isensys
intelligent sensing

User Manual

SandAlert System

FIFTH EDITION

August 08

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WARRANTY AND LIABILITY

Pulsar Process Measurement Limited/Isensys LLP guarantee for a period of 12 months from the date of delivery that it will either exchange or repair any part of the Sand Monitoring System returned to Pulsar Process Measurement Limited/Isensys LLP if it is found to be defective in material or workmanship, subject to the defect not being due to fair wear and tear, misuse, modification or alteration, accident, misapplication or negligence.

DISCLAIMER

Pulsar Process Measurement Limited/Isensys LLP gives nor implies any process guarantee for the Sand Monitoring System or other products, and shall have no liability in respect of any loss, injury or damage whatsoever arising out of the application or use of any product or circuit described herein.

TECHNICAL ENQUIRIES

Please contact Isensys LLP or your local distributor for technical support.

COMMENTS AND SUGGESTIONS

If you have any comments or suggestions about the SandAlert system, then please contact:

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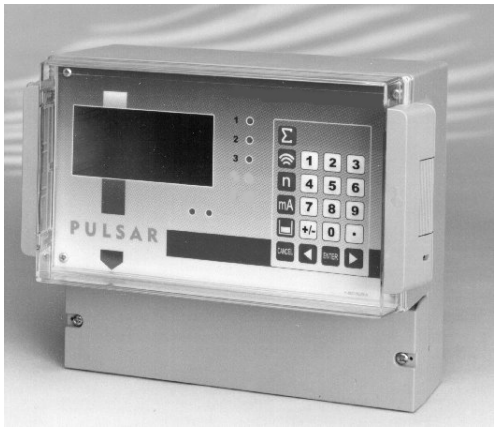
Contents

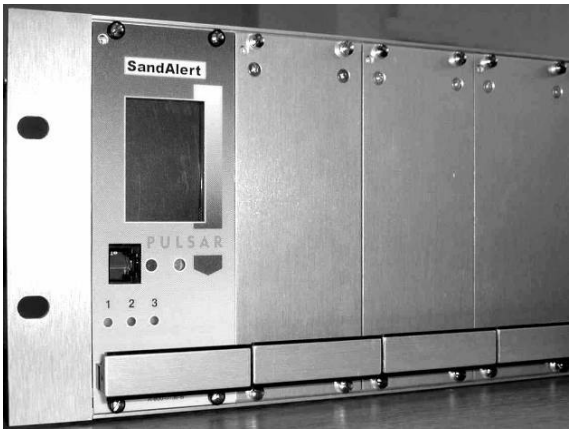
1 System Overview/Introduction

The single channel sand monitoring system comprises two main elements, the acoustic sensor "PulsarGuard 2001"and the SandAlert control unit.

The pictures below shows the wall mount and rack mount SandAlert unit:

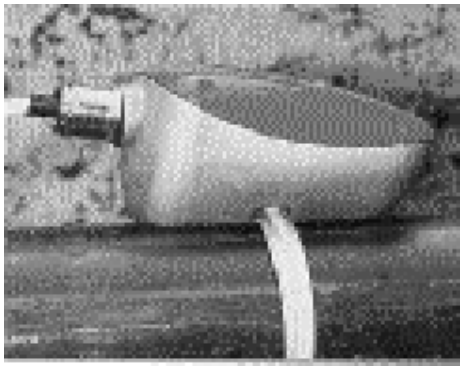


SandAlert Wall mounting unit



SandAlert Rack mount unit

Acoustic Sensor



PulsarGuard 2001

The sensor is a Pulsar Process Measurement intrinsically safe acoustic sensor. The sensor is housed in a robust cast Type 316 stainless steel enclosure. The Sensor is called the PulsarGuard 2001 and is intrinsically safe, certified to ATEX and to EEx ia IIC T4

Explanation of the IS approval description:

EEx	denotes a hazardous area approval.
ia	denotes the device is intrinsically safe category 'ia', and therefore is suitable for all zones (0, 1 and 2).
IIC	denotes the gas group. Group IIC, typical gas hydrogen..
T4	denotes the temperature classification.

The sensor housing is rated at IP68 giving protection against temporary immersion to a depth of 3 metres.

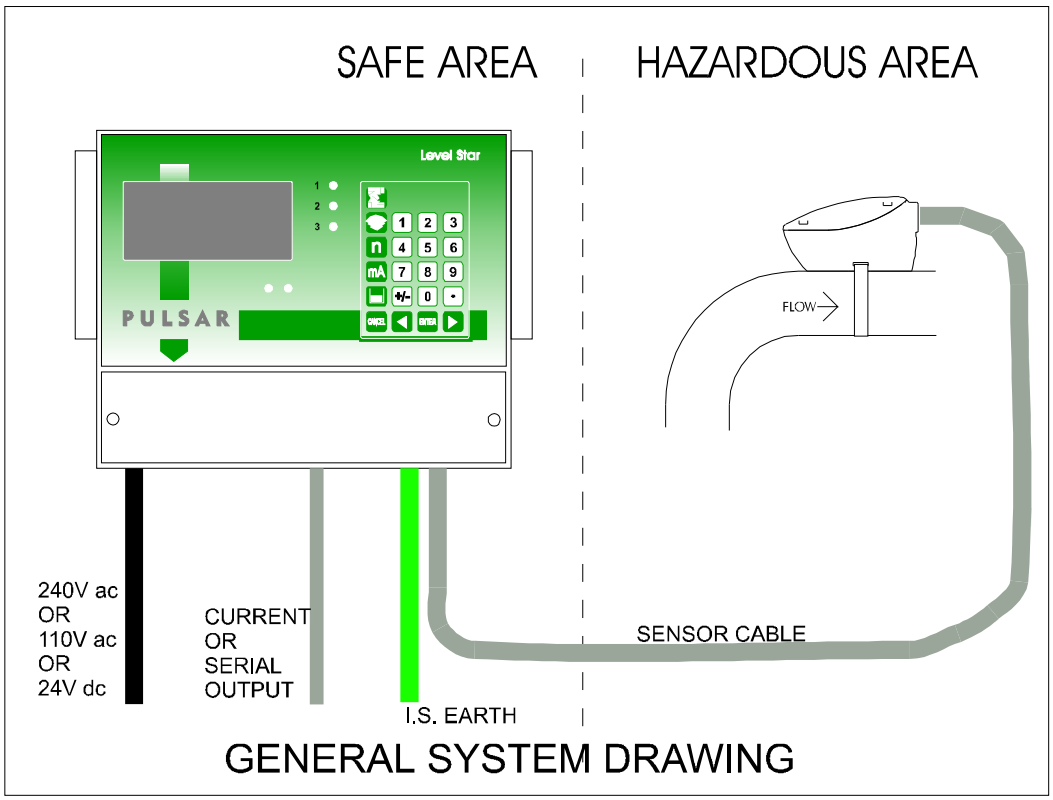
The sensor is powered from a power supply via a Galvanic or Zener safety barrier.

The wall mount unit contains the zener safety barrier and the 24v power supply.

The rack mount unit contains the power supply but the Galvanic or Zener safety barrier must be fitted externally.

The sensor is attached to the outside of the pipe, on or just after a bend, by means of a stainless steel band (see picture above). The sensor is connected to the SandAlert control unit via 4 core cable with an overall braided screen.

Wall mount SandAlert Control Unit

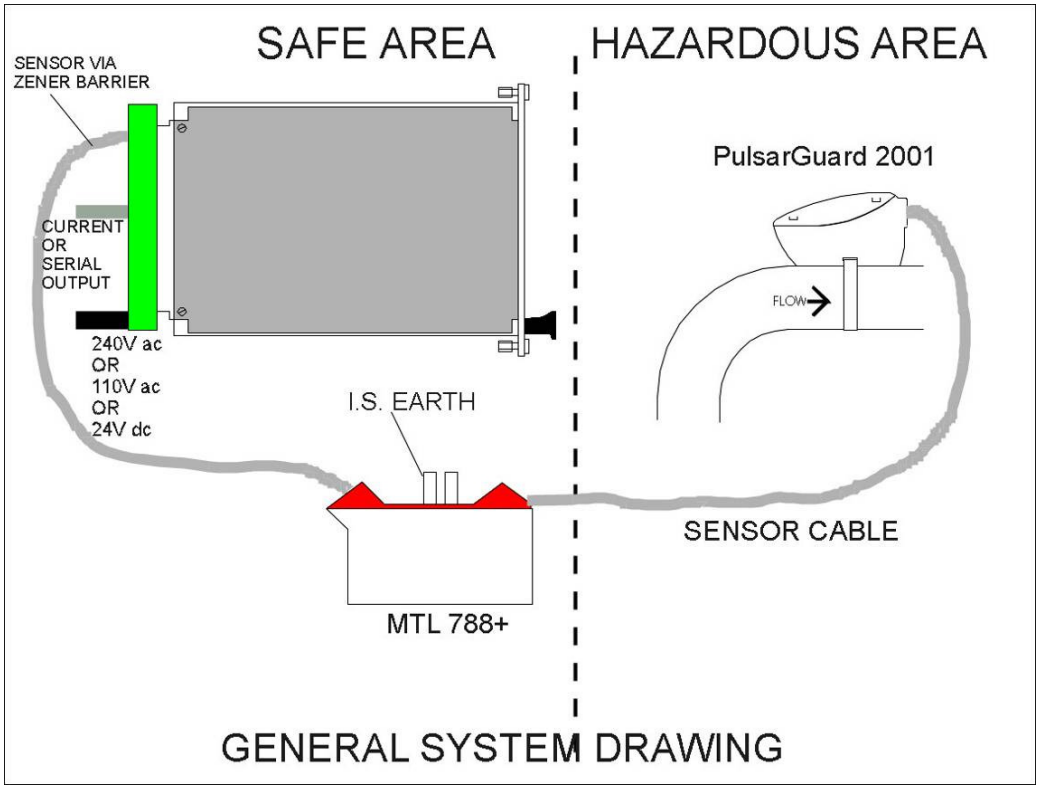


The wall mount SandAlert control unit is housed in an IP65 Polycarbonate enclosure. The electrical interface between hazardous and non-hazardous area is provided by an internal zener safety barrier.

The SandAlert uses a microprocessor and internal electronics to convert the analogue sensor signal to allow further processing by the microprocessor. The unit is programmed via the integral keypad or an infra red remote control. It is also possible to change parameters via the serial port if a suitable terminal is connected (i.e. a PC running terminal). Sand data is displayed on the unit's LCD and transmitted via the current output or via the RS232 serial port.

UNDER NO CIRCUMSTANCES MUST THE SANDALERT CONTROL UNIT BE OPERATED IN A DESIGNATED HAZARDOUS AREA.

Rack mount SandAlert Control Unit



The Rack mount SandAlert control unit is housed in a standard 160mm deep 3U high by 10HP wide housing, this is should be fitted into a subrack or similar (Not supplied as standard). The electrical interface between rack unit and the outside world is via a 32 way 'Phoenix' connector, which is mounted at the rear of the subrack.

The SandAlert uses a microprocessor and internal electronics to convert the analogue sensor signal to allow further processing by the microprocessor. The unit is programmed via an infra red remote control. It is also possible to change parameters via the serial port if a suitable terminal is connected (i.e. a PC running terminal). Sand data is displayed on the unit's LCD and transmitted via the current output or via the RS232 serial port.

Power Requirements

The SandAlert System is powered from either a mains power supply which can be 115 or 230V ac, or from a 24V dc source (see specification for power requirements). In the event of power failure during monitoring, the unit will continue monitoring when the power is returned (the time and date of the last 6 starts are saved in parameters under "Log"). The ac mains supply is fused by a 100mA fuse (240V operation), accessible when the wiring cover is removed. The dc is fused by a self resetting internal fuse, to reset the fuse the power must be removed and then reconnected. There is no power switch the unit will monitor once power is supplied and the unit has booted.

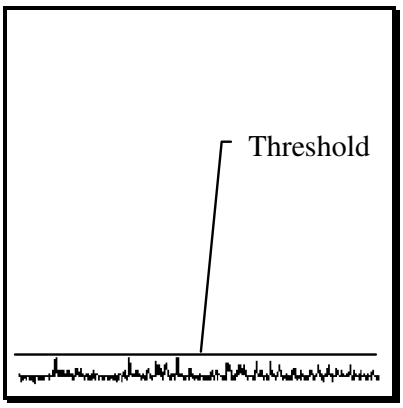
UNDER NO CIRCUMSTANCES MUST THE WIRING COVER BE REMOVED WITH-OUT DISCONNECTING THE POWER SOURCE. THERE ARE TWO MAIN REASONS: 1.SAFETY AND 2. THE I.S. CERTIFICATION IS BREACHED WHEN THE COVER IS REMOVED.

Signal Processing Technique

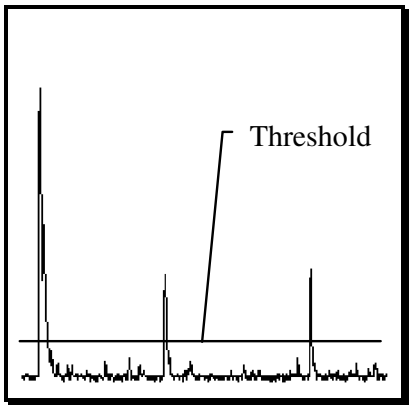
The high frequency structure borne acoustic signal generated by a sand impact on the internal wall of the pipe, travels through the pipe wall and is detected by the acoustic sensor. The acoustic signal is then converted to an electrical signal by the sensor.

The electrical signal or sensor output is processed by the electronics in the SandAlert control unit to provide a sand impact rate (SIR) in impacts per second (IPS). (This figure is then used by the calibration algorithm to give sand mass).

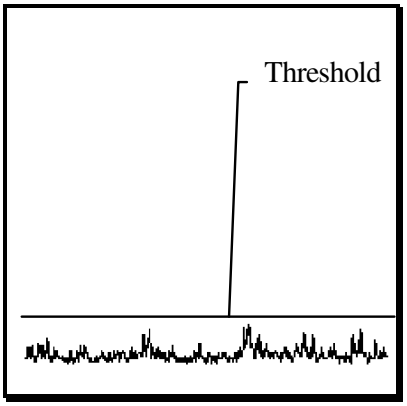
To illustrate this the following figures (a,b,c & d) show the types of signals that you would expect under conditions of high and low flow rates, with and without sand impacts:



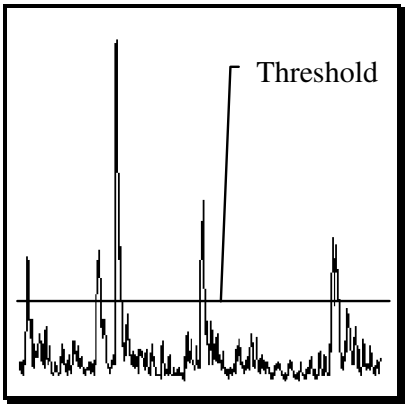
a - Low Flow, No Sand



b - Low Flow, With Sand



c - High Flow, No Sand



d - High Flow, With Sand

The SandAlert unit monitors the input signal and determines automatically a value for the threshold. The unit will automatically vary the threshold depending on the signal. The SandAlert unit eliminates the flow noise by automatically placing a threshold just above the flow related noise signal (average), and when the signal cuts the threshold then it is due to sand impacts, which can be seen in *b* and *d* as short duration, high energy spikes, as compared with the flow related noise that is of lower energy. There is one parameter that influences the threshold and this is P160, this sets the starting level for the threshold.

Calibration

The SandAlert unit can be calibrated to give sand produced by one of two methods:

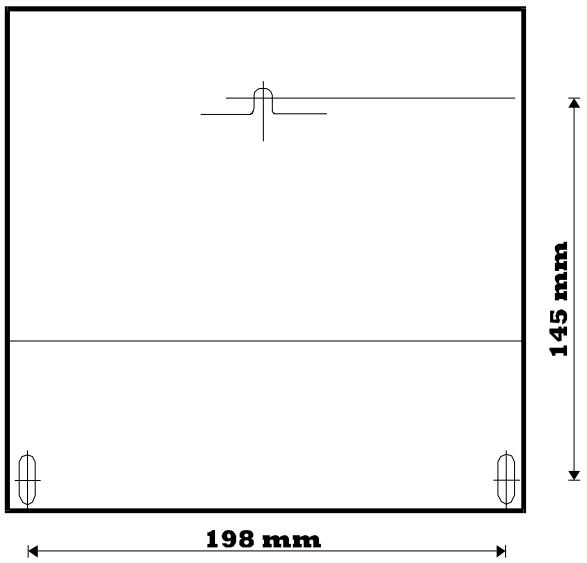
1. Collecting and measuring the mass of produced sand or by injecting a known mass over an known period, this figure is then used to autocalibrate the unit, the mass/time figure will be based on this calibration.
2. Estimating sand generation and manually editing the calibration factor.

Method 1 gives the most accurate calibration and should be chosen.

2 Installation

Installation, commissioning and servicing of the system must be strictly in accordance with the applicable standards for the location of the installation. All equipment and system approvals, specifications, warranties and statements of fitness for purpose are conditional upon this requirement being met.

The sensor is certified to ATEX for use in hazardous areas and it is important to ensure that this level of certification is adequate for the area in which the sensor is intended to be installed. **The SandAlert control unit must be situated in a non-hazardous area.**



Mounting detail for the wall enclosure

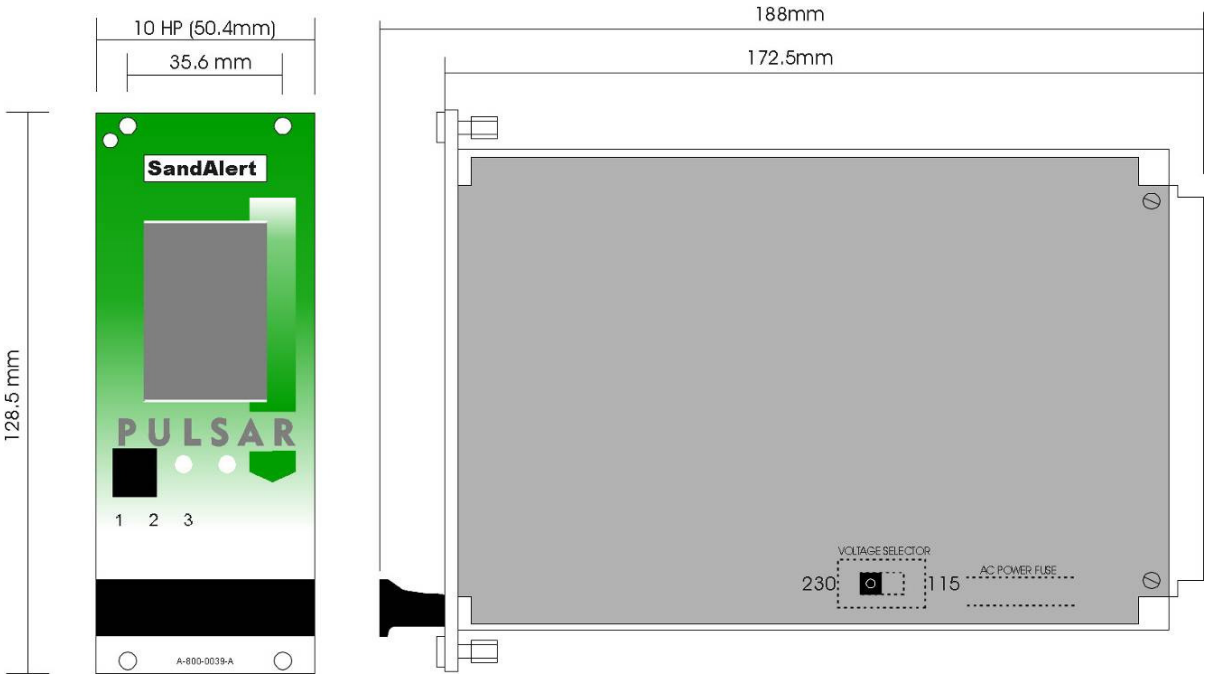
The control unit should be attached to a suitable wall (in a safe area) with reference to the mounting detail shown above.

Cable Entry

There are 6 cable gland knockouts on the base of the Control unit (4 x PG11, 1 x PG9, 1 x PG13.5) and 5 on the rear (5 x PG11). Select which ones you wish to take out, and remove them by using a circular cutter, such as a tank cutter. Take care not to damage the circuit board inside whilst undertaking this. Do not use a hammer, as this may cause damage to the enclosure.

It is recommended that you use suitable cable glands to ensure that the ingress rating is maintained.

The rack mount unit should be fitted in a suitable sub rack assembly with the 'Phoenix' connector mounted at the back.



Rack Unit detail

Sensor Positioning

The acoustic sensor detects the high frequency sound generated by the impacts of sand and other solid particles e.g. proppant on the inside of the pipe wall. **Therefore, the best results will be obtained if the sensor is positioned on or just after a bend** (within two pipe diameters of the bend), or fixed restriction to the flow.

Do not position the sensor in close proximity to a choke, or other variable restriction, since changes in the choke position may affect the SIR readings.

Pulsarguard 2001 & 2011 test stimulation

We have in the past had working sensors returned as the customer thought they were faulty. This is due to the sensors (especially the 2001) being only sensitive to high frequencies.

The way we suggest you test a transducer is either by rubbing the unpainted part with rough sandpaper or lightly dragging a metal object such as a screwdriver over the rough unpainted casting.

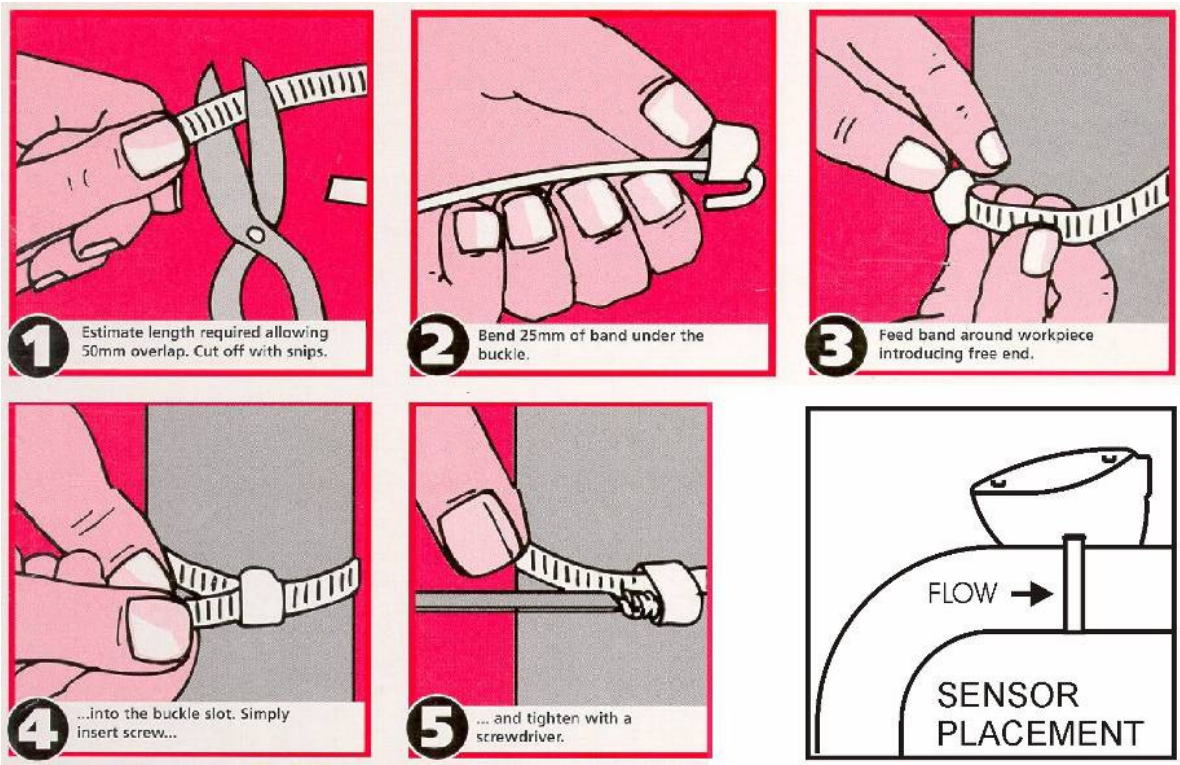
Either of these methods should give an output from the transducer, this will show on the display as sand impacts.

Alternatively drop a continuous stream of sand or salt on the face of the transducer.

PulsarGuard 2001 is an acoustic sensor and the coupling between the pipe and the sensor is critical, make sure the pipe is clean and smooth (use sandpaper if necessary to clear the surface of paint or rust).

How to fit the sensor to the pipe

The sensor is fastened to the pipe using the supplied banding. The sensor should be mounted on a straight section of pipe close to a bend on the outside of the bend. The illustration below shows the method of fixing. The banding is passed through the slot in the sensor, the base of the sensor is covered with silicon grease (acoustic couplant) and is then fixed around the pipe (see photo).



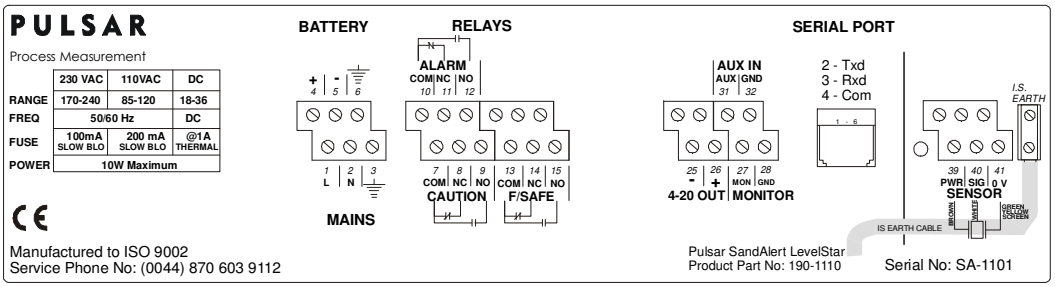
IMPORTANT: The point of contact with the pipe should be cleaned of paint, to ensure that the sensor contacts with bare metal. Some suitable grease, such as silicon grease, must be applied between the pipe and the sensor. This improves the acoustic coupling.

IMPORTANT: The sensor cannot be damaged by overtightening since the banding is in contact with the metal part of the sensor and not the electronics which are contained within the body of the housing.

Where vibratory conditions exist it is recommended that the free end of the band be restrained or bent so that it will not produce any noise that could be construed as sand impacts.

Electrical Installation of SandAlert

Wall Mount unit:



TERMINAL WIRING DIAGRAM FOR WALL MOUNT

All connections are made under the wiring cover of the control unit, the drawing above (replicated in the wiring cover) shows the terminal layout. All connections are made with screw terminal except for the serial port which is on a telephone type connector.

The mains supply voltage must be the same as that set on the SandAlert voltage selection switch, i.e. 115 or 230 V ac (Live - 1, Neutral - 2, Earth - 3) or from a 24V dc source (24V - 4, 0V - 5). Irreparable damage may occur if the wrong supply voltage is applied. Damage of this nature is not covered under warranty.

The relay connections are detailed above and should be setup, see operating system for details.

Aux in is not implimented at this time.

4-20 out (Current output) is wired as follows: negative - 25, positive - 26. The span and top and bottom levels can be set, see operating system for details.

Monitor output allows the raw signal from the sensor to be displayed on an oscilloscope for diagnostics or setup.

The serial port connector allows sand data to be sent to a terminal for logging etc.

Rack Mount unit:

All connections are made to the 32 way 'Phoenix' connector at the rear of the unit. All connections are made with screw terminals except for the serial port which is on a telephone type connector on the front of the unit.

The mains supply voltage must be the same as that set on the SandAlert voltage selection switch, i.e. 115 or 230 V ac (Live – A30, Neutral – A28, Earth – A32) or from a 24V dc source (24V – A4, 0V – A2). Irreparable damage may occur if the wrong supply voltage is applied. Damage of this nature is not covered under warranty.

The mains supply voltage selector switch and the mains fuse are positioned under the bottom cover strip.

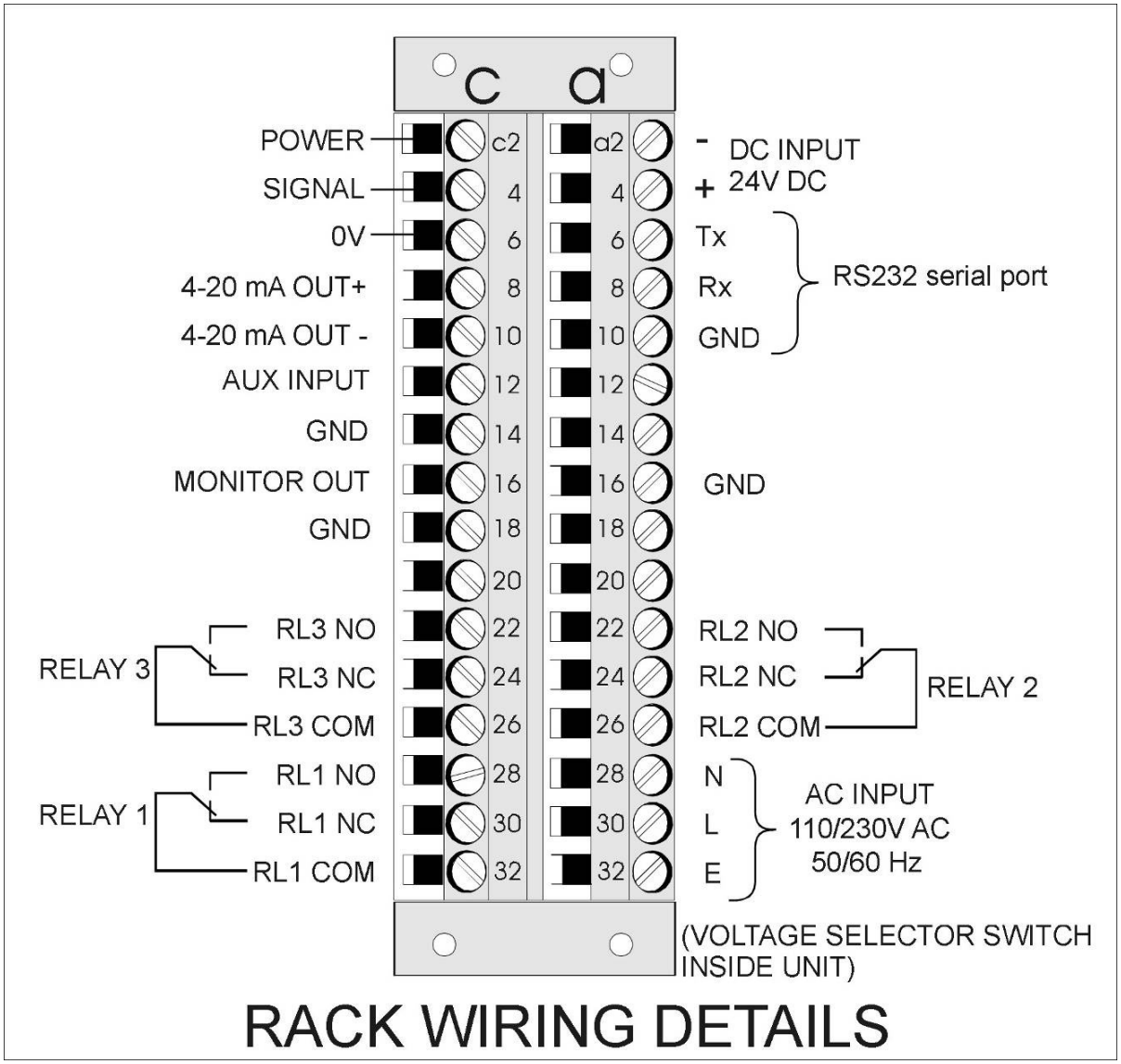
The relay connections are detailed below and should be setup, see operating system for details.

Aux in is not implimented at this time.

4-20 out (Current output) is wired as follows: negative C10, positive C8. The span and top and bottom levels can be set, see operating system for details.

Monitor output allows the raw signal from the sensor to be displayed on an oscilloscope for diagnostics or setup.

The serial port connector allows sand data to be sent to a terminal for logging etc.



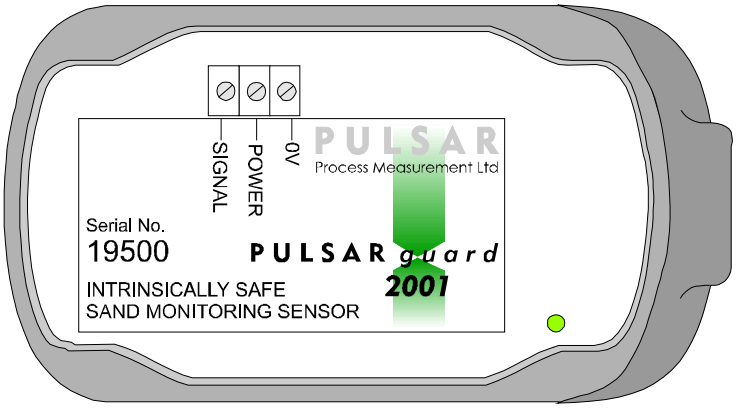
Wiring of the Sensor (PulsarGuard 2001)

Route the cable from the non-hazardous area, in which the SandAlert is to be operated, to the sensor position. Avoid running the cable parallel to HV cables to reduce the risk of electrical noise. Be careful not to route the cable in such a way as to obstruct doorways or walkways.

The SandAlert control unit must not be operated in a designated hazardous area. It must be located in a designated safe area.

The cable recommended is a two pair screened cable, it is possible to use up to 1000 metres of cable between the sensor and the control unit. One end of the cable connects to the SandAlert control unit and the other end is wired to the internal terminal block inside the sensor housing. A suitable 20mm gland will be required at the entry to the sensor.

Refer to the diagram (below) to ensure that all the electrical connections have been made correctly



Terminal block inside the sensor

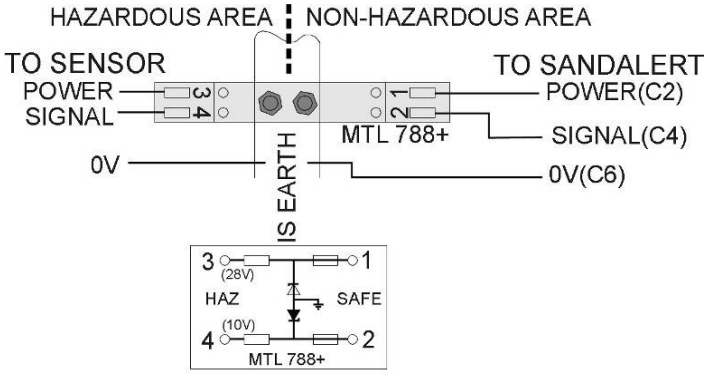
If you use the cable we recommend the colours should be as follows for the wall mount unit:

Description	**Control Unit**	**Sensor**
Power	Brown (terminal no. 39)	Brown (power)
Signal	White (terminal no. 40)	White (signal)
0V	Green, yellow and screen (terminal no. 41)	Green and yellow wires (0V)

Note that the screen is not connected at the sensor end.

Wall mount unit: It is imperative that all wiring from the sensor into the control unit is kept in the partitioned area by the sensor terminal block, this is to maintain the IS integrity.

Rack mount unit:



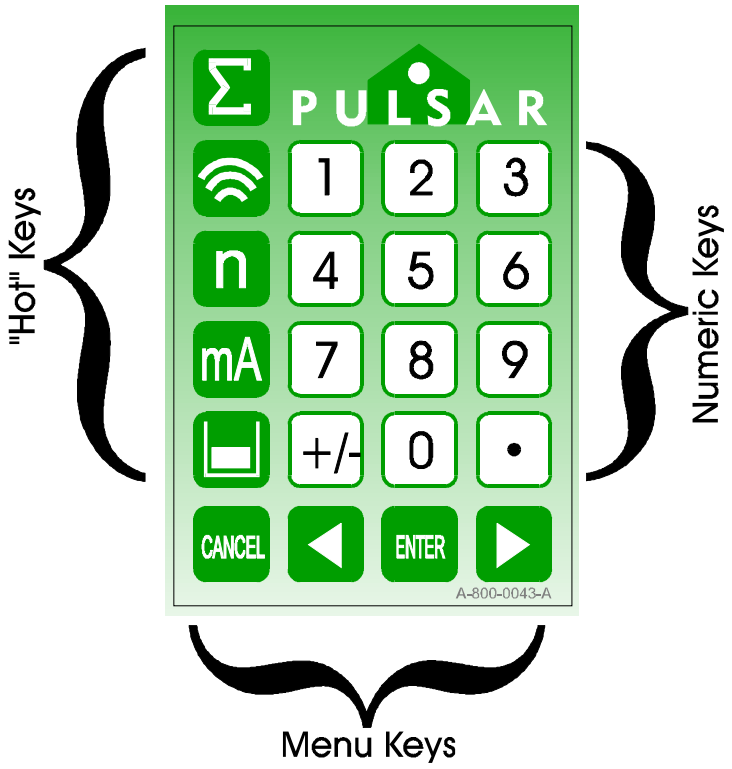
BARRIER WIRING FOR RACK UNIT

Connect the cable screen to IS earth at the barrier, connect the screen to the sensor housing via the cable gland.

3 OPERATION

Keyboard

The Unit is set up using either the integrated keyboard or by using an infrared remote control, both methods have the same key layout as shown below:



The keypad consists of three main areas, Numeric keys, Menu keys and Hot keys.

Numeric keys - Allow the entry of numbers

Menu keys - Let you move around the menuing system

Hot keys - Give quick access to the most popular functions.

Before you can setup the unit you need to key in a password (number) to give you access to the menu system. Enter the passcode, followed by the ENTER key. The default passcode is 1997, so you would press the following:

You would then have access to the menu system, you can disable the need for a password

HOT KEYS

The hot keys can be to gain further information as follows:-


(sigma)

Will show the totaliser. If the ‘0’ key is pressed while the totaliser is showing, the user will be prompted to ask if he wants to reset the totaliser. A confirmation will be required before reset, press cancel to leave the totaliser as it was.


(curved lines)

Not Used


(n)

Show display of impacts per second. This display is not damped, and so will show rapid changes, it can be useful for diagnostics.

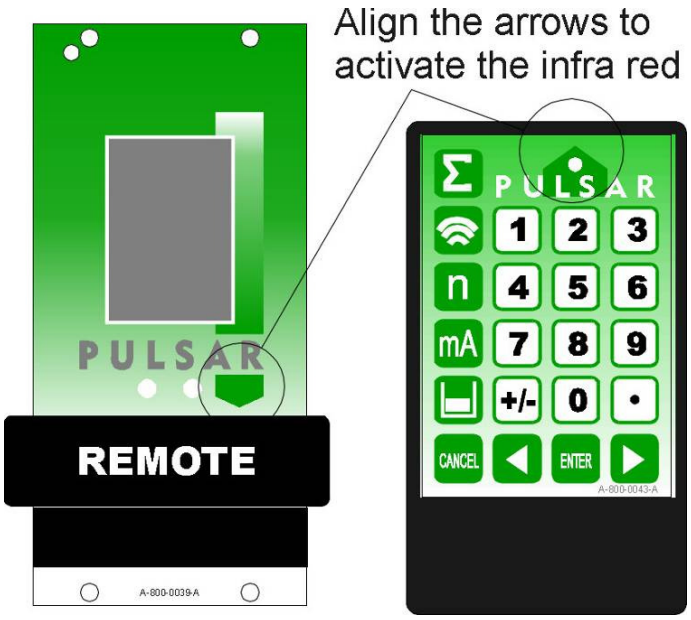

(mA)

Show the level of the Current output.


(level key)

Show the average voltage signal to aid setup.
The other keys are reasonably self explanatory.

Activating the infra red sensor



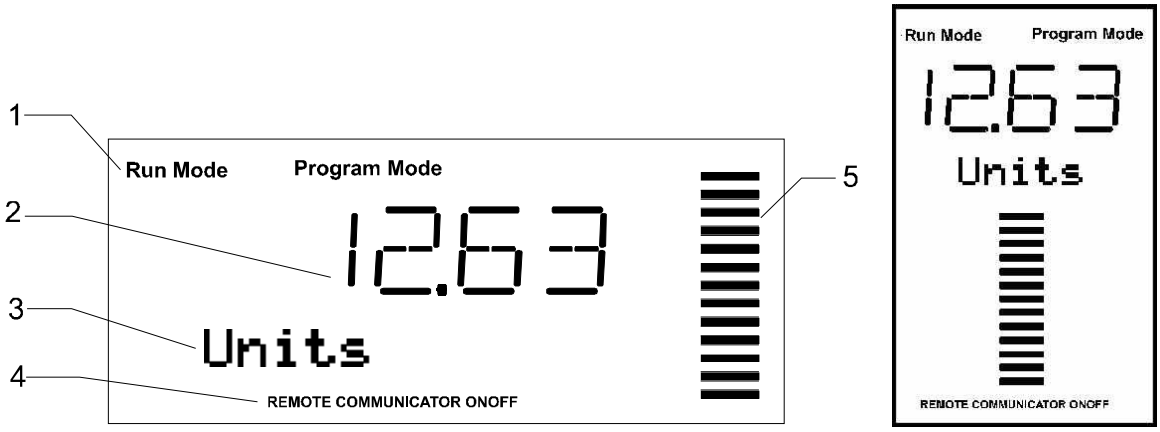
Remote 'Kissing'

When using the remote control it is necessary to activate the infra red port by 'kissing' the front of the remote over the area of the front panel just above the handle. You will see the text at the bottom of the LCD change from 'Communicator Off' to 'Remote Communicator On', the remote will active for about 15 mins and will then automatically return to communicator off.

Display

The display provides information on the current mode of operation, and status of the remote communication. Whilst in the Run Mode it will display the sand level reading and its units of measure. When in the Program mode the display is used to read information on the Menu System, Parameter Number, parameter details and values, which can be entered. A bargraph is also provided which will provide a visual reading of the level, the span of this is one of the parameters that can be set.

Below is a drawing of the LCD Display:



1. Mode status enunciator displays the current mode, run mode or program mode
2. Main 6 digit numeric display - normally shows the sand rate, used for data entry during programming.
3. Alphanumeric display that gives units in run mode and text in program mode
4. Remote communicator status
5. Bargraph display, gives visual indication of sand production.

The SandAlert software has 2 main modes;

RUN - Run mode (Normal mode)
PROG - Program mode (Allows changing of parameters etc.)

RUN MODE

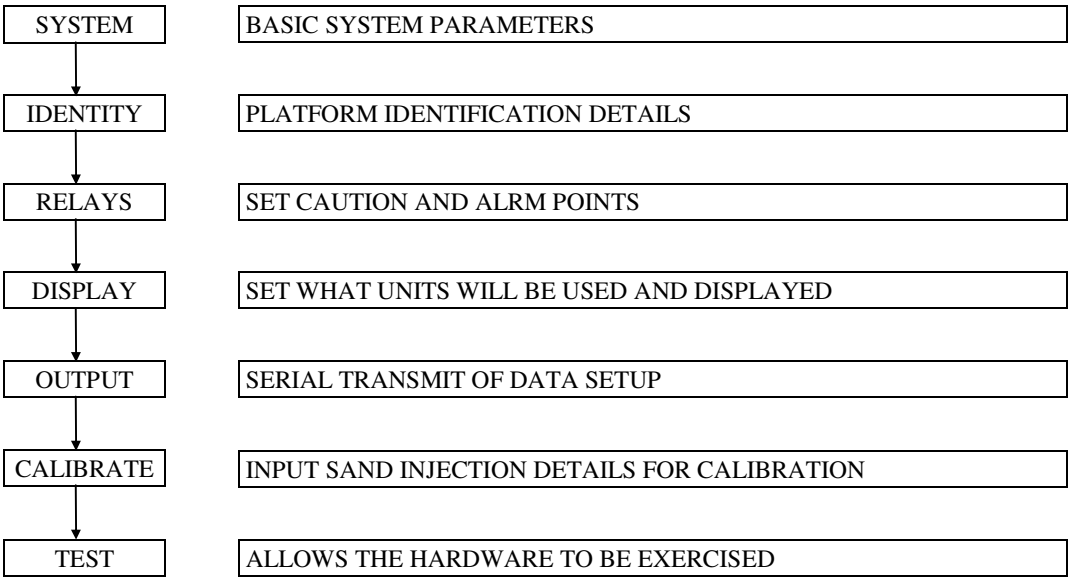
Displays the sand figure in units set up by the user, this defaults to grams per second. The user can choose other units in program mode to allow different weights, times, percentage of a set maximum, or impacts per second.

The hot key displays will revert to the normal display after 10 seconds, or immediately if the CANCEL key is pressed.

PROGRAM MODE allows the setting of all settable parameters and is accessible by entering a user settable passcode, or if passcodes are disabled (P121), by hitting the enter key.

Program Mode includes parameters to calibrate and test the unit.

TOP LEVEL MENU

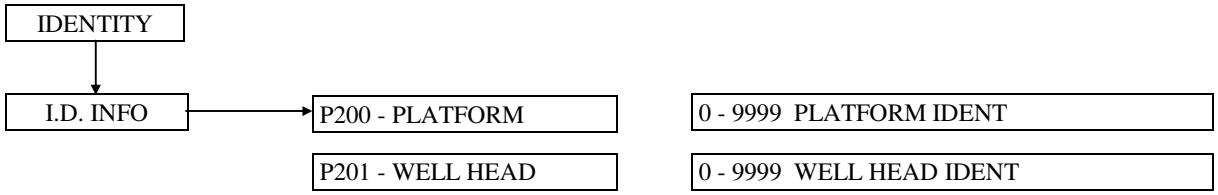


The following pages give more detail of the sub menus below the top level categories shown above.

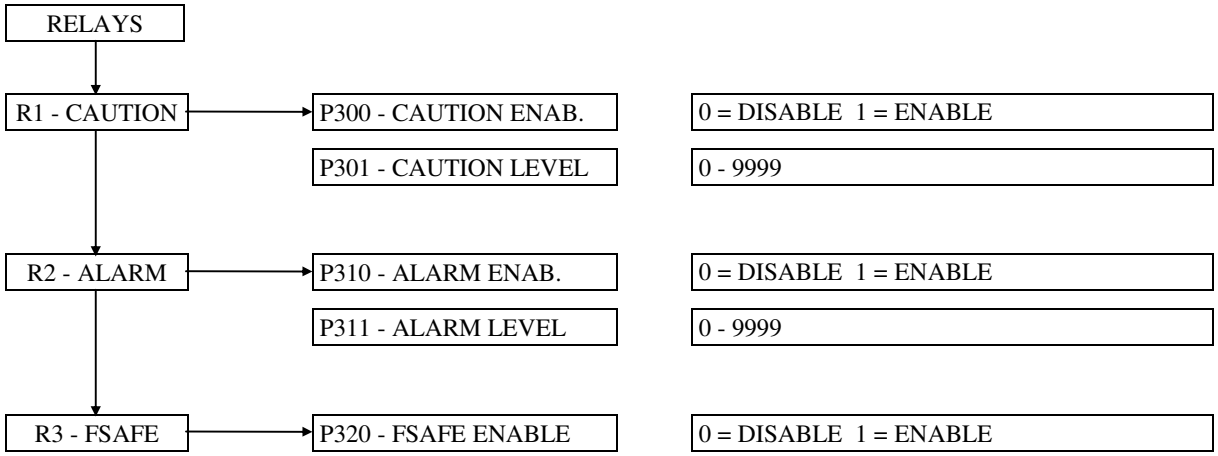
SYSTEM MENU

SYSTEM		
SYSTEM INFO	P100 - SOFTWARE REV.	READ ONLY
	P101 - HARDWARE REV.	READ ONLY
	P102 - SERIAL No.	READ ONLY
	P103 - SITE IDENT	0 - 999999
DATE/TIME	P110 - DATE	ENTER DATE
	P111 - TIME	ENTER TIME
	P112 - DATE FORMAT	1 : DD-MM-YY 2 : MM-DD-YY
PASSCODE	P120 - PASSCODE EN.	0 - DISABLE 1 - ENABLE
	P121 - PASSCODE	0 - 99999
RESETS	P130 - FACTORY DEF.	0 - NO 1 - SET FACTORY DEFAULTS
LOG	P140 - NUM STARTS	0 -9999
	P141 - START DATE 1	READ ONLY
	P142 - START TIME 1	READ ONLY
	P143 - START DATE 2	READ ONLY
	P144 - START TIME 2	READ ONLY
	P145 - START DATE 3	READ ONLY
	P146 - START TIME 3	READ ONLY
	P147 - START DATE 4	READ ONLY
	P148 - START TIME 4	READ ONLY
	P149 - START DATE 5	READ ONLY
	P150 - START TIME 5	READ ONLY
	P151 - START DATE 6	READ ONLY
	P152 - START TIME 6	READ ONLY
	P153 - LOG RESET	1 = RESET
SENSOR	P160 - THRESHOLD	0 -5000mV

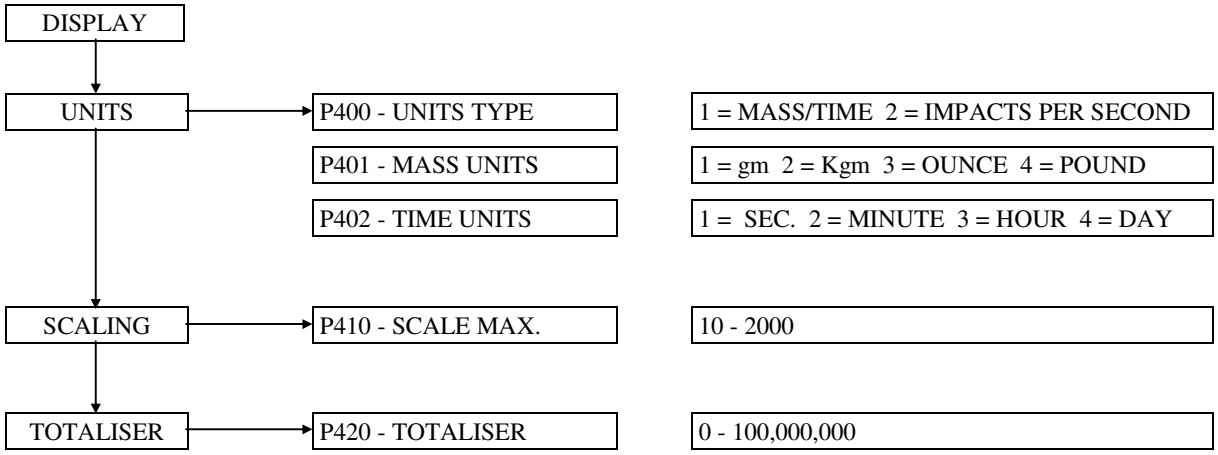
IDENTITY



RELAYS



DISPLAY

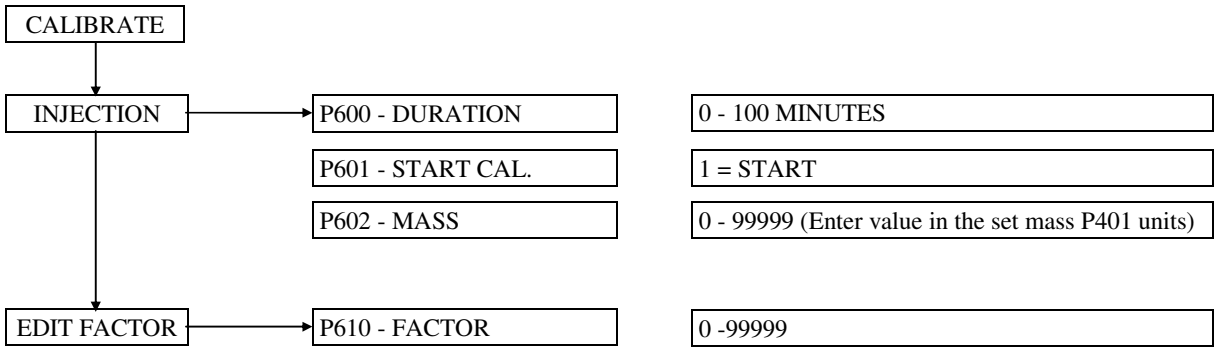


OUTPUT

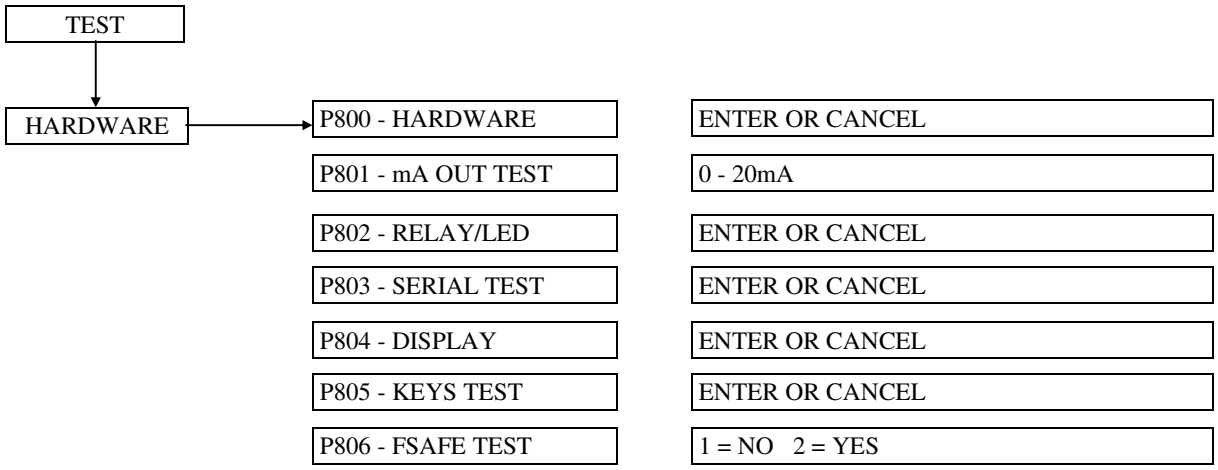
OUTPUT

CURRENT	P500 - mA ENABLE	0 = DISABLE 1 = ENABLE
	P501 - mA MODE	1 = MASS/TIME 2 = IMPACTS PER SEC.
	P502 - mA RANGE	1 = 0-20 2 = 4-20 3 = 0-25 4 = 4-25mA
	P503 - LOW VALUE	0 - 9999
	P504 - HIGH VALUE	0 - 9999
	P505 - mA LOW TRIM	-30 to +30 mA
	P506 - mA HIGH TRIM	-30 to +30 mA
SERIAL	P510 - SERIAL ENAB.	0 = DISABLE 1 = ENABLE
	P511 - DATA FORMAT	1 = DATE,TIME,AV.MASS/sec.,AV.MASS/SI 2 = DATE,TIME,TOTALISER 3 = DATE,TIME,AV.MASS/sec.,AV.MASS/SI,TOTAL 4 = PLATFORM No.,WELL No.,DATE,TIME,SIR, AV.MASS/sec.,AV.MASS/SI.,TOTALISER /SI is Set Interval in seconds in P512. This is a new parameter in software 1.4.4 onwards, earlier versions it was 1minute fixed.
	P512 – OUTPUT INTERVAL	In Seconds, the unit will output on the serial port the data set with P511 every set seconds, default 60 seconds
RS 232/485	P518 – SERIAL PORT	1 =RS232 2 =RS485 3 =RS232PC
	P519 - PROTOCOL	1 =Std Ascii 7 bit 2 =Modbus RTU 3 =Modbus Ascii
	P520 - BAUD RATE	1 =19200 2 =9600 3 =4800 4 =2400 5 =1200
	P521 - ADDRESS	0 to 255 (default 126)
	P522 - PARITY	0 = None 1 = Odd 2 = Even
	P523 – STOP BITS	1 = 1 Stop bit 2 = 2 Stop bits
	P524 – DEVICE DELAY	0 to 9999mS

CALIBRATE



TEST



DESCRIPTIONS OF THE MENUS:

SYSTEM:

SYSTEM INFO - gives details of the hardware and software revisions, unit serial number and the site ident, a number that can be used to identify the site the unit is or was installed on.
DATE/TIME - allows setting of the current date and time and the date format, UK or American.
PASSCODE - lets you change the passcode from the default of “1997” to any number from 0 - 99999. Passcode enable allows you to switch off the need for a password, just press the “ENTER” key to give programming menu access.
RESETS - allows the unit to be set up as it was when it left the factory, if you use this you will loose your settings.
LOG - gives a record of the number of times the unit is powered up and the date and time of the last 6 times the unit was powered up.
SENSOR - lets the user change the threshold (this figure is the value in mV above the average signal strength that the threshold sits) between 0 - 5000mV.

IDENTITY

I.D. INFO - allows a number from 0 - 9999 to be chosen for the identification of the platform and wellhead, this information can be included in the serial data transmission for identification purposes.

RELAYS

R1 - CAUTION - this is for setting up Relay 1 switching point as an indication that a caution set point has been exceeded, the relay will return to its normal state once the sand rate drops. The units are the same as those chosen for display. LED 1 is associated with this relay and will be Green under normal conditions and change to Red if a caution condition is seen.
R2 - ALARM - this is for setting up Relay 2 switching point as an indication that an Alarm set point has been exceeded, the relay will return to its normal state once the sand rate drops. . The units are the same as those chosen for display. LED 2 is associated with this relay and will be Green under normal conditions and change to Red if an alarm condition is seen.
R3 - FSAFE - this relay for indication of power failure, when the unit is functioning normally the relay is energised and LED 3 is green. You can disable this relay (P320).

DISPLAY

UNITS - lets you set the units that are displayed and transmitted, the display choice is mass/time or Impacts per second (this figure is the raw number that all calculations of sand mass are based on). The mass and time values are set with parameters P401 and P402.
SCALING - sets the maximum value for the bargraph and the numeric display.
TOTALISER - gives a running total of sand produced.

OUTPUT

CURRENT - lets you set the current output to give one of four current ranges and also allows the span of the ranges to be set.
For example: Set P500 to 1 to enable the current output, set P501 to 1 for mass/time as the units, set P502 to 2 to give 4-20 as the current output limits, P503 and P504 set the low value and high value that the current range specified will scale too. This means that you select 10 -1000 as the low and high points, this means that 4mA would = 10 and 20mA would = 1000, and 12mA would = 495.
High and Low trim allow the user to adjust the current output.
SERIAL - this switches on or off serial data transmission and lets you set what is transmitted.
RS 232 - set up the baud rate for transmission, the other parameters are fixed at Parity-none, 8 bits and 1 stop bit. The parameter P518 sets the type of serial port in use, if you set 1, then you will be using RS232 with the settings from P519 to P524 if you set 2, then you will be using RS485 with the settings from P519 to P524, if you select 3, (PC232) then it is RS232 @ 19200 baud, 8 data bits, 1 stop bit and no parity, these are the default settings for SandAlertPC.
A new parameter P512 was added at software version 1.4.4, this allows you to change the interval of the serial output, in previous versions it was fixed at a minute, now with P512 you can set the interval in seconds, the default is 60seconds. The AverageMass/minute in the output string is now AveraggeMass/SI, where SI is serial interval set in P512.

CALIBRATE

INJECTION - this mode is used for calibrating the unit to give an approximate weight of sand produced. To use this mode you can either inject a known amount of sand or collect produced sand for a known time and weigh it. All you do is set the duration of the test and when you are ready to start set parameter P601

to 1 and press enter. After this enter the weight of sand, the unit will then calibrate itself, the value used for the conversion of Impacts per second to weight is stored in P610 this is the calibration factor and can be edited manually if required, it may be a good idea after calibration to note down the factor the unit calculated.

TEST

HARDWARE - this set of menus allow for the testing of the hardware:
P800 - tests internal microprocessor peripherals
P801 - allows the 4-20mA output to be set to a known value for test purposes
P802 - illuminate the LED's and toggles the relays
P803 – Serial test, sends 'Pulsar Test' continuously
P804 - Allows testing of the LCD display
P805 - asks for all keys to be pressed to test the keypad
P806 - toggles the failsafe relay

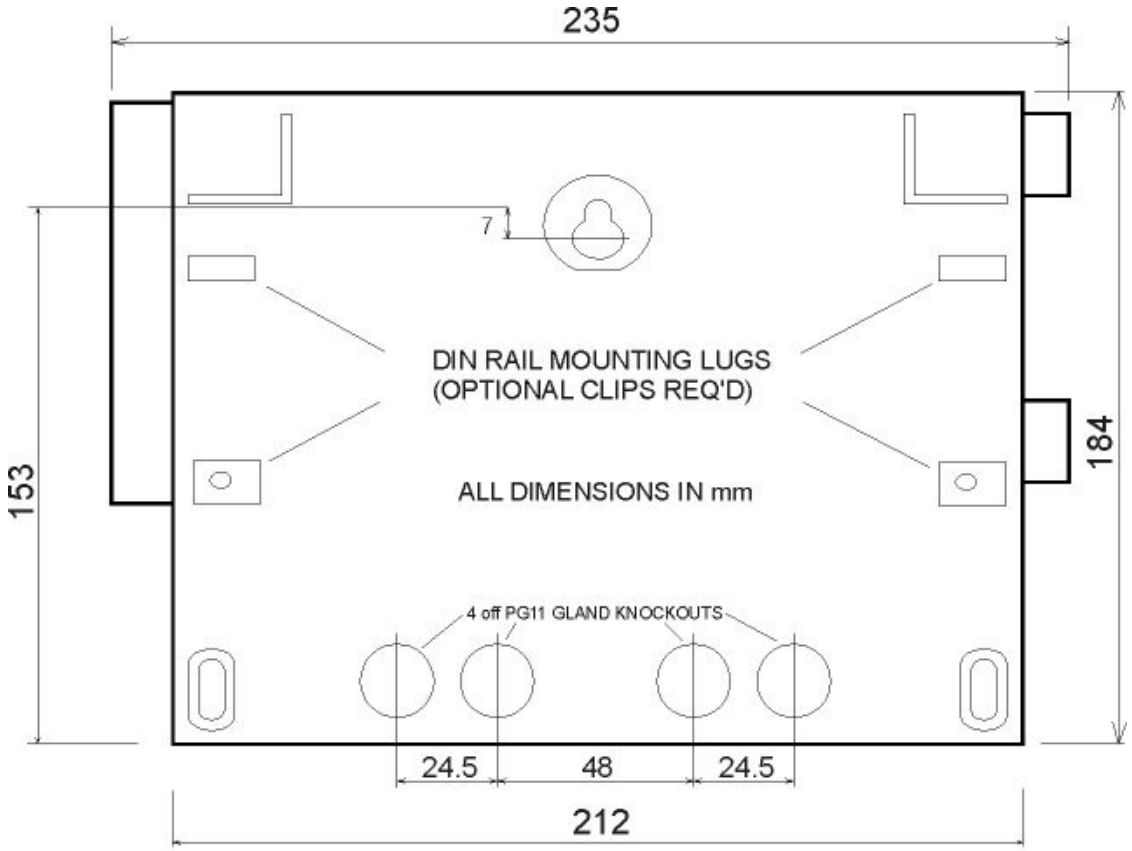
4 SPECIFICATION

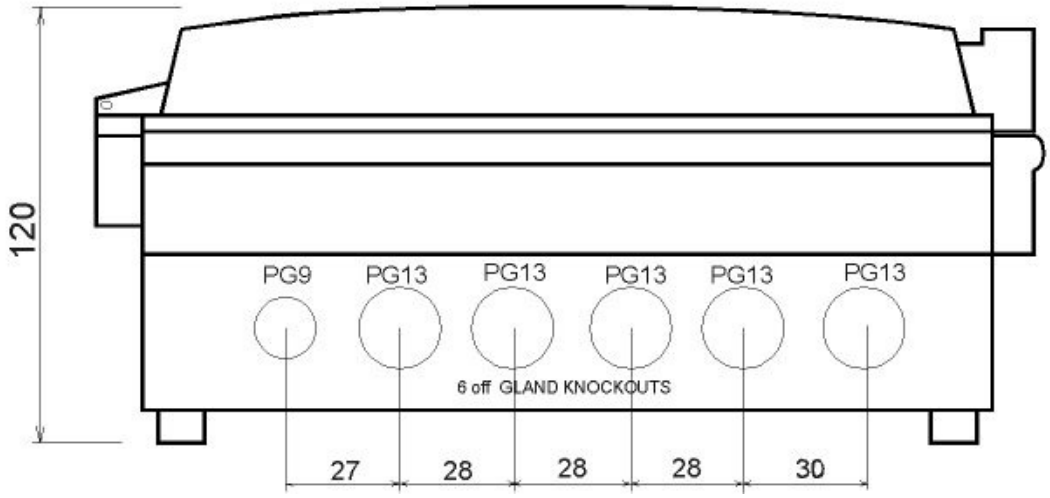
CONTROL UNIT

DESCRIPTION	The unit is designed to give an indication of sand being produced during the extraction of oil and gas as it is transported along pipework. This is achieved by the use of an Ultrasonic sensor attached to the pipework, when sand hits the wall of the pipe an electrical signal is produced that is then processed by this control unit to give an indication of the quantity of sand present.
POWER REQUIREMENTS	230/115 VAC 50 - 60Hz or 24 - 30 VDC (consumption 10W max.)
OUTPUTS	4-20 mA output Monitor output to view sensor signal on an oscilloscope. RS 232 for data output and reprogramming.
INPUTS	Input for a PulsarGuard 2001 ultrasonic Sensor via an internal (Wall mount version) or External (Rack mount version) zener barrier by MTL part number MTL 788+ Auxiliary input 0-10V (Not implemented in the current software)
RELAYS	3 off for Caution, Alarm and Failsafe, rated at 6A 250VAC/30VDC
ENVIRONMENTAL	Wall mount: Polycarbonate Enclosure to IP65 Rack mount: Aluminium not IP rated
PHYSICAL SIZE	Wall mount Enclosure overall 245 x 190 x 120mm Rack mount 3U high x 10HP wide x 160mm deep

SENSOR

DESCRIPTION	The sensor is the PulsarGuard 2001, which is intrinsically safe (EEx ia IIC T4), and housed in a 316 stainless steel IP68 enclosure. It is attached to the pipework by means of a stainless steel band.
OUTPUT	0-5V





Wall mount gland detail

Appendix 1

Modbus implementation on the Wall and Rack mount SandAlert unit

Modbus (SandAlert is a slave unit) over RS485 is implemented on the Rack version of SandAlert as detailed below:

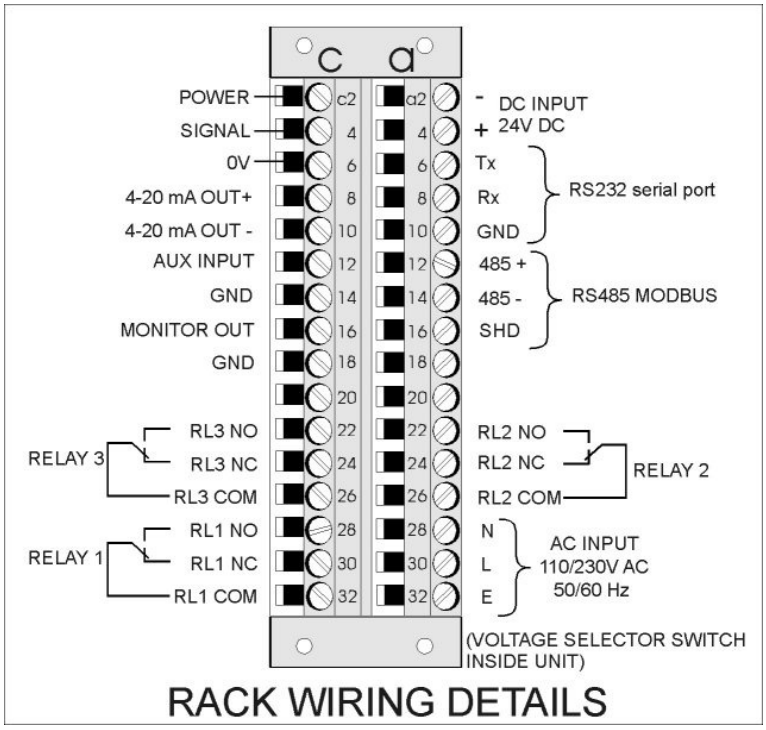
DESCRIPTION	RACK TERMINAL	WALL TERMINAL
485 + 485 positive	a12	30
485 - 485 negative	a14	29
SHIELD Cable screen	a16	Any GND

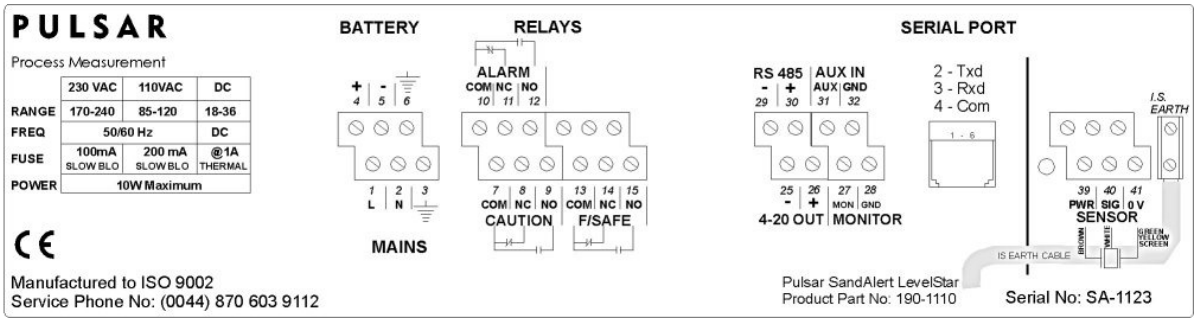
The SandAlert Rack mount unit is designed for 2 wire RS 485, however, if your controller has a 4 wire system then link as follows:

4 wire RS 485	SandAlert RACK Unit	SandAlert WALL Unit
RX+	RS 485 positive (a12)	RS 485 positive (30)
TX+	RS 485 positive (a12)	RS 485 positive (30)
RX-	RS 485 negative (a14)	RS 485 negative (29)
TX-	RS 485 negative (a14)	RS 485 negative (29)

RX+ and TX+ are to be linked and connected to RS 485 positive and RX- and TX- are to be linked and connected to RS 485 negative. It should be noted this method of wiring can only be used where all units on the loop are configured to work with a 2 wire interface.

Terminal Layout for the Rack Mount showing the RS485 connections





Wall unit with Modbus

The RS 232, which is fitted as standard on all Pulsar units, is used for connecting to a PC when using Pulsar software, to carry out programming, echo analysis or data retrieval. It should be noted that the RS 485 communications will be interrupted when connected to the RS 232 interface.

Important Information

THE LAST UNIT IN THE RS 485 LOOP SHOULD HAVE A 120R LINE TERMINATOR FITTED. IT WILL BE NECESSARY TO FIT AN EXTERNAL RESISTOR (SUPPLIED) TO PROVIDE THIS.

DO NOT FORGET TO CORRECTLY TERMINATE THE LAST UNIT ON THE LOOP.

Setting up the SandAlert Unit

The following parameters will be found in the SandAlert Rack mount Unit under the Device Set Up menu and will require programming before the RS 485 communications can be used.

Parameter No.	Options	Description
P 518	1 – RS232 2 – RS485 3 – PC232	Select serial port, RS232 or RS485 Sets serial port to talk to PC in Ascii
P 519	1 – Std Ascii 2 – Modbus RTU 3 – Modbus ASCII	Protocol , 1 for Ascii, select either 2 or 3 for Modbus RTU or ASCII
P 520	1 – 19200 2 – 9600 3 – 4800 4 – 2400 5 – 1200	Select Baud Rate
P 521	1 to 255	Device Address – Enter the device number for this unit
P 522	0 – No Parity 1 – Odd Parity 2 – Even Parity	Parity – set your system parity

P 523	1 – One stop bit 2 – Two stop bits	Stop Bits – set to your system stop bit setting.
P 524	0 to 9999	Delay in mS

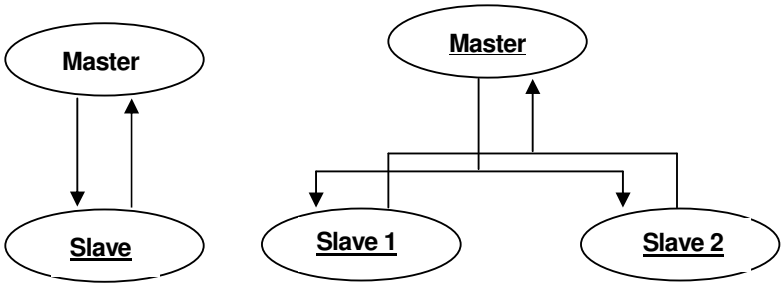
Note : Only Slave operation with Modbus RTU and Modbus ASCII are available

Protocol Basics

A data communication protocol defines the rules and structure of messages used by all devices on a network for data exchange. This protocol also defines the orderly exchange of messages, and the detection of errors.

Modbus

MODBUS defines a digital communication network to have only one MASTER and one or more SLAVE devices. Either a single or multi-drop network is possible. The two types of communications networks are illustrated in the diagram below



A typical transaction will consist of a request sent from the master followed by a response from the slave. The message in either direction will consist of the following information

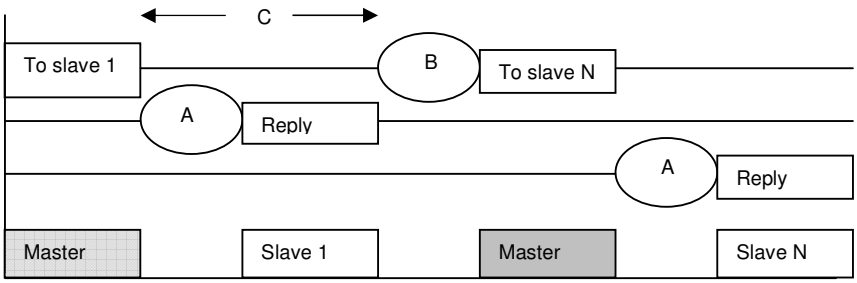
Start of Transmission	Device Address	Function Code	Data or List of Data	CRC Error Check	End of Transmission

- Each slave has a unique *Device Address*
- The device address 0 is a special case and is used for message broadcast to all slaves. This is restricted to parameter write operations
- Level controllers support a subset of Modbus standard function codes. There are 7 Modbus functions used : 1, 2, 3, 4, 6, 8 and 16
- The data will include instrument parameters referenced by a *Register Address*

- Sending a communication with a unique device address will cause only the device with that address to respond. That device will check for errors, perform the requested task and the reply with its own address, data and a checksum
- Sending a communication with the device address 0 is a broadcast communication that will send information to all devices on the network. Each will perform the required action but will not transmit a reply

Typical Transmission Line Activity

This diagram is to illustrate typical sequence of events on a Modbus transmission line



- Period ‘A’: the processing time (latency) required by the slave to complete the command and construct a reply
- Period ‘B’: the processing time required by the master to analyse the slave response and formulate the next message
- Period ‘C’: the wait time calculated by the master for the slaves to perform the operation. None of the slaves will reply to a broadcast message

Message Frame Format

Device Address

Each slave has a unique address. The Modicon Modbus protocol defines the address range limits as 1 to 247. The SandAlert Unit will support an address range of 1 to 254. The device address used by the instrument is set using the Set up Parameters List according to the instrument manuals.

Device address 0 is a special case that will broadcast a message to all slaves simultaneously.

Parameter Address

Data bits or data words exchange information between master and slave devices. This data consists of parameters. All parameters communicated between master and slaves have a 16-bit parameter address, which is referred to as *Register Address*.

The Modbus Register Address range is 100 to 999 according to parameter list of P100-P999 on the SandAlert Unit. Accessing parameters that are not used will result in an error code 02 (data unavailable – refer to Error Checking Section for more details).

Function Codes

Standard Modicon Modbus provides function codes from 1 to 247. Pulsar Modbus protocols support function 1, 2, 3, 6, 8 and 16. For more details of query and response correspond to each function, refers to Section 5 for more descriptions.

Function Code	Function Descriptions	Data Type
01	read coil status	bit mapped
03	read holding register	integer
06	write single register	integer
08	diagnostic loop back	none
16	write multiple registers	integer

It is recommended that function code 03 is used for reads and function code 06 is used for writes. This includes Boolean data. Other codes are supplied for purposes of compatibility.

The SandAlert will transmit error code if they receive a request including an unsupported function code.

Request & Response Conventions

Parameter Resolution and Scaling

Standard Modbus protocol limits data to 16 bits per parameter. This reduces the active range of parameters from 0 to 65535 (decimal) as unsigned integer and from –32767 to +32767 as signed integer.

The protocol is also limited to integer communication only. The Pulsar SandAlert provides data in either signed or unsigned integer type (word). In Integer Format, all parameters will be rounded to the specified units. Example of this protocol is shown in Section 5. The following table shows the unit symbols and their corresponding conversions

Unit Symbol	Scaling	Descriptions
U_NO	None	no unit
U_TIME	Hhmm	hh:mm
U_DATE	packed date	see Example (1)
U_MA	× 0.01 mA	mA input/output
U_Ave.LEVEL	x .0048	Volts
U_Th.LEVEL	x .0195	Volts
U_RELAY	Bit pattern	0 de-energised, 1 energised, BIT 0 = relay 1, BIT 1 = relay 2 and BIT2 = relay 3

Register	Description	Unit
30001	Instantaneous SIR	U_NO
30002	Average SIR/second	U_NO
30003	Average Mass/second	U_NO
30004	Displayed Average Mass	U_NO
30005	System Totaliser (top)	U_NO
30006	System Totaliser (bottom)	U_NO
30007	Current Time	U_TIME
30008	Current Date	U_DATE
30009	Relay Status	U_RELAY
30010	mA Output	U_MA
30011	Peak SIR	U_NO
30012	Average signal level	U_Ave.LEVEL
30013	Threshold level	U_Th.LEVEL

Example 1 Write date to Modbus

To write to Modbus a date of 02/03/01 – the coded date is calculated as follows

Note

This date presentation comprises of coded date in the form yxxx, where xxx is calculated as follows to give the date and month.

xxx = (month * 50) + day = (03 * 50) + 02 = 152
yxxx = (year * 1000) + xxx = (01 * 1000) + 152 = 1152 (decimal)

To decode back to normal format of ddmmyy,

yy = 1152 mod 1000 = 1
mm = (1152 rem 1000) mod 50 = 3
dd = 1152 – yy * 1000 – mm * 50 = 2

Therefore,
ddmmyy = dd * 10000 + mm * 100 + yy = 20301 (decimal)
which has string equivalent of 02/03/01

Error Checking

The Modbus protocol defines the response to a number of error conditions. A slave device is able to detect a corrupted command or, one that contains an incorrect instruction, and will respond with an error code.

With some errors the slave devices on the network are unable to make a response. After a wait period the master will interpret the failure to reply as a communication error. The master should then re-transmit the command.

A slave device that has detected a corrupted command or a command that contains an incorrect instruction will respond with an error message. The error message has the following syntax.

Device Address	Function Code	Error Response Code	CRC checksum	
1 byte	1 byte	1 byte	MSB	LSB

The function code byte contains the transmitted function code but with the most significant bit set to 1.
(This is the result of adding 128 to the function code)

The error response code indicates the type of error detected. The level instruments support the following error response code:

Error Code	Error	Description
0x01	Illegal function	The message function received is not an allowable action
0x02	Illegal address	The address referenced in the data field is not an allowable address for the slave
0x03	Illegal data value	The value referenced in the data field is not allowable in the addressed slave location
0x04	Failure in associated device	The slave has failed to respond to a message or an abortive error occurred
0x05	Acknowledge	The slave has accepted and is processing the long duration program command
0x06	Busy, rejected message	The message was received without error, but the slave is processing a long duration program command
0x07	NAK Negative Acknowledgement	The PROGRAM function just requested could not be performed
0x08	Invalid checksum	Checksum is incorrect or corrupted
0x09	Invalid data count	The number of data count is outside the specified data range

Message Timings

Mode of Transmission

The mode of transmission describes the structure of information within a message and the number coding system used to exchange a single character of data.

The Modbus protocols define a mode of transmission for both ASCII and RTU modes of transmission. The Pulsar SandAlert support both transmission modes. Details of how to set up these modes are provided in the appropriate controller manuals.

The definition of the mode of transmission for a single character is

Start bit (1 bit)	Data bits (7 or 8 bits)	Parity bit (odd, even or none)	Stop bits (1 or 2 bits)

Transmission baud rate can be set ranges from 1200 – 38400 baud.
Factory default setting is 19200 baud.

Wait Period

There are several errors for which the slave devices on the network are unable to make a response:

- If the master attempts to use an invalid address then no slave device will receive the message
- For a message corrupted by interference, the transmitted CRC will not be the same as the internally calculated CRC. The slave device will reject the command and will not reply to the master

After a wait period, the master will re-transmit the command.

A wait period is also required after a broadcast communication to device address 0.

The wait period should exceed the instrument latency plus the message transmission time. Typical wait periods, for a single parameter read are at most 100 ms for the level controller.

Caution

Failure to observe the wait period, after a broadcast, will negate the broadcast message.

Latency

The time taken for the level controller to process a message and start the transmission of a reply is called the latency. This does not include the time taken to transmit the request or reply.

The parameter functions read 1 word (function code 03), write 1 word (function code 06) and Loopback (function code 08) are processed within the latency of between 20 and 100 ms.

For parameter functions, read N bits (function 01), read N words (function 03) and write N words (function 16) the latency is indeterminate. The latency will depend on the instrument activity and the number of parameters being transferred and will take from 100 to 500 ms approximately.

It is possible to artificially increase the latency by setting the *Device Delay* parameter in the Set Up configuration list. This is sometimes required to allow a guaranteed gap between requests and responses needed by some RS485 adapters to switch from transmit to receive states.

Message Transmission Time

The time required to transmit a message will depend on the length of the message and the baud rate.

$$TransmissionTime = \frac{(NumberOfBytes * 3.5) * BitsPerCharacter}{BaudRate}$$

To find the number of bytes, refer to the relevant function code. The three extra bytes are for the end of transmission characters

The number of bits per character will be ten, or eleven if a parity bit is used. (For Modbus RTU: 1 start bit, 8 data bit, an optional parity bit and 1 stop bit)

For example reading a single word with the function code 03 at 19200 baud (no parity bit)

$$transmission = \frac{(8*3.5)*10}{19200} = 6ms$$

$$response = \frac{(9*3.5)*10}{19200} = 6.5ms$$

The wait period for this transmission will exceed 22.5 ms (6 + 6.5 + 10.0)

For a broadcast command (device address 0) the master would not expect a reply. In this case the wait period will exceed 16 ms (6 + 10.0)

Modbus Functions

Function 1: Read Output Status

Registers Address	Description	Data Type	Unit/Range
00001 – 00003	Relay status	Bit mapped	None

Note

1. Bit value of **1** represents an **ACTIVE STATE** of the corresponding relay.
2. Bit value of **0** represents an **IN-ACTIVE STATE** of the corresponding relay.

Example: Query: reading relay 1 to 3

Slave address	11
Function	01
Addr Hi	00
Addr Lo	01
No. of points hi	00
No. of points lo	03
Error check	

Response: relay 1 = on, relay 2 = off, relay 3 = on

Slave address	11
Function	01
Byte count	01
Data (coil 1-3)	05
Error check	

Function 3: Read Holding Registers (Static Parameters)

Registers Address	Description	Unit/Range
40100 – 40999 (1)	Set up Parameters	See Appendix

Note

1. All parameters from P100-P999 in the parameter list, (refer to appropriate Pulsar instrument manual), are available on Modbus for reading.

Example: Query: reading parameter P518

Slave address	11
Function	03
Addr Hi	02
Addr Lo	06
No. of points hi	00
No. of points lo	01
Error check	

Response: P518=2 (transmit as RS485 Modbus)

Slave address	11
Function	03
Byte count	02
Data Hi (MSB)	00
Data Lo (LSB)	02
Error check	

Function 4: Read Input Registers (Common Dynamic Variables)

This function provides accesses to common system variables of the SandAlert unit.

Register	Description	Unit
30001	Instantaneous SIR	U_NO
30002	Average SIR/second	U_NO
30003	Average Mass/second	U_NO
30004	Displayed Average Mass	U_NO
30005	System Totaliser (top)	U_NO
30006	System Totaliser (bottom)	U_NO
30007	Current Time	U_TIME
30008	Current Date	U_DATE
30009	Relay Status	U_RELAY
30010	mA Output	U_MA
30011	Peak SIR	U_NO
30012	Average signal level	U_Ave.LEVEL
30013	Threshold level	U_Th.LEVEL

Function 6: Write Single Register (Static Parameters)

Registers Address	Description	Unit/Range
40100 – 40999 (1)	Setup parameters (2)	(3)

Note

1. Only parameters from P100 to P999 are available for writing from remote communication. Parameters less than P100 have to be accessed directly on the unit keypad or infra-red communicator
2. Refer to Pulsar instrument's manual for list of accessible parameters.

Example:Query: writing to P160 = 1000

Slave address	11
Function	06
Addr Hi	00
Addr Lo	A0
Data Hi	03
Data Lo	E8
Error check	

Response:

Slave address	11
Function	06
Addr Hi	00
Addr Lo	A0
Data Hi	03
Data Lo	E8
Error check	

Function 8: Diagnostic Loopback

This function provides a means of testing the communications link by means of a 'Loopback' operation. The data sent to the instrument is returned unchanged. Only diagnostic code 0 from Modicon Specification is supported.

Device address	Function Code	Diagnostic Code		Loopback Data		CRC	
1 byte	1 byte	MSB	LSB	MSB	LSB	MSB	LSB

The reply to function 08 is the same as the command

Example:Command

Device address	Function Code	Diagnostic Code		Loopback Data		CRC	
02	08	00	00	12	34	ED	4F

Example: Reply

Device address	Function Code	Diagnostic Code		Loopback Data		CRC	
02	08	00	00	12	34	ED	4F

Function 16: Write Multiple Registers (Static Parameters)

Registers Address	Description	Unit/Range
40100 – 40999 (1)	Set up parameters (2)	(3)

Note

1. Only parameters from P100 to P999 are available for writing from remote communication. Parameters less than P100 have to be accessed directly on the unit keypad or infra-red communicator
2. Refer to Pulsar instrument's manual for list of accessible parameters.

Example: Query: writing to P300 = 1, P301=200

Slave address	11
Function	10
Addr Hi	01
Addr Lo	2C
No. of registers hi00	
No. of registers lo02	
Data Hi	00
Data Lo	01
Data Hi	00
Data Lo	C8
Error check	

Response:

Slave address	11
Function	06
Addr Hi	01
Addr Lo	2C
No. of registers hi00	
No. of registers lo02	
Error check	

List Of Static Parameters

Register	Description	Unit
40101 - HARDWARE REV	READ ONLY	U_NO
40102 - SERIAL No.	READ ONLY	U_NO
40103 - SITE IDENT	0 - 999999	U_NO
40110 - DATE	ENTER DATE	U_Date
40111 - TIME	ENTER TIME	U_Time
40112 - DATE FORMAT	1 : DD-MM-YY 2 : MM-DD-YY	U_NO
40120 - PASSCODE EN.	0 - DISABLE 1 - ENABLE	U_NO

40121 - PASSCODE	0 - 99999	U_NO
40130 - FACTORY DEF.	0 - NO 1 - SET FACTORY DEFAULTS	U_NO
40140 - NUM STARTS	0 -9999	U_NO
40141 - START DATE 1	READ ONLY	U_Date
40142 - START TIME 1	READ ONLY	U_Time
40143 - START DATE 2	READ ONLY	U_Date
40144 - START TIME 2	READ ONLY	U_Time
40145 - START DATE 3	READ ONLY	U_Date
40146 - START TIME 3	READ ONLY	U_Time
40147 - START DATE 4	READ ONLY	U_Date
40148 - START TIME 4	READ ONLY	U_Time
40149 - START DATE 5	READ ONLY	U_Date
40150 - START TIME 5	READ ONLY	U_Time
40151 - START DATE 6	READ ONLY	U_Date
40152 - START TIME 6	READ ONLY	U_Time
40153 - LOG RESET	1 = RESET	U_NO

40160 - THRESHOLD	0 -5000mV	mV

40200 - PLATFORM	0 - 9999 PLATFORM IDENT	U_NO
40201 - WELL HEAD	0 - 9999 WELL HEAD IDENT	U_NO

40300 - CAUTION ENAB.	0 = DISABLE 1 = ENABLE	U_NO
40301 - CAUTION LEVEL	0 - 9999	U_NO
40310 - ALARM ENAB.	0 = DISABLE 1 = ENABLE	U_NO
40311 - ALARM LEVEL	0 - 9999	U_NO
40320 - FSAFE ENABLE	0 = DISABLE 1 = ENABLE	U_NO

40400 - UNITS TYPE	1 = MASS/TIME 2 = IMPACTS PER SECOND	U_NO
40401 - MASS UNITS	1 = gm 2 = Kgm 3 = OUNCE 4 = POUND	U_NO
40402 - TIME UNITS	1 = SEC. 2 = MINUTE 3 = HOUR 4 = DAY	
40410 - SCALE MAX.	10 - 2000	U_NO
40420 - TOTALISER	0 - 100,000,000	U_NO

40500 - mA ENABLE	0 = DISABLE 1 = ENABLE	U_NO
40501 - mA MODE	1 = MASS/TIME 2 = IMPACTS PER SEC.	U_NO
40502 - mA RANGE	1 = 0-20 2 = 4-20 3 = 0-25 4 = 4-25mA	U_NO
40503 - LOW VALUE	0 - 9999	U_NO
40504 - HIGH VALUE	0 - 9999	U_NO
40505 - mA LOW TRIM	-30 to +30 mA	mA
40506 - mA HIGH TRIM	-30 to +30 mA	mA
40510 - SERIAL ENAB.	0 = DISABLE 1 = ENABLE	U_NO
40511 - DATA FORMAT	1 = DATE,TIME,AV.MASS/sec.,AV.MASS/min 2 = DATE,TIME,TOTALISER 3 = DATE,TIME,AV.MASS/sec.,AV.MASS/min,TOTAL 4 = PLATFORM No.,WELL No.,DATE,TIME,SIR, AV.MASS/sec.,AV.MASS/min.,TOTALISER	U_NO
40520 - BAUD RATE	1 =19200 2 =9600 3 =4800 4 =2400 5 =1200	U_NO

40600 - DURATION	0 - 100 MINUTES	minutes
40601 - START CAL.	0 - 99999	U_NO
40602 - MASS	0-99999 (Enter Value in the set massP401 units)	U_NO
40610 - FACTOR	0-99999	U_NO