UNIVERSITY OF THE SOUTH PACIFIC

DEPARTMENT OF TECHNOLOGY

TE300 PROJECT

FINAL REPORT

TITLE : RECONDITIONING OF ASEA MHU ROBOT

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PREFACE

This project involves the repairing and maintenance of the ASEA MHU JUNIOR robotic unit, which was donated by the University of Auckland, and assigning a task to this robotic unit so that it can be used as a teaching and demonstration unit.

This project was done as a group work with my project partner Kamal Chand (S98006671). Most of contents of the project are similar to that of my project partner since we had submitted one preliminary and progress report to our supervisor.

This report is to present readers with a sound understanding of the ASEA MHU JUNIOR robotic system. It includes written program codes in Dynamic C language for the automatic operation and the task that the robot has been programmed for. The program codes can be easily altered to suit the users applications.

This report may not provide all the details about the hardware and software and readers are advised to refer to the users manual, which is available with the project, for maintenance and troubleshooting.

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I would like to express my sincere thanks to the following people for their suggestions and guidance towards the successful completion of this project

1. Dr. Samuel Aborhey – Project Supervisor

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3. Mr. Ravinesh Singh – Electrical/Electronics Project Co-ordinator

4. Mr. Mahendra Prasad – Project Supervisor

5. Mr. Jeff La'ava – Electrical/Electronics Technician

6. Mr. Shiu Dayal – Metal Workshop Technician

7. Mr. Krishna K. Sami – Wood Workshop Technician.

Also not forgetting my project partner and all TE 300 colleagues who helped me in anyway possible towards this project.

AIM

To troubleshoot and refurbish (repair) the ASEA MHU Robotic System in order to bring it to a state where it can be used as a teaching module and demonstration unit.

OBJECTIVES

1. To obtain complete understanding about the operation of the ASEA MHU Robotic System.

2. To test the various pneumatic and electro-pneumatic components such as solenoid valves, sensors, dampers, etc and carry out maintenance of the faulty parts.

3. To design a suitable control unit consisting of switching units, interfacing circuits and the BL1400 Z180 microcontroller.

4. To allow control of the ASEA MHU Robotic System both manually and automatically.

5. To design and construct a suitable task for the robotic unit to perform.

6. To test the robotic system using a suitable task both manual and automatic.

INTRODUCTION

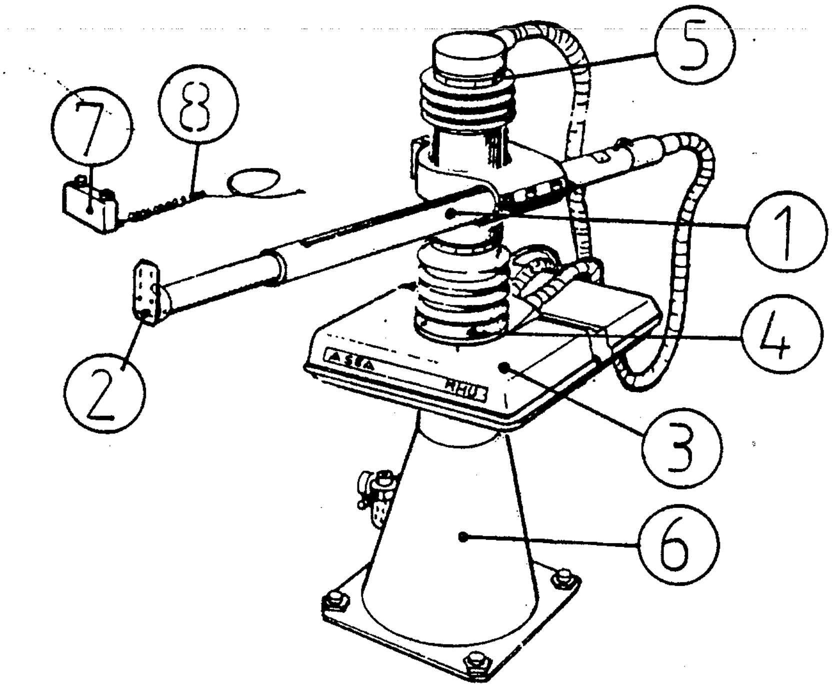
Robots, a marvel of science and technology, are invading the lives of ordinary human beings as technology advances on a day to day basis. Due to the excellent record of robots in the industrial (manufacturing) area and recent technological advances they are finding new applications in non-manufacturing industries such as the service sector, agriculture, health and retirement care, outdoor mobile robots and the construction industry.

The true creators of robots saw robots as intelligent beings. This vision of intelligence has been lost in the real world of techniques and it does not or rather not yet exists in the actual industrial robots. Industrial robotics is an automation technology that has received considerable attention since about 1960. The requirements on the performance of industrial robots continue to increase as they tend to be used for more demanding tasks rather than simple handling jobs.

Robots have parts that can be seen as analogous to the human body such as hands, arms and the brain which is a logical controller controlling the actions of the robot. The gripper represents the fingers of a human and is used for holding and picking up things. The robot hand is called an efflector and the arm is called the manipulator. Robots are classed according to their methods of actuation of force. The most common drives are electrical, pneumatic and hydraulic. Electrical robots are the most precise out of the three as latest technology permits electrical motors to be built with incredible accuracy taking advantage of feedback control. These robots are small, clean, quiet and require less maintenance. Then come pneumatic robots, which are suitable for light duty work. These robots do not have the accuracy of electrical robots but possess good range and speed. They use air pressure to actuate their movement. Hydraulic robots can be classed as the strongest and most dirtiest of all. They use fluids at very high pressure to actuate their movements. The most common fluid is oil.

The ASEA MHU Industrial robot is a pneumatic robot and consists of one arm, a gripper, a column (for vertical movement) and a rotation module. From its construction and performance it can be said that the robot was used in the manufacturing industry to handle only a specified task. The vertical column motion of the robot is 150mm and it moves at a maximum speed of 500mm/s. The rotation movement of the robot is 200° (maximum), and it can be adjusted from 0°- 200° as required by changing the damper setting. The radial arm can move up to 500mm at a maximum speed of 1000mm/s.

All of the robot axes are powered by pneumatic means between adjustable stop positions, which gives rapid motion with a high degree of accuracy. The robot operates at an air pressure of 0.7MPa. Valves controlling the flow of air control the movement of the arm. These valves are driven by solenoids powered by 24V DC power supplies and the valves can attain two positions only. They are either fully open or fully closed. Since the robot has five different movements, which are reversible, 10 solenoid-operated valves are needed. The ASEA MHU Robot has position sensors (Reed Relays) on each of its dampers to determine at which position the robot is.



1	Arm	2	Intermediate Plate
3	Valve Box	4	Rotation Module
5	Column	6	Floor Stand
7	Junction Box	8	Gripper Cable

Figure 1 : Mechanical Robot – ASEA MHU Robot

BACKGROUND

The ASEA MHU Robot is an electro-pneumatic robotic system donated by the University of Auckland. Along with the unit were some manuals regarding the installation, circuit diagrams, parts list and programming using a PLC. In order to thoroughly understand about the robotic system, the whole unit was inspected and manuals were read to find out the specific functions of the components. The robotic system does not have any input control unit and we have to make a suitable input control unit to control the robotic system. The unit is 17 years old and it was also not in a working condition. The robotic system consists of two independent units, a free standing mechanical robot and a control unit (which is not available), connected to each other via wiring and a terminal box.

The robotic unit consists of a base and one arm, which is mounted on a shaft. The shaft is supported in a vertical position by the top plate of the base and it also has a column, which moves up and down (150mm maximum). The robot has a rotation module, which allows the shaft to rotate (200° maximum) together with which the arm of the robot rotates. The arm consists of two tubes arranged to slide telescopically in each other, one of which, the inner tube, is hard chromed for minimum friction and maximum service life. It is driven by a pneumatic cylinder (diameter 26mm), the end positions of which have pneumatic damping. To adjust the end positions, the entire arm is moved in the arm holder. Arranged round the cylinder is a number of telescopic tubes, four of which are for supplying air to the gripper. All electric and air supply lines to the arm are run in a protective hose. The gripper unit consists of an aluminium housing in which a slide is carried on two shafts with ball-bearing bushes. One end position of the slide, which is driven by a pneumatic cylinder (diameter 20mm), is adjustable by means of a screw. End position signals are obtained form adjustable reed element switches.

The control unit, which is not available, has to be constructed. This unit contains all of the electronics for the robotic system. The control unit shall consist of a control panel, a BL1400 microcontroller, interfacing circuits and the mains supply. The control unit should have an input of 240V 50Hz AC and should be able to output 24V DC to energize the solenoids to control the movement of the robot.

The main robot components are castings and the construction is resistant to the effects of severe industrial environments.

The control unit of the robot ~~would~~ ~~consist~~ consists of a BL1400 microcontroller and the relevant interfacing circuits. The robot movements are controlled by a number of digital outputs which control the corresponding pneumatic drive units (solenoids and pneumatic valves) of the different axes. All the main movements are supervised through digital inputs. When the solenoid is energized, the valve is opened and compressed air is allowed through which permits the movement of the components. The base unit accommodates five valves operated by ten solenoids, an inlet for the air pressure and an outlet for excess air to go out. To operate the solenoids about 4.8W of power is required per solenoid. This was calculated by the voltage rating of the solenoid (24V) and the resistance of the coil (120Ω).

THEORY

This project, which is about the reconditioning of the ASEA MHU Robotic System required knowledge of Electrical, Electronics and Pneumatics. Not much research was required for the electrical and electronics part but being totally new to pneumatics a lot of research was required for this. Help from lecturers and reference materials provided enough theory for us to allow work to proceed smoothly.

Compressed air is a universally recognized unique power from the fact that it embraces many facets of industrial control. It is fundamental to pneumatics, which inherently utilizes the speeds, flexibility, reliability and environmentally safe characteristics of this medium in practical forms. Pneumatics is itself a major contributor to low cost automation and thus plays an important role in industries worldwide.

Pneumatics can essentially be categorized into the areas of:

- the compressed air source (compressors)
- compressed air distribution and preparation
    - airline layout (pipes, moisture traps)
    - air service units (valves, etc)
- overall pneumatic system
    - power units (air cylinders, air machines, etc.)
    - control components (valves, etc)
    - logic circuits (interfacing circuits)

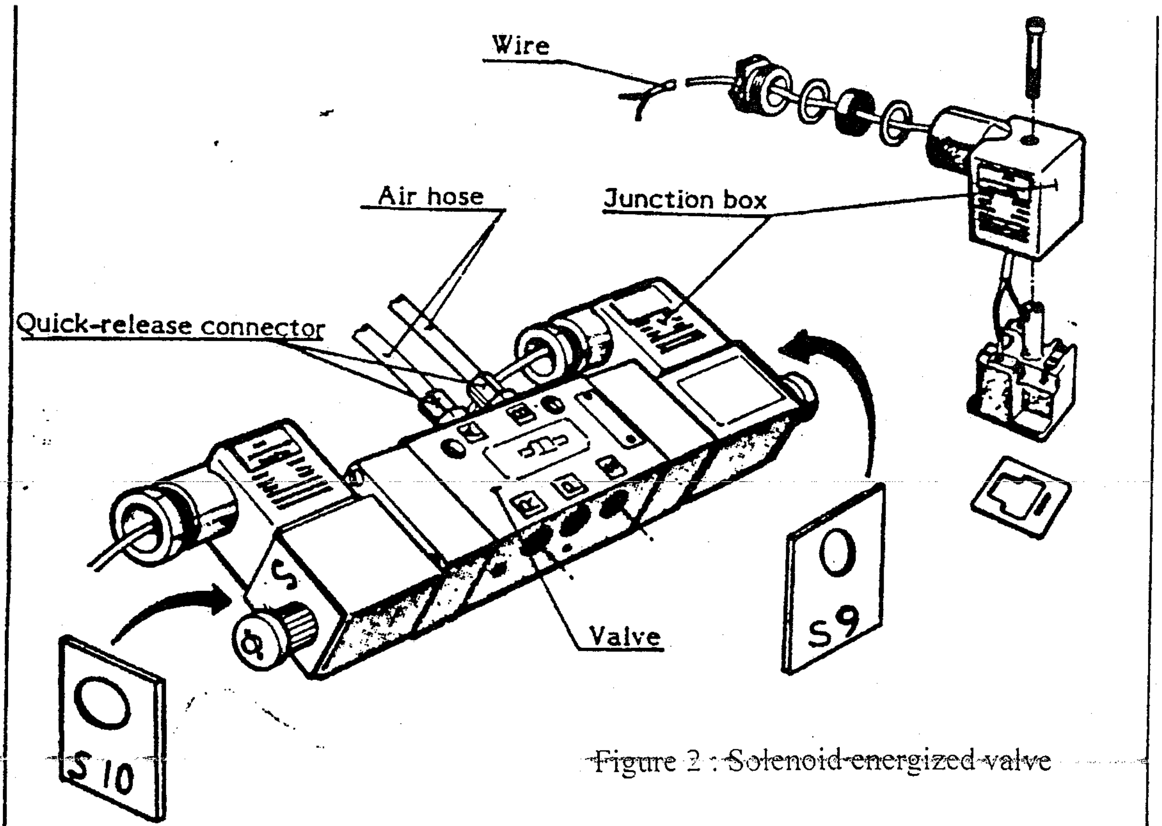
The compressors more widely used in pneumatics are positive displacement types. Some form of water removal is necessary from the compressed air and preparation of air involves the use of filters for the removal of contaminants. Pressure regulators are also used to set working pressure to an optimum range. The main objective of our project is to recondition the ASEA MHU pneumatic robot and program it to perform a suitable task.

From the theoretical and practical knowledge gathered, it became evident that the major components of pneumatic control systems are compressors, valves, flow regulators, pressure regulators, solenoid coils, and pressure reducing valves. The compressor compresses the air and allows it to be used as a form of energy for movement. There are many types of valves but for the project we studied about five port valves.

The valves in most cases can attain a number of positions but for the case of the project a valve which attains two positions either fully closed or fully open was studied. The valve for the project is operated by electromechanical devices called solenoids. Figure 2 shows a solenoid energized valve. When the solenoid is energized it allows the valve to open and allows compressed air to flow through and cause movement of the specific parts.

Pressure reducing valves control the pressure and reduces the speed at which the parts move. For our project we would use the reducing valve and try to have a more precise control of the robot.

The feedback signals to the control unit are provided by means of dry reed relays. The switch capsule of a typical reed relay is shown in Figure 4. The basic reed switch capsules consist of solid metallic contacts sealed in a glass envelope. These flattened ferromagnetic reeds are sealed at each end of the capsule. The reeds are separated by an air gap and overlap inside the tube. When the capsule is surrounded by an electromagnetic coil of sufficient flux density or is exposed to a magnetic field, the extreme ends of the reeds assume opposite polarity as shown in Figure 4. The attraction forces of the opposing magnetic poles overcome the reeds stiffness, causing them to move toward each other and close. Removal of the magnetic field will return the reeds to their open position.



~~Figure 2 : Solenoid-energized valve~~

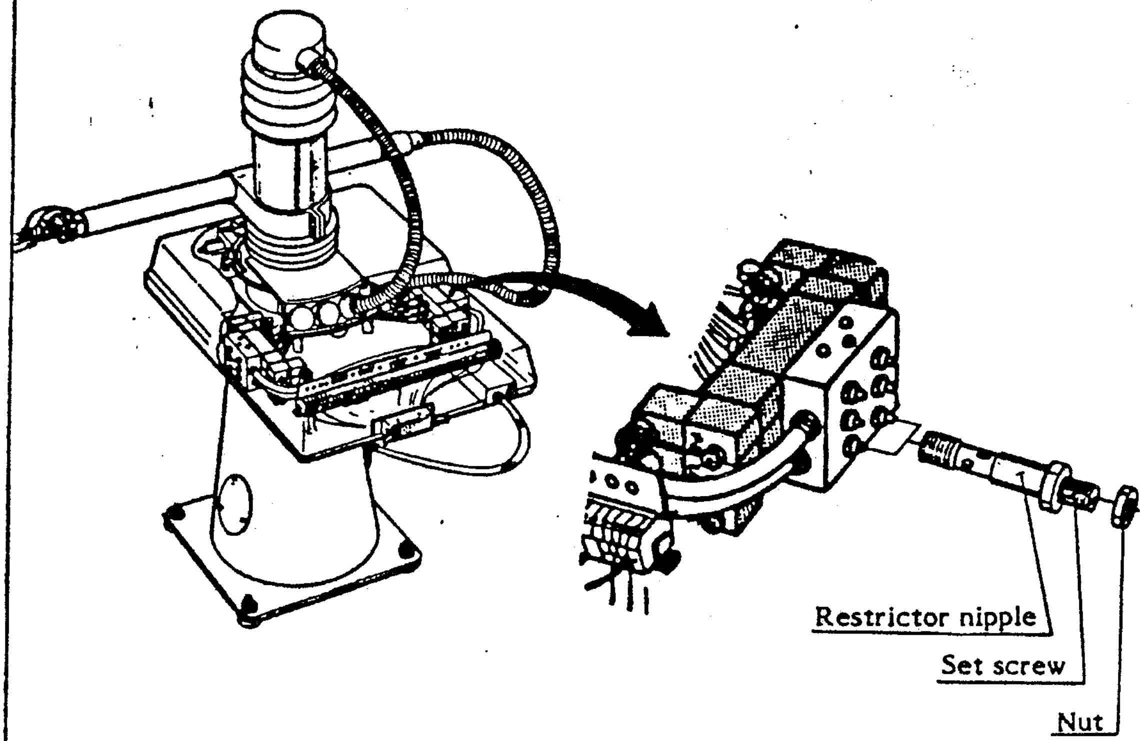


Figure 3 : Five-Port Valve Installation

SELLECTION OF CONTROLLER

We were given the option to choose between a PLC and a BL1400 Microprocessor to be used as the main control part of our system. We decided to use a microcontroller for control because microprocessors are among the most elaborate of all integrated circuits. Microprocessors can be used to control almost anything in an industry. They are very flexible because they themselves are controlled by a software. Software is a set of instructions and data that directs the step – by – step operation of a microprocessor.

The BL1400 is an 8 – bit, 6 MHz microprocessor that would be used for our project. The advantages of using a microprocessor over a PLC is that we can change portions of our project programming with only little extra work being required. But for the PLC, if we want to change a program, we may need to re-write the whole program.

The BL1400 micro-controller allows us to either take the 8-bits as input or as output at any one time. It is also easy to replace and easy to carry. It also takes very little space for installation and it has a high memory capacity.

Thus using a microprocessor saves us much time and effort when in the initial programming stages and allows the users to easily replace the controller if there is any malfunction.

METHODOLOGY

The ASEA MHU Robotic Unit was not in a working condition when the department received it. The unit was thoroughly cleaned before any testing was carried out. The robotic unit did not have any input control unit so the initial testing had to be done by individually energizing each coil and allowing the compressed air to move in and cause movement.

Before starting the work on the robotic unit a work schedule was prepared and various tasks were divided into different categories.

Stage 1 : Cleaning and testing of all pneumatic, electro-pneumatic and electrical components.

Stage 2 : Design and Construction of new switching and control unit for the robotic system.

Stage 3 : Design and construction of a task for the robotic unit to perform.

Stage 4 : Programming the robotic unit to perform the task.

Stage 5 : Final testing of the robotic unit manually and by the program executed by micro-controller and making appropriate changes to meet the set objectives.

Stage 6 : Final cleaning of the whole system and painting the whole unit.

STAGE 1 CLEANING AND TESTING

The whole robotic system was thoroughly cleaned and the following tests were carried out in order to determine the state of the components.

TESTING OF ELECTRICAL COMPONENTS

SOLENOIDS AND VALVES

The pneumatic hoses were removed from the valves inlet and outlet and the solenoids were removed from the mounting inside the base unit. The coil of the solenoid was tested using a multimeter (i.e. the resistance of the coil was measured to check for open and short circuit). Since the solenoids were rated at 24V DC they were powered from a DC power supply. To check the status of the valve air was blown into the valve from one end. When the solenoid was energized air passed through the valve and when de-energized the passage was blocked. This revealed that the solenoid was in working condition. Each solenoid was tested using this method and all revealed to be in working condition. The solenoid valves were then mounted back in the mounting place and the pneumatic hoses were attached to the inlets and outlets.

REED RELAYS

The reed relays wiring was stripped from the junction box. Each reed relay was tested by moving the robot to its extreme positions manually in order to bring the activating magnet close to the reed switch. A short circuit test using a multimeter was performed to determine whether the reed switch closed or opened when the activating magnet was brought close to it. It was found that for all reed relays the reed switch closed when the activating magnet was brought close to the reed switch.

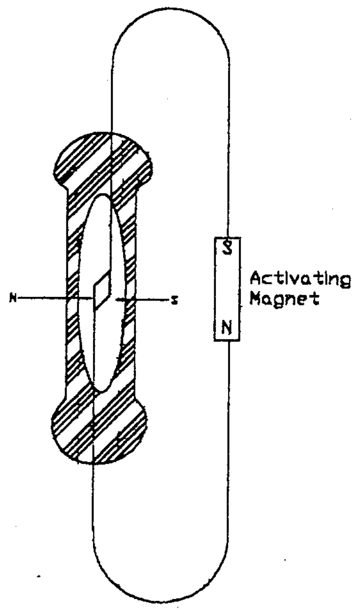


Figure 4 : Unbiased Reed Relay

TESTING OF PNEUMATIC COMPONENTS

After all the main electrical components were tested, the pneumatic components were tested. A compressed air hose was connected from the compressor outlet to the main inlet of the mechanical robot. The compressor outlet was opened slowly at first and then adjusted to an estimated appropriate pressure. It was seen that the rotating module moved to its initial position. It was also noted that there was small leakage of air form loose pipes around the gripper. After the leaks were eliminated by tightening the connectors, various coils were energized to test for the respective motions of the robot.

It was noted that when the efflector was fully out, the pipes came out of its connections. After re-connecting the pipes the opposite coil was energized and it was seen that the arm did not go back to its original position at once. A little tap was needed for the arm to go to its original position. It was also noted that the arm moved very slowly to its end position. The main reason for this was that the damping was set too hard. The damper settings were adjusted and this problem was overcome.
When the rotation module was tested the only problem encountered was that the rotation unit bottoms at the end positions. The reason for this could be that the damper settings were not done correctly. To overcome this problem the damper settings were adjusted until the rotation was going smoothly. The testing for the column was done and it was noted that the column was operating well. After that the gripper testing was done. The only problem that we came across was that the gripper did not move initially, but after a little tap it was working well. The reason for this could be a faulty air hose. The air hose would be replaced to overcome this problem.

The recommendations for the pneumatic components was to replace all the air hose with new ones. If there are any leakage's it would be overcome and it would ensure optimum performance in future.

The complete troubleshooting guide is given in the users manual available with the project.

TESTING/MAINTENANCE OF ALL MOVEABLE PARTS

All the mechanical parts of the existing robot were tested. It was tested to see whether the existing robot was in a condition to perform any work or not. First, the robotic arm was tested. The arm was found to be in a good condition but it required oiling and adjustments to its damper for smooth movement. Apart from testing for movement it was also tested for any possible leaks. Due to the air hose being very old, there were some leaks in the arm. Apart from the arm all other moveable components were also tested for movement and possible leaks in the system.

To overcome any possibility of pressure leaks from the hoses and connectors in future, all the old pressure hoses were replaced by new ones and all moveable parts were oiled. This allowed more smooth and efficient movement of the parts. We also needed to do some repairing to two sensors that was not available in the local market.

The compressible packing inside the sensors were replaced with springs which allowed it to function properly.
Some modifications were also needed on the gripper to suit our selected task. Since the stamping machine uses small objects for demonstration purposes, we had to modify the gripper so that it could pick small objects. In order to make the robot useful for other tasks as well, we thought of designing a gripper which had adjustable hold positions. The adjustable hold positioning of the gripper would allow the gripper to hold objects of different sizes. The new design of the gripper is given below.

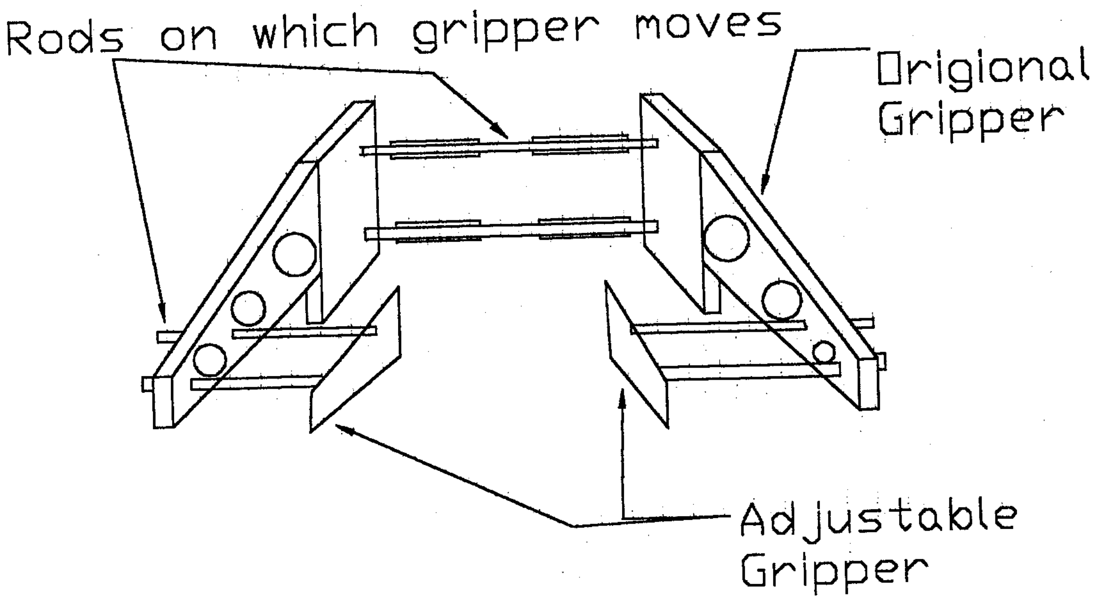


Figure 5 : Gripper with adjustable hold positions.

STAGE 2 DESIGN & CONSTRUCTION OF A NEW SWITCHING AND CONTROL UNIT

SWITCHING UNIT (Manual Control Unit)

The switching unit (manual control unit) consists of 10 momentary push button switches, which are used to control the robot by a remote control which is connected to the control unit. To allow the remote control unit to operate, the mode changeover switch on the Control Panel has to be on the Manual position and the start/stop switch for the automatic cycle has to be on the OFF position. The main switch should also be on the ON position. The remote control would not be operational if the mode is OFF or on AUTO position as 5V would not be supplied to the remote control.

CONTROL UNIT

The control unit consists of 7 circuit boards, a BL1400 micro-controller, a 240V-24V transformer, and some rectifier circuits to give a regulated DC voltage. These are all mounted inside a box, which is called the control unit. The Control Panel of the box has a ON/OFF Main Switch, a Mode Changeover Switch, and a START/STOP Switch for switching on the automatic cycle for the task.

TRANSFORMERS AND RECTIFIER CIRCUITS

The solenoid coils on the robotic unit uses 24V DC power supply to open and close the valve for the robot to operate. The BL1400 uses 12V DC power supply and the circuits use 5V, 12V and 24V. the solenoid coils are rated at 0.25A each and there are a total of 10 solenoid coils in the robot. The transformer that has been used for our project provides 5V, 9V, 12V, 15V, 20V, and 24V AC voltages, therefore the supply from the transformer needs to be connected to a rectifier , regulator and some capacitors to make it a regulated DC supply and decrease the transients in the supply.

The transformer is rated at 240VA and it is able to completely support the whole load of the project. The rectifier and the regulator is used to convert the AC supply to DC. After the regulator, the power supply is filtered to decrease the spikes from it. The figure on the next page shows the basic power supply that we have used for our project.

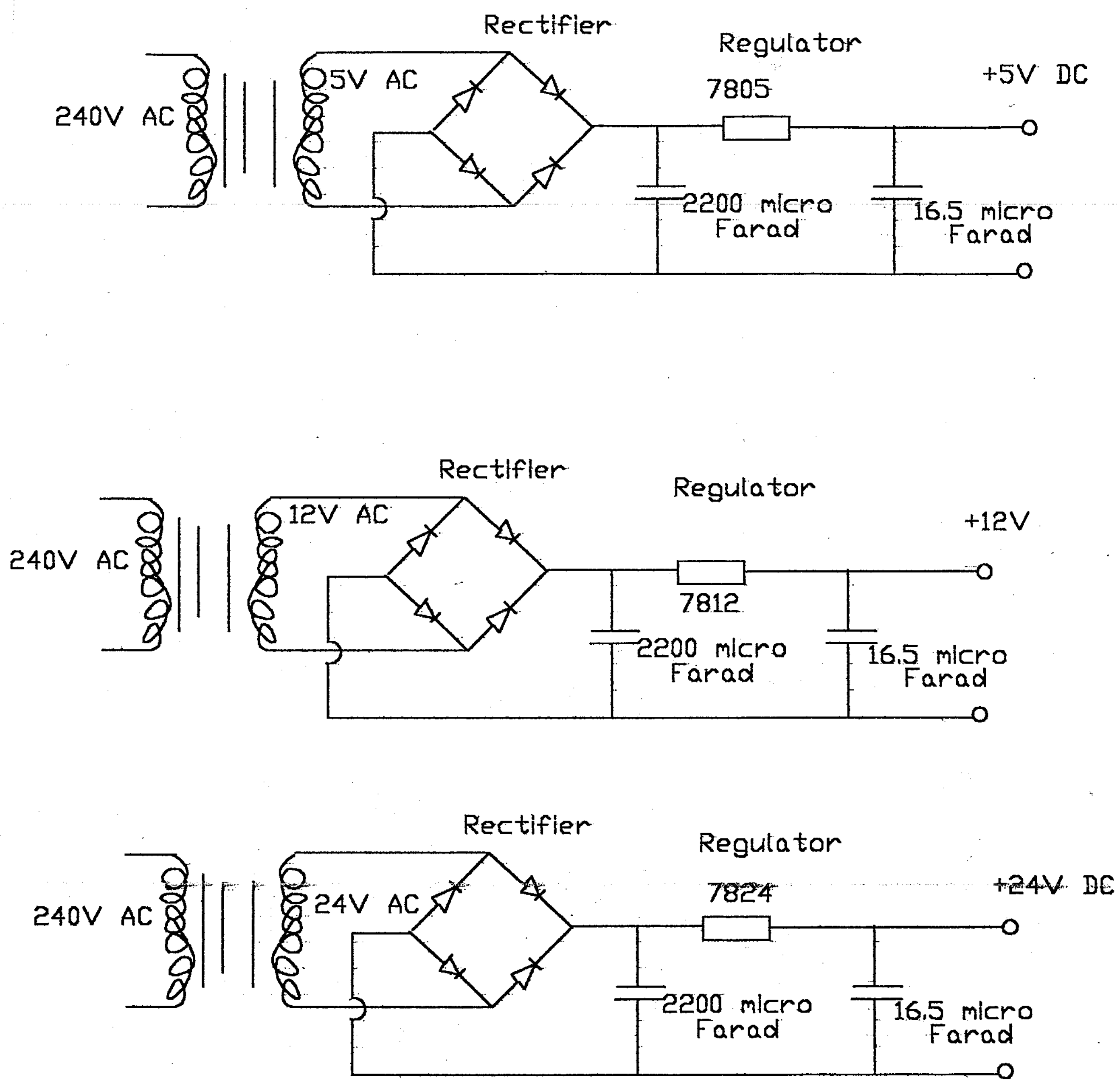


Figure 6 : Simple power supply circuit

INTERFACING CIRCUIT

The micro-controller's output signals are low power signals and cannot drive the robotic unit, which has the power requirements per solenoid of about 6W. for this reason an interfacing circuit between the microcontroller and the solenoid valve is used. The interfacing circuit consists of ten comparators (LM324), ten power transistors (TIP31C), 2 D type latches (74LS373) and 1k ohm resistors.

In the interfacing circuit one of the components input is set at a reference of about 0.538V and the other would be connected to the output of the switch from the remote control and the output from the microcontroller is connected to the D-type latch which are connected to the Op-Amp. If the input voltage is above the reference voltage, the output voltage would saturate to its supply voltage (the voltage that is used to power up the chip), thus switching on the power transistor. If the input voltage is less than the reference voltage, the output voltage would saturate to the minimum value, that is, 0V and hence the power transistor would be switched off. The power transistors amplify the output voltage to 24V and control the energizing and de-energizing of the solenoids thus controlling the opening and closing of the valves and hence controlling the robotic unit for both manual and automatic operation.

The figure 7 shows the interfacing circuit.

POSITION SENSOR CIRCUIT

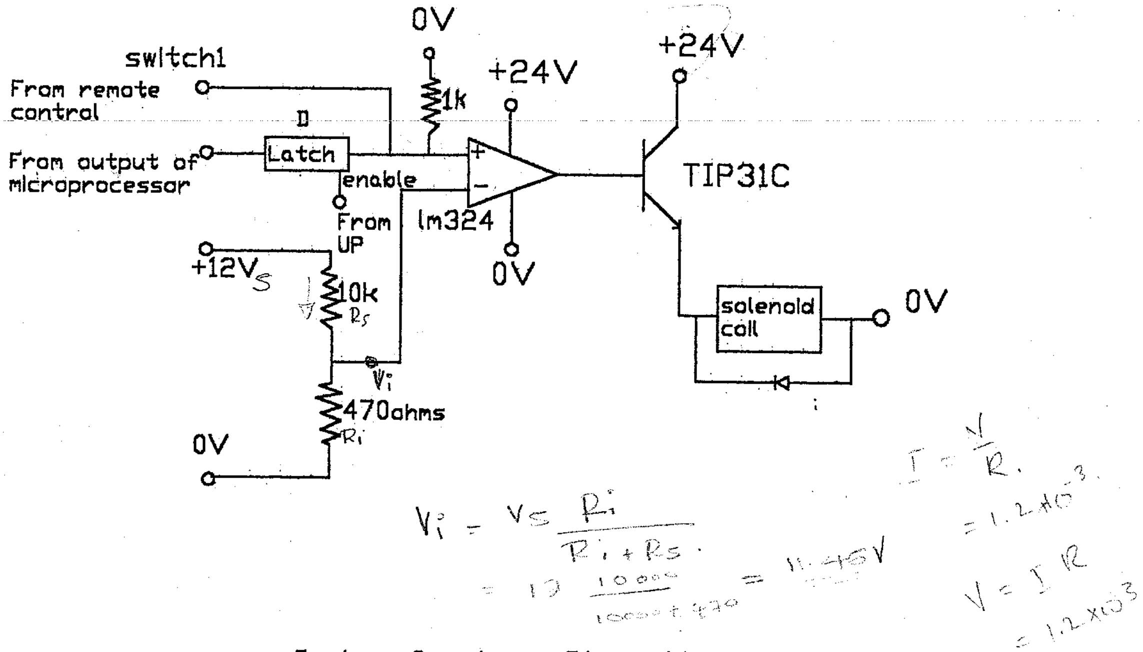
The position sensor circuit indicates the positions of the robotic unit. As stated earlier that the robotic unit has only two positions for all its motions, it has Reed Relays at both its end positions. The Reed Relays closes the contact when the magnetic part of the relay, which is on the moveable axis, comes in contact with the relays at its two extreme positions. This provides the feedback to the controller which then executes the instructions.

From the theory of BL1400 microcontrollers, parallel input/output (PIO) ports and PIO Operation, it was decided that mode 3 (Bitwise I/O) would be used (See appendix for more information). Ten of the twelve configurable I/O bits would be used for both input and output. This means that the sensor feedback signal and the microprocessor output signal would travel on the same line at different times. To ensure that only one signal is on the line at a time, D-type latches have been used. The D-type latches enable signal would be controlled by one of the two remaining PIO bits.

Figure 8 shows the position sensor circuit.

Interfacing Circuit

Interfacing Circuit



Interfacing Circuit

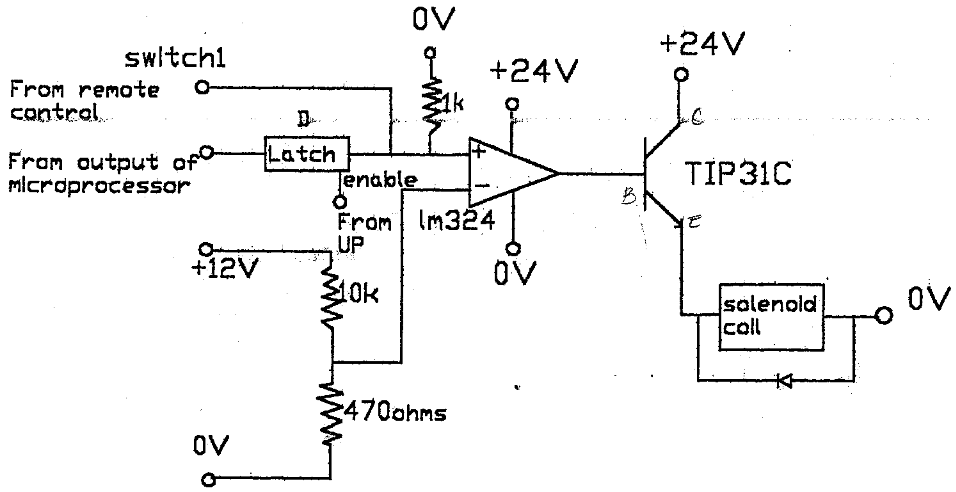


Figure 7 : Interfacing Circuit
Note that only two of the circuits are shown above. The interfacing circuit consists of 10 such circuits.

Position Sensor Circuit

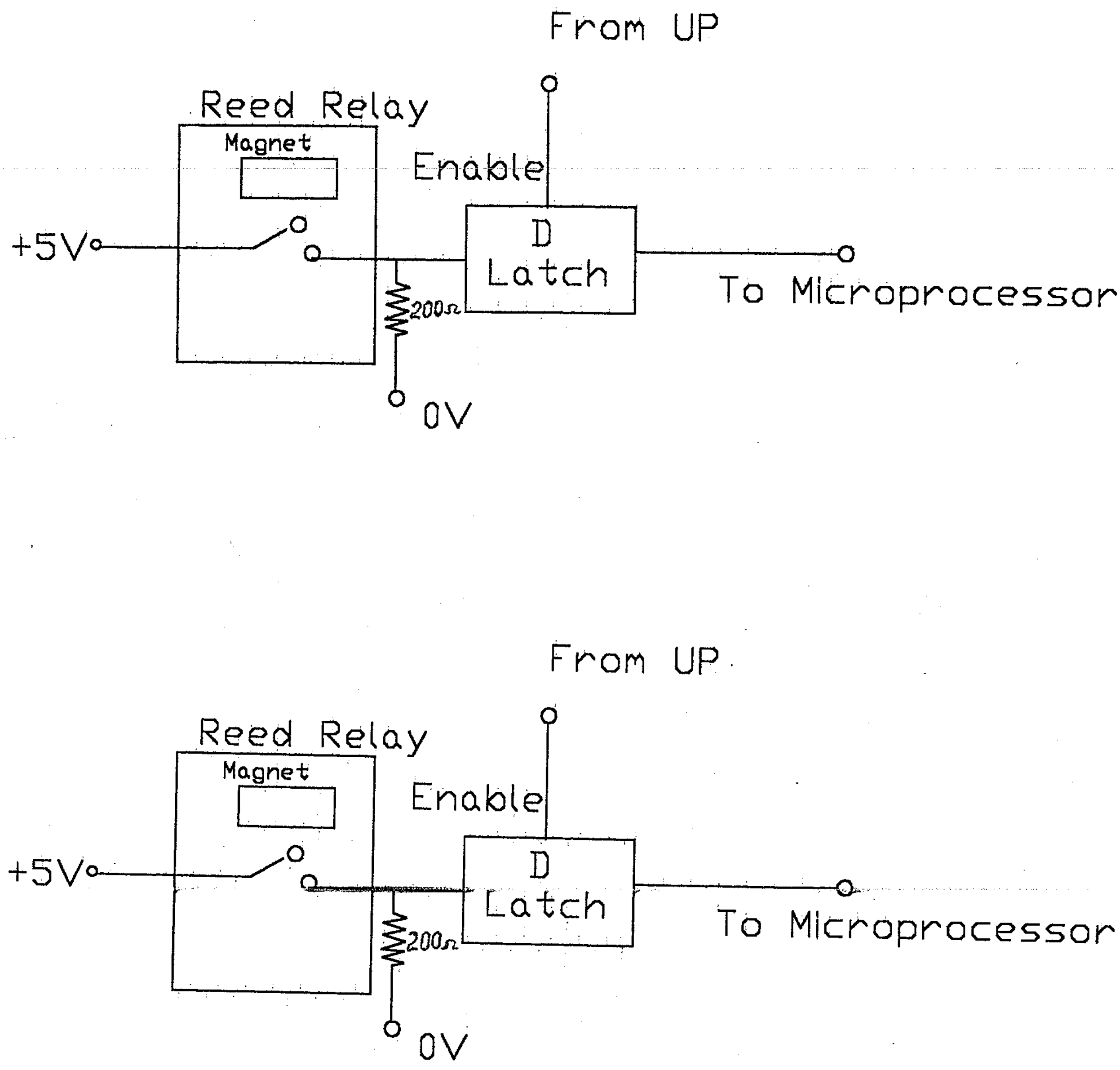


Figure 8 : Position Sensor Circuit
Note that only two of the circuits are shown above but there are 10 such circuits in the control unit.

Main Control Unit

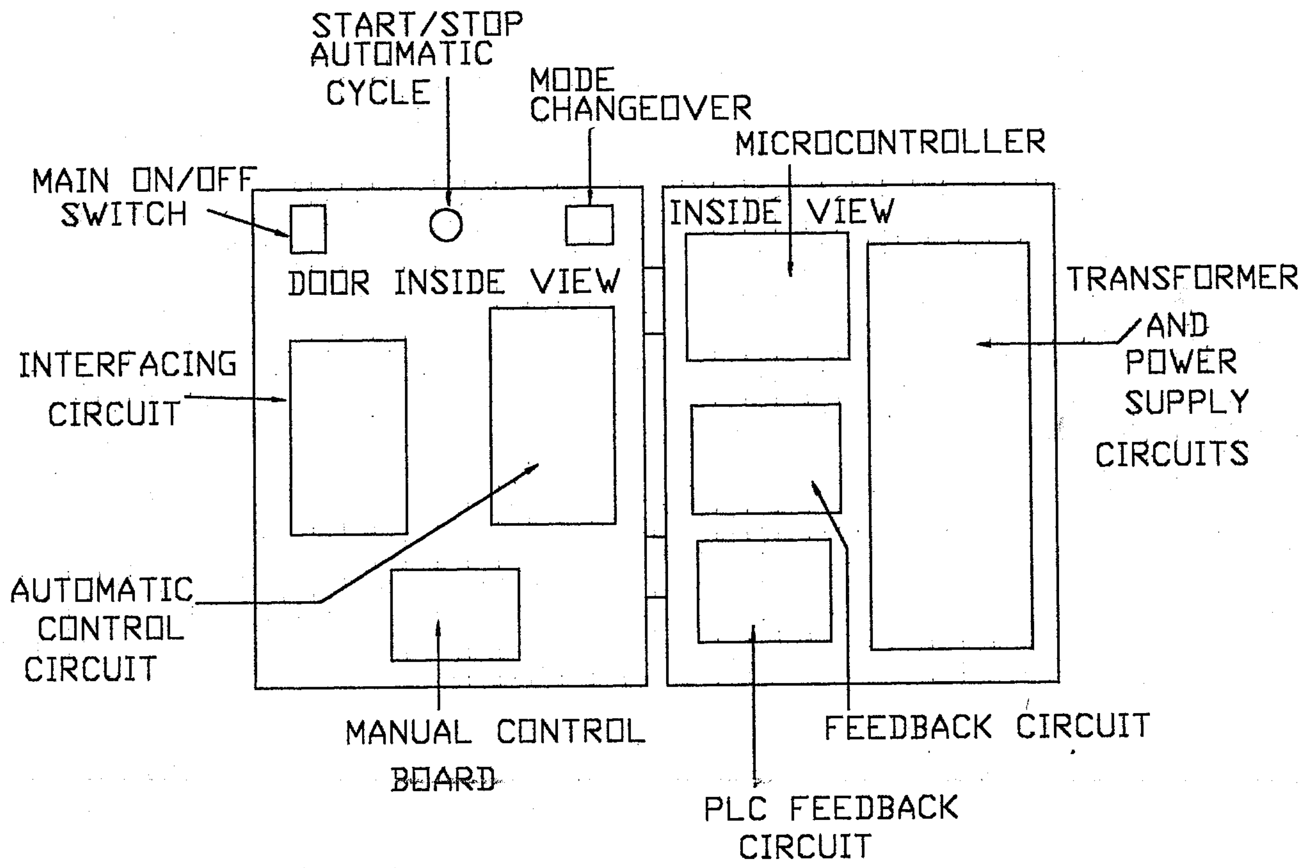


Figure 9 : Main Control Unit

HEAT SINKS

As the transistors were getting very hot some means of cooling was required. The best cooling method is to mount the transistors on the heat sinks. The heat sinks have a larger surface area and are able to dissipate heat to the ambient very rapidly. The material commonly used for heat sinks is aluminiun. Shown below is some calculation done during choosing the right size heat sink.

Vce = 2.23V
Ic = 0.56A
Pd = Vce * Ic
= 2.23 * 0.53
= 1.17W

Tc = Ta + Pd(Rc-a)
The maximum case temperature desired is 60°C

Tc = 60°C
Ta = 35°C
Pd = 1.17W
Rc-a = (Tc – Ta)/Pd
= (60 – 35)/1.17
= 21.37°C

Rj-c = 60°C
Tjmax = Ta + Pd(Rj-c + Rc-s + Rs-a)
Rs-a = (85/1.17) - 61.5°C
= 11.14°C

Comparing this value with the given value in catalogues which is around 8.9°C indicates that the heat sink used is suitable for the application

Note:

Tc - Case Temperature
Ta - Ambient Temperature
Rc-a - Thermal Resistance Between Case and Ambient
Rs-a - Thermal Resistance Between Sink and Ambient
Rj-a - Thermal resistance Between Junction and Case

STAGE 3 DESIGN & CONSTRUCTION OF TASK

DESIGNING

Since a robot is almost useless without a task, it was decided that for demonstration purpose, that robot would be incorporated with the stamping machine that is available in the Technology Department. After looking at resources and time available, the stamping machine was thought to be the most suitable task as it is used in laboratory classes to demonstrate the actual process of stamping products in a manufacturing environment.

The product to be stamped would come on the conveyer and after being stamped by the machine it would be picked up by the robot and put in the cylinder for stamping again. This would form a repetitive task but it would be good for demonstration to test the accuracy of the robotic unit.

CONSTRUCTION

The work on the stamping machine is almost complete. The program was modified a little to suit the task and as the compressor was down the timers in the program could not be adjusted. The connection of the stamping machine was done with the help of the connection diagram given by the Electronics Technician. There were also some pressure leaks in the stamping machine and it was controlled by the help of the Mechanical Technician.

Since the maximum height that the robotic unit can rise is 15cm, a cylinder was constructed that was less than 15 cm in height but the inside diameter and outside diameter was the same to suit the task.

The program for the BL1400 has been written and it follows the correct sequence to suit the given task. After the first task is tested , the robotic unit can be programmed to carry out the tasks defined by the user.

Figure 10 shows the layout of task for the robotic unit and Figures 11 and 12 show the circuits that have been used to get the sensor output from BL1400 to start conveyer and to obtain sensor input from PLC to BL1400 to stop conveyer and pick up part from the conveyer respectively.

Task for the Robotic Unit

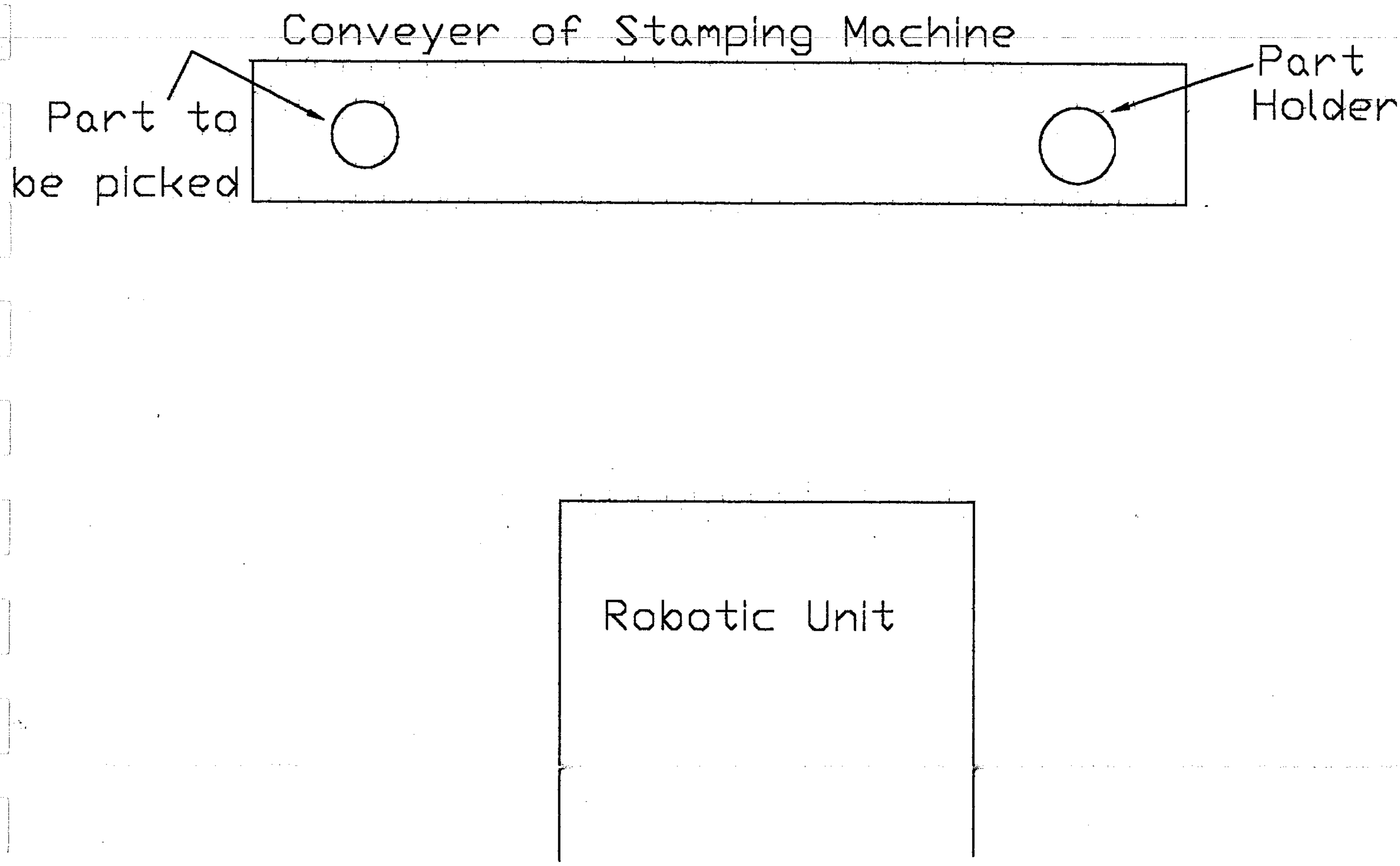


Figure 10 : task for the Robotic Unit

Circuit to Obtain Sensor Output from BL1400 to Start Conveyer

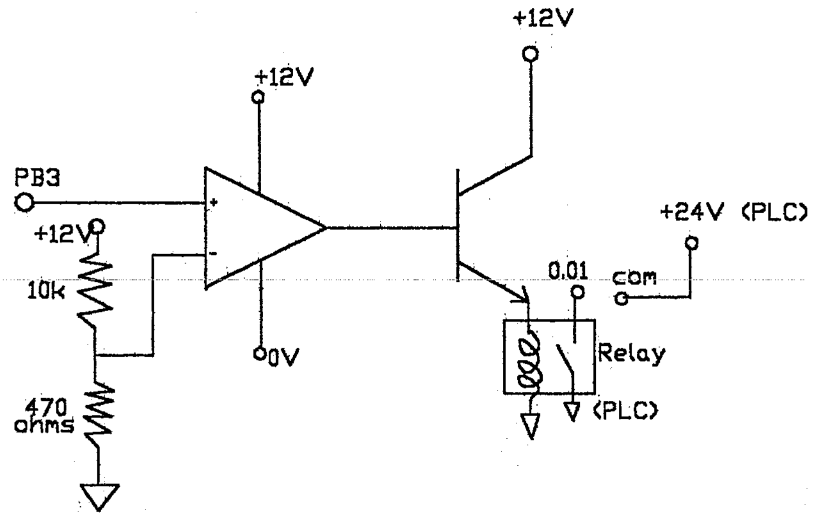


Figure 11 : Circuit to Start Conveyer

Circuit to Obtain Sensor Input to BL1400 from PLC to Stop Conveyer and Pick Up Part

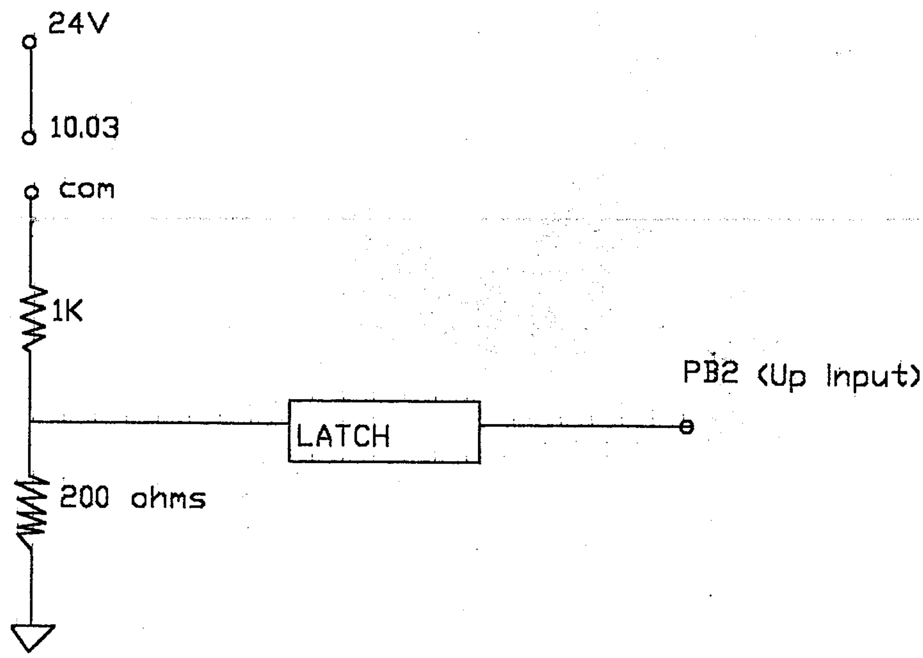


Figure 12 : Circuit to obtain input to BL1400 to stop Conveyer and Pick Part

STAGE 4 PROGRAMMING THE ROBOTIC UNIT

The following program was written in Dynamic C language for the Automatic Operation of the robot. This program is working correctly according to the task that we have given to the robotic unit.

The robotic unit can be reprogrammed in Dynamic C to suit the task defined by the user.

Note that this program uses the STDIO window. Before the EPROM is burned these STDIO commands will be removed.

```
/* This program is for the automatic operation of the ASEA MHU
   ROBOTIC SYSTEM.
   When Start switch is ON the robots arm is initialized to
   a set position.
   This program checks if a part is ready to be picked from the stamping
   machine. If a part is ready to be picked then it is picked up and placed
   in the parts holder. The conveyor is stopped when a part is ready to be
   picked.
   PB2 is used to sense a part. When a part is ready to be picked PB2 is high
   and this starts the sequence of movements to move the part to its
   destination.
   PB3 is a sensor input to the stamping machine. When PB3 is high the
   stamping machines conveyor is restarted.
   The program loops to check the Start switch again and then to check if a
   part is ready to be picked. This procedure is repeated.
*/

#use "default.h"
#use drivers.lib

char TESTSTART, SENSORIN, ONSENSOR, ON, TESTON;

void coil_output(char, char);

main()
{

BEGIN:

printf("This is a program for the automatic operation \n");
printf("of the robot\n");

resPIOCB('\B10111000'); // to set bit 7,5,4,3 as output
resPIODB('\B11111100'); // activate input latches thru bit 7
```

```
resPIODA('\B11111111'); // reset all data bits in port A
setPIODB('\B10000000'); // enable output latches

TESTSTART = 0; // initialize TESTSTART
SENSORIN = 0; // initialize SENSORIN
ONSENSOR = 68; // ONSENSOR value
ON = 192; // ON value

START: // to test if start switch is on

TESTSTART = inport(PIODB); // input to port b to check start signal
printf("TESTSTART = %d\n", TESTSTART);

if (TESTSTART == ON){
                goto INITIALIZE;
} else{
                hitwd();
                runwatch();
                goto START;
}

INITIALIZE:

setPIODB('\B10100000'); // enable output latches and set gripper acw
coil_output(0xa6, 0x26);
resPIODB('\B00100000');

PARTCHECK:

resPIODB('\B10000000');

SENSORIN = inport(PIODB); // To test if a part is ready to be picked
printf("SENSORIN = %d\n", SENSORIN);

if (SENSORIN == ONSENSOR){
                goto TASK;
} else{
                hitwd();
                runwatch();
                goto PARTCHECK; // if a part is not detected then check again
}

TASK:

// This sequence takes place if a part is ready to be picked

coil_output(0x10, 0x16); // move the arm out
coil_output(0x08, 0x1a); // move the column down
coil_output(0x40, 0x1a); // grip the part
```

```
coil_output(0x04, 0x16); // move the column up
setPIODB('\B00001000'); // signal to start conveyor
coil_output(0x20, 0x26); // move the arm in
resPIODB('\B00001000'); // reset signal to conveyor
coil_output(0x01, 0x25); // rotate arm clockwise
coil_output(0x10, 0x15); // move the arm out
coil_output(0x80, 0x15); // release the part
coil_output(0x20, 0x26); // move the arm in

goto START;


}

// This is the function that energizes the coils and reads the sensors
void coil_output(char MOTION, char SENSOR){

char SENSORIN2;
long i, n;

// To output to the coils ie energize them
setPIODB('\B10000000');

outport(PIOCA, 0xcf); // mode 3 for port A
outport(PIOCA, 0x00); // all bits as output

resPIODA('\B11111111');

outport(PIODA, MOTION);

if (MOTION == 0x40){
                n = 12000;
} else if (MOTION == 0x80){
                n = 12000;
} else{
                n = 3000;
}

// delay for signal propagation
for (i=0; i<n; i++){
                hitwd();
                runwatch();
                i=i;
}

if (MOTION == 0x40){
                goto EXIT; // because of no gripper sensor
} else if (MOTION = 0x80){
                goto EXIT; // because of no gripper sensor
```

```
}

// To read the sensors
resPIODB('\B10000000'); // change to input mode

outport(PIOCA, 0xcf); // mode 3 for port A
outport(PIOCA, 0xff); // all bits as input

READ:

SENSORIN2 = inport(PIODA);
printf("SENSORIN2 = %d\n", SENSORIN2);

if (SENSORIN2 == SENSOR){
                goto EXIT;
} else {
                hitwd();
                runwatch();
                goto READ;
}

EXIT:

setPIODB('\B10000000');
}
```

STAGE 5 FINAL TESTING

After all the boards and the components were mounted inside the control unit and the wiring was completed, testing was done to see if all the circuits were performing the required functions.

TRANSFORMERS AND RECTIFIER CIRCUITS

After the power supply to the control unit was switched on, the output from the transformers was measured and it gave 24V AC, 12V AC and 5V AC. After it was rectified, regulated and filtered, the voltage was measured which gave 24V DC, 12V DC and 5V DC. There were some problems with the filtering of transients which was corrected by changing the values of the capacitor.

INTERFACING UNIT

The interfacing unit was tested before mounting and it was only tested by manual control (Remote Control). The changeover switch was switched to the manual position and the remote control unit was used to operate the robotic unit. The robotic unit operated smoothly and no further testing of the interfacing circuit was required. The only problem that was encountered here was that one of the op-amps (LM324) was damaged and had to be replaced.

POSITION SENSOR CIRCUIT

The changeover switch on the control panel was put in the auto position and the continuity was tested when the robot moved to its extreme positions. The reed relays were supplied 5V and it showed that all the sensors were working and was connected properly.

STAMPING MACHINE

This is the additional part that we are doing in this project. The stamping machine is controlled by a PLC and its program needed to be modified to suit the robots task. The program was modified and several test runs were done to check if it was correct. It was noted that the program was working well but there was some problem with the timing of the PLC program. This gave the robot incorrect feedback. This problem would be corrected by Wednesday 29th November, 2000.

TESTING USING MAIN PROGRAM

The manual testing showed that all the boards were working correctly. The main program was compiled and the automatic cycle was tested for the robotic unit. The program compiled successfully and it was working in the correct sequence for the specified task. Because of some PLC timing problem the arm picks up the part at the wrong place, otherwise the program is working correctly. The robotic unit can be programmed by the user to suit his task.

STAGE 6 CLEANING AND PAINTING

After the final testing was carried out, the robotic unit was cleaned up. The robotic unit was painted in its original colours which were grey, black, and blue. The control box was painted in blue and grey so that it can easily be noticed as a part of the robotic system.

SUMMARY

A lot of time and effort has been put towards the successful completion of this project. All the set objectives have been completed and an extra part has been added to this project. This involves interfacing the stamping machine with the robotic unit, which is almost complete. The only task left here is to set the timing of the PLC for the stamping machine so that everything works as expected. The work schedule handed out to the supervisor could not be followed consistently due to extra work and also due to unavailability of some parts such as transformer and also due to some technical problems with the compressor.

At present the robotic unit is operating satisfactorily with the problem being the timing of the task. This problem should be corrected by the next Wednesday following the submission of this report. The damper settings of the robotic arm need to be adjusted and the unit must be maintained as advised in the users manual. The compressed air pressure needs to be maintained between 600kPa and 700kPa for effective operation of the robot.

The robotic unit can be reprogrammed to suit the user requirements.

By doing this project I have learnt a lot of things such as about pneumatics and valves, about the BL1400 microcontroller and about the procedures in designing and troubleshooting of common electrical and electronic faults.

RECOMMENDATIONS

My project partner and I have come up with the following recommendations.

1. For precision control of the robotic unit, the valves need to be changed. The current valves remain open once the coil is energized. For precision control a valve is required that opens only when the switch is pressed and is closed as soon as the switch is released.
2. In order to be used for precision control in automatic operation the sensors would also need to be changed. The reed relays need to be replaced with appropriate position transducers. Since the BL1400 is a digital input digital output microcontroller a digital displacement transducer would need to be used and this could be either a shaft encoder or digitiser.
3. This project can be given next year to a student whose task would be to design a C^{++} Builder based controller for the robot.
4. As the program can be changed, this project can also be used as a teaching aid for students in TE321 and TE322 and students could change the program to see what is the outcome.
5. Users can also read the users manual with the robotic system to troubleshoot the robotic unit and its control box.

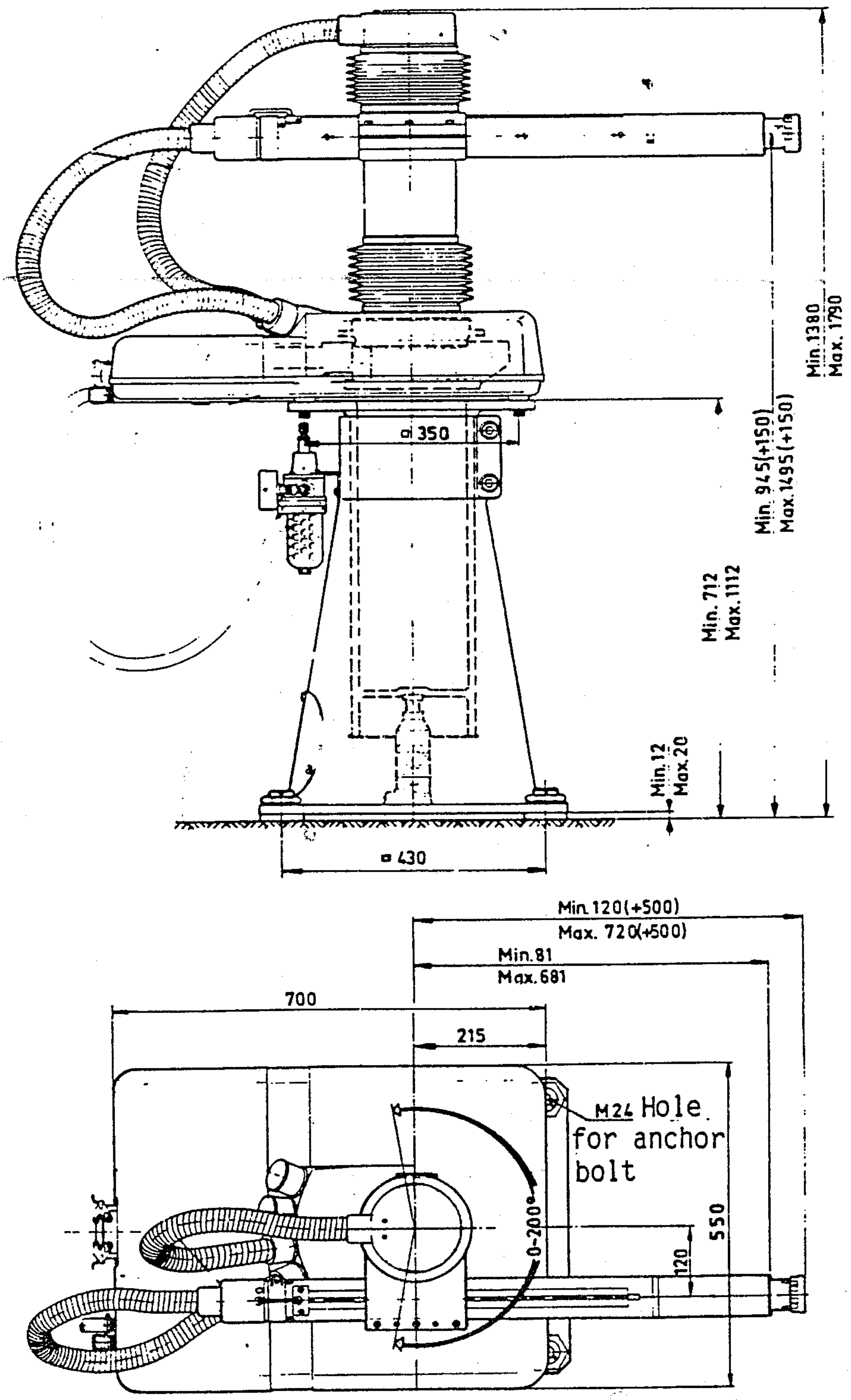
APPENDICES

APPENDIX A : ADDITIONAL DIAGRAMS

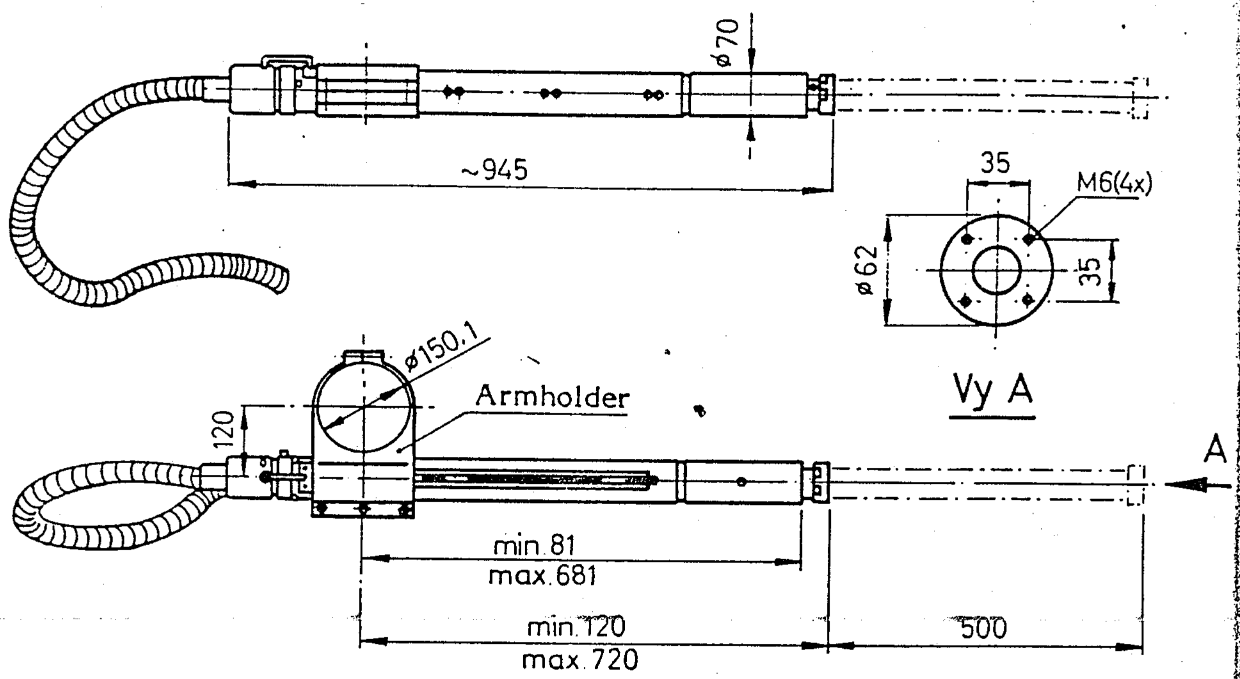
Measurement drawings

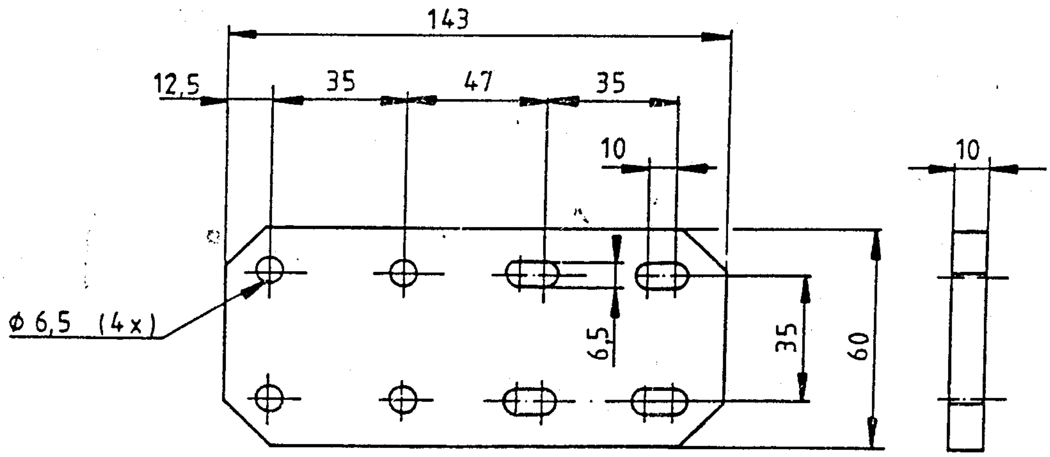
Measurements in millimeter. ASEA reserves the right to change technical data and measurements without previous notice.

Mechanical robot, basic version

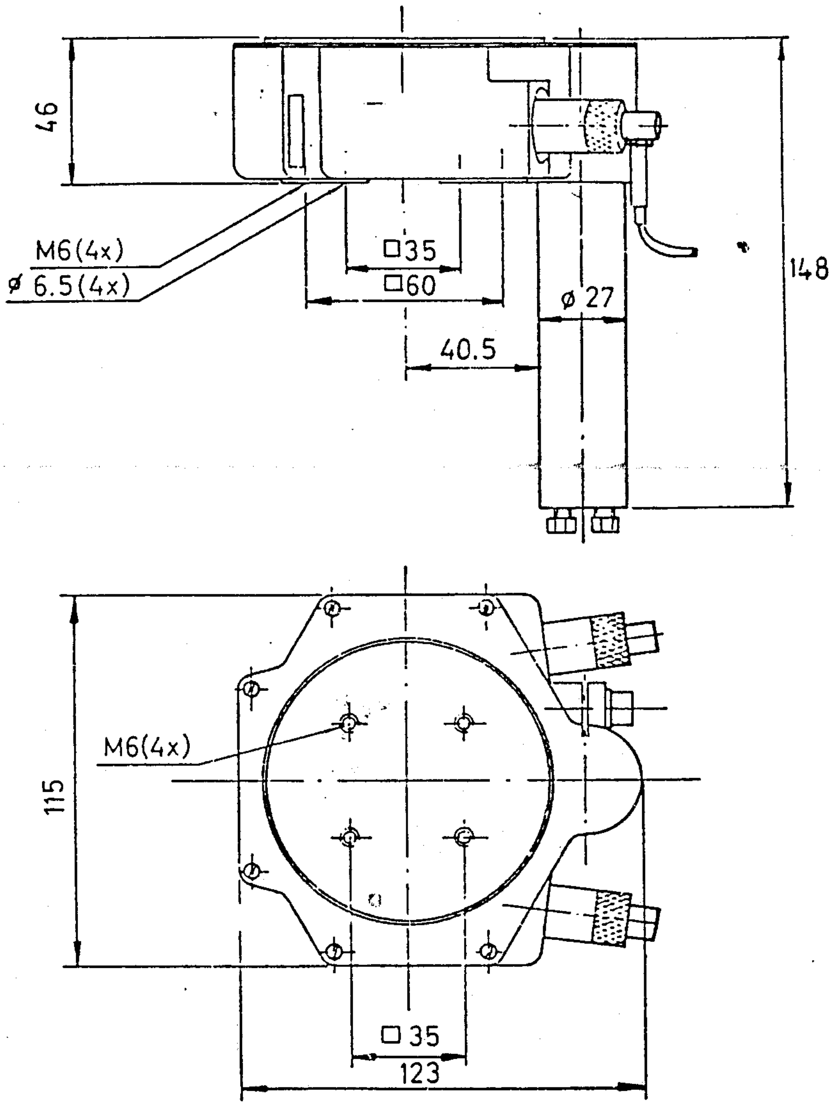


Mechanical robot, accessories

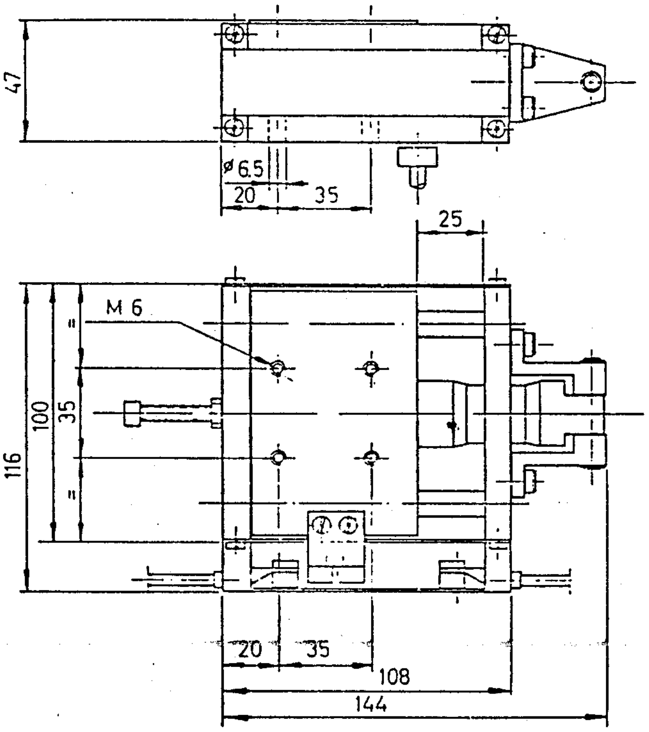




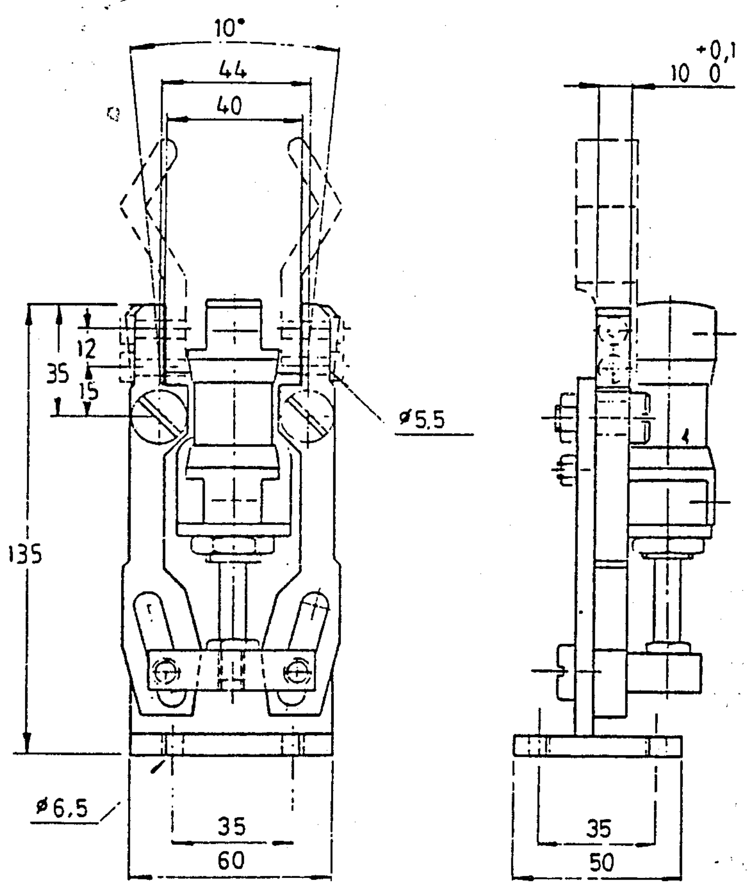
Extra arm (M5.105) PC80



Extra robot axis, rotary unit (M5.300)



Extra robot axis, linear unit (M5.315)



Gripper (M5.330)

2
FAULT TRACING, GENERAL

The MHU Junior is designed for a high degree of availability but certain faults can develop and parts subject to wear may need replacement. The following fault tracing programme can be used to localize and correct faults. A description of the dismantling of the different modules is given in section 3 below.

When the robot function is interrupted, always check that:

- No emergency stop in the control system, machines, any central panel or protective enclosure has been tripped.
- The HOLD function in the control system or any central panel has not been tripped.
- The robot and peripheral equipment receive voltage.
- The robot and peripheral equipment receive the correct air pressure.

2.1
Fault tracing - Arm

Symptoms	Probable Fault	Corrective Action
The cylinder does not move	Leakage in the air connections.	Check the air connection on the arm and in the valve box.
	Throttling too hard.	Adjust the throttling with the throttle screw in the valve box.
	Faulty solenoid valve.	Check the solenoid valve. Replace if faulty.
	Limit switch faulty.	Check the sensors in the arm. Replace if faulty.
The cylinder runs roughly	The arm fixing is too tight.	Loosen slightly the clamp screws on the arm fixing.
The cylinder changes direction	Faulty solenoid valve.	Replace solenoid valve.
The arm moves slowly to its end position or bounces on an air cushion	The damping is set too hard.	Adjust the damping.
	Oil in the damper chambers.	Slacken the damper screws.

Symptoms	Probable Fault	Corrective Action
The arm bottoms at its end position	Damping too soft.	Adjust the damping.
	Speed too high in relation to the load.	Adjust the speed of the arm with the throttle nipple in the valve box.
The inner tube runs roughly	Glide bearings run roughly.	Dismantle and clean.
	The cylinder runs roughly.	Contact ASEA SERVICE.

2.2
Fault tracing - Rotation module

Symptoms	Probable Fault	Corrective Action
~~Vane motor does~~ not start	~~Air connection faulty.~~	~~Check the air connections.~~
	Throttling faulty.	Check the throttling in the valve box.
	Acknowledgement signals from sensors not received.	Check the sensors and magnets.
	Solenoid valve faulty.	Check the solenoid valve and replace if faulty.
Rotation unit bottoms at the end position	Incorrect damper setting.	Adjust damper setting.
Rotation unit moves slowly at the end position	Dampers set too hard.	Adjust damper setting. See section 2.4.
Knocking sound during rotation	Gears running dry.	Lubricate the gears.
End position changes	Stop loose.	Tighten stop fixing screws.

2.3
Fault tracing - Column

Symptoms	Probable Fault	Corrective Action
Column does not lift or sink	Insufficient air pressure.	Check air hoses and air connections.
	Control signal not received.	Check signals S12, S11.
	Faulty solenoid valve.	Run the valve manually. Replace if faulty.
Column not damped effectively	Incorrect damper setting.	Check dampers. See below.

2.4
Damper generally

Check the return stroke of the damper. The piston rod of the damper should automatically return to its unloaded position without play at the end position. If this is not obtained, replace the damper.

Check for any leakage. If there are any leaks, the faults listed above become evident quickly. Replace a faulty damper as soon as possible as a faulty damper can cause further damage.

Check the damper during its motion. This should be even and progressive during the complete stroke. If the movement is braked too quickly and then moves slowly to its end position or bounces at the end of the motion, the damper is set too hard. If the damper strikes bottom, it is set too loosely. Note that the damper is to be unloaded during adjustment and that the adjustment should be performed carefully. The complete scale range is 0 - 20. The energy absoption with setting 20 is 100 times that at setting 0.

After installing a new damper, adjust in accordance with the following:

- o Set the damper adjustment to 20.
- o Reduce the speed of movement considerably.
- o Run several cycles while turning the damper towards 0 until the full stroke of the damper is reached and a soft damping is obtained.
- o Gradually increase the speed to that at which the equipment is to run and adjust the damper control towards 20 until a full and soft end position damping is obtained.

Note that the damper control is not to be operated while the damper is loaded.

2.5
Fault tracing - Gripper and Extra Axes

Symptoms	Probable Fault	Corrective Action
No gripper movements	Signal not received.	Operate the valve (in the valve box) manually. Check the electrical connections to the valve.
	Solenoid valve faulty.	Replace solenoid valve.
	Faulty air hose or connection	Replace faulty connections or hose.
	Control system fault	Refer to control system manual.
	Leakage in telescopic tube in arm.	See Fault tracing, "Arm".

APPENDIX C : WORK SCHEDULE

WEEK 1 : FAMILIARIZE, TESTING, MAINTENANCE, ORDERING OF PARTS

WEEK 2 :.

WEEK 3 :

WEEK 4 : HAND INPRELIMINARY REPORT.

WEEK 5 : DESIGN AND CONSTRUCTION OF CONTROL UNIT.

WEEK 6 : TESTING USING MANUAL CONTROL.

WEEK 7 : PROGRAMMING AND TESTING USING AUTOMATIC CONTOL, DESIGN FOR AUTOMATIC CONTROL

WEEK 8 : CONTINUE TESTING AND PROGRAMMING.

WEEK 9 : DESIGN SUITABLE TASK, PROGRESS REPORT.

WEEK 10 : TESTING OF ROBOT USING SUITABLE TASKS..

WEEK 11 : FINAL TESTING USING SUITABLE TASKS.

WEEK 12 : CLEANING AND PAINTING OF THE UNIT.

WEEK 13 : PREPARE FINAL REPORT, ETC.

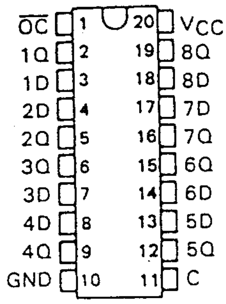
WEEK 14 : STUDY BREAK – FINAL SEMINAR

APPENDIX D

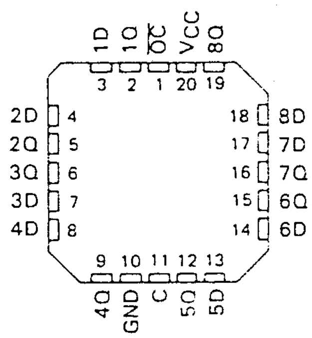
74LS373 DATA SHEET

- 8 Latches in a Single Package
- 3-State Bus-Driving True Outputs
- Full Parallel Access for Loading
- Buffered Control Inputs
- P-N-P Inputs Reduce D-C Loading on Data Lines
- Package Options Include Small Outline (SO) and Plastic and Ceramic Chip Carriers in Addition to Plastic and Ceramic DIPs
- Dependable Texas Instruments Quality and Reliability

SN54ALS373, SN54AS373 . . . J PACKAGE
SN74ALS373, SN74AS373 . . . N PACKAGE
SN74ALS373, SN74AS373 . . . DW PACKAGE
(TOP VIEW)



SN54ALS373, SN54AS373 . . . FH OR FK PACKAGE
SN74ALS373, SN74AS373 . . . FN PACKAGE
(TOP VIEW)



2

description

These 8-bit latches feature three-state outputs designed specifically for driving highly capacitive or relatively low-impedance loads. They are particularly suitable for implementing buffer registers, I/O ports, bidirectional bus drivers, and working registers.

The eight latches of the 'ALS373 and 'AS373 are transparent D-type latches. While the enable (C) is high the Q outputs will follow the data (D) inputs. When the enable is taken low, the Q outputs will be latched at the levels that were set up at the D inputs.

A buffered output-control input ($\overline{OC}$) can be used to place the eight outputs in either a normal logic state (high or low logic levels) or a high-impedance state. In the high-impedance state the outputs neither load nor drive the bus lines significantly. The high-impedance third state and increased drive provide the capability to drive the bus lines in a bus-organized system without need for interface or pull-up components.

The output control $\overline{OC}$ does not affect the internal operations of the latches. Old data can be retained or new data can be entered while the outputs are off.

The SN54ALS373 and SN54AS373 are characterized for operation over the full military temperature range of −55 °C to 125 °C. The SN74ALS373 and SN74AS373 are characterized for operation from 0 °C to 70 °C.

FUNCTION TABLE (EACH LATCH)

INPUTS			OUTPUT
$\overline{OC}$	ENABLE C	D	Q
L	H	H	H
L	H	L	L
L	L	X	Q_0
H	X	X	Z

TEXAS INSTRUMENTS

APPENDIX E

BL 1400 PARALLEL INPUT/OUTPUT

Four of port B's lines are preassigned, as shown in Table 3-3 (see also Figure 3-3).

Table 3-3. Preasssigned PIO Lines

PIO Port	Pin Signal	Pin Function
PB3	RTCCLK	DS1302 RTC serial clock
PB2	RTCDAT	DS1302 RTC serial data
PB1	EN485	RS485 transmit enable
PB0	/RTCRST	555 trigger and DS1302 RTC reset

PB3 and PB2 can be used as two additional parallel I/O if the real-time clock is not being used.

The PIO uses /INT0 of the Z180. The PIO can be programmed to interrupt the Z180 upon the transfer of each byte of data during handshake mode, or upon the change of state of individual bits during bit I/O mode.

Refer to Zilog's ***Z80180/Z180 MPU User's Manual*** for complete details.

PIO Operation Modes

Mode 0 (Strobed Byte Output)

When the microprocessor stores a byte in a port's data register, the eight associated output lines change their level according to how each bit is set: to high for a 1 and low for a 0. The ready handshake line goes high. When an external device pulses the strobe line (low), the ready line is reset. If interrupts are enabled for the port, a PIO interrupt is requested. This allows for interrupt-driven parallel output.

Mode 1 (Strobed Byte Input)

The PIO latches eight bits into a register upon the strobe signal from an external device. The strobe signal also causes the ready line to go low. An interrupt is then requested. After the microprocessor reads the register, the ready line is raised to indicate that the port is ready for another byte.

Mode 2 (Bidirectional Data Transfer)

Mode 2 is not available on the BL1400.

Mode 3 (Bitwise I/O)

This is a general-purpose I/O mode. Each bit can be individually specified as input or output. In this mode, the input lines can also serve as interrupt request lines. Either transition to high or transition to low can be specified for the interrupt request. Interrupts for specific input lines are controlled with a mask and by specifying an AND or an OR function for the masked lines. Interrupts on PIO ports are edge-triggered.

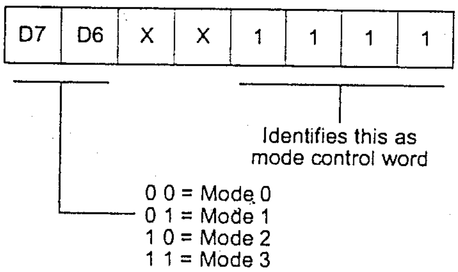
Control Register Byte Sequence

To set up a port for I/O, first write a sequence of bytes to its control register. Then read, or write, its data register to transfer data.

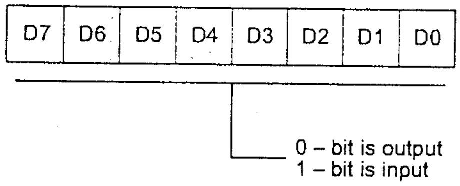
The control register byte sequence is shown below.

mode control word
I/O register control word (only if mode 3)
interrupt vector word
interrupt control word
mask control word
interrupt disable word

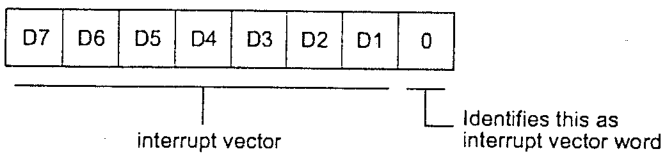
The ***mode control word*** specifies the mode for the port.



The ***I/O register control word*** must immediately follow the mode control word, but only in Mode 3 (bitwise I/O). This byte specifies which bits are inputs and which bits are outputs for bitwise I/O.



The ***interrupt vector word*** specifies the interrupt vector for the particular PIO channel.

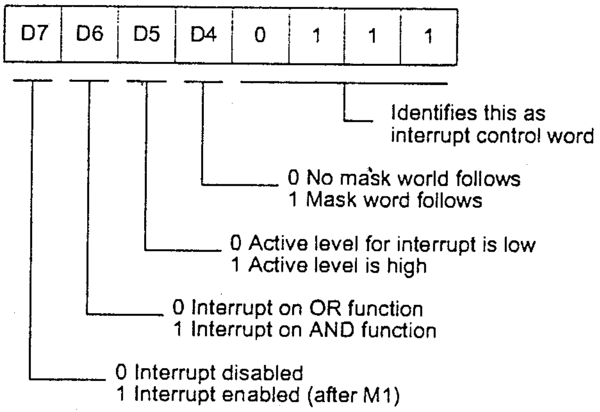


The vectors for the PIO ports are as follows.

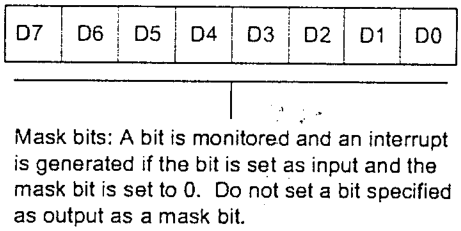
0x12	(`PIOA_VEC`)	PIO Port A
0x14	(`PIOB_VEC`)	PIO Port B

E2

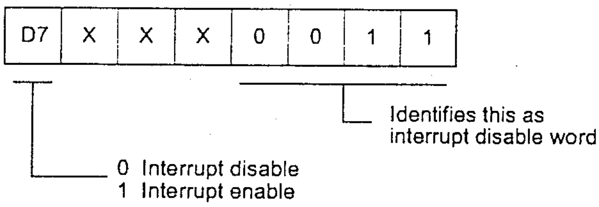
The ***interrupt control word*** specifies the conditions under which an interrupt is generated.



The ***mask control word*** must immediately follow the interrupt control word if bit D4 of the interrupt control word is set.



The ***interrupt disable word*** is used to enable and disable an interrupt for a port that is already defined by an interrupt control word. This byte can also be used to disable interrupts on an unconfigured port.



E3

Header H2 Signals (RS-232 Port)

Header H2 provides one 5-wire RS-232 interface. Header H2 is also the programming port if the development board is not used for programming. When header H2 is used as the programming port, it cannot be used as a communication port by the application.

Figure 3-4 illustrates the signals on header H2.

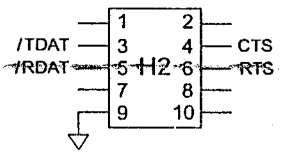


Figure 3-4. Header H2 Signals

Refer to Chapter 4, "System Development," for further details.

Header H3 Signals (PIO Ports)

Header H3 carries all I/O signals, except for the RS-232 signals, as shown in Figure 3-5.

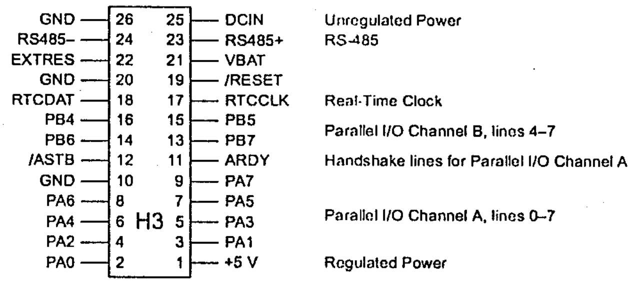


Figure 3-5. Header H3 Signals

Header H3 is also the expansion "bus," intended for engineers who wish to develop their own "piggyback" expansion boards for the BL1400. These signals are described later in this chapter.

E4