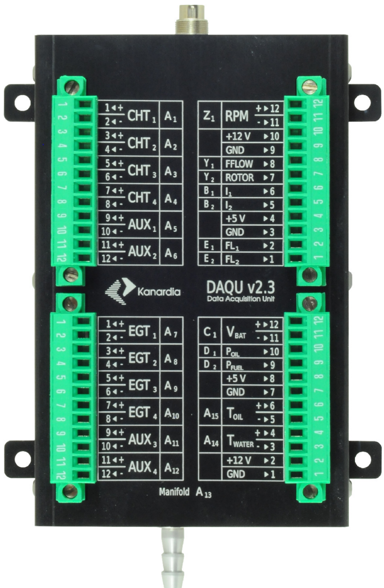
Daqu v2.3 EMS Box
Installation Manual

September 2020



Revision 1.1

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A lot of useful and recent information can be also found on the Internet. See `http://www.kanardia.eu` for more details.

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Revision History

The following table shows the revision history of this document.

Rev.	Date	Description
1.0	January 2019	Release
1.1	September 2020	Some clarifications, troubleshooting section.

Contents

1 Introduction

First of all, we would like to thank you for purchasing our product. Daqu is data acquisition unit designed for monitoring engine parameters. Daqu reads various engine sensors, processes the readings and transmits them to the CAN bus, where other units can make use of these readings.

We strongly recommend to carefully read this manual before connecting Daqu unit with engine sensors. The manual provides information about the installation of the Daqu unit and connecting it with sensors, probes and transducers.

This manual is dedicated to Daqu with hardware version 2.3. For earlier hardware versions (mostly 2.1), please refer to previous manual.

1.1 General Description

Daqu is en electronics device, which is used to connect various engine sensors, probes and transducers. It reads analogue or digital signals, converts the signals into digital CAN messages and transmits the messages over CAN network where other devices connected to the network access these messages.

Daqu electronics is enclosed in thin anodized aluminum case. Electronics is designed to sustain elevated ambient temperatures and with some care it can also be mounted in an engine compartment. A shield is required in this case as electronics is not waterproof.

Only one cable connects Daqu and other devices on the CAN network. This cable carries CAN messages and provides power for Daqu. Daqu uses modified CANaerospace protocol for the communication. A separate document provides details about this protocol.

Daqu comes in two versions:

- Standard, larger version is used for most engines: Rotax, Lycoming, Continental, UL-Power, Simonini, Hirth, etc. Here, engine sensors are directly connected to four twelve pin connectors. It also has one five pin CAN connector and ϕ 5 mm outer diameter intake manifold pressure connector.
- Mini version a.k.a. *Mini Daqu* is used for some modern engines equipped with digital output from their ECU. Here, most engine sensors are connected to ECU and mini Daqu simply reads sensor values from ECU digital output. Besides information from ECU, mini Daqu allows connecting additional sensors like rotor RPM, fuel level, trim position, etc.

Mini Daqu is used with Rotax iS, D-motor, UL Power, Geiger wankel and MW Fly engines. Mini Daqu has only one twelwe pin connector for sensors and two D-SUB nine pin connectors – one for ECU and the other for CAN network.

Optionaly, standard Daqu can be also modified to connect to engine ECU, which effectively makes standard Daqu to act like a miniDaqu with mich more input channels.

1.2 Channels

Daqu has digital type and analog type channels where each type has several versions. Some channels are using two pins and some only one. They are designated using capital letters.

1.2.1 Analog Channels

Most of the channels on Daqu are analog. They appear in following variations:

A – analog channels with -2.5 V to +2.5 V input. These channels are floating – they are not connected with GND internally. They are typically used to connect passive resistive sensors and thermocouples. Supported resistive sensors are various VDO pressure sensors, most temperature sensors, some fuel level sensors, trim potentiometers, etc. J and K type thermocouples are supported.

B – analog channels with 0 to +5 V input. They are mostly used to read active sensors. Active sensors require power in order to operate properly. Do NOT connect any sensor with an output greater than +5 V. This will permanently damage the unit.

C – analog channel with 0 to +30 V input, used to read higher voltage levels. Only one such channel is available and is used to measure the system voltage.

D – This is the same as B channel, but with additional internal 120 Ω resistor. This allows connecting sensors with current output (4 mA – 40 mA). Rotax oil pressure is an example of such a sensor.

E – This is the same as B channel, but with stronger current generator. This generator is used when the channel measures resistance in low resitance range. The following currents are used to measure resistance. In all cases, the voltage difference is limited to 0-5 V.

- for 0–200 Ω range – 20 mA current,
- for 0–400 Ω range – 10 mA current,
- for 0–1000 Ω range – 5 mA current.

They are typically used to connect resistive fuel level sensors and this solves many contact problems, which appear when A channel used for the same purpose.

1.2.2 Digital Channels

The digital channels are used to measure time between pulses. Typical sensors connected to digital channels are engine RPM, rotor RPM and fuel flow. There are two types of digital channels used in Daqu.

Z – is used to measure engine RPM. This channel has a special signal normalizing circuit. Different engines have a very different signal levels. For example, Rotax has up to 400 V (peak to peak) and Jabiru down to 1 V (peak to peak). The circuit brings these different levels to a common denominator. The circuit is able to process from 1.25 to 1000 pulses per second. The upper limit equals to 20 pulses per revolution at 3000 PRM or 10 pulses at 6000 RPM. On lower end this equals to 75 RPM at one pulse per revolution, 37.5 RPM at two pulses per revolution and 7.5 RPM at 10 pulses per revolution.

Y – is used for signals with nicer shape and voltage level, like rotor RPM sensors, fuel flow sensors, etc. Time between signals and sometimes duty cycle is measured. The signal voltage can be in 0-30 V range. From 1.25 to 1000 pulses per second can be processed.

More details and examples of channel use are given in forthcoming chapters.

1.3 Technical Specifications

Table 1 lists technical specifications and figures 1 and 2 shows principal dimensions of Daqu.

Daqu has two connectors on opposite sides. One is used to connect manifold pressure hose and the other is used to connect CAN bus cable. Both connectors require some additional clearence.

Four removable connectors on top are used to connect sensors. Some minimal wire clearance is required, too.

Description	Value
Weight	135 g
Size	125 x 80 x 20 mm
Operational voltage	7–32 V
Current (sensors not connected)	60 mA at 12 V
Typical current (sensors conn.)	100 mA at 12 V
Operating temperature	–30 °C to +85 °C
Humidity	30% to 90%, non condensing
Max current load of 5V power source (both sources together)	150 mA
Max current load of 12V power source (both sources together)	150 mA
Digital channels	3: (1xZ, 2xY)
Analog channels	22: (15xA, 2xB, 1xC, 2xD, 2xE)
Processor	Cortex M3, 60 MHz
Communication	CAN bus, Kanardia protocol
Connector	Binder 99 0414 00 05 (cable side)

Table 1: Technical specifications for standard Daqu.

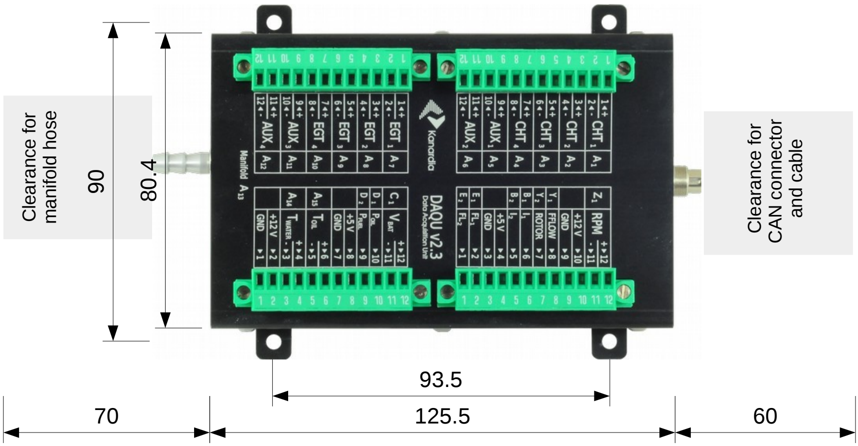

Figure 1: Dimensions and connection clearence of standard Daqu – Top View.

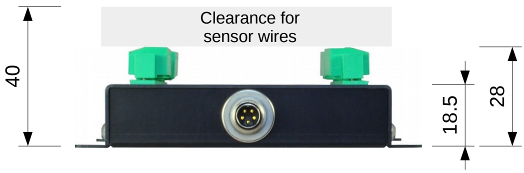

Figure 2: Dimensions and connection clearence of standard Daqu – Front View.

2 Installation

This section reveals details about Daqu mechanical installation and main connectors. It does not tell much about configuration and installation of sensors, probes and transducers. A separate section with general principles starts on page 13 and practical examples section starts on page 23.

2.1 General Rules

Daqu shall be installed close to the engine in order to keep the sensor cables short. This can save significant weight on cables.

It may be installed on the engine side of the firewall providing that it is not under direct influence of engine and/or exhaust heat.

The orientation or position of Daqu is not critical. Just make sure that Daqu connectors are easily accessible and sensor cables are guided properly. A good access to sensor connectors significantly simplifies the wiring, troubleshooting, service and maintenance.

Daqu must NOT be mounted directly on the motor or on a place where significant vibrations may occur.

Daqu is not waterproof. Significant measures were made to protect Daqu electronics from moisture, but direct contact with fluid will cause invalid sensor readings or even permanent failure. Make sure that Daqu will not be exposed to fluids or moisture. Do not put Daqu under coolant expansion bottle.

Please consider that flying trough rain delivers vast amount of water into engine compartment. If Daqu is in engine compartment, please make sure that this water will not reach it. If you intent to fly trough rain, the best way is to enclose Daqu within some watertight compartment.

Daqu is not shipped with the mounting hardware. Any appropriate removable fittings may be used. Do not rivet it in place.

2.2 Intake Manifold Pressure

Daqu has a built in MEMS pressure sensor that is used to measure the intake manifold pressure.

Use a ϕ 5 mm inner diameter tube to connect the manifold pressure engine source with the Daqu manifold connector. Secure the tube on all connections using pipe clamps. Please, consult engine manual to locate the source of the manifold pressure. On most engines a the protection cap and the protection nipple first shall be removed first.

Installing a flow restrictor is higly recommended. This is an element with a small hole in the middle, which allows the pressure to pass, but limits amount of air that can go trough. Install the restrictor as close to the manifold pressure source as possible. This is mostly due to the safety reasons. If tube slips from Daqu or if internal tube inside Daqu leaks, the restrictor prevents pressure change in the intake manifold.

2.3 Connectors and Cables

Power and CAN bus connector details are presented in this section. Sensor connectors are described in a separate chapter.

2.3.1 CAN Bus Cable

Standard Daqu has a five pin Binder connector, which connects Daqu to the CAN bus system. Figure 3 illustrates the pins on the cable side.

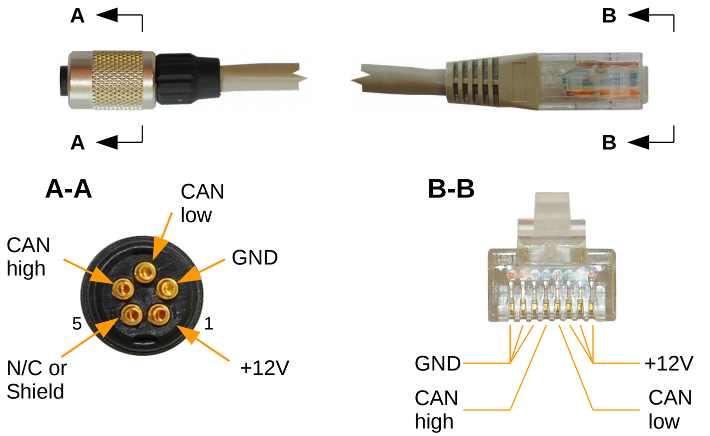

Figure 3: Details of the cable connecting Daqu and other devices. Binder connector is on the left and RJ45 connector is on the right. Binder connector is shown from the soldering side. On the soldering part, small numbers 1 and 5 are visible. RJ45 connector is shown from front.

Only four pins (sometimes five) are used on Binder connector, while RJ45 connector uses all eight pins. On RJ45, three pins are used for GND, one for CAN high, one for CAN low and the remaining three pins for +12V. This means that three leads for GND must be soldered together to one GND pin on Binder. The same is true for three +12V leads. This requires some patience and skill. The fifth pin on Binder is connected to cable shield, when such shielded cable is used. In majority of cases, shielded cable is not necessary.

Binder part numbers on the cable side are 99-0096-100-05 and 99-0414-00-05. These two are equivalent. The connector on the housing has part number 09-0415-00-05.

Standard cable length supplied with Daqu is 1.5 m (4.9 feet). A different length may be also provided without any additional costs, when such length is specified at the time of the order.

3 Wiring in General

This section reveals some basic principles of correct wiring. Not all options are described, just the most common ones. The schematics presented in this section shall be considered as general wiring guideline rather than a recipe. There are also other sensors that Daqu can make use of and are not described here.

When a problem is encountered, contact Kanardia and we will try to provide you with a solution.

Check sensor manual and specifications before wiring and installing the sensor. Follow the sensor instructions. Make sure that the wires are secured and they will not get loose due to vibrations.

3.1 Connection Wires

Tefzel (or similar grade insulation) is recommended for all wires. The signal wires thickness shall be AWG 22 unless other thickness is recommended.

3.2 Daqu Ground Pin (GND)

NEVER connect any Daqu ground pin (GND) directly to the aircraft or engine block or to common system ground. Routing ground through aircraft/engine block will not damage Daqu, but will create unnecessary ground loops, which in turn may cause incorrect readings from the engine sensors, especially resistive ones.

Daqu ground pin should be used only when:

1. An active sensor is installed and GND pin is used together with some +5/+12 V power pin to power the sensor and sensor signal is connected to one of B, D, E or Y channels.
2. Isolated resistive (two wire) sensor is installed and GND pin is used as a reference ground for the sensor. In this case sensor is connected to some A or E channel.

Special caution should be applied when dealing with fuel level sensors. If they are resistive type, they should be connected to E channel.

3.3 Resistive Sensors on A Channels

Resistive sensors are often used for various temperature probes, pressure sensors, fuel level probes, trim positions, etc. The resistive sensors can be connected either to A or to E channels. The principles are a bit different regarding to the channel type used. This section describes connection to A channels and section 3.4 describes connection to E channels.

For A channels, two basic schematics can be used, based on the sensor type.

- One wire sensors have slightly simpler schematics, but they are more sensitive to ground loops. When a large current consumer is turned on, sensor values may *jump* a bit, sometimes they may even go crazy.
- Two wire sensors have slightly more complex schematics, but they are less susceptible towards large currents.

3.3.1 One Wire Sensors

Some sensors connect with only with one wire. The wire is connected to + pin of A channel. Although it seems that there is no second wire, in fact it is. The "invisible" ground wire is provided by the engine block. This means that negative terminals of selected A channel must be connected to the engine block, which acts as a second wire.

Figure 4 illustrates such situation for two resistive sensors. A thick ground wire (use AWG 17 or less) must be routed directly from the engine block close to Daqu, where it is split and connected to negative terminals of one wire resistive sensors.

In theory, any system ground point could be used to connect the negative terminals. In practice this is causing problems (ground loops) and taking ground directly from the engine block and splitting this ground close to terminals works the best.

There may be several one-wire resistive sensors connected to Daqu. Figure 5 illustrates situation where two CHT, one oil temperature and one resistive oil pressure sensors are connected. They all are one wire sensors and all are grounded via engine block. The engine block is connected with one AWG 17 wire, which leads to the splitter and from the splitter separate wires lead to each negative terminal.

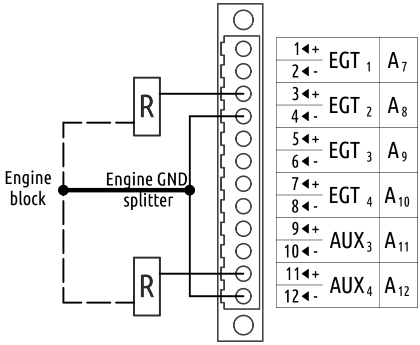

Figure 4: One wire resistive sensor principle. The *invisible* ground wire is routed via engine block, represented by the dashed line.

3.3.2 Two Wire Sensors

Two wire resistive sensors (also known as sensors with isolated return) have two wires. One wire connects to positive terminal of A channel and the other to the negative terminal. As A channels are isolated too, they are floating by default. This means that negative terminal requires some reference. Typically, any Daqu GND pin can be used for the reference. Figure 6 gives an example where two such sensors are connected.

3.4 Resistive Sensors on E Channels

Resistive fuel level sensors that are submerged in fuel may have problems when connected to the A channel. They may be losing contact. Namely, A channel uses pretty weak measuring current, and consequently a very small voltage difference to measure the resistance.

E channel is designed to apply larger measuring current, and consequently also larger voltage difference for the same resistance. This reduces contact problems with sensors submerged in fuel. Thus a fuel level resistive sensor shall be connected to an E channel whenever this is possible. The current and voltage are still low enough to be safe. Figure 7 illustrates such connection. Additional wire to reference ground is not needed with E channel. See also section 1.2.1 for more details.

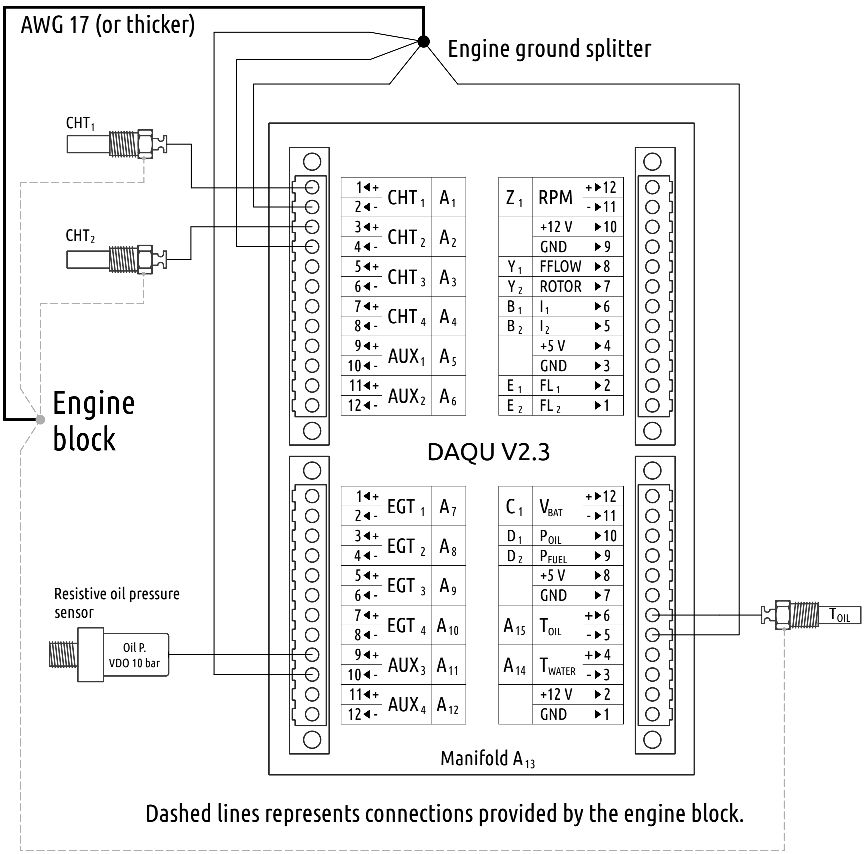

Figure 5: Several one wire resistive sensors connection principle.

3.5 Thermocouples

Thermocouples are used as temperature sensors. Usually, they measure EGT or CHTs, but they may be used to measure other temperatures as well. They always connect to A channels.

Thermocouples differ in type. Thermocouple types are designated with letters. Daqu supports thermocouple types J and K. Thermocouple probes also differ by electrical isolation principle.

- An isolated thermocouple sensor has its tip electrically isolated from

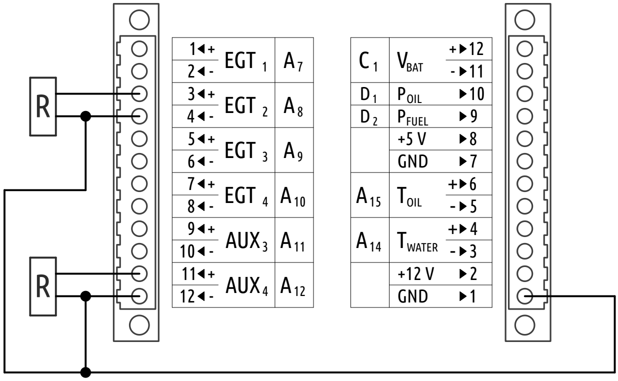

Figure 6: Two wire resistive sensor principle. The return line is isolated and does not connect to the engine block. Additional connection to GND reference is needed for each negative terminal.

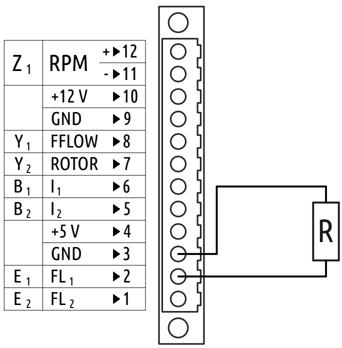

Figure 7: Two wire resistive sensor connection on E channel.

either wire. A multimeter will read infinite resistance (no contact) between the sensor tip and either wire end.

- A non-isolated thermocouple sensor has its tip in contact with either wire. A multimeter will read very small resistance (one or two ohms, max) between the tip and either wire end.

Connection schematics is the same in both cases, but the channel must be configured properly in software.

Thermocouples have a positive and negative wire. The positive wire is connected to the + pin and negative wire is connected to − pin of the same A channel. See Figure 8.

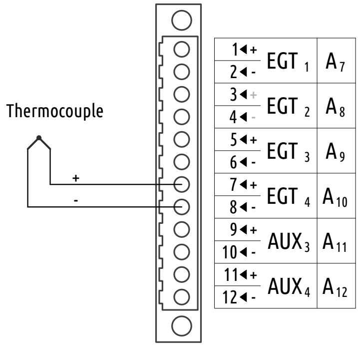

Figure 8: Thermocouples connection schema.

Thermocouple wires can be shortened. Wires can be also extended, but in this case the extension wire must be made of the same material as wire being extended. In addition, care must be taken for connection joints.

Thermocouple wires follow some color coding. Unfortunately, there is no common standard for the wire colors. US uses different color codes than EU, etc. Table 2 shows most often used colors.

Description	Material	US	EU
K type, + wire	nickel-chromium	yellow	green
K type, - wire	nickel-aluminum	red	white
J type, + wire	iron	white	black
J type, - wire	copper-nickel	red	white

Table 2: Thermocouple wire color coding.

3.6 Analog Active Sensors

Active sensors require external power to operate and provide some active signal. Some sensors require 12 V and some 5 V to operate. These sensors are often used to measure various pressures, fuel levels, etc. An active sensor

has its own built-in electronics, which takes care for voltage fluctuations. This makes their signal more stable and robust.

Most of these sensors fall into one of two groups:

- Sensors with voltage output.
- Sensors with current output.

3.6.1 Voltage Output

Daqu can connect sensors with varying voltage output signal in range of 0-5 V. These sensors can connect to B, D and E channels.

An active sensor with voltage output usually has three wires. +5/+12 V sensor input wire is connected to appropriate +5/+12 V Daqu pin, ground wire to GND Daqu pin and the sensor signal output wire to one of B, D or E channels.

The sensor signal output voltage must be limited to 5 V. Higher voltage may permanently damage Daqu.

A few different standards appear within this voltage range.

- *0.5 – 4.5 V* output range is the most frequent one. The sensor outputs 0.5 V when not loaded and 4.5 V when it is maximally loaded.
- *0 – 5 V* output range. Sensor outputs 0.0 V when not loaded and 5 V on maximal load.
- *0.25 – 4.75 V* output range. Sensor outputs 0.25 V when not loaded and 4.75 V on maximal load.

Figure 9 illustrates an example of active sensor with voltage output connected to a B channel. The sensor requires 12 V to operate, but some other sensor might require 5 V. Always check sensor's specifications.

3.6.2 Current Output

Some active sensors have varying current. The current vary between 4 mA when sensor is unloaded and 20 mA when sensor is fully loaded. These sensors can connect to D channels, which have an internal 120 Ω resistor. The resistor is automatically engaged when current output sensor is selected.

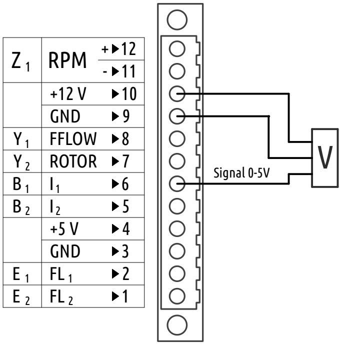

Figure 9: An example of active sensor with voltage output.

Sensors may have two or three wires. +5/+12 V *input* is connected to appropriate +5/+12 V Daqu pin. Signal is connected to one of the D channels, see Figure 10. The third wire is connected to the GND Daqu pin. Some sensors do not require GND connection and they are grounded via engine block instead. Rotax oil pressure sensor is one such example.

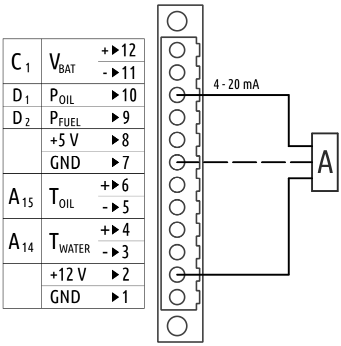

Figure 10: An example of active sensor with current output. Symbol A stands for *Ampere* which is synonym for electrical current. For some sensors, connection with GND is not required.

3.7 Potentiometers

Some resistive sensors are in fact potentiometers (fuel level, trim, etc.). They can be connected as variable resistors or as variable voltage dividers.

3.7.1 Variable Resistor

Section 3.3 applies, when they are connected as variable resistors. In this case, two wires are used mostly. (One wire version works, too). A two wire example is shown on Figure 11. An A channel shall be used in this case. In fact, the principle is identical to Figure 6.

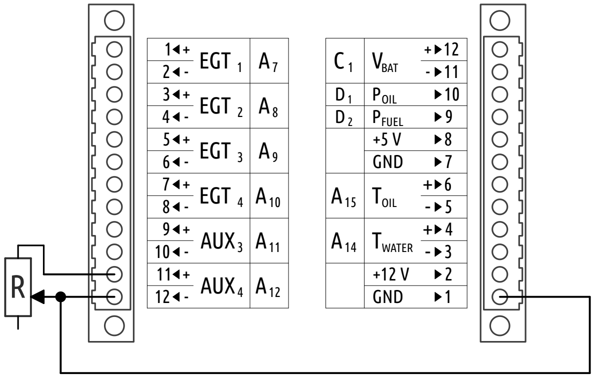

Figure 11: An example of potentiometer, connected as variable resistor.

3.7.2 Variable Voltage Divider

The same potentiometer can be also connected as a voltage divider. A voltage is applied across the potentiometer and the varying part is connected to one of B, D or E channels. Supplying voltage must not exceed 5V. In this case, the output voltage will remain within 0-5 V interval. Figure 12 illustrates possible connection.

3.8 Digital Active Sensors

Digital active sensors require external power to operate. They produce a step like signal, which can be viewed at as pulses. Daqu measures time between these pulses. Such sensors are used for measuring engine RPM, rotor RPM and fuel flow.

Digital pulses are typically accompanied with a pulse divider value. This value tell how many pulses are needed for one event. The value varies in regards to the sensor type and intended function. For RPM measurements, the divider

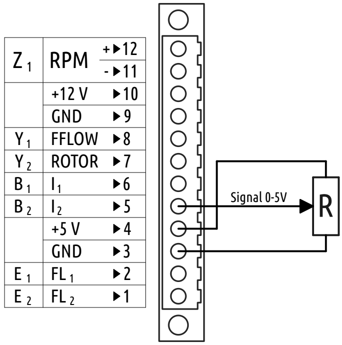

Figure 12: An example of potentiometer, connected as variable voltage divider.

equals to number of digital pulses for one revolution. In the case of fuel flow, the divider equals to number of pulses required per one litre.

The pulse sensors are typically of two types NPN or PNP.

Attention must be paid to apply correct voltage for the sensor. Figures show connection to a 12 V, but some sensor may require 5 V supply.

3.8.1 NPN – Open Collector Output

Figure 13 illustrates a typical connection for the NPN case. Here all wires are connected directly.

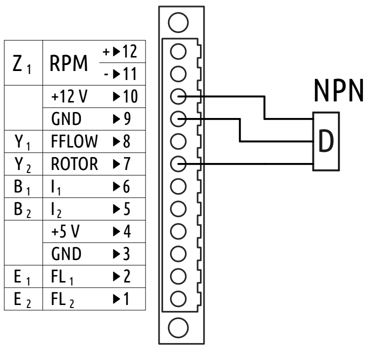

Figure 13: An example of NPN digital sensor connection.

3.8.2 PNP – Open Drain Output

Figure 14 illustrates a typical connection for the PNP case. Here, an additional 10 kΩ resistor between GND and signal is needed.

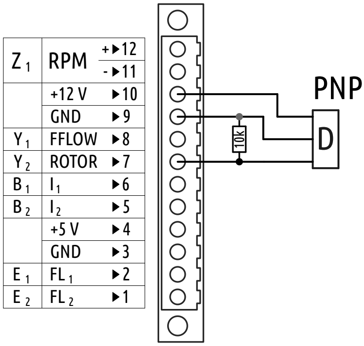

Figure 14: An example of PNP digital sensor connection.

4 Examples

This section shows various sensor installation details that are common in practice. Only connections to Daqu are described and some general guidelines are given. Relevant engine manual or sensor manual shall be used for details on sensor installation.

4.1 EGT – Exhaust Gas Temperature

Almost all EGT probes are K type thermocouples, so general information from section 3.5 apply here. Figure 15 shows two examples.

4.1.1 Installation

Some EGT probes have long wires. If wires are too long, they can be trimmed. It is recommended that both wires are trimmed to the same length.

A lot of EGT probes have ridiculously short wires and they require extension. These wires must never be extended using standard wires (copper or similar). When extended, the same wire material must be used for extension otherwise Daqu will give false readings for sure.

Figure 15: Hose clamp type EGT probe (left), bayonet type EGT probe (right).

EGT probes are typically placed on the exhaust pipes. Correct placement is important to get precise readings. The placement may vary between engine type and model and exhaust pipe construction. Consult your engine manual for proper EGT probe placement.

Usually, most appropriate position is 5 – 20 cm from the cylinder. For best results, mount all probes at the same distance from each cylinder. Gases in the exhaust pipe are cooling very quickly and installing probes at different distances may result in different temperatures. (Difference between the EGT temperatures are more important than the actual absolute temperatures.)

A probe can come loose during the flight due to vibrations and can come in contact with the propeller or engine parts. Use safety wire on each probe to prevent this and to keep the probe in its place.

Any leak in the exhaust system can cause carbon monoxide to enter the cockpit (cabin), which may cause severe (lethal) poisoning. A detailed inspection of the final installation and a carbon monoxide detector are highly recommended.

Channels A7 – A10 are labeled as EGTs, but any A channel can be used to connect a thermocouple.

Polarization is very important. Connect positive wire to + pin and negative wire to – pin of the same A channel. See Figure 8 for proper connection schematics.

A tip of the thermocouple probe can electrically isolated or non-isolated. Any multimeter can be used to find this out.

Hose Clamp Type Mark a spot on the exhaust pipe, where the probe will be installed. Make sure that the spot is on the straight portion of the pipe

to ensure better grip for the hose clamp. Make also sure that the probe does not interfere with the cowl or any other obstacle or engine part.

Drill appropriate hole on the marked spot and carefully clean any chips and burrs.

Insert the probe and fasten it by tightening the clamp with a screwdriver. Check that the clamp provides a firm grip and secure fit, but do not overtighten it. Use safety wire to additionally fix the clamp to the pipe.

Example for hose clamp EGT probe can be seen on figure 15 (left).

Bayonet Type Bayonet type EGT probe requires a nut welded on the exhaust pipe. Test the nut with the probe, to make sure that threads match. Kanardia EGTs require M8x1 nuts (fine thread).

Take into consideration the straght rigid part of EGT, which may interfere with cowling if not installed properly.

In the nut centre must be a hole trough exhaust pipe. If there is no hole, measure the probe tip diameter and drill a hole that matches the measured diameter. Typical diameter is 1/8" (3.2 mm). Some probes have adjustable tip length.

Thread the probe into welded nut and adjust the tip so that the tip is in the middle of the pipe. Tighten all the nuts, one used to adjust the tip and the other which holds the probe in the pipe.

Example for bayonet EGT probe can be seen on figure 15 (right).

4.1.2 Configuration

Once a EGT probe is wired properly, the channel must be also configured. Table 3 shows a channel configuration example.

Option	Selection/Setting
Channel	Any A, but A13
Function	EGT 1, EGT 2, ...
Sensor	K type
Isolated	Yes/No – check with multimeter
Report time	0.5 – 1.0 s
Filter	2.0 s

Table 3: EGT channel configuration.

4.2 CHT – Thermocouple

CHT sensors come in many forms. When thermocouple types are used to measure CHT, they are mostly in a form of a ring terminal or spring loaded insert type. Mostly they are J type thermocouples, but K types may be also used. Figure 16 shows two examples.

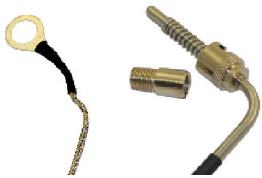

Figure 16: CHT ring terminal CHT probe (left), spring loaded bayonet type CHT probe with insert (right).

4.2.1 Installation

Same principles as defined in section 3.5 apply here. Wires can be shortened. But for extension, correct wire material must be used. If this is not respected, Daqu will give false readings.

Channels A1 – A4 are labeled as CHTs, but any A channel can be used to connect a thermocouple.

Polarization is very important. Connect positive wire to + pin and negative wire to – pin of the same A channel. See Figure 8 for proper connection schematics.

A tip of the thermocouple probe can electrically isolated or non-isolated. Any multimeter can be used to find this out.

Ring Terminals CHT ring terminals are installed under spark plugs. The terminals are usually made of copper. Use torque wrench and respect the torque limitations from the engine manual for the installation. The ring terminals are usually non-isolated.

Spring Loaded Probes With Inserts Cylinders on some engines have a factory prepared holes between the cooling fins. Inserts are threaded into the hole. Use a torque wrench and respect the limiting torque provided by the

engine manual. Once the insert is fixed, insert the spring loaded probe into the insert.

4.2.2 Configuration

Once a CHT thermocouple is wired properly, the channel shall be configured according to the Table 4.

Option	Selection/Setting
Channel	Any A, but A13
Function	CHT 1, CHT 2, . . .
Sensor	K type or J type, depending on the probe
Isolated	Yes/No – check with multimeter
Report time	0.5 – 1.0 s
Filter	2.0 s

Table 4: CHT thermocouple channel configuration.

4.3 CHT - Resistive Sensors

Many different resistive temperature sensors exist that may be used for CHT measurements. Most of them are NTC types (e.g. VDO 150) and some of them are PTC (e.g. PT 100). Form connection point of view, there is no difference between NTC and PTC.

4.3.1 Installation

The installation example is given for Rotax 912 engine family, where these sensors are most common. Usually a VDO 150, thread M10x1.5 is used, VDO part number is 323-801-010-001D. This sensor mounted in the cylinder head and is grounded via engine block, hence connection principle from section 3.3.1 applies. Usually two such sensors are used on Rotax 912. Figure 17 shows connection schematics.

The sensor shall be inserted per engine manual. Torque must be respected. As sensors are grounded via engine block, a good contact between engine block and sensor must be assured.

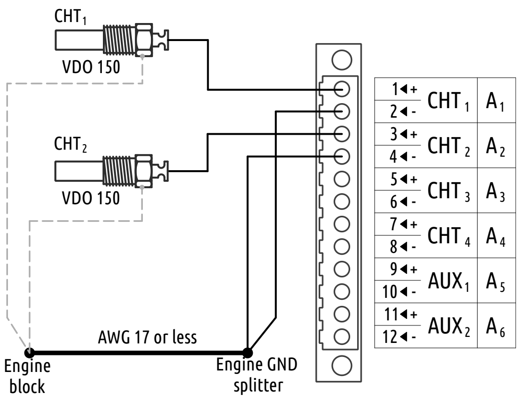

Figure 17: Typical connection of CHT sensors on Rotax 912 engines.

4.3.2 Configuration

The configuration is shown on table 5.

Option	Selection/Setting
Channel	Any A, but A13
Function	CHT 1, CHT 2, . . .
Sensor	VDO 150C
Report time	0.5 – 1.0 s
Filter	2.0 s

Table 5: VDO 150 sensor configuration for CHT, Rotax 912.

4.3.3 Other Sensor Types

The same principles apply for other resistive temperature sensors types. When they are grounded via engine block (majority), connect them according to Figure 4 and when they use two wires (isolated return line), connect them according to Figure 6.

At the time of the writing, the following sensors are supported. They differ only in temperature – resistance curves. This means that proper *sensor type* must be selected in the configuration.

- PTC, platinum based sensors: PT 100 and PT 1000.

- NTC (negative temperature coefficient) sensors: VDO 100C, VDO 120C, VDO 150C, VDO 200C, Westach 399, Flybox N1K, Bosh 2500 Ohm, NTC WTS05, NTC JPI, NTC KT 3000 Ohm, NTC TS 103A, Dynon 100409, Dynon 100468, NTC 703-8016 10k, NTC Fusion Copter, Denso 2212, Denso 176-17-5L.
- Other sensors: LM 335, ST-20.

4.4 Oil Temperature

Oil temperature sensors are almost always one wire resistive sensors. This means that same principles as indicated on the section 4.3 apply here as well.

4.4.1 Installation

Each engine may have its own specific thread, but in general two different threads are in use:

- 1/8 - 27 NPT thread is used on Rotax and Jabiru engines.
- 5/8 - 18 UNF thread is used on Lycoming and Continentals.

⚠ NPT threads are tapered. Be careful and respect the torque limitations from the engine manual. It is normal that some thread remain visible once the limiting torque is reached. Special sealant must be usually applied on the thread to ensure tightness.

⚠ UNF threads are uniform (parallel) and sensor should be installed with a crush washer made of soft metal (copper). Washer is used to seal the sensor. Refer to the engine manual for the proper washer type and torque limitation.

ℹ Rotax note: Oil temperature sensor and CHT sensor seem very similar. They have same temperature – resistance curve, but they differ in the thread. VDO part number for the oil temperature sensor is 323-801-009-001D.

Typical connection for Rotax engine is shown on Figure 18.

4.4.2 Configuration

The configuration is shown on table 6.

The temperature sensor type is not limited to VDO. Other types can be used as well. See section 4.3.3 for the list of supported sensors.

Option	Selection/Setting
Channel	Any A, but A13
Function	Oil temp
Sensor	VDO 150C
Report time	0.5 – 1.0 s
Filter	2.0 s

Table 6: Rotax oil temperature configuration.

4.5 Coolant (Water) Temperature

Same sensors as listed in section 4.3.3 may be used for coolant temperature measurement.

4.5.1 Installation

Coolant temperature sensors are usually installed on the water tube between the expansion tank and radiator. The installation point is usually electrically isolated from the engine. This means that althogh the one wire resistive sensors may be used, the second grounding wire from the sensor housing to the Daqu may be needed. This effectively makes it a two wire installation. The solution shown on Figure 18 shows a typical case for Rotax 912 engine.

However, one wire installation is also possible. This differes from aircraft to aircraft.

4.5.2 Configuration

The configuration is shown on Table 7. The temperature sensor type is not limited to VDO. Other types be used as well.

Option	Selection/Setting
Channel	Any A, but A13
Function	Water temp
Sensor	VDO 150C
Report time	0.5 – 1.0 s
Filter	2.0 s

Table 7: Rotax coolant (water) temperature configuration.

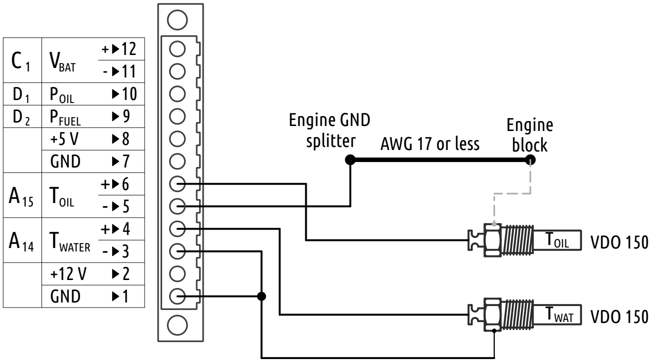

Figure 18: Typical oil and coolant (water) sensor connection. *One wire* principle is used for the oil sensor and *two wire* principle for the coolant sensor.

4.6 Oil Pressure

Engines typically require an oil pressure sensor that operates in 0-10 bar range (0-150 psi), although sometimes 5 bar pressure sensors are used as well.

Both active sensors types: variable voltage and variable current are supported. Passive resistive sensors are also quite common.

4.6.1 Sensor Type Selection

Often, a sensor of given range appears in different type regarding reference pressure. In principle there are three basic options:

- Absolute type works like a barometer. The sensor has a membrane and a chamber. The chamber has pure vacuum inside, which serves as the reference. On one side of the membrane is vacuum and on the other side is applied pressure. The sensor measures deflection of the membrane against vacuum chamber and then translates this to an absolute pressure reading.

- Vented gage type works like a speed sensor in principle. Measuring pressure is applied on one side of the membrane and on the other side is atmospheric (or better said surrounding) pressure, (hence term vented). This surrounding pressure serves as reference. This is what you usually

need to measure oil or fuel pressure. You get the pressure relative to the surroundings.

- Sealed gage type is similar to absolute sensor in principle. However, it does not have vacuum inside the chamber, but some known reference pressure. So, the membrane deflection will be zero if the applied pressure is the same as the reference pressure inside the chamber.

4.6.2 Installation

Active pressure sensors are available in many different versions and care must be taken to select the proper sensor. Some of these sensors measure absolute pressure. Absolute pressure sensors are NOT suitable. Sensor shall measure differential pressure against engine compartment ambient pressure (vented gage type).

Also, passive (resistive) sensors come in many versions. Do not let number of contacts misled you. Some sensors may have two contacts, but are still one wire sensors (the second contact is for warning light) and some have three contacts, but are two wire sensors (the third one is for a warning light) and some have only one contact, which is for warning light only and can't be used to measure pressure at all.

Most engines use 1/8 - 27 NPT thread, but not all. A care must be taken with Rotax 912 engines. While most older Rotax engines use 1/8 - 27 NPT thread, newer Rotax 912 engines use metric M10x1 uniform thread instead. Both threads look similar from a distance.

Try to use sensors, which can be disconnected close to the sensor head. This reduces the problems with sensor installation – sensor is installed first and then connected.

During installation, always respect the limiting torque and other details from the engine installation or maintenance manual. Sensors with NPT threads require application of special sealant.

4.6.3 Variable Current

Rotax engines use 10 bar variable current sensor by default. This is described in section 3.6.2. Schematics is repeated here, adapted for typical Rotax installation, Figure 19. The sensor requires 12 V for power and it is grounded via engine block, so GND lead is not connected. Signal output is currect between 4 and 20 mA.

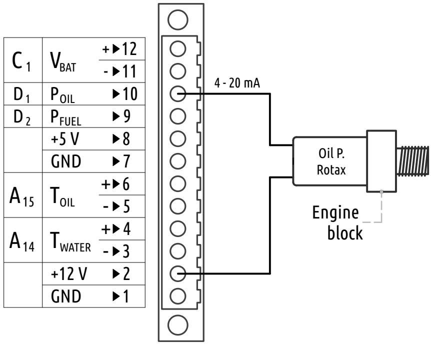

Figure 19: Typical oil pressure sensor connection for Rotax engine. Active, current variable sensor is used.

Corresponding configuration is shown in Table 8. D channels shall be used with variable current sensor. These channels have high precision internal resistor, which is automatically activated when *4-20 mA Int Res* sensor is selected. Because this sensor is a generic one, max value (or reference value) must be also specified. This value is sensor specific. For the Rotax case it is 10 bar.

Option	**Selection/Setting**
Channel	Any D
Function	Oil pressure
Sensor	4-20 mA Int Res
Report time	0.5 – 1.0 s
Filter	2.0 s
Max value (at 20 mA)	10

Table 8: Typical Rotax oil pressure configuration.

4.6.4 Variable Voltage

Sensors with variable voltage output were described in section 3.6.1. Connection example is given on Figure 20. It shows an active sensor with 0.5 – 4.5 V output. The sensor requires 5 V to operate. The sensor max range is 10 bar.

The sensor configuration is shown on Table 9. As this is a 10 bar sensor, the max value is set to 10 bar. Your sensor may have a different max value.

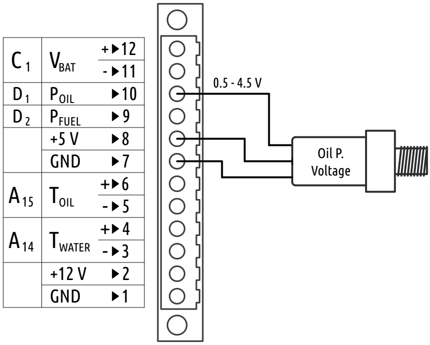

Figure 20: Oil pressure sensor with variable voltage (0.5 – 4.5 V) output. Sensor is powered with 5V.

Option	Selection/Setting
Channel	Any B, D or E
Function	Oil pressure
Sensor	Active 0.5 – 4.5 V
Report time	0.5 – 1.0 s
Filter	2.0 s
Max value (at 4.5 V)	10

Table 9: An example of active pressure sensor with 0.5 – 4.5 V output. Max value is set to 10 bar.

4.6.5 Resistive, One Wire

Some older engines may still use (passive) resistive sensors. In this case sensor acts as a resistor. When sensor is installed directly on the engine, it is almost always grounded via engine block – and one wire sensor is typically used. See section 3.3.1. Connection schematics for one such sensor (a 10 bar VDO) is shown on Figure 5. A configuration for this example is given on Table 10.

Daqu supports the following resistance ranges for oil pressure sensors.

- *10 – 180* Ω range. Unloaded sensor will give 10 Ω and maximally loaded sensor will have 180 Ω resistance. VDO senders use this range.
- *3 – 160* Ω range. When unloaded sensors gives 3 Ω and under max load it gives 160 Ω.

Option	Selection/Setting
Channel	Any A, but A13
Function	Oil pressure
Sensor	Res. 10 – 180 Ohm
Report time	0.5 – 1.0 s
Filter	2.0 s
Max value (at 180 Ohm)	10

Table 10: An example of passive VDO pressure sensor with *10–180* Ω output. Max value is set to 10 bar.

- *240 – 33* Ω range. This range is reversed. Sensor with no load has 240 Ω resistance and under maximal load it has 33 Ω.

We recommend using active type pressure sensors. Passive (resistive) sensors may be sensistive to ground loops and shall be generally avoided.

Resistive sensor are sometimes installed on the firewall rather than directly on the engine. This may reduce problems with premature sensor failures due to engine vibrations. In this case, a high pressure hose connects the engine oil pressure measuring port with the oil pressure sensor. These sensors may have isolated return and are two wire sensors. This means that slightly different schematics is required – see section 3.3.2 for more details. Configuration is identical to the one wire sensor.

4.7 Fuel Pressure

Fuel pressure section does not tell much more than the oil pressure section. All considerations are almost identical. The only difference is the operating pressure range.

Two typical ranges are found for fuel pressure sensors:

- *0 - 1 bar (15 PSI)* for engines with carburetor. Typical operating pressure is 0.3–0.35 bar.
- *0 - 5 bar (72 PSI)* for engines with fuel injection. Typical operating pressure is around 3 bar.

For engines with fuel injection system a 10 bar pressure sensor is often used – same as for the oil pressure. This reduces number of different sensors used on an engine.

Most fuel pressure sensors use 1/8 – 27 NPT thread and some special sealant to prevent fuel leaks.

4.7.1 Installation – Rotax 912 Engines With Two Carburetors

We prepared a schematic, which defines the best position of fuel pressure and fuel flow sensor. Please note that this is only our recommendation. Aircraft producer may provide some different schematics, which takes precedence over our recommendation.

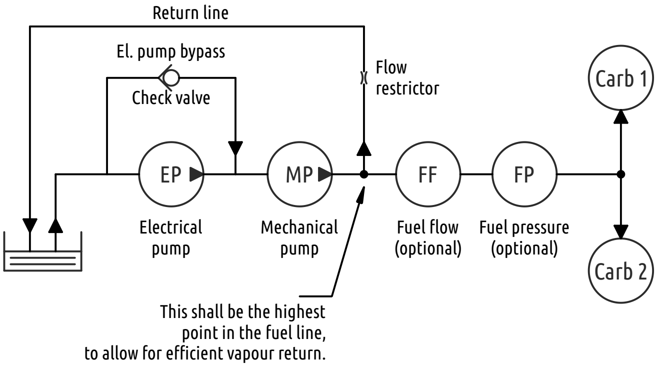

Figure 21: Recommended positions for fuel pressure and fuel flow sensors on Rotax 912 engines with two carburetors.

Fuel pressure sensor shall be installed just before the fuel line splits to both carburetors. This position ensures that fuel pressure detects the pressure, which is also felt by carburetors.

Fuel flow sensor shall be installed after the return line junction. This ensures that fuel flow sensors does not count for the fuel that returns back to the fuel tank.

Note that there may be some limitations given with the orientation of the fuel flow sensor. Please consult the fuel flow sensor manual or installation guide for proper orientation.

4.7.2 VDO Sensors

VDO sensors are passive sensors who vary resistance according to applied pressure. The resistance varies in the *10 – 180* Ω range, where 10 Ω is indicated when no pressure is applied and 180 Ω when max pressure is applied.

The VDO sensor max range can be 1 bar (15 psi), 2 bars (30 psi), 5 bars, 6 bars, 10 bars (150 psi), etc. They are vented gage type of sensor – they measure pressure difference against enviroment pressure.

Each VDO sensor is avilable in four versions:

- With only one contact (one wire sensor), where the sensor housing is contact with the engine block (ground) and this represents the second (hidden) wire. The connection principle is shown on Figure 4.
- With two contacts, where one contact is *isolated return*. Two wires are connected here. This sensor is internally isolated from the engine block – hence two wires must be used. The connection principle is shown on Figure 6.
- With two contacts. One is used for signal, exactly as int the first case. It is usually labeled with letter *G – Geber*. The other is labeled as *WK – Warnung Kontakt*. This acts as a switch and it is activated when pressure is too low. As in the first case, the sensor housing is in contact with the engine and provides a third hidden wire. If you have such a sensor, only *G* contact can be used. Connection is as in the first case and *WK* is not used.
- With three contacts. One is used for signal *G*, the second for the ground connection (it can be labeled as *M – Masse* and the third is *WK*, which is not used. If you have such a sensor, it can be used in the same way as the sensor in the second case., whre *WK* is not connected.

Let's assume that a 2 bar VDO sensor is used for the fuel pressure. The channel shall be configured according to Table 11 .

Option	Selection/Setting
Channel	Any A, but A13
Function	Fuel pressure
Sensor	Res. 10 – 180 Ohm
Report time	0.5 – 1.0 s
Filter	2.0 s
Max value (at 180 Ohm)	2

Table 11: An example of passive VDO pressure sensor with *10–180* Ω output. Max value is set to 2 bar.

4.8 Voltage

Daqu can measure voltages from 0 to +30 V DC on the channel C. The system voltage is usually measured on this channel.

4.8.1 Installation

This connection does not power Daqu. Daqu gets power via CAN bus cable. Daqu will work properly even when system voltage is not connected to the C channel.

Since system bus may provide significant power, it is very important to install an inline protection fuse on the wire that connects positive terminal of the C channel with the system bus. The fuse shall be close to the system bus. The fuse protects from shortcuts due to accidental slip of the wire. The measuring current is negligible, so a low current fuse can be used. Figure 22 illustrates an example.

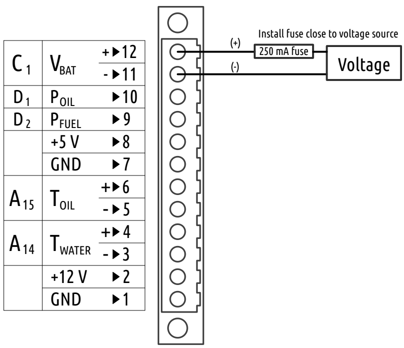

Figure 22: System voltage measurements. A 250 mA (or less) fuse is required close to the system bus source.

4.8.2 Configuration

The table 12 shows correct channel settings.

4.9 Additional Voltages

In certain cases additional voltage measurements are required. As Daqu has only one C channel, an external volage sensor is required in order to measure

Option	Selection/Setting
Channel	C only
Function	Voltage
Sensor	Voltage
Report time	0.5 – 1.0 s
Filter	1.0 s

Table 12: Channel C configuration for system voltage.

additional voltage. The sensor is connected to any A channel. Figure 23 illustrates an example.

The voltage sensor can measure voltages between -48 to 48 V. Although negative voltages are possible they are very rare in practice. So, if you see negative voltage, but correct absolute value, exchange the leads.

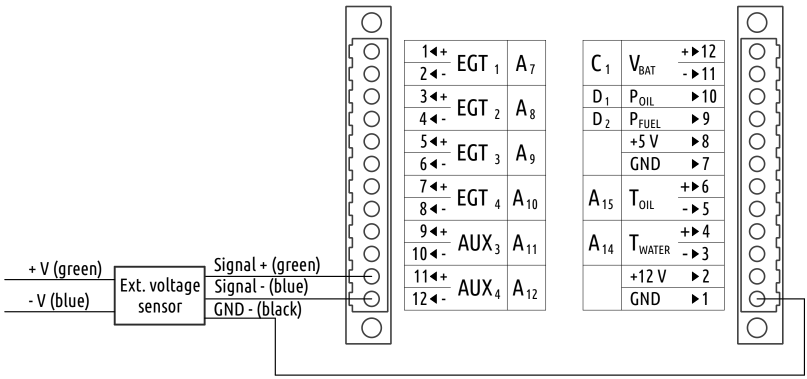

Figure 23: Voltage sensor is connected to the A channel.

The table 13 shows correct channel settings.

4.10 Current

In order to measure electrical current a CT-30 sensor or a CT-60 sensor is required. These sensors are produced by Kanardia. Standard shunts are not supported.

CT-30 measures current between -30 and +30 A and CT-60 measures current between -60 and +60 A. CT-30 is used for most applications.

Option	Selection/Setting
Channel	Any A
Function	Voltage
Sensor	Ext volt sensor
Report time	0.5 – 1.0 s
Filter	1.0 s

Table 13: Channel A12 configured for an external voltage sensor.

4.10.1 Installation

The power cable, which current shall be measured, must be cut at the place where sensor is to be installed. On each cable end, a M6 round cable terminal shall be fitted. Use two M6 screws with self locking nuts to connect the power cable to sensor fitting hole, so that the current will flow trough sensor in the arrow direction. Any current that flows in arrow direction produces positive readings and any reverse current produces negative readings.

Sensor has three wires. Red wire provides power for the sensor operation and connects to +5 V pin. Black wire provides sensor ground and connects to GND pin. White wire provides signal and connects to one of B, D or E channels. See Figure 24 for proper connection schema.

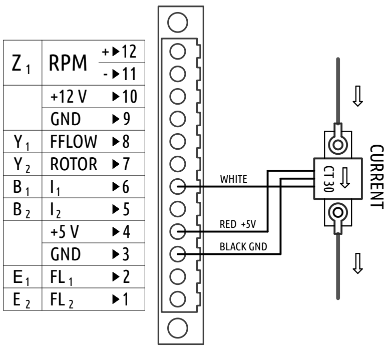

Figure 24: CT-30 sensor connection schematics.

4.10.2 Configuration

The table 14 shows possible channel settings. Alternatively, *El. current 2* can be also selected for the second current sensor.

Option	Selection/Setting
Channel	Any B, D or E
Function	El. current 1
Sensor	Current 30 A
Report time	0.5 – 1.0 s
Filter	2.0 s

Table 14: Connection of -30 to +30 A electrical current sensor.

4.11 Fuel Level

Up to two fuel level sensors can be connected to Daqu. They are usually connected to E channels. Fuel level sensors are either resistive type or active type. Capacitive sensors are just a special case of active sensors.

4.11.1 Installation

Before installing fuel level sensor into fuel tank, ensure that the tank is completely empty. Make sure to ventilate the tank – fuel vapours are highly explosive. Fuel level sensor must be grounded at all time. Ground connection must never break to prevent any electrical sparks near or inside the fuel tank. When removing fuel level sensor, make sure to disconnect other wires before the ground wire. When (re)installing fuel level sensor, connect the ground wire first.

4.11.2 Resistive Fuel Level Sensors

Connection schematics for these type of sensors was already shown in section 3.4, Figure 7, starting on page 15.

Typical configuration is shown in Table 15. The filter time shall be set to maximum. This softens the response. Several resistance ranges can be selected from the sensor list. Select the one, which fits your sensor the most. The two most frequently used are: *Res 160 Ohm* and *Res 400 Ohm*.

Option	Selection/Setting
Channel	Any A, E (recommended)
Function	Fuel level 1
Sensor	Res 400 Ohm
Report time	0.5 – 1.0 s
Filter	2.5 s

Table 15: Typical fuel level configuration.

Channel A can be also used for same purpose, but channel A is using weaker measuring current, which may yield to problems with sensors where mechanism is in contact with fuel. Channel A works fine with reed-relay based sensors, where mechanism is protected from fuel.

4.11.3 Active Sensors

In most cases, active fuel level sensors are capacitive ones. They require some input power to operate. Please consult the sensor manual for correct voltage.

In the case of capacitive sensors, some special sensor specific calibration procedure is usually required – consult the sensor manual.

Capacitive sensors may be sensitive to the fuel type. If a sensor is calibrated to aviation fuel (without any alcohol) and then automotive fuel is used (or vice versa), a significant error in fuel level indication may appear.

Figure 25 shows an example of a capacitive fuel level sensor, which requires 12 V input and provides a signal in 0-5 V range. Configuration for such sensor is given in Table 16.

Option	Selection/Setting
Channel	Any B, D, E (recommended)
Function	Fuel level 1
Sensor	Linear 5V
Report time	0.5 – 1.0 s
Filter	2.5 s

Table 16: Typical fuel level configuration for a capacitive sensor.

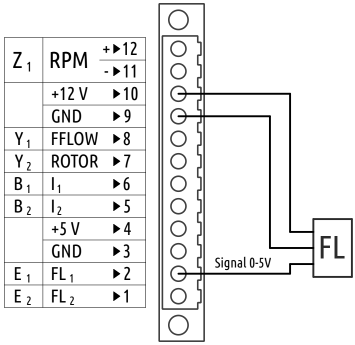

Figure 25: An example of capacitive fuel level probe connected to the +12 V power source. Some probes require 5 V, be careful.

4.11.4 Tank Shape Calibration

After sensor was installed, properly connected (and calibrated when necessary) and appropriate channel was configured, tank shape must also be calibrated. The calibration binds sensor output signal to actual fuel level value. Please consult the display manual (Nesis/Aetos/Emsis/Digi/etc.) for details on the tank shape calibration procedure.

4.12 Trim, Flap And Other Position Sensors

Different position sensors/potentiometers can be connected to Daqu in order to provide control position information for one of the following functions:

- pitch trim,
- roll trim,
- flap position,
- throttle position,
- and some others.

These sensors are usually potentiometers (variable resistors) with different ranges. Daqu supports ranges of 400 Ω, 5 kΩ and 10 kΩ.

A potentiometer can be connected as variable resistor or variable voltage. Refer to the potentiometer datasheet for pin identification.

Connection schematics for both cases are given in section 3.7 starting on page 20. Here, configurations are shown for both cases.

4.12.1 Variable Resistance

Figure 11 shows typical schematics for the variable resistance. The corresponding channel is configured something like shown by Table 17.

Option	Selection/Setting
Channel	Any A, but A13
Function	Pitch trim
Sensor	Res 400 Ohm / 5 kOhm / 10 kOhm
Report time	0.2 – 0.5 s
Filter	about 0.5 s

Table 17: An example configuration for pitch trim resistive sensors.

Similar configuration can be used for flaps, various positions and other trim functions.

4.12.2 Variable Voltage Divider

Figure 12 shows typical schematics for the variable voltage divider. The corresponding channel is configured something like shown by Table 18.

Option	Selection/Setting
Channel	Any B, D or E
Function	Pitch trim
Sensor	Linear 5 V
Report time	0.2 – 0.5 s
Filter	about 0.5 s

Table 18: An example configuration for pitch trim sensor connected as variable voltage divider.

Ray Allen servos are often used in practice. They use a 5 kOhm potentiomener internally and three wires come out from the sensor. Connect them according

to Figure 12. According to the Ray Allen documentation, the wires colors are orange, green and blue. Connect the orange to `GND`, blue to `+5V` and green to any channel of B, D or E type. Important: Consult the Ray Allen documentation to verify this before connecting the sensor.

4.12.3 Min/Max Values

Once sensors are properly connected and configured, their stopping limits must be determined – their minimal and maximal values must be entered into the system.

Some displays (e.g. Nesis, Aetos) show popup windows showing trim or flap position, when system detects that a trim or flaps are moving. In this case, time of travel between both limiting values is also important.

Please refer to appropriate display manual for the details.

4.13 Engine RPM – Tachometer

In order to measure engine RPM, one of the digital channels are used. This depends on the shape the signal.

Please refer to the engine manual to get more information about the signal and the type of the sensor used.

The following types of signals are often found:

- *Trigger coil* principle is used on Rotax engines. A metal passing near coil creates voltage spikes. The signal is ugly and voltage is pretty high – it can reach +/- 200 V. Also, voltage changes with RPM. Z channel shall be used.
- *Variable-reluctance (magnetic induction) pickup* sensors are also sometimes used. They give lower voltage spikes and they shall also be connected to the Z channel. Such sensor is used on Jabiru engines.
- *Active inductive (Hall effect)* sensors have a clean signal and shall be connected to Y channel.

Number of pulses per one engine RPM must be also known. Some engines have only one sensor pulse per one RPM, some have two pulses and some can have much more.

When reduction gearbox is attached to an engine, propeller PRMs are smaller than engine RPMs. When reduction ratio is provided, Daqu emits propeller

RPMs instead of engine RPMs. Usually, the reduction ratio is 1.0, which means that engine RPMs are emitted.

Let N denotes number of pulses per RPM, T denotes time between pulses measured in seconds and R denotes reduction ratio. N and R are given by configuration and T is measured by Daqu. Output RPM is then calculated as:

$$\text{RPM} = \frac{60}{N \cdot T \cdot R}$$

4.13.1 Z Channel

Trigger coil and variable-reluctance pickup sensors connect to the Z channel. Schematics shown on Figure 26 illustrates the connection principle.

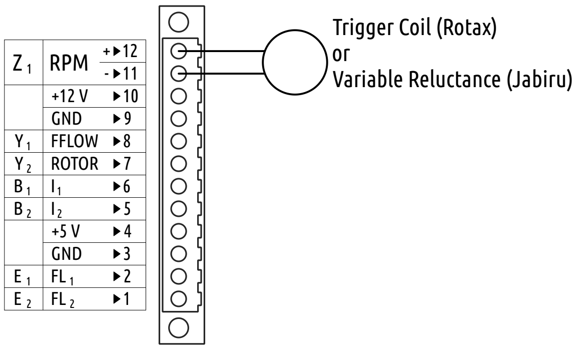

Figure 26: Connection of *trigger coil* sensor or *variable reluctance* sensor to Z channel.

Table 19 shows appropriate settings for Rotax 912 engine. *Pulses* is set to one as there is only one pulse per RPM. *Prop reduction* value is set to one – no reduction is applied and output value will be engine RPMs.

Table 20 shows typical settings for Jabiru engines. *Pulses* is set to two as two metal tabs are attached to the inside of the flywheel. Prease refer to the Jabiru installation manual for more details.

4.13.2 Y Channel

When active inductive (Hall effect) sensors are used, signal shapes are much more polite and Y channel shall be used to handle them.

Option	Selection/Setting
Channel	Z only
Function	Engine RPM
Sensor	Rotax
Report time	0.2 – 0.5 s
Filter	about 0.5 s
Pulses	1
Prop reduction	1

Table 19: Settings appropriate for Rotax 912 engine.

Option	Selection/Setting
Channel	Z only
Function	Engine RPM
Sensor	Jabiru
Report time	0.2 – 0.5 s
Filter	about 0.5 s
Pulses	2
Prop reduction	1

Table 20: Settings appropriate for Jabiru engine.

Connection schematics were already given in section 3.8. Two schematics were given, one for NPN sensor, Figure 13 and the other for PNP sensor, Figure 14.

Sensors often do not specify wheather they are NPN or PNP types. Trial and error may be used here. Connect the sensor first as NPN and of there is no output, install a resistor as well. The resistor can be ordinary 1/4 Watt carbon resistor.

Let's assume a Lycoming engine, with Hall sensor and two pulses per RPM. In this case, the configuration is shown in table 21. Note that there are many different sensors solutions for Lycomming and Continental engines.

See also section 1.2.2 for more information about channel limitations.

4.13.3 Light Speed Engineering – Plasma

Please refer to the original Plasma documentation for more details. Plasma documentation supersedes any instructions given in this manual.

Option	Selection/Setting
Channel	Any Y
Function	Engine RPM
Sensor	Digital Pulse
Report time	0.2 – 0.5 s
Filter	about 0.5 s
Pulses	2
Prop reduction	1

Table 21: An example for engine RPM connected to Y channel and two pulses per RPM.

Plasma devices are frequently used on Lycoming and Continental engines. They have a special analogue output where output voltage varies linearly with RPM: 0V for 0 RPM and 0.3V for 3000 RPM. This equals 1 mV per 10 RPM.

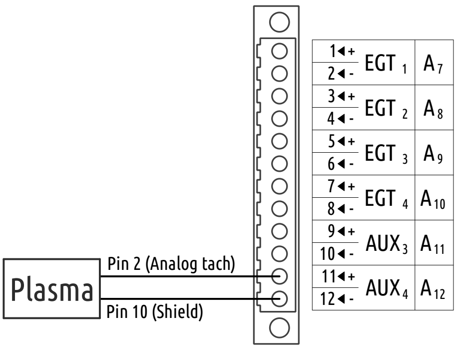

Figure 27: Connection of Plasma RPM analogue voltage output signal to A channel.

One of *A* channels must be used to connect Plasma to Daqu. Signal voltage comes from pin 12 and connects to + terminal and shield from pin 10 connects to the - terminal. Figure 27 illustrates the connection.

The A channel must be configured as shown on table 22.

Option	Selection/Setting
Channel	Any A
Function	Engine RPM
Sensor	LS RPM 1mV/10 RPM
Report time	0.2 s
Filter	about 0.5 s

Table 22: Plasma configuration example. Connection to channel A 12.

4.14 Manifold Pressure

4.14.1 Internal Sensor

Daqu has a built-in MAP sensor. See section 2.2 for the installation. No wiring is required here. It is internally connected to A13 channel. This channel can't be used for anything else. Table 23 shows typical configuration.

Option	Selection/Setting
Channel	A13
Function	Manifold press
Sensor	MPXM 2202
Report time	0.2 s
Filter	about 0.5 s

Table 23: Internal MAP sensor configuration. Always connected to A13.

4.14.2 External Sensor – Bosch 0 261 230 037

When enhanced precision of manifold pressure is required, an automotive sensor from Bosch can be used. Its part number is 0 261 230 037. This sensor measures MAP pressure between 0.2 – 1.05 bar (2.9 – 15.2 PSI). This means it is not suitable for turbo engines.

It can be found in a shop with car parts. Appropriate connector is also needed. Figure 28 illustrates the sensor and connector.

The sensor can be connected to any B, D or E channel. When purchased at Kanardia, the sensor comes equipped with a cable. The connection schematics is given on Figure 29.

An example of channel configuration is shown in Table 24.

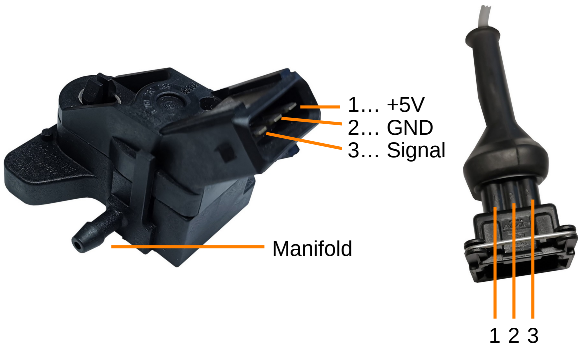

Figure 28: External manifold pressure sensor, Bosch 0 261 230 037.

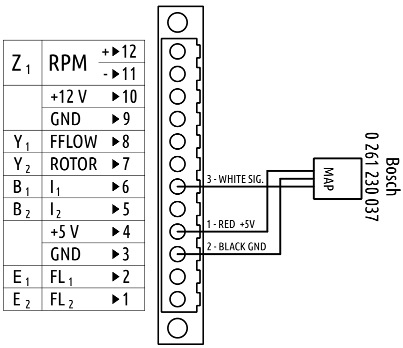

Figure 29: External MAP sensor from Bosch, connection schematics.

Option	Selection/Setting
Channel	Any B, D or E
Function	Manifold press
Sensor	Bosch 261 230 037
Report time	0.2 s
Filter	about 0.5 s

Table 24: Configuration example for external Bosch MAP sensor.

4.15 Rotor RPM

Active inductive sensors are most oftenly used for rotor RPM sensors. They either detect holes in metal or count teeth producing pulses..

Connection schematics were already given in section 3.8. Two schematics were given, one for NPN sensor, Figure 13 and the other for PNP sensor, Figure 14.

Let's assume that sensors is applied to a rotor and it is counting teeths in the rotor head. There are 72 teeth for one RPM, which equals to 72 pulses. Table 25 shows appropriate settings for this assumption. Your case will be probalby have a different number of pulses.

Option	Selection/Setting
Channel	Y only
Function	Rotor RPM
Sensor	Digital Pulse
Report time	0.2 – 0.5 s
Filter	about 0.5 s
Pulses	72
Reduction	1.0

Table 25: An example for rotor RPM connected to Y channel. Sensor is in rotor head, hence the reduction ratio is set to 1.0.

See also section 1.2.2 for more information about channel limitations.

Since software version 3.6 pulses per revolution can be combined with a reduction ratio. In most circumstances this value shall be set to 1.0, which means no reduction – direct drive.

In cases, where sensor is not installed on the rotor head, but on the drive train with some fixed reduction ratio, this option comes handy. Set pulses according to the drive train revolution and then also set the reduction ratio of the drive train.

4.16 Fuel Flow

Fuel flow sensors are active sensors with *pulse* output. Each sensors gives out specific number of pulses per some volume and this value must be set to Daqu. Daqu expects number of pulses per liter.

Option	Selection/Setting
Channel	Y only
Function	Rotor RPM
Sensor	Digital Pulse
Report time	0.2 – 0.5 s
Filter	about 0.5 s
Pulses	2
Reduction	5.814

Table 26: Another example for rotor RPM connected to Y channel. Sensor measures shaft directly from engine drive with two pulses per shaft revolution. The shaft turns rotor via reductor. Reductor's ratio is 5.814.

Sensors are either calibrated, where each sensors has its own value attached to it (FloScan sensors, for example), or a general number for all sensors of the same type is given (FT-60, for example).

Practice shows that factory specifed number of pulses do not always give precise results. Thus a correction factor can be applied. Idealy, the correction factor is 1.0. When indicated fuel flow seems too low, a factor larger than 1.0 shall be applied and vice versa.

Let N denotes number of pulses per liter, T denotes time between pulses in seconds and C correction factor. The fuel flow rate in liters per hour is then calculated as:

$$\mathrm{FuelFlow[l/h]} = C \cdot \frac{3600}{N \cdot T}$$

Daqu measures average time between pulses and the other two values must be specified in configuration.

4.16.1 Installation

Each sensor may have specific installation requirement. Please check the sensor manual for details.

In general:

- Sensor shall not be installed close to hot parts, like exhaust system.

- Some sensors use NPT fittings (tapered). Always respect maximal torque allowed, when tightening the fitting.
- Never use Teflon tape or Pipe dope for sealing! Use special thread sealant paste instead.
- Respect input and output ports. Reversing ports may cause fuel starvation.
- Sensor orientation may be important. Please check the sensor manual.
- Each sensor will cause some pressure drop in the fuel line. Check this pressure drop – sensor data sheet shall reveal it. The pressure drop may be larger if sensor's rotor is blocked. You must ensure that there is enough fuel pressure even in the case of blocked sensor rotor. Pressure drop increases with fuel flow rate.
- If feasible, install fuel pressure sensor after the fuel flow sensor, so that indicated fuel pressure will take fuel flow sensor pressure drops into account.

4.16.2 Configuration

Example configuration is made for FT-60 fuel flow sensor, a.k.a. *Red cube.* This sensor connects to 12 V. Figure 13 shows connection schematics for this sensor (NPN type). The sensor has 68000 pulses per US gallon. This equals to $68000/3.7854 \approx 18000$ pulses per liter. Table 27 shows configuration details.

Option	Selection/Setting
Channel	Any Y
Function	Fuel flow 1
Sensor	Digital Pulse
Report time	0.2 – 0.5 s
Filter	about 0.5 s
Pulses	18000
Correction	1.0

Table 27: An example for rotor RPM connected to Y channel.

4.16.3 Differential Fuel Flow

In order to measure differential fuel flow, a second fuel flow sensor must be connected. The first sensor is connected normally and measures fuel flow towards the engine. The second sensor is connected as Fuel flow 2 and measures flow from the engine back into the tank. When Fuel flow 2 is configured and sensor is connected, its reading will be automatically subtracted from the reading of the Fuel flow 1 sensor. No other configuration is necessary.

Note that each sensor may have its own pulses per liter value. Channel Y1 is typically used for the first fuel flow sensor and Y2 for the reverse fuel flow (Fuel flow 2).

5 Engine ECU Connection

This Daqu version in not designed to connect to an engine ECU. Mini Daqu shall be used instead. But there are cases, where mini Daqu is not enough and a modify standard Daqu steps in.

Namely, mini Daqu has quite limited number of additional channels. In addition, it does not support A type channels, so thermocouple sensors can't be used. Standard Daqu has much more channels, but it does not have an ECU connection. For this reason, a modified version of standard Daqu was developed, which allows connection to ECU's with a CAN bus (Rotax iS, for example).

Modifications include removing manifold pressure sensor and installing an additional connector. This connector is used to connect to ECU CAN bus. In most cases, this is a Rotax iS engine.

5.1 Rotax iS

This section refers to Rotax 912 iS and Rotax 915 iS engines. The connection principles are identical for both engines.

The Rotax iS engine comes with a complete set of sensors. ECU unit on the engine reads the sensors and transmits the information on the outgoing CAN bus using CANaerospace protocol. Daqu reads this CAN bus and retransmits the same information using Kanardia protocol on a different CAN bus. See Figure 30.

Rotax iS ECU unit transmits the following information: engine RPM, fuel flow rate, manifold pressure, oil pressure, oil temperature, coolant temperature,

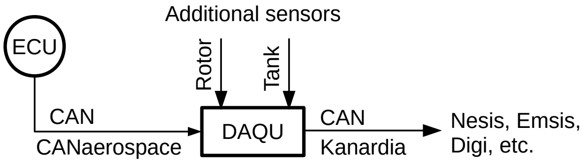

Figure 30: Illustration of the connection principle. Almost all information comes from the ECU. Rotor RPM and fuel tanks and other additional sensors can be still connected directly to Daqu.

EGT 1–4, manifold air temperature, engine ambient temperature, throttle position, engine ambient pressure, ECU bus voltage, engine status, engine hours, ECU hours, sensors status.

Additonal sensors like, fuel pressure, rotor RPM, fuel level, various trims, additional voltages, . . . are connected directly do Daqu to supplement the ECU information.

5.1.1 Connection - Three Pin Connector

This connector type is obsolete. You may find it on some existing Daqus.

The iS engine has two CAN bus lanes: lane A and lane B. To get complete data from the ECU you have to connect both lanes as in Figure 31. Both lanes should be connected together near Daqu, connect Lane A CANL to Lane B CANL and Lane A CANH to Lane B CANH. Now connect Daqu CAN-LOW and CAN-HIGH to the junction of Lane A nad Lane B. The cable length between T-junction and Daqu should not be longer than 30 cm. Note that GND is usually not connected.

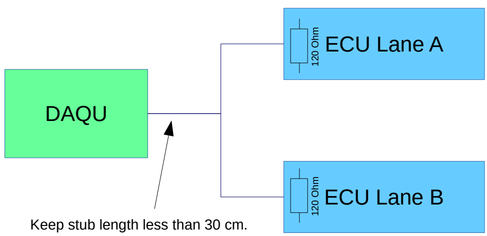

Figure 31: CAN bus connectivity.

It is also possible to connect only single lane but the information will be limited

or not shown when the lane is turned off. Usage of single lane connection only is not recommended.

Special three pin Binder connector (commes with Daqu) must be fitted. When connector is opened markings 1, 2 and 3 are visible. Figure 32 shows the back side connector with pins. Solder the wires onto the connector as it is marked on the photo.

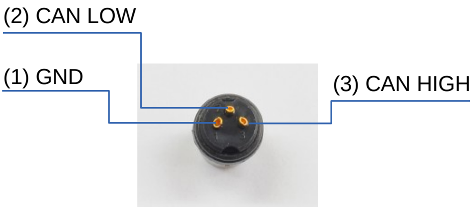

Figure 32: Photo of connector back side. Note the three small numbers, which define the pin positions. GND is usually not connected.

Once the connector is made, plug it into Daqu and the installation is ready. Do not forget to set (or to verify) correct engine model in Nesis/Emsis/Aetos/Digi.

5.1.2 Connection - Four Pin Connector

All new Daqus that require ECU CAN bus modification will be equipped with a four pin connector. Two pins are used to connect to Lane A and the other two for Lane B. Figure 33 shows pin numbers. This is the back side of the cable plug.

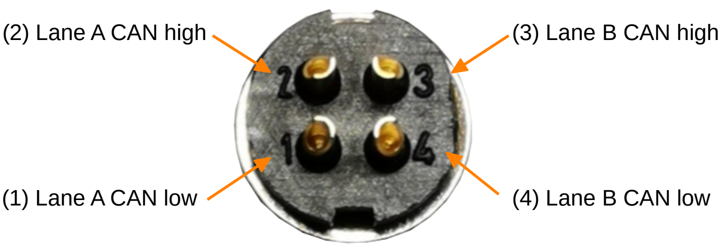

Figure 33: Cable plug back side. Note the four small numbers, which define the pin positions inside the plug. This is Binder part number 99 0979 100 04.

The cable plug is produced by Binder. Its part number is: 99 0979 100 04. (Its associated mating part number is 09 0982 00 04 and it is a part of Daqu.)

In most cases, the cable will be already manufactured with four leads soldered to the pins from Figure 33. Table 28 defines the lead colors and their corresponding Rotax iS ECU connector and pin positions.

Pin	Function	Color	iS Connector & Pin
1	Lane A: CAN low	Brown	HIC A: (5) CAN_LOW_1_A
2	Lane A: CAN high	Red	HIC A: (6) CAN_HIGH_1_A
3	Lane B: CAN high	Green	HIC B: (8) CAN_HIGH_1_B
4	Lane B: CAN low	Blue	HIC B: (7) CAN_LOW_1_B

Table 28: Pin description and cable colors.

6 Troubleshooting

This section reveals some troubleshooting ideas.

6.1 Incorrect Indication

In a situation, where the indicated value of the sensor seems to work somehow, but the values of the sensor are wrong, you should check:

- Is sensor configured for the proper range?
- Is sensor lying for some small, but constant offset?
- Is sensor value jumping up and down and/or is it sensitive if you turn on/off some electric load, which consumes significant power (landing lights, for example).
- Is the problem in the Daqu AD converter or in sensor?

6.1.1 Daqu AD Converter Check for a Resistive Sensor in Linear Range

This check is used to locate if the the problem is either in the sensor/sensor installation or in Daqu AD controller or in channel in settings.

In order to perform this test, the sensor must be disconnected from Daqu and replaced by some known resistor, which value is somewhere in the middle of the sensor range. This means that you must know sensor operating range.

Lets show this on an example with VDO fuel pressure resistive sensor of 2.0 bar range. This sensor operates in the 10 to 180 Ohm range. When pressure is zero, its resistance is 10 Ohm and when the pressure is 2.0 bar, its resistance is 180 Ohm.

A general equation that is used to calculate the sensor value (in its system units) is given below. Note that this formula does not work for temperature sensors.

$$\mathrm{V} = \frac{\mathrm{V_{max}} - \mathrm{V_{min}}}{\mathrm{R_{max}} - \mathrm{R_{min}}} (\mathrm{R} - \mathrm{R_{min}}) + \mathrm{V_{min}} + \mathrm{V_{offset}} \tag{1}$$

Here V means the calculated value, V_{min} is the sensor value when not loaded (usually 0), V_{max} is the sensor value when sensor is fully loaded, R_{min} is the resistance when sensor is not loaded, R_{max} is the resistance when sensor is fully loaded, V_{offset} is the channel offset value (small error correction) and R is the resistance measured by Daqu. In most cases, V_{min} is zero. Channel offset V_{offset} must be set to zero before this test.

In the case of VDO fuel pressure test, the sensor is disconnected and replaced with a 100 Ohm resistor. So the indicated value shall be:

$$\mathrm{V} = \frac{2.0 - 0.0}{180 - 10} (100 - 10) + 0.0 + 0.0 = 1.06$$

Or, if 47 Ohm resistor is used, the value shall be:

$$\mathrm{V} = \frac{2.0 - 0.0}{180 - 10} (47 - 10) + 0.0 + 0.0 = 0.43$$

Let's assume that A14 channel was used to connect the sensor. Figure 34 illustrates the sensor replacement with a 100 Ohm resistor. After the replacement, the value on the screen must be equal to 1.06 bar.

What does this tell? If indicated value is correct (1.06 or close) for a 100 Ohm resistor, then Daqu is working correctly and the problem is either in the sensor or in fuel pressure system.

If indicated value is incorrect, the problem is either in incorrect settings of the channel, wrong channel offset, wrong grounding of the channel or there is a defect in the Daqu.

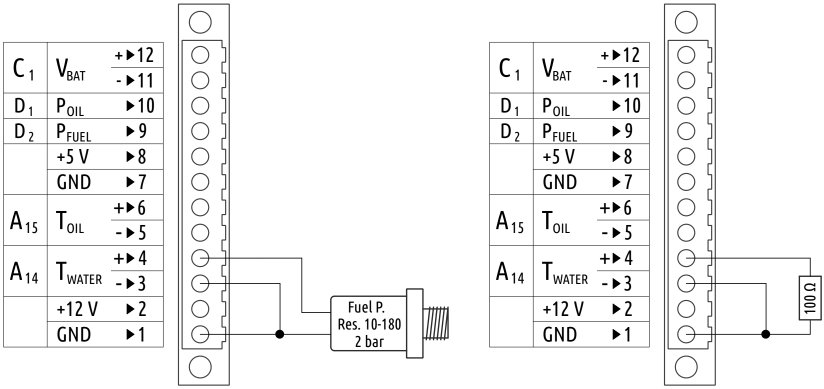

Figure 34: Example: VDO 2 bar sensor was replaced by a fixed 100 Ohm resistor.

7 Limited Conditions

Although a great care was taken during the design, production, storage and handling, it may happen that the Product will be defective in some way. Please read the following sections about the warranty and the limited operation to get more information about the subject.

7.1 Warranty

Kanardia d.o.o. warrants the Product manufactured by it against defects in material and workmanship for a period of twenty-four (24) months from retail purchase.

Warranty Coverage

Kanardia's warranty obligations are limited to the terms set forth below:

Kanardia d.o.o. warrants the Kanardia-branded hardware product will conform to the published specification when under normal use for a period of twenty-four months (24) from the date of retail purchase by the original end-user purchaser ("Warranty Period"). If a hardware defect arises and a valid claim is received within the Warranty Period, at its option and as the sole and exclusive remedy available to Purchaser, Kanardia will either (1) repair the hardware defect at no charge, using new or refurbished replacement parts,

or (2) exchange the product with a product that is new or which has been manufactured from new or serviceable used parts and is at least functionally equivalent to the original product, or, at its option, if (1) or (2) is not possible (as determined by Kanarida in its sole discretion), (3) refund the purchase price of the product. When a refund is given, the product for which the refund is provided must be returned to Kanardia and becomes Kanardia's property.

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To the extent permitted by applicable law, this warranty and remedies set forth above are exclusive and in lieu of all other warranties, remedies and conditions, whether oral or written, statutory, express or implied, including, without limitation, warranties of merchantability, fitness for a particular purpose, non-infringement, and any warranties against hidden or latent defects. If Kanardia cannot lawfully disclaim statutory or implied warranties then to the extent permitted by law, all such warranties shall be limited in duration

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