To: File
From: Jon Hagen
Date: 8-19-99
Subject: Testing a Kollmorgen B606 motor to replace the original (smaller) tiedown motors.

A spare azimuth drive system amplifier, a Kollmorgen BDS4A-220H, was connected in the lab to a spare Gregorian drive motor, a Kollmorgen B606-A-B2-B9S-095. The amplifier was first fitted with a 606 compensation board on which the velocity feedback components (R4, R13, and C12) had been replaced. Vertex had removed these components to disable the internal velocity feedback loop. With this restored compensation board, the full model number of the amplifier would be BDS4A-220H\606A2. Attached is the Kollmorgen data sheet for this compensation board.

The amplifier was powered by a PSR4/5A-275 supply, a spare for the Gregorian drive system. A dual lab supply with a 5k pot supplied a -10V to +10V manual control signal. A hand-held tachometer measured the speed of the motor shaft. A second lab supply provided 24 volts to release the brake. Primary 3-phase voltage (220V between phases) was taken from a breaker above the cable tray. Other connections were 120VAC for the power supply, a bias voltage jumper cable from the power supply to the amplifier, and a toggle switch to enable the amplifier.

Test results:
Sense of rotation when facing the end of the output shaft: **Clockwise** for positive differential control voltage.

Control voltage	Speed	Speed Monitor voltage
0V	0 RPM 0	
+1.05V	160	
+2.04	321	
+4.05	638	+3.3
+9.95	1466	
-4.00	640	+3.3
-10.06	1484	

With the brake applied and the control voltage set at zero, the motor did not move and the current monitor port (pin 18) read only a few millivolts. Increasing the control voltage slightly made only a slight change - the current did not integrate up to any appreciable value. (The op-amp integrator in the Kollmorgen amplifier has a large value resistor shunting the integration capacitor). The control voltage was increased all the way to the full 10 volts. At nearly full control voltage, the motor began to creep, overcoming the brake. At this point, the current monitor voltage read 5.3 volts (Kollmorgen states that a reading of 8 volts corresponds to the peak RMS current rating of the BDS4). No over-current trip occurred.

Control voltages up to +/- 14V produced correspondingly increased speeds without tripping the amplifier's overspeed circuit.

8-25-99
The amplifier and motor were installed at Tiedown 4. Performance was sluggish; in a sinewave test, this tiedown would stop at the turnarounds until the PI loop in the Little Star controller integrated up a sizeable drive signal- several volts - to overcome the static friction. The system seemed to lack gain and, indeed, it was found that Vertex had made another modification to the compensation board to lower the dc gain by a factor of 400. The modification consisted of replacing C2 by a shorting jumper. This bridged R9 directly across the op amp. (One wonders why Vertex didn't simply externally enable "Torque Hold" mode externally by grounding pin 14 of connector C1). After reinstalling C2 (0.15uF) and R9 (14k), the amplifier was finally back to being a stock BDS4A-220H\606A2 and the tiedown behaved properly.

Description of the Kollmorgen Amplifier

Kollmorgen rates their motor/amplifier combinations for torque and speed but they gives no information about the dynamics of the velocity loop apart from what can be inferred from their simplified schematic of the BDS4 amplifier.

Referring to the description of the BDS4 on page 1-4 of the Kollmorgen manual and looking at the simplified schematic on page F-55, we see that the motor current and therefore the torque, is forced to be proportional to the output voltage of the loop filter op amp, i.e. the voltage at the top end of the Stability pot. We could bring out a test point and do a lab test to measure the proportionality constant. We can also make a guess: Since the speed monitor and current monitor outputs produce 8 volts for maximum speed and maximum current, let's guess that the maximum current is produced when the output of the op amp is 8 volts.

DC Gain

The most basic characteristic of the amplifier is its dc gain. The loop filter does not contain a perfect integrator, as the op amp is bridged with a 10M resistor. At dc, therefore, the gain is finite. We can calculate the dc gain as follows: The differential voltage at the Command Input is first multiplied by a factor of 0.81 by the differential input amplifer. Referring to the schematic, 16.2k/(10k+10k) = 0.81. Note that this factor, 0.81, may be reduced by adjusting the Command Scale pot. The resulting voltage, 0.81Vdiff, is connected to the summing point of the op amp through a 20k resistor. At dc, the only feedback is provided by the 10M bridging resistor, so the gain of the op amp is 10M/20k = 500 and the gain from the Command Input to the output of the op amp is 0.81·500 = 405. Suppose the motor is stopped and the velocity command is zero. A velocity command of only 20mV will produce 8 volts at the output of the op amp, i.e. full torque.