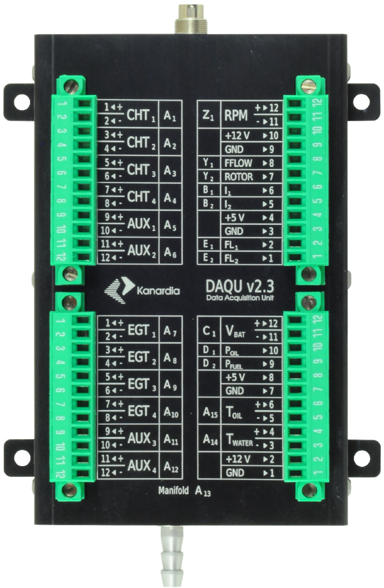
Daqu v2.3 & v3.0 EMS Box
Installation Manual

Jul 2024



Revision 1.12

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WEEE Statement

Disposal of Waste Electrical and Electronic Equipment. This electrical item cannot be disposed of in normal waste. Check with your local authority for kerbside collection, or recycle them at a recycling centre.

Revision History

The following table shows the revision history of this document.

Rev.	Date	Description
1.12	Jul 2024	Voltage divider adapters on A channels.
1.11	Jun 2024	Some standard connection schematics were added at the back.
1.10	Feb 2024	Current Hall sensor was added, some clarification.
1.9	Jan 2024	Support for metal debris detectors/switch.
1.8	May 2023	Pull-up resistors NPN sensors clarification.
1.7	Jan 2023	Daqu v3.0 clarification note added.
1.6	Dec 2022	Bosch 2.5 bar MAP sensor added.
1.5	Mar 2022	ULPower ECU CAN bus connection added.
1.4	May 2021	Clarifications for RPM and Fuel level sensors.
1.3	Apr 2021	Change pull-down resistor value for PNP type of digital sensors.
1.2	Mar 2021	More examples for fuel pressure sensors. RPM settings for Rotax 582.
1.1	Sep 2020	Some clarifications, troubleshooting section.
1.0	Jan 2019	First release

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 or version 3.0. For earlier hardware versions (mostly 2.1), please refer to previous manual.

Note: From the user's point perspective there is no difference between Daqu 2.3 and Daqu 3.0. Daqu 3.0 is using a sligtly different micro-controller and analogue-digital contverter chips as its predecessor. However they all are from the same family as before. We did not want this change. We were forced into it, due to the unavailability of certain chips on the market, which continues up to this day (at the day of writing this note.)

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 three versions:

- Standard, larger version is used for most engines like Rotax 912 UL/ULS, Lycoming, Continental, Simonini, Hirth, etc. These engines usually do not have ECU and are typically equipped with a carburetor. 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 (CAN bus or RS-232). Besides information from ECU, mini Daqu allows connecting additional sensors like rotor RPM, fuel level, trim position, etc. Mini Daqu is typically used for Rotax iS, D-motor and UL Power engines. Mini Daqu has only one twelve pin connector for sensors and two D-SUB nine pin connectors – one for ECU and the other for CAN network.
- Modified standard Daqu is used for engines equipped with ECU (same as miniDaqu) for cases where miniDaqu does not have enough channels for all additional sensors. This is often a case for ULPower and WMFly engines. Only ECUs with CAN bus is supported (no RS-232).

This manual addresses standard Daqu and modified standard Daqu.

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 Output Pins

Daqu has several output pins labeled as GND, +5V and +12V. No not connect any power source to these pins. Daqu is powered via CAN bus cable and does not require external power connection over the pins.

`+12 V` output pin shall be only used to provide power for some active sensor, which requires 12V to operate. Always check sensor manufacturer specifications first. The voltage on this pin is not regulated. It will be the same as the bus voltage, which is usually between 11 and 15.

`+5 V` output pin shall be only used to provide power for an active sensor, which requires 5V to operate. This voltage is regulated.

`GND` output/reference pin is either used as a reference for some (not all) resistive sensors or as a power sink for active sensors that require power. All GND pins on Daqu are interconnected and are in direct relation with the system bus GND. See also section 3.2.

1.4 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.

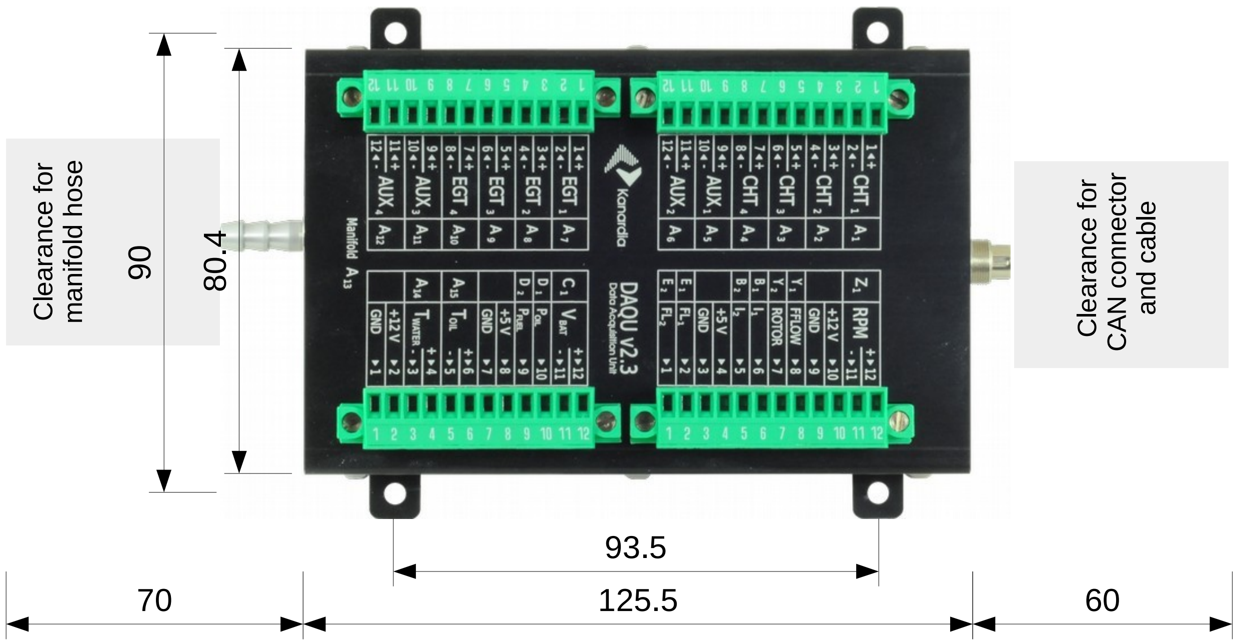


Figure 1: Dimensions and connection clearence of standard Daqu – Top View.

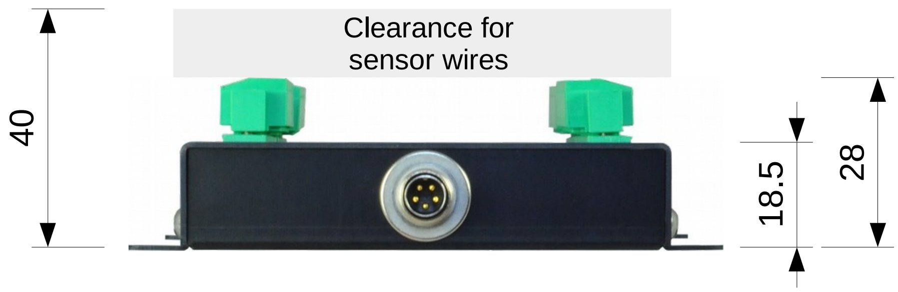


Figure 2: Dimensions and connection clearence of standard Daqu – Front View.

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 22.

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.

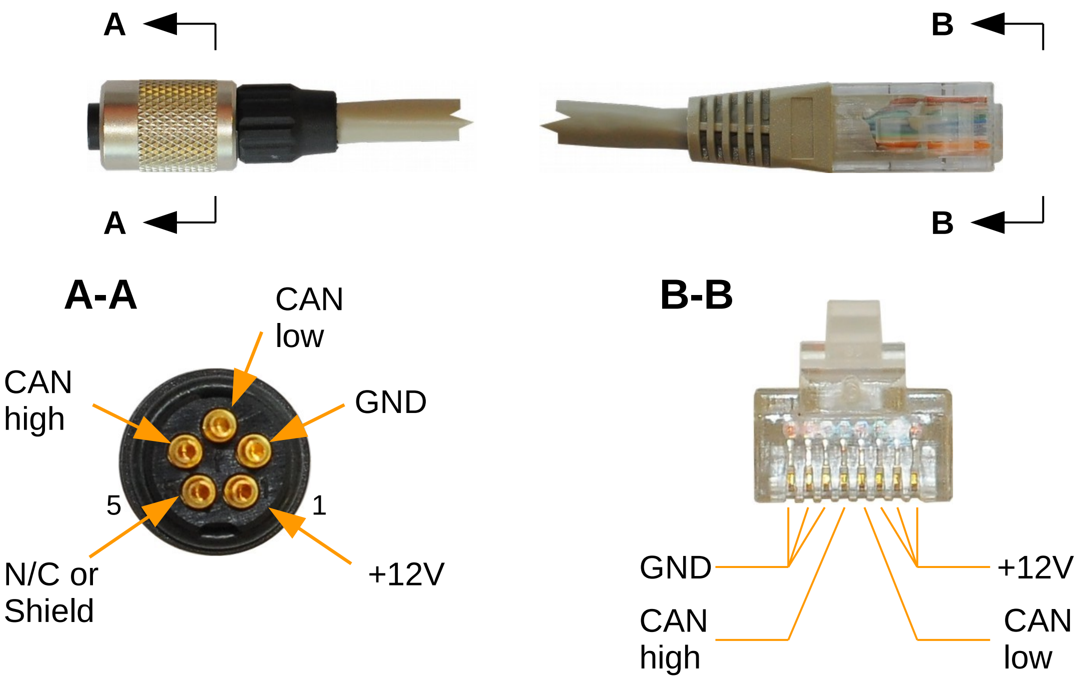


Figure 3: Details of the cable connecting Daqu and other devices. Binder connector is on the left and RJ45 connector is on the right. Binder connector is shown from the soldering side. On the soldering part, small numbers 1 and 5 are visible. RJ45 connector is shown from front.

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 A- 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 Daqu terminals works the best. Do not use this wire for anything else but for the Daqu A- terminals.**

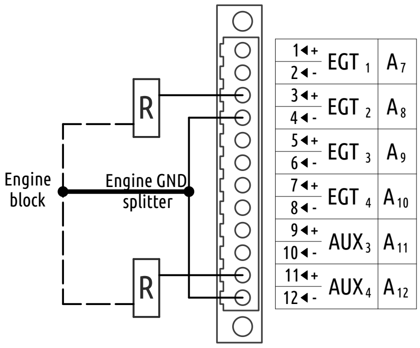


Figure 4: One wire resistive sensor principle. The *invisible* ground wire is routed via engine block, represented by the dashed line.

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.

3.3.2 Two Wires Sensors

Two wires 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 external 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 supply 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.

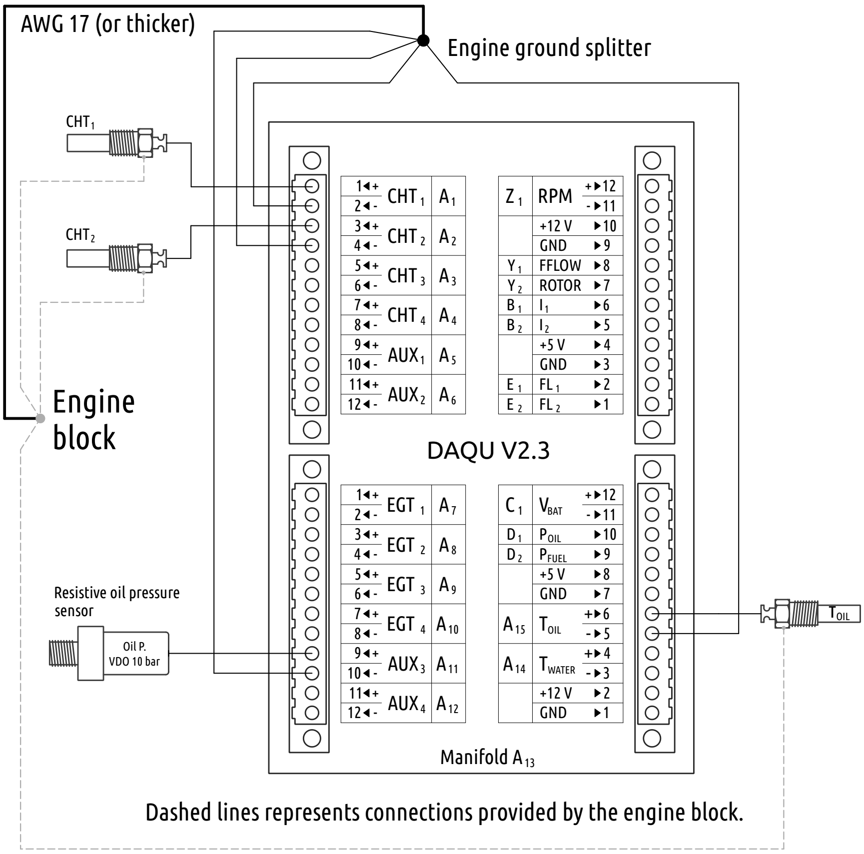


Figure 5: Several one wire resistive sensors connection principle.

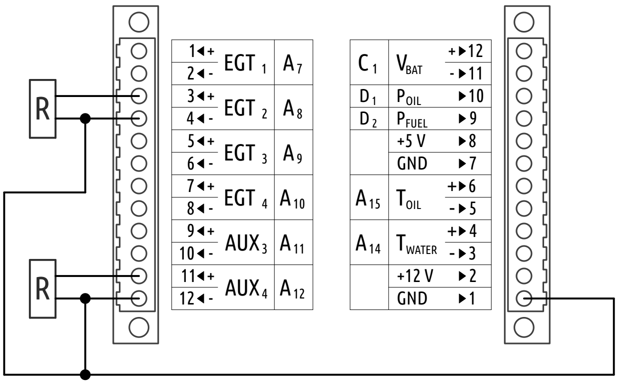


Figure 6: Two wires resistive sensor principle. The return line is isolated and does not connect to the engine block. Additional connection to GND reference is needed for each negative terminal.

3.5 NTC Thermistors

Most resistive temperature sensors are using NTC thermistor element in the tip of the sensor. The relationship between the resistance of sensor and temperature is given by the Steinhart-Hart equation, which is also used in Daqu. Please refer to the `https://en.wikipedia.org/wiki/Thermistor` for more details.

$$\frac{1}{T} = a + b \ln R + c(\ln R)^3$$

Here R is resistance in Ohms measure by Daqu, T is temperature in Kelvins and a, b, c are Steinhart-Hart coefficients, which are specific for each sensor model. See Table 2.

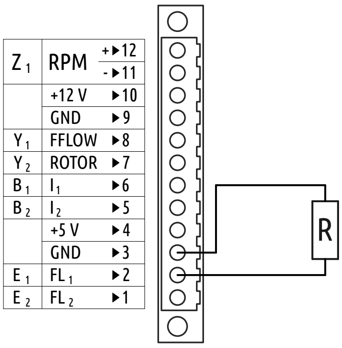


Figure 7: Two wire resistive sensor connection on E channel.

Sensor	a	b	c
VDO 120	1.77082E-03	2.47599E-04	1.10553E-07
VDO 150	1.572336E-03	2.732929E-04	-2.862122E-07
Bosch 2500 Ohm	1.288831E-03	2.622053E-04	1.518898E-07
Dynon 100409	1.63577E-03	2.64823E-04	-9.94675E-08

Table 2: Steinhart-Hart coefficients for some frequently used sensors.

3.6 PT100 & PT1000

PT100 and PT1000 types are also supported by Daqu. These sensors are also resistive sensors with linear characteristics in the operation range. The following formulas are used for PT100:

$$T = \frac{R - 100}{\alpha_{100}}$$

and PT1000:

$$T = \frac{R - 1000}{\alpha_{1000}}$$

Here T is temperature in Celsius, R is resistance, $\alpha_{100} = 0.385$ and $\alpha_{1000} = 3.85$.

3.7 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 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.

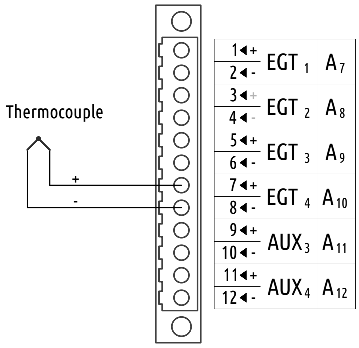


Figure 8: Thermocouples connection schema.

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.

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 3 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 3: Thermocouple wire color coding.

3.8 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.

3.8.1 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.

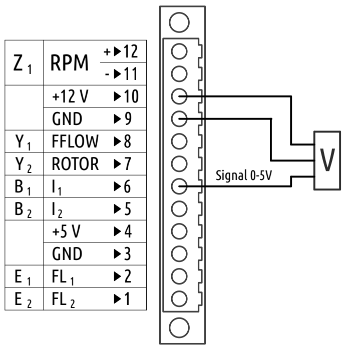


Figure 9: An example of active sensor with voltage output.

3.8.2 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.

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.

3.9 Potentiometers

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

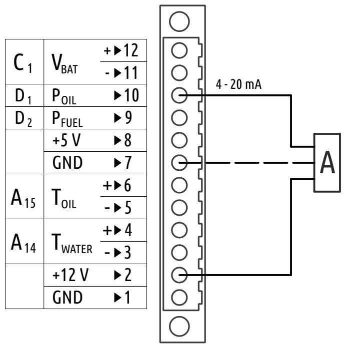


Figure 10: An example of active sensor with current output. Symbol A stands for *Ampere* which is synonym for electrical current. For some sensors, connection with GND is not required.

3.9.1 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.

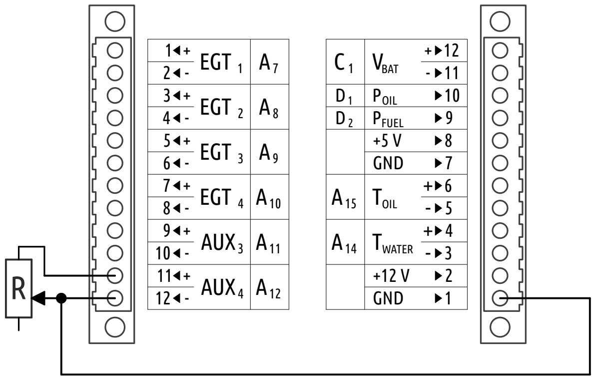


Figure 11: An example of potentiometer, connected as variable resistor.

3.9.2 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.

3.10 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 equals to number of digital pulses for one

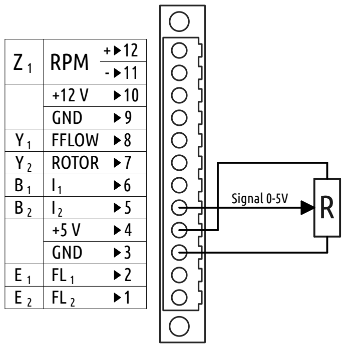


Figure 12: An example of potentiometer, connected as variable voltage divider.

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.

3.10.1 NPN – Open Collector Output

Figure 13 left illustrates a typical connection for the NPN case. Here all wires are connected directly. Daqu has internal 47 kΩ resistor connected between the signal line and the +12V. This means that in most cases you can connect a NPN sensor according to the left figure. However, it may happen that the default resistor is too weak. In this case you must install an external 1.0–4.7 kΩ resistor between the signal line and the power source +12V. Start with 4.7 kΩ resistor first. Do not use resistors below 1.0 kΩ.

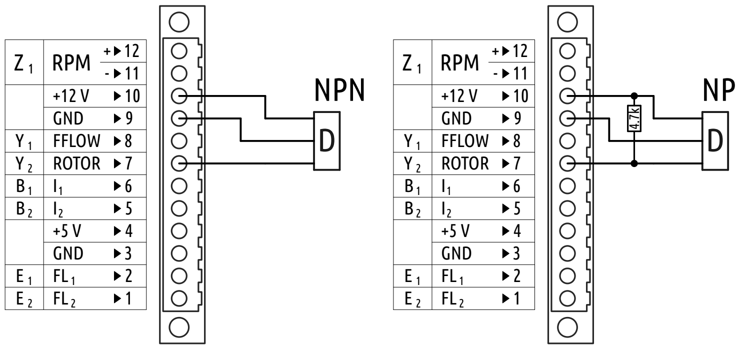


Figure 13: Left: a typical example of NPN digital sensor connection. Right: In some cases an external pullup resistor is needed.

3.10.2 PNP – Open Drain Output

Figure 14 illustrates a typical connection for the PNP case. Here, an external 1 kΩ to 4.7 kΩ resistor between GND and signal is always needed. Try with 4.7 kΩ resistor first and if no output is provided, use resistors with lower resistance down to 1.0 kΩ. Do not use resistors less than 1 kΩ.

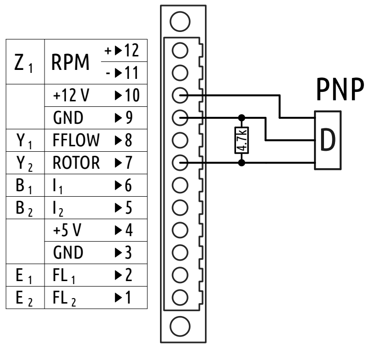


Figure 14: An example of PNP digital sensor connection. Use/experiment with 1.0–4.7 kOhm resistor.

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 3.7 apply here. Figure 15 shows two examples.

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

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.

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 over-tighten 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 4 shows a channel configuration example.

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.

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 4: EGT channel configuration.

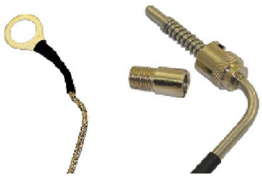


Figure 16: CHT ring terminal CHT probe (left), spring loaded bayonet type CHT probe with insert (right).

4.2.1 Installation

Same principles as defined in section 3.7 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 5.

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.

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 5: CHT thermocouple channel configuration.

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.

This sensor is very similar to oil temperature sensor, but it differs in thread. See also section 4.4.

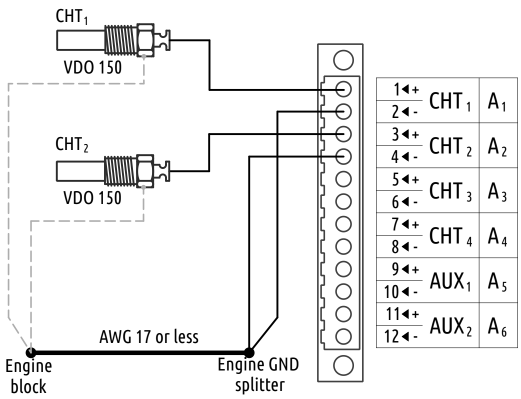


Figure 17: Typical connection of CHT sensors on Rotax 912 engines.

4.3.2 Configuration

The configuration is shown on table 6.

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 6: 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.

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 7.

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 7: 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.

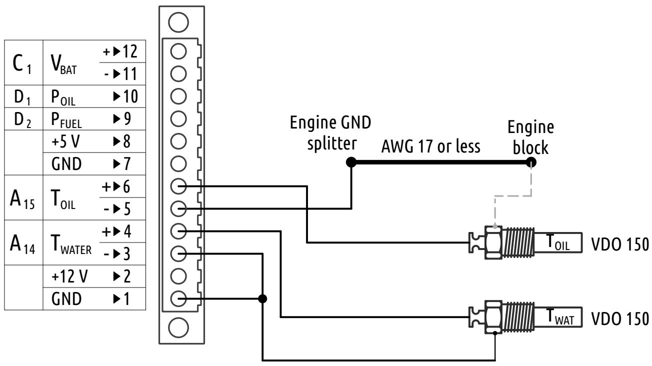


Figure 18: Typical oil and coolant (water) sensor connection. *One wire* principle is used for the oil sensor and *two wire* principle for the coolant sensor.

4.5.2 Configuration

The configuration is shown on Table 8. 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 8: Rotax coolant (water) temperature configuration.

4.6 Airbox Temperature

Airbox temperature sensor measures air temperature that enters into the engine collectors. Usually it is installed in the airbox. We recommend using sensor with the PT-1000 sensing element, but any other supported NTC sensor will do the job as well.

The sensor is usually connected as a two wire resistive sensor, following principles described in Section 3.3.2 and Figure 19.

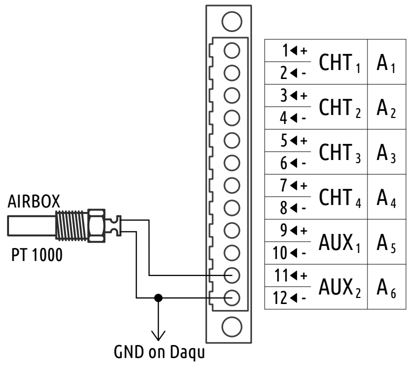


Figure 19: Typical connection of Airbox sensor with PT1000 sensing element.

The coresponding configuration is shown on Table 9. Note that the temperature sensor type is not limited to PT1000. Other types may be used as well.

Option	Selection/Setting
Channel	Any A, but A13
Function	Airbox temp
Sensor	PT 1000
Report time	0.5 – 1.0 s
Filter	2.0 s

Table 9: Airbox temperature configuration.

4.7 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.

4.7.1 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.

4.7.2 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 very similar.

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.

4.7.3 Variable Current

Rotax engines use 10 bar variable current sensor by default. This is described in section 3.8.2. Schematics is repeated here, adapted for typical Rotax installation, Figure 20. 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.

Corresponding configuration is shown in Table 10. 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.

4.7.4 Variable Voltage

Sensors with variable voltage output were described in section 3.8.1. Connection example is given on Figure 21. 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.

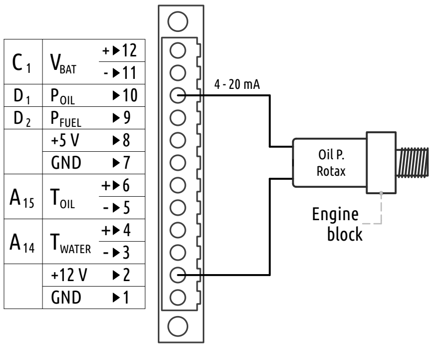


Figure 20: Typical oil pressure sensor connection for Rotax engine. Active, current variable sensor is used.

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 10: Typical Rotax oil pressure configuration.

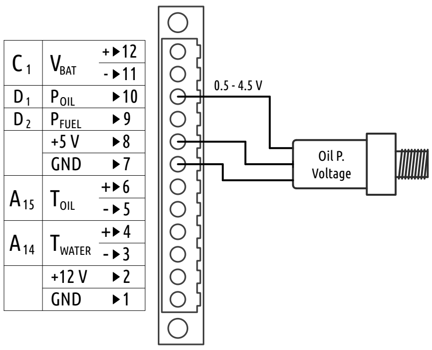


Figure 21: Oil pressure sensor with variable voltage (0.5 – 4.5 V) output. Sensor is powered with 5V.

The sensor configuration is shown on Table 11. As this is a 10 bar sensor, the max value is set to 10 bar. Your sensor may have a different max value.

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

4.7.5 Resistive, One Wire (VDO)

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 22. A configuration for this example is given on Table 12. This is not the only possibility. See section 4.8.3 for more options.

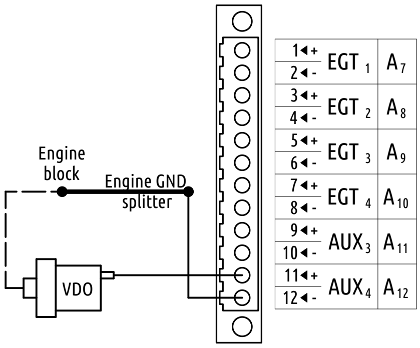


Figure 22: VDO oil pressure sensor with one wire principle. The second wire is *hidden* and connects via engine block.

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

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.
- *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 insulated return and are two wire sensors. This means that slightly different schematics is required – see section **??** for more details. Configuration is identical to the one wire sensor.

4.8 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.

The following 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 (about 70 PSI)* for engines with fuel injection. Typical operating pressure is around 3 bar.
- *0 - 10 bar (about 150 PSI)* for engines with fuel injection.

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.

4.8.1 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.

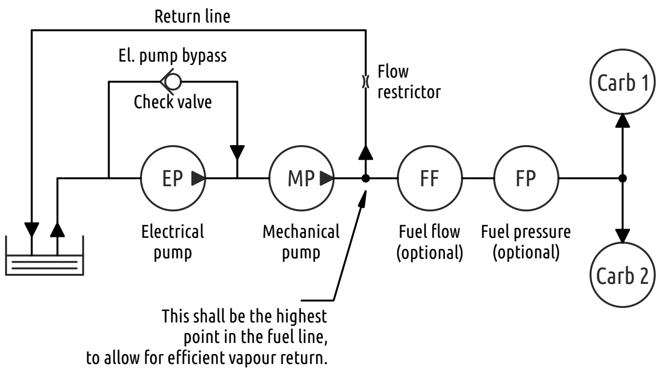


Figure 23: Recommended positions for fuel pressure and fuel flow sensors on Rotax 912 engines with two carburetors.

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.

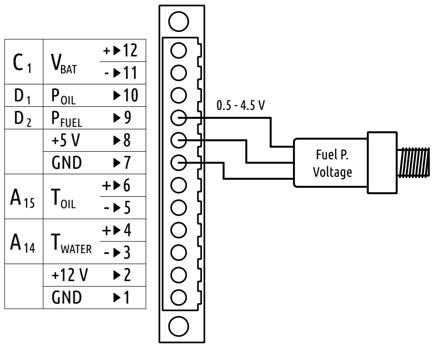


Figure 24: Fuel pressure sensor with variable voltage (0.5 – 4.5 V) output. Sensor is powered with 5V.

4.8.2 Variable Voltage

Sensors with variable voltage output were described in section 3.8.1. Connection example is given on Figure 24. It shows an active sensor with 0.5 – 4.5 V output. The sensor requires 5 V to operate. The sensor max range is 1 bar (15 PSI), which is typically used on carbureted engines.

The sensor configuration is shown on Table 13. As this is a 1 bar (15 PSI) sensor, the max value is set to 1 bar. Your sensor may have a different max value.

Option	Selection/Setting
Channel	Any B, D or E
Function	Fuel 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)	1

Table 13: An example of active pressure sensor with 0.5 – 4.5 V output. Max value is set to 1 bar.

4.8.3 Resistive Sensors (VDO)

This subsection is appears in fuel pressure section, but all discussion given here is also valid for oil pressure 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 Figures 4 and 22.

- With two contacts, where one contact is *insulated 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 Figures 6 and 25.

- 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 shall be used as in the second case (*WK* is not connected), Figure 25.

When a VDO sensor is used for fuel pressure, it is usually a sensor with insulated return. Let's assume that a 2 bar VDO sensor is used for the fuel pressure. Connection schematics in given in Figure 25 and the channel shall be configured according to Table 14.

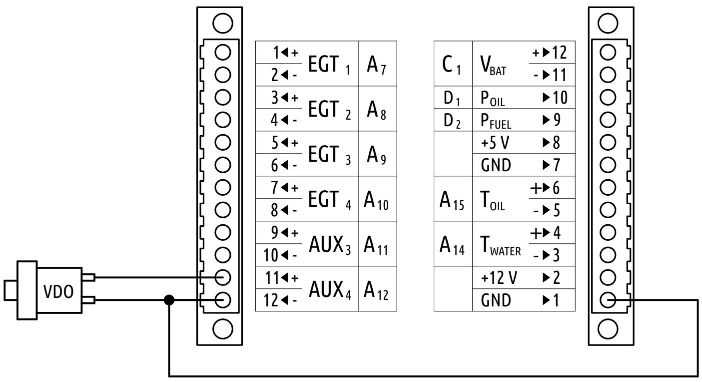


Figure 25: VDO fuel pressure sensor with two wire principle. The sensor body is isolated from the engine, hence second wire is necessary. Such sensor is *floating* and it must be expliciely grounded.

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

4.9 Voltage

Daqu can measure voltages from 0 to +20V DC on the channel C. The system voltage is usually measured on this channel.

4.9.1 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 26 illustrates an example.

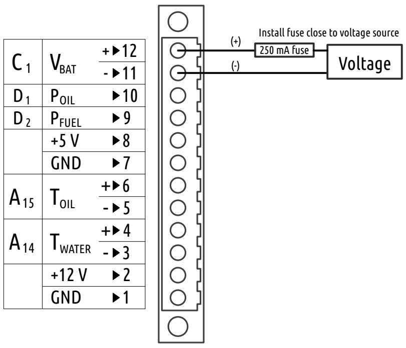


Figure 26: System voltage measurements. A 250 mA (or less) fuse is required close to the system bus source.

4.9.2 Configuration

The table 15 shows correct channel settings.

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

Table 15: Channel C configuration for system voltage.

4.9.3 Additional Voltage +/-46 V

Sometimes additional voltage measurements are required. As Daqu has only one C channel, an external adapter called `v div 1:23`[1] is required in order to measure additional voltage. The adapter is connected to any A channel. Figure 28 illustrates an example. Connect the positive voltage source to `Sig +` and negative voltage source to `Sig -`.

If the voltage source is capable of significant power, it is highly recommended to include a 250 mA fuse on the positive lead close to the source. See Figure 26. If you are in doubt, install the fuse.

The `v div 1:23` adapter can measure voltages between -46 to 46 V. Although negative voltages are possible they are very rare in practice. If you see negative voltage instead of positive, exchange the signal leads.

[1] `v div 1:23` stands for voltage divider with ratio 1:23.

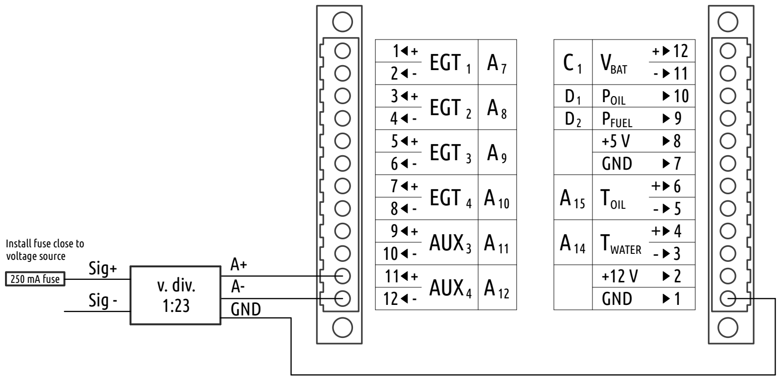


Figure 27: Voltage adapter is connected to the A channel.

The table 16 shows channel settings.

Option	Selection/Setting
Channel	Any A
Function	Voltages, cell voltages
Sensor	v div 1:23
Report time	0.5 – 1.0 s
Filter	1.0 s

Table 16: Channel A12 using voltage divider 1:23 adapter for flap position.

4.9.4 Voltage Adapter +/-6 V

Daqu A channel can be also used to measure voltages in +/-6 volt range using special adapter. This can come handy when you are running out of B or E channels. This case is very similar to case described in Section 4.9.3. Here slightly different adapter is used. It is named as `v div 1:3`[2], which works in -6V to +6V range. This adapter is supported by following functions: voltages, cell voltages, trim/flap positions, throttle position.

The table 17 shows an example for flap sensor position with voltage output connected via the adapter. Note that other functions can be used as well.

Option	Selection/Setting
Channel	Any A
Function	Flap pos (also other positions, voltages)
Sensor	v div 1:3
Report time	0.5 – 1.0 s
Filter	1.0 s

Table 17: Channel A12 using voltage divider 1:3 adapter for flap position.

If the voltage source is capable of significant power, it is highly recommended to include a 250 mA fuse on the positive lead close to the source. See Figure 26. If you are in doubt, install the fuse.

[2] `v div 1:3` stands for voltage divider with ratio 1:3.

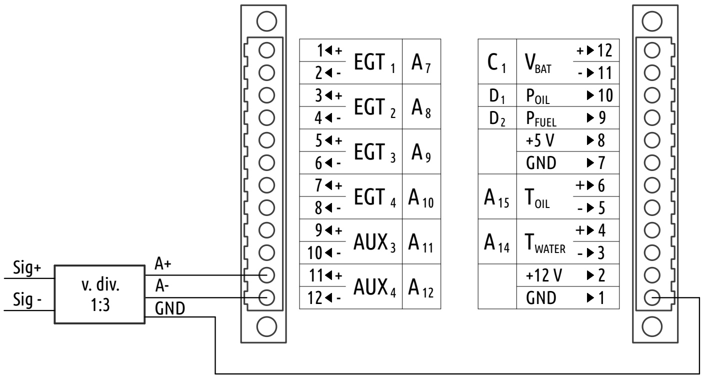


Figure 28: Voltage adapter 1:3 is connected to the A channel.

4.10 Current

You can connect three types of current sensors to Daqu.

- Since 2024 we mostly supply Current Hall 30/60/100 sensors. These simply clamp around the power cable.
- Until 2024 we mostly supplied CT-30/60 sensors. They were installed in-line on the power cable. The cable had to be cut.
- We also support MGL sensor.

Standard shunts, which work on the resistive princip are not supported. Details are given in following subsections.

4.10.1 Kanardia Current Hall 30/60/100 Sensors

Kanardia Current Hall 30/60/100 Sensors are used to measure electrical current. The number in the sensor name tells maximal current it can measure. For example, Current Hall 30 can measure current between -30 and +30 amperes.

Figure 29: Photo of Current Hall 60 sensor.

The sensor simply is clipped around the cable, which shall be measured. If indicated polarity is wrong (you see negative current, where positive current is expected), unclip the sensor and flip it around. Fix the sensor to the power cable or to some other relevant point, so that it will not slide up/down on it due to vibrations.

The sensor has three wires that connect to Daqu: black connects to GND, red to +5V and green is signal to any of B, D or E channel as also shown on Figure 30. Table 18 shows possible channel settings.

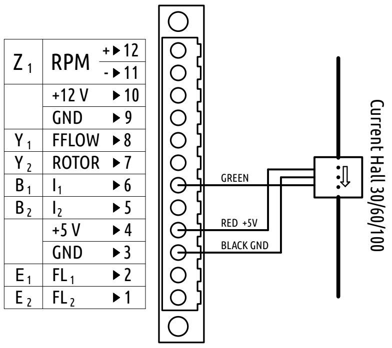


Figure 30: Current Hall 30/60/100 sensor connection schematics.

Option	Selection/Setting
Channel	Any B, D or E
Function	El. current 1 (or 2)
Sensor	Current Hall 30/60/100A
Report time	0.5 – 1.0 s
Filter	2.0 s

Table 18: Connection of Current Hall 30/60/100 A current sensor.

4.10.2 Kanardia CT-30 and CT-60 Sensors

Note: this sensor is obsolete and is not in production anymore. If possible use sensor from Section 4.10.1 instead.

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.

The power cable 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 31 for proper connection schema.

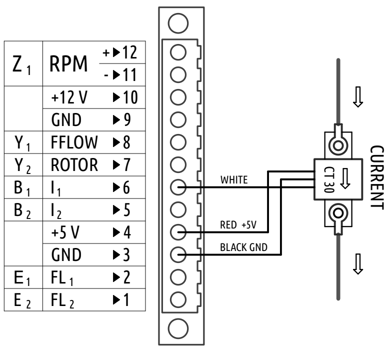


Figure 31: CT-30 sensor connection schematics.

The white wire will provide 2.5V (regarding to the GND pin) when there is no current, 0.5V when there is -30A (-60A) and 4.5V when there is +30A (+60A).

In the case of some troubleshooting, you shall measure 2.5V between white wire and GND when there is no current through sensor.

The table 19 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 (or 2)
Sensor	Current 30 A
Report time	0.5 – 1.0 s
Filter	2.0 s

Table 19: Connection of -30 to +30 A electrical current sensor.

4.10.3 MGL 50A Magnetic Closed Loop Current Sensor

A third party MGL 50A sensor can be also connected to Daqu. This sensor works in ±50 amperes range. Please refer to the sensor manual for more details. According to the manual the sensor has three wires.

The red wire shall be connected to the +12V power source. You can use one of Daqu +12V outputs. The black wire shall be connected to common ground. Use the GND pin on Daqu. The green wire shall be connected to a B, D or E input pin. Figure 32 illustrates the case.

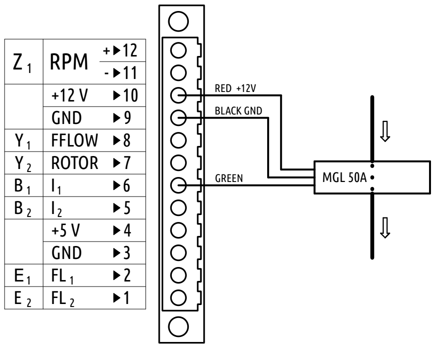


Figure 32: MGL 50A Close Loop sensor connection schematics.

Channel shall be configured according to Table 20.

Option	Selection/Setting
Channel	Any B, D or E
Function	El. current 1 (or 2)
Sensor	MGL 50A
Report time	0.5 – 1.0 s
Filter	2.0 s

Table 20: Channel settings for MGL 50A Close Loop sensor.

The green wire provides 2.5V (regarding to the GND pin) when there is no current.

Multi turn winding is not supported by Daqu – the cable with measuring current can pass trough the sensor only once.

Please note that this sensor is not very precise in low current situation. If you want to measure currents below 5A, use CT-30 sensor instead.

4.11 Fuel Level

Up to two fuel level sensors can be connected to Daqu. They shall be connected to E channels, though in some other cases other channels can be also used. Fuel level sensors are either resistive type or active type. Note that *capacitive* sensors are just a special case of active sensors.

4.11.1 General Principles

It is important that you know the correct type of your fuel level sensor. Do not judge the type of the sensor just on number of connection contacts. Read the sensor manual or datasheet. Consult an expert when unsure.

> CAUTION: Connecting a resistive sensor according to active sensor principle is extremely dangerous. It may ignite fuel or even create an explosion.

This section only reveals connection principles. Once a fuel sensor sensor is properly connected, it must be also calibrated to indicate fuel level in the tank properly. The tank calibration procedure is not part of this secion. Please also note that some sensors (capacitive ones) usually require sensor calibration before any tank calibration may begin.

These are steps required for fuel level sensor installation:

1. Sensor installation: installation to the fuel tank, sealing the sensor, proper grounding, etc. See aircraft manual, sensor manual and guidelines in section 4.11.2.
2. Sensor calibration (capacitive sensors only): Follow sensor manual and calibrate sensor accordingly to get proper sensor output. In general, after sensor calibration, you should get about 0V sensor output when tank is empty and about 5V output when full. This must be done before any further steps are made.
3. Daqu channel connection: Connect sensor to Daqu. See subsections 4.11.4 and 4.11.3 for more details.
4. Daqu channel configuration: Use Nesis/Aetos/Emsis/Blu to enter Daqu channel configuration values. Consult values given in tables 21 and 22. All steps so far are necessary to get raw readings from sensor. In the active (capacitive) case, the readings will be voltages in 0-5 V range. In the case of resistive sensor the readings will be resistances in the 0-200 (400) Ohm range.
5. Finally, these raw readings must be converted into liters/US gallons. This step is called the tank calibration. This is not covered in this manual. Please refer to the Nesis/Aetos/Emsis/Blu manual for more details.

4.11.2 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 times. 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.

4.11.3 Resistive Fuel Level Sensors

Connection principles for resistive sensors were already given in section 3.4, starting on page 15.

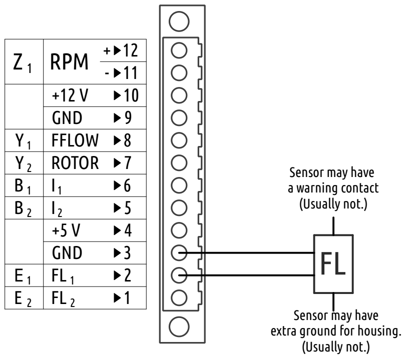


Figure 33: An example of resistive fuel sensor. Usually it has only two connections. But it can have more. Please refer to the sensor manual for more details.

Typical configuration for a sensor from Figure 33 is shown in Table 21. 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 most frequent one is *Res 400 Ohm*, but *Res 160 Ohm* is also often used.

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

Table 21: 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.

4.11.4 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 for more details. This calibration will *teach* sensor to give proper voltage output on empty and full case.

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 34 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 22.

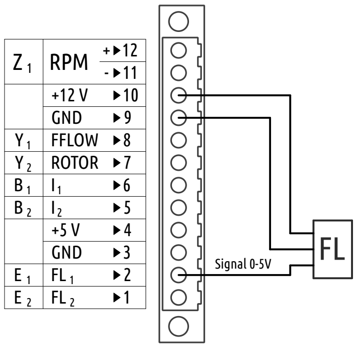


Figure 34: An example of capacitive fuel level probe connected to the +12 V power source. Some probes require 5 V, be careful.

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

Table 22: Typical fuel level configuration for a capacitive sensor.

4.11.5 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 3.9 starting on page 19. 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 23.

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 23: 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, Ray Allen Trim

Figure 12 shows typical schematics for the variable voltage divider. The corresponding channel is configured something like shown by Table 24.

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 24: 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 `+5V`, blue to `GND` and green to any channel of B, D or E type. Figure 35 illustrates the connection. Important: Consult the Ray Allen documentation to verify this before connecting the sensor.

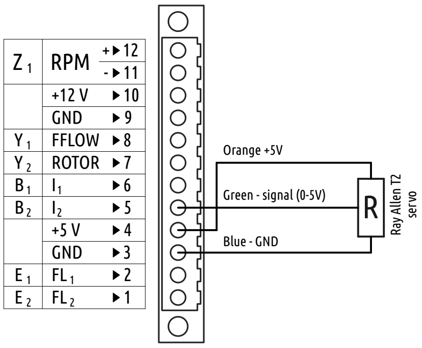


Figure 35: Direct connection to Ray Allen T2 servo.

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 36 illustrates the connection principle.

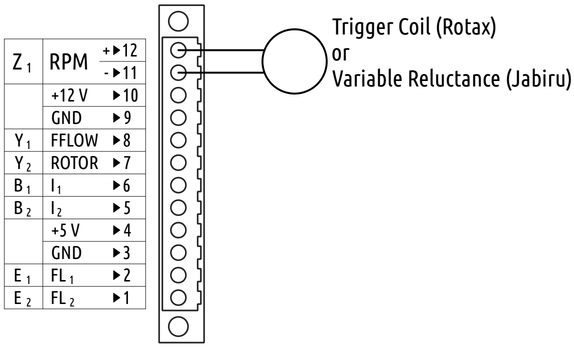


Figure 36: Connection of *trigger coil* sensor or *variable reluctance* sensor to Z channel.

Next, we show three tables: for Rotax 912, for Rotax 582 and for Jabiru engine.

Rotax

Table 25 shows 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.

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 25: Settings appropriate for Rotax 912 engine.

Table 26 shows appropriate settings for Rotax 582 engine. When engine is equipped with Ducati DCDI ignition (newer engines) then *Pulses* shall be set to 6. If the engine has some other ingition then *Pulses* may be set to 2 or 3, depending on the ignition used – you will have to experiment. *Prop reduction* value is set to one – no reduction is applied and output value will be engine RPMs. Also note that *Sensor* must be set to `Rotax 582`. Namely, the signal of 582 engine is exeptionaly ugly and requires different processing.

Jabiru

Table 27 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.

Option	Selection/Setting
Channel	Z only
Function	Engine RPM
Sensor	Rotax 582
Report time	0.2 – 0.5 s
Filter	about 0.5 s
Pulses	6 for Ducati DCDI (2 or 3 otherwise)
Prop reduction	1

Table 26: Settings appropriate for Rotax 582 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 27: Settings appropriate for Jabiru engine.

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.

Connection schematics were already given in section 3.10. 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.

Lycoming & Continental

Let's assume a Lycoming engine, with Hall sensor. Such sensors are usually installed in magneto vent hole. They typicaly give one pulse per revolution in 4 cylinder engine and 1.5 pulses in 6 cylinder engine. In this case, the configuration is shown in table 28. A trick is used for 6 cylinder engine: 3 pulses are used with reduction of 0.5, which yields 1.5 pulses per revolution.

An example of Hall effect secnsor is UMA magnetic pickup tach sender T1A9 or N1A9. Connection example for this sensor is given on figure 37. Note that other sensors may connect slightly differently. Please refer to the sensor documentation for more details.

There are many different sensors solutions for Lycomming and Continental engines and some other settings may be required.

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.

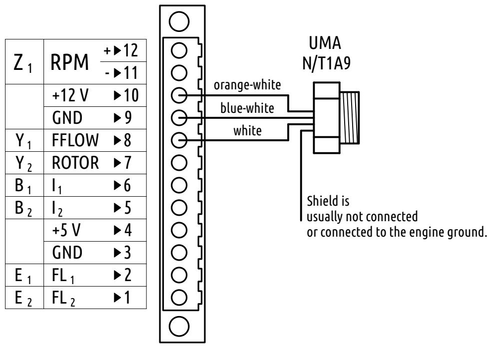


Figure 37: Connection of *UMA T1A9 or N1A9* sensor to Y channel. Any Y channel can be used.

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	1 (4 cylinder), 3 (6 cylinder)
Prop reduction	1 (4 cylinder), 0.5 (6 cylinder)

Table 28: An example for Lycoming engine. 6 cylinder version uses trick with reduction setto 0.5 in order to get 1.5 pulses per revolution.

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.

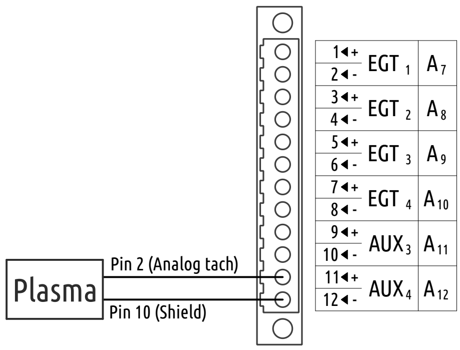


Figure 38: Connection of Plasma RPM analogue voltage output signal to A channel.

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 38 illustrates the connection.

The A channel must be configured as shown on table 29.

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 29: 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 30 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 30: 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 39 illustrates the sensor and connector.

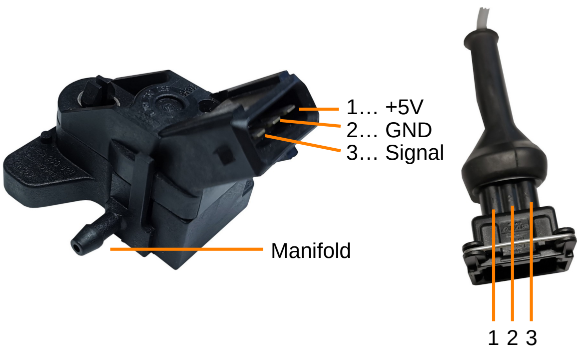


Figure 39: External manifold pressure sensor, Bosch 0 261 230 037.

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 40.

An example of channel configuration is shown in Table 31.

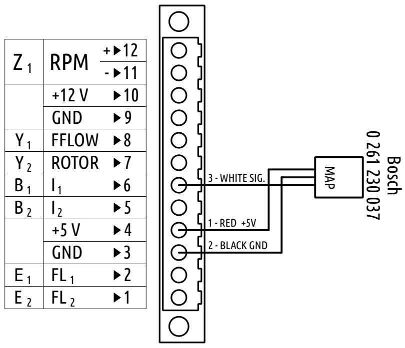


Figure 40: External MAP sensor from Bosch, connection schematics.

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 31: Configuration example for external Bosch MAP sensor.

4.14.3 External Sensor – Bosch 0 281 002 593

The Bosch 0 281 002 593 boost sensor may be used with turbo engines. The measuring range is up to 2.5 bar. The same principles as shown in section 4.14.2 apply here. The only difference is the part number in the configuration table.

4.15 Rotor RPM

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

Connection schematics were already given in section 3.10. 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 32 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 32: 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.

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 33: 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.

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.

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:

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

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. Please note that although the FT-60 is a NPN sensor type, it usually needs an external resistor, see connection schematics in Figure 13, right[3]. The sensor has 68000 pulses per US gallon. This equals to $68000/3.7854 \approx 18000$ pulses per liter. Table 34 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 34: An example for the FT-60 fuel flow sensor 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).

[3] You may try without a resistor first and if the sensor does not indicate correct values at higher engine power settings, you must install the pullup external resistor between signal and +12V source.

4.17 Metal Debris

Metal debris (metal particle) detectors are special sensors, which start conducting once enough metal particles collect on the sensor. The sensor shall be connected to Daqu A channel as a *resistive sensor*. Depending on the sensor design, it can be connected either as *one wire* or as *two wire* resistive sensor. Please see Section 3.3 on page 14 for more details about wireing and proper grounding.

The channel shall be configured according to Table 35.

Option	Selection/Setting
Channel	Any A
Function	Metal debris 1-4
Sensor	Resistive switch
Report time	1.0 s
Filter	2.0 s

Table 35: An example of metal debris sensor configuration.

Daqu will measure resistance of the sensor. If there are no debris/particles then sensor will be open and it will not conduct. Once enough debris are collected, the sensor will close (resitance will drop significantly) and it is reported as closed.

At the time of wiriting, the *threshold* is set approximately at 460 Ω. When resistance is below this threshold, the sensor is considered as closed. When it is above, it is considered as open.

5 Engine ECU Connection

This Daqu version in not designed to connect to an engine ECU. Mini Daqu shall be used instead. However there are cases, where mini Daqu does not have enough channels. In this case a modified 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 or ULPower, for example).

Please also refer to the mini Daqu manual. Some ECU specific solutions are described there. MiniDaqu and standard Daqu share the same software base. They only differ in channels and connectors.

Modifications include removing manifold pressure sensor and installing an additional connector. This connector is used to connect to ECU CAN bus.

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 41.

5.1 Connection

In this section we are using the Rotax iS terminology for the ECU CAN bus connection. Two CAN buses can be connected. The first one is refered to as Lane A and the second one as Lane B. Other engines may also use two buses, but slighly different names are used to identify them.

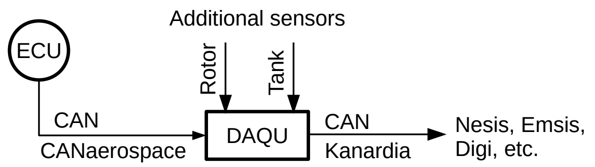


Figure 41: Illustration of the connection principle. Almost all information comes from the ECU. Rotor RPM and fuel tanks and other additional sensors can be still connected directly to Daqu.

5.1.1 Connection - Three Pin Connector

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

The Rotax 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 42. 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.

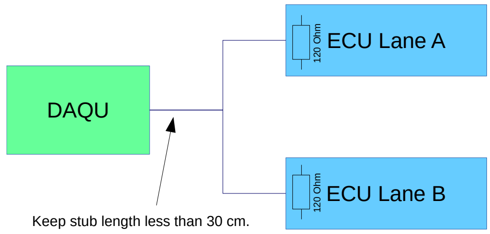


Figure 42: CAN bus connectivity.

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 43 shows the back side connector with pins. Solder the wires onto the connector as it is marked on the photo.

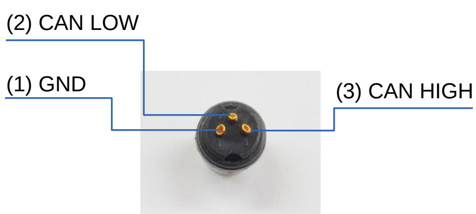


Figure 43: Photo of connector back side. Note the three small numbers, which define the pin positions. GND is usually not connected.

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 44 shows pin numbers. This is the back side of the cable plug.

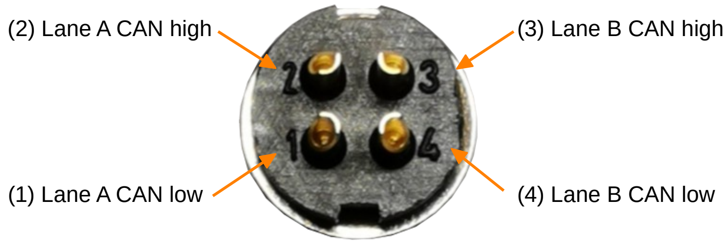


Figure 44: Cable plug back side. Note the four small numbers, which define the pin positions inside the plug. This is Binder part number 99 0979 100 04.

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 44 and Figure 45.

Please note that standard CAN bus principles apply here too. Each lane shall be terminated with a 120 Ohm resistor. Some ECUs have this built in, some don't. Measure the resistance betwen CAN high and CAN low wires of the same lane, if you are unsure.

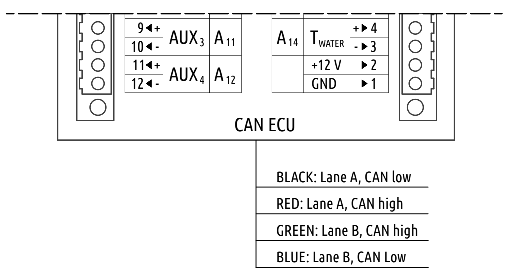


Figure 45: Color codes of the 4-pin connector. Two lanes can be connected, each has two wires. Some engines connect only one lane. WMFly Engine - CCM module, for example.

5.2 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 an almost complete set of sensors. Rotax iS ECU unit transmits the following information: engine RPM, fuel flow rate, manifold pressure, oil pressure, oil temperature, coolant temperature, 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.

Table 36 shows correct connection to the Rotax iS engine.

Pin	Function	Color	iS Connector & Pin
1	Lane A: CAN low	Black/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 36: Pin description and cable colors.

5.3 ULPower

ULPower engines come equipped with their own ECU. Sometimes they are also equipped with two ECUs. This Daqu type can only connect to ECU CAN bus – it does not support RS-232 connection (while miniDaqu, does support it.)

5.3.1 One ECU

The four pin connector shown on Figure 44 allows connection of two ECUs. When a single ECU is used, then only Lane A (or CAN bus 1) is connected. The Lane B (CAN bus 2) is not used. This means the green and blue leads of the CAN bus 2 shall be connected together with a 120 Ohm resistor in-between. Any standard 120 Ohm resistor can be used.

Note that the Pin 1 on the ULPower CAN cable (White/Orange – COMMON) is not connected. In the case when you do not get any communication between ECU and Kanardia (this should not be the case), try to connect the Pin 1 lead to some common ground in your aircraft.

Pin	Function	Color	ULPower Connector & Pin
1	ECU 1: CAN low	Black/Brown	Pin 2: CAN L (White/Blue)
2	ECU 1: CAN high	Red	Pin 3: CAN H (White)
3	ECU 2: CAN high	Green	Connect leads together with a 120 Ohm resistor in-between.
4	ECU 2: CAN low	Blue	

Table 37: Pin description and cable colors for ULPower single ECU connection.

5.3.2 Two ECUs

The four pin connector shown on the Figure 44 allows connection of two ECUs. Connect ECU 1 to Lane A (or CAN bus 1) and ECU 2 to the Lane B (CAN bus 2).

Note that the Pin 1 on the ULPower CAN cable (White/Orange – COMMON) is not connected. In the case when you do not get any communication between ECU and Kanardia (this should not be the case), try to connect the Pin 1 lead to some common ground in your aircraft.

Pin	Function	Color	ULPower Connector & Pin
1	ECU 1: CAN low	Black/Brown	ECU 1: Pin 2: CAN L (White/Blue)
2	ECU 1: CAN high	Red	ECU 1: Pin 3: CAN H (White)
3	ECU 2: CAN high	Green	ECU 2: Pin 3: CAN H (White)
4	ECU 2: CAN low	Blue	ECU 2: Pin 2: CAN L (White/Blue)

Table 38: Pin description and cable colors for ULPower dual ECU connection.

5.4 WMFly Engines

WMFly engines are not connected directly to the engine's ECU module. An interface module called CC-m must be installed between the ECU and Daqu. This module is supplied by WMFly.

Only pins 4 and 5 of the D-SUB 9 connector of the CC-m module are used. CAN channel (AEROPSACE OUT) is connected according to Table 39.

Pin	Function	Color	CC-m Connector & Pin
1	ECU 1: CAN low	Black/Brown	Pin 4: CAN L Aerospace (out)
2	ECU 1: CAN high	Red	Pin 5: CAN H Aerospace (out)
3	ECU 2: CAN high	Green	Not connected.
4	ECU 2: CAN low	Blue	Not connected.

Table 39: Pin description and cable colors for WMFly CC-m module interface.

6 Troubleshooting

This section reveals some troubleshooting ideas.

6.1 General Guidelines

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 the channel configured according to the sensor properties. Make sure you undestand the sensor and its properties.
- Is the channel to which the sensor is connected configured for the proper range?
- Is there any other channel which is configured for the same function? One function, say *fuel pressure* can be used by one channel only. If more channles are set to the same function, then they are in contradiction.
- 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 sensor lying for some small, but constant offset?
- Is the problem in the Daqu AD converter or in the sensor?

6.2 Resistive Sensor – VDO Fuel Pressure Sensor Example

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.

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

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 46 illustrates the sensor replacement with a 100 Ohm resistor. After the replacement, the value on the screen must be equal to 1.06 bar.

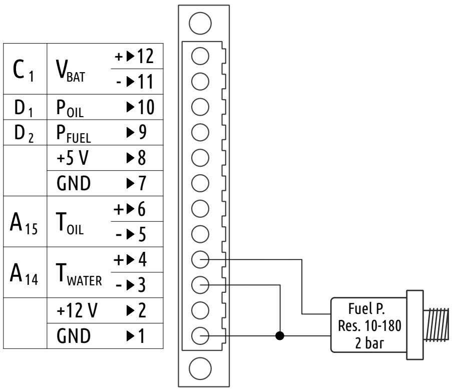


Figure 46: Example: VDO 2 bar sensor was replaced by a fixed 100 Ohm resistor.

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.

6.3 Resistive Sensor – Oil Temperature Indication

This section shows an example for oil temperature sensor troubleshooting. Here we assumed that sensor is properly connected and corresponding channel is properly configured. Oil temperature sensor is almost always connected as a one wire resistive sensor, which is grounded via engine block. See section 3.3.1 starting on page 14 and section 4.4 starting on page 26 for more details. The later section also show proper channel configuration, table 7.

6.3.1 Test Resistors

If the sensor still shows wrong temperature, you can try to identify the problem by replacing the sensor with some known resistor. Simple, 1% precision carbon wire resistors can be used.[4]

[4] Please do not use 5% precision resistors, as the resistance vs temperature has a very non-linear curve and minor deviations in resistance may lead to a significant error in temperature.

A pair of crocodile clip cables will come handy, but a simple bare end cable will do as well. It is also good to have a multimeter at hand.

VDO 150		Dynon		PT 100		PT1000	
R [Ω]	T [°C]	R [Ω]	T [°C]	R [Ω]	T [°C]	R [Ω]	T [°C]
510	38.7						
100	83.6						
33	124.4						

Table 40: Recommended test resitors values and their corresponding temperatures for four most often used sensors.

Data source for VDO 150: Document *TU00-0770-5104620, Characteristic Curve Table 2* obtained from `www.vdo.com`.

We recommend to do checks with test resistors at two places:

- at the sensor installation position,
- at Daqu connector.

6.3.2 Check on Sensor

The best way to start the check is at the sensor installation position. Take two crocodile clip wires.

1. If you have a multimeter, measure the test resistor. Its resitance must be accurate (1% tolerance or less).
2. Remove the lead from the temperature sensor head and use crocoldile clip cable to connect to one side of the test resistor.
3. Use second crocodile clip cable to connect the other side of the test resistor to some ground point on the engine block.[5]
4. Turn on the system and check the indicated oil temperature value.

Figure 47 shows an illustration of the test setup. This allows for quick change of test resistors.

Check the indicated value on Kanardia main instrument. If the indicated oil temperature value is close to the value given in table for selected test resistor, then the problem is in the temperature sensor.

If the value is different then the problem can be either on the Daqu side or on the leads connected to Daqu. In this case, we recommed to make a second check.

[5] Make sure that connection point of the engine block is grounded to the system ground. Check this with multimeter. Namely, some points on the engine may not be grounded.

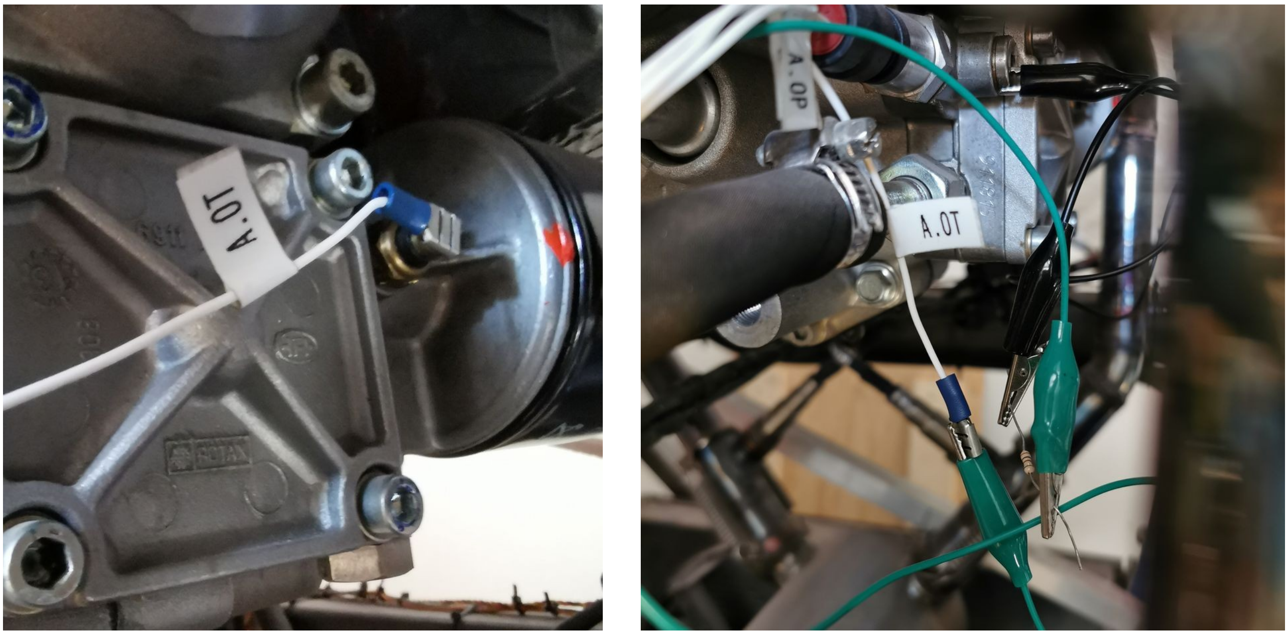


Figure 47: Test setup. Left: Location of the oil temperature sensor and its lead to Daqu (labeled as A.OT). Right: Oil temperature lead was detached and connected with green cable to one side of the test resistor. The other side of the resitor connects to an appropriate engine point (black cable).

6.3.3 Daqu Check

A similar check with test resistors can be made directly on Daqu.

1. Locate the oil temperature lead connecting to Daqu. In most cases the lead from the sensor will be connected to some A channel. The illustration here is given for channel A15, but your case may be different.
2. The lead from the sensor is connected to `A+` pin and a lead from engine block is connected to `A-` pin of the channel. Remove both leads.
3. Insert a test resistor according to Figure 48. Do not forget to make additional ground with some GND output port on Daqu. Connecting only resistor without any GND connection will make channel to *float* and indications will be wrong.

Check the indicated value on Kanardia main instrument. If the indicated oil temperature value is close to the value given in table for selected test resistor, then the problem is either in the temperature sensor or in its connecting leads. There are two leads to be checked. One which connects sensor head with `A+` pin and the lead from the engine ground point to the `A-` pin. In most cases the grounding lead is the problematic one. You may try to move the engine ground point to some other engine location. Also make sure that lead is thick enough. Please refer to section 3.3.1 for more details.

If the indicated value is significantly different than the coresponding reference value from the Table 40, the problem can be:

- Channel configuration - wrong sensor is selected.

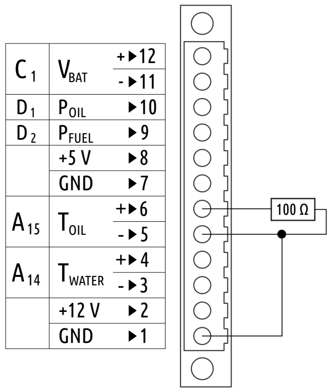


Figure 48: Example: VDO oil temperature sensor was replaced by a known test resistor. A 100 Ω resistor is shown, but any other test resitor from Table 40 can be also used.

- There are two channels with the same function. Check all the channels. Make sure that only one channel is used for oil temperature and its channel designation matches to the designation where the sensor lead is connected.
- There is an internal defect in Daqu and it must be reapired. Please contact `support@kanardia.eu`.
- Maybe the channel in use was damaged, but some other A channel may still work well. Try to connect the oil temperature leads to some other free A channel and then reconfigure the channel settings (set old channel as *not used*) and assign oil temperature function to a new A channel.

6.4 Differential Fuel Flow – Forward and Backward Flow

Daqu allows for combining two flows into one differential flow. Here one fuel flow sensor measures flow from the tank and the other measures flow back to tank. The difference is the flow consumed by the engine and this is what it is displayed on the screen. Such combination may be sometimes difficult to troubleshoot and here we provide some hints.

6.4.1 Display Flows in Debug Mode

Since software version 3.11 SVN(21498 or larger), Daqu transmits the fuel flow values once per second as Console output on the CAN bus. This output comes handy when troubleshooting the fuel flow indications.

Nesis and Aetos

The debug output can be displayed in Nesis/Aetos using the following procedure:

1. Switch to the `Options` screen.
2. Select `Service` icon and enter the password. If you do not know the password, you can find it under `Info` icon. Search for the `Service pass`.
3. Select `CAN Devices` icon. A list of devices appears, search for `Daqu`.

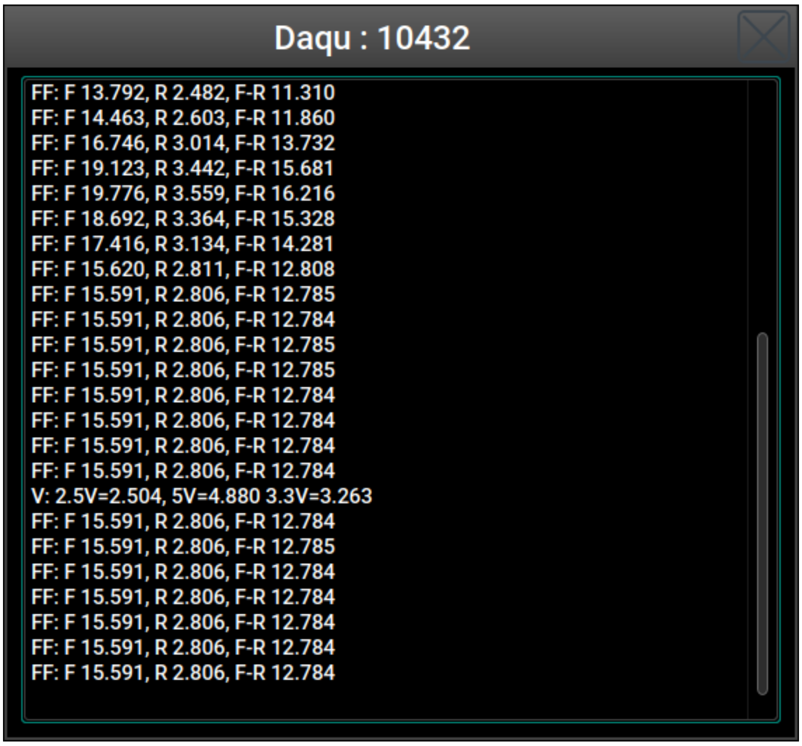


Figure 49: An example of Daqu console output in Nesis.

4. The `Open console` is the correct option. This opens console window for Daqu. You will see something like shown on Figure 49.

Lines which start with the `FF:` dislpay current fuel flow values detected by Daqu. All numbers are given in liters per hour [l/h]:

F shows detected *forward* flow (from tank system towards engine).

R shows detected *reverse* flow (from engine back to tank system).

F-R shows the difference. This is what it is transmitted to the CAN bus. You see this value on screens and this value is used for fuel consumption related calculations.

Blu & Kanja

You can also use the `Blu` dongle and `Kanja` Android app to see the same output.

1. Connect `Blu` into one of CAN bus ports. Perhaps you will have to disconnect part of the CAN network. Make sure that `Daqu` is not disconnected.
2. Start Kanja app and connect to Blu. See Kanja & Blu manual for the details.
3. Select `Daqu` from the list of devices.
4. Select `Console` option.

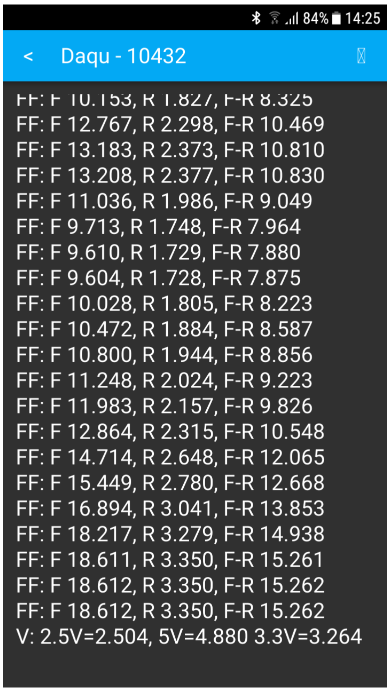


Figure 50: An example of Daqu console output in Kanja Android app.

6.4.2 FT-60 Precision

We tested several fuel flow FT-60 sensors and we found no significant difference between them. The producer claims 1% precision. We measured about 2% precision. However, we noticed that precision worsens when sensor is approaching its low operational limit (about 2.3 l/h). In principle the sensor does not detect flows below 2.3 l/h. At this low limit, the flow no longer maintains smoothness upon exiting the line; instead, it resembles a rapid dripping.

Our recommedation is that if you use dual sensor measurements, the return flow shall not be less than 3-4 liters per hour. Any flow below this limit, will give bad results.

6.4.3 Sensor Orientation

The sensor orientation may play significant role. Make sure you follow producer's recommendations.

6.4.4 Test Configuration

If you suspect that one sensor is not indicating correctly, you may consider to combine both sensors to the same fuel line, perhaps to the same return line. This is for testing purposes only. In such arrangement both sensor sense the same flow and they should indicate the same value (with some tolerance). The resulting `F-R` value should be close to zero. FYI: During our tests we observed differences up to 0.7 l/h between the sensors. In most cases the difference was in the 0.2-0.4 l/h range.

As sensors are not that precise, some error will occur, but this error should be contained in some reasonable limits.

Make sure the flow is adquate as weak flows can't be detected by sensors. Air/fuel vapor bubbles play significant role in the precision. Try to get rid of them.

If you are able to vary the flow, try to simulate real working conditions for your engine.

Fire hazard: Working with fuel is always messy and dangerous. Take all possible safety precautions. Sudden spills of fuel on a hot engine are possible. Sparks, etc., may happen spontaneously. Make sure you have a proper fire extinguisher at your immediate disposal.

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 Kanardia 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.

Exclusions and Limitations

This Limited Warranty applies only to hardware products manufactured by or for Kanardia that have the "Kanardia" trademark, trade name, or logo affixed to them at the time of manufacture by Kanardia. The Limited Warranty does not apply to any non-Kanardia hardware products or any software, even if packaged or sold with Kanardia hardware. Manufacturers, suppliers, or publishers, other than Kanardia, may provide their own warranties to the Purchaser, but Kanardia and its distributors provide their products *AS IS*, without warranty of any kind.

Software distributed by Kanardia (with or without the Kanardia's brand name including, but not limited to system software) is not covered under this Limited Warranty. Refer to the licensing agreement accompanying such software for details of your rights with respect to its use.

This warranty does not apply: (a) to damage caused by use with non-Kanardia products; (b) to damage caused by accident, abuse, misuse, flood, fire, earthquake or other external causes; (c) to damage caused by operating the product outside the permitted or intended uses described by Kanardia; (d) to damage caused by service (including upgrades and expansions) performed by anyone who is not a representative of Kanardia or an Kanardia Authorized Reseller; (e) to a product or part that has been modified to significantly alter functionality or capability without the written permission of Kanardia; (f) to consumable parts, such as batteries, unless damage has occurred due to a defect in materials or workmanship; or (g) if any Kanardia serial number has been removed, altered or defaced.

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 to the duration of this express warranty and to repair or replacement service as determined by Kanardia in its sole discretion. Kanardia does not warrant that the operation of the product will be uninterrupted or error-free. Kanardia is not responsible for damage arising from failure to follow instructions relating to the product's use. No Kanardia reseller, agent, or employee is authorized to make any modification, extension, or addition to this warranty, and if any of the foregoing are made, they are void with respect to Kanardia.

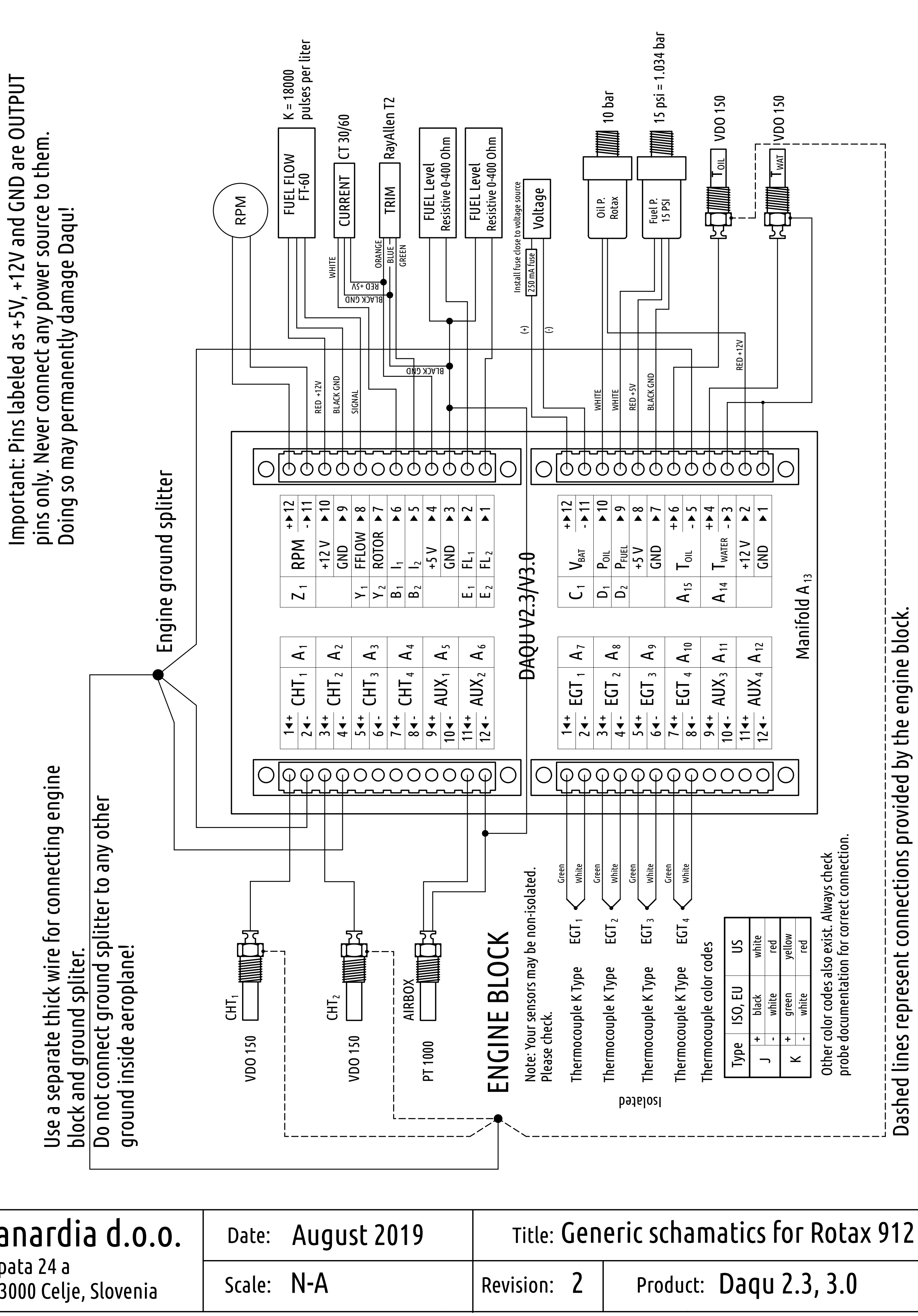
Limitation of Liability

To the extent permitted by applicable law, Kanardia is not responsible for indirect, special, incidental or consequential damages resulting from any breach of warranty or condition, or under any other legal theory, including but not limited to loss of use; loss of revenue; loss of actual or anticipated profits (including loss of profits on contracts); loss of the use of money; loss of anticipated savings; loss of business; loss of opportunity; loss of goodwill; loss of reputation; loss of, damage to or corruption of data; or any other loss or damage howsoever caused including the replacement of equipment and property, any costs of recovering, programming, or reproducing any program or data stored or used with Kanardia products and any failure to maintain the confidentiality of data stored on the product. Under no circumstances will Kanardia be liable for the provision of substitute goods or services. Kanardia disclaims any representation that it will be able to repair any product under this warranty or make a product exchange without risk to or loss of the programs or data. Some jurisdictions do not allow for the limitation of liability for personal injury, or of incidental or consequential damages, so this limitation may not apply to you.

7.2 TSO Information — Limited Operation

This product is not TSO approved as a flight instrument. Therefore, the manufacturer will not be held responsible for any damage caused by its use. The Kanardia is not responsible for any possible damage or destruction of any part on the airplane caused by default operation of instrument.

Important: This connection schamatics and the assosiated configuration form are just suggestions based on the data avaialbe to us. Your sensors may be different and they may require different schematics and form. Please refer to the Daqu manual for more details.



Type		ISO, EU	US
J	+	black	white
	-	white	red
K	+	green	yellow
	-	white	red

Kanardia d.o.o.
Lopata 24 a
SI-3000 Celje, Slovenia

Date: August 2019

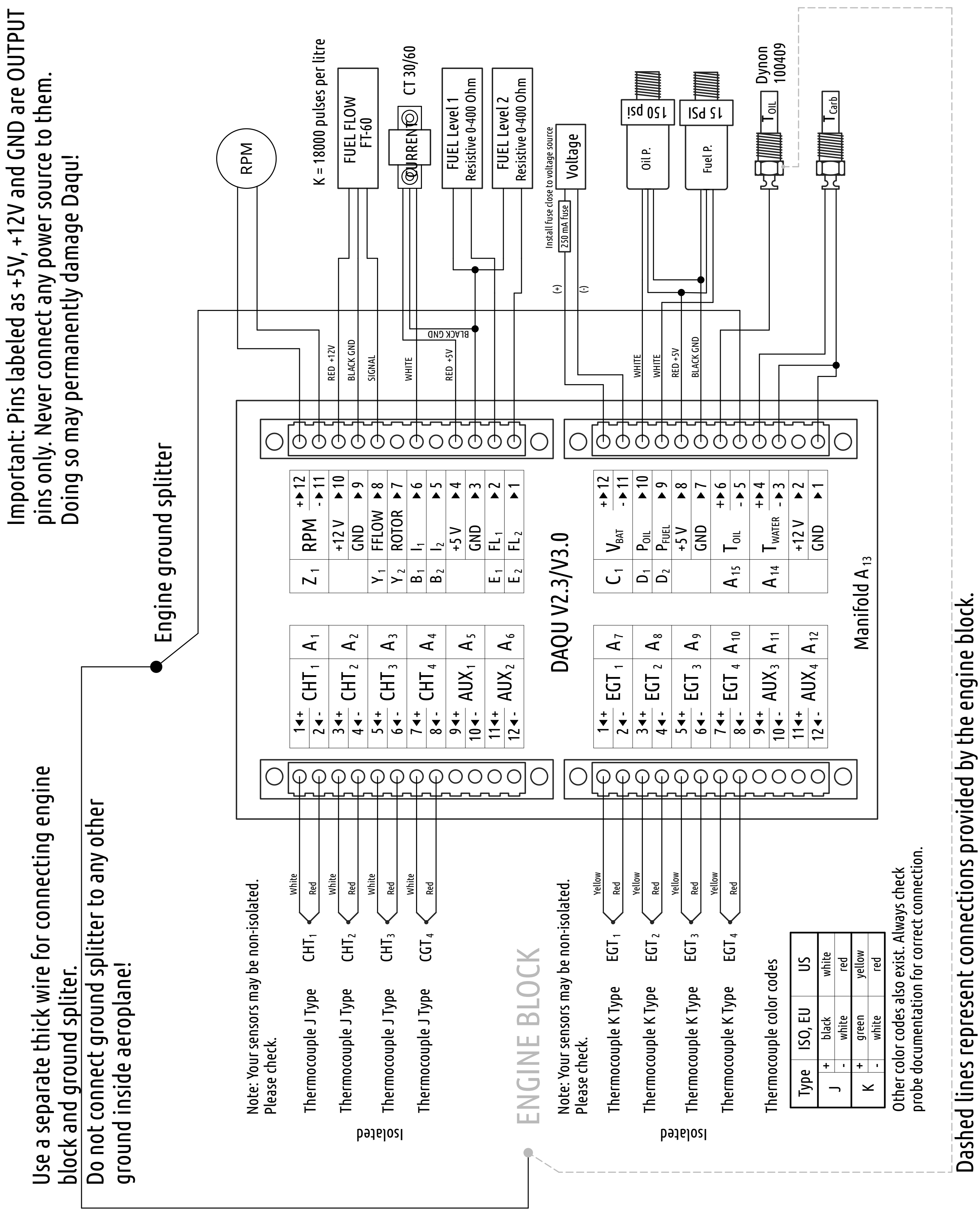
Title: Generic schamatics for Rotax 912

Scale: N-A

Revision: 2

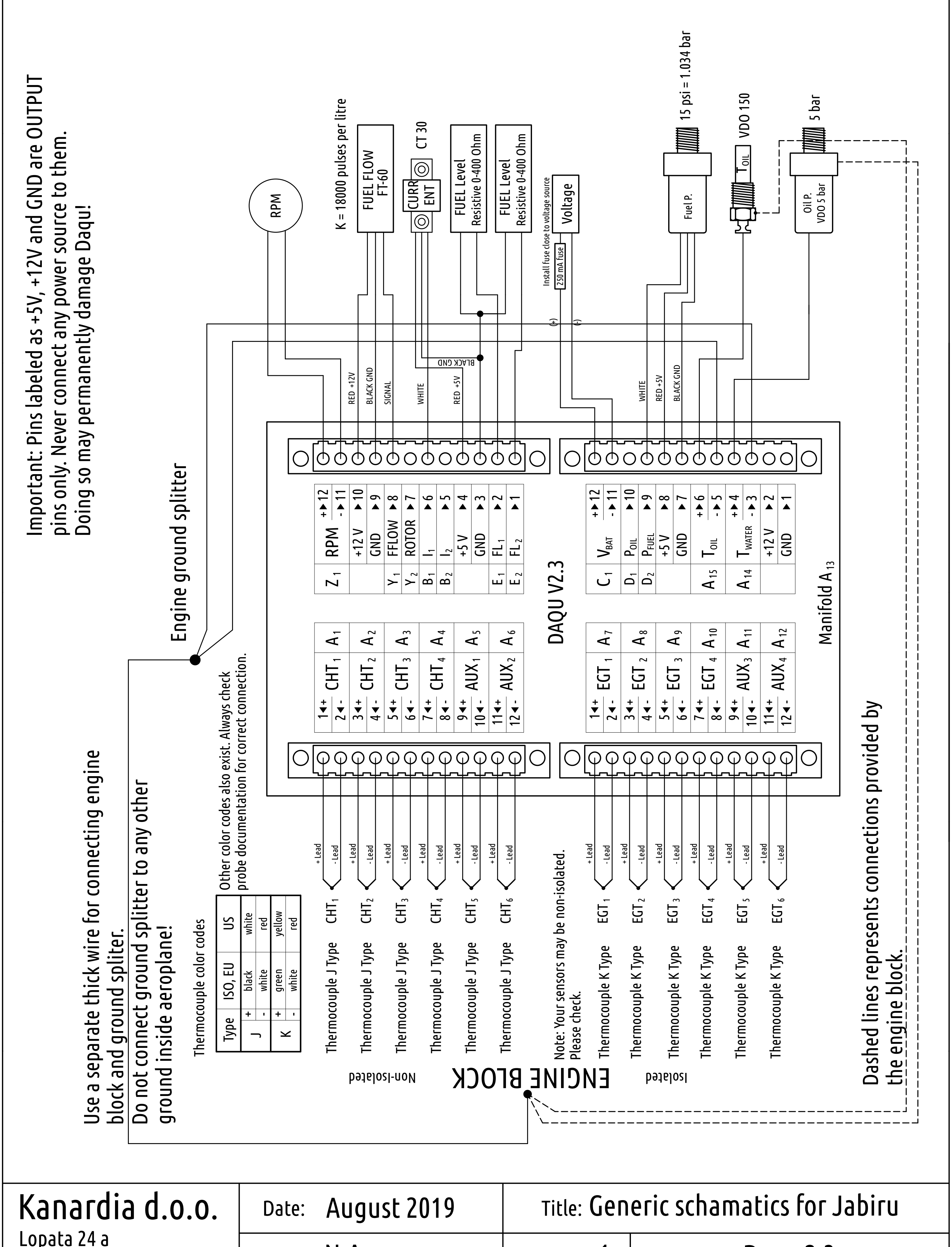
Product: Daqu 2.3, 3.0

Important: This connection schamatics and the assosiated configuration form are just suggestions based on the data avaialbe to us. Your sensors may be different and they may require different schematics and form. Please refer to the Daqu manual for more details.



Kanardia d.o.o. Lopata 24 a SI-3000 Celje, Slovenia	Date: April 2020	Title: Generic sch. Lycoming carburetor	
	Scale: N-A	Revision: 2	Product: Daqu 2.3, 3.0

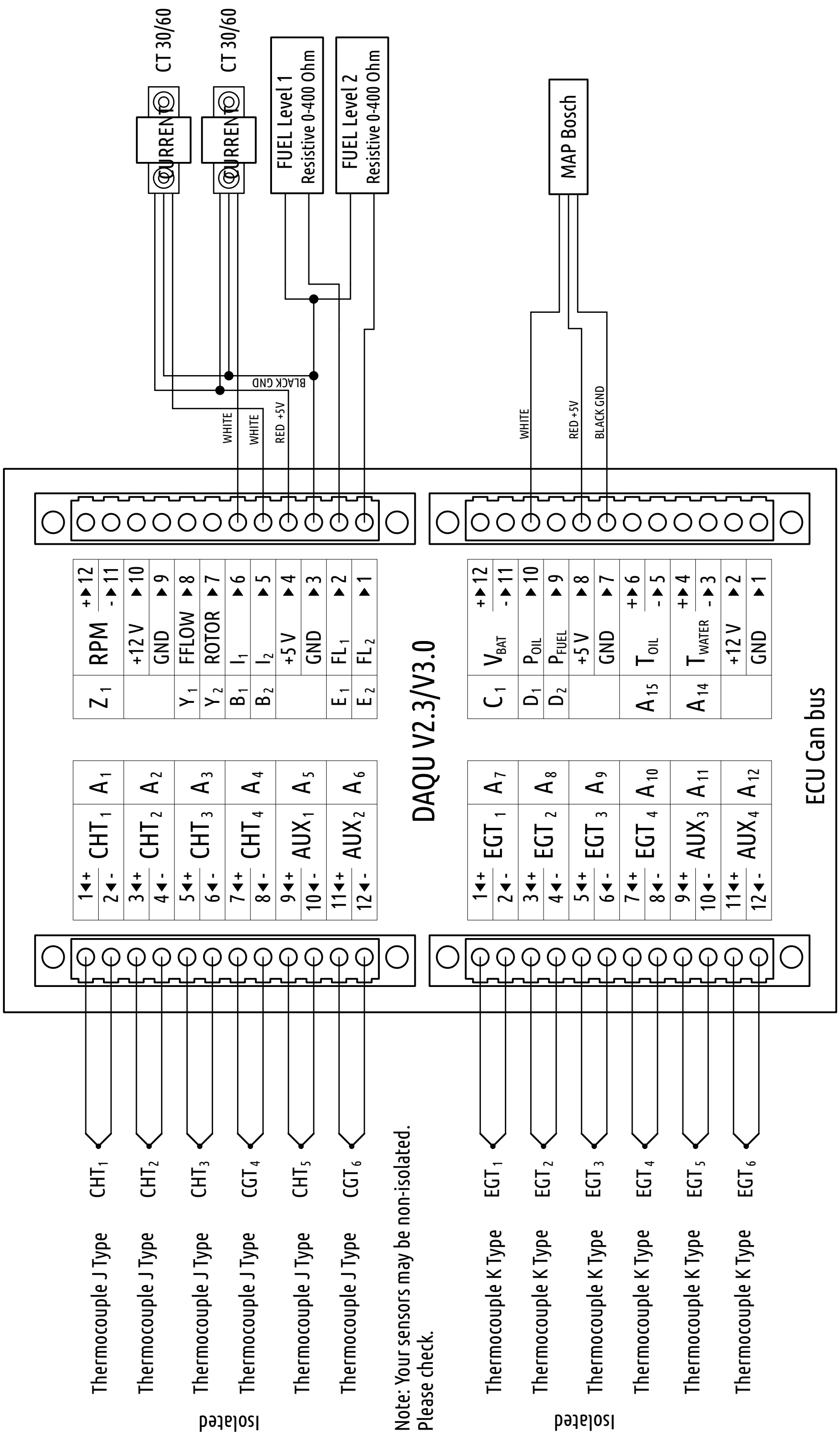
Important: This connection schamatics and the assosiated configuration form are just suggestions based on the data avaialbe to us. Your sensors may be different and they may require different schematics and form. Please refer to the Daqu manual for more details.



Kanardia d.o.o. Lopata 24 a SI-3000 Celje, Slovenia	Date: August 2019	Title: Generic schamatics for Jabiru	
	Scale: N-A	Revision: 1	Product: Daqu 2.3

Important: This connection schamatics and the assosiated configuration form are just suggestions based on the data avaialbe to us. Your sensors may be different and they may require different schematics and form. Please refer to the Daqu manual for more details.

Important: Pins labeled as +5V, +12V and GND are OUTPUT pins only. Never connect any power source to them. Doing so may permanently damage Daqu!



ECU	Function	Color
1	CAN low	black/brown
	CAN high	red
2	CAN low	blue
	CAN high	green

Thermocouple color codes

Type		ISO, EU	US
J	+	black	white
	-	white	red
K	+	green	yellow
	-	white	red

Other color codes also exist. Always check probe documentation for correct connection.

Kanardia d.o.o. Lopata 24 a SI-3000 Celje, Slovenia	Date: Jan 2021	Title: Generic schamatics for ULPower	
	Scale: N-A	Revision: 2	Product: Daqu 2.3