



# TMS 2200 TORQUE METERING SYSTEM

## Installation & Operation Manual

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## Table of Contents

SYSTEM DESCRIPTION .....	5
TORQUE METERING SYSTEM OPERATION .....	5
SYSTEM ARRANGEMENT .....	5
OUTPUTS .....	7
APPLICABLE DOCUMENTS & DATA .....	9
LIST OF DRAWINGS .....	9
UNITS AND CONVERSIONS .....	9
INSTALLATION .....	10
INSTALLATION PROCEDURE .....	10
GENERAL PREPARATIONS .....	10
CABLE ROUTING AND CONNECTIONS .....	13
ESC AND MONITOR INSTALLATION .....	19
SPARE/RECALIBRATED COUPLING INSTALLATIONS (IF APPLICABLE) .....	20
THEORY OF OPERATION .....	21
SYSTEM ORGANIZATION .....	21
PRINCIPLES OF TORQUE MEASUREMENT .....	21
ELECTRONICS SIGNAL FLOW .....	22
OPERATION .....	27
POWERING UP THE SYSTEM .....	27
OPERATOR CONTROLS .....	28
CONFIGURATION AND CALIBRATION OPERATIONS .....	30
AUTOMATIC SENSOR SELECTION .....	33
ANALOG OUTPUTS - <i>TORQUE (AVERAGE), SPEED, POWER</i> .....	33
DYNAMIC TORQUE OUTPUTS (IF APPLICABLE) .....	34
THE USB COMMUNICATION PORT, INTERFACE APPLICATION .....	35
SYSTEM POWER .....	35
TROUBLE SHOOTING .....	36
HAZARDOUS LOCATION WARNINGS .....	37
REPAIRS .....	38
Fuse Replacement .....	38
Line Cord (Mains Supply Cord) Replacement .....	38
Other Repairs .....	38

SPECIFICATIONS .....	39
Sensors .....	39
Display .....	39
Analog Output (average).....	39
Analog Outputs (dynamic torque) .....	39
Field Wiring Connectors.....	39
Operating Power .....	39
Mechanical.....	39
Approvals .....	39
Environmental.....	40
Instrumented Couplings.....	40
Operating Temperature and Accuracy (Where T is the ambient temperature).....	40
Comments on Elevated Temperatures .....	40
ESC (Excitation and Signal Conditioning Module).....	40
Monitor .....	40
Stator to ESC Cable .....	40
ESC to Monitor Cable .....	40
System.....	41
LIMITED WARRANTY .....	42
REDUNDANT HARDWARE .....	42
REPAIRS .....	42
INSTRUMENTATION OF A SPARE COUPLING .....	43
SPARE PARTS .....	43
LIMITED WARRANTY CONTINUED .....	43

## Table of Figures

Figure 1: RACK MOUNT MONITOR BLOCK DIAGRAM.....	6
Figure 2: STATOR-TO-ESC CABLE OUTLINE .....	14
Figure 3: STATOR ALIGNMENT .....	17
Figure 4: STATOR COIL ALIGNMENT .....	18
Figure 5: ELECTRONICS BLOCK DIAGRAM TYPICAL.....	22
Figure 6: SHAFT WITH ZERO TORQUE APPLIED .....	23
Figure 7: SHAFT WITH TORQUE APPLIED .....	24
Figure 8: GAGE DIAGRAM #1 .....	25
Figure 9: GAGE DIAGRAM #2 .....	25
Figure 10: RACK MOUNT FRONT/REAR PANEL.....	26

## SYSTEM DESCRIPTION

### TORQUE METERING SYSTEM OPERATION

Torque transmitted between the driving and driven machines is measured in an instrumented section of the coupling or spacer tube connecting the two. Generally this is accomplished within a flexible coupling which has been instrumented with strain gages to measure the strain, or twist, in a section of the coupling or spacer tube.

The system consists of three major parts, the Monitor, the ESC (Excitation & Signal Conditioning module), and the Instrumented Coupling. The Monitor provides DC power to the ESC. The ESC generates AC (Alternating Current) at a frequency of 43.2 KHz (fixed and crystal controlled) and provides that to the power winding of a stator which is part of a rotary transformer. The corresponding winding of the rotor powers the in-shaft circuitry and strain gages. The signal from the strain gages is amplified and fed to a precision V/F (Voltage to Frequency converter), which operates between 1.5 KHz and 9 KHz. This signal is sent to the ESC through the signal windings of the rotor and stator. Magnets located in the rotor are sensed by Hall-effect sensors in the stator producing a pulsed signal that also goes to the ESC, representing the rotating speed of the coupling. The ESC conditions and buffers the signals and sends them to the Monitor.

In the Monitor, the signals are processed and displayed on digital readouts as torque, speed, and power. Analog and serial digital data are available for each of the parameters.

The term “sensor” is used herein to mean either a set of electronics that provide a signal corresponding to torque or a Hall-effect sensor that provides a signal corresponding to speed.

Two complete and independent sensor groups provide signals to the ESC for torque and for speed. If a sensor fault condition occurs, the monitor will automatically switch from a non-working sensor to a working sensor.

### SYSTEM ARRANGEMENT

Figure 1 shows the configuration of the torque metering system. For complete information on a particular system, the System Arrangement and Systems Parameter Documents from the documentation package should be consulted.

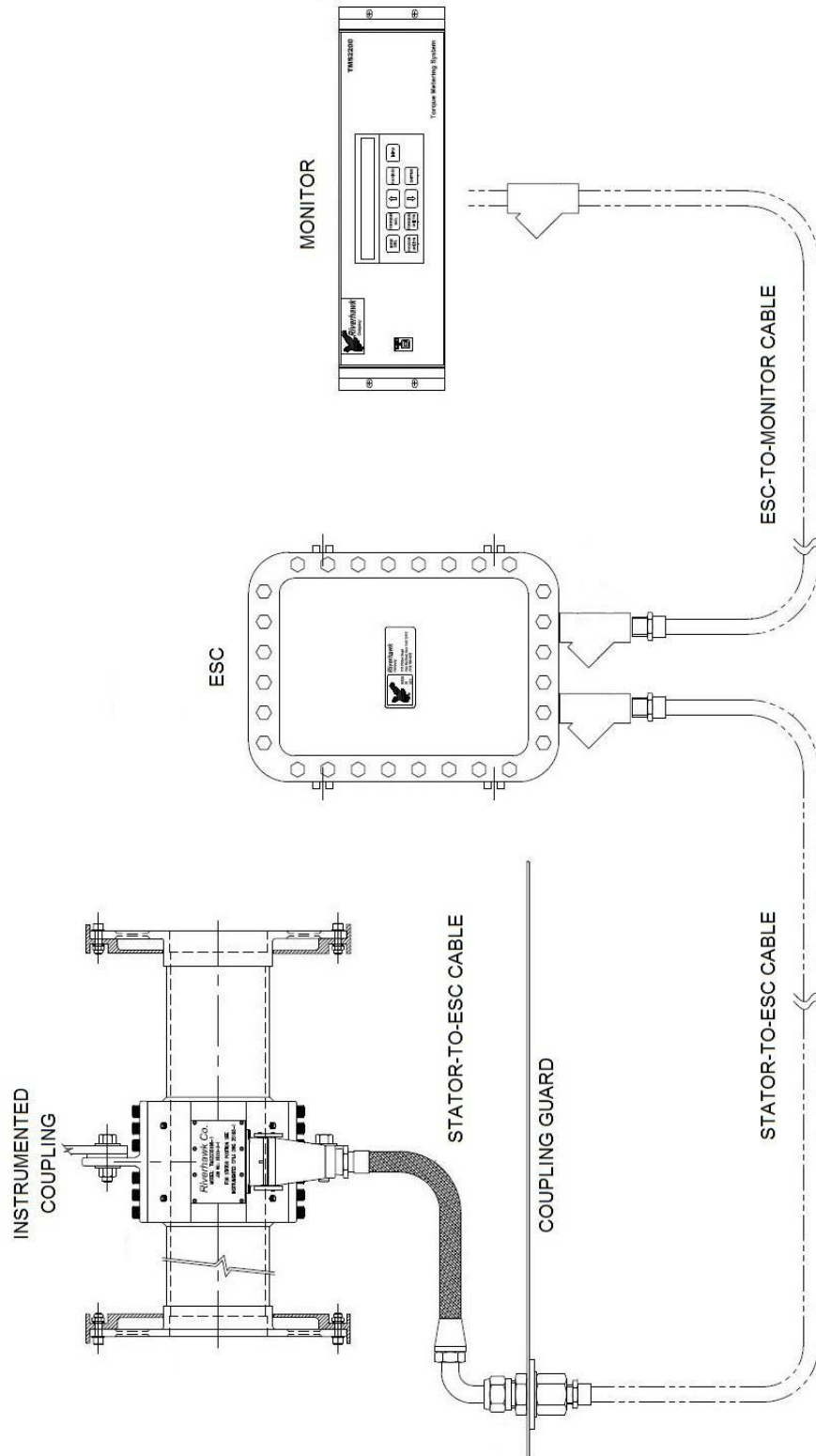


Figure 1: RACK MOUNT MONITOR BLOCK DIAGRAM

## CAUTION SYMBOL



CAUTION: Documentation must be consulted in all cases where the CAUTION symbol is marked.

ATTENTION: Il faut consulter la littérature partout où le symbole ATTENTION apparaît.

*CAUTION: For this system, be sure to consult all appropriate specifications prior to powering the system or changing fuses. Consult all drawing provided when making any wiring changes. Do not disconnect or change any wiring while power is applied.*

*ATTENTION: Pour ce système, Il faut absolument consulter toutes les normes en vigueur avant de le mettre sous tension ou de changer les fusibles. Consulter tous les dessins fournis avant de changer le câblage. Ne pas débrancher ni modifier le câblage quand l'appareil est sous tension.*

## OUTPUTS

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

- Torque (the torque being transmitted through the shaft, including polarity)
- Speed (the absolute value of rotational speed of the shaft)
- Power (the absolute value of power being transmitted by the shaft)

The “Units and Conversions” section gives definitions of various units and conversions between them.

Because the zero of the torque metering 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 at connector P10 on the rack mount style monitor (Figure 10). An independent output is provided for each of the three measured parameters, torque, speed, and power. The form of these outputs may be 4-20 mA or 0-5 Vdc. Dynamic torque outputs are also available at connector P11. The scale factor for each output can be found on the System Parameters Drawing located in the provided documentation package.



## APPLICABLE DOCUMENTS & DATA

### LIST OF DRAWINGS

Drawings are supplied in a separate, printed drawing package and as well as soft copy.

### UNITS AND CONVERSIONS

#### DEFINITIONS:

1 Newton (N) =	1 Kilogram-meter per second-second (kgm/sec <sup>2</sup> ) = 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) 33,000 foot-pounds per minute (lb-ft /min)
1 Horsepower (HP) =	

#### CONVERSIONS:

1 Newton (N) =	0.10197 kilograms force (kgf) = 0.22481 pounds force (lbf)
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)

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

## INSTALLATION

### INSTALLATION PROCEDURE

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

- Be sure to read through and understand all of the General Considerations (See Section III.B General Preparations)
- Install the ESC (See Section III.D.1: ESC (Excitation & Signal Conditioning Module Installation))
- Route the cable conduit from the Coupling Guard to the ESC Module. (See Section III.C.1: Stator to ESC Cable Installation)
- Plan the best route for the Stator-to-ESC Cable from the stator to the coupling guard, and determine if any cable clamps are needed. (See Section III.C.1: Stator to ESC Cable Installation)
- Mount the Fittings on the Coupling Guard. (See Section III.C.1: Stator to ESC Cable 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.

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

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

### GENERAL PREPARATIONS

#### BALANCING

The shaft or flexible coupling is normally given a preliminary balance by the manufacturer 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, 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 area must be protected at all times and not used to support the weight of the shaft.

Often, the shaft/tube of the flexible coupling is long enough that the stator may be slid away from the rotor section to one end. Since the diameter of the rotor section is generally greater than the diameter of the tube, moving the stator away from the raised rotor 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 damaged.

### 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 is designed to have adequate radial clearance between the inside of the stator and outside of the rotating rotor 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: Shaft/Stator Installation. In the absence of Riverhawk personnel, 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, 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.**

*WARNING: Do not use the stator ears to lift, carry, or support the weight of the coupling.*

*MISE EN GARDE: Ne pas se servir des oreilles du stator pour lever ou transporter l'accouplement ou pour en soutenir le poids.*

## COUPLING INSTALLATION

*NOTE: The Instrumented Coupling must be contained within a coupling guard between the two machines to which it is attached. The guard must meet the requirements of IP44 to ensure that the hazardous protection technique (non-arcing) is maintained*

The system is supplied with a 6 inch square plate that includes labels identifying the coupling, the certification, and the required warnings. This plate must be attached to the outside of the coupling guard in a location that is readily visible.

## CABLE TERMINATION AT THE ESC AND THE MONITOR

Careful installation of the cables between units is essential. 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 in the non-hazardous area, and in this case, a clear record of the terminal numbers and wire colors is essential.

*NOTE: If junction boxes are installed, careful attention must be given to the wiring of shields to prevent ground loops and noise problems. Shield connections should be carried through on separate terminals, rather than a single point.*

It is particularly important to consult the supplied installation drawings.

Unintended connections or inadvertent shorts may cause transients that could damage to components or shorten the life of the system. Do not make cabling changes while power is applied to the system.

Stator position should also not be changed while power is applied.

*CAUTION: Do not apply power until all connections are verified after final wiring.*

*ATTENTION: Ne pas mettre sous tension avant d'avoir contrôlé tous les raccordements après le câblage final.*

## CABLE ROUTING AND CONNECTIONS

### STATOR TO ESC CABLE INSTALLATION

The cable must be run in rigid conduit between the coupling guard and the ESC. Install the provided pass-through fitting in the coupling guard wall from the outside. Install the conduit between the coupling guard and the ESC enclosure. After the conduit is installed, the cable can be fed through the conduit starting at the inside of the coupling guard. Once fed through, the fitting on the end of the hose of the cable assembly must be attached to the fitting on the inside of the coupling guard. Connect the cable to the mating connector on the stator and lock it in place with the locking lever. Install clamps on the cable inside the guard at intermediate points to restrict movement of the cable due to vibration as needed.

Connect the stripped wire end to the ESC Board using the captive wire clamps of the pluggable connectors. Connect the cable in accordance with the supplied installation drawings.

Standard cable lengths for the stator-to-guard section of the cable are 2, 3, 4, 5 and 6 feet, while the guard-to-ESC section can be selected in 1-foot increments up to 45 feet.

*NOTE: Do not shorten the cable. Excess cable length can be coiled up within the ESC enclosure.*

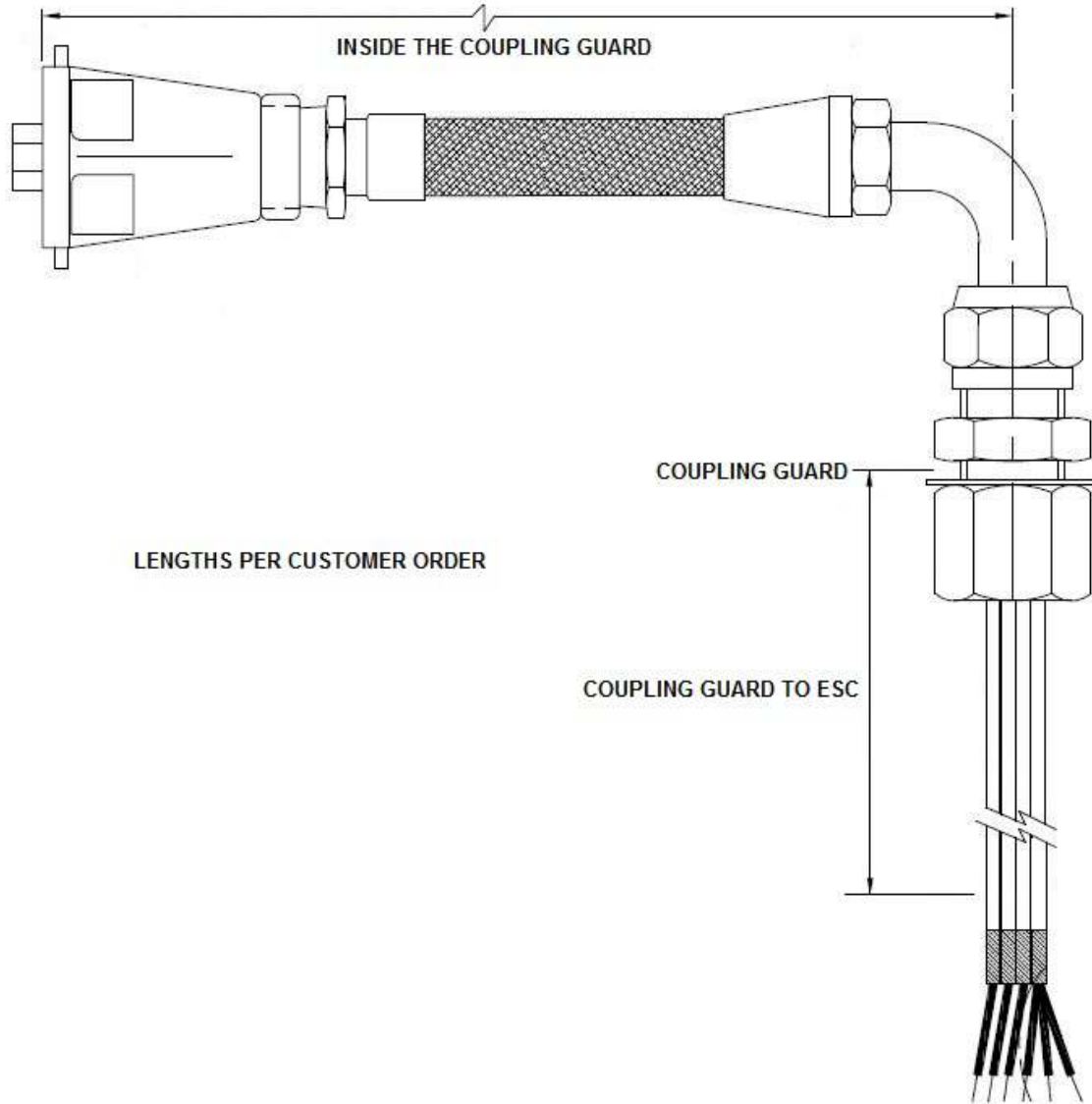


Figure 2: STATOR-TO-ESC CABLE OUTLINE

## ESC TO MONITOR CABLE INSTALLATION

The cable must be run in rigid conduit between the ESC and the non-hazardous area. A sealing gland must be installed after the conduit passes into the non-hazardous area. After the conduit is installed, the cable can be fed through the conduit starting in the non-hazardous area. Connect the stripped wire ends to the ESC Board using the captive wire clamps of the pluggable connectors. Connect the stripped wire ends at the rear of the monitor using the captive wire clamps of the pluggable connectors. Connect the cable in accordance with the supplied installation drawings.

*NOTE: Do not shorten the cable. Excess cable length can be coiled up in the cabinet containing the Monitor.*

## COUPLING/STATOR INSTALLATION

### STATOR INSTALLATION

*WARNING: Do not use the stator ears to lift, carry, or support the weight of the coupling.*

*MISE EN GARDE: Ne pas se servir des oreilles du stator pour lever ou transporter l'accouplement ou pour en soutenir le poids.*

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 rotor and stator of the coupling must be handled carefully to prevent damage during assembly and disassembly. Moving the stator exposes the rotor. The rotor 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 mating 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 diameter of the stator has been made larger than the outside diameter of the rotor to provide sufficient radial clearance for normal coupling misalignment. The rotor and stator have been designed to allow for typical axial motion of the coupling.

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 stator position and other important details. Figure 4 and Figure 5 pertain to proper stator alignment.

*NOTE: Prior to any movement of the stator, remove or loosen any gap adjustment shims/devices to prevent damage to the rotor/stator surfaces.*

After the coupling has been installed, the stator may be moved to its optimum axial position; stator centered over the raised rotor section.

*NOTE: See the Coupling Outline Drawing for the optimum axial position dimension.*

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 outside diameter and the stator inside diameter is uniform during normal machine operation.

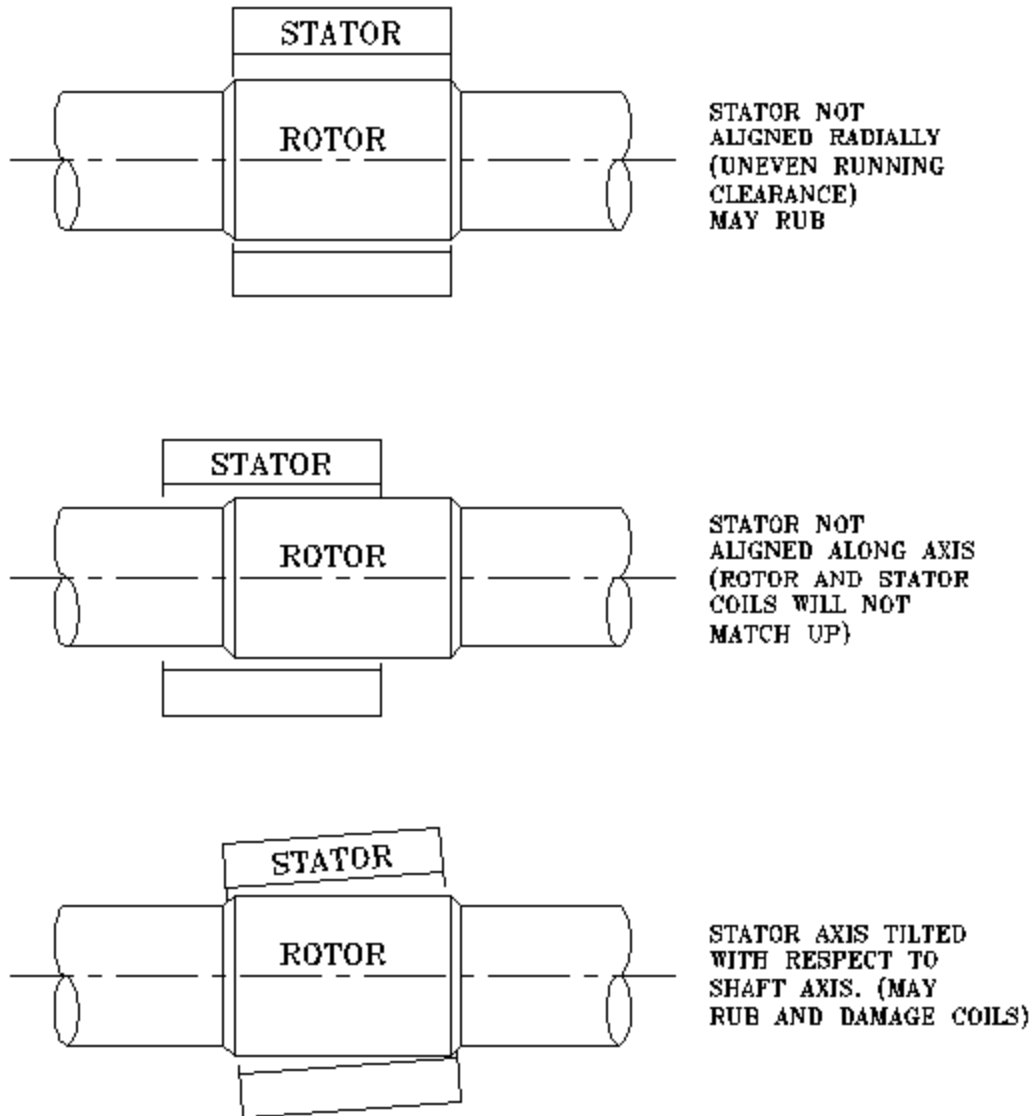
After verifying that both axial and radial positions are correct, complete final tightening of the bolts.

*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.*

*ATTENTION: Contrôlez les positions radiales et axiales et vérifiez qu'on n'a oublié aucune cale de positionnement radiale dans l'interstice afin d'éviter des dégâts lors du démarrage de la machine.*



## STATOR ALIGNMENT



**NOTE: COMBINATIONS OF THESE MISALIGNMENTS MAY EXIST.**

*Figure 3: STATOR ALIGNMENT*

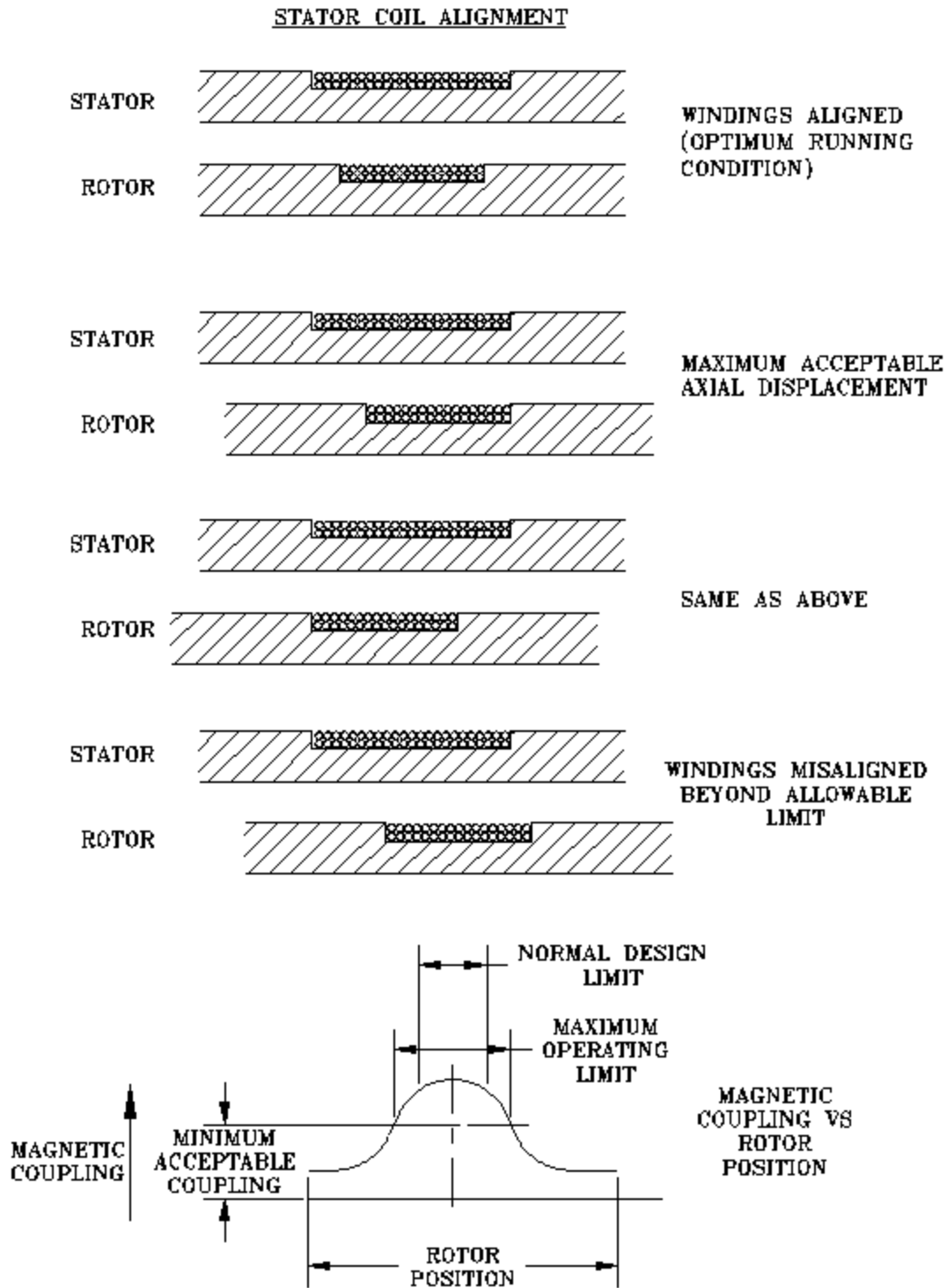


Figure 4: STATOR COIL ALIGNMENT

## ESC AND MONITOR INSTALLATION

### ESC (EXCITATION & SIGNAL CONDITIONING MODULE) INSTALLATION

Refer the ESC Installation Drawing for mounting dimensions, and appropriate wiring connections. For acceptable environmental conditions, refer to page 45. Plan accordingly for conduit and wiring accessibility.

### MONITOR INSTALLATION

See the Monitor installation drawings for complete dimensions and appropriate wiring connections. Acceptable environmental conditions are on page 45. When choosing a location, consider the accessibility of the wiring terminals.

Connect the marked/labeled wiring to the appropriate connectors supplied.

#### *Analog Outputs*

Ensure the wires to the system are clearly identified and then connect them to the analog outputs at the connector provided on the Monitor.

*NOTE: If the user prefers their own isolated power supply for the analog outputs, the jumper on the analog out connector 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. 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, so at least one of the returns must 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 output connector with the external supply. See Figure 10.

The analog output stages can tolerate a supply voltage from 18 to 30 volts DC. 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 the Riverhawk Interface Software. This connection port is located on the front panel of the Monitor.

#### *Power Input*

The rack mount enclosure comes with a pluggable power cord and fuses are located within the power AC input module.

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

## 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 coupling has unique calibration parameters that reside within the memory of the Monitor electronics and are associated with each individual coupling. This data is also saved within an INI type file for each coupling. **When changing out the coupling, the file that was created for that particular coupling must be uploaded into the Monitor and additional Monitor adjustments must be made.**

## THEORY OF OPERATION

### SYSTEM ORGANIZATION

The basic torque metering system consists of an Instrumented Coupling (usually not merely a spacer tube), ESC (Excitation and Signal Conditioning Module), and a Monitor (readout device), as shown in the diagram of Figure 1. Figure 5 is a block diagram of the system, showing more details on the connectivity between the major parts.

The Instrumented Coupling includes two sets of electronics and associated parts to provide redundancy. In case of failure of one sensor, the other sensor is automatically selected to permit continued operation.

### 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. They measure the strain, or elastic deflection of the shaft material under load. This deflection is directly 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 5 shows a shaft with zero torque applied. Grid lines are applied and in the figure they define a square area 1-2-3-4. Figure 6 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 longer and thinner, with an increase in electrical resistance (tension).

In Figure 7, the coupling 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.

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 8 and Figure 9. The gages in tension or compression are placed on opposite arms of the bridge, causing an unbalance when torque is applied to the shaft. The output of the bridge has a linear relationship to the torque applied. The resultant signal is fed to the electronics for processing and is transmitted through the ESC to the Monitor. The ESC provides power to the selected sensor, receives torque and speed signals, and provides signal conditioning for more reliable and accurate data transmission over a longer distance. The ESC is placed relatively close to the instrumented coupling and can transmit signals over a long distance to the Monitor.

### ELECTRONICS SIGNAL FLOW

The Torque Metering System consists of an Instrumented Coupling, ESC, Monitor, and cable assemblies. Figure 5 is a block diagram of the system, depicting the connectivity as previously described in Section IV.A: System Organization.

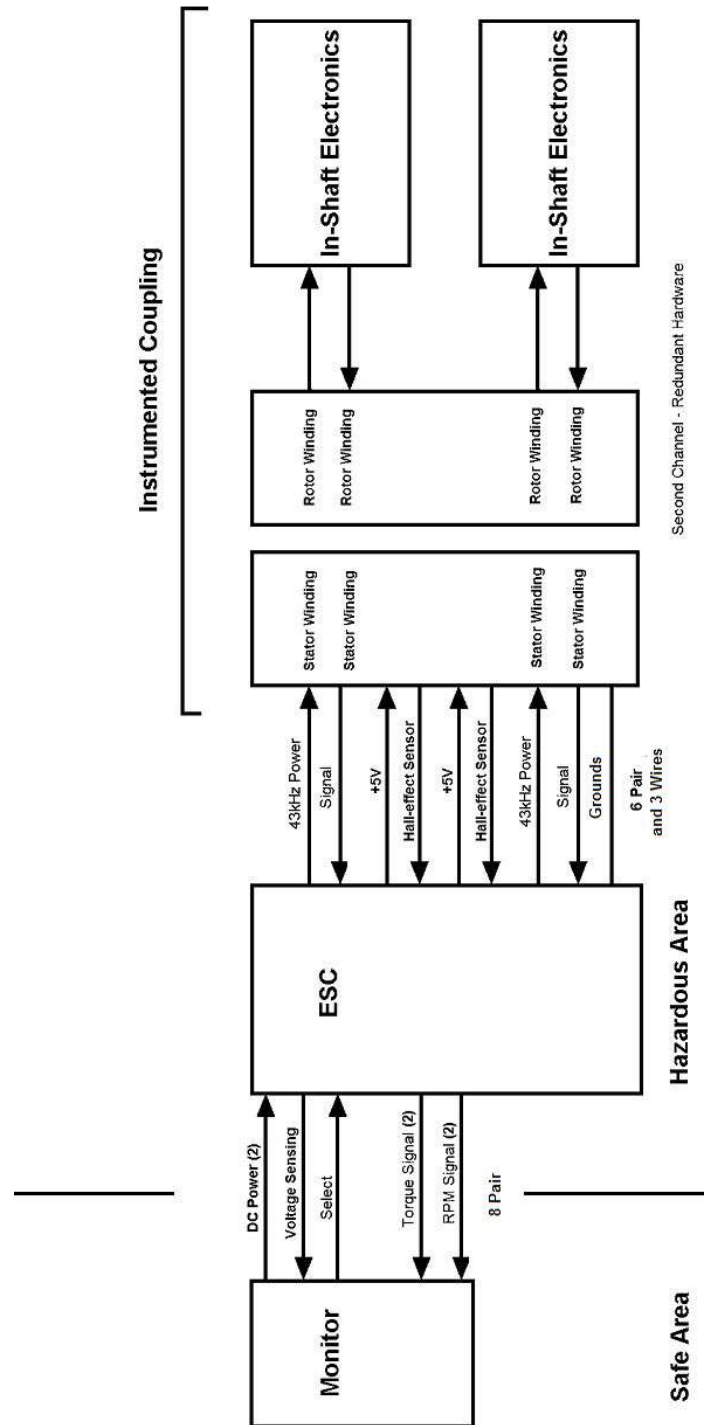
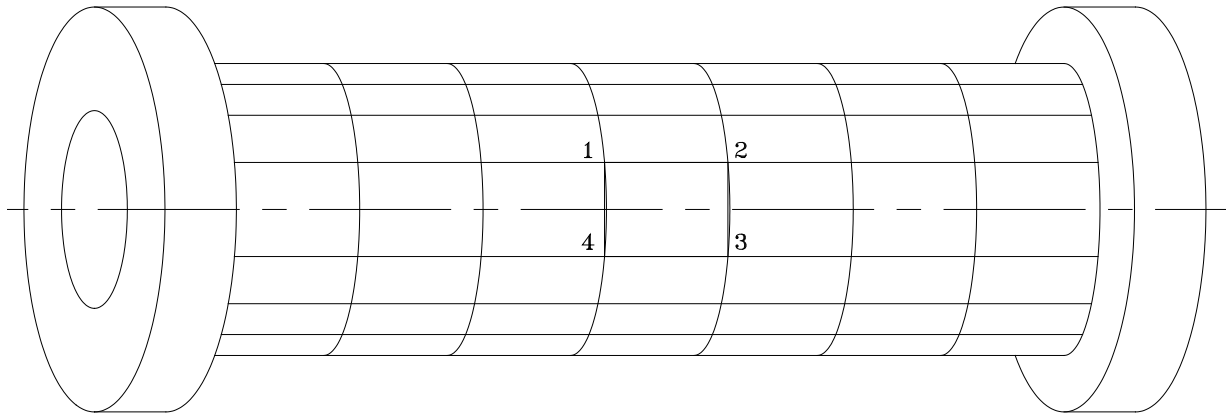


Figure 5: ELECTRONICS BLOCK DIAGRAM TYPICAL



SHAFT WITH ZERO TORQUE APPLIED

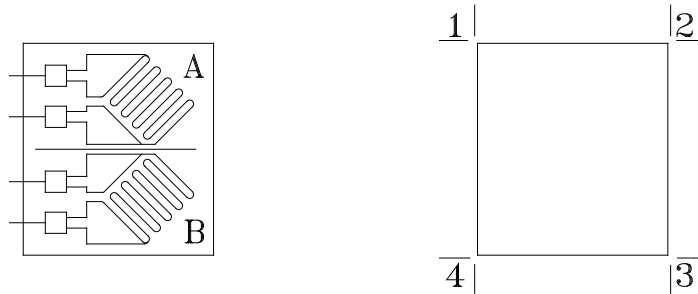
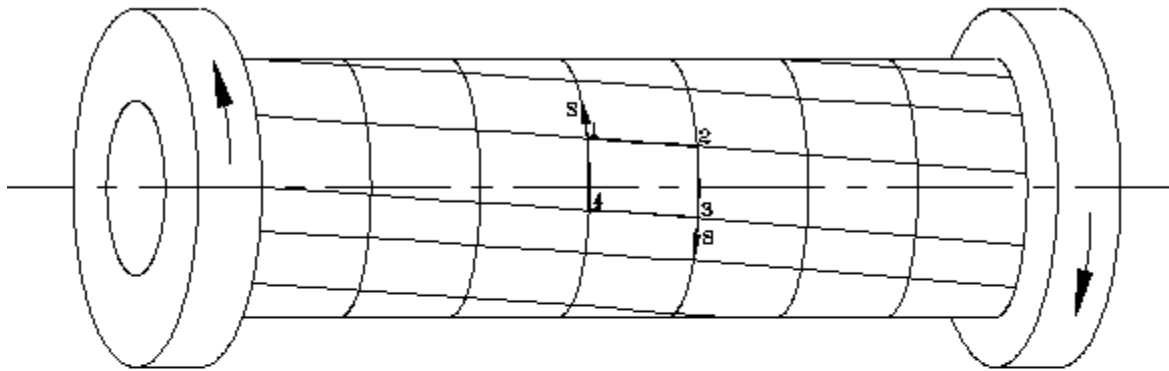


Figure 6: SHAFT WITH ZERO TORQUE APPLIED



**SHAFT WITH TORQUE APPLIED**

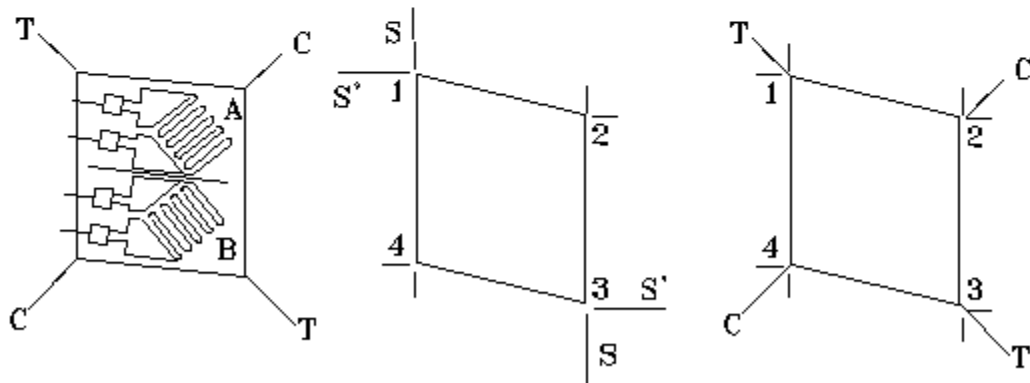


Figure 7: SHAFT WITH TORQUE APPLIED



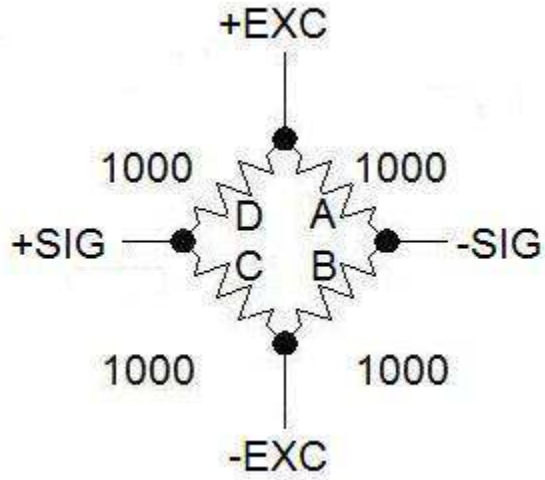


Figure 8: GAGE DIAGRAM #1

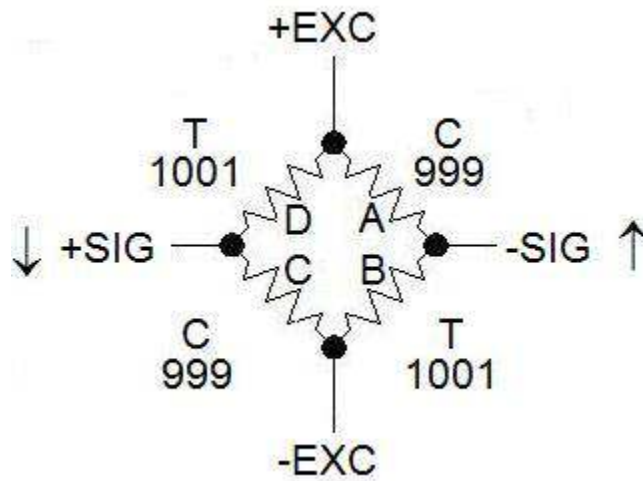
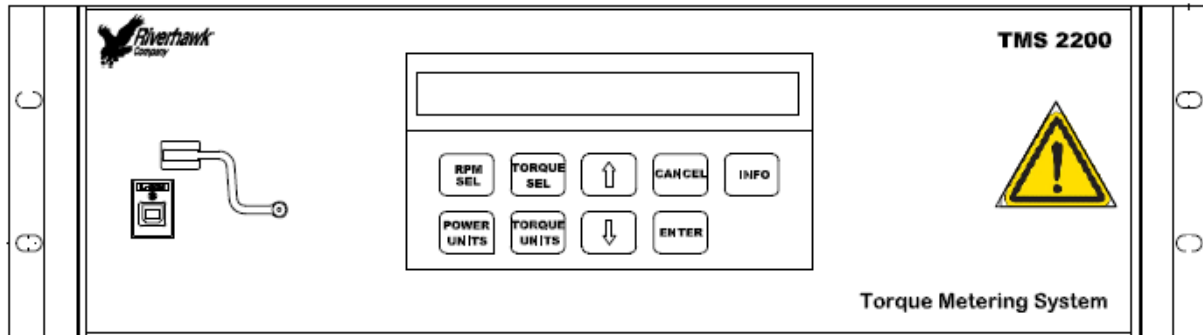
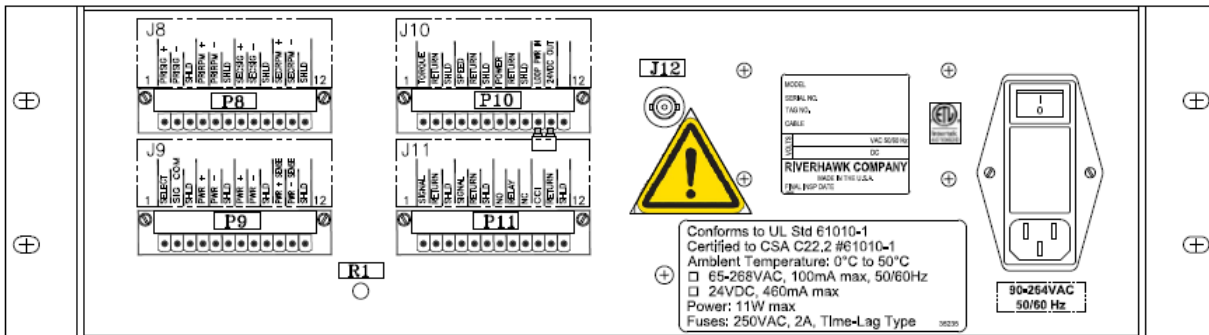


Figure 9: GAGE DIAGRAM #2



AC OPTION SHOWN



DC OPTION SHOWN

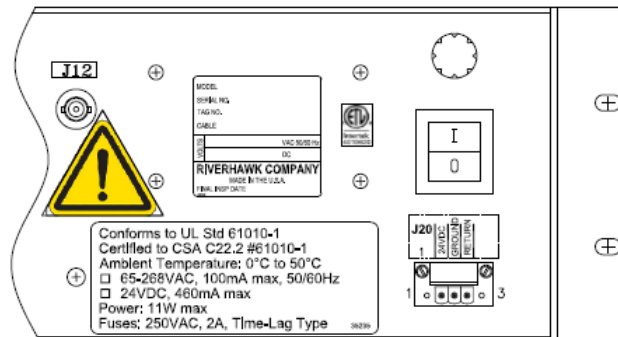


Figure 10: RACK MOUNT FRONT/REAR PANEL

## OPERATION

### POWERING UP THE SYSTEM

At power-up, the system will first display a 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 configuration and calibration data. The message (and all subsequent messages on the display) will be displayed for about two seconds to allow them to be easily read.

After the 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, checks all four sensor signals from the coupling. If all four are available and operable, the system will proceed to select the sensors that were previously selected before the last power-down, and calculate values 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 normal operating range, the system will begin to display the normal screen. This normal screen displays torque, speed, and power, along with sensor status:

<i>Trq: +063.7 ft-lb (x1000)</i>	<i>Spd: 9780 RPM</i>
<i>Pwr: 118.6 hp (x1000)</i>	<i>Status: OK</i>

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

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

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 speed) are both defective and the system will be unable to calculate power. If the system status is 'OK' or 'WARN', the display will be

updated every 750 milliseconds (above 800 RPM). This update rate corresponds to the internal measurement and update rate of the instrument, which is the update rate of the analog outputs and serial data output.

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.

## OPERATOR CONTROLS

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



### THE INFO KEY

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

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 speed 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 messages then revert to the normal display. Holding the INFO key down suspends further data updates until released.



### THE TRQ SEL KEY

The TRQ SEL key is used to alternately select the primary or secondary torque sensor. 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 normal display, and the parameters will reflect the use of the newly selected sensor.



#### THE RPM SEL KEY

The RPM SEL key is used to alternately select the primary or secondary speed sensor. 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 normal display, and the parameters will reflect the use of the newly selected sensor.



#### 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, 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 normal display:

*Select torque units: in-lbs  
Press again to change, or [ENTER/CANCEL]*

When this message 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.



#### THE PWR UNITS KEY

The PWR UNITS key is used to change the units for power. There are two units of measurement supported by this instrument: Horsepower (Hp) and 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, 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 normal display:

*Select power units: hp  
Press again to change, or [ENTER/CANCEL]*

When this message 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.



#### OTHER KEYS

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

## 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 will be performed in the field. Some of the calibration/configuration 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.

The 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.

### SUPERVISORY LOCKOUT OPERATION

To protect against inadvertent use of the calibration/configuration functions, they 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 display will prompt for the invoked function.

To 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 normal display will resume.



#### 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 specified by 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 SEL key briefly. Presuming that the security lockout is bypassed, the following message will appear:

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

After this message, the system will resume the normal 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 cycle.



#### 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. 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.

*NOTE: 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 press 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 subtract that value from all subsequent calculations. 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 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.*



## AUTOMATIC SENSOR SELECTION

This system employs redundant hardware for both torque and speed, along with an automatic system for selecting a working sensor if one has failed. The speed 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 via the display, and any dependent output variables will become invalid.

The system keeps track of the selected sensors, 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 sensor when it initializes.

## ANALOG OUTPUTS - *TORQUE (AVERAGE), SPEED, POWER*

This system has three independent analog outputs, one each for torque, speed, and power. Each analog output is configured as a current source output, referred to a positive power supply, and capable of sourcing between 0 and 25 mA into a ground-referred resistive load. Each output 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 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 to about 22.5 mA (5.625 volts), as an indication that the value is invalid and/or unavailable.

## ANALOG OUTPUT OVERHEADS AND COMPLIANCE

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

## 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 **internally** via jumpers J11 (torque), J12 (Speed), and J13 (Power), which will result in the outputs appearing as voltages in the 0 to 5 volt range.

## ANALOG OUTPUT PROTECTION

Each output is protected against accidental shorts or inadvertent connections to external voltages of up to  $\pm 200$  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.

## ANALOG OUTPUT RANGES

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

The Speed 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 speed or torque, and the maximum output corresponds to full scale speed 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.

## 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.

## COMPLIMENT OF I/O

The additional I/O includes two 4-20mA outputs (pluggable connector, J11), one voltage output (BNC, J12), one relay output, and a contact-closure input (switch or relay). A typical configuration may be as follows:

- 4-20mA Output for Instantaneous Torque
- 0-10 Volt Output for Instantaneous Torque (BNC)
- 4-20mA Output for Peak-to-Peak Torque
- Relay Output for Peak-Peak Torque Alarm
- Digital Input for Alarm Reset

\*\* 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\*\*

## CONFIGURATION

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. This includes the configuration of the following:

20mA Torque or Peak-Peak Torque Values

Alarm Type and Alarm Point

Peak-Peak Torque Update Frequency

## TORSIONAL VIBRATION

Measuring torsional vibration on non-synchronous motor applications represents no unusual challenges. This assumes that the neckdown 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).

## 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.

## VFD DYNAMIC 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.

## 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.

## SYSTEM POWER

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

*DC POWER 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.

## TROUBLE SHOOTING

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

- CONFIRM PROPER VOLTAGE IS BEING SUPPLIED.
- TURN POWER OFF.
- CONFIRM CABLE CONNECTIONS ARE SECURE.
- CONFIRM THE STATOR GAP AND AXIAL ALIGNMENT.
- CAREFULLY INSPECT THE CABLE HARNESS (MONITOR CABLE) FOR DAMAGE.
- REAPPLY POWER, CAUSING A 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](mailto:info@riverhawk.com)

USA

## HAZARDOUS LOCATION WARNINGS

**WARNING** - ENCLOSURE NOT TO BE USED AS EXPLOSION PROOF.

**AVERTISSEMENT** – LE BOÎTIER NE CONVIENT PAS AUX ENVIRONNEMENTS EXPLOSIFS.

While the ESC enclosure is an explosion proof (flame proof) enclosure, it is not used as such in this system as part of the certification for Class I, Division 2. The protection method used for the ESC and Instrumented Coupling is non-arcing.

**WARNING** - EXPLOSION HAZARD - DO NOT DISCONNECT WHILE CIRCUIT IS LIVE UNLESS AREA IS KNOWN TO BE NON-HAZARDOUS.

**AVERTISSEMENT** - RISQUE D'EXPLOSION – NE PAS DEBRANCHER TANT QUE LE CIRCUIT EST SOUS TENSION, A MOINS QU'IL NE S'AGISSE D'UN EMPLACEMENT NON DANGEREUX.

## REPAIRS

### Fuse Replacement

Fuses should only need replacement due to some unusual occurrence. If fuses need to be replaced frequently, consult the factory.

To check or replace a fuse:

Set the power switch to off and unplug the power cord at the Monitor.

Using a small flat blade screwdriver, insert the tip in the slot above the power input blades and gently pry out the rectangular fuse holder.

Inspect the fuses and replace them as necessary.

Be sure to use only UL Recognized, 250Vac, 2A, 5mm x 20mm, time-lag fuses.

Install the fuse holder with the small arrow to the right.

Reinstall the line cord.

### Line Cord (Mains Supply Cord) Replacement

Should the line cord need replacement, set the power switch to off, unplug the cord from the outlet, and unplug the cord from the Monitor.

Replace the cord only with a UL Recognized 18AWG 3 conductor line cord.

### Other Repairs

Other than replacing fuses and the line cord, no other repairs are intended to be attempted by the customer or other responsible bodies. The system or parts thereof should be returned to the factory for any other repairs.

*CAUTION: While it is not recommended to access the inside of the Monitor enclosure, should anyone decide to do so, be sure that the line cord is unplugged to avoid the risk of electric shock, primarily in the area of the AC input module and the power supply.*

*ATTENTION: Bien qu'il ne soit pas recommandé d'accéder à l'intérieur du boîtier de l'écran, si on décidait toutefois de le faire, il faut s'assurer que le cordon électrique est débranché pour éviter le risque de choc électrique, particulièrement dans la zone du module d'entrée et de l'alimentation en C.A .*

## SPECIFICATIONS

### Sensors

Torque Sensor  
Sensing Range  
Speed Sensor  
Torque Accuracy

Strain gages  
+/-500 microstrain, typical  
Hall-effect sensor  
Refer to the temperature specifications

### Display

Type  
Viewing Area

2 Lines by 40 Character VFD  
5.5" wide by 0.5" high

### Analog Output (average)

Calibrated range  
Accuracy  
Compliance

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

### Analog Outputs (dynamic torque)

Compliance  
Actual Range  
Accuracy

For load resistance less than 500 ohms  
0-25mA, typical. 0-10V, typical  
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 connectors with captive wire clamps

### Operating Power

Power Consumption

6 Watts typical  
11 Watts maximum  
65-268VAC, 50/60Hz  
100mA maximum

AC Voltage Option

Fuses: 2A, 5mm x 20mm, Time-Lag

DC Voltage Option

24VDC nominal  
460mA maximum  
Fuse: 2A, 3AG, Time-Lag

### Mechanical

Refer to Installation Drawings

### Approvals

Instrumented Coupling & ESC

ETL Listed

	Conforms to UL Std 61010-1 ANSI/ISA-12.12.01 Certified to CSA C22.2 #61010-1 CAN/CSA Std C22.2 No. 213 Class I, Division 2, Group A, B, C, and D, T4 USA and Canada classified hazardous locations
Monitor	ETL Listed Conforms to UL Std 61010-1 Certified to CSA C22.2 #61010-1 Must be installed in a non-hazardous location

## Environmental

### Instrumented Couplings

#### Operating Temperature and Accuracy (Where T is the ambient temperature)

Storage Temperature	-40°F to 239°F (-40°C to 115°C)
Operating Temperature	32°F to 239°F (0°C to 115°C)
T = 25°C: ±0.5% accuracy, typical	
0°C < T ≤ 85°C: ±1.0% accuracy	
85°C < T ≤ 115°C: ±1.5% accuracy	

### 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	32°F to 185°F (0°C to 85°C)

### Monitor

Storage Temperature	-40°F to 185°F (-40°C to 85°C)
Operating Temperature	32°F to 131°F (0°C to 50°C)

### Stator to ESC Cable

Storage Temperature	-40°F to 392°F (-40°C to 115°C)
Operating Temperature	32°F to 239°F (0°C to 115°C)

### ESC to Monitor Cable

Storage Temperature	-40°F to 221°F (-40°C to 105°C)
Operating Temperature	32°F to 221°F (0°C to 105°C)



## System

Relative Humidity

0 to 100% (non-condensing)

Transportation Vibration

IAW Commercial Handling/Shipping

## LIMITED WARRANTY

All torque metering systems are warranted to operate normally under normal use and service for a period of one year from system startup or two years from shipment, whichever is shorter. While Riverhawk's systems are very reliable, there is always the possibility of malfunctions or failures. Due to the nature of these systems and the applications that they are used in, it is important that issues associated with repairing such systems are understood.

## REDUNDANT HARDWARE

Due to the nature of the overall systems in which the torque metering systems 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 sensor to be used in the event of a failure of the primary sensor. Both sensors shall be operational when they leave the factory. Only one sensor is warranted to be operational during the warranty period, as only a single sensor is necessary for normal operation. The second sensor is included to avoid a non-operational system should the primary sensor 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.

### 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.

### 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 shut down 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 un-instrumented spare coupling is available, Riverhawk will instrument the customer’s spare should a failure occur in the instrumented coupling. This presumes that the un-instrumented 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 Company  
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New Hartford, NY 13413  
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