Engine Polygraph® (enginepolygraph.com)

with PicoScope 6 Automotive psdata files

July 2020

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A newer version of this document might be available on our website: www.EnginePolygraph.com .

Introduction

This document is to provide Engine Polygraph users with the information to assign the settings when using a PicoScope PC Oscilloscope for capturing engine 'signature' data from the exhaust and oil dipstick or oil filler tubes. This information is not needed if you are using the EPReader software from Predictive Fleet Technologies since the parameters are system calculated within EPReader.

The Engine Polygraph® (www.EnginePolygraph.com) is an application 'in the cloud' to store the FirstLook® sensor output (signatures) from an engine for future reference and to, optionally, request an engine analysis report. To collect the signature data (waveforms), one uses an Engine Polygraph® kit that includes two piezoelectric sensors, an automotive PicoScope, your laptop and the Internet with a subscription to EnginePolygraph.com.

This document covers the functionality of the online web-based application, www.enginepolygraph.com appropriate to uploading the **psdata** files from your PicoScope to the Engine Polygraph system and for the analysis reports. Other documents describe details of the reports produced and the associated (optional) EPReader PC application that simplifies the data collection and editing of the data obtained (the signature). Those documents are available for download from the landing page of www.enginepolygraph.com.

A SenX signature (Fig. 1) is a record of voltage from one or more piezoelectric sensors recording simultaneous pressure changes (pulses) from an exhaust sensor and a crankcase sensor and optionally additional sensors collecting data from other parts of an internal combustion engine. The value to these signatures is that internal combustion engines repeat firing in the cylinders of the engine in a regular fashion. If everything is working well in the engine the pulses repeat in very regular waveforms; however, engine problems usually present variations that repeat every engine cycle (two revolutions for 4-stroke engines).

The user may request an analysis (report) of the data in view of the engine model identified and parameters of the test conditions. Currently the report choices are Assessment, Diagnostic, or none. The Engine Polygraph® reports automate many of the steps that a user would perform manually in interpreting a 'signature'.

If your engine has an intermittent problem, you might run your PicoScope to collect 32 consecutive waveforms and visually review them, looking for an example of what you think might be the intermittent problem. You can save that single signature and upload it with the ADD Signature function to get a Diagnostic report for that timeframe. (Try to find one that has the abnormality away from the very beginning, but somewhat near the early part of the waveform.)

In Figure 1 below, the signature is from the exhaust (blue) and the pressure in the crankcase (red) from a 6 year old, V6 engine. The vertical dashed bars mark the boundaries of a 720° full 2 rotations of the crankshaft which took 74.02 ms, indicating that the 4-stroke engine was running at 'Load' of 1621 rpm.

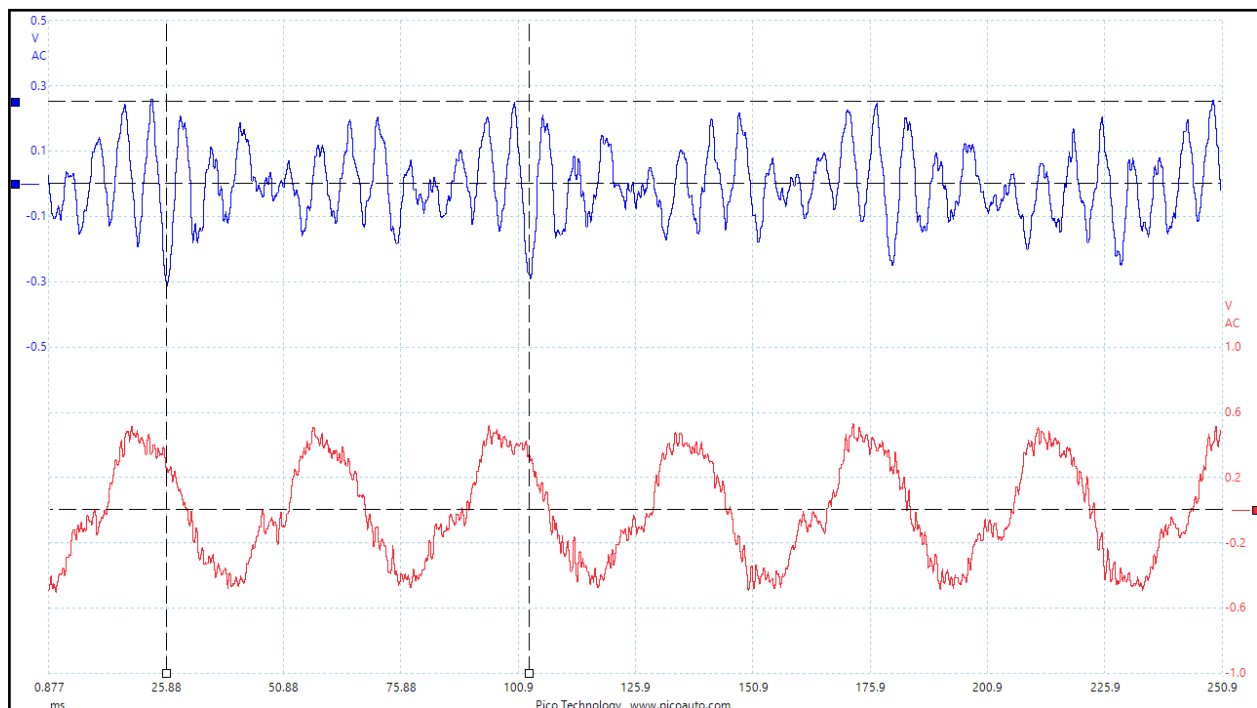The engine cycle, the rpm, and cylinder boundaries are calculated from the analysis of the waveform by the system.

Figure 1. A SenX Signature by using a PicoScope PC Oscilloscope.

Why are the signatures important?

In a 4-stroke engine, each cylinder of a well-running engine fires once during two rotations of the crankshaft (every 720°); in a 2-stroke engine, every cylinder fires once during one rotation of the crankshaft (360°).

In an engine with a problem of 'physical integrity', one or more (usually one) cylinders output an abnormal pressure, resulting in an irregular pulse that is quite obvious. We use the term, 'physical

integrity' to refer to the engine moving parts: head gasket, valves, pistons, rings, cylinders, fuel delivery, or ignition. Depending on where the signature is taken and the nature of the abnormality, the problem can often be identified. In this way, an engine with a mechanical problem can be diagnosed. [If the engine has tripped an OBD code AND the engine shows physical component compromise, the problem might not be correctly identified by the code. Most codes assume that the engine has no mechanical problems (no loss of physical integrity) but might have sensor problems, or ancillary control system problems. If the engine **has** mechanical problems, the code may well be erroneous.]

Over time, wear and tear on the engine will cause less-than-failure variation from cylinder to cylinder. Most engines are not 'broken', but many are dirty (carbon buildup) or parts wearing out. The cylinder that is changing the most is typically the one that will fail first. That is why it is important to 'look back' at the signatures of an engine over time to identify if one (or a few) cylinders are degrading and might need attention. By looking at the rate of degradation, one can estimate the future time of failure. In this way, the sensor data can be used for 'predictive failure' to give you the option of preventative maintenance/repair or retirement. You may want to watch the videos on the SenX Technology website: www.senxtech.com.

The Engine Polygraph® application

The EnginePolygraph application is designed for a shop of one or more people (mechanics and technicians) who will take SenX signatures from engines. There are two ways to collect the signature data. One approach can be used if there is not Internet access at the site of the engine being tested. It is described in this document. The other approach that might be used is a PC based software, EPReader, that does require Internet access while obtaining the data but also provides prompts, edits and a much simpler process. It is described in the downloadable *EP Reader Installation and User Guide*.

For the non-Internet method, it is necessary to have the signature stored on your local computer, typically a laptop in the shop with your PC oscilloscope. The local storage of the signature can be done without connection to the internet. An overview of the procedure for the non-Internet method is described in the downloadable *Polygraph Quick reference Guide*.

EnginePolygraph allows you to attach 'index' data to the signatures for easy future retrieval; the index data **and** the signature are then sent to the EnginePolygraph application. EnginePolygraph is a web-based application and database, so it is necessary that your computer be attached to the internet, perhaps at a later time after you have collected the signature data, in case you do not have internet access at the vehicle location when obtaining the signature.

Add a new Signature

It is important to add the index information to a new signature when you upload it on the Add Signature screen.

For the cases when you are using the non-Internet approach for collecting the signature, we show an (almost) empty screen for what needs to be input to EnginePolygraph.com when you are Internet connected. See Figure 2. Copy this empty screen to write in the info of the engine you are testing at the time you are running the test for later keying when you are on the EnginePolygraph.com, 'Add Signature' screen.

Owner		Vehicle ID			

Engine Manufacturer	Engine Model	Engine Configuration	Displacement
Deere			

Location	Measurement Date	Odometer	Engine Temperature
	2020-07-11		

Condition	RPM Source	RPM
Load	Estimate	

Channel A	Channel B	Channel C	Channel D
exhaust	oil tube		

Engine Poly Purpose	Trigger Cylinder	Comments

Report Selection	Send Report (PDF) to:
Diagnostic	

Upload File
Choose File   No file chosen

Save

Figure 2. (Almost) empty screen to fill out when capturing data for EnginePolygraph.com

The paper illustration on Fig. 2 has the Engine Manufacturer filled out so that the Engine Model pull-down displays. On a blank screen, the Model field will not appear until you make a selection of Manufacturer.

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The **Owner** field is the Fleet name if the vehicle/engine is part of a fleet. If not a Fleet, use a description relevant to you.

The **Vehicle id** is the vehicle number painted on the door, hood, or somewhere visible if it belongs to the Fleet (Owner); if not part of a fleet, I like to use license number, but there is no edit unless it is part of the Fleet.

The **Engine Manufacturer** is from a pulldown list that we at PFT maintain. Once an entry is selected, the **Engine Model** field appears with a pulldown of the engines that we have in our database, sorted by displacement (in liters) in ascending order.

The **Engine Configuration** and **Displacement** are displayed from the values in our database for the Model that was selected. If you can't find the Model in our database, pick one that is similar and enter the info for your engine in the Comments files and let us know at support@PredictiveFleetTechnologies.com so that we can add it and reprocess the signature.

The **Location** entry will rarely require change if the shop name is used; the **Measurement Date** is pre-loaded to today's date, so if this is an entry for a signature from times past, replace the current date with the correct date for the signature.

The **Odometer** reading probably will not change between multiple signatures for the same vehicle on the same date. But be sure to verify it. It can be entered in miles, kilometers, or hours-of-service. The engine coolant **Temperature** is also important to know because some interpretation (especially for diesels) is dependent on the engine temperature. If the input value is under 105, it will be interpreted as °C; otherwise as °F.

Condition is important to be correct for valid interpretation of the signatures. For example, the blow-by is greatest in a cold-crank ('c-c') near the end of a compression stroke, but it is maximum in the power stroke during a hot test ('Idle' or 'Load'). The **RPM Source** is a selection from a pull-down of options. Choices include:

a. **None** indicates that you want the system to provide a default that will be obtained based on the Condition and number of cylinders. **RPM** may be left blank.
b. **Estimate** means that you will input a value for **RPM** that is based on reading a tachometer or other method to provide a reasonable RPM value.
c. **ECM** means that you have a Bluetooth ECM reader plugged in to transmit the engine RPM to the EP Reader while the signature data is collected. **RPM** may be left blank.
d. **Set RPM** means that your engine has a digital input to command the ECM to control the engine speed that you specify to the digital throttle. You then also provide that value to the input **RPM** field.
e. **Trigger channel** (not yet implemented) means that you have assigned an ignition detection device (such as an induction coil to provide voltage to a coil-on-to or spark plug) as one of the channels on the PicoScope,

If the **RPM** is known accurately, it is valuable in the interpretation of the signature. In the case of RPM, if the value input is less than 200 or greater than 6000, a report will not be generated; otherwise, it may be used in the RPM calculation process. If it is more than 15% off from the actual engine speed, it may make the calculation inaccurate.

The '**Channel** x' fields need to be aligned with the oscilloscope channels and how they are attached to the sensors. If you happen to discover a mix-up on the assignments after the fact, you may use the EDIT button on the Signatures screen to submit a revised assignment and get a new report.

You typically will want to record the **Purpose** for the requested report: 'Before' indicates the signature is being taken before some procedure is to be considered; an 'After is for a report on the engine 'health' following the procedure. Choose 'Single' if the report is a routine evaluation of the engine without an intended maintenance procedure that will be validated after the procedure; 'Base' is used to report an 'as new' engine report for future reference.

The **Trigger Cylinder** is important if you have a sensor for identifying ignition events. If your sensor (often a current induction clamp or a spark antenna) is designed to detect the ignition events on only one cylinder, input the cylinder number that is monitored; if the sensor records the events for multiple cylinders, do not specify any one cylinder. The trigger signal is used to calculate RPM; but if one cylinder can be uniquely identified, it can be very useful in identifying which cylinder(s) has/have diagnosed conditions.

You may want to input **Comments** to further uniquely represent this signature in the future or to 'group' the signatures for your particular analysis or organization needs.

You chose the report you desire in the **Report Selection** pull-down: Assessment, Diagnostic, or 'none'. If you chose a report, a 'Send Report (PDF) to:' email address will be requested.

If the submitted signature does not have data that can generate a meaningful report, the system will produce a PDF 'Exception' report describing the issue and suggesting corrective action. You will not be charged for a request that results in this circumstance. The most common reason for inadequate data in the signature file for a meaningful report is that the PC oscilloscope settings might not be appropriate for the engine you are working with. Please review the Appendix: *PicoScope Startup Settings* if you want more information.

PicoScope Settings for Engine Polygraph Signatures.

The PicoScope software controls many important settings for capture, display, and storage of your FirstLook® Signature data. The key parameters are shown in Figure 3. This document is focused on use of the PicoScope to obtain Engine Polygraph® Assessment reports on engine physical integrity.
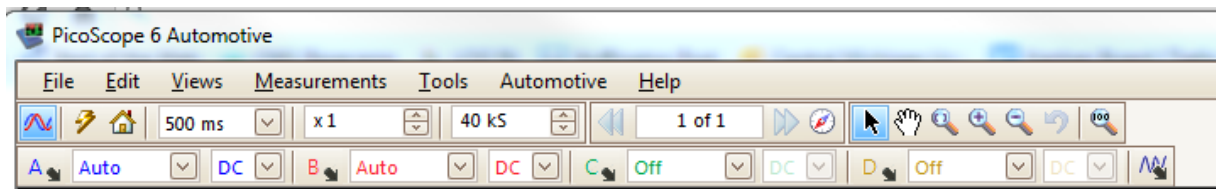
Figure 3. Image of the PicoScope screen with settings that we recommend signatures with Load Condition.

The values of the PicoScope screen with settings that we recommend for signatures taken at Condition = Load (over 1000 rpm) are shown in Figure 3 above (Number of Samples = 40 kS and sweep duration = 500 ms). However, if you are running your engine at Idle (400 – 1000 rpm), cut the Number of Samples from 40 k to 20 kS per second and increase the sweep time to 1 s. And for cold-crank (usually less than 400 rpm) set Number of Samples = 20 kS and sweep = 1.5 s.

We recommended that you save the settings for **each** Condition as a file on your PC. When you download the '[**condition**].pssettings' where [Condition is one of (c-c, Idle, Load) and store it (**Save As**) somewhere on your PC, you can start your PicoScope6 Automotive application and chose **File > Open** to select the downloaded [condition].settings. This will import the settings to your session.

We now will discuss why we provide the recommendations that we do and how you may modify them as needed. This is not meant to replace your use of the PicoScope6 Automotive documentation.

The settings and preferences screens are where you control some of these the settings. First, let's look at the '**preferences'**:

1. The time interval displayed on the screen can be controlled on the **Tools > Preferences > General** screen. The choices are to set the time interval across the screen (Total collection time), or to set the total sweep interval in terms of the time between the 10 equi-distant vertical bars (Times per Division).

    This parameter is critical for obtaining a meaningful report since the software that generates the signature Assessment report requires at least 2.7 cycles of all cylinders firing. For a 4-stroke engine, that is 5.4 rotations of the crankcase. If the engine is running at 1500 rpm, one 4-stroke cycle takes 80ms, so the time (duration) on the screen should be 216 ms, and longer if the engine is running slower. We recommend 500 ms which should be acceptable until about 650 rpm (typical idle). Similarly for c-c and Idle.

2. The **Preferences > General** screen also controls the Waveform Buffer. This parameter controls the number of waveforms that may be stored in the buffers.

    Although having up to 32 buffers is very useful for some analyses, we recommend that you set it to 1 for signatures that are to be analyzed by the EnginePolygraph application. The reason is to make it

easier to save the signature on your PC and then sending it to EnginePolygraph for analysis. EnginePolygraph cannot take the set of signatures as a group for analyses, but can only process one at a time.

For intermittent engine problems, you may want to look at 32 waveforms to find one that captures the abnormality of concern. Then save that one waveform under a unique name to be uploaded by EnginePolygraph.com for analysis.

Figure 4 shows the layout of the Preferences > General screen. You may want to review the settings on the other Preference tabs also.
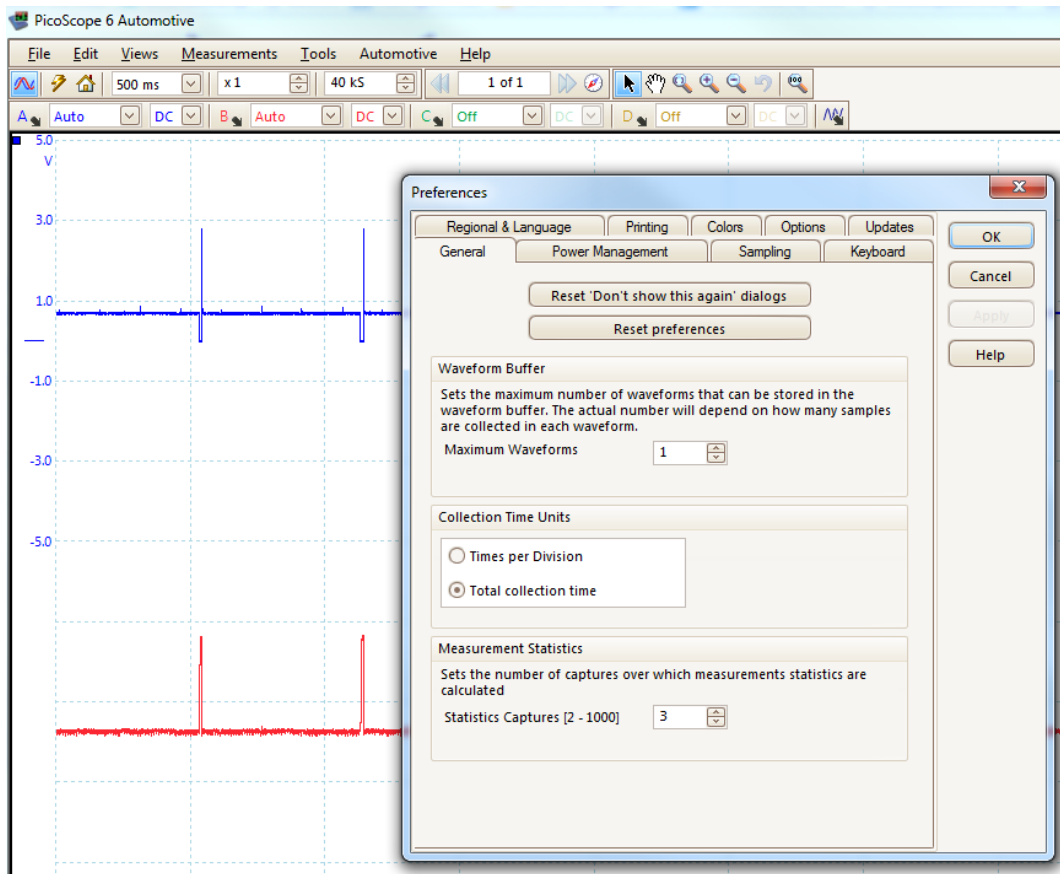

Figure 4. The **PicoScope6 Tools > Preferences > General** screen for controlling important parameters to get EnginePolygraph Assessment reports on engine physical integrity.

Other parameters that can be stored in your Default settings can be altered immediately below the menu bar. Under Tools, is the **sample frequency**. See Fig. 5. We recommend about 40 kS (40,000 samples per second) to get good detail of what is going on in the engine at over 1000 rpm. We do not have any properties that we consider in the analysis that interpret data at a higher frequency, but higher

frequency of sampling increases the file size and slows down the ability of the PC to do any other work. For Idle and c-c, use the values described earlier.

On the next row under the menu bar, the voltage range for each channel is displayed; it can be changed and stored in the Default settings. 'Auto' might be the best choice for all active channels. The pressure/voltage varies by many factors such as rpm, diameter of tailpipe, etc.
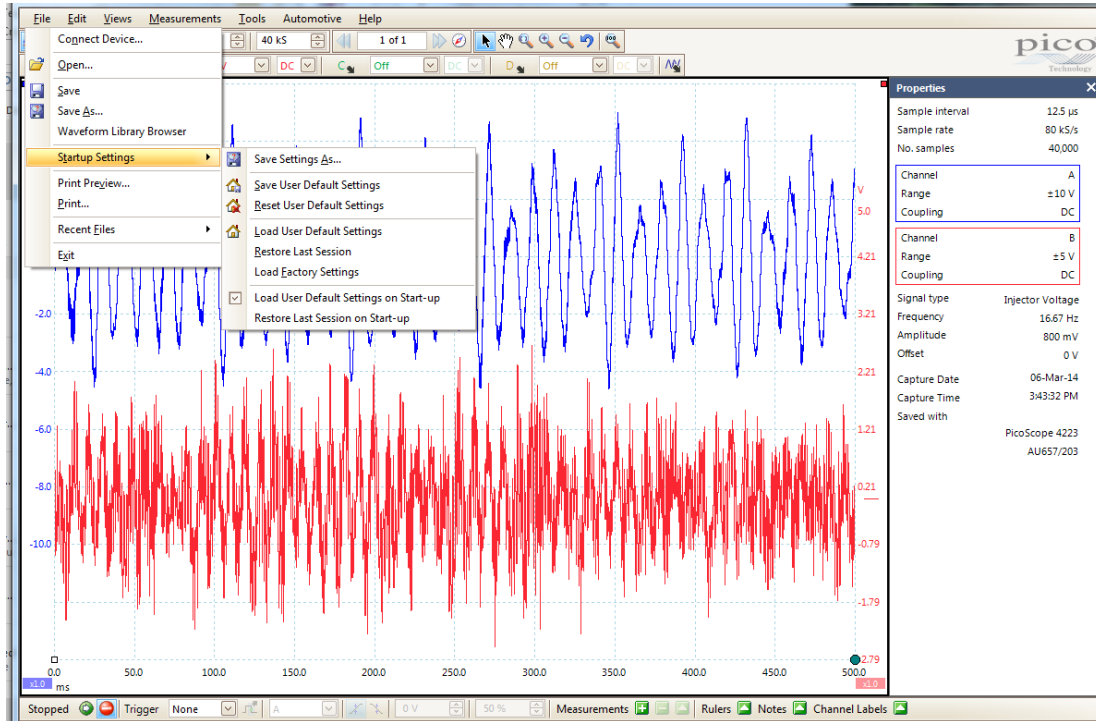

Figure 5. These are the Startup Settings on the PicoScope6 **File > Setup Settings** Menu.

Once you have selected the settings that you want to use going forward, we recommend that you click 'Save User Default Settings' to save them. But we also recommend that you click on 'Load User Default Settings on Startup' to simplify future use of this PC for use with EnginePolygraph. Below is a short description of the behavior for each of the menu items of the **File > Startup Settings** list.

1. The 'Save Settings As …' allows you to save the settings under a unique name in a specific directory of your choice for future reference.
2. 'Save User Default Settings' is used to save the current settings as your Defaults in the future.
3. 'Reset User Default Settings' can be used to go back to the last saved Default Settings in case you have changed the settings during the session, but now want to go back to the Default Settings.
4. Use 'Load User Default Settings' to read the Default Settings and use them going forward.
5. 'Restore Last Session' will reload the settings from your previous session.
6. 'Load Factory Settings' will reset the current settings to the values from the download of your PicoScope software.

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7. Checking 'Load User Default Settings on Startup' will cause the system to load the default settings in the future on start-up.
8. Or you may check 'Restore Last Session on Startup', if that is what you prefer.

If you are not fully trained on the use of your PicoScope, you will want to use the Pico literature and Help screens to get full value from your investment. The material above is presented to focus on the capabilities important for using your PicoScope to obtain SenX signatures for EnginePolygraph Engine Integrity Reports.

We wish you great success on the use of your PicoScope and the Engine Polygraph® (www.EnginePolygraph.com). Engine Polygraph is a product of Predictive Fleet Technologies, Inc.

Contact Us

Learn more about us at www.PredictiveFleetTechnologies.com, www.EnginePolygraph.com, and www.EngineAngel.com.

For specific questions about the Engine Polygraph® functionality, please email us at support@PredictiveFleetTechnologies.com or call us at 1-833-364-2645.

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