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The IRTF purchased Baldor Servo Motion equipment to upgrade its Dome Servo System. This baldor system is quite complex, and the IRTF is seeking expert advice with configuring and deploying this servo system. This memo outlines a request for consulting services.

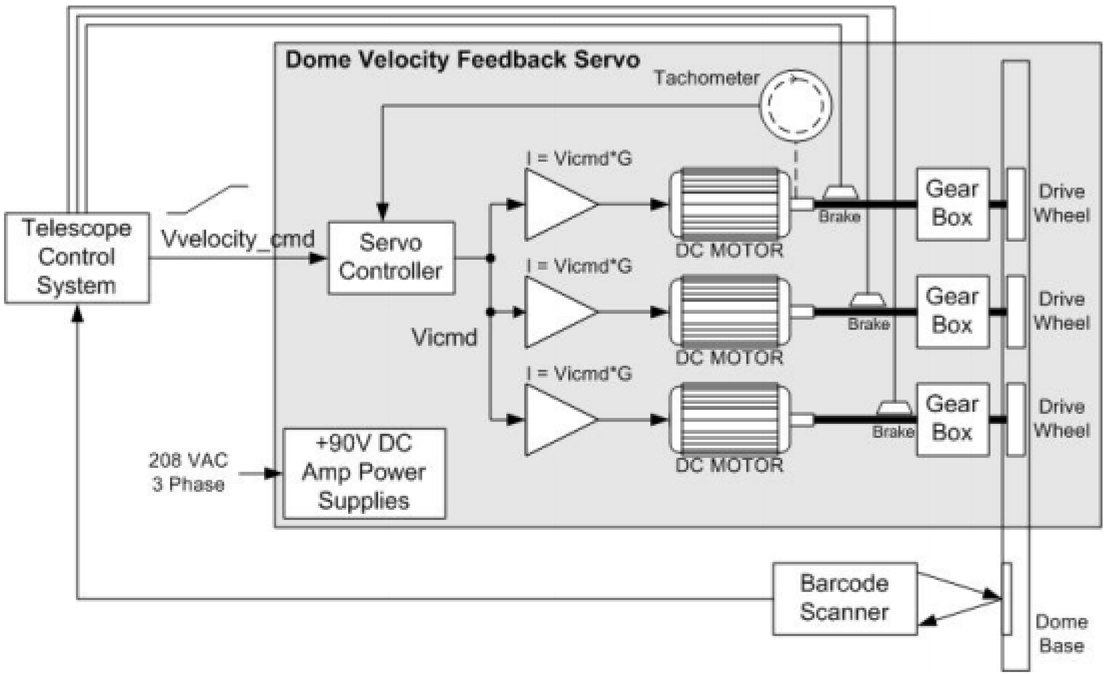
1. Current System

The Dome Servo controls are command by the IRTF Telescope Control System (TCS). The TCS command the dome from a 10 Hz software loop. A general dome command sequence would be:

1. Release brakes via TTL. Wait 0.5 seconds.
2. Ramp up to desired velocity using -/+ 10v analog output. Accel is 0.150 deg/sec^2. Max velocity is 2 deg/sec.(10volts=2deg/sec).
3. Decelerate a velocity of 0 (0volts), rate is 0.150 deg/sec^2. (same as accel).
4. Wait 10 seconds. Set brakes vi TTL.

Here a simple diagram of the current system (from http://irtfweb.ifa.hawaii.edu/~tcs3/tcs3/1202_dome_upgrade_docs/DomeDriveServoSpecifications.pdf)

The complete system consists of a servo with tachometer feedback, 3 amplifiers, 3 brushed DC motors, and DC power supplies. The telescope control system (TCS) provides a velocity command to the servo and receives dome position feedback from a barcode reader and barcodes pasted onto the dome base. The servo in turn provides an identical current command to all 3 amplifiers as required to reach the commanded velocity. The velocity feedback servo being specified is contained within the shaded box.



- The gray box ("Dome Velocity Feedback Servo") is to be replace the the baldor hardware.
- The TCS provides the servo controller with Vvelocity_cmd, a -/+10 volt representing -/+2deg/sec velocity command for the dome.
- The servo controller uses the velocity request (Vvelocity), and tachometer (sensor) to compute a current request to the Amp (Vicmd). All 3 amplifier see the same current request. i=Vicmd*G indicates the current has a gain term.
- Dome Motor current from each amplifier is obtain by the TCS using 3 analog inputs (-/+2.5 volts representing -/+ 30 amps).

At the time the hardware was purchased, some discussion with IRTF and Baldor about the CFHT (Canda France Hawaii Telescope) upgrade was discussed. It was indicate a similar control scheme would work for the IRTF. Here is an email except:

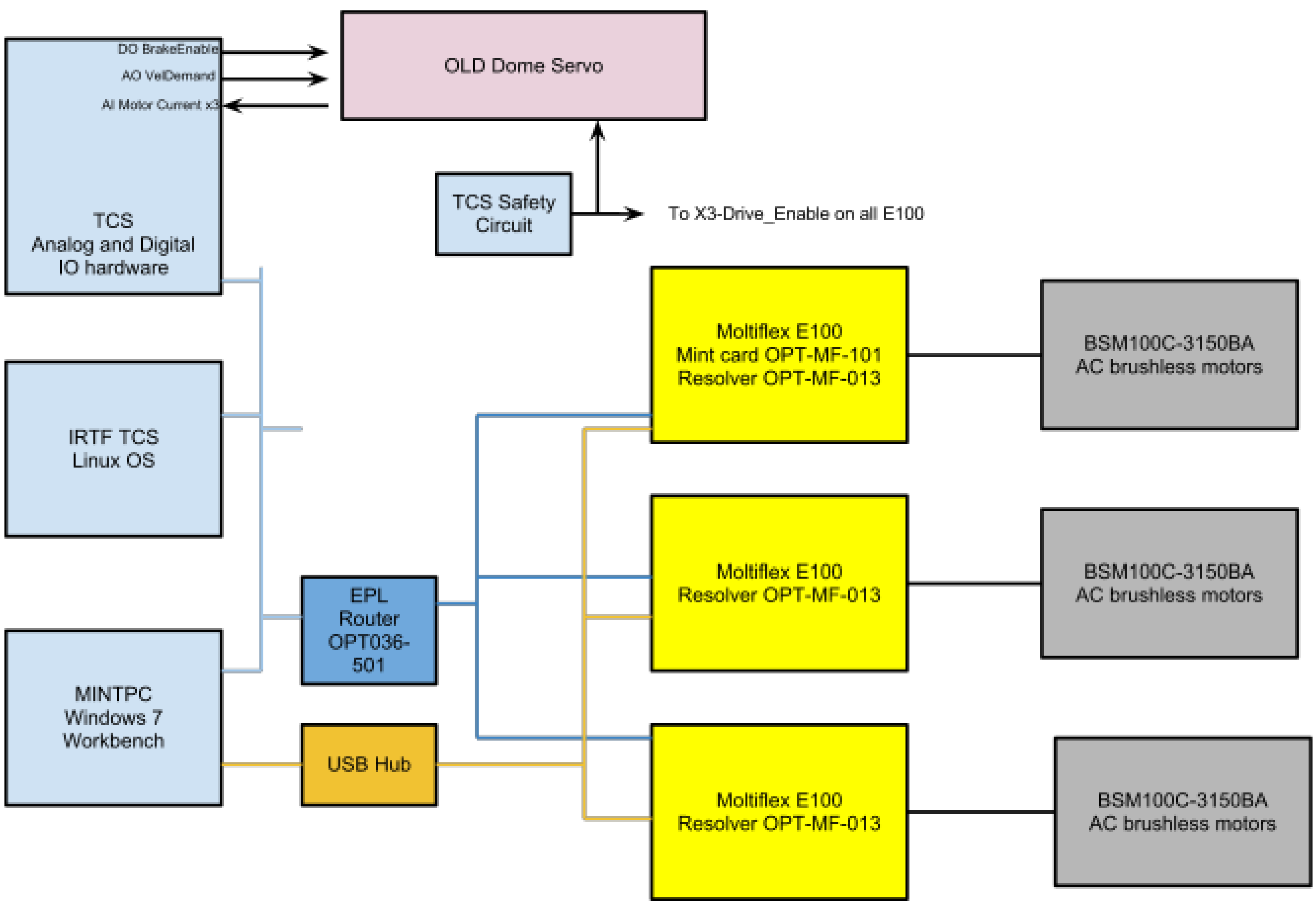
"On the control scheme – we actually did speed matching with torque override. Essentially, we had a master control that was strictly in velocity mode. We buffered the encoder of the master into the 1st slave (120 degrees apart as well) – for velocity control. However, we also took the current output of the master and brought it into one side of a differential input on the follower. We brought the current output of the follower into the other side of the differential input thus being able to compare currents of the master to the follower. We ran a sloppy PID loop with a set point of 0, allowing for a maximum speed variation of something like 10 RPM tomatch current. This allowed us to balance the current, without erratic speed or torque changes enabling a smooth system."

2. Baldor System

The IRTF Baldor equipment consist of these items. However, it is possible to adjust the options.

1. Moltiflex E100B MFE460A021B, 3 each
2. Baldor Resolver, OPT-MF-013, 3 each
3. Baldor Servo Motor, BSM100C-3150BA, 1 each
4. Baldor Mint card, OPT-MF-101, 1 each
5. Baldor PowerLinx Router, OPT036-501

Below is a diagram of the system of the current system.



A more detailed writing diagram is here:
http://irtfweb.ifa.hawaii.edu/~tcs3/tcs3/1202_dome_upgrade_docs/.

The TCS computer runs Linux. A direct interface between the TCS and the Baldor controller is highly desired. We do not want a Window's PC to be required for normal operations. But a window PC will be dedicated to the baldor servo system for diagnosis, connect via USB.

A TCS safety circuit is connected to the X3-Drive enable. This circuit monitors various input (limit sensor, current sensor, watchdog timer, emergency button), and will disable the amplifier to the telescope if any safety condition exist.

Suggested Interface between the TCS and Baldor controller for commands and/or telemetry:

1) Analog or Digital IO. The following IO exist for the current system:

Digital Out - Brake Off/On (also Enable/Disable AMPs).
Analog OUT - Velocity Request (-/+10volt) to servo controller
Analog IN - 3 channel (-/+10 volt) to indicate dome current.

For the Baldor servo system, we request that the TCS Digital out(Brake off/on), and Analog Out (velocity request) be used to command the Baldor Servo System.

2) COMMS Array- We have implement COMM array read/write using the Mint API/ICM protocol over TCP/IP (MN1948) in linux. However only the Get/SetCOMM single, and Get/SetCOMM multiples functions are implemented.

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Telemetry information - we desire telemetry information to the TCS a a ~10HZ update rate. This information should include:

Error Indicator
Drive Current (CURRENTMEAS)
Brake Status (MOTORBRAKESTATUS)
Demand/Actual Velocity (VEL/VELDEMAIND)
DriveEnable (DRIVEENABLE)
AxisStatusWord (AXISSTATUSWORD).
Others to be determined

This telemetry data should be written into the COMMS array area. Our linux system will read the COMMS array at a minimum of 5Hz (10HZ is preferred) for updated information. The data will be updated using a MINT loop. This will enable the IRTF to customize or modified the telemetry information.

Servo Algorithm

The Moltiflex e100 with the MINT option will acts as the Manager Node. The 2 Controller nodes will configured as followers. Having the ability of select either a Velocity follower or Position follower (at compile time) is desired. The exact algorithm and configuration will be recommended by the consultant, and agreed upon by the IRTF.

4. Gear Ratios, Encoder Counts, Velocity and Acceleration

Max Dome Vel is 2.0 deg/sec.
Max Dome accel is 0.166 deg/sec.

Gearing Ratio between Motor shaft and Dome:

- The gearbox ratio is: 24.64
- The spur gear ratio is: 76/21=3.62
- The bogie wheel to dome ratio is: 768/20=38.4
- The total ratio is: 3424.2559

We need 3424.2559 rotations of the motor shaft to have a 1 revolution of the dome.

User Unit - 1 Motor Rotation has 4096 encoder counts. Baldor suggest we set the scale factor to 4096 user unit are in Rotation. Velocity will be in Revs/Sec.

```
rpm2deg = 0.0017522054937541322  // Motor RPM to Dome deg/sec
                                // R/M * 1/60 min/sec *  360 deg/rot / 3424.2559 gearing

uu2deg = 0.10513232962524792    // Motor UU  to Dome deg/sec
                                // R/S *  360 deg/rot / 3424.2559 gearing


deg2rpm = 570.70931666666672  // Dome deg/sec to Motor RPM
                             // deg/s * (1 rot/360 deg) * (60sec/min)  * 3424.2559

deg2uu  = 9.5118219444444456  // Motor UU r/s to Motor RPM
                              // r/s * (1 r/360 deg) * 3424.2559
```

	Dome deg/sec	Motor RPM	UU (user units) rev/sec
Max Vel	2.0	1141.41	19.0236
Max Acc	0.166	94.7377	1.57896

5. Deliverable

A baldor configuration will be delivery. This should include device configuration files (dfc), mint program files (.mnt), and Mint workbench project files (.wbx), Parameter table (.ptx), and a controller archives (.zip).

A document describing the servo setup, and key configuration elements shall be provided. Also include would be key servo parameter to be used during tuning the servo system.