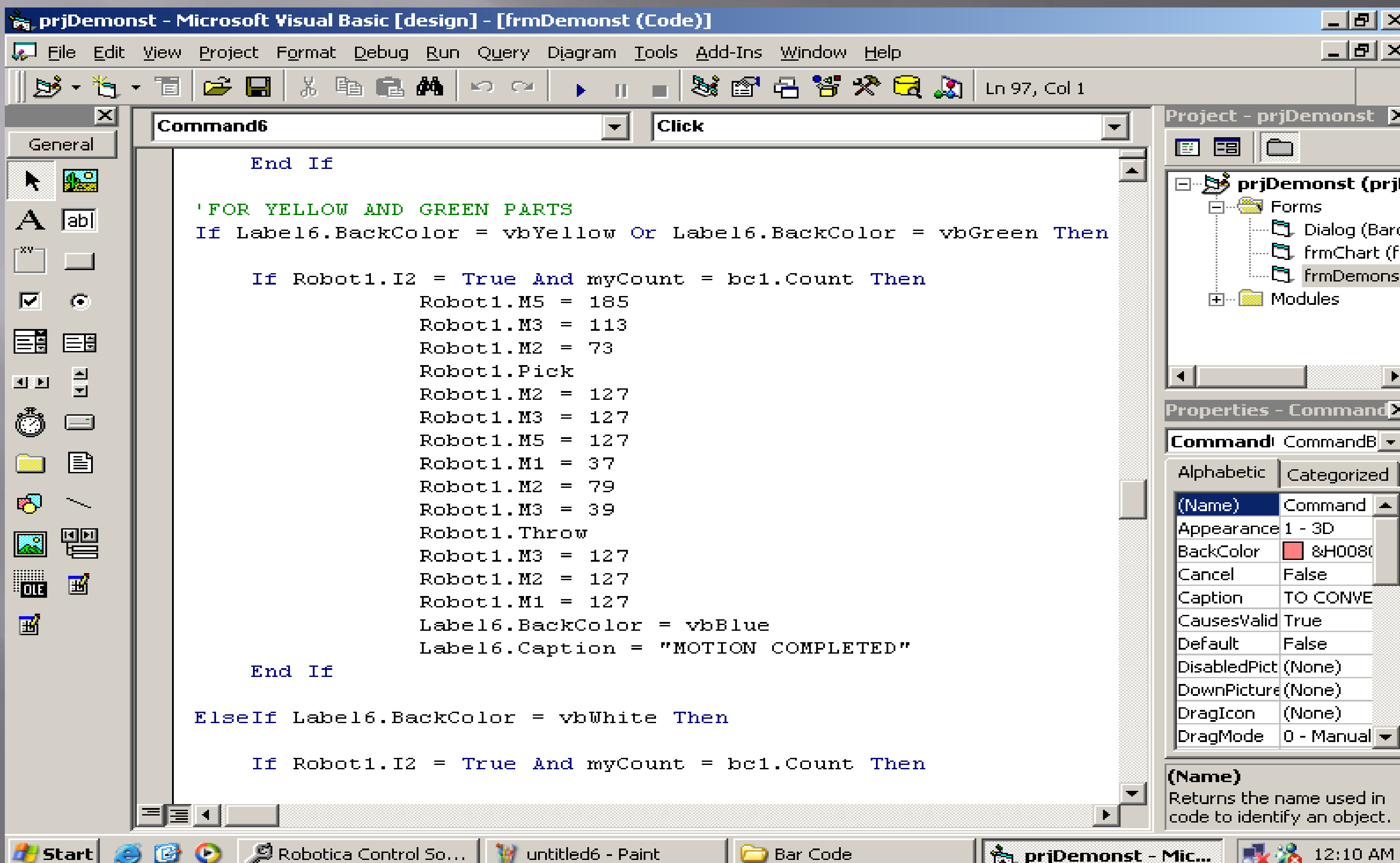


Now the coordinates for the conveyor are defined in the program.

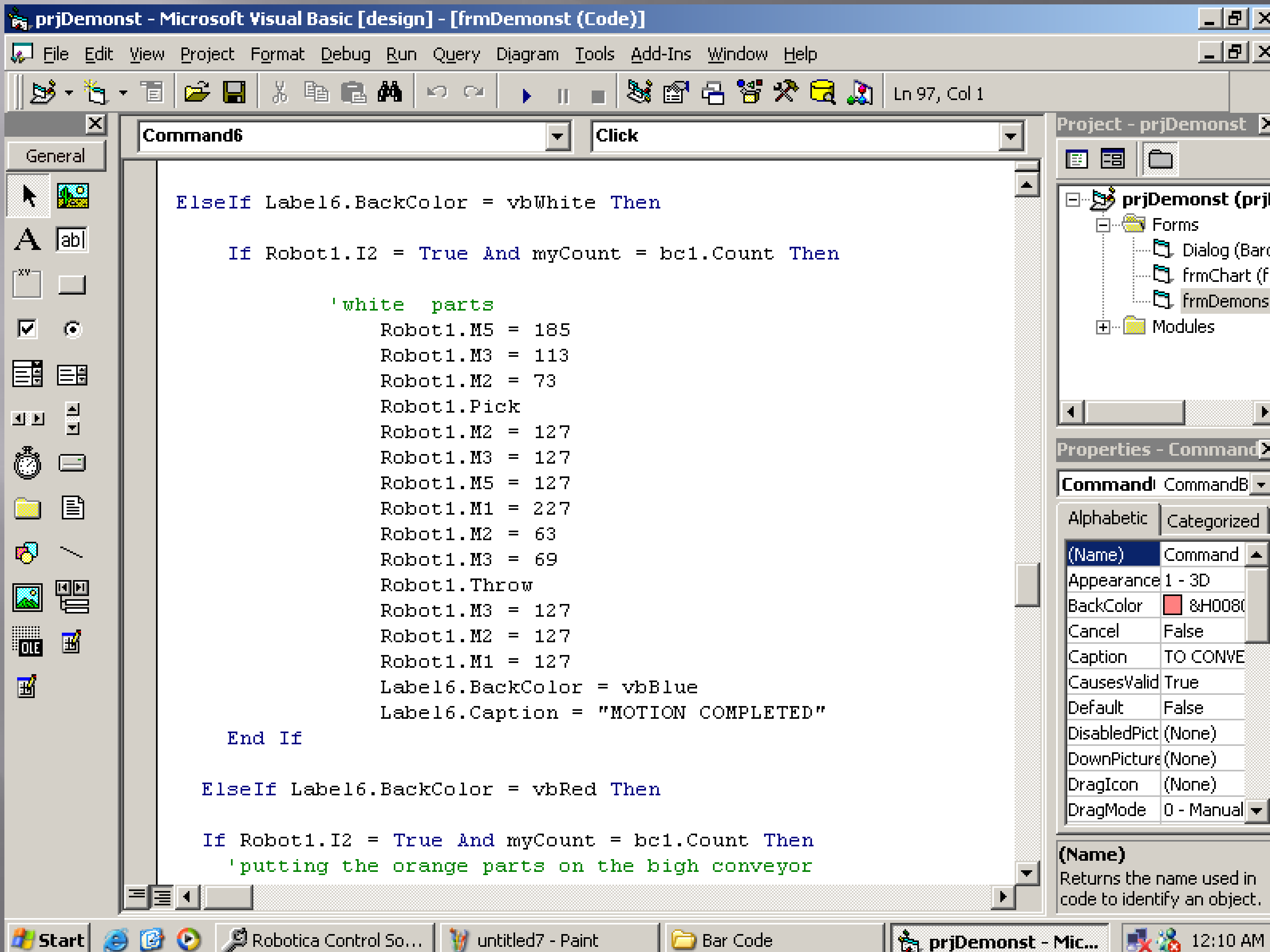


I mentioned that a part is placed in machine 1 or machine 2 or conveyor 1 according to its bar code. In this part of the program it is defined how each part is placed according to its bar code. The bar code for each object defines its color and for each color a series of codes similar to the tree potions mentioned are written. Here for example the position for an object with yellow or

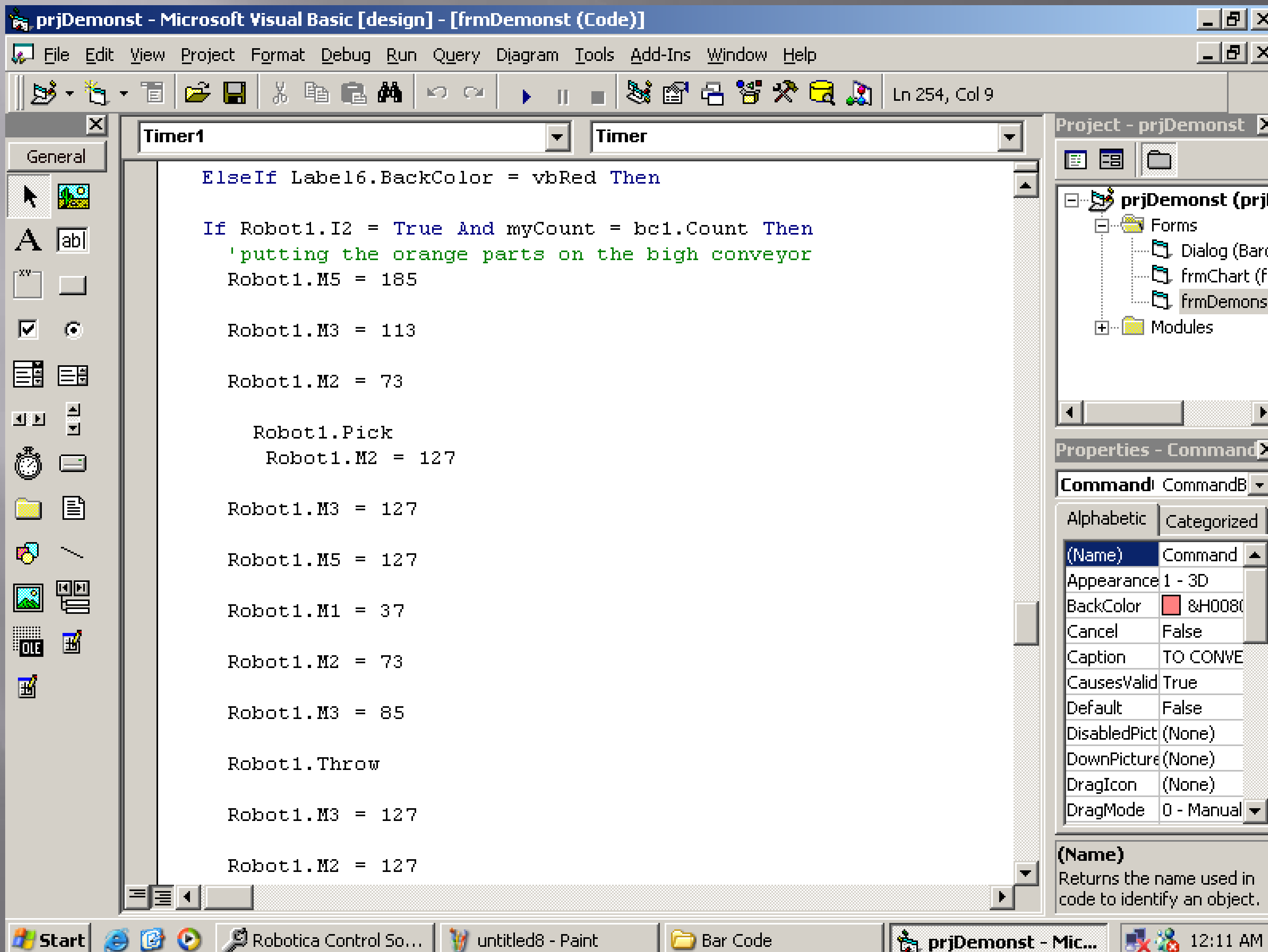
green color is defined.



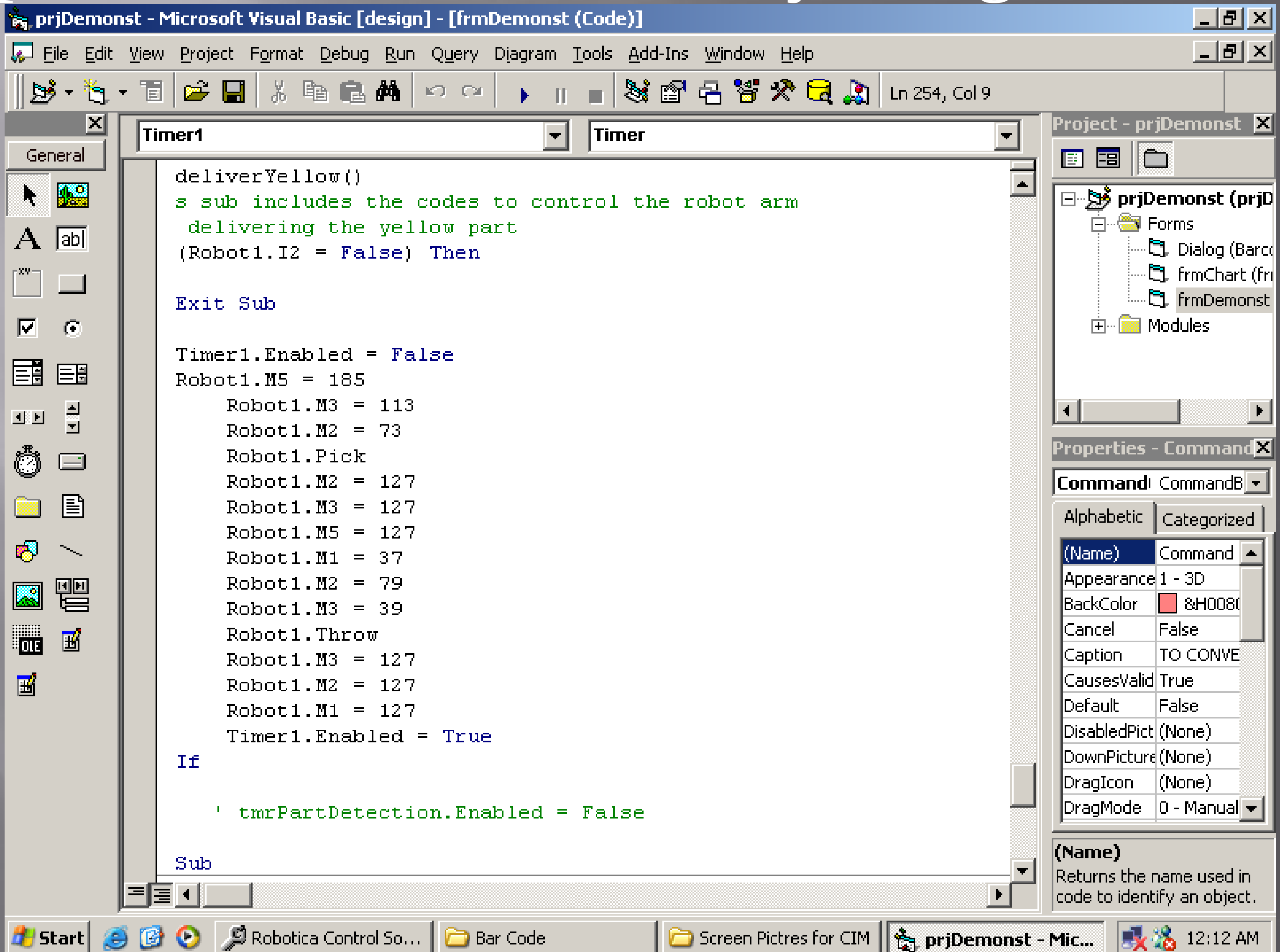
Coordinates for a white part:



Coordinates for a



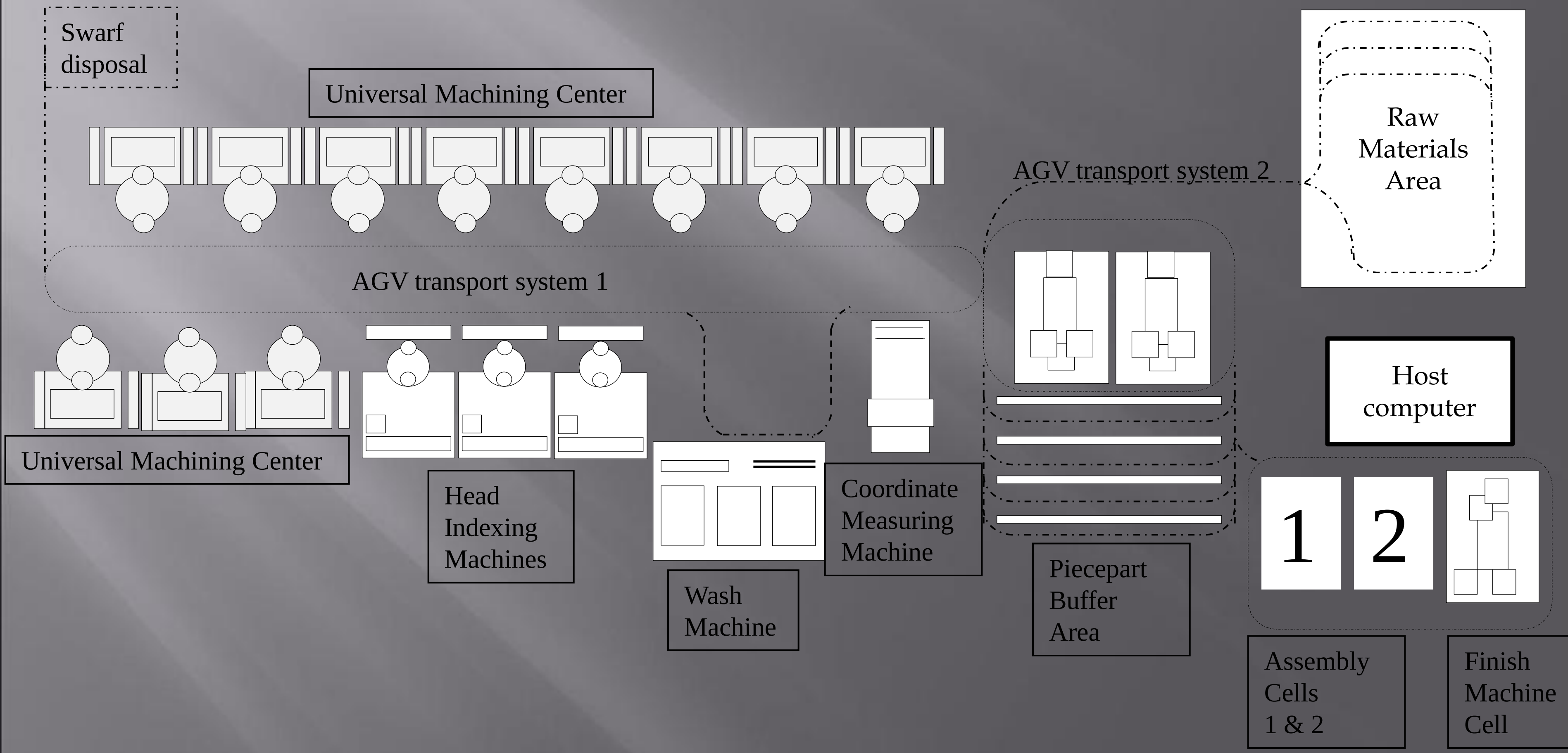
There are also a set of codes written for parts which are not in any categories.



Computer integrated manufacturing and PLC

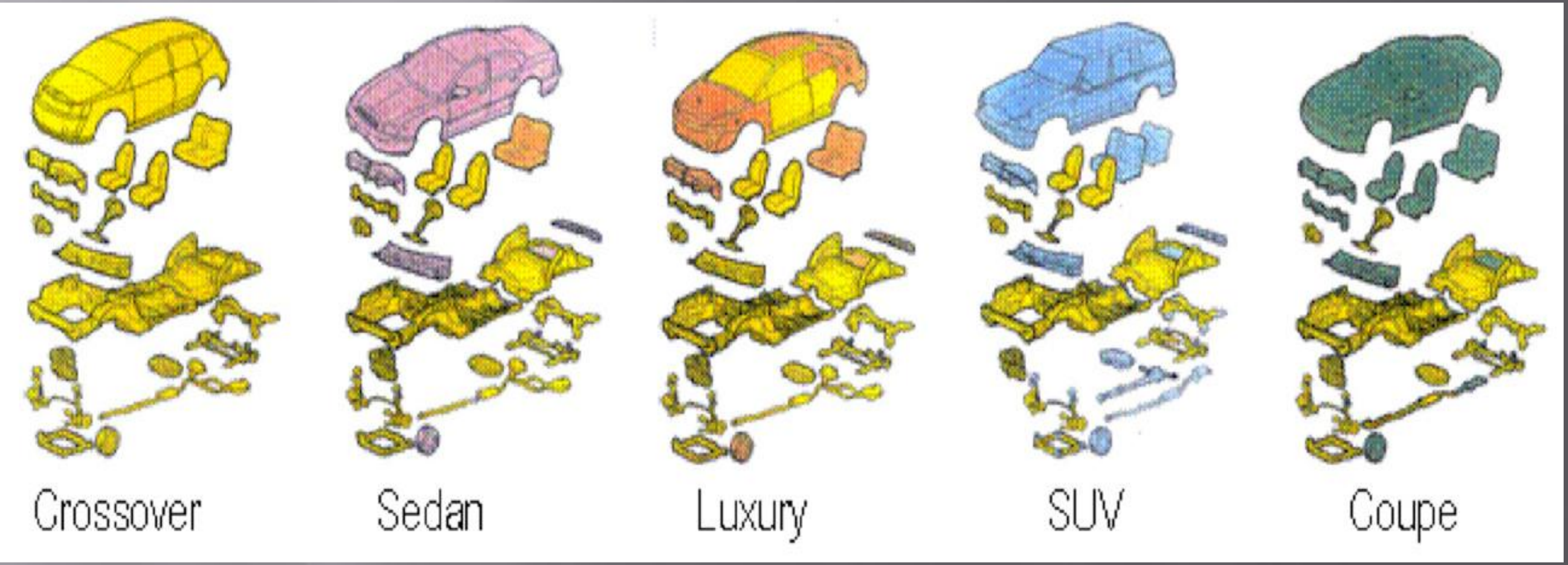
In today's manufacturing units several PLCs are used to switch on or off robots ,conveyer belts and other part of manufacturing systems. The advantages of PLC in automated systems made PLC one of the main component of any Manufacturing unit.

An example of a simple and modern manufacturing



FMS Example

One Design + One Assembly Process = Multiple Models



When different models are designed to be assembled in the same sequence they can be built in the same plant.
This maximizes efficiency and allows the company to respond quickly to changing customer

FMS Example

Through the use of reprogrammable tooling in the body shop, standardized equipment in the paint shop and common build sequence in final assembly, Ford can build multiple models on one or more platforms in one plant.

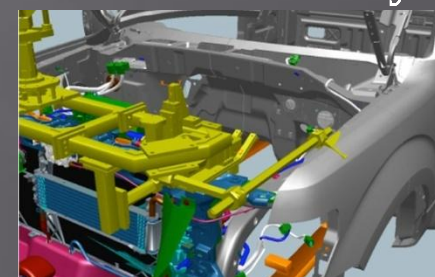
Body Shop

In the body shop, where the sheet metal comes together to form the vehicle's body, flexibility means more than 80 percent of the tooling is not specific to one model. It can be reprogrammed to weld a car or a truck or a crossover of similar size.

Paint Shop

In the paint shop, flexibility means robotic applicators are programmed to cover various body styles – as they move through the paint booth – with equal precision. This results in minimizing waste and environmental impact while maximizing quality.

Final Assembly



In the final assembly area, flexibility means the build sequence is the same among multiple models on one or more platforms allowing for efficient utilization of people and equipment.

FMS Example

Virtual Verification

Virtual manufacturing technology allows Ford to quickly add various models into an existing facility – or to reconfigure an existing facility to produce a new model. In the virtual world, manufacturing engineers and plant operators evaluate tooling and product interfaces before costly installations are made on the plant floor. This method of collaboration improves launch quality and enables speed of execution.