

Sasquatch

User's Manual



Revision 4
April 23, 2018

Table of Contents

1	Background	1
2	Physical Connections.....	1
2.1	Power	1
2.2	Output Signal	1
2.2.1	Dry Contact Input.....	2
2.2.2	Voltage Input.....	2
2.3	Communications Port	3
2.3.1	Communications Settings	3
2.3.2	Modbus Slave.....	4
2.3.3	Program Mode	4
2.3.4	Wiring.....	4
3	Sensitivity	6
3.1	Default Sensitivity	6
3.2	Adjusting the Default Sensitivities	7
4	Operating Modes	7
4.1	Normal	7
4.2	Capture - Full Debug	7
4.3	Capture - Raw Samples	7
5	Configurable Options	8
5.1	Output Switch Parameters.....	8
5.1.1	Minimum Output Hold Time.....	8
5.1.2	Output Hold Scale	8
5.2	Output Switch - Modes of Operation.....	8
5.2.1	Static Time.....	8
5.2.2	Velocity Scaled	9
5.2.3	Plunger Hold.....	9
5.3	Detection Algorithm Timers.....	10
5.3.1	Baseline Update Timer	10
5.3.2	Arrival Detection Period.....	10
5.3.3	Velocity Gathering Period	10

5.3.4	Velocity Gathering Timeout	10
5.3.5	Velocity Calculation Timer	10
5.3.6	Departure Detection Period.....	10
5.3.7	Re-Initialize Timer	10
5.4	Lubricator / Spring Wear Settings.....	10
5.4.1	Plunger Mass.....	10
5.4.2	Hard Arrival Velocity Threshold	10
5.4.3	Hard Arrival Kinetic Energy Threshold	11
5.4.4	Dangerous Arrival Velocity Threshold.....	11
5.4.5	Dangerous Arrival Kinetic Energy Threshold.....	11
5.4.6	Consecutive Hard Arrival Alarm Threshold	11
5.4.7	Cumulative Hard Arrival Threshold.....	11
5.4.8	Cumulative Kinetic Energy Threshold	11
6	History.....	11
6.1	Parameters.....	11
6.1.1	Date and Time	12
6.1.2	Units	12
6.2	Arrival Log	12
6.2.1	Arrival Time	12
6.2.2	Velocity.....	12
6.2.3	Velocity Confidence Code	12
7	Lubricator / Spring Wear Monitoring	12
8	Hazardous Locations Certification	14
9	Cathodic Protection	15
10	Company Contact Information	15

Index of Tables

<i>Table 1 - Dial Setting and Threshold Relationship</i>	<i>6</i>
<i>Table 2 – Lubricator / Spring Wear Settings.....</i>	<i>13</i>
<i>Table 3 – General Specifications (Normal Mode)</i>	<i>16</i>
<i>Table 4 – Performance.....</i>	<i>16</i>
<i>Table 5 – Environmental Data</i>	<i>16</i>
<i>Table 6 - Double Word Register Format</i>	<i>17</i>

<i>Table 7 - Elapsed Time Register Format</i>	<i>17</i>
<i>Table 8 - Date/Time Register Format</i>	<i>18</i>
<i>Table 9 - Available Coils</i>	<i>19</i>
<i>Table 10 - Available Input Discretes.....</i>	<i>20</i>
<i>Table 11 - Available Input Registers</i>	<i>21</i>
<i>Table 12 - Available Holding Registers</i>	<i>26</i>

Table of Figures

<i>Figure 1 - Sasquatch Physical Connections</i>	<i>1</i>
<i>Figure 2 - Typical Dry Contact Interface.....</i>	<i>2</i>
<i>Figure 3 - External Resistor for Voltage Input.....</i>	<i>2</i>
<i>Figure 4 – RS-485 Connection</i>	<i>4</i>
<i>Figure 5 - Sensitivity Dial.....</i>	<i>6</i>
<i>Figure 6 - Static Time Output Mode.....</i>	<i>8</i>
<i>Figure 7 - Velocity Scaled Output Mode</i>	<i>9</i>
<i>Figure 8 - Plunger Hold Output Mode.....</i>	<i>9</i>
<i>Figure 9 – Vision Sasquatch Kinetic Energy Settings.....</i>	<i>14</i>

Installation Location: Class I, Division 2, Groups A, B, C, D or Non-Hazardous Locations Only

Applicable to all models



WARNING - DO NOT REMOVE, REPLACE OR DISCONNECT WHILE CIRCUIT IS LIVE UNLESS THE AREA IS KNOWN TO BE FREE OF IGNITIBLE CONCENTRATIONS OF FLAMMABLE SUBSTANCES.

WARNING – EQUIPMENT SHALL BE CONNECTED TO AN APPROVED POWER SOURCE OR BARRIER THAT DOES NOT PROVIDE MORE THAN 24VDC AND 8A.

WARNING - EXPLOSION HAZARD – SUBSTITUTION OF COMPONENTS MAY IMPAIR SUITABILITY FOR CLASS I, DIVISION 2.

WARNING - THIS EQUIPMENT IS SUITABLE FOR USE IN CLASS I, DIVISION 2, GROUPS A, B, C, D OR NON-HAZARDOUS LOCATIONS ONLY.

WARNING - NO SERVICEABLE PARTS.

WARNING - IF EQUIPMENT IS USED IN A MANNER NOT SPECIFIED BY THE MANUFACTURER, THE PROTECTION PROVIDED BY THE EQUIPMENT MAY BE IMPAIRED.



AVIS – NE PAS ENLEVER, REMPLACER OU COUPER SI LE CIRCUIT EST SOUS TENSION À MOINS QUE LA RÉGION EST SAUF ET SANS SUBSTANCES INFLAMMABLES.

AVIS – L'ÉQUIPEMENT DOIT ÊTRE BRANCHER À UNE SOURCE D'ALIMENTATION APPROUVÉE OU UNE BARRIÈRE QUI NE FOURNIRA PAS PLUS QUE 24VDC ET 8A.

AVIS – RISQUE D'EXPLOSION – LA SUBSTITUTION DE COMPOSANTS PEUT RENDRE CE MATERIEL INACCEPTABLE POUR LES EMPLACEMENTS DE CLASSE I, DIVISION 2.

AVIS – L'ÉQUIPEMENT EST ADAPTÉ POUR UTILISATION DANS CLASS I, DIVISION 2, GROUPS A, B, C, D OU DANS DES RÉGIONS SAUFS.

AVIS – PAS DE COMPOSANTS SERVICEABLES.

AVIS – SI L'ÉQUIPEMENT N'EST PAS UTILISÉ TANT QU'AUX INSTRUCTIONS DU FABRICANT, LA PROTECTION PEUT ÊTRE RÉDUITE.

Installation Location: Class I, Division 1, Groups C, D or Class 1 Zone 0 Locations Only

Applicable to model ET-11000-1031-0000 **ONLY**



WARNING – INTRINSICALLY SAFE WHEN CONNECTED PER DRAWING ET-11000-1031-2001.

WARNING – EQUIPMENT SHALL BE CONNECTED TO AN APPROVED POWER SOURCE OR BARRIER THAT DOES NOT PROVIDE MORE THAN 24VDC AND 8A.

WARNING – SUBSTITUTION OF COMPONENTS MAY IMPAIR INTRINSIC SAFETY.

WARNING – NO SERVICEABLE PARTS.

WARNING – AVOID STRIKING OR EXCESSIVE FRICTION ON THE EQUIPMENT SURFACE DUE TO IGNITION HAZARD.

WARNING – TO PREVENT IGNITION OF FLAMMABLE OR COMBUSTIBLE ATMOSPHERES, DISCONNECT POWER BEFORE OPENING.



AVIS – L'ÉQUIPEMENT EST EN SÉCURITÉ INTRINSÈQUE QUAND IL EST BRANCHÉ SELON LE DESSIN ET-11000-1031-2001.

AVIS – L'ÉQUIPEMENT DOIT ÊTRE BRANCHER À UNE SOURCE D'ALIMENTATION APPROUVÉE OU UNE BARRIÈRE QUI NE FOURNIRA PAS PLUS QUE 24VDC ET 8A.

AVIS – LA SUBSTITUTION DE COMPOSANTS PEUT COMPROMETTRE LA SECURITE INTRINSEQUE.

AVIS – PAS DE COMPOSANTS SERVICEABLES.

AVIS – ÉVITER DE FRAPPER OU FRICTION EXCESSIVE SUR LA SURFACE DE L'ÉQUIPEMENT EN RAISON DE RISQUES D'INFLAMMATION.

AVIS – POUR ÉVITER L'ALLUMAGE DES ATMOSPHÈRES INFLAMMABLES OU COMBUSTIBLES, COUPER LE COURANT AVANT OUVERTURE.

1 Background

The Sasquatch is a revolutionary new magnetic field sensor that can not only detect the movement of a ferrous object, but calculate and store its velocity. It features a rugged aluminum case with support for two hose clamps, a ½" NPT strain relief port, and captive screws in the lid. The adjustable sensitivity dial allows the operator to reduce sensitivity to eliminate false detections in noisy environments or increase sensitivity for hard to detect objects.

Sasquatch is the only velocity sensor on the market that features a communication mode where you can upgrade the firmware, access more sensitivity settings, and see real time readings to troubleshoot hard to detect situations. This microprocessor based design incorporates noise reducing filters and also controls the output switch to give a clean, user configurable switch closure that is easy for any controller to detect.

2 Physical Connections

The Sasquatch provides two connectors so that it can be powered, configured, and communicated with. All cables should be labeled with the corresponding signal connection to inserting into terminals. Ensure cables used meet the temperature and electrical ratings of the equipment. (See Table 2, 4)

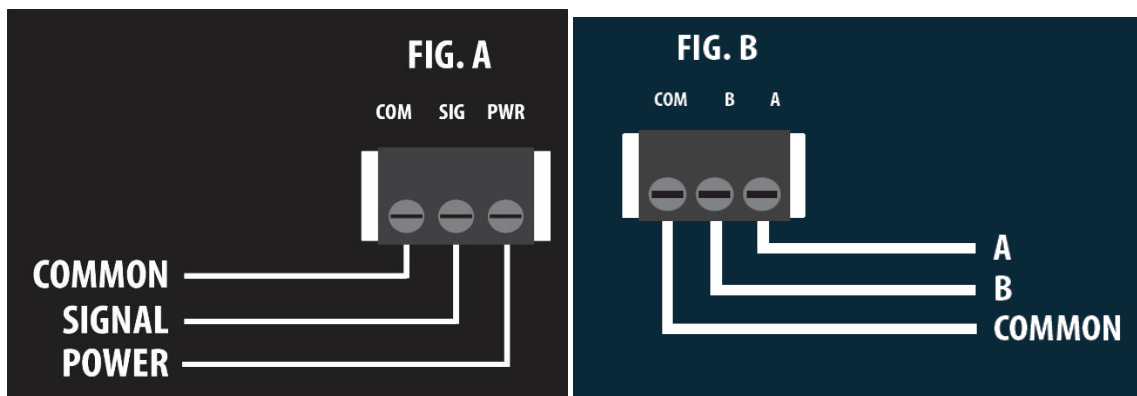


Figure 1 - Sasquatch Physical Connections

2.1 Power

The Sasquatch requires a DC power source with a voltage of 5 V to 24 V. Power must be supplied while waiting for an arrival and during any time the interface will be accessed as there is no internal battery.

- PWR – 5 V to 24 V DC
- COM – Ground

2.2 Output Signal

Each Sasquatch sensor is factory programmed to operate an internal switch when an arrival occurs. The physical wiring and descriptions of the connections are shown below:

- SIG – Connect this to the input signal on your controller.

- COM – The common (COM) is connected to ground. When an arrival occurs, current will flow through the signal (SIG) connection to ground. There is 100 Ohms of impedance in this path to limit the current.

This output can be used with controllers that support a dry contact or voltage input.

2.2.1 Dry Contact Input

The Sasquatch has been designed with an open collector field effect transistor (FET) so that it acts as a dry contact, which ensures that it can be connected directly to most controllers. Most magnetic sensors available on the market are designed to act as a dry contact, so the Sasquatch can easily be used as a replacement sensor for any system. A dry contact input on a controller features an internal pull up resistor. When the contact is open, the internal input will read the system voltage. When the contact closes, the input will now read ground.

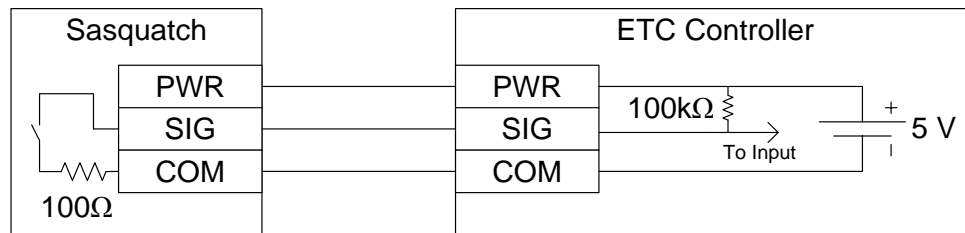


Figure 2 - Typical Dry Contact Interface

2.2.2 Voltage Input

When using a programmable logic controller (PLC) or other application specific controller (i.e. Flow Computer) it is possible that you need to connect to a voltage based input. This type of input is expecting to see a change in the voltage and is not directly compatible with the Sasquatch because it closes a switch instead of sending back a voltage. The difference is that there is no internal pull up resistor provided by these controllers, so an external pull up resistor must be connected. Connecting a 100kΩ resistor between the power and input on the controller will allow these systems to connect to a Sasquatch.

When the Sasquatch switch is open, the input will see the voltage coming from the power connection. When the switch closes, the input will be pulled to ground. This difference in voltage can then be detected.

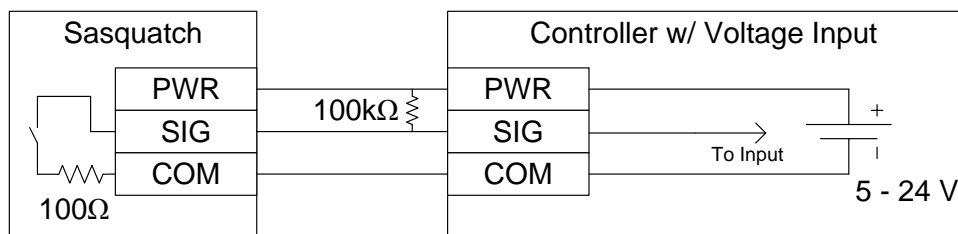


Figure 3 - External Resistor for Voltage Input

2.3 Communications Port

The Sasquatch also provides a serial communications port. This is a standard 2 wire RS-485 differential signal with a common (ground). It is used for accessing settings, reading the device status and history, upgrading firmware, and configuring the operating mode.

- A/B – Two wire RS-485 Differential Signal
- COM – An additional ground connection to be used with an RS-485 connection.

2.3.1 Communications Settings

The settings for the communications port are fully configurable so that the Sasquatch can be used with any other RS-485 compatible communication device. The following outlines the parameters that can be configured.

2.3.1.1 Baud Rate

This is the data rate, represented in bits per second. The default is 9600 bps. The following are the available rates:

- 1200 bps
- 2400 bps
- 4800 bps
- 9600 bps
- 19,200 bps
- 38,400 bps
- 56,000 bps
- 115,200 bps
- 128,000 bps
- 256,000 bps

2.3.1.2 Parity

The parity can be configured as no parity, even, or odd.

2.3.1.3 Data Bits

This is the number of data bits used to send one byte of data. It can be configured to 7 or 8, which is the default.

2.3.1.4 Stop Bits

This is the number of bits that are appended at the end of the data to indicate the end of byte. The default is 1 stop bit, but can be configured to 2.

2.3.1.5 Station Address

This is the Modbus slave station address. It is used to distinguish one Modbus slave from another and must be unique on a given network. It can be configured between 1 and 247. The default is 1.

2.3.1.6 Protocol

The default protocol is RTU, which transmits data in binary format. This is the most efficient protocol for Modbus. It can also be set to ASCII, which sends the equivalent ASCII code for each digit, essentially doubling the amount of data required.

2.3.2 Modbus Slave

The COM port supports the Modbus protocol. The Sasquatch acts as a Modbus slave device and only responds to communication from the master. There is no special cable required and any other RS-485 compatible device can be connected directly to these connections. Please note that there may be a requirement for an intrinsic safety barrier depending on the installation location and certification of the master device.

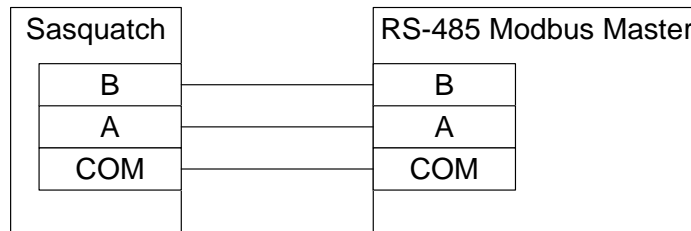


Figure 4 – RS-485 Connection

2.3.3 Program Mode

When the sensitivity dial is set to 0, Sasquatch enters a mode where it listens for external commands on the RS-485 COM port. Using ETC Vision, you can program new firmware, change the operating mode, and adjust the sensitivity levels.

2.3.4 Wiring

Most computers do not come with an RS-485 port, so a USB to RS-485 adapter must be used. The connection is relatively straightforward.

2.3.4.1 Using the Raven USB to RS-485 Adapter

The Raven is the only adapter that has been certified for use in hazardous locations. When connecting to the Sasquatch in hazardous locations, a Raven adapter should be used.

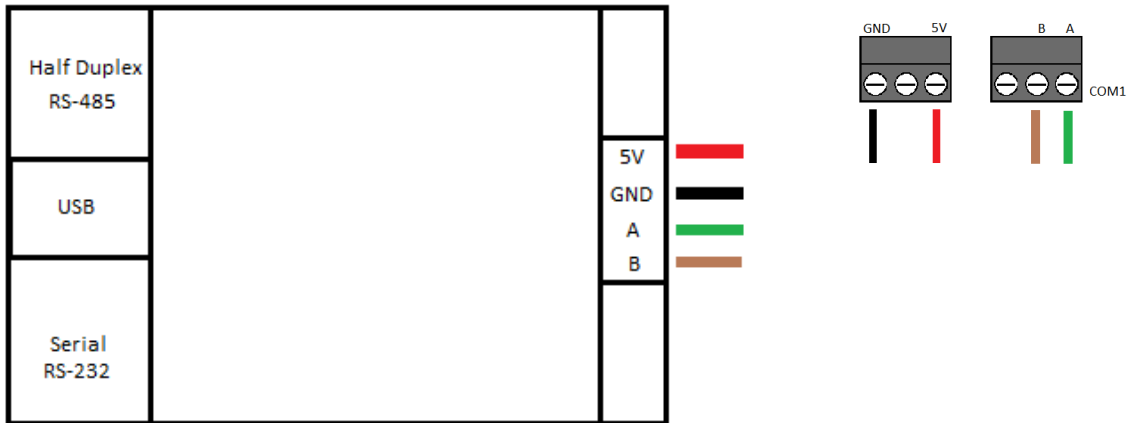


Figure 5 - USB to RS-485 Adapter Wiring using the Raven

2.3.4.2 Using the Link™ Device Connection Adapter

Use the Sasquatch device cable that came with Link to connect to the device. Before connecting Link to Sasquatch, ensure that the switch on Link is set to position 1 (the leftmost position).



Figure 6 - USB to RS-485 Adapter Wiring using the Link

2.3.4.3 Using the B&B Electronics ULin^x™ RS-422/RS-485 Adapter

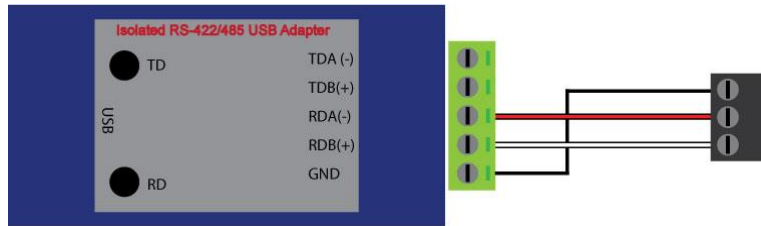


Figure 7 - USB to RS-485 Adapter Wiring

3 Sensitivity

The sensitivity dial does not change the signal in any way. It is simply an interface to allow the operator to adjust the threshold at which the switch will be closed and the velocity will be calculated. By default, the switch is set to 4, which is the middle of the range. The higher the number, the more sensitivity or lower the threshold. When set to 0, the Sasquatch enters the program mode, does not take magnetic readings, and does not operate the switch.

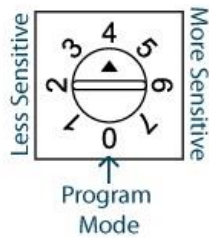


Figure 5 - Sensitivity Dial

3.1 Default Sensitivity

The magnetic sensor has an incredible amount of sensitivity, more than is needed for sensing any material type. To prevent false detections the maximum sensitivity has been limited by default. Setting 7 has a default detection threshold of 25 counts, even though it could go as low as 1. As the sensitivity is turned down, the sensor looks for twice the amount of change in the signal.

The table below highlights the relationship between sensitivity setting and detection threshold:

Table 1 - Dial Setting and Threshold Relationship

Setting	Threshold	Default Value
7	T	25
6	T x 2	50
5	T x 4	100
4	T x 8	200

3	T x 16	400
2	T x 32	800
1	T x 64	1600

3.2 Adjusting the Default Sensitivities

Using the program mode, the detection threshold for setting 7 can be adjusted to make the sensor more or less sensitive. Because there is some noise in the readings, the threshold can only be set as low as 10. The threshold for each sensitivity dial setting is automatically calculated by doubling the threshold from the next most sensitive setting. The net result is that each dial setting is twice as sensitive as the previous setting.

4 Operating Modes

There are several operating modes that can be entered while the sensitivity dial is in position 0. The sensor will not start operating in a given mode until the sensitivity dial is set to a non-zero position. Before connecting the Sasquatch to a controller, the mode must be set to back to Normal. If the mode is not set to Normal, the detection algorithm will not run and the COM port will be setup to interact with ETC Vision instead of running the Modbus slave. Data transmitted out the COM port will cause a controller to interpret it as an arrival.

4.1 Normal

This is the mode that each sensor is shipped in by default. When the sensitivity dial is set to any number other than 0, the sensor will take magnetic readings, calculate a baseline and compare the current reading to see if it has surpassed the threshold. When the threshold is exceeded, the velocity is calculated and stored in a Modbus register that can be read from the RS-485 port and the switch is closed on the SIG wire. (See 5.2 Output Switch - Modes of Operation).

ETC Vision provides a SCADA viewer to view and modify registers on the Sasquatch when it is operating in Normal Mode

4.2 Capture - Full Debug

This mode will run just like the normal mode, except the RS-485 port is used to stream live data to ETC Vision. This data includes the current readings, baseline, current switch position and velocity. Run a capture in ETC Vision to see the real time stream of these values.

4.3 Capture - Raw Samples

The Raw Samples mode is similar to the Full Debug mode. It will take magnetic readings and stream data that is captured by ETC Vision. The difference is that no other filtering or calculations is done on the data before being sent to ETC Vision. This mode essentially eliminates all internal algorithms to give an accurate picture of the readings coming from the magnetic sensor.

5 Configurable Options

The following parameters can be used to modify the way that the Sasquatch operates. This allows for maximum flexibility for a variety of different applications.

5.1 Output Switch Parameters

These parameters are used for one or more of the modes of operation in the following section.

5.1.1 Minimum Output Hold Time

This sets the minimum time that the output switch is closed when the plunger arrives. In some modes, this will be extended based on the behaviour of the plunger or its velocity. The default is 1000 ms or 1 s.

5.1.2 Output Hold Scale

This is a scaling parameter used to extend the close time of the switch in relation to the velocity of the plunger. The default is 10 ms per m/min of velocity.

5.2 Output Switch - Modes of Operation

The behavior of the switch can be modified to operate in one of 3 modes to integrate better with different systems.

5.2.1 Static Time

This mode ensures that the output signal is held for a specified amount of time each time that the plunger arrives. The default Minimum Output Hold Time is 1 seconds. The length of the output switch closure does not get extended while the plunger is moving in front of the sensor. Another switch closure will not occur until after the plunger has departed (5 Departure Detection Periods have passed without seeing the plunger; typically 5 s) and arrived again.

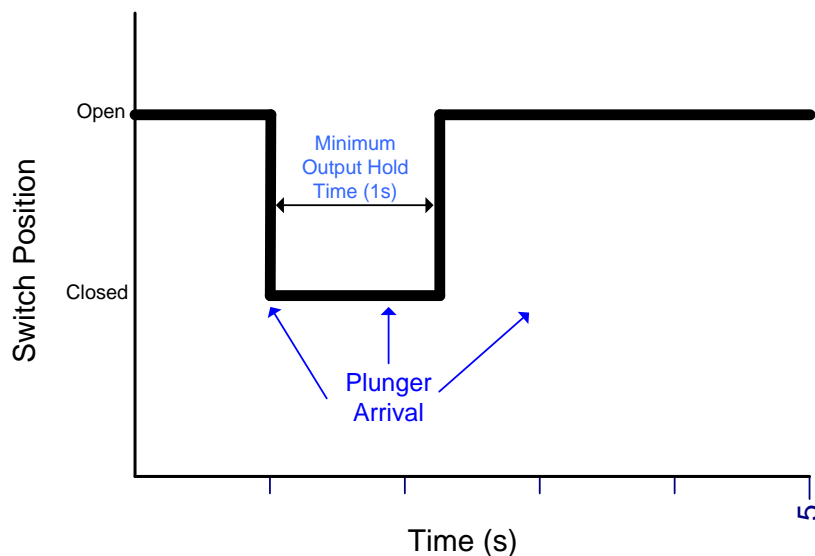


Figure 6 - Static Time Output Mode

5.2.2 Velocity Scaled

This allows for the velocity information to be transmitted along with the switch closure. The switch will always close for the Minimum Output Hold Time as above, but will be held closed for an additional time that is calculated based on the Output Hold Scale parameter. In the example below, the Output Hold Scale is set to 10 ms per m/min of velocity, which is the default. The plunger arrived at 200 m/min, so 2000 ms or 2 seconds was added.

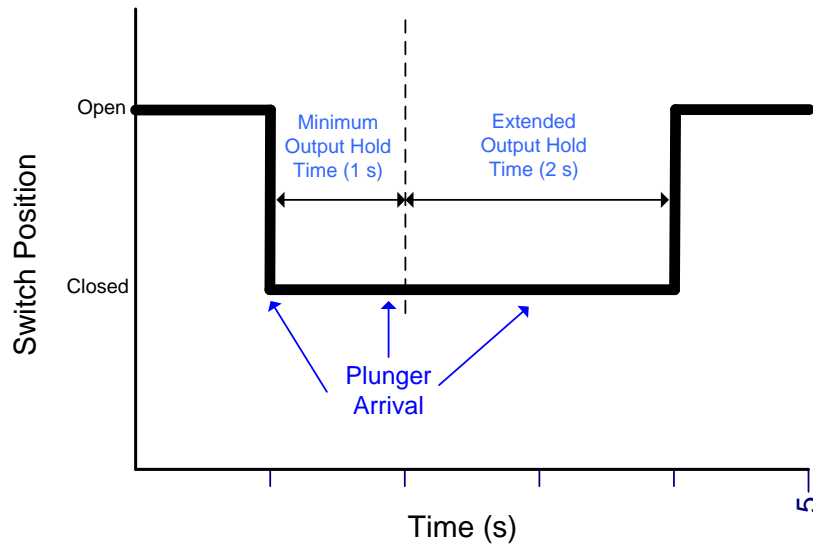


Figure 7 - Velocity Scaled Output Mode

5.2.3 Plunger Hold

This mode works similar to the Cyclops. When the plunger arrives, the output switch is closed for the Minimum Output Hold Time (default of 1 s). As long as the plunger continues to move in front of the sensor, the output switch is held closed as the plunger is considered present. While the plunger is departing (5 Departure Detection Periods; typically 5 s), the switch will continue to be held. If the plunger does not appear within this window, the switch is then released.

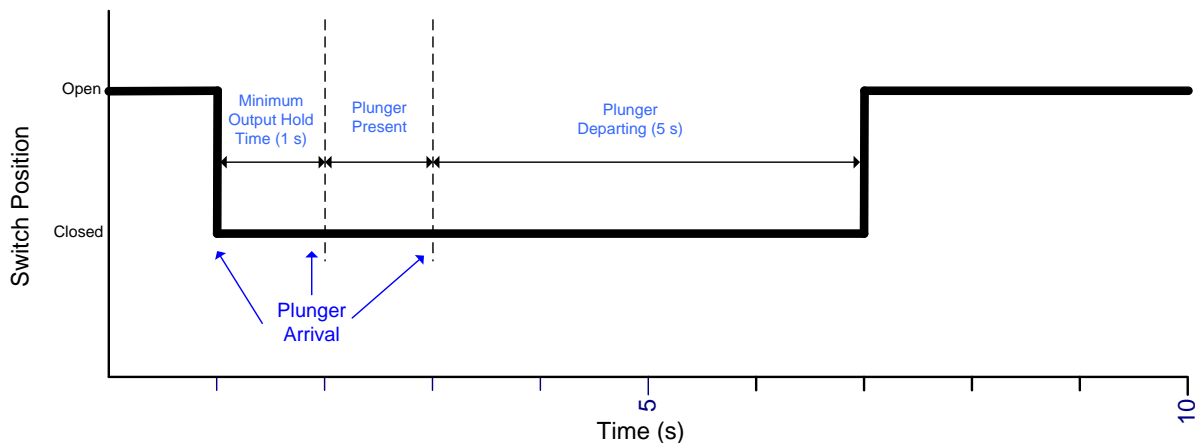


Figure 8 - Plunger Hold Output Mode

5.3 Detection Algorithm Timers

The following detection algorithm timers help set the filtering and data gathering rates. By default they are configured to detect the arrival and velocity of a plunger. They are made available to fine tune the operation of the sensor for other applications.

5.3.1 Baseline Update Timer

This is the frequency at which the baseline is updated.

5.3.2 Arrival Detection Period

This is the rate at which the magnetic signal is sampled while waiting for a plunger to arrive.

5.3.3 Velocity Gathering Period

This is the rate at which the magnetic signal is sampled once the plunger has been detected.

5.3.4 Velocity Gathering Timeout

This specifies how long we gather data after an arrival has been detected before we stop to calculate the velocity.

5.3.5 Velocity Calculation Timer

This specifies a time that the Sasquatches uses to process all other operations once the velocity has been calculated before it begins looking for the plunger departure.

5.3.6 Departure Detection Period

This is the rate at which the magnetic signal is sampled when waiting for the plunger to depart. The plunger is not considered departed until we see 5 consecutive periods pass without detecting the plunger.

5.3.7 Re-Initialize Timer

This timer specifies how long to wait after the plunger has departed before re-initializing the sensor.

5.4 Lubricator / Spring Wear Settings

The Sasquatch provides alarms and statistics for monitoring spring wear due to hard plunger arrivals. This functionality is useful for monitoring well safely and for maintenance scheduling

5.4.1 Plunger Mass

The mass of the plunger in thousandths of a pound (x1000 lbs) or grams. This is required in order for the Sasquatch to calculate accurate kinetic energy of the arriving plunger as it hits the lubricator. If this information is not provided, the velocity-based lubricator / spring alarms will still operate.

5.4.2 Hard Arrival Velocity Threshold

If the velocity of the plunger exceeds this threshold a hard arrival has occurred. If enough consecutive hard arrivals occur an alarm flag will be set. Hard arrivals can also trip the Cumulative Hard Arrival Alarm and the Cumulative Kinetic Energy Alarm

Associated Alarms: Consecutive Hard Arrival Alarm, Cumulative Hard Arrival Alarm, Cumulative Kinetic Energy Alarm

5.4.3 Hard Arrival Kinetic Energy Threshold

This is the equivalent kinetic energy of the Hard Arrival Velocity Threshold. This value is linked with the Hard Arrival Velocity Threshold so that if one is changed the other changes as well.

Associated Alarms: Consecutive Hard Arrival Alarm, Cumulative Hard Arrival Alarm, Cumulative Kinetic Energy Alarm

5.4.4 Dangerous Arrival Velocity Threshold

If the velocity of the plunger exceeds this threshold a dangerous arrival has occurred. This will trigger a Dangerous Alarm.

Associated Alarm: Dangerous Arrival Alarm

5.4.5 Dangerous Arrival Kinetic Energy Threshold

This is the equivalent kinetic energy of the Dangerous Arrival Velocity Threshold. This value is linked with the Hard Arrival Velocity Threshold so that if one is changed the other changes as well.

Associated Alarm: Dangerous Arrival Alarm

5.4.6 Consecutive Hard Arrival Alarm Threshold

This setting defines when a consecutive hard arrival alarm will trip. For example, if this setting is 3, then 3 consecutive arrivals with a velocity higher than the Hard Arrival threshold will cause an alarm flag to be set.

Associated Alarm: Consecutive Hard Arrival Alarm

5.4.7 Cumulative Hard Arrival Threshold

The Sasquatch counts the number of arrivals above the Hard Arrival threshold. If this count exceeds the Cumulative Hard Arrival Threshold, and alarm flag is set. These do not need to be consecutive hard arrivals to trip the alarm.

Associated Alarm: Cumulative Hard Arrival Alarm

5.4.8 Cumulative Kinetic Energy Threshold

The Sasquatch accumulates (adds together) all kinetic energies for arrivals that exceed the Hard Arrival threshold. When that sum exceeds the Cumulative Hard Arrival Threshold, an alarm will occur.

Associated Alarm: Cumulative Kinetic Energy Alarm

6 History

The following outlines the parameters that are required and the history records that are stored during normal operation.

6.1 Parameters

The following parameters are used when storing each entry in the history.

6.1.1 Date and Time

The date/time defaults to January 1, 2000. This is non-persistent and should be set after powering up the Sasquatch. The Date/Time Set flag can be queried to see if this has been done. The logs will use this information to timestamp each log entry. If the date/time is changed, all new log entries will use the new date/time. Old entries will not be updated and will remain in the order in which they were recorded.

6.1.2 Units

The units of the Sasquatch can be set to either Metric or Imperial. This setting will affect the internal calculations and the velocity will be logged in the given units.

6.2 Arrival Log

The Arrival Log is a historical log that stores the last 120 arrivals in reverse chronological order. This means that the most recent log entry will always appear at the top of the log. The following information is stored in the Arrival Log.

6.2.1 Arrival Time

This is the date/time of the arrival. It is accessible as a collection of registers that each represents part of the date and time or two registers that represents the total number of seconds since January 1, 2000.

6.2.2 Velocity

The velocity value is the calculated velocity of the given arrival. It is either reported as m/min or feet/min, depending on the configured units.

6.2.3 Velocity Confidence Code

The velocity code indicates whether the calculated velocity is valid, or if an error occurred during the calculation. If the velocity is valid, this code also provides a figure of merit in the confidence of the velocity.

7 Lubricator / Spring Wear Monitoring

An important reason for knowing plunger speed at surface is to know if the lubricator is being damaged by hard plunger hits. The Sasquatch can monitor plunger arrivals to determine if the well is operating safely and if the lubricator spring may need maintenance or replacement. The ability for a lubricator to absorb a plunger hit is specified in kinetic energy units – inch-pounds (in-lbs) in imperial or Joules (J) in metric. The Sasquatch can convert plunger speed into kinetic energy and activate an alarm to indicate that the lubricator is under stress.

The API standard for plunger lift well heads specifies that manufactures should stamp a kinetic energy rating on the equipment they produce. The standard lists kinetic energy and plunger mass in these imperial units: in-lbs and lbs, so for convenience, the Sasquatch uses the same units. Likewise, for the metric units of kg and J.

Two key pieces of information are required to configure the Sasquatch for this functionality:

	Where to get it	Imperial Units	Metric Units
Plunger Mass	Ask vendor to provide it or weigh it	Pounds (lbs)	Kilogram (kg)
Lubricator Kinetic Energy Rating	Stamped on lubricator or ask vendor to provide it	Inch-pounds (in-lbs)	Joules (J)

Table 2 – Lubricator / Spring Wear Settings

The Dangerous Arrival Kinetic Energy Threshold should be set to the lubricator’s kinetic energy rating. We recommend that the Hard Arrival Kinetic Energy Setting be set to 85% of the lubricator’s kinetic energy rating.

The Sasquatch allows you to specify alarm thresholds in either velocity or kinetic energy units. It is up to the user to decide which to use. Velocity thresholds may be more familiar to some users but requires a manual calculation to check that it is within the lubricator specifications. Kinetic energy lets you use the lubricator rating directly.

Vision provides a settings page (below) to make the settings changes to the Sasquatch for your specific lubricator and plunger. You can also check/reset alarm status and statistics. This settings page is shown below. This tool is useful for initial integration and site auditing. The functionality of this page would typically be integrated into a SCADA system for automated lubricator / spring wear monitoring.

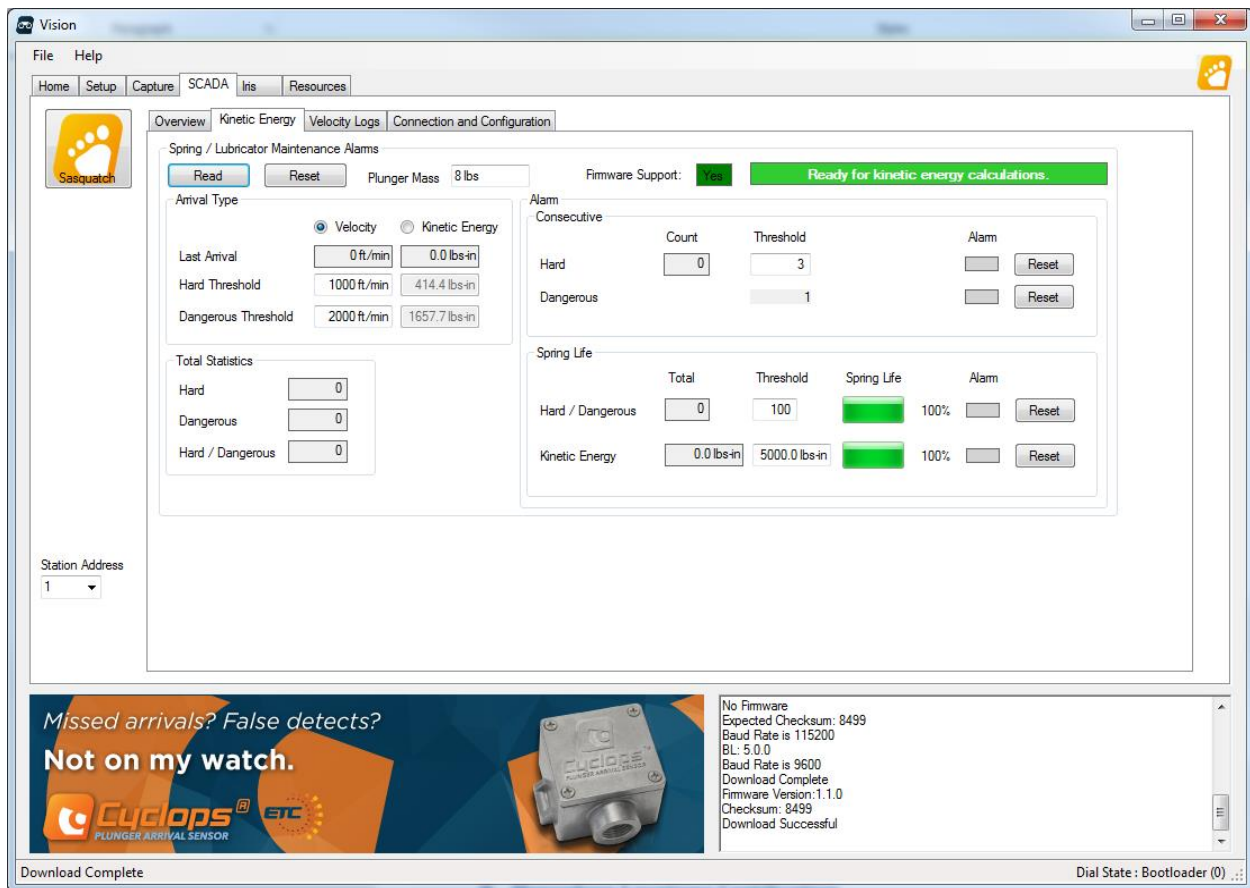


Figure 9 – Vision Sasquatch Kinetic Energy Settings

8 Hazardous Locations Certification

Sasquatch is certified as follows in Canada and the US:

Model: ET-11000-1030-0000

- Class 1, Division 2, Groups A, B, C and D T4
- Class 1, Zone 2, Group IIC T4

Model: ET-11000-1031-0000

- Class 1, Division 1, Groups C, D T4
- Class 1, Zone 0, AEx ia [ia] IIB T4 Ga
- Ex ia [ia] IIB T4 Ga
- Class 1, Division 2, Groups A, B, C and D T4
- Class 1, Zone 2, Group IIC T4

9 Cathodic Protection

A common problem with magnetic sensors is that they often become an electrical path between the well and the controller. Often, high voltages associated with cathodic protection can leak back through the sensor to the controller, causing erratic behavior or permanent damage.

The Sasquatch has been designed such that its internal circuitry does not come in contact with the case. This means that even if the case comes in contact with a surface that has a stray voltage; it will not be transmitted back through the wiring to the controller.

Please do keep in mind that any shielding on the cable that is connected to the case of the Sasquatch will act as a path for any stray voltage to travel.

10 Company Contact Information

Extreme Telematics Corp.

5925 12th Street SE, Bay 14
Calgary, Alberta, Canada
Ph. 403-290-6300

Appendix A Specifications

The following is a high level list of specifications:

Table 3 – General Specifications (Normal Mode)

Supply Voltage	5 V DC – 24 V DC
Power Consumption	@5V - 37.5mW @24V - 180mW
Average Current Draw	7.5mA
Peak Current Draw	8mA
Switch Impedance	100 ohms
Communications Port	2 wire RS-485
Protocol	Modbus
Baud Rates (bps)*	<ul style="list-style-type: none"> • 1200 bps • 2400 bps • 4800 bps • 9600 bps • 19,200 bps • 38,400 bps • 56,000 bps • 115,200 bps • 128,000 bps • 256,000 bps

*Baud rates may vary based on barrier type

Table 4 – Performance

Range	50 to 1000 m/min (164 to 3281 ft/min)
Accuracy	+/- 8% @ 250 m/min
Arrival Latency	Min = 251 ms, Typ = 710 ms, Max = 2 s

Table 5 – Environmental Data

Operating Temperature	-40 to +70 C (-40 to +158 F)
Storage Temperature	-40 to +125 C (-40 to +257 F)
Certification	<p>Model: ET-11000-1030-0000</p> <ul style="list-style-type: none"> • Class 1, Division 2, Groups A, B, C and D T4 • Class 1, Zone 2, Group IIC T4 <p>Model: ET-11000-1031-0000</p> <ul style="list-style-type: none"> • Class 1, Division 1, Groups C, D T4 • Class 1, Zone 0, Ex ia IIB T4 Ga • Class 1, Division 2, Groups A, B, C and D T4 • Class 1, Zone 2, Group IIC T4

Appendix B Modbus Register Formats

Register Formats

The following are the available register formats that are used throughout the register map.

- MSW = most significant word (16 bits)
- LSW = least significant word (16-bits)

Double Word Register

Table 6 - Double Word Register Format

Number	Description
Start	MSW
Start + 1	LSW

Elapsed Time Register

- Range: 0 – 3,599,999 seconds (1000 hours)
- Write LSW first when writing in seconds format
- Use the Time Format coil to switch the format

Table 7 - Elapsed Time Register Format

Number	Description (Seconds Format)	Description(H:M:S Format)
Start	Seconds (MSW)	Hours
Start + 1	Seconds (LSW)	Minutes
Start + 2	Reserved	Seconds

Date/Time Register

- Range: 0 – 4,294,967,295
- Write MSW first when writing in seconds format, followed by LSW
- Use the Time Format coil to switch the format

Table 8 - Date/Time Register Format

Number	Description (Seconds Format)	Description(H:M:S Format)
Start	Seconds since January 1, 2000 (MSW)	Year
Start + 1	Seconds since January 1, 2000 (LSW)	Month
Start + 2	Reserved	Day
Start + 3	Reserved	Hours
Start + 4	Reserved	Minutes
Start + 5	Reserved	Seconds

Appendix C Modbus Register Map

The following sections outline each of the sections of registers as defined by the Modbus protocol. These groups are as follows:

- Coils – Single bit registers that can be written to cause an action
- Input Discretes – single bit registers that are a read only status
- Input Registers – 16 bit registers that are a read only status
- Holding Registers – 16 bit registers that can be read and written.

Note: Any registers that are grayed out have not been implemented. Writes to these registers will be ignored. Reads from these registers will return unpredictable results.

Note: Modbus uses a register number, which starts at 1 to describe the location of data. The actual address that is passed in the protocol layer is 0. This means that depending on the tool you are using, you may need to subtract 1 from the register number to access the appropriate data.

Coils

Table 9 - Available Coils

Register	Description	Read	Write
Basic Control			
0:0001	Restart Sensor	N/A	1 - Restart
0:0002	Reset Velocity Log	N/A	1 - Reset Log
0:0003	Reset Error Log	N/A	1 - Reset Log
0:0004	Time Format	Current Value	0 – Seconds 1 – H:M:S
0:0005	Units	Current Value	0 – Imperial 1 - Metric
0:0006	Restart Modbus Interface	N/A	1 - Restart
0:0007	Reset Daily Statistics Log	N/A	1 – Reset Log
0:0008	Reset Total Statistics Log	N/A	1 – Reset Log
0:0009	Reset Modbus peripheral Error Log	N/A	1 – Reset Log
0:0010	Reset Arrival Log	N/A	1 – Reset Log

Register	Description	Read	Write
0:0011	Start Plunger Detection	N/A	1 – Start detection
0:0012	Stop Plunger Detection	N/A	1 – Stop detection
0:0013	Reset Kinetic Energy Statistics	N/A	1 - Reset statistics (except last arrival kinetic energy)
Kinetic Energy Alarm Control			
0:0014	Reset Consecutive Hard Arrival Alarm	N/A	0 – Reset alarm
0:0015	Reset Dangerous Arrival Alarm	N/A	0 – Reset alarm
0:0016	Reset Cumulative Hard Arrival Alarm	N/A	0 – Reset alarm
0:0017	Reset Cumulative Kinetic Energy Alarm	N/A	0 – Reset alarm

Input Discretes

Table 10 - Available Input Discretes

Register	Description	Read
General Information		
1:0001	Date/Time Set	0 – date/time not set 1 - date/time set
1:0002 – 1:0010	Reserved	N/A
Input Status		
1:0011	Plunger Arrival Status	0 – Absent 1 – Present

Register	Description	Read
1:0012	New Velocity Indicator	0 – No new velocity measured since last polled 1 – New velocity measured since last polled (value resets to 0 once it has been read)
Kinetic Energy Alarm Status		
1:0013	Consecutive Hard Arrival Alarm Status	0 - Consecutive Hard Arrival Statistic under threshold 1 - Consecutive Hard Arrival Statistic over threshold
1:0014	Dangerous Arrival Alarm Status	0 - Dangerous Arrival Alarm Statistic under threshold 1 - Dangerous Arrival Alarm Statistic over threshold
1:0015	Cumulative Hard Arrival Alarm Status	0 - Cumulative Hard Arrival Alarm Statistic under threshold 1 - Cumulative Hard Arrival Alarm Statistic over threshold
1:0016	Cumulative Kinetic Energy Alarm Status	0 - Cumulative Kinetic Energy Alarm Statistic under threshold 1 - Cumulative Kinetic Energy Alarm Statistic over threshold

Input Registers

Table 11 - Available Input Registers

Register	Description	Read
Controller Information		
3:0001 – 3:0002	Serial Number	Double Word format: 0 - 99999

Register	Description	Read
3:0003	Firmware Version – Major Version	0 – 99
3:0004	Firmware Version – Minor Version	0 – 99
3:0005	Firmware Version – Fix Version	0 – 99
3:0006	Hardware Version	0 – 99
3:0007 – 3:0008	Reserved	N/A
3:0009	Hardware Model	3
3:0010	Product Variant	0
State Information		
3:0011	Sensor State	0 – Initializing 1 – Detect
3:0012	Dial Switch Setting	1 – 7
3:0013	Sensor Sensitivity Threshold	0 - 65535
3:0014 – 3:0020	Reserved	N/A
Kinetic Energy Statistics		
3:0021 – 3:0022	Last Arrival Kinetic Energy	Floating-point format: 0 – 3.402823 × 10 ³⁸ ft-in (J)
3:0023	Consecutive Hard Arrivals	0 – 65535
3:0024	Cumulative Hard Arrivals	0 – 65535
3:0025	Cumulative Dangerous Arrivals	0 – 65535
3:0026 – 3:0027	Cumulative Kinetic Energy	Floating-point format: 0 – 3.402823 × 10 ³⁸ ft-in (J)
3:0028	Total Hard/Dangerous Arrivals	0 – 65535
3:0029 – 3:0100	Reserved	N/A
Arrival/Velocity Log		
3:0101	Log Count	0 – 120

Register	Description	Read
3:0102 + 6(n-1) to 3:0107 + 6(n-1)	Arrival Time – Entry n n = 1 to 120	Date/Time format
3:822 + (n-1)	Velocity – Entry n n = 1 to 120	0 – 1000 m/min (0 – 3281 ft/min)
3:942 + (n – 1)	Velocity Calculation Code – Entry n n = 1 to 120	0 – Reserved 1 – No multipoint velocity was calculated 2 – Two points used to calculate velocity 3 – Three points used to calculate velocity 4 – Four points use to calculate velocity 5 – Five points use to calculate velocity 6 – Six points use to calculate velocity 7 - Seven points used to calculate velocity 8 – Eight points used to calculate velocity 20 - Velocity under range 21 – Velocity over range 22 – Velocity Waveform Sync. Failed 23 – False Arrival

Register	Description	Read
3:1062 + (n-1)	Kinetic Energy – Entry n n = 1 to 120	0 – 315.0 J (0 – 2788.2 lbs-in)
3:1282 – 3:1500	Reserved	N/A
Modbus Error Log		
3:1501	Slave Access Failure Type This register may be read to view details of the last <i>Slave Device Failure</i> or <i>Illegal Data Address</i> exception response.	0 – 12
3:1502	Slave Access Failure Bank Contains the Modbus bank in which the last <i>Slave Device Failure</i> or <i>Illegal Data Address</i> exception response occurred. The bank returned does not include any address information.	0 – 4
3:1503	Slave Access Failure Register Contains the register number at which the last <i>Slave Device Failure</i> or <i>Illegal Data Address</i> exception response occurred. The address returned does not include any bank information. For example, <i>abcd</i> is returned for an error at address 0: <i>abcd</i> , 1: <i>abcd</i> , 3: <i>abcd</i> , or 4: <i>abcd</i> .	0 – 65535
3:1504 – 3:1510	Reserved	N/A
Firmware Error Log		
3:1511	Number of Log Entries	0 - 10

Register	Description	Read
3:1512 + 3(n - 1)	Error Log Type 10 Available error logs. "n" in the register column represents the error log number.	1 = System Definition Error 2 = Assertion Failure 3 = Check Failure 255 = No Error Log Available
3:1513 + 3(n - 1)	Error Log Data 1 10 Available error logs. "n" in the register column represents the error log number.	Contact for Details
3:1514 + 3(n - 1)	Error Log Data 2 10 Available error logs. "n" in the register column represents the error log number.	Contact for Details
Daily Production Log		
3:2101	Daily Production Log Count	0 - 15
3:2102 + 6(n-1) to 3:2107 + 6(n-1)	Daily Production Log Save Time – Entry n n = 1 - 15	Date / Time Format
3:2192 + (n-1)	Daily Production Log Plunger Arrival Count – Entry n n = 1 – 15	0 - 65534
3:2207 + (n-1)	Daily Production Log Maximum recorded Velocity – Entry n n = 1 - 15	0 – 1000 m/min (0 – 3281 ft/min)
3:2222 + (n-1)	Daily Production Log Minimum recorded Velocity – Entry n n = 1 – 15	0 – 1000 m/min (0 – 3281 ft/min)
3:2237 – 3:2500	Reserved	N/A

Register	Description	Read
Total Production Log		
3:2501 – 3: 2506	Total Production Save Time	Date / Time Format
3:2507	Total Production Log Plunger Arrival Count	0 - 65535
3:2508	Total Production Log Maximum recorded Velocity	0 – 1000 m/min (0 – 3281 ft/min)
3:2509	Total Production Log Minimum recorded Velocity	0 – 1000 m/min (0 – 3281 ft/min)

Holding Registers

Table 12 - Available Holding Registers

Register	Description	Read/Write
General Controller Settings		
4:0001	Modbus Write Time The amount of time to wait after the last written value before saving all changes to the controller.	0 – 65535 seconds. Writing zero (which is the default) will save all changes as they are made.
4:0002 – 4:0007	Controller Date/Time	Date/Time
4:0008	Daylight Savings Time configuration	0 = Disabled 1 = Enabled
4:0009 – 4:0010	Day Start Time – Start of the gas day.	Elapsed Time format: 0 – 86340 (00:00: – 23:59) When in HH:MM:SS format, only Hours and Minutes are available.
4:0011 – 4:0030	Reserved	N/A

Register	Description	Read/Write
Output Configuration		
4:0031	Output Mode	0 = Static Time 1 = Velocity Scaled 2 = Plunger Hold (default)
4:0032	Output Hold Scale	1 – 600 ms per m/min (ft/min) default = 10 ms
4:0033	Minimum Output Hold Time	100 – 65,535 ms default = 1000 ms
4:0034 – 4:0040	Reserved	N/A
Data Processing Timers		
4:0041	Baseline Update Timer	500 – 10,000 ms default = 999 ms
4:0042	Arrival Detection Period	1 – 500 ms default = 3 ms
4:0043	Velocity Gathering Period	1 – 10 ms default = 1 ms
4:0044	Velocity Gathering Timeout	250 – 1000 ms default = 700 ms
4:0045	Velocity Calculation Timer	1 – 1000 ms default = 10 ms
4:0046	Departure Detection Period	1 – 1000 ms default = 1000 ms
4:0047	Re-initialize Timer	1 – 65,535 s default = 1 s
4:0048	False Arrival Period	150 – 750 ms Default = 500ms
4:0049 – 4:0050	Reserved	N/A

Register	Description	Read/Write
Modbus Settings		
4:0051	Baud Rate	0 = 1200 bps 1 = 2400 bps 2 = 4800 bps 3 = 9600 bps 4 = 19,200 bps 5 = 38,400 bps 6 = 56,000 bps 7 = 115,200 bps 8 = 128,000 bps 9 = 256,000 bps
4:0052	Parity	0 = None 1 = Even 2 = Odd
4:0053	Data Bits	0 = 7 Data Bits 1 = 8 Data Bits
4:0054	Stop Bits	0 = 1 Stop Bit 1 = 2 Stop Bits
4:0055	Modbus Slave Station Address	1 - 247
4:0056	Modbus Protocol	0 = RTU 1 = ASCII
Kinetic Energy Configuration		
4:0061	Plunger Mass	0 – 65.535 lbs (kg) Where 65535 = 65.535
4:0062	Hard Arrival Velocity Threshold	0 – 65535 ft/min (m/min)
4:0063 – 4:0064	Hard Arrival Kinetic Energy Threshold	Floating-point format: 0 – 3.402823 × 10 ³⁸ ft-in (J)
4:0065	Consecutive Hard Arrival Alarm Threshold	0 – 65535
4:0066	Dangerous Arrival Velocity Threshold	0 – 65535 ft/min (m/min)

Register	Description	Read/Write
4:0067 – 4:0068	Dangerous Arrival Kinetic Energy Threshold	Floating-point format: 0 – 3.402823×10^{38} ft-in (J)
4:0069	Cumulative Hard/Dangerous Arrival Threshold	0 – 65535
4:0070	Cumulative Kinetic Energy Threshold	Floating-point format: 0 – 3.402823×10^{38} ft-in (J)