



RDT-2100
TORQUE METERING
SYSTEM

Operator's Manual

Revision	Description	Date
1.0		
1.1		
1.2	Revised Section on Outputs, Spare Coupling Installations, and Dynamic Torque Outputs	1/14/2025

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I. SYSTEM DESCRIPTION

A. TORQUE SYSTEM OPERATION

Torque transmitted between the driving and driven machines is measured in an instrumented section of the shaft connecting the two. Generally this is accomplished within a flexible coupling, which has been instrumented with strain gage sensors to measure the strain, or twist, in a section of the coupling spacer (spool piece). The signal from the strain gages are amplified and fed to a precision V/F (voltage to frequency converter), which operates between 1.5 KHz and 9 KHz. It is this signal that is sent through the signal windings on the rotary transformer from the shaft through the ESC (Excitation & Signal Conditioning) module to the monitor main board. Power for the shaft circuitry is supplied as AC (alternating current) at a frequency of 43.2 KHz (fixed and crystal controlled). Marker magnets located on the rotor are sensed by Hall Effect Sensors on the stator in order to measure the speed of rotation of the shaft.

From the stator, the signals are sent through the ESC to the monitor, where they are processed and displayed on digital readouts as speed, torque, and power. Analog and serial digital data are available for each of the parameters.

Two complete and independent systems are provided to the monitor box. If a sensor fault condition occurs, then the monitor will automatically switch from a non-working system to a working system.

B. SYSTEM ARRANGEMENT

Figure 1 and Figure 2 shows the basic configuration of the torque system (for complete information on the user's particular system, the System Arrangement and Systems Parameter Documents from the documentation package should be consulted). The shaft is provided with strain gages, associated electronics, and a rotary transformer. The rotary transformer has a dual function: to transmit power to the strain gages and electronics on the shaft, and to receive the signals representing torque from the shaft to the monitor. From here the signals make their way to the ESC for proper conditioning before being sent to the monitor for display through the associated cable arrangements.

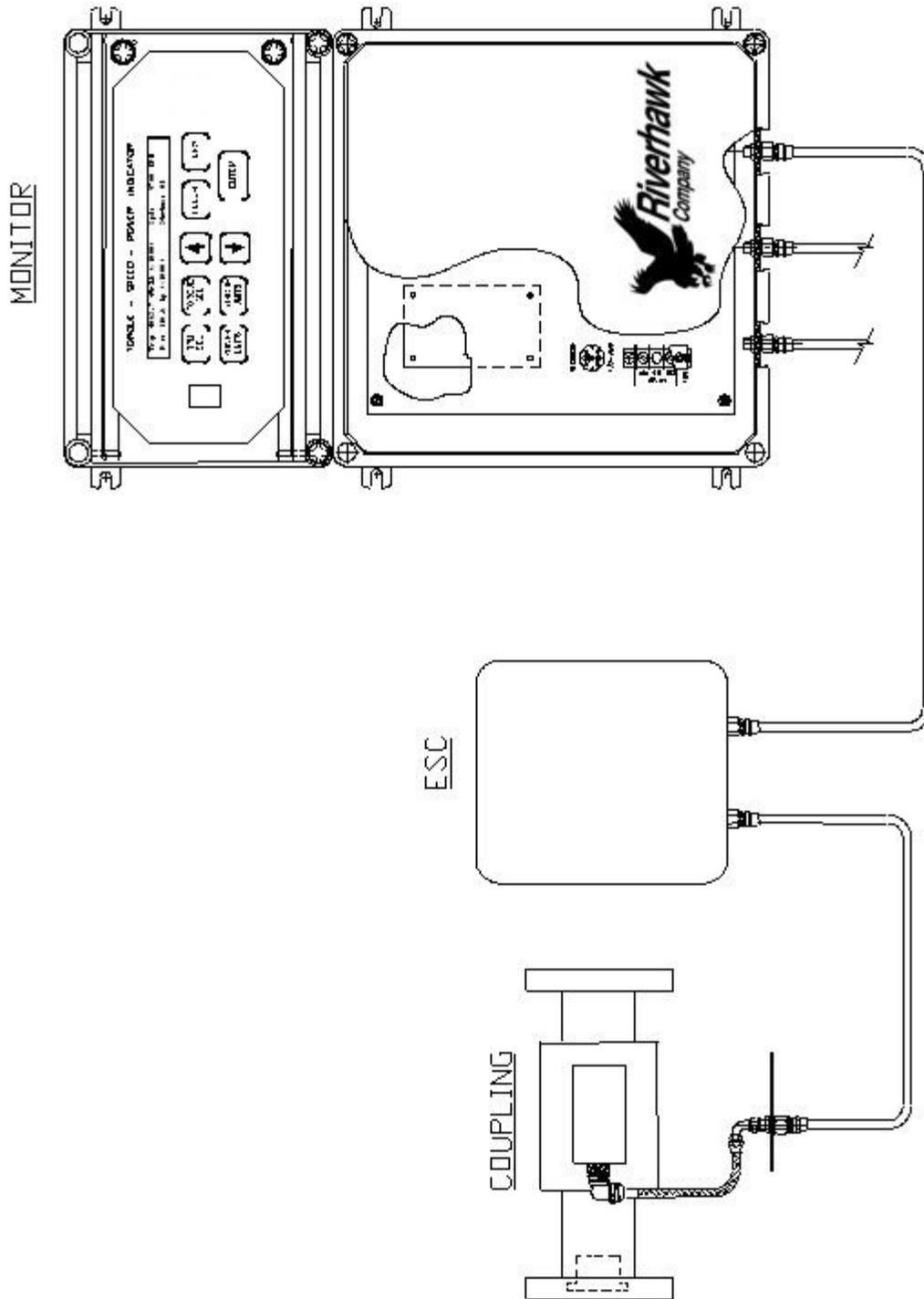


FIGURE 1: WALL MOUNT MONITOR BLOCK DIAGRAM

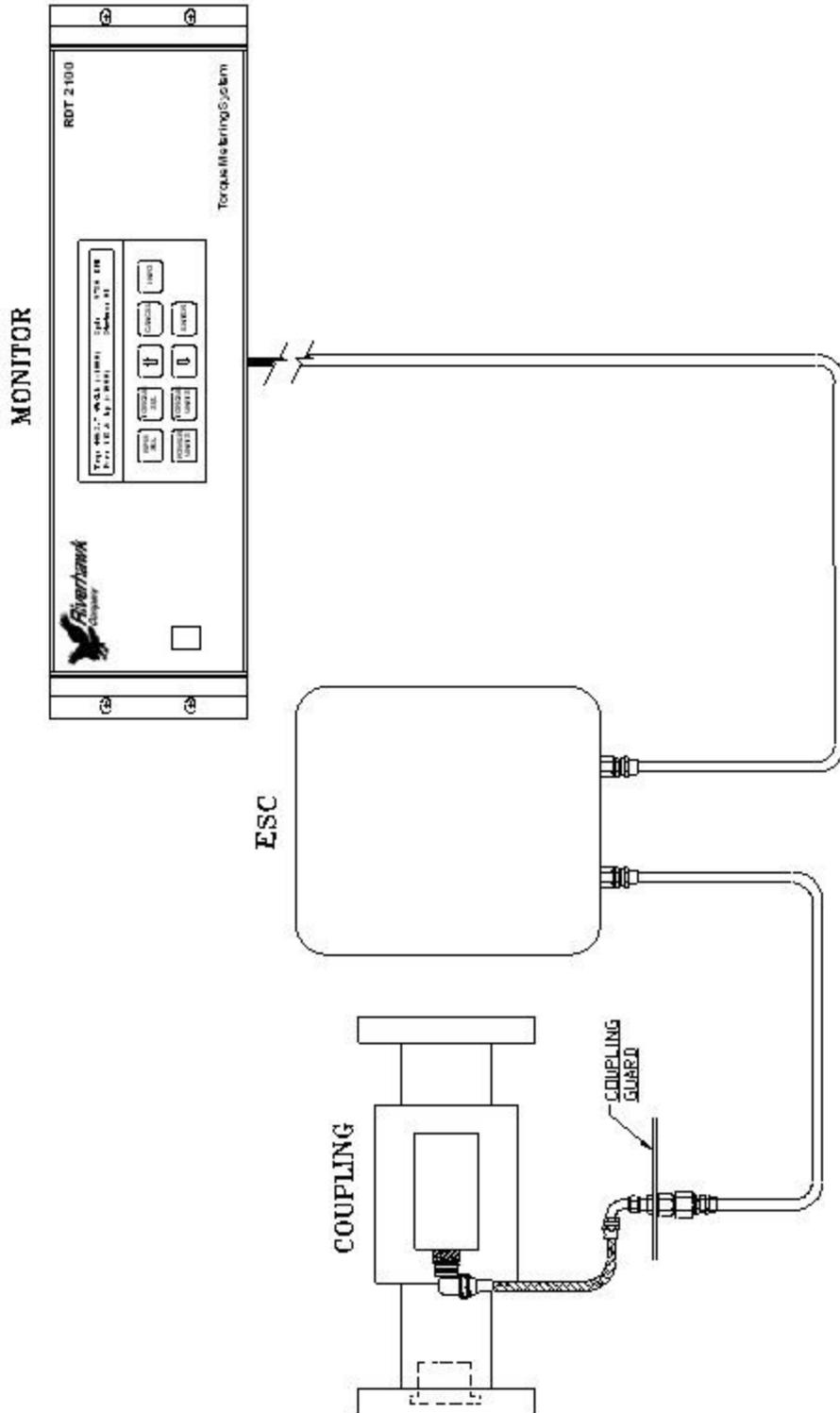


FIGURE 2: RACK MOUNT MONITOR BLOCK DIAGRAM

C. OUTPUTS

For the Torque System, the values of three parameters may be viewed in the display of the instrument. These are:

Speed (the absolute value of rotational speed of the shaft)

Torque (the torque being transmitted through the shaft, including polarity)

Power (the absolute value of power being transmitted by the shaft)

Under “Units and Conversions”, this section also gives definitions of various units and conversions between them.

Because the zero of the torque system will vary depending on conditions at installation as well as operational conditions, provisions have been made to set the torque reading to zero (this must be done when the torque is known to be close to zero, for example, when the machine is stopped or operating under turning gear).

Analog outputs are available on the Terminal Block Panel (Figure 11), or at connector P10 on the rack mount style monitor (Figure 12). An independent output is provided for each of the three measured parameters, Power, Torque and Speed, and for the form of this output (i.e. whether 4-20 mA or 0-5 vdc). Dynamic torque outputs are also available. The scaling parameters for each output can be found on the Instrumented Coupling Drawing located in the documentation package provided. **It is important to note that an Instrumented Coupling is precisely calibrated to its paired monitor. They are a matched-set and should not be interchanged with another system.** For more information see Section SPARE/RECALIBRATED COUPLING INSTALLATIONS.

II. APPLICABLE DOCUMENTS & DATA

A. LIST OF DRAWINGS

Drawings are supplied in a separate drawing package, both hard and soft copy.

B. TOOLS AND HARDWARE

Tool or Hardware	Riverhawk P/N	QTY
N/A	N/A	N/A

C. UNITS AND CONVERSIONS

DEFINITIONS:

1 Newton (N) =	1 Kilogram-meter per second-second (kgm/sec ²) = the force needed to accelerate 1 Kg to a velocity of 1 meters/sec
1 Kilowatt (kW) =	60,000 Newton-meters per minute (N-m/min) = 6118.3 Kilogram-meters per minute (kgm/min)
1 Horsepower (HP) =	33,000 foot-pounds per minute (lb ft /min)

CONVERSIONS:

1 Newton (N) =	0.10197 kilograms force (kgf) = 0.22481 pounds force (lbf) ¹
1 Kilogram force =	9.8067 Newtons (N) = 2.2046 pounds force (lbf)
1 Pound force (lbf) =	4.4482 Newtons (N) = 0.4536 kilograms force (kgf)
1 Kilogram-meter (kg-m) =	9.80665 Newton-meters (N-m) = 86.7962 in lb = 7.2330 ft lb
1 Newton-meter (N-m) =	0.10197 Kilogram-meters (kg-m) = 8.85075 in lb = 0.73756 ft lb
1 Kilowatt (kW) =	1.341 HP
1 Horsepower =	0.7457 kW

FORMULAS (for rotating machinery)²

Power = Torque x Speed

Power (in HP) = (in-lb) x (rpm) / 63025 = (ft lb) x (rpm) / 5252.1

Power (in kW) = (N-m) x (rpm) / 9549.3 = (kg-m) x (rpm) / 973.76

¹ A pound force (lbf) is the force exerted by gravity upon a mass of one pound (lb). The kilogram force (kgf) has a similar definition

² Torque is a force (lbf, or N, or kgf) acting at a radius (inches, or feet, or meters). During one revolution, that force acts over a distance equal to 2π times the radius. Hence the conversion factors: $60000 / 2\pi = 9549.3$ and $33000 / 2\pi = 5252.1$

III. INSTALLATION

A. INSTALLATION PROCEDURE

1. COMPLETE THE FOLLOWING STEPS TO INSURE A PROPER INSTALLATION OF THE RIVERHAWK TORQUE SYSTEM.

Check-mark here:

Be sure to read through and understand all of the General Considerations (See Section [III.B](#) General Preparations)

Install the ESC Module (See Section III.D.1: ESC (Excitation & Signal Conditioning (ESC) Module Installation)

Route the cable conduit from the Coupling Guard’s Bulkhead connector to the ESC Module. (See Section III.C.1: Stator to ESC Installation)

Plan the best route for the Stator-to-Bulkeahd Cable to Coupling Guard, and determine if any cable clamps are needed. (See Section III.C.1: Stator to ESC Installation)

Mount the Bulkhead Connector on the Coupling Guard. (See Section III.C.1: Stator to ESC Installation)

Install the coupling according to the Coupling Manufacturer’s instructions (See Section III.B.2: Coupling Considerations)

Determine necessary shims for stator axial position; also consider any known axial changes after start-up (See III.C.3: Stator Installation)

Install the Stator with shims, bolts, and washers. Do not tighten bolts. (See Section III.C.3: Stator Installation)

Adjust the stator for a uniform radial gap (See Section III.C.3: Stator Installation)

Verify axial position according to the Installation Details Drawing. (See Installation Details Drawing and Section III.C.3: Stator Installation)

Connect the Stator to ESC Cable to the Stator and the ESC module. (refer to ESC Module Installation Drawing)

Once Stator alignment is completed, tighten all bolts.

2. THESE ADDITIONAL STEPS CAN BE PERFORMED IN PARALLEL WITH THE ABOVE STEPS:

Route and install the monitor to ESC cable. (See Section III.C.2: ESC to Monitor Cable Installation)

Install the Monitor. (See Section III.D.2: Monitor Installation)

Connect Analog Outputs to Monitor. (See Section III.D.2: Monitor Installation)

Connect power cord to Monitor. (See Section III.D.2: Monitor Installation)

B. GENERAL PREPARATIONS

1. BALANCING

The shaft or flexible coupling is normally given a preliminary balance by the manufacturer (Riverhawk or other) before delivery to Riverhawk. The installation of the instrumentation upsets the balance to a small degree, therefore after the instrumentation has been installed and calibrated, the shaft is returned to the coupling manufacturer for a final 'trim' balance.

Provisions must be made to support the stator during balancing to protect the rotor coils, the stator, and the internal electronics from physical damage. This is easily assured by proper fixturing, to prevent contact between the stator and the rotor. The rotor coil area must be protected at all times and not used to support the weight of the shaft.

Often, the spool piece of the flexible unit is long enough that the stator may be slid away from the raised rotor coil section to one end. Since the diameter of this rotor coil section is generally greater than the diameter of the spool piece, moving the stator away from the raised section will provide additional radial clearance to facilitate fixturing.

In unusual cases, the diameter of the flexible unit end flanges is smaller than the inside diameter of the stator. In this instance, the stator may be removed from the shaft completely by sliding it off the end. The only precaution in this case is to ensure the stator is re-installed, with correct orientation or the system will not work properly and may be severely damaged.

2. COUPLING CONSIDERATIONS

Strict adherence to manufacturer's recommendations is essential to obtaining optimum performance and long-term reliability.

Several considerations are paramount:

The instrumented shaft (usually a flexible coupling), although equipped with instrumentation supplied by Riverhawk, must be installed according to the shaft manufacturer's instructions. Among the precautions in this regard; careful handling to protect the flexible elements, installation of hubs, correct alignment, shimming the axial distance between ends, obtaining the recommended pre-stretch, and the accurate fitting and torquing of bolts.

The stator assembly, a part of the instrumentation system, contains delicate coil windings. It is designed to have adequate radial clearance between the inside of the stator and outside of the rotating shaft in order to accommodate variations in the alignment as well as axial motion of the machines. Initial alignment is critical to the operation after it is installed in the machine and prior to startup. If installation is not in accordance with the drawings and instructions, the system may not work, or worse yet, fail prematurely. Refer to Section III, D: ESC/Monitor Installation. In the absence of Riverhawk personnel, then all documentation should be reviewed carefully; contact Riverhawk if there are any questions.

Electronic assemblies are located within the hollow shaft. Although these are securely mounted and protected by end covers, care must be exercised in handling. If standing the shaft on end is unavoidable, then it should be placed on a flat cushioned surface.

Electrical connections to the monitor must be checked before power is applied to ensure that wiring is in accordance with the drawings and that connections are secure.

Use Caution, Do not use the stator ears to lift, carry, or support the weight of the coupling.

3. CABLE TERMINATION AT THE ESC AND THE MONITOR

Careful installation of the cables between units is essential. Obviously, the equipment will not work properly if the connections are not correct, but there are additional considerations beyond that.

It is also important to keep accurate wiring connection records, particularly when deviations are made from the original wiring diagrams. Sometimes junction boxes and terminal panels are inserted into cable runs, and in this case, a clear record of the terminal numbers and wire colors is essential.

NOTE:

Careful attention must be given to the wiring of shields to prevent ground loops and noise problems; they should be carried through on separate terminals rather than a single point.

Since cabling details vary from system to system, it is particularly important to consult the supplied installation drawings.

Unintended connections or inadvertent shorts may cause damage to components, or other internal components or transients could occur which may damage or shorten the life of the system. It is important not to adjust the stator position while power is applied. ***Do Not*** apply power until all connections are verified after final wiring.

C. CABLE ROUTING AND CONNECTIONS

Between the coupling's stator and ESC Module (Excitation Signal Conditioning) there are three (3) cable components; stator-to-bulkhead cable, bulkhead connector (mounted in guard) the guard-to-ESC cable. A separate cable connects the ESC to the Monitor. Normally conduit is supplied by the customer, and provides protection from the coupling guard bulkhead fitting to the ESC and the ESC to the Monitor.

Connect wiring to connectors in accordance with supplied drawings. Pay particular attention to the wire insulation clearance to prevent clamping of wire.

1. STATOR TO ESC INSTALLATION

It is recommended that the conduit from the guard to the ESC be installed prior to making connections to the bulkhead connector in the guard.

It is recommended that clamps be installed at intermediate points when routing the stator-to-bulkhead cable to restrict movement due to vibration. Standard cable lengths for the stator-to-bulkhead cable consist of 2, 3, 4, 5 or 6 feet while bulkhead-to-ESC lengths can be selected in 1-foot integers up to 45 feet.

CAUTION:

It is important not to rotate either the straight or 90-degree shell at the back of the connector, or change the

angle of the stator junction box connector since these are encapsulated and may damage internal wiring.

Connect the stator-to-bulkhead cable to the stator's junction box first then plan the best routing for the cable to avoid tight bends and kinks.

Note each connection point between coupling and ESC involves a keyway in each connector. Be sure to align accordingly before final connections are to be finalized. This includes placement of the bulkhead connector fitting in the guard. Also if any intermediate clamps are desired, plan for their mounting at this time.

NOTE:

Do not loosen the cable connector nuts or allow the wires to twist, or damage may occur.

Position the hole in the guard for the bulkhead connector in a location that will not put too much stress on the stator-to-bulkhead cable.

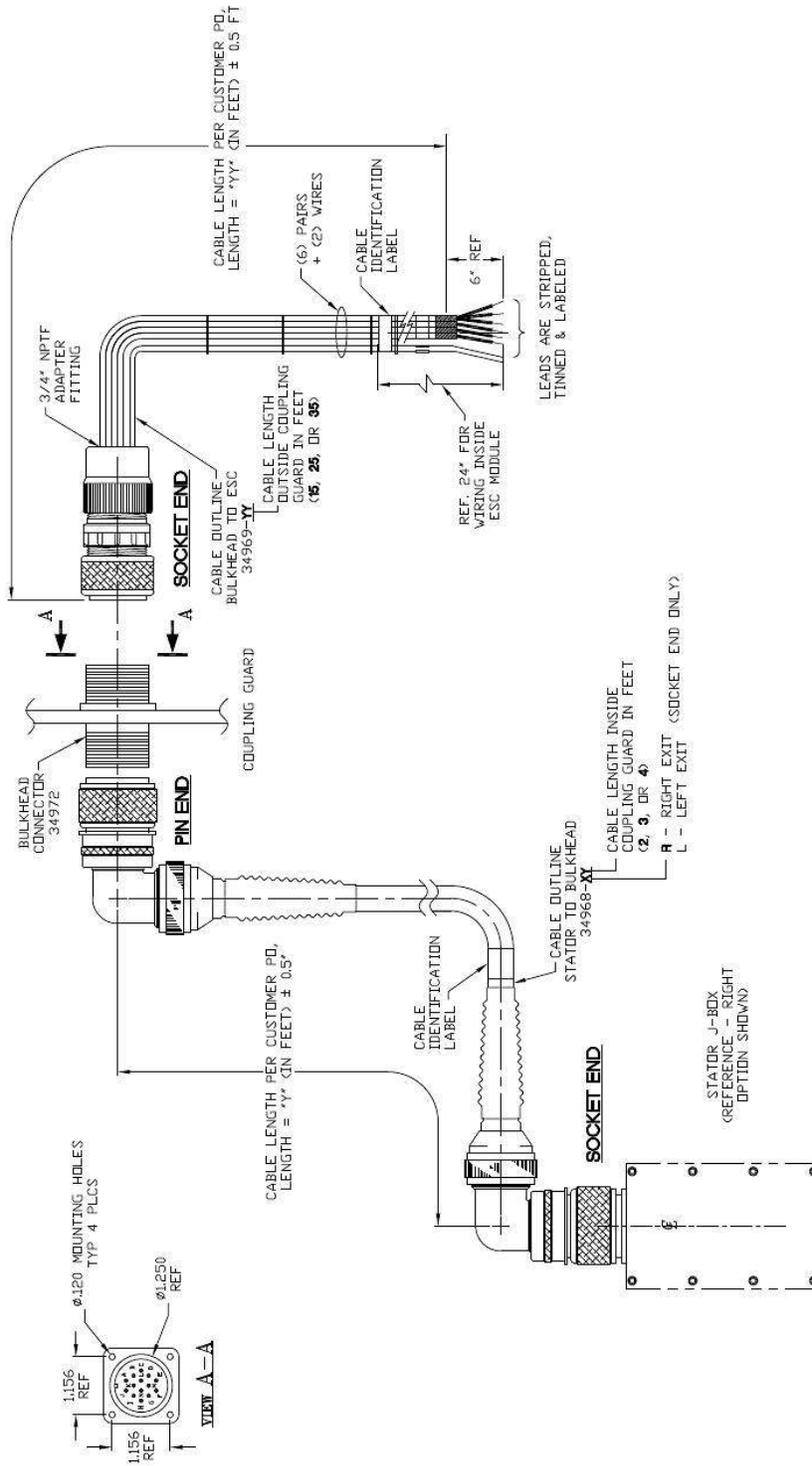


FIGURE 3: STATOR-TO-ESC CABLE OUTLINE

2. ESC TO MONITOR CABLE INSTALLATION

A conduit provided by the customer will house and protect the cable from the ESC to the Monitor. Terminate the ESC to Monitor wiring in accordance with the supplied installation drawings. Do not shorten the lengths of either cable; excess cable lengths can be coiled up without affecting normal operations.

3. STATOR INSTALLATION

CAUTION:

Do not use the stator ears to lift, carry, or support the weight of the coupling during handling to prevent damaging the rotor surface.

Although the stator structure is captive on the coupling, it may be moved to one end to give additional clearance for bolting up the coupling. The wire wound section of the coupling must be handled carefully to prevent damage during assembly and disassembly. The installer must remember that moving the stator exposes the delicate transformer windings on the coupling spacer or spool. This area must never be used to support or lift the coupling.

The stator 'ears' have a mounting face which is perpendicular to the axis of the coupling. The mounting brackets (typically part of the coupling guard), should be flat and in a plane perpendicular to the machine axis, to prevent the stator from twisting when it is attached.

The inside of the stator has been made larger than the outside diameter of the rotor, to provide sufficient radial clearance for normal coupling misalignment. Likewise, the rotor and stator coils have been designed to allow for typical axial motion of the coupling under the stator.

Because of the inevitable tolerances in the positioning of the coupling and the mounting brackets, radial slots in the stator ears and corresponding orthogonal slots in the mounting brackets allow for radial adjustment. Shims are used between the stator "ears" and the mounting bracket to adjust the axial position of the stator.

Refer to the Instrumented Coupling drawing supplied in the documentation package for the particular coupling being installed to obtain the correct dimensions and other important details such as cable routing. Figure 4 depicts the significance of obtaining true stator alignment.

NOTE:

Prior to any movement of the stator, remove or loosen any gap adjustment Shims/devices to prevent damage to the rotor surface.

After the coupling has been installed, the stator may be moved to its optimum axial position - stator centered over the raised rotor section, which is painted blue.

Determine the shims necessary to position the stator axially within **0.20 inches (5.1 mm)** of the optimum position, also taking into consideration any known axial changes that occur after start-up. Install the shims, bolts, and flat washers as indicated in the appropriate installation drawing for the coupling, and draw up the bolts sufficiently enough to hold the stator in position (snug but not tight).

Adjust the stator radial position such that the gap between the rotor wrap and the stator inside diameter is uniform during normal machine operation.

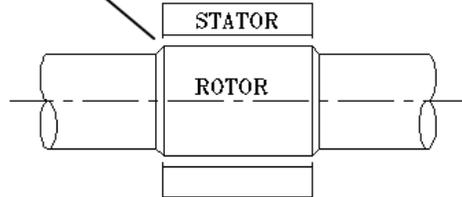
After verifying that both axial and radial positions are correct, final tightening of the bolts can be completed.

CAUTION:

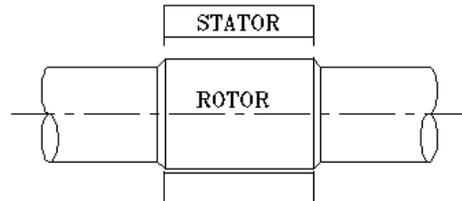
Verify the axial and radial positions, and that no radial positioning shims have been left in the gap to avoid damage during machine startup.

STATOR/ROTOR ALIGNMENT AND MISALIGNMENT EXAMPLES

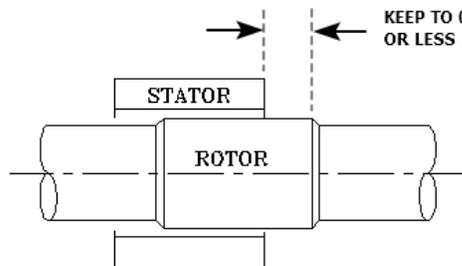
APPROXIMATELY 1/8"
[3.2mm] AIR GAP



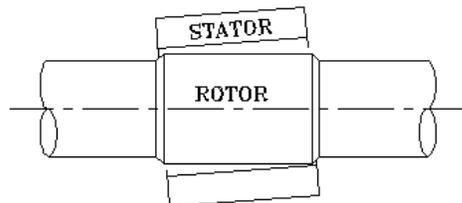
GOOD ALIGNMENT. MAXIMUM AND ACCURATE POWER AND SIGNAL TRANSFER



RADIAL MISALIGNMENT. UNEVEN RUNNING CLEARANCE; MAY RUB



AXIAL MISALIGNMENT. ROTOR/STATOR COILS WILL NOT TRANSFER ADEQUATE



TILTED MISALIGNMENT. MAY RUB, DAMAGE COILS

NOTE: A COMBINATION OF THESE MISALIGNMENTS MAY EXIST. ANY SINGLE OR COMBINED MISALIGNMENT MAY CAUSE INACCURATE TORQUE AND/OR RPM SIGNALS

FIGURE 4: STATOR ALIGNMENT

D. ESC/MONITOR INSTALLATION

1. EXCITATION & SIGNAL CONDITIONING (ESC) MODULE INSTALLATION

Refer the ESC Module Installation Drawing for mounting dimensions, and appropriate wiring connections. For acceptable environmental conditions, refer to page 46. Plan accordingly for conduit and wiring accessibility.

2. MONITOR INSTALLATION

The Monitor is available in a wall mount enclosure (Figure 1), or in a rack mount enclosure (Figure 2).

The wall mounted enclosure should be placed in a location that provides protection from damage and accessibility for maintenance. Conduit holes and ¼” fittings are provided at the bottom of the enclosure. If additional holes are required, the Greenlee Cutter is a preferred method to fashion conduit holes on the enclosure. To operate the cutter, place the punch of the Greenlee Cutter on the inside of the enclosure and draw the punch through to the outside.

See the Monitor installation drawings for complete dimensions and appropriate wiring connections. Acceptable environmental conditions are on page 46. When choosing a location, consider the accessibility of the wiring terminals and conduit mounting.

Connect the marked/labeled wiring to the appropriate screw terminals, or connectors supplied.

Analog Outputs

Ensure the wires are labeled, and then connect the analog outputs to the output terminal block inside the enclosure or to the connectors provided on the rack type monitor.

NOTE:

If the user prefers their own isolated power supply for the analog outputs, then the jumper on the analog out terminals must be removed and the power return connected to their 24-volt power supply.

The terminations for the analog outputs provide for an independent return path for each output current; users are advised to use a termination for each output independently, to avoid excessive voltage drops on the return path. In the event that the analog output stages are powered from an

external supply, the return current will go to the external supply; however, at least one of the returns should connect to the negative side of the external supply ground.

Normally, the analog output stages are powered from the same +24 volt power supply that powers the rest of the instrument. However, in cases where it is preferred to power the output circuits from a separate supply, replace the jumper on analog out terminals with the external supply (See Figure 11 or Figure 12).

The analog output stages can tolerate a supply voltage from 18 to 30 volts DC; however, voltages below +24VDC will reduce the compliance range, specified in Section V.E.1: Analog Output Overheads and Compliance.

USB Communications Port

A USB port is provided on the monitor. This permits connection to a PC for viewing system data through Riverhawk Interface software. This connection port is located on the front panel of both the wall mount and rack mount enclosure types.

Power Input

For the wall mount enclosure a terminal strip is provided on the interconnect panel to connect the input power, which should be wired according to the practices of the particular installation. A fuse is located on the interconnect panel. The Monitor must be grounded for proper operation.

For the rack mount enclosure a power cord is supplied, and a fuse is located within the power input module.

It is recommended that a 5 Amp individual circuit breaker be provided in the line supplying power to the system.

E. SPARE/RECALIBRATED COUPLING INSTALLATIONS (IF APPLICABLE)

Installation of either spare or recalibrated instrumented couplings will involve the same steps as previously described. The customer must contact Riverhawk for additional instructions on critical adjustments of monitor hardware and ESC.

Each instrumented coupling has unique calibration parameters that reside within the memory of the Monitor that was supplied with that individual/matching coupling. **It is important to note that the coupling and monitor are matched set when they leave the factory and interchanging either component in the field will result in uncalibrated outputs.**

When ordering a spare instrumented coupling it is important to obtain a matching monitor at the time of order. If this is not doable and/or a matching monitor is unavailable at the time of installation, **the existing monitor on-site will need to be reprogrammed at the Riverhawk factory prior.**

IV. THEORY OF OPERATION

A. SYSTEM ORGANIZATION

The basic Torque system consists of an Instrumented Shaft (usually a coupling), Excitation and Signal Conditioning (ESC) Module and a Readout Instrument (monitor), as shown in the simplified block diagram, see Figure 1 or Figure 2. Figure 6 is a more detailed block diagram of the system, showing the individual elements for each of these units and their relationship to one another.

On the shaft, all of these elements are duplicated and assigned to one or the other of two separate systems to provide redundant operation. In case of failure of the 'primary' system, the 'secondary' system is automatically selected to permit continued operation.

The torque systems signal chain begins at a strain gage bridge located in the shaft. The strain gage signal is amplified and supplied to a precision V/F (voltage to frequency converter) that operates between 1.25 kHz and 9.25 kHz. That signal that is sent through the signal windings on the rotary transformer on the shaft, through the ESC and to the Monitor electronics. The torque meters A/D circuit processes the signals for the digital display and the analog output.

Marker magnets on the rotating shaft are sensed by Hall Effect Sensors mounted on the stator and provide the means for measuring the speed, either by counting pulses in a unit of time, or by determining the period between them.

B. PRINCIPLES OF TORQUE MEASUREMENT

Strain gages have proven to be one of the most accurate and reliable methods of measuring the torque being transmitted through a rotating shaft. As the name implies, they measure the strain, or elastic deflection of the shaft material under load. Knowing the torsional stiffness of the shaft, this deflection may be related to the torque that was required to produce it.

In actual practice, a number of individual strain gages are applied to a small section of the shaft, with their orientation at an angle of 45 degrees to the shaft axis. Oriented in this fashion, they measure the tensile and compressive strains in the material caused by the applied torque. Figure 7 shows a shaft with zero torque applied. Grid lines are shown; in the figure they define a square area 1-2-3-4. Figure 7 also indicates this area and the orientation of the gages within it.

An individual strain gage consists of a number of parallel conductors, connected electrically in series to produce a total resistance on the order of 1000 ohms. These conductors are supported on a thin insulated backing, which is then cemented to the shaft so as to move along with it. In other words, when the shaft material stretches or compresses (strains), the gage backing and the conductors stretch or compress as well. If the strain is in the same direction as the conductors, they respond by becoming shorter and fatter, with a decrease in electrical resistance (compression); or long and thin, with an increase in electrical resistance (tension).

In Figure 8, the spacer is shown with torque applied. The square has distorted to become a rhombus (a parallelogram with equal sides). The shear forces S caused by torsion produce forces S' as well; these may be resolved into tensile and compressive forces as shown. Points 1 and 3 have moved apart (tension), and points 2 and 4 have moved closer together (compression). As a consequence, gage A has decreased in electrical resistance, while gage B has increased in electrical resistance.

It must be appreciated that the actual strains are less than a thousandth of an inch over the length of the gage, and the changes in electrical resistance are consequently very small. In order to develop a useable signal, and to cancel the effects of thrust and bending, four gages are connected in a bridge configuration as shown in Figure 9 and Figure 10. The gages in tension or compression are placed on opposite arms of the bridge, causing an unbalance when torque is applied to the shaft. When compensated for temperature, the output of the bridge has a linear relationship to the torque applied, and the resultant signal is fed to the electronics package for digital processing and is transmitted through the ESC junction to the Monitor. The ESC provides power to the selected power transformer, receives torque and speed signals, and provides signal conditioning for more reliable and accurate data transmission over a longer distance. The ESC is usually placed close to the instrumented shaft and transmits over a long distance to the monitor.

C. ELECTRONICS SIGNAL FLOW

The Torque system consists of an Instrumented Shaft, ESC, monitor, and cable assemblies.

Figure 6 is a block diagram of the system, depicting the signal flow between the various components, as previously described in Section IV.A: System Organization.

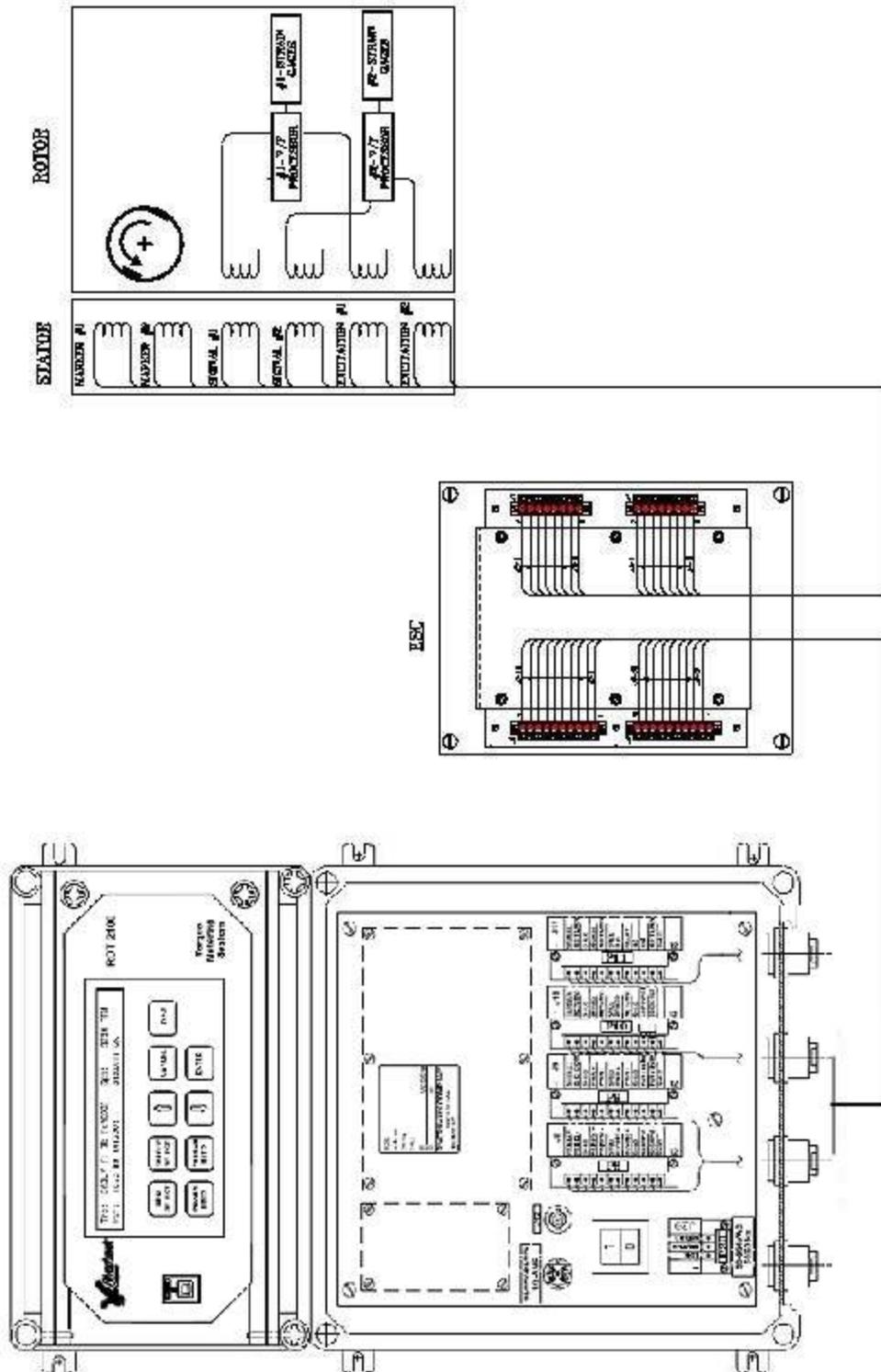
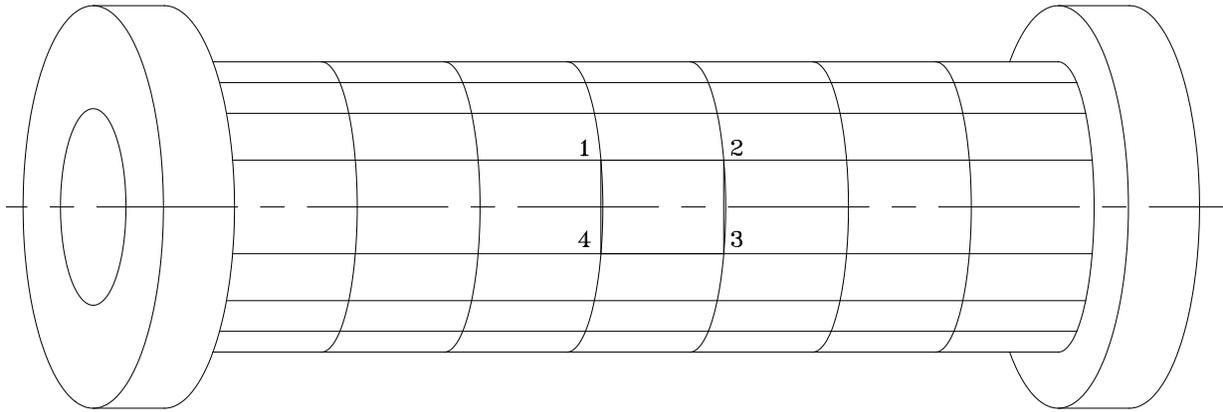


FIGURE 5: ELECTRONICS BLOCK DIAGRAM TYPICAL



SHAFT WITH ZERO TORQUE APPLIED

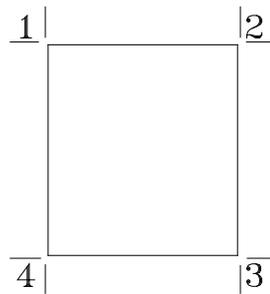
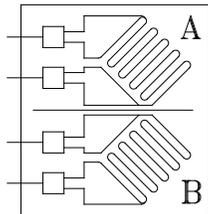
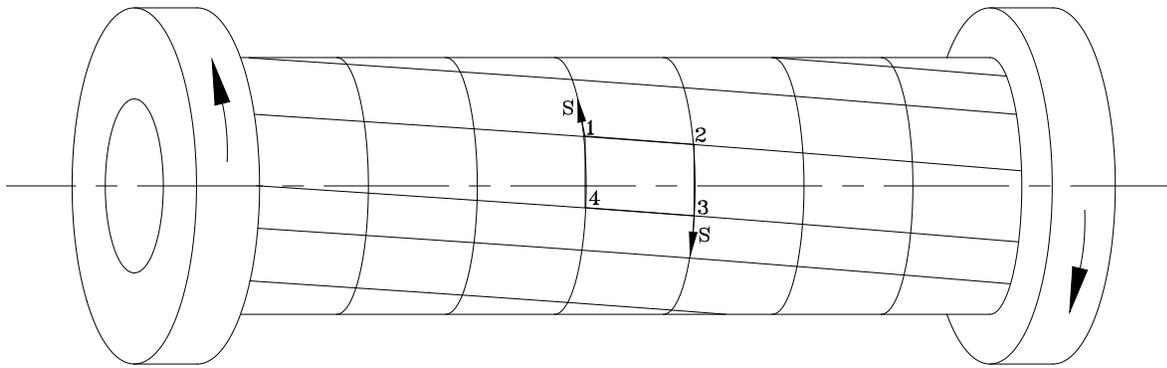


FIGURE 6: SHAFT WITH ZERO TORQUE APPLIED



SHAFT WITH TORQUE APPLIED

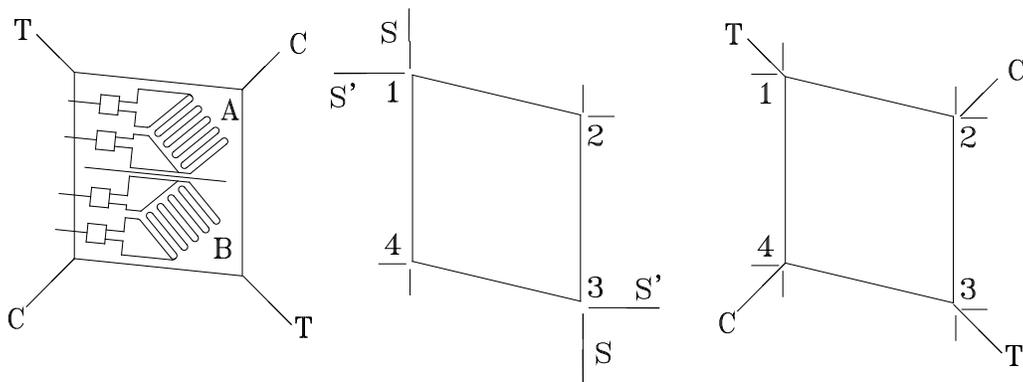


FIGURE 7: SHAFT WITH TORQUE APPLIED

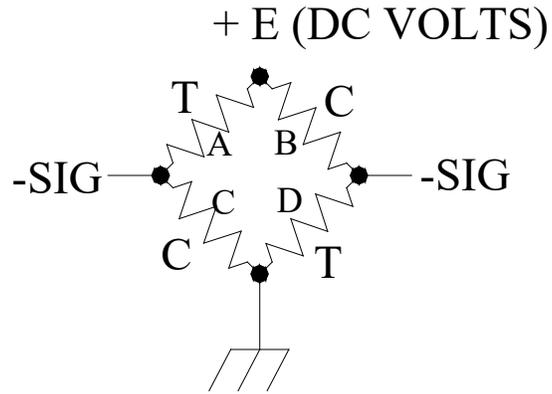


FIGURE 8 – GAGE DIAGRAM #1

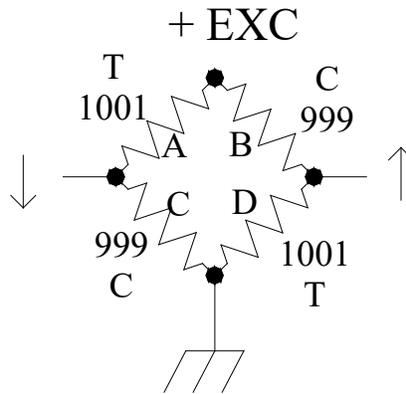


FIGURE 9 – GAGE DIAGRAM

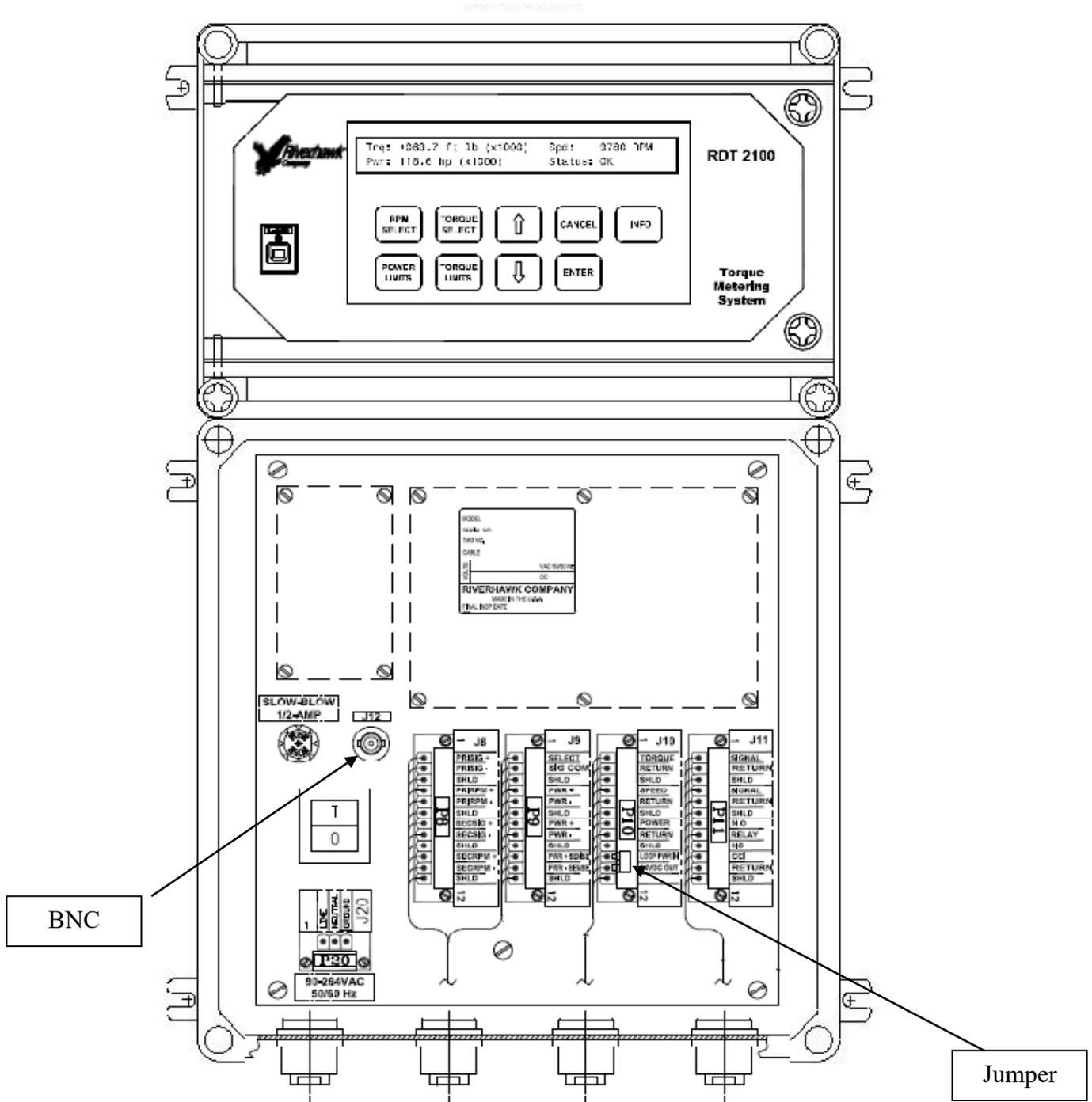
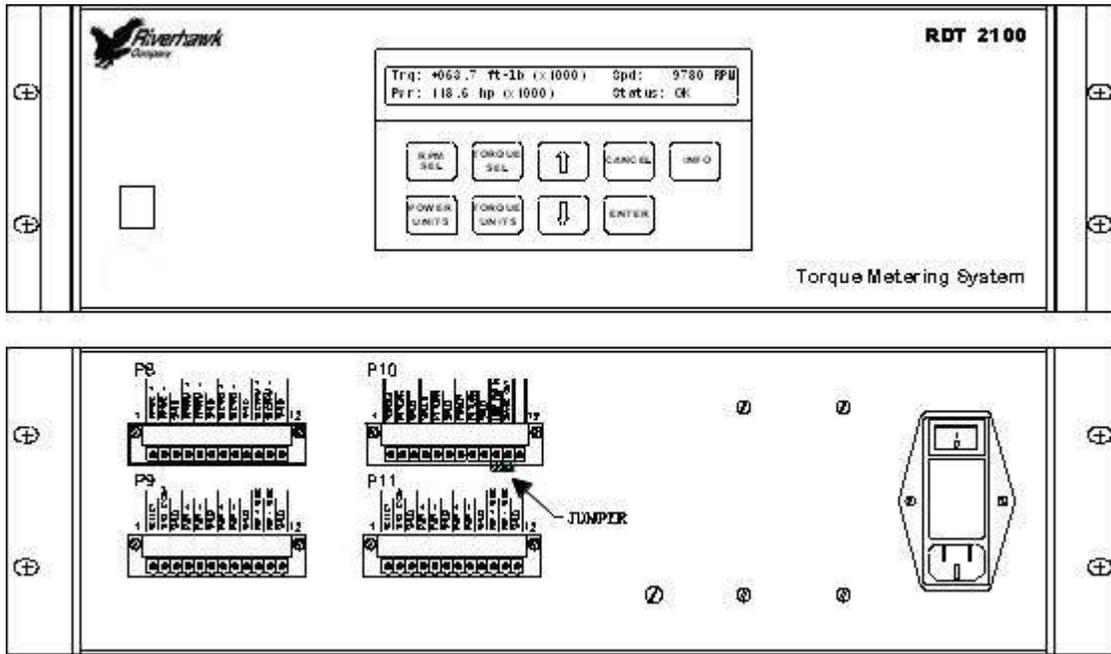


FIGURE 10: WALL MOUNT MONITOR

FIGURE 11: RACK MOUNT FRONT/REAR PANEL



V. OPERATION

A. POWERING UP THE SYSTEM

At power-up, the system will first display a sign-on message, identifying the model number, system type and the software version:

Riverhawk Company Model RDT 2100

Torque Measurement System Ver: x.x

Then the system displays a second message identifying the coupling associated with the loaded software. The message (and all subsequent messages on the display) will be held for a minimum of two seconds to allow them to be easily read.

After the opening messages, the system will begin to search for the signals from the shaft, associated with each sensor. While it is searching, it displays the following message:

Searching for Sensors,

Please wait...

This search, which takes a few seconds, locates all four sensor signals from the shaft. If all four are available and operable, then the system will proceed to select the sensors that were previously selected before the last power-down, and calculate the standard parameters based on those sensors.

If any are missing or out of range, their condition is noted internally, and the system will automatically switch to an alternate sensor. If all four sensors are missing, the system will continuously retry, looking for sensors, until at least one sensor becomes available.

Once the search for sensors is complete, and presuming that all sensor signals are found and are within operating parameters, the system will begin to display the standard parameter screen. This standard screen displays torque, power, and shaft speed, along with sensor status:

Trq: +063.7 ft-lb (x1000) Spd: 9780 RPM

Pwr: 118.6 hp (x1000) Status: OK

As seen in the example above, each of the three main parameters is displayed, with unit notation, along with a system sensor status indication.

An 'OK' status means that all sensors are functional and within bounds.

A ‘WARN’ status means that one or more sensors are faulty or missing, but the system is still capable of operating with the available sensors.

A ‘FAULT’ status means that two sensors of a given type (either torque or RPM) are both defective and the system will be unable to calculate power. If the system status is ‘OK’ or ‘WARN’, then the parameter display will be updated every 750 milliseconds (above 800 RPM). This update rate corresponds to the internal measurement and update rate of the instrument, as well as the update rate of the analog outputs and serial data outputs.

An ‘OVRNG’ displayed in the place of values for torque, speed, or power will occur in the event of any of these values being severely over range compared to what was programmed.

B. OPERATOR CONTROLS

The instrument keyboard provides a means of controlling certain aspects of the instrument’s display behavior. There are nine keys, used singly, and in combination, to alter the behavior of the device or to provide information. Sections V.B.1 through V.B.6 below describe the operation of keys that are available to any operator, and are not protected via a lockout mechanism.



1. THE INFO KEY

Pressing the INFO Key will cause the display to indicate the status of each of the four sensors within the shaft and display subsequent screens identifying coupling specific information loaded into the software. To freeze info displays, depress and hold the INFO key.

Stator status example:

<i>Pri Trq: fault</i>	<i>Pri RPM: selected</i>
<i>Sec Trq: selected</i>	<i>Sec RPM: OK</i>

An indication of ‘Selected’ means that the sensor is operating properly and is currently the selected sensor for that particular parameter. An indication of ‘OK’ means that the sensor is not selected, but is operating properly. An indication of ‘Fault’ means that the sensor signal is missing or unreadable. In the example above, the system is operating with the secondary torque sensor (the primary torque sensor is missing or inoperable), and is also operating using the primary RPM sensor (although the secondary sensor is operable).

The INFO key may be held down for longer viewing, if required. After the INFO key is released, the display will cycle through all displays messages then revert to the standard parameter display. Holding the INFO key down suspends further data updates, until released.



2. THE TRQ SEL KEY

The TRQ SEL key is used to alternately select the primary or secondary torque sensor. If the primary torque sensor is currently selected, pressing the TRQ SEL key will cause the system to select the secondary sensor, and vice versa. When the key is pressed, a message will appear to confirm the change of selected sensor:

***Switching to secondary torque sensor,
Please wait...***

After two seconds, the display will switch back to the standard parameter display, and the parameters will reflect the use of the newly selected sensor.



3. THE RPM SEL KEY

The RPM SEL key is used to alternately select the primary or secondary RPM sensor. If the primary RPM sensor is currently selected, pressing the RPM SEL key will cause the system to select the secondary sensor, and vice versa. When the key is pressed, a message will appear to confirm the change of selected sensor:

***Switching to secondary RPM sensor,
Please wait...***

After two seconds, the display will switch back to the standard parameter display, and the parameters will reflect the use of the newly selected sensor.



4. THE TRQ UNITS KEY

The TRQ UNITS key is used to change the units representation of torque, as desired by the operator. There are four units of measurement supported by this instrument: in-lbs, ft-lbs, meter-kilograms, and Newton-meters. When the TRQ UNITS key is initially pressed, the display will show the currently selected units of measurement, and prompt the operator to either change the units representation (by pressing the TRQ UNITS key repeatedly until the desired units are displayed, followed by the ENTER key), or to press CANCEL to return to the standard parameter display:

Select torque units: in-lbs

Press again to change, or [ENTER/CANCEL]

When this screen is displayed, each time the TRQ UNITS key is pressed, the indicated units on the top line will change to the next measurement units. The ENTER key is pressed to accept the specified units, or the CANCEL key is pressed to cancel any change and revert to the previously selected units of representation.



5. THE PWR UNITS KEY

The PWR UNITS key is used to change the units representation of power, as desired by the operator. There are two units of measurement supported by this instrument: Horsepower (Hp), or Kilowatts (kw). When the PWR UNITS key is initially pressed, the display will show the currently selected units of measurement, and prompt the operator to either change the units representation (by pressing the PWR UNITS key repeatedly until the desired units are displayed, followed by the ENTER key), or to press CANCEL to return to the standard parameter display:

Select power units: hp

Press again to change, or [ENTER/CANCEL]

When this screen is displayed, each time the PWR UNITS key is pressed, the indicated units on the top line will change to the next measurement units. The ENTER key is pressed to accept the

specified units, or the CANCEL key is pressed to cancel any change and revert to the previously selected units of representation.

6. OTHER KEYS

The ENTER, CANCEL, and UP and DOWN keys have no function for ordinary keyboard operations, unless their use is prompted by the onscreen display. These keys are used more extensively for keyboard operations that are protected by a lockout mechanism, such as calibration and configuration operations (see the next section).

C. CONFIGURATION AND CALIBRATION OPERATIONS

Calibration and configuration of this system is performed at the factory at the time of manufacture. A complete calibration requires the ability to apply a known calibrated amount of torque to the shaft; consequently, it is not expected that a full calibration process will be performed in the field. Some of the cal/config commands may be used in the field to change optional settings (such as the sense of polarity of the shaft, or the mode of operation for the analog outputs).

This system contains keyboard commands that are used for configuring the system, as well as performing calibration of the torque sensors and analog outputs. These functions are invoked by a two key combination, where one key (either ENTER or CANCEL) is held down, while another key is briefly depressed.

1. SUPERVISORY LOCKOUT OPERATION

To protect against inadvertent use of the calibration/configuration functions, the calibration/configuration commands are protected with a lockout mechanism. If an operator attempts to invoke one of these functions, the following message appears:

***Cal/Config function lockout; enter
supervisory code, or CANCEL***

To release the lock, the authorized operator **must press the UP arrow key six times in succession**, after which, the following message will briefly appear.

***Security bypassed, cal/config
functions are enabled***

Once the lockout is bypassed, the screen will then prompt for the invoked function.

To re-lock the keyboard (and re-enable the security lockout), the operator must press the DOWN arrow key once, which will produce the following display:

***Cal/config function lockout
re-enabled, please wait...***

After the security lockout is re-enabled, the display will resume the normal parameter presentation.



2. SHAFT DIRECTION FUNCTION

The Shaft Direction function allows the operator to change the sense of the rotation of the shaft, for the purposes of assigning polarity to the torque value (which is the only bipolar parameter in the system). The Shaft Direction is defined as the rotation direction when viewed from the driver end. (Either clockwise or counter-clockwise). The direction for each machine train is gathered from the customer and set at the factory. However, there may be circumstances where the application demands that the sense of rotation be reversed.

NOTE:

Bear in mind that the polarity of the torque value affects not only the displayed value of torque, but the behavior of the analog outputs and serial data stream, as well.

The shaft direction function is entered by holding down the **CANCEL** key, and pressing the **TRQ UNITS** button briefly. Presuming that the security lockout is bypassed, the following display will appear:

***Switching to counter-clockwise torque
mode, please wait...***

After this message, the system will resume the normal parameter display; the user will note that the sign of the torque value will be the opposite of what it was before.

This function is ‘alternate action’ in nature; invoking it a second time will restore the polarity to the opposite sense, producing the following display:

***Switching to clockwise torque
mode, please wait...***

The selection of shaft direction (like all selections made using the configuration / calibration functions) is non-volatile and will persist through a power-down / power-up cycle.



3. TORQUE OFFSET ZEROING FUNCTION

The torque offset zeroing function is provided to re-establish the zero-torque operating point after system installation. This function is NOT the same as the zero calibration function; instead, this function applies an offset to the entire span of torque data, leaving the ‘gain’, or ‘slope’ of the torque sensor, unchanged. Normally, this function would be used to insure that the system reads a zero torque, after installation, while the shaft is not turning. It is intended to remove a small amount of residual torque indication due to flexure or misalignment of the shaft, and is not intended to be used as a calibration function.

CAUTION:

The torque offset zeroing function is NOT a reversible function. When used, this function presumes that there is NO torque being applied to the shaft. If this function is used while torque is applied, all torque readings will be offset by the amount of torque applied when the function was invoked. Use with caution!

To use this function, first be sure that the shaft is not rotating, and that there is no torque being applied. Then press and hold the CANCEL key, and while holding it, depress the UP_ARROW key. The display will prompt the operator, as shown:

***Primary torque sensor offset function
Are you sure? [ENTER/CANCEL]***

When the ENTER key is pressed, the system will make an accurate measurement of the value of torque of the indicated sensor, store it in non-volatile memory, and apply it subtractively to all subsequent calculations and displays for that sensor. During the measurement, the following message is displayed:

*Primary torque sensor zeroed,
please wait...*

NOTE:

This function applies to whatever sensor is currently selected, and the sampled offset value is applied to only that sensor. The alternate sensor can be zeroed separately, by first selecting it with the TRQ SEL key, and then applying this command).

D. AUTOMATIC SENSOR SELECTION

This system employs redundant sensors for both torque and RPM, along with an automatic system for selecting a working sensor if any sensor has failed. The RPM sensors are continuously monitored, but only the torque sensor that is selected is monitored. If any sensor fails, an attempt is made to automatically switch to the alternate sensor. If the alternate sensor is inoperable, the system informs the user of this fact (via a display message), and any dependent output variables will become invalid.

The system keeps track of the selected sensor, and this information is retained in nonvolatile memory. If the system is powered down and then powered up again, the system will attempt to utilize the last selected sensors when it initializes.

E. ANALOG OUTPUTS - AVERAGE TORQUE/SPEED/POWER

This system features three independent analog outputs, one each for speed (RPM), torque, and power. Each analog output stage is configured as a current source output, referred to a positive power supply, and capable of sourcing from 0 to 25 mA into a ground-referred resistive load. Each output stage is also designed to tolerate capacitive or inductive loads without uncontrolled oscillation.

The value of each analog output tracks the displayed parameter value, and is updated at the same rate as the primary display. During any calibration or configuration operations, the output updates are suspended, and each analog output will hold its last value. If any of the data variables are invalid, the corresponding analog output will be set for 22.5 mA (5.625 volts), as an indication that the value is invalid and/or unavailable.

1. ANALOG OUTPUT OVERHEADS AND COMPLIANCE

The overhead of the current source output stage of each analog output is less than 4 volts, so when powered from a 24 volt supply, each output stage will have compliance for loads of up to 800 ohms maximum.

2. VOLTAGE MODE OUTPUTS

In applications where a voltage output, rather than a current output, is desired, each output is equipped with an internal 250-ohm resistor load. The loads may be connected via jumpers J11 (torque), J12 (Speed), and J13 (Power), which will result in the outputs appearing as voltages in the 0-5 volt range.

3. ANALOG OUTPUT PROTECTION

Each output stage is protected against accidental shorts or inadvertent connections to external voltages of up to ± 200 volts DC, with respect to the local ground. This protection does not apply, however, when the internal resistive loads are connected via their respective jumpers.

4. ANALOG OUTPUT RANGES

The range and calibration of each analog output is accomplished via the calibration/configuration process.

The Speed (RPM) output and the Power output are unipolar variables, and may be configured for either 0-20mA or 4-20mA operation. In either case, the minimum output corresponds to zero RPM and/or zero torque, and the maximum output corresponds to full scale RPM and/or torque, as defined by the customer. A voltage output mode is available (via internal jumpers), where the maximum outputs will correspond to 5 volts, and the minimum outputs will correspond to 0 volts or 1 volt (depending on whether the unit was configured for 0-20mA or 4-20mA).

Torque is treated as a bipolar variable, since, in some cases (such as motor/generator arrangements), the driving force may be transmitting power to the load, or the load may be dragging on the driving force. When torque is positive, it is assumed that the power source is driving the load; when torque is negative, it may be assumed that the load is driving the source. Because of this, the system provides for the ability to configure the analog output for the power variable as a bipolar signal or a unipolar signal.

When configured as a unipolar signal (0-20mA or 4-20mA), negative torque values are clipped, and only positive values are transmitted. When configured as a bipolar signal (0-10-20mA or 4-12-20mA), both positive values and negative values can be represented. In the latter case, the middle value (10mA, in the case of 0-10-20mA, or 12mA, in the case of 4-12-20mA) represents zero torque.

Analog outputs for average Torque/Speed/Power are located on connector P10 of the monitor. Refer to Riverhawk drawing 35227 for wiring diagram.

F. DYNAMIC TORQUE OUTPUTS (IF APPLICABLE)

This monitor option adds hardware that provides several features related to dynamic torque, which could be transient or torsional (due to vibration). Torsional vibration, for example, can be short term or ongoing that could have magnitudes of 10% of normal torque or higher in some cases. The dynamic torque signal output has a much faster sampling rate and response compared to the average torque analog output.

1. COMPLIMENT OF I/O

The additional I/O includes two 4-20mA outputs (pluggable connector, **J11**), one voltage output (BNC, **J12**). A typical configuration may be as follows:

- *Dynamic output #1: 4-20mA, scaled for 0-110% calibration torque*
- *Dynamic output #2: 4-20mA, scaled for 0-125% calibration torque*
- *Dynamic output #3: 0-10 volt output scaled for 0-120% calibration torque (BNC)*

**** Exact dynamic torque configurations are discussed with customer once receiving order and listed on Instrumented Coupling drawing for customer review prior to shipment. All configurations are programmed into monitor at the factory before shipment****

2. CONFIGURATION

The dynamic torque outputs are located on connector J11 (two 4-20mA outputs) and J12 (BNC, voltage output). The front panel USB connection provides two Serial Communications connections. One serial port is used for the calibration and configuration of the standard analog section of the system. The second serial port is used for the calibration and configuration of the added dynamic-torque board that provides the optional features. All programming is performed at the factory at time of calibration.

3. TORSIONAL VIBRATION

Measuring torsional vibration on non-synchronous motor applications represents no unusual challenges. This assumes that the neckdowned portion of the coupling (if needed) provides in the neighborhood of 15,000 PSI or 500 microstrain, and that the magnitude of the torsional vibration is of reasonable magnitude (at least a few percent of full scale).

4. HIGH STARTUP TORQUES

Measuring peak torques and the critically damped response (decaying oscillations) on synchronous motor applications represents some challenges. The assumption is that the tube will see no more than 60,000psi or 2,000microstrain. This provides four times the normal signal, so one-quarter of the typical amplification is needed. This improves the signal-to-noise ratio over the full-scale capability, but worsens resolution and accuracy at normal torque levels. Accuracy is stated as a percent of full-scale.

Torque generating 2,000 microstrain is not an issue for the strain gage bridges used. Operating under that limit has little effect on the gages and causes essentially no fatigue.

5. VFD DYNAMC TORQUE

The system will be able to measure torsional vibration from 0 to about 1000Hz (3dB point). VFD issues generating frequencies above 1000Hz can't be diagnosed with the system.

G. THE USB COMMUNICATION PORT, INTERFACE APPLICATION

The USB Comm port is reserved for communications to/from an external device such as a laptop computer, or PC. This port should only be utilized in conjunction with Riverhawk provided application program (EXE file type). This port emits a stream of data from the microprocessor,

containing the values of each of the three primary calibration parameters, as well as status information about the condition of the instrument. It also permits limited control capabilities from an external computer, and has the ability to allow service personnel to retrieve, or load, coupling specific calibration parameters. Also, as previously stated in last section, The USB includes two serial communication ports; the second port. In addition to that described above, the second serial port is used for the calibration and configuration of the dynamic torque portion of the monitor. When connecting to the USB port, it is recommended to keep cable lengths to 50' or less.

H. SYSTEM POWER

This instrument requires nominal 115 or 230 VAC power. The Monitor will operate on 90-264 VAC, 50/60 Hz.

OPTION:

This instrument can be supplied for use with a +24VDC power supply, drawing approximately 200mA (260mA, if the analog outputs are powered by the same supply). The power supply may be unregulated, as long as the voltage remains within the +18 to +30 VDC range.

Power supply voltages below +18VDC may cause failure of the sensor electronics within the shaft. If the same power supply is used to power the analog output stages, voltages below +24VDC may reduce the available compliance range of the analog outputs.

VI. TROUBLE SHOOTING

In the event a system fault or warning occurs, five steps are recommended.

1. CONFIRM PROPER VOLTAGE IS BEING SUPPLIED.
2. CONFIRM CABLE CONNECTIONS ARE SECURE.
3. CONFIRM THE STATOR GAP AND AXIAL ALIGNMENT.
4. CAREFULLY INSPECT THE CABLE HARNESS (MONITOR CABLE) FOR DAMAGE
5. POWER OFF THE TORQUE METER FOR ONE MINUTE AND POWER BACK ON FOR SYSTEM RESET

If warnings or fault indications continue, contact Riverhawk for further technical assistance.

Tel: (315) 768-4855 Fax: (315) 768-4941

email: info@riverhawk.com

USA

VII. SPECIFICATIONS

Sensors

Torque Sensor	Strain gages
Sensing Range	+/-500 microstrain
Speed Sensor	Hall-effect sensor
Torque Accuracy	Refer to the temperature specifications

Display

Type	2 Lines by 40 Character VFD
Viewing Area	5.5" wide by 0.5" high

Analog Outputs (average)

Calibrated range	4-20mA, typical
Accuracy	0.25% of full scale mA, over calibrated range
Compliance	For load resistance less than 500 ohms

Analog Outputs (dynamic torque)

Compliance	For load resistance less than 500 ohms
Actual range	0-25mA, typical 0-10V, typical
Accuracy	0.25% of full scale
Relay Output	SPDT, rated 5A resistive Suitable for signal level switching until they actuate a high current load
Frequency Response	DC to 1000Hz 1000Hz is the 3dB point; 30% signal reduction
Sampling	5000 samples/second, typical Varies with torque level, 2500 to 7500 s/s

Field Wiring Connectors

Pluggable Phoenix type connectors with captive wire clamps

Operating Power - AC

Voltage	90 to 264 VAC, 50/60 Hz (24 VDC optional)
Power Consumption	8 watts maximum
Fuse Rating	2A, 5mm x 20mm, Time-Lag

Operating Power – DC Option

Voltage	18 to 30 VDC, 24 VDC nominal
Power Consumption	8 watts maximum
Fuse Rating	2A, 3AG, Time-Lag

Mechanical

Refer to Installation Drawings

Environmental (Instrumented Couplings)**Operating Temperature and Accuracy (Where T is the ambient temperature)**

T = 25°C: ±0.5% accuracy, typical

25°C < T ≤ 85°C: ±1.0% accuracy

85°C < T ≤ 115°C: ±1.5% accuracy

T > 115°C: May compromise performance and/or long term reliability

T > 135°C: Operation not recommended

Comments on Elevated Temperatures

Device specifications are typically limited to 125°C, and for integrated circuits that is the junction temperature. Our 115°C specification allows for a 10°C degree temperature rise between the ambient and junction temperature. Empirical testing may demonstrate that components continue to work well above 125°C, but there are no guaranteed characteristics nor long term reliability information for such operation. Consequently, operation above 115°C is not guaranteed, even though the product may work fine with only a slight degradation in performance.

ESC (Excitation and Signal Conditioning Module)

Storage Temperature -40°F to 185°F (-40°C to 85°C)

Operating Temperature -40°F to 185°F (-40°C to 85°C)

Monitor

Storage Temperature 32°F to 185°F (0°C to 85°C)

Operating Temperature 32°F to 131°F (0°C to 55°C)

Stator to ESC Cable

Storage Temperature -40°F to 392°F (-40°C to 200°C)

Operating Temperature -40°F to 392°F (-40°C to 200°C)

ESC to Monitor Cable

Storage Temperature -40°F to 221°F (-40°C to 105°C)

Operating Temperature -40°F to 221°F (-40°C to 105°C)

As with all electronic equipment, life and reliability are maximized when temperatures are limited as much as possible.

System

Relative Humidity 0 to 100% (non-condensing)

Transportation Vibration IAW Commercial Handling/Shipping

VIII. LIMITED WARRANTY

All torque metering systems are warranted to operate within specification under normal use and service for a period of one year from system startup or two years from shipment, whichever is shorter.

REDUNDANT HARDWARE

Due to the nature of the overall systems in which the torque meters are used, it is often not possible to take the system off-line for diagnosis or repair, should a malfunction occur. This is especially true if a failure occurs within the instrumented coupling. As such, Riverhawk has included redundant hardware in the instrumented coupling to provide a secondary, independent channel to be used in the event of a failure of the primary channel. Both channels shall be operational when they leave the factory. Only one channel is warranted to be operational during the warranty period, as only a single channel is necessary for normal operation. The second channel is included to avoid a non-operational system should the primary channel fail during shipment, installation, or operation during the warranty period.

REPAIRS

The paragraphs that follow apply to a failure that occurs within the warranty period.

A. REPAIRS TO ITEMS OUTSIDE THE COUPLING GUARD

Should a failure occur outside the coupling guard, Riverhawk will repair or replace items to restore normal operation.

B. REPAIRS TO ITEMS INSIDE THE COUPLING GUARD

The term instrumented coupling will be used to refer to all hardware included inside the coupling guard, which is inaccessible whenever the overall system is operating (or the coupling is spinning above turning gear speed).

Should a failure occur in the in electronic boards assembly in the instrumented coupling, Riverhawk will replace the electronics assembly as practical. This is only practical if the system will be shutdown and the instrumented coupling is removed for the repair, and Riverhawk has sufficient lead time to produce a replacement assembly and install it prior to the need to reinstall the coupling. Such a repair can only be done on-site if the coupling manufacturer and customer agree that rebalancing and calibration are not required. Without calibration, the absolute values of torque and power cannot be guaranteed to be accurate. In many cases, only the relative value and its trend are of primary importance. If rebalancing and/or calibration are required, sufficient down time must be available for transit and processing.

Should a failure occur elsewhere in the instrumented coupling (other than in the electronic assembly), Riverhawk will repair the instrumented coupling, provided it is shipped to their facility and is available to them for 20 weeks. This time is required as it is not likely that a simple repair can be done. It is likely that all added material, including the stator, rotor, strain gages, electronics, wiring, and hardware must be removed by machining, the coupling restored to its initial condition, and the instrumentation rebuilt from scratch. After that, the newly instrumented coupling will be calibrated and sent to the coupling manufacturer for balancing, prior to its return to the customer.

INSTRUMENTATION OF A SPARE COUPLING

Based upon the information in the “Repairs to Items Inside the Coupling Guard” section, it is often not practical to repair an instrumented coupling. If an uninstrumented spare coupling is available, Riverhawk will instrument the customer's spare should a failure occur in the instrumented coupling. This presumes that the uninstrumented spare is identical to the instrumented coupling, meaning that the neck-down area and all other additional features have been included or will be included. Riverhawk will instrument the coupling, provided it is shipped to their facility and is available to them for 16 weeks. After that, the newly instrumented coupling will be sent to the coupling manufacturer for balancing, prior to its return to the customer.

SPARE PARTS

Depending on the nature of the application and the criticality of the torque metering system, it is wise to consider having an appropriate complement of spares on-site. It is important to keep in mind that the timing of a failure relative to a shutdown may not provide sufficient time to facilitate the repair to an instrumented coupling or having a spare coupling instrumented. In many cases, the only appropriate approach is to have a spare instrumented coupling.

LIMITED WARRANTY CONTINUED

This warranty is in lieu of and excludes any other warranty, express or implied, including, but not limited to, any implied warranty derived from quote or fitness of purpose. (Manufacturer's liability and Buyer's limited remedies under Manufacturer's warranty shall be limited solely to repair, replacement, credit or refund, at the manufacturer's option, with respect to products supported by a Return Material Authorization number obtained from the Manufacturer. The Manufacturer shall not be liable, under any circumstances, for consequential or incidental damages, including, but not limited to, labor costs or loss of profits arising in connection with the use of or inability to use products purchased from the Seller.)

Product Application: The Buyer is solely responsible in determining the suitability of the Manufacturer's products in its application regardless of circumstances.

Manufacturer reserves the right to make future design changes to any of its products without thereby incurring any obligations to make changes to or replacements of this product.

Manufacturer neither makes nor authorizes any person to make on its behalf any other guarantee or warranty concerning its products.

Service: To obtain service under this Limited Warranty call the Riverhawk Company directly to obtain an RMA (Return Material Authorization) number.

If returning the system in its entirety or in part:

Pack the item(s) in its original shipping container (or equivalent)

Put the RMA number on the address label

Put the RMA number on the shipping carton

Insure it (or assume the risk of loss / damage during shipment)

Ship the product freight pre-paid to the Riverhawk Headquarters.

Manufacturer is not responsible for damage to inbound product.

Riverhawk (Headquarters)

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