TorqueTrak Sensor Interface
Installation and Operation Manual

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1   SYSTEM OVERVIEW

The Binsfeld Engineering TorqueTrak Sensor Interface (TTSI) is a companion subsystem to other products providing a simple intuitive user interface along with additional analog and digital I/O. Off-the-shelf components with custom programming are used to create flexible and economical solutions.

System Features include:
- Adaptable to existing customer equipment
- Simple, intuitive operator interface
- Customizable software
- Compatible with any Modbus sensor
- Variety of mounting options

1.1   SYSTEM COMPONENTS

The complete measurement system would consist of a sensor with a Modbus interface (e.g. Binsfeld TPM2 Torque and Power Meter), the TorqueTrak Sensor Interface (described here), and customer instrumentation.

1.1.1   TTSI Sub System

As the name describes, the TTSI is the interface between the sensor and the customer equipment. On the customer side, the TTSI can provide operator displays, analog I/O, digital communications, and/or discrete digital I/O that are compatible with customer equipment. The TTSI can be provided in a self-contained enclosure, or as DIN rail mountable components that can be added to existing control cabinets. The purpose of the TTSI is to provide a low-cost interface between the sensor and the customer equipment.

The main components of the TTSI are a PLC and the Operator Display(s).

2   INSTALLATION

> *DO NOT USE* this product as a safety or emergency stop device or in any application where failure of the product could result in personal injury.
>
> **Failure to comply with these instructions could result in death or serious injury.**
>
> The end user is responsible for the proper installation and operation of this device. Improper installation or operation could result in damage, injury or death.
>
> Certain environments could cause damage or degradation to the components of the system resulting in failure.
>
> User installed connections to the system must be sealed by the installer for operation in wet/harsh environments.

Install the sensor using the installation instructions provided with the sensor.

Physically mount the TTSI enclosure or components.

If using a standalone TTSI with an enclosure, route AC power through the grommet then connect to the terminal block according to the terminal block label. See chart and image below.

Connect the Modbus COM cable from the torque sensor to the M12 connector.

If mounting TTSI components in an existing control cabinet, terminate wires according to the provided wiring diagram. Typical connections are analog output signals and analog signal ground.

CAUTION: Do not connect or disconnect the COM cable while power is applied or damage due to arcing may occur and damage the connectors.

CONNECTOR PIN	DESCRIPTION
1	RS-485 signal GND
2	+24 VDC
3	0 VDC
4	RS-485 A+
5	RS-485 B-

Table 1: M12 Connector Pinout

Table 2: Terminal Block Layout

Position	Label	Color	Description
1	TRQ ALARM	Orange	Torque alarm dig out
2	TORQUE OUT	Gray	Analog torque signal
3	RPM OUT	Orange	Analog speed signal
4	N/C	Gray	Not used.
5	N/C	Orange	Not used.
6	MODBUS TX-	Gray	TPM2 ModBUS
7	MODBUS RX-	Gray	TPM2 ModBUS
8	MODBUS TX+	Orange	TPM2 ModBUS
9	MODBUS RX+	Orange	TPM2 ModBUS
10	N/C	Gray	Not used.
11	N/C	Orange	Not used.
12	MODBUS GND	Gray	ModBUS signal ground
13	ANALOG GND	Gray	Analog signal ground
14	TPM2 GND	Gray	TPM2 power ground
15	SPARE GND	Gray	Not used.
16	N/C	Orange	Not used.
17	CHASSIS GND	Yel/Green	Chassis ground
18	N/C	Gray	Not used.
19	N/C	Orange	Not used.
20	N/C	Orange	Not used.
21	TPM2 +24VDC	Orange	TPM2 power
22	N/C	Gray	Not used.
23	N/C	Orange	Not used.
24	AC LOAD	Gray	AC line in
25	AC NEUTRAL	Orange	AC neutral in
26	CHASSIS GND	Yel/Green	Chassis ground
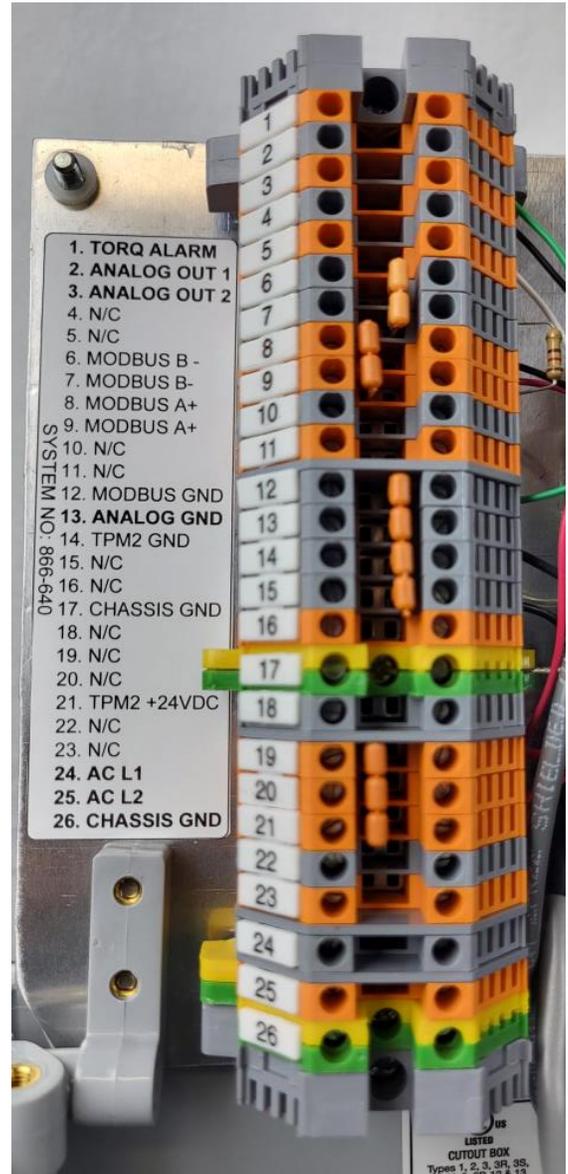
3   PLC INDICATORS AND SET-UP

3.1   PLC INDICATOR LEDS

There are three indicator LEDs on the PLC: Pwr, Run and Err (Power, Run and Error). The Power and Run LEDs are solid green when the PLC is operating properly. The Error LED flashes red when a PLC error is active.

The OUT 1 red LED on the PLC option slot module indicates the status of the Torque Alarm output (illuminated is ON, dark is OFF).

The Operator Display will flash "Low PLC Battery" when the PLC battery needs replacing. The PLC memory is battery backed using a CR2032 coin cell. The coin cell is located in a slide-out tray in the top back left corner of the PLC.

3.2   PLC RUN/STOP SWITCH

The Run/Stop switch on the PLC should always be in the Run position.
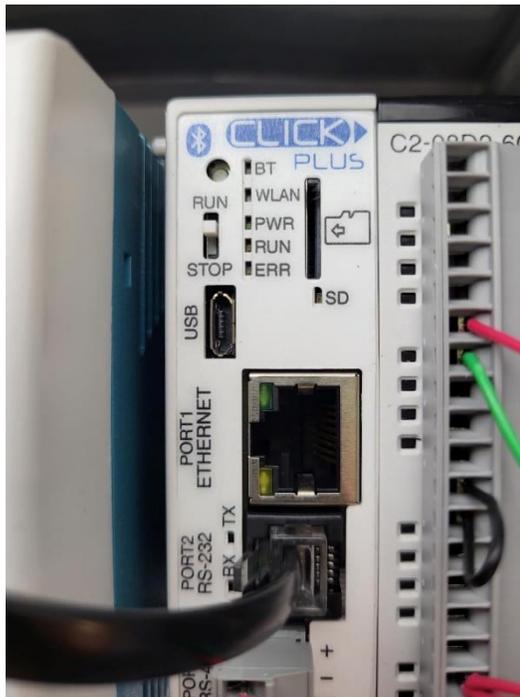
PLC Front Panel

4   OPERATOR DISPLAY

On the Operator Display, buttons correspond to button labels (generally in black) directly above the buttons. For example, in the screen shown here, F1 corresponds to Units.

The Torque screen acts as the Home screen.

Press F5(next) to cycle through the main menus. Pressing F3(scrn) provides access to submenus and screens.

4.1   DISPLAY MAIN MENUS

When F3(scrn) is selected on the Torque screen, a list of menus appears:

- Parameters Menu

- Controls Menu

- Diagnostics Menu, and

- Miscellaneous Menu.

Through these main menus, the operator can navigate to all other screens for system data, information and configuration.

4.2   DISPLAY OPERATION

The Shaft Dimensions screen is an example of a screen used for system configuration. By selecting F1(OD), the operator can enter the outside diameter of the shaft.
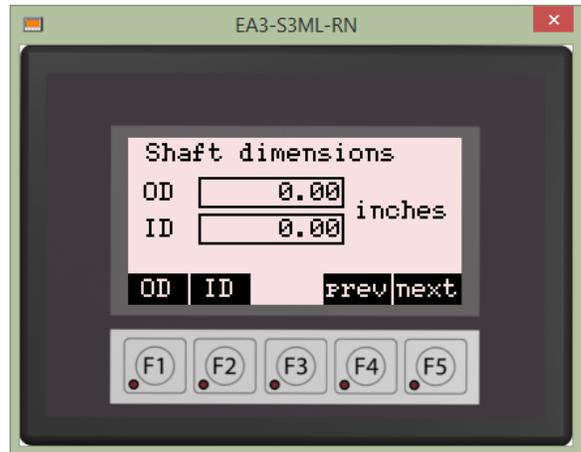
Selecting F1(OD) on the Shaft Dimension screen allows editing of the value. Selecting F2(SHF) will shift the cursor to the right, one digit at a time. When a digit is selected, the value can be increased by selecting F3(UP) or decreased by selecting F4(DWN). Once all digits have the desired values, press F5(ENT) to save and stop editing. F1(ESC) will cancel editing the value without saving changes.
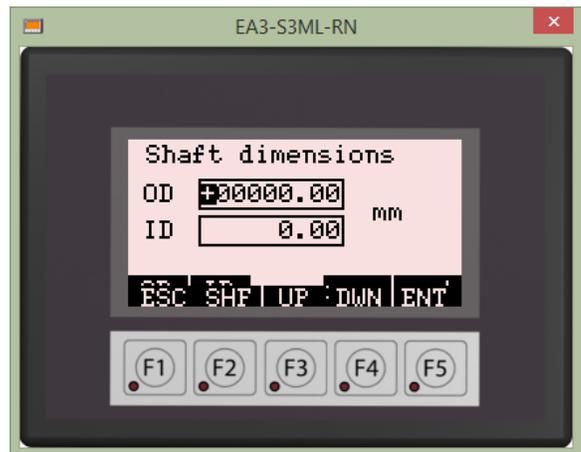
The Input Source screen is an example of a second type of screen used in configuration. Pressing F1(InSrc) repeatedly cycles through four available input sources:

- TPM2

- (+) Full Scale

- (-) Full Scale and,

- Mid Scale.

5   MENU TREE

This list summarizes the entire set of TTSI menu screens.

1) Torque (Home) > Shaft + RPM > Power (kW/HP) + RPM

2) Parameters Menu
   a) Shaft Dimensions
      i) OD (Outer Diameter)
      ii) ID (Inner Diameter)
   b) Range-GF (Gage Factor)
      i) Range
      ii) Gage Factor
      iii) Modulus of Elasticity
      iv) Poisson Ratio
   c) Speed Configuration
      i) Pulses per Revolution
      ii) Zero Speed Threshold
      iii) PFS RPM (Positive Full Scale RPM)
   d) Units Select
      i) English/Metric
   e) Torque Alarm
      i) Set Value
      ii) Hysteresis

3) Controls Menu
   a) Rest Torque
      i) Capture   [Selecting 'next' on this screen will jump to the Auto Zero screen]
      ii) Manual Entry
   b) Dead Cal Select
      i) Select: ON
         (1) Dead Weight Calibration
            (a) Reference Torque
            (b) Apply Reference Torque
               (i) Live
               (ii) Captured
      ii) Select: OFF
   c) Frequency Response
   d) Scale & Offset Configuration
      i) Torque Scale
      ii) %FS (Full Scale) Torque Offset
      iii) Speed Scale
      iv) %FS (Full Scale) Speed Offset
      v) Power Scale
      vi) %FS (Full Scale) Power Offset
      vii) Analog Output #1
      viii) Analog Output #2
   e) Auto Zero
      i) Toggle: ON/OFF

4) Diagnostics Menu
   a) Input Source
      i) TPM2
      ii) +Full Scale
      iii) -Full Scale
      iv) Mid Scale
   b) Shunt Control
      i) Shunt Status
         (1) Shunt/No Shunt   [Selecting 'next' on this screen will jump to the Controls Menu]
   c) TPM2
      i) Status 1-0
      ii) Status 2
   d) Diagnostic Registers
      i) SI Voltage
      ii) SI Amperes
      iii) SI Temperature
      iv) Inductive Amplifier Voltage
      v) Inductive Power Duty Cycle
      vi) Transmitter Power Voltage
      vii) Rotating Receiver Error Count
   e) Reset
      i) F1 – Reset Transmitter
      ii) F2 – Reset TPM2

5) Miscellaneous Menu
   a) SD Card
      i) Eject
   b) System Information
   c) Time
      i) Current Time
      ii) Current Date
   d) PLC Battery Status

6   TTSI CONFIGURATION

TTSI Configuration is accomplished using the Parameters and Controls Menus.

6.1   PARAMETERS SUBMENU

To configure the TTSI, first set the units you want to use (English or metric). Units Select is in the Parameters Submenu.

From the Parameters submenu, navigate to Units Select and press F5(ENT.)

6.1.1   Units Select

In the Units Select screen, press F1(Units) to toggle between English and metric. ***This should be done first because the program does NOT automatically convert values.***

Next, press F5(next) to enter shaft dimensions and parameters (unless a Dead Weight Calibration is to be used). Pressing F5(next) will cycle through all required shaft physical parameters.

NOTE: When using the Dead Weight Calibration method of applying a calibrated load to the shaft, shaft dimensions and parameters are not used to calculate the torque scale. To enter Dead Weight Calibration points and values, navigate to the Controls Menu.

6.1.2   Shaft Dimensions

Press F1(OD) to specify shaft outer diameter.

Press F2(ID) to specify shaft inner diameter. For solid shafts, inner diameter is 0.00.
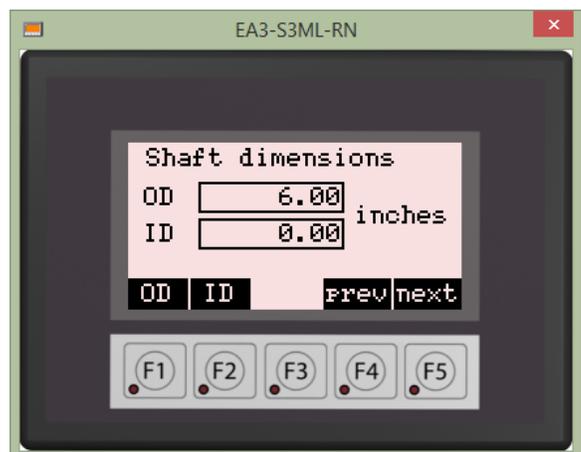
6.1.3 Range – GF (Gage Factor)

6.1.3.1 Range

The Range parameter determines the maximum input signal allowed at the sensor, and therefore affects the full scale output signal, effectively acting as a gain setting.

Pressing the F1(Rng) button will cycle through eight input ranges from 0.25mV/V to 32 mV/V (corresponding to 125 to 16000 microstrain at gage factor of 2.0).

6.1.3.2 Gage Factor

The Gage Factor is the inherent gain of the (torque) sensor. The value is provided by the sensor manufacturer and can be entered by pressing F2(GF).

6.1.3.3 Modulus of Elasticity

The Modulus of Elasticity is intrinsic to the metal of the shaft being measured. The most common shaft material is common steel which has a Modulus of 30 million PSI (pounds-per-square-inch).

For other material types, press F1(ME) to enter the appropriate value.

6.1.3.4 Poisson Ratio

The Poisson Ratio is also intrinsic to the metal of the shaft being measured. For common steel the ratio is 0.3 (unitless).

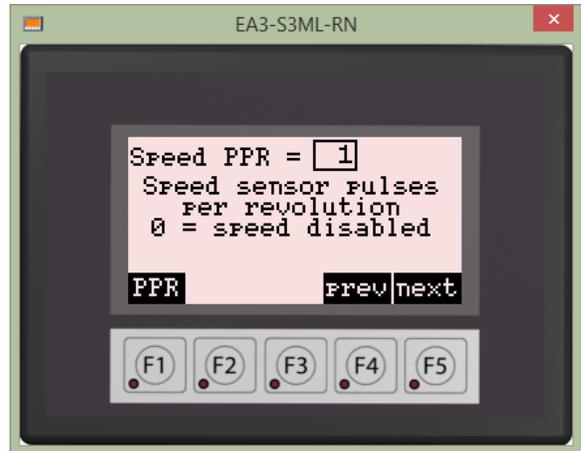For other material types, press F1(PR) to enter the appropriate value.
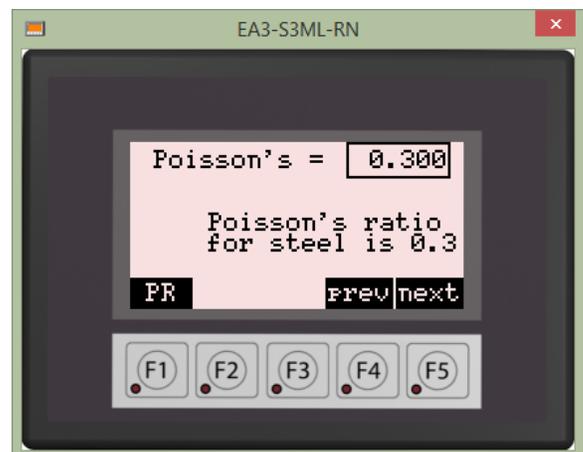
6.1.4 Speed Configuration

6.1.4.1 Speed PPR (Pulse per Revolution)

Speed PPR is used to specify the number of (magnet) pulses per shaft revolution. Press F1(PPR) to enter the correct value. (For the TPM2 system the PPR is one.)

To disable the speed function of the system set the PPR to zero.

6.1.4.2 Zero Speed Threshold.

The Zero Speed Threshold is used to specify the minimum speed that will register an RPM reading. Any speed below the Zero Speed Threshold will be processed as RPM=0. This feature can be helpful to differentiate a shaft that is idling (slowly rolling but not driven) from a shaft that is powered.

Press F1(ZeroSpd) to enter the desired value.
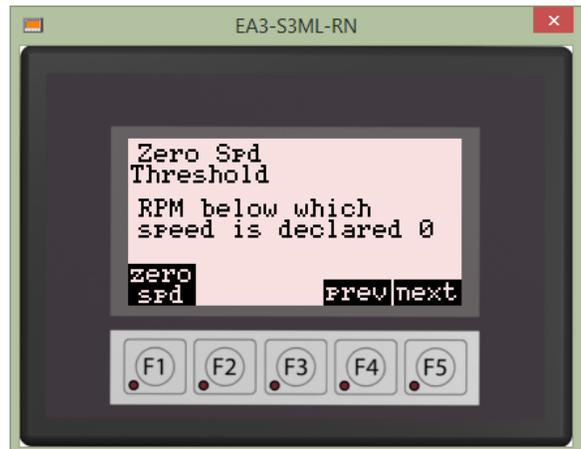
6.1.4.3 PFS (Positive Full Scale) RPM

The Positive Full Scale RPM field sets the full scale for the speed measurement and should be set at or above the expected maximum shaft speed.

Press F1(RPM) to enter the desired value.

6.1.5 Torque Alarm

The Torque Alarm feature controls a discrete +24V current sourcing output to indicate when a user-specified torque threshold is exceeded.

The Torque Alarm value is the threshold above which the alarm output turns ON. Press F1(TrqAlr) to enter a threshold (trigger) value.

If and while the measured torque exceeds the Torque Alarm threshold, the display will show ON. Otherwise the display will show OFF.

Hysteresis is the amount of torque below the threshold that the torque must fall in order to turn the alarm output back OFF. Press F2(Hys) to enter the Hysteresis value.

As an example, if the expected maximum torque is 100,000 ft-lbs, the Torque Alarm might be set at 110,000 ft-lbs (110% of expected torque) and the Hysteresis might be set for 10,000 ft-lbs so that the alarm shuts OFF when the torque drops below the maximum expected level.

Next navigate to the Controls Menu and press F3(scrn).

6.2   CONTROLS SUBMENU

6.2.1   Rest Torque

Rest Torque is the residual torque value indicated by the sensor when the shaft is under zero load. Typically it is a function of the sensor (e.g. strain gage) installation and can be considered an offset that must be "zero-ed" out as part of the system calibration process.

Scroll Up/Down to highlight the Rest Torque submenu then press Enter (ENT).

The current Rest Torque level is displayed as a "live" reading.

Ensure that there is no load applied to the shaft (zero torque load). Then press F1(Capture) to capture the rest torque (offset) value. You will see that the "live" value is now shown as "captured". Pressing F1 again will update the captured value.

When Auto Zero is ON, the Rest Torque captured value is subtracted from all torque samples to zero out the rest torque. See Auto Zero Section 6.2.6.

6.2.2 Dead (Weight) Cal Select

The F1(Sel) select button toggles between using shaft dimensions or Dead Weight Calibration to establish the full scale torque value. When the desired option is displayed, press the appropriate function key to continue. If using shaft dimensions, "next" will return to the Controls Menu. If using a dead weight calibration technique, "next" leads to the Dead Weight Calibration Configuration screens (see section 6.2.5).
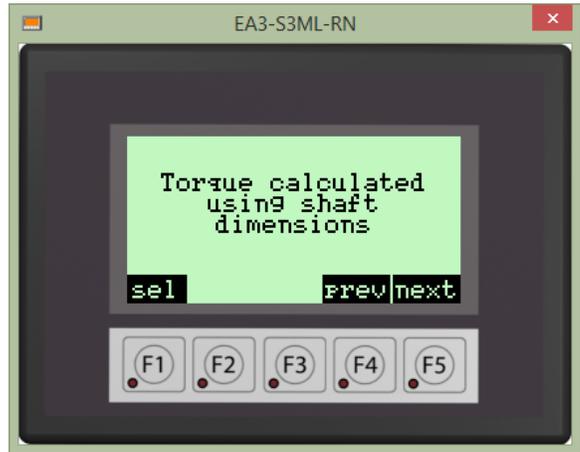
6.2.3 Frequency Response

This feature allows the user to select the 3dB cut-off frequency for the torque data during processing when using the TPM2 system. By using a lower frequency response value, the user can "smooth out" the torque data to present a more stable signal. This is useful when the intent is to monitor the nominal or average torque value on the shaft.

Pressing F1(Freq) will cycle through eight preset values:
- 3 Hz
- 6 Hz
- 12 Hz
- 25 Hz
- 50 Hz (default value)
- 100 Hz
- 200 Hz
- 380 Hz
- 740 Hz
- 1000 Hz (maximum frequency response of TPM2)

6.2.4 Scale & Offset Configuration

The Scale and Offset Configuration screen sets scale and offset values for the torque, speed and power signals. The scale and offset values only apply to the analog outputs.

The Scale value is multiplied by the analog output value for each respective parameter and is normally set to 1.0. Setting a scale to 0 will cause the associated analog output to always be 0 (at the analog output 0 signal level).

The % Full Scale Offset value sets corresponding analog output zero signal level. For example, a setting of 50% sets the analog output zero signal level to 12mA for a 4 to 20mA analog output. Setting the offset to 0% would move the zero output level to 4mA. Typically, the Offset value should be set to 50% (i.e. zero input = mid-scale).
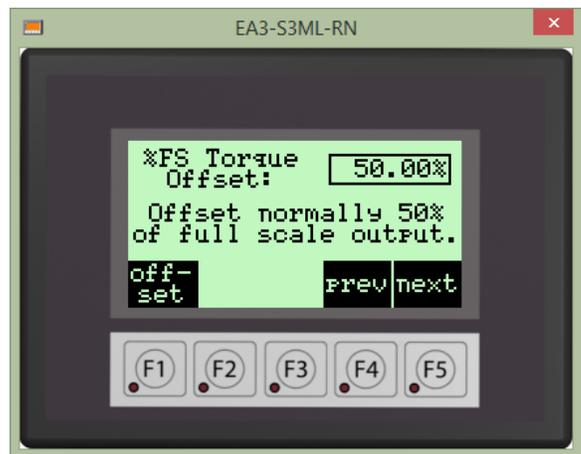
6.2.5 Dead Weight Calibration

If Dead Weight Calibration is selected, F3(next) leads to the Dead Weight Cal Reference Torque value entry screen.

6.2.6 Auto Zero

When Auto Zero is ON, the Rest Torque captured value is subtracted from all torque samples to zero out the rest torque. Press F1(Toggle) to turn Auto Zero ON or OFF.

6.2.6.1 Dead Weight Calibration Value

Press F1(RefTrq) to enter the reference torque value that is/will be applied to the shaft. Then press F5(next).

The Reference Torque capture screen works just like the Rest Torque capture screen. The only difference is that it captures the Reference Torque TPM2 value.

The value has no units and ranges from 0 to 16,000. The value can be negative (down to -16,000) depending on the direction of the reference torque. Press F1(capture) to capture the live value. *Note: For accuracy, the applied reference torque should be greater than 50% of expected full scale torque.*

After capturing the reference torque value, press F5(next) to return to the Controls Menu.

That completes the TTSI configuration.

7   DIAGNOSTICS SUBMENU

The Diagnostics submenu options are useful for testing and troubleshooting.

7.1   INPUT SOURCE

Pressing Input Source F1(InSrc) repeatedly cycles through four available input sources:

- TPM2: the torque and speed input signals are being produced by the TPM2

- (+) Full Scale: sets the output signals to full scale

- (-) Full Scale: sets the output signals to negative full scale

- Mid Scale: sets the output signals to the center point, halfway between positive and negative full scale

These alternate input sources are only valid while on this screen. For example, you cannot set the system to + Full Scale and then change screens to view the full-scale torque reading.

7.2   SHUNT CONTROL

The Shunt Control applies one of two simulated loads to the torque sensor at the transmitter. Pressing F1(Shunt) cycles through three available settings:
- No shunt applied
- Shunt 1 (200uV/V) is ON
- Shunt 2 (1000uV/V) is ON

NOTE: System commands that modify either the gain or shunts may take as much as 10 seconds to take effect.

7.3   TPM2 STATUS

TPM2 Status values display certain memory registers (status bits) in the TPM2 Torque and Power Meter which can aid in troubleshooting. The status bits are detailed in the TPM2 User Guide.


7.4   DIAGNOSTIC REGISTERS

The diagnostic registers display certain memory registers (status bits) in the TTSI which can aid in troubleshooting including:

Stationary Interface voltage

Stationary Interface amps

Stationary Interface temperature

Induction amplifier voltage

Induction power duty cycle

Transmitter power voltage

Rotating Receiver error count

Press F1(get) to update (refresh) diagnostic register values.
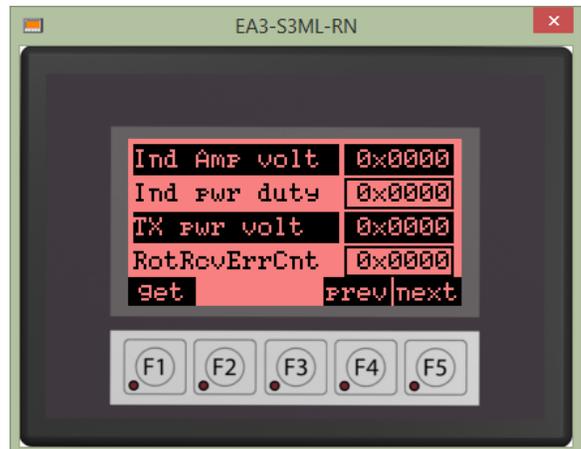
7.5   RESET

Press F1(RstTX) to cycle the power on the TPM2 transmitter module (only).

Press F2(RstTPM2) to cycle the power on the entire TPM2 system.

8   MISCELLANEOUS SUBMENU

The Miscellaneous Menu options provide system information, date and time setting, PLC battery status and micro-SD memory card status/eject.
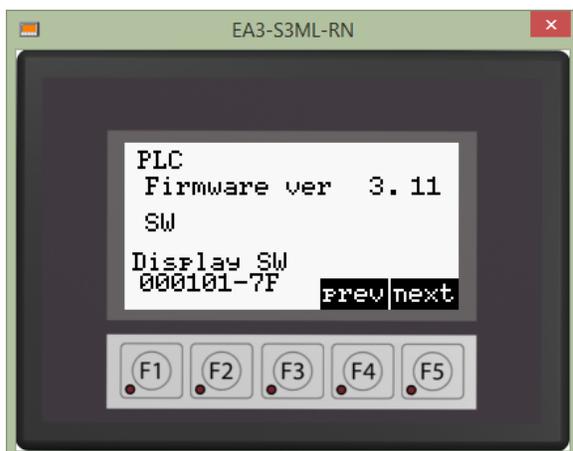

8.1   SD CARD

Press F1(Eject SD) to safely eject a local PLC micro-SD memory card.
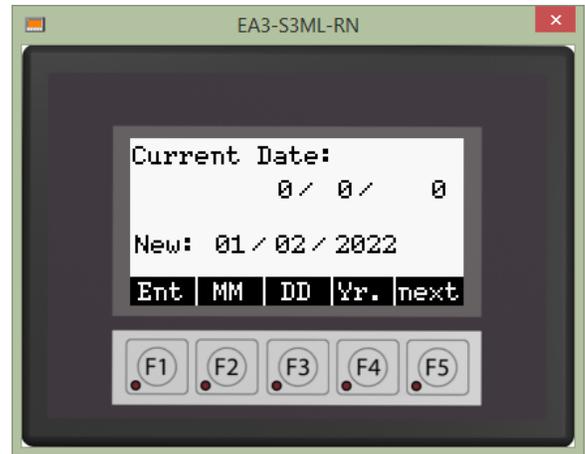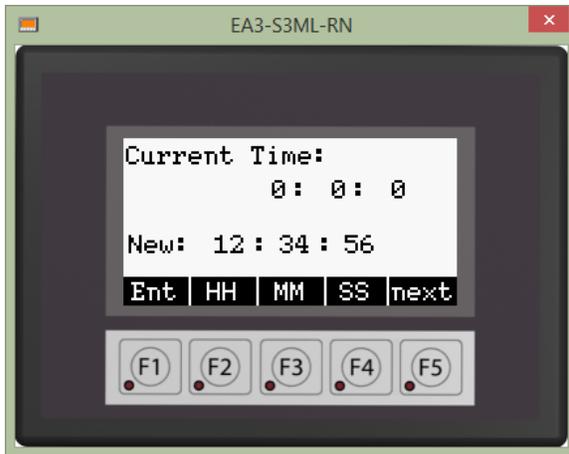

8.2   SYSTEM INFO

8.3 TIME

Enter new time value and press F1 (Ent) to update.
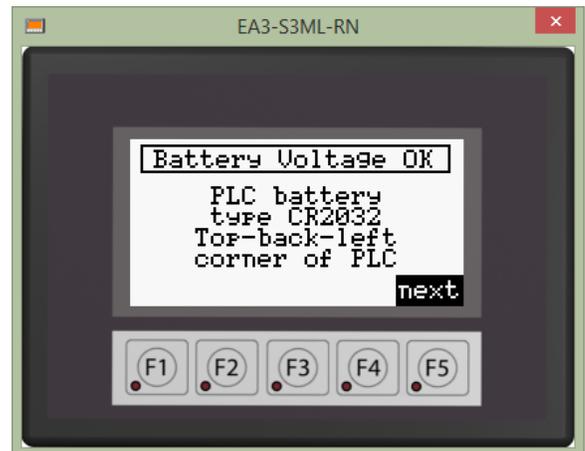
Press F5(next) to advance to the date screen.

Enter new date value and press F1 (Ent) to update.

8.4 PLC BATTERY

Indicates battery voltage status.

9   APPENDIX A: SYSTEM SPECIFICATIONS

Input voltage: 85 to 240VAC

Input power: 3amp D-curve 2 pole 240VAC circuit breaker.

Analog outputs (as available):

Current sourcing analog output load impedance must be 200 to 800Ω. Full scale calibration error ±2% max, accuracy vs. temperature ±100ppm/°C, output range 4-20mA sourcing, 12 bit resolution.

Voltage output into > 4KΩ load. Full scale calibration error ±2% max, accuracy vs. temperature ±100ppm/°C, output range 0 to 10VDC, 12 bit resolution.

Operating temperature: 0 to 40°C ambient.

IP rating: IP67

Modbus communications spec: 115.2Kbaud, 8 data, no parity, 1 stop. Modbus slave address 31.

10 APPENDIX B: CALCULATIONS

Calculations used in the system.

Torque = (Val_sample - Val_rest) * T_k

Power = [(Val_sample - Val_rest) * P_k] / SpeedCounts

The torque scale factor T_k results from:

T_k = (2 * π * E * (OD^4 - ID^4)) / (G_{iamp} * GF * K_T * OD * (1 + v))

T_k = torque scale factor (N-m or ft-lbs)
E = modulus of elasticity of the shaft material (N/mm^2 or Mpsi)
OD = shaft outside diameter (mm or inches)
ID = shaft inside diameter (mm or inches)
G_{iamp} = user selectable instrumentation amp gain
GF = gauge factor
K_T = torque units dependent constant
    (for N-m, K_T = 16x10^9: for ft-lbs, K_T = 192)
v = Poisson's ratio of the shaft material

The power scale factor P_k results from:

P_k = (T_k * 2π * $ω_k$) / K_p

P_k = power scale factor (watts or hp)
2π is radians/revolution
$ω_k$ = 1,769,472,000 speed timer counts / minute
K_p = units dependent power constant
    (for watts, K_p = 60: for hp K_p = 33,000)

The Dead Weight torque scale factor T_k results from:

T_k = T_{ref} / (Val_ref - Val_rest)

T_k = torque scale factor
T_{ref} = reference torque applied
Val_ref = TPM2 torque value for the applied reference torque
Val_rest = TPM2 torque value when no torque is applied.

The Dead Weight power scale factor is calculated the same.

11 APPENDIX C: TROUBLESHOOTING

If the TTSI cannot communicate with the TPM2 over the RS-485 communications cable, the banner message "No TPM2 Communications" flashes along the top border of the display. This could be caused by incorrect RS-485 wiring, a broken RS-485 connection, or incorrect configuration of the TPM2
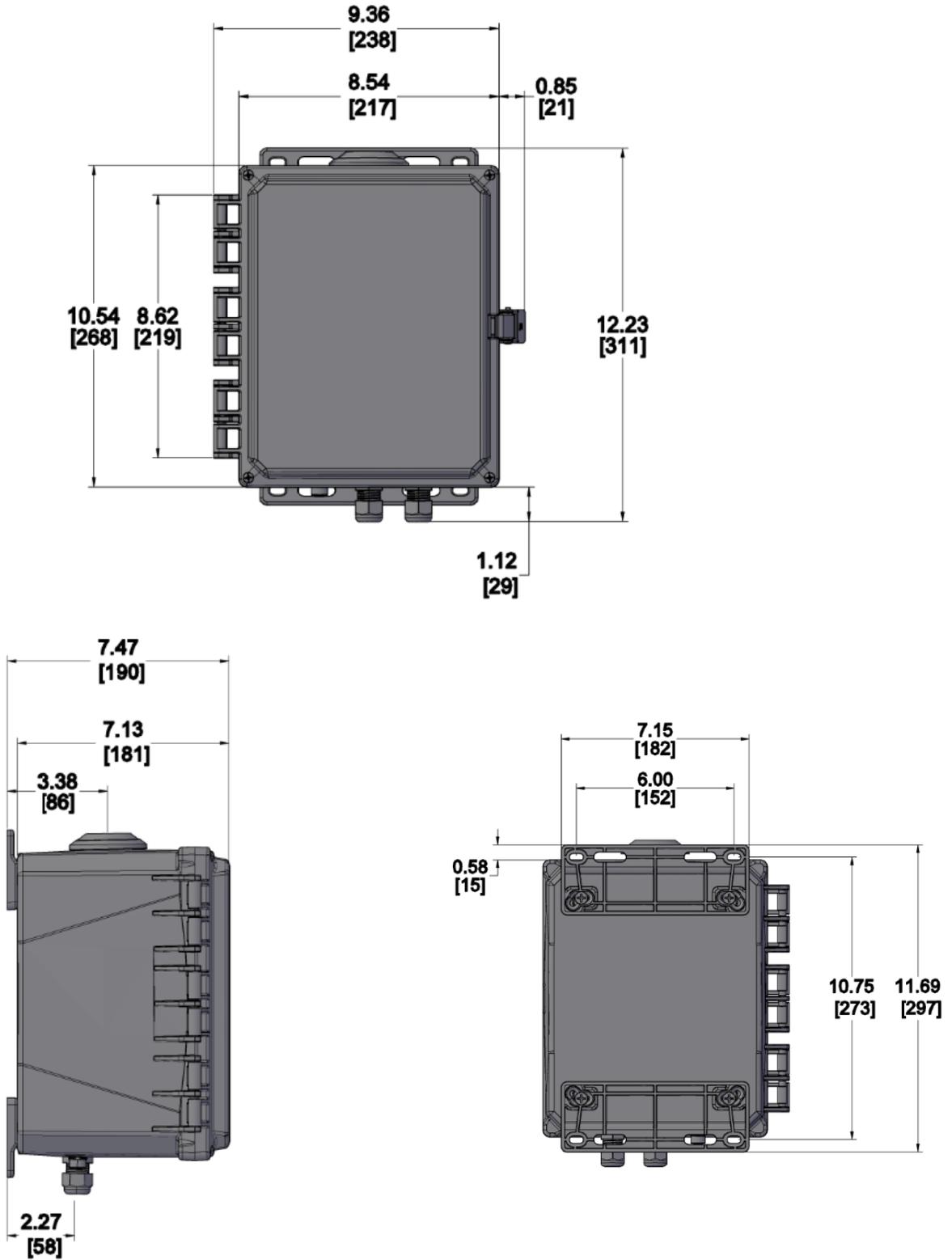
Note: The TPM2 must be configured as Modbus slave address 31, 115.2Kbaud, 8 data bits, 1 stop bit, no parity.

If the PLC battery needs replacing, the banner message "Low PLC Battery" is displayed. Navigate to the Miscellaneous Menu and the PLC battery screen for battery type and location.

12 APPENDIX D: SYSTEM DIMENSIONS

13 WARRANTY AND SERVICE INFORMATION

ONE YEAR LIMITED WARRANTY

Binsfeld Engineering Inc. warrants solely to the original purchaser of the Products for a period of (1) one year after the date of delivery, the Products to be free from defect in material and workmanship under normal use and will conform to Binsfeld Engineering Inc. published specifications of the Products. Notwithstanding the foregoing, Binsfeld Engineering Inc. retains its right to deviate from published specifications due to latest improvements in function and design of the Product. The foregoing warranty is subject to proper storage, transportation and use of the Products, and does not include defects due to normal wear and tear or deterioration. Upon delivery, Customer shall immediately inspect the Products for conformity and visible defects. Customer shall give Binsfeld Engineering Inc. immediate written notice of any conformities or visible defects regarding the Products and contact Binsfeld Engineering Inc. in writing concerning return or repair, as the case may be.

Binsfeld Engineering Inc.'s sole obligation under this warranty is, upon evaluation by Binsfeld Engineering Inc., and at Binsfeld Engineering Inc. 's option, to repair or correct any defect or to replace or exchange the Product with a copy of the original invoice to Binsfeld Engineering Inc. at its own cost. Any repaired, corrected, replaced or exchanged Products shall be subject to the warranty and limitations set forth. If Binsfeld Engineering Inc. has received notification from Customer, and no defects of the Product could be found, Customer shall bear the costs that Binsfeld Engineering Inc. incurred as a result of notice.

DISCLAIMER OF IMPLIED WARRANTIES

This warranty set forth is exclusive and in lieu of all other warranties (whether expressed or implied), rights or conditions and Customer acknowledges that except for such limited warranty the Products are provided "as is". Binsfeld Engineering Inc. specifically disclaims, without limitation, all other warranties of any kind including any implied warranties of merchantability and fitness for a particular purpose or use. Handling of this Product is to be as stated in the Installation and Operating Instructions of this manual. In no event shall Binsfeld Engineering Inc. be liable for any special, indirect, incidental, or consequential damages or loss, whether in contract, tort, or otherwise, even if advised of the possibility of such damages. Some states and provinces do not allow limitation of implied warranties or the exclusion of incidental or consequential damages so the above limitations or exclusions may not apply to you. This warranty gives you specific legal rights and you may have other rights which vary from state to state or province to province.

For technical support, installation services, or request for repair please contact us:

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