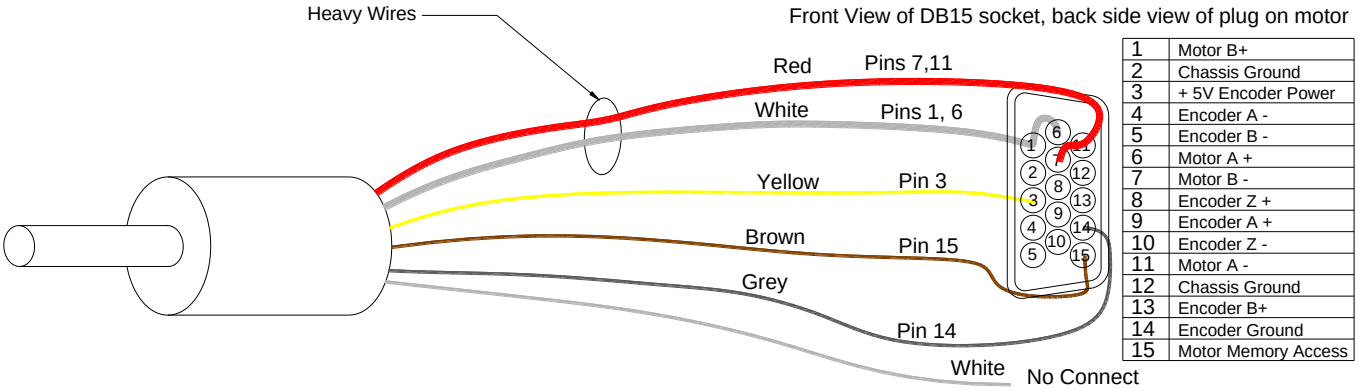
Voice Coil Motors with Analog Feedback

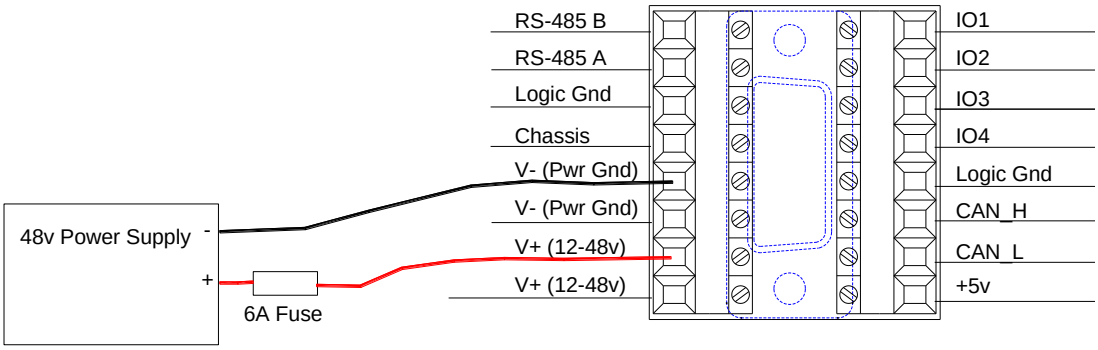
BEI Kimco (and others) provide voice coil motors with analog (Hall Effect) feedback. These motors may be ordered with a .1 to 3.3v output range and 2kHz internal filter. These settings will optimize their performance with the the SilverSterling™ controller family.

Driver Connections

The Voice Coil Motor has two wires associated with the motor. These are typically color coded as RED for plus (+) and WHITE for minus (-). A positive current moves the shaft in the positive reference direction (see BEI documentation). The SilverSterling™ supports the connection of either a single driver channel (5A continuous) or both driver channels (10A continuous). The input power current is limited to 5A average, but the drivers act switched mode converters. Operation of a 12 or 24v actuator from a 48v supply will allow the full 10A capability (usually limited by the thermal capability of the motor). The driver circuit in the SilverSterling includes output inductors. These inductors allow the two phase outputs to be directly connected when operating a DC motor. If the higher currents are needed, connect Motor A+ to Motor B+, Motor A- to Motor B-. For smaller motors use Motor A+ and Motor A- connections.

If the motor is ordered with the sensor output configured for 0.1 to 3.3v outputs, the motor can





be directly connected to the motor port with no voltage divider needed. The driver should be ordered with the –B option to remove an internal 1k pullup so the analog sensor can drive the analog input over the full input range.

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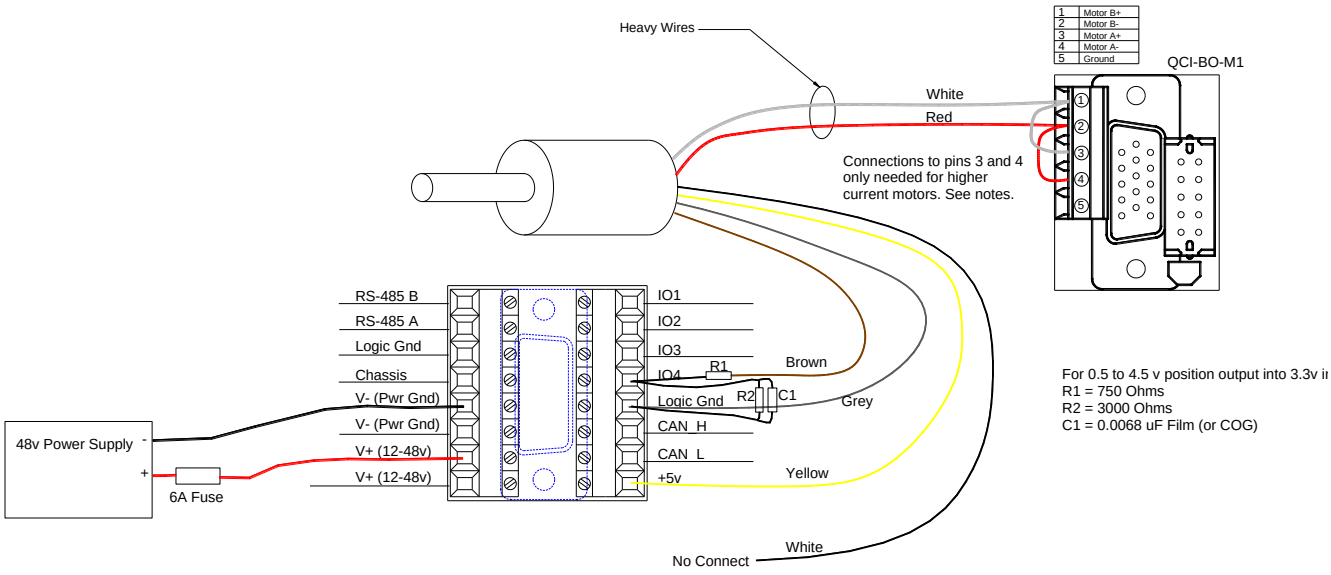
If the motor is ordered with the 0.5 to 4/5v outputs, a voltage divider will be needed. These connections can be made directly to a 15 pin male high density D-sub connector or the QCI-BO-M1 breakout board. The connections are shown below:



Sensor Connections

The BEI linear actuators typically have four (4) wires associated with the analog feedback sensor. These are +5v, Ground, Analog out, and Vp. Vp is used at the factory to configure the gain and offset of the sensor and should not be connected to anything in the customer installation. The 5v power may be connected to the 5v output on the QCI-BO-S1 break out board; the Ground connection should be connected to the Logic Ground connection. The output needs to use a voltage divider if the feedback sensor output range exceeds the 3.3v used for the IO. (Note: the actuator can be ordered with the output sensor range set to 0.1v ot 3.3v to eliminate the need for a voltage divider. It should be ordered with the 2kHz sensor bandwidth for optimal performance).

The voltage divider is accomplished using a 750 ohm resistor in series with the sensor output line and connected to IO4 (the analog input) and a 3 kohm resistor from the Analog input (IO4) to Logic Ground. Some noise filtering and more accurate readings require the addition of a .005 to .01uF capacitor. This capacitor should have low leakage and low dielectric absorption. A film capacitor or a COG ceramic should work well.

The Motor Memory input has a 3.3k pullup to 3.3v, which should not affect the direct drive sensor output (.1 to 3.3v) but will affect a voltage divider if not buffered.

Initialization Code

The controller should be initialized using the Linear DC Motor using MEM Pin.qcp file included in this application note. You will also need a devAux file for your linear actuator. (Contact Support.).

Line# Oper	Label	Command
1:REM		========== DC MOTOR Initialization - SilverSterling with -B option only ========== These programs contains the initialization commands. It can be edited directly or through Tools -> Initialization Wizard Download the program at the end of the wizard or by pressing the "Download" button in the Program Info Toolbar. Reboot the device. (See the description in Scaling for more details)
2:REM		========== *** Communications (COMM) ==========
3:REM		**COMM:Identity
4:IDT		Identity: Unit ID = 16, Group ID = 20
5:REM		**COMM:Protocol
6:PRO		Protocol = 8-Bit ASCII 2 Stop Bits, No Parity
7:REM		**COMM:Serial Interface
8:SIF		Serial Interface = RS485
9:REM		**COMM:Baud Rate
10:BRT		Baud Rate = 57.6K
11:REM		**COMM:ACK Delay
12:ADL		ACK Delay = Auto
13:REM		Load and Run Flash Seq if there was a Factory Block fault
14:JRE		Jump to "FAC BLK OK" When "User[41]" = 0
15:LRP		Load And Run Program: Program = "Factory Block Fault"
16:REM	FAC BLK OK	Factory Block Ok
17:REM		Startup Error Conditions. A special "Startup" Kill Motor Recover program is used for only a short time during initialization. It allows the motor to come up to a point where it can communicate with a host before it gets shut down by an existing error condition. The following commands setup a minimum set of error conditions and configure the Startup Kill Motor Recovery to be run in the event of an existing error.
18:KMR		Kill Motor Recovery: Program = "Startup Recovery"
19:KMC		Kill Motor Conditions: If Temp/Driver Enable Fault or Over Voltage TRUE or Low Voltage TRUE
20:ERL		Error Limits: Moving Limit = 0 counts Holding Limit = 0 counts Delay to Holding = 30 mSec
21:LVT		Low Voltage Trip = 10 volts
22:REM		Startup Power Low Recovery This is simular to the above explained Startup Kill Motor Recovery.
23:PLR		Power Low Recovery: Program = "Startup Recovery"
24:REM		Read the factory set ADC calibration data from NV memory. Athe analog inputs are factory calibrated. This command reads the calibration data from NV memory and calibrates the ADC.
25:CAI		Calibrate Analog Input from Non-Volatile
26:REM		Phase Align torque limits

Set the identity, protocol, and baud rate as needed.

Error limits are set to 0 to disable them when starting up. These can be enabled at a later time by setting them to a non-zero value. The “running” torque level is available for 30 ms following a motion to allow the motion to complete while minimizing the heating if the actuator is not able to make the motion.

Line# Oper	Label	Command
27:TQL		Torque Limits: Closed Loop Holding = 0 Closed Loop Moving = 0 Open Loop Holding = 0 Open Loop Moving = 0
28:GOL		Go Open Loop
29:SLC		Single Loop Control
30:REM		========== *** Motor (MOTOR) ==========
31:REM		The commands: Motor Constants (MCT) Phase Advance (PAC) are set dependent on input voltage by a factory derived formula. These commands should only be edited by the Initialization Wizard.
32:DMD		Disable Motor Driver
33:REM		Set mode 2 1 enables DC motor operation. Must be done before motor drive is enabled
34:SMD		Set Mode: DC Motor Mode Enable
35:REM		Set mode 7 to select analog feedback from MEM 1=IO4, 2=MEM
36:SMD		Set Mode extended
37:REM		Set mode 8 to select analog cutoff frequency 0 120 uS 1 240 us 2 360 us 3 .5 mS 4 1mS 5 2 ms 6 5 ms 7 10ms 8 20ms 9 40ms
38:SMD		Set Mode extended
39:REM		Set mode 5 filter value sets the filter value used to filter the DC_MOTOR drive voltage (only DC motor mode)
40:SMD		Set Mode: DC Motor PWM Filter 3999 Hz
41:REM		**MOTOR:Motor And Phase Advance Constants
42:MCT		Motor Constants: Auto
43:REM		Phase Advance Constants This command is edited the same time MCT is edited. The edit dialog box does both at the same time.
44:PAC		Phase Advance Constants
45:REM		Set overvoltage to no more than 4v above the voltage for which the unit was initialized
46:OVT		Over Voltage Trip = Auto
47:REM		========== *** Servo Tuning (SERVO) ==========
48:REM		**SERVO:Filter Constants
49:FLC		Filter Constants: Default Settings
50:REM		**SERVO:Control Constants
51:CTC		Control Constants: Default Settings
52:DLY		Delay for 100 mSec
53:REM		========== *** Motion (MOTION) ==========
54:REM		Set the target to the position (Potentiometer feedback = absolute positioning)
55:TTP		Target to Position

Line 34 puts the driver into the DC motor mode of operation (defaults to an encoder feedback).

Line 36 selects feedback from the MEM pin on the motor port (or from IO4)

Line 38 sets a 240 us filter (sampling every 40 us)

Line 40 adds a filter to the output of the torque command.

Line 49 and 51 contain the main system tuning parameters. These will need to be adjusted according to the actuator used, the load attached, and the desired operation of the system.

56:REM		With the motor in DC mode, not alignment is needed - this does not need the "encoder" to settle.
57:GCL		Go Closed Loop
58:REM		**MOTION:Torque Limits
59:TQL		Torque Limits: Closed Loop Holding = 6000 Closed Loop Moving = 30000 Open Loop Holding = 0 Open Loop Moving = 0
60:AHC		Anti-Hunt Constants: Anti-Hunt Disabled
61:REM		**MOTION:Set S-Curve Factor
62:SCF		S-Curve Factor = 0
63:REM		========== *** Error Limits(LIMITS) ==========
64:REM		Disable KMC we can change values
65:KMC		Kill Motor Conditions: If Temp/Driver Enable Fault
66:REM		**LIMITS:Low Voltage Trip
67:REM		Temporarily disable the limits we are about to change
68:LVT		Low Voltage Trip = 10 volts
69:REM		**LIMITS:Over Voltage Trip BEI coil limited to 30v, so hard code the limit
70:OVT		Over Voltage Trip = 53 Volts
71:REM		**LIMITS:Error Limits
72:KMR		Kill Motor Recovery: Program = "Kill Motor Recovery"
73:PLR		Power Low Recovery: Program = "Power Low Recovery"
74:REM		Set maximum end of travel limits
75:WRP		Write 1500 to "Positive limit[26]" Register
76:WRP		Write -1500 to "Negative limit[25]" Register
77:SSL		Soft Stop Limits: "Negative limit[25]" Register for Minimum "Positive limit[26]" Register for Maximum
78:REM		========== *** Misc (MISC) ==========
79:REM		**MISC:Set Digital Input Filters
80:DIF		Digital Input Filter: "All I/O Lines" = 10 mSec
81:DDB		Disable Done Bit
82:MDC		Modulo Clear
83:REM		**MISC:Start Location of User Program
84:LRP		Load And Run Program: Load and Run Program @NV Memory Location=512

Line 59 sets the torque limits. The holding torque is only about 1/5 of the peak torque in this example.

Lines 75, 76, and 77 set up soft limits to prevent motions from asking for more motion than the actuator can provide. These may be adjusted for your particular application.

```
55:REM      **MOTION:Torque Limits
56:TQL      Torque Limits:
            Closed Loop Holding = 6000
            Closed Loop Moving = 30000
            Open Loop Holding = 0
            Open Loop Moving = 0
57:AHC      Anti-Hunt Constants:
            Anti-Hunt Disabled
58:REM      **MOTION:Set S-Curve Factor
59:SCF      S-Curve Factor = 0
60:REM      ==================
            *** Error Limits(LIMITS)
            ==================
61:REM      Disable KMC we can change values
62:KMC      Kill Motor Conditions:
            If Temp/Driver Enable Fault
63:REM      **LIMITS:Low Voltage Trip
64:REM      Temporarily disable the limits we are about to change
65:LVT      Low Voltage Trip = 10 volts
66:REM      **LIMITS:Over Voltage Trip

            BEI coil limited to 30v, so hard code the limit
67:OVT      Over Voltage Trip = 53 Volts
68:REM      **LIMITS:Error Limits
69:KMR      Kill Motor Recovery:
            Program = "Kill Motor Recovery"
70:PLR      Power Low Recovery:
            Program = "Power Low Recovery"
71:REM      Set maximum end of travel limits
72:WRP      Write 1600  to
            "Positive limit[26]" Register
73:WRP      Write -1600  to
            "Negative limit[25]" Register
74:SSL      Soft Stop Limits:
            "Negative limit[25]" Register for Minimum
            "Positive limit[26]" Register for Maximum
75:REM      ==================
            *** Misc (MISC)
            ==================
76:REM      **MISC:Set Digital Input Filters
77:DIF      Digital Input Filter:
            "All I/O Lines" = 10 mSec
78:DDB      Disable Done Bit
79:MDC      Modulo Clear
80:REM      **MISC:Start Location of User Program
81:LRP      Load And Run Program:
            Load and Run Program
            @NV Memory Location=512
```

Line 56 sets the holding and moving torque limits. The voice coil motors may have a fairly high ratio of peak to average allowable current. They will become overheated if operated continuously at the peak rated currents.

Lines 72 thorugh 74 provide soft limits for the requested motions to make sure that they do not exceed or come too close to the limits of the position sensor. Exceeding the limits can lock the actuator at the hardware feedbadk limit. With a requested (Target) position greater than available feedback values can cause very rapid heating as the servo Position is unable to reach the Target. The Soft Stop Limits prevents this from happening.