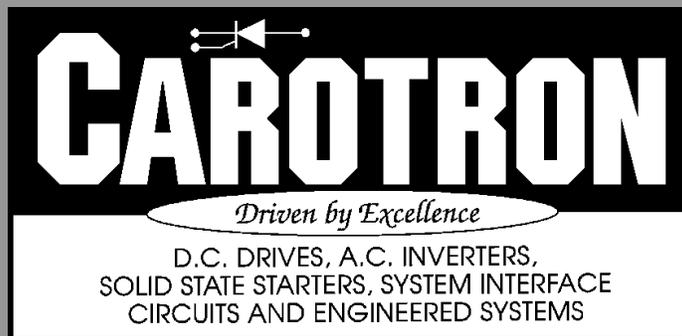


# **Sonictrac<sup>®</sup> Pro**

**Instruction Manual  
STP200-000**



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## 1 General Description

The Sonictrac® Pro Model STP200-000 is a distance measuring device that uses ultrasonic technology to detect and measure targets up to 30 feet away. An Environmental Grade electrostatic transducer combined with Carotron's microprocessor technology interface and processing circuitry provides reliable and accurate operation in a wide range of applications.

Measuring distance with ultrasonics makes use of the fact that sound travels through air at a known speed. The Sonictrac® Pro sends out a stream of ultrasonic pulses and precisely measures the time until the pulse echoes return. This round trip time period is used with the speed of sound constant to calculate an accurate distance reading.

Basic setup can be achieved by utilizing the teach input to "teach" the unit the minimum and maximum distances. Advanced functions are available by connecting the unit to a personal computer and using Carotron's STP Link software.

In linear mode, the unit outputs a voltage signal either proportional or inversely proportional to the distance. The hyperbolic mode is useful in center driven winder applications that require diameter correction in order to provide a constant material line speed.

### Additional Features

- 120VAC operation
- Two relay outputs (N.O./N.C. selectable)
- Status LEDs
- External scaling input
- No target fault detection
- Modbus® RTU communications
- Field upgradable firmware
- Clock in-out for multi unit synchronization

# 2

## Specifications

### 2.1 Electrical

#### A.C. Input Voltage Range - Single Phase

- 115 VAC  $\pm$  10%, 50/60 Hz  $\pm$  2 Hz
- Fused internally

#### Analog Input

- 10 bit resolution (over-sampled to achieve 12 bit)
- Voltage Range: 0 to +10 VDC
- Input Impedance:  $>2M\Omega$

#### Relay Outputs (2 Total)

- 2 A max
- 120VAC / 60VDC
- Jumper selectable for N.O. or N.C.

#### Analog Output

- 12 bit, 0 to +10 VDC max

#### Communications

- Modbus® RTU
- RS485 Multidrop (2 or 4 wire)

#### Temperature Range

0-55°C

### 2.2 Physical

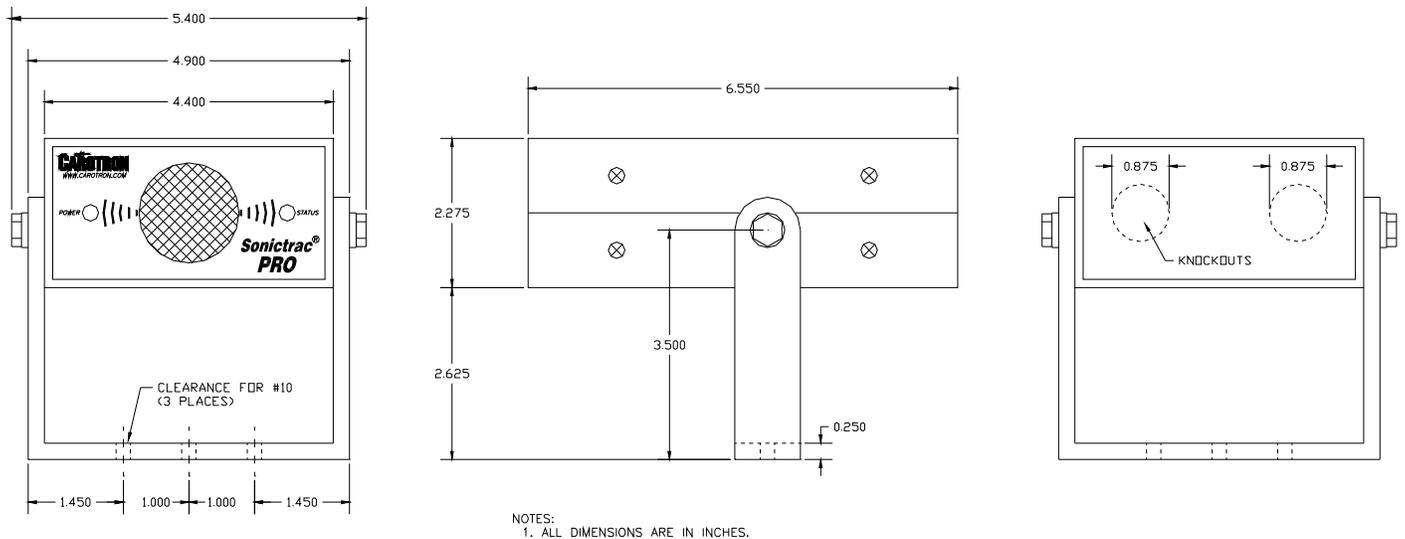


Figure 1: Physical Dimensions

# 3

## Installation

### 3.1 Installation Considerations

The Sonictrac® Pro can be mounted in any position but there are several practical suggestions that can be used to obtain the longest, most accurate and trouble-free operation.

- The ideal application would position the unit above the target with the transducer facing down. This would reduce the possibility of moisture, dust, or other contaminants from falling on the sensor and causing corrosion or reduced sensitivity.
- Rigid or vibration free mounting is desirable for accuracy and consistent output.
- Since the Sonictrac® Pro uses reflected echoes to determine distance, stronger echoes increase the likelihood of detection and accurate measurement. Positioning the flat face of the sensor parallel to flat surfaced targets will maximize the echo strength. The transmitted signal must strike and reflect directly back to the sensor.
- The actual shape of the emitted ultrasonic sound signal can be pictured as a cone with the point behind the ultrasonic sensor. The diameter of the sensor itself is 1.5 inches. At 5 feet the "cone" diameter is approximately between 12 & 18 inches. At 10 feet the diameter is approximately between 24 & 36 inches. Obviously, the size and shape of the target affect how well it is detected at the edge of the signal "cone".
- Round objects make good targets because some part of the surface is always parallel to the face of the sensor. This is true of tubular targets as long as the length dimension of the tube is parallel with the face of the sensor.
- Other sources of ultrasonic sound should be accounted for and eliminated if possible. Other Sonictrac® Pro units in close proximity should be sequenced properly. Please refer to *4.3 Dual Unit Operation* on page 8 and connection diagram D13515 on page 25. There can also be non-electrical sources of ultrasonic sound such as compressed air leaking or blown in the direction of the sensor.

### 3.2 Wiring Guidelines

---

To prevent electrical interference and to minimize start-up problems, adhere to the following guidelines:

Make no connections to ground other than at the designated terminal strip location.

Use fully insulated and shielded cable for all signal wiring. The shield should be connected to circuit common at one end only. The other end of the shield should be clipped and insulated to prevent the possibility of accidental grounding.

Signal level wiring such as listed above should be routed separately from high level wiring such as armature, field, operator control and relay control wiring. When these two types of wire must cross, they should cross at right angles to each other.

Any relay, contactor, starter, solenoid or other electro-mechanical device located in close proximity to or on the same line supply as the Sonictrac® Pro should have a transient

suppression device such as an MOV or R-C snubber connected in parallel with its coil. The suppressor should have short leads and be connected as close to the coil as possible.

### 3.3 Terminal Connections

In order to make terminal connections, the top cover must be removed. Once the 4 screws are removed, simultaneously pull each of the 4 corners out while lifting up. Refer to Figure 2 below for the basic connections. Refer to D13515 on page 25 for advanced setups using multiple units and network communications.

### 3.4 Jumpers

J1 selects the type of contact that is connected to terminal 4, either Normally Open or a Normally Closed, for Relay Output 1 (CR1).

J2 selects the type of contact that is connected to terminal 6, either Normally Open or a Normally Closed, for Relay Output 2 (CR2).

For single unit installations, J3 should be set to INT (internal). For multiple unit installations that are in close proximity to one another, one unit should be set to INT and all others should be set to EXT (external).

Jumper J4 can be used to either float circuit common (GND≠COM) or tie it to earth ground (GND=COM). The factory preset state of GND=COM typically provides for greater electrical noise immunity and improved stability of the sonic transducer.

With the jumper in this position, care should be taken to ensure that any equipment connected to the Sonictrac® Pro will not be damaged by having circuit common grounded. If non-isolated drives or any other non-isolated type equipment needs to be connected to this unit, a signal isolator (like Carotron's Model C10209-000) **MUST** be used to prevent ground faults. If an isolator is not used, the jumper **MUST** be placed in the GND≠COM position. However, Carotron does not recommend this method due to the increased likelihood of erratic sensor operation caused by electrical noise.

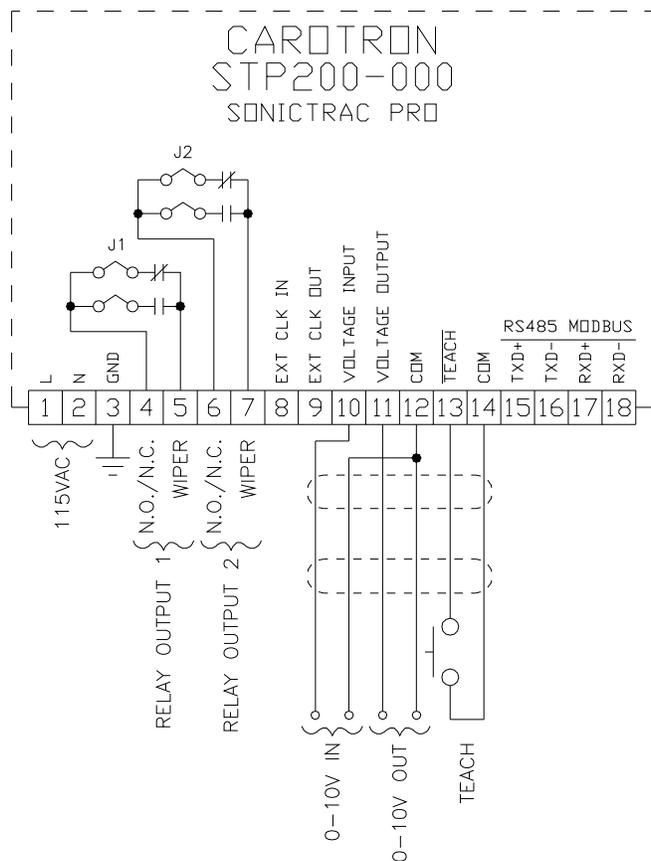


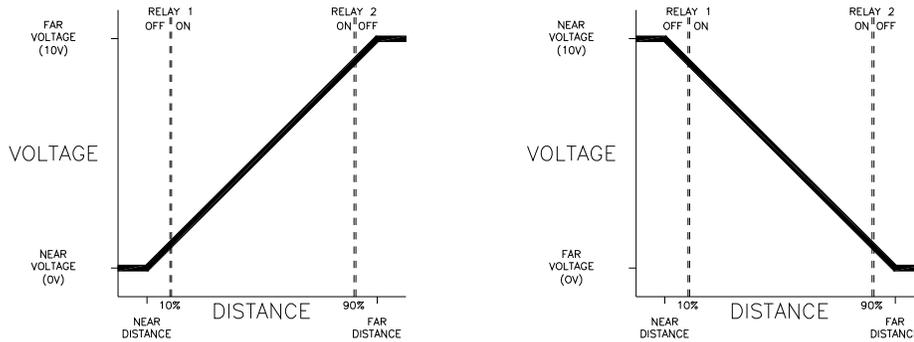
Figure 2: Terminal Connections

# 4

## Basic Setup

### 4.1 Distance Calibration

In the unit's most basic mode of operation, the unit provides a 0 to 10V signal that is proportional or inversely proportional to the detected distance. The Teach input can be used to teach the unit the Near and Far distances.



**Figure 3: Voltage vs. Distance**

Follow the steps below to teach the unit the desired 0V and 10V distances. It makes no difference in which order the distances are taught.

**NOTE: If the Sonictrac® Pro's programming is in doubt or is unknown, the unit can be returned to the factory preset configuration by powering up the device with the Teach input connected to common. Once power has been applied, disconnect the input from common.**

#### **Teach 0V Distance**

1. Adjust target to the appropriate distance where a 0V output is desired.
2. Connect the Teach input (terminal 13) to common (terminal 12 or 14).
3. Wait 5 seconds until the green Status LED starts blinking slowly.
4. Within the next 5 seconds, disconnect the Teach input terminal from common.

#### **Teach 10V Distance**

1. Adjust target to the appropriate distance where a 10V output is desired.
2. Connect the Teach input (terminal 13) to common (terminal 12 or 14).
3. Wait 5 seconds until the green Status LED starts blinking slowly.
4. Wait an additional 5 seconds until the green Status LED starts blinking rapidly.
5. Within the next 5 seconds, disconnect the Teach input terminal from common.

### 4.2 Relay Outputs

The relay outputs are pre-configured to operate at 10% and 90% of the Near and Far distances respectively. Both relays are energized when the measured distance is between 10% and 90%. Relay 1 de-energizes when the distance falls below 10%. Relay 2 de-energizes if the distance is greater than 90%. Refer to *3.4 Jumpers* on page 25 for jumper

settings J1 and J2. Refer to the Advanced Setup section below for information on modifying these thresholds.

### 4.3 Dual Unit Operation

When multiple Sonictrac® Pro units are used in close proximity to one another, a coordinated clocking scheme must be used to prevent units from interfering with each other. Two Sonictrac® Pro units can be setup and used together using only the Teach input and some additional wiring (see below). Three or more units can easily be setup with the use of Carotron's STP Link software. Refer to *5.10 Clock Control* on page 17 for details on setting up a coordinated clocking scheme on three or more units.

#### **Dual Unit Setup**

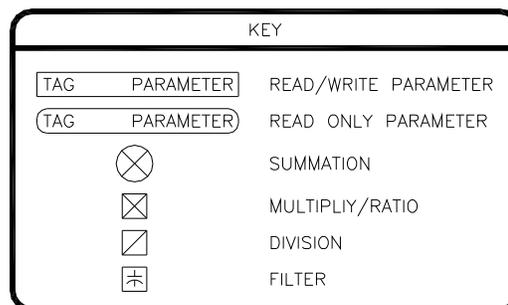
1. Wire the Ext Clock Out signal from one unit to the Ext Clock Input on the other. Refer to D13515 on page 25 for details. Initially leave Jumper J3 set to INT on both units.
2. Apply power to one unit and perform the basic distance calibration via procedure in *4.1 Distance Calibration*. Remove power when complete.
3. Repeat Step 2 on second unit.
4. Move Jumper J3 to EXT position on second unit.
5. Power can now be applied to both units. Verify that each unit outputs the desired signal levels.

## 5

# Advanced Setup

With the use of a personal computer running Carotron's STP Link software, the advanced features of the Sonictrac® Pro (STP) can be utilized. The software provides a Wizard interface to assist the user in setting up the unit.

Each parameter has a descriptive name and a tag (or number) identifier. The following sections contain each software block diagram and descriptions of each parameter function. Refer to Figure 4 below for key conventions that are used in the block diagrams. Each parameter is either a Read-Only (RO) or Read-Write (RW). Remember that parameter changes must be saved by setting Save (parameter 1) to 1.



**Figure 4: Block Diagram Key**

## 5.1 Distance Measurement

### **Actual Distance (32, Read Only)**

The Sonictrac® Pro sends out a burst of ultrasonic pulses, and then waits for an echo. Distance is calculated by measuring the time it takes for the echo to return. This parameter displays the current distance measured by the unit in inches. If no valid echo is received (Echo Received is False), the last valid distance is displayed.

### **Distance Offset (31, Read-Write, default: 0)**

An offset can be applied to the measured distance to calibrate the **Actual Distance** reading. With a target at a known distance from the unit, this parameter can be adjusted until the **Actual Distance** parameter is equal to the actual distance to the target.

### **Echo Received (38, Read Only)**

This value is True when valid echoes are being received and False otherwise. An echo is considered valid if its calculated distance is  $\geq$  Min Range and  $\leq$  Max Range.

### **Distance Filter (30, Read-Write, default: 4)**

A filter can be applied to the calculated distance to average the readout. A value of 0 turns off the filter while a value of 15 is very heavily filtered.

### **Min Range (24, Read-Write, default: 4.90")**

This defines the minimum distance that the unit can measure. For proper operation, this value should be set at least 1.1 inches less than the **Near Distance**.

### **Max Range (25, Read-Write, default: 420.00")**

This defines the maximum distance that the unit can measure. For proper operation, this value should be set at least 1.1 inches greater than the **Far Distance**.

### **Near Distance (28, Read-Write, default: 6.00")**

This defines the distance where the **Near Voltage** level is output. For proper operation this value should be less than the **Far Distance**.

### **Far Distance (29, Read-Write, default: 420.00")**

This defines the distance where the **Far Voltage** level is output. For proper operation this value should be greater than the **Near Distance**.

## 5.2 Voltage Output

---

### **Output Mode (39, Read-Write, default: Linear)**

#### **0=MANUAL**

In the manual mode, the output voltage is controlled by **Manual Output**. This mode is typically used in conjunction with the serial port to remotely control the voltage output.

### 1=LINEAR (default)

The output voltage is linearly proportional (or inversely proportional) to the measured distance.

### 2=HYPERBOLIC

A hyperbolic curve based on distance is used to generate the voltage output. This mode is useful when the unit is used with a center driven winder/unwinder. Refer to *5.6 Diameter Measurement* on page 14 for additional details.

### 3=TABLE

A lookup table is used to generate the voltage output. See below for details.

#### Manual Output (40, Read-Write, default: 0)

When **Output Mode** is set to *Manual*, this parameter can be used to manually set the voltage output. This is a raw data value. Zero equates to zero volts, and 4095 equates to 10V.

#### Linear Output (41, Read Only, default: 0)

This status parameter displays the raw data value derived from the distance to voltage conversion. This is a raw data value where zero equates to zero volts and 4095 equates to 10V. **Output Mode** must be set to *Linear* for this value to be used.

#### Hyperbolic Output (42, Read Only, default: 0)

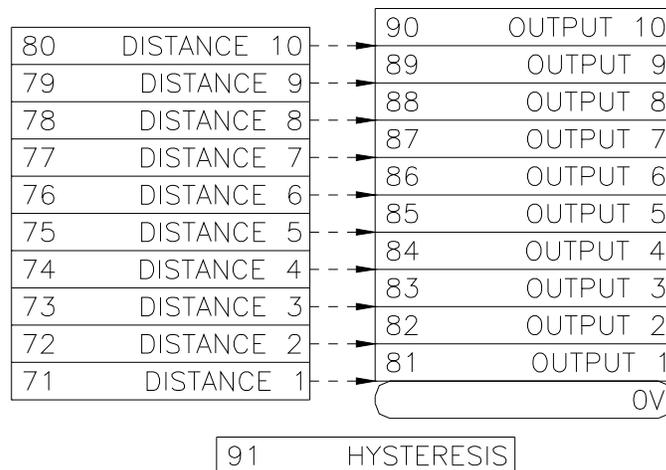
Refer to *5.6 Diameter Measurement* on page 14.

#### Table Distance 1-10 (71-80, Read-Write)

#### Table Output 1-10 (81-90, Read-Write)

#### Table Hysteresis (91, Read-Write)

A lookup table is used to generate the voltage output. The table (Figure 5) consists of 10 input distances and 10 output levels. If the **Actual Distance** is less than **Distance 1**, 0V is output. If the **Actual Distance** is greater than **Distance 1** but less than **Distance 2**, the **Output 1** level is output, etc... The Output levels are set in raw data values where zero equates to zero volts and 4095 equates to 10V.



**Figure 5: Lookup Table**

The **Hysteresis** parameter is used to prevent the output from switching rapidly between two adjacent output levels when the **Actual Distance** reading is near one of the **Distance** points. For example, without hysteresis, when the **Actual Distance** value is near the **Distance 4** setpoint, the output level may switch between the **Output 3** and **Output 4** levels.

**Near Voltage (36, Read-Write, default: 0.00V)**

This defines the **Linear Output** voltage level when the **Actual Distance** is equal to the **Near Distance**.

**Far Voltage (37, Read-Write, default: 10.00V)**

This defines the **Linear Output** voltage level when the **Actual Distance** is equal to the **Far Distance**.

**Output Filter (44, Read-Write)**

Sets the level of averaging applied to the output signal.

**Output Status (45, Read Only)**

The raw digital to analog value. A value of 0 equates to 0V and a value of 4095 equates to 10V.

**Output Voltage (46, Read Only)**

This status parameter displays the commanded voltage output level.

### 5.3 Voltage Input

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**Input Status (47, Read Only)**

This status parameter displays the raw analog to digital value based on the input voltage on terminal 10. A value of 0 equates to 0V and a value of 4092 equates to 10V.

**Input Voltage (48, Read Only)**

This status parameter displays the voltage level on terminal 10.

**0% Calibration (49, Read-Write, default: 0)**

The level of **Input Status** that defines 0% signal. Apply the minimum input signal to terminal 10. Set this parameter equal to the current value of **Input Status**.

**100% Calibration (50, Read-Write, default: 4092)**

The level of **Input Status** that defines 100% signal. Apply the maximum input signal to terminal 10. Set this parameter equal to the current value of **Input Status**.

**Input Filter (51, Read-Write, default: 0)**

Sets the level of averaging applied to the voltage input signal.

**External Scaling (52, Read Only)**

This status parameter displays the calibrated and filtered external voltage input. A properly calibrated signal will range from 0% at minimum input to 100% with

maximum input.

### **Scaling Select (53, Read-Write, default: Internal)**

#### **0=INTERNAL (default)**

The output voltage level is not affected by the input voltage on terminal 10.

#### **1=EXTERNAL**

The output voltage level is scaled by the input voltage on terminal 10.

## 5.4 Relay Outputs

---

Jumpers J1 and J2 select the type of relay contact (Normally Open or Normally Closed) on terminals 4 and 6 respectively.

### **Relay 1 & 2 Mode (54-55, Read-Write, default: Distance)**

This parameter determines the function of the relay output. Each mode is described in detail below:

#### **0=OFF**

This mode de-energizes the relay. This mode is typically used in conjunction with the serial port to manually control the relay.

#### **1=ON**

This mode energizes the relay. This mode is typically used in conjunction with the serial port to manually control the relay.

#### **2=DISTANCE (default)**

In this mode, the relay energizes or de-energizes based on the distance measured by the sonic transducer. The **On Threshold** and **Off Threshold** values to determine the switching points of the relay.

#### **3=NO ECHO**

The relay remains energized as long as a valid echo is received. The relay de-energizes if no echo is received. The relay will re-energize once a valid echo is again detected.

#### **4=FAULT**

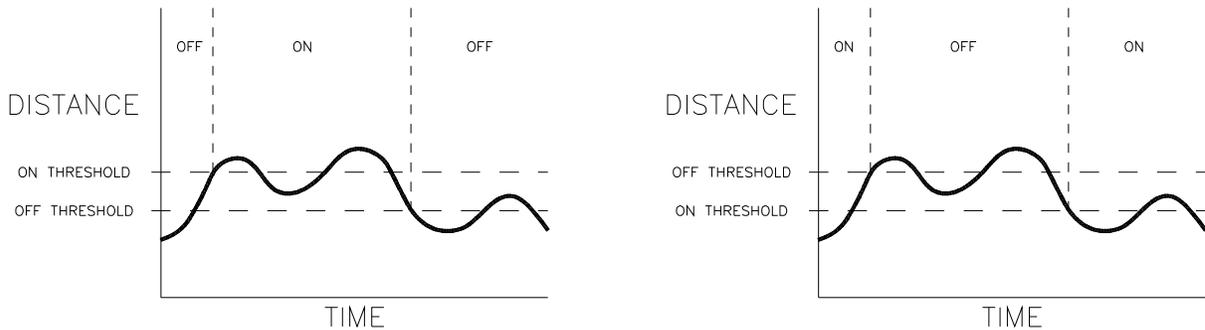
The relay is energized when no fault is present. A fault de-energizes the relay. Refer to *5.5 Fault Logic* on page 13 for additional info on faults.

### **Relay 1 & 2 On & Off Thresholds (56-59, Read-Write)**

When the **Relay Mode** is set to *Distance*, the **On Threshold** and **Off Threshold** determine the energize and de-energize levels. Each relay has an On and an Off Threshold. Two thresholds are provided instead of a single turn on/off threshold to prevent rapid switching of the relay while operating around the threshold. The difference between these thresholds is called hysteresis. The On and Off Thresholds can also be used to invert the logic of the relay.

In the first example below, the relay is initially off since Distance is below the Off Threshold. The relay remains off until the Distance reaches the On Threshold. Now that the relay is on, it does not turn off until the Distance falls below the Off Threshold. There is no change in the state of the relay when the distance is in the hysteresis region (area between the On and Off Thresholds).

The second example is identical to the first except the On and Off Threshold values have been reversed. This reversal inverts the logic state of the relay.



**Figure 6: Relay Thresholds**

#### **Relay 1 & 2 Status (60-61, Read Only)**

This status parameter displays the current state of the relay (On or Off).

### 5.5 Fault Logic

---

#### **Fault Time (63, Read-Write, default: 1.0 sec)**

This parameter sets the amount of time before a fault is generated whenever the unit does not receive valid echoes.

#### **Fault Status (64, Read Only)**

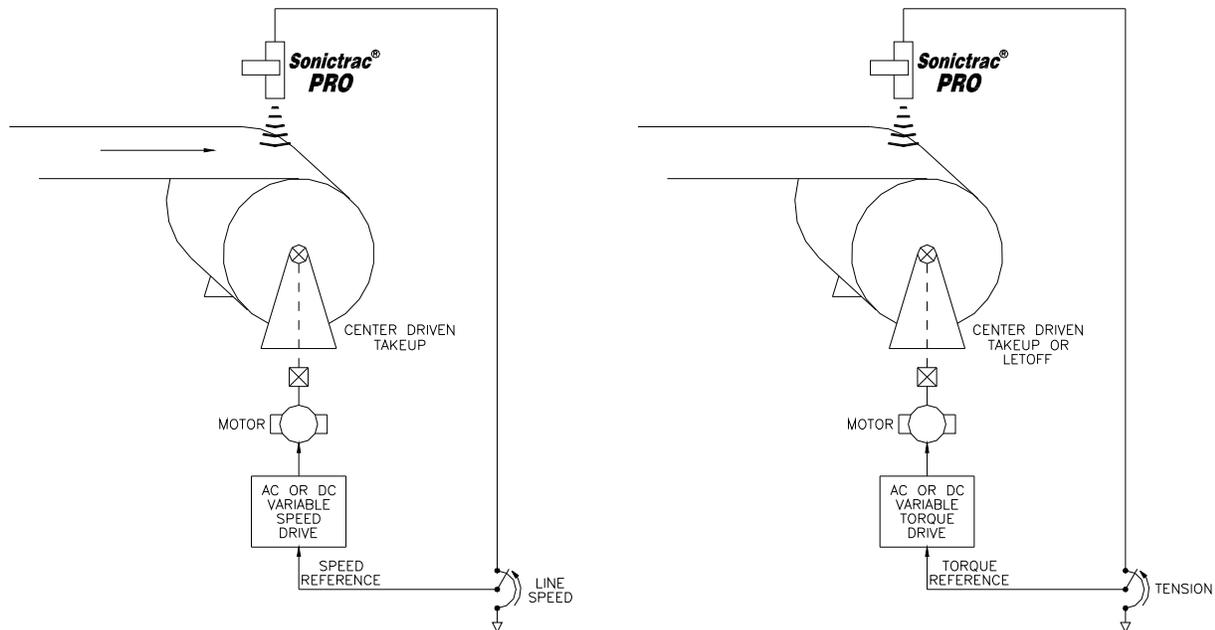
This parameter displays the current fault state. A True level indicates the unit is in a fault condition. When this occurs, any relay output that has its mode parameter set to Fault will de-energize. The fault can be cleared by momentarily connecting the Teach input to common or via the serial port by using the **Fault Reset** parameter.

#### **Fault Reset (62, Read-Write, default: False)**

Momentarily setting this parameter to True resets **Fault Status**. This parameter is typically used in conjunction with the serial port to remotely reset a fault condition.

## 5.6 Diameter Measurement

A common application for the Sonictrac® Pro is to measure the diameter of a center-driven takeup (winder) or letoff (unwinder). The STP can be used with industrial drives that operate in either torque or velocity modes.



**Figure 7: Diameter Measurement**

The STP can be used in velocity takeup (winder) applications where the winder sets the line speed. In this type of application, the STP outputs the required velocity reference so that the material speed remains constant. This is achieved by setting the **Output Mode** to *Hyperbolic*.

In the torque mode, the STP outputs a torque reference that is proportional to the measured diameter in order to maintain constant tension. The **Output Mode** must be set to *Linear*.

In either case, a potentiometer wired in series with the STP output then becomes the tension or line speed adjustment. The setup Wizard in Carotron's STP Link software can be used to easily setup these applications.

### **Core Diameter (33, Read-Write, default: 1.00 inches)**

Enter the diameter of an empty core in inches. If multiple size cores are used, enter the smallest.

### **Max Diameter (34, Read-Write, default: 10.00 inches)**

Enter the diameter of the largest full roll in inches. If multiple size rolls are used, enter the largest.

### **Diameter (35, Read Only)**

A status display of the currently sensed diameter.

### **Hyperbolic Output (42, Read Only)**

This is a status display of the hyperbolic diameter calculator output. The Output Mode parameter must be set to Hyperbolic for this output to be used.

## 5.7 Communications

---

The Sonictrac® Pro is equipped with a Modbus® RTU RS485 slave port. The port can operate in 2 or 4 wire mode. Refer to D13515 on page 25 for connection information. Refer to Section 7.1 *Modbus® Protocol* on page 28 for more details.

### **Network Address (65, Read/Write, default: 1)**

The address of the Sonictrac® Pro on the Modbus® network. Each device on the bus must have a unique network address.

### **Baud Rate (66, Read/Write, default: 4)**

Sets the transmit and receive rate of data over the serial port.

| Setting  | Baud         |
|----------|--------------|
| 0        | 2400         |
| 1        | 4800         |
| 2        | 9600         |
| 3        | 19200        |
| <b>4</b> | <b>38400</b> |

**Table 1: Baud Rate Settings**

### **Parity/Stop Bits (67, Read/Write, default: 1)**

Sets the parity and number of stop bits for the serial port.

| Setting  | Parity, Stop Bits |
|----------|-------------------|
| 0        | None,1            |
| <b>1</b> | <b>None,2</b>     |
| 2        | Even,1            |
| 3        | Odd,1             |

**Table 2: Parity Stop Bits Settings**

### **Addressing Mode (68, Read/Write, default: 1)**

In the Modbus® specification, registers are addressed using an offset. For example, to read register 1, an address of 0 must be used. Much of the available Modbus® master communications equipment (PLC's and touchscreens) take this offset into account. Therefore, to read register 1, an address of 1 is used when programming. The master device will decrement the address before requesting it from the slave.

However, not all master devices take this offset into account. The **Addressing Mode** parameter can be used to implement either scheme and "match up" the addresses so that the actual address is used to address that register (making the master programming much easier).

In order to determine which mode to use with a particular master, have the master read the **Address Mode Test 2** parameter. If the returned value is 0xAAAA in hex, everything is correct. If the returned value is 0x5555 (the value of **Address Mode Test 1**), then the **Addressing Mode** parameter needs to be changed.

#### **Addressing Mode Test 1 (69, Read Only)**

Test parameter that has a fixed value of 21845 (5555 in hex) .

#### **Addressing Mode Test 2 (70, Read Only)**

Test parameter that has a fixed value of 43690 (AAAA in hex) .

### 5.8 Auxiliary Parameters

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The Sonictrac® Pro provides 10 auxiliary parameters for general use. A Modbus® master can read/write to these parameters at addresses 92 through 101.

### 5.9 System Parameters

---

#### **Save (1, Read/Write, default: 0)**

When parameters are changed in the Sonictrac® Pro via the communications port, the changes take affect immediately. However, if not saved, these changes will be lost if power is cycled or the unit is reset. Parameters can be saved by setting this parameter to one. Once saved, the Sonictrac® Pro will automatically reset this value back to zero.

#### **Save Status (2, Read Only, default: 0)**

When a Save command has been given, this parameter displays the status of the save operation.

| Value | Status             |
|-------|--------------------|
| 0     | Saved Successfully |
| 1     | Save In Progress   |
| 2     | Save Error         |

**Table 3: Save Status**

#### **Re-Initialize (3, Read/Write, default: 0)**

The Sonictrac® Pro can be returned to its factory preset state by setting this parameter to one. All parameters will be returned to their default setting. The unit may also be re-initialized by powering up the unit with the Teach input connected to common.

#### **Custom Code (LSW) (4, Read Only, default: 0)**

#### **Custom Code (MSW) (5, Read Only, default: 0)**

Carotron can provide the Sonictrac® Pro with custom firmware to meet your specific custom application needs. In these cases, the Custom Code parameters are used to identify the custom firmware. Please contact Carotron for additional details.

#### **Processor ID (6, Read Only)**

Identification code for the internal processor. For engineering use only.

**Processor Revision (7, Read Only)**

Hardware revision of the internal processor. For engineering use only.

**Firmware Version (8, Read Only)**

Version code of the internal firmware.

**Boot Firmware Version (9, Read Only)**

Version code of the internal boot firmware.

**System Status (10, Read Only)**

Status register that provides the source of the most recent reset. For engineering use only.

| System Status | Description          |
|---------------|----------------------|
| 1             | Brown Out Reset      |
| 2             | Power On Reset       |
| 4             | Power Down Detection |
| 8             | Watchdog Timeout     |
| 16            | Reset Instruction    |

**Table 4: System Status Readings**

**Board Revision (11, Read Only)**

Version code of the printed circuit board (PCB).

**Total Parameters (12, Read Only)**

The total number of parameters.

**Teach Status (x, Read Only)**

This parameter displays the status of the Teach input on terminal 13. *Off* indicates that Teach is not connected to common. *On* indicates that the Teach input is connected to common.

5.10 Clock Control

---

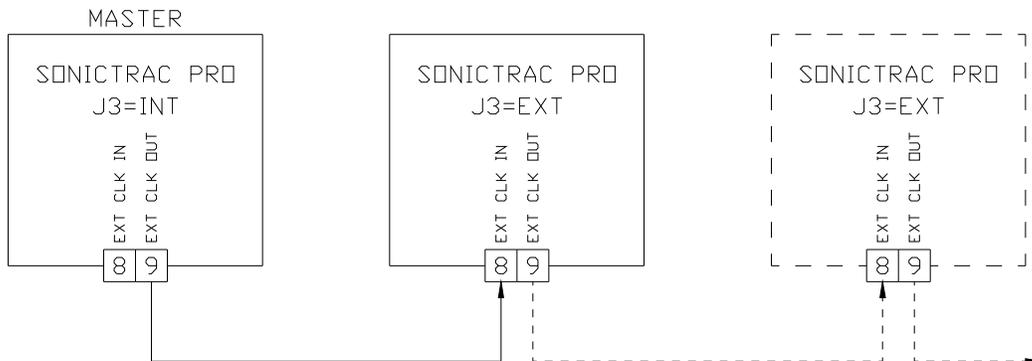
When used as a standalone unit, the Sonictrac® Pro uses an internally generated clock that controls the sonic transducer. Jumper J3 should be set to INT (internal) for this mode of operation.

When multiple Sonictrac® Pro units are used in close proximity to one another, a coordinated clocking scheme must be used in order to prevent the ultrasonic signal from one unit interfering with other units. In these cases, one Sonictrac® Pro is designated as the Master and its jumper J3 should be set to INT. All other units must have their jumper J3 set to EXT (external).

The master unit uses its own internally generated clock signal for its ultrasonic transmission. The master's External Clock Output signal on terminal 9 is used to trigger the transmission of the next Sonictrac® Pro unit via its External Clock Input on terminal 8. Additional units are simply daisy chained. The Transmit Delay adjustment on the Master unit must be set long enough to allow all of the slave units to perform their transmission and reception.

**Multi-Unit Setup Procedure**

1. Wire the Ext Clock Out and Ext Clock In signals per drawing D13515 on page 25. Initially leave Jumper J3 set to INT on all units.
2. Connect communication cable and apply power to one slave unit only and perform the basic distance calibration via the setup Wizard in the STP Link software. When complete, make a note of the Max Range (parameter 25) and Transmit Delay Low (parameter 21) values. Remove power from the Sonictrac® Pro and move Jumper J3 to the EXT position.
3. Repeat Step 2 for each of the slave Sonictrac® Pro units.
4. Apply power to the master unit and perform the basic distance calibration via the setup Wizard. When complete, select Transmit Delay Calculator from the Tools pull-down menu. Enter the sums of the Max Range and the Transmit Delay Low values in the appropriate fields. Click the 'Write above values to the Transmit Delay parameters' button and then click 'Close'.
5. Power can now be applied to all units. Verify that each unit outputs the desired signal levels.



**Figure 8: Multi-Unit Sync**

**Clock Select (20, Read Only, default: Internal)**

This status parameter reflects the current jumper J3 selection of internal or external.

**External Clock In Status (19, Read Only, default: Off)**

This status parameter reflects the current state of the External Clock input on terminal 8.

**Transmit Delay (LSW) (21, Read-Write, default: 3000)**

**Transmit Delay (MSW) (22, Read-Write, default:1 )**

These parameters determine the amount of time the unit delays before initiating an ultrasonic transmission. When the unit is in the external clock mode (J3=EXT), the delay begins when the Ext Clock Input signal transitions from high to low. In the internal mode (J3=INT), the delay begins after the previous transmission is complete. Refer to Figure 9 below.

In order to provide a wide range of adjustment, the delay value is composed of a 32 bit number made up of two 16 bit words (designated Most Significant Word and Least Significant Word). The total delay time is determined by one of the formulas below dependent upon the position of Jumper J3.

$$J3=INT: \text{Total Delay(ms)} = (TD[MSW]*65536+TD[LSW])/1000$$

$$J3=EXT: \text{Total Delay(ms)} = TD[LSW]/1000$$

where TD[MSW] and TD[LSW] are the most significant and least significant Transmit Delay values.

For single and dual (synchronized) installations, the default values should be satisfactory. In multi-unit installations, the Transmit Delay on the master unit must be set long enough to allow all slave units to transmit and receive before the master unit re-initiates its own transmission. The STP Link software provides a Transmit Delay Calculator to assist in setting this value properly.

### **Clock Out Select (23, Read-Write, default: Clock Out)**

The External Clock Output signal on terminal 9 is typically used to sequence the ultrasonic transmissions in multiple unit installations. The output is an open-collector transistor. A pull-up resistor may be required if interfacing this output to equipment other than a Sonictrac® Pro.

#### **0=OFF**

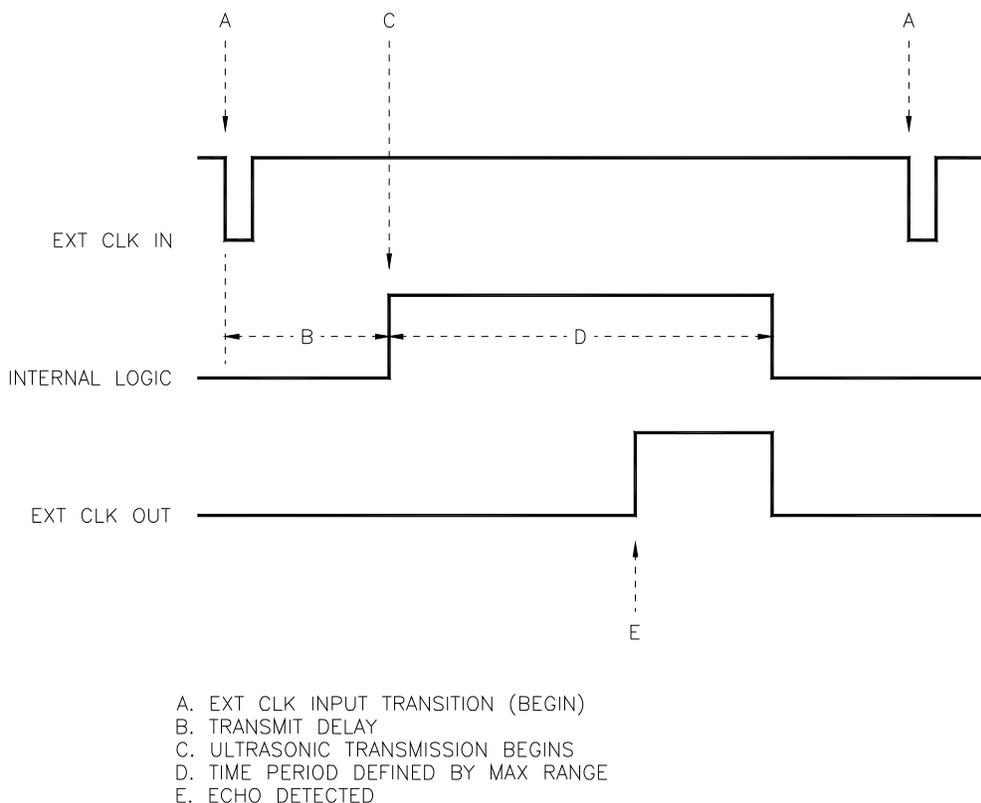
This mode turns off the output transistor. This mode is typically used in conjunction with the serial port to manually control the output.

#### **1=ON**

This mode turns on the output transistor. This mode is typically used in conjunction with the serial port to manually control the output.

#### **2=CLOCK OUT (default)**

In this mode, the output transistor is internally controlled by the STP to allow sequencing of multiple units in close proximity. The transistor is initially on (displayed as a low level below) when a ultrasonic transmission begins. When an echo is detected, the transistor turns off (transition from low to high below at point E). At the end of the period defined by Max Range, the transistor turns on.



**Figure 9: Clock Out Waveform**

## 5.11 Parameter Table

**Table 5: Parameter List**

| Tag | Name                      | Min  | Max     | Preset     | Type | User |
|-----|---------------------------|--|---------|------------|------|------|
| 0   | Trash                     | 0  | 65535   | 0          | RW   |      |
| 1   | Save                      | 0  | 1       | 0          | RW   |      |
| 2   | Save Status               | 0  | 2       | 0          | RO   |      |
| 3   | Re-Initialize             | 0  | 65535   | 0          | RW   |      |
| 4   | Customization Code (low)  | 0  | 65535   | 0          | RO   |      |
| 5   | Customization Code (high) | 0  | 65535   | 0          | RO   |      |
| 6   | Processor ID              | 0  | 2047    | 0          | RO   |      |
| 7   | Processor Hardware Rev.   | 0  | 31      | 0          | RO   |      |
| 8   | Firmware Version          | 0.00   | 99.99   | ◆          | RO   |      |
| 9   | Boot Version              | 0.00   | 99.99   | ◆          | RO   |      |
| 10  | System Status             | 0  | 65535   | 0          | RO   |      |
| 11  | Board Revision            | 0  | 65535   | 0          | RO   |      |
| 12  | Total Parameters          | 0  | 65535   | 102        | RO   |      |
| 13  | Reserved                  | 0  | 65535   | 0          | RO   |      |
| 14  | Reserved                  | 0  | 65535   | 0          | RO   |      |
| 15  | Reserved                  | 0  | 65535   | 0          | RO   |      |
| 16  | Reserved                  | 0  | 65535   | 0          | RO   |      |
| 17  | Reserved                  | 0  | 65535   | 0          | RO   |      |
| 18  | Teach Status              | 0:OFF  | 1:ON    | 0:OFF      | RO   |      |
| 19  | Ext Clock In Status       | 0:OFF  | 1:ON    | 0:OFF      | RO   |      |
| 20  | Clock Select              | 0:INT  | 1:EXT   | 0:INT      | RO   |      |
| 21  | Transmit Delay (low)      | 0  | 65535   | 3000       | RW   |      |
| 22  | Transmit Delay (high)     | 0  | 65535   | 1          | RW   |      |
| 23  | Clock Out Select          | 0: OFF<br>1: ON<br><b>2: CLK OUT</b>                       |         | 2: CLK OUT | RW   |      |
| 24  | Min Range                 | 4.90"  | 420.00" | 4.94"      | RW   |      |
| 25  | Max Range                 | 6.00"  | 420.00" | 420.00"    | RW   |      |
| 26  | 0V Distance               | 6.00"  | 420.00" | 6.00"      | RO   |      |
| 27  | 10V Distance              | 6.00"  | 420.00" | 420.00"    | RO   |      |
| 28  | Near Distance             | 6.00"  | 420.00" | 6.00"      | RW   |      |
| 29  | Far Distance              | 6.00"  | 420.00" | 420.00"    | RW   |      |
| 30  | Distance Filter           | 0  | 15      | 4          | RW   |      |
| 31  | Distance Offset           | -5.00"   | 5.00"   | 0.00"      | RW   |      |
| 32  | Actual Distance           | 6.00"  | 420.00" | 6.00"      | RO   |      |
| 33  | Core Diameter             | 0.01"  | 200.00" | 1.00"      | RW   |      |
| 34  | Max Diameter              | 0.01"  | 200.00" | 10.00"     | RW   |      |
| 35  | Diameter                  | 0.01"  | 200.00" | 0.01"      | RO   |      |
| 36  | Near Voltage              | 0.00V  | 10.00V  | 0.00V      | RW   |      |
| 37  | Far Voltage               | 0.00V  | 10.00V  | 10.00V     | RW   |      |
| 38  | Echo Received             | 0: FALSE   | 1: TRUE | 0: FALSE   | RO   |      |
| 39  | Output Mode               | 0: MANUAL<br><b>1: LINEAR</b><br>2: HYPERBOLIC<br>3: TABLE |         | 1: LINEAR  | RW   |      |
| 40  | Manual Output             | 0  | 4095    | 0          | RW   |      |
| 41  | Linear Output             | 0  | 4095    | 0          | RO   |      |
| 42  | Hyperbolic Output         | 0  | 4095    | 0          | RO   |      |
| 43  | Table Output              | 0  | 4095    | 0          | RO   |      |
| 44  | Output Filter             | 0  | 15      | 0          | RW   |      |
| 45  | Output Status             | 0  | 4095    | 0          | RO   |      |
| 46  | Output Voltage            | 0.00V  | 10.00V  | 0.00V      | RO   |      |
| 47  | Input Status              | 0  | 4092    | 0          | RO   |      |

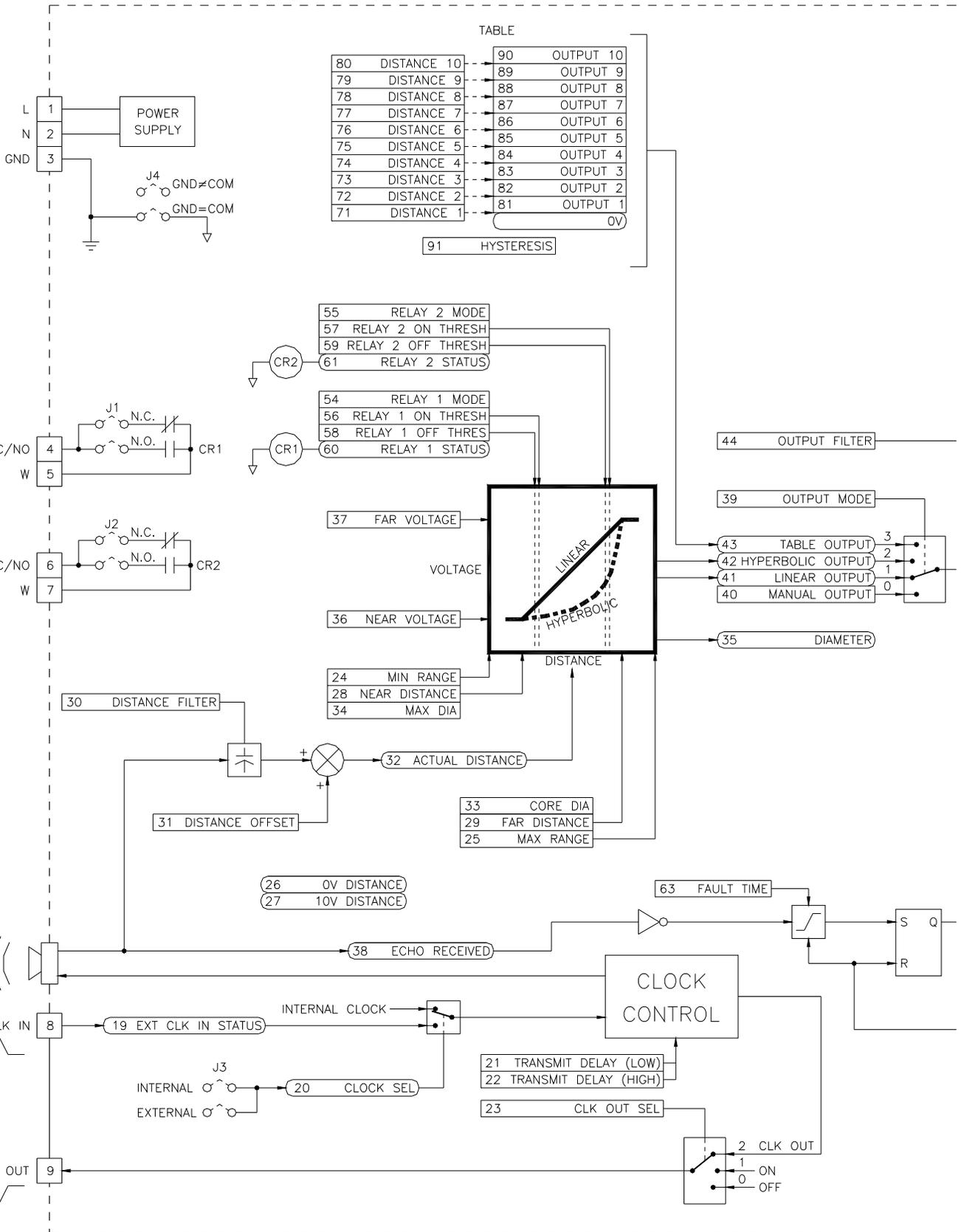
|    |                        |   |         |           |    |  |
|----|------------------------|---|---------|-----------|----|--|
| 48 | Input Voltage          | 0.00V   | 10.00V  | 0.00V     | RO |  |
| 49 | Input 0% Calibration   | 0   | 4092    | 0         | RW |  |
| 50 | Input 100% Calibration | 0   | 4092    | 4092      | RW |  |
| 51 | Input Filter           | 0   | 15      | 0         | RW |  |
| 52 | Ext Scaling            | 0.00%   | 100.00% | 0.00%     | RO |  |
| 53 | Scaling Sel            | 0: INT  | 1: EXT  | 0: INT    | RW |  |
| 54 | Relay 1 Mode           | 0: OFF<br>1: ON<br><b>2: DISTANCE</b><br>3: NO ECHO<br>4: FAULT |         | 2         | RW |  |
| 55 | Relay 2 Mode           |   |         | 2         | RW |  |
| 56 | Relay 1 On Threshold   | 6.00"   | 420.00" | 7.00"     | RW |  |
| 57 | Relay 2 On Threshold   | 6.00"   | 420.00" | 419.00"   | RW |  |
| 58 | Relay 1 Off Threshold  | 6.00"   | 420.00" | 7.00"     | RW |  |
| 59 | Relay 2 Off Threshold  | 6.00"   | 420.00" | 419.00"   | RW |  |
| 60 | Relay 1 Status         | 0: OFF  | 1: ON   | 0: OFF    | RO |  |
| 61 | Relay 2 Status         | 0: OFF  | 1: ON   | 0: OFF    | RO |  |
| 62 | Fault Reset            | 0: FALSE  | 1: TRUE | 0: FALSE  | RW |  |
| 63 | Fault Time             | 0.0s  | 20.0s   | 1.0s      | RW |  |
| 64 | Fault Status           | 0: FALSE  | 1: TRUE | 0: FALSE  | RO |  |
| 65 | Network Address        | 1   | 247     | 1         | RW |  |
| 66 | Baud Rate              | 0: 2400<br>1: 4800<br>2: 9600<br>3: 19200<br><b>4: 38400</b>    |         | 4: 38400  | RW |  |
| 67 | Parity/Stop Bits       | 0: None,1<br><b>1: None,2</b><br>2: Even, 1<br>3: Odd,1         |         | 1: None,2 | RW |  |
| 68 | Addressing Mode        | 0   | 1       | 1         | RW |  |
| 69 | Address Mode Test 1    | 21845   | 21845   | 21845     | RO |  |
| 70 | Address Mode Test 2    | 43690   | 43690   | 43690     | RO |  |
| 71 | Table Distance 1       | 6.00"   | 420.00" | 10.00"    | RW |  |
| 72 | Table Distance 2       | 6.00"   | 420.00" | 20.00"    | RW |  |
| 73 | Table Distance 3       | 6.00"   | 420.00" | 30.00"    | RW |  |
| 74 | Table Distance 4       | 6.00"   | 420.00" | 40.00"    | RW |  |
| 75 | Table Distance 5       | 6.00"   | 420.00" | 50.00"    | RW |  |
| 76 | Table Distance 6       | 6.00"   | 420.00" | 60.00"    | RW |  |
| 77 | Table Distance 7       | 6.00"   | 420.00" | 70.00"    | RW |  |
| 78 | Table Distance 8       | 6.00"   | 420.00" | 80.00"    | RW |  |
| 79 | Table Distance 9       | 6.00"   | 420.00" | 90.00"    | RW |  |
| 80 | Table Distance 10      | 6.00"   | 420.00" | 100.00"   | RW |  |
| 81 | Table Output 1         | 0   | 4095    | 819       | RW |  |
| 82 | Table Output 2         | 0   | 4095    | 1638      | RW |  |
| 83 | Table Output 3         | 0   | 4095    | 2457      | RW |  |
| 84 | Table Output 4         | 0   | 4095    | 3276      | RW |  |
| 85 | Table Output 5         | 0   | 4095    | 4095      | RW |  |
| 86 | Table Output 6         | 0   | 4095    | 3686      | RW |  |
| 87 | Table Output 7         | 0   | 4095    | 2867      | RW |  |
| 88 | Table Output 8         | 0   | 4095    | 2048      | RW |  |
| 89 | Table Output 9         | 0   | 4095    | 1229      | RW |  |
| 90 | Table Output 10        | 0   | 4095    | 410       | RW |  |
| 91 | Table Hysteresis       | 0   | 100.00" | 0.25"     | RW |  |
| 92 | Aux 1                  | 0   | 65535   | 0         | RW |  |
| 93 | Aux 2                  | 0   | 65535   | 0         | RW |  |
| 94 | Aux 3                  | 0   | 65535   | 0         | RW |  |
| 95 | Aux 4                  | 0   | 65535   | 0         | RW |  |

|     |        |   |       |   |    |  |
|-----|--------|---|-------|---|----|--|
| 96  | Aux 5  | 0 | 65535 | 0 | RW |  |
| 97  | Aux 6  | 0 | 65535 | 0 | RW |  |
| 98  | Aux 7  | 0 | 65535 | 0 | RW |  |
| 99  | Aux 8  | 0 | 65535 | 0 | RW |  |
| 100 | Aux 9  | 0 | 65535 | 0 | RW |  |
| 101 | Aux 10 | 0 | 65535 | 0 | RW |  |

◆ Device Dependent





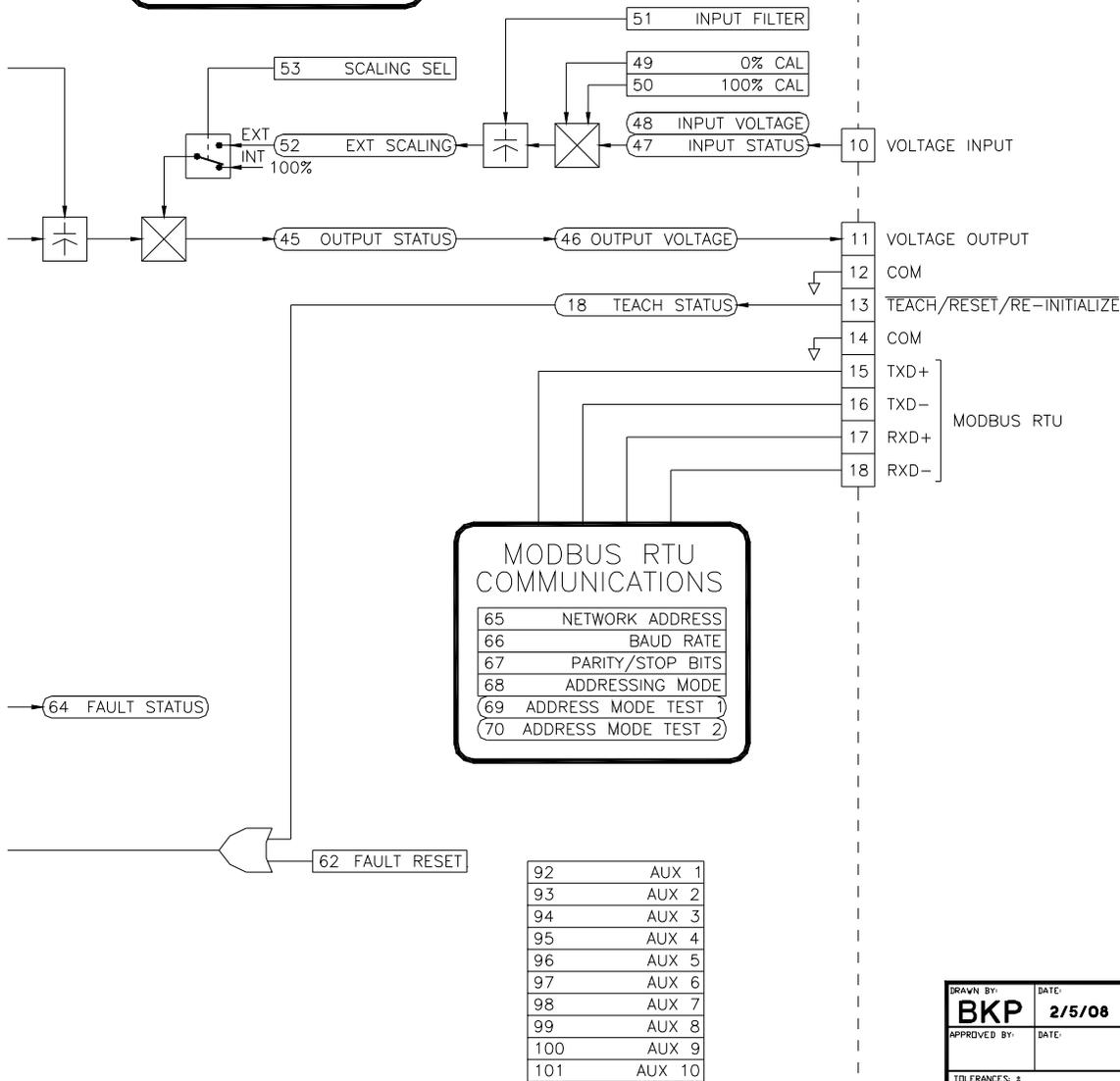


### SYSTEM

|    |                    |
|----|--------------------|
| 1  | SAVE               |
| 2  | SAVE STATUS        |
| 3  | RE-INITIALIZE      |
| 4  | CUSTOM CODE (LOW)  |
| 5  | CUSTOM CODE (HIGH) |
| 6  | PROCESSOR ID       |
| 7  | PROCESSOR REVISION |
| 8  | FIRMWARE VERSION   |
| 9  | BOOT VERSION       |
| 10 | SYSTEM STATUS      |
| 11 | BOARD REVISION     |
| 12 | TOTAL PARAMETERS   |
| 13 | RESERVED           |
| 14 | RESERVED           |
| 15 | RESERVED           |
| 16 | RESERVED           |
| 17 | RESERVED           |

### LEGEND

|     |                  |
|-----|------------------|
|     | FILTER (AVERAGE) |
|     | SUMMING JUNCTION |
|     | MULTIPLIER/SCALE |
| TAG | READ/WRITE NAME  |
| TAG | READ ONLY NAME   |



|   |                        |   |
|---|------------------------|---|
| DRAWN BY:<br><b>BKP</b>                                   | DATE:<br><b>2/5/08</b> | <br><i>Driven by Excellence</i>                           |
| APPROVED BY:  | DATE:                  |   |
| TOLERANCES: ±<br>2 DEC. PL. = .010"<br>3 DEC. PL. = .005" |                        | HEATH SPRINGS, SC<br>TEL 803-286-8614<br>FAX 803-286-6063 |
| SCALE:  |                        | TITLE:<br>SONICTRAC<br>PRO<br>SOFTWARE<br>BLOCK DIAGRAM   |
| DRAWING NUMBER:<br><b>D13457</b>                          |                        | REV. <b>A</b> SH. <b>1</b> OF <b>1</b>                    |

## 7.1 Modbus® Protocol

The Sonictrac® Pro supports a subset of the Modbus® RTU communications protocol. This section describes the Sonictrac® Pro's implementation of the protocol. For a complete detailed specification of the entire Modbus® protocol, please refer to <http://www.modbus.org>.

In the Sonictrac® Pro, functions 1,2,3,4,5,6,8,15, & 16 are supported. The message format or frame varies depending upon which function code is used. Each frame is started by the slave address and ends with a CRC-16 error checking code. If the slave addresses do not match or the CRC-16 code is invalid, the slave ignores the message and no response is returned. The Sonictrac® Pro acts as a slave (server) to a single master (client). Bus contentions are avoided since the Modbus® master initiates all communications. Slave devices only place data on the bus in response to a master's request. Each slave device on the bus must have a unique network address.

Frames consist of 8 bit data bytes. Parity can set for None, Odd, or Even. Frames are separated on the bus by a silent period in which no data transmissions occur. This silent period signals devices on the bus when a frame has ended and can now begin to examine the frame data. Bytes within a frame must therefore be sent in a continuous stream to avoid silent periods.

The Modbus® protocol uses two general types of data: bits and registers. Registers are composed of 16 bits. Some slave devices further divide each of these data types depending upon its method of access (read-write or read-only). The Sonictrac® Pro makes no distinction between read-write and read-only with respect to the command. For example, any register can be read by using Function Code 3 or 4, and any bit can be read using Function Codes 1 or 2. Attempts to write a value to a read-only parameter are ignored.

Since all of the Sonictrac® Pro's parameters are implemented internally as 16 bit registers, each parameter can be accessed by using a bit or a register command. Thus, a register can be read or written to by a bit command. In these cases, any non-zero value is interpreted as True (1) and zero is interpreted as False (0).

In the following, hexadecimal number are represented with an 'h' suffix and binary numbers with a 'b' suffix. Decimal data is shown with no suffix.

| Code     | Function                 | Data Type       | Access       | Data Type Code |
|----------|--------------------------|-----------------|--------------|----------------|
| 1 (01h)  | Read Bits                | bit             | (read-write) | 0x             |
| 2 (02h)  | Read Bits                | bit             | (read-only)  | 1x             |
| 3 (03h)  | Read Multiple Registers  | 16 bit register | (read-write) | 4x             |
| 4 (04h)  | Read Multiple Registers  | 16 bit register | (read-only)  | 3x             |
| 5 (05h)  | Write Single Bit         | bit             | (read-write) | 0x             |
| 6 (06h)  | Write Single Register    | 16 bit register | (read-write) | 4x             |
| 8 (08h)  | Diagnostics (Loopback)   | -               | -            | -              |
| 15 (0Fh) | Write Multiple Bits      | bit             | (read-write) | 0x             |
| 16 (10h) | Write Multiple Registers | 16 bit register | (read-write) | 4x             |

**Table 6: Supported Modbus® Functions**

## 7.2 Modbus® Functions

### Function Code 1 (01h) Read Bits

In this example, Function Code 1 is used to read the status of the 2 relay outputs i.e. parameters 60-61). Both Relay Outputs are energized in this example.

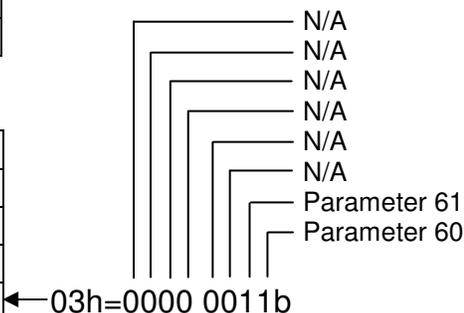
#### Master Command

| Description      |       | Data |
|------------------|-------|------|
| Slave Address    |       | 01h  |
| Function Code    |       | 01h  |
| Starting Address | Upper | 00h  |
|                  | Lower | 3Bh  |
| Quantity         | Upper | 00h  |
|                  | Lower | 02h  |
| CRC-16           | Lower | CCh  |
|                  | Upper | 06h  |

} 60-1=59=003Bh\*

#### Normal Slave Response

| Description   |       | Data |
|---------------|-------|------|
| Slave Address |       | 01h  |
| Function Code |       | 01h  |
| Byte Count    |       | 01h  |
| Data          |       | 03h  |
| CRC-16        | Lower | 11h  |
|               | Upper | 89h  |



#### Error Slave Response

| Description   |       | Data |
|---------------|-------|------|
| Slave Address |       | 01h  |
| Function Code |       | 81h  |
| Error Code    |       | 02h  |
| CRC-16        | Lower | C1h  |
|               | Upper | 91h  |

\*This assumes the Sonictrac® Pro Addressing Mode (parameter 137) is set to 1 (default). If Addressing Mode is set to 0, then the Address does not need to be decremented by one. In this mode a value of 003Ch would be used.

### Function Code 2 (02h) Read Bits

In this example, Function Code 2 is used to read the status of the 2 relay outputs (i.e. parameters 60-61). Relay Output 1 is de-energized and Relay Output 2 is energized in this example.

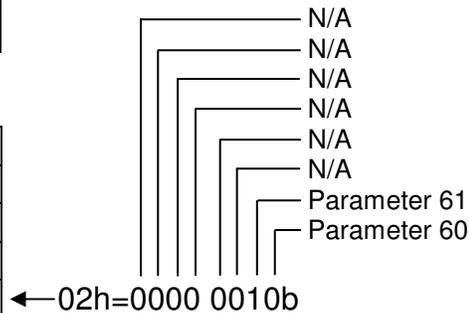
#### Master Command

| Description      |       | Data |
|------------------|-------|------|
| Slave Address    |       | 01h  |
| Function Code    |       | 02h  |
| Starting Address | Upper | 00h  |
|                  | Lower | 3Bh  |
| Quantity         | Upper | 00h  |
|                  | Lower | 02h  |
| CRC-16           | Lower | 88h  |
|                  | Upper | 06h  |

} 60-1=59=003Bh\*

#### Normal Slave Response

| Description   |       | Data |
|---------------|-------|------|
| Slave Address |       | 01h  |
| Function Code |       | 02h  |
| Byte Count    |       | 01h  |
| Data          |       | 02h  |
| CRC-16        | Lower | 20h  |
|               | Upper | 49h  |



#### Error Slave Response

| Description   |       | Data |
|---------------|-------|------|
| Slave Address |       | 01h  |
| Function Code |       | 82h  |
| Error Code    |       | 03h  |
| CRC-16        | Lower | 00h  |
|               | Upper | A1h  |

\*This assumes the Sonictrac® Pro Addressing Mode (parameter 137) is set to 1 (default). If Addressing Mode is set to 0, then the Address does not need to be decremented by one. In this mode a value of 003Ch would be used.

### Function Code 3 (03h) Read Multiple Registers

In this example, Function Code 3 is used to read the Core Diameter and Max Diameter settings (i.e. parameters 33-34). In this example, Core Diameter is 1.00" and Max Diameter is 10.00".

#### Master Command

| Description      |       | Data             |
|------------------|-------|------------------|
| Slave Address    |       | 01h              |
| Function Code    |       | 03h              |
| Starting Address | Upper | 00h              |
|                  | Lower | 20h              |
|                  |       | } 33-1=32=0020h* |
| Quantity         | Upper | 00h              |
|                  | Lower | 02h              |
| CRC-16           | Lower | C5h              |
|                  | Upper | C1h              |

#### Normal Slave Response

| Description   |       | Data         |
|---------------|-------|--------------|
| Slave Address |       | 01h          |
| Function Code |       | 03h          |
| Byte Count    |       | 04h          |
| Register Data | Upper | 00h          |
|               | Lower | 64h          |
|               |       | } 0064h=100  |
| Register Data | Upper | 03h          |
|               | Lower | E8h          |
|               |       | } 03E8h=1000 |
| CRC-16        | Lower | BBh          |
|               | Upper | 52h          |

#### Error Slave Response

| Description   |       | Data |
|---------------|-------|------|
| Slave Address |       | 01h  |
| Function Code |       | 83h  |
| Error Code    |       | 02h  |
| CRC-16        | Lower | C0h  |
|               | Upper | F1h  |

\*This assumes the Sonictrac® Pro Addressing Mode (parameter 137) is set to 1 (default). If Addressing Mode is set to 0, then the Address does not need to be decremented by one. In this mode a value of 0021h would be used.

### Function Code 4 (04h) Read Multiple Registers

In this example, Function Code 4 is used to read the value of Actual Distance (i.e. parameter 32). When read, the value of Line Speed was 31.23".

#### Master Command

| Description      |       | Data |
|------------------|-------|------|
| Slave Address    |       | 01h  |
| Function Code    |       | 04h  |
| Starting Address | Upper | 00h  |
|                  | Lower | 1Fh  |
| Quantity         | Upper | 00h  |
|                  | Lower | 01h  |
| CRC-16           | Lower | 00h  |
|                  | Upper | 0Ch  |

} 32-1=31=001Fh\*

#### Normal Slave Response

| Description   |       | Data |
|---------------|-------|------|
| Slave Address |       | 01h  |
| Function Code |       | 04h  |
| Byte Count    |       | 02h  |
| Register Data | Upper | 0Ch  |
|               | Lower | 33h  |
| CRC-16        | Lower | FCh  |
|               | Upper | 25h  |

} 0C33h=3123

#### Error Slave Response

| Description   |       | Data |
|---------------|-------|------|
| Slave Address |       | 01h  |
| Function Code |       | 84h  |
| Error Code    |       | 03h  |
| CRC-16        | Lower | 03h  |
|               | Upper | 01h  |

\*This assumes the Sonictrac® Pro Addressing Mode (parameter 137) is set to 1 (default). If Addressing Mode is set to 0, then the Address does not need to be decremented by one. In this mode a value of 0020h would be used.

### Function Code 5 (05h) Write Single Bit

In this example, Function Code 5 is used to write a value of 1 to Fault Reset (i.e. parameter 62).

#### Master Command

| Description   |       | Data |
|---------------|-------|------|
| Slave Address |       | 01h  |
| Function Code |       | 05h  |
| Address       | Upper | 00h  |
|               | Lower | 3Dh  |
| Data          | Upper | FFh  |
|               | Lower | 00h  |
| CRC-16        | Lower | 1Dh  |
|               | Upper | F6h  |

}  $62-1=61=003Dh^*$   
} FF00h is used to turn bit on. 0000h would be used to turn bit off.

#### Normal Slave Response

| Description   |       | Data |
|---------------|-------|------|
| Slave Address |       | 01h  |
| Function Code |       | 05h  |
| Address       | Upper | 00h  |
|               | Lower | 3Dh  |
| Register Data | Upper | FFh  |
|               | Lower | 00h  |
| CRC-16        | Lower | 1Dh  |
|               | Upper | F6h  |

#### Error Slave Response

| Description   |       | Data |
|---------------|-------|------|
| Slave Address |       | 01h  |
| Function Code |       | 85h  |
| Error Code    |       | 02h  |
| CRC-16        | Lower | C3h  |
|               | Upper | 51h  |

\*This assumes the Sonictrac® Pro Addressing Mode (parameter 137) is set to 1 (default). If Addressing Mode is set to 0, then the Address does not need to be decremented by one. In this mode a value of 003Eh would be used.

### Function Code 6 (06h) Write Single Register

In this example, Function Code 6 is used to write a value of 12.3s to Fault Time (i.e. parameter 63).

#### Master Command

| Description   |       | Data |
|---------------|-------|------|
| Slave Address |       | 01h  |
| Function Code |       | 06h  |
| Address       | Upper | 00h  |
|               | Lower | 3Eh  |
| Data          | Upper | 00h  |
|               | Lower | 7Bh  |
| CRC-16        | Lower | A8h  |
|               | Upper | 25h  |

} 63-1=62=003Eh\*

} 123=007Bh

#### Normal Slave Response

| Description   |       | Data |
|---------------|-------|------|
| Slave Address |       | 01h  |
| Function Code |       | 06h  |
| Address       | Upper | 00h  |
|               | Lower | 3Eh  |
| Register Data | Upper | 00h  |
|               | Lower | 7Bh  |
| CRC-16        | Lower | A8h  |
|               | Upper | 25h  |

#### Error Slave Response

| Description   |       | Data |
|---------------|-------|------|
| Slave Address |       | 01h  |
| Function Code |       | 86h  |
| Error Code    |       | 02h  |
| CRC-16        | Lower | C3h  |
|               | Upper | A1h  |

\*This assumes the Sonictrac® Pro Addressing Mode (parameter 137) is set to 1 (default). If Addressing Mode is set to 0, then the Address does not need to be decremented by one. In this mode a value of 003Fh would be used.

### Function Code 8 (08h) Diagnostics, Echo Data

In this example, Function Code 8 (Diagnostics) with Sub Code 0 (Echo Data) is used to test communications with a slave device. The slave should echo back the received data.

#### Master Command

| Description   |       | Data |
|---------------|-------|------|
| Slave Address |       | 01h  |
| Function Code |       | 08h  |
| Sub Code      | Upper | 00h  |
|               | Lower | 00h  |
| Data          | Upper | AAh  |
|               | Lower | 55h  |
| CRC-16        | Lower | 5Eh  |
|               | Upper | 94h  |

#### Normal Slave Response

| Description   |       | Data |
|---------------|-------|------|
| Slave Address |       | 01h  |
| Function Code |       | 08h  |
| Sub Code      | Upper | 00h  |
|               | Lower | 00h  |
| Data          | Upper | AAh  |
|               | Lower | 55h  |
| CRC-16        | Lower | 5Eh  |
|               | Upper | 94h  |

#### Error Slave Response

| Description   |       | Data |
|---------------|-------|------|
| Slave Address |       | 01h  |
| Function Code |       | 88h  |
| Error Code    |       | 01h  |
| CRC-16        | Lower | 87h  |
|               | Upper | C0h  |

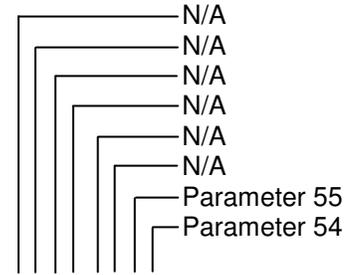
### Function Code 15 (0Fh) Write Multiple Bits

In this example, Function Code 15 is used to write a value of 0 to Relay 1 Mode and a value of 1 to Relay 2 Mode (i.e. parameters 54 & 55).

#### Master Command

| Description   |       | Data |
|---------------|-------|------|
| Slave Address |       | 01h  |
| Function Code |       | 0Fh  |
| Start Address | Upper | 00h  |
|               | Lower | 35h  |
| Num Bits      | Upper | 00h  |
|               | Lower | 02h  |
| Byte Count    |       | 01h  |
| Data          |       | 02h  |
| CRC-16        | Lower | D3h  |
|               | Upper | 52h  |

} 54-1=53=0035h\*



← 02h=0000 0010b

#### Normal Slave Response

| Description   |       | Data |
|---------------|-------|------|
| Slave Address |       | 01h  |
| Function Code |       | 0Fh  |
| Start Address | Upper | 00h  |
|               | Lower | 35h  |
| Num Bits      | Upper | 00h  |
|               | Lower | 02h  |
| CRC-16        | Lower | C4h  |
|               | Upper | 04h  |

#### Error Slave Response

| Description   |       | Data |
|---------------|-------|------|
| Slave Address |       | 01h  |
| Function Code |       | 8Fh  |
| Error Code    |       | 02h  |
| CRC-16        | Lower | C5h  |
|               | Upper | F1h  |

\*This assumes the Sonictrac® Pro Addressing Mode (parameter 137) is set to 1 (default). If Addressing Mode is set to 0, then the Address does not need to be decremented by one. In this mode a value of 0036h would be used.

### Function Code 16 (10h) Write Multiple Registers

In this example, Function Code 16 is used to write the values 8.76" and 32.10" to the Min Range and Max Range parameters (i.e. parameters 24 & 25).

#### Master Command

| Description    |       | Data |
|----------------|-------|------|
| Slave Address  |       | 01h  |
| Function Code  |       | 10h  |
| Start Address  | Upper | 00h  |
|                | Lower | 17h  |
| Register Count | Upper | 00h  |
|                | Lower | 02h  |
| Byte Count     |       | 04h  |
| Register Data  | Upper | 08h  |
|                | Lower | 76h  |
| Register Data  | Upper | 0Ch  |
|                | Lower | 8Ah  |
| CRC-16         | Lower | D4h  |
|                | Upper | 58h  |

} 24-1=23=0017h\*

} 876=036Ch

} 3210=0C8Ah

#### Normal Slave Response

| Description    |       | Data |
|----------------|-------|------|
| Slave Address  |       | 01h  |
| Function Code  |       | 10h  |
| Start Address  | Upper | 00h  |
|                | Lower | 17h  |
| Register Count | Upper | 00h  |
|                | Lower | 02h  |
| CRC-16         | Lower | F1h  |
|                | Upper | CCh  |

#### Error Slave Response

| Description   |       | Data |
|---------------|-------|------|
| Slave Address |       | 01h  |
| Function Code |       | 90h  |
| Error Code    |       | 02h  |
| CRC-16        | Lower | CDh  |
|               | Upper | C1h  |

\*This assumes the Sonictrac® Pro Addressing Mode (parameter 137) is set to 1 (default). If Addressing Mode is set to 0, then the Address does not need to be decremented by one. In this mode a value of 0018h would be used.

## 7.3 CRC-16 Calculations

CRC stands for Cyclical Redundancy Check and is a 16 bit value appended to all Modbus® frames. When a device (either master or slave) places data on the bus, the CRC value is appended to the message. The receiving device also calculates a CRC value as it receives the message. The receiver compares its calculated value to the one received. A transmission error has occurred if the values do not match.

Please note that when the CRC value is appended to a message, the low byte is appended first followed by the upper byte. This is different from all other Modbus® data fields where the upper byte is sent first followed by the lower byte.

Below is some example C code to generate a CRC-16 value. The method used below provides for fast generation of the CRC value by using lookup tables that contain pre-calculated CRC values. Please refer to the Modbus® specification (available at <http://www.modbus.org>) for more details.

```
// The function returns the CRC value. Note that this function internally swaps the high and low CRC bytes.
// Thus, the resulting value can be appended directly to the Modbus® message. Msg is a pointer to the
// message that CRC is to be calculated from. DataLen is the quantity of bytes in the message
unsigned int CRC16 (unsigned char *Msg, unsigned char DataLen)
```

```
{
    unsigned char CRCHi = 0xFF;           // Initialize high byte of CRC
    unsigned char CRCLo = 0xFF;         // Initialize low byte of CRC
    unsigned char Index;                // index into CRC lookup table
    while (DataLen--)                   // pass through message buffer
    {
        Index = CRCLo ^ *Msg++;         //calculate the CRC
        CRCLo = CRCHi ^ CRCHi[Index] ;
        CRCHi = CRCLo[Index] ;
    }
    return (CRCHi << 8 | CRCLo) ;
}
```

### High-Order Byte Table

```
// Table of CRC values for high-order byte
```

```
static unsigned char CRCHi[] = {
    0x00, 0xC1, 0x81, 0x40, 0x01, 0xC0, 0x80, 0x41, 0x01, 0xC0, 0x80, 0x41, 0x00, 0xC1, 0x81, 0x40,
    0x01, 0xC0, 0x80, 0x41, 0x00, 0xC1, 0x81, 0x40, 0x00, 0xC1, 0x81, 0x40, 0x01, 0xC0, 0x80, 0x41,
    0x01, 0xC0, 0x80, 0x41, 0x00, 0xC1, 0x81, 0x40, 0x00, 0xC1, 0x81, 0x40, 0x01, 0xC0, 0x80, 0x41,
    0x00, 0xC1, 0x81, 0x40, 0x01, 0xC0, 0x80, 0x41, 0x01, 0xC0, 0x80, 0x41, 0x00, 0xC1, 0x81, 0x40,
    0x01, 0xC0, 0x80, 0x41, 0x00, 0xC1, 0x81, 0x40, 0x00, 0xC1, 0x81, 0x40, 0x01, 0xC0, 0x80, 0x41,
    0x00, 0xC1, 0x81, 0x40, 0x01, 0xC0, 0x80, 0x41, 0x01, 0xC0, 0x80, 0x41, 0x00, 0xC1, 0x81, 0x40,
    0x01, 0xC0, 0x80, 0x41, 0x00, 0xC1, 0x81, 0x40, 0x00, 0xC1, 0x81, 0x40, 0x01, 0xC0, 0x80, 0x41,
    0x00, 0xC1, 0x81, 0x40, 0x01, 0xC0, 0x80, 0x41, 0x01, 0xC0, 0x80, 0x41, 0x00, 0xC1, 0x81, 0x40,
    0x01, 0xC0, 0x80, 0x41, 0x00, 0xC1, 0x81, 0x40, 0x00, 0xC1, 0x81, 0x40, 0x01, 0xC0, 0x80, 0x41,
    0x01, 0xC0, 0x80, 0x41, 0x00, 0xC1, 0x81, 0x40, 0x00, 0xC1, 0x81, 0x40, 0x01, 0xC0, 0x80, 0x41,
    0x00, 0xC1, 0x81, 0x40, 0x01, 0xC0, 0x80, 0x41, 0x01, 0xC0, 0x80, 0x41, 0x00, 0xC1, 0x81, 0x40
};
```

### Low-Order Byte Table

// Table of CRC values for low-order byte

```
static char CRCLo[] = {  
    0x00, 0xC0, 0xC1, 0x01, 0xC3, 0x03, 0x02, 0xC2, 0xC6, 0x06, 0x07, 0xC7, 0x05, 0xC5, 0xC4, 0x04,  
    0xCC, 0x0C, 0x0D, 0xCD, 0x0F, 0xCF, 0xCE, 0x0E, 0x0A, 0xCA, 0xCB, 0x0B, 0xC9, 0x09, 0x08, 0xC8,  
    0xD8, 0x18, 0x19, 0xD9, 0x1B, 0xDB, 0xDA, 0x1A, 0x1E, 0xDE, 0xDF, 0x1F, 0xDD, 0x1D, 0x1C, 0xDC,  
    0x14, 0xD4, 0xD5, 0x15, 0xD7, 0x17, 0x16, 0xD6, 0xD2, 0x12, 0x13, 0xD3, 0x11, 0xD1, 0xD0, 0x10,  
    0xF0, 0x30, 0x31, 0xF1, 0x33, 0xF3, 0xF2, 0x32, 0x36, 0xF6, 0xF7, 0x37, 0xF5, 0x35, 0x34, 0xF4,  
    0x3C, 0xFC, 0xFD, 0x3D, 0xFF, 0x3F, 0x3E, 0xFE, 0xFA, 0x3A, 0x3B, 0xFB, 0x39, 0xF9, 0xF8, 0x38,  
    0x28, 0xE8, 0xE9, 0x29, 0xEB, 0x2B, 0x2A, 0xEA, 0xEE, 0x2E, 0x2F, 0xEF, 0x2D, 0xED, 0xEC, 0x2C,  
    0xE4, 0x24, 0x25, 0xE5, 0x27, 0xE7, 0xE6, 0x26, 0x22, 0xE2, 0xE3, 0x23, 0xE1, 0x21, 0x20, 0xE0,  
    0xA0, 0x60, 0x61, 0xA1, 0x63, 0xA3, 0xA2, 0x62, 0x66, 0xA6, 0xA7, 0x67, 0xA5, 0x65, 0x64, 0xA4,  
    0x6C, 0xAC, 0xAD, 0x6D, 0xAF, 0x6F, 0x6E, 0xAE, 0xAA, 0x6A, 0x6B, 0xAB, 0x69, 0xA9, 0xA8, 0x68,  
    0x78, 0xB8, 0xB9, 0x79, 0xBB, 0x7B, 0x7A, 0xBA, 0xBE, 0x7E, 0x7F, 0xBF, 0x7D, 0xBD, 0xBC, 0x7C,  
    0xB4, 0x74, 0x75, 0xB5, 0x77, 0xB7, 0xB6, 0x76, 0x72, 0xB2, 0xB3, 0x73, 0xB1, 0x71, 0x70, 0xB0,  
    0x50, 0x90, 0x91, 0x51, 0x93, 0x53, 0x52, 0x92, 0x96, 0x56, 0x57, 0x97, 0x55, 0x95, 0x94, 0x54,  
    0x9C, 0x5C, 0x5D, 0x9D, 0x5F, 0x9F, 0x9E, 0x5E, 0x5A, 0x9A, 0x9B, 0x5B, 0x99, 0x59, 0x58, 0x98,  
    0x88, 0x48, 0x49, 0x89, 0x4B, 0x8B, 0x8A, 0x4A, 0x4E, 0x8E, 0x8F, 0x4F, 0x8D, 0x4D, 0x4C, 0x8C,  
    0x44, 0x84, 0x85, 0x45, 0x87, 0x47, 0x46, 0x86, 0x82, 0x42, 0x43, 0x83, 0x41, 0x81, 0x80, 0x40  
};
```



# Standard Terms & Conditions of Sale

## 1. General

The Standard Terms and Conditions of Sale of Carotron, Inc. (hereinafter called "Company") are set forth as follows in order to give the Company and the Purchaser a clear understanding thereof. No additional or different terms and conditions of sale by the Company shall be binding upon the Company unless they are expressly consented to by the Company in writing. The acceptance by the Company of any order of the Purchaser is expressly conditioned upon the Purchaser's agreement to said Standard Terms and Conditions. The acceptance or acknowledgement, written, oral, by conduct or otherwise, by the Company of the Purchaser's order shall not constitute written consent by the Company to addition to or change in said Standard Terms and Conditions.

## 2. Prices

Prices, discounts, allowances, services and commissions are subject to change without notice. Prices shown on any Company published price list and other published literature issued by the Company are not offers to sell and are subject to express confirmation by written quotation and acknowledgement. All orders of the Purchaser are subject to acceptance, which shall not be effective unless made in writing by an authorized Company representative at its office in Heath Springs, S.C. The Company may refuse to accept any order for any reason whatsoever without incurring any liability to the Purchaser. The Company reserves the right to correct clerical and stenographic errors at any time.

## 3. Shipping dates

Quotation of a shipping date by the Company is based on conditions at the date upon which the quotation is made. Any such shipping date is subject to change occasioned by agreements entered into previous to the Company's acceptance of the Purchaser's order, governmental priorities, strikes, riots, fires, the elements, explosion, war, embargoes, epidemics, quarantines, acts of God, labor troubles, delays of vendors or of transportation, inability to obtain raw materials, containers or transportation or manufacturing facilities or any other cause beyond the reasonable control of the Company. In no event shall the Company be liable for consequential damages for failure to meet any shipping date resulting from any of the above causes or any other cause.

In the event of any delay in the Purchaser's accepting shipment of products or parts in accordance with scheduled shipping dates, which delay has been requested by the Purchaser, or any such delay which has been caused by lack of shipping instructions, the Company shall store all products and parts involved at the Purchaser's risk and expense and shall invoice the Purchaser for the full contract price of such products and parts on the date scheduled for shipment or on the date on which the same is ready for delivery, whichever occurs later.

## 4. Warranty

The Company warrants to the Purchaser that products manufactured or parts repaired by the Company, will be free, under normal use and maintenance, from defects in material and workmanship for a period of one (1) year after the shipment date from the Company's factory to the Purchaser. The Company makes no warranty concerning products manufactured by other parties.

As the Purchaser's sole and exclusive remedy under said warranty in regard to such products and parts, including but not limited to remedy for consequential damages, the Company will at its option, repair or replace without charge any product manufactured or part repaired by it, which is found to the Company's satisfaction to be so defective; provided, however, that (a) the product or part involved is returned to the Company at the location designated by the Company, transportation charges prepaid by the Purchaser; or (b) at the Company's option the product or part will be repaired or replaced in the Purchaser's plant; and also provided that (c) the Company is notified of the defect within one (1) year after the shipment date from the Company's factory of the product or part so involved.

The Company warrants to the Purchaser that any system engineered by it and started up under the supervision of an authorized Company representative will, if properly installed, operated and maintained, perform in compliance with such system's written specifications for a period of one (1) year from the date of shipment of such system.

As the Purchaser's sole and exclusive remedy under said warrant in regard to such systems, including but not limited to remedy for consequential damages, the Company will, at its option, cause, without charges any such system to so perform, which system is found to the Company's satisfaction to have failed to so perform, or refund to the Purchaser the purchase price paid by the Purchaser to the Company in

regard thereto; provided, however, that (a) Company and its representatives are permitted to inspect and work upon the system involved during reasonable hours, and (b) the Company is notified of the failure within one (1) year after date of shipment of the system so involved.

The warranties hereunder of the Company specifically exclude and do not apply to the following:

a. Products and parts damaged or abused in shipment without fault of the Company.

b. Defects and failures due to operation, either intentional or otherwise, (1) above or beyond rated capacities, (2) in connection with equipment not recommended by the Company, or (3) in an otherwise improper manner.

c. Defects and failures due to misapplication, abuse, improper installation or abnormal conditions of temperature, humidity, abrasives, dirt or corrosive matter.

d. Products, parts and systems which have been in any way tampered with or altered by any party other than an authorized Company representative.

e. Products, parts and systems designed by the Purchaser.

f. Any party other than the Purchaser.

The Company makes no other warranties or representation, expressed or implied, of merchantability and of fitness for a particular purpose, in regard to products manufactured, parts repaired and systems engineered by it.

## 5. Terms of payment

Standard terms of payment are net thirty (30) days from date of the Company invoice. For invoice purposed, delivery shall be deemed to be complete at the time the products, parts and systems are shipped from the Company and shall not be conditioned upon the start up thereof. Amounts past due are subject to a service charge of 1.5% per month or fraction thereof.

## 6. Order cancellation

Any cancellation by the Purchaser of any order or contract between the Company and the Purchaser must be made in writing and receive written approval of an authorized Company representative at its office in Heath Springs, S.C. In the event of any cancellation of an order by either party, the Purchaser shall pay to the Company the reasonable costs, expenses, damages and loss of profit of the Company incurred there by, including but not limited to engineering expenses and expenses caused by commitments to the suppliers of the Company's subcontractors, as determined by the Company.

## 7. Changes

The Purchaser may, from time to time, but only with the written consent of an authorized Company representative, make a change in specifications to products, parts or systems covered by a purchase order accepted by the company. In the event of any such changes, the Company shall be entitled to revise its price and delivery schedule under such order.

## 8. Returned material

If the Purchaser desires to return any product or part, written authorization thereof must first be obtained from the Company which will advise the Purchaser of the credit to be allowed and restocking charges to be paid in regard to such return. No product or part shall be returned to the Company without a "RETURN TAG" attached thereon which has been issued by the Company.

## 9. Packing

Published prices and quotations include the Company's standard packing for domestic shipment. Additional expenses for special packing or overseas shipments shall be paid by the Purchaser. If the Purchaser does not specify packing or accepts parts unpacked, no allowance will be made to the Purchaser in lieu of packing.

## 10. Standard transportation policy

Unless expressly provided in writing to the contrary, products, parts and systems are sold f.o.b. first point of shipment. Partial shipments shall be permitted, and the Company may invoice each shipment separately. Claims for non-delivery of products, parts and systems, and for damages thereto must be filed with the carrier by the Purchaser. The Company's responsibility therefor shall cease when the carrier signs for and accepts the shipment.



# CAROTRON

*Driven by Excellence*

D.C. DRIVES, A.C. INVERTERS,  
SOLID STATE STARTERS, SYSTEM INTERFACE  
CIRCUITS AND ENGINEERED SYSTEMS

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MAN1050-00 Rev. B  
Issued 11-12-2014