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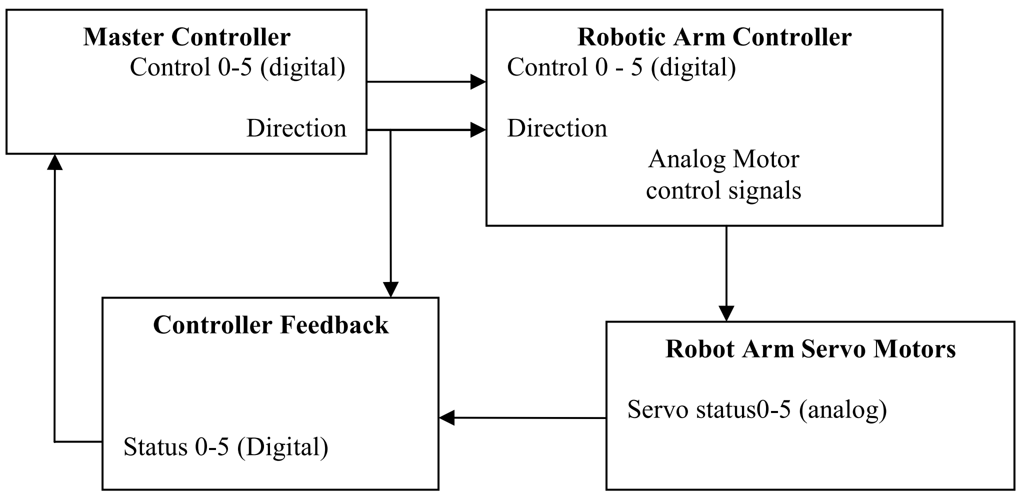
Project: VHDL/VLSI Robotic Arm Controller

Introduction:

A Rhino Robotic XR-2 Arm is a mechanical robot arm with six individual servo motors. While these motors are driven by analog signals, the controller often wants to use a microcontroller or similar device to run a preset set of commands. Thus a controller is used to translate the digital signals from the master system to appropriate analog motor signals. The project will be to design a controller which will allow a digital system to drive a XR-2 Rhino Robotic Arm. Figure 1 is the system block diagram.

Figure 1: System Block Diagram



Robot Arm Servo Motors:

The Rhino robot arm uses six individual servo motors to control various aspects of the arm movement. Servo motors are standard DC or brushless motors with an encoder feedback loop. These feedback loops will also be used by the controller to ensure precise handling and prevent overextending the arm. The characteristic equations of these motors will have to be determined to properly configure the input signals. Figure 2 illustrates the letter assigned to each motor as designated by Rhino Industries as well as the motor location and its corresponding control line.

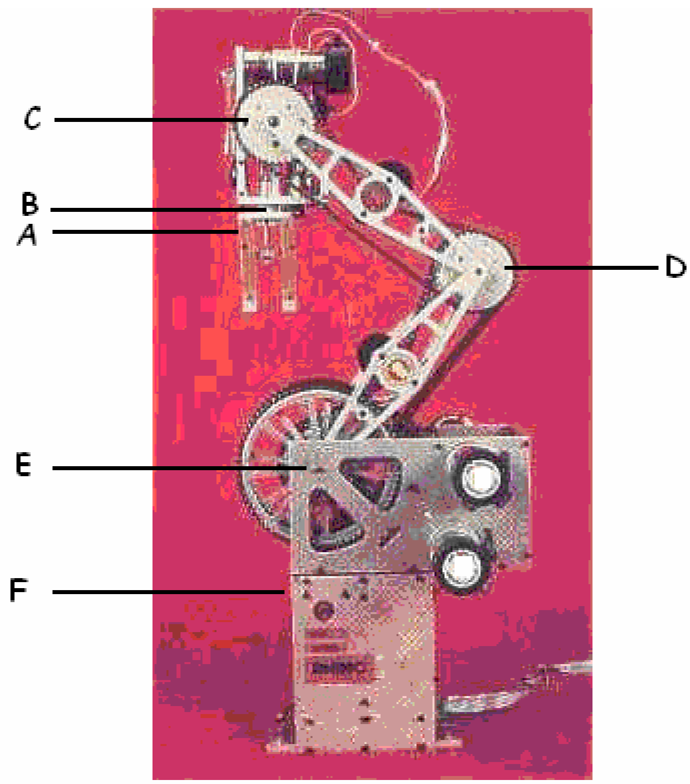
Master Controller:

The master controller or alternative control device will use a set of digital timed inputs. There will be seven lines from the master system that will be simulated using a simple 5V source and some switches. Lines 0-5 will denote which motors to move while the final line represents direction. This configuration cuts down on the number of input lines but will prevent the controller from simultaneously running two motors in opposite directions. The microcontroller will also read in six status lines from the controller based on the motor position. These status lines will be based on the current setting of the direction bit. Figure two lists the motor letters as designated by Rhino Industries, the control line corresponding to each motor, and the location of each motor. Figure 3 is a diagram of the actual XR-2 Rhino Robotic Arm which also shows the location of each motor.

Figure 2: Motor Control Lines

Motor Letter (as designated by Rhino Industries)	Control Line from Master control unit	Motor Location
Motor F	Control 0	Waist
Motor E	Control 1	Shoulder
Motor D	Control 2	Elbow
Motor C	Control 3	Wrist
Motor B	Control 4	Grip-turn
Motor A	Control 5	Grip- close

Figure 3: XR-2 Rhino Robotic Arm



Robot Arm Controller:

The robot arm controller takes in six digital lines to control the motors and one direction line. It will translate these into analog signals for the robot arm. Specific information on the motor behavior will be necessary to create an exact relationship between the digital and analog signals. This will originally be implemented on a FPGA chip programmed with VHDL using the VSIM program. Later work will investigate implementing this design in a cheaper VLSI format. The controller will run off of a ±5V power source. This allows for the controller to be used at TTL levels so it will be more universal.

Robot arm controller feedback:

The robot arm controller feedback circuit will alert the microprocessor when a motor has reached the end of its turn radius. This determination will be based on the microcontroller's direction bit as well as control signals from the servo motors. Further investigation is necessary to determine what signals will be used to determine actual motor position. Specifically, whether the sensors built in to the servo can be used or whether additional sensors must be added is still in question. Further, when a motor is determined to be at the end of its rotation, further movement should be prohibited by the robotic arm controller to prevent damage to the arm.

Additional Implementation:

As time allows, there will be further investigation on additional functionality of the system. One such addition is the addition of a Micropac 515 microcontroller board to drive the system using either a predetermined array of movements or with the keypad. Another addition is to investigate a low power VLSI implementation. This can be useful to extend battery life if the controller needs to be placed on an actual mobile robot. Additional hardware can be added to run multiple motors simultaneously.