

DC Motor-Clutch-Generator Control Workstation
Functional Requirements List and Performance Specifications

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Introduction:

The project is the design of a motor-clutch-generator workstation. The plant of the system is the motor-clutch-generator. This plant is controlled with software implemented on the EMAC 80515 development board using C language programming. The EMAC development board will allow users to choose operation modes of the system, and will also display data regarding the operation of the system. In addition, the EMAC board will communicate with a PC running Matlab and Simulink via an RS232 serial interface. This serial link will allow data to be uploaded and downloaded between the EMAC board and the Matlab software. Matlab and Simulink will be used to generate parameters and command signals for the EMAC board to use when controlling the motor-clutch-generator system. Also, the EMAC board will be able to upload the feedback control data of the physical system to Matlab which can be analyzed and compared to a Simulink model of the physical system. Non-linear modeling techniques will be used to create an accurate simulation model of the physical system in Simulink.

Goals of the project are as follows:

- A plant controller implemented in C language with the EMAC 80515 development board.
- A user interface that allows for changing control parameters and for motor control; as well as allowing the display of real time operation data.
- Serial communication between the EMAC 80515 development board and a PC using an RS232 serial interface for data sharing.
- Non-linear modeling of the physical system using control theory, Simulink, and Matlab.
- A graphical user interface (GUI) in Simulink for the purpose of easy manipulation of the model for simulation and its data.

System Block Diagram:

The block diagram of the motor-clutch-generator workstation, with subsystems labeled for reference, is shown in figure 2-1. The motor subsystem consists of the Pittman DC motor with its rotary encoder and the hardware used to interface the motor with the EMAC development board. The motor is controlled by the EMAC 80515 subsystem using a pulse width modulation (PWM) signal. The speed of the motor is then fed back to the EMAC 80515 subsystem by the rotary encoder which produces pulses proportional to the speed of the internal shaft of the motor. The interface hardware consists primarily of an H-bridge which amplifies the PWM signal from 5 Volts to 20 Volts. The clutch subsystem consists of a clutch that is electronically activated and, when activated, is used to couple the motor shaft to the DC generator shaft, thus changing the plant model. The DC generator subsystem is the DC generator and its variable load. The DC generator is a second Pittman motor. Its load will be determined by a high power rated resistor whose value is selected by the user. This value may be selected

either manually or through software. Subsystem four is the external joystick hardware. This joystick will be designed for the user to operate the motor in both closed loop and open loop modes. The x and y directions of the stick will be set up to produce an analog voltage signal to be converted by the A/D converter of the EMAC 80515 subsystem. Other hardware, consisting of pull-ups and protection circuitry, will be implemented in this subsystem.

The EMAC 80515 subsystem will use a liquid crystal display (LCD) for displaying its interface to the user. The LCD will also be used to display real time data of the operation of the physical system. A keypad will be used as the primary user input, allowing the user to enter parameters and choose between options. Another element of the EMAC 80515 subsystem is the software based controller. This controller will be used with feedback to implement a closed loop controller. The controller will be used to control velocity, acceleration, torque, position and other possible operating variables of the motor. Various control theory methods are to be explored for the implementation of this controller such as proportional control, proportional-integral-derivative (PID) control, root-locus design, and frequency domain design. The final component of the EMAC 80515 subsystem is the RS232 serial interface. The microcontroller will take the feedback information from the rotary encoder of the motor and send this data to a PC running Matlab and Simulink using the serial interface. This data can be used to analyze the operation of the physical system without heavy use of lab equipment such as the oscilloscope. Also, the microcontroller will use the serial interface to receive command signals from the PC. The command signal will be stored in RAM and will allow the microcontroller to produce complex command signals without the need for implementing an extensive algorithm in the microcontroller code itself.

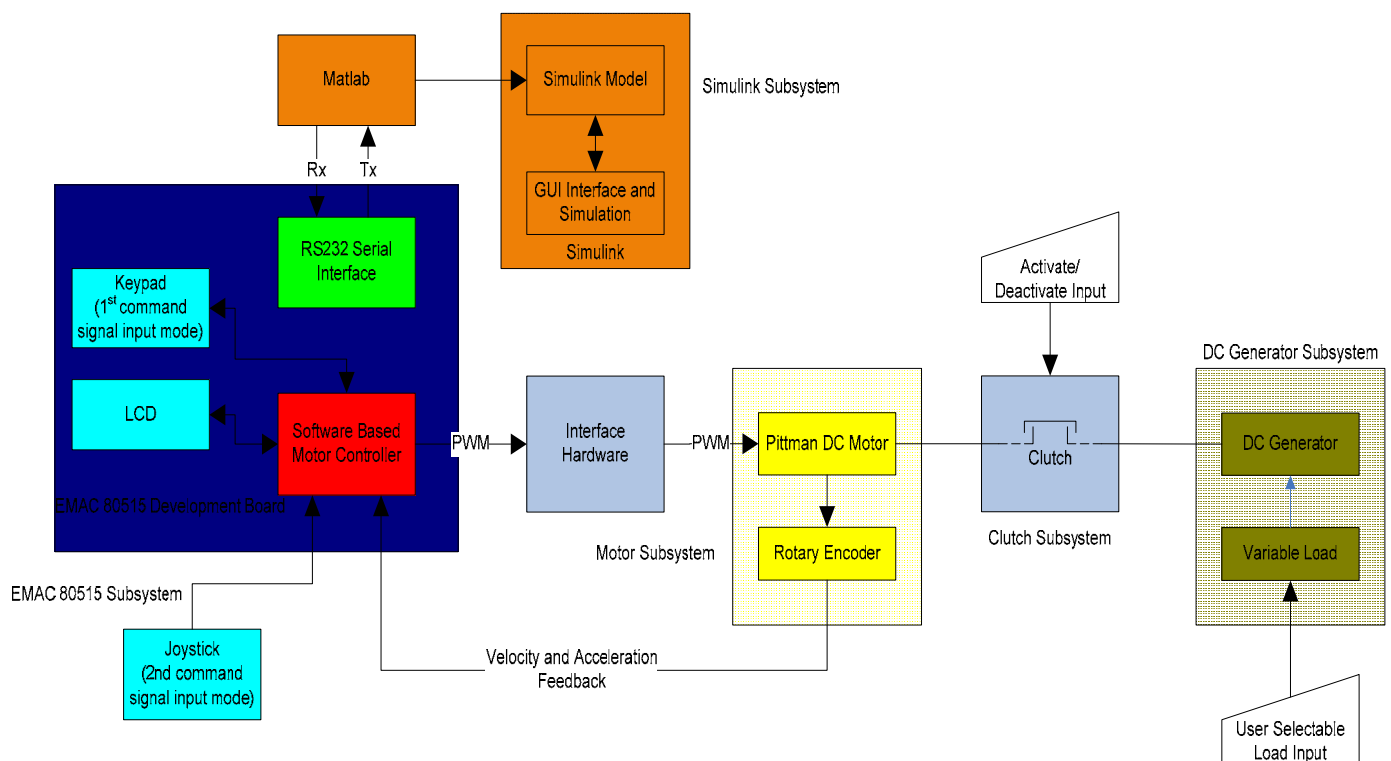


Figure 2-1: System Block Diagram

Finally, the Simulink subsystem consists of Matlab and Simulink software running on a PC. Simulink is used to model the physical system using control block diagram elements and other functions. The model is non-linear, with its parameters determined using the motor data sheets and experimental data. Also, Simulink is used to generate a GUI for the user to change parameters of the model and other possible options. Matlab will be used both for actual serial communication programming as well as for storing variables such as command signals and control parameters.

Functional Requirements and Performance Specifications:

Motor subsystem:

- 1) Operation temperature: 0 to 40°C
- 2) Power supply voltage: 30V DC
- 3) Maximum torque: x N-m ****yet to be determined****
- 4) Analog circuit-hardware protection
- 5) Printed circuit board implementation
- 6) Operating direction: clockwise and counter-clockwise (when decoupled from load)

Clutch subsystem:

- 1) Power supply voltage: 12V DC
- 2) Maximum torque: 1.7 N-m
- 3) Operating direction: clockwise

DC generator subsystem:

- 1) Maximum load: x Ω ****yet to be determined****
- 2) Load power rating: x W ****yet to be determined****
- 3) Maximum torque: x N-m ****yet to be determined****
- 4) Variable load by way of software control
- 5) Variable load by way of manual user control
- 6) Operating direction: counter-clockwise

Joystick interface subsystem:

- 1) D2 button: RPM up if trigger is pressed
- 2) D3 button: RPM down if trigger is pressed
- 3) D4 button (multi-use): (1) Motor brake (2) Exits from closed-loop control. (3) Enable closed-loop control if trigger active, regulate at last commanded velocity
- 4) Trigger button: Enables D2 and D3 buttons and enables closed-loop control if D4 is active
- 5) X and Y axis control open-loop RPM
- 6) Protection circuitry and printed circuit board implementation

EMAC 80515 subsystem:

- 1) Two line LCD main display: Measured parameters on line 1 including RPM, torque, etc. Control parameters on line 2 including command RPM, PWM generation duty cycle
- 2) Secondary display of menu which consists of operation mode selection and parameter selections
- 3) Display refresh rate: 0.5 seconds
- 4) Motor Velocity: display accuracy ± 20 RPM
- 5) PWM: period waveform (1 millisecond), variable duty cycle (0 to 100% in 0.2% or less increments), display accuracy: $\pm 0.2\%$
- 6) Serviced every 40 ms (default), keypad selectable from 5 to 250ms
- 7) If system saturates, controller returns PWM to open-loop operation
- 8) Proportional, proportion-integral, and proportion-integral-derivative controller implementations (more methods optional)
- 9) Partial RS232 serial interface with use of EMAC 80515 development board UART with rate of 9600 baud.
- 10) Simulink operation mode: Ability to send physical system data and receive command signals to store in RAM.

Simulink subsystem:

- 1) System model: Open-loop and closed-loop modeling of the physical system
- 2) Non-linear modeling: Non-linear modeling for the static, Coulomb, and viscous frictions of the motor, and for the clutch subsystem non-linearity.
- 3) GUI for changing parameters of the model and other options
- 4) Serial communication with EMAC 80515 development board for sending command signal variables and for receiving physical system data
- 5) Method for comparing and analyzing the physical system with the modeled system, with the goal of method realized in real time

References:

Pittman Motor Datasheet.

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Pittman Motor Application Notes.

http://blackboard.bradley.edu/courses/1/EE451_01_06FA/content/_455117_1/220000ALL.pdf

Clutch Product Information with Data Sheet.

<http://www.reel.com/products/ec15.htm>

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http://blackboard.bradley.edu/@@cb65f20b7d29e2f11466cc12ddf1fae5/courses/1/EE450_01_06FA/content/_390634_1/mini_project_figures_diagrams_06.doc