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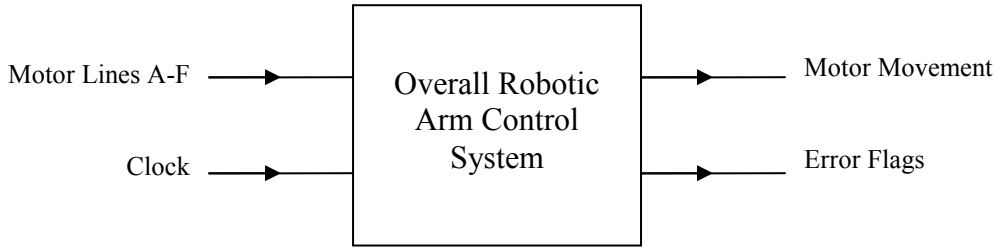
Project: VHDL/VLSI Robotic Arm Controller

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 user 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.

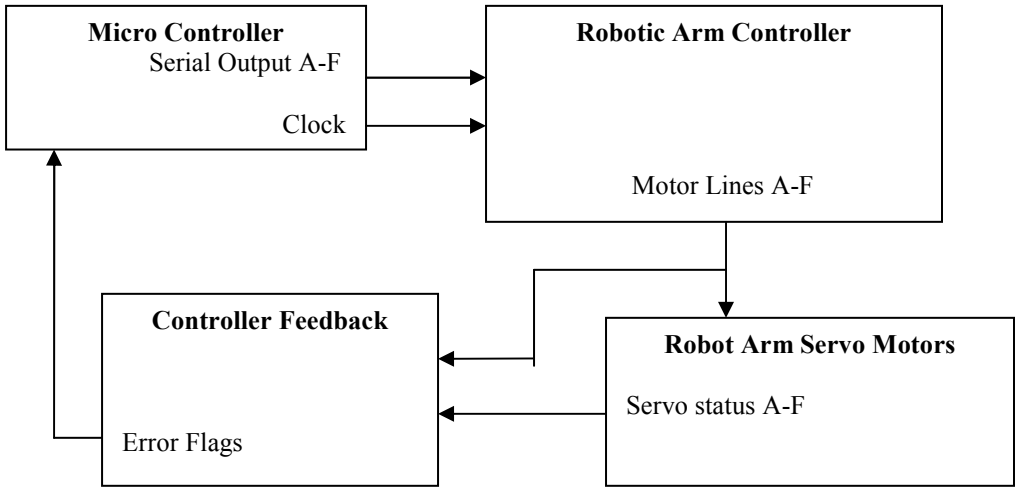
General Overview:

Figure 1: System Block Diagram



Motor lines A-F will provide serial data to the controller on the new robot arm position. The system will take in a synchronous clock to read the serial data. Aside from the actual moving of the robot arm, the system will also output error flags which will alert the user if the arm is moving when it should be stationary or visa versa. Figure 8 illustrates the overall software flowchart of the robotic arm controller.

Figure 2: Subsystem Block Diagram

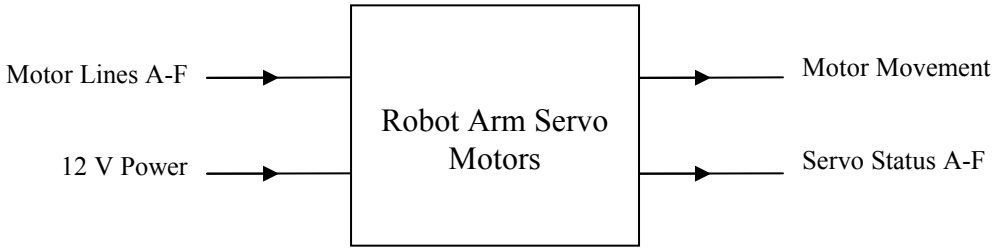


The system can be broken down into four subsystems as seen in Figure 2. The micro controller provides a serial output and clock to the robotic arm controller. The robotic arm controller then uses these signals to generate a motor control signal. The robot arm servo motors will then move based on the motor lines and send the servo status back to the controller feedback. The controller feedback will use the servo

status received from the robot arm servo motors and the motor lines received from the robot arm controller to generate appropriate error flags.

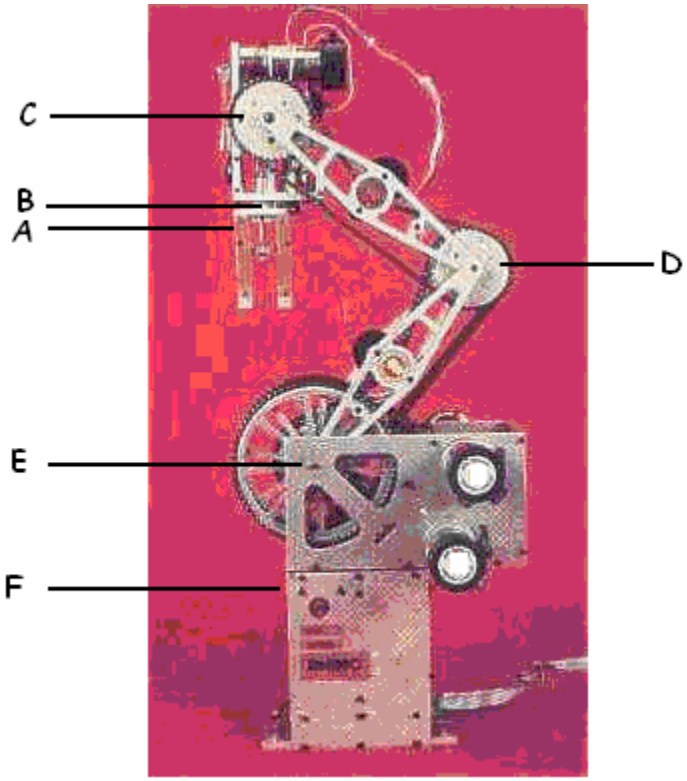
Robot Arm Servo Motors:

Figure 3: Robot Arm Servo Motors Block Diagram



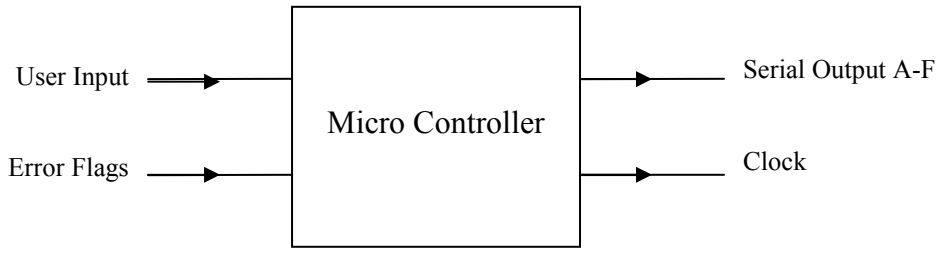
The robot arm servo motors block diagram is shown in Figure 3. The Rhino robot arm uses six individual servo motors to control various aspects of the arm movement. The servo motors will be driven by motor control lines A-F from the robotic arm controller. These digital signals are used to control the connection of the 12V power supply to the motors. 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. The servos will send a signal when each motor is running by using a photo diode, an optical transistor, and a pair of optical discs. Figure 4 illustrates the XR-2 Rhino Robotic arm and the location of each servo motor along with its corresponding letter.

Figure 4: XR-2 Rhino Robotic Arm



Micro Controller:

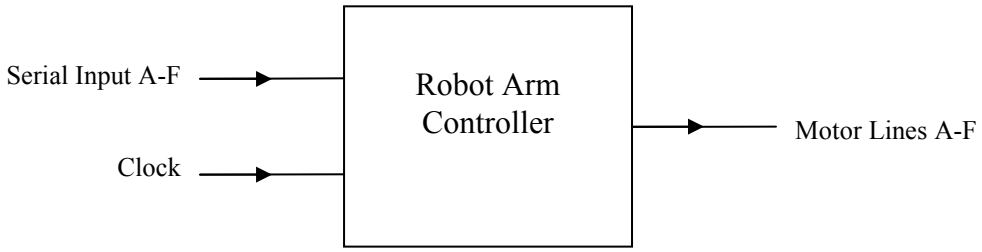
Figure 5: Micro Controller Block Diagram



The micro controller block diagram is shown in Figure 5. The micro controller will accept a series of user inputs to acquire the desired position of the robotic arm. It will then check the error status to determine if the robotic arm is stationary and ready to accept new inputs. The micro controller will output a set of digital timed outputs representing the desired arm position. It will send this data synchronously along with a clock signal.

Robot Arm Controller:

Figure 6: Robot Arm Controller Block Diagram



The robot arm controller block diagram is shown in Figure 6. The robot arm controller takes in six serial lines to control the motors. It will read in these serial lines using synchronous communication from the clock signal output from the micro controller. The robot arm controller will output the control lines to actually control the motors. 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:

Figure 7: Robot Arm Controller Feedback Block Diagram

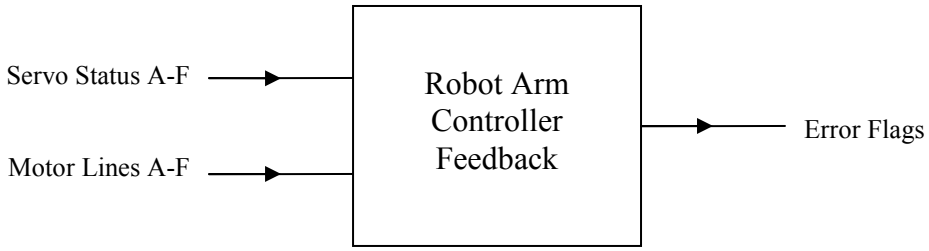


Figure 7 illustrates the robot arm controller feedback block diagram. The robot arm controller feedback circuit will alert the microprocessor if the servo motors are active when they should not be or vise versa, which will only occur during an error in operation. Furthermore, when a motor is determined to be at the end of its rotation, further movement should be prohibited by the robotic arm controller to prevent damage to the arm. This determination will be based on the current servo status lines and the motor control lines. Although the controller feedback subsystem will be contained on the same chip, it will be largely independent hardware and thus was assigned its own subsystem block.

Figure 8: Software Flowchart for the Robotic Arm Controller