ELECTRICAL INTERFACE TO DC BRUSHLESS MOTORS SUPPLIED IN TECNADYNE THRUSTERS, LINEAR & ROTARY ACTUATORS & HPU's

1. Introduction

The electrical interface to the Tecnadyne DC brushless motors and controllers (supplied with Tecnadyne thrusters, linear and rotary actuators and hpu's) is very simple and straightforward. This application note describes the necessary interface requirements and options for the full range of Tecnadyne DC brushless motors using integral controllers that accept a +/-5v control signal. For a more general discussion of the issues related to the filtering of back EMF generated noise and to the elimination of ground loop generated noise, please refer to Tecnadyne application note AN601 – *Back EMF & Ground Loops*. For remotely installed controller options, please refer to Tecnadyne application note AN607 – *Available DC Brushless Drive Options*.

The following glossary of terms applies to this application note:

- Motor power – the electrical power supplied by the customer's DC power source and used to power Tecnadyne DC brushless motors.
- Rated motor voltage – the voltage at which the motor power must be supplied. Please consult the individual product data sheet for the available rated motor voltages for each product.
- Steady state voltage – the voltage supplied by the customer's DC power source when it is fully loaded by all connected DC brushless motors (and other devices). Can be measured with a multimeter.
- Steady state current – the current, in amperes, drawn by the Tecnadyne DC brushless motor when operating at its maximum speed at the rated motor voltage. The steady state current of a given Tecnadyne product (be it a thruster, linear or rotary actuator, or HPU) is determined by the desired performance of that product and also by the rated motor voltage. The steady state current for common rated motor voltages are listed in the individual product data sheets. Please consult the factory for the steady state current for a configuration or for a voltage that is not listed on the product data sheet.
- Open circuit voltage – the maximum voltage of the customer's DC power source when no load is applied. Can be measured with a multimeter.
- Full charge voltage – the maximum battery voltage, generally measured when fully charged and before any discharge of the batteries. Can be measured with a multimeter.
- Voltage ripple – a cyclical variation in the steady state voltage and the open circuit voltage generally caused by insufficiently filtered rectified AC power. Must be measured with an oscilloscope.

- Back EMF – back EMF (electromotive force) is the very short duration voltage spike produced by an inductor when the applied voltage is instantly removed. All DC brushless motors generate back EMF and the magnitude of the back EMF can easily exceed the steady state voltage supplied to the motor. Unless filtered, back EMF can cause electrical noise that can reduce performance levels and reduce reliability.
- Capacitor bank – in many cases (as described in the following sections), it is necessary to install a capacitor bank to filter the back EMF produced by the DC brushless motors. In all cases, select low ESR (equivalent series resistance) aluminum electrolytic capacitors (Cornell Dublier 380LX are good) with a voltage rating that is 50% greater than the rated motor voltage. The capacitor bank should be connected between the positive and negative conductors from the power source. The capacitor bank must be connected as close to the DC brushless motor as is physically practical and must be connected with conductors of the same size as those from the power source.

2. Motor Power

2.1. General DC Power Source Considerations

Tecnadyne DC brushless motors operate on DC power at rated motor voltages between 12vdc and 500vdc. The available rated motor voltages for each product are listed in that product's data sheet. In general, the following simple guidelines apply to all DC power sources supplying Tecnadyne DC brushless motors, regardless of the rated motor voltage or of the power source type.

- The steady state voltage supplied by the customer's DC power source should be within 15% of the rated motor voltage. Open circuit voltage (when no motors are being operated) and full charge voltage (when batteries are fully charged) should not exceed the rated motor voltage by more than 15%. Please consult the factory if these limits cannot be met.
- Voltage ripple (as measured with an oscilloscope) must not exceed 10% of the steady state motor voltage.
- The DC power to each DC brushless motor must have a fast blow type fuse with a current rating 50% greater than the steady state current for the motor and a voltage rating 25% greater than the rated motor voltage.
- It is highly recommended that an overvoltage protection device (either a transorb or an MOV) be placed across the motor power conductors at a point between the fuse and the motor. This overvoltage protection device should have a forward conduction voltage 30-50% greater than the motor voltage and should be large enough to carry 150% of the fuse current.

2.2. Comments Regarding Specific DC Power Sources

All DC brushless motors generate back EMF and this must be filtered for optimum performance and reliability of the DC brushless motors. Assuming that the Tecnadyne DC brushless motors are being used on subsea equipment with power supplied either through an umbilical cable from the surface or from subsea batteries, the following guidelines apply.

- DC power supply located on the vehicle – if located close to the DC brushless motors (the source of the back EMF), a well regulated DC power supply has sufficient internal capacitance to filter the back EMF generated by DC brushless motors
- Remote voltage sensing DC power supply located on the surface – in this case, the surface DC power supply uses dedicated conductors to remotely sense the voltage on the subsea vehicle. Make sure that the DC power supply uses high speed switching devices, to minimize voltage transients on the umbilical cable. Due to voltage transients on the umbilical and the distance to the DC power supply filters, it is recommended that a capacitor bank be installed on the vehicle using low ESR capacitors with a combined capacitance of 100-150 mfd / ampere of total steady state current.
- Fixed voltage DC power supply located on the surface – in this case, care must be taken select conductors in the umbilical of sufficient size that the open circuit voltage does not exceed the rated motor voltage by more than 15%. As in the previous case, install a capacitor bank of low ESR capacitors with a combined capacitance of 100-150 mfd / ampere of total steady state current.
- Rectified AC supply located on the vehicle – if, as is often the case, high voltage AC is transformed to lower voltage on the vehicle, design the transformer so that the open circuit voltage, after rectification and filtering, does not exceed the rated motor voltage by more than 15%. Install a capacitor bank of low ESR capacitors with a combined capacitance of 600-700mfd / ampere of total steady state current.
- Batteries located on the vehicle – even though batteries provide a very stable voltage source, they have very low internal capacitance and therefore it is necessary to install a capacitor bank of low ESR capacitors with a combined capacitance of 400-500mfd / ampere of total steady state current.

3. Control Signal

3.1. General

This application note applies to Tecnadyne DC brushless motors (thrusters, linear & rotary actuators, & HPU's) that use a +/-5v analog control signal for speed and direction control. The following comments apply to the +/5v analog control signal.

- If +5v is applied to the control signal line, the DC brushless motor will run at full speed in the forward direction And if -5v is applied to the control signal line, the DC brushless motor will run at full speed in the reverse direction. If a voltage in the range of -0.5v to +0.5v is applied to the control signal line, the DC brushless motor will be stopped. All other voltages in the range of -0.5v to -5v and in the range of +0.5v to +5v provide continuously variable speed control of the DC brushless motor. (Note that full speed in the forward direction is actually reached at about +4.75v and full speed in the reverse direction is actually reached at about -4.75v. This assures full speed operation even though the +/-5v signal may be degraded by line and connector losses).

- The control signal must be electrically isolated from the motor power. This means that a multimeter connected between the motor power ground and the instrumentation ground (control signal ground) will indicate open (infinite resistance).
- The control signal has an impedance of about 2.5kΩ.
- The control signal must be held at 0v when the DC brushless motor is stopped. It is not OK to allow the control signal line to go “open circuit” in order to stop the DC brushless motor.
- Any change in control signal value should be a linear ramp over time and not a step function. The slope of this ramp is determined by the size and inertia of the motor being controlled and also by the amount of filtering on the power bus. For the smaller Tecnadyne motors, such as are used on the Model 260, 280, 540 and 560 thruster motors, a control signal ramp of 10 milliseconds / volt is sufficient. For mid sized Tecnadyne motors, such as used on the Model 1020 and 1080 thruster motors, the ramp should be around 25 milliseconds / volt. And for the larger Tecnadyne motors, such as are used in the Model 2020 and 8020 thruster, the ramp should be 100 milliseconds / volt.
- If multiple DC brushless motors are installed in a system, it is often advisable that the control signal to each motor be isolated from the other control signals. Please consult Tecnadyne application note AN601 – *Back EMF & Ground Loops* for additional information.

Please contact the factory if the control signal requirements are not fully understood or if changes must be made to the control signal characteristics.

4. Instrumentation Power

4.1. General

In some cases, it is necessary to supply a +12vdc instrumentation power to the Tecnadyne DC brushless motor. This is necessary on the smaller DC brushless motors which do not have sufficient space within their electronics cavity for the necessary DC-DC converter assembly. Please consult the specific product data sheet to see if it is necessary to supply instrumentation power. The following comments apply to those Tecnadyne DC brushless motors that require instrumentation power:

- The instrumentation power must be electrically isolated from the motor power. However the instrumentation power must share the instrumentation ground with the analog control signal.
- The instrumentation power draws approximately 200 milliamps.
- If multiple DC brushless motors are installed in a system, it is best that each have in independent and isolated instrumentation power supply.

5. Feedback Signals

5.1. General

All Tecnadyne DC brushless motors output a speed feedback signal. In some cases, this signal is an analog DC voltage that is proportional to motor rpm. In other cases, this signal is a digital pulse train with the frequency proportional to motor rpm. Thruster motors and hydraulic pumps and HPU's can be supplied with one of these speed feedbacks signals. Rotary actuators can also be supplied with internal position feedback. The standard internal position feedback option for rotary actuators consists of two digital pulse trains in quadrature. Depending on the model of actuator and its internal gearing ratio, this quadrature signal can be configured to resolve from 16 pulses / revolution to in excess of 5,000 pulses / revolution. Please consult the individual product data sheets for available feedback options for that model thruster or actuator..