SRI/PMD SERIES 300 DIGITAL TELEMETRY SYSTEMS

A BRIEF INTRODUCTION

With over 25 years of experience in the field of industrial and commercial telemetry systems, SRI/PMD stands as an industry leader in providing an efficient means of transporting measurement data from one location to another. The use of ***Wireless Link®*** technology allows these systems to be utilized to obtain information from hard to get to locations, or from places where it is simply inconvenient and/or insecure to run hard wired interconnects.

With the advent of our newest **Series 300 Digital Telemetry Systems**, we have released the power of Digital Signal Processing into what was previously a purely “analog” marketplace. The use of all digital signal processing not only furnishes a more robust and versatile means of gathering, transmitting, processing, and outputting highly accurate measurement data, but it also provides this capability at a cost affordable for even budget conscientious consumers.

In developing the **Series 300** systems, SRI/PMD has taken technology developed for highly critical space telemetry applications and applied it to designs suited for a wide variety of applications here on earth. Whether your particular need is gathering real-time torque, pressure, or temperature data from large industrial equipment, or is more simply oriented toward sending a basic analog signal across a parking lot, we believe you will find the right solution to your requirements at a price far below what has previously been offered.

LIMITED WARRANTY

SRI/PMD warrants that the receiver and accessory equipment’s of its manufacture as identified within this document shall, at the time of shipment to the original purchaser, be free from defects in material and workmanship and conform to the specifications at time of purchase (incorporated herein) for a period of one (1) year from the date of original shipment. Encapsulated transmitters and batteries shall be covered under these same warranty terms for a period of 90 days from the date of original shipment.

This warranty applies only to equipment installed, operated, and maintained in accordance with SRI/PMD recommendations, and such warranty does not apply where SRI/PMD determines that any claimed defect has been caused by installation or repair, alteration, accident, or excessive deterioration due to environmental contamination.

SRI/PMD’s obligation under this warranty is limited to repairing, or replacing, exclusive of cost of installation and labor charges, any part that SRI/PMD determines to be defective, provided that such part is received at SRI’s principal office, freight prepaid. All equipment's must receive prior approval for return to SRI for warranty repair, and must be sent prepaid. If they are returned collect, they will not be accepted.

This warranty is subject to any existing conditions of supply which may directly affect SRI/PMD’s ability to obtain materials or manufacture replacement parts.

SRI/PMD makes no warranty that the equipment shall be merchantable or fit for any particular purpose; nor does SRI make other warranties, express or implied, by operation of law or otherwise, except such as are expressly set forth herein. SRI/PMD shall not be liable to buyer, or to any third persons for any incidental, consequential, special or contingent damages for breach of any warranty.

IMPORTANT NOTICE

Most Series 300 products are designed as component devices that require external components to function. The products are intended to allow for full Part 15 compliance; however, they are not approved by the FCC or any other agency worldwide. The purchaser understands that approvals may be required prior to the sale or operation of this device, and agrees to utilize the component in keeping with all laws governing its operation in the country of operation.

Some specific Series 300 models have been fully certified for FCC part 15 unlicensed operation. Contact SRI/PMD for further information for these units.

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RECORD OF CHANGES

REVISION	DATE	TITLE OR BRIEF DESCRIPTION
N/A	March 1998	Draft Market Research Release Breadboard Version 0.00
-	August 1998	ST-320/SR-340 Beta Test Release FW Versions 1.00
A	February 1999	Production Upgrade Release – ST-360/SR-380 FW Versions 2.00
B	May 1999	Firmware Upgrade and Pinout Corrections FW Versions 2.01
C	June 1999	Upgrade to All Firmware FW Versions 2.05
D	November 1999	Production Release for Software 3.00 Including Extended SW Capabilities

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SECTION 1 INTRODUCTION

The Series 300 Digital Telemetry Equipment represents the next generation of SRI/PMD's Wireless Link® products. Due to a unique mixture of high technology RF, analog and digital circuitry, a highly versatile measurement capability is provided in a variety of compact packages fully supporting applications requiring low power consumption and high reliability while still being offered at an affordable price.

Supporting anywhere from 1 to 16 sensor channel inputs, all Series 300 products provide both highly accurate analog and high-speed digital measurement outputs.

FIGURE 1-1 SRI/PMD WIRELESS LINK® PRODUCT

1.1 Scope

This manual describes the SRI/PMD Series 300 Digital Telemetry Product Line, including both transmit and receive processing units. The manual includes specifications, design description, installation, and operation instructions along with routine maintenance requirements for these products.

1.2 Product Overview

SRI/PMD (formerly known as Physical Measurement Devices or simply PMD) has been designing and producing ruggedized wireless telemetry systems for in excess of 25 years. An old slogan in the instrumentation community states that "Measurement is the beginning of knowledge". Previous versions of PMD's **Wireless Link®** product have assisted customers in gaining insight into operational parameters which were, at best, difficult to acquire with any amount of reliability or longevity, if not totally unobtainable.

With the advent of the new, fully digital, SRI/PMD **Wireless Link®** products, potential users are being offered an improved solution that not only provides better technology for existing customers and applications, but also significantly expands the possible uses of these designs. By offering:

• lower cost, • improved measurement accuracy,
• true "hands-off" operation, and
• more robust and user selectable wireless communications methods,

these products offer a cost effective and timely solution to a multitude of here-to-fore "hard-wired" applications.

In a nutshell, telemetry can encompass the entire process by which a measurement value is obtained, possibly quantified, qualified, or processed in other ways, and then transmitted via some mechanism to the "end user" for final processing or response actions. The "end user" in this case may be a human for manual interpretation and analysis or, more often, a machine for automated processing functions. The phrase "Digital Telemetry" simply specifies that the methodology utilized to obtain, process, and transmit the measurement data incorporates digital techniques, a highly efficient and more reliable means of handling data processing and transmission.

Typical measurements which telemetry can provide access to include:

temperature, speed, direction, motion,
location, distance, displacement, strain,
torque, energy, power, pressure,
humidity, density, ...

Furthermore, many applications require access to multiple and/or a variety of these measurements at the same time to allow for meaningful interpretation of the data. One of the significant benefits of digital telemetry is that it can be easily and readily customized to the end user requirements, allowing various measurement (or sensor) inputs to be sampled nearly simultaneously, cross correlated if need be, and presented as parallel analog or digital outputs to the end user. For certain implementations, the sampling and correlation algorithms can be configured in real-time, providing for adaptive measurement and response requirements.

1.3 Product Description

The series 300 products are available in a variety of design options. The ST-320/SR-340 versions of products provide digital telemetry capability operating in the versatile 902 to 928 MHz ISM frequency band while the ST-360/SR-380 versions operate in the classic 88 to 108 MHz FM frequency bands. Based on the exact end-user requirements, an optimized product choice can be found to provide extremely robust wireless communications, even in indoor environments where building structures may obstruct a direct line-of-site transmission or in contaminated environments such as inside engine compartments.

The following diagram presents a simplified overview of the latest generation SRI/PMD Wireless Link® system.

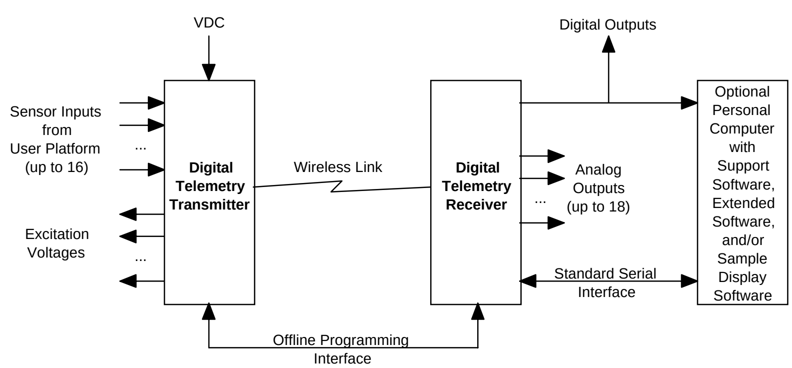


FIGURE 1-2 SYSTEM OVERVIEW

As shown, the system consists of the following major elements:

1) The Digital Telemetry Transmitter is a miniaturized and ruggedized radio frequency (RF) transmitter providing the interface circuitry to select and sample up to 16 sensor inputs and transmit the detected readings in digital format over the Wireless Link®.

2) The Digital Telemetry Receiver provides the logic to recover the transmitted data, detect and account for errors which might have been introduced via the transmission path, and output error free and digitally compensated samples of the sensor data in both analog and digital output formats. The receive system also supports an optional interface to a standard personal computer for status, control, and analysis functions.

3) The optional Personal Computer can be utilized to execute additional software packages available from SRI/PMD. These optional support software packages include:

    a) Standard support software for monitoring general system health, communications performance, and sensor gain/offset calibration functions.
    b) Extended support software providing for editing of sensor definitions including type, sampling frequency, filtering, measurement ranges, and so forth.
    c) Display capture/display software for storing measurement data to the PC disk or displaying the data in graphical/scope type formats.

The transmitter portion of the series is available in a variety of shapes and sizes depending on the exact end user requirements. This includes miniaturized, single channel versions, or versatile, multi-channel, mixed sensor type packages. The design also readily supports custom packaging for unique end user applications.

The receiver is offered as both a stand-alone desk or bench top enclosure configuration or as a 19” rack mountable chassis.

The communications link for the telemetry transmission is supported in either the popular 900 MHz ISM band or the classic 90 MHz FM band. Depending upon the exact application, an ideal solution is available to provide a robust and reliable communications path.

1.4 Model Numbers

Each version of the Series 300 products assigned a model number. Transmitters for this series are always designated as an ST-3xx where xx defines the exact model type. Similarly, receivers are designated as an SR-3xx. The following table provides an overview of each of the available standard models for this series.

TABLE 1-1 SERIES 300 MODEL DESCRIPTIONS

Model Number	Description
ST-321	A 900 MHz Wireless Link Transmitter housed in a 1.75” diameter, < 1” tall disk shaped epoxy compound mold. Intended for severe environment applications. Available in 1 to 16 sensor input channel versions.
ST-325	A 900 MHz Wireless Link Transmitter housed in a 1.3” x 3.8” by 5.6” plastic casing. Intended for non-shock, industrial type applications. Available in 1 to 8 sensor input channel versions.
ST-326	Same product and versions as the ST-321 but fully tested and certified for FCC part 15 unlicensed operation.
ST-361	A 90 MHz Wireless Link Transmitter housed in a 1.75” diameter, <1” tall disk shaped epoxy compound mold. Intended for severe environment applications. Available in 1 to 16 sensor input channel versions.
ST-363	A 90 MHz Wireless Link Transmitter housed in a 1.2” x 3.6” x 0.65” moon shaped epoxy compound mold. Intended for automotive piston mount applications. Available in 1 to 16 sensor input channel versions.
ST-364	A 90 MHz Wireless Link Transmitter housed as 2 individual 0.75” x 0.6” x 0.4” packages. Intended for miniaturized, severe environment applications. Limited to fixed frequency and single sensor input channel version.
ST-366	A 90 MHz Wireless Link Transmitter housed in a 1.3” x 3.8” by 5.6” plastic casing. Intended for non-shock, industrial type applications. Available in 1 to 8 sensor input channel versions.
SR-341	Benchtop receiver compatible with any model ST-32x transmitter model. Available in 1 to 18 output channel versions.
SR-342	19” rack mount receiver compatible with any model ST-32x transmitter model. Available in 1 to 18 output channel versions.
SR-381	Benchtop receiver compatible with any model ST-36x transmitter model. Available in 1 to 18 output channel versions.
SR-382	19” rack mount receiver compatible with any model ST-36x transmitter model. Available in 1 to 18 output channel versions.

1.5 Technical Specifications

A summary of the technical specifications and characteristics of the referenced telemetry equipment is presented in the paragraphs that follow.

1.5.1 Transmitter Specifications

The specifications indicated in the following table apply to the Digital Telemetry Transmitter.

TABLE 1-2 TRANSMITTER SPECIFICATIONS

PARAMETER	SPECIFICATION
OUTPUT FREQUENCIES	8 Channels from 902 to 928 MHz (Series ST-320) 88 to 108 MHz in 200 KHz Channels (Series ST-360)
MODULATION FORMATS	Minimum Shift Keyed (MSK) -or- Standard Frequency Shift Keyed (FSK)
NUMBER OF SENSOR INPUTS	Up to 16
INPUT SENSOR LEVEL RANGE	Programmable within the range of 0.625 uVDC to 5 VDC.
SENSOR EXCITATION	Optional sensor excitation voltage driven during sensor sampling period. Excitation voltage is selectable from 0.625 to 5 VDC.
TYPICAL SENSOR TYPES	Absolute voltage measurements, such as Type J/K Thermocouples (up to 1000° measurement range), Displacement Sensors, Generic Analog Voltages, ... Relative voltage measurements, such as Strain Bridges (120, 350 ohm, or 700 ohm, 4 arms, up to +/- 2000 uStrain measurement range), Pressure Transducers, ... Custom
MEASUREMENT RESOLUTION	8 bits
SAMPLING RATE	Up to 3 K samples per second (Series ST-320) Up to 27 K samples per second (Series ST-360)
SENSOR MULTIPLEXING OPTIONS	High speed sequential, or optional dwell/step operation Custom
INPUT POWER	+7 Vdc to +18 Vdc Custom
POWER CONSUMPTION	< 20 mA (excluding sensor loads on excitation outputs)
OPERATING TEMPERATURE	Standard - 0 to +70° C Industrial - 0 to +85° C Automotive – 0 to +125° C (ST-360 only)
ACCELERATION	5,000 G Rotational Typical

1.5.2 Receiver Specifications

The specifications indicated in the following table apply to the Digital Telemetry Receiver.

TABLE 1-3 RECEIVER SPECIFICATIONS

PARAMETER	SPECIFICATION
RECEIVE/DEMODULATION CAPABILITIES	Compatible with transmitter waveform
NUMBER OF ANALOG OUTPUTS	Up to 18
SENSOR TO ANALOG CHANNEL ASSIGNMENTS	Selectable
ANALOG OUTPUT RANGES	2 Channels fixed at 0 to 5 Vdc Additional channels selectable from 0 to 5 Vdc, +/- 5 Vdc, 0 to 10 Vdc or +/- 10 Vdc
ANALOG OUTPUT RESOLUTION	2 Channels fixed at 8 bits Additional channels 12 bits
DIGITAL OUTPUT	16 bits of parallel digital samples 6 bit channel indicator Data Strobe Sample Error Indicator
ERROR DETECTION	Data checksum capable of detecting error rates of up to 1 in 100
SENSOR DATA COMPENSATION OPTIONS	Fixed gain/offset compensation TX operational temp dependent compensation Custom
DATA PROCESSING OPTIONS	None Infinite Impulse Response Averaging (K = ½, ¼, or 1/8) Custom
INPUT POWER	+12 Vdc (AC/DC Wall Plug Standard)
POWER CONSUMPTION	< 12 Watt typical
PACKAGING OPTIONS	9″ x 7″ x 3″ Bench Top Enclosure 1U 19″ Rack Mount Custom
OPERATING TEMPERATURE	Standard - 0 to +70° C Industrial - 0 to +85° C

1.5.3 Optional Accessory Equipment and Software

In addition to the standard Digital Telemetry Equipment listed above, the following optional support equipment is also supported.

TABLE 1-4 OPTIONAL SUPPORT EQUIPMENT

DESCRIPTION
Antenna’s for the Digital Telemetry Receiver. Typically available in ¼ or ½ wavelength versions for either direct mounting onto the enclosure, as a stand-alone bench/desktop standing unit, or as a magnet mounted unit.
Batteries for operating the Digital Telemetry Transmitter, available in rechargeable or disposable versions.
Inductively coupled power generator modules for shaft or piston mount applications. Generates the 7 Vdc power required by the Digital Telemetry Transmitter for these applications.

Software for a standard Personal Computer. May include the following packages:

Standard Software Package (included with all systems):

Basic system support functions including query telemetry system, monitor self-test results, print a detailed system configuration report, ...

Link analysis functions for the Digital Telemetry System. Provides a means to analyze all potential communications links for the system to select the optimum channel. Also provides error rate analysis capabilities to determine expected link performance characteristics as well as online monitoring features of an active systems transmission characteristics.

Calibration control functions for the Digital Telemetry System. Provides a means for a user to alter the compensation and calibration data associated with a transmitter based on actual sensor or other types of measurement errors.

Extended Software Package:

Configuration control functions for the Digital Telemetry System. Allows a user to reassign sensor and analog channels, reconfigure a transmitter for alternate sensor types, alter the transmission bandwidth allocation of the Wireless Link, set filtering controls for individual channels, and so forth.

Display Software Package:

Sample capture/display functions for the Digital Telemetry System. Provides real time capture of data samples from the Digital Telemetry Receiver and displays the samples in a scope like format on a PC while also supporting the means to save the samples to disk for later viewing or analysis by other programs.

SECTION 2   DIGITAL TELEMETRY SYSTEM DESCRIPTION

Series 300 Wireless Link Digital Telemetry Systems are accomplished with an optimum mix of analog and digital circuitry in order to provide a low-cost, flexible system capable of handling a wide variety of telemetry requirements. Utilization of state-of-the-art design technology combined with a latest generation micro-controller allows the design to meet requirements of a high performance, high reliability communications link for transferring measurement data while still maintaining a highly cost-effective price.

2.1   Transmitter Details

Figure 2-1 presents a more detailed overview of a Digital Telemetry Transmitter.

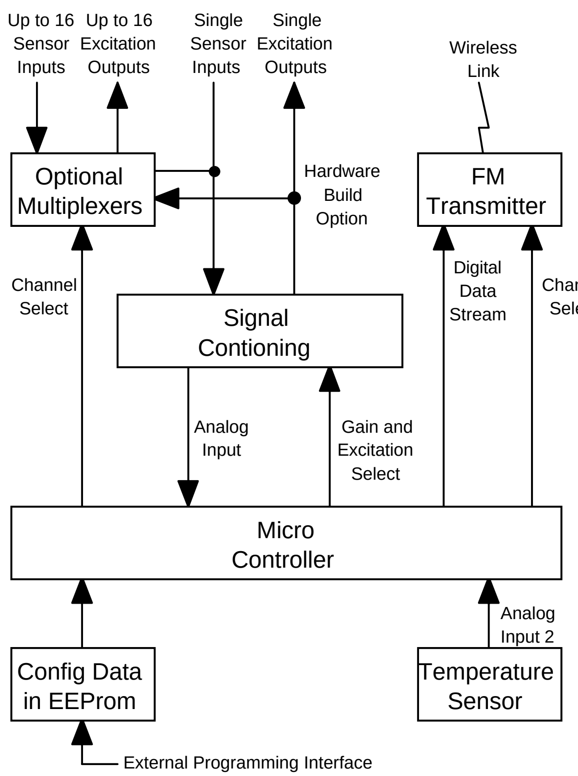


FIGURE 2-1 TRANSMITTER BLOCK DIAGRAM

At the heart of the transmitter design is a high-speed micro-controller with embedded analog to digital conversion capabilities. For most series 300 products, execution processing of the micro-controller is determined via configuration data stored within electronically erasable programmable read-only-memory (EEProm). The configuration tables contained within this memory dictates operational characteristics such as the number of input sensor channels, the type of each input, the desired sampling sequence to be utilized for data transmission purposes, output RF frequency selection, and so forth. Since the EEProm memory space can be reprogrammed via the external programming interface to the Digital Telemetry Receiver, all significant operational characteristics of the Transmitter can be readily modified, even for fielded units. Certain single channel, miniaturized series 300 models (e.g., ST-364) do not support the transmitter EEProm memory space and are built with fixed gain and sampling characteristics.

For transmitters limited to a single input sensor channel, onboard circuitry is available to process the input measurement data through signal conditioning circuitry. When the number of input sensor channels exceeds one (1), an optional multiplexer card is provided. This card includes a sixteen (16) to one (1) multiplexer to support connecting multiple sensor channels to the single input of the main board. All sensor-input logic also includes associated excitation voltage output circuitry that may be utilized to drive sensors requiring an input voltage, such as balanced bridges.

Operation of the signal conditioning logic is controlled via the micro-controller to establish appropriate gain settings. This powerful feature of the design allows the same circuitry to be reprogrammed to support a wide variety of potential input sensor types. Furthermore, because the sensor type information is also included in the EEProm configuration tables, these settings can be changed for various user requirements.

Data transmission across the wireless link is accomplished with dual data channels known as the primary and the background channels respectively. The primary data channel is allocated in excess of 90% of the transmit bandwidth and typically includes the input sensor data measurement information. The background channel is relatively low rate and contains information required for receive side frame synchronization and error detection.

Another key feature to the design is that the background channel can also be utilized to transmit data pertaining to the current transmitter operational temperature. For applications which require a high degree of data accuracy, this information may be utilized to support real-time temperature based compensation of sensor data samples through the receive chain.

2.2 Receiver Details

Figure 2-2 presents a more detailed overview of the Series 300 Digital Telemetry Receiver's.

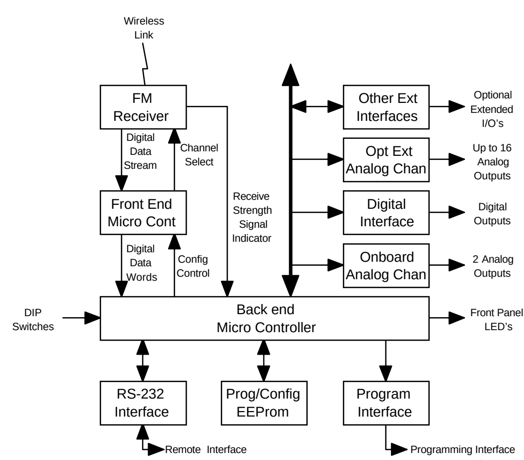


FIGURE 2-2 RECEIVER BLOCK DIAGRAM

The receiver incorporates two (2) high-speed micro-controllers to provide for full real time processing of incoming measurement samples. The front-end micro-controller interfaces with the Wireless Link receiver to recover bit, byte, word, and frame synchronization with the incoming data stream. The process of achieving this level of synchronization is known as the acquisition process and is in-turn reflected on the front panel “SYNC” indicator. Once frame synchronization has been achieved, the “SYNC” indicator is illuminated.

After proper acquisition, the front-end micro-controller begins sending received data sensor samples to the back-end processor. In parallel with this process, the front-end performs error detection functions via embedded checksums within the incoming data. All received data samples during a frame detected to have an error within it are flagged as error samples.

The back-end micro-controller accepts the data samples and provides configurable data processing on the information prior to outputting the data to analog and digital output channels. Data processing, in this case, may include standard gain adjustment multiplication, offset addition, transmitter temperature dependent data compensation, as well as alternate data averaging and or filtering functions.

Program execution of the back-end micro-controller is directed via code and configuration tables stored in EEProm memory space resident on the card. The contents of this memory space can be loaded via the remote control RS-232 interface to a standard personal computer. This feature allows fielded Digital Telemetry Receiver systems to be upgraded to new releases of executable firmware, or modified to support new transmitters or alter the processing characteristics of existing transmitters.

The minimum configuration of a Digital Telemetry Receiver supports two (2) analog output channels. These onboard channels, designated as Analog Channel 1 and 2, are limited to eight (8) bits of data resolution and support an output voltage range of 0 to 5 Vdc. An optional extension card may be added to support up to 16 additional analog output channels (designated as Analog Channels 3 through 18). These channels support 12 bits of data resolution and can be programmed to cover an entire output voltage range of -10 to +10 Vdc. Furthermore, the optional extension card contains highly accurate voltage reference circuitry to guarantee the accuracy of the +/- 10 Vdc range to better than +/- 0.2 percent.

2.3 System Data Processing Overview

The Series 300 products can be configured to process input sensor measurements anywhere within the range of 0 to 5 VDC. Typically, instrumentation sensors do not utilize this entire measurement range. For instance, a single active arm, 350 ohm strain gage with 5 V excitation will only produce a +/- 1.25 millivolt DC (mVDC) signal for strain levels of +/- 500 micro-strain (uE). Obviously, these signal levels are not overly useful to most end-user processing equipment.

To create a useful signal, the product line provides programmable gain, offset, and data filtering functions on the input sensor signals. The following sections describe this processing in more detail.

2.3.1 Gain and Offset Processing

The Digital Telemetry process applies various stages of gain to the input signal such that the configured measurement input levels of the sensor end up corresponding to a specified output analog voltage range (e.g., -10 to +10 VDC). For the strain gage example, this implies a gain of x 8000 in order to translate -1.25 mVDC to -10 VDC and +1.25 mVDC to +10 VDC.

A gain of this magnitude is never 100% accurate. Furthermore, small errors introduced by the exact mechanical installation of the sensor, ground differentials, cabling losses, or transmitter sensor input to digital measurement processing circuitry end up causing additional errors. These errors are reflected as incorrect gain or variations in offset (i.e., where a 0 reading does not correspond to a 0 output).

In order to compensate for these factors, the Digital Telemetry System provides programmable gain and offset control that are invoked at various stages within the system. The following figure provides a very simplistic overview of this process.

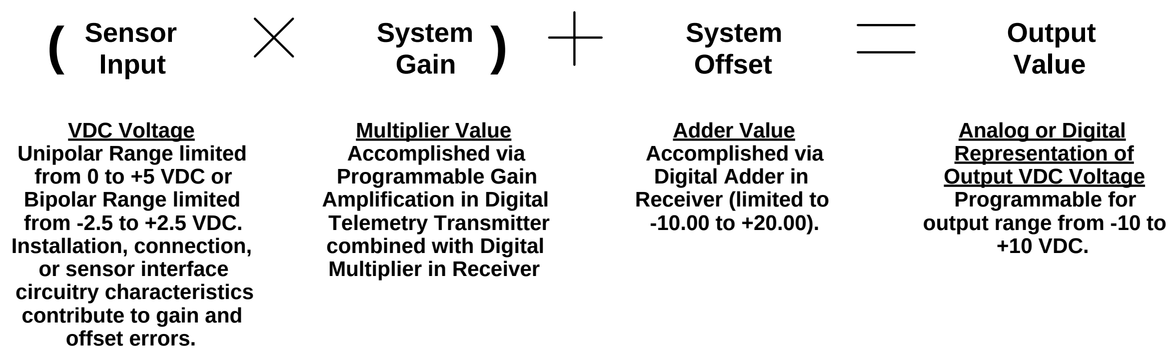


FIGURE 2-3 DATA PROCESSING OVERVIEW

The system gain and offset values are set to not only translate the input measurement signal range to the desired analog output voltage range, but can also be utilized to account for the gain and offset errors discussed above.

The following figure presents a more detailed view of the entire signal processing of the Digital Telemetry System.

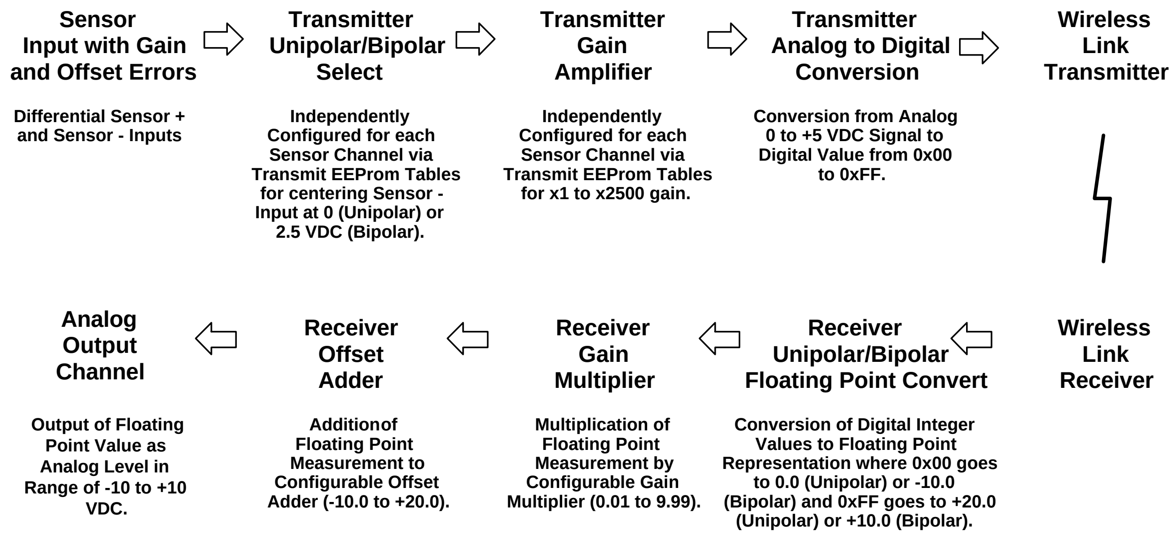


FIGURE 2-4 DATA PROCESSING DETAILS

As shown, the processing varies based on whether the measurement input is a unipolar (i.e., positive only) or bipolar (i.e., positive and negative) signal. For unipolar signals, the 0 reading is eventually output as a -10 VDC analog output (for channels configured for -10 to +10 output voltage range) and all gains are applied in a positive direction from that point. For bipolar signals, the 0 reading is eventually output as a true 0 VDC analog output and gains work in both directions from that center point up to the maximum output values of -10 VDC for negative values and +10 VDC for positive values.

The processing through the receive side can also be made dependent upon the transmitter operational temperature at the time of the measurement. The transmitter logic monitors it’s own temperature and periodically reports this value across the wireless link. For sensor data which varies with temperature (e.g., thermocouples), this feature is utilized to dynamically modify the receiver gain multiplier and offset adder to compensate for these variations.

The table on the following page provides four (4) examples of the data processing stages and the affects on the measurement values.

TABLE 2-1 SAMPLE DATA PROCESSING STAGES

Processing Stage	Case 1 Generic Unipolar 0 to 5 VDC Analog Input	Case 2 Generic Bipolar +/- 25 mVDC Analog Input	Case 3 Unipolar Type J Thermocple for 32 to 500° F Measurements	Case 4 Bipolar 350 Ohm Strain Gage for +/- 500 uE Measurements with +5V Excitation
Sensor Input	**0 VDC to 5 VDC**	**-25 mVDC to +25 mVDC**	**0 VDC (32° F) to +28.5 mVDC (500° F)**	**-1.25 mVDC (-500 uE) to +1.25 mVDC (+500 uE)**
Transmit Unipolar Bipolar Select	**0 VDC to 5 VDC**	**2.475 VDC (-25 Input) to 2.525 VDC (+25 Input)**	**0 VDC (32° F) to +28.5 mVDC (500° F)**	**2.49875 VDC (-500 uE) to 2.50125 (+500 uE)**
Transmit Gain Amplifier	**= x1 0 VDC to 5 VDC**	**=x50 1.25 VDC (-25 Input) to 3.75 VDC (+25 Input)**	**= x100 0 VDC (32° F) to 2.85 VDC (500° F)**	**= x1000 1.25 VDC (-500 uE) to 3.75 VDC (+500 uE)**
Transmit Analog to Digital Convert	**0x00 (0 Input) to 0xFF (5 Input)**	**0x40 (-25 Input) to 0xc0 (+25 Input)**	**0x00 (32° F) to 0x91 (500° F)**	**0x40 (-500 uE) to 0xC0 (+500 uE)**
Receive Floating Point Convert	**0.0 (0 Input) to 20.0 (5 Input)**	**-5.0 (-25 Input) to +5.0 (+25 Input)**	**0.0 (32° F) to 11.375 (500° F)**	**-5.0 (-500 uE) to +5.0 (+500 uE)**
Receive Gain Multiplier	**= x1.0 0.0 (0 Input) to 20.0 (5 Input)**	**= x2.0 -10.0 (-25 Input) to +10.0 (+25 Input)**	**= x1.76 0.0 (32° F) to 20.0 (500° F)**	**= x2.0 -10.0 (-500 uE) to +10.0 (+500 uE)**
Receive Offset Adder	**= 0.0 0.0 (0 Input) to 20.0 (5 Input)**	**= +10.0 0.0 (-25 Input) to +20.0 (+25 Input)**	**= 0.0 0.0 (32° F) to 20.0 (500° F)**	**= +10.0 0.0 (-500 uE) to +20.0 (+500 uE)**
Analog Output Channel	**-10 VDC (0 Input) to +10 VDC (5 Input)**	**-10 VDC (-25 Input) to +10 VDC (+25 Input)**	**-10 VDC (32° F) to +10 VDC (500° F)**	**-10 VDC (-500 uE) to +10 VDC (+500 uE)**

2.3.2 Data Filtering

In addition to offset and gain processing, the Series 300 Product Line also supports digital data filtering of the measurement samples. Filtering may be utilized to eliminate high frequency noise from the sensor inputs which may be present due to power supply noise or other equipment operating near the telemetry system.

Standard filters supported by the system all utilize the following basic formula:

$$OUT(n) = (K \times IN(n)) + ((1-K) \times OUT(n-1))$$

In this formula, OUT(n) implies the output value to the analog channel for time period “n”, while IN(n) implies the new measurement sample for the analog channel during time period “n”. K is a simple constant that may be programmed to be equal to ½, ¼, or 1/8, 1/16, 1/64, 1/256.

This type is filter is known as an “Infinite Impulse Response” (or IIR) filter, since any given input sample affects all future outputs. On a custom basis, a more sophisticated “Finite Impulse Response” (or FIR) filter, or higher order IIR filters are available.

2.4 Digital Telemetry Control Software

Each Digital Telemetry System is typically delivered with Control Software compatible with running on a standard Personal Computer (PC) operating under the Windows 95 or 98 operating system. This software provides a number of critical functions for the system, including the following:

Initial Set-up and Introduction
- Assistance in getting started with the Digital Telemetry System

Communications Analysis Functions
- On-line monitoring of communications performance
- Analysis of all possible communications frequencies
- Altering of the wireless link frequency and/or baud rate

System Calibration
- Modifications to system gain and offset settings

Table Control Functions
- List functions of currently defined Digital Telemetry Systems
- Download functions to update or restore EEProm memory space

In addition, an extended version of the above software may be purchased which provides the user full configuration control over transmitters and receivers, including altering sensor definitions, channel assignments, and so forth.

Later sections of this document provide a detailed description of the operation of this control software. The remaining portion of this section describes some of the system elements that are referenced by this software and defines the meaning of each.

2.4.1 Serial Numbers and Versions

Each Series 300 Product is assigned a unique 4-digit serial number to identify the receiver or transmitter and its assigned hardware configuration. In addition to the serial number, a single digit version number is also utilized to delineate software configurations for the hardware element. For instance, a transmitter built for a single sensor channel input may be configured via software to accept a 350-ohm strain gage input (version 0) and then be altered to support a type J thermocouple input (version 1).

The initial version number for any factory delivered item is 0. As such, a new receiver assigned serial number 0123 will be displayed by the control software as “Receiver S/N 0123 V0”. Similar designations are utilized for the transmitters. Hence, in the above transmitter example, the unit would be displayed with two (2) designations as “Transmitter S/N 0123 V0” and “Transmitter S/N 0123 V1”.

Any given receiver can support up to 16 transmitters or versions of transmitters. Beyond this, the user must delete unused versions of transmitters or purchase additional receiver units.

2.4.2 File Structure

Corresponding to the Digital Telemetry System are disk files on the installed program directory referred to as a Receiver Definition Tables (RDT’s) and Transmitter Definition Tables (TDT’s). These are further identified by the unit serial number. Hence, for the examples given in the previous section, a disk file would exist in the program directory called “RDT01230.cfg” along with disk files called “TDT01230.cfg” and “TDT01231.cfg”.

The above referenced files are mirror images of what is stored in the receiver EEProm in order to fully define the Digital Telemetry System. They include information such as the unit serial number, number of configured and/or active sensor and analog channels, transmit frequency and baud rate, and so forth. The control software provides an easy means of downloading these file images to the receiver in case EEProm space is corrupted for some reason. It should be noted that if the control software has access to both the disk files and to EEProm space in the receiver via the serial port connection, it will always utilize the EEProm tables as opposed to those stored on disk.

Along with the above information, the TDTxxxxx.cfg files also contain calibration information for the corresponding transmitter. If the system calibration data is altered via the control program, new values are stored both in the EEProm memory of the receiver and on the disk file. Users are encouraged to back-up these disk files to an alternate media source if changes are made. In addition, if an installation of the Digital Telemetry Control Software is performed on another PC, the installed files will contain calibration data from the factory. Users may wish to copy updated files between PC’s to insure the latest data is maintained.

Along with the above files, transmitters definitions provided by SRI/PMD also include files named “TDTxxxxx.fac”. These files contain the definition and calibration data for the transmitter as it was delivered from the factory. The Digital Control Software discussed in later sections of this document use these files to support “revert” functions to factory settings. Users may also utilize these files to restore factory defaults by manually copying the “.fac” files to the “.cfg” version of the same file.

Finally, anytime a system calibration is performed utilizing the Digital Control Software, a file named "TDTxxxxx.cal" is created if it doesn't already exist on the PC. The ".cal" file contains detailed information on the calibration process which was performed and is utilized to print out a report on this information. If the ".cal" file already exists from a previous calibration, data on the new calibration is added onto the end of the file.

2.5 Configurable System Parameters and Processing

As indicated above, the power of the system architecture is contained within the number of features that are programmable and/or selectable. This not only allows the same product to be utilized for a wide variety of applications but also supports modifications to existing equipment for new applications or data processing schemes.

The following table indicates some of the programmable features of the system and provides standard, optional, or custom selections that may be specified for each parameter.

TABLE 2-2 SELECTABLE CONFIGURATION AND PROCESSING OPTIONS

PARAMETER	PROGRAMMABLE OPTIONS OR SETTINGS
Transmission Data Rate	**6.25 to 32.6 Kbps (ST-320)** **62.5 to 250 Kbps (ST-360)**
Number of Sensor Inputs	**Standard : 1, 2, 4, 8, or 16** **Custom : 3, 5 - 7, 9 - 15, 17+**
Sensor Types	**<u>Standard</u>** **Type J/K Thermocouple** **Strain Gages (1, 2 or 4 active arms)** **Pressure Transducers** **Accelerometer** **Thermistors** **Generic 0 to 5 VDC** **Generic Analog Voltage** **<u>Custom</u>** **User specified**
Measurement Resolution	**8 bit**
Sensor Sampling Algorithms	**<u>Maximum Rate Sequential Sampling</u>** **Each sensor channel is sampled sequentially and issued at the maximum rate supported by the transmission path.** **<u>Dwell/Step Sequential Sampling</u>** **The sensor channels are selected sequentially but at each selection setting the system dwells for a configurable number of output sample periods (from 2 to 65535 samples (e.g. > 28 seconds)) before the next sensor channel is selected.** **<u>Custom</u>** **Mixed or alternate sampling rates, sensor channel ordering schemes, or measurement resolution settings.**

Sensor to Analog Channel Assignment	**<u>Standard</u>** **Varies based on number of input sensor channels versus available analog channels. Assignments are sequential in nature with lower number sensor inputs given priority to analog assignments.** **<u>Optional</u>** **Any sensor input channel to any analog output channel.**
Analog Output Voltage Range	**<u>Standard</u>** **Fixed at 0 to +5 VDC for analog channels 1 and 2. Selectable from -10 to +10 VDC, +5 to -5 VDC, 0 to +10 VDC, or 0 to +5 VDC for analog channels 3 through 18.** **<u>Optional</u>** **Any voltage range within maximum supported ranges.**
Sample Processing Logic	**<u>Standard</u>** **None, standard gain/offset compensation, sample compensation based on TX operating temperature, and/or IIR filtering (K = ½, ¼, or 1/8, 1/16, 1/64, 1/256).** **<u>Custom</u>** **FIR filtering, custom filtering, multi-channel math functions, other.**

The ease with which these parameters can be modified not only allows SRI/PMD to provide a Digital Telemetry System ideally suited for an initial customers requirements, but also supports modifying the systems definition and characteristics to meet new and different sets of needs, even for previously fielded equipment’s.

SECTION 3 RECEIVING, INSPECTION AND INSTALLATION

3.1 Unloading and Unpacking

NOTE

If shipping carton is damaged upon receipt, request carrier's agent be present during unpacking and inspection of the system.

Upon receipt of the equipment, inspect the shipping container for damage. If the container or the cushioning material is found damaged, they should be kept until the contents of the shipment have been verified for completeness and the equipment has been inspected for mechanical and electrical defects. If the contents are incomplete or if there is a mechanical or electrical defect, please notify:

SRI/PMD
751 North Drive
Melbourne, Florida 32934

3.2 Receiving Documentation

Each Digital Telemetry System is shipped with a copy of this manual and a packing slip. The packing slip should be carefully checked against the contents of the shipping container.

3.3 Installation and Connection Requirements

Users should be aware that the Digital Telemetry Receiver and the Digital Telemetry Transmitter contain sensitive electronic components. Proper "Electrostatic Discharge" (ESD) handling procedures should be utilized for this equipment as with any other electronic apparatus.

The transmitter may be delivered in a variety of standard or custom molds based on the actual end application of the telemetry system. The available connections and pin locations will vary based on the packaging style and purchased configuration.

The receiver is typically delivered either as a stand-alone bench or desktop enclosure or as a standard 19 inch rack mountable chassis. Due to its light-weight, slides are not provided as part of the standard product for the rack mount version. Holes on the front panel ears may be used to secure the chassis directly into the rack.

Prior to establishing external connections from the transmitter to any sensor equipment or the receiver to any user processing equipment, it is recommended that both units be validated in a stand-alone mode as discussed in section 4.0 of this document.

3.4 Transmitter Signal Definitions and Characteristics

This section describes the standard connector interfaces of the Digital Telemetry Transmitter, including the definition and associated requirements of all signals. As previously indicated, pin locations and assignments will vary based upon the exact model of Transmitter that is purchased. Appendix A of this document provides model dependent pin assignments and interconnect information.

The following table details the signal definitions common to all models of the Digital Telemetry Transmitters.

TABLE 3-1 TRANSMITTER SIGNAL DEFINITIONS, AND CHARACTERISTICS

SIGNAL	DESCRIPTION
	PROGRAMMING INTERFACE SIGNALS
PROG_VCC	ALTERNATE 5 VDC POWER SUPPLIED TO TRANSMITTER WHEN IT IS BEING REPROGRAMMED FROM THE DIGITAL TELEMETRY RECEIVER.
PROG_GND	GROUND SIGNAL UTILIZED WITH THE PROGRAMMING CABLE.
PROG_RESET*	MICRO-CONTROLLER RESET LINE UTILIZED WITH THE PROGRAMMING CABLE.
PROG_DATA	DATA LINE UTILIZED TO REPROGRAM EEPROM SPACE OF THE TRANSMITTER.
PROG_CLOCK	CLOCK LINE UTILIZED TO REPROGRAM EEPROM SPACE OF THE TRANSMITTER.
	COMMON SIGNALS
VCC	PRIMARY VDC POWER FOR THE TRANSMITTER DURING NORMAL OPERATION. THE SOURCE FOR THIS POWER MAY PROVIDE ANYWHERE FROM +7 TO +18 VDC AS THE PRIMARY POWER LEVEL. EXCESSIVELY NOISY GROUND CHARACTERISTICS ON THIS INPUT LINE MAY BE REFLECTED IN POOR MEASUREMENT ACCURACY RESULTS. THE PRIMARY POWER SOURCE MUST BE ABLE TO SUPPORT A MINIMUM 20 mA LOAD ON THIS INPUT LINE.
GND	PRIMARY GROUND FOR THE TRANSMITTER. EXCESSIVELY NOISY GROUND CHARACTERISTICS ON THIS INPUT LINE MAY BE REFLECTED IN POOR MEASUREMENT ACCURACY RESULTS.
EXC+COM	EXCITATION OUTPUT + VOLTAGE COMMON. THIS OUTPUT WILL ALWAYS BE AT THE POSITIVE EXCITATION VOLTAGE (+5, +2.5, +1.25, OR +0.625 VDC) AND SHOULD BE CONNECTED TO ANY SENSOR CHANNEL REQUIRING EXCITATION VOLTAGES. THE OUTPUT SHOULD BE COMMON TO ALL SENSORS REQUIRING THIS CAPABILITY. EACH SENSOR ON THIS LINE MAY EXHIBIT A MINIMUM LOAD IMPEDANCE OF 150 OHMS. NOTE - ADDITIONAL CURRENT DRAW ON THE PRIMARY VCC DUE TO SENSOR UTILIZATION OF THIS OUTPUT IS NOT INCLUDED IN THE < 20 mA MAXIMUM CURRENT SPECIFICATION.
EXC-COM	EXCITATION OUTPUT - VOLTAGE COMMON. THIS OUTPUT WILL ALWAYS BE AT APPROXIMATELY - VDC AND SHOULD BE CONNECTED TO SINGLE CHANNEL SENSOR CONFIGURATIONS REQUIRING EXCITATION VOLTAGES. FOR MULTIPLE CHANNEL CONFIGURATION, THE MULTIPLEXED EXC- SIGNALS DISCUSSED BELOW SHOULD BE UTILIZED. A SENSOR ON THIS LINE MAY EXHIBIT A MINIMUM LOAD IMPEDANCE OF 150 OHMS. NOTE - ADDITIONAL CURRENT DRAW ON THE PRIMARY VCC DUE TO SENSOR UTILIZATION OF THIS OUTPUT IS NOT INCLUDED IN THE < 20 mA MAXIMUM CURRENT SPECIFICATION. FOR OPTIMUM MEASUREMENT ACCURACY, THE EXC-COM ***SHOULD NOT*** BE TIED TO THE PRIMARY GROUND SIGNAL DISCUSSED ABOVE VIA ANY PATH.
	SENSOR INTERFACE SIGNALS
SIG+x	POSITIVE SENSOR SIGNAL INPUT FOR CHANNEL x WHERE x IS VALID FOR THE POPULATED NUMBER OF AVAILABLE SENSOR CHANNELS (1 THROUGH 16). THIS INPUT SHOULD PROVIDE THE POSITIVE SIDE OF THE MEASUREMENT VALUE FOR DIFFERENTIAL SIGNALS OR THE PRIMARY MEASUREMENT VALUE FOR NON-DIFFERENTIAL SIGNALS. ABSOLUTE MAXIMUM VOLTAGE RATING ON THIS INPUT IS 0 TO 5.5 VDC. VALID SIGNAL MEASUREMENT RANGE DEPENDS ON SELECTED CONFIGURATION AND MAY BE VARIED VIA CONFIGURATION TABLES
SIG-x	NEGATIVE SENSOR SIGNAL INPUT FOR CHANNEL x WHERE x IS VALID FOR THE POPULATED NUMBER OF AVAILABLE SENSOR CHANNELS (1 THROUGH 16). THIS INPUT SHOULD PROVIDE THE NEGATIVE SIDE OF THE MEASUREMENT VALUE FOR DIFFERENTIAL SIGNALS OR GROUND FOR NON-DIFFERENTIAL SIGNALS. OTHER SIGNAL CHARACTERISTICS AND RESTRICTIONS FOR THIS

	INPUT ARE IDENTICAL TO SIG+x.
EXC-x	NEGATIVE EXCITATION OUTPUT VOLTAGE FOR CHANNEL x WHERE x IS VALID FOR THE POPULATED NUMBER OF AVAILABLE SENSOR CHANNELS (1 THROUGH 16). THIS OUTPUT WILL BE EQUAL TO EXC+COM WHEN THE CHANNEL IS NOT BEING SAMPLED OR EQUAL TO EXC-COM DURING AN ACTIVE MEASUREMENT PERIOD. **THIS OUTPUT SHOULD ONLY BE CONNECTED TO THE CORRESPONDING SENSOR PROVIDING THE SIG+x AND SIG-x INPUTS.**

3.5 Receiver Indicators, Controls, and Connector Interfaces

This section describes the status, control, and connector interfaces of the Digital Telemetry Receiver, including the types of connectors used and the definition of the signals associated with each. In general, these connectors are identical for all models of the Series 300 Receivers, although the connector locations may vary.

3.5.1 Antenna Input

The Antenna input is a bulkhead mount type TNC jack located on the rear panel and labeled “ANTENNA”. The Digital Telemetry Receiver provides the female side of this connector and as such the user interface cable must provide the male side.

Characteristics of this input signal are as indicated in the following table.

TABLE 3-2 RF INPUT CHARACTERISTICS

INPUT CENTER FREQUENCY	913.5 MHz (SR-340 Model) 98 MHz (SR-380 Model)
INPUT BANDWIDTH	+/- 15 MHz RF BANDWIDTH
MAXIMUM INPUT SIGNAL LEVEL	+ 10 dBm CONTINUOUS WITHOUT DAMAGE (NOTE: PROPER OPERATION UP TO - 10 dBm ONLY)
INPUT IMPEDANCE	50 OHMS
VSWR	2.0:1 MAXIMUM

3.5.2 VDC Input

The power input to the receiver is a standard DC power jack located on the rear panel and labeled “VDC”. This input is compatible with the AC to DC wall plug unit supplied with the receiver.

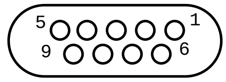
Characteristics of the input power signal are as indicated in the following table.

TABLE 3-3 INPUT POWER CHARACTERISTICS

INPUT VOLTAGE	10 TO 14 VDC (+/- 5%)
CAPACITY	2 Amp (MINIMUM)

3.5.3 Remote Status/Control

The remote status/control input/output is a serial interface compatible with the EIA Standard RS-232 (MIL-STD-188, Section 114, Unbalanced). The connector for this interface is a 9 position D-type connector as depicted in Figure 3-1 and is labeled "REMOTE". The Digital Telemetry Receiver provides the female side of this connector and as such the user interface cable must provide the male side.



REAR PANEL VIEW

FIGURE 3-1 REMOTE STATUS/CONTROL INTERFACE CONNECTOR

The Digital Telemetry Receiver operates as standard Data Terminal Equipment (DTE) utilizing the signal definitions defined in the following table.

TABLE 3-4 REMOTE STATUS/CONTROL PIN ASSIGNMENTS

PIN	SIGNAL	INPUT/OUTPUT
1	GND - GROUND	N/A
2	TD - TRANSMIT DATA	OUTPUT
3	RD - RECEIVE DATA	INPUT
5	GND - GROUND	N/A
7	CTS - CLEAR TO SEND	INPUT
8	RTS - REQUEST TO SEND	OUTPUT
9	GND - GROUND	N/A

The standard product does not support hardware handshaking via the CTS and RTS signals. Custom versions incorporating this protocol can be supplied if required.

3.5.4 Digital Telemetry Transmitter Programming Interface

The receiver provides a programming interface connection for the Digital Telemetry Transmitter. This connection is a 5 pin DIN style connector located on the rear panel and labeled “PROGRAM”.

The pin assignments for this connection are defined in the following table.

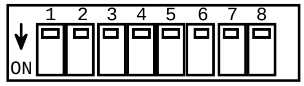
TABLE 3-5 PROGRAMMING INTERFACE PIN ASSIGNMENTS

PIN	SIGNAL
1	DATA
2	GND - GROUND
3	CLOCK
4	VCC - +5 VDC
5	RESET*

This interface should only be utilized with the programming cable supplied with the Digital Telemetry System. Section 4 of this manual describes the proper utilization of this interface via the programming cable.

3.5.5 DIP Switch Control

The receiver provides an access hole on the rear panel to an internal side actuated DIP switch. The DIP switch itself is depicted in the following figure.



REAR PANEL VIEW

FIGURE 3-2 DIP SWITCH CONTROL INTERFACE

The switch assignments for this interface are defined in the following table.

TABLE 3-6 DIP SWITCH ASSIGNMENTS

SWITCH	SIGNAL
1	SPARE
2	SPARE
3	SPARE
4	SPARE
5	TX SELECT 3
6	TX SELECT 2
7	TX SELECT 1
8	TX SELECT 0

TX SELECT 3 through 0 act as a 4 bit control input where TX SELECT 3 is the most significant bit (MSB) and TX SELECT 0 is the least significant bit (LSB). Each Digital Telemetry Receiver may be configured to interface with up to 16 unique transmitters. Each transmitter is assigned an index number ranging from 0 to 15 within the receiver when it’s configuration is loaded into the unit. By altering the switch selections of TX SELECT 3 through 0, the operator may select which of the 16 transmitters from which the unit is expecting to receive data. Invalid switch settings to selections that have not been assigned to a transmitter will cause a fault condition until a valid selection is realized. The following table details the various switch selections of the receiver.

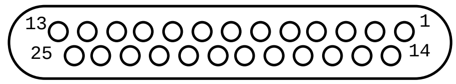
TABLE 3-7 DIP SWITCH SELECTIONS

Switch 1	**Switch 2**	**Switch 3**	**Switch 4**	**Switch 5**	**Switch 6**	**Switch 7**	**Switch 8**	**TX Selection**
OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	TX Index 0
OFF	OFF	OFF	OFF	OFF	OFF	OFF	ON	TX Index 1
OFF	OFF	OFF	OFF	OFF	OFF	ON	OFF	TX Index 2
OFF	OFF	OFF	OFF	OFF	OFF	ON	ON	TX Index 3
OFF	OFF	OFF	OFF	OFF	ON	OFF	OFF	TX Index 4
OFF	OFF	OFF	OFF	OFF	ON	OFF	ON	TX Index 5
OFF	OFF	OFF	OFF	OFF	ON	ON	OFF	TX Index 6
OFF	OFF	OFF	OFF	OFF	ON	ON	ON	TX Index 7
OFF	OFF	OFF	OFF	ON	OFF	OFF	OFF	TX Index 8
OFF	OFF	OFF	OFF	ON	OFF	OFF	ON	TX Index 9
OFF	OFF	OFF	OFF	ON	OFF	ON	OFF	TX Index 10
OFF	OFF	OFF	OFF	ON	OFF	ON	ON	TX Index 11
OFF	OFF	OFF	OFF	ON	ON	OFF	OFF	TX Index 12
OFF	OFF	OFF	OFF	ON	ON	OFF	ON	TX Index 13
OFF	OFF	OFF	OFF	ON	ON	ON	OFF	TX Index 14
OFF	OFF	OFF	OFF	ON	ON	ON	ON	TX Index 15

The assignment of internal transmitter indexes to actual transmitter serial numbers may be viewed via support software discussed in section 4 of this manual.

3.5.6 Digital Output

The digital output is a 25 pin D-type connector as depicted in Figure 3-2. It is located on the rear panel and labeled “DIGITAL”. The receiver provides the female side of this connector and as such the user interface cable must provide the male side.



REAR PANEL VIEW

FIGURE 3-3 DIGITAL OUTPUT CONNECTOR

Characteristics of these output TTL signals are as identified in the following table.

TABLE 3-8 DIGITAL OUTPUT SIGNAL CHARACTERISTICS

OUTPUT VOLTAGE FOR A “1”	2.0 V (MINIMUM)
OUTPUT VOLTAGE FOR A “0”	0.55 V (MAXIMUM)
OUTPUT SINK CAPABILTY	64 mA
OUTPUT SOURCE CAPABILITY	32 mA

The connector provides 6 bits of analog channel address information as well as 16 bits of digital representation of the analog data value. In addition, a data strobe line is provided to serve as a clock latch for any data change on the interface and an error sample line indicates when data has not been updated due to a detected receive data error. The following pin assignments apply to this connector.

TABLE 3-9 DIGITAL OUTPUT PIN ASSIGNMENTS

PIN	SIGNAL	PIN	SIGNAL	PIN	SIGNAL
1	GROUND	9	ERROR SAMPLE	17	DATA 7
2	STROBE	10	DATA 0	18	DATA 8
3	ADDRESS 0	11	DATA 1	19	DATA 9
4	ADDRESS 1	12	DATA 2	20	DATA 10
5	ADDRESS 2	13	DATA 3	21	DATA 11
6	ADDRESS 3	14	DATA 4	22	DATA 12
7	ADDRESS 4	15	DATA 5	23	DATA 13
8	ADDRESS 5	16	DATA 6	24	DATA 14
				25	DATA 15

Each time a sensor sample is recovered by the receiver, the processed and compensated data is written to this digital interface as well as being reflected on the corresponding analog channel. The address bits are interpreted as a 6 bit value where ADDRESS 0 is the least significant bit and ADDRESS 5 is the most significant bit. The three (3) lower order bits reflect a Digital to Analog Converter (DAC) address (0 through 7) while the upper three (3) bits reflect an DAC group number (0, 1, or 2). The resulting value indicates which receiver analog channel is being updated as shown in the following table.

TABLE 3-10 ANALOG CHANNEL TO DIGITAL ADDRESS CORRELATION

ANALOG CHAN	DAC GROUP #	DAC CHANNEL #	OUTPUT ADDRESS
1	0	0	0x00
2	0	1	0x01
3	1	0	0x08
4	1	1	0x09
5	1	2	0x0a
6	1	3	0x0b
7	1	4	0x0c
8	1	5	0x0d
9	1	6	0x0e
10	1	7	0x0f
11	2	0	0x10
12	2	1	0x11
13	2	2	0x12
14	2	3	0x13
15	2	4	0x14
16	2	5	0x15
17	2	6	0x16
18	2	7	0x17

In this table, the 0x indicates a hexadecimal representation of the 6 ADDRESS bits.

When the receiver receives a sensor sample, the correct address lines are set on the interface as well as the data lines. For analog channels 0 and 1, the maximum 8 bit sample is contained on DATA 8 (LSB) through DATA 15 (MSB) while DATA 0 through DATA 7 are undefined. For analog channels 2 through 18, the maximum 12 bit samples are driven on DATA 4 (LSB) through DATA 15 (MSB) while DATA 0 through DATA 3 are undefined.

During the initial write of the DATA and ADDRESS lines, the STROBE line is held low. After sufficient setup time, STROBE is driven high and then returns low again. The minimum timing of this interface is reflected in figure 3-3.

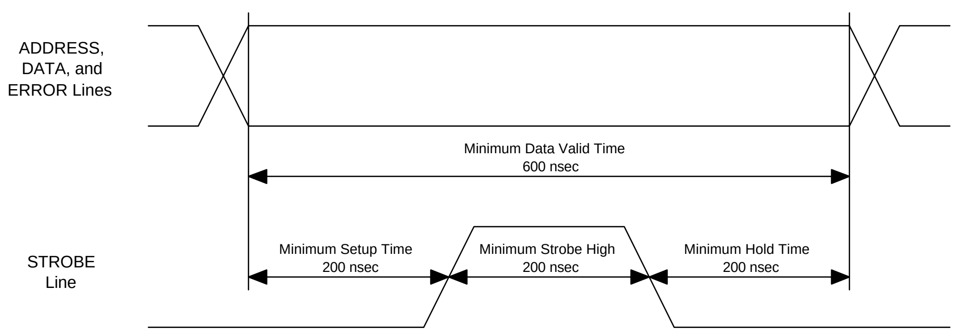


FIGURE 3-4 DIGITAL OUTPUT TIMING DIAGRAM

If the received sensor input sample is detected to have no error’s present in it, the ERROR line is driven low simultaneously with the DATA and ADDRESS lines being set. If error’s are detected in the received sample, the ERROR line will be driven high and the DATA lines will be driven to reflect the last valid data sample for that analog channel. Other than start-up periods when no valid samples are available, the Digital Telemetry Receiver will not output invalid data samples onto the digital output port.

It is important to note that the digital values reflected on this interface contain the compensated and processed data content. Processing in this case includes gain and offset adjustments required to satisfy the selected output voltage range of the analog channel. Analog channels 2 through 18 have a full-scale range of -10 VDC (represented by a digital value of 0x0000) to +10 Vdc (represented by 0xFFFF). If the customer specified receiver configuration has limited the output voltage range to 0 to 5 VDC, output digital samples will be limited to the range of 0x8000 to 0xBFFF. These values equate to 0 VDC (representing the minimum input sensor level) and 5 VDC (representing the maximum input sensor level) respectively.

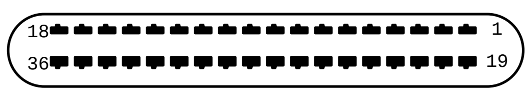
The following table supplies some typical output voltage range selections and the corresponding minimum and maximum digital sample output values for each setting.

TABLE 3-11 DIGITAL OUTPUT RANGES

MIN ANALOG VDC	MAX ANALOG VDC	MIN DIGITAL VAL	MAX DIGITAL VAL
-10	+10	0x0000	0xFFFF
-5	+5	0x4000	0xBFFF
-2.5	+2.5	0x6000	0x9FFF
0	+5	0x8000	0xBFFF
0	+10	0x8000	0xFFFF

3.5.7 Analog Outputs

The optional analog outputs for channels 3 through 18 are provided via a 36 pin comb style connector (AMP part number 552742-1) located on the rear panel and labeled “ANALOG”. This connector is not present for receiver systems limited to 1 or 2 analog channels. As depicted in figure 3-4, the receiver provides the female side of this connector and as such the user interface cable must provide the male side (for example, SPC Technology Type 57-30360).



REAR PANEL VIEW

FIGURE 3-5 ANALOG OUTPUT CONNECTOR

Characteristics of these output analog signal are as shown in the following table:

TABLE 3-12 ANALOG OUTPUT SIGNAL CHARACTERISTICS

FREQUENCY RESPONSE	DC TO 10 KHz
VOLTAGE RANGE	-10 to +10 VDC (USER SELECTABLE)
LOAD IMPEDANCE	1 KOHM MINIMUM

The pin assignments for this connector are as follows:

TABLE 3-13 ANALOG OUTPUT PIN ASSIGNMENTS

PIN	SIGNAL	PIN	SIGNAL	PIN	SIGNAL
1	ANALOG 3	7	ANALOG 9	13	ANALOG 15
2	ANALOG 4	8	ANALOG 10	14	ANALOG 16
3	ANALOG 5	9	ANALOG 11	15	ANALOG 17
4	ANALOG 6	10	ANALOG 12	16	ANALOG 18
5	ANALOG 7	11	ANALOG 13	17	+VREF (+10 VDC)
6	ANALOG 8	12	ANALOG 14	18	-VREF (-10 VDC)
				19-36	GROUND

3.5.8 Channel 1 Analog

The analog channel 1 output is located on the front panel of the receiver and is labeled “CHANNEL 1”. The connection for this interface is a standard BNC. The receiver provides the female side of this connector and as such the user interface cable must provide the male side.

Characteristics of this output analog signal are as shown in the following table:

TABLE 3-14 ANALOG CHANNEL 1/2 SIGNAL CHARACTERISTICS

FREQUENCY RESPONSE	DC TO 10 KHz
VOLTAGE RANGE	0 to +5 VDC
OUTPUT IMPEDANCE	1 KOHM MINIMUM

3.5.9 Channel 2 Analog

The analog channel 2 output is located on the front panel of the receiver and is labeled “CHANNEL 2”. The connection for this interface is a standard BNC. The receiver provides the female side of this connector and as such the user interface cable must provide the male side. Characteristics of this output analog signal are identical to those shown for analog channel 1.

3.5.10 Power On/Off Switch

The Power On/Off switch is a standard toggle switch located on the front panel of the receiver with positions labeled for “ON” and “OFF” settings. Before making any connections for the receiver, the user should insure this switch is in an “OFF” position. Reference section 4 of this document for further information on power on sequencing.

3.5.11 Front Panel LED Indicators

There are four (4) front panel LED indicators on each receiver system. The labels, colors, and meaning of each of these indicators is presented in the following table.

TABLE 3-15 LED INDICATOR DESCRIPTIONS

LED LABEL	“ON” COLOR	DESCRIPTION
POWER	GREEN	When illuminated, indicates that the front panel power switch is in an “ON” position and that valid 12 VDC power is available at the rear panel “VDC” connection.
SYNC	GREEN	When off, indicates the system has not acquired frame synchronization with the currently selected transmitter. When illuminated, indicates that the system is properly receiving data from the selected transmitter sufficient to achieve frame synchronization.
ERROR	YELLOW	Illuminated when an error is detected in the data contained within a receive frame. Turned off when no errors are detected in a frame. The error LED is also illuminated briefly during receive acquisition processing if a valid signal is not detected within ~8 seconds. This is utilized to inform the operator that the system is still searching for a valid telemetry signal.
FAULT	RED	Illuminated when an internal fault condition is detected within the receiver. A fault condition exists under the following possible circumstances and will be reflected as indicated: Self-Test Failure – ALL LED’s Illuminated Invalid EEProm Table Content – or - Invalid Transmitter Selected via Dip Switch – Fault LED Flashes 2 Times/Second Internal RX Communications Failure – Fault LED Flashes once per second Failure to Program Transmitter on Requested Change – Fault LED Flashes every 2 Seconds

Note that all front panel LED’s also illuminate when the receiver is actively being programmed via the remote serial port interface. This is not a failure condition.

SECTION 4 BASIC OPERATION

The Series 300 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 a limited number of 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.***

4.1 Getting Started

Each Series 300 delivery typically includes a set of 3.5 inch diskettes or a CD ROM disk which includes control software for the system. Directions on the diskette or CD ROM label should be followed to properly install this software onto a personal computer (PC) operating with the Windows 95 or 98 operating system. The installation procedure creates a program on the PC called "Digital.exe" as well as associated data and support files to fully define the purchased equipment. The "Digital.exe" program is also referred to as the Digital Control Program within the context of this document

"Digital.exe" 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***" and insure 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 "***Controls : Display Online Help Window***" or "***Controls : Display Online Help Window***". 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.

A set-up and introduction feature of the program provides a step by step tutorial on how to connect the equipment, as well as validating various operational parameters of the system as it is powered on and exercised through a variety of processes.

To activate the set-up and introduction process, 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 on the label of the received diskettes or CD ROM.
3. Connect the Digital Telemetry Receiver to one of the PC's serial ports 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 rear panel of the receiver. Note that the factory delivered software assumes the use of the PC's COM1: port, but this may be altered during the set-up and introduction process.
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 (110 VAC, 50 to 70 Hz). ***DO NOT POWER ON THE RECEIVER AT THIS TIME.***
5. Start the "Digital.exe" program on the PC from the installed program directory.
6. Select "***General : Set-up and Initialization***".

The following diagram shows the screen that will be displayed on the PC as well as the selection action to start the set-up and initialization process.

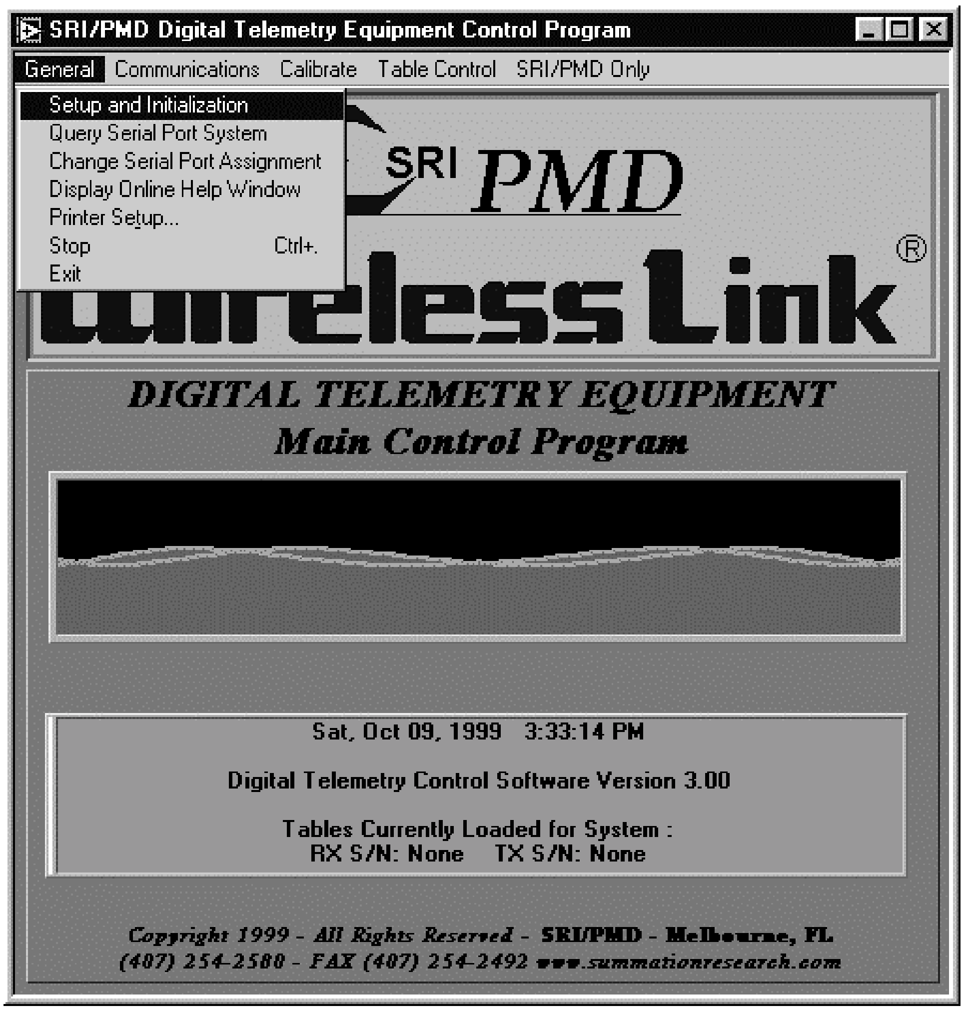


FIGURE 4-1 DIGITAL CONTROL PROGRAM START-UP SCREEN

All remaining steps for this procedure are given in easy to follow instructions on the PC screen. The instructions include help suggestions in case problems are detected during any given phase of the set-up process.

4.2 Stand-alone Validation of the Digital Telemetry System

Users without access to an appropriate PC can still monitor system start-up processing with any equipment available that can display an ASCII text from an RS-232 serial data stream. After making sure the front panel power switch is in an “OFF” position, the user should connect the wall plug AC to DC converter into the rear of the Digital Telemetry Receiver and then into a standard 110 VAC wall outlet. Next, a connection should be established from the “REMOTE” connection on the rear panel to the equipment capable of displaying ASCII text. The power switch may then be placed in the “ON” position.

During initial boot-up processing, the receiver executes a number of self-tests and outputs results of this process on the “REMOTE” serial port on the rear panel. The expected ASCII text for a successful system start-up will be:

TABLE 4-1 EXPECTED BOOT-UP ASCII TEXT

```
******************
     RAM Test
   Test  Passed
     ROM Test
   Test  Passed
     ALU Test
   Test  Passed
RESPIC FW Version x.yy
EEPROM FW Version x.yy
  Start-up Complete
******************
```

Within this text, the two (2) “x.yy” numbers will be replaced with text such as “1.01”. These values indicate the firmware version number of key elements of the receiver system. When requesting problem resolution assistance from SRI/PMD, it is sometimes useful if these firmware version numbers are available.

If start-up does not successfully complete, an error code will be reported indicating what type of failure occurred. The following error codes have currently been established for the Series 300 Digital Telemetry Receivers:

TABLE 4-2 SELF-TEST FAILURE CODES

10	Micro-Controller RAM failure
20	EEPROM failure (low byte of EEPCHECK1 location)
21	EEPROM failure (high byte of EEPCHECK1 location)
22	EEPROM failure (low byte of EEPCHECK2 location)
23	EEPROM failure (high byte of EEPCHECK2 location)
24	EEPROM failure (low byte of EEPCHECK3 location)
25	EEPROM failure (high byte of EEPCHECK3 location)
26	EEPROM failure (low byte of EEPCHECK4 location)
27	EEPROM failure (high byte of EEPCHECK4 location)
28	EEPROM failure (TDT first byte = 0)
29	EEPROM failure (TDT first byte = 0xFF)
30	ALU failure (Invalid Overflow on Increment)
31	ALU failure (Invalid non-Overflow on Increment)
32	ALU failure (Final result not zero)
33	ALU failure (Final result didn't carry)

EEProm error codes (i.e., 20 through 29) can sometimes be corrected with a reload of the EEProm memory space. This can be accomplished from a PC with the appropriate support tools as discussed in a later section. All other failures are indicative of a hardware failure, most likely requiring SRI/PMD repair action.

If no equipment is available to monitor the ASCII stream, the operator is left to rely on the front panel LED indicators. If after power-on, all indicators illuminate and remain illuminated for more than 3 seconds, the system should be returned to SRI/PMD for repair action. If the “FAULT” LED blinks but the other LED’s are off, check the fault indications detailed at the end of section 3 of this document for further clarification.

Assuming no failures, the front panel indicator should display power on (“POWER” LED illuminated), no fault (“FAULT” LED off), and no system synchronization (“SYNC” LED off). The “ERROR” LED may be intermittently flashing on and off as noise is detected by the receive system.

Furthermore, if no Digital Telemetry Transmitter is present for data reception, the system will periodically “reset” in order to restart system acquisition. This occurs approximately every 8 seconds. The “reset” can be detected on the front panel by the “ERROR” LED momentarily illuminating and then returning to an off condition. This provides a simple means of knowing that the system is operating and attempting to receive data from a Digital Telemetry Transmitter.

At this point, the Digital Telemetry Transmitter can be activated. Paying careful attention to the pinouts shown in appendix A of this document, appropriate primary power should be applied to the transmitter.

If an antenna has been purchased with the Digital Telemetry System, it can now be fastened to the “ANTENNA” connector on the receiver rear panel. Otherwise, the operator should fasten the user-supplied antenna. Regardless, 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. Furthermore, if this is a newly delivered system, the operator should validate that the DIP switches accessible through the rear panel of the receiver are all turned to an OFF or up position. Although they should be turned OFF by default from the factory, shipment of the units may sometimes alter these settings. 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.

4.3 Establishing 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.

4.3.1 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 Series 300 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 "Digital.exe" 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 "ANTENNA" port on the rear panel of 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. Establish connections from the Digital Telemetry Receiver to the PC's serial port and to the VDC power input source. Power on the receiver.
3. Start the "Digital.exe" program on the PC from the installed program directory.
4. Select "***Communications : Scan Input RF Frequency Spectrum***".

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 select "***Controls : Exit***" to return to the main screen. During the exit procedure, the program will report to the operator the exact frequency that indicated the lowest level of background noise. Procedures discussed below can then be utilized to change the frequency.

4.3.2 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. Start the "Digital.exe" program on the PC from the installed program directory.
3. Select "***Communications : Monitor Online Communications Performance***".

Once activated, a new screen will appear showing numeric fields on the left-hand side and two (2) graphs on the right-hand side.

The numeric fields will indicate the number of digital telemetry data frames received, how many of these frames had errors detected during the reception process, and how many frames were considered lost due to poor reception quality causing the system to activate the acquisition 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.

The graphs depict the resulting frame error rate and estimated input signal level. The frame error rate is calculated as (frames in error)/(frames received). Lost frames are not considered in the error rate calculation. Both cumulative and per sample plots are provided. The input signal level provides an estimate of the signal plus noise level of the input signal expressed in dBm. Again, both cumulative and per sample plots are provided.

A data frame is approximately 32 sensor sample periods long. Any frames in error result in the loss of 32 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 –70 dBm is considered a high quality signal, although reception can typically be to as low as –85 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.

Select "***Controls : Exit***" to return to the main selection screen.

4.3.3 Changing the Communications Settings

If either online monitoring of the communications performance or the RF spectrum scan dictate a need for changing the current communications settings, the Digital Telemetry Control Program provides the means to accomplish this task.

To modify either the current frequency or transmission baud rate selection of the Digital Telemetry System, take the following steps:

1. Establish normal connections between the Digital Telemetry Receiver and the PC.
2. Changes to baud rate or frequency settings require modifications to EEProm space in both the Receiver and the Transmitter. As such, the Digital Telemetry Transmitter must be connected to the Receiver via the special Programming Interface Cable supplied with the system. To accomplish this connection, perform the following steps:
   a. Turn off power to the Digital Telemetry Receiver.
   b. Connect the Programming Interface Cable to the DIN connector on the rear panel of the receiver labeled “PROGRAM”.
   c. Turn off power to the Digital Telemetry Transmitter.
   d. Connect the other end of the Programming Interface Cable to the 5 pin Programming Interface Connection on the Transmitter, insuring proper pin 1 alignment.
   e. Restore power to the Digital Telemetry Receiver.

   NOTE – if the green POWER LED on the receiver front panel does not illuminate, immediately turn off power and validate the Programming Interface Cable connection. During programming operations, the receiver provides power to the transmitter, but if the cable connection to the transmitter is reversed, a short condition will be introduced to the receiver and the POWER LED will not illuminate. ***Introducing a short condition to the equipment can cause damage to the electronic components of the system.***
3. Start the “Digital.exe” program on the PC from the installed program directory.
4. Select “***Communications : Change Frequency and/or Baud Rate***”.

Once activated, a new screen will appear showing the current frequency and baud rate selections. By clicking and holding on the arrow next to the current settings, the user can access menu’s showing all supported settings of these parameters. Select the desired setting and then release the mouse button.

The actual change does not go into affect until the user selects “***Controls : Set New Frequency/Data Rate***”. Once activated, the system will download the new information to the Digital Telemetry Receiver and will the reprogram the Digital Telemetry Transmitter via the Programming Interface Cable.

When all changes have been accomplished, remove power from the Digital Telemetry Receiver, disconnect the Programming Interface Cable, and return the Digital Telemetry Transmitter to it’s normal operational connections. Select “***Controls : Exit***” to return to the main selection screen.

In general, reductions in link baud rate will improve the communications link performance by reducing the number of frame error’s encountered. Conversely, higher link baud rates provide faster sensor sampling rates and the cost of potentially higher susceptibility to link errors.

Some miniaturized Digital Telemetry Transmitters (e.g., ST-364) do not support a programming interface. For these systems, the transmit frequency is established via a fixed set resistor across two (2) pins on the transmit module. In this case, a change in the resistor value still requires a change in the expected receive frequency. All steps indicated above should be followed with the exception of any dealing with the programming interface cable. The software will warn the operator that the changes will only affect the receiver and transmit frequency must be accomplished via the resistor change.

For users with multiple receivers supporting the same transmitters, it is imperative that changes in communications settings invoked through one (1) receiver are also reflected into any additional receivers. Follow the instruction indicated in the following section to achieve this transfer of information to each additional receiver system.

4.4 Loading/Restoring Configuration Tables/Software

The Digital Telemetry Control Program can also be utilized to restore or upgrade new configuration tables into the Digital Telemetry System. There are a multitude of reasons for taking this action as follows.

SRI/PMD may send new Configuration Tables periodically either via diskette or electronic connections. These updates may be issued under the following circumstances:

1) The customer has purchased a new transmitter and wishes to utilize it with an existing Digital Telemetry Receiver, or
2) The customer has requested an alteration to the current configuration of an existing transmitter or receiver.

For users with multiple receivers supporting the same transmitters, changes to configuration information (such as frequency, baud rate, calibration data, and so forth) in one receiver must be carried over to all other receivers.

Finally, although configuration tables are stored in non-volatile EEProm memory space in both the receiver and the transmitter, operation in severe environments or with noisy power supply systems can sometimes corrupt these tables.

After insuring that the correct files are on the PC being utilized, or in the case of new configuration files, insuring that the files are copied into the install directory, the information must be loaded into the Digital Telemetry Receiver to activate the configuration information. In order to update all of the EEProm tables within the receiver from the PC, the following steps should be taken:

1. Establish normal connections between the Digital Telemetry Receiver and the PC.
2. Start the “Digital.exe” program on the PC from the installed program directory.
3. Select “***Table Control : Download : Receiver and Transmitter Definition Table Space***”.

This action will activate a screen indicating the progress of the download process. After the download has completed, the main screen will return.

The same EEProm memory space that contains the configuration tables also includes the executable code for the main micro-controller within the receiver. This not only allows for restoring the executable code in case it becomes corrupted for some reason, but also supports field upgrades of the receiver executable code. Each release of the Digital Telemetry Control Program includes an embedded copy of the latest receiver micro-controller executable code thus enabling users to upgrade existing fielded systems whenever new control software is installed on the PC.

To restore or update the receiver executable code, follow the same process outlined above but at step 3, select "***Table Control : Download : Receiver MicroController Executable Code***"**.** This action will activate a screen indicating the progress of the download process. After the download has completed, the main screen will return.

4.5 Changing Transmitter Versions

As previously indicated, any given transmitter may be configured for different sensor or digital telemetry configurations.

In order to change the active version of any given transmitter, take the following steps:

1. Establish normal connections between the Digital Telemetry Receiver and the PC.
2. The Digital Telemetry Transmitter must be connected to the Receiver via the special Programming Interface Cable supplied with the system. To accomplish this connection, perform the following steps:
   a. Turn off power to the Digital Telemetry Receiver.
   b. Connect the Programming Interface Cable to the DIN connector on the rear panel of the receiver labeled "PROGRAM".
   c. Turn off power to the Digital Telemetry Transmitter.
   d. Connect the other end of the Programming Interface Cable to the 5 pin Programming Interface Connection on the Transmitter, insuring proper pin 1 alignment.
   e. Restore power to the Digital Telemetry Receiver.

   NOTE – if the green POWER LED on the receiver front panel does not illuminate, immediately turn off power and validate the Programming Interface Cable connection. During programming operations, the receiver provides power to the transmitter, but if the cable connection to the transmitter is reversed, a short condition will be introduced to the receiver and the POWER LED will not illuminate. ***Introducing a short condition to the equipment can cause damage to the electronic components of the system.***
3. Start the "Digital.exe" program on the PC from the installed program directory.
4. Select "***Table Control : Download : Transmitter Definition via Programming Cable***"**.**
5. From the list provided, select the desired version number of the transmitter by double clicking on the line item.

The system will program the transmitter to the new version information and then respond with a completion message. After the update has completed, select "OK" to return to the main screen.

Note that each different transmitter version is treated as unique transmitter by the system. As such, once the transmitter configuration has been altered, the Digital Telemetry Receiver must be configured to expect data from the new version. Reference the following section for the procedure to change the selection of the receiver to the new transmitter version.

4.6 Interfacing to Different Transmitters

Each Digital Telemetry Receiver may be configured to interface with up to 16 unique transmitters or different versions of the same transmitter. As new transmitters are added to a receiver's capability, the specific serial number of the transmitter is assigned a receiver transmit index code ranging from 0 to 15. The transmit index code of available transmitters can be viewed via utilization of the Digital Telemetry Control Program as follows:

1. Establish normal connections between the Digital Telemetry Receiver and the PC.
2. Start the "Digital.exe" program on the PC from the installed program directory.
3. Select "***General : Query Serial Port System***".

The resulting display will depict what transmitter serial numbers and versions the current receiver is compatible with receiving data from. The first transmitter shown corresponds to a transmitter index selection of 0, the second corresponds to 1, and so forth through a possible maximum index of 15.

On the rear panel of the Receiver, four (4) DIP switches previously defined in section 3 of this document select which of the transmit index codes should be utilized. These switch settings may be altered at any time during normal operation and the system will automatically reconfigure itself for the new setting.

If the operator selects a transmit index that is not assigned for this receiver, the front panel "FAULT" light will illuminate indicating an invalid selection. This indicator will turn off once a valid transmitter setting is established.

The transmitter index selection may also be altered via serial port commands through the remote control interface. Reference later paragraphs of this section for more information on this capability.

4.7 System Shut-Down

In order to shutdown the Digital Telemetry Receiver, simply place the two (2) 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.

SECTION 5 REMOTE STATUS/CONTROL

The remote status/control interface supports control and status functions for the Digital Telemetry Receiver across the "REMOTE" RS-232 interface located on the rear panel. The following paragraphs describe the protocol associated with this interface.

5.1 Remote Interface Frame Format

The remote status/control interface is an asynchronous RS-232 link capable of operating at rates up to 19200 bps and can support even, odd, or no parity. As shown in Figure 4-1, each data byte is transferred asynchronously, least significant bit first, and is surrounded by one (1) start bit, one (1) stop bit, and one (1) parity bit (when parity is used). ***The default operating parameters for the interface is 9600 bps, 1 start bit, 1 stop bit, and no parity.*** Additional interface characteristics are available upon request.

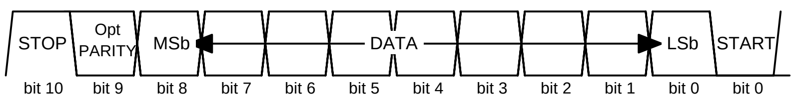


FIGURE 5-1 REMOTE STATUS/CONTROL BYTE FORMAT

The interface is a byte oriented bus (eight (8) bits). Bytes are grouped together to form frames which constitute an entire message. All transfers are accomplished starting with byte 0 and ending with the last byte of the frame (frame checksum).

Frame formats are the same for both sides of the interface (i.e., input and/or output to the Digital Telemetry Receiver). All frames are composed of three (3) fields as shown in Figure 4-2.

	b7	b6	b5	b4	b3	b2	b1	b0
BYTE 0	FRAME BYTE COUNT FIELD							
BYTE 1	FIRST BYTE OF DATA FIELD							
BYTE 2	SECOND BYTE OF DATA FIELD							
	...							
	...							
BYTE N-1	LAST BYTE OF DATA FIELD							
BYTE N	FRAME CHECKSUM FIELD							

FIGURE 5-2 REMOTE STATUS/CONTROL FRAME FORMAT

The byte count field contains a count of the total number of bytes in the frame, including the byte count field.

The data field bytes contain the commands on the input side of the receiver and provide the status on the output side from the receiver. Section 4.2.2 below describes the contents of this field.

A frame checksum field is included on all frames and is used to verify that no errors occurred during the frame transfer. The checksum is calculated by performing a two’s compliment addition of all frame bytes preceding the checksum field, truncating the result to eight (8) bits, and performing a two's complement negate of the result. On the receive side, the checksum is verified by adding all bytes together including the checksum byte and verifying that the result is zero (0). The parity, start, and stop bits are not included when calculating the frame checksum.

When a command is received, the receiver validates the byte count and checksum, and then attempts to process the command, invoke any necessary configuration changes, and respond with an appropriate status message. Invalid byte counts, checksums, or data field parameters result in a negative acknowledgment. In order to accommodate this entire process, a minimum three (3) second time-out waiting for response should be incorporated after any command is issued to the receiver.

5.2 Data Field Contents

The data field of the remote status/control frame contains the commands to be performed by the Digital Telemetry Receiver or the response in return from these commands. The following sections describe the contents of the data field for each message type. Please note that byte offsets shown in the following paragraphs indicate offsets within the data field as opposed to frame offsets.

5.2.1 Set Configuration Command

The set configuration command is used to establish the operating parameters of the Digital Telemetry Receiver. This command will override the current settings of the rear panel DIP switches until such time as the system experiences a power up restart. Figure 4-3 depicts this command format.

BYTE 0	COMMAND FIELD (0)
BYTE 1	TRANSMITTER INDEX SELECT
BYTE 2	DO NOT USE
BYTE 3	DO NOT USE

FIGURE 5-3 SET CONFIGURATION COMMAND FORMAT

Fields contained within this command are defined in the following table.

TABLE 5-1 SET CONFIGURATION COMMAND PARAMETERS

FIELD	DEFINITION
COMMAND FIELD	VALUE OF 0 INDICATING A SET CONFIGURATION COMMAND
TX INDEX SELECT	BIT 7 CONTROLS WHETHER THE COMMAND SHOULD RESULT IN A DOWNLOAD OF THE TRANSMITTER DEFINITION TO THE TRANSMITTER VIA THE PROGRAMMING INTERFACE CABLE (1) OR NOT (0). BIT 6 CONTROLS WHETHER A NEW TRANSMITTER INDEX IS BEING SELECTED BY THE COMMAND (1) OR WHETHER THE CURRENTLY ACTIVE RECEIVER TRANSMITTER INDEX SHOULD BE USED (0). THE LOW ORDER 4 BITS SELECT A VALUE BETWEEN 0 AND 15 TO SPECIFY A NEW TRANSMITTER INDEX SETTING FOR THE RECEIVER. IF BIT 7 IS SET AND THE RECEIVER DOES NOT DETECT THE PRESENCE OF A TRANSMITTER ON THE PROGRAMMING INTERFACE CABLE, A NEGATIVE ACKNOWLEDGEMENT WILL RESULT. IF BIT 6 IS SET AND THE RECEIVER DOES NOT HAVE A CORRESPONDING TRANSMITTER DEFINED FOR THE SELECTED INDEX, THE COMMAND WILL RESULT IN A NEGATIVE ACKNOWLEDGEMENT. OTHERWISE, THE SYSTEM WILL BEGIN ATTEMPTING TO ACQUIRE A TRANSMISSION FOR THE NEW TRANSMITTER. ALL OTHER VALUES ARE INVALID
DO NOT USE	THESE FIELDS MUST BE SET TO 0 FOR PROPER OPERATION OF THE COMMAND.

5.2.2 Report Status Command

The report status command is used to request a status response from the Digital Telemetry Receiver. Figure 4-4 depicts this command format.

BYTE 0	COMMAND FIELD (255)

FIGURE 5-4 REPORT STATUS COMMAND FORMAT

The command field is simply set to a value of 255 to invoke this command. The command causes the receiver to respond with a status response without changing any operational parameters.

5.2.3 Read Analog Channel Command

The read analog channel command causes the Digital Telemetry Receiver to respond with the last valid output value for any given analog channel. The following figure depicts the format of this command.

BYTE 0	COMMAND FIELD (1)
BYTE 1	ANALOG CHANNEL SELECT

FIGURE 5-6 READ ANALOG CHANNEL COMMAND FORMAT

The command field is simply set to a value of 1 to invoke this command. The analog channel select is a value between 0 and 17 corresponding to analog channels 1 through 18. All other values are invalid in this field.

5.2.4 System Status Response

The system status response is returned from the Digital Telemetry Receiver at the completion of successfully processing any command with the exception of the read analog channel command. The following figure depicts the format of this response.

BYTE 0	STATUS RESPONSE (0)
BYTE 1	BACK-END STATUS
BYTE 2	FRONT-END STATUS
BYTE 3	TRANSMITTER SERIAL NUMBER (HIGH BYTE)
BYTE 4	TRANSMITTER SERIAL NUMBER (LOW BYTE)
BYTE 5	RECEIVE STRENGTH SIGNAL INDICATOR
BYTE 6	TRANSMITTER OPERATIONAL TEMPERATURE MEASUREMENT

FIGURE 5-7 STATUS RESPONSE FORMAT

The status response field of 0 simply indicates the message type. Bytes 1 through 8 are defined as follows:

TABLE 5-2 STATUS RESPONSE PARAMETERS

FIELD	**DEFINITION**
BACK-END STATUS	VALUE INDICATING THE CURRENT STATUS OF THE BACK-END MICRO-CONTROLLER OF THE DIGITAL TELEMETRY RECEIVER: Bit 7 indicates the system sync status as in-sync (1) or out of sync (0). Bit 6 indicates the last received frame had an error (1) or was error free (0). Bit 5 indicates the system has detected an error in the configuration tables (1) or not (0). Bit 4 indicates the back-end micro-controller has encountered errors in communicating with the front-end micro-controller (1) or not (0). Bit 3 indicates the last attempt to program a new transmitter frequency either because of a remote command or due to dip switch settings failed (1) or was successful (0). ALL OTHER BITS ARE RESERVED.

FRONT-END STATUS	VALUE INDICATING THE STATUS OF THE FRONT-END MICRO-CONTROLLER OF THE DIGITAL TELEMETRY RECEIVER: Bit 4 indicates the last received frame had a frame-sync error (1) or not (0). Bit 3 indicates the last received frame had a check-sum error (1) or not (0). Bit 2 indicates the last received byte had an data overrun error (1) or not (0). Bit 1 indicates the last received byte had a framing error (1) or not (0). Bit 0 indicates the front-end micro-controller is in-sync with the incoming signal (1) or attempting to acquire synchronization (0). ALL OTHER VALUES ARE INVALID.
TRANSMITTER SERIAL NUMBER (HIGH BYTE)	BITS 15 (MSB) THROUGH 8 (LSB) OF THE SERIAL NUMBER OF THE TRANSMITTER WHICH THE RECEIVER IS CURRENTLY CONFIGURED TO COMMUNICATE WITH.
TRANSMITTER SERIAL NUMBER (LOW BYTE)	BITS 7 (MSB) THROUGH 0 (LSB) OF THE SERIAL NUMBER OF THE TRANSMITTER WHICH THE RECEIVER IS CURRENTLY CONFIGURED TO COMMUNICATE WITH.
RECEIVED STRENGTH SIGNAL INDICATOR	CURRENT VALUE (0 TO 255) OF THE RECEIVE STRENGTH SIGNAL INDICATOR.
TX OPERATIONAL TEMPERATURE MEASURE	CURRENT VALUE (0 TO 255) OF THE LAST RECEIVED TRANSMITTER OPERATIONAL TEMPERATURE MEASUREMENT. VALUE REFLECTS CENTIGRADE TEMPERATURE OF TRANSMITTER IN 0.5 DEGREE INCREMENTS.

5.2.5 Analog Channel Value Response

The analog channel value response is returned from the receiver whenever a valid read analog channel command is received. The following figure depicts the format of this response.

BYTE 0	ANALOG CHANNEL VALUE RESPONSE (1)
BYTE 1	ANALOG CHANNEL VALUE HIGH BYTE
BYTE 2	ANALOG CHANNEL VALUE LOW BYTE

FIGURE 5-8 ANALOG CHANNEL VALUE RESPONSE FORMAT

The byte 0 value of 1 indicates it is an analog channel value response. The remaining two (2) bytes form a 16 bit number which reflects the last output value for the analog channel. Refer to the section 3 paragraph on digital outputs for further information on the formatting of this number.

5.2.6 Negative Acknowledgment Response

The negative acknowledgment response is returned from the receiver whenever problems are encountered in processing any command. Figure 4-6 depicts the format of this response.

BYTE 0	NAK RESPONSE (NEGATIVE NUMBER)

FIGURE 5-9 NEGATIVE ACKNOWLEDGMENT RESPONSE FORMAT

Any negative byte 0 value (i.e., bit 7 = 1) indicates a negative acknowledgment response. The actual value in these cases indicates why the received command was considered invalid as follows:

TABLE 5-3 NEGATIVE ACKNOWLEDGEMENT CODES

-1	Byte level parity error occurred.
-2	Invalid command word received.
-4	Invalid byte count field received.
-5	Unexpected communications error occurred.
-6	Message checksum error.
-7	Data overrun error on incoming message.
-8	Byte framing error occurred (i.e., invalid start/stop bits).
-10	Entire message not received within timeout period.
-16	Undefined transmitter index selected on a configuration control command.
-17	No transmitter connected to programming cable on a download transmitter configuration command.
-18	Wrong transmitter connected to programming cable on a download transmitter configuration command.
-19	Invalid analog channel selected for read command.

The Digital Telemetry Receiver takes no action on any command received which results in a negative acknowledgment.

SECTION 6 SYSTEM CALIBRATION

A key to successful utilization of the Digital Telemetry System is to insure that given sensor input stimuli result in known and accurate output analog values on the receiver. This process requires that the system is programmed for the correct offset and gain settings as previously discussed in section 3 of this document.

Although all Series 300 Products are calibrated at the factory to establish the initial gain and offset settings, periodic adjustments may be required to these values due to equipment aging and/or gain/offset errors introduced by end-user installation or sensor selection. Fortunately, the Digital Telemetry Control Software provides a simple means of performing this calibration process.

6.1 Calibration Set-up

System calibration requires that the operator can establish a minimum of two (2) known stimuli conditions for any given sensor input to the Digital Telemetry System. The “known” setting may be the defined minimum and maximum measurement values to the system, or any level in-between. Regardless, the accuracy of the calibration process will be established by the accuracy of this stimulus setting.

Suppliers of sensors typically provide a means of establishing these known conditions. Examples of this capability include shunt calibration resistors for balanced bridge strain or pressure gages, simulators for thermocouples, or accurate voltage references for general purpose sensors.

During system calibration, the user should attempt to establish conditions for the Digital Telemetry System as close to the actual end application environment as possible. This includes such parameters as the mounting of the Digital Telemetry Transmitter, location of the receive antenna with respect to the transmitter, utilizing the actual transmitter power source (battery, generator, ...) which will be utilized during the telemetry process, and so forth.

In addition, some systems require what is referred to as temperature based calibration. In these cases, the gain and offsets will vary within the system based on the current reported operational temperature of the transmitter. In order to accomplish temperature based calibration, the user must be able to establish a minimum of two (2) known stimuli conditions on each sensor input at a minimum of two (2) transmitter operating temperatures. This implies a means of controlling the ambient temperature of the transmitter either via use of a thermal chamber or some other temperature control means.

For systems only operating within a limited operating temperature range, temperature based calibration may not be required. Typically, balanced bridge measurements limited to the industrial temp range (i.e., 0 to 85° C) can bypass this feature.

In thermocouple applications, the transmitter is frequently utilized as the “zero junction reference box” for the sensor. In this case, temperature based calibration is recommended, unless the accuracy requirements of the end-user data can tolerate these offsets.

6.2 Computer Assisted System Calibration

The following paragraphs describe how to utilize the PC and the “Digital.exe” software to calibrate a Digital Telemetry System.

6.2.1 Starting the Calibration Function

Once the operator has established the system configuration and test equipment as described above, the calibration process can be started from the Digital Telemetry Control Software as follows:

1. Establish normal connections between the Digital Telemetry Receiver and the PC and active wireless link operation between the transmitter and the receiver.
2. Start the “Digital.exe” program on the PC from the installed program directory.
3. Select “***Calibrate : Calibrate Telemetry System***”.

This action will result in a screen being displayed as depicted in the following example with several tabs along the top for selecting different screens of display information.

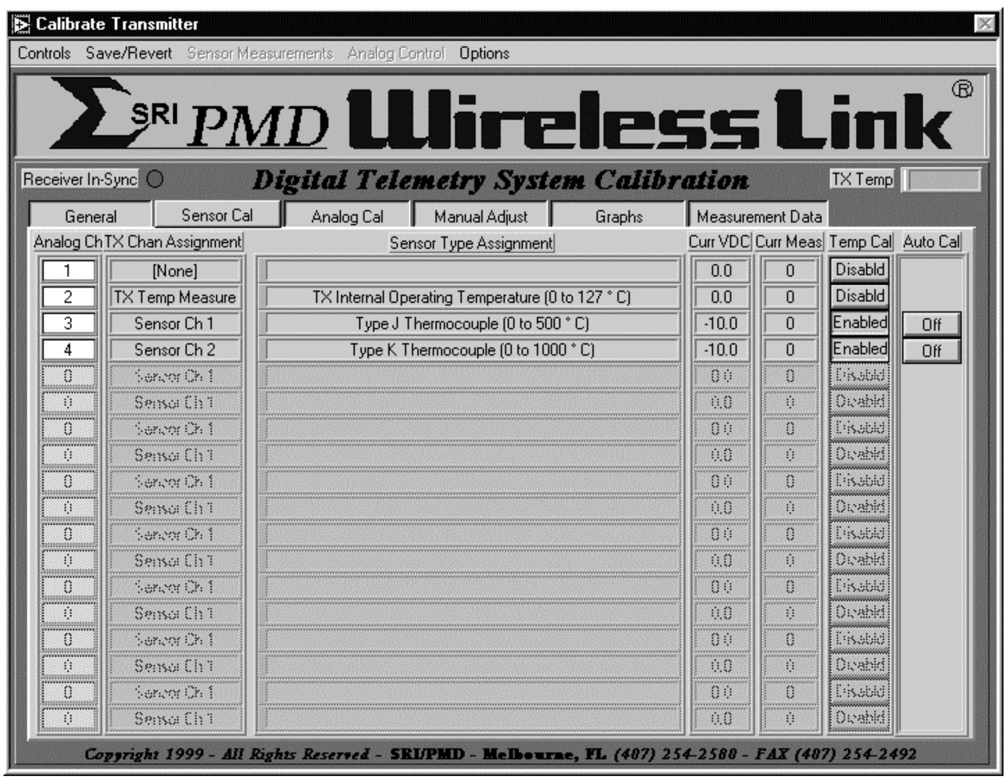


FIGURE 6-1 SAMPLE CALIBRATION DISPLAY SCREEN

The “General” tab selects the display to general information about the telemetry system connected to the serial port including serial numbers, descriptions, last calibration date, and so forth. There are no controls for this screen.

The “Sensor Cal” tab selects the display to a table with each of the defined analog channels shown as well as:

a) the channels associated transmitter sensor assignment,
b) the sensor type and measurement range, and
c) the current reading for the channel presented both as the analog channel output VDC level and the corresponding sensor measurement levels.

The indicated levels are only valid if the system is receiving data from the selected transmitter. The controls on the right hand side of the screen are utilized to calibrate the sensor channel as indicated below.

The “Analog Cal” tab also selects the display to a table with each of the defined analog channels, but depicts active data filtering and selected output VDC ranges as opposed to the sensor information indicated above. The control on the right hand side of the screen is utilized to calibrate the analog channel as indicated below.

The “Manual Adjust” tab selects the display to detailed information about sensor calibration gain and offset settings for a particular analog/sensor channel. The channel selection is located at the top of the screen while the detailed data fills the remaining portion of the screen. If temperature based calibration is enabled for the selected channel, then the detailed data includes gain and offset settings for all temperatures from 0 to 126°C in 2°C increments. If temperature based calibration is not enabled, the gain/offset adjust data is limited to a single setting. This screen can be utilized for manual adjustment to the calibration data as described below.

The “Graphs” tab selects the display to three (3) graphs which correlate to current sensor channel measurement data, gain adjust curve, and offset adjust curve. As with the “Manual Adjust” screen, the channel selection for the graphs is located at the top of the screen while the graphs fill the remaining portion of the screen.

The “Measurement Data” tab selects a screen allowing the operator to view measurements that have been made during the computer assisted calibration process as discussed below. Measurement information shown includes the transmitter temperature at the time of the measurement, the desired output analog voltage, as well as the actual output analog voltage.

6.2.2 Calibrating Sensor Channels

At the far right-hand side of the “Auto Cal” screen is a column also labeled “Auto Cal” with control buttons initially showing an “OFF” condition. This indicates calibration is not active for any channel. The column next to this is labeled “Temp Cal” and will show “Enabled” if temperature based calibration is enabled for the channel or “Disabld” if it is not enabled. Before starting calibration, the “Temp Cal” selection should be verified and/or changed to the correct setting for each channel. This is accomplished by placing the cursor over the corresponding "Temp Cal" button and doing a left hand click to toggle the setting..

To activate a computer assisted calibration process on an individual channel, the operator should click on the "Auto Cal" button corresponding to that particular channel. This will change the state of this control to an "ON" condition. If the transmitter definition includes multiple sensor channels with the exact same definition AND if the set-up described above will support driving multiple channels at the same time, the operator may activate calibration on multiple channels at the same time. To enable this capability, select "***Options : Enable Multi-Channel Calibration***" which then allows multiple, identically defined sensor channel "Auto Cal" controls to be turned "ON".

To perform the calibration process on the channel or channels, execute the following steps:

1. Establish a known stimuli condition for the corresponding sensor for this channel. Also establish a stable transmitter operating temperature if temperature based calibration has been invoked. A stable operating temperature can be detected by a non-changing value on the reported temperature status indicator near the top of the calibration screen.
2. Invoke a measurement on the sensor channel by selecting "***Sensor Measurements : Sensor(s) is at xxxx***" where xxxx will be replaced with the text corresponding to one (1) or five (5) measurement points. These points will be dependent upon the defined sensor type, total measurement range, and measurement units and will correspond to 0, 25, 50, 75, and 100% of the measurement range for unipolar (i.e., positive only) sensor definitions, or –100, -50, 0, 50 and 100% of the measurement range for bipolar(i.e., positive and negative) sensor definitions.

   For instance, a strain gage defined to measure –200 to +200 micro-strain will depict the following measurement options:
   a. ***Sensor is at –200 uE***
   b. ***Sensor is at –100 uE***
   c. ***Sensor is at 0 uE***
   d. ***Sensor is at 100 uE***
   e. ***Sensor is at 200 uE***

   Similarly, a thermocouple defined to measure 0 to 500° C will depict the following measurement options:
   a. ***Sensor is at 0° C***
   b. ***Sensor is at 125° C***
   c. ***Sensor is at 250° C***
   d. ***Sensor is at 375° C***
   e. ***Sensor is at 500° C***

   For stimuli conditions not covered by the fixed selections described above, the operator may choose one of the following options:

   a. Select "***Sensor Measurements : Channel is at User Specified Level : Specified as Sensor Input Measurement Level***". This will activate an additional screen where the operator may enter a value between the minimum and maximum defined valid sensor measurement units for the active channel (e.g., +225° C or –93 uE).
   b. Select "***Sensor Measurements : Channel is at User Specified Level : Specified as Percentage of Measurement Range***". This will activate an additional screen where the operator may enter between 0.00 and

100.00 percent for unipolar values or between –100.00 to +100.00 percent for bipolar values. For instance, a strain gage configured for +/- 500 micro-stain strain with a stimuli of –250 uE should result in a selected measurement percentage of –50%.

c. Select “***Sensor Measurements : Channel is at User Specified Level : Specified as Desired Analog Output Voltage Level***”. This will activate an additional screen where the operator selects an actual VDC output level the analog channel should be at for the current sensor stimuli. With the same example as above on an analog channel configured for +/- 10 VDC output, the selection should be for –5.00 VDC.

3. After establishing the appropriate selection, the system will indicate that a measurement is active on the analog channel. After the measurement has completed, the “Auto Cal” control for each “ON” channel will turn yellow to indicate that a measurement has been made, but insufficient information exists to calibrate the channel. To validate the measurement, the operator may select the “Measurements” tab and view the results.
4. Repeat steps 1 and 2 for a different input stimulus. After this has completed, the number of measurements made as shown on the “Measurements” tab display should reflect 2. Furthermore, if temperature based calibration is not enabled, the “Auto Cal” control for each “ON” channel will turn green, indicating successful initial calibration.
5. If temperature based calibration is enabled, repeat the above process for a different stable transmitter operating temperature. For this case, once 4 measurements have been made (2 each at 2 discrete temperatures), the “Auto Cal” control for each “ON” channel will turn green.

Additional measurements beyond the 2 or 4 discussed above can be activated which will improve the accuracy of the calibration process.

If an error is made in the setting of the stimuli or the selection of the measurement function, the operator may either:

a) Delete individual measurements that are in error. This is accomplished by selecting the “Measurements” tab display, locating the erroneous measurement, and then selecting the “Ignore this Measurement Point” control to “Point Disabled”.
b) Select “***Save/Revert : Revert to Last Stored in Receiver EEProm***”. This action will discard all measurement data and calibration information from the current calibration session and reload the gain/offset tables from the receiver EEProm memory space.
c) Select “***Save/Revert : Revert to Factory Settings***”. This action will reset the calibration and configuration data for the active transmitter and receiver to the “as-delivered” factory settings. Any calibration changes done since the transmitter was delivered from SRI/PMD will be discarded.

The calibration and measurement process outlined above only updates calibration data within the PC’s local memory. Once the operator is satisfied with the calibration data for the channel, “***Save/Revert : Update Receiver Calibration Data***” should be selected. This will update both the receiver non-volatile storage space as well as the PC resident disk files associated with the transmitter. Note that multiple sensor channels can be calibrated prior to storing the values within receiver EEProm memory space if the operator so desires. Turning the “Auto Cal” control “OFF” on a previously calibrated channel does not lose the calibration data associated with that channel.

6.3 Manual Adjustments to Calibration Data

For users lacking the capability to perform the Computer Assisted Calibration process discussed above, manual alteration of the calibration data is possible. To invoke this procedure, activate the “Manual Adjust” tab from the calibration program screen. Note that for manual adjustments to the calibration data, the “Auto Cal” controls for the channel in question must be set to “OFF”

For channels with temperature based calibration disabled, the single gain/offset adjustment value will be displayed for the analog channel selected via the control located at the top of the display. Utilizing the up/down arrows located next to the gain adjust and offset adjust values, the operator may raise or lower the values. Alternatively, standard text entry methods may be utilized to change the settings.

Since gain is a multiplicative function, the nominal control setting for adjusting gain is 1.000. Gain can be decreased by taking this value below the nominal or increased by taking it above the nominal. Offset is an additive function and, as such, the nominal control setting for this adjustment is 0.

For channels invoking temperature-based calibration, all temperature point gain and offset values will be displayed. In addition, a “Common Adjust All Gains” and “Common Adjust All Offsets” will be displayed. These controls provide an easy means of shifting the entire gain or offset curves by common amounts. In addition, individual temperature points may be adjusted as discussed above.

As with computer assisted calibration, the manual process outlined above only updates calibration data within the PC’s local memory. Once the operator is satisfied with the calibration data for the channel, “***Save/Revert : Update Receiver Calibration Data***” should be selected. This will update both the receiver non-volatile storage space as well as the PC resident disk files associated with the transmitter.

6.4 Analog Channel Calibration

Independent of the sensor calibration discussed above, the system provides calibration support functions for the receivers’ analog channels. These functions may be utilized to accurately measure any analog channels output voltages from the Digital Telemetry System.

To enable the analog calibration support functions, start the calibration process as discussed above and then select the “Analog Cal” tab at the top of the screen. This will activate a screen showing each of the analog channels and providing miscellaneous information about the channels current configuration.

On the far right hand side of the display is a control labeled “Analog Cal”. This control will initially indicate “Disabld”. By placing the cursor on one of the controls and clicking, the control will change to “Enabled”. Note that channels currently selected for an active “Auto Cal” cannot be simultaneously enabled for “Analog Cal”.

The above action will enable a menu at the top of the screen labeled “Analog Control”. This menu supports the following options:

a. Select "***Analog Control : Force channel(s) to minimum output level***" in order to establish the minimum output VDC level as indicated on the "Output Volt Range" field on each of the "Enabled" channels.
b. Select "***Analog Control : Force channel(s) to mid-range output level***" in order to establish the output VDC level half way between the minimum and maximum levels as indicated on the "Output Volt Range" field on each of the "Enabled" channels.
c. Select "***Analog Control : Force channel(s) to maximum output level***" in order to establish the maximum output VDC level as indicated on the "Output Volt Range" field on each of the "Enabled" channels.
d. Select "***Analog Control : Force channel(s) to sine wave output***" in order to cause a sine wave to be output on each of the "Enabled" channels varying in VDC level from the minimum to the maximum output VDC levels as indicated on the "Output Volt Range" field.

Note that analog calibration functions are only supported to provide information for the user pertaining to analog VDC levels. The system does not store any calibration data directly associated with this process.

SECTION 7 Digital Telemetry System Definitions

The versatile nature of the Digital Telemetry System allows the system to be readily modified to a multitude of input sensor types, output analog voltage configurations, sampling schemes, and so forth. These capabilities are utilized by SRI/PMD to initially establish the system configuration and may also be utilized for fielded systems by those users electing to purchase the extended software capabilities package.

Even without the extended software package, users can still purchase additional system configurations from SRI/PMD, or return systems to the factory for configuration changes combined with system calibration functions. This powerful capability provides the means to utilize the product for a wide variety of applications and installations.

The following paragraphs describe in detail the system definition parameters that may be viewed through the Digital Control Software. This section also provides the procedure for users of the extended software capabilities to modify these parameters.

7.1 Viewing System Definitions

Any user of the Digital Control Software can display the current configuration of the Digital Telemetry System connected to the PC’s serial port by selecting “***Table Control : View Telemetry System Information : View Current Serial Port System***”. Once invoked, this action will interrogate the active serial port system and initialize a display showing the configuration.

Alternatively, the user may select “***Table Control : View Telemetry System Information : View a Defined Telemetry System***”. This action will allow the user to view the configuration of any system currently defined on the PC’s disk. For users of multiple systems, an additional selection screen will appear for choosing which system the user wishes to view.

The configuration display, shown in the following figure, is similar in nature to the calibration display in that display “tabs” are provided along the top of the screen for selecting what portions of the definition the user wishes to view. The following paragraph’s detail each of these displays and the data definitions of the fields contained within each.

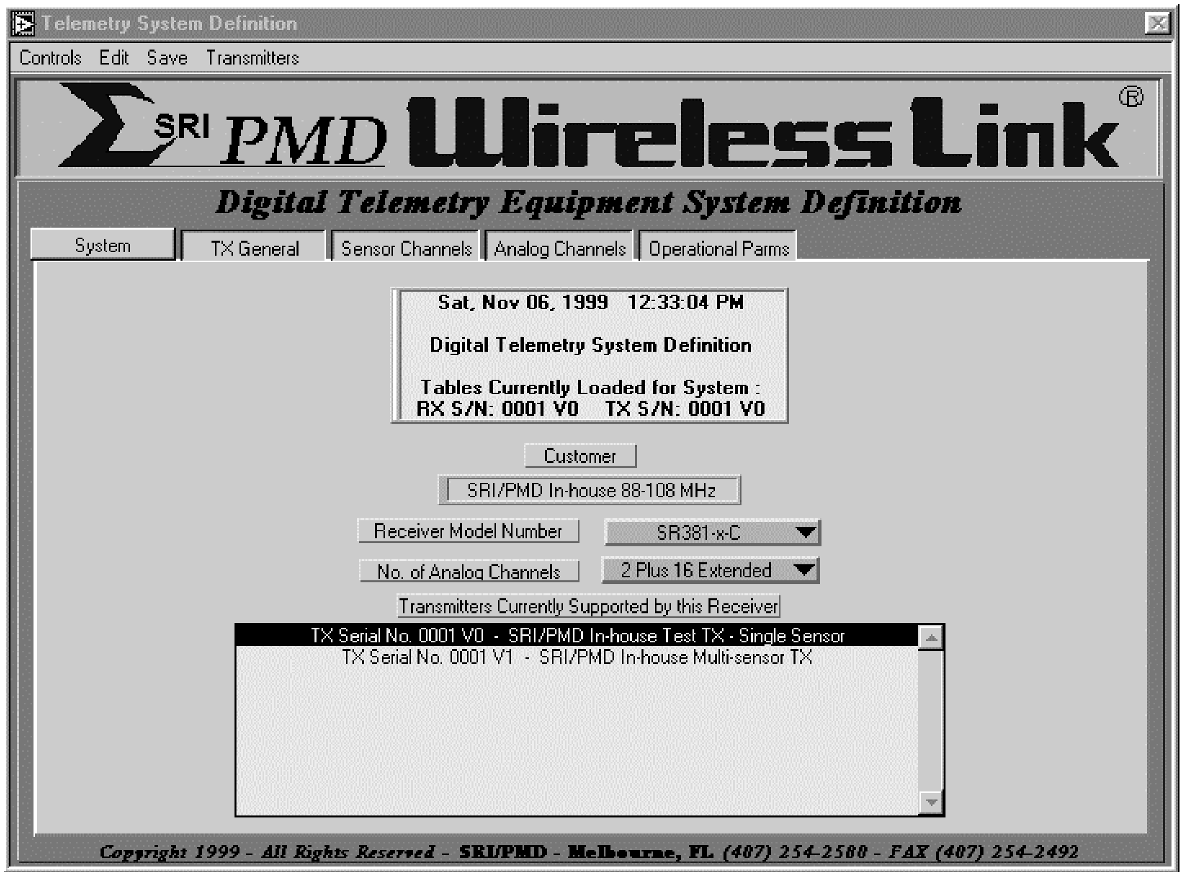


FIGURE 7-1 SAMPLE CONFIGURATION DISPLAY SCREEN

7.1.1 “System” Display

A Digital Telemetry System is comprised of a single receiver along with one (1) to 16 transmitters for which the receiver is currently configured. The “System” display depicts this information and includes the following detailed information.

1) Title block – shows current date, the RX serial number for the displayed Digital Telemetry System as well as the TX serial number currently active for display and/or edit purposes. When the configuration display is initially activated, the active TX serial number is always the first TX from the list of all supported TX’s.

2) Customer - a 30 character text field which normally defines the customer of this particular RX.

3) Receiver Model Number - depicts the model number for the displayed RX.

4) Number of Analog Channels – shows the number of analog channels for the RX. The first 2 channels (i.e., analog channels 1 and 2) are located on the front panel of the receiver via BNC connectors. Extended channels 1 through 16 (if present) are provided via the rear panel "Analog" connector.

5) Transmitters Currently Supported by this Receiver - a table containing the list of transmitters which the RX is configured to support. The table includes the TX serial number and the text description of that serial number. The table is ordered by transmitter index that also corresponds to the rear panel dipswitch selection for activating TX's. Reference section 3 of this manual for further description of the dip switch settings required to activate interfacing with different transmitters.

All remaining screens of the configuration display pertain to detailed information about a particular transmitter. The transmitter being displayed is indicated in both the title block of the "System" display and via a selection indicator in the "Transmitters Currently Supported by this Receiver" table. To select viewing of another TX, users should move the cursor to the table entry corresponding to that TX and click the mouse on that entry. A "Loading TX Tables" indicator will be shown after which all other display tab selections will reflect the new TX selection.

7.1.2 "TX General" Display

General information pertaining to the specific TX selected through the "System" display as discussed above includes the following information:

1) Serial Number – displays the serial number of the current TX. The serial number includes the basic 4-digit serial number plus a 1-digit version number for this particular definition.

2) Description - a 50 character description of this particular version definition of the TX.

3) Transmitter Model Number - depicts the model number for the displayed TX.

4) Transmit Frequency - indicates the current transmit frequency associated with this TX.

5) Transmit Baud Rate - indicates the current transmit baud rate associated with this TX.

6) Configured Sensor Channels - depicts the number of sensor channels which were configured (i.e., built) for the associated TX.

7) Active Sensor Channels - shows the number of sensor channels that have been activated for this particular version definition of the associated TX. The number of active sensor channels must always be less than or equal to the number of configured sensor channels.

8) Excitation Voltage - indicates the VDC level of the output excitation voltage from the TX for sensors requiring a drive voltage.

9) Front-end Gain - depicts the fixed gain setting configured (i.e., built) for the associated TX. The fixed gain precedes the programmable gain stage of the TX and is established at the factory by installed hardware.

7.1.3 "Sensor Channels" Display

Transmitters may be configured for 1 to 16 "active" sensor input channels. The "Sensor Channels" display shows the configuration of each of these inputs as well as defining the time period over which the sensor is sampled. The following sections describe the details of this display.

7.1.3.1 Sampling Dwell Control

The dwell control (labeled as “Dwell Cont” on the display) setting determines the sampling algorithm that will be employed for multiple sensor channel systems. This field has no meaning for single sensor channel systems and will typically be set to 0 for these cases. For all multi-sensor channel systems, the dwell control works the same regardless of configured sensor type.

For multi-sensor channel, lower speed systems (i.e., 900 MHz ST-32x models), the dwell control field reflects the number of individual measurement samples that are taken for the channel before the multiplex logic switches to the next channel. The actual sensor sampling rate is determined as TX Baud Rate divided by 11.

For example, a TX configured for a 25 Kbps baud rate will result in an aggregate sampling rate of ~2272.72 samples per second (i.e., 25K/11) or a sampling period of 440 micro-seconds. If a system defined with four (4) active sensor channels has the dwell control set to 1 for each, the logic will switch channels between each sampling period, thus producing a single channel sampling rate of ~568.18 samples per second (i.e. 2272.72/4) or a sampling period of 1.76 milli-seconds.

If for this same definition the dwell control is taken to 2272 for each sensor, the system will “dwell” on each input for a period of approximately one (1) second before switching to the next channel. During the one (1) second period, the system will transmit 2272 consecutive samples of the active sensor channel. On the receive side, the currently selected sensor channel is indicated via address lines output on the digital output interface.

For these lower speed systems, a requirement exists that the end of an even 16-sample period must coincide with the end of a sensor channel dwell period, unless the sensor channel dwell period is greater than 16 samples. In the latter case, the end of the channels dwell period must coincide with the end of an even 16-sample period. Hence, for the four (4) sensor channel system discussed above, dwell selections of 4, 8, 2, 2 are valid (i.e., total of 16 samples) as is 32, 8, 7, 1. A setting of 64, 64, 64, 1 would be invalid.

For higher speed systems (i.e., 88-108 MHz ST-36x models), a minimum dwell period of 32 samples exists for each channel. As such, the dwell control field reflects the number of 32 sample periods that are taken for the channel before the multiplex logic switches to the next channel. For these systems, the actual minimum sampling rate is determined as TX Baud Rate divided by 9.

For example, a TX configured for a 250 Kbps baud rate will result in an aggregate sampling rate of ~27777.77 samples per second (i.e., 250K/9) or a sampling period of 36 micro-seconds. If a system defined with four (4) active sensor channels has the dwell control set to 1 for each, the logic will switch channels between each set of 32 sample periods. This will produce a single channel dwell rate of 1.152 milli-seconds (i.e. 32 x 36 micro-seconds). During this dwell period, the TX and hence RX will output 32 consecutive samples of the sensor.

7.1.3.2 Sensor Definitions

The remaining fields on the “Sensor Channels” display define the configuration of the sensor channel itself. This includes the following fields:

1) Sensor Type Assignment – displays the type of sensor which will be connected to the sensor input channel (i.e., strain gage, pressure transducer, ...).
2) Sensor Scale/Sensor Offset – fields which further define the characteristics of the exact sensor being utilized. The interpretation of these fields varies with each type of defined sensor.
3) Measurement Units – defines the measurement units which should be utilized for the sensor. This field also varies with the sensor type and includes selection such as milli-volts DC (mVDC), micro-strain (uE), degree’s C/F, and so forth.
4) Minimum/Maximum – controls the range of measurement units which the sensor channel is configured to measure.

The definition and content of each of these fields varies based on the configured sensor type as defined in the following paragraphs.

7.1.3.2.1 Generic Analog Voltages

There are two (2) possible selections under the “Sensor Type Assignment” utilized to define sensors in terms of generic analog voltages. These are “Generic 0-5 VDC” and “Generic Analog Voltage”.

The “Generic 0-5 VDC” selection is unique from all other sensor types in that it is limited to a single ended input voltage. As such, the Signal+ input for the channel contains a voltage between 0 and 5 VDC referenced to the ground source of the TX power supply. Signal– is not utilized for this case.

The “Measurement Units” for a “Generic 0-5 VDC” channel is limited to mVDC and the minimum and maximum range values can be set anywhere from 0 to 5000 mVDC. Note that for this sensor type, the transmitter does not apply any gain. Setting the minimum and maximum range values to other than 0 and 5000 simply causes the RX gain setting to be increased. Sensor Scale/Sensor Offset fields have no meaning for this sensor type.

The “Generic Analog Voltage” selection measures a differential voltage range between the Signal+ and Signal– inputs. The measurement units may be specified as mVDC or micro-volts DC (uVDC). The minimum and maximum range values can be set anywhere from -1250 to +1250 for mVDC and –32768 to +32768 for uVDC although this may be further limited by the minimum gain settings of the TX. Scale/Sensor Offset have no meaning for this sensor type.

7.1.3.2.2 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 appendix B 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 micro-strain (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 TX.

7.1.3.2.3 Thermocouple’s

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’s C (°C)” and “Degree’s 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 TX as well as limitations of the specified thermocouple type.

7.1.3.2.4 Pressure Transducers

The “Sensor Type Assignment” can also be selected to “Pressure Transducer”.

The measurement units for a pressure transducer may be selected between Pounds per Square Inch (PSI) or Killi-grams per Square Centi-meter (kg/cm^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 TX 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 in terms of mVDC/(1000 PSI) or mVDC/(1000 kg/cm^2) depending upon the selected measurement units. For example, a pressure transducer which outputs a 10 mVDC level for 500 PSI 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.

7.1.3.2.5 Accelerometers

The “Sensor Type Assignment” can be selected to “Accelerometer”. The measurement units for an accelerometer are limited to Gravitational Forces (G’s). 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 TX as well as limitations of the specified accelerometer type.

The “Sensor Scale” field for an accelerometer defines the output voltage range of the sensor in terms of mVDC/G. For example, an accelerometer which outputs a 25 mVDC level for 5 G’s would have a “Sensor Scale” field of 5.0.

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.

7.1.3.2.6 Thermistors

The “Sensor Type Assignment” can be selected to “Thermistor”. The measurement units for a thermistor may be selected between “Degree’s C (°C)” and “Degree’s 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 TX 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 appendix B 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 TX. 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.

7.1.4 “Analog Channels” Display

Receivers may be configured for 1 to 18 analog output channels. Channels 1 and 2 are known as the “Basic Channels” and are located on the front panel of the RX via BNC connectors. Channels 3 through 18 are optional and designated as “Extended Channels” located on the rear panel “Analog” connector.

The “Analog Channels” display depicts each of the configured analog channels in tabular format. Each entry provides the following information for the channel:

1) TX Channel Assignment – displays the TX sensor channel that has been assigned to this RX analog output channel. Note that any given TX sensor channel may only be assigned to one (1) analog output channel.
2) Data Filtering – specifies the type of data filtering which is being performed on the samples prior to output to the analog channel. Supported data filtering options is discussed in more detail in section 2 of this document.
3) Output Voltage Range – this field is only present on the “Extended Channels” and specifies the output VDC levels that should correspond to the minimum and maximum measurement unit values for the sensor. Valid settings include 0 to +5 VDC, 0 to +10 VDC, -5 to +5 VDC, and –10 to +10 VDC. Note that “Basic Channels” are limited to 0 to +5 VDC output voltage ranges.

In addition to sensor channels, an analog output may also be assigned to the detected transmitter operational temperature. This detected temperature is what is utilized by the receive system to perform temperature based gain and offset adjustment functions. When presented on an analog output, 0 °C corresponds to the minimum output voltage while +128 °C corresponds to the maximum output voltage.

7.1.5 "Operational Parameters" Display

The "Operational Parameters" of the Digital Telemetry System control the operational characteristics of the system with respect to link acquisition, signal tracking, and so forth. The factory settings of these fields have been established through extensive testing by SRI/PMD and are, in general, applicable to the vast majority of system applications. Periodically a unique customer environment or requirement lends itself to minor modifications to these programmable parameters.

7.1.5.1 Transmitter Parameters

For all Digital Telemetry Systems, there are two (2) parameters applicable to transmitter operation. These are:

1) Target Transmit Gain % - establishes what amount of the total required system gain for sensor channels should be achieved through the transmitter as opposed to the receiver. This parameter is typically set to 90%, thus allowing for offset and gain errors within the sensor interface without causing the sensor input to exceed the measurement range of the transmitters digitizer. Lowering this parameter increases the amount of external offset/gain errors that can be tolerated at the price of reducing the total measurement resolution through the system.
2) Frame Sync Value – establishes the data content of the 8-bit frame sync transmitted across the wireless link. The frame sync data allows the receive side to detect and maintain correct data synchronization with the incoming bit stream from the transmitter.

For 88-108 MHz Digital Telemetry Systems, operational parameter tables are also present for "TX Frequency Cal" and "TX Frequency Deviation Cal". These tables establish the correct settings within the transmitter to achieve a selected output transmit frequency with a known frequency deviation amount.

7.1.5.2 Receiver Parameters

For all Digital Telemetry Systems, there is a single common parameter applicable to receiver operation. This is:

1) In-sync Error Threshold - indicates the number of consecutive frames which the receiver will tolerate being in error before declaring a loss of synchronization and forcing the system back into signal acquisition mode. Increasing this value allows the system to tolerate longer periods of signal drop out at the cost of not detecting data sync slips as quickly.

For 88-108 MHz Digital Telemetry Systems, an operational parameter table is also present for "RX Frequency Cal". This table establishes the correct settings within the receiver to achieve a selected input tuning.

All remaining receive side operational parameters are dependent upon the mode of operation of the wireless link. Lower speed systems (i.e., 900 MHz ST-32x models) operate in what is known as an asynchronous receive mode while higher speed systems (i.e., 88-108 MHz ST-36x models) operate in synchronous receive mode. The following paragraphs detail the parameters associated with each mode of operation.

7.1.5.2.1 Asynchronous Operation

Asynchronous receive mode operational parameters include the following:

1) USART Retry Count - indicates the number of times the receive logic attempts to achieve USART data frame synchronization (i.e., proper start/stop bits) before completely restarting the acquisition process.
2) USART In-sync Threshold - controls the number of times the receive logic must detect proper USART data byte synchronization (i.e., correct start/stop bits) before proceeding on to attempt to find data frame synchronization. Increasing this number makes it more difficult for the system to falsely declare USART synchronization at the expense of increased acquisition time.
3) Frame Sync Search Count - establishes the number of bytes the receive logic will scan looking for frame sync on the background data channel after USART synchronization has been declared. Since the frame sync is transmitted once per data frame, this value should at least be a frames worth of bytes (i.e., 32) or greater.

7.1.5.2.2 Synchronous Operation

Synchronous receive mode operational parameters include the following:

1) Frequency Range Control, Positive Frequency Range Control, and Frequency Step Size Control - establishes the search frequency range utilized by the receiver during acquisition. While attempting to locate a signal, the receiver scans the possible valid frequency range looking for a signal from the Digital Telemetry Transmitter. This is done by continuously stepping the receive frequency over a range of settings. These values establish the size of each step where each unit count equals approximately 20 KHz. Hence, the setting of the step size x 20 KHz x Frequency Range Control equals the approximate scan width of the receive acquisition logic. The (step size x 20 KHz x Positive Frequency Range Control) + Transmit Frequency equals the starting point of the scan, which then proceeds in a negative direction.
2) Bit-sync Range Control and Bit-sync Step Size Control - establishes the search bit-sync range utilized by the receiver during acquisition. While attempting to locate a signal, the receiver scans the possible valid frequencies and at each frequency setting attempts to lock up the bit-sync. This is done by continuously stepping the bit-sync over a range of settings. The step size control set the size of each step where each unit count equals approximately 250 bps. Hence, the setting of step size x 200 bps x Bit-Sync Range Control equals the approximate bit rate scan width of the receive acquisition logic.
3) Signal Detect Threshold – establishes the minimum signal level that must be detected for the system to attempt data lock on a signal. Lowering this value increases the potential sensitivity of the system for locking onto weak signals at the cost of increasing acquisition time for all signals.
4) Frame-sync Bit Search Count and Frame-sync Byte Search Count – The bit search count establishes the number of bits the receive logic will scan

looking for the correct orientation of the background data channel with respect to the primary data channel. Since the word length of the system is 9 bits, this is the minimum value this field should be set to. Increasing it beyond this setting allows some noise hits to be tolerated during the data sync lock attempt logic at the price of increasing acquisition time. The byte search count control the number of bytes the receiver attempts to gain frame lock with the incoming signal. This field controls how many background channel byte locations are scanned looking for the frame sync value. Since the frame length of the system is 32 words, this is the minimum value this field should be set to. Increasing it beyond this setting allows some noise hits to be tolerated during the data sync lock attempt logic at the price of increasing acquisition time.

5) AFC Minimum Offset Threshold and AFC Loop Multiplier Control – once the system is in-sync and tracking a signal, the Automatic Frequency Control (AFC) logic tracks dynamic changes in the transmit frequency due to doppler or changing TX operational temperatures. The minimum offset threshold establishes how large of a frequency error must be present before AFC tracking takes action while the loop multiplier control establishes how fast the logic tracks a frequency error.

6) Bit-sync Tracking Lead Multiplier and Bit-sync Tracking Lag Multiplier – once the system is in-sync and tracking a signal, the bit-sync tracking logic tracks dynamic changes in the transmit baud rate due to doppler or changing TX operational temperatures. The lead and lag multiplier values establish the constants utilized in a classic type 2 loop filter for this tracking function.

7.2 Changing System Definitions

Extended software users have available menu selections from the main Digital Control Software display for "***Table Control : Edit Existing Telemetry System Definition : Edit Current Serial Port System***" to change the definition of the system currently connected to the PC's serial port.

Alternatively, selecting "***Table Control : Edit Existing Telemetry System Definition: Edit a Defined Telemetry System***" can be utilized to edit a system defined on the PC's disk. Users who modify the definition of a disk resident system should insure that the disk file used properly reflects all configuration and calibration data that may have been modified in the EEProm memory space of the system in question. After editing, the new definition files should be downloaded to the receiver and/or transmitter to affect the update.

Either of these selections produces the same display as the configuration screens discussed above but enable editing of most configurable parameters.

7.2.1 Transmitter Definition Control

To change parameters of an existing transmitter serial number and version, the user need only select the appropriate definition from the "Transmitters Currently Supported by this Receiver" on the "System" configuration page and then proceed to the appropriate tab selections for the parameter of interest and make the necessary changes.

Users wishing to maintain the current definition but wanting to create a new version of a transmitter configuration for an alternate application should select “***Transmitters : Define/Add New Transmitter***”. If the user currently has only a single version of the transmitter definition existing, the system will automatically create an identical definition to that version and assign it to a new serial number with the version digit portion incremented by 1. For example, TX S/N 1234 V0 would produce the new version of TX S/N 1234 V1.

If the user already has multiple versions of the transmitter definition existing or owns multiple Series 300 TX’s, the system will query the user as to which of the transmitter definitions the new one should be based on. It will then create an identical definition and assign the next available version digit number for that serial number.

For users owning multiple Series 300 systems, transmitter definitions supported by one (1) receiver may be added to another receiver by selecting “***Transmitters : Add Existing Transmitter***”. The user will then be queried as to which transmitter to add.

Regardless, any of the above actions will cause the new transmitter serial number to appear on the “Transmitters Currently Supported by this Receiver” list. The user may then select that definition and edit it accordingly.

In the case where a user no longer requires a specific transmitter definition, selecting “***Transmitters : Remove/Delete a Currently Supported Transmitter***” should be used to delete the definition. After querying the operator as to which definition should be deleted, that specific serial number will be removed from the “Transmitters Currently Supported by this Receiver” list. Furthermore, the operator will be queried as to whether the delete process should also remove disk files associated with that definition. Answering yes will totally eliminate the transmitter definition from both the EEProm memory space and the disk resident versions.

7.2.2 Editing Parameters

In general, users of the extended software capabilities may modify any parameter identified in section 7.1 of this document with the exception of those associated with the actual hardware build of the system. Consistent with this, the user is *not* allowed to modify the following parameters even with the extended software capabilities:

1) Receiver Model Number
2) Number of Analog Channels
3) Transmitter Serial Number – the user may create a new version of an existing 4 digit basic serial number, but is not allowed to change the basic serial number value.
4) Transmitter Model Number
5) Configured Sensor Channels – the user may modify the Active Sensor Channels to be anything less than or equal to the configured, but may not change the configured sensor channels.
6) Front-end Gain

Changes to editable parameters are via standard Windows techniques with menu type selection options, up/down control arrows, or standard text entry methods. For text entry fields, the system supports standard copy/paste functions under an “***Edit***” menu.

Some fields within the configuration are interrelated. Where possible, the Digital Control Software will attempt to insure that the user cannot create invalid relationships during the edit process. For example, since any given sensor input channel can only be assigned to a single analog output channel, changing a sensor channel output assignment will cause the system to automatically reassign the previous analog channel which might have been assigned to that sensor.

In some cases the automatic correction logic is not practical. For instance, a change to a sensor type assignment requires that all parameters associated with the sensor type be established before the logic can validate the settings. For these instances, the logic waits until the user invokes a save operation before testing the validity of the new configuration. If an invalid condition is determined to exist, the save function is inhibited until the configuration is corrected to a valid state.

For instance, a system built to a front-end gain setting of x25 has a minimum total TX gain of x50 (ignoring the unity gain setting for a Generic 0 to 5 VDC sensor type selection). Defining a “Generic Analog Value” sensor with a measurement range of +/- 200 mVDC would create a condition where the maximum sensor inputs would exceed the TX’s digitizer input range (i.e., 200 x 50 = 10,000 mVDC > +/- 2.5 VDC). If a save operation is invoked with these settings, the Digital Control Software will detect the violation, notify the operator, and inhibit the save function from proceeding.

7.2.3 Saving Updates

When an extended software user has enabled editing of a telemetry system definition, the “***Save***” menu provides four (4) options for saving changes. These are:

1) Select “***Save : Save to Disk***” to update the disk resident copy of the telemetry system definition without changing a receivers EEProm version.
2) Select “***Save : Save to Disk and Exit***” to update the disk resident copy of the telemetry system definition and exit the edit session.
3) Select “***Save : Save to Disk and Download to Serial Port System***” to update the disk resident copy of the telemetry system definition as well as the receivers EEProm version currently connected to the PC’s serial port.
4) Select “***Save : Save to Disk, Download to Serial Port System and Exit***” to update the disk resident copy of the telemetry system definition as well as the receivers EEProm version currently connected to the PC’s serial port and exit the edit session.

In general, users are encouraged to update both the disk resident and EEProm versions of the definitions to insure consistency. For edit sessions involving extensive changes, periodic “***Save : Save to Disk***” selections can be utilized to backup the change process at interim time periods.

For system definitions involving multiple transmitters or versions of the same transmitter, the Digital Control Software is limited to maintaining a single TX definition within memory at any given time. When an editing session involves changes to multiple TX definitions, the user should select “***Save : Save to Disk***” upon completing the changes to one (1) TX definition before proceeding to the next definition. After all changes have been accomplished, the operator may select "***Save : Save to Disk and Download to Serial Port System***" one time to update the EEProm resident version.

When updating a serial port system, the Digital Control Software will automatically detect if a Digital Telemetry Transmitter is connected to the programming interface of the receiver. If so, the user will be queried as to whether the transmitter should also be updated with its definition. Selecting yes will cause the system to prompt the operator for which definition should be loaded into the programming interface transmitter.

To insure proper operation of the Digital Telemetry System, the transmitter definition must be updated via the programming interface for any changes affecting sensor definitions, dwell period controls, and/or transmit frequency/baud rate. If the user does not have the transmitter connected to the programming interface upon exiting the edit session, it may be updated at a later time via the "***Table Control : Download : Transmitter via Programming Interface***" from the Digital Control Software main screen.

7.3 Printing System Reports

From the main screen of the Digital Control Software, the user may select "***Table Control : Print Telemetry System Report : Print Current Serial Port System***" to generate a text report to a printer detailing the configuration of the telemetry system currently connected to the PC's serial port. The report includes all information about the systems configuration discussed in previous paragraphs of this section.

Alternatively, selecting "***Table Control : Print Telemetry System Report : Print a Defined Telemetry System***" allows the user to print a configuration report on any system defined on the PC's disk.

As previously mentioned, the system maintains records on all calibration sessions for a telemetry system. When printing a report, if the system detects the presence of these records, it will query the operator as to whether a calibration report should be printed in addition to the configuration report. If selected, the calibration report includes detailed information pertaining to measurements made, associated gain/offset adjustments affected by the calibration process, and before/after gain/offset curves of the telemetry system.

The Digital Telemetry System report requires a graphics compatible printer. Users may establish the printer selection and other configurable printer options by selecting "***General : Printer Setup...***" from the main screen.

SECTION 8 MAINTENANCE

In order to ensure that the Digital Telemetry System is always ready for operation, it should be checked periodically such that defects may be discovered and corrected before they develop into any serious damage or system failure. A minimal preventive maintenance program will significantly increase the systems life span.

This section describes the necessary preventive maintenance checks and tests the user can perform to easily identify most defects and problems. Any other defects or problems discovered during the normal operation of the system should be noted for future corrective measures.

CAUTION

Stop the operation of the system immediately if a problem is noted during normal operation that can otherwise damage the system.

This section also describes the corrective maintenance checks that can be performed on the Digital Telemetry Systems.

8.1 Maintenance Concept

The maintenance concept for the Digital Telemetry Equipment is limited to period preventive maintenance actions as identified in the following sections.

8.2 Preventive Maintenance Requirements

The following is a recommended timetable for performing preventive maintenance checks on Series 300 Digital Telemetry Systems.

CAUTION

Power to the chassis must be turned OFF when performing preventive maintenance on the equipment.

8.2.1 Inspection

The Digital Telemetry System, chassis, and interface cables should be inspected periodically for defects or physical damage developed during operation. Inspect all the interface cables for cracks, breaks and proper seating with their mating connectors. Inspect all cables for frayed, broken or damaged wires. In addition, inspect all connections for accumulation of dirt, grease, or any foreign material that can cause a non-connection. If a cable is found damaged or non-repairable, it should be replaced before operating the system again.

Inspection should be performed at least once every month. The frequency of inspection should be increased for units exposed to dusty or heavy particulate environments.

8.2.2 Cleaning

Clean the outside surfaces and areas around the connectors periodically. Clean the surfaces with a clean, soft, lint-free cloth. Clean the areas around the connectors with a soft bristle brush. Cleaning can be done with a cloth moistened in warm soapy water after all the excess water has been squeezed out of the cloth.

To remove grease, fungus, or corrosion, use a cloth dampened in high quality electronic cleansing solution.

Cleaning should be done at least once every month. The frequency of cleaning should be increased for units exposed to dusty or heavy particulate environments.

8.3 Corrective Maintenance Requirements

SRI/PMD does not recommend any corrective maintenance actions be performed for fielded units except as specifically directed by SRI/PMD during any potential service assistance calls. In general, if a transmitter or receiver is exhibiting suspect behaviors, the operational start-up procedures discussed in section 4 of this document should be followed in an attempt to isolate potential areas of failure. Following this action, SRI/PMD should be contacted directly for further maintenance recommendations.

APPENDIX A   MODEL DEPENDENT PIN ASSIGNMENTS

The following pages detail the pin assignments for the various models of the Series 300 Digital Telemetry Transmitters. The indicated signal names correspond to the definitions provided in section 3 of this document.

A.1 Single Channel Model ST-321, ST-326, and ST-361

The models ST-321, ST-326, and ST-361 are a 1.75" diameter disk shape. For product versions limited to one (1) sensor input channel, a single transmitter card is housed in the 0.6" tall enclosure. The pinouts for this product version is depicted in the following diagram.

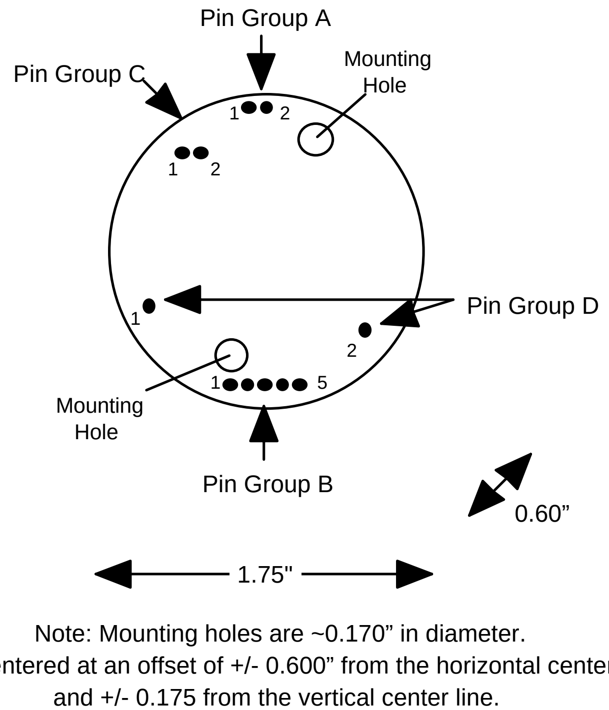


FIGURE A-1 MODEL ST-321/326/361 SINGLE SENSOR TX PIN LOCATIONS

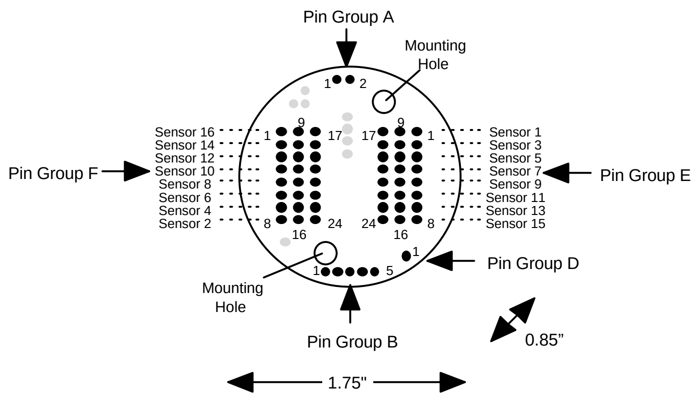
The pin assignments reflected in the following table apply to this packaging style.

TABLE A-1 MODEL ST-321/ST-326/ST-361 SINGLE CHANNEL TX PIN ASSIGNMENTS

PIN	SIGNAL	PIN	SIGNAL	PIN	SIGNAL
A1	VCC (+7 to 18 VDC)	B1	PROG_VCC (+5 VDC)	C1	SIG-1
A2	GROUND	B2	PROG_RESET*	C2	SIG+1
		B3	PROG_CLK		
		B4	PROG_DAT	D1	EXCOM-
		B5	PROG_GND	D2	EXCOM+

A.2 Multi-Channel Model ST-321, ST-326 or ST-361

The models ST-321, ST-326 and ST-361 are a 1.75″ diameter disk shape. For product versions from two (2) to 16 sensor inputs, a dual card arrangement is housed in the 0.85″ tall enclosure. The pinouts for these product versions is depicted in the following diagram.



Note: Mounting holes are ~0.170” in diameter.
They are centered at an offset of +/- 0.600” from the horizontal center line
and +/- 0.175 from the vertical center line.

FIGURE A-2 MODEL ST-321/326/361 MULTI-SENSOR TX PIN LOCATIONS

Pin locations shown in gray in this figure indicate factory test points which may be present on the transmitter but which should not be utilized for end-user applications.

The pin assignments reflected in the following table apply to this packaging style.

TABLE A-2 MODEL ST-321/ST-326/ST-361 MULTI-CHANNEL TX PIN ASSIGNMENTS

PIN	SIGNAL	PIN	SIGNAL	PIN	SIGNAL
A1	VCC (+7 to 18 VDC)	B1	PROG_VCC (+5 VDC)	D1	EXCOM+
A2	GROUND	B2	PROG_RESET*		
		B3	PROG_CLK		
		B4	PROG_DAT		
		B5	PROG_GND		
E1	SIG+01	E17	EXC-01	F9	SIG-16
E2	SIG+03	E18	EXC-03	F10	SIG-14
E3	SIG+05	E19	EXC-05	F11	SIG-12
E4	SIG+07	E20	EXC-07	F12	SIG-10
E5	SIG+09	E21	EXC-09	F13	SIG-08
E6	SIG+11	E22	EXC-11	F14	SIG-06
E7	SIG+13	E23	EXC-13	F15	SIG-04
E8	SIG+15	E24	EXC-15	F16	SIG-02
E9	SIG-01	F1	SIG+16	F17	EXC-16
E10	SIG-03	F2	SIG+14	F18	EXC-14
E11	SIG-05	F3	SIG+12	F19	EXC-12
E12	SIG-07	F4	SIG+10	F20	EXC-10
E13	SIG-09	F5	SIG+08	F21	EXC-08
E14	SIG-11	F6	SIG+06	F22	EXC-06
E15	SIG-13	F7	SIG+04	F23	EXC-04
E16	SIG-15	F8	SIG+02	F24	EXC-02

A.3 Piston Mount Multi-Channel Model ST-363

The model ST-363 is a moon shaped version of the telemetry system typically utilized for piston mount or similar types of applications. For product versions up to 16 sensor inputs, a dual card arrangement is housed in the 0.65” tall enclosure. The pinouts for these product versions is depicted in the following diagram.

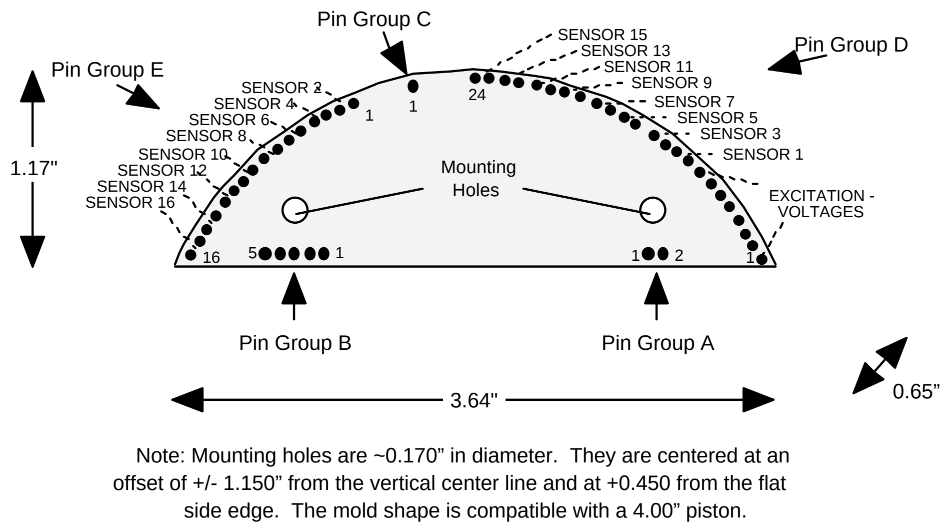


FIGURE A-3 MODEL ST-363 MULTI-SENSOR TRANSMITTER PIN LOCATIONS

The pin assignments reflected in the following table apply to this packaging style.

TABLE A-3 MODEL ST-363 TRANSMITTER PIN ASSIGNMENTS

PIN	SIGNAL	PIN	SIGNAL	PIN	SIGNAL
A1	VCC (+7 to 18 VDC)	B1	PROG_VCC (+5 VDC)	C1	EXCOM+
A2	GROUND	B2	PROG_RESET*		
		B3	PROG_CLK		
		B4	PROG_DAT		
		B5	PROG_GND		
D1	EXC-01	D15	SIG+07	E5	SIG+06
D2	EXC-02	D16	SIG-07	E6	SIG-06
D3	EXC-03	D17	SIG+09	E7	SIG+08
D4	EXC-04	D18	SIG-09	E8	SIG-08
D5	EXC-05	D19	SIG+11	E9	SIG+10
D6	EXC-06	D20	SIG-11	E10	SIG-10
D7	EXC-07	D21	SIG+13	E11	SIG+12
D8	EXC-08	D22	SIG-13	E12	SIG-12
D9	SIG+01	D23	SIG+15	E13	SIG+14
D10	SIG-01	D24	SIG-15	E14	SIG-14
D11	SIG+03	E1	SIG+02	E15	SIG+16
D12	SIG-03	E2	SIG-02	E16	SIG-16
D13	SIG+05	E3	SIG+04		
D14	SIG-05	E4	SIG-04		

Note that excitation voltages are only supported for sensor channels 1 through 8 on this model of the Digital Telemetry Transmitter.

A.4 Miniaturized Single Channel Model ST-364

The model ST-364 is a miniaturized, 3 component, modularized package for fixed sensor types where mounting space and/or weight is at a premium. The actual telemetry system is broken into a processor module and a transmitter module. A battery pack in a similar mold form/fit is also available for this product type. The pinouts for this product version is depicted in the following diagram.

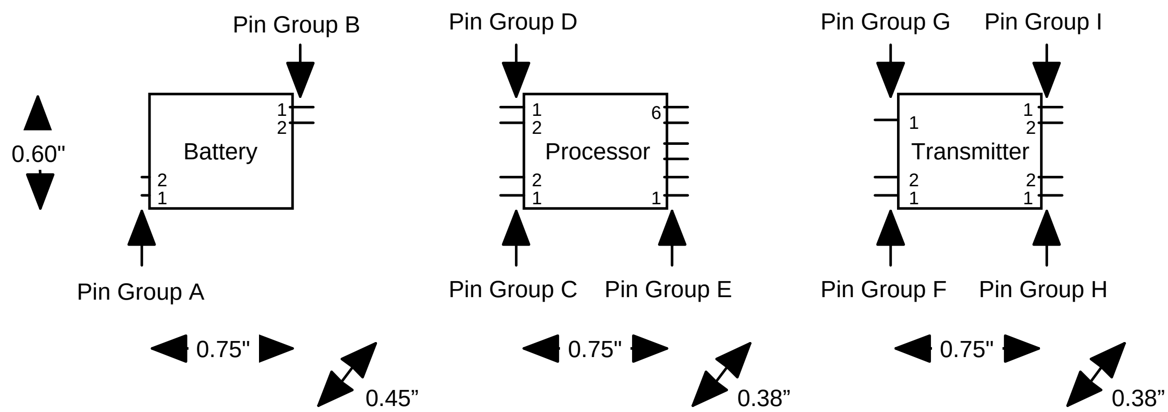


FIGURE A-4 MODEL ST-364 SINGLE SENSOR TRANSMITTER PIN LOCATIONS

The pin assignments reflected in the following table apply to this packaging style.

TABLE A-4 MODEL ST-364 TRANSMITTER PIN ASSIGNMENTS

PIN	SIGNAL	PIN	SIGNAL	PIN	SIGNAL
A1	BATTENA+	D1	EX2.5V+	F1	VCC (+5 VDC)
A2	BATTENA-	D2	EXCOM-	F2	GROUND
B1	GROUND	E1	TXDATA	G1	TXDATA
B2	VCC (+5 VDC)	E2	EX5.0V+		
		E3	GAINSEL+	H1	FREQSEL+
C1	VCC (+5 VDC)	E4	GAINSEL-	H2	FREQSEL-
C2	GROUND	E5	SIG+1		
		E6	SIG-1	I1	RFOUT-
				I2	RFOUT+

For this product version, some signals are not part of the standard set described in section 3 of this document. These signals, and other interconnect considerations for the ST-364 are as follows:

1. BATTENA+ and BATTENA- are utilized to enable the Battery Module +5 VDC output (VCC). These pins should be open when the battery pack is not being utilized or shorted together for active operation. Note – Pin Group A are the shorter pins when compared to Pin Group B on the Battery Module.
2. The VCC pins on each of the three (3) modules should be interconnected. Similarly, the GRUOND pins should also be interconnected.
3. EX2.5V+ is a 2.5 VDC excitation + signal which may be utilized for sensors just as EXCOM+ is utilized for other transmitter models. Optionally, EX5.0V+ is a 5.0 VDC excitation + signal. Although either can be utilized, the delivered system is configured for only one of the

excitation voltage levels. Refer to the configuration data delivered with the system to determine which pin to utilize.

4. TXDATA on the Processor Module should be interconnected to TXDATA on the Transmitter Module.
5. GAINSEL+ and GAINSEL- are an interconnect utilized to establish the sensor gain of the system. The appropriate resistor will be factory installed by SRI/PMD. Consult the factory for potential modifications to this resistor.
6. FREQSEL+ and FREQSEL- are an interconnect utilized to establish the transmit frequency of the Transmitter Module. The system will be delivered with a resistor installed by SRI/PMD for mid frequency range transmission. Test data supplied with the system will indicate appropriate values to select alternate transmission frequencies.
7. RFOUT+ and RFOUT- are the RF output pins from the Transmitter Module. An optional external antenna may be connected to these pins if required. RFOUT+ is the actual RF output signal from the transmitter. RFOUT- is an internal RF GROUND signal through the Transmitter Module, although it is NOT the system GROUND referenced above.

A.5 Single/Multi-Channel Model ST-325 and ST-365

The model ST-366 is a less ruggedized version of the telemetry system typically utilized for industrial or other benign type of applications. It is housed in a plastic case with rear panel connectors and a single front panel power LED. The pinouts for these product versions is depicted in the following diagram.

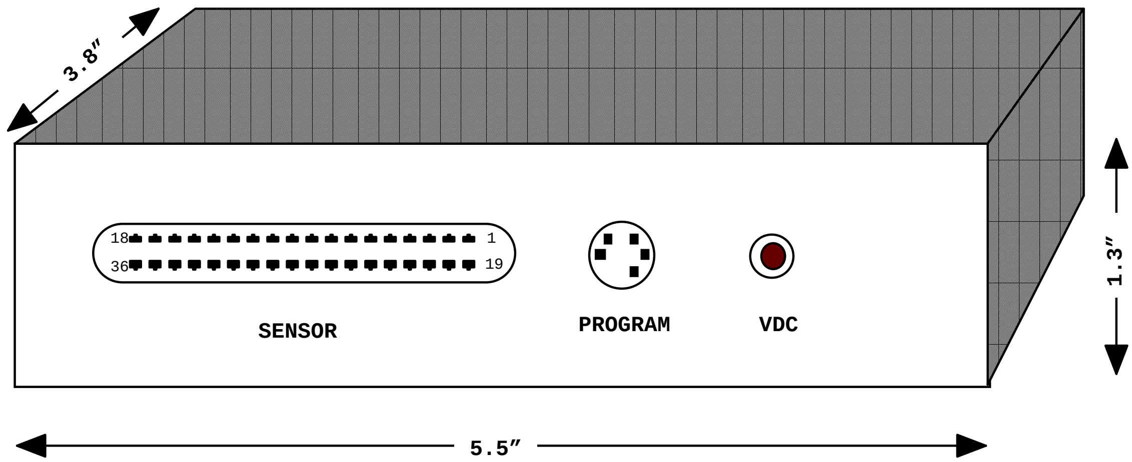


FIGURE A-5 MODEL ST-325/365 TRANSMITTER PIN LOCATIONS

The "SENSOR" connector is a 36 pin comb style connector (AMP part number 552742-1) which requires the user to provide a compatible male connector (for example, SPC Technology Type 57-30360). The pin assignments reflected in the following table apply to this packaging style.

TABLE A-5 MODEL ST-325/365 TRANSMITTER PIN ASSIGNMENTS

PIN	SIGNAL	PIN	SIGNAL	PIN	SIGNAL
VDC Inner	VCC (+7 to 18 VDC)	PROGRAM1	PROG_DAT	PROGRAM3	PROG_CLK
VDC Outer	GROUND	PROGRAM2	PROG_GND	PROGRAM4	PROG_VCC
				PROGRAM5	PROG_RESET*
SENSOR1	EXC-01	SENSOR13	SIG+05	SENSOR25	GND
SENSOR2	EXC-02	SENSOR14	SIG+06	SENSOR26	GND
SENSOR3	EXC-03	SENSOR15	SIG+07	SENSOR27	SIG-01
SENSOR4	EXC-04	SENSOR16	SIG+08	SENSOR28	SIG-02
SENSOR5	EXC-05	SENSOR17	EXC+COM	SENSOR29	SIG-03
SENSOR6	EXC-06	SENSOR18	EXC+COM	SENSOR30	SIG-04
SENSOR7	EXC-07	SENSOR19	GND	SENSOR31	SIG-05
SENSOR8	EXC-08	SENSOR20	GND	SENSOR32	SIG-06
SENSOR9	SIG+01	SENSOR21	GND	SENSOR33	SIG-07
SENSOR10	SIG+02	SENSOR22	GND	SENSOR34	SIG-08
SENSOR11	SIG+03	SENSOR23	GND	SENSOR35	EXC+COM
SENSOR12	SIG+04	SENSOR24	GND	SENSOR36	EXC+COM

APPENDIX B   TYPICAL SENSOR INTERCONNECTS

The Series 300 Digital Telemetry Systems are not usually provided with the actual sensors that they will telemeter. Most often, the end user of the product selects and installs the appropriate sensor and provides the interconnection to the Digital Telemetry Transmitter. This is typically accomplished either via direct solder connections or connectorized/header interfaces to the pins identified in appendix A of this document. The following sections describe some of the typical sensors which may be utilized with this product, and discusses the interconnect considerations for each type.

B.1 Balanced Bridge Sensors (Strain/Pressure/...)

Balanced bridge sensors are most often accomplished with sensors forming what is classically called the “Wheatstone Bridge Circuit”. As shown in the following figure, the balanced bridge is created via four (4) nominally equal resistance values, one (1) or more of which may vary with the parameter being measured (i.e. strain, pressure, ...).

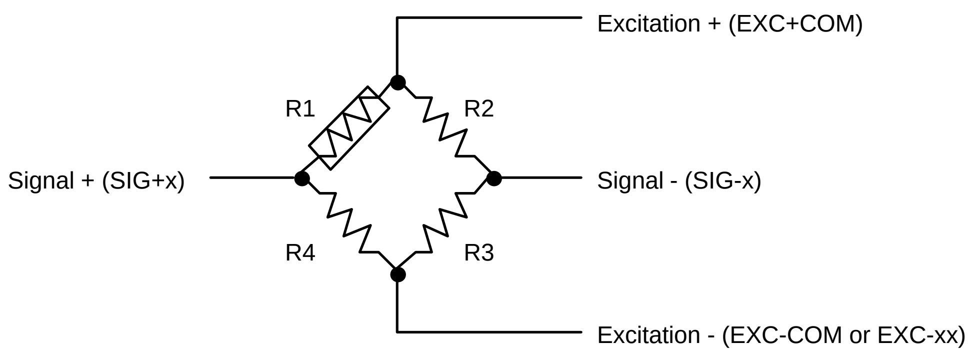


FIGURE B-1 TYPICAL BALANCED BRIDGE CIRCUIT

The figure depicts what is known as a single active arm circuit. In this case, R1 is the only arm of the balanced bridge that varies with the measurement parameter. The R1 in this case is a single active gage, widely available from a number of sensor manufacturers. R2 through R4 are fixed resistance values (typically 120, 350, or 700 ohm each), most often formed via a bridge completion circuit. Again, bridge completion circuits are available from these same manufactures.

Under nominal (i.e., zero (0) measurement value) conditions, the circuit creates a balanced, voltage divider network. As such, the excitation voltage from the Digital Telemetry Transmitter (i.e., EXC+COM and EXC-COM or EXC-x for multi-sensor channel systems) is divided in half via the path R1 to R4. This creates the positive sensor signal back to the transmitter (i.e., SIG+x). Similarly, path R2 to R3 creates the negative sensor signal (i.e., SIG-x).

As the measurement parameter varies, the resistance of the active gage varies, thus creating a small differential voltage between Signal + and Signal -. The magnitude of this differential voltage determines the actual measurement value, which is then translated through by the Digital Telemetry System to the analog output port associated with that sensor. Each system is configured at the factory for the maximum measurement range of the sensor, which determines the maximum amount of differential voltage between the + and – Signal inputs which will correspond to the maximum and minimum voltage outputs of the analog port.

Users may also incorporate sensor configurations that utilize multiple active arms. For instance, by replacing R4 with an active gage and limiting the bridge completion circuit to R2 and R3, a two (2) active arm bridge is created. With no changes to the telemetry system, this in affect doubles the resolution of the circuit while halving the maximum measurement range. For instance, a single active arm strain gage sensor may be configured to measure +/- 1000 micro-strain (uE), which would equate to 100 uE/VDC on a +/- 10 VDC analog output channel. By modifying the circuit to a two (2) active arm bridge, the analog output port will reflect 50 uE/VDC if no other parameters are modified. Similarly, a four (4) active arm system, with R1 through R4 all being accomplished via active gages with increase the resolution by 4 when compared to a single active arm system.

The Digital Telemetry System also supports selectable excitation voltage levels. This feature may be utilized to reduce the current utilization of sensors utilizing the excitation voltage. Typical sensors utilizing +5 VDC excitation will require twice as much system current as compared to a reduced excitation voltage of +2.5 VDC. However, the output differential voltage associated with any given measurement value will also be reduced by half. Although the Digital Telemetry System automatically compensates for this reduced output value by doubling the invoked gain settings, the accuracy of resulting measurements is reduced as a consequence. Note that the output excitation voltage level is a configurable parameter on a per transmitter basis. As such, this level cannot be varied for different sensor inputs to any given, single transmitter.

It is also important to note that on multi-sensor input systems, the Digital Telemetry Transmitter only activates the excitation voltage to any given sensor during the actual measurement period associated with that channel. This reduces the total power consumption of the system by eliminating current draw from sensors that are not being actively measured. The multiplexing of the excitation voltage is accomplished by allowing the excitation – voltage associated with the sensor channel (i.e., EXC-x) to float during non-active periods. In order to realize the power consumption savings of this feature, users should not incorporate sensor configurations that tie the EXC-x signal to an external ground reference.

B.2 Thermocouples

A thermocouple is a temperature measurement sensor that consists of two (2) dissimilar metals joined together at one end (i.e., a junction) that produces a small thermoelectric voltage when the junction is heated. As shown in the following figure, this thermoelectric voltage causes a differential voltage between the signal + and – inputs (i.e., SIG+x and SIG-x) to the Digital Telemetry System for the particular sensor input channel.

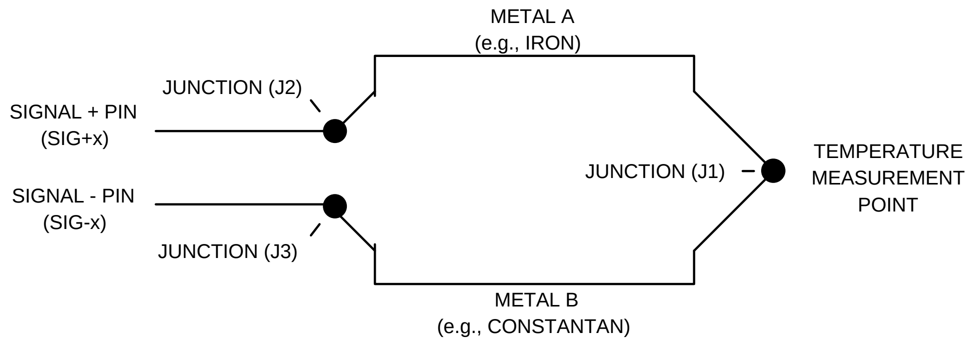


FIGURE B-2 TYPICAL THERMOCOUPLE CIRCUIT

Different types of thermocouples incorporate varying types of dissimilar metals. For instance, the Iron-Constantan version shown above is known as a type J thermocouple, while Chromel-Alumel is utilized for type K, and so forth. Each type of thermocouple provides varying levels of output differential voltages for different input measurement temperatures. When purchasing a Digital Telemetry System, the user will specify the type of thermocouple(s) being incorporated, thus allowing the factory to establish the appropriate gain settings for each sensor input.

Note that although the point labeled J1 in the diagram is the dissimilar metal junction of interest, the actual pin interconnects to the Digital Telemetry Transmitter (shown as J2 and J3 in the figure) also form dissimilar metal junctions. If the affects of junction J2 and J3 are ignored, small offsets or errors in the measurement value may be present, which will vary with the transmitters operating temperature. This may be acceptable for thermocouple applications measuring a large temperature range as compared to the variation of operating temperature for the transmitter itself.

However, any purchased Digital Telemetry System configured for one or more thermocouple sensor inputs will be calibrated with temperature compensation at the factory. As described in the main text of this document, temperature based calibration provides the means by which the systems gain and offset values will vary with operating temperature of the transmitter. This provides the means by which the temperature varying errors produced by junctions J2 and J3 are eliminated, thus producing an accurate measurement representation at the analog output port. Furthermore, end users may perform this same calibration process in the field via the Digital Telemetry Control Software.

It should be noted that under dynamically varying transmitter operational temperature conditions, there is sometimes a minor temperature differential between the Signal + and – pins (i.e., J2 and J3 in the example figure) and the detected operational temperature of the transmitter itself. This is true since the transmitter operational temperature measurement is based on an internal sensor embedded within the transmitter mold as opposed the Signal + and – pins which are located on the exterior surface of the mold. In these cases, a slight offset in sensor measurement may be present through the telemetry system until such time as the two (2) temperatures have stabilized and are equal.

B.3 Thermistors

Thermistors are sensors that vary in resistance based on temperature. This is similar to operation of a strain gage and, in fact, thermistors may incorporate balanced circuitry like the Wheatstone bridge to provide a differential voltage measurement to the Digital Telemetry System proportional to the thermistor temperature.

Thermistor circuits may also utilize a simpler voltage divider network as depicted in the following diagram.

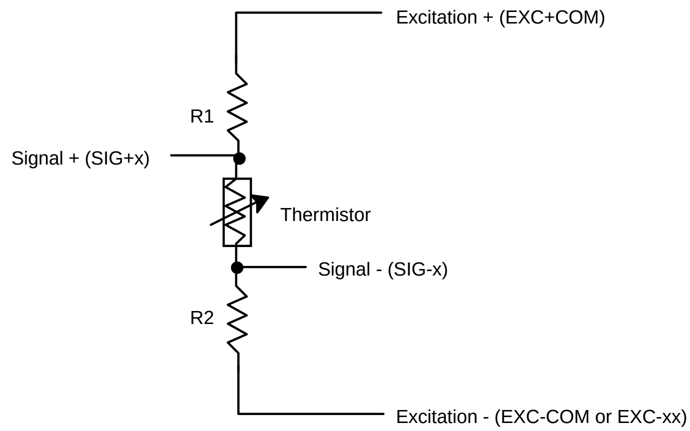


FIGURE B-3 SIMPLE THERMISTOR CIRCUIT

This circuit is typically less accurate than the balanced bridge approach, but may still be sufficient for some measurement applications.

The exact voltages which will be produced by a balanced bridge thermistor configuration or the simplified voltage divider network shown above depends on the resistance values implemented. This directly affects the necessary sensor definition for this input in the Digital Telemetry System. Users may contact SRI/PMD for assistance in determining these values and the corresponding sensor definition settings for the thermistor.

B.4 Accelerometers

Accelerometers are sensors that produce a differential voltage proportional to the acceleration forces on the sensor in a specific axis or direction. Multi-axis accelerometers are frequently utilized (bi-axial or tri-axial) to measure forces in more than one (1) direction. For applications incorporating multi-axis devices, the differential voltage outputs from each axis are typically interconnected to different sensor inputs on the Digital Telemetry System.

Most accelerometers are active devices, thus requiring an excitation voltage in order to produce the measurement output(s). They also typically require a significant amount of “power-on” initialization time before producing accurate results. This initialization or settling time is usually not compatible with the multiplexed excitation voltage of the Series 300 equipment.

To circumvent this limitation, the accelerometer power leads may be connected to EXC+COM output (which always produces a selectable DC output voltage) and the GROUND pin of the primary power input to the transmitter. By bypassing the multiplexed EXC-x outputs from the transmitter, power will be constantly provided to the sensor during transmitter operation. Users need to be aware of the extra current draw this places on the primary power source to the transmitter and adjust the associated power budget accordingly.

B.5 Other Sensor Types

As noted within the main text of this document, the Series 300 Digital Telemetry Systems can be configured for almost any type of sensor input, ranging from those which produce micro-volt DC level inputs to 0 to +5 VDC inputs. Due to the simplicity and versatility of configuring these systems, custom sensor types can also be readily accommodated.

It is important to note that for all defined sensor types other than “Generic 0 to 5 VDC” inputs, the standard product always treats the Signal + and – inputs (i.e., SIG+x and SIG-x) as differential, bipolar signals. As such, any positive or negative relationship is allowed to exist between these input signals within the configured measurement range. However, due to this implementation, neither input should ever be tied to any ground reference of the Digital Telemetry Transmitter via any path. Establishing a direct path between the input sensor signals and the transmitter ground will cause offsets that cannot be compensated for by the telemetry system.

Certain sensors require external circuitry to make them compatible with the input/output requirements of the Series 300 equipment. For example, certain piezoelectric type sensors require an external charge amplifier to produce a compatible voltage output. Similarly, some sensors require an excitation signal from a frequency source. SRI/PMD frequently delivers custom external circuitry that can readily be connected to a standard transmitter to accomplish these adaptations.

Potential users with unique or special sensor input needs should contact SRI/PMD directly for assistance in determining the suitability of the Series 300 products for these applications.