Application Note - AN-118

Material Spreading

NOTICE

This application note is provided for use as a general example and a guide. Divelbiss assumes no responsibility, liability or warranty regarding this application, its use, functionality or reliability to meet application needs. User assumes all responsibility to ensure all safety precautions are taken when using this application note. This application must not be used alone in applications which would be hazardous to personnel in the event of a failure. Precautions must be taken by the user to provide mechanical and/or electrical safeguards external to this application and controllers shown.

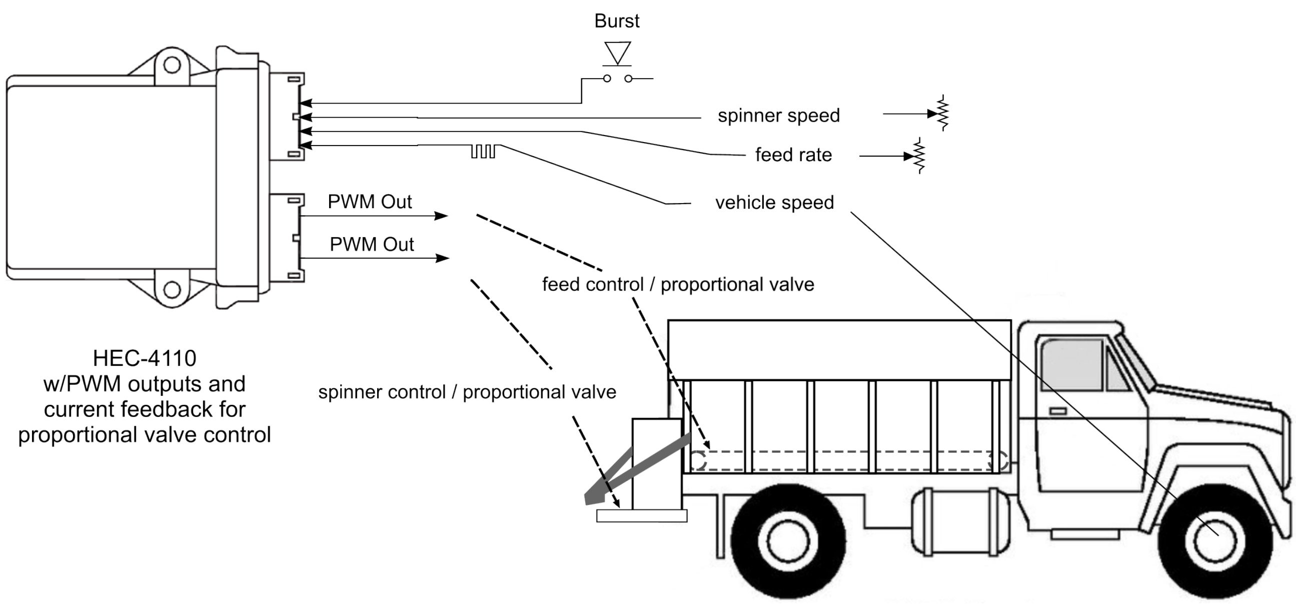
Application Description

This application controls the spreading of material over an area using the HEC-4110 controller. Vehicle speed is calculated and monitored (via pulses on a high speed counter input) and a feed rate auger is proportionally controlled based on the vehicle speed and a knob setting the feed rate. The feed rate is controlled based on the knob (potentiometer connected to an analog input) from 0-100% and based on speed from 0-30 MPH. If the rate is set to 100%, then at 15 MPH, the feed rate would be 50% and at 30 MPH the feed rate would be 100%. If the rate is set to 50%, then at 15 MPH, the feed rate would be 25% and at 30 MPH, the feed rate would be 50%.

The feed rate is verified by measuring the proportional valve's coil current in a closed loop configuration. This current is used in a PID algorithm to control the Pulse Width Modulation for the proportional valve. As the vehicle moves, the auger speed / feed is automatically adjusted based on vehicle speed.

The spinner speed is set in the cab by potentiometer connected to an analog input. A Burst mode is included that will place the maximum amount of material (maximum feed rate) for as long as the burst button is pressed. The Spinner will operate normally in burst mode.

System Diagram



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Equipment Used

Harsh Environment 4000 Series		
Controller Part #:		HEC-4110
Programming Software:		EZ LADDER Toolkit
Digital I/O:		On -Board
Application Filename:		AN118-HEC4X.dld
Programming Cable:		HEC-910 & Null Modem

Input / Output Description

CNT 1 : Counter Channel 1. This is where the sensor is connected to read the pulses from the drive train or sensor (for vehicle speed measurement).

AN0: Analog Input 0. This is where 5VDC and potentiometer to determine feed rate is connected. See the wiring diagram for details.

AN1: Analog Input 1. This is where 5VDC and potentiometer to determine spinner rate is connected. See the wiring diagram for details.

GPI2: This input is connected to the Burst Momentary Switch. Closing this switch activates the burst mode as described earlier.

PWM1: This is where the proportional valve to control the feed rate is connected. Also labeled GPO0.

PWM3: This is where the proportional valve to control the spinner speed is connected. Also labeled GPO1.

Program Variables

BurstMode:	This is a boolean variable (internal control relay) that is used to identify when burst mode is active (Burst button is pressed).
CR1	Internal control relays used to control high speed timers and to calculate vehicle speed based on input pulses.
CR2	Internal control relays used to control high speed timers and to calculate vehicle speed based on input pulses.
GPI2	Boolean variable representing general purpose input (GPI) number 2. This is connected to the Burst mode momentary switch.
AN0	Integer variable representing analog input 0 (connected to feed rate potentiometer). AN0 represents the analog input value of 0-5VDC as an integer 0-4095 respectively.
AN1	Integer variable representing analog input 0 (connected to spinner rate potentiometer). AN1 represents the analog input value of 0-5VDC as an integer 0-4095 respectively.
ITemp1 - ITemp4	Integer variables used to temporarily hold values for comparisons and calculations.
I_500	Integer variable that represents 500 (default value of 500). To be used for comparisons and calculations.
I_Zero	Integer variable that represents 0 (default value of 0). To be used for comparisons and calculations.
NumPulse	Integer variable that represents the number of pulses equal to 1 foot of vehicle travel.
PulseCnt	Actual number of pulses counted in last 100mS sample period.
TimVal1	Integer variable to hold output from High Speed Timer 1.
TimVal2	Integer variable to hold output from High Speed Timer 2.

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AugPct	Feed Rate Auger valve coil current set point in % (0-100). (Real Variable)
AugSetpt	Feed Rate Auger valve coil current set point, actual current in Amps. (Real Variable)
AugSptSw	Variable that represents either the set point in current or Maximum Valve current based on control conditions.(Real Variable)
AugerOut	Actual signal from PID block to Pulse Width Modulation Output, expressed as a percent (%) from 0 to 100. (Real Variable)
CntStore	Actual number of pulses counted in last 100 mSec converted and stored as a Real Variable
Error	This real variable is an output of the PID function. It is the amount of error between the desired set point and the actual output (coil current).
Kp	Proportional PID input process variable (real variable).
Ki	Integral PID input process variable (real variable). Generally, the larger Ki, the slower the output changes to set point changes.
Kd	Derivative PID input process variable (real variable). This is generally zero.
IO	This is the default I/O setting for the output when the PID function first starts.
Slope:	This is a calculated real variable that represents the slope for the valve's current to flow diagram.
OffSet	This is a Real variable that is used for calculations.
PV	PV is the process variable (real variable) that is an input to the PID function.
Multiplier	Real Variable used for calculating scale of auger/feed rate control.
Mult2	Real variable used to convert coil current % to actual coil current.
R_100	Real variable that represents 100 (default value of 100). To be used for comparisons and calculations.
R_30	Real variable that represents 30 (default value of 30). To be used for comparisons and calculations.
R_36000	Real variable that represents 36000 (default value of 36000). To be used for comparisons and calculations.
R_4095	Real variable that represents 4095 (default value of 4095). To be used for comparisons and calculations.
R_5280	Real variable that represents 5280 (default value of 5280). To be used for comparisons and calculations.
R_AN4	Analog Input 4 (current feedback for proportional valve on PWM1) in Real Variable format.
R_NumPulse	Number of pulses in one foot of vehicle movement converted to a Real Variable.
R_Temp1 - R_Temp9	Real variables used as temporary holders for calculations or comparisons.
R_TempV	Real variable used as a temporary holder for calculations or comparisons.
R_VehSpeed	Calculated Vehicle speed as a Real Variable.
SpinSpeed	Actual control signal to PWM3 for control of Proportional valve controlling spin speed. Represented as a Real Variable from 0-100%.
ValveMax	Maximum coil current in amps for the feed rate proportional valve (max flow rate).
ValveMin	Minimum coil current in amps for the feed rate proportional valve (minimum for flow to occur).
ZeroSpeed	Real variable representing what is considered no motion (truck not moving).

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Program Description

Rungs 10-15: High Speed Timers are used to create a 100 millisecond scan rate for reading vehicle speed pulses.

Rungs 16-19: Based on the High speed timers, the actual pulses are counted and stored for each 100mS scan period.

Rungs 20-21: The integer Number of pulses per foot (NumPulse) is converted to a real variable (R_NumPulse).

Rungs 23-25: The counted pules are divided by the number of pulses per foot. That result is divided by 5280 (number of feet in one mile) and then multiplied by 36000 (number of sample periods per hour). The result is the vehicle speed in Miles per Hour.

Rungs 29-31: Analog input 0 (feed rate knob) is read, average and converted to a real variable. It is then divided by 4095 (maximum counts on the analog input). This provides a multiplier that will be used to scale the feed rate set point.

Rungs 32-34: If the vehicle speed is > 30 MPH, limit the variable we use for control to 30 (MPH).

Rungs 35-37: If the vehicle speed is < 30 MPH, copy the current speed to a new variable for control use.

Rungs 38-40: 100 (top % of control) is divided by max speed range (30 MPH) then multiplied by the vehicle speed. That result is then multiplied by the Multiplier to calculate the actual set point for the valve's coil current; represented as a percent (%).

Rungs 41-43: A different multiplier is calculated. The valve's coil operation range is used by subtracting the minimum coil current that has flow from the maximum coil flow current. This result is divided by 100 and the result is a new multiplier (Mult2) that will be used to convert coil current % to coil current Amps.

Rungs 44-46: The Mult2 is then multiplied by the Auger set point (AugPct) and the Valve minimum is added to the result. The output from this is the actual Auger set point for coil current (in Amps).

Rungs 47-50: The current feedback from the coil current is read and a process variable (PV) is calculated based on slope and offset (which must be calculated based on the actual characteristics of the proportional valve).

Rungs 51-53: If Burst Mode is active, use the maximum flow rate for the valve (ValveMax).

Rungs 54-62: The PID function uses the set point , process variables to calculate the PWM signal and then outputs the PWM signal as a % to the PWM function block.

Rungs 66-68: If the vehicle speed is less than the preset Zero Speed (what the program is set to use as zero), then a 0 set point is used for spinner speed. If the vehicle speed is greater, then the analog input (spinner knob) is used as a set point for the spinner speed.

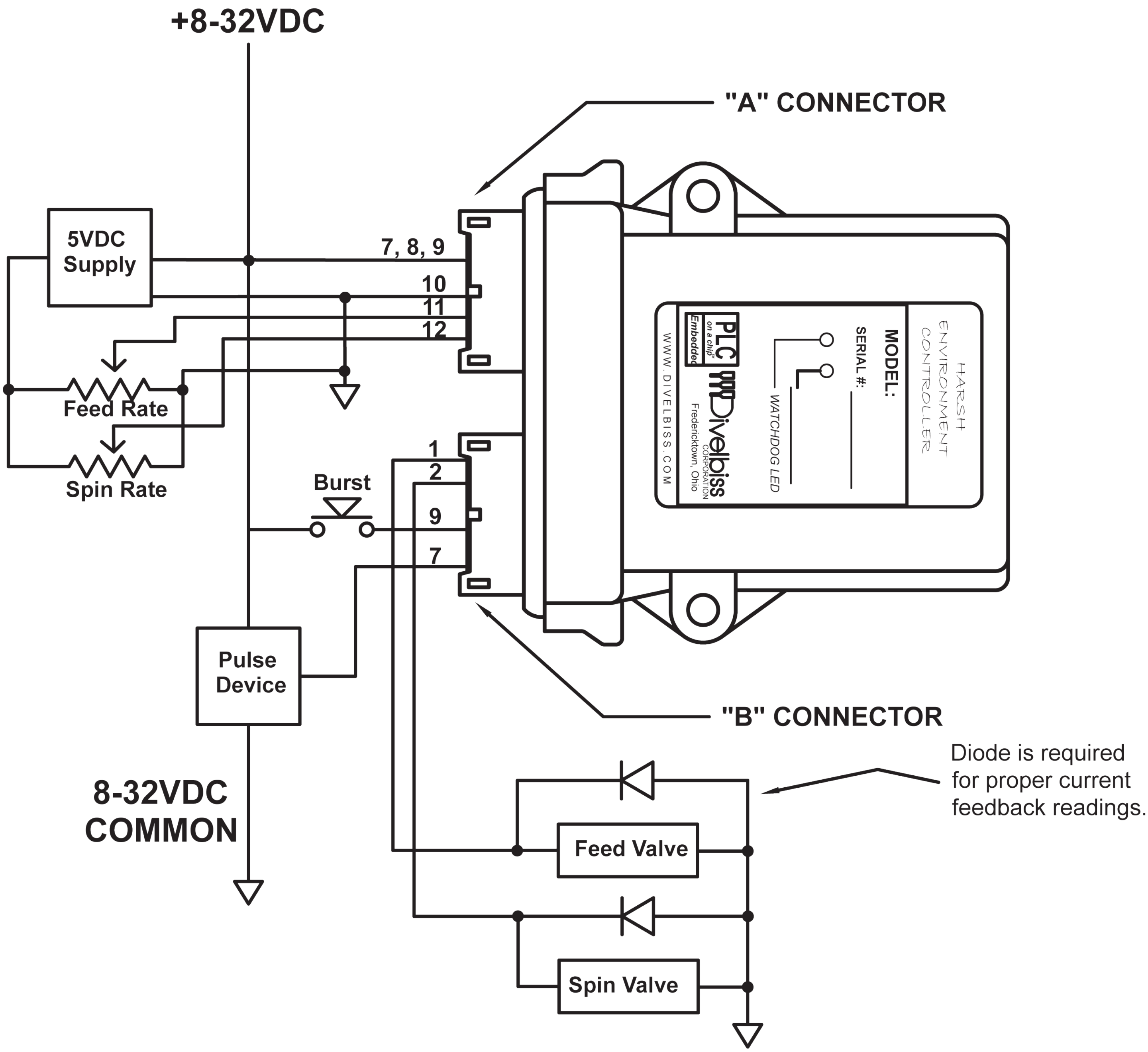
Rungs 69-71: If the Burst Mode is active, restore the knob setting for the spinner speed set point (if vehicle speed is zero).

Rungs 72-73: Analog input 1 (Knob, potentiometer for spin speed) is averaged and converted to a real variable.

Rungs 74-76: The real variable AN1 is then divided by 4095 (maximum counts on the analog input) and then multiplied by 100 (for a scale of 0-100%). This is the duty cycle for the PWM2 function block controlling the proportional valve for the spinner speed.

Rung 80: GPI2 is monitored (Burst Button Input) and when true, enables the Burst Mode via the BurstMode control relay.

Connection Diagrams



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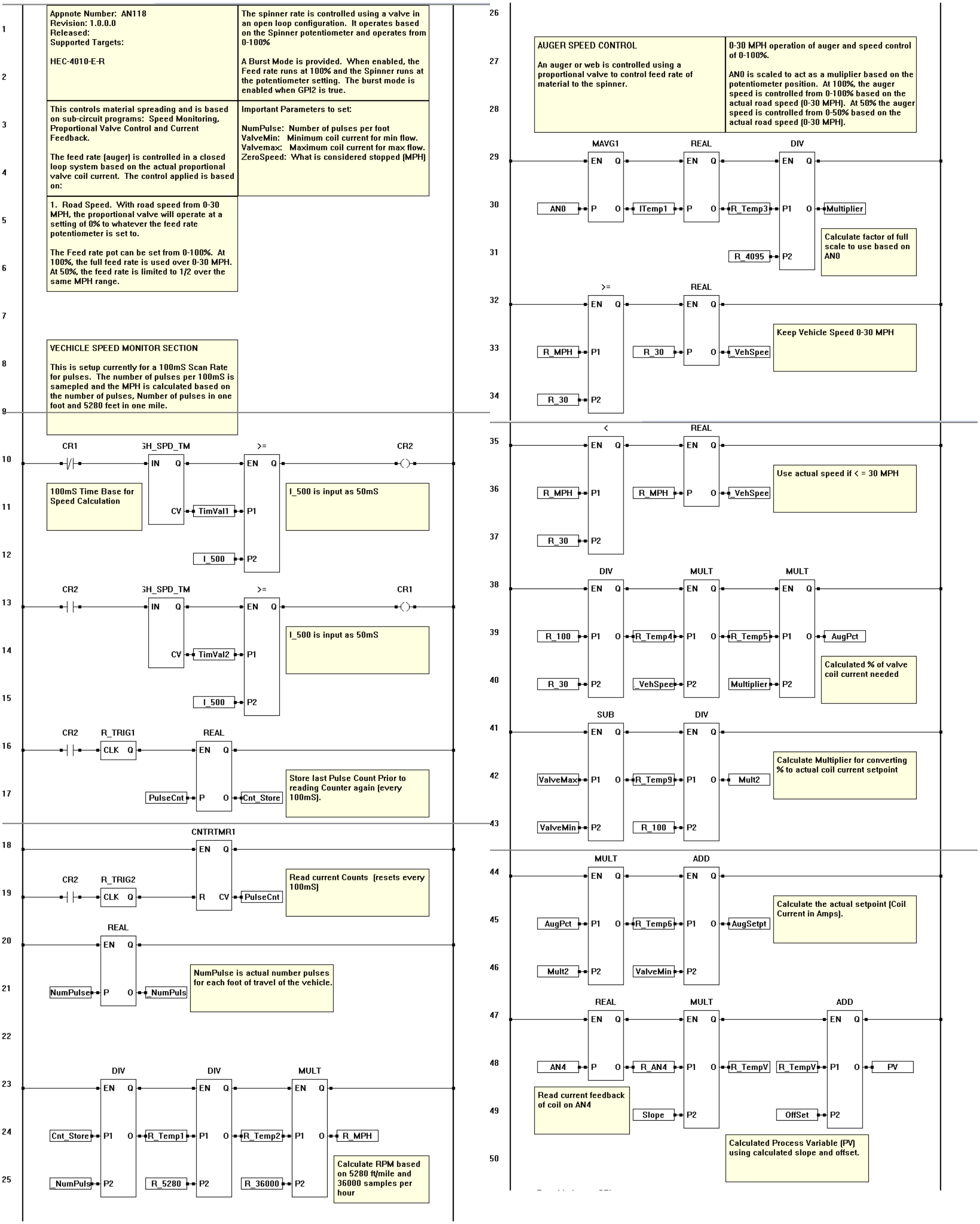
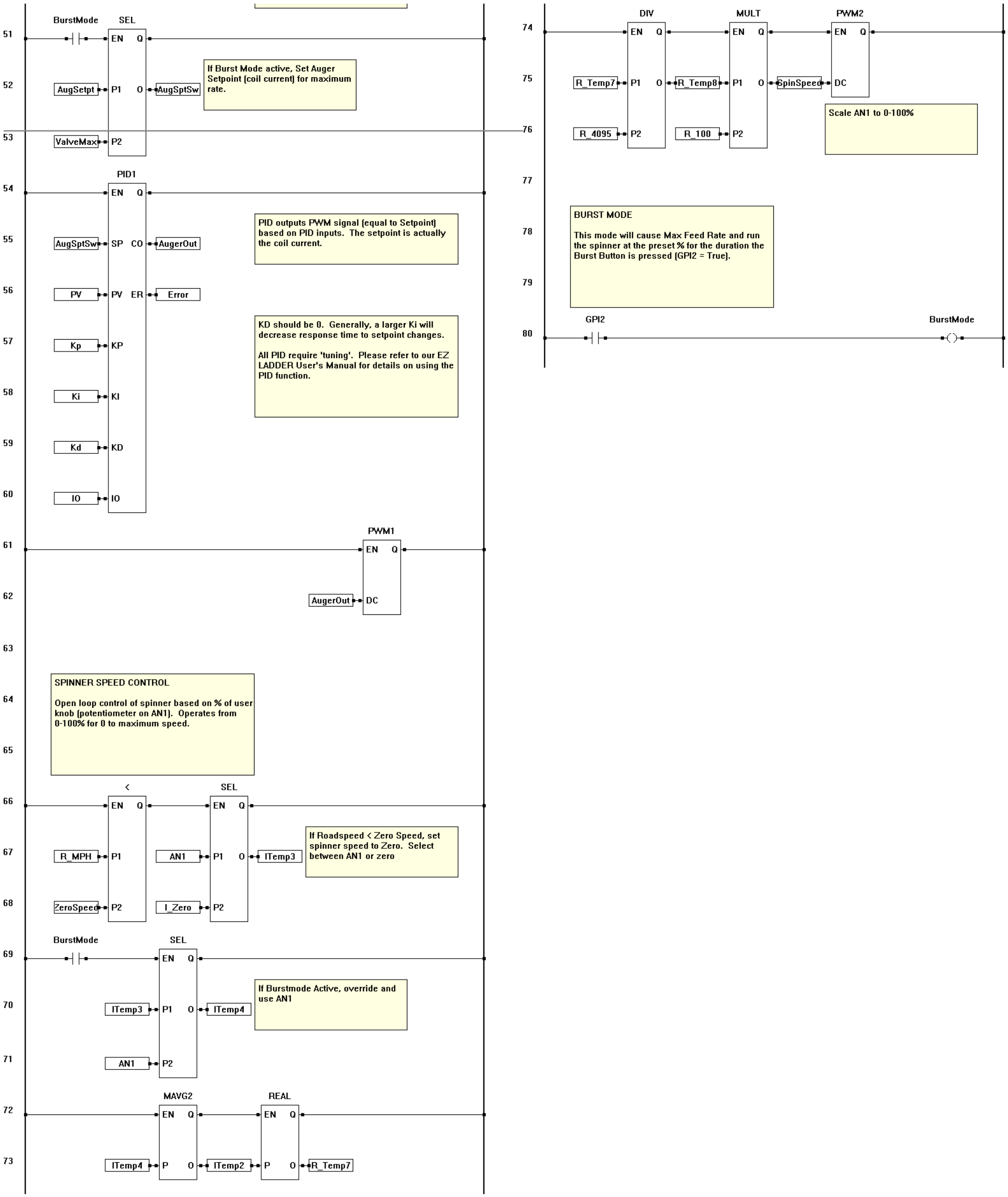
Ladder Diagram





BurstMode
SEL
EN Q
AugSetpt
P1 O
AugSptSw
ValveMax
P2
If Burst Mode active, Set Auger Setpoint (coil current) for maximum rate.
PID1
EN Q
AugSptSw
SP CO
AugerOut
PV
PV ER
Error
Kp
KP
Ki
KI
Kd
KD
IO
IO
PID outputs PWM signal (equal to Setpoint) based on PID inputs. The setpoint is actually the coil current.
KD should be 0. Generally, a larger Ki will decrease response time to setpoint changes.
All PID require 'tuning'. Please refer to our EZ LADDER User's Manual for details on using the PID function.
PWM1
EN Q
AugerOut
DC
SPINNER SPEED CONTROL
Open loop control of spinner based on % of user knob (potentiometer on AN1). Operates from 0-100% for 0 to maximum speed.
<
SEL
R_MPH
ZeroSpeed
AN1
I_Zero
ITemp3
If Roadspeed < Zero Speed, set spinner speed to Zero. Select between AN1 or zero
BurstMode
SEL
ITemp3
ITemp4
AN1
If Burstmode Active, override and use AN1
MAVG2
REAL
ITemp4
ITemp2
R_Temp7
DIV
MULT
PWM2
R_Temp7
R_Temp8
SpinSpeed
R_4095
R_100
Scale AN1 to 0-100%
BURST MODE
This mode will cause Max Feed Rate and run the spinner at the preset % for the duration the Burst Button is pressed (GPI2 = True).
GPI2
BurstMode