6. Tune-Up Procedure

The Series 500e Digital Telemetry Product Line has been designed to provide a user friendly interface environment while minimizing the amount of operator interaction which must be taken to achieve proper measurement transmission functions. In general, the system design is oriented towards a "hands-off" philosophy while still supporting the necessary interfaces and capabilities to allow detailed status and control of the unit if required for specific applications.

The following paragraphs describe the procedures for verifying the basic operation of the system and altering system parameters. **Users should be aware that the Digital Telemetry System contains sensitive electronic components. Proper "Electrostatic Discharge" (ESD) handling procedures should be utilized for this equipment as with any other electronic apparatus.**

Getting Started

Each delivery typically includes a CD ROM disk which provides control software for the system. Directions on the CD ROM should be followed to properly install this software onto a personal computer (PC) operating with the Windows operating system. The installation procedure creates a program on the PC called "SRIPMD Control Software.exe" as well as associated data and support files to fully define the equipment. The program is also referred to as the Digital Control Program within the context of this document.

The software provides the interface from the PC to the Digital Telemetry System. This software supports standard Windows type operation, including menu based selection processes. Throughout the remaining portions of this document, a reference such as "select ***aaaa : bbbb***" indicates a Windows type menu selection process where ***aaaa*** is the text name which appears at the top of the active "Digital" program screen and ***bbbb*** is the submenu item displayed once the ***aaaa*** menu is selected.

The Digital Control Program has been developed utilizing standard Windows small fonts settings. Systems that deviate from these standard settings may produce undesirable display results. If the program exhibits these characteristics, locate the current display font settings by following the Windows path for "***Start : Settings : Control Panel : Display*** : ***Settings : Advanced***" and ensure small fonts is selected. Furthermore, the minimum Desktop Area setting should be 800 by 600 pixels.

All of the screens associated with the Digital Control Program support online help functions. This display of information can be activated by selecting "***Display Online Help Window***" within the menu of the main program screen. By moving the mouse over the field of interest, the help window will depict a description of any control or display field on the displays.

To get started with the control software, take the following steps:

1. Unpack and validate the contents of the shipping package.
2. Install the Digital Telemetry System Control Software on a PC as directed from the received CD ROM.

3. Connect the Digital Telemetry Receiver to one of the PCs serial ports or to an available USB port. For serial ports, the connection should be via a standard RS-232 serial port cable (9 pin D to 9 pin D). The cable should connect to the "REMOTE" connection on the receiver. For USB connection, the connection should be via a standard USB cable to the USB connector on the receiver.
4. Connect the AC to DC wall plug to the "VDC" input on the rear panel of the receiver and then to an AC wall socket (110VAC, 50 to 70 Hz).
5. Power up the receiver from its power on/off switch after all of the above connections have been established.
6. Verify during power up that all LEDs on the receiver momentarily illuminate, and then all except the power LED turn off.
7. Start the control program on the PC from the installed program directory.
8. Select "***General : Communications Port***" and select the appropriate COM or USB port selection.

At this point, the Digital Telemetry Transmitter can be activated. Paying careful attention to the pinouts shown in the preceding section of this document, appropriate primary power should be applied to the transmitter. Once this has been accomplished, the front panel "SYNC" indicator should illuminate within a maximum of 5 seconds. This indicates that the Digital Telemetry Receiver has successfully recognized the output signal from the transmitter at a sufficiently low error rate to achieve synchronization. In a close proximity set up such as this, the "ERROR" LED should never illuminate, thus indicating error free reception of the data.

If any of the above indications are not true, the user should validate proper connections at all points in the set-up. If all of the above has been verified and the basic Digital Telemetry System communications test still fails, SRI/PMD should be contacted for further assistance.

Setting the System Configuration

The following sections describe how to change, save, and restore all configurable parameters associated with the digital telemetry system.

Changing Configuration Settings

To modify any user configurable parameter of the telemetry system, take the following steps:

1. Establish normal connections between the Digital Telemetry Receiver and the PC.
2. For configuration changes that affect operation of the Digital Telemetry Transmitter, connect the transmitter to the receiver via the custom programming cable.
3. At the PC, select "***Table Control : Edit System Definition***".

Once activated, a new screen will appear showing the current receiver and model for the connected system. This information cannot be modified on this screen. The top part of the screen also depicts the currently assigned transmitter serial number. For users who own multiple transmitters, a special menu selection item invoked by "**Tools : Assign a Different Transmitter to this Receiver**" can be used to change this assignment.

Information contained at the bottom part of this screen, as well as sensor information which can be displayed by selecting the "Sensor Channels" tab at the top of the screen can be modified by any user. All fields within these screens are either menu based selection parameters, 2-way toggle switches, or numeric fields with adjacent increment/decrement controls. Standard Windows based edit mechanisms should be employed to alter the settings.

General System Parameters

System parameters are displayed with the "System" tab is selected at the top of the screen and includes the following:

- **Transmit Frequency** – menu selection of the frequency on which the wireless transmission will occur. See subsequent sections for recommendations on how to establish optimum transmit frequency selection.
- **Transmit Baud Rate** – menu selection of the over the air data rate for transmit operation. Slower data rates will yield better communications performance, but slower sensor sample update rates.
- **Output Power** – menu selection of the transmit power for the wireless link. High output power will yield better communications performance at the cost of increased transmitter power supply draw.
- **Receiver Optimization** – toggle switch selection to optimize the receiver performance for sensitivity (longer range communications), or linearity (sometimes better for high interference environments).
- **Operational Mode** – future selection to support burst mode of system operation.
- **Sampling Resolution** – selects whether sensor samples are digitized to 8, 12, or 16 bits of resolution. Using higher resolution will provide increased system measurement accuracy at the price of slower sample update rates.
- **Output of Samples in Error** – toggle switch selection which enables or disables the outputting of recovered sensor samples by the receiver during frames which have a detected checksum error.

Sensor Channel Parameters

Sensor channel parameters are displayed with the "Sensor Channel" tab that can be selected at the top of the screen. The top of this screen shows the number of active sensor channels. This is a menu based selection from 1 to 16, limited to the number of channels configured for the specific transmitter.

The remainder of the page includes the following for each active sensor channel. Subsequent paragraphs within this section provide more sensor type specific information on each field.

- **Sensor Type Assignment** – menu selection of the type of sensor which will be connected to the channel, including Analog Voltages, Generic Sensor Voltages, Strain Gages (1 to 4 active arms), Thermocouples, Accelerometers, and so forth.
- **Sensor Scale** - a numeric field which changes based on the type of sensor selected, but provides sensor specific information. For instance, on strain gages, this field provides what is known as the Gage Factor, which is typically 2.0 for common strain gages.
- **Sensor Offset** - a numeric field which changes based on the type of sensor selected.

- **Measurement Units** – menu selection which selects the measurement units over which the input sensor range will be defined. The supported values change with each sensor type. For example, thermistors can be Degrees C or F, while for strain gages are limited to microstrain.
- **Minimum** and **Maximum** – numerical fields which define the minimum and maximum input levels for the sensors in the predefined measurements units value. Measurement ranges do not need to be bi-polar or even balanced.
- **Output Volt Range** – a menu selection which selects the output voltage range for the receiver analog channels which will be utilized to represent the sensor output levels. Hence, for a –10 to +10 VDC output range selection, the minimum sensor measurement unit will be output as -10 VDC, while the maximum will be output as +10 VDC.
- **Data Filtering** – a menu selection to invoke optional digital filtering on the sensor samples, and configure for various levels of IIR or averaging.
- **Freq Response** – a toggle field which activates an additional screen for the specific sensor which shows the anticipated frequency response for the sensor measurement given current values of sample rates and data filtering settings.
- **Max Error % -** the maximum anticipated error in the input levels due to sensor calibration errors. This value must be set low enough to allow the system calibration logic to fully account for all sensor induced gain or offset errors.

Analog Input Voltages

As previously stated, Analog inputs are those voltages not requiring input amplification and conditioning through the transmit circuitry. They are typically in the range of 0 to 5 VDC, or ±2.5 VDC, but may be any voltages the user wishes to invoke recognizing that the only gain that will be applied is on the receive side. These channels are only available on multi-channel systems. When selected, the user input pins for these channels switch from the Sensor input connector to the Analog input connector.

There are two possible selections under the “Sensor Type Assignment” utilized to define Analog input voltages. These are “Anlg 2.5 VDC Differential” and “Anlg 0-5 VDC Single Ended”. The first selection is only available for Channels 1 and 2, while the second one is available for Channels 1 through 4.

The “Anlg 2.5 VDC Differential” measures up to ±2.5 VDC differentially between the two (2) assigned input pins. The “Anlg 0-5 VDC Single Ended” measures up to 5VDC on the single assigned input pin. The input levels for either type of analog voltage are referenced to the ground source of the Transmitter power supply.

The “Measurement Units” for these type channels are limited to mVDC and the minimum and maximum range values can be set anywhere from -2500 to 2500 or 0 to 5000 mVDC for differential/single ended respectively. Setting the minimum and maximum range values to other than these ranges simply causes the RX gain setting to be increased and does not affect the measurement resolution through the transmitter logic. Sensor Scale/Sensor Offset fields have no meaning for this sensor type.

Sensor Input Voltages

The "Generic Sensor Voltage" selection measures a differential voltage range between the Signal+ and Signal– on the Sensor Input connection pins. The measurement units may be specified as mVDC or micro-volts DC (uVDC). The minimum and maximum range values can be set anywhere from -45 to +45 for mVDC and –32768 to +32768 for uVDC although this may be further limited by the minimum gain settings of the Transmitter. Scale/Sensor Offset have no meaning for this sensor type.

Strain Gages

There are three (3) possible selections under the "Sensor Type Assignment" utilized to define strain gage sensor types. These are "Strain Gage – 1 Active Arm", "Strain Gage – 2 Active Arms", and "Strain Gage – 4 Active Arms". The proper selection is determined by the balanced bridge configuration utilized for the implementation of the strain gage. Reference appendices of this document for further information on balanced bridge configurations.

Regardless of the number of active arms, the "Sensor Scale" field for a strain gage defines what is known as the gage factor. Most strain gages incorporate a gage factor of 2.0, although custom sensors may vary from this setting. The range of gage factors supported by this field is 0.0 to 255.996 in approximately 0.004 count increments. The Sensor Offset field has no meaning for this sensor type.

The measurement units for a strain gage is limited to microstrain (uE). The minimum and maximum range values can be set anywhere from -32768 to +32768, although this may be further limited by the minimum and maximum gain settings of the Transmitter.

Thermocouples

There are two (2) possible selections under the "Sensor Type Assignment" utilized to define thermocouple sensor types. These are "Type J Thermocouple", and "Type K Thermocouple". The Sensor Scale/Sensor Offset fields have no meaning for these sensor types.

The measurement units for a thermocouple may be selected between "Degree C (°C)" and "Degree F (°F)" corresponding to Celsius and Fahrenheit respectively. The minimum and maximum range values can be set anywhere from -32768 to +32768, although this may be further limited by the minimum and maximum gain settings of the Transmitter as well as limitations of the specified thermocouple type.

Pressure Transducers

The "Sensor Type Assignment" can also be set to "Pressure Transducer". The measurement units for a pressure transducer may be selected between "Pounds per Square Inch (PSI)" or "kilograms per Square Centimeter (kg/cm^2)", "PSI (High Sensitivity)" or "Bar". The minimum and maximum range values can be set anywhere from -32768 to +32768, although this may be further limited by the minimum and maximum gain settings of the Transmitter as well as limitations of the specified transducer type.

The "Sensor Scale" field for a pressure transducer defines the output voltage range of the sensor based on the selected measurement units. If the measurement units field is selected to "Pounds per Square Inch (PSI)" the sensor scale specifies this voltage range in terms of mVDC/(1000 PSI). For "kilograms per Square Centimeter (kg/cm^2)", the range is defined as mVDC/(1000 kg/cm^2). For "PSI (High Sensitivity)", this range is defined in terms of mVDC/(10 PSI). For "Bar", the range is defined in terms of mVDC/(1 Bar). For example, a pressure transducer which outputs a 10mVDC level for 500 PSI which has been selected to "Pounds per Square Inch (PSI)" measurement units would have a "Sensor Scale" field of 20.0.

The range of "Sensor Scale" factors supported by this field is 0.0 to 255.996 in approximately 0.004 count increments. The Sensor Offset field has no meaning for this sensor type.

Accelerometers

The "Sensor Type Assignment" can be set to "Accelerometer". The measurement units for an accelerometer are "Gravitational Force (g)", "High Sensitivity (g)", or "m/s^2". The minimum and maximum range values can be set anywhere from -32768 to +32768, although this may be further limited by the minimum and maximum gain settings of the Transmitter as well as limitations of the specified accelerometer type.

The "Sensor Scale" field for an accelerometer defines the output voltage range of the sensor based on the selected measurement units. If the measurement units field is selected to "Gravitational Force (g)", the sensor scale should reflect the output mVDC/(100 g). If the measurement units field is selected to "High Sensitivity (g)", the sensor scale should reflect the output mVDC/(1 g). If the measurement units field is selected to "m/s^2", the sensor scale should reflect the output mVDC/(1 m/s^2). For example, an accelerometer which outputs a 25 mVDC level for 5 g would have a "Sensor Scale" field of 5.0 if the measurement units was selected to "High Sensitivity (g)".

The range of "Sensor Scale" factors supported by this field is 0.0 to 255.996 in approximately 0.004 count increments. The Sensor Offset field has no meaning for this sensor type.

Note that certain accelerometers (as well as other transducers) that output a DC offset or bias (e.g., 2.5 VDC or 1/2 Excitation Voltage) are considered Analog signals (see Section 4.2.1.2.1) due to input voltage levels in excess of 45 mV.

Thermistors

The "Sensor Type Assignment" can be selected to "Thermistor". The measurement units for a thermistor may be selected between "Degree C (°C)" and "Degree F (°F)" corresponding to Celsius and Fahrenheit respectively. The minimum and maximum range values can be set anywhere from -32768 to +32768, although this may be further limited by the minimum and maximum gain settings of the Transmitter as well as limitations of the thermistor circuit implementation.

Thermistors are typically incorporated into a balanced bridge configuration or a simpler voltage divider circuit. Reference appendices of this document for further information on thermistor sensor implementations.

The "Sensor Scale" field for a thermistor defines the output voltage range of the sensor in terms of mVDC/(°C) or mVDC/(°F) based on which measurement units have been selected for the channel. The range of "Sensor Scale" supported by this field is 0.0 to 255.996 in approximately 0.004 count increments.

The "Sensor Offset" field defines the °C or °F which are represented by a 0 differential input voltage been the Signal+ and Signal– inputs to the Transmitter. The range of the "Sensor Offset" field for a thermistor is –32768 to +32768.

For example, a thermistor circuit which produces a `+10 mVDC` output for 100°C input and a 0 mVDC output for a 50°C input would have a "Sensor Offset" value of 50 and a "Sensor Scale" field of 5.0.

Load Cells

The "Sensor Type Assignment" can be selected to "Load Cell". The measurement units for a Load Cell are "pound-force (lbf)", "High Sensitivity (lbf)", "Newton(N)", and "kilonewton (kN)". The minimum and maximum range values can be set anywhere from -32768 to +32768, although this may be further limited by the minimum and maximum gain settings of the Transmitter as well as limitations of the specified accelerometer type.

The "Sensor Scale" field for a Load Cell defines the output voltage range of the sensor based on the selected measurement units. If the measurement units field is selected to "pound-force (lbf)", the sensor scale should reflect the output mVDC/(100 lbf). If the measurement units field is selected to "High Sensitivity (lbf)", the sensor scale should reflect the output mVDC/(1 lbf). If the measurement units field is selected to "Newton (N)", the sensor scale should reflect the output mVDC/(1 N). And if the measurement units field is selected to "kilonewton (kN)", the sensor scale should reflect the output mVDC/(1kN). For example, a Load Cell which outputs a 5 mVDC level for 100lbf would have a "Sensor Scale" field of 5.0 if the measurement unit was selected to "pound-force (lbf)".

The range of "Sensor Scale" factors supported by this field is 0.0 to 255.996 in approximately 0.004 count increments. The Sensor Offset field has no meaning for this sensor type.

Generic Excited Sensor Input Voltages

The "Gen Excited Sensor Volt" selection measures a differential voltage range between the Signal+ and Signal– on the Sensor Input connection pins identically to the "Generic Sensor Voltage" previously discussed. However, for the "Gen Excited Sensor Volt" selection, calibration corrections are applied to the input measurement corresponding to drifts of the +5 VDC excitation voltage across temperature. This allows for of the use of generic sensors where the output voltage varys in proportion to the provided output excitation voltage. The measurement units may be specified as mVDC or micro-volts DC (uVDC). The minimum and maximum range values can be set anywhere from -45 to +45 for mVDC and –32768 to +32768 for uVDC although this may be further limited by the minimum gain settings of the Transmitter. Scale/Sensor Offset have no meaning for this sensor type.

Invoking Changed Settings

Once all changes have been accomplished, the user should select "**Tools : Update System Definition**". This will cause the program to download the changed tables to the receiver and, if necessary, the transmitter. The screen will then close and return to the main control screen.

If the user elects to not change any settings, the configuration window may be exited by clicking in the Close Window "X" box. If changes have been made but not downloaded to the system, the user will be queried as to whether it is acceptable to discard these changes.

Saving/Restoring Configuration Settings

The system allows the user to save configuration settings to the PC disk and restore them at later time. Thus, multiple sensor configurations can be utilized with the telemetry transmitter and easily invoked for future requirements.

To save the current configuration settings, the user should:

1. Establish normal connections between the Digital Telemetry Receiver and the PC.
2. From the main control screen, select "***Table Control : Files : Save System Definition to File***".

The program will query the user as to the desired file name to be utilized for saving the information, and then copy the appropriate tables from the receiver to the disk. The transmitter does not need to be connected to the receiver for this operation to occur.

To restore this configuration at a later point in time, the user should:

1. Establish normal connections between the Digital Telemetry Receiver and the PC.
2. Connect the transmitter to the receiver via the custom programming interface cable.
3. From the main control screen, select "***Table Control : Files : Restore System Definition from File***".

Transmitter EEPROM Updates

On rare occasions, a telemetry transmitter may stop operating due to corrupted executable or table space within its circuitry. This can occur due to unexpected primary power fluctuations during operation or other noise induced EMC type of situations. To account for these occurrences, the system supports forced loading of the transmitter EEPROM space from the receiver via the following procedure:

1. Establish normal connections between the Digital Telemetry Receiver and the PC.

2. Connect the transmitter to the receiver via the custom programming interface cable.
3. From the main control screen, select "***Table Control : Transmitter Control : Update TX Configuration Tables***".
4. If the problem persists after the above action, the user should select "***Table Control : Transmitter Control : Update TX Executable Code***". This action will take the user to a file selection process for a file ending with the file acronym of ".encexe" for encrypted executable. Usually users will only have one such file for the system and should simply select that file.

Determining Wireless Link Communications Settings

It is imperative that the settings for the Wireless Link operation be optimized for each end-user application. To assist in this process, the Digital Telemetry Control Program provides easy-to-use functions that monitor and/or alter the characteristics of the link. The following paragraphs detail the operation of this portion of the software.

Scanning the Available Communications Channels

In certain cases, select RF frequencies (or channels) may not be as robust as others based on interfering signals or susceptibility to other external elements. By default, each Digital Telemetry System is delivered from the factory set to a link frequency utilized for factory test. Based on experimentation or data gathered from other sources, the operator may elect to change the RF frequency to other available channels.

To assist in this process, the control program provides an RF spectrum analysis function. This process can be utilized to scan all available communications frequencies and detect potential sources of interference.

To activate the RF spectrum analysis process, take the following steps:

1. Connect the antenna input that will be utilized during actual operation of the system to the "ANT" port on the Digital Telemetry Receiver. **Do not power on any digital telemetry Transmitter during this process. Also, insure potential sources of interfering signals which will not be present during actual operation are not active.**

2. With an active receiver, select "***Tools : Scan Input Frequency Spectrum***" from the control program.

Once activated, the available communications channels (or frequencies) will be scanned and plotted on a graph. The user may leave this function running as long as desired and the available channels will be repetitively scanned from the lowest to the highest. The graph will depict both individual measurement samples for the frequency as well as the cumulative averages as multiple samples are accumulated.

Typically, the optimum frequency selection is the channel that exhibits the lowest background noise level. Once a complete scan of the input spectrum has been completed, the program indicates this channel by placing a red line at that frequency setting. Some interpretation by the operator may be required if channels of significant interfering signal levels surround the selected lowest background noise channel.

When sufficient samples have been collected, the user may close the frequency scan window by clicking in the Close Window "X" box. Procedures discussed below can then be utilized to change the frequency.

Monitoring Online Communications Performance

The Digital Telemetry Control Software supports full real-time monitoring of the communications link performance. This feature allows operators to accurately assess signal levels and resulting communications error rates in order to determine if the wireless link is providing acceptable measurement transfer functions. Although ideally, the wireless link will provide error free operation, in reality, any communications link is susceptible to periodic errors.

To activate online communications performance analysis, take the following steps:

1. Establish normal operation of the Digital Telemetry Receiver and Transmitter and connections to the PC.
2. From the control program, select "***Windows : Receiver Status***".

Once activated, a new screen will appear showing text, numeric and graphical data.

The text information depicts miscellaneous operational information, such as what receiver is connected to the PC and what transmitter from which it is configured to receive data. A receiver in-sync indicator is also provided to indicate whether data is actively being received from the transmitter.

The numeric fields will indicate the number of digital telemetry data frames received, and how many of these frames had errors detected during the reception process. Numeric values are provided for the last sample period (approximately 1 second) as well as cumulative figures since the start of the monitoring process. At any time during window operation, pressing the space bar will cause the cumulative figures to reset to 0.

The graphs depict the measured input signal level expressed in approximate dBm levels and the current reported transmitter operational temperature in either °C or °F.

A data frame is 32 sensor sample periods long for 8 bit sampling or 16 sensor sample periods for 12 bit or 16 bit sampling operation. Any frames in error result in the loss of 32 or 16 consecutive sensor samples. Although ideally no frames in error will ever be detected, some installations can accept a certain error rate as long as sufficient data is being recovered to support accurate analysis functions.

Pertaining to signal levels, typically any reading above -90 dBm is considered a high quality signal, although reception can typically be to as low as -100 dBm input level. These figures are not absolute in that the reported signal level reflects signal AND noise, where noise can be any external interfering signals or simply background thermal noise. As such, reported signal levels as high as 0 dBm may still yield no usable data if signals or noise other than the desired wireless link telemetry signal is driving the input level.

The user may close the receiver status window by clicking in the Close Window "X" box.

System Shut-Down

In order to shutdown the Digital Telemetry Receiver, simply place the two position power switch into the "OFF" position. The front panel power LED should immediately turn off indicating shut down completion. Exercising prudent care of electronic equipment, a power-on sequence from the front panel should not be attempted for five (5) seconds after a system shutdown.

Calibration Files

A unique Calibration, or "CAL", file is created during factory testing and installed with the supplied Monitor & Control application. In general the CAL files correct for nonlinearities resulting from the wide operating temperature range of SRI PMD systems. Each transmitter has a unique CAL file that can be found in the directory into which the M&C application was installed. These files are about 10kb in size and can be identified by the transmitter serial number included in the filename. For example, a calibration file named "TX00305.cal" will correspond with an ST-540 Transmitter serial number 00305.

When using the M&C application a warning will be displayed if the CAL file corresponding to the connected or configured transmitter is not found. To correct this condition verify that the CAL file corresponding to the attached transmitter is located in the application directory, by default "C:\Program Files\SRI_PMD Series 500e Control".

Occasionally a new or updated CAL file is required due to factory repair. These are generally supplied either on a CD with the returned transmitter or via email directly to the user. To install the new CAL file, simply copy it into the SRI PMD application directory. It is not necessary to delete CAL files for other transmitters, however if the transmitter serial number has not changed, for example due to a repair, any old CAL files will need to be replaced.

For convenience the most current CAL files are maintained on the SRI web site and are accessible through your SRI PMD Sales or Technical contact.