SAAPZ

Contents

1. Introduction

Figure 1.1: PZ1_vw sensor mounted to 27 mm ID PVC conduit (SAA inside). The VW piezometer (made by Geokon) is on the left and the Measurand microprocessor-based interface is on the right

The SAAPZ is a digital piezometer that combines a standard vibrating wire (VW) pressure sensing element (Geokon 4500S) with a VW-to-digital interface. The digital interface, referred to as the processor pod, is permanently connected to the VW element with a short length of cable.

Both the VW element and the processor pod can be directly buried or grouted into a borehole. A cable carries the digital pressure data back to the surface and eventually to a Data Logger or PC. The SAAPZ uses the same digital data format as the SAA, and may be used in combination with other SAAPZ and/or an SAA, or by itself.

Multiple SAAPZ cables and one SAA cable can be spliced together requiring only one SAA interface at either the Data Logger or PC. Data are collected using either a PC running the SAARecorder Application found in SAASuite, an Android device running SAADroid found in the Google Play Store, or a Campbell Scientific CR6/CR300/CR800/CR1000/CR3000 Data Logger.

The combination of a trusted VW element with SAA digital techniques simplifies cabling, eliminates the need for VW interfaces and multiplexers, and makes it possible to obtain pressure data using a PC.

2. Description

A photograph of the SAAPZ is shown in the figure below. The SAAPZ has a 133 mm x 19.05 mm Ø vibrating wire piezometer which is connected to an SAA processor pod which transforms the analog signal from the piezometer to a digital signal.

The processor pod is located approximately 60 cm behind the piezometer. The SAAPZ comes with 30 m of cable attached, though more can be attached during manufacturing. The SAAPZ piezometer and processor pod assembly weighs approximately 0.6 kg. SAAPZ can either have a 4-pin circular connector (as shown in the figure below) for easy connection via an SAAFPU (or SAAUSB) or the ends can be left bare and the wires can be connected via the 5-pin terminal block on an SAA232 or (SAA232-5).

Figure 2.1: SAAPZ Unit containing the SAAPZ processor and digital temperature sensor. (A) Vibrating wire piezometer element, (B) Processor pod

3. Taking Readings

Readings can be collected from SAAPZ units in one of two ways:

- The SAAPZ can be connected to a PC or laptop via an SAAFPU or an SAAUSB connection and read using SAARecorder application in SAASuite OR
- The SAAPZ can be connected to a Campbell Scientific Data Logger via a SAA232 or SAA232-5.

*Note: It is imperative that you establish an initial reading for each piezometer prior to installing them as this reading will be used in all subsequent data reduction. For information on how to prepare the SAAPZ for initial readings, refer to Geokon's "Instruction Manual: Model 4500 series Vibrating Wire Piezometers". This manual can be downloaded at **http://www.geokon.com/**.*

3.1. Preparing the SAAPZ for initial readings

The SAAPZ uses a Geokon 4500 series vibrating wire piezometer in its construction. As such, preliminary testing should be done in accordance with the instructions provided in Geokon's "Instruction Manual: Model 4500 series Vibrating Wire Piezometers". Geokon outlines several methods with which to prepare the piezometer for taking initial readings. Refer to Section 2.1 "Preliminary Tests" for more information.

Note that it is imperative that you establish an initial reading for each piezometer prior to installing these as this reading will be used in all subsequent data reduction.

3.2. Operating with SAARecorder

SAAPZ units can be read with versions 4.48 or higher of SAARecorder; if you do not have this version or higher, use SAASuite to update the version of SAARecorder. SAASuite is available for download from the **Measurand** website.

3.2.1. Connecting SAAPZ to a PC

There are three possible ways to connect an SAAPZ to a PC running SAASuite. The two most common ways are using an SAAFPU or SAAUSB. It is also possible to connect an SAAPZ to an SAA232 and to connect the SAA232 to the PC using a SAA232-USB cable. This last method is most commonly used when testing or troubleshooting connections on earth stations using a PC.

Figure 3.1: a) SAAFPU Model 3, (b) SAAUSB Model 2 cable connection, (c) SAA232-USB cable connection for the (d) SAA232

Instructions on how to use these methods can be found here:

- 'Connecting using the SAAFPU' Guide
- 'Connecting using the SAAUSB' Guide

- 'Connecting using the SAA232' Guide

3.2.2. Using SAARecorder to read SAAPZ data

Once the SAAPZ is connected to the PC, it is possible to read the SAAPZ unit using the SAARecorder utility. The menu options for reading the SAAPZ are described below. For further details on how to use SAARecorder, please read **SAARecorder'**.

3.2.2.1. Setting SAAPZ output options

SAARecorder defaults to calculating the SAAPZ pressures using a polynomial equation modified from the one provided by Geokon. If you wish to use the linear equation provided by Geokon, you must go to the menu option 'SAA setup | Piezometer Options'. This will open the window shown in the figure below. Once the window is open, select 'Use Linear Calibration Coefficients' from the drop down box at the bottom.
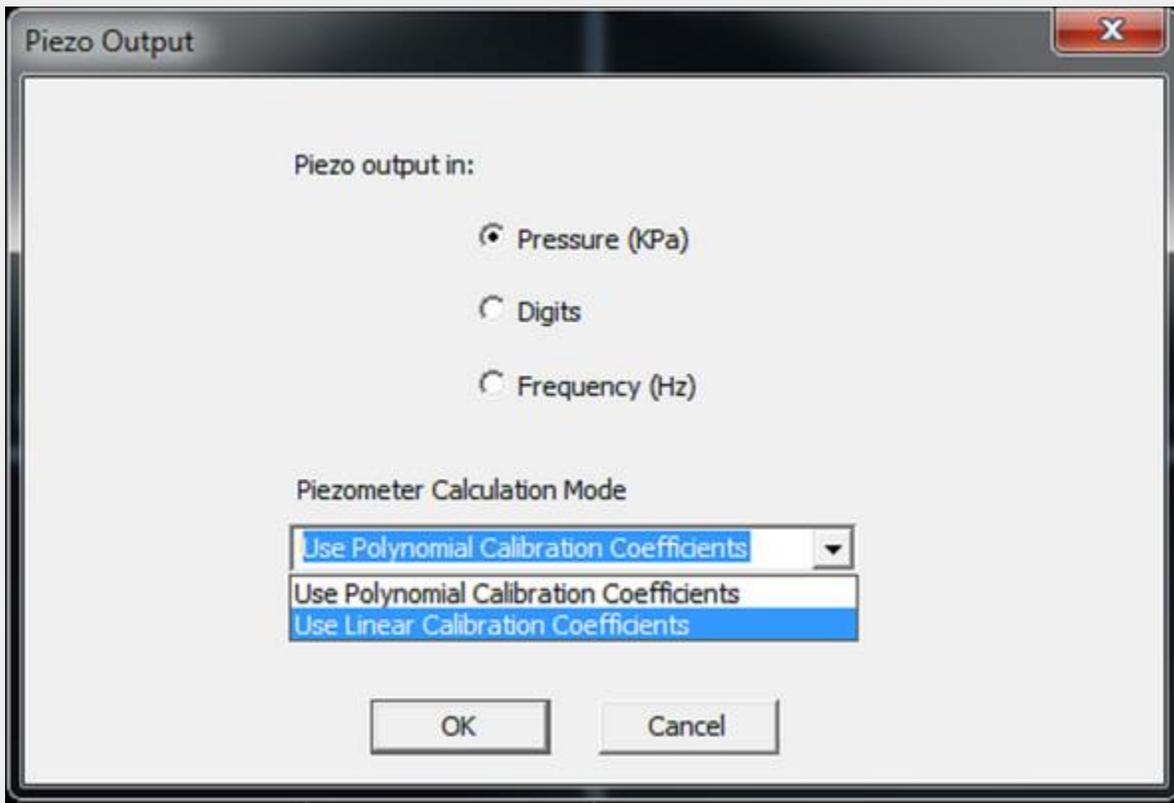
Figure 3.2: SAAPZ piezometer output window

3.2.2.2. Calculating pressures using polynomial calibration

When 'Use Linear Calibration Coefficients' is selected, SAARecorder uses a modified version of the following polynomial equation given by Geokon for calculating pressures:

$$P = AR_1^2 + BR_1 + C + K(T_1 - T_0) - (S_1 - S_0)$$

Where P = Pressure (kPa)
A, B, and C = polynomial gauge factors
K = thermal factor
R = reading in digits
T = temperature
S = barometric pressure

SAARecorder lumps together the C and (S1-S0) into one offset value, giving the following equation.

$$P = AR_1^2 + BR_1 + C + K(T_1 - T_0)$$

In SAARecorder, the C polynomial gauge factor is calculated by setting the pressure to zero and inserting the initial field zero reading into the polynomial equation. In order to set this zero offset, go to menu option 'Calibrations | Calibrate Piezometer Offset'.

If you have more than one SAAPZ connected at the same time, you will be prompted to select the SAAPZ for which you want to set the zero offset. You can set the zero offset for a single SAAPZ unit, or for all connected SAAPZ units at once.

Again note, due to the construction of the piezometer element, it takes between 5 – 15 minutes for the temperature to equilibrate; setting the zero offset should be done after the temperature has finished equilibrating.

Once the calibration has been completed, a backup copy of the updated SAAPZ calibration file should be made in case something happens to the PC containing the file.

The polynomial equation will return the most precise measurement of pore pressure, however in cases where only the changes in pore pressure are being monitored, either the polynomial or the linear equation will return acceptable results.

3.2.2.3. Calculating pressures using the linear equation

When 'Use Linear Calibration Coefficients' is selected, SAARecorder uses the following linear equation given by Geokon for calculating pressures:

$$P = G(R_1 - R_0) + K(T_1 - T_0)$$

Where P = Pressure (kPa)
G = linear gauge factor
K = thermal factor
R = reading in digits
T = temperature

Earlier SAAPZ used Geokon piezometers calibrated using the following equation:

$$P = G(R_0 - R_1) + K(T_1 - T_0)$$

The linear gauge factors for these piezometers are positive. Version 2.64 or higher of SAACR_raw2data is required in order to correctly convert piezometers data. These versions of SAACR_raw2data can convert piezometer data for SAAPZ with either positive or negative linear gauge factors.

Note that SAARecorder does not take into account the barometric correction. In order to use this equation, it is necessary to obtain an initial field reading. Setting the initial reading is done in two steps.

To set the initial reading:

1. Ensure that SAARecorder is using the linear equation (See the 'Setting SAAPZ output options' Section above).
2. Once this is done go to menu option 'Calibrations | Calibrate Piezometer Offset':
    o If you have more than one SAAPZ connected at the same time, you will be prompted to select the SAAPZ for which you want to set initial reading
    o You can set the initial reading for a single SAAPZ unit, or for all connected SAAPZ units at once
    o If you plan to use a Data Logger to collect data from an SAAPZ, and you prefer to use linear calibration, you can choose the Linear Calibration in 'Calibrations | Calibrate Piezometer Offset'
3. Once the calibration has been completed, a backup copy of the updated SAAPZ calibration file should be made in case something happens to the PC containing the file.

3.2.2.4. Viewing and saving data

It is possible to view the numeric data collected from the SAAPZ using the 'Data and graphs | Numeric Data' menu option. This will open a data table window as shown in the figure below. The data table can display the SAAPZ piezometer data in Digits, Frequency, Pressure (kPa), as well as the SAAPZ temperature.

Figure 3.3: Numeric data table in SAARecorder

To view a graph of the data, use the 'Data and graphs | Graph Data' menu option. This will open a data selection box, as shown in the figure below. Select the SAAPZ which you wish to view and save data from and click the 'Add' and then the 'OK' buttons. This will produce a graph as shown in the figure below.
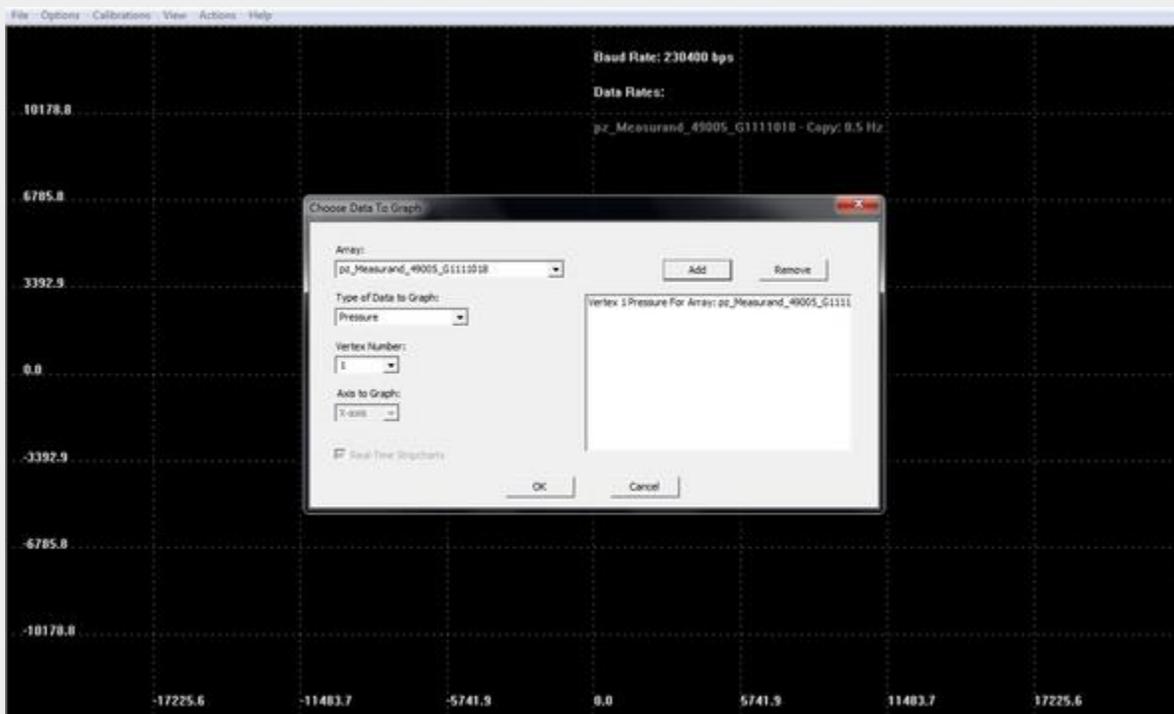
Figure 3.4: Graph data selection in SAARecorder

Once the graph is open, it is possible to change the scaling options by clicking on the 'Graph Options' button. It is also possible to save data from the SAAPZ by clicking the 'Save File' button then entering the desired file name. Data will be collected until the 'Close File' button is clicked. A sample data file is given is in the 'Sample SAAPZ Data File Collected Using SAARecorder' Section below.
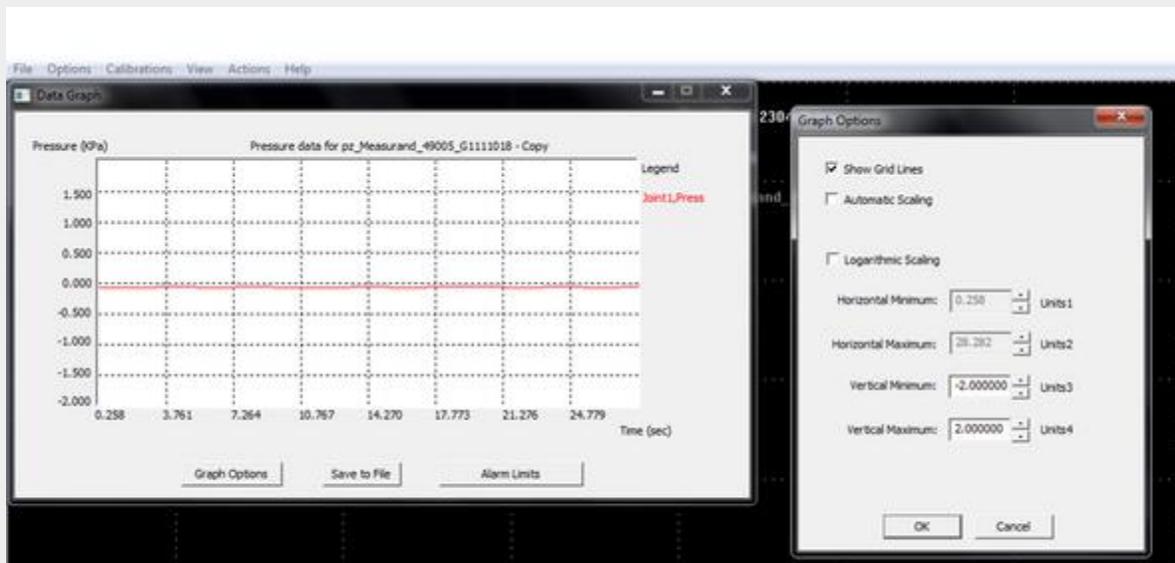
Figure 3.5: Data graph window and Graph Options window

3.3. Operating with Campbell Scientific CR Data Loggers

Figure 3.6: Campbell Scientific CR Data Loggers

Once the initial field reading is taken using SAARecorder, it is possible to connect the SAAPZ to a CR800, CR1000 or CR3000 Data Logger. A Data Logger program can be written using the SAACR_FileGenerator application found in SAASuite. If necessary, the logger program can be modified using the Loggernet 'CRBasic Editor' utility in order to add other sensors to the logger.

For more information on how to program the Data Logger, refer to 'LoggerNet'.

SAAPZ and SAAF data stored on the Data Logger is composed of raw data counts. It must be converted into engineering units using the SAACR_raw2data application in SAASuite. In order to properly convert the SAAPZ data, you will need to create a Site file. This Site file will be used to tell the converter which equation to use for the conversion process.

For more information on how to create Site files and how to use the SAACR_raw2data application, please read 'Site Files' Section of the 'SAACR_raw2data'.

Once the data has been converted, it can be viewed using the SAAView application in SAASuite. Data tables are also created by the conversion application; these can be imported into programs which accept text file imports.

For more information on how to use the SAAView application, please read 'SAAView'.

4. Installation

4.1. Preliminary tests

Prior to installing the SAAPZ, make sure that the initial readings have been done in accordance to the methods outlined in the Geokon Instruction Manual. Refer to the 'Preparing the SAAPZ for initial readings' Section above for more information.

4.2. Installation in boreholes

Individual SAAPZs can be installed using conventional sand and bentonite grout installation methods. However, if more than one SAAPZ is installed per borehole location, it is recommended that the SAAPZ be installed fully grouted in. This is consistent with the SAA installation methods which are currently outlined in 'SAA Installation'. For recommendations regarding bentonite cement grout mixes, refer to the 'SAA+PVC Installation' Section and Section 2.3 in the Geokon Instruction Manual.

When multiple SAAPZs are installed in a single borehole, the SAAPZs are attached to the outside of the 27 mm ID conduit used for carrying an SAAF prior to inserting the conduit into the ground. This allows for easy control of the piezometer depth. It is recommended that the piezometer be placed with the element pointing upwards, but the element can be pointed down.

The cable is then run up the PVC conduit. Piezometers and cables should be carefully cinched to the PVC conduit, keeping spacing between cinch points within 1 m. If desired, multiple SAAPZ cables and one SAAF cable can be spliced together into one cable. This single cable is then connected to the SAA232 or SAA232-5. For added protection against power surges from nearby lightning strikes ('SAA Lightening Protection'), it is recommended that an SAASPD be used; see 'SAASPD'.

Figure 4.1: SAAPZ mounted to PVC conduit

4.3. SAAPZ Splice Kit

Up to four SAAPZs, or three SAAPZs and one SAAF may have their cables connected together using a single SAAPZ Splice Kit, with a common single cable running from the splice point to the Data Logger. Note that in some cases it may be possible to join more than four instruments onto one cable, contact **Measurand** for more information. This single cable can go into an SAA232 or SAA232-5 port.

Figure 4.2: SAAPZ Splice Kit

The SAAPZ splice kit shown in the figure above consists of the following items:

*An SAATERM board with 5 terminal blocks

- A clear plastic potting tube
- ScotchcastTM 2131 B two part potting compound

To use the splice kit go to the 'SAAPZ Splice kit' Guide.

5. Specifications

Dimensions:	19.1 mm Ø x 133 mm (piezometer), 18.1 mm Ø x 180 mm (processor pod)
Weight	0.6 kg
Standard Ranges	-100 kPa to 350 kPa; -100 kPa to 700 kPa
Over Range	2 x rated pressure
Resolution	0.025% F.S.
Accuracy	± 0.1% F.S.
Linearity	<0.5% F.S.
Temperature Range	-20°C to 80°C
Thermal Zero Shift	<0.05% F.S./°C
Diaphragm Displacement	<0.001 cm^3 at F.S.
Power	12 V@ 8 mA

6. Sample SAAPZ Data File Collected Using SAARecorder