Observatory Automation Project
Detail Design Review – Control of Electric Dome Drive System

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1. Overview

After the preliminary design review, it's been decided that an electric drive solution will be implemented. Also, the Baldor solution was settled on as the controller unit.

Preliminary Design Document

Preliminary Design Comments

2. Background and Scope

The dome rotation is presently controlled with an Allen Bradley PLC based system mounted in the 4th floor computer room of the observatory. The PLC takes care of the low level controls of the dome's rotation. It sends commands to turn on and off pumps on the ground floor. The PLC sends a +/- 10 Volt signal to a servo amplifier (also in the computer room) which drives the hydraulic servo valves mounted at the three hydraulic drive units. The current Dome Control (rotation) documentation can be found here - Link.

TCS interfaces to the PLC. TCS commands the PLC to take care of the necessary low level functions of controlling the dome. The PLC acquires various pieces of status that TCS is able to read.

This document will address issues associated to the detail design of the control aspects of this project. There will be some overlap from this part of the project to the overall project. It is for this reason I am working in conjunction with Steve Bauman. Steve is the overall lead on the Electric Dome Drive project. All decisions and conversations go through him.

This document will not cover details of integration and implementation of the mechanics. However, it is understood that some aspects of integration and implementation of the mechanics will affect this aspect of the project. Where necessary, I will try to illustrate these parts as they affect the control system integration.

3. Requirements

3.1. The Requirements below were taken directly from the Preliminary Design Document (Link). Comments from the design review can be found here. Items in blue text were notes added by me. They were added to clarify in more detail what the requirement means.

Dome drive requirements needed for OAP

a) **Remote Dome drive Operation** The Dome drive must be capable of being operated in a "safe" reliable manner from Waimea.
   - When running at the summit (via manual control), there can be no possible way of running remotely from Waimea.

b) **Remote monitoring and status** The electronic drive system shall provide necessary status and system information.
   - The control system will work as well as the present system.
   - Phase 2 will access the additional status the electric drive units provide.

c) **Manual Control** The drive system control panel must allow local control of the drive system.
   - When in Manual (Local) Control, all the same safety features must be provided.
     - Sounding of audible alarm
     - No possible movement from computer control – See bullet "f" below.

d) **Preventative Maintenance** The dome drive system shall provide access to all serviceable components and minimize the need for scheduled maintenance.

e) **Improved Reliability** The new electronic dome drive system should increase the reliability and minimize repairs.

f) **Safe Interlocking** The dome drive system shall provide safety interlocking to prevent unauthorized remote control of the drive system. It shall protect personal and other critical systems when/if other systems shutdown or malfunction.
   - Also allow complete lock out of system for maintenance. This means Daycrew can safely service equipment without fear of any chance of unexpected dome movements.

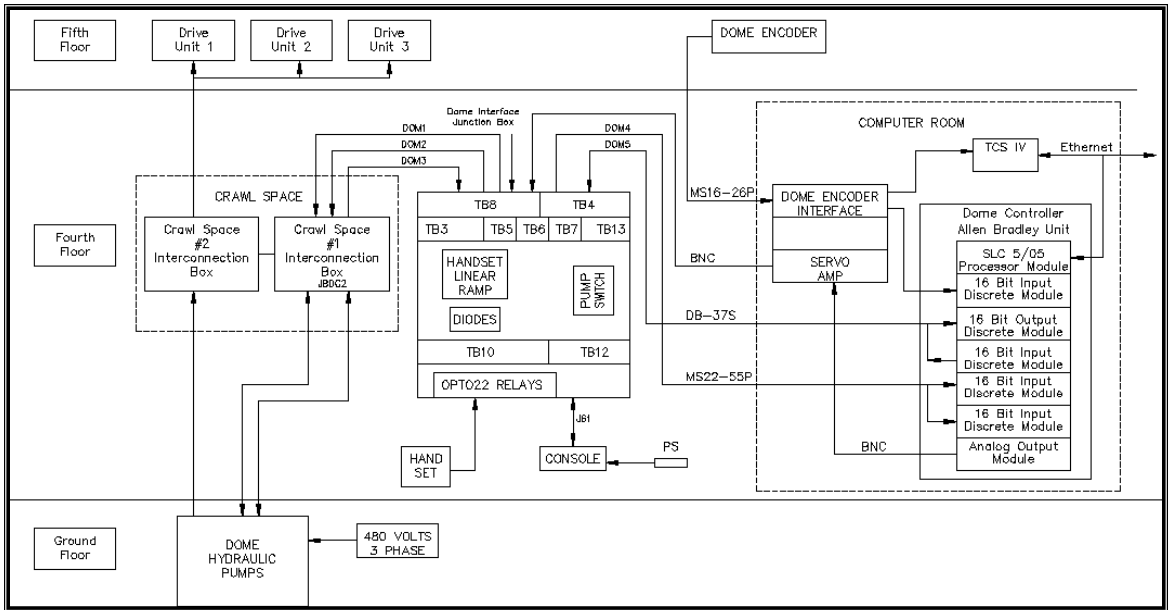
3.2. Phase 2 will include the status information available from the Baldor motor drive units. This is done via access to the RS232 channel. Hardware will be ordered and wired allowing access to this information. However, presently, this is not a requirement for implementation of this part of the project.

4. Detail System Design

4.1. The concept of reading the status and controlling the dome rotation will be the same PLC based system being utilized now. Modifications to the PLC controller will allow us to test and integrate the new system while still running the old system.

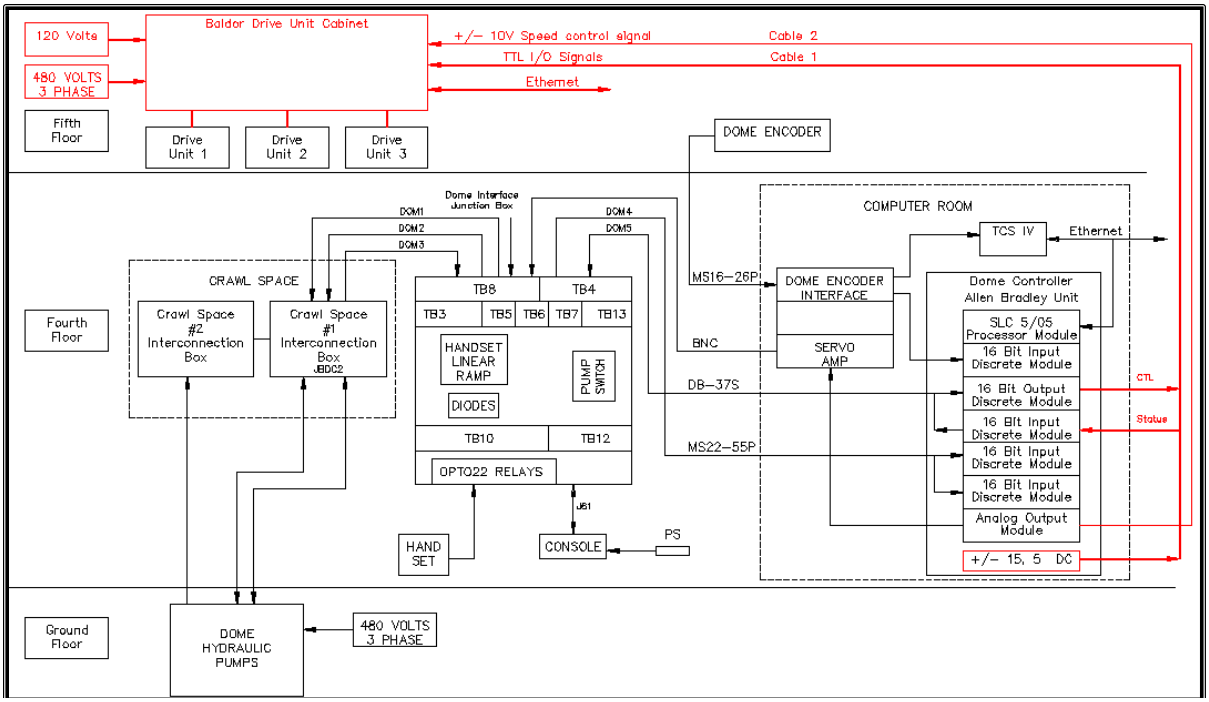
4.2. The Block Diagram below depicts the current system - Link

a) The Allen Bradley Unit (PLC) does low level control of dome rotation.
   - The PLC receives dome position via the Dome Encoder.
   - The PLC turns on/off the pumps (Ground Floor) via the 16 bit output module.
   - The PLC drives the 3 drive units by sending an analog output signal to the servo amp. The servo amp signal goes through the crawl space and drives the servo valve at the drive units.



4.3. The Block Diagram below depicts the system to be implemented. - Link

a) The red lines indicate the changes to the existing system.
b) A new drive unit (motor controller) cabinet will be mounted in the visitor's gallery.
c) Control and status information will be passed between the PLC and the Baldor drive unit cabinet via two cables.
   - Cable 1
     - On/Off – Control of the drive units.
     - Manual/Off/Automatic status – Same as existing dome panel in 5th floor.
   - Cable 2
     - Analog +/-10V control signal to drive speed and direction of dome.
d) Ethernet to obtain status of the motor drive units.
   - A Perle Device will be mounted in the Baldor cabinet to interface to each of the drive units' RS232 channel (optional module).
   - Phase 2.



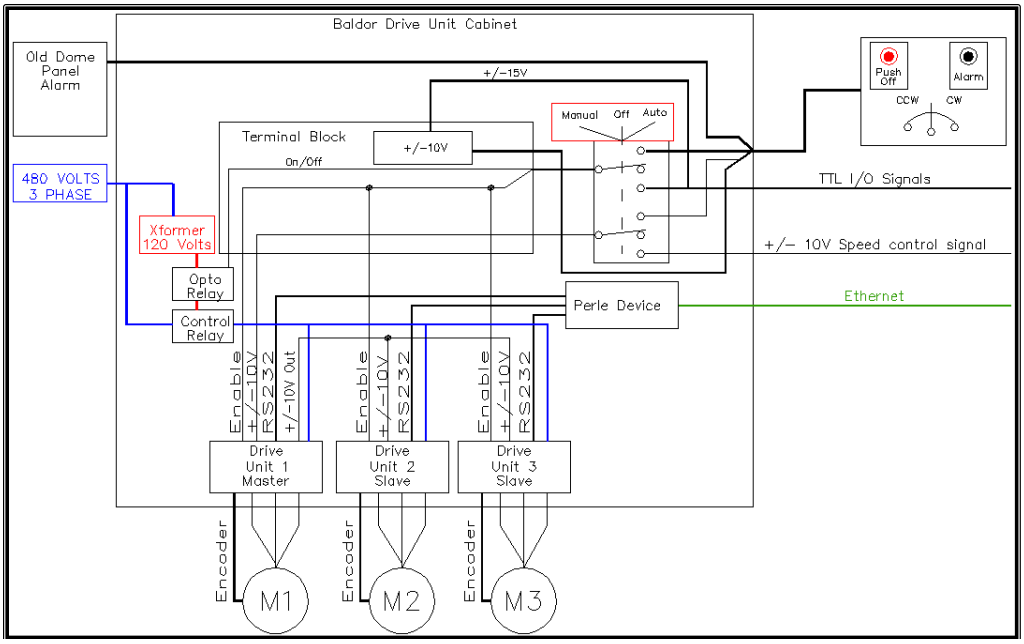
4.4. Phase 2 (future) can tap into this capability as the need arises. Information can be available to people via web pages, GUI's. Alerts can also be generated based on desires of technical staff.

4.5. Block Diagram of the Baldor Drive Unit Cabinet below. - Link

a) 3 Baldor Drive units drive the three electric motors.
   - 1 Master unit with 2 units configured as "following" units.
     - Master unit will receive +/-10V speed/direction signal. Follower units will sync to the master and match the master's speed and direction.

b) Manual/Off/Automatic selector switch on the front panel will act like the switch on the existing dome drive panel on the 5th floor.
   - Switch position will feed back to PLC.
   - Manual – Allow manual movements of the dome from the 5th floor.
     - Features a handheld manual control box with a 100' umbilical cord.
       - On/Off Control from box.
       - Audible alarm push button for warning – Will use existing audible alarm in dome.
       - Allow positioning of the dome in a safe manner from different positions within the dome.
   - Off – Allow lock out of the dome for servicing.
   - Automatic – Allow computer, remote control of the dome's rotation.

c) Perle Device allowing future acquisition of status from motor driver units.



4.6. PLC Schematic
- a) Items in black illustrate existing PLC panel wiring.
- b) Items in red illustrate modifications necessary to the PLC panel.
  - +5V – Opto Relay control power (interface to Relays and Drive units).
  - +/- 15 volts – Create the +/- 10 volt signal for Manual Control.
  - On/Off and Enable of the drive units.
  - +/- 10 volt drive signal to control speed and direction of dome.
  - Input status of Manual/Off/Automatic switch position.

4.7. Baldor Cabinet schematic:
- a) Baldor will build the cabinet and deliver it to us for install. Several items will be provided by us to be installed into the cabinet. A list of these items will be provided further down in this document. The schematic diagrams below are for reference. I have produced them so I can plan what it will take to control the dome. Baldor will deliver schematics with their documentation.
- b) Schematics:
  - Page 1
    - Power hook up and control of the 3 Baldor drive units.
    - Interface via manual and remote (computer) control.
  - Page 2
    - Parts detail call out.
    - Schematic detail illustrating control of the actuators.
    - Detail schematic of the manual control.
    - Detail layout of the opto relay board required to interface the PLC to the motor driver units.
    - Wiring of the Perle device for RS232 communications.

5. Control System Design

5.1. Basic Flow of Commands:
- a) TCS/PLC interface will not change. All commands and status will stay the same.

5.2. Control Modes:

a) This too will be the same as before. No OAP requirement of dome rotation. Only status of 5th floor panel as it is now.
   - Local (Manual) – Allow manual movements of dome rotation from within the 5th floor environment.
   - Remote (Computer) – Allow remote control of the dome's start up and functionality.
   - Off – Removal of power from the dome drive units. Allow safe maintenance by personnel. No possible way of any manual or computer control signals turning on or moving the dome.
   - Low level Engineering status and control when needed for testing and integration via RSLogx PLC software.

6. Software Interface

6.1. Dependencies on other projects.
   a) TCS – All interfaces, controls and GUI's are currently in place.
   b) OAP – All GUI's and interfaces go through TCS. No changes necessary.
      - Phase 2 will provide for necessary status as required.

6.2. Software Data Registers.
   a) No changes required to data registers.
   b) Control code
      - Minor changes to code to allow running of both hydraulic and electric drives. This will be required so integration and testing can take place during daytime hours while still allowing uninterrupted observing at night.

7. Implementation Plan – It is assumed that Baldor will fabricate the cabinet that will house the drive units. I (CFHT) will supply the necessary hardware (Opto relay board, connectors, etc) necessary for PLC interfacing.

7.1. Modify the PLC Panel in the computer room. – 1 day (gm)
   a) Add 2 connectors and wires to panel.
      - Isolated BNC connector for +/- 10 V drive to drive units.
      - MS12-10S connector to interface I/O to drive unit cabinet.

7.2. Cabling between computer room PLC to dome drive unit cabinet 5th floor. – 1 day (gm, LR, LM?)
   a) Route cables from computer room to approximate location of Baldor cabinet.
   b) Put connectors on both ends.
   c) Test PLC code through cables.

7.3. PLC code modification – 2 days (gm)
   a) Allow parallel outputs to both the servo amp (hydraulic control) and electric drive. This will allow integration and testing to occur without affecting observing.
   b) Allow inputs from "Manual/Off/Automatic" switch on new panel to act the same as the switch in the old dome panel.
   c) Tests without Baldor cabinet.
      - Behavior of existing Manual/Off/Automatic switch?
      - Dome On/Off via PLC (engineering level) and user (TCS) level controls.
      - Dome moves via PLC (engineering level) and user (TCS) level controls.

7.4. Integration – This is integration of the controls. This is not integration of the motor, motor plates, adapters and gear train. Control integration can occur in parallel with the mechanical work needing to be completed.
   a) Assumed the motor unit cabinet will be mounted in its location on the 5th floor.
   b) Test operation of S1 (Manual/Off/Automatic switch).
      - Switch between modes

- What does PLC do?
- Status displays?

c) Testing of PLC controls. All tests to be done at low level engineering level using RSLogix. When satisfactory operation is achieved, testing to be checked with TCS and verified at the OAP level (OAP status).
   - Conduit and wiring to motors ready and in place. Motor on a stand.
     - Manual Mode - S1 switch in Manual position (using Manual Control Box)
       - Test Horn.
       - Be able to turn on and off the unit via red push button switch.
       - Drive units enabled?
       - What happens when manually turned on and S1 switch moved from Manual to Off and then to Automatic?
       - With drive unit on and enabled,
         - Be able to drive electric motor CW and CCW with manual control.
           7.4.c.....1. Have dome being driven hydraulically. With motor on test stand have electric motor driven and compare acceleration, deceleration behavior.
     - Automatic Mode - S1 switch in Automatic position
       - Be able to turn on and off the unit via PLC.
       - Drive units enabled?
       - What happens when Automatically turned on and S1 switch moved from Automatic to Off and then to Manual?
       - Be able to drive electric motor CW and CCW manually via PLC (Engineering commands).
       - With drive unit on and enabled
         - Test acceleration and deceleration via PLC during typical dome moves.
           7.4.c.....1. Have dome being driven hydraulically. With motor on test stand have electric motor driven and compare acceleration, deceleration behavior.
     - Off Mode - S1 switch in Off position
       - Are we able to turn on dome via Manual or Automatic controls?

d) Air actuators integration and testing. – (daycrew, SB, gm)?? days
   - Test implementation of air actuator without connection to drive unit.
     - Up/Down?
     - Loss of power?
     - Loss of air?
   - Integration of air actuators
     - Lift one hydraulic unit.
       - Remove hydraulic actuator and install air actuator.
       - Test actuator
         - Up and down.
         - Close off needle valve(s),
           7.4.d.....1. Remove air from system.
           7.4.d.....1.1. Does actuator stay in up position?
           7.4.d.....2. Remove power from actuator valve.
           7.4.d.....2.1. Does actuator stay in up position?
       - Test dome drive using air actuator and hydraulic drive motor.
     - With operation of air actuator proven:
       - Replace 2nd actuator with air actuator.
         - Test 2nd actuator like first.
       - Test drive with two air actuators and hydraulic motors.
       - Repeat with 3rd actuator.

e) Motors integration and testing. – (daycrew, SB, gm)?? days
   - After we have all 3 electrical motors running on stand with desired performance:

- Verify performance with 2 hydraulic drive units.
- With satisfactory performance, start replacement of hydraulic drive units with electrical units.
- After completion of 2nd electrical motor integration, lift the 1 hydraulic drive unit and run with 2 electrical motors until 3rd motor can be integrated.

f) Final acceptance: – (daycrew, SB, gm)?? days
   - Does dome drive using electrical drive meet requirements?

8. Drafts spares list.

8.1. See cost estimates

9. Safety Implications

9.1. Same precautions exist as with current dome operations.

a) Lock Out/Tag Out - Two levels:
   - Main breaker to panel – Electrical maintenance work by electrician.
   - Manual/Off/Automatic – Maintenance via daycrew or instrumentation personnel.

10. Time and Resource Estimate.

10.1. See Implementation plan above

11. Cost Estimates

11.1. Many of the items are already in stock. Many of the items will be supplied with the panel delivered by Baldor. Listing only parts that need to be provided for controls and upgrades to existing equipment.

11.2. * - Items to be delivered to Baldor by CFHT to be installed into cabinet.

Item	Qty	Spare	Description	Cost (ea)	Total	Notes
1*	0	1	Opto22 – G4PB16T Relay PC Board	140.25	140.25	Spare unit required – recycling old PFB unit taken out of old controller. Newark Link
2*	2	4	Opto22 – G4 OAC5 AC Output Relay	13.09	78.54	AC Opto Output relay - Newark Link
3*	0	4	Opto22 – G4 ODC5 DC Output Relay	13.09	52.36	DC Opto Output relay – Newark Link
4*	1	0	4 port Perle IOLAN	450.00	450.00	Same devices used in other areas of company. Spares throughout. - Link
3	1	N/A	MS12-10P cable connector – PLC interface cable	--	--	Lab Stock – already acquired.
4	1	N/A	MS12-10S cable connector – PLC interface cable	--	--	Lab Stock – already acquired.
5*	1	N/A	MS12-10P panel connector – PLC interface	--	--	Lab Stock – already acquired.
6	1	N/A	Isolated BNC connector – PLC motor drive	--	--	Lab Stock – already acquired.
7	1	N/A	MS12-3S cable connector – PLC motor drive.	--	--	Lab Stock – already acquired.
8*	1	N/A	MS12-3P panel connector – PLC motor drive	--	--	Lab Stock – already acquired.
9*	1	N/A	MS14-18P panel connector – Manual Control Box	--	--	Lab Stock – already acquired.
10*	1	N/A	MS14-18S cable connector – Manual control	--	--	Lab Stock – already acquired.
11*	1	N/A	MS14-18P cable connector – Manual control	--	--	Lab Stock – already acquired.
12*	1	N/A	MS14-18S panel connector – Manual control	--	--	Lab Stock – already acquired.
13	1	N/A	MS10-6S cable connector – Horn connection	--	--	Lab Stock – already acquired.
14*	1	N/A	MS10-6P panel connector – Horn connection	--	--	Lab Stock – already acquired.
15			Various wire and cable stock.	--	--	Lab Stock – already acquired.
				Total:	**$721.15**	

12. Summary

12.1. Work on the PLC rack and software can commence immediately following design review. Cable routing and some testing can also commence immediately.
12.2. Schematics still need to be updated with more current part numbers etc.
a) This will not affect the controls (PLC) aspect of the project.
12.3. Once again, this document only illustrates the necessary work package for the controls.

13. Notes:

13.1. For Phase 2 and future – Potential ideas?
a) RS232 communications can be used to acquire status from the Baldor drive units.
- Baldor RS232 module - Link
b) Air actuator status????
- State of air pressure at actuators?
c) Wiring of PLC control output to sound audible (horn) alarm?
- Currently the dome can move automatically via computer control. I know there is plan in works to have audio announcement in dome during observing. However, during daytime hours, there is potential for the dome to be turned on and moved via computer control and no one would even know it. We will have safeties in place for daytime service of dome but this would be an issue if people are not working on dome systems and a dome on and move was commanded.