AUTOMATION OF FIBER COMPOSITE MANUFACTURING PROCESS

(In the partial fulfillment for the course of Mechatronics, ME5643)

(Group 8)

Duc Anh
Sang Yoon Lee
Chandresh Dubey

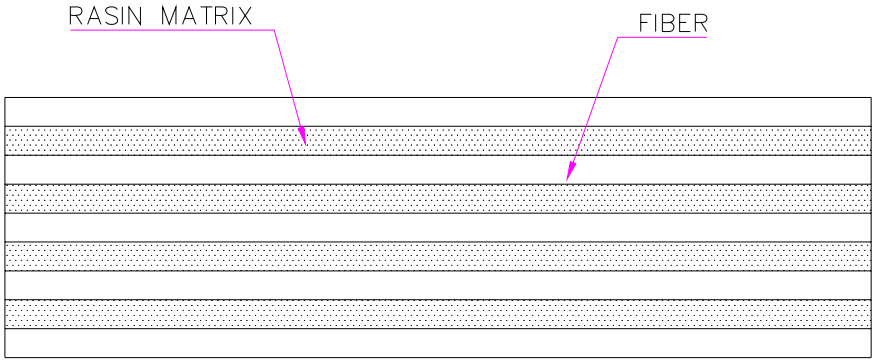
Prof. V. Kapila

Polytechnic University

Overview

- Introduction
- Objective
- Mechanical Design and Layout
- Electrical/Electronic Design
- PBASIC Code
- Cost Estimation
- Limitations
- Future developments
- Conclusion
- Acknowledgement

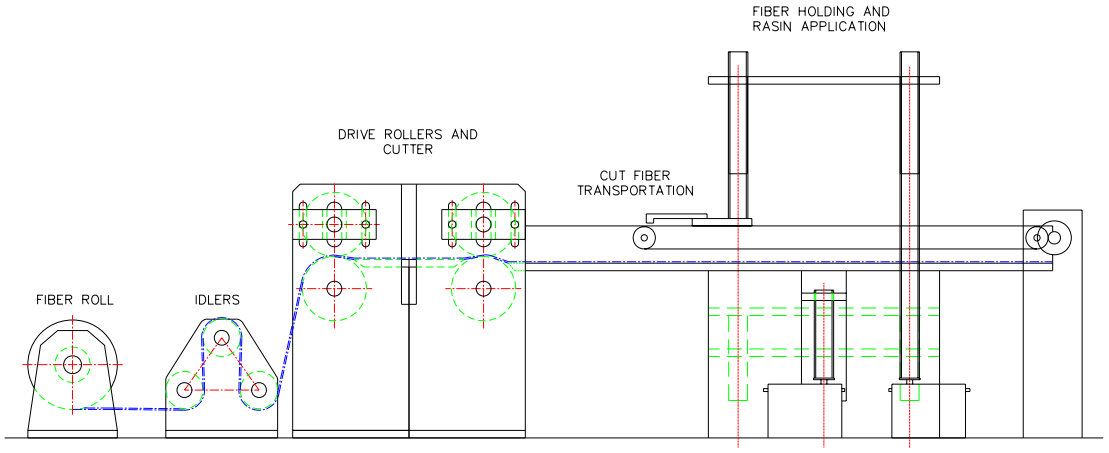
Introduction

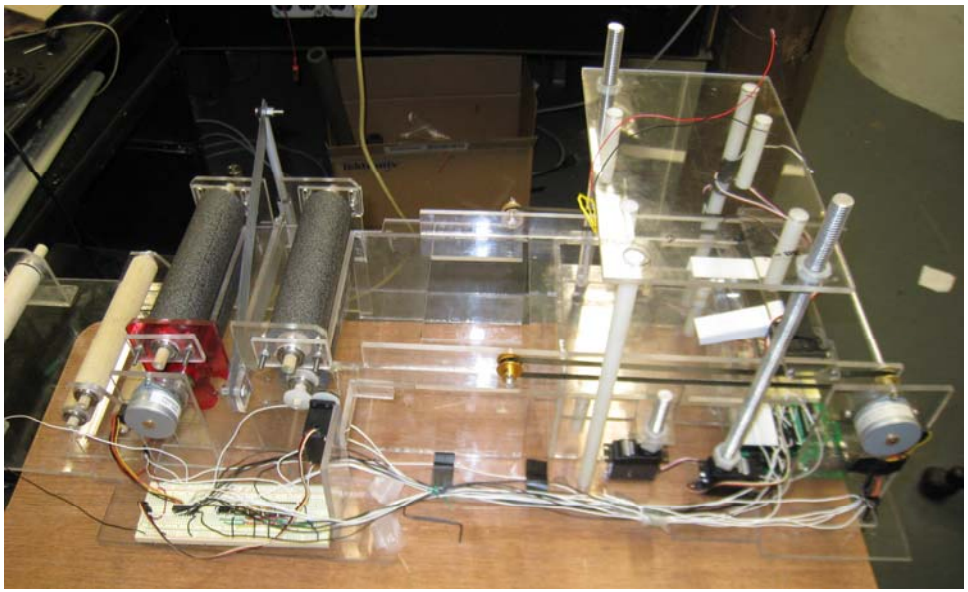


Objective

- Device a prototype model demonstrating automation of fiber composite material manufacturing process.
- Prototype should be capable of cutting pieces up to length of 6 inches.
- Up to 30 mm composite stack should be handled.

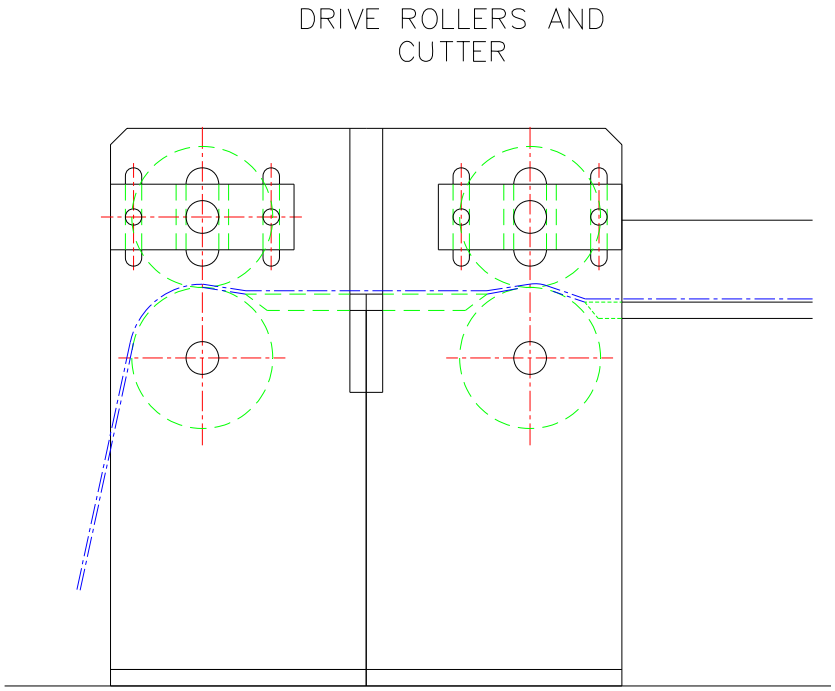
Mechanical Design and Layout

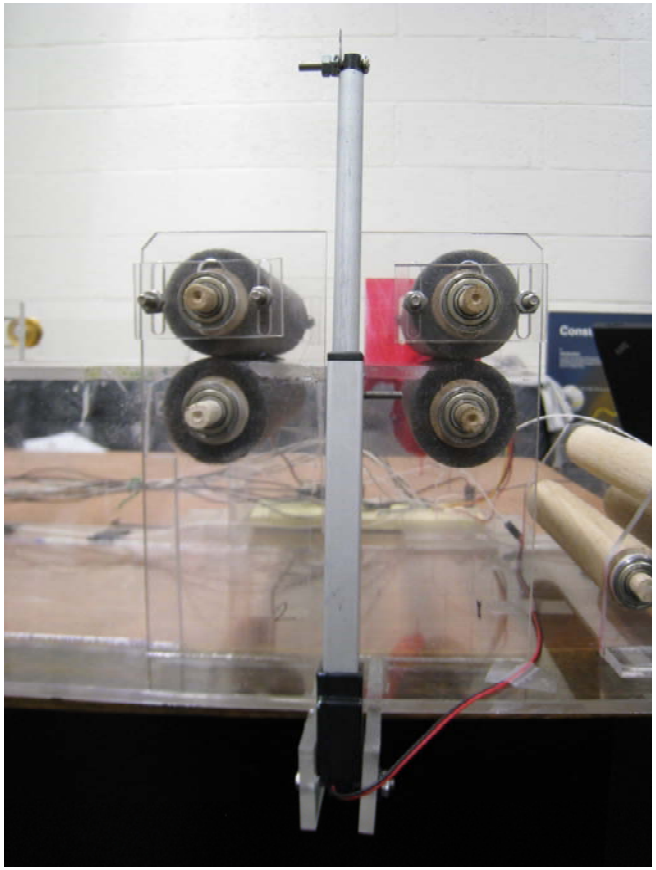




Mechanical Design

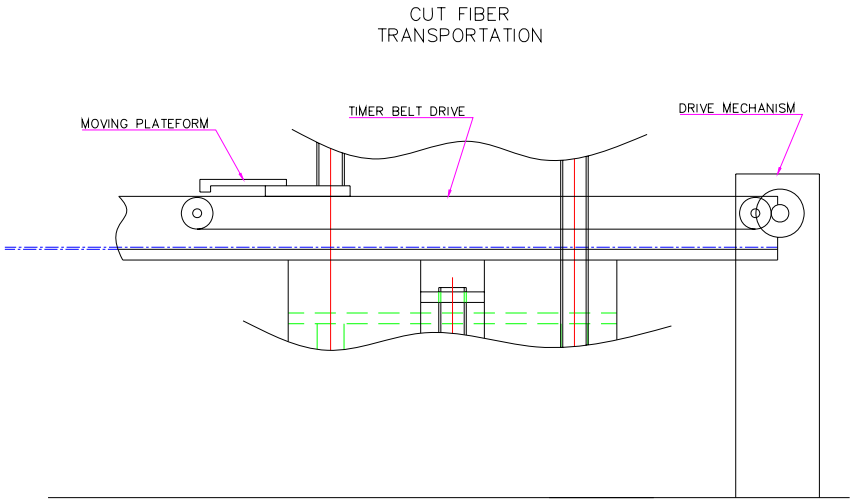
(Drive Rollers and Cutter)

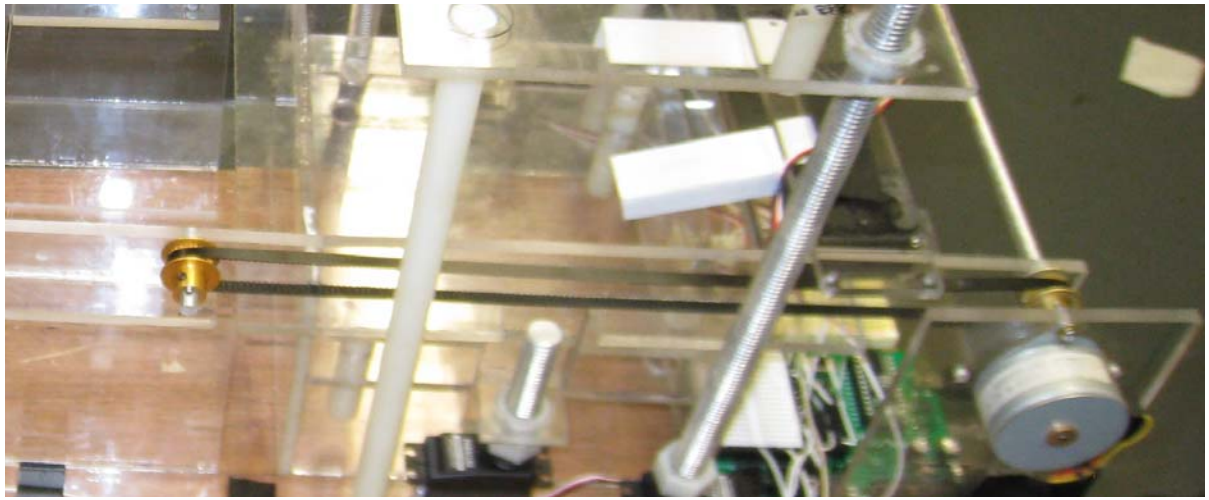




Mechanical Design

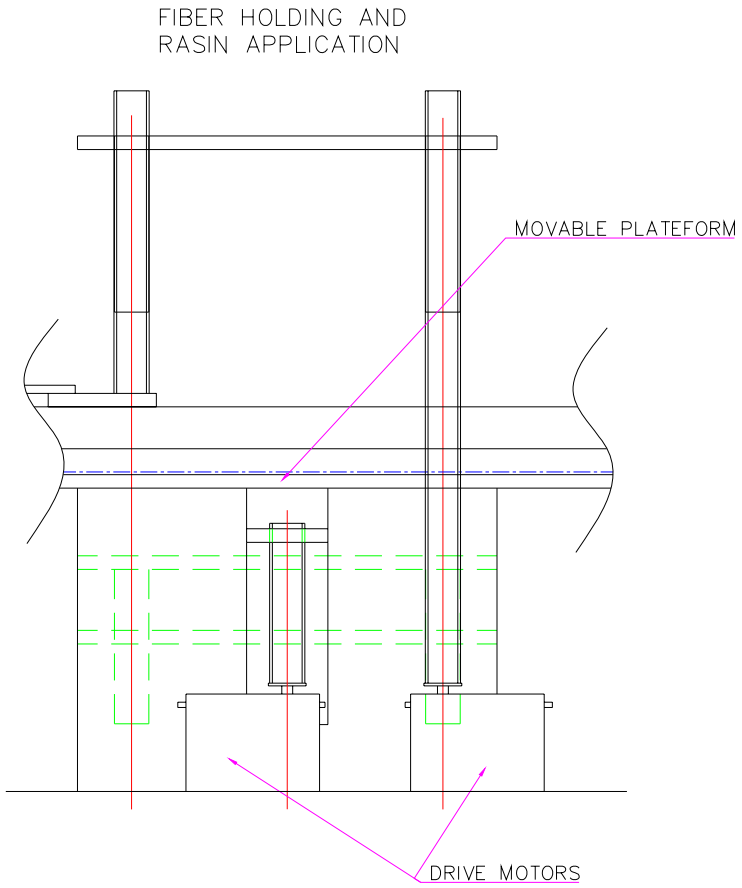
(Fiber Transportation)

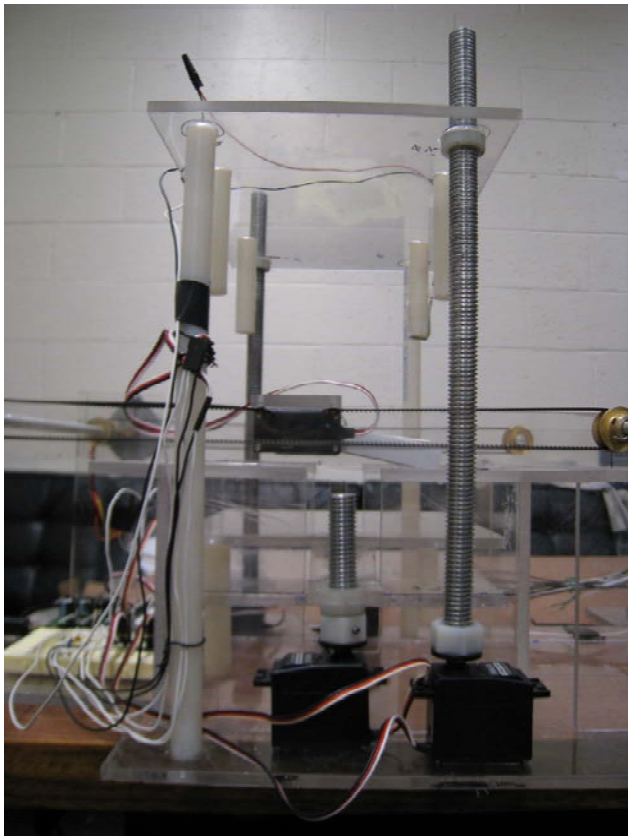




Mechanical Design

(Fabric Holding and Resin Application)





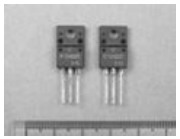
Electrical/Electronic Design

Key Hardware

1. Stepper motors
2. Servomotors (continuous and standard)
3. Linear Actuator
4. Pressure sensor
5. Stepper motor drive IC (ULN2803)
6. Mosfets
7. 12V power supply etc.

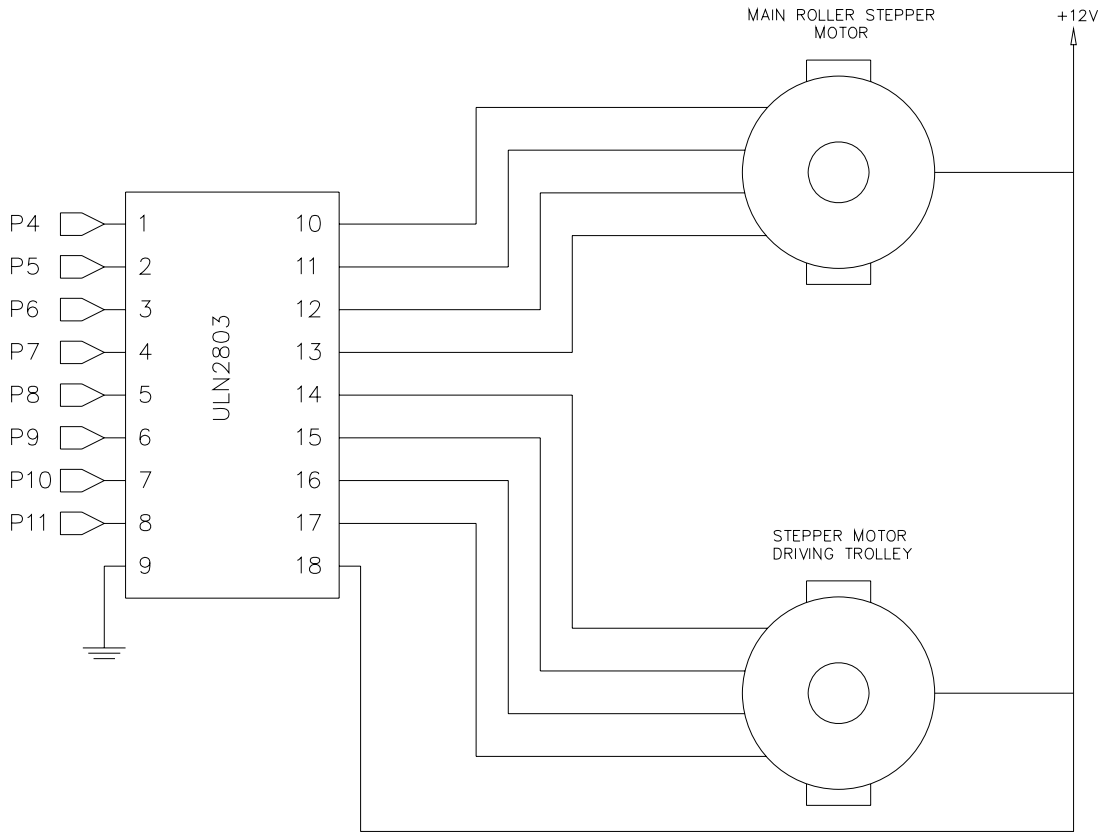






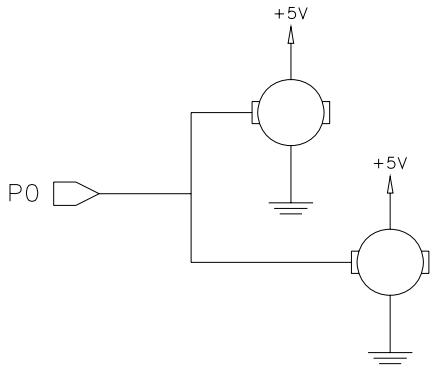
Circuit Diagram

(Stepper Motor – Main roller and transport drive)

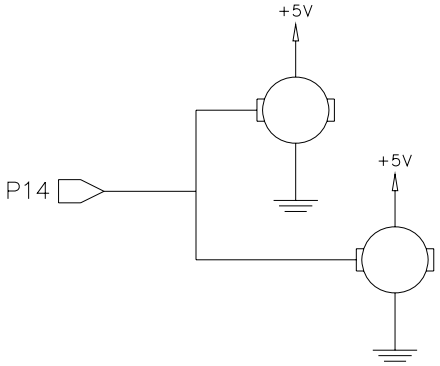


Circuit Diagram

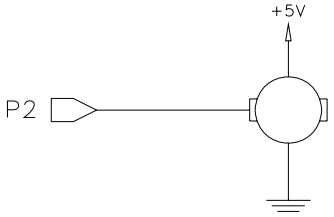
(Servo Motors – Pull roller, transport and holding platform)



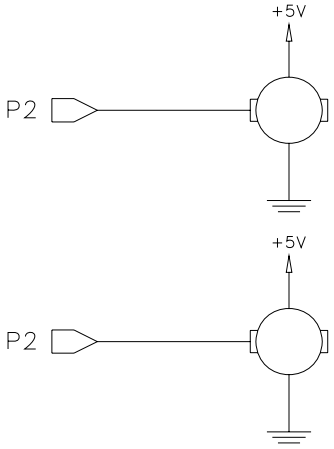
LOWER TABLE CONTROL



UPPER TABLE CONTROL



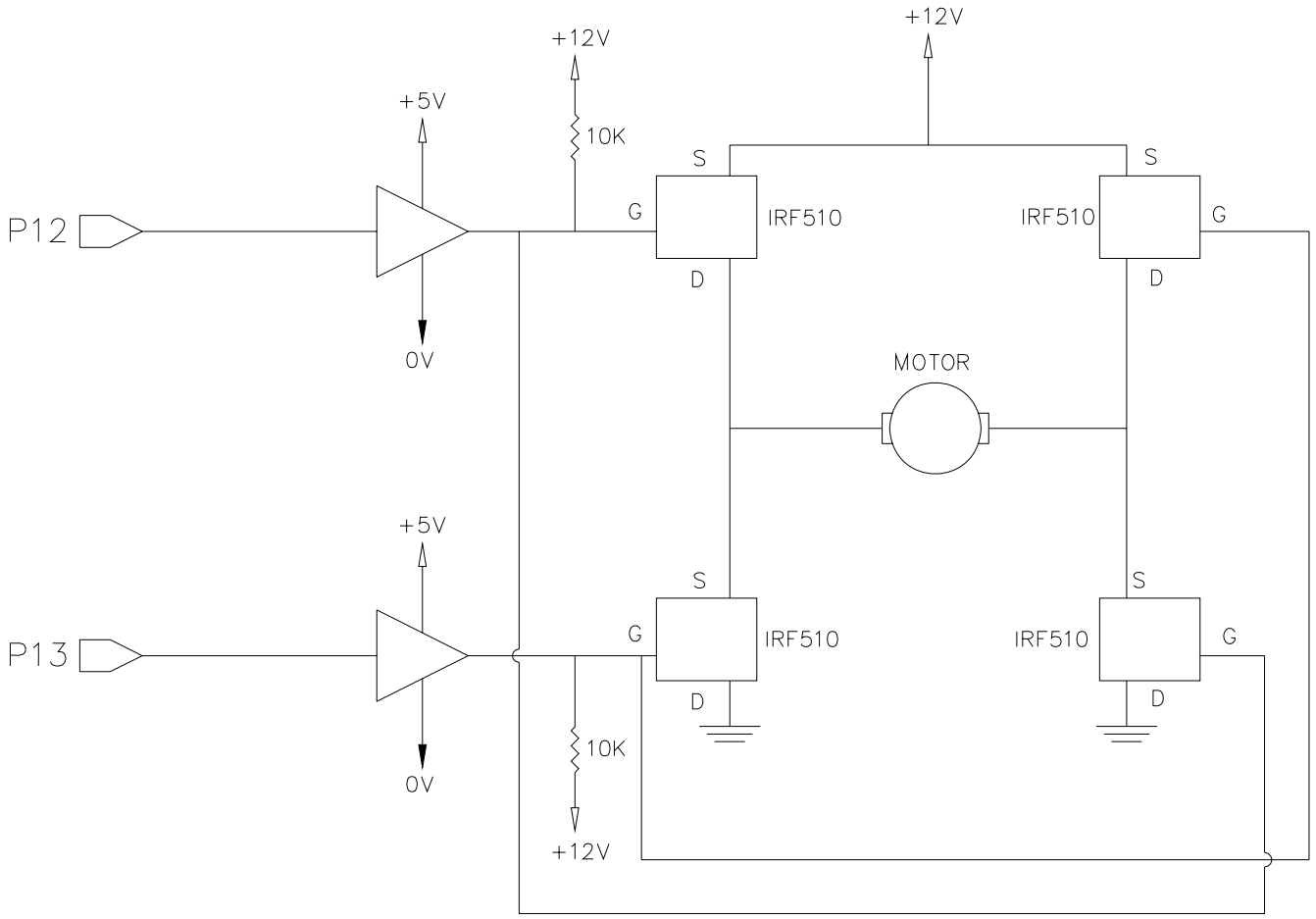
PULL IN ROLLER MOTOR CONTROL



SERVO MOTOR CONTROL

Circuit Diagram

(Linear Actuator - Cutter)



PBASIC Code - 1

```
' {$STAMP BS2}
' {$PBASIC 2.5}

'-----[ I/O Definitions ]-------------------------------------------------------------
OUTPUT 0
OUTPUT 2
OUTPUT 3
OUTPUT 14
OUTPUT 15

'-----[ Constants ]-------------------------------------------------------------------
StpsPerRev_01 CON 48                                        ' One revolution
StpsPerRev_02 CON 48

'-----[ Variables ]-------------------------------------------------------------------
Phase_01    VAR OUTB                                        ' phase control outputs
Phase_02    VAR OUTC
x           VAR Byte
idx         VAR Byte                                        ' loop counter
tau         VAR Word                                        ' RCtime
stpIdx      VAR Nib                                         ' step pointer
stpDelay    VAR Byte                                        ' delay for speed control
```

PBASIC Code - 2

```
'-----[ Subroutine - Stepper_Motor_01 ]-----------------------------------------------------
 Steps_01 DATA %0011, %0110, %1100, %1001
 DIRB = %1111                                                    ' make P4..P7 outputs
 stpDelay = 15

 FOR idx = 1 TO 3*StpsPerRev_01
  stpIdx = stpIdx + 1 // 4
  READ (Steps_01 + stpIdx), Phase_01                             ' output new phase data
  PAUSE stpDelay
  PULSOUT 2, 700
 NEXT

'-----[ Subroutine - Linear_Motor ]---------------------------------------------------------
FOR x = 1 TO 2
 HIGH 12
 PAUSE 13000
 LOW 12
 PAUSE 10
 HIGH 13
 PAUSE 13000
 LOW 13
NEXT
PAUSE 200
```

PBASIC Code - 3

```
'-----[ Subroutine - Stepper_Motor_02 ]-------------------------------------------------
 Steps_02 DATA %0011, %0110, %1100, %1001
 DIRC = %1111
 stpDelay = 15

 FOR idx = 1 TO 255
    stpIdx = stpIdx + 3 // 4                                    ' Run forward
    READ (Steps_02 + stpIdx), Phase_02                          ' output new phase data
    PAUSE stpDelay
 NEXT

 PAUSE 100

 FOR idx = 1 TO 200
    stpIdx = stpIdx + 1 // 4                                    ' Run reverse
    READ (Steps_02 + stpIdx), Phase_02                          ' output new phase data
    PAUSE stpDelay
 NEXT

 PAUSE 1000
                                                                ' Pause for holding the cut piece
 FOR idx = 1 TO 55
    stpIdx = stpIdx + 1 // 4                                    ' Run back to start position
    READ (Steps_02 + stpIdx), Phase_02
    PAUSE stpDelay
 NEXT
 PAUSE 100
```

PBASIC Code - 4

```
'-----[ Subroutine - Two Servo Motor ]-------------------------------------------------------
FOR x = 1 TO 500
 PULSOUT 3, 500
 PULSOUT 15, 1000
 PAUSE 10
NEXT
PAUSE 100

'-----[ Subroutine - Upper Table ]-----------------------------------------------------------
FOR x = 1 TO 500
 PULSOUT 14, 1000                                                    ' Upper table goes down
 PAUSE 10
NEXT
PAUSE 100

'-----[ Subroutine - Pressure Sensor ]-------------------------------------------------------
DO
 HIGH 1
 PAUSE 3
 RCTIME 0, 1, tau
 PAUSE 100

 IF tau > 500 THEN                                                   ' Threshhold pressure
    GOTO TableGoUp                                                   ' Upper table goes up
 ENDIF
LOOP
```

Limitations

- The model proposed in its current state doesn’t provide any means to check the fiber orientation which drastically affects composite material property
- Resin application is to be done manually
- The holding mechanism proposed is slow due to use of threads but can be easily changed to other linear actuators

Future Developments

- Incorporate a sensory system to check fiber orientation as it directly affects the composite strength and sorting out incorrect pieces
- Device the mechanism which would allow differently oriented fibers to be processed serially so that mixed type composites can be produced

Conclusion

- The mechanism operates slowly but satisfactorily.
- It was found that individually the components performed as required but in integrated form synchronization difficulties exist
- The methodology can be easily adopted is simple and adaptive for manufacturing

Acknowledgement

- Prof. N. Gupta (process and design methodology)
- Mr. Alessandro Betti (model making assistance)
- www.paralax.com (circuit and code references)
- www.trossenrobotics.com (robotics components)

Questions ???

Thank You

Cost Estimation

Sr. No.	Component Name	Quantity	Cost
1	Basic stamp BOE	1	99.95
2	Linear actuator	1	70
3	Stepper motor	2	21.9
4	Continuous servo	5	64.75
5	Standard servo	2	25.9
6	Mosfets IRF510	4	16
7	Stepper motor driverULN2803	1	1.5
8	Pressure sensor	1	6
9	Acrylic sheet, wooden rod and hardware		50.49
10	Ball Bearings	16	40.8
11	Timing belt	2	17.07
12	Timing belt pulley	4	35.52
13	Gears	6	39.20
14	Nylon rods, nuts etc		47.22
15	Others (Transportation, mailing, taxes etc.)		35.68
Total			**571.98**