SAUER DANFOSS

User Manual

MC200 Dual Path Personality

Software: S0409220
Hardware: 1090548,
1090549,
1090550

Software: S0576220
Hardware: 1090824,
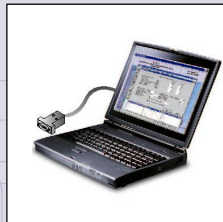1090825,
1090826

POWER
SYSTEM
MODE
STATUS

55,75

8,5

9

10

123,5

10,5

17

15

0,25

AMP Stecker
AMP Connector

1   14
15   28
29   42

55

Table of Contents:

1 Revision History

Version No.	Rel. Date	Changes	Name
Rev. 1.00	19Dec00	First Release	D. Dyvig
Rev 2.00	13SEP01	V2.67 WebGPI Object Library, Parse Int., Commas	D. Dyvig
Rev 2.01	13Dec01	Update Max current Cal	J. Wandersee
Rev 2.02	08Jan02	Update Cal routine	J. Wandersee
Rev 2.10	15Apr02	Update to PDA, latest Web Lib 2.72	J. Wandersee
Rev 2.20	10Oct02	Update to HC08A	D. Dyvig

2   User Manual Description

This document describes how to configure and operate the MC200 Dual Path Personality. It is intended for use by the customer, and it is maintained by Sauer-Danfoss.

The MC200 Dual Path Personality supports a PC-based service and configuration tool called WebGPI. Reference the WebGPI user's manual for help downloading, data logging, and performing other tasks with WebGPI.

This User Manual does not contain hardware or electrical specifications.

2.1   MC200 Controller

3 Description Of Operation

This section describes, in both text and block diagram form, how the MC200 Dual Path Personality operates.

3.1 Inputs/Outputs

This section describes the physical characteristics of the inputs and outputs.

3.1.1 Analog Inputs

1)   Propel command

- Center Neutral, Forward, Reverse Pot

- Max Speed pot - Will limit the maximum propel command from a value of 0 to 100%.

2)   Steer Command

- Center Neutral, Left, Right Steer Pot

3.1.2 Digital Inputs

1)   Calibrate Switch, High Active

2)   Neutral or Brake Switch, High Active

3)   FNR select switch input, High Active

4)   FNR select switch input, High Active

3.1.3 Valve Output

1)   Two Bi-Directional Current drivers (160 ma., 240 ma. Or 2.00Amp)

3.2 Basic Operation

This is an MC200 based Dual Path Personality control system. This software solution is intended to provide the basic propel and steering control for dual path paving machines with four configurations of Propel command input, propel pot, forward-neutral-reverse (FNR) switch and max speed pot. Another analog input will provide the steering input.

One digital input will be used for a Neutral switch or Brake input. Absence of this signal when controller is powered up will prevent movement of the machine. The signal must be present prior to the initial propel command. A second digital input would be used for calibration of the valve drives. To enter calibrate mode, the calibrate switch must be held on while powering up the system.

The MC200 has 4 proportional PWM outputs that will be used to drive two bi-directional outputs (left and right tracks). Output current is hardware configurable up to 2 amps.   Software features will include separate acceleration and deceleration parameters.

3.3 System Block Diagrams

3.3.1 FNR Pot Configuration
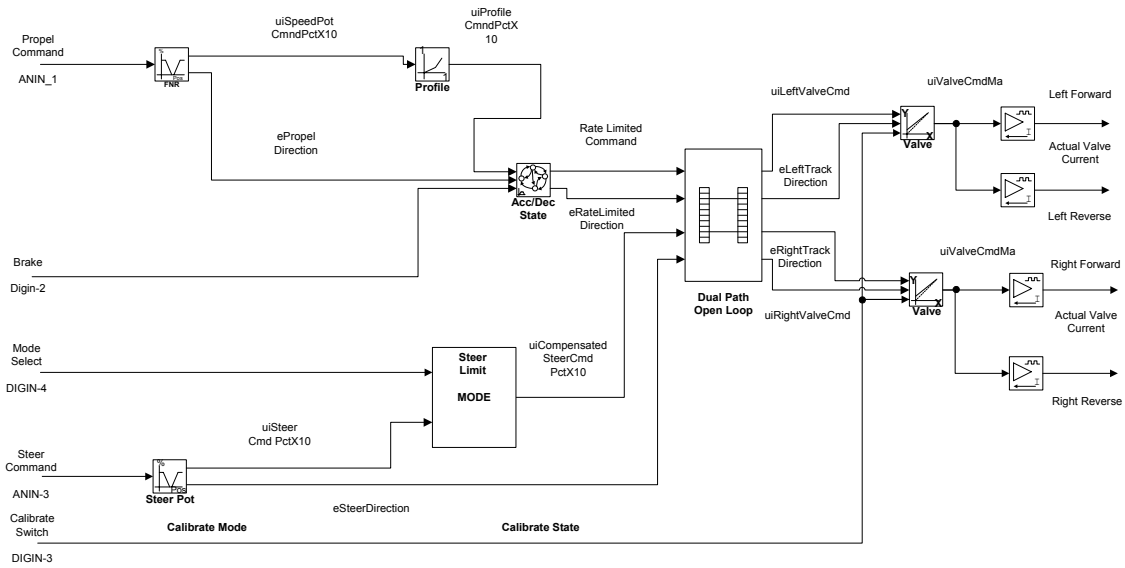
3.3.2 FNR Pot with Max Speed Pot Configuration
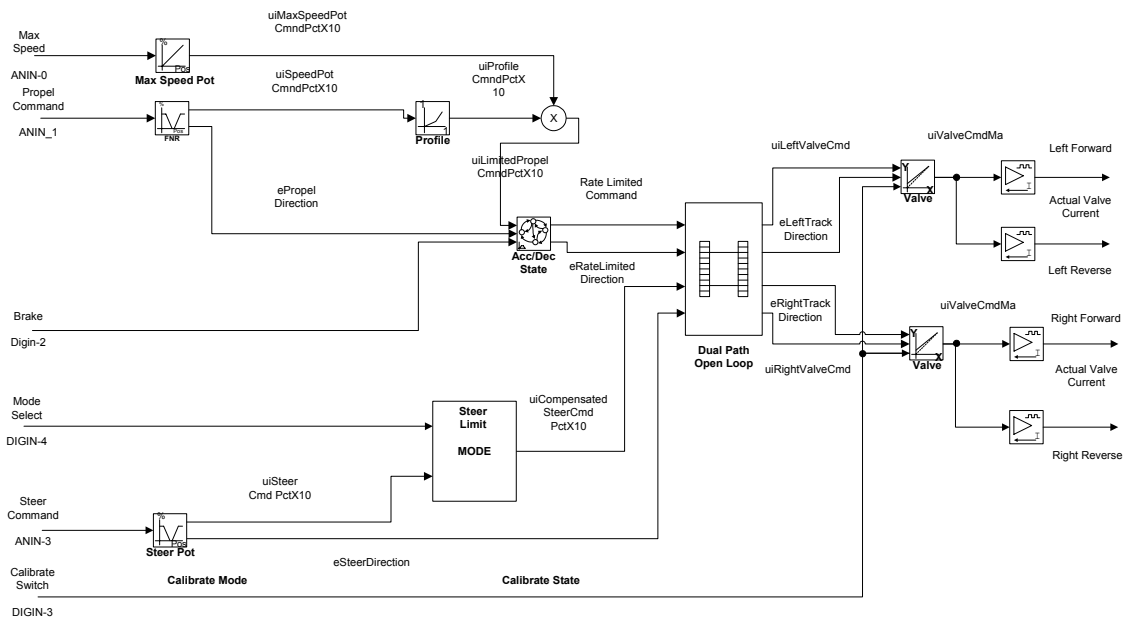
3.3.3 FNR Switch Configuration

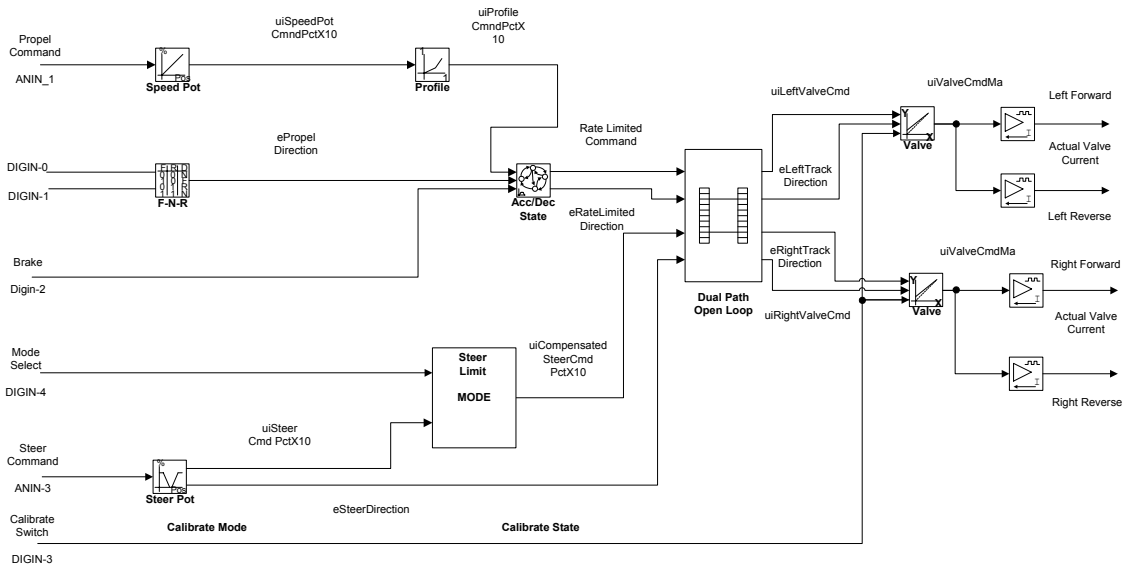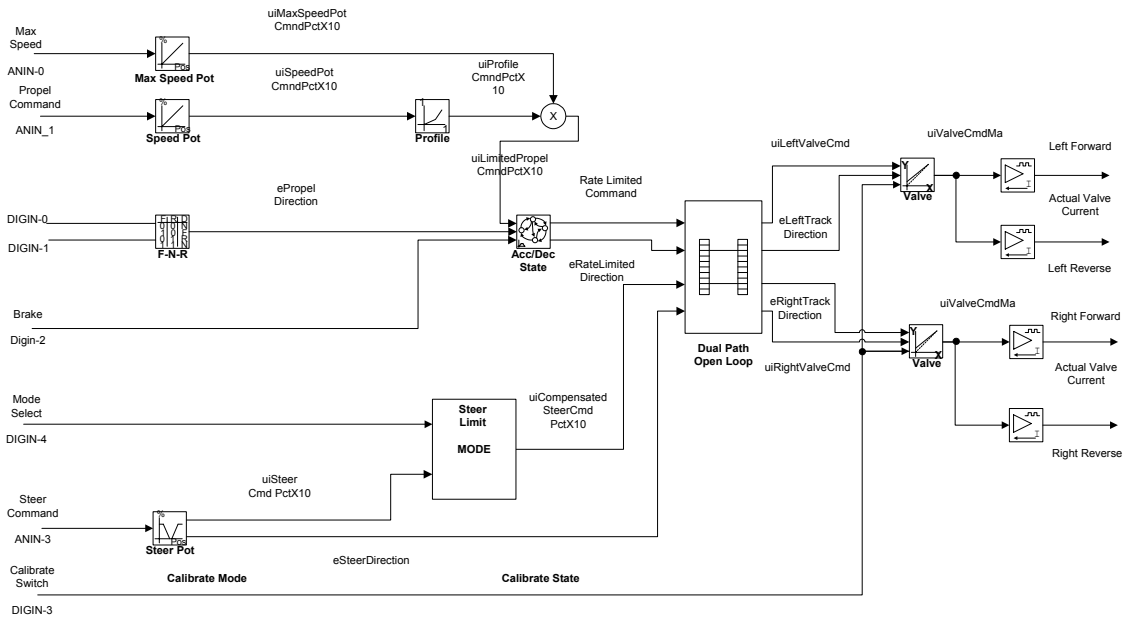### 3.3.4 FNR Switch with Speed Pot Configuration

3.3.5 Configuration and Tuning

This section describes what needs to be configured and how to configure the MC200 Dual Path Personality.

3.4 First Configuration on a Prototype Machine Model

This section describes how to configure the MC200 Dual Path Personality a for specific machine model. The configurations can be saved and made into the default file for a specific machine model. WebGPI is required to perform most of the actions.

1. Apply power to the MC200. It is not necessary to have the machine running yet.

2. Choose the Configuration screen and choose the appropriate configuration for your application.

3. Re-power the MC200.

4. Choose the dual path screen to set the Pivot(counter rotate) point and pivot deadband.

5. Choose the accel/decel screen to change the acceleration and deceleration of the machine.

6. Choose Steer Limit screen and set the maximum steer percent allowed for each mode.

7. Calibrate any sensors used.

8. Start the machine.

9. Calibrate the Valve Drivers .

10. Drive the machine and make adjustments as needed.

3.5 First Calibration on an Individual Machine

Once the defaults have been established from the previous section, there are only a few steps to calibrate the MC200 Dual Path Personality for each machine.

1. Apply power to the MC200. It is not necessary to have the machine running yet.

2. Calibrate the FNR Pot and the Steer Pot.

3. Start the machine.

4. Calibrate the Valve Drivers. See section   **3.6.3.1.**

3.6   Calibration

See section   **3.6.3.1. Threshold and Max- Current/Steer-Tracking Calibration**

3.6.1   Sensors

3.6.1.1   Three Position Sensors

The three position sensors are:

- Steer Pot
- Propel FNR Pot

To calibrate a three position sensor, the following three actions must be performed in any order:

- Hold the sensor in the neutral position for at least three seconds.
- Hold the sensor in the maximum position for at least three seconds.
- Hold the sensor in the minimum position for at least three seconds.

3.6.2   Disconnecting Sensors

If a sensor is disconnected while the power is still on, a fault is indicated by the red Status LED (See Fault Codes in section 6.2). In addition, the calibration points are set to zero and the calibration state is changed to uncalibrated. When the sensor is reconnected, the calibration procedure needs to be repeated in order to put the sensor back into the calibrated state.
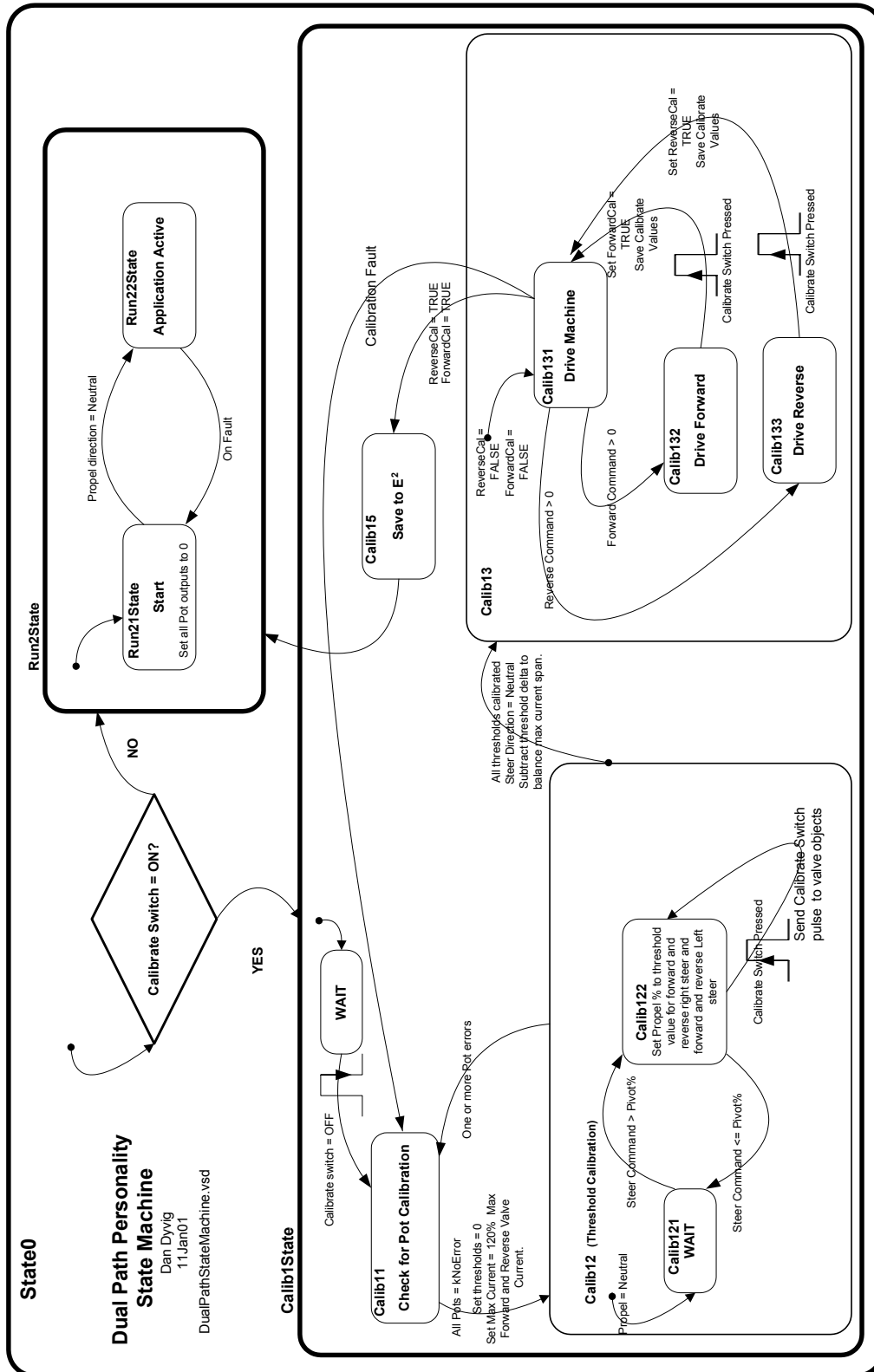
3.6.3 Valve Calibration State Machine

State0

Dual Path Personality
State Machine
Dan Dyvig
11Jan01
DualPathStateMachine.vsd

Calibrate Switch = ON?

NO

YES

Run2State

Propel direction = Neutral

Run22State
Application Active

On Fault

Run21State
Start
Set all Pot outputs to 0

Calib1State

Calibration Fault

Calib15
Save to E²

ReverseCal = TRUE
ForwardCal = TRUE

Calib13

ReverseCal = FALSE
ForwardCal = FALSE

Reverse Command > 0

Calib131
Drive Machine

Set ForwardCal = TRUE
Save Calibrate Values

Set ReverseCal = TRUE
Save Calibrate Values

Forward Command > 0

Calibrate Switch Pressed

Calib132
Drive Forward

Calibrate Switch Pressed

Calib133
Drive Reverse

All thresholds calibrated
Steer Direction = Neutral
Subtract threshold delta to balance max current span.

Calibrate switch = OFF

WAIT

One or more Pot errors

Calib11
Check for Pot Calibration

All Pots = kNoError
Set thresholds = 0
Set Max Current = 120% Max
Forward and Reverse Valve Current.

Calib12 (Threshold Calibration)

Steer Command > Pivot%

Calib122
Set Propel % to threshold value for forward and reverse right steer and forward and reverse Left steer

Send Calibrate Switch pulse to valve objects

Calibrate Switch Pressed

Propel = Neutral

Calib121
WAIT

Steer Command <= Pivot%

Fig 1. State Diagram

3.6.3.1   Threshold and Max- Current/Steer-Tracking Calibration

Calibrating the Valve Drivers sets their threshold values, maximum current for each side and straight steer correction. The threshold values are the minimum current outputs for the Valve Drivers that are just under the current required for the track to start moving. Before starting the calibrate procedure there are a few set up actions to do.   These steps are as follows:

A. Set the nominal resistance value for the coils in use on the Valve fault set up screens.

B. When you enter calibrate mode, the maximum current values for each valve are set to the system default values. These values will be increased by 20% during the calibrate procedure to ensure that the valves are saturated with full propel command. These values will be optimized during the calibrate procedure

C. The Configuration Screen will display the Maximum Current Available for each controller.

D.   Refer to figure 1 on the previous page and calibrate by performing the steps below in the order given :

1) Set the propel command Pot at neutral position.

2) Set steering wheel to full CW position.

3) Turn power to the controller OFF.

4) Turn or press the calibrate switch to ON and hold in position.

5) Turn machine power ON. Machine goes to Calib 1 State - Wait

6) Release(Turn off) Calibrate switch. Machine goes to Calib 1 State – Calib 11

7) If there are no pot faults, enter state Calib 12 - Calib122, all thresholds are set to zero, and max current is set to max available current.

8) Set the FNR switch to Forward and slowly increase the speed pot or, depending on configuration, slowly move the FNR propel pot to the forward position until the left track just begins to move, back off until the track just stops. This is the threshold current. Press and release the calibrate button then return the propel handle to neutral. Move FNR propel handle to the reverse position and wait until the left track just begins to move, press and release the calibrate button then return the propel handle to neutral. This completes the threshold calibration for one side.

9) Repeat steps 7 and 8 with the steer pot in the full CCW position

The next procedure will calibrate the maximum current for each track so that the vehicle tracks in a straight line when steering straight ahead or neutral steer position. This procedure requires that the machine have ample space to run in a straight line forward and backward for at least 30 seconds.   Calibrate by performing the steps below in the order given:

1) Set the steer pot to the straight-ahead or neutral position. This will put the controller in the calib131 State.

2) Move the propel control handle to the full forward position then slowly move the handle back toward neutral until a speed change is detected. Try to find the point where increased handle command does not increase speed. Then steer the machine until it maintains a straight ahead direction. When this condition is met, press and release the calibrate button then return the propel handle to neutral. Repeat steps 1 and 2 for the reverse direction.

3) When both sides are calibrated, the controller will save the new calibrated values in state Calib15 and then return to normal operation in the Run22 state after the propel is returned to neutral.

4 WebGPI Screens

This section explains all screens specific to the MC200 Dual Path Personality. For help with general WebGPI screens, see the WebGPI User Manual.

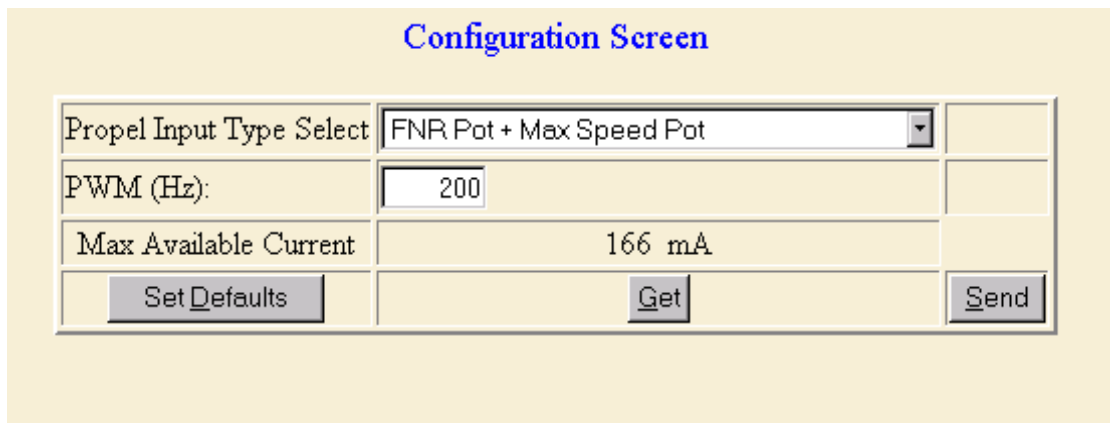## 4.1 Table of Contents Screen and Main Run Screens for each propel command type configuration.

4.1.1 Table of contents screen

Clicking on an item beneath **Sensors** or **Control Parameter** opens the corresponding adjustment screen.

Main opens the main run screen.

Help disabled disables or enables the help display messages.

Disconnect disconnects the computer from the MC200 controller.
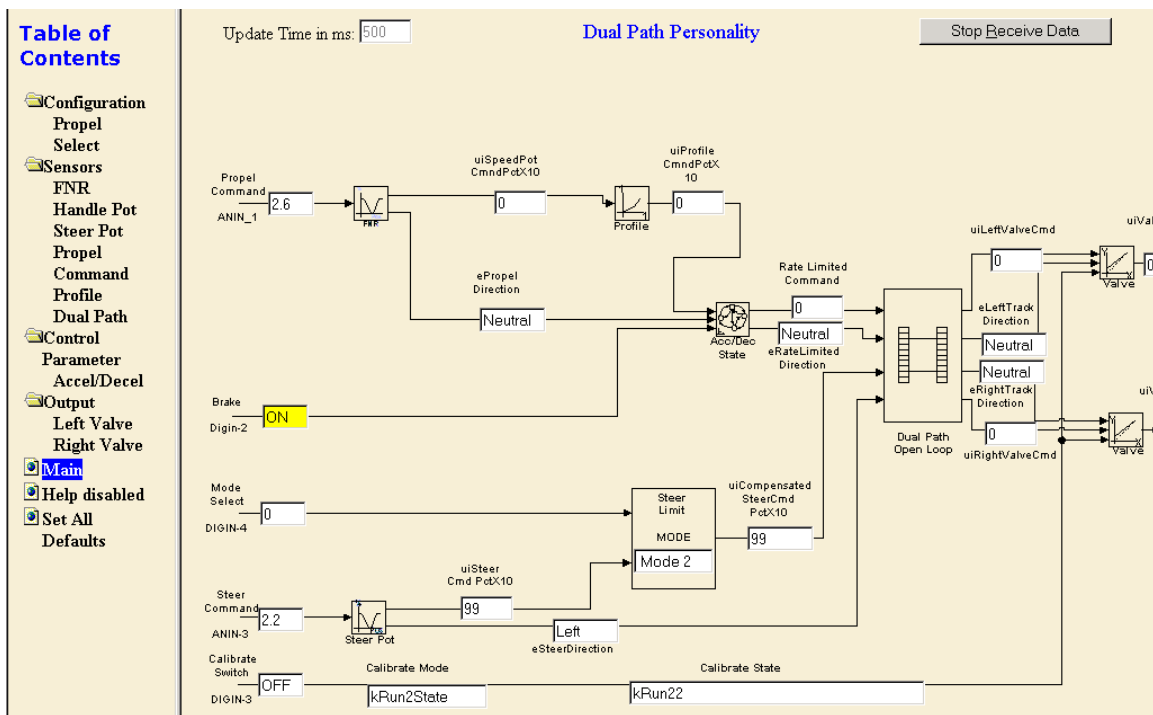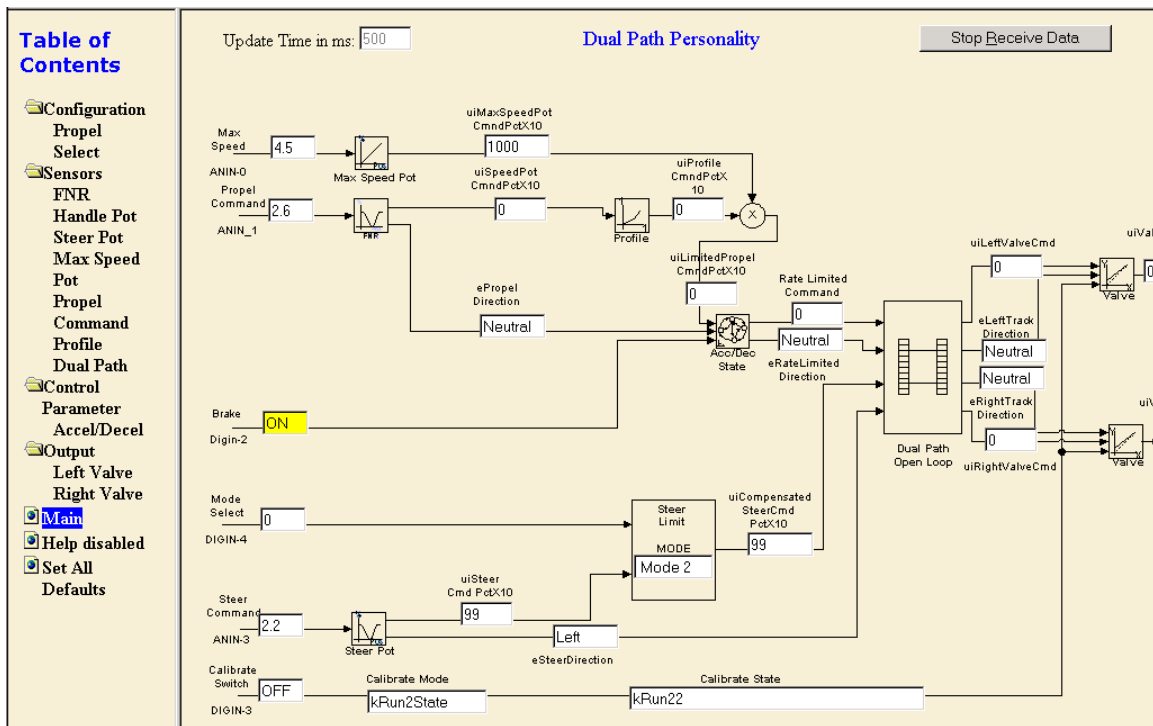
4.2 Configuration Screen.

| Parameter Description		Unit	Range
Propel Input Type Select	Select 1 of 4 possible choices. These choices are shown in the following four paragraphs		1 of 4
PWM (Hz)	Selects the frequency that the valve outputs will run at.	Hz	80 to 200
Max Available Current.	This is the maximum current capability of this hardware	mA	166 to 2000

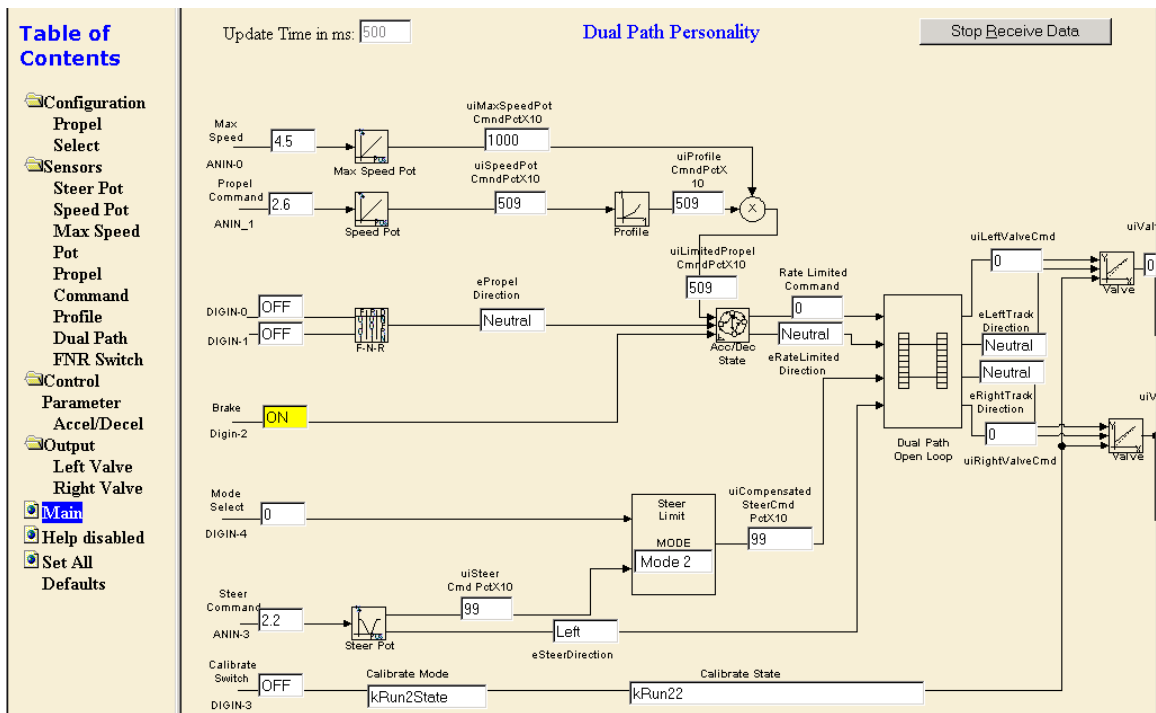### 4.2.1 FNR Pot Configuration.

4.2.2   FNR Pot with Max Speed Pot Configuration.

4.2.3   FNR Switch Configuration.
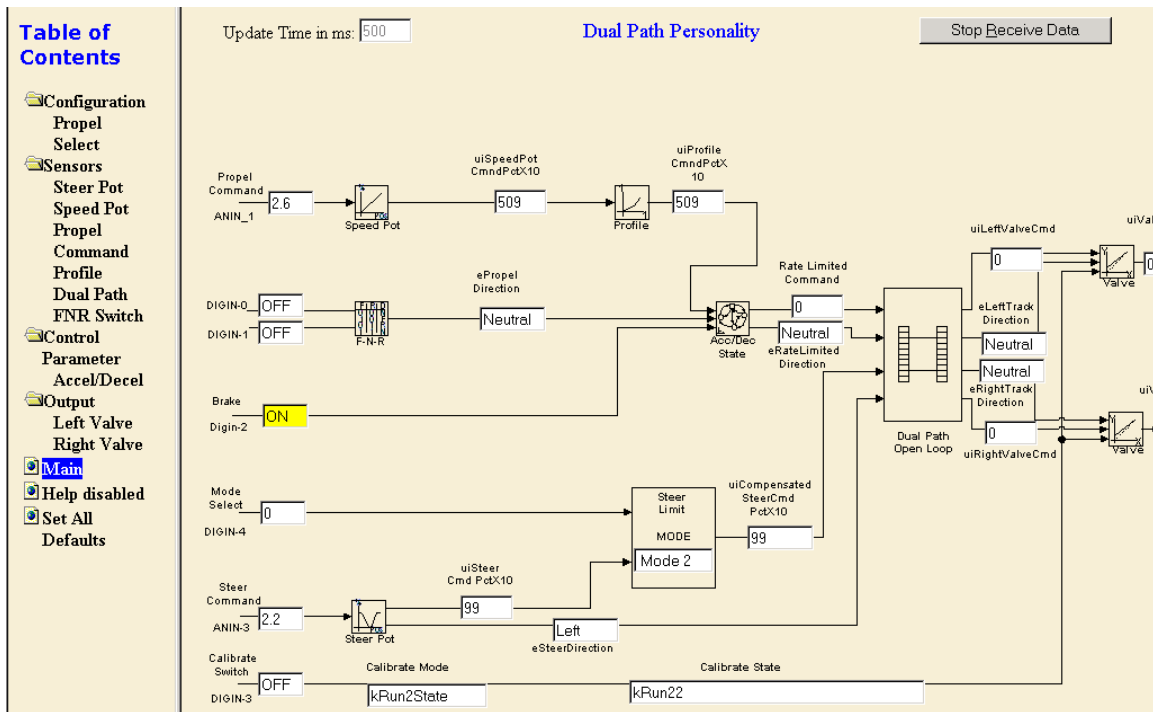
4.2.4 FNR Switch with Max Speed Pot Configuration.

4.3 Common Buttons

There are three buttons that are common to most adjustment screens, and they are only described here: SetDefaults , Get , and Send . The SetDefaults button resets all values in the current adjustment screen to the factory defaults. The Get button retrieves the current values from the controller (this is done automatically when a new screen is loaded). Pressing the Send button first initiates a data

validation check, which will stop the transmission of non-conforming data. Then, if the validation passes, the values displayed on the adjustment screen are sent to the controller.

4.4   Sensors Screens

Sensors screens allow access to sensor object parameters.

4.4.1   FNR Pot

Command Handle Parameter

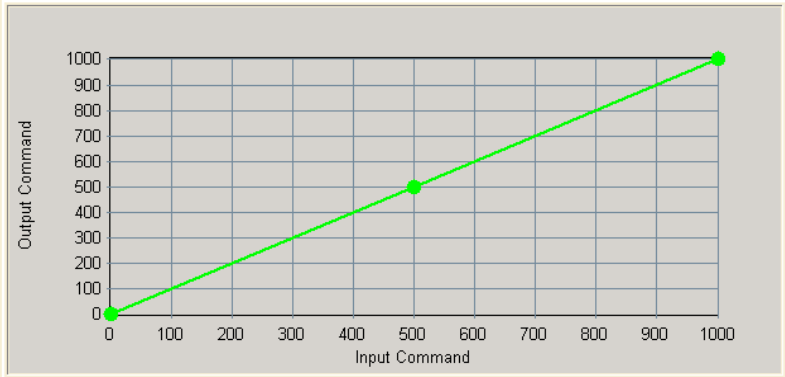|	MinValue	CalValue	MaxValue
HighSide	4.2 Volt	4.7 Volt	4.8 Volt
Neutral	2 Volt	2.5 Volt	2.9 Volt
LowSide	0.2 Volt	0.4 Volt	0.8 Volt
Neutral Deadband	0.2 Volt		
Fault Detection Time	2 Seconds		
Upper Deadband %	2		
Lower Deadband %	2		
Status: OK	SetDefaults	Get	Send

Parameter	Description	Unit	Range
HighSide	HighSide refers to the high voltage end of the pot. MinValue and MaxValue define the acceptable range of HighSide pot values. CalValue is the value learned during calibration of the pot.	Volts	0.0-5.0
Neutral	Neutral refers to the centered voltage of the pot. MinValue and MaxValue define the acceptable range of Neutral pot values. CalValue is the value learned during calibration of the pot.	Volts	0.0-5.0
LowSide	LowSide refers to the low voltage end of the pot. MinValue and MaxValue define the acceptable range of LowSide pot values. CalValue is the value learned during calibration of the pot.	Volts	0.0-5.0
Fault Detection Time	Fault Detection Time is used to set a delay time before a fault is registered. The delay time is in Seconds with one decimal place i.e: 1.3	Seconds	0.0-100.0
Neutral Deadband	NeutralDeadband refers to the band on either side of the center voltage of the pot. If the actual pot value is within Neutral CalValue +/- Neutral Deadband, the pot will be considered in Neutral.	%	0 to 30

| Upper and Lower Deadband | Deadband refers to the band on either end of the pot in % of pot travel. If the actual pot value is within the specified % value of full pot travel, the pot is treated as if it at 100%. This is to prevent the pot from falling short of 100% because of sight changes in pot travel. | % | 0 to 30 |
| Status: | Possible status values are: OK, Value at 5V, Value too High, Value at 0V, Value too Low, and Not Calibrated. | | |

4.4.2 Propel Profile

Parameter	Description	Unit	Range
Min Value	The minimum value accepted on input and minimum value to the output	%x10	0-1000
Knee Value	This is the point at which the slope of the profile changes	%x10	0-1000
Max value	The maximum value accepted on input and maximum value to the output	%x10	0-1000

4.4.3 Steer Pot

The pot3obj takes in a voltage as input and outputs a percentage of calibrated range and a direction. The input voltage is considered out of range when less than half the LowSide CalValue or greater than half way between HighSide CalValue and 5V.

Steer Command Parameter

	MinValue	CalValue	MaxValue
HighSide	4.2 Volt	4.5 Volt	4.8 Volt
Neutral	2 Volt	2.5 Volt	2.9 Volt
LowSide	0.2 Volt	0.5 Volt	0.8 Volt
Neutral Deadband	0.2 Volt		
Fault Detection Time	2 Seconds		
Upper Deadband %	2		
Lower Deadband %	2		
Status: OK	SetDefaults	Get	Send

Parameter	Description	Unit	Range
HighSide	HighSide refers to the high voltage end of the pot. MinValue and MaxValue define the acceptable range of HighSide pot values. CalValue is the value learned during calibration of the pot.	Volts	0.0-5.0
Neutral	Neutral refers to the centered voltage of the pot. MinValue and MaxValue define the acceptable range of Neutral pot values. CalValue is the value learned during calibration of the pot.	Volts	0.0-5.0
LowSide	LowSide refers to the low voltage end of the pot. MinValue and MaxValue define the acceptable range of LowSide pot values. CalValue is the value learned during calibration of the pot.	Volts	0.0-5.0
Neutral Deadband	NeutralDeadband refers to the band on either side of the center voltage of the pot. If the actual pot value is within Neutral CalValue +/- Neutral Deadband, the pot will be considered in Neutral.	%	0 to 30
Upper and Lower Deadband	Deadband refers to the band on either end of the pot in % of pot travel. If the actual pot value is within the specified % value of full pot travel, the pot is treated as if it at 100%. This is to prevent the pot from falling short of 100% because of sight changes in pot	%	0 to 30

	travel.		
Fault Detection Time	Fault Detection Time is used to set a delay time before a fault is registered. The delay time is in Seconds with one decimal place i.e: 1.3	Seconds	0.0-100.0
Status:	Possible status values are: OK, Value at 5V, Value too High, Value at 0V, Value too Low, and Not Calibrated.		

4.4.4 Steer Mode Limit

Parameter	Description	Unit	Range
Mode 0 Steer (%)	Limits the output from the steer pot in mode 0 to Mode 0 steer percent. 100% means 0 – 100% steer command allowed.	%	0-100.0
Mode 0 Steer (%)	Limits the output from the steer pot in mode 1 to Mode 1 steer percent. 100% means 0 – 100% steer command allowed.	%	0-100.0

4.4.5   Steer Profile

Steer Profile
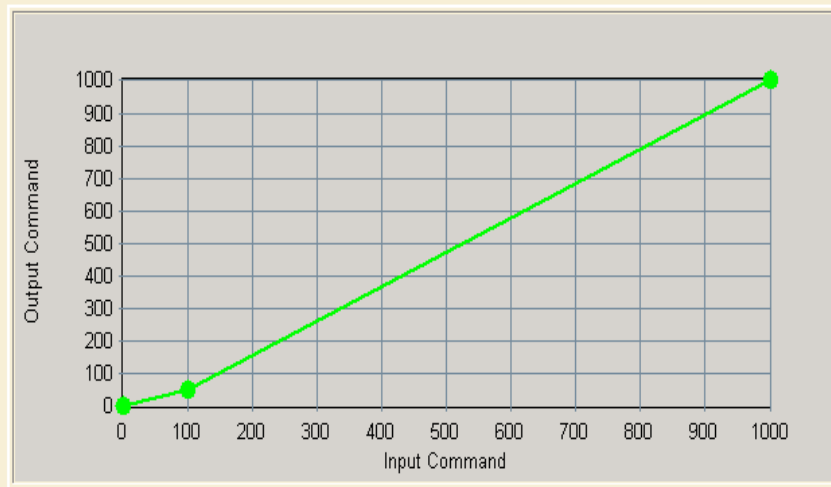
	MinValue	KneeValue	MaxValue
Input Command	0	100	1000
Output Command	0	50	1000
	SetDefaults	Get	Send

Parameter	Description	Unit	Range
Min Value	The minimum value accepted on input and minimum value to the output	%x10	0-1000
Knee Value	This is the point at which the slope of the profile changes	%x10	0-1000
Max value	The maximum value accepted on input and maximum value to the output	%x10	0-1000

4.4.6 Max Speed Pot

Parameter	Description	Unit	Range
HighSide	HighSide refers to the high voltage end of the pot. MinValue and MaxValue define the acceptable range of HighSide pot values. CalValue is the value learned during calibration of the pot.	Volts	4.2-4.8
LowSide	LowSide refers to the low voltage end of the pot. MinValue and MaxValue define the acceptable range of LowSide pot values. CalValue is the value learned during calibration of the pot.	Volts	0.2-5.0
Fault Detection Time	Fault Detection Time is used to set a delay time before a fault is registered. The delay time is in Seconds with one decimal place i.e: 1.3	Seconds	0.0-100.0
Status:	Possible status values are: OK, Value at 5V, Value too High, Value at 0V, Value too Low, and Not Calibrated.		

4.4.7 Speed Pot

Speed Pot Parameter

	MinValue	CalValue	MaxValue
HighSide	4.2 Volt	4.7 Volt	4.8 Volt
LowSide	0.2 Volt	0.4 Volt	0.8 Volt
Fault Detection Time	2 Seconds		
Status: OK	SetDefaults	Get	Send

Parameter	Description	Unit	Range
HighSide	HighSide refers to the high voltage end of the pot. MinValue and MaxValue define the acceptable range of HighSide pot values. CalValue is the value learned during calibration of the pot.	Volts	4.2-4.8
LowSide	LowSide refers to the low voltage end of the pot. MinValue and MaxValue define the acceptable range of LowSide pot values. CalValue is the value learned during calibration of the pot.	Volts	0.2-5.0
Fault Detection Time	Fault Detection Time is used to set a delay time before a fault is registered. The delay time is in Seconds with one decimal place i.e: 1.3	Seconds	0.0-100.0
Status:	Possible status values are: OK, Value at 5V, Value too High, Value at 0V, Value too Low, and Not Calibrated.		

4.4.8 Dual Path Steer

Parameter	Description	Unit	Range
Counter Rotate (%)	Percent of steer wheel position from center to reach the pivot steer deadband	%	0-100.0
Pivot Deadband (%)	Amount of deadband around the pivot point	%	0-100.0

4.4.9 FNR Switch

Parameter	Description	Unit	Range
Fault detection time (s)	Fault Detection Time is used to set a delay time before a fault is registered. The delay time is in Seconds with one decimal place e.g.: 1.3	Seconds	0.0-10.0
Status:	Possible status values are: OK, Value at 5V, Value too High, Value at 0V, Value too Low, and Not Calibrated.		

4.5   Outputs

4.5.1   Left Valve Parameters

Parameter	Description	Unit	Range
X Input Min.	Minimum expected value of the command input to this module.	%	0-100
X Input Max.	Maximum expected value of the command input to this module	%	0-100
Y Output Max	Output value at Max. Input value.	Milliamps	0-2500
Thresholds	Minimum value of current to just put the pump into stroke.	Milliamps	
Status	Possible status values are: O.K. or not calibrated		

4.5.2 Right Valve Parameters

Parameter	Description	Unit	Range
X Input Min.	Minimum expected value of the command input to this module.	%	0-100
X Input Max.	Maximum expected value of the command input to this module	%	0-100
Y Output Max	Output value at Max. Input value.	Milliamps	0-2500
Thresholds	Minimum value of current to just put the pump into stroke.	Milliamps	
Status	Possible status values are: O.K. or not calibrated		

4.5.3 Valve Fault Parameters

Parameter	Description	Unit	Range
Fault Detection Time (s)	Time delay before fault is reported	Sec	0.1 –10.0
Coil Resistance (ohms)	Nominal resistance value of the Control coil	Ohms	1-60
Status	Possible status values are: O.K. , Forward or Reverse coil Short or Open		

4.6   Control Parameter Screens

Control screens allow access to control object parameters.

4.6.1   State Brake AccelDecel

Parameter	Description	Unit	Range

T1 Up (ms)	Final non-linear up ramp	Ms	0 - 1000
TR Up (ms)	Acceleration ramp up time.	Ms	0 - 10000
TR1 UP (ms)	Initial non-linear up ramp		
Coasting Neutral Dir Change Brake	These are the deceleration values used for each of these conditions, Coasting means handle toward but not at neutral. Neutral means handle from some value to neutral. Direction change means when moving the handle from forward to reverse or vice versa without stopping at neutral. Brake is when the Enable Propel signal is removed		
TR1 Down	TR1 Up is the ramp up time in ms for an input of 1000. An input of 500 would ramp up in half the specified time.	Ms	0-10000
TR Down	Deceleration ramp down time.		
T1 Down	T1 Down is the ramp down time in ms for an input of 1000. An input of 500 would ramp down in half the specified time.	Ms	0-10000

5   Data Logging

5.1   Selecting the channels to log.
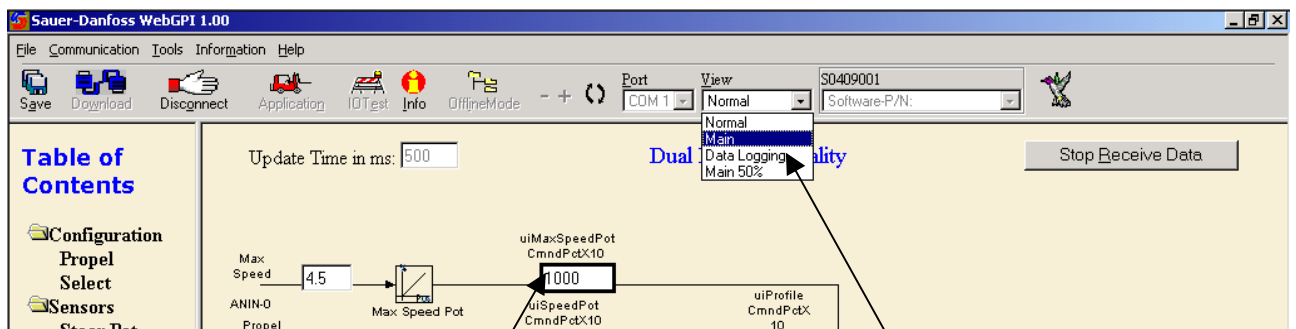
Select the Data Logging function to see the data logging screen.

Click on a data box and the box will be highlighted. These data will be displayed on the graph on the data logging screen. Select as many data channels as you need for your analysis.

5.2 The Data Logging Screen
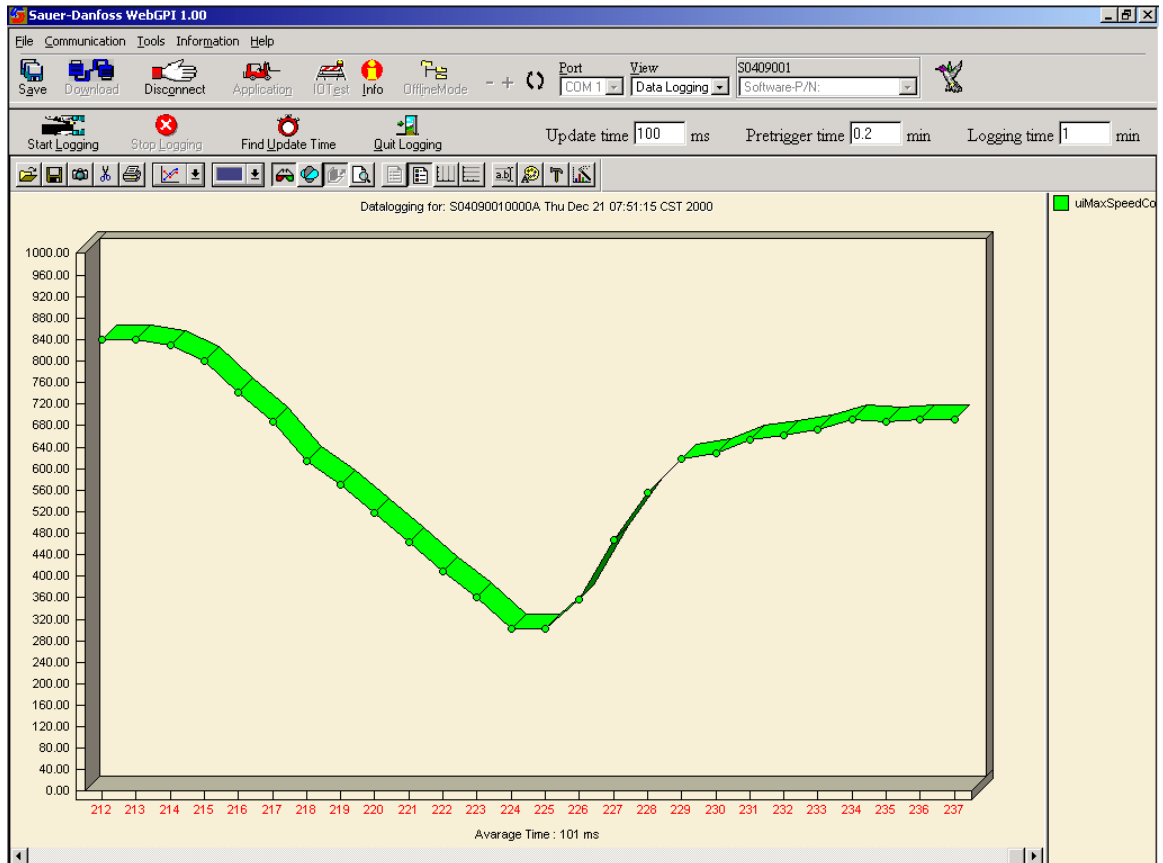
6   Troubleshooting Guide

This section outlines a strategy that can be used to solve problems in the control system. A common technique used in problem-solving is exchanging components. However, a very important element necessary to the timely and successful conclusion of this activity is the correct selection of the malfunctioning component. A thorough understanding of the entire system and an elimination process leading to the malfunctioning component is absolutely necessary before starting the exchange activity.

Reduce the random exchange of components by carefully analyzing the symptoms and then conducting tests to determine which of the elements in the system is likely to be the problem. The technician should use the flow chart below as a guide to locate the problem.

Since it is new, the electronic controller is often the first component targeted for exchange. However, the malfunction of an electronic controller is extremely rare and, therefore, it should be the last component considered for replacement. In fact, the electronic controller has an internal ability to diagnose itself and the connections attached to it. This information can be very helpful in finding the problem area. If the electronic controller is responding to commands and not giving diagnostics that indicate an internal problem, the likelihood that the problem is internal to the electronic controller is remote.

6.1 Troubleshooting Procedure

System function — No → **Controller Type** — All other Controllers → **Power Led** — On → **System Led**

Controller Type — DC2, S2X →

Power Led — Off →

System Led — Abnormal →

Power Led — On → **Status Led**

Power Led — Off → **Check Power to Controller** — OK → **Replace Controller**

Status Led — ON → **See description of display codes**

Status Led — Off → **Spare controller available?**

System Led — Off →

System Led — On →

Replace Controller ← Solid Off or Solid On — **Mode Led**

Mode Led — Blinking 0.5 Hz → **Status Led** — Off → Spare controller available?

Status Led — Blinking Code → **See description of blink algorithm in next section**

Mode Led — Blinking Code → **See description of blink algorithm in next section**

Mode Led — Blinking 10Hz → **No application loaded. Download application or replace controller.**

Spare controller available? — Yes → **Check all external switches w/ Spare controller**

Spare controller available? — No → **Check all external switches w/ voltmeter**

Check all external switches w/ Spare controller — Not OK → **Fix external switches**

Check all external switches w/ Spare controller — OK → **Check hydraulic system**

Check all external switches w/ voltmeter — Not OK → Fix external switches

Check all external switches w/ voltmeter — OK → **Check hydraulic system**

Check hydraulic system — OK → **Need to Connect to PC with WebGPI for online diagnostic**

Check hydraulic system — Not OK → **Fix hydraulic system**

Generic Trouble Shooting procedure

6.2 Fault Codes

When the controller detects a fault condition, it signals the specific fault using the red Status LED. Under normal conditions with no error present, the red LED is off and the yellow LED blinks at a 0.5 Hz rate. If no application code is loaded in the controller, the red LED is off and the yellow LED blinks at a 10 Hz rate. All other errors (those specific to the application) are decoded by observing "blink codes" generated by the red LED.

Yellow LED (Mode)	Red LED (Status)	System Status:
10 Hz blink rate	Off	No application loaded
0.5 Hz blink rate	Off	Application loaded and no error
0.5 Hz blink rate	4 bit blink code to describe fault	Application loaded and error

6.2.1 Description of Blink Code Algorithm

If the yellow LED blinks at an unvarying 0.5 Hz rate and the red LED is blinking, the cause of the fault can be decoded from the red LED alone as follows: the red LED will flash a four bit sequence, followed by a pause, followed by the four bit sequence, the pause, and so on. The long flash, symbolized by a "-", lasts approximately one second. The short flash, symbolized by a "•", lasts approximately one-half second. The pause between the four bit sequence lasts approximately 3.5 seconds. If more than one fault exists, each fault will be displayed in sequence before being repeated.

6.2.2 Blink Code Translation

Fault Code	Flash Bit Sequence	Device at Fault	Cause of Fault	Machine Response
1	– • • •	Speed pot, unidirectional command Input	Voltage signal is out of range or input is uncalibrated.	No output from the speed pot will cause machine to stop.
2	• – • •	Max speed pot, unidirectional command Input	Voltage signal is out of range or input is uncalibrated.	No output from the max speed pot. Machine will stop.
3	– – • •	FNR pot Bi-directional command input	Voltage signal is out of range or input is uncalibrated.	FNR command will return to neutral and machine will stop.
4	• • – •	Steer pot Bi-directional command input	Voltage signal is out of range or input is uncalibrated.	Machine will steer straight. at any handle setting.
5	– • – •	FNR Object	RPM below 200, or no RPM at all.	Machine will revert to neutral causing the machine to stop.
7	– – – •	Left Valve	Uncalibrated.	Machine will revert to neutral causing the machine to stop.

Fault Code	Flash Bit Sequence	Device at Fault	Cause of Fault	Machine Response
8	● ● ● –	Right Valve	Uncalibrated.	Machine will revert to neutral causing the machine to stop.
9	– ● ● –	Right Valve Forward Coil	Open or Short.	Machine will revert to neutral causing the machine to stop.
10	● – ● –	Right Valve Reverse Coil	Open or Short.	Machine will revert to neutral causing the machine to stop.
11	– – ● –	Left Valve Forward Coil	Open or Short.	Machine will revert to neutral causing the machine to stop.
12	● ● – –	Left Valve Reverse Coil	Open or Short.	Machine will revert to neutral causing the machine to stop.

"●" = short flash = 0

"–" = long flash = 1

7   System Wiring

7.1   Wiring Guidelines

1.   Protect all wires from mechanical abuse. Wire can be run in flexible metal or plastic conduits.

2.   Use 85°C wire with abrasion resistant insulation. 105°C wire should be considered near hot surfaces.

3.   Use #18 gauge wire or greater. #14 or #16 wire is preferred.

4.   Separate high current wires such as solenoids, lights, alternators, or fuel pumps from control wires.

5.   Run wires along the inside of, or close to, metal machine frame surfaces where possible. This simulates a shield, which will minimize the effects of EMI/RFI radiation.

6.   Do not run the wires near sharp metal corners. Consider running the wire through a grommet when rounding a corner.

7.   Do not run wires near hot machine members.

8.   Provide strain relief for all wires.

9.   Avoid running wires near moving or vibrating components.

10.   Avoid long, unsupported wire spans.

11.   Twist all sensor lines. (About one turn every 4 inches or 10 cm.)

12.   Use harness anchors which will allow wires to "float" with respect to the machine frame rather than rigid anchors.

7.2 Wiring Diagram
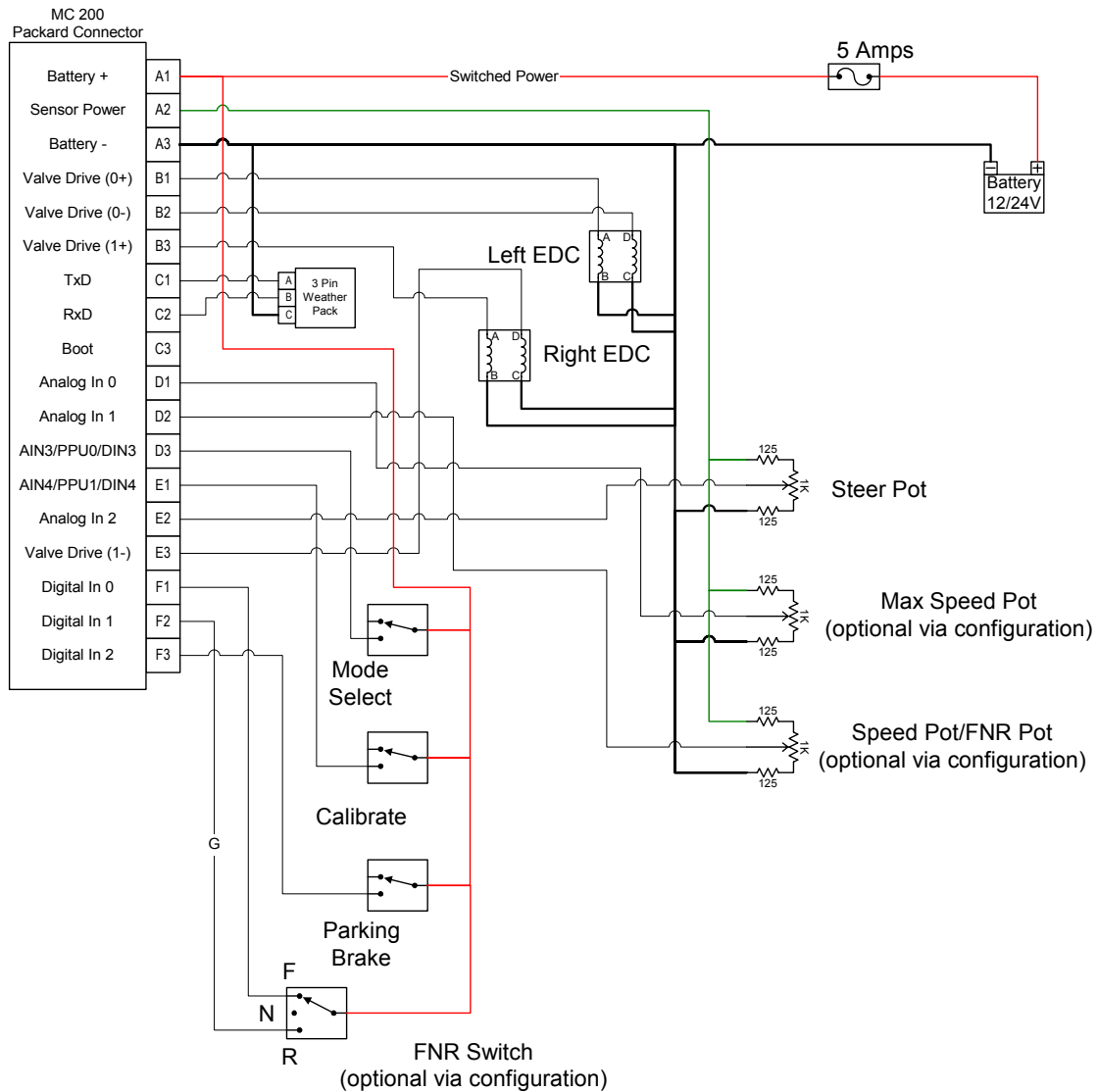
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Sauer-Danfoss (EH-US) Company
3500 Annapolis Ln. N.
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Sauer-Danfoss (US) Company
2800 East 13th Street
Ames, IA 50010, USA
Phone: + 1 515 239-6000, Fax: +1 515 239 6618

Sauer-Danfoss (Neumünster) GmbH & Co. OHG
Postfach 2460, D-24531 Neumünster
Krokamp 35, D-24539 Neumünster, Germany
Phone: +49 4321 871-0, Fax: +49 4321 871 284

Sauer-Danfoss (Nordborg) A/S
DK-6430 Nordborg, Denmark
Phone: +45 7488 4444, Fax: +45 7488 4400

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