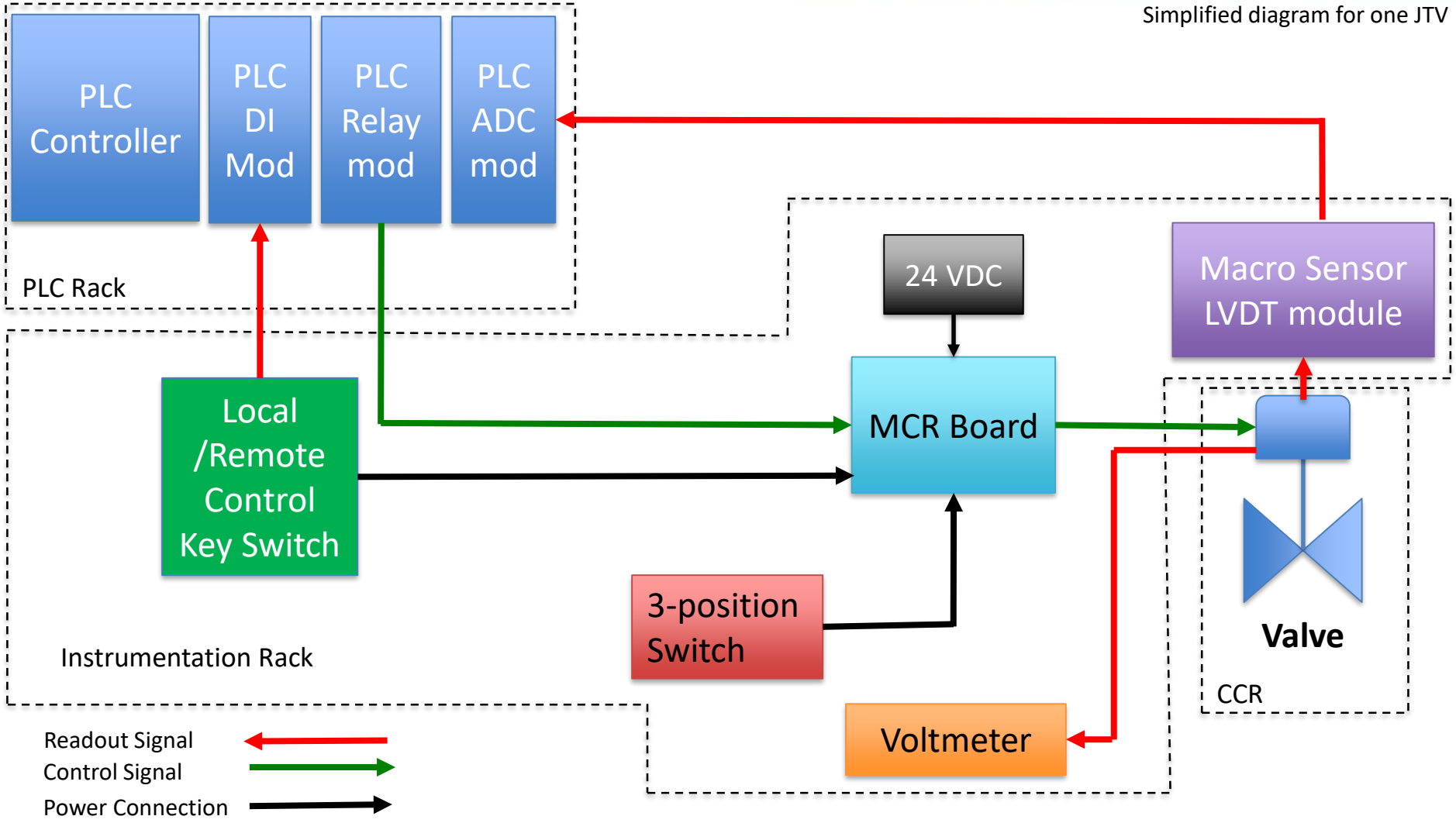
Hall A SoLID Solenoid PLC Controls for CCR LN_2 Valves

Pablo Campero & Mary Ann Antoniloi
and the Detector Support Group
7/30/2021

Contents

- Overview
- Valve control modes
- Remote mode
- HMI screens to control and monitor valves
- Conclusion

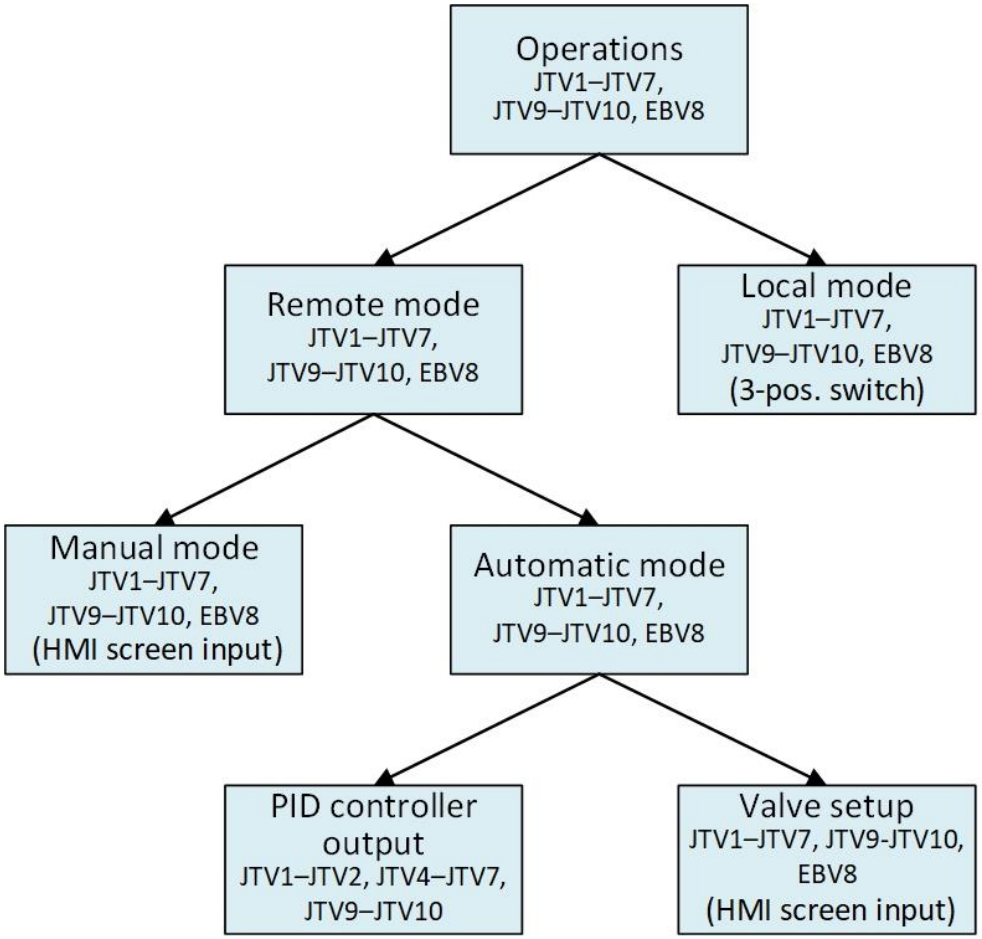
Controls Overview



Detailed connections diagram is available at [Motor Controller Relay Board] talk

Valve Control Modes

- Joule Thomson Valves (JTV) can be controlled either locally or remotely
- A keyed switch installed in valve panel at instrumentation rack controls operation mode
- Remote mode is performed by the PLC



SoLID Valve Control Modes Process Diagram
M. A. Antonioli
7/21/21

Valve Control Modes – Cont.

- **Local control**
  - Local LVDT voltage readout
  - Fully open and close valve with the manual three-position switch
  - Monitor local or remote status by viewing switch
  - Check relay status by viewing MCR board LEDs

Valve Control Modes – Cont.

- **Remote PLC controls**
  - Valve position
    - readout (LVDT in %)
    - control—fully close or open valve, or set position (operator input mode)
    - control using PID algorithm (only in automatic mode)
  - Alarms when valve positioning errors are present
  - Data archiving of valve position
  - Automatic control of valves while cooling down or warming up magnet

Valve Control Modes – Cont.

- **Remote PLC controls**
  - Interlocks to protect the magnet
  - Real time monitoring via HMI screens
  - Monitoring of local/remote control mode status
  - Monitoring of relay status associated with valve motor drive for each valve

Remote Mode

PLC controls JTVs in two remote modes: **Automatic and Manual**; user selects mode from HMI screen

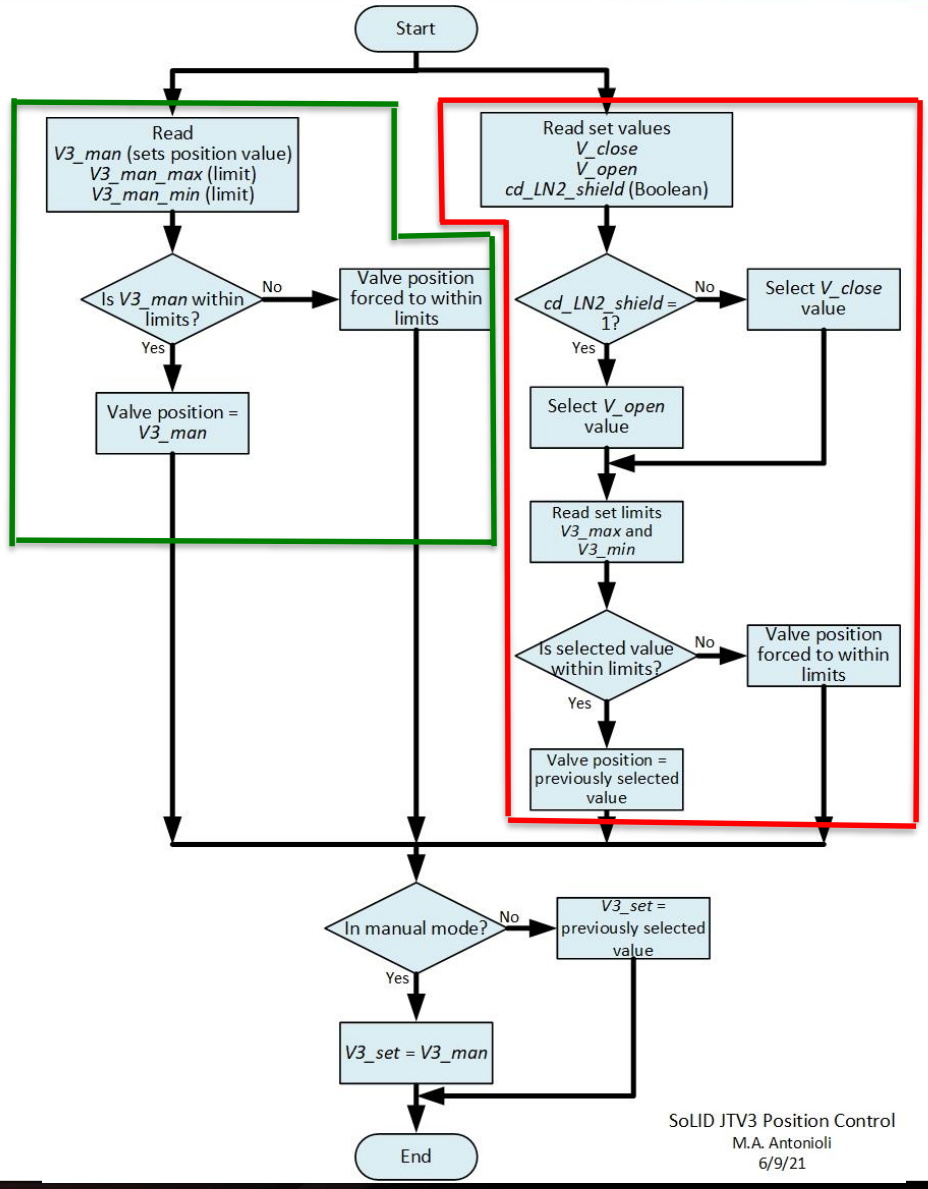
- **Automatic Mode**
  - Valve setpoint is selected automatically by the PLC based on cryogenic and cooldown conditions
  - Valve setpoint to open or close valve can be determined by
    - **PID control:** Output value of the PLC PID instruction controls the set value for the valve position
      - Parameters for PID are entered on *Valve Setup* HMI screen
    - **Setting up values:** Values entered by operator on *Valve Setup* HMI screen to set valve position

Remote Mode (Cont.)

- **Manual Mode**
  - JT valve setpoint is determined by user-entered value within of maximum and minimum limits
  - Valve position is determined by values entered on *Valve Page* HMI screen

Remote Mode for JTV3

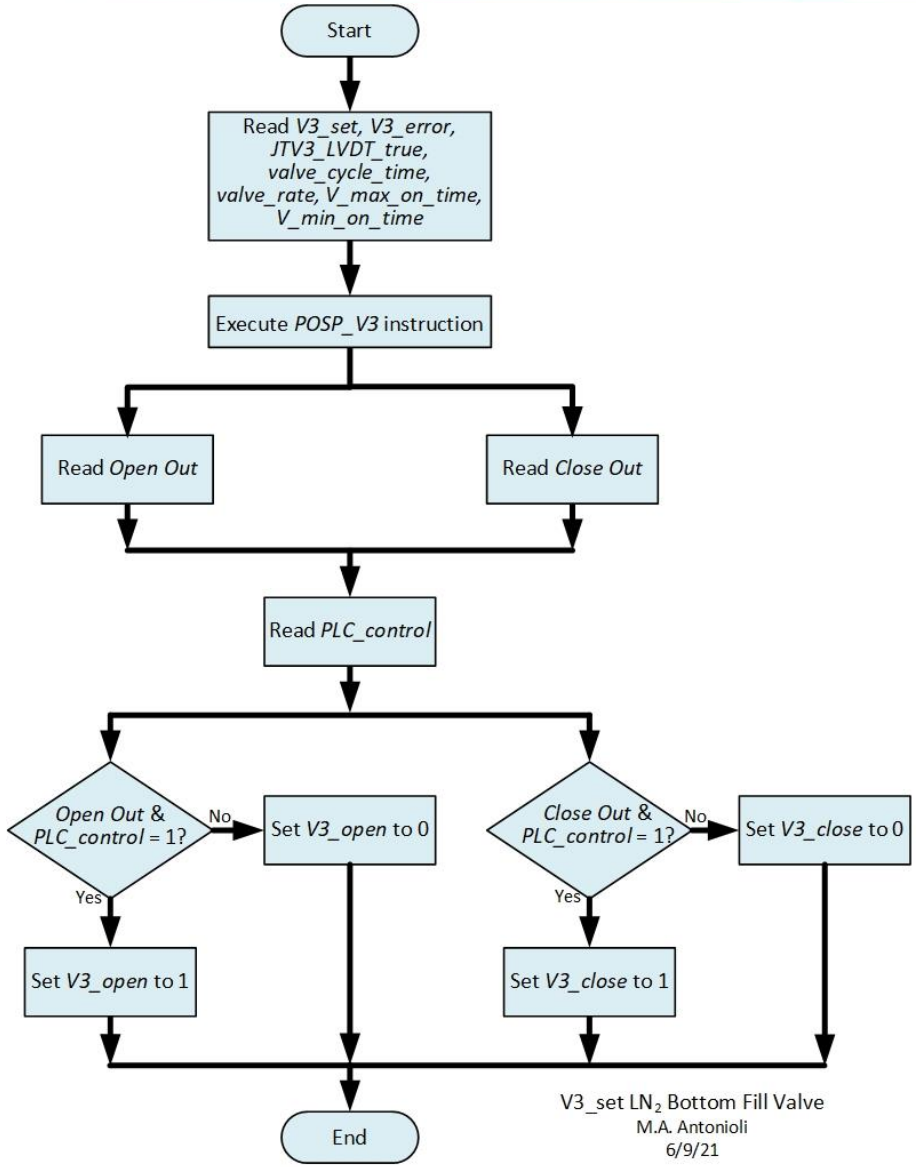
Manual mode



Automatic mode

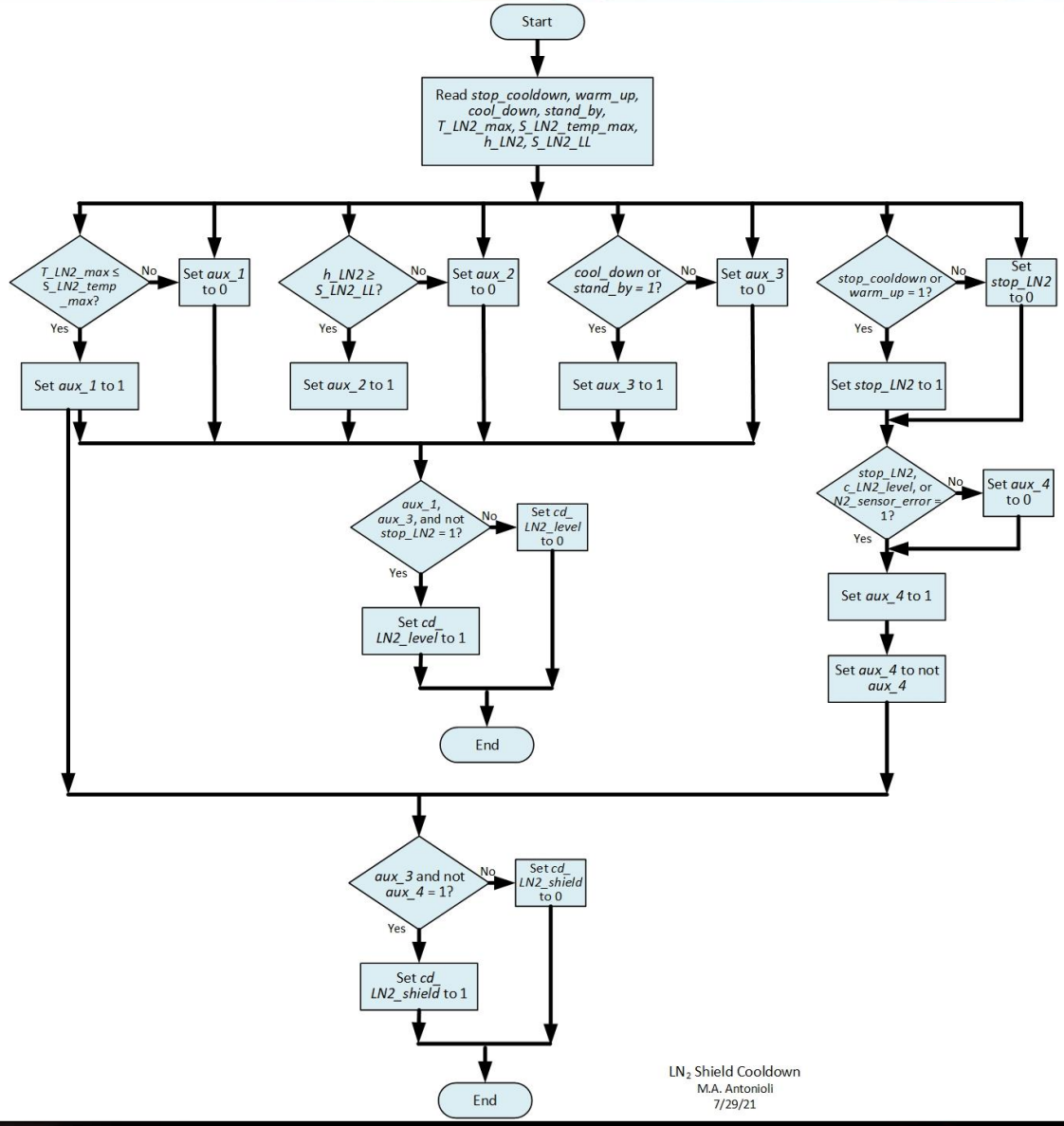
Remote Mode for JTV3(Cont.)

- Flow chart shows logic to control valve's closing and opening
- Position proportional (POSP) instruction's output controls relay contact that is pulsed with a width proportional to difference between desired and actual position, to open or close at a defined cycle time



Remote Mode for JVT3 and JTV5 Cooldown Conditions

- Flowchart shows logic to read cooldown parameters and conditions to set Boolean PLC tags
  - cd_LN2_Shield
  - cd_LN2_level
- PLC tags determine the value to set valve aperture while it is on PLC Remote-Automatic control mode (PID output or *Valve Setup* HMI input values)



PLC Controls True-False Table for JTV3 and JVT5

		Cryogenic Conditions												JTV3 Setting Action (Value)	JTV5 Setting Action (Value)
		Cooldown ?	Stand By ?	Stop_Cooldown ?	Warm_Up ?	Stop_LN2 ?	T_LN2_max<set limit?	LN2_level > set limit?	~stop_LN2?	**cd_LN2_level?**	N2_sensor_error ?	~(Stop_LN2 OR cd_LN2_Level OR LN2_sensor_error) ?	**cd_LN2_shield ?**		
Operating Mode	Fill LN2 Reservoir (LN2 level)	1	0	0	0	0	1	1	1	1	0	0	0	Valve Close (Setting Min.)	Valve Open (from PID)
	Fill Magnet Shield	1	0	0	0	0	1	0	1	0	0	1	1	Valve Open (Setting Max.)	Valve Close (Setting Min.)
Color Code															

True/False table to control LN_2 valves for JTV3 and JTV5 in automatic mode

Labels	
~	Not Boolean
0	FALSE
1	TRUE

Summary of JTV5 Operating Conditions in Auto Mode

- In automatic mode, JTV5 valve regulates LN_2 flow to nitrogen reservoir in CCR (top fill valve)
- Valve is open (takes PID output value to set valve aperture) while:
  1. Cooldown **or** Stand_by operating modes are active
  2. **AND** read temperature in magnet shield is below set limit
  3. **AND** read LN_2 level > set limit
  4. **AND** Warm_up **or** Stop_cooldown operating modes are not active
- Otherwise, valve will be closed, taking *Min. Setting* value from HMI screen

Summary for JTV3 Operating Conditions in Auto Mode

- JTV3 valve regulates LN_2 flow to magnet shield (bottom fill valve)
- Valve is open (takes *Max. Setting* set value) while:
  1. Cooldown_Stop **or** Warm_up operations modes are not active
  2. **OR** JTV5 is closed (same as having cd_LN2_level bit = 0)
  3. **OR** there ares no errors on LN_2 level sensors
  4. **AND** Cooldown **or** Stand_by mode are active
- Otherwise, valve will be closed, taking *Min. Setting* value from HMI screen

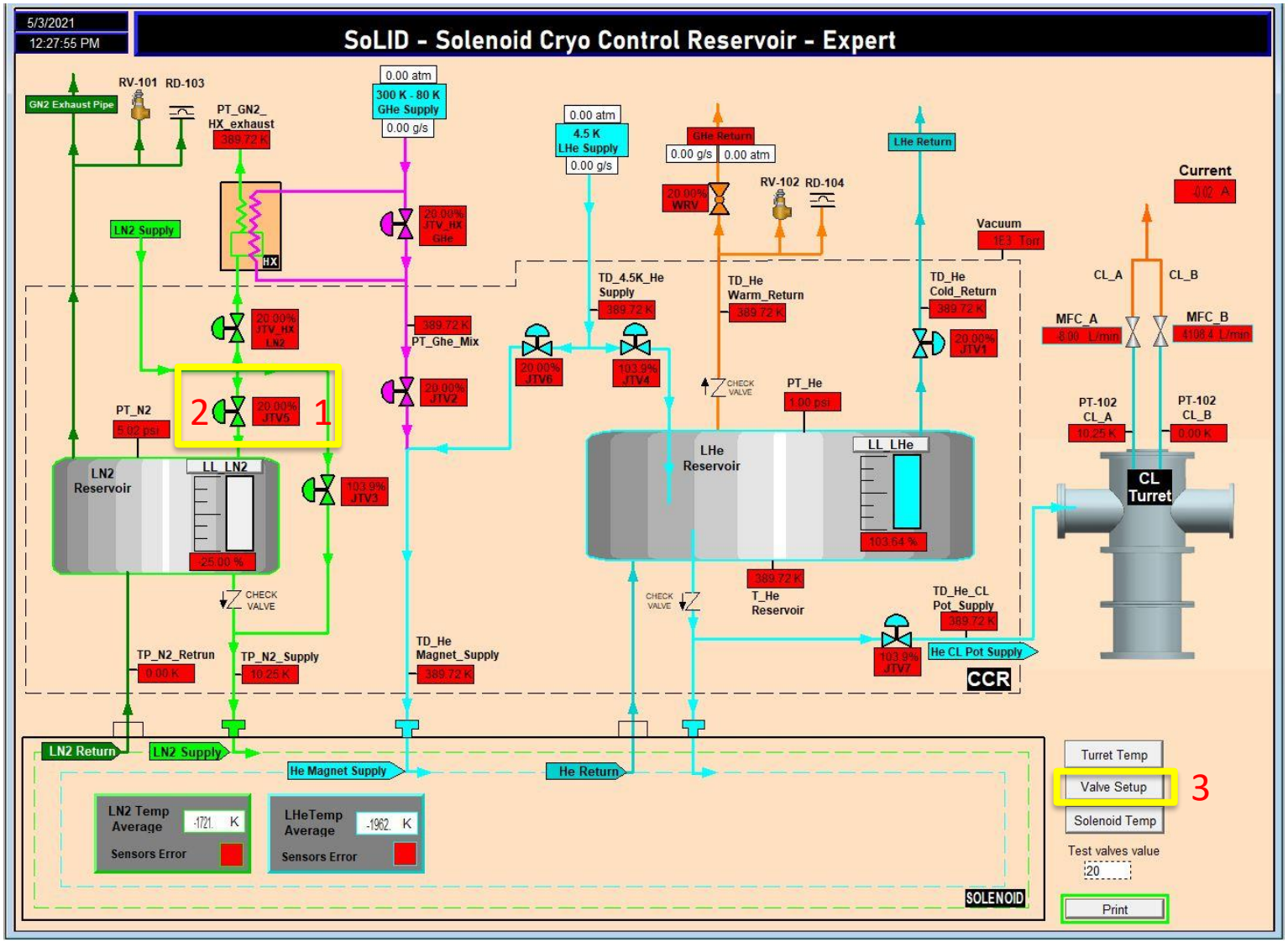
HMI Valve Controls - Cryo Control Reservoir

CCR Expert HMI screen

1. Overview status and monitoring of all valves

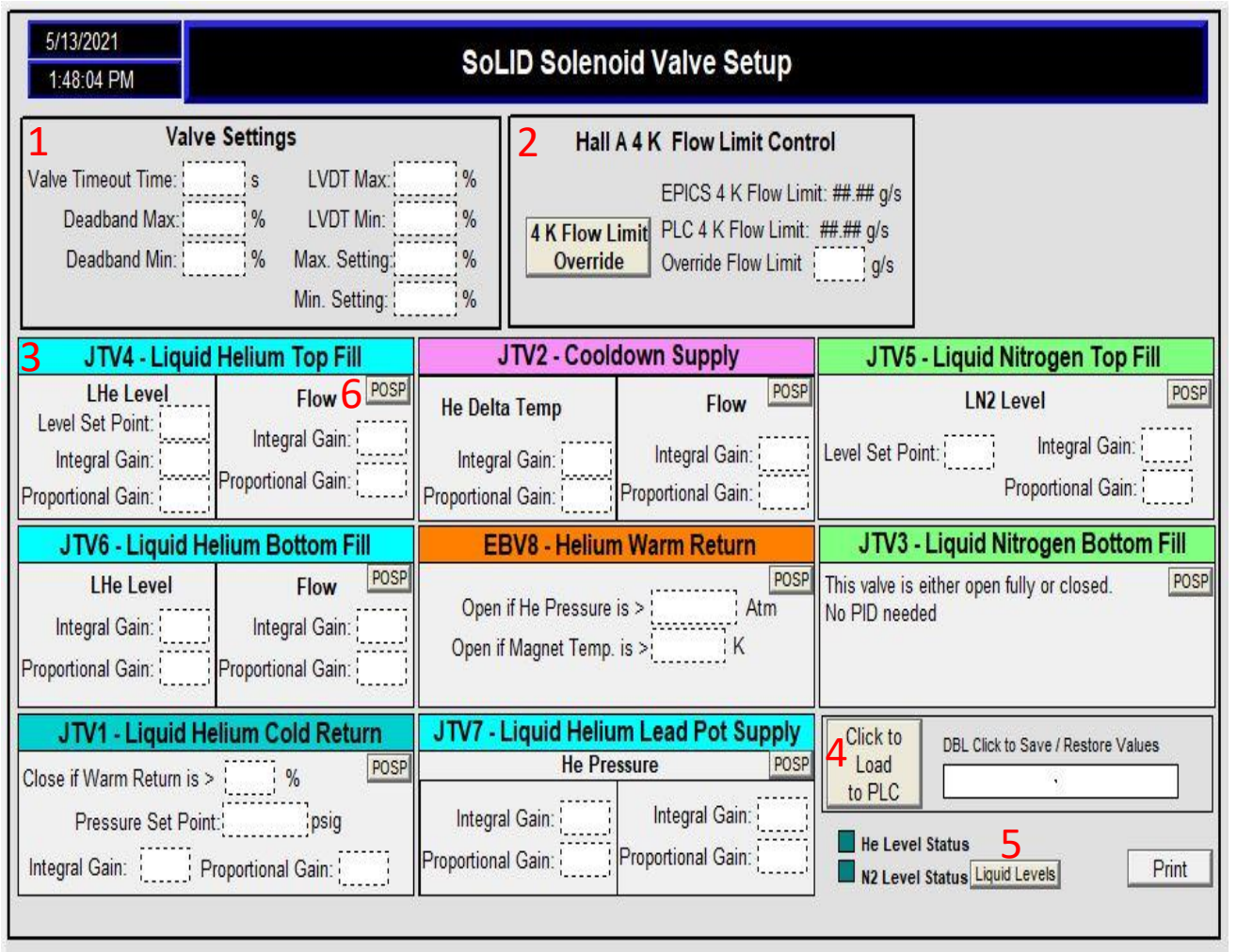
2. Clicking valve symbol opens corresponding *JTV_Page* HMI screen

3. Navigation to HMI screens used to control and monitor each JTV and EBV valve



HMI Valve Controls - Valve Setup

1. Valve settings
2. Hall A 4 K flow limit
3. Valve PID parameters control or setpoints for process variables
4. Save and restore options
5. Liquid level status
6. The position proportional (POSP) button opens POSP screen for each valve

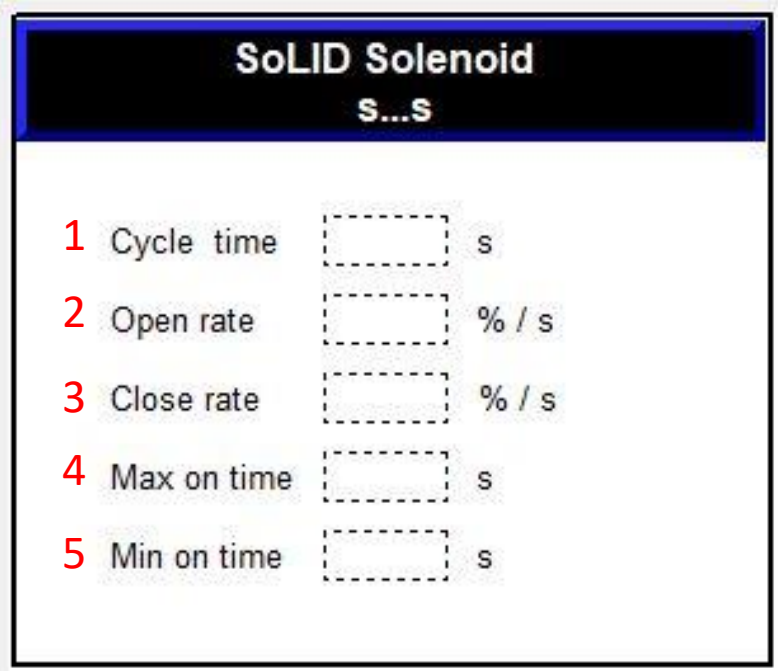


Valve Setup screen for setting values to control valves in automatic mode

HMI Valve Controls – Valve POSP

- Each JT valve has a screen
  - Accessed from *Valve Setup* screen
- Controls input parameters required for *POSP* instruction running in PLC controller

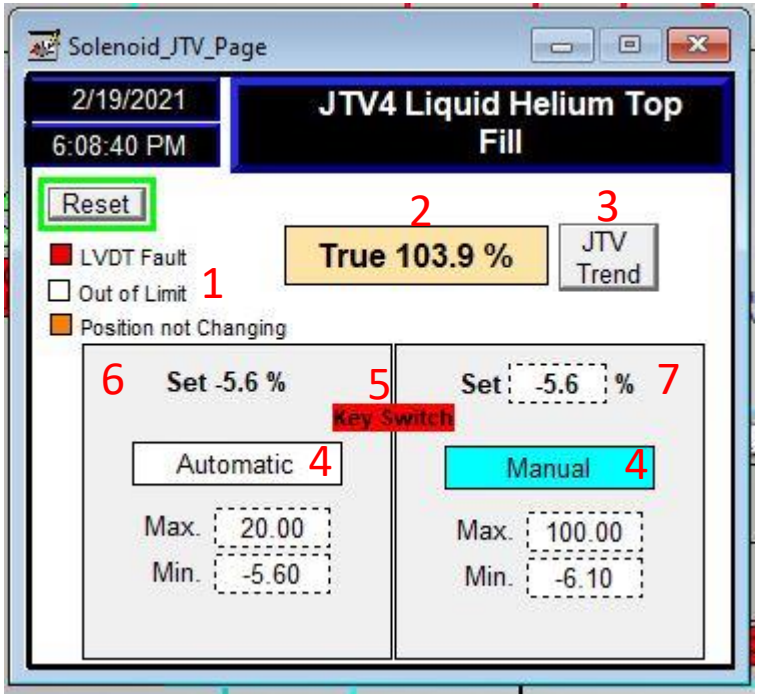
1. Period of output pulse
2. Percentage of valve to be opened per second
3. Percentage of valve to be closed per second
4. Maximum time that open or close pulse can be on
5. Minimum time that open or close pulse can be on



POSP screen developed for valves

HMI Valve Controls – JTV Page

1. Monitors valve positioning fault status
2. Readout value for valve aperture
3. Allows navigation to valve position readback trend plots
4. Allows selection of automatic or manual mode by clicking buttons
5. Monitors key switch status (local or remote)
6. **In automatic mode**
   - Values entered on max and min limits are used to set :
     - PID instruction limits
     - Entered limits for *Max Setting* and *Min Setting*
7. **In manual mode**
   - Directly controls valve position (*Set* value)
   - Max and min inputs ensures that *Set* value is within limits



JTV Page screen for JTV4 valve

Conclusions

- PLC programming and HMI screen development to control valves are mostly completed
- Documentation for valve control systems is in progress as part of the PLC Control Manual

Thank You