Interface Inc.

Operating Manual

Project: **HRDT – High Resolution Digital Telemetry System**

Issue: **15-143 Revision F**

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Contents

System Description

The Interface HRDT torque sensing system is an innovative and user-friendly instrument for use in applications where the measurement data needs to be transferred from the rotating sensor using telemetry techniques.
The system is designed to be flexible so that the maximum range of applications can be covered by the same architecture. The system has a minimum set of rules that need to be followed by the installer, therefore making the product very easy to use. The high levels of accuracy and reliability are achieved by the use of new generation fully digital two-way radio links between rotor and stator, and by careful system design and implementation.
The system comprises three main components, which can be described as follows:

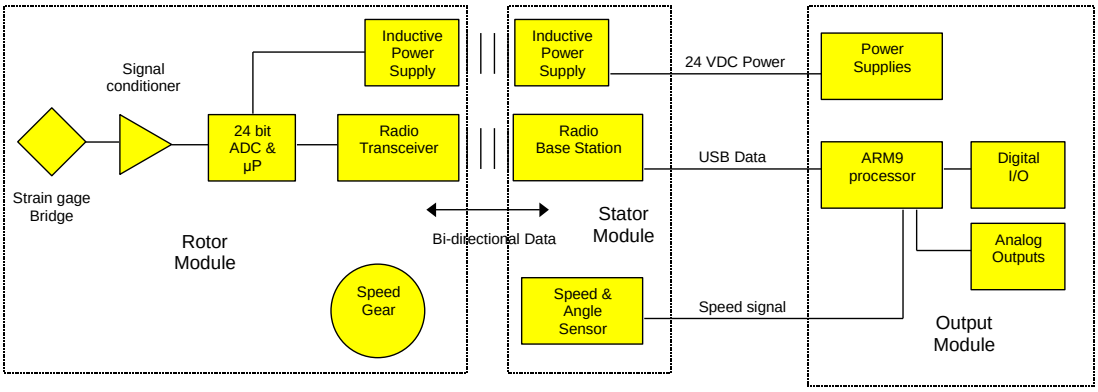
ROTOR MODULE – comprising a torque sensing element, complete with internally bonded strain gage bridge and shunt resistor**.** The rotor also houses the electronics that process the signal from the strain gage bridge, and the radio transceiver. A separate rotor feature harvests the power from the induction link, conditions it, and then supplies the other rotor electronics.
The standard configuration is a short DIN flanged style sensor with threaded mounting holes on one flange and thru-holes on the other. As an option the rotor is available with integrated couplings to facilitate installation. SAE flange, custom flange, and shaft style rotors are also available as an option.

STATOR MODULE – this comprises the fixed part of the induction loop power supply, and also houses the second radio transceiver. For applications where space is at a premium, a miniaturized version of the stator can be supplied, with the radio transceiver housed in a separate enclosure that can be mounted nearby. Only one stator module is used per rotor, but there is no limit on the number of separate radio transceivers that can be used to “listen” to the data stream for purposes of providing additional, independent data outputs.

OUTPUT MODULE – this module gathers the data from the rotor via the stator then processes it and converts it to one of the following outputs:

Current (12mA +/-8)
Voltage (+/-5V, +/-10V)
Frequency (10kHz +/-5, 60kHz +/-20, 60kHz +/-30)
Digital USB

This module is self-contained and connects to the stator via a direct cable connection (USB). A dual-row display and a six-button keypad are provided for convenience when setting up a new system and for monitoring an established system. For applications where a second or third data output stream is required, separate and independent output modules can be fed by additional USB base station modules. As a supporting item, a software application named HRDT Assistant is provided for PC’s or laptops running Microsoft® Windows™ operating system. When setting up a new HRDT installation, the Assistant software is only needed for the more complex applications such as those involving quadrature encoders or digital Input/Output. In most cases, the front panel display and keypad will provide enough flexibility to allow a system to be configured without the need for a PC or laptop.



Typical System Functional Block Diagram

Installation & Operation

This section provides general information for installing an HRDT torque measurement system. Specific dimensions, tolerances and specifications are included in the data sheet for each product.

Rotor module

The rotating sensor must be mounted using screws of the correct size and type. Tighten all screws in incremental steps to the proper torque. Use the screw tightening sequence in **Figure 1** as a guide. The torque sensor can be mounted in any position, provided the load is applied through the loading axis.

Couplings should be used to compensate for angular and parallel misalignment. The preferred installation is with single-flex style couplings on either side of the rotor. Alternatively one side of the rotor can be hard-mounted with a double-flex style coupling on the other side. Care should be taken to minimize misalignment thereby reducing bending loads into the sensor. Interface can provide standard integral coupling versions of the HRDT.

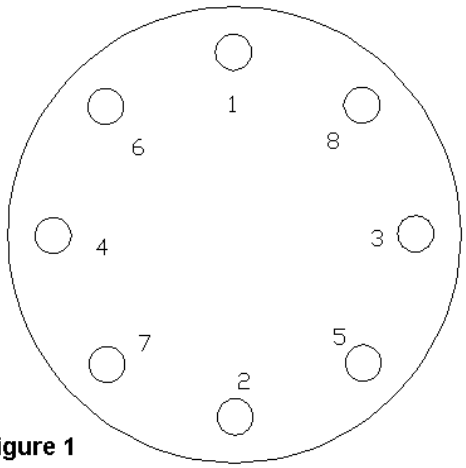
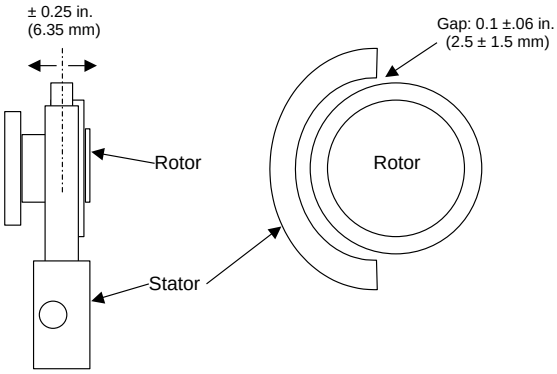


Figure 1

Stator module

For best power coupling with the rotor unit, the stator should be centered laterally, on the power-coupling ring of the rotor and the radial gap should be about 0.1 in. (2 mm). Use the provided alignment tool to ensure that the stator is properly aligned and not touching the rotating sensor as this could cause damage to both the rotor and stator during operation.



The mounting plate on the stator module can be removed if a custom-mounting bracket is being used. A shorter stator to output module cable can be used if excess cable is a problem.

Output module

The output module may either be mounted using 4 mounting holes or alternatively using the DIN rail adapter kit (see data sheet). For harsh environments, a suitable enclosure should be used to protect the output module. The HRDT Output Module Connection diagram further along in this manual shows the various electrical connections. For analog output connections, shielded twisted pair cable is recommended. These cables should also be kept away from any AC mains wiring to limit induced noise.

The recommended power is a 24 ± 2 VDC, 20W switching or linear type power supply.

The case of the output module should be connected to a reliable earth ground.
For DIN rail mount using the DIN rail mounting kit provided, remove the end plates of the output module case and slide the plastic din rail mount on to the groove on the bottom of the case. Install new end plates without mounting flanges (provided). The output module will clip onto a DIN rail.

HRDT Assistant

HRDT Assistant software requirements:
PC or laptop running Windows XP, Vista, or Windows 7
2 GB ram

On the installation disk find and run the file HRDTInstall.exe and follow the instructions on the screen.
For software operation and features, see the HRDT Assistant section.

For Windows XP, Microsoft Activesync may have to be downloaded and installed.

For Windows Vista, an updated version of Windows Mobile Device Center may be required.

Speed Sensor

For models equipped with an integral speed sensing gear there is a factory bracket suitable for mounting some speed sensors to the stator module, however, many other types of speed sensors are compatible with the HRDT output module. Consult the factory for specific applications.

System Operation

This section provides a description of the facilities that are available for setup, configuration, calibration and use of the system. Guidelines and examples are included to help users choose the most suitable settings for their application.

Output Module Operation
The output module gives the user control over the system scaling and output filtering and calibration.

Display
The output module is equipped with a 2 x 20 character LCD display. During normal operation the upper line displays the torque sensor input value. The lower line displays the percent of full scale of the analog output.

Using the MENU key the user can also select speed or power as the main display if a speed sensor is connected to the Output Module.

Controls
The output module is equipped with a six button keypad. The ▲up and ▼down arrow keys control the display brightness in normal operating mode. In menu mode they adjust the numeric values or are used to select different settings.

The MENU/ENTER button is used to select different display options or change the system settings. One of the options given by pressing the MENU button is: “Enter pass code”. Entering the correct pass code will allow the user to change some of the system settings. When a value or setting is changed use the ENTER button to save the change.

TEST will manually enable a fixed analog output. The output value can be changed by using the up and down arrow keys. When test mode is engaged the SUNT CAL/TEST LED will blink. Hold the TEST key to disengage test mode.

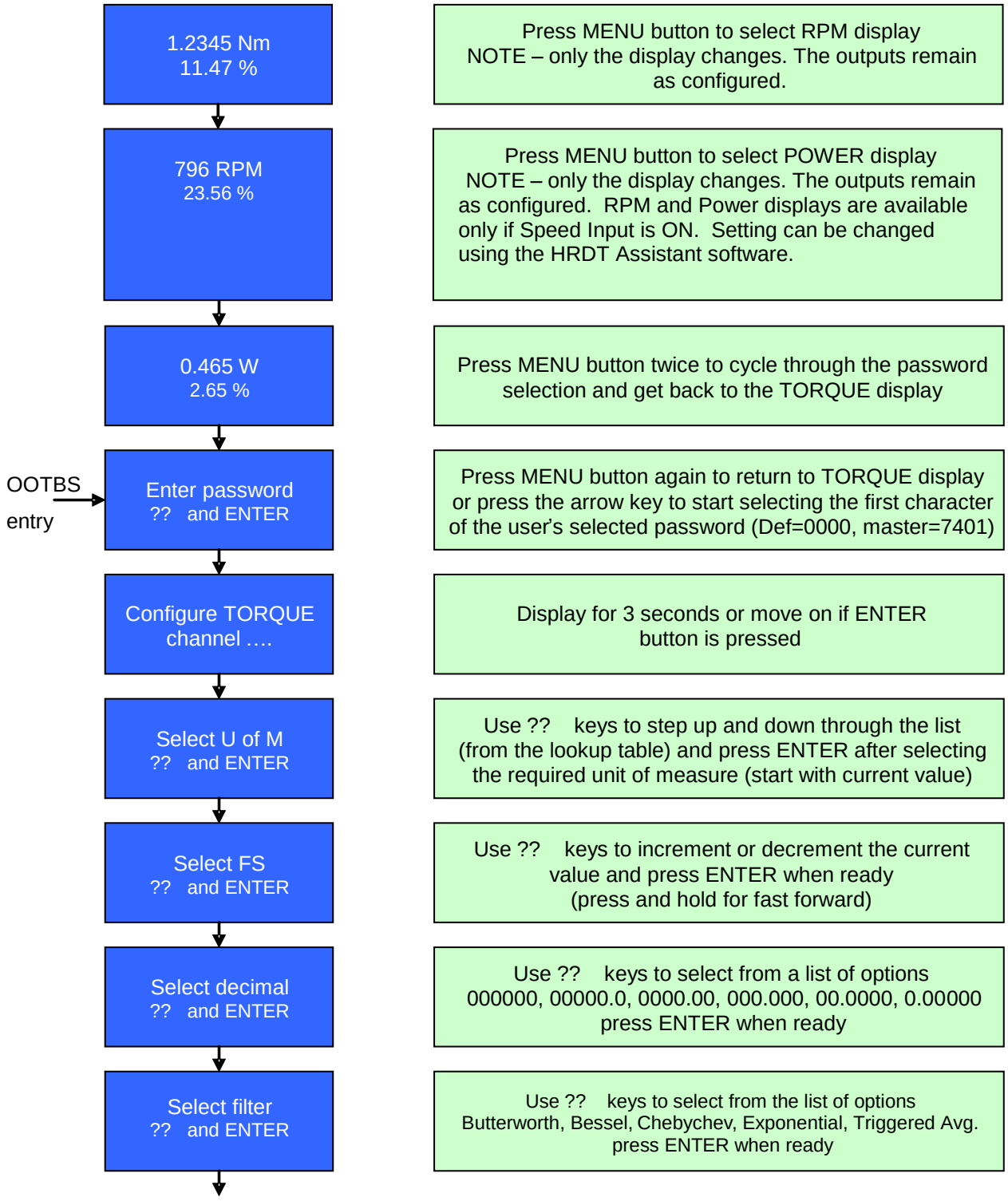
SHUNT CAL signals the rotor module to engage an internal shunt resistor across the strain gage bridge. This will give the user a simulated load condition and also serve as a system check. When the shunt calibration resistor is engaged the LED labeled SHUNT CAL/TEST will be steadily illuminated.

ZERO tares the current reading. Holding the ZERO key will untare the reading.

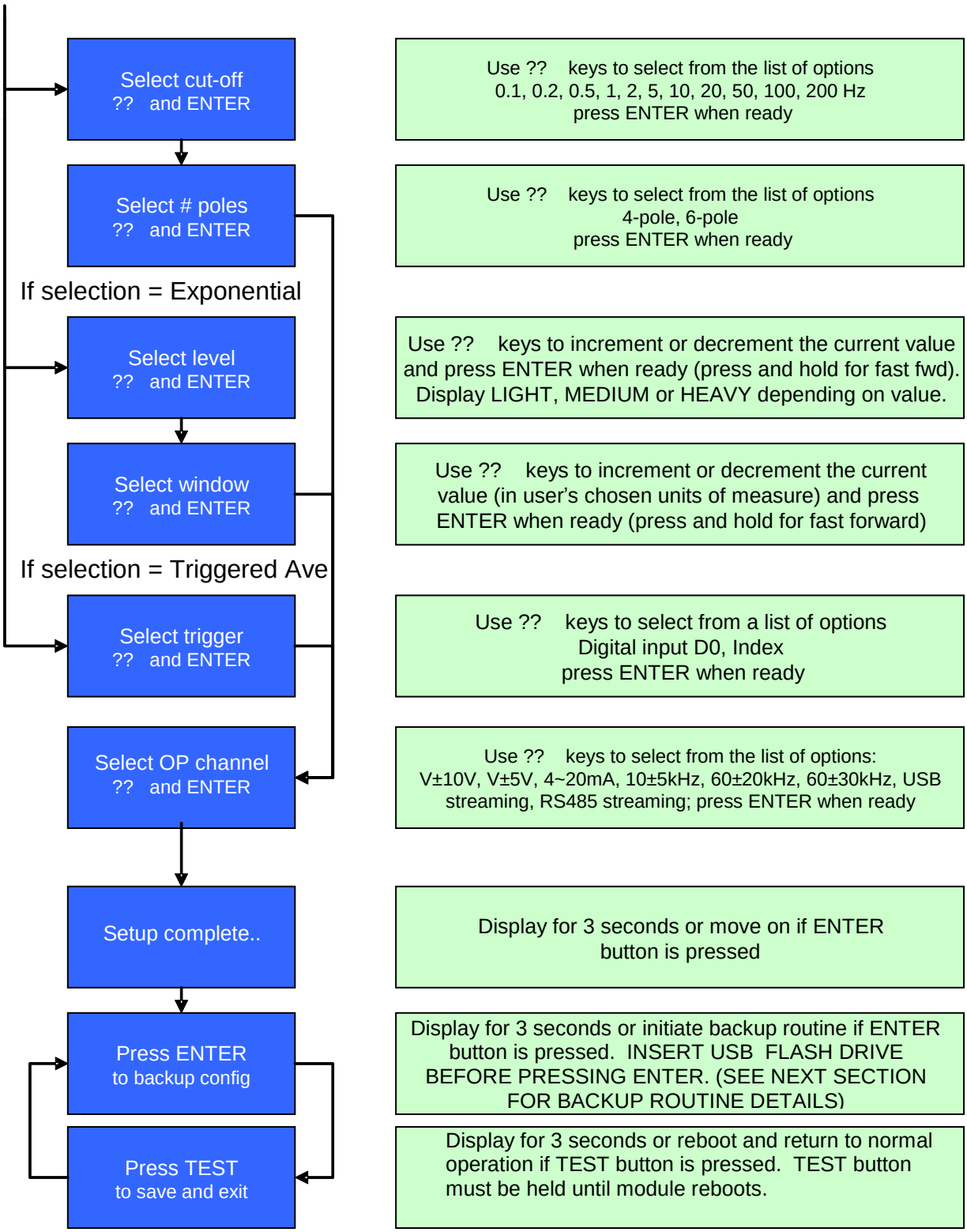
Menu Navigation: the following pages show a detailed explanation of the display and setup menus available directly on the output module. Included are some of the menu steps for the Out Of The Box Setup (OOTBS).

HRDT menu handling

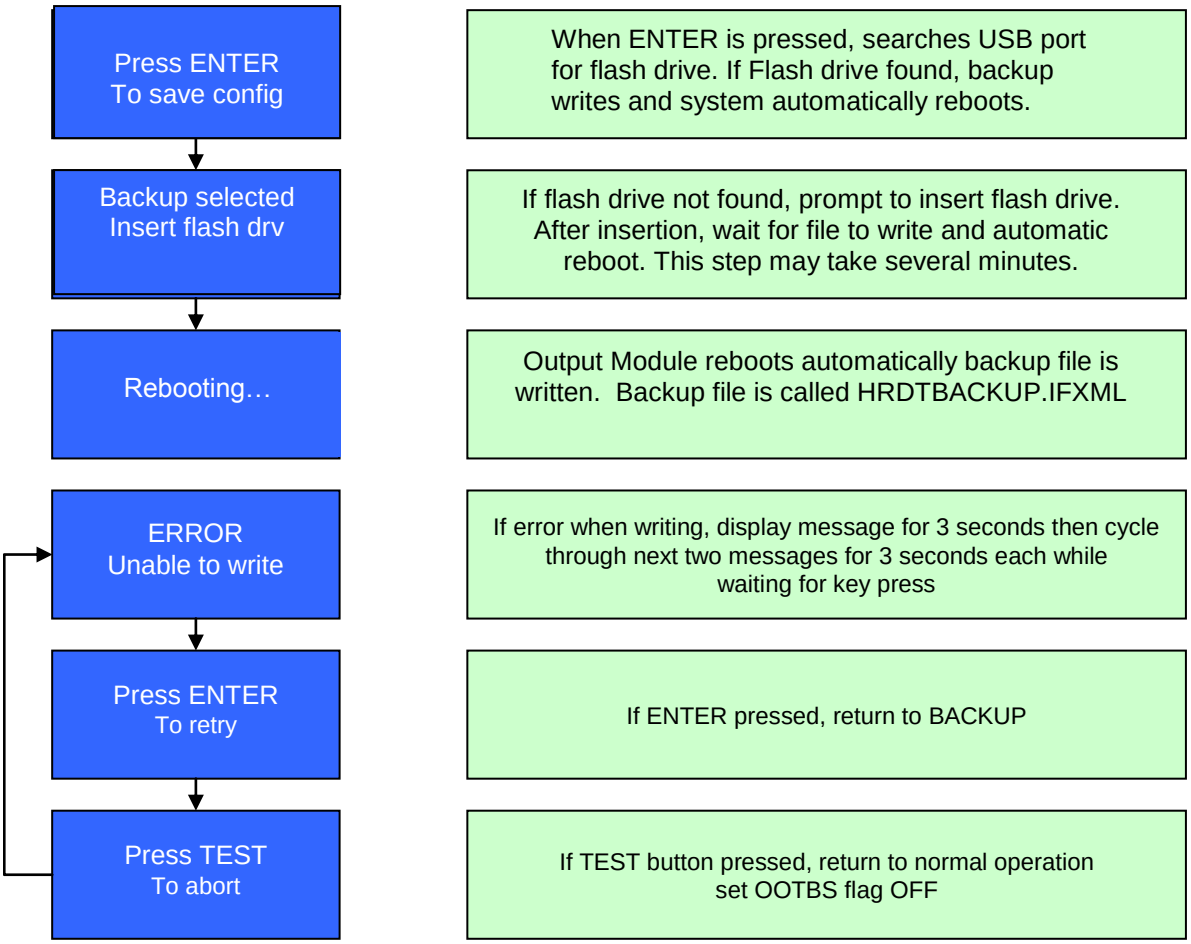
This flowchart defines the menu handling functionality for the HRDT and allows a user to perform basic configuration or rotor module field service replacement without having to connect a PC and load the HRDT Assistant application.



If selection = Butterworth or Bessel or Chebychev:



BACKUP routine



Inputs & Outputs

USB: There are three USB connections located on the side of the unit, one of these is needed for the stator USB connection. The other USB type A connection is intended for a flash drive used to load or store configuration files.
The USB type B connection is intended for a connection to a laptop or personal computer.

Digital Inputs & Outputs: The digital inputs are used to remotely trigger functions, like SHUNT CAL and ZERO. Digital Input 0 is a fast trigger when used with Triggered Average. The digital outputs operate as alarms to show: LIMIT STATUS, DATA INVALID, SHUNT CAL ACTIVE or ZERO ACTIVE. The digital outputs are open drain configuration and must have a resistor pull up to operate correctly. (see wiring section for more details)

Speed & Angle: Dual channel (quadrature) or single channel speed signals are accepted. As an OPTION, the HRDT rotor can be ordered with a speed gear and an external speed sensor.

Analog Outputs: One of the following analog output formats can be chosen:
CURRENT (12 mA ± 8 mA)
VOLTAGE (± 5V or ± 10V)
FREQUENCY (10kHz ± 5kHz or 60kHz ± 20kHz or 60kHz ± 30kHz)

Analog output behavior during ERROR conditions: Under certain conditions the output module may lose communication with the stator. Under these conditions:

1. the output module data light will go out
2. the analog output from the output module will go to ZERO (0V, 12mA, 10Hz, or 60Hz, depending on which analog output is active)
3. Digital output will activate. Digital Output 0 is factory set for DATA NVALID and should be monitored to distinguish between a data-loss conditions and a true NO-TORQUE condition. (Digital Output assignments can be changed using HRDT Assistant Software)

CAUTION: AT DATA LOSS, ANALOG OUTPUT WILL GO TO ZERO. PLEASE ENSURE THAT YOUR CONTROL SYSTEM CAN HANDLE THIS CONDITION.

Typical configurations

The simplest installation will comprise of a single rotor, with accompanying stator module, and a single output module, with the data stream being directed to an analog output. The easiest way to set up such an installation will be to use the **"Out-of-the-box" Setup** routine which is built into the Output Module (refer to the relevant section below).

Two examples of simple configurations that can be configured using the "Out-of-the-box" Setup routine are shown in the diagrams below:

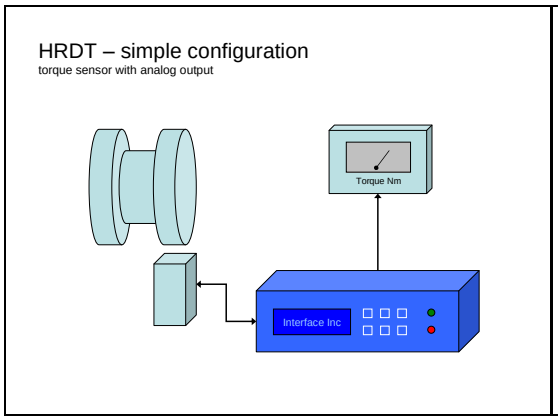


Figure 2

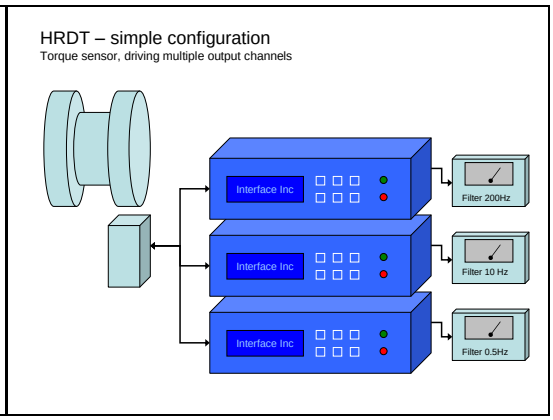


Figure 3

In practice, there is a limit on the degree of complexity that can be built in to a menu system for a display and six pushbuttons, while still claiming "ease of use". The diagrams above represent the vast majority of installations where it is quite practical to use the front panel controls to configure the system.

The diagram on the right, figure3 shows three Output Modules being used to gather data from a single rotor. This would be typical of an application where one measurement data source is being used to provide output signals that have different characteristics, such as filter settings, units of measure or scaling values. Each Output Module is fully independent of the others, but because there is a common rotor, if the SHUNT CAL button is pressed on any one Output Module, then all three would receive the shunt cal data from the common rotor and all three would illuminate their red shunt cal LED's and show the shunt cal result on their displays.

To configure more complex systems with ease, the HRDT system is delivered with the HRDT Assistant software for use on PC's or laptops. This software uses the USB "B" connection to the Output Module to gather setup information and measurement data from the system, and is also used to make changes to the setup and to make backup copies of the configuration file.

An example of a more complex installation would be involving several rotors, each with their accompanying stator module, and several Output Modules such that each rotor could provide two

independently scaled and filtered output streams, and each shaft would have its own Quadrature Encoder to provide Speed and/or Power measurement capability. Such a system would require the use of the HRDT Assistant software when configuring!

Some other, more typical installations are shown in the diagrams below, and the HRDT Assistant would be required when configuring such systems.

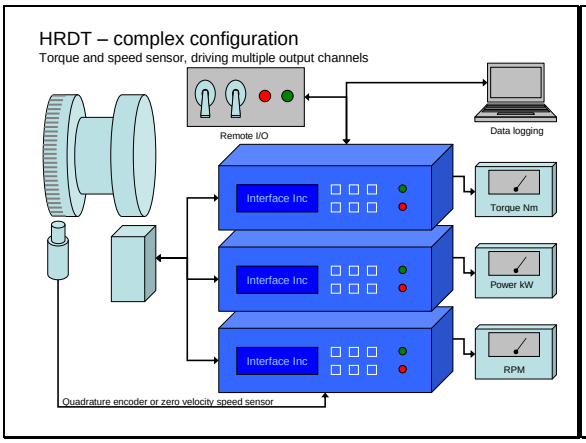


Figure 4

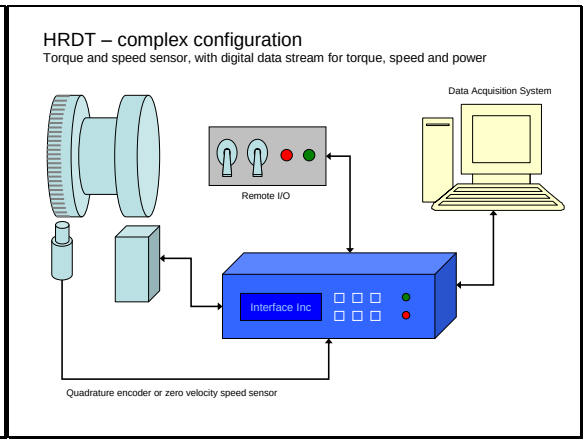


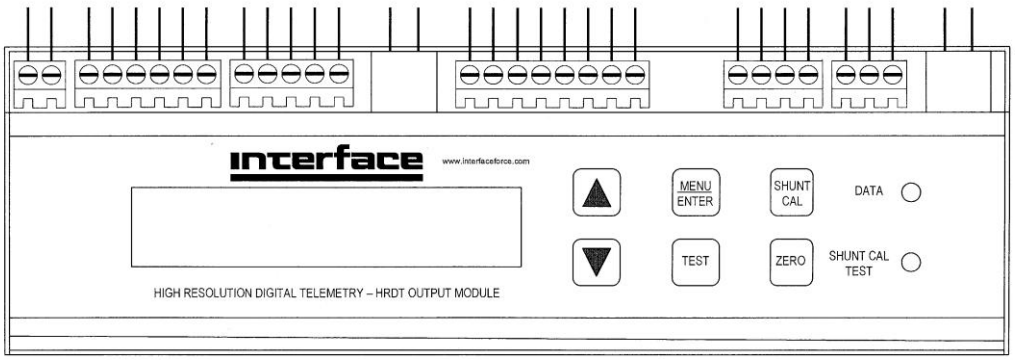
Figure 5

"Out-of-the-box" Setup

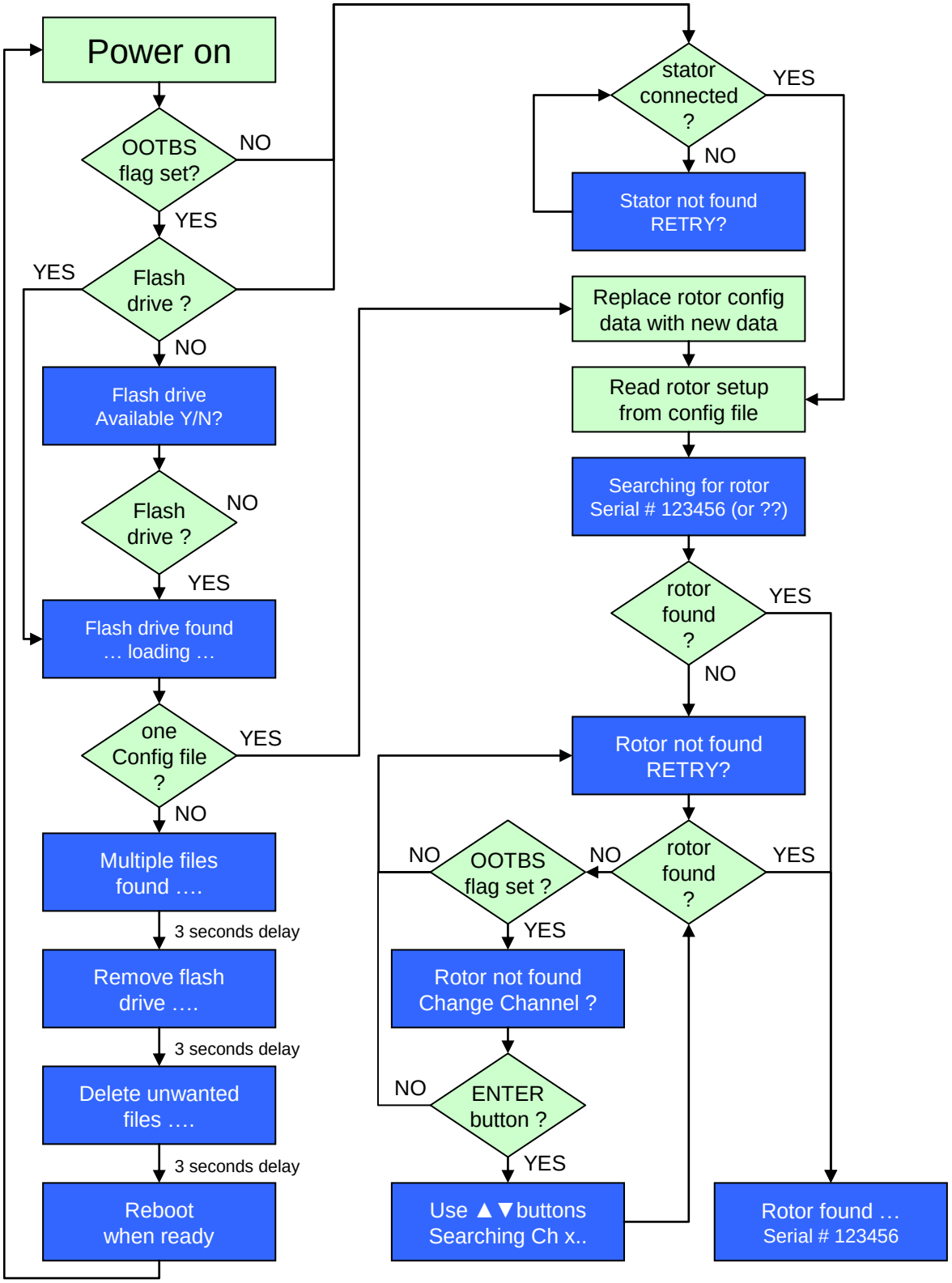
This facility provides a quick and convenient method of configuring a new installation without the need to connect a PC or laptop. When being configured for the first time, the built-in display is used to guide the user through the process of defining the key parameters, and the factory calibration is automatically loaded so that the system is functional within a matter of minutes.

The user can decide to switch to the HRDT Assistant method of configuring at any time, if any of the more complex features need to be set up, such as speed measurement or digital Input/Output, or if local calibration needs to be performed as part of commissioning.

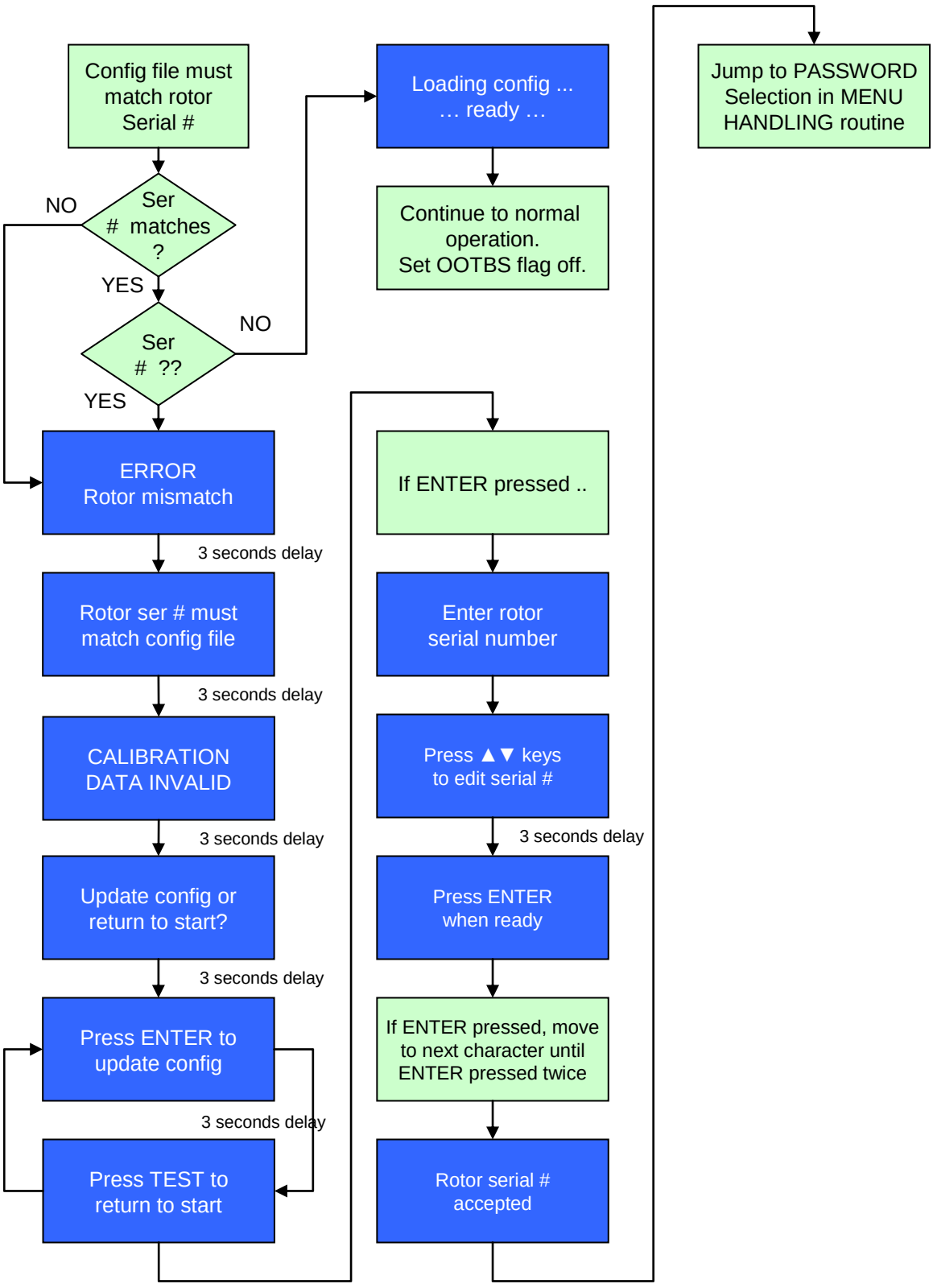
1. Install the rotating sensor noting the mounting instructions for the particular sensor.
2. Install the stator using the provided gap tool to properly align the rotor and stator. Be sure to leave room for adjustment if necessary.
3. Wire the stator and power supply to the output module; do not permanently mount the output module until a basic functional test has been performed.
4. Apply 24 volts DC power to the output module, wait for the unit to fully boot.
5. The torque display should read approximately zero, taking into account any stresses imposed by the installation.
6. Press the ZERO button to tare the display.
7. Press the SHUNT CAL button and check if the reading is correct. The factory checked shunt cal reading is found on the calibration certificate.
8. If system checks out, mount the output module in its permanent location.
9. Wire the appropriate analog output to the required instrumentation.



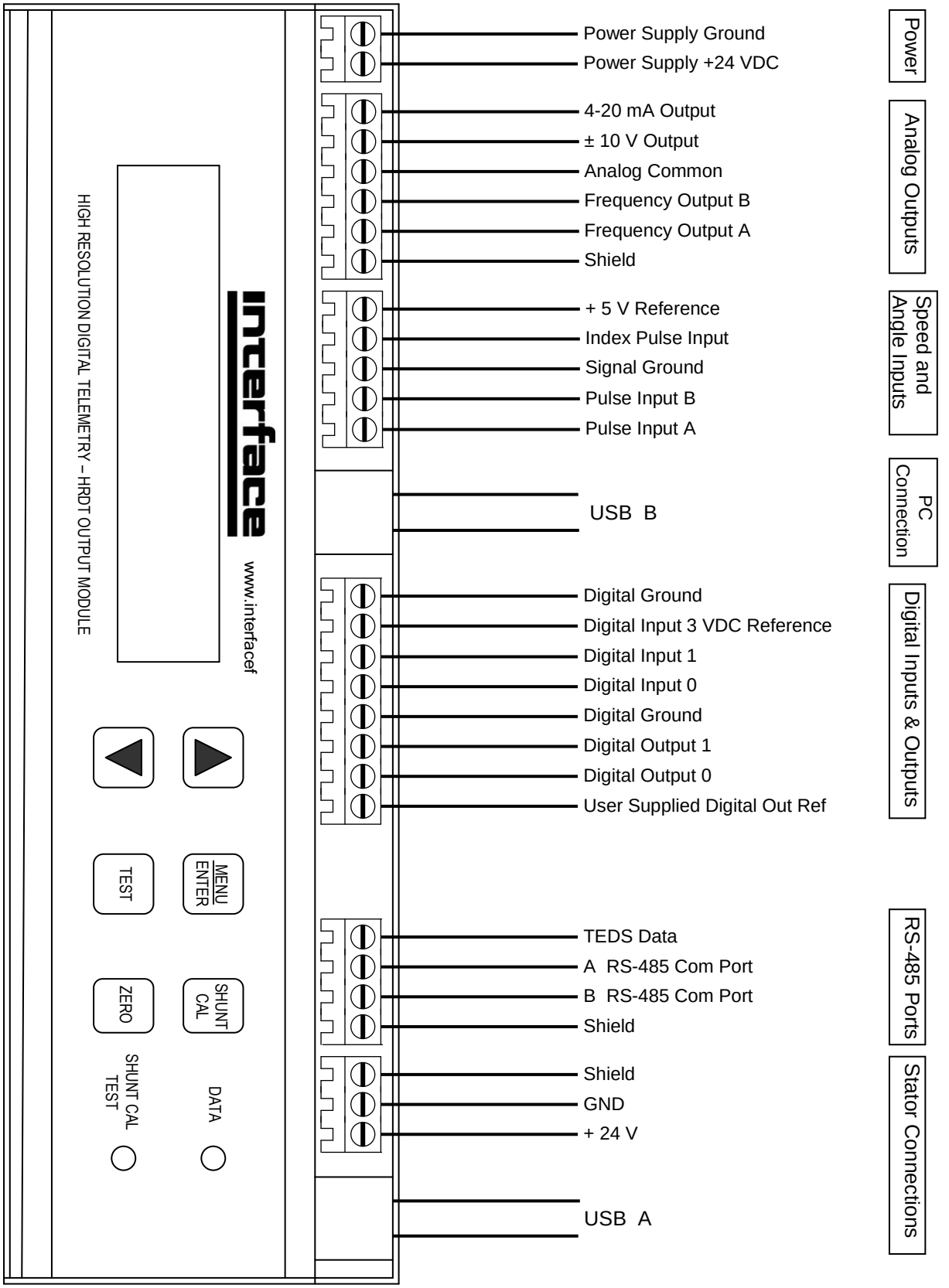
The flow chart below details the logical process that is used by the “Out-of-the-box” (OOTBS) Setup routine:



The output module is designed to accept a standard USB flash drive containing factory calibration and setup information.


Config file must match rotor Serial #
Ser # matches ?
NO
YES
Ser # ??
NO
YES
ERROR Rotor mismatch
3 seconds delay
Rotor ser # must match config file
3 seconds delay
CALIBRATION DATA INVALID
3 seconds delay
Update config or return to start?
3 seconds delay
Press ENTER to update config
3 seconds delay
Press TEST to return to start
Loading config ... … ready …
Continue to normal operation. Set OOTBS flag off.
If ENTER pressed ..
Enter rotor serial number
Press ▲▼ keys to edit serial #
3 seconds delay
Press ENTER when ready
If ENTER pressed, move to next character until ENTER pressed twice
Rotor serial # accepted
Jump to PASSWORD Selection in MENU HANDLING routine

HRDT Output Module Connection Diagram

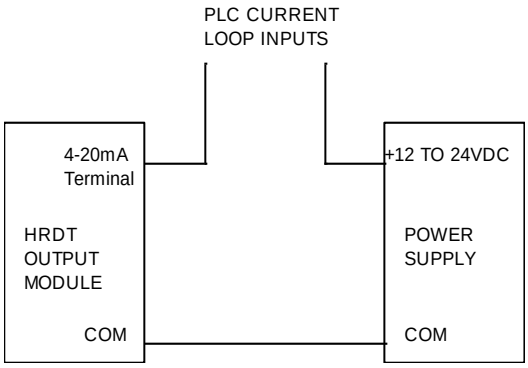


System Wiring

Analog Outputs

The frequency outputs are fully differential. This will allow them perform better in noisy or long distance situations. It is recommended that shielded twisted pair cable be used to wire these outputs. A terminal is available for connecting the shield of this cable.

Both the ±10VDC and 4-20mA outputs are referenced to the COM terminal.

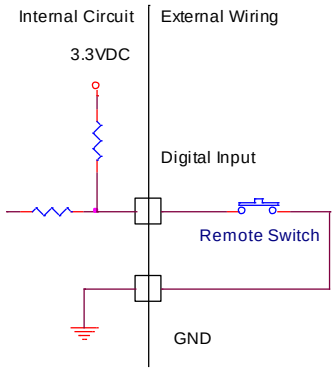


Since the 4-20mA output is configured to sink 4-20mA, a provision must be made to power the loop. This is usually accomplished by using power available at the data acquisition equipment, a PLC current input card for example. Power from the 24 V supply terminals on the Output Module may also be used.

NOTE: If the output module loses communication with the stator, due to an unplugged cable for instance, the display will read 0.00 and the analog output will also output a zero signal. If this could cause a problem, there is an invalid data alarm, which can be configured as one of the two digital outputs.

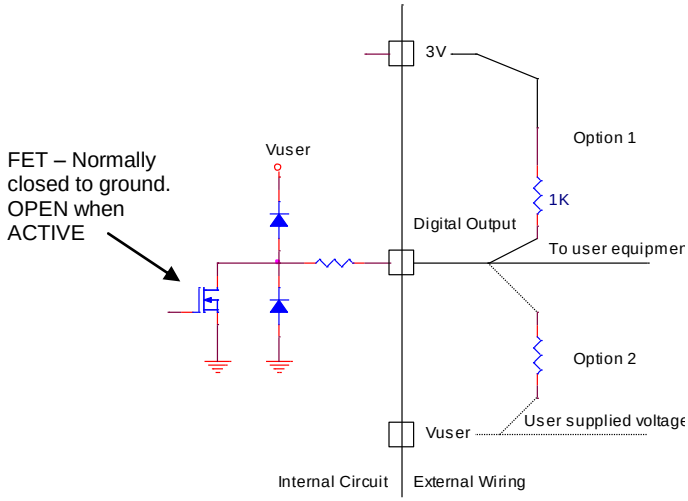
Digital Inputs & Outputs

The digital inputs are designed to function using a switch closure. There is an internal pull-up resistor to 3.3VDC therefore to change the state of the input a ground is applied to the digital input terminal using a switch or relay contact. See figure 6 below.
The digital outputs are controlled by FETs (field effect transistors) wired in an open drain configuration. The current capability of these outputs is 100 mA maximum. This configuration allows the user to reference the output to voltages other than the supplied 3.3VDC in order to match input voltage requirements to the user's automation/data acquisition equipment. See figure 2 below with option 1 using the 3.3V supplied by the output module and option 2 with a user supplied voltage.



Digital Intput Wiring

Figure 1



Digital Output Wiring

Figure 2

Speed & Angle

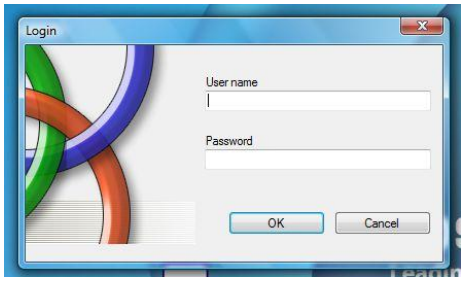
5VDC is supplied to power Hall Effect type sensors. For quadrature type sensors both Ain and Bin terminals are used; for single channel (speed only) sensors the Ain terminal is used.

Using the HRDT Assistant software

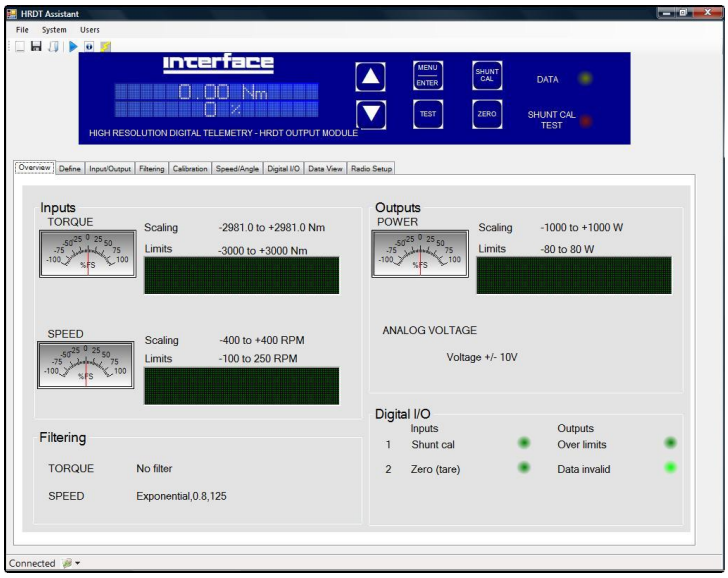
The Assistant software takes full advantage of the Windows CE operating system that runs within the Output Module to provide an easy way of configuring and calibrating the installation, and also provides useful facilities for data logging, display, and troubleshooting.

The software runs under Windows™ and uses the latest Windows Mobile® techniques for automatic device recognition and management. For ease of installation, USB connections are provided on the Output Module, for both a type A, which is used when the Output Module is reading or writing data from or to a USB Flash Drive for example, and a type B, which is used when the PC is the host and the Output Module is being read from or written to.

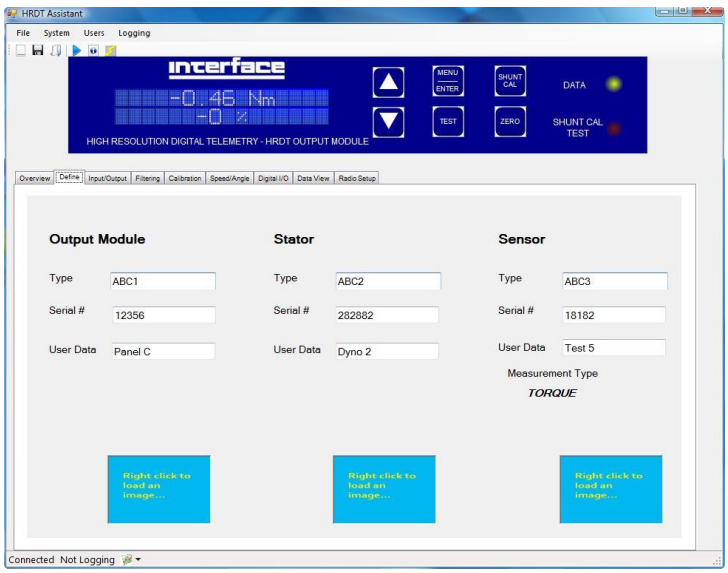
Once the HRDT Assistant software is installed, connect the output module to the PC using the USB B connector on the output module.



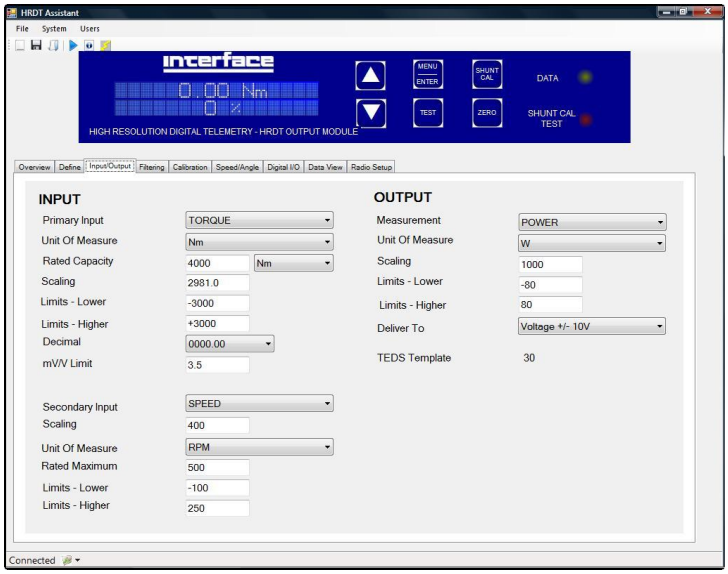
Start the HRDT Assistant, the first screen should be a login screen:
Using the mouse click once on the login screen then type in the user name “supervisor” and the password “interface”. Select OK.



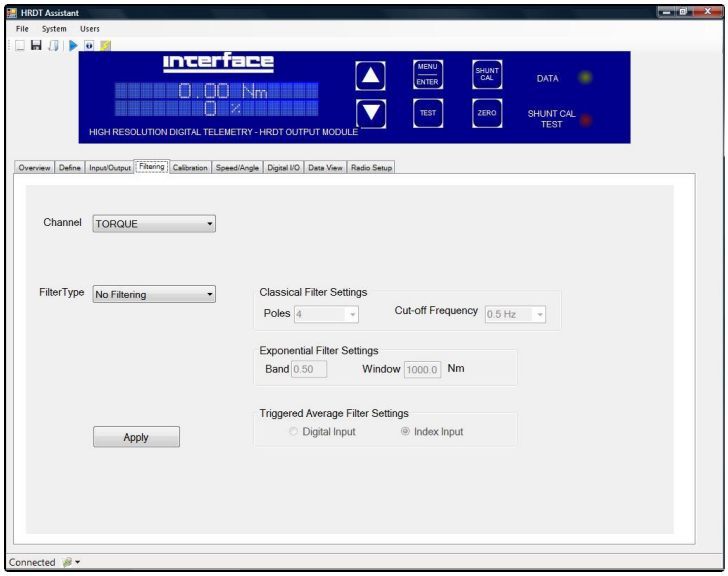
The Overview page should appear. The overview page allows the user to monitor the inputs and outputs of the system. The displays on the lower portion of the screen will only show data if the unit is in USB streaming mode. (see Input/output page) In the top left corner of each screen there is a ► (Program HRDT) control that must be used to permanently load the new configuration file to the output module. It does not have to be used after each change; the user can wait until satisfied with all changes. When this control is used the output module will automatically reboot. It will tale a few moments before the unit returns to normal operation.



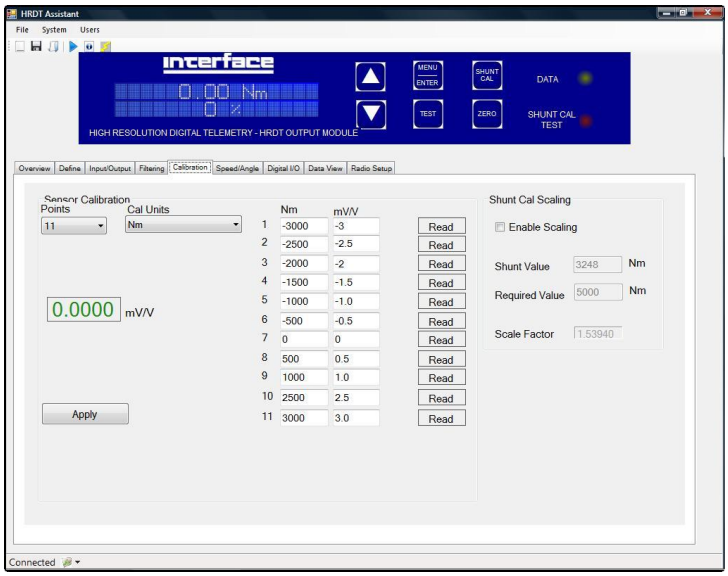
The Define page allows the components of the system to be identified.
Jpeg images of the installation or location can be loaded to the boxes at the bottom of the screen.



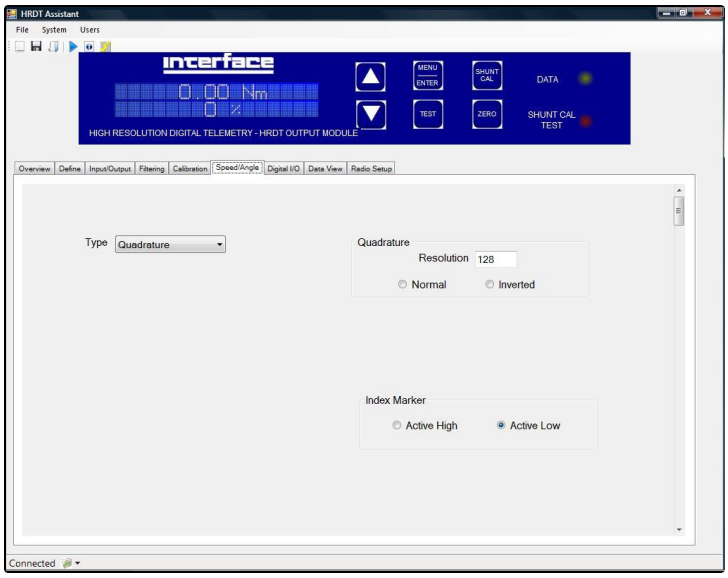
If the analog output is going to be used to monitor the main input (torque) set the scaling for the value required for the full scale of the analog output. In the example below if torque was selected for the output then the output would be 10V at 2981 Nm. Since power is selected to be delivered to the analog output the output will be 10V at 1000 W.



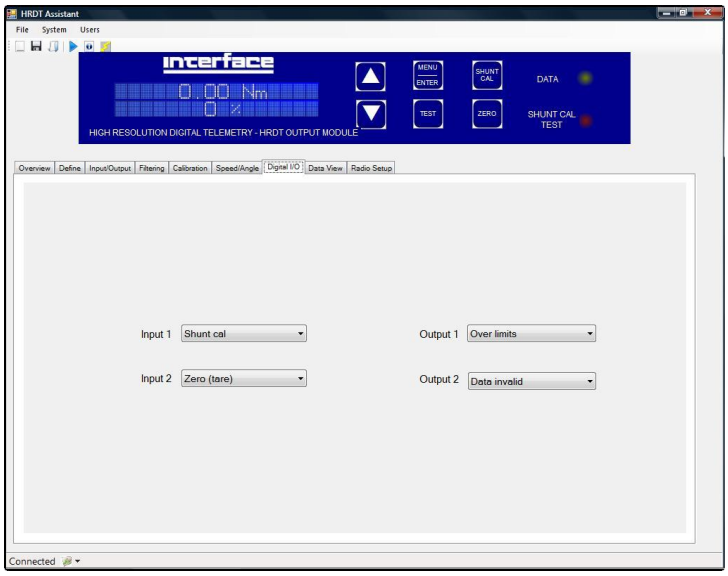
The apply button on the lower right of the filter page will temporarily set the filter to a new value to allow the new setting to be tested. As with other settings the ► Program HRDT control must be clicked to permanently change the filter setting.



The calibration page works in a similar way. The calibration points must be entered from lowest (negative) to highest. The shunt cal scaling feature allows the user to re-scale the shunt cal to a different value. This is useful in cases where the required shunt cal may be exactly half of the transducer rated capacity or if the transducer is being used to only a fraction of it's rated capacity.
To rescale the shunt cal value: turn on the shunt cal, enter the current value in the "Shunt Value" field, turn off the shunt cal and enter a new value in the "Required Value" field. Click the ► Program HRDT control to finalize the change.



Speed and angle is used to set up an auxiliary speed sensor. When TYPE is set to NONE, RPM and POWER displays on the Output Module are displayed.



This page allows setting Digital Inputs and Outputs. Digital inputs can be set to control functions like SHUNT CAL and ZERO. Outputs can be set for Over limits, Invalid data, SHUNT CAL, or ZERO active. Factory default settings are

DIG IN 0 = Shunt Cal
DIG IN 1 = Zero
DIG Out 0 = Invalid Data
DIG Out 1 = Over limits

Protecting your setup and data

Regardless of the method used for setup and configuration, facilities are provided for the creation of a backup file that includes both configuration and calibration data. This file is in standard PC format, and is easily copied onto the flash drive or a PC for safekeeping.

Normally, the backup file is simply kept as a record of the initial installation, but it may also be called upon to restore a system to a known condition after temporary changes have been made as part of a development process or after being operated by more than one user. The ability to download a known and trusted configuration is a quick and safe way of avoiding lost time.

In the event of more serious trouble, a full range of recovery scenarios are included under the Troubleshooting section of this manual, to give guidance on the quickest way to return a damaged or failed system to operation using factory supplied replacement modules and backups.

Troubleshooting

This section provides help and guidance when results are not as expected.

Rotor module

Condition: The DATA light has mixed blinking and steady behavior; there are times when it appears that the data from the rotor has interference.

> Action: If 2 HRDT systems are being operated within 10 to 50 feet of each other, one of them may need to have the radio channel changed. This can be accomplished using he Radio Setup controls in the Assistant software.

Condition: The DATA light is not illuminated or is blinking slowly.

> Action: Check the alignment of the stator. Confirm that the stator cable is connected at both ends.

Stator module

Condition: No response from the rotor.

> Action: Ascertain that both the stator power connector and USB connector are properly attached to the output module.

Output module

Condition: The display on the output module is reading 0.00 and does not change with applied torque.

> Action: Ascertain that the DATA light is illuminated. If not, try repositioning the stator module. If there is still no illumination, try disconnecting and then reconnecting the USB cable at the stator.

Condition: The output module has stopped communicating with a PC while using a USB connection and the Assistant software.

> Action: Reset the output module by pressing the reset button with a small screwdriver through the small hole in the plastic side cover.

Condition: No output from the 4-20 mA analog output.

> Action: The 4-20 mA output is not internally powered. A power supply needs to be connected in the output loop. See the System Wiring section.

Condition: No output from the digital outputs.

> Action: These outputs are open drain and require a pull-up resistor to a voltage source. A 3 volt source is provided for convenience. See the System Wiring section.

Recovery Scenarios

The following sections describe the actions to be taken in the event of having to replace one of the modules. Facilities have been provided to allow the rapid and risk-free replacement of modules without the need for costly downtime and re-calibration. The procedures below do not require the use of a PC or laptop, provided that the configuration files have been backed up previously and are available for restore.

Replacing the Rotor module

A replacement rotor will ship with a flash drive containing a new system config file. Re-enabling the **Out-of-the-box Setup** mode will load the new config file and is detailed below.

Replacing the Stator module

The stator module is a stand-alone device that does not require matching to other system modules, so it can be replaced with a new unit at any time without any effect on configuration or calibration.

Replacing the Output module

If the current backup copy of the configuration file is available, then it is very easy to replace the Output module and re-activate the new one by following the "**Out-of-the-box"** Setup routine as described below. Otherwise, it will be necessary to connect a PC or laptop and review all relevant settings and either use the original factory calibration data for the rotor module (if available) or perform a local calibration. This scenario shows the value of maintaining a current backup copy of the configuration file.

Re-enabling the "Out-of-the box" Setup mode

This procedure is used to force the Output Module to load a new or previously backed-up config file from a USB flash drive. The config file must be named set3.ifxml and must be in the upper level directory of the flash drive. (it cannot be in a folder) DO NOT ENABLE THIS MODE UNLESS YOU HAVE A VALID CONFIG FILE ON A USB FLASH DRIVE. To enable the Out-of-the-box Setup mode, press and hold the **SHUNT CAL** button and the **ZERO** button simultaneously and hold until the display acknowledges that the mode has been activated and reboots. After reboot, the Output Module looks for the config file on the inserted flash drive. If it can't find the flash drive the message "Flash drive Available Y/N?" appears. After inserting the flash drive, the config file will load and you will be prompted for your previously used password. Factory default is 0000.

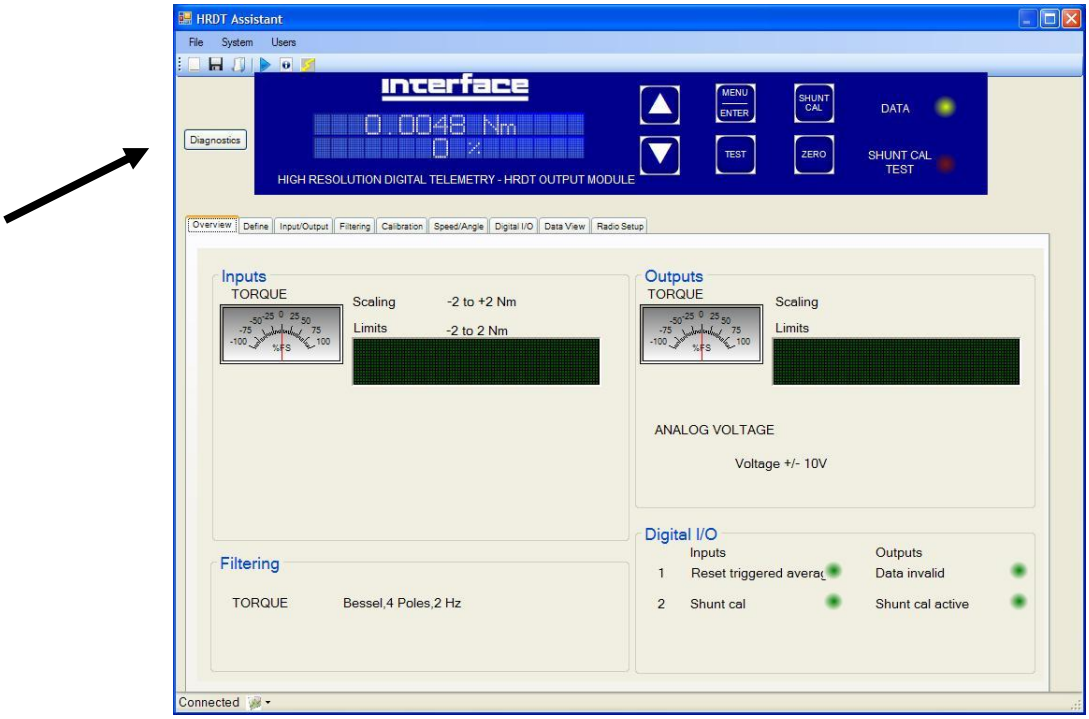
HRDT Pairing

The transceiver unit located in the rotor is "paired" at the factory to the specific stator and output modules that will be used as a system. This prevents crosstalk from other nearby units from disrupting a test. The only time pairing would need to be performed in the field would be in instances where a rotor or output module is being replaced.

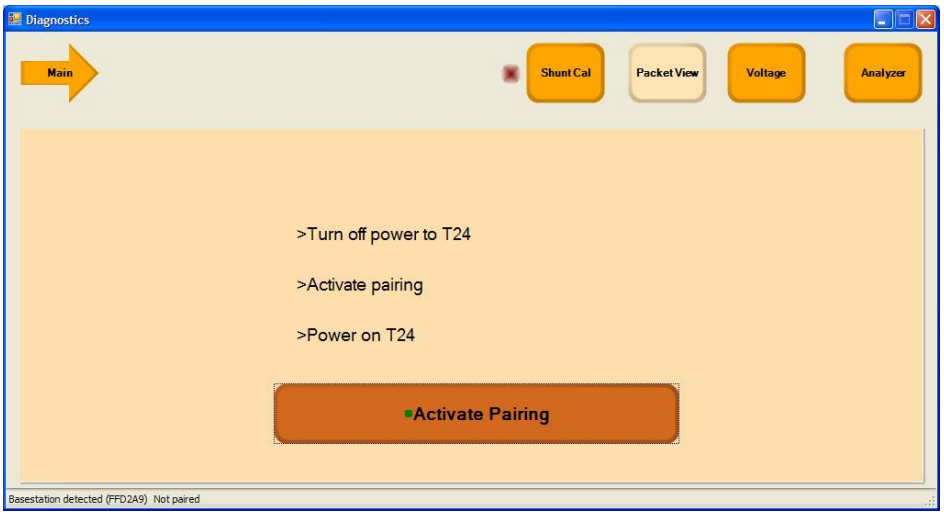
NOTE: if the rotor serial number is changed in the assistant software define page this will also cause a loss of pairing.
If a user alters the sensor serial number and loads this new configuration to the HRDT system, the system will need to be re-paired.

Pairing is accomplished on the Radio Setup page in the assistant software. Make sure the unit is properly aligned and powered up, click on the Activate Pairing & Serialize box. When prompted to power cycle the sensor, unplug the stator power terminal block from the output module, wait a few seconds and click "OK", then plug in the stator power connector within 10 seconds.
Once pairing has been successful, a box will pop up saying pairing complete.

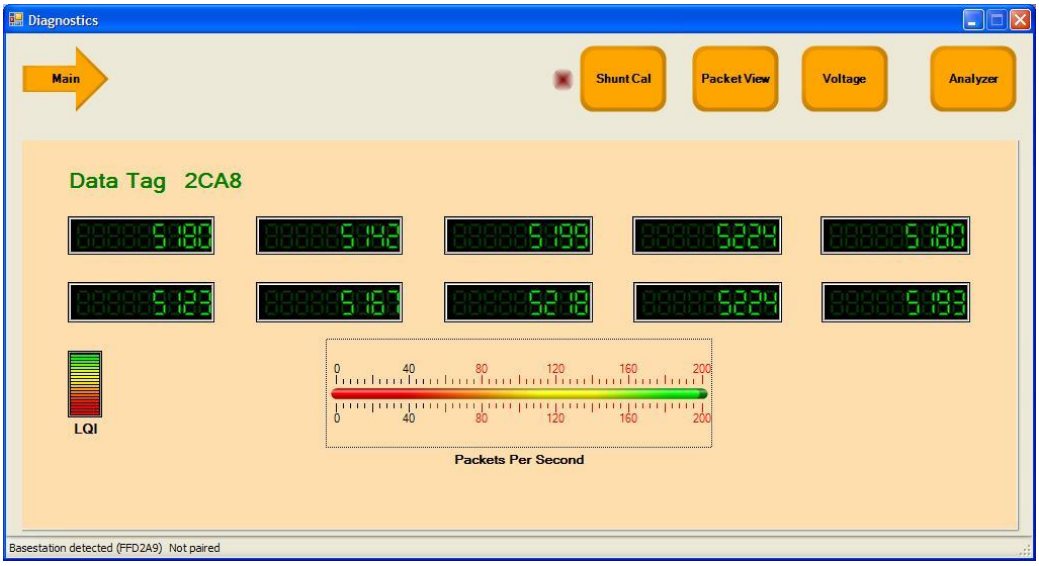
HRDT Assistant Diagnostics



Use the Diagnostic control button on the upper left of the HRDT Assistant to activate the diagnostics. To use the diagnostics the USB plug on the stator cable needs to be connected to a USB port on the computer.

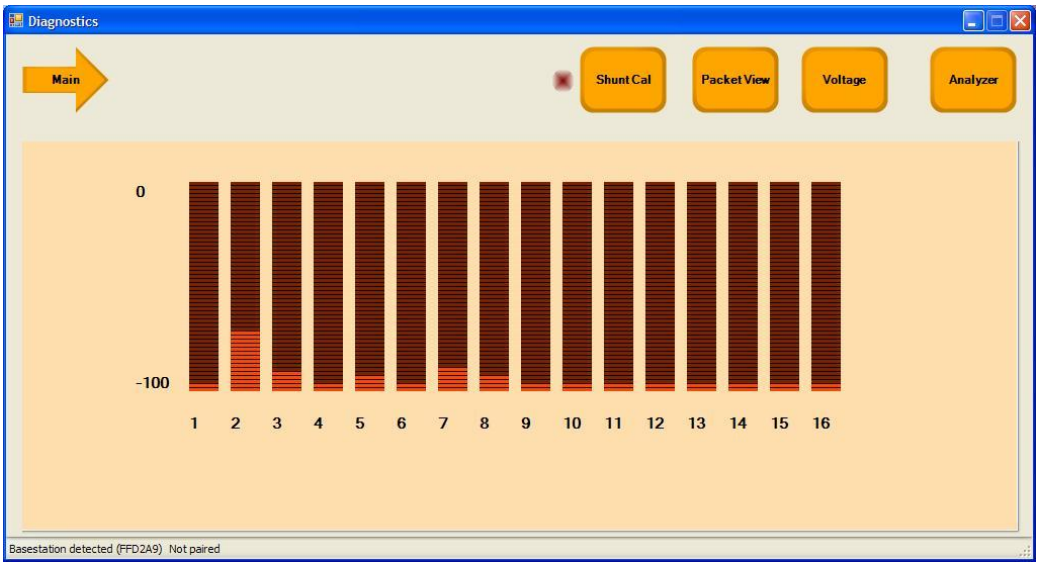


Click on a button to activate a specific function. Available selections will be highlighted upon mouse hover.



The Packet View page allows the user to see the raw ADC data from the rotor, the data packet rate, and a radio signal quality display (LQI).

There should be approximately 200 packets per second and the LQI should be in the green region.



The spectrum analyzer page is helpful for determining radio traffic on the various channels.

Appendices

This section will include supporting data such as specifications, flow charts, menu algorithms, engineering unit conversion tables, and certificate of conformance for CE marking, etc.

Appendix A: Interface HRDT Specifications

General Environmental Specifications

Ref	Parameter	Value range	Unit	Notes
1	Operating temperature range	0 to 158	Deg F	
2	Storage temperature range	-40 to 185	Deg F	
3	Environmental protection level	NEMA IV / IP65		Sensor only. The Output Module as standard conforms to IP54 and needs an additional external housing to comply with IP65
4	Power supply	24 ± 2	V DC	
5	Power consumption	<20.0	W	

Approvals and Compliance

Ref	Parameter	Title	Notes
1	IEC 1010 (EN 61010)	Safety requirements for measurement, control and laboratory equipment – general requirements	
2	IEC 61000 (EN 61000)	Electromagnetic compatibility (EMC)	
3	IEC 61326 (EN 61326)	Electrical equipment for measurement, control and laboratory use – EMC requirements	
4	FCC, ETSI, IC, JIS	Regulations for radio devices	

Rotor Electronics Specifications

Ref	Parameter	Value range	Unit	Notes
1	Measurement	Full bridge strain gage		
2	Excitation	5	V DC	
3	Bridge resistance	1400	Ohms	
4	Sensitivity for full scale (FS)	+/- 3.3	mV/V	

5	Sensitivity to meet performance specification	+/- 1.0	mV/V	
6	Measurement bandwidth	200	Hz	
7	A/D resolution	+/- 18 bit or better		
8	A/D sampling rate	4000	Samples/ sec	
9	Output data rate	2000	Results/ sec	
10	Non-linearity	<= 0.005	%FS	
11	Temp effect on zero	<=0.01	%FS/degF	
12	Temp effect on span	<=0.01	%FS/degF	
13	Compensated temperature range	+15 to +122	Deg F	
14	Digital linearization	none		
15	Calibration facilities	Factory calibrated in mV/V to an accuracy of 0.1%		
16	Shunt cal resistor	120k	Ohm	
17	Power requirements	2.2 to 3.6	V DC	
18	Power requirements	<= 60	mA	inrush current can create peak demands of 100mA
19	Radio frequency	2.4000 to 2.4835	GHz	
20	Radio data rate	250k	bps	
21	Radio power	1	mW	
22	Radio channels	16		
23	Modulation technique	MSK (QPSK)		
24	Measurement delay	12 to 20	ms	
25	Displacement tolerance between rotor and stator	<= 5	mm	
26	Connections			
27	Physical dimensions	37.5 x 16.8 x 8	mm	
28	Physical orientation			
Stator Electronics Specifications				
Ref	Parameter	Value range	Unit	Notes
1	Power supply	24 ±2	V DC	
2	Power supply	<= 10	W	
3	Frequency	80	KHz	

4	Tuning method	none		
5	Power delivery across the gap	0.4	W	
6	Radio			All details as per Rotor Electronics Specifications
7	Digital communications			USB
8	Connections	6 pin circular		
9	Physical dimensions	Electronics housing 4 X 2.5 X 1.25, See product outline drawing for stator coil dimensions.		
10	Physical configuration	Electronics housing Aluminum Stator coil		
Output Electronics Specifications				
Ref	Parameter	Value range	Unit	Notes
1	Power supply	24 ±2	V DC	
2	Power supply	<=10.0	W	
3	Radio			The radio base station connects via the USB port.
4	Digital communications	USB (host)		Two type A for connecting remote devices such as the radio base station or memory sticks
5	Digital communications	RS-485 2-wire		Two ports provided, either of which can be factory set to RS-485 or RS-232. *NOTE: Reserved for future version – not yet implemented in firmware.*
6	Digital communications	USB 2.0		One type B for connection to a remote host such as a PC
7	**Analog output channel #1**	**Bipolar Voltage**		User selects channel # 1, 2 or 3
7a	Standard output level (FS)	0 ±10	V	Setting for ± 5V is provided
7b	Maximum output levels	0 ±10.7	V	
7c	Resolution	16	Bits	
7d	Bandwidth	3	kHz	At the -3dB point
7e	Linearity	0.005	%FS	
7f	Temperature effect on zero	±0.001	%FS/°F	
7g	Temperature effect on span	±0.005	%FS/°F	
7h	Delay time	<= 0.5	ms	In addition to the delay time of the rotor and stator modules
7i	Minimum load impedance	20000	Ohm	
8	**Analog output channel #2**	**Current loop**		
8a	Standard output level (FS)	12 ± 8	mA	

8b	Maximum output levels	3.5 to 20.5	mA	
8c	Resolution	16	Bits	
8d	Bandwidth	3	kHz	at the -3dB point
8e	Linearity	0.02	%FS	
8f	Temperature effect on zero	±0.01	%FS/°F	
8g	Temperature effect on span	±0.01	%FS/°F	
8h	Delay time	<= 1.0	ms	In addition to the delay time of the rotor and stator modules
8i	Maximum load impedance	500	Ohm	Current sinking type. Requires remote device to source the current.
9	**Analog output channel #3**	**Frequency**		
9a	Output format	± 3.5	V	Differential square wave, RS-485 compatible, can be used with standard RS-485 line drivers
9b	Standard output level (FS)	10 ± 5	kHz	
9c	or	60 ± 20	kHz	
9d	or	60 ± 30	kHz	
9e	Resolution	16	Bits	
9f	Bandwidth	3	kHz	At the -3dB point
9g	Linearity	0.015	%FS	
9h	Temperature effect on zero	±0.0025	%FS/°F	
9i	Temperature effect on span	±0.005	%FS/°F	
9j	Delay time	<= 0.5	ms	In addition to the delay time of the rotor and stator modules
9k	Minimum load impedance	120	Ohm	
10	**Speed & Angle**	Quadrature input with index marker capability		Note - Can also accept TTL pulse train input
10a	Bandwidth	200	kHz	
10b	Accuracy	±1	rpm	At 1000 rpm
10c	Encoder power supply	5	V	
10d	Encoder power supply	100	mA	Protected with self-resetting thermal fuse
11	Data memory on board	16MB flash		
12	Data memory backup	USB flash drive		using PC via USB port

13	**Filtering**	Digital		Two channels – one for the primary input (typically torque), the other for the secondary input (speed measurement)
13a	Characteristics	Exponential (RC), Triggered averaging, or Classical filters selected from Bessel, Butterworth or Chebychev		Exponential filter has two parameters (VALUE and BAND). Triggered Average is triggered from the digital input or the Index input of the speed & angle channel (response time <=1ms)
13b	Number of poles (Classical filters only)	4 or 6	Poles	Selectable
13c	Cut-off frequencies (Classical filters only)	0.1, 0.5, 1, 2, 5, 10, 20, 50, 100, 200, NONE	Hz	Selectable
14	**Digital I/O**			
14a	Number of digital inputs	2		
14b	Response time of fast input	<=0.1	ms	Digital input 0 when set to Triggered Average
14c	Response time of standard input	<=200	ms	
14d	Maximum voltage rating of digital input	3.3	V	Digital input is activated by shorting to ground.
14e	Number of digital outputs	2		Open drain
14f	Response time of digital outputs	2	ms	Driven from internal flags, events, or user-set limits
14g	Digital output current sink capacity	100	mA	
14h	Maximum voltage rating of digital outputs	5	V	Suitable voltage source is provided (protected).
15	**TEDS**			
15a	Hardware device	DS2431		Fully compliant with IEEE 1451.4 standard
15b	Template	Template 30 - when Voltage output is selected Template 31 - when current loop output is selected No template has been defined by IEEE for a frequency output.		For output channels where TEDS templates have been defined, the TEDS chip contents are re-written automatically, any time the configuration or calibration is altered. The “Basic TEDS” remains unchanged and is available for all channels, regardless of template availability. Requires testing and requires availability of an instrument that can read TEDS and use the data (eg National Instruments DAQ system) [NOTE: TEDS still in development phase]

16	Display	Dual row 16 character LCD with backlight		Character size 2.95 x 5.55 mm
				Viewing area 66 x 16 mm
				Each character 8 x 5 dot matrix
				NOTE – display does not work at temperatures below -20C
16a	LED's	1 x RED, 1 x GREEN, both 3mm diameter, high brightness		Green LED labeled "DATA" to be illuminated whenever valid data packets are arriving from the rotor module. Red LED labelled "TEST" to illuminate whenever SHUNT CAL is active and to flash at 1 Hz whenever the TEST function is active
17	Pushbuttons	6 total, tactile		Assigned in firmware as follows :
				From top left (nearest display) to top right
				- Up arrow
				- MENU or ENTER
				- Shunt Cal
				From bottom left to bottom right
				- Down arrow
				- Test
				- Zero
18	Connections	Two-part plug and socket type, on 3.81mm pitch, 1.5mm^2 nominal cable size, screw type rising clamp, except USB for which industry standard USB type A and type B connectors are provided		
19	Physical dimensions	L x W x H 10.3 x 3.0 x 2.6 261 x 76 x 66	 inch mm	Allowance should be made for the space required by cables and connectors, in particular the bend radius of the USB cables that enter at the connector areal. The minimum overall space envelope is considered to be 10.3 x 5 x 4 inch (261 x 127 x 102) mm.