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VSVO Servo Control

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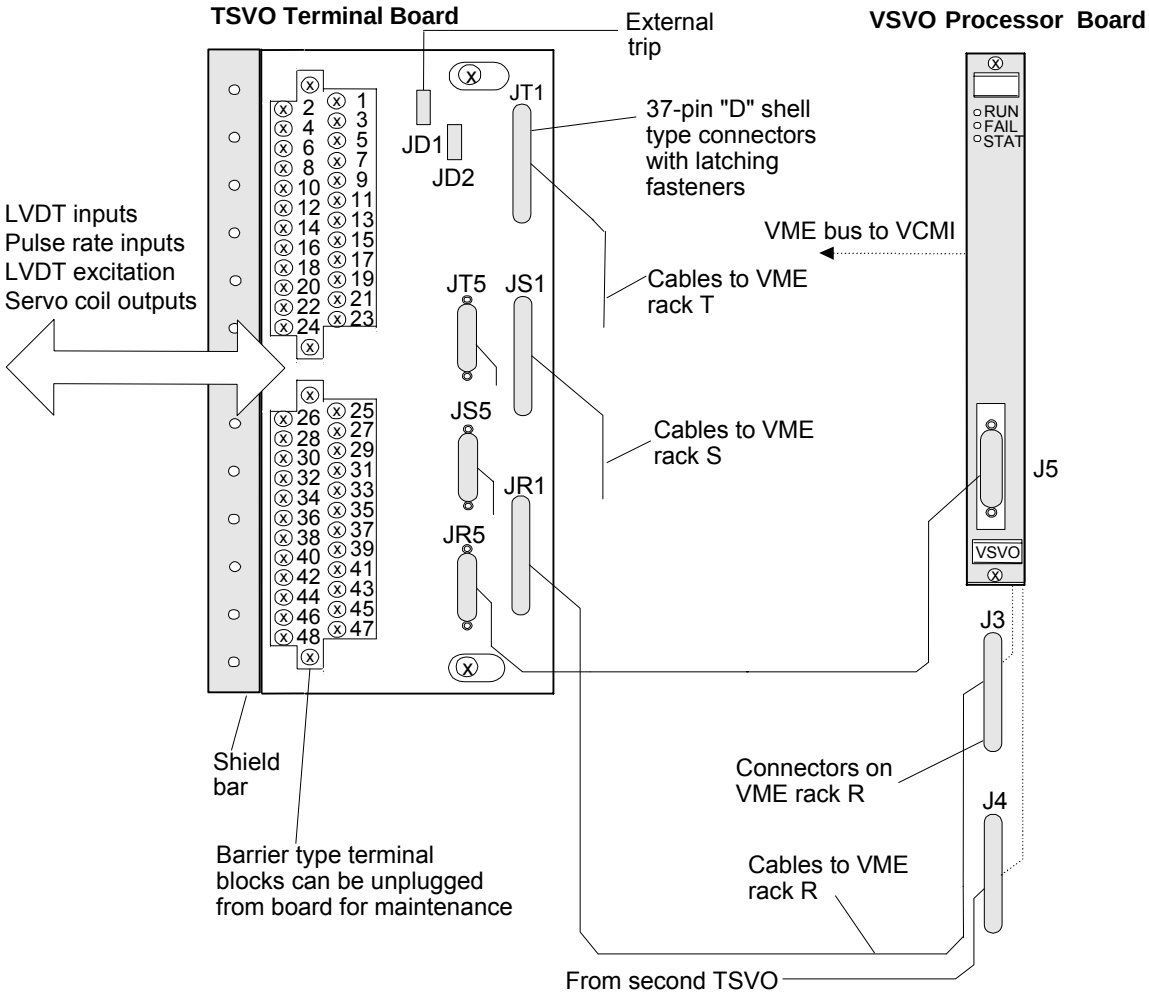
Functional Description

The Servo Control (VSVO) board controls four electro-hydraulic servo valves that actuate the steam/fuel valves. These four channels are usually divided between two servo terminal boards (TSVO or DSVO). Valve position is measured with linear variable differential transformers (LVDT). The loop control algorithm is run in the VSVO.

Three cables connect to VSVO on J5 plug on the front panel and the J3/J4 connectors on the VME rack. TSVO provides simplex signals through the JR1 connector, and fans out TMR signals to the JR1, JS1, and JT1 connectors. Plugs JD1 or JD2 are for external trips from the protection module.



Servo/LVDT Terminal Board, VSVO Processor Board, and Cabling

Installation

➢ **To install the V-type board**

1. Power down the VME processor rack
2. Slide in the board and push the top and bottom levers in with your hands to seat its edge connectors
3. Tighten the captive screws at the top and bottom of the front panel

Note Cable connections to the terminal boards are made at the J3 and J4 connectors on the lower portion of the VME rack. These are latching type connectors to secure the cables. Power up the VME rack and check the diagnostic lights at the top of the front panel. For details, refer to the section on diagnostics in this document.

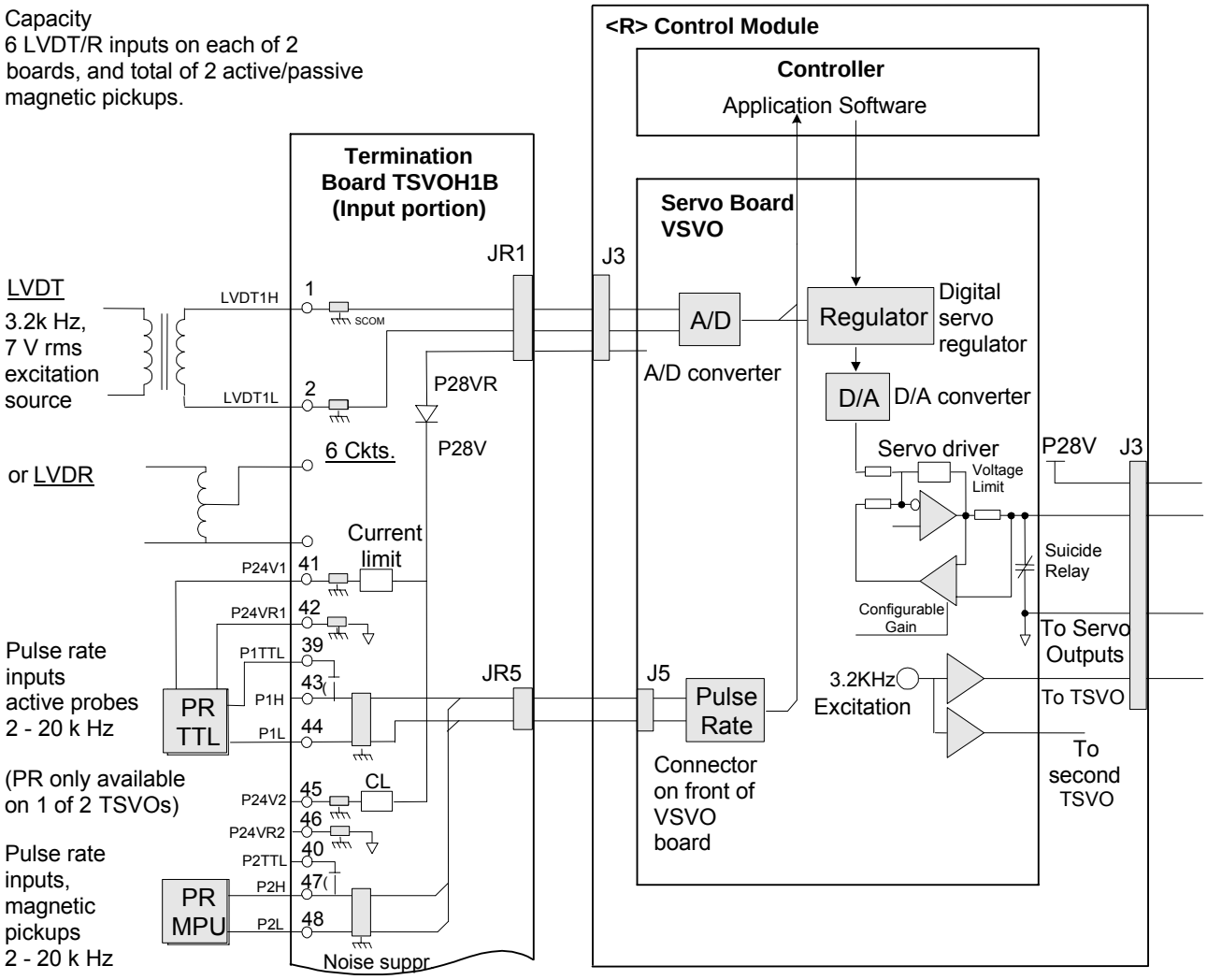
Operation

VSVO provides four channels consisting of bi-directional servo current outputs, LVDT position feedback, LVDT excitation, and pulse rate flows inputs. The TSVO provides excitation for, and accepts inputs from , up to six LVDT valve position inputs. There is a choice of one, two three, or four LVDTs for each servo control loop. Three inputs are available for gas turbine flow measuring applications. These signals come through TSVO and go directly to the VSVO board front at J5.

Each servo output is equipped with an individual suicide relay under firmware control that shorts the VSVO output signal to signal common when de-energized, and recovers to nominal limits after a manual reset command is issued. Diagnostics monitor the output status of each servo voltage, current, and suicide relay.

Simplex Systems

VSVO circuits for a simplex system are shown in the following figures.

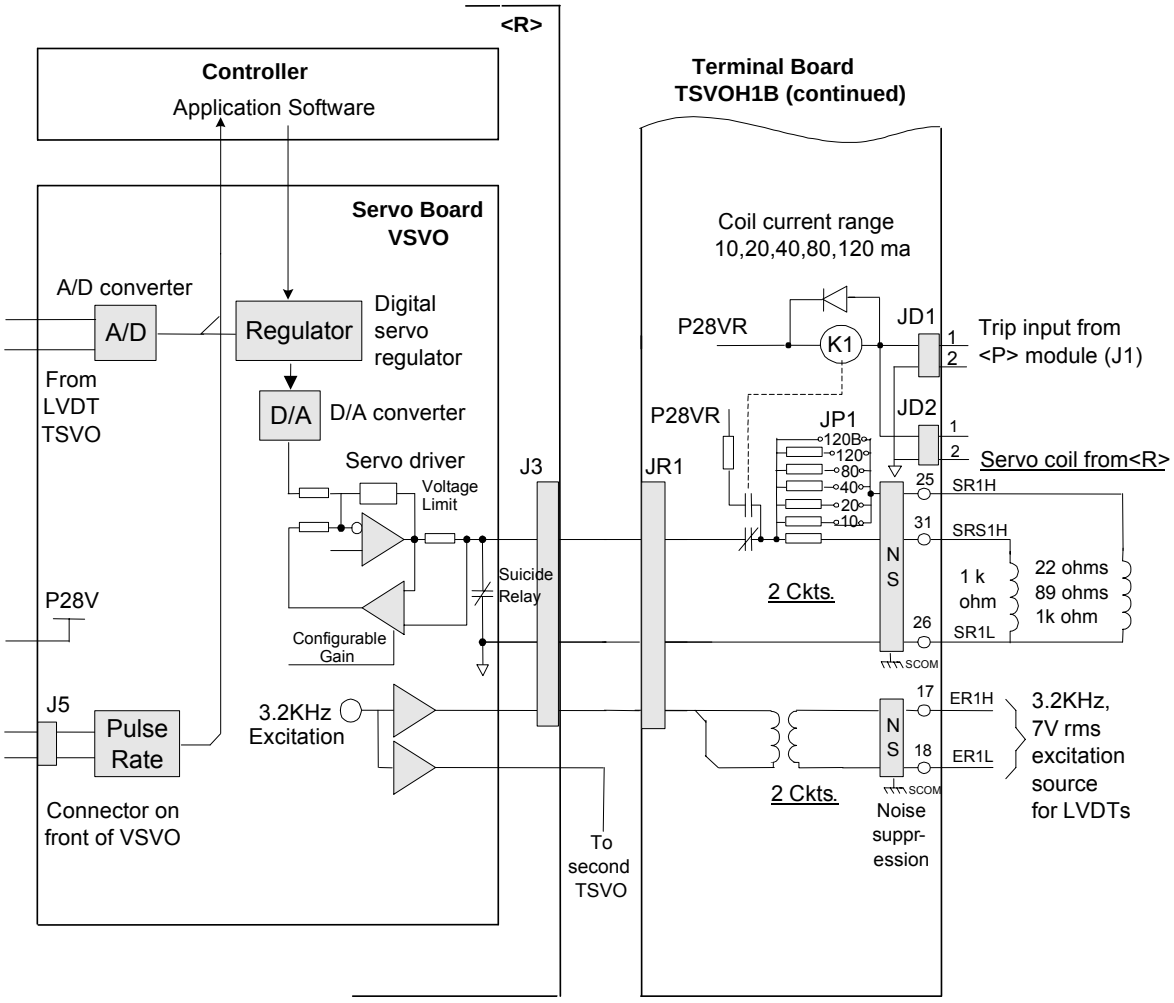


LVDT and Pulse Rate Inputs, Simplex

Each servo output channel can drive one or two-coil servos in simplex applications, or two or three-coil servos in TMR applications. The two-coil TMR applications are for 200# oil gear systems where each of two control modules drive one coil each and the third module interfaces with the servo. Servo cable lengths up to 300 meters (984 feet) are supported with a maximum two-way cable resistance of 15 ohms. Because there are many types of servo coils, a variety of bi-directional current sources are selectable by configuring jumpers.

Another trip override relay, K1, is provided on each terminal board and is driven from the <P> Protection Module. If an emergency overspeed condition is detected in the Protection Module, the K1 relay energizes and disconnects the VSVO servo output from the terminal block and applies a bias to drive the control valve closed. This is only used on simplex applications to protect against the servo amplifier failing high, and is functional only with respect to the servo coils driven from <R>.

Note The primary and emergency overspeed systems can trip the hydraulic solenoids independent of this circuit.

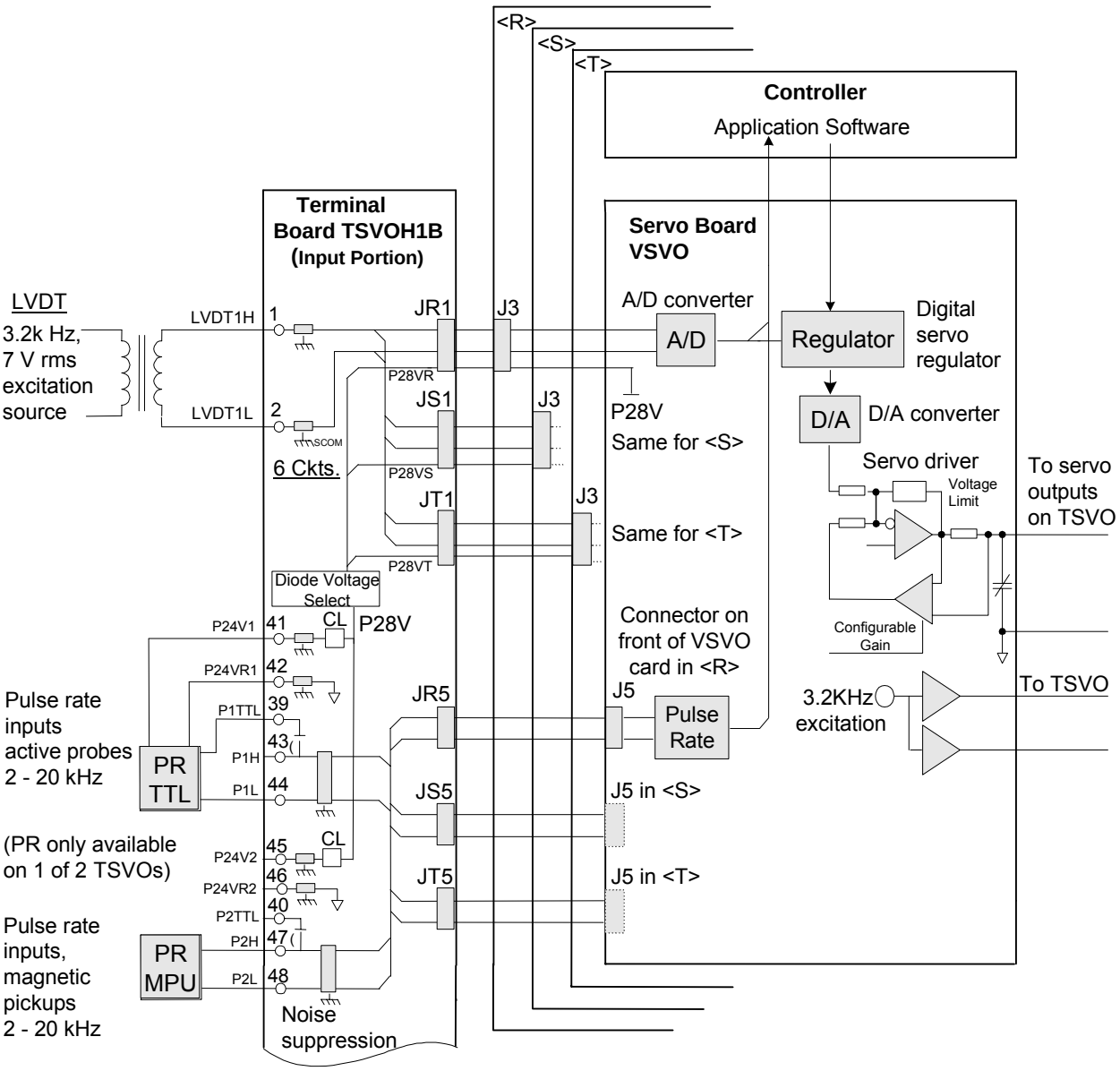


Servo Coil and LVDT Outputs, Simplex (continued) LVDT Outputs, Simplex

TMR Systems

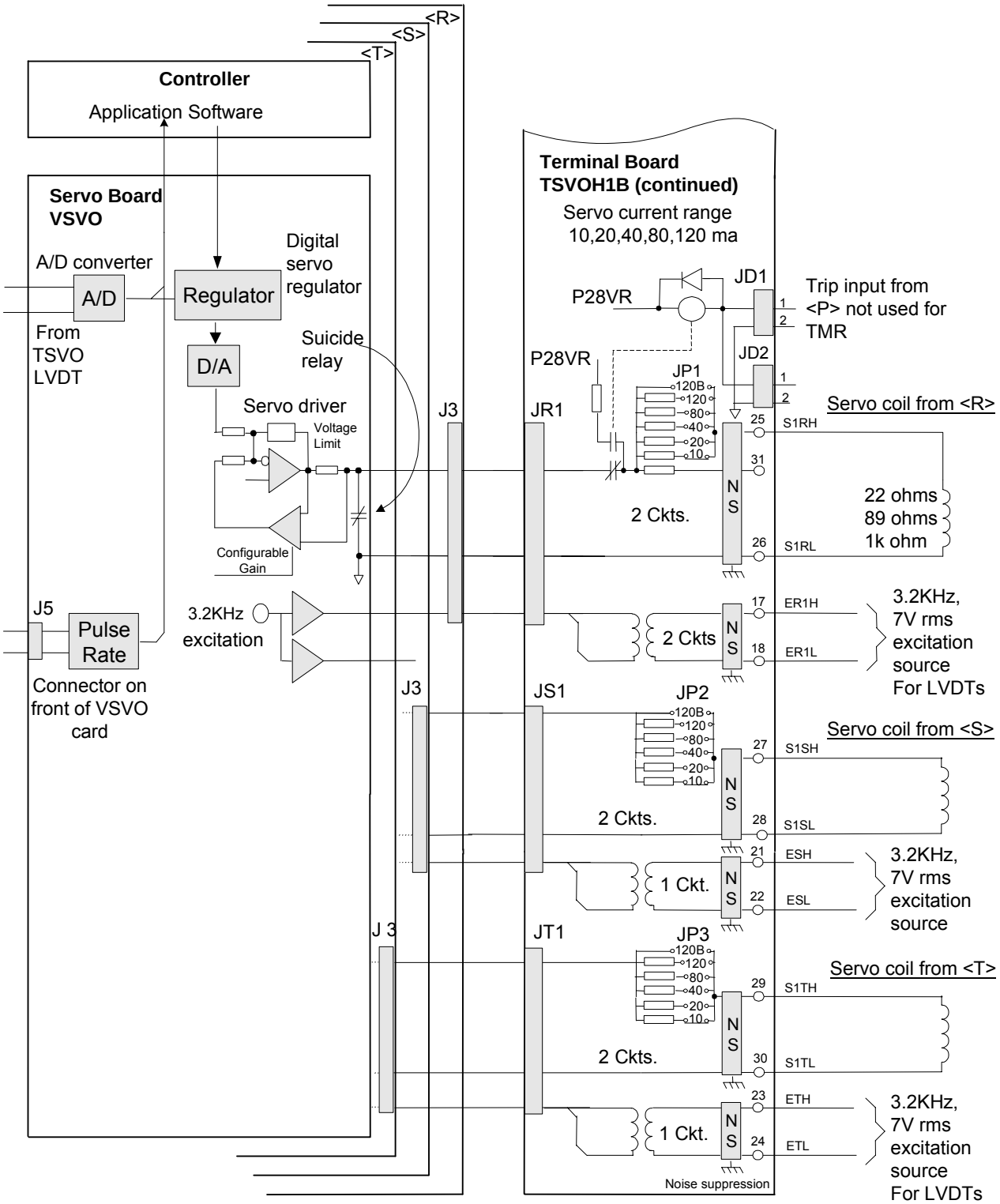
In TMR applications, the LVDT signals on TSVO fan out to three racks through JR1, JS1, and JT1. Three connectors also bring power into TSVO where the three voltages are diode high-selected and current limited to supply 24 V dc to the pulse rate active probes. VSVO circuits for a TMR system are shown in the following figures.

Note Only two pulse rate probes on one TSVO are used.



LVDT and Pulse Rate Inputs,TMR

For TMR systems, each servo channel has connections to three output coils with a range of current ratings up to 120 mA selected by jumper.



Servo Coil Outputs and LVDT Excitation, TMR

The following table defines the standard resistance of servo coils, and their associated internal resistance, selectable with the terminal board jumpers shown in the figure above. In addition to these standard servo coils, non-standard coils can be driven by using a non-standard jumper setting. For example, an 80 mA, 125 Ω coil can be driven by using a jumper setting 120B.

Servo Coil Ratings

Coil Type	Nominal Current	Coil Resistance (Ohms)	Internal Resistance (Ohms)	Application
1	±10 mA	1,000	180	Simplex and TMR
2	±20 mA	125	442	Simplex
3	±40 mA	62	195	Simplex
4	±40 mA	89	195	TMR
5	±80 mA	22	115	TMR
6	±120 mA (A)	40	46	Simplex
7	±120 mA (B)	75	10	TMR

Note The total resistance is equivalent to the standard setting.

The control valve position is sensed with either a four-wire LVDT or a three-wire linear variable differential reluctance (LVDR). Redundancy implementations for the feedback devices is determined by the application software to allow the maximum flexibility. LVDT/Rs can be mounted up to 300 meters (984 feet) from the turbine control with a maximum two-way cable resistance of 15 Ω.

Each terminal has two LVDT/R excitation sources for simplex applications and four for TMR applications. Excitation voltage is 7 V rms and the frequency is 3.2 kHz with a total harmonic distortion of less than 1% when loaded.

Note The excitation source is isolated from signal common (floating) and is capable of operation at common mode voltages up to 35 V dc, or 35 V rms, 50/60 Hz.

A typical LVDT/R has an output of 0.7 V rms at the zero stroke position of the valve stem, and an output of 3.5 V rms at the designed maximum stoke position (these are reversed in some applications). The LVDT/R input is converted to dc and conditioned with a low pass filter. Diagnostics perform a high/low (hardware) limit check on the input signal and a high/low system (software) limit check.

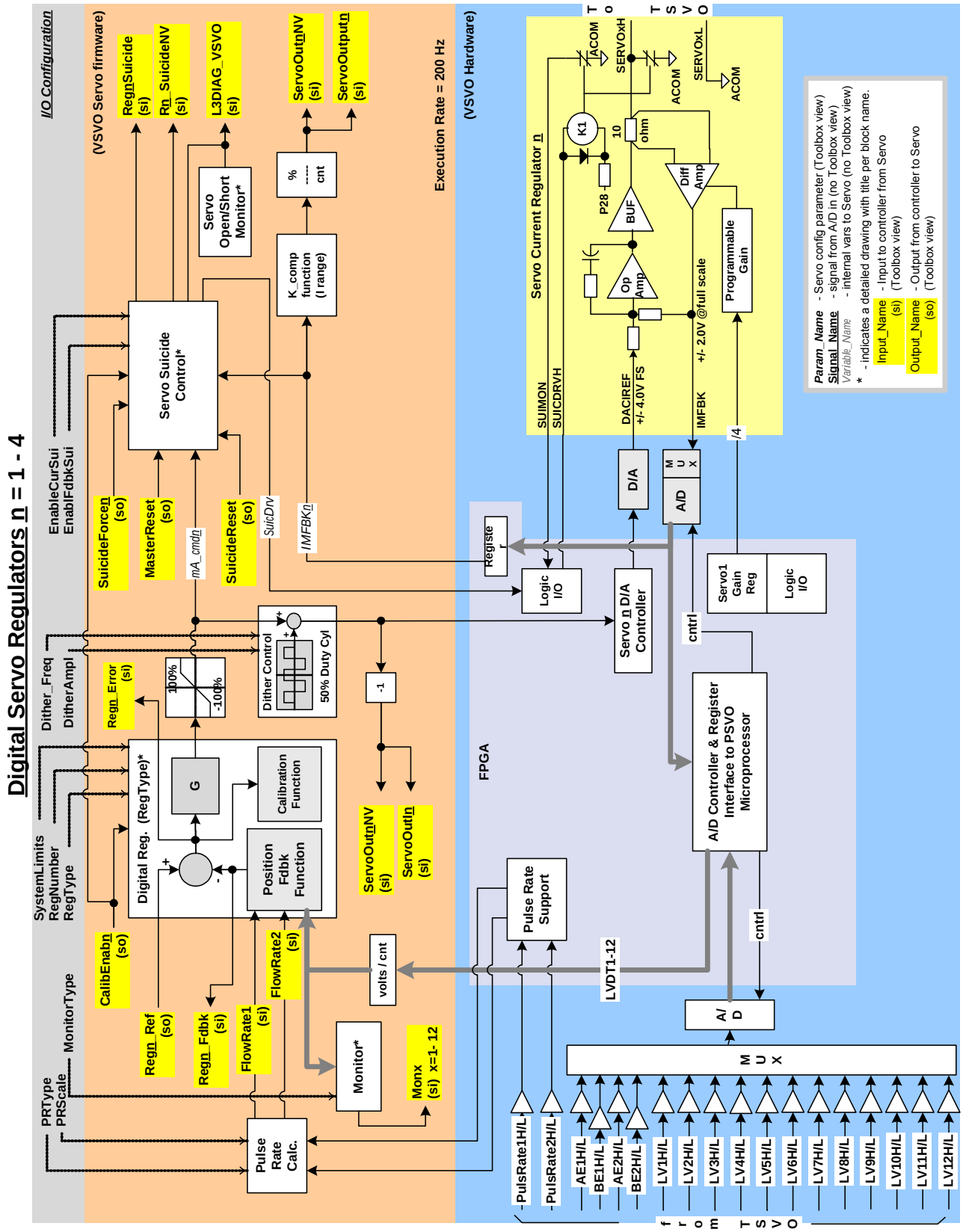
Two pulse rate inputs connect to a single J5 connector on the front of VSVO. This dedicated connection minimizes noise sensitivity on the pulse rate inputs. Both passive magnetic pickups and active pulse rate transducers (TTL type) are supported by the inputs and are interchangeable without configuration. Pulse rate inputs can be located up to 300 meters (984) from the turbine control cabinet, assuming a shielded-pair cable is used with typically 70 nF single ended or 35 nF differential capacitance and 15 Ω resistance.

Note The maximum short circuit current is approximately 100 mA with a maximum power output of 1 W.

A frequency range of 2 to 30 kHz can be monitored at a normal sampling rate of either 10 or 20 ms. Magnetic pickups typically have an output resistance of 200 Ω and an inductance of 85 mH excluding cable characteristics. The transducer is a high impedance source, generating energy levels insufficient to cause a spark.

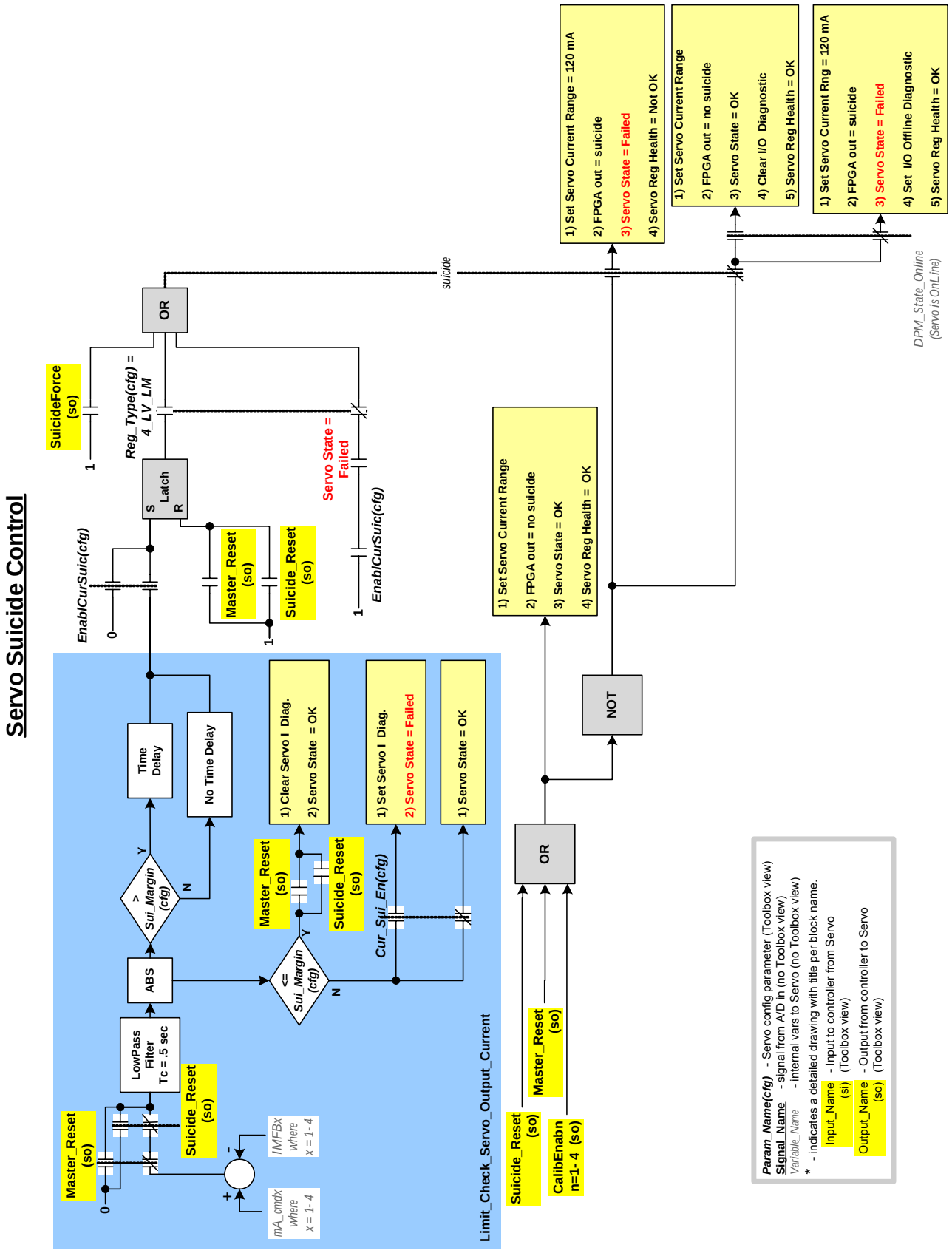
Digital Servo Regulators

The Digital Servo Regulators n = 1-4 in the following figure divides the servo regulators into the software and hardware portions of the control loop. The user can choose the LVDT and pulse rate inputs as the servo feedback. The LVDT input is a 3.2 kHz sinusoidal signal with a magnitude proportional to the position of the electro-mechanical valve that is controlled by the servo output. The pulse rate input is TTL-type signal or a periodic signal that triggers a comparator input. The comparator output transitions are counted by an FPGA on VSVO and converted to a flow rate. For LVDT feedbacks, LVDT1 – 12 are scaled and conditioned in the Position Feedback function of the Digital regulator and can also be independently conditioned by a separated Monitoring function. The asterisk after a block name indicates a more detailed drawing exists to better define the block function. All signal space I/O for the VSVO is identified as either *si* for system input (the controller reads the signal space variable from the servo) or *so* for system output (the controller writes the signal space variable to the servo card). Italic text is defined as a configuration parameter that can be changed in the toolbox to redefine the operation of the VSVO. Internal variables, for example *Variable_Name,* are not visible to the user through the toolbox.


Digital Servo Regulators n = 1 - 4
I/O Configuration
(VSVO Servo firmware)
(VSVO Hardware)
Execution Rate = 200 Hz
FPGA
Servo Current Regulator n
Digital Reg. (RegType)*
Servo Suicide Control*
Servo Open/Short Monitor*
K_comp function (I range)
Dither Control
50% Duty Cyl
Servo n D/A Controller
A/D Controller & Register Interface to PSVO Microprocessor
Pulse Rate Support
Pulse Rate Calc.
Monitor*
Position Fdbk Function
Calibration Function
Logic I/O
Servo1 Gain Reg
Programmable Gain
Op Amp
Diff Amp
BUF
D/A
A/D
MUX
A/D
volts / cnt
SystemLimits
RegNumber
RegType
MonitorType
PRType
PRScale
Dither_Freq
DitherAmpl
EnableCurSui
EnablFdbkSui
SUIMON
SUICDRVH
DACIREF +/- 4.0V FS
IMFBK +/- 2.0V @full scale
ACOM
SERVOxH
SERVOxL
P28
K1
10 ohm
SuicideForcen (so)
MasterReset (so)
SuicideReset (so)
CalibEnabn (so)
Regn_Ref (so)
Regn_Fdbk (si)
FlowRate1 (si)
FlowRate2 (si)
Regn_Error (si)
RegnSuicide (si)
Rn_SuicideNV (si)
L3DIAG_VSVO (si)
ServoOutnNV (si)
ServoOutputn (si)
ServoOutnNV (si)
ServoOutIn (si)
Monx (si) x=1- 12
LVDT1-12
PulsRate1H/L
PulsRate2H/L
AE1H/L
BE1H/L
AE2H/L
BE2H/L
LV1H/L
LV2H/L
LV3H/L
LV4H/L
LV5H/L
LV6H/L
LV7H/L
LV8H/L
LV9H/L
LV10H/L
LV11H/L
LV12H/L
from TSVO
to TSVO
Param_Name - Servo config parameter (Toolbox view)
Signal_Name - signal from A/D in (no Toolbox view)
Variable_Name - internal vars to Servo (no Toolbox view)
* - indicates a detailed drawing with title per block name.
Input_Name (si) - Input to controller from Servo (Toolbox view)
Output_Name (so) - Output from controller to Servo (Toolbox view)

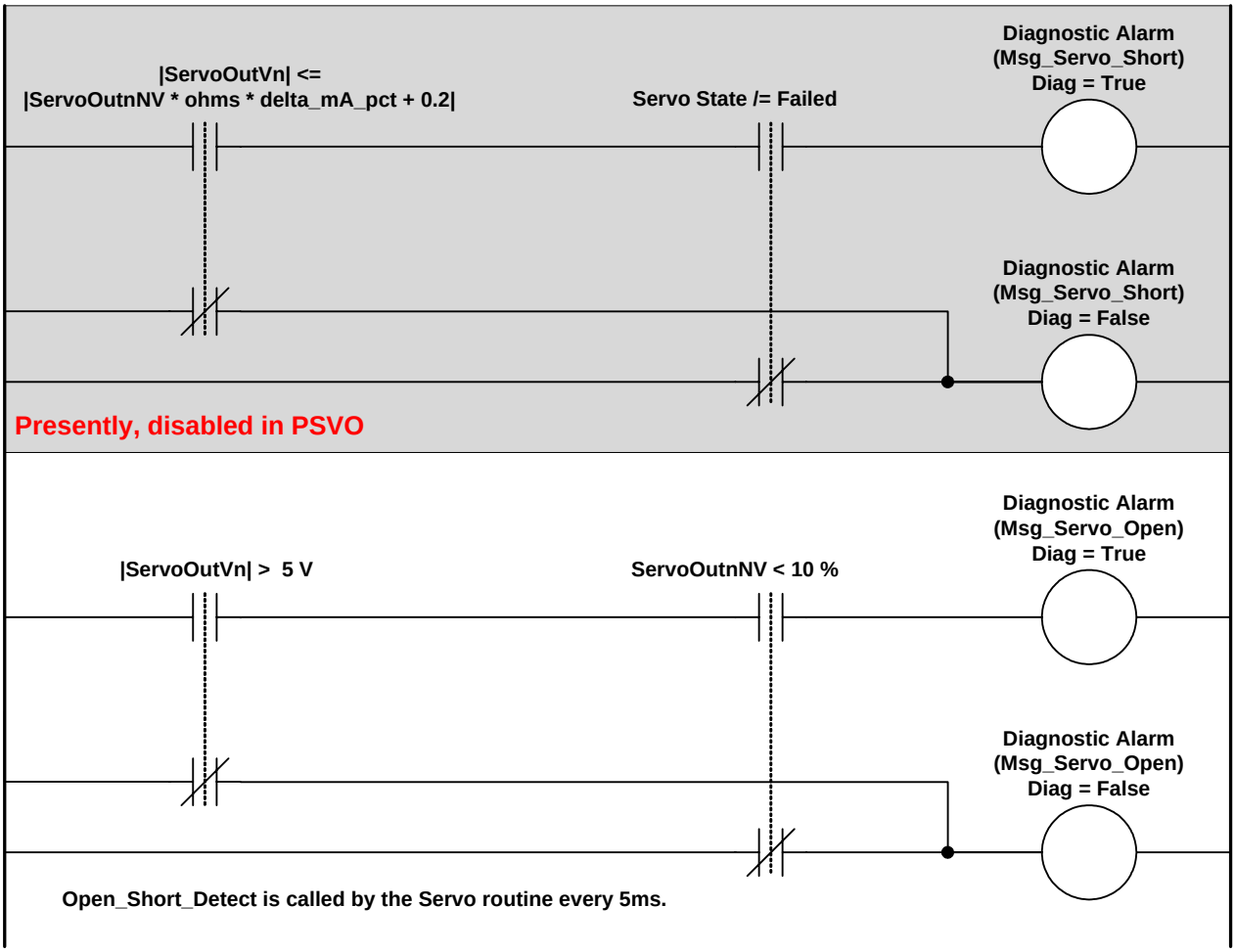
Servo Suicide Control

The Servo Suicide Control function compares the absolute value of the filtered servo current error against the configuration parameter value, *Sui_Margin*. This function determines if the hardware servo current regulator has lost control of the current. If the current feedback is not following the current command, a diagnostic is generated and the servo current output is suicided (disabled and put in a safe state).


Servo Suicide Control
SuicideForce (so)
Reg_Type(cfg) = 4_LV_LM
OR
suicide
S Latch R
Servo State = Failed
EnablCurSuic(cfg)
Master_Reset (so)
Suicide_Reset (so)
EnablCurSuic(cfg)
1) Set Servo Current Range = 120 mA
2) FPGA out = suicide
3) Servo State = Failed
4) Servo Reg Health = Not OK
1) Set Servo Current Range
2) FPGA out = no suicide
3) Servo State = OK
4) Clear I/O Diagnostic
5) Servo Reg Health = OK
1) Set Servo Current Rng = 120 mA
2) FPGA out = suicide
3) Servo State = Failed
4) Set I/O Offline Diagnostic
5) Servo Reg Health = OK
DPM_State_Online (Servo is OnLine)
1) Set Servo Current Range
2) FPGA out = no suicide
3) Servo State = OK
4) Servo Reg Health = OK
NOT
OR
Master_Reset (so)
Suicide_Reset (so)
CalibEnabn n=1- 4 (so)
Limit_Check_Servo_Output_Current
Master_Reset (so)
Suicide_Reset (so)
LowPass Filter Tc = .5 sec
ABS
> Sui_Margin (cfg)
Time Delay
No Time Delay
<= Sui_Margin (cfg)
Master_Reset (so)
Suicide_Reset (so)
1) Clear Servo I Diag.
2) Servo State = OK
Cur_Sui_En(cfg)
1) Set Servo I Diag.
2) Servo State = Failed
1) Servo State = OK
mA_cmdx where x = 1- 4
IMFBx where x = 1- 4
Param_Name(cfg) - Servo config parameter (Toolbox view)
Signal_Name - signal from A/D in (no Toolbox view)
Variable_Name - internal vars to Servo (no Toolbox view)
* - indicates a detailed drawing with title per block name.
Input_Name (si) - Input to controller from Servo (Toolbox view)
Output_Name (so) - Output from controller to Servo (Toolbox view)

Open/Short Detect Function

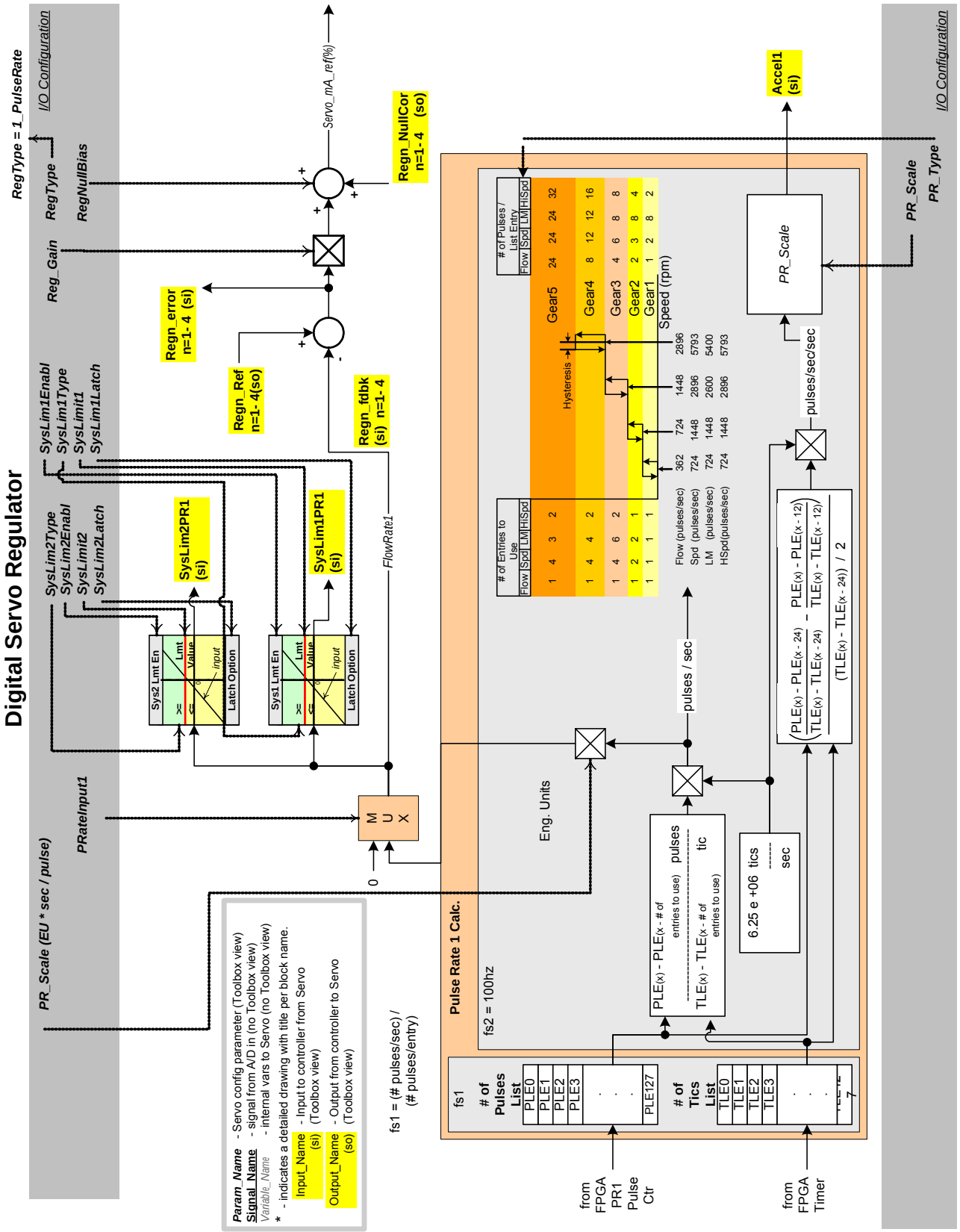
The servo output open circuit detection function checks for open or broken wires between the terminal screws of the terminal board and the servo coil. If the servo driver voltage is high and no current is flowing, the diagnostic alarm, *Msg_Servo_Open*, is issued.

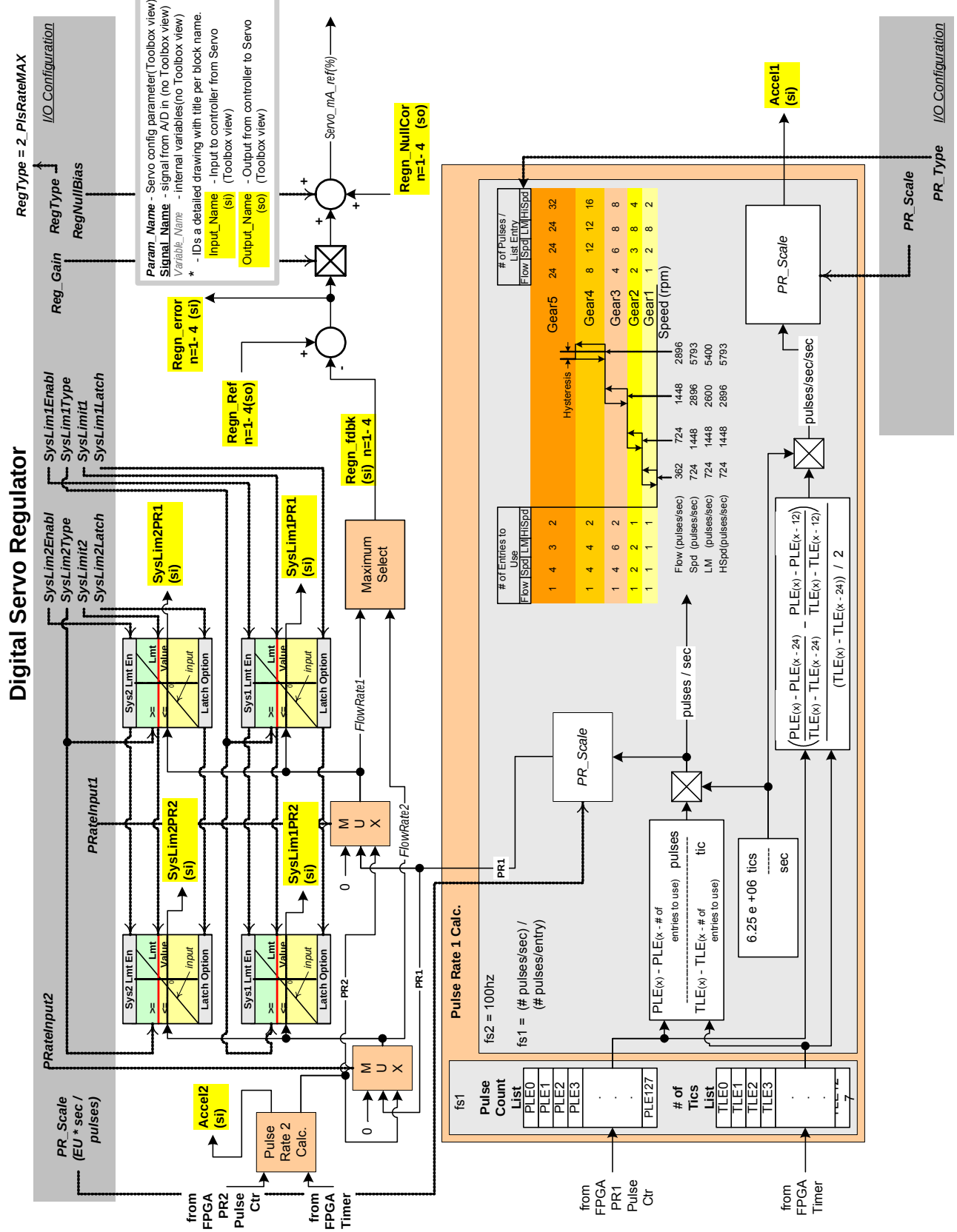


Open Short Detect Function

1 PulseRate /2 PulseRateMax

The Digital Servo Regulator is configured as a flow-rate regulator. A pulse signal with a frequency proportional to the flow-rate of the liquid fuel is the feedback for the *1 PulseRate* version of the flow-rate regulator. With the dual input, the larger pulse rate frequency is selected as the feedback for the flow rate regulator. System Limit functions monitor each pulse rate input and are enabled through the configuration parameter, *SysLimxEnabl.* It can latch the signal space limit flags *SysLimxPR1* and/or *SysLimxPR2*.


Digital Servo Regulator
RegType = 1_PulseRate
I/O Configuration
RegType
RegNullBias
Reg_Gain
Servo_mA_ref(%)
Regn_NullCor n=1- 4 (so)
Regn_error n=1- 4 (si)
Regn_Ref n=1- 4(so)
Regn_fdbk (si) n=1- 4
SysLim1Enabl
SysLim1Type
SysLimit1
SysLim1Latch
SysLim2Type
SysLim2Enabl
SysLimit2
SysLim2Latch
SysLim2PR1 (si)
SysLim1PR1 (si)
FlowRate1
PRateInput1
PR_Scale (EU * sec / pulse)
Sys2 Lmt En
Sys1 Lmt En
Lmt
Value
input
Latch Option
MUX
0
fs1 = (# pulses/sec) / (# pulses/entry)
Param_Name - Servo config parameter (Toolbox view)
Signal_Name - signal from A/D in (no Toolbox view)
Variable_Name - internal vars to Servo (no Toolbox view)
* - indicates a detailed drawing with title per block name.
Input_Name (si) - Input to controller from Servo (Toolbox view)
Output_Name (so) - Output from controller to Servo (Toolbox view)
Pulse Rate 1 Calc.
fs1
fs2 = 100hz
# of Pulses List
PLE0
PLE1
PLE2
PLE3
PLE127
# of Tics List
TLE0
TLE1
TLE2
TLE3
TLE7
Eng. Units
pulses / sec
PLE(x) - PLE(x - # of entries to use) pulses
TLE(x) - TLE(x - # of entries to use) tic
6.25 e +06 tics
sec
# of Entries to Use
Flow Spd LM HISpd
1 4 3 2
1 4 4 2
1 4 6 2
1 2 2 1
1 1 1 1
Gear5 24 24 24 32
Gear4 8 12 12 16
Gear3 4 6 8 8
Gear2 2 3 8 4
Gear1 1 2 8 2
# of Pulses / 1st Entry
Hysteresis
Speed (rpm)
Flow (pulses/sec) 362 724 1448 2896
Spd (pulses/sec) 724 1448 2896 5793
LM (pulses/sec) 724 1448 2600 5400
HSpd(pulses/sec) 724 1448 2896 5793
PR_Scale
pulses/sec/sec
Accel1 (si)
PR_Scale
PR_Type
I/O Configuration
from FPGA PR1 Pulse Ctr
from FPGA Timer


Digital Servo Regulator
RegType = 2_PlsRateMAX
I/O Configuration
RegType
RegNullBias
Reg_Gain
Param_Name - Servo config parameter(Toolbox view)
Signal_Name - signal from A/D in (no Toolbox view)
Variable_Name - internal variables(no Toolbox view)
* - IDs a detailed drawing with title per block name.
Input_Name (si) - Input to controller from Servo (Toolbox view)
Output_Name (so) - Output from controller to Servo (Toolbox view)
Servo_mA_ref(%)
Regn_NullCor n=1- 4 (so)
Regn_error n=1- 4 (si)
Regn_Ref n=1- 4(so)
Regn_fdbk (si) n=1- 4
SysLim1Enabl
SysLim1Type
SysLim1
SysLim1Latch
SysLim2Enabl
SysLim2Type
SysLim2
SysLim2Latch
PRateInput1
PRateInput2
PR_Scale (EU * sec / pulses)
SysLim2PR1 (si)
SysLim2PR2 (si)
SysLim1PR1 (si)
SysLim1PR2 (si)
Sys2 Lmt En
Sys1 Lmt En
Lmt
Value
input
Latch Option
Maximum Select
FlowRate1
FlowRate2
MUX
PR1
PR2
Accel2 (si)
Pulse Rate 2 Calc.
from FPGA PR2 Pulse Ctr
from FPGA Timer
Pulse Rate 1 Calc.
fs1
fs2 = 100hz
fs1 = (# pulses/sec) / (# pulses/entry)
Pulse Count List
PLE0
PLE1
PLE2
PLE3
PLE127
# of Tics List
TLE0
TLE1
TLE2
TLE3
PR_Scale
pulses / sec
PLE(x) - PLE(x - 24) / TLE(x) - TLE(x - 24) pulses / tic
PLE(x) - PLE(x - # of entries to use)
TLE(x) - TLE(x - # of entries to use)
6.25 e +06 tics / sec
(PLE(x) - PLE(x - 24) / TLE(x) - TLE(x - 24)) - (PLE(x) - PLE(x - 12) / TLE(x) - TLE(x - 12)) / (TLE(x) - TLE(x - 24)) / 2
pulses/sec/sec
Accel1 (si)
# of Entries to Use
Flow Spd LM HSpd
# of Pulses / List Entry
Flow Spd LM HSpd
Gear5
Gear4
Gear3
Gear2
Gear1
Hysteresis
Speed (rpm)
Flow (pulses/sec) 362 724 1448 2896
Spd (pulses/sec) 724 1448 2896 5793
LM (pulses/sec) 724 1448 2600 5400
HSpd(pulses/sec) 724 1448 2896 5793
PR_Type
PR_Scale
I/O Configuration

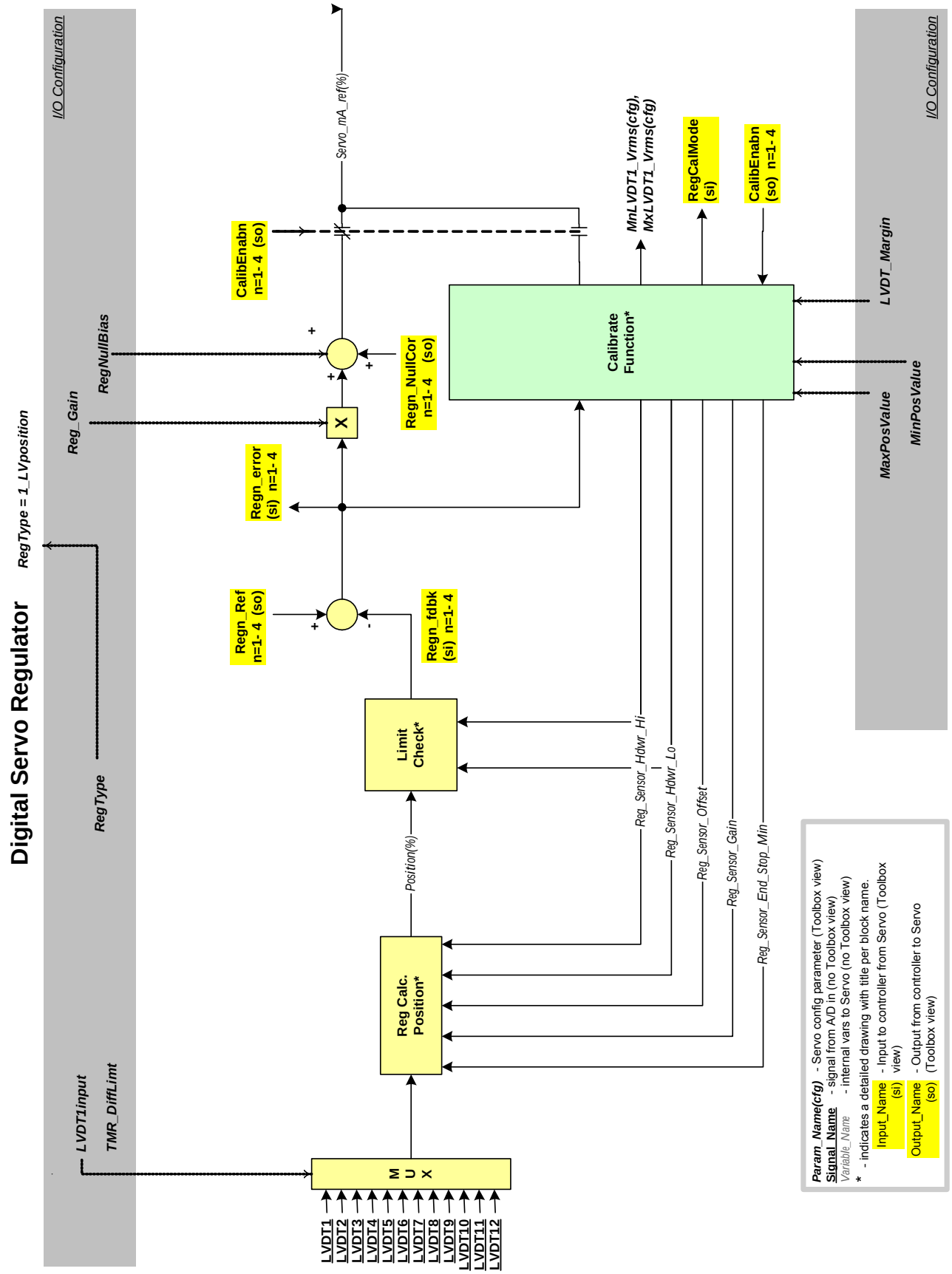
1 LVposition, 2 LVposMIN, 2LVposMAX, 3LVposMID

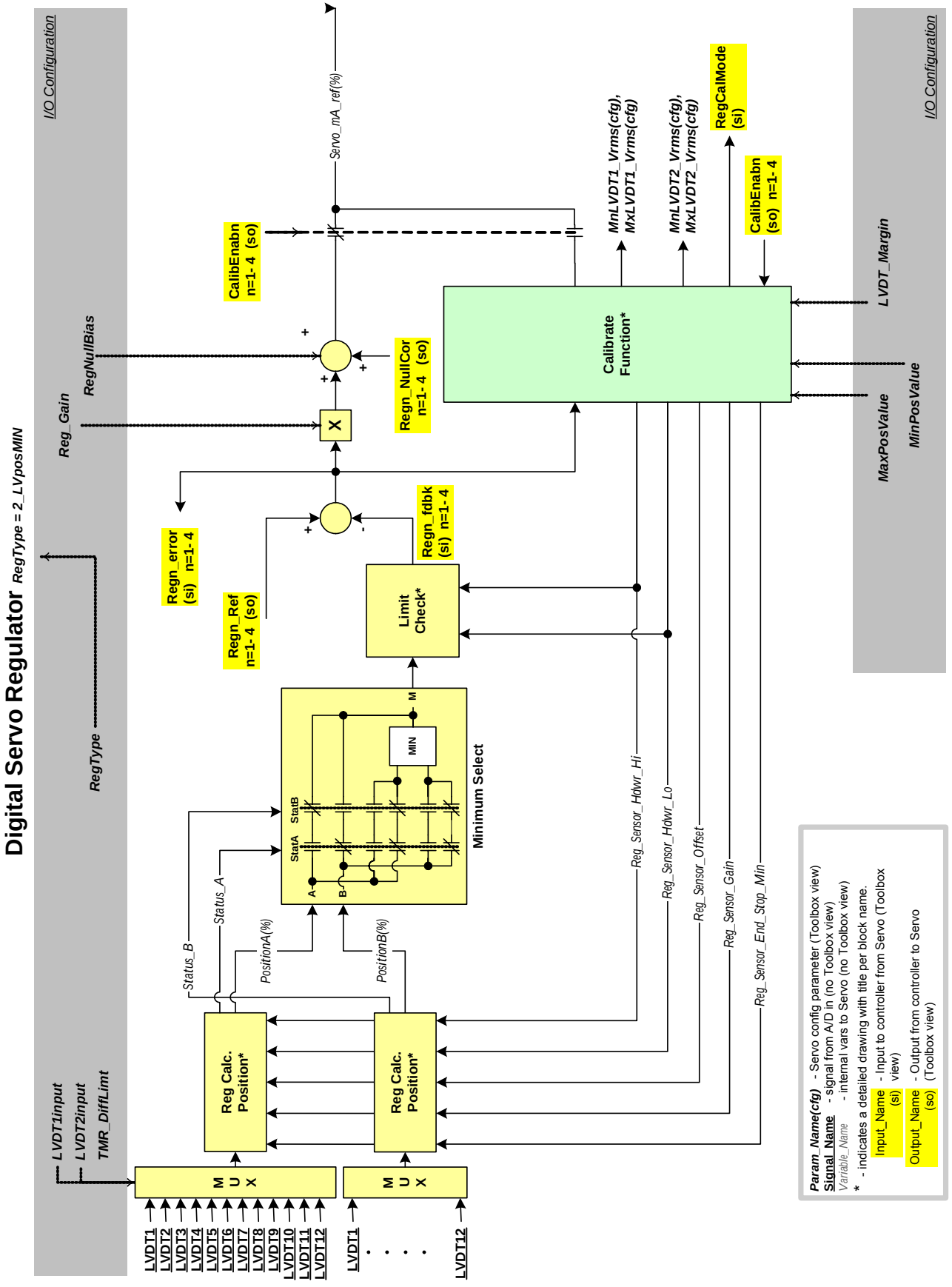
The following LVDT feedback configurations are provided for the servo value position loop:

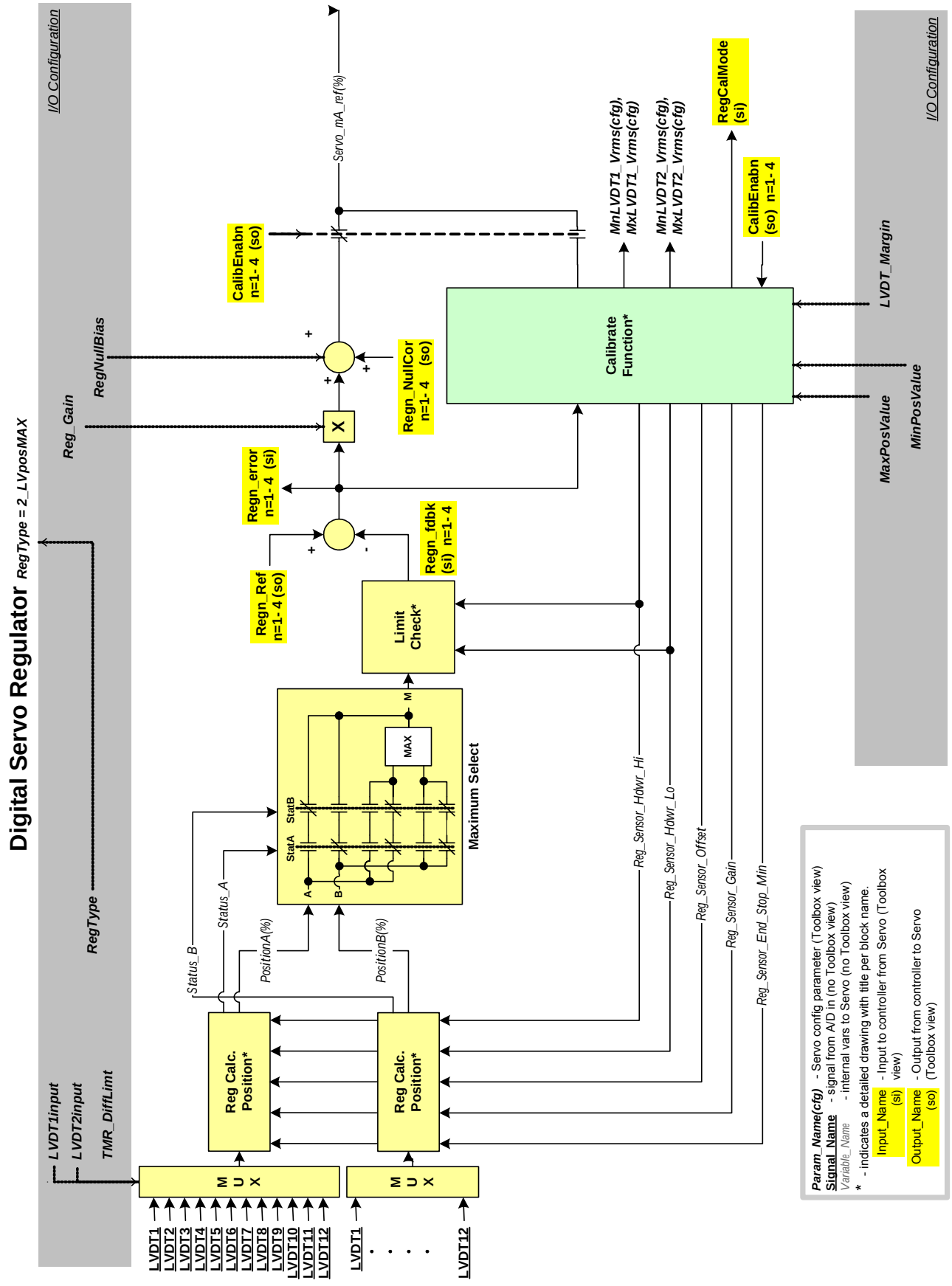
- 1_LVposition – one LVDT signal is used as the position feedback.
- 2_LVposMIN – the minimum of two LVDT signals is selected as the position feedback.
- 2_LVposMAX – the maximum of two LVDT signals is selected as the position feedback.
- 3_LVposMID – the median of three LVDT signals is selected as position feedback.

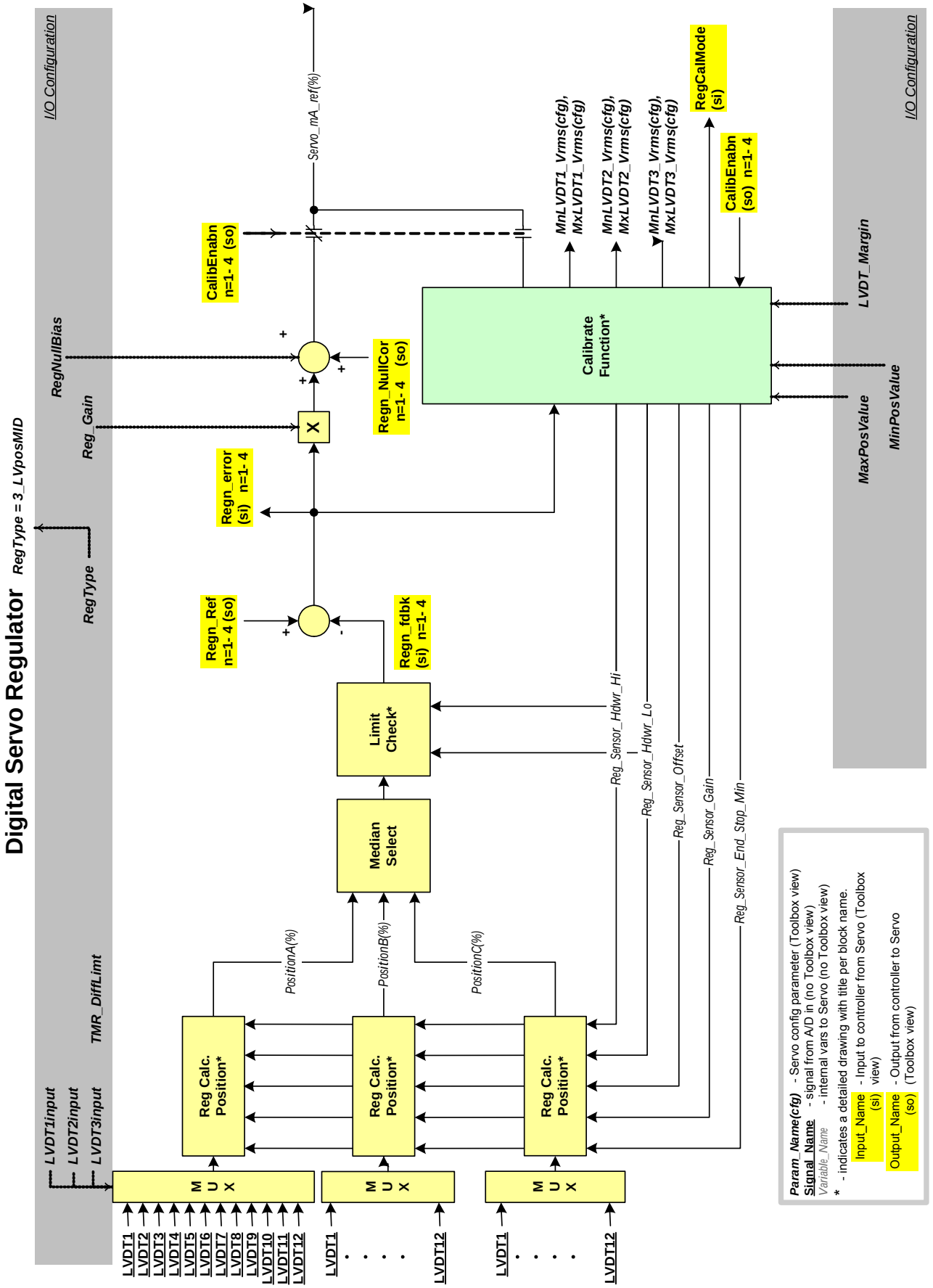
The LVDT feedback signals are bounded and scaled using the Calibration function. The Calibration function uses the following configuration parameters: position at the minimum end stop in engineering units (EU), *MinPOSvalue,* and the position at the maximum end stop in EU, *MaxPOSvalue*. In the calibration mode the LVDT sensors are forced into the minimum and maximum positions. The feedback voltages, *MnLVDTx_Vrms* and *MxLVDTx_Vrm,s* are recorded for each of the LVDT feedbacks used. From these values, the internal constants *Reg_Sensor_Hdwr_Hi*, *Reg_Sensor_Hdwr_Lo, Reg_Sensor_Offset, Reg_Sensor_Gain,* and *Reg_Sensor_End_Stop_Min* are calculated. These internal constants are used by the Regulator Calculation Position function.

The Regulator Calculation Position function performs an input boundary check that makes sure the input signal is between the values, *Reg_Sensor_Hdwr_Hi* and *Reg_Sensor_Hdwr_Lo*. If the feedback input is out of range a diagnostic alarm is generated. The scaling from volts_rms to position feedback in EU is calculated next. A limit check is then performed on the selected feedback.

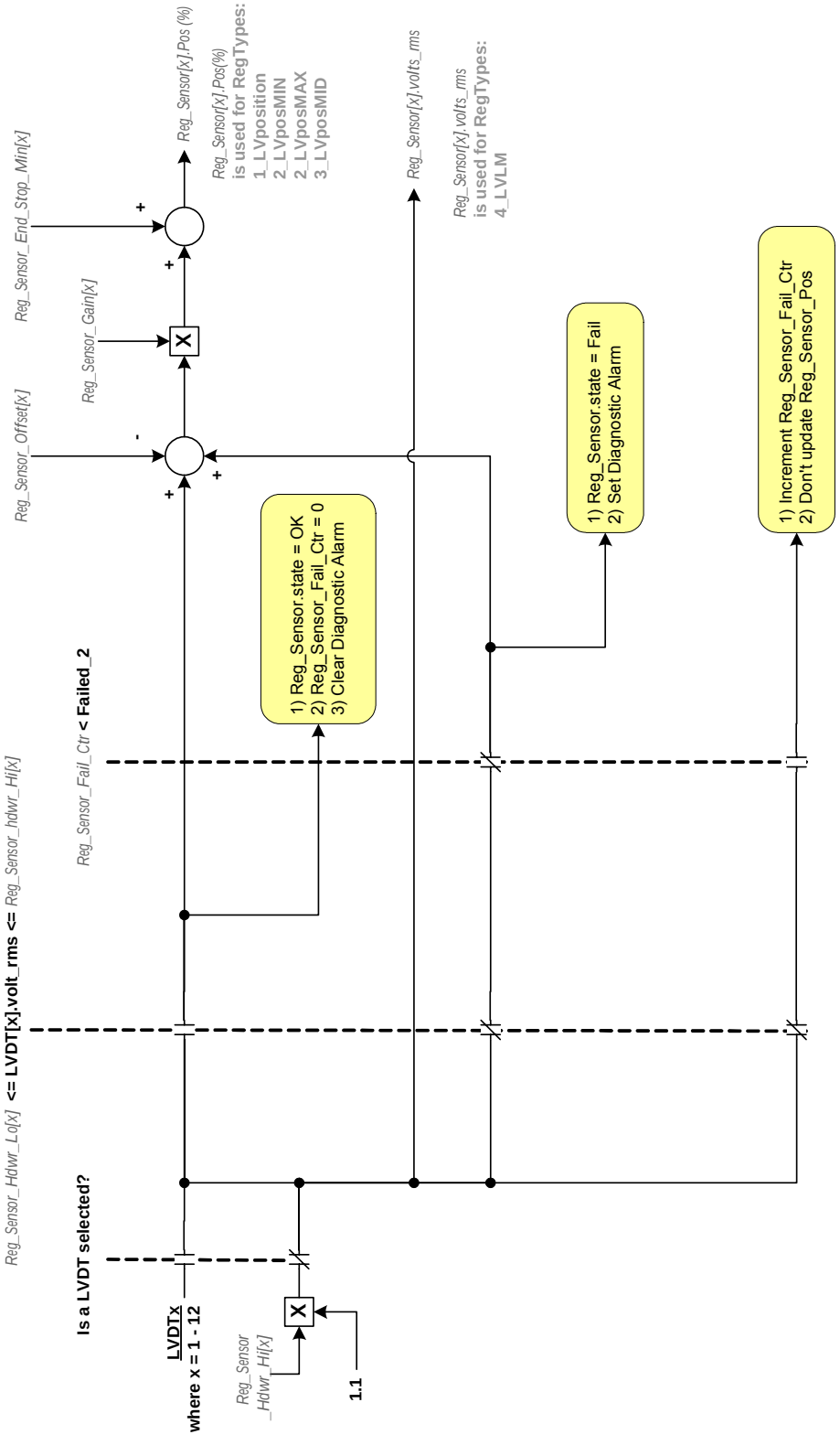

Digital Servo Regulator
RegType = 1_LVposition
I/O Configuration
LVDT1input
TMR_DiffLimt
RegType
Reg_Gain
RegNullBias
LVDT1
LVDT2
LVDT3
LVDT4
LVDT5
LVDT6
LVDT7
LVDT8
LVDT9
LVDT10
LVDT11
LVDT12
MUX
Reg Calc. Position*
Position(%)
Limit Check*
Regn_Ref n=1- 4 (so)
Regn_fdbk (si) n=1- 4
Regn_error (si) n=1- 4
X
Regn_NullCor n=1- 4 (so)
CalibEnabn n=1- 4 (so)
Servo_mA_ref(%)
Calibrate Function*
MnLVDT1_Vrms(cfg),
MxLVDT1_Vrms(cfg)
RegCalMode (si)
CalibEnabn (so) n=1- 4
LVDT_Margin
MaxPosValue
MinPosValue
I/O Configuration
Reg_Sensor_Hdwr_Hi
Reg_Sensor_Hdwr_Lo
Reg_Sensor_Offset
Reg_Sensor_Gain
Reg_Sensor_End_Stop_Min
Param_Name(cfg) - Servo config parameter (Toolbox view)
Signal_Name - signal from A/D in (no Toolbox view)
Variable_Name - internal vars to Servo (no Toolbox view)
* - indicates a detailed drawing with title per block name.
Input_Name (si) - Input to controller from Servo (Toolbox view)
Output_Name (so) - Output from controller to Servo (Toolbox view)


Digital Servo Regulator RegType = 2_LVposMIN
I/O Configuration
LVDT1input
LVDT2input
TMR_DiffLimt
RegType
Reg_Gain
RegNullBias
LVDT1
LVDT2
LVDT3
LVDT4
LVDT5
LVDT6
LVDT7
LVDT8
LVDT9
LVDT10
LVDT11
LVDT12
MUX
MUX
Reg Calc. Position*
Reg Calc. Position*
Status_B
Status_A
PositionA(%)
PositionB(%)
StatA
StatB
A
B
M
MIN
Minimum Select
Limit Check*
Regn_Ref n=1- 4 (so)
Regn_error (si) n=1- 4
Regn_fdbk (si) n=1- 4
Regn_NullCor n=1- 4 (so)
CalibEnabn n=1- 4 (so)
Servo_mA_ref(%)
Calibrate Function*
MnLVDT1_Vrms(cfg), MxLVDT1_Vrms(cfg)
MnLVDT2_Vrms(cfg), MxLVDT2_Vrms(cfg)
RegCalMode (si)
CalibEnabn (so) n=1- 4
LVDT_Margin
MaxPosValue
MinPosValue
I/O Configuration
Reg_Sensor_Hdwr_Hi
Reg_Sensor_Hdwr_Lo
Reg_Sensor_Offset
Reg_Sensor_Gain
Reg_Sensor_End_Stop_Min
Param_Name(cfg) - Servo config parameter (Toolbox view)
Signal_Name - signal from A/D in (no Toolbox view)
Variable_Name - internal vars to Servo (no Toolbox view)
* - indicates a detailed drawing with title per block name.
Input_Name (si) - Input to controller from Servo (Toolbox view)
Output_Name (so) - Output from controller to Servo (Toolbox view)


Digital Servo Regulator RegType = 2_LVposMAX
I/O Configuration
LVDT1input
LVDT2input
TMR_DiffLimit
RegType
Reg_Gain
RegNullBias
Servo_mA_ref(%)
CalibEnabn n=1- 4 (so)
Regn_NullCor n=1- 4 (so)
Regn_error n=1- 4 (si)
Regn_Ref n=1- 4 (so)
Regn_fdbk (si) n=1- 4
Limit Check*
Calibrate Function*
MnLVDT1_Vrms(cfg), MxLVDT1_Vrms(cfg)
MnLVDT2_Vrms(cfg), MxLVDT2_Vrms(cfg)
RegCalMode (si)
CalibEnabn (so) n=1- 4
LVDT_Margin
MaxPosValue
MinPosValue
I/O Configuration
Maximum Select
StatA
StatB
MAX
Status_B
Status_A
PositionA(%)
PositionB(%)
Reg Calc. Position*
Reg Calc. Position*
MUX
MUX
LVDT1
LVDT2
LVDT3
LVDT4
LVDT5
LVDT6
LVDT7
LVDT8
LVDT9
LVDT10
LVDT11
LVDT12
LVDT1
LVDT12
Reg_Sensor_Hdwr_Hi
Reg_Sensor_Hdwr_Lo
Reg_Sensor_Offset
Reg_Sensor_Gain
Reg_Sensor_End_Stop_Min
Param_Name(cfg) - Servo config parameter (Toolbox view)
Signal_Name - signal from A/D in (no Toolbox view)
Variable_Name - internal vars to Servo (no Toolbox view)
* - indicates a detailed drawing with title per block name.
Input_Name (si) - Input to controller from Servo (Toolbox view)
Output_Name (so) - Output from controller to Servo (Toolbox view)


Digital Servo Regulator
RegType = 3_LVposMID
I/O Configuration
RegNullBias
Reg_Gain
RegType
TMR_DiffLimt
LVDT1input
LVDT2input
LVDT3input
LVDT1
LVDT2
LVDT3
LVDT4
LVDT5
LVDT6
LVDT7
LVDT8
LVDT9
LVDT10
LVDT11
LVDT12
MUX
Reg Calc. Position*
PositionA(%)
PositionB(%)
PositionC(%)
Median Select
Limit Check*
Regn_Ref n=1- 4 (so)
Regn_fdbk (si) n=1- 4
Regn_error (si) n=1- 4
X
Regn_NullCor n=1- 4 (so)
CalibEnabn n=1- 4 (so)
Servo_mA_ref(%)
Calibrate Function*
MnLVDT1_Vrms(cfg), MxLVDT1_Vrms(cfg)
MnLVDT2_Vrms(cfg), MxLVDT2_Vrms(cfg)
MnLVDT3_Vrms(cfg), MxLVDT3_Vrms(cfg)
RegCalMode (si)
CalibEnabn (so) n=1- 4
LVDT_Margin
MaxPosValue
MinPosValue
Reg_Sensor_Hdwr_Hi
Reg_Sensor_Hdwr_Lo
Reg_Sensor_Offset
Reg_Sensor_Gain
Reg_Sensor_End_Stop_Min
Param_Name(cfg) - Servo config parameter (Toolbox view)
Signal_Name - signal from A/D in (no Toolbox view)
Variable_Name - internal vars to Servo (no Toolbox view)
* - indicates a detailed drawing with title per block name.
Input_Name (si) - Input to controller from Servo (Toolbox view)
Output_Name (so) - Output from controller to Servo (Toolbox view)

Reg_Calc_Position

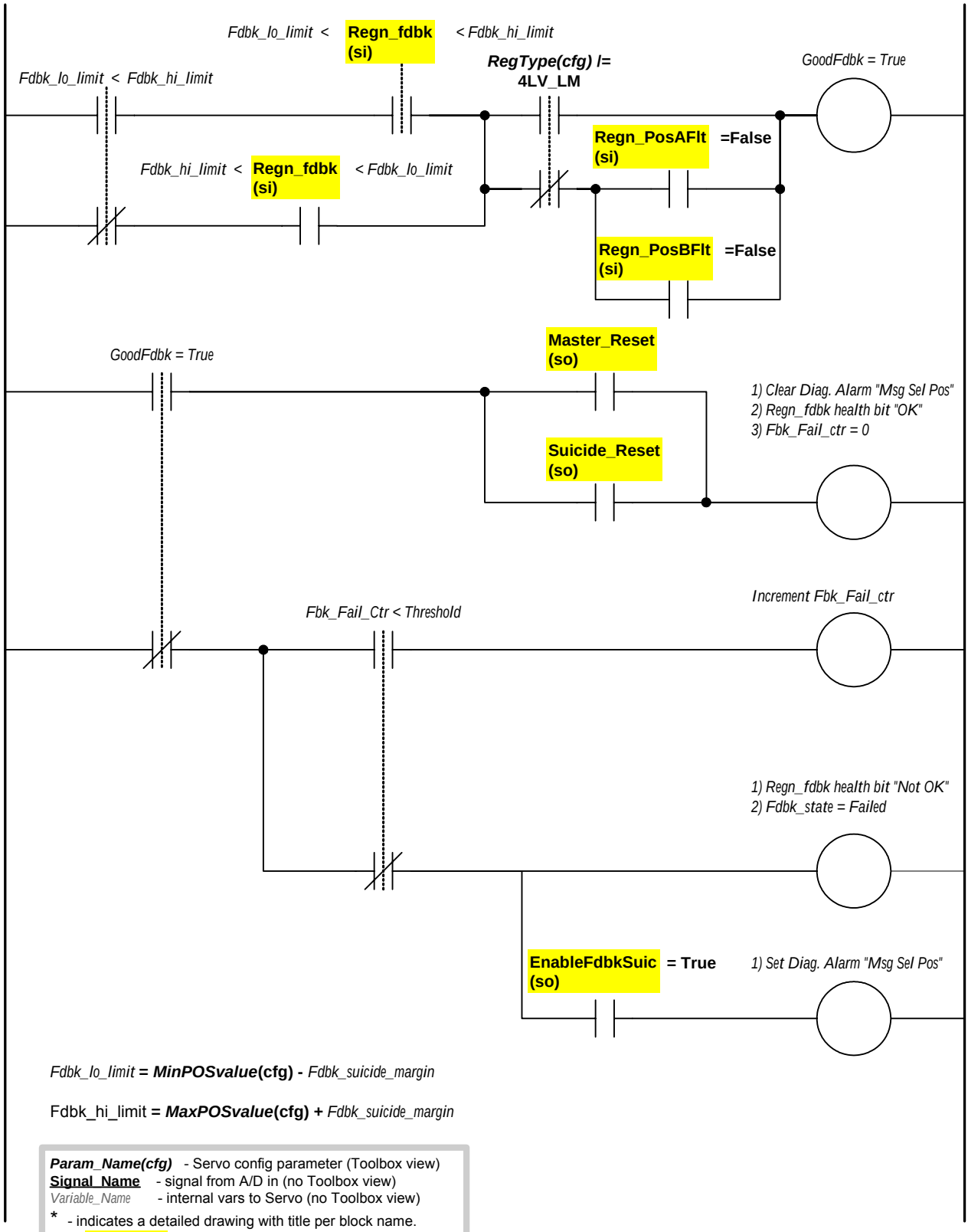


Reg_Sensor_Hdwr_Lo[x] **= *MnLVDT_Vrms(cfg) - (MxLVDT_Vrms(cfg) - MnLVDT_Vrms(cfg)) * LVDT_Margin(cfg) / 100*** **before calibration.**

Reg_Sensor_Hdwr_Hi[x] **= *MxLVDT_Vrms(cfg) + (MxLVDT_Vrms(cfg) - MnLVDT_Vrms(cfg)) * LVDT_Margin(cfg) / 100*** **before calibration.**

Param_Name(cfg) - Servo config parameter (Toolbox view)
Signal_Name - signal from A/D in (no Toolbox view)
Variable_Name - internal vars to Servo (no Toolbox view)

Limit Check Function



Fdbk_lo_limit **= *MinPOSvalue*(cfg) -** *Fdbk_suicide_margin*

Fdbk_hi_limit **= *MaxPOSvalue*(cfg) +** *Fdbk_suicide_margin*

Param_Name(cfg) - Servo config parameter (Toolbox view)
Signal_Name - signal from A/D in (no Toolbox view)
Variable_Name - internal vars to Servo (no Toolbox view)
* - indicates a detailed drawing with title per block name.
Input_Name (si) - Input to controller from Servo (Toolbox view)
Output_Name (so) - Output from controller to Servo (Toolbox view)

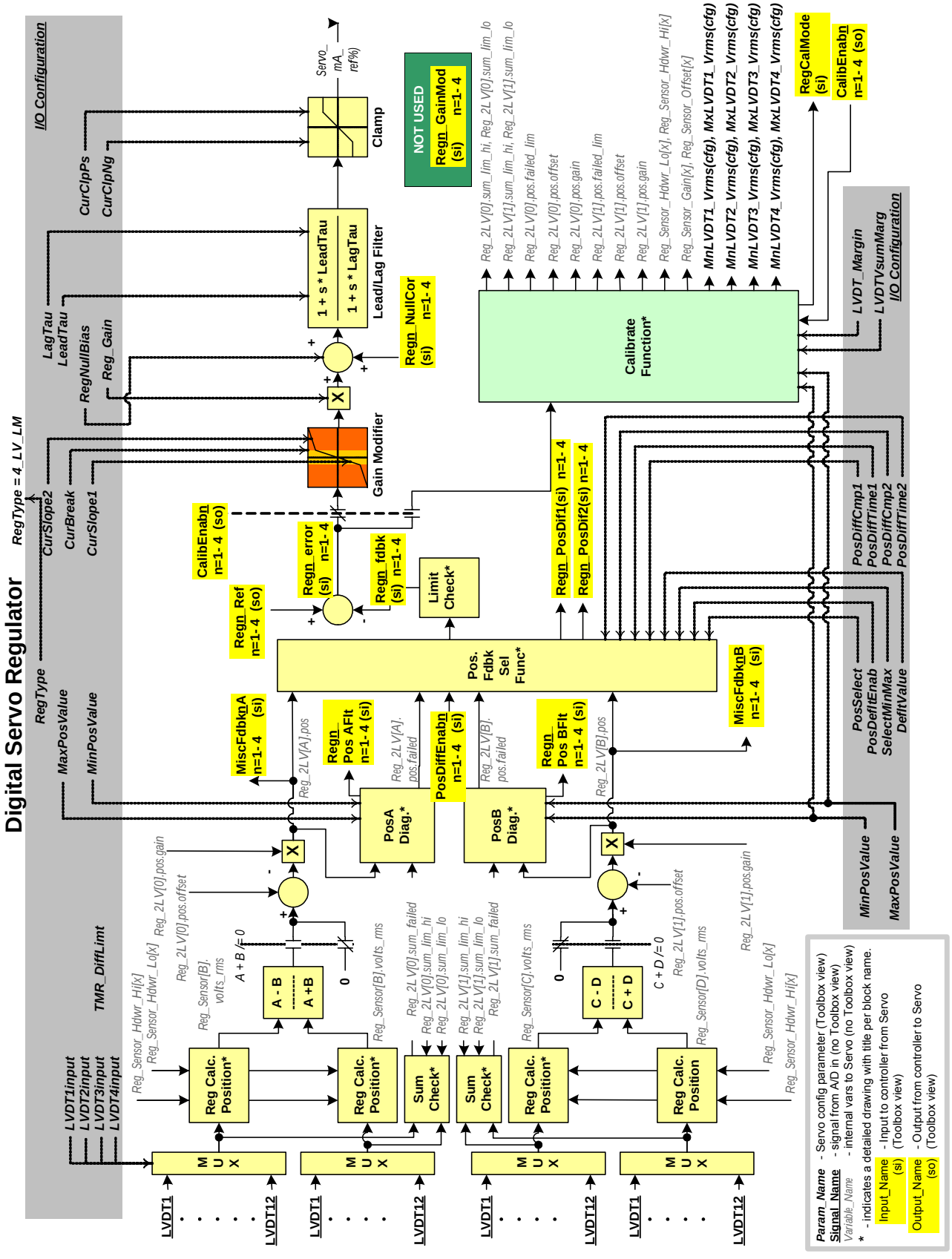
4 LV_LM

The 4_LV_LM Digital Servo regulator uses four LVDT inputs to calculate the single position feedback required for the servo position loop. The Regulator Calculation Position performs the boundary check for the LVDT input signals. The scaling from volts_rms to position in EU is not calculated, but the volts_rms value for each of the LVDT feedbacks is calculated. The ratio of (A – B) / (A + B) is performed on the LVDT input pairs and scaling is calculated using the input from the Calibration function.

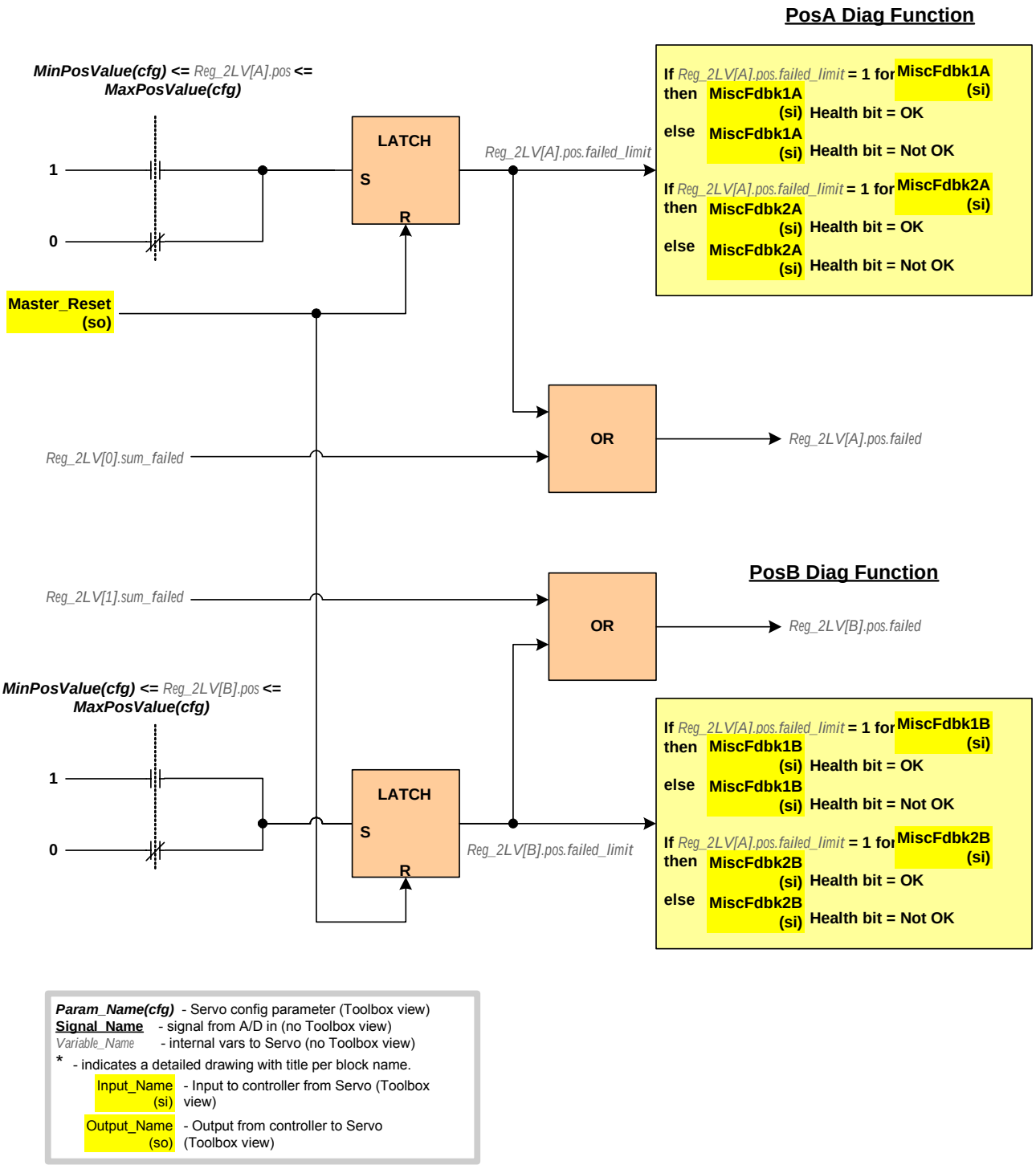
The internal variables, Reg_2LV[A].pos, *PosA* and Reg_2LV[B].pos, *PosB* are checked against the configuration parameter limits, MinPOSvalue and MaxPOSvalue in the Position A & B Diagnostic function. Results from PosA, PosB, and the diagnostic Booleans feed the Position Feedback Selection function. Refer to the *Position Feedback Selection* block diagram to understand the details of the function.

Other differences in the LM servo regulator are the following:

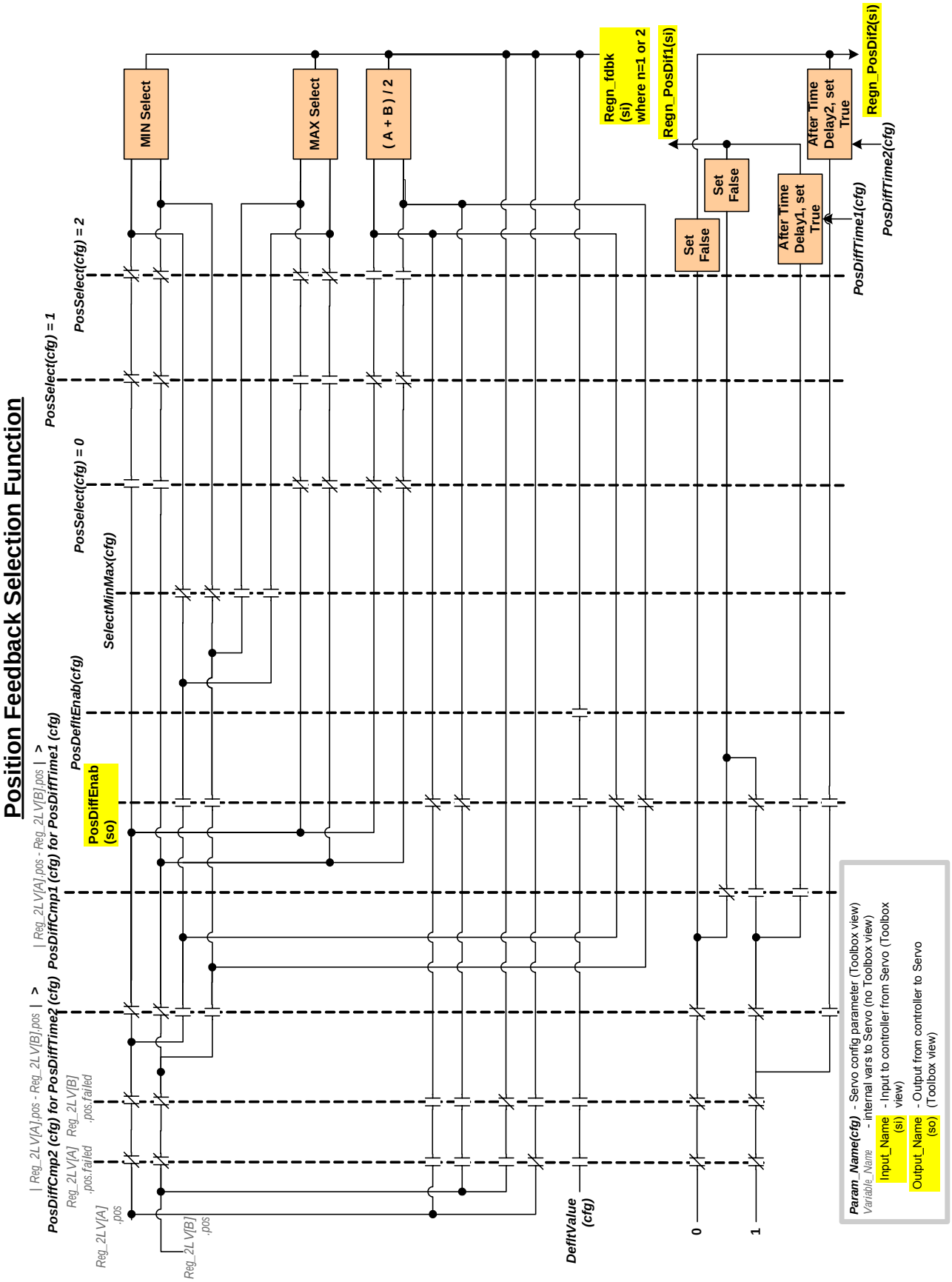
- Gain Modifier function
- Lead/Lag filter on the position error
- Configurable servo position error output clamp


Digital Servo Regulator
RegType = 4_LV_LM
I/O Configuration
RegType
MaxPosValue
MinPosValue
TMR_DiffLimt
CurSlope2
CurBreak
CurSlope1
LagTau
LeadTau
RegNullBias
Reg_Gain
CurClpPs
CurClpNg
LVDT1input
LVDT2input
LVDT3input
LVDT4input
Servo_ mA_ ref%)
Clamp
NOT USED
Regn_GainMod (si) n=1- 4
1 + s * LeadTau
1 + s * LagTau
Lead/Lag Filter
Regn_NullCor (si) n=1- 4
Gain Modifier
CalibEnabn n=1- 4 (so)
Regn_error (si) n=1- 4
Regn_fdbk (si) n=1- 4
Limit Check*
Regn_Ref n=1- 4 (so)
Pos. Fdbk Sel Func*
Calibrate Function*
Reg_2LV[0].sum_lim_hi, Reg_2LV[0].sum_lim_lo
Reg_2LV[1].sum_lim_hi, Reg_2LV[1].sum_lim_lo
Reg_2LV[0].pos.failed_lim
Reg_2LV[0].pos.offset
Reg_2LV[0].pos.gain
Reg_2LV[1].pos.failed_lim
Reg_2LV[1].pos.offset
Reg_2LV[1].pos.gain
Reg_Sensor_Hdwr_Lo[x], Reg_Sensor_Hdwr_Hi[x]
Reg_Sensor_Gain[x], Reg_Sensor_Offset[x]
MnLVDT1_Vrms(cfg), MxLVDT1_Vrms(cfg)
MnLVDT2_Vrms(cfg), MxLVDT2_Vrms(cfg)
MnLVDT3_Vrms(cfg), MxLVDT3_Vrms(cfg)
MnLVDT4_Vrms(cfg), MxLVDT4_Vrms(cfg)
RegCalMode (si)
CalibEnabn n=1- 4 (so)
LVDT_Margin
LVDTVsumMarg
I/O Configuration
Regn_PosDif1(si) n=1- 4
Regn_PosDif2(si) n=1- 4
MiscFdbknA n=1- 4 (si)
Regn_Pos AFlt n=1- 4 (si)
PosDiffEnabn n=1- 4 (si)
Regn_Pos BFlt n=1- 4 (si)
MiscFdbknB n=1- 4 (si)
PosA Diag.*
PosB Diag.*
Reg_2LV[A].pos
Reg_2LV[A].pos.failed
Reg_2LV[B].pos.failed
Reg_2LV[B].pos
PosDiffCmp1
PosDiffTime1
PosDiffCmp2
PosDiffTime2
PosSelect
PosDeftEnab
SelectMinMax
DeftValue
MinPosValue
MaxPosValue
LVDT1
LVDT12
MUX
Reg Calc. Position*
Reg Calc. Position
Sum Check*
Reg_Sensor_Hdwr_Hi[x]
Reg_Sensor_Hdwr_Lo[x]
Reg_Sensor[B].volts_rms
Reg_Sensor[C].volts_rms
Reg_Sensor[D].volts_rms
Reg_2LV[0].pos.gain
Reg_2LV[0].pos.offset
Reg_2LV[1].pos.gain
A + B /= 0
C + D /= 0
A - B / A + B
C - D / C + D
Reg_2LV[0].sum_failed
Reg_2LV[0].sum_lim_hi
Reg_2LV[0].sum_lim_lo
Reg_2LV[1].sum_lim_hi
Reg_2LV[1].sum_lim_lo
Reg_2LV[1].sum_failed
Param_Name - Servo config parameter (Toolbox view)
Signal_Name - signal from A/D in (no Toolbox view)
Variable_Name - internal vars to Servo (no Toolbox view)
* - indicates a detailed drawing with title per block name.
Input_Name (si) - Input to controller from Servo (Toolbox view)
Output_Name (so) - Output from controller to Servo (Toolbox view)

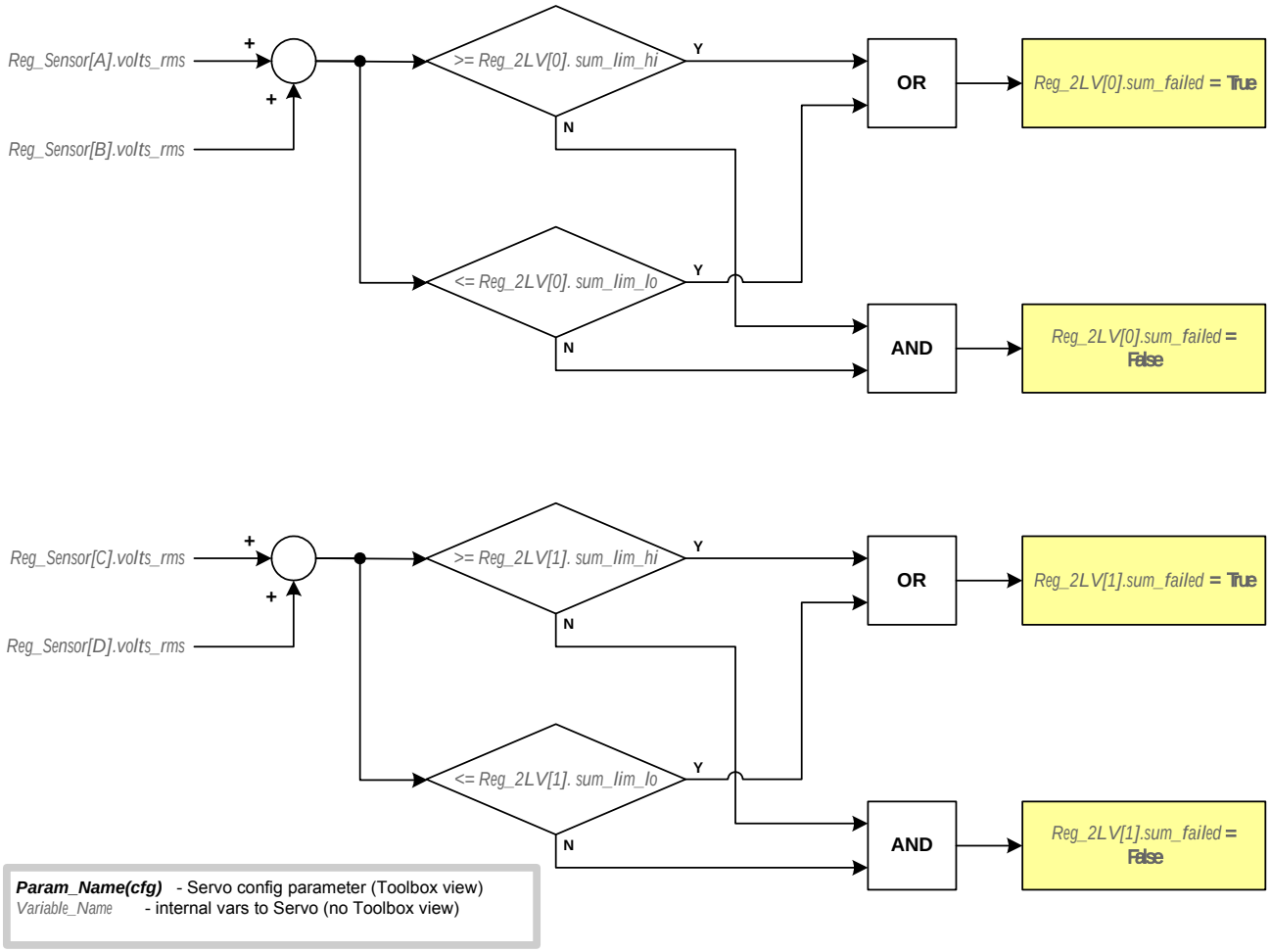
Position A & B Diagnostic Function



Param_Name(cfg) - Servo config parameter (Toolbox view)
Signal_Name - signal from A/D in (no Toolbox view)
Variable_Name - internal vars to Servo (no Toolbox view)
* - indicates a detailed drawing with title per block name.
Input_Name (si) - Input to controller from Servo (Toolbox view)
Output_Name (so) - Output from controller to Servo (Toolbox view)


Position Feedback Selection Function
PosSelect(cfg) = 1
PosSelect(cfg) = 2
PosSelect(cfg) = 0
SelectMinMax(cfg)
PosDeftEnab(cfg)
PosDiffCmp1 (cfg) for PosDiffTime1 (cfg)
PosDiffCmp2 (cfg) for PosDiffTime2 (cfg)
| Reg_2LV[A].pos - Reg_2LV[B].pos | >
| Reg_2LV[A].pos - Reg_2LV[B].pos | >
PosDiffEnab (so)
MIN Select
MAX Select
(A + B) / 2
Regn_fdbk (si) where n=1 or 2
Regn_PosDif1(si)
Regn_PosDif2(si)
Set False
Set False
After Time Delay1, set True
After Time Delay2, set True
PosDiffTime1(cfg)
PosDiffTime2(cfg)
Reg_2LV[A].pos
Reg_2LV[A].pos.failed
Reg_2LV[B].pos
Reg_2LV[B].pos.failed
DeftValue (cfg)
0
1
Param_Name(cfg) - Servo config parameter (Toolbox view)
Variable_Name - internal vars to Servo (no Toolbox view)
Input_Name (si) - Input to controller from Servo (Toolbox view)
Output_Name (so) - Output from controller to Servo (Toolbox view)

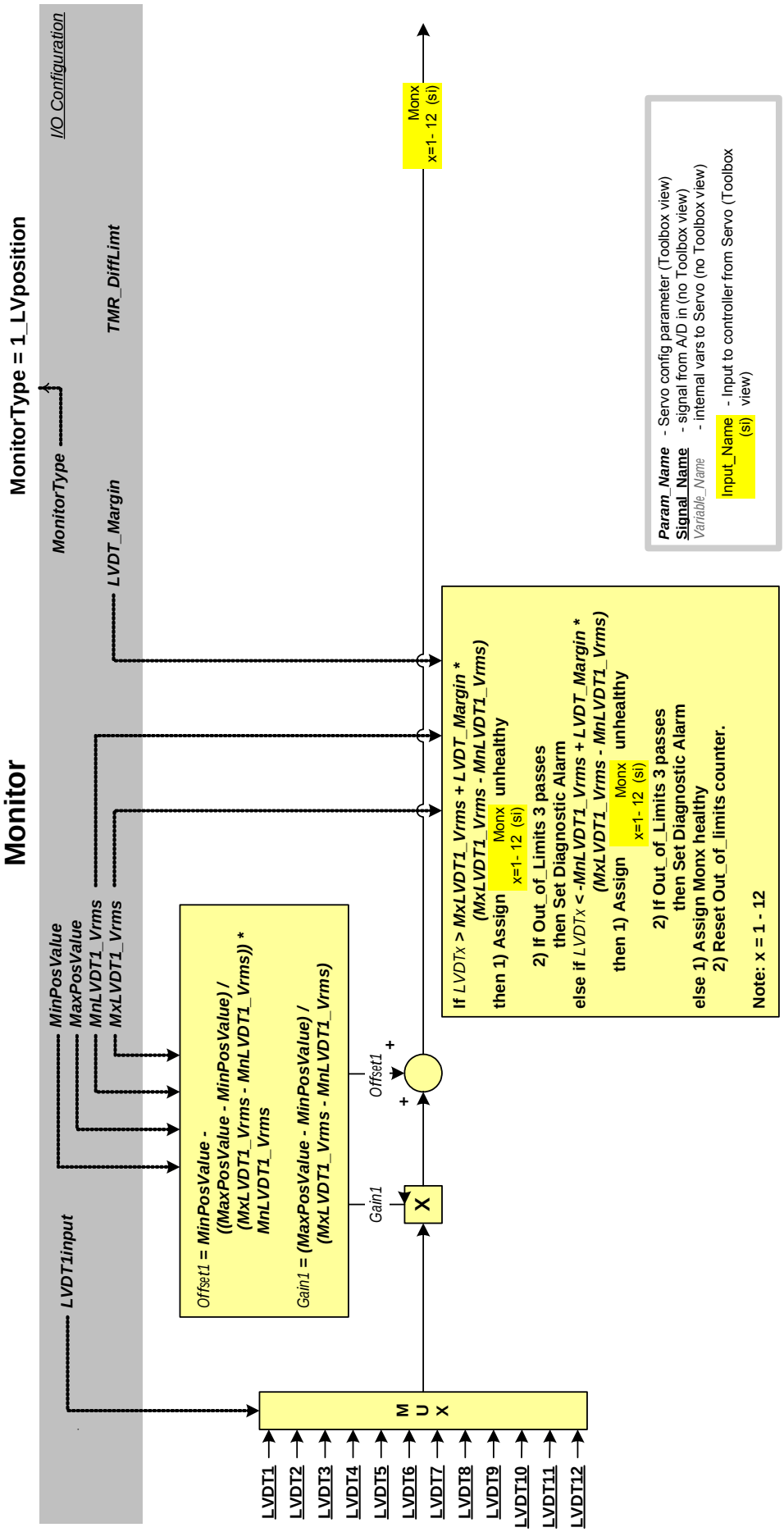
Sum Check Calc

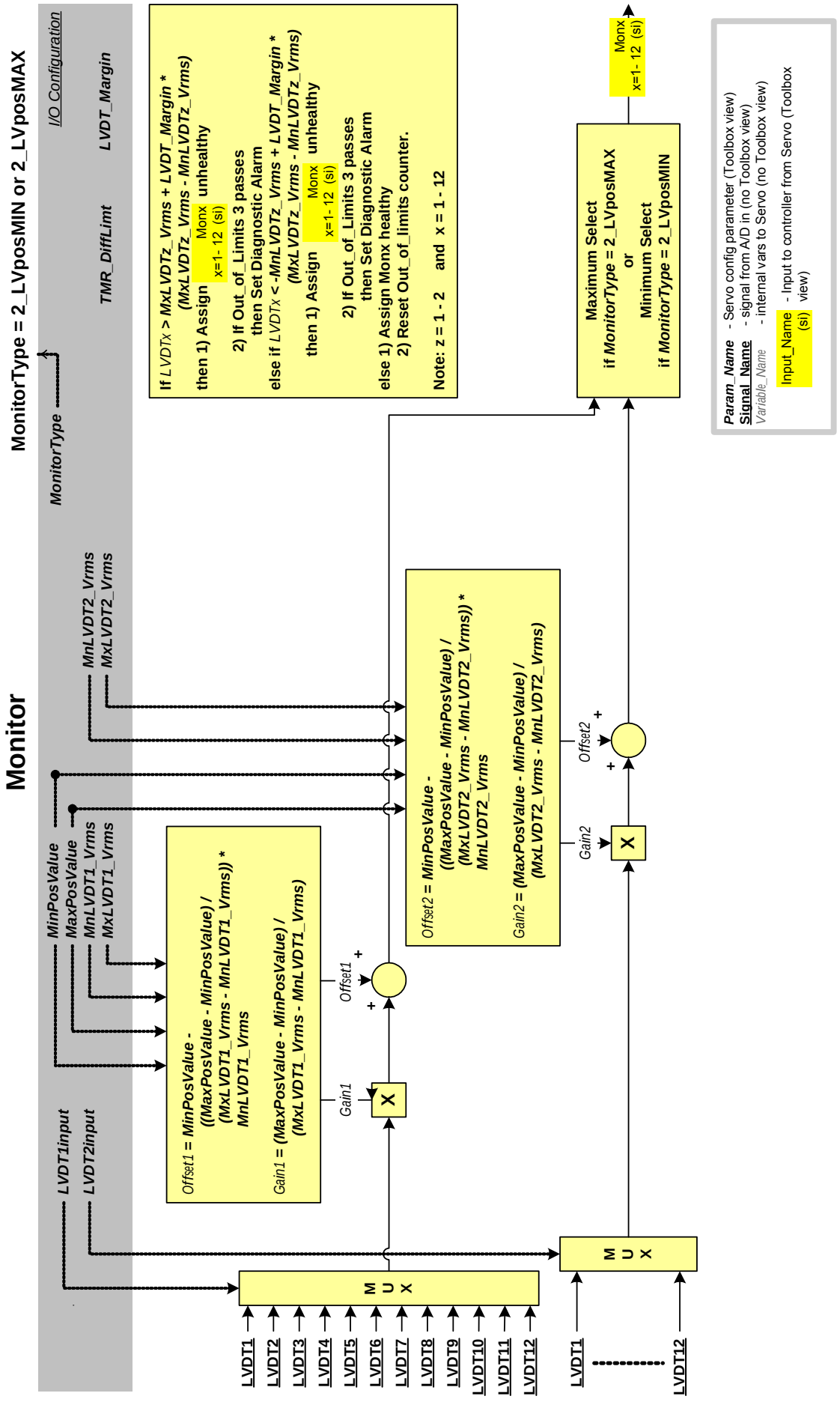


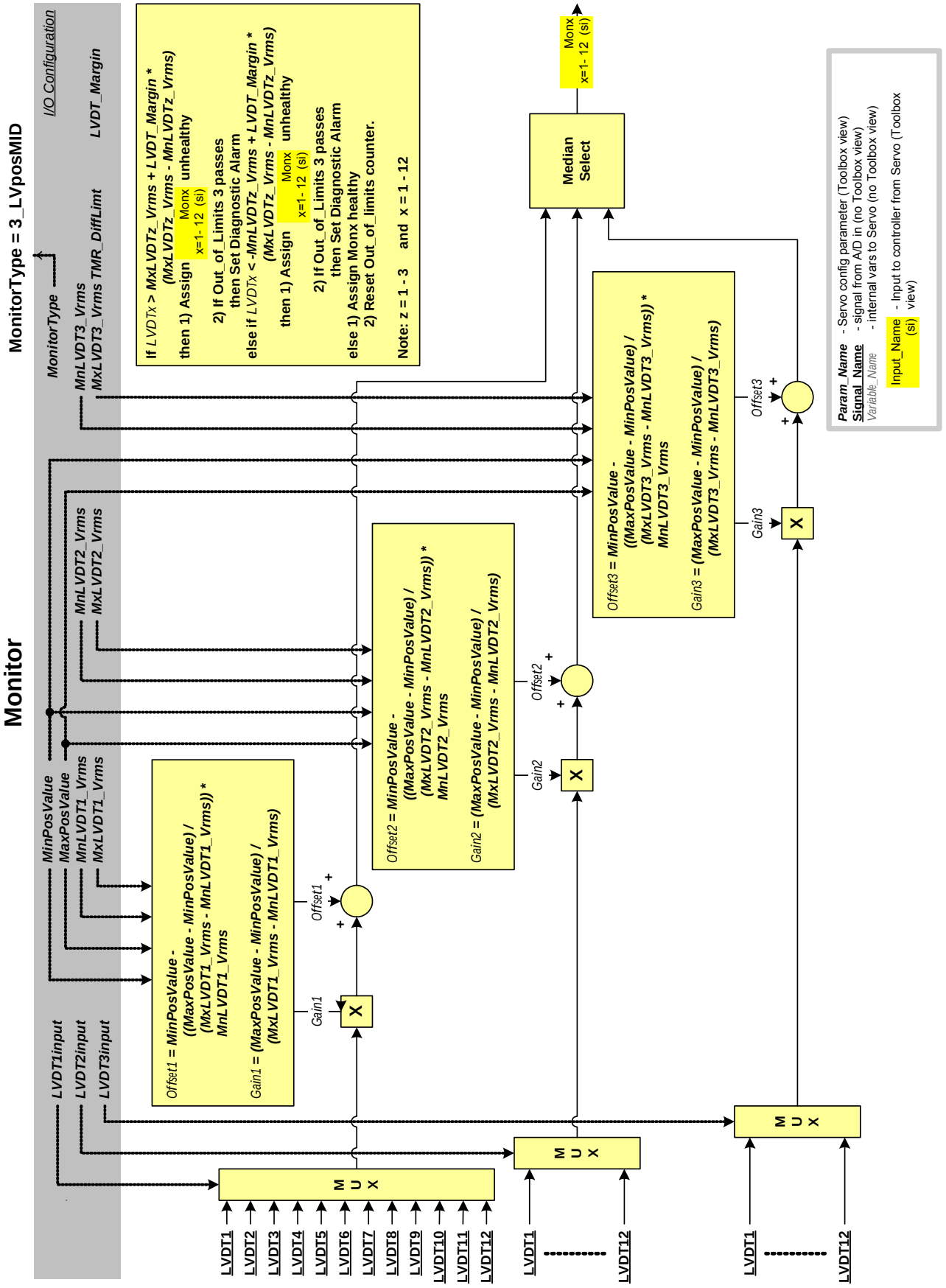
Monitors - 1 LVposition, 2 LVposMIN, 2LVposMAX, 3LVposMID

The following Monitor configurations are available:

- 1_LVposition – one LVDT signal is used as the position feedback.
- 2_LVposMIN – the minimum of two LVDT signals is selected as the position feedback.
- 2_LVposMAX – the maximum of two LVDT signals is selected as the position feedback.
- 3_LVposMID – the median of three LVDT signals is selected as the position feedback.


Monitor
MonitorType = 1_LVposition
I/O Configuration
MonitorType
LVDT_Margin
TMR_DiffLimt
LVDT1input
MinPosValue
MaxPosValue
MnLVDT1_Vrms
MxLVDT1_Vrms
Offset1 = MinPosValue - ((MaxPosValue - MinPosValue) / (MxLVDT1_Vrms - MnLVDT1_Vrms)) * MnLVDT1_Vrms
Gain1 = (MaxPosValue - MinPosValue) / (MxLVDT1_Vrms - MnLVDT1_Vrms)
Gain1
Offset1
LVDT1
LVDT2
LVDT3
LVDT4
LVDT5
LVDT6
LVDT7
LVDT8
LVDT9
LVDT10
LVDT11
LVDT12
MUX
Monx x=1- 12 (si)
If LVDTx > MxLVDT1_Vrms + LVDT_Margin * (MxLVDT1_Vrms - MnLVDT1_Vrms) then 1) Assign Monx x=1- 12 (si) unhealthy
2) If Out_of_Limits 3 passes then Set Diagnostic Alarm
else if LVDTx < -MnLVDT1_Vrms + LVDT_Margin * (MxLVDT1_Vrms - MnLVDT1_Vrms) then 1) Assign Monx x=1- 12 (si) unhealthy
2) If Out_of_Limits 3 passes then Set Diagnostic Alarm
else 1) Assign Monx healthy
2) Reset Out_of_limits counter.
Note: x = 1 - 12
Param_Name - Servo config parameter (Toolbox view)
Signal_Name - signal from A/D in (no Toolbox view)
Variable_Name - internal vars to Servo (no Toolbox view)
Input_Name (si) - Input to controller from Servo (Toolbox view)


Monitor
MonitorType = 2_LVposMIN or 2_LVposMAX
I/O Configuration
MonitorType
TMR_DiffLimt
LVDT_Margin
LVDT1input
LVDT2input
MinPosValue
MaxPosValue
MnLVDT1_Vrms
MxLVDT1_Vrms
MnLVDT2_Vrms
MxLVDT2_Vrms
Offset1 = MinPosValue - ((MaxPosValue - MinPosValue) / (MxLVDT1_Vrms - MnLVDT1_Vrms)) * MnLVDT1_Vrms
Gain1 = (MaxPosValue - MinPosValue) / (MxLVDT1_Vrms - MnLVDT1_Vrms)
Offset2 = MinPosValue - ((MaxPosValue - MinPosValue) / (MxLVDT2_Vrms - MnLVDT2_Vrms)) * MnLVDT2_Vrms
Gain2 = (MaxPosValue - MinPosValue) / (MxLVDT2_Vrms - MnLVDT2_Vrms)
Gain1
Offset1
Gain2
Offset2
X
+
MUX
LVDT1
LVDT2
LVDT3
LVDT4
LVDT5
LVDT6
LVDT7
LVDT8
LVDT9
LVDT10
LVDT11
LVDT12
If LVDTx > MxLVDTz_Vrms + LVDT_Margin * (MxLVDTz_Vrms - MnLVDTz_Vrms)
then 1) Assign Monx x=1- 12 (si) unhealthy
2) If Out_of_Limits 3 passes then Set Diagnostic Alarm
else if LVDTx < -MnLVDTz_Vrms + LVDT_Margin * (MxLVDTz_Vrms - MnLVDTz_Vrms)
then 1) Assign Monx x=1- 12 (si) unhealthy
2) If Out_of_Limits 3 passes then Set Diagnostic Alarm
else 1) Assign Monx healthy
2) Reset Out_of_limits counter.
Note: z = 1 - 2 and x = 1 - 12
Maximum Select if MonitorType = 2_LVposMAX
or
Minimum Select if MonitorType = 2_LVposMIN
Monx x=1- 12 (si)
Param_Name - Servo config parameter (Toolbox view)
Signal_Name - signal from A/D in (no Toolbox view)
Variable_Name - internal vars to Servo (no Toolbox view)
Input_Name (si) - Input to controller from Servo (Toolbox view)


Monitor
MonitorType = 3_LVposMID
I/O Configuration
MonitorType
MnLVDT3_Vrms
MxLVDT3_Vrms TMR_DiffLimt
LVDT_Margin
If LVDTx > MxLVDTz_Vrms + LVDT_Margin * (MxLVDTz_Vrms - MnLVDTz_Vrms)
then 1) Assign Monx x=1- 12 (si) unhealthy
2) If Out_of_Limits 3 passes then Set Diagnostic Alarm
else if LVDTx < -MnLVDTz_Vrms + LVDT_Margin * (MxLVDTz_Vrms - MnLVDTz_Vrms)
then 1) Assign Monx x=1- 12 (si) unhealthy
2) If Out_of_Limits 3 passes then Set Diagnostic Alarm
else 1) Assign Monx healthy
2) Reset Out_of_limits counter.
Note: z = 1 - 3 and x = 1 - 12
LVDT1input
LVDT2input
LVDT3input
MinPosValue
MaxPosValue
MnLVDT1_Vrms
MxLVDT1_Vrms
MnLVDT2_Vrms
MxLVDT2_Vrms
Offset1 = MinPosValue - ((MaxPosValue - MinPosValue) / (MxLVDT1_Vrms - MnLVDT1_Vrms)) * MnLVDT1_Vrms
Gain1 = (MaxPosValue - MinPosValue) / (MxLVDT1_Vrms - MnLVDT1_Vrms)
Offset2 = MinPosValue - ((MaxPosValue - MinPosValue) / (MxLVDT2_Vrms - MnLVDT2_Vrms)) * MnLVDT2_Vrms
Gain2 = (MaxPosValue - MinPosValue) / (MxLVDT2_Vrms - MnLVDT2_Vrms)
Offset3 = MinPosValue - ((MaxPosValue - MinPosValue) / (MxLVDT3_Vrms - MnLVDT3_Vrms)) * MnLVDT3_Vrms
Gain3 = (MaxPosValue - MinPosValue) / (MxLVDT3_Vrms - MnLVDT3_Vrms)
Offset1
Gain1
Offset2
Gain2
Offset3
Gain3
MUX
LVDT1
LVDT2
LVDT3
LVDT4
LVDT5
LVDT6
LVDT7
LVDT8
LVDT9
LVDT10
LVDT11
LVDT12
Median Select
Monx x=1- 12 (si)
Param_Name - Servo config parameter (Toolbox view)
Signal_Name - signal from A/D in (no Toolbox view)
Variable_Name - internal vars to Servo (no Toolbox view)
Input_Name (si) - Input to controller from Servo (Toolbox view)

Specifications

Item	Specification
Number of inputs (per TSVO)	6 LVDT windings
	2 pulse rate signals (total of 2 per VSVO)
	External trip signal
Number of outputs (per TSVO)	2 servo valves (total of 4 per VSVO board)
	4 excitation sources for LVDTs
	2 excitation sources for pulse rate transducers
Internal sample rate	200 Hz
Power supply voltage	Nominal 24 V dc
LVDT accuracy	1% with 14-bit resolution
LVDT input filter	Low pass filter with 3 down breaks at 50 rad/sec ±15%
LVDT common mode rejection	CMR is 1 V, 60 dB at 50/60 Hz
LVDT excitation output	Frequency of 3.2 ± 0.2 kHz
	Voltage of 7.00 ± 0.14 V rms
Pulse rate accuracy	0.05% of reading with 16-bit resolution at 50 Hz frame rate
	Noise of acceleration measurement is less than ± 50 Hz/sec for a 10,000 Hz signal being read at 10 ms
Pulse rate input	Minimum signal for proper measurement at 2 Hz is 70 mVpk, and at 12 kHz is 827 mVpk.
Magnetic PR pickup signal	Generates 150 V p-p into 60 kΩ
Active PR Pickup Signal	Generates 5 to 27 V p-p into 60 kΩ
Servo valve output accuracy	2% with 12-bit resolution
	Dither amplitude and frequency adjustable
Fault detection	Suicide servo outputs initiated by:
	Servo current out of limits or not responding
	Regulator feedback signal out of limits

Diagnostics

Three LEDs at the top of the VSVO front panel show status information. The normal RUN condition is a flashing green, and FAIL is solid red. The third LED is STATUS and is normally off but displays a steady orange if an alarm condition exists on the board. Diagnostic checks include the following:

- The output servo current is out of limits or not responding, which creates a fault.
- The regulator feedback (LVDT) signal is out of limits. A fault is created and if the associated regulator has two sensors, the bad sensor is removed from the feedback calculation and the good sensor is used.
- The servo has suicided. This creates a fault.
- The A/D converter calibration voltage is out of limits and a default value is being used.
- The LVDT excitation voltage is out of range. A fault is created
- The input signal varies from the voted value by more than the TMR differential limit. This causes a fault to be created indicating a problem with this sensor input.
- If any one of the above signals go unhealthy a composite diagnostic alarm, L#DIAG_VSVO, occurs. Details of the individual diagnostics are available from the toolbox. The diagnostic signals can be individually latched, and reset with the RESET_DIA signal if they go healthy.
- Connectors JR1, JS1, JT1 on the terminal board have their own ID device that is interrogated by the I/O board. The ID device is a read-only chip coded with the terminal board serial number, board type, revision number, and the plug location. When the chip is read by VSVO and a mismatch is encountered, a hardware incompatibility fault is created.

Configuration

Parameter	Description	Choices
Configuration		
System Limits	Select system limits	Enable, disable
Regulator 1	LVDT/R calibration	Online LVDT calibration, yes/no
RegType	Algorithm used in the regulator	Unused 1_PulseRate 2_PlsRateMAX 1_LVposition 2_LVposMIN 2_LVposMAX 3_LVposMID 2_LvpilotCyl 4_LVp/cylMAX 4_LV_LM no_fbk
RegGain	Position loop gain in (%current/%position)	-200 to 200
RegNullBias	Null bias in % current, balances servo spring force	-100 to 100
DitherAmpl	Dither in % current (minimizes hysteresis)	Dither amp: 0 to 10
MinPOSvalue	Position at Min End Stop in engineering units.	-15 to 150
MaxPOSvalue	Position at Max End Stop in engineering units.	-15 to 150
MnLVDT1_Vrms	LVDT1_Vrms at Min End Stop (Normally set by the Calibration function)	0 to 7.1
MxLVDT1_Vrms	LVDT1_Vrms at Max End Stop (Normally set by the Calibration function)	0 to 7.1
:		
MnLVDT4_Vrms	LVDT4_Vrms at Min End Stop (Normally set by the Calibration function)	0 to 7.1
MxLVDT4_Vrms	LVDT4_Vrms at Max End Stop (Normally set by the Calibration function)	0 to 7.1

Parameter	Description	Choices
LVDT_Margin	Used in the calibration function to calculate the internal variables, Reg_Sensor_Hdwr_Lo and Reg_Sensor_Hdwr_Hi for LVDT sensor check.	0 to 7.1
TMR_DiffLimt	Difference limit off voted pulse inputs (EU)	0 to 12000
Monitor 1		
Monitor type	Monitor algorithm	Unused 1_LVposition 2_LVposMIN 2_LVposMAX 3_LVposMID
MinPOSvalue	Position at Min End Stop in engineering units.	-15 to 150
MaxPOSvalue	Position at Max End Stop in engineering units.	-15 to 150
MnLVDT1_Vrms	LVDT1_Vrms at Min End Stop (not set by the Calibration function)	0 to 7.1
MxLVDT1_Vrms	LVDT1_Vrms at Max End Stop (not set by the Calibration function)	0 to 7.1
:		
MnLVDT4_Vrms	LVDT4_Vrms at Min End Stop (not set by the Calibration function)	0 to 7.1
MxLVDT4_Vrms	LVDT4_Vrms at Max End Stop (not set by the Calibration function)	0 to 7.1
LVDT_Margin	Used in the calibration function to calculate the internal variables, Reg_Sensor_Hdwr_Lo and Reg_Sensor_Hdwr_Hi for LVDT sensor check done by the Monitor function.	0 to 7.1
TMR_DiffLimt	Difference limit off voted pulse inputs (EU)	0 to 12000
J3:IS200TSVOH1A	Terminal board 1 connected to VSVO through J3	Connected, not connected
Servo Output1	Measured output current in percent – Board point	Point edit (input FLOAT)
Reg Number	Identify regulator number	Unused, Reg1, Reg2, Reg3, Reg4
Servo_MA_Out	Select current output for coil windings	10, 20, 40, 80, 120 mA
EnableCurSuic	Select Suicide function based on current	Enable, disable
Curr_Suicide	Percent current error to initiate suicide	0 to 100% (output current error)
EnablFbkSuic	Select Suicide function based on position feedback	Enable, disable
Fdbk_Suicide	Percent position error to initiate suicide	0 to 100% (actuator position error)
Servo Output2	Measured output current in percent - Board point	Point edit (input FLOAT)
J4:IS200TSVOH1A	Terminal Board 2 connected to VSVO via J4	Connected, not connected
Servo Output3	Servo current output wired to valve - Board point	Point edit (input FLOAT)
Servo Output4	Servo current output wired to valve - Board point	Point edit (input FLOAT)
J5:IS00TSVOH1A	Pulse Rate inputs cabled to J5 connector	Connected, not connected
FlowRate1	Pulse rate input selected - Board point	Point edit (input FLOAT)
PRType	Select speed or flow type signal	Unused, Speed, Flow, Speed_High, Speed_LM
PRScale	Convert Hz to engineering units	0 to 1,000
SysLim1Enabl	Select system limit	Enable, disable
SysLim1Latch	Select whether alarm will latch	Latch, not latch
SysLim1Type	Select type of alarm initiation	>= or <=
SysLimit	Select alarm level in GPM or RPM	0 to 12,000
SystemLim2	Same as above	Same as above
TMR_DiffLimt	Difference limit off voted pulse inputs (EU)	0 to 12,000
FlowRate2	Pulse rate input selected - Board point (as above)	Point edit (input FLOAT)

Board Points Signals	Description - Point Edit (Enter Signal Connection)	Direction	Type
L3DIAG_VSVOR	Board diagnostic	Input	BIT
L3DIAG_VSVOS	Board diagnostic	Input	BIT
L3DIAG_VSVOT	Board diagnostic	Input	BIT
R1_SuicideNVR	Regulator 1 Suicide relay status, non-voted for VSVO-R	Input	BIT
R1_SuicideNVS	Regulator 1 Suicide relay status, non-voted for VSVO-S	Input	BIT
R1_SuicideNVT	Regulator 1 Suicide relay status, non-voted for VSVO-T	Input	BIT
R2_SuicideNVR	Regulator 2 Suicide relay status, non-voted for VSVO-R	Input	BIT
R2_SuicideNVS	Regulator 2 Suicide relay status, non-voted for VSVO-S	Input	BIT
R2_SuicideNVT	Regulator 2 Suicide relay status, non-voted for VSVO-T	Input	BIT
R3_SuicideNVR	Regulator 3 Suicide relay status, non-voted for VSVO-R	Input	BIT
R3_SuicideNVS	Regulator 3 Suicide relay status, non-voted for VSVO-S	Input	BIT
R3_SuicideNVT	Regulator 3 Suicide relay status, non-voted for VSVO-T	Input	BIT
R4_SuicideNVR	Regulator 4 Suicide relay status, non-voted for VSVO-R	Input	BIT
R4_SuicideNVS	Regulator 4 Suicide relay status, non-voted for VSVO-S	Input	BIT
R4_SuicideNVT	Regulator 4 Suicide relay status, non-voted for VSVO-T	Input	BIT
SysLim1PR1	System Limit 1 indication for Pulse Rate 1	Input	BIT
SysLim2PR1	System Limit 2 indication for Pulse Rate 1	Input	BIT
SysLim1PR2	System Limit 1 indication for Pulse Rate 2	Input	BIT
SysLim2PR2	System Limit 2 indication for Pulse Rate 2	Input	BIT
Reg1Suicide	Regulator 1 suicide relay status	Input	BIT
:	:	Input	BIT
Reg4Suicide	Regulator 4 suicide relay status	Input	BIT
Reg1_PosAFlt	Reg1, LM machine only, position A failure	Input	BIT
:	:	Input	BIT
Reg4_PosAFlt	Reg4, LM machine only, position A failure	Input	BIT
Reg1_PosBFlt	Reg1, LM machine only, position B failure	Input	BIT
:	:	Input	BIT
Reg4_PosBFlt	Reg4, LM machine only, position B failure	Input	BIT
Reg1_PosDif1	Reg1, LM machine only, position difference failure	Input	BIT
:	:	Input	BIT
Reg4_PosDif1	Reg4, LM machine only, position difference failure	Input	BIT
Reg1_PosDif2	Reg1, LM machine only, position difference failure	Input	BIT
:	:	Input	BIT
Reg4_PosDif2	Reg4, LM machine only, position difference failure	Input	BIT
RegCalMode	Regulator under calibration	Input	BIT
Reg1_Fdbk	Regulator 1 feedback	Input	FLOAT
:	:	Input	FLOAT
Reg4_Fdbk	Regulator 4 feedback	Input	FLOAT
MiscFdbk1a	Reg1, PosA when 4_LV_LM or Pilot when 2_LvpilotCy or 4_LVp/cylMax	Input	FLOAT
MiscFdbk1b	Reg1, PosB when 4_LV_LM or otherwise not used.	Input	FLOAT
MiscFdbk2a	Reg2, PosA when 4_LV_LM or Pilot when 2_LvpilotCy or 4_LVp/cylMax	Input	FLOAT
MiscFdbk2b	Reg2, PosB when 4_LV_LM or otherwise not used.	Input	FLOAT
MiscFdbk3a	Reg3, PosA when 4_LV_LM or Pilot when 2_LvpilotCy or 4_LVp/cylMax	Input	FLOAT
MiscFdbk3b	Reg3, PosB when 4_LV_LM or otherwise not used.	Input	FLOAT
MiscFdbk4a	Reg4, PosA when 4_LV_LM or Pilot when 2_LvpilotCy or 4_LVp/cylMax	Input	FLOAT

Board Points Signals	Description - Point Edit (Enter Signal Connection)	Direction	Type
MiscFdbk4b	Reg4, PosB when 4_LV_LM or otherwise not used.	Input	FLOAT
Reg1_Error	Regulator 1 position or flow rate error	Input	FLOAT
:	:	Input	FLOAT
Reg4_Error	Regulator 4 position or flow rate error	Input	FLOAT
Accel1	GPM/sec based on Pulse Rate 1	Input	FLOAT
Accel2	GPM/sec based on Pulse Rate 2	Input	FLOAT
Mon1	Position feedback based on Monitor 1	Input	FLOAT
:	:	Input	FLOAT
Mon12	Position feedback based on Monitor 12	Input	FLOAT
ServoOut1NVR	Servo Current Output 1, non-voted for VSVO-R	Input	FLOAT
ServoOut1NVS	Servo Current Output 1, non-voted for VSVO-S	Input	FLOAT
ServoOut1NVT	Servo Current Output 1, non-voted for VSVO-T	Input	FLOAT
ServoOut2NVR	Servo Current Output 2, non-voted for VSVO-R	Input	FLOAT
ServoOut2NVS	Servo Current Output 2, non-voted for VSVO-S	Input	FLOAT
ServoOut2NVT	Servo Current Output 2, non-voted for VSVO-T	Input	FLOAT
ServoOut3NVR	Servo Current Output 3, non-voted for VSVO-R	Input	FLOAT
ServoOut3NVS	Servo Current Output 3, non-voted for VSVO-S	Input	FLOAT
ServoOut3NVT	Servo Current Output 3, non-voted for VSVO-T	Input	FLOAT
ServoOut4NVR	Servo Current Output 4, non-voted for VSVO-R	Input	FLOAT
ServoOut4NVS	Servo Current Output 4, non-voted for VSVO-S	Input	FLOAT
ServoOut4NVT	Servo Current Output 4, non-voted for VSVO-T	Input	FLOAT
CalibEnab1	Enable calibration Reg 1	Output	BIT
:	:	Output	BIT
CalibEnab4	Enable calibration Reg 4	Output	BIT
SuicideForce1	Force suicide on Reg 1	Output	BIT
:	:	Output	BIT
SuicideForce4	Force suicide on Reg 4	Output	BIT
PossDiffEnab1	Position difference enable reg 1, LM only	Output	BIT
:	:	Output	BIT
PossDiffEnab4	Position difference enable reg 4, LM only	Output	BIT
Reg1_Ref	Reg 1 position reference	Output	FLOAT
:	:	Output	FLOAT
Reg4_Ref	Reg 4 position reference	Output	FLOAT
Reg1-GainMod	Reg 1 gain modifier (don't use)	Output	FLOAT
:	:	Output	FLOAT
Reg4-GainMod	Reg 4 gain modifier (don't use)	Output	FLOAT
Reg1_NullCor	Reg 1 null bias correction	Output	FLOAT
:	:	Output	FLOAT
Reg4_NullCor	Reg 4 null bias correction	Output	FLOAT
Internal Variables	Internal variables to service the auto-calibration display, not configurable		

Alarms

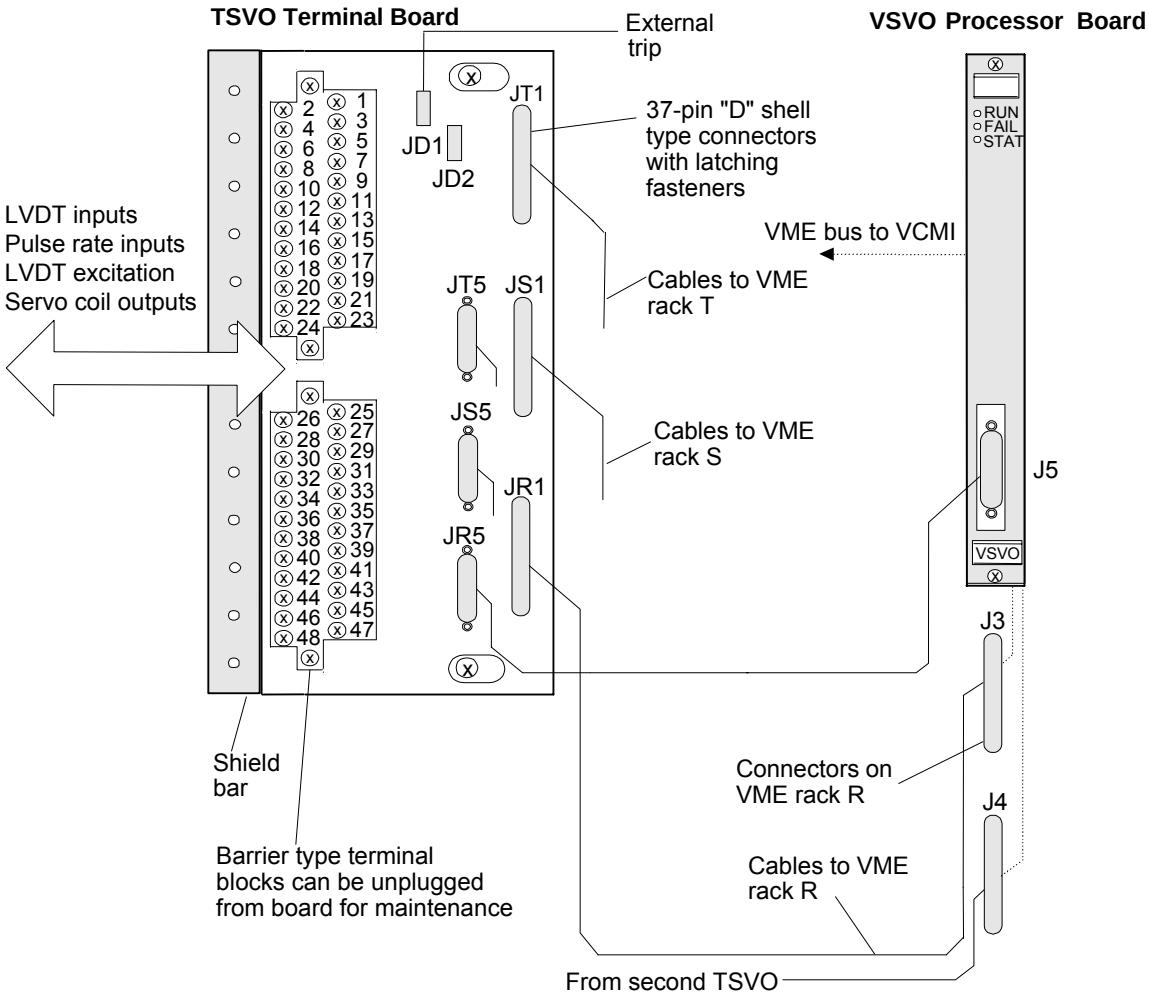
Fault	Fault Description	Possible Cause
2	Flash Memory CRC Failure	Board firmware programming error (board will not go online)
3	CRC failure override is Active	Board firmware programming error (board is allowed to go online)
16	System Limit Checking is Disabled	System checking was disabled by configuration.
17	Board ID Failure	Failed ID chip on the VME I/O board
18	J3 ID Failure	Failed ID chip on connector J3, or cable problem
19	J4 ID Failure	Failed ID chip on connector J4, or cable problem
20	J5 ID Failure	Failed ID chip on connector J5, or cable problem
21	J6 ID Failure	Failed ID chip on connector J6, or cable problem
22	J3A ID Failure	Failed ID chip on connector J3A, or cable problem
23	J4A ID Failure	Failed ID chip on connector J4A, or cable problem
24	Firmware/Hardware Incompatibility	Invalid terminal board connected to VME I/O board
30	ConfigCompatCode mismatch; Firmware: #; Tre: # The configuration compatibility code that the firmware is expecting is different than what is in the tre file for this board	A tre file has been installed that is incompatible with the firmware on the I/O board. Either the tre file or firmware must change. Contact the factory.
31	IOCompatCode mismatch; Firmware: #; Tre: # The I/O compatibility code that the firmware is expecting is different than what is in the tre file for this board	A tre file has been installed that is incompatible with the firmware on the I/O board. Either the tre file or firmware must change. Contact the factory.
33-44	LVDT # RMS Voltage Out of Limits. Minimum and maximum LVDT limits are configured	The LVDT may need recalibration.
45	Calibration Mode Enabled	The VSVO was put into calibration mode.
46	VSVO Board Not Online, Servos Suicided. The servo is suicided because the VSVO is not on-line	The controller (R, S, T) or IONet is down, or there is a configuration problem with the system preventing the VCMI from bringing the board on line.
47-51	Servo Current # Disagrees with Reference, Suicided. The servo current error (reference - feedback) is greater than the configured current suicide margin	A cable/wiring open circuit, or board problem.
52-56	Servo Current # Short Circuit. This is not currently used	NA
57-61	Servo Current # Open Circuit. The servo voltage is greater than 5V and the measured current is less than 10%	A cable/wiring open circuit, or board problem.
62-66	Servo Position # Feedback Out of Range, Suicided. Regulator number # position feedback is out of range, causing the servo to suicide	LVDT or board problem
67-71	Configuration Message Error for Regulator Number #. There is a problem with the VSVO configuration and the servo will not operate properly	The LVDT minimum and maximum voltages are equal or reversed, or an invalid LVDT, regulator, or servo number is specified.
72	Onboard Calibration Voltage Range Fault. The A/D calibration voltages read from the FPGA are out of limits, and the VSVO will use default values instead	A problem with the Field Programmable Gate Array (FPGA) on the board
73-75	LVDT Excitation # Voltage out of range	There is a problem with the LVDT excitation source on the VSVO board.

Fault	Fault Description	Possible Cause
77	Servo output assignment mismatch. Regulator types 8 & 9 use two servo outputs each. They have to be consecutive pairs, and they have to be configured as the same range	Fix the regulator configurations.
128-191	Logic Signal # Voting mismatch. The identified signal from this board disagrees with the voted value	A problem with the input. This could be the device, the wire to the terminal board, the terminal board, or the cable.
224-259	Input Signal # Voting mismatch, Local #, Voted #. The specified input signal varies from the voted value of the signal by more than the TMR Diff Limit	A problem with the input. This could be the device, the wire to the terminal board, the terminal board, or the cable.

TSVO Servo Input/Output

Functional Description

The Servo Input/Output (TSVO) terminal board interfaces with two electro-hydraulic servo valves that actuate the steam/fuel valves. Valve position is measured with LVDTs. Two cables connect to VSVO using the J5 plug on the front of VSVO and the J3 or J4 connector on the VME rack. TSVO provides simplex signals through the JR1 connector, and fans out TMR signals to the JR1, JS1, and JT1 connectors. Plugs JD1 or JD2 are for an external trip from the protection module.



TSVO Servo Terminal Board and VSVO Processor Board