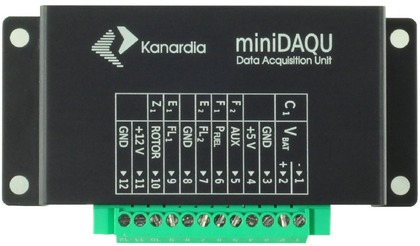
miniDaqu
Engine Management System
Manual

June 2022



Revision 1.5

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

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Revision History

The following table shows the revision history of this document.

Rev.	Date	Description
1.5	Dec 2022	ULPower fuel pressure clarification, Bosch MAP sensors.
1.4	Jun 2022	PNP pull-down value corrected.
1.3	Jun 2021	Clarify description of output pins.
1.2	Jul 2020	Digital PNP sensor schema fix.
1.1	Mar 2019	Unified DB9 markings.
1.0	Jan 2019	Initial release.

Contents

1 Introduction

First of all, we would like to thank you for purchasing our product. Mini Daqu is data acquisition unit designed for monitoring engine parameters. Mini Daqu reads various engine sensors, processes the readings and transmits them to the CAN network, where other units can make use of these readings. In addtition, mini Daqu connects to engine ECU and reads data from it. The data is then transmitted on the Kanardia CAN network.

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

Daqu comes in two versions:

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

This manual is dedicated to mini Daqu, hereinafter referred to as Daqu.

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.

In addition, it connects to engine ECU unit. The data received from the ECU is converted and re-transmitted on the CAN network. This way it efficiently uses information available from ECU and only minimal amount of additional sensors (if any) is required.

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.

1.2 Technical Specifications

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

Description	Value
Weight (without cables)	90 g
Size	76 x 44 x 30 mm
Operational voltage	7–32 V
Current (sensors not connected)	100 mA at 12 V
Current (sensors connected)	up to 200 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	1: (1xY)
Analog channels	5: (1xC, 2xD, 2xE)
Processor	Cortex M3, 60 MHz
ECU Communication	RS232, second CAN bus
Communication	CAN bus, Kanardia protocol
Connector Engine ECU	D-SUB 9 female (cable side)
Connector Kanardia CAN	D-SUB 9 male (cable side)

Table 1: Basic technical specifications for mini Daqu.

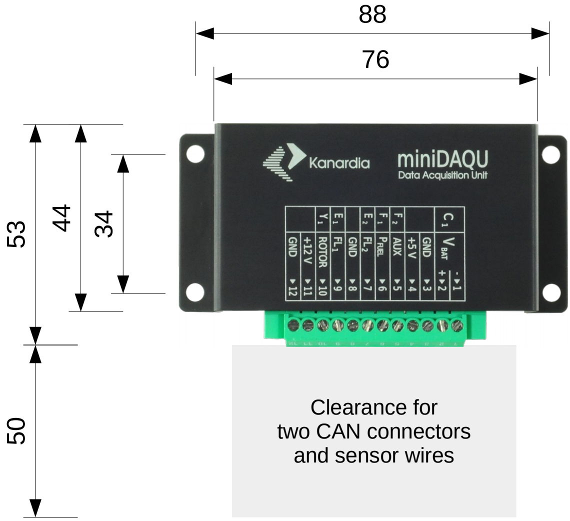

Figure 1: Dimensions and connection clearence of mini Daqu – Top View.

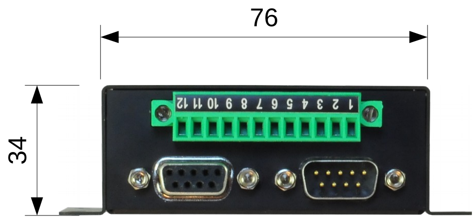

Figure 2: Dimensions and connection clearence of mini Daqu – Front View.

1.3 Power Supply

Daqu gets its power supply via CAN bus cable, which is typicall connected to some display like Nesis, Aetos, Emsis, Digi, . . . This means that displays are the power source for Daqu.

Never connect any power source directly to Daqu (Channel C is an exception). Please refer to section 2.2 for details.

1.4 Output Power Pins

Daqu has several OUTPUT power pins labeled as `+5V`, `+12V` and `GND`. These pins are OUTPUT pins only. They shall be only used to supply power from Daqu to sensors connected to them. For example, active pressure sensors require power to operate and these pins shall be used to provide power for them.

Never connect any power source to +5V or +12V pins. This will permanetly damage Daqu. Please refer to the sensor documentation for proper supply voltage.

1.5 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.

1.5.1 Analog Channels

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

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. Note this is NOT power source for Daqu. Daqu is just measuring the voltage.

E – 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. This channel has also a current generator, which used to measure resistance in low resitance range. The following currents are used to measure resistance.

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

The channel is typically used to connect resistive fuel level sensors.

F – This is the same as E channels with an additional possibility to connect current output sensors (4 mA – 20 mA). For this reason it has an internal 120 Ω resistor. Rotax oil pressure is an example of such sensor.

1.5.2 Digital Channels

The digital channels are used to measure time between pulses. Typical sensors connected to digital channels are rotor RPM and fuel flow. Mini Daqu uses only one digital channel.

Y – Used for signals with nice 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. The channel 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.

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

1.6 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 inter-connected and are in direct relation with the system bus GND.

2 Installation

This section reveals details about Daqu mechanical installation and main connectors. This section does not tell much about configuration and installation of sensors, probes and transducers. A separate section with general principles starts on page 14.

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. So when you install Daqu in engine compartment, 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 with watertight compartment.

Daqu is not shipped with the mounting hardware. You may use any appropriate removable fittings that suit the need – just do not use rivets.

2.2 Connectors and Cables

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

Mini Daqu has two D-SUB 9 connectors as shown on figure 3. The left connector is used to connect mini Daqu to Kanardia CAN bus, which also supplies power. The right connector is used to connect mini Daqu to engine ECU, Rotax iS for example.

The 12 pin connector on top is used to connect additional sensors and probes.

2.2.1 Kanardia CAN Bus Connector

This connector is used to connect Daqu to Kanardia CAN bus system. It also brings power for Daqu at the same time. On the Daqu cable side, a male

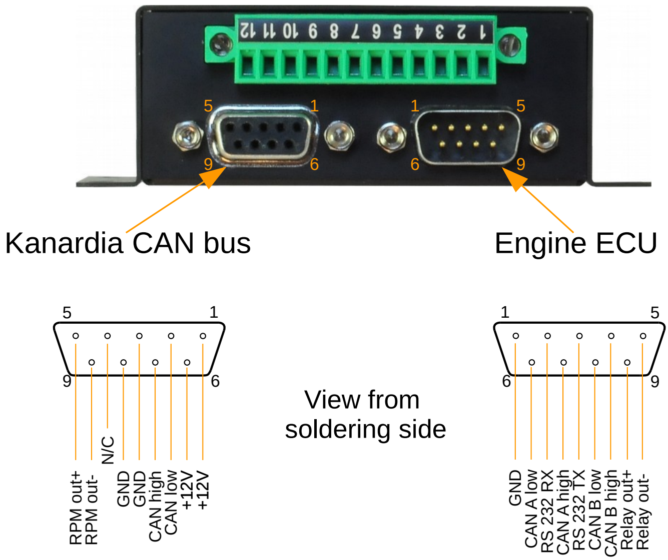

Figure 3: Details of the mini Daqu connectors. The left is used for Kanardia CAN bus and the right connects to an engine ECU.

D-SUB 9 connector is needed. The pinout of the connector is given in table 2. On the other side of the cable is usually RJ45 connector. Figure 4 shows details of RJ45 pins.

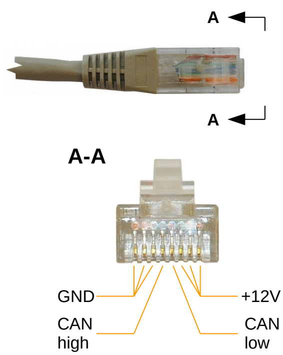

Figure 4: Details of the RJ45 connector.

Pins 5 and 9 on the D-SUB 9 can be used to send the RPM signal out, for some other instrument (e.g. propeller pitch controller). The pins are not connected to the CAN cable. Two separate wires must soldered directly to the pins and routed to the instrument.

Table 2: Daqu CAN bus connector pinout.

Pin	Description
1	+12 V - power supply for Daqu
2	CAN low
3	GND - ground
4	Not used
5	RPM out +
6	+12 V - power supply for Daqu
7	CAN high
8	GND - ground
9	RPM out -

2.2.2 ECU Connector

This connector is used to connect Daqu and engine ECU. Normally, not all pins are used. Some ECUs are connected via CAN bus and some are connected as a RS-232 device. On the Daqu cable side, a female D-SUB 9 connector is needed. On the other side of the cable are free ends. The pinout of the connector is given in table 3.

This connector also host two pins, which can drive an external relay. This can be used for automatic start switch or to trigger some external alarm.

3 Wiring in General

This section reveals some basic principles of correct wiring. Not all options are described, just typical and most common ones. The following schematics shall be considered as general wiring help. There are also other sensors that Daqu can make use of and are not described here.

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

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

Table 3: Daqu ECU connector pinout.

Pin	Description
1	GND - ground
2	RS232 RX
3	RS232 TX
4	CAN B high
5	Relay out - (or Alarm -)
6	CAN A low
7	CAN A high
8	CAN B low
9	Relay out + (or Alarm +)

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 power +5/+12 V pin to power the sensor and sensor signal is connected to E, F 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 an E channel.

3.3 Resistive Sensors

E and F channels are designed to apply a large enough measuring current, and consequently also a large enough voltage difference in order to measure resistance. The current and voltage are still low enough to be safe to be used for fuel level sensors submerged in fuel. Figure 5 illustrates connection.

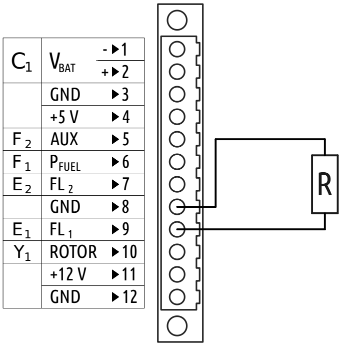

Figure 5: Resistive sensor connection on E channel.

3.4 Thermocouples

Thermocouples can not be connected to mini Daqu. If thermocouples are essential, then a modified version of standard Daqu must be used.

3.5 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 and, 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.

3.5.1 Voltage Output

Daqu can connect sensors with varying voltage output signal in range of 0-5 V. These sensors can connect to E or F channels.

An active sensor with voltage output usually has three wires. +5/+12 V sensor input wire is connected to appropriate +5/+12 V pin on Daqu, ground wire to GND on Daqu and the sensor signal output wire to one of B, D, E or F 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 6 illustrates an example of active sensor with voltage output connected to an E channel. The sensor requires 5 V to operate, but some other sensor might require 12 V. Check sensor's specs.

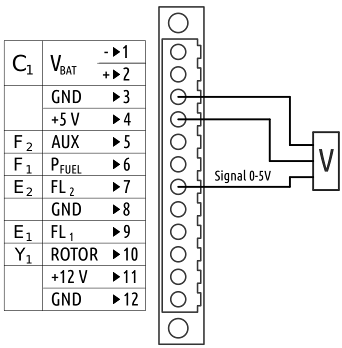

Figure 6: An example of active sensor with voltage output.

3.5.2 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 are connected F channels only. These channels have an internal 220 Ω resistor, which 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 pin. Signal is connected to one of the F channels, see Figure 7. The third wire is connected to the GND. Some sensors do not require GND connection as they are grounded via engine block.

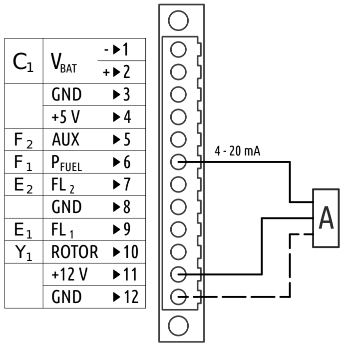

Figure 7: An example of active sensor with current output. Symbol A stands for *Ampere* which is synonym for electrical current. For some sensors connection with GND is not required.

3.6 Potentiometers

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

3.6.1 Variable Resistor

Section 3.3 applies, when they are connected as variable resistors. Figure 8 shows and example of variable resistor connection. One of F channels is used in this case, but E could be used as well.

3.6.2 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 E or F channels. Supplying voltage must not exceed 5V. In this case, the output voltage will remain within 0-5 V interval. Figure 9 illustrates possible connection.

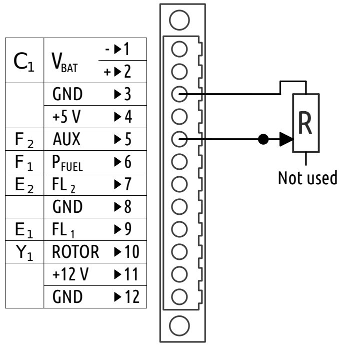

Figure 8: An example of potentiometer, connected as variable resistor to a F channel.

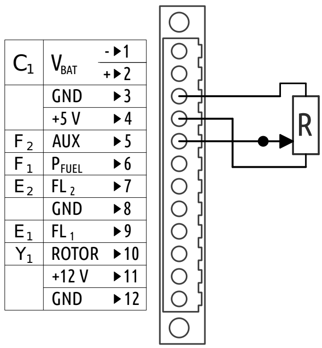

Figure 9: An example of potentiometer, connected as variable voltage divider.

3.7 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 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 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.

3.7.1 NPN – Open Collector Output

Figure 10 illustrates a typical connection for the NPN case. Here all wires are connected directly. Internaly the miniDaqu provides week pull up resistor connected to internal 5V.

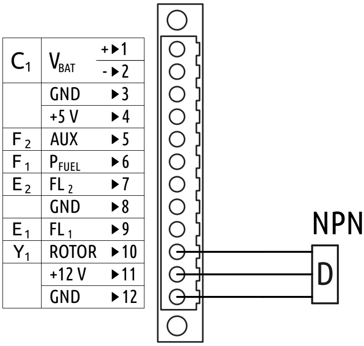

Figure 10: An example of NPN digital sensor connection.

3.7.2 PNP – Open Drain Output

Figure 11 illustrates a typical connection for the PNP case. Here, an additional 2.2 kΩ resistor is needed between GND and signal. Do not use higher resistance because internal pull-up resistor must be overriden.

4 Alarm Signal

This section gives installation details for the alarm signal. The signal is issued, when some main instrument (Nesis, Aetos, Emsis, Digi, etc.) detects a warning and transmits the alarm request to Daqu. Daqu receives the request and it activates the alarm (relay) pins on the ECU connector. This can be then used to trigger some action (e.g. illuminate a warning light on the instrument panel).

Alarm signal option can not be used in parallel with *Automatic start power switch relay*. The function of these pins must be specified in the configuration.

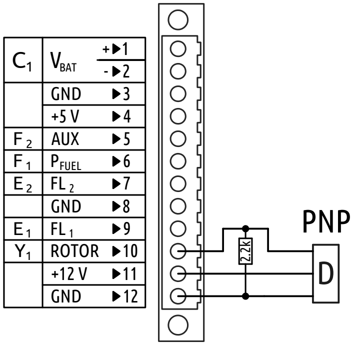

Figure 11: An example of PNP digital sensor connection.

The alarm signal uses two pins. When active, the positive alarm pin provides system voltage (usually 12 V) and the negative pin connects to ground. These pins can be used directly or indirectly.

See Figure 3 and Table 3 for ECU connector pin description.

4.1 Direct Connection

The direct connection of some load (e.g. warning light) to alarm pins is limited to 150 mA current. When load requirements are higher, the indirect solution must be used.Figure 12 illustrates a direct connection to the alarm pins.

4.2 Indirect Connection

In the cases, where load exceeds 150 mA an indirect load connection is required. A relay can be used in this example. The relay must be rated according to the load and the relay coil must match the system voltage. The system voltage is usually 12 V (but can be also 24 V on some airplanes). Figure 13 shows connection schematics. The relay signal lines must be protected by a flyback diode. Use a diode, which reverse voltage V_R is rated higher than the system voltage.

4.3 Configuration

Pins 5 and 9 on Daqu ECU connector can be used for different purposes. The function for these pins (Relay, Alarm) must be configured in software. Please

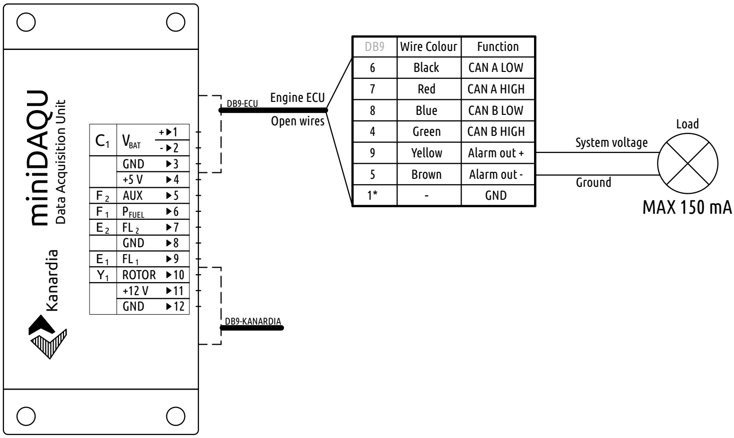

Figure 12: Direct load connection to alarm pins. The load is limited to 150 mA.

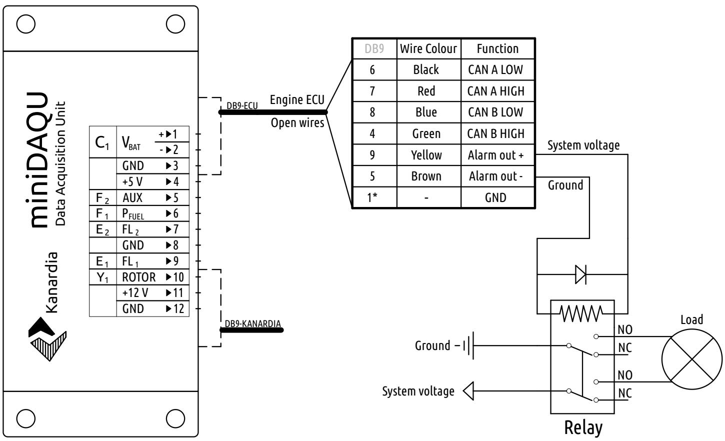

Figure 13: Load is connected indirectly using a relay.

refer to the display manual for more details. Here, solution for Nesis and Aetos is shown, Figure 14.

1. Open the *Options* page and select the *Service* icon.
2. Enter the service password and service options page appears.

3. Select the *Engine* icon.
4. On the *Daqu switch function* line select the *Alarm light* option.

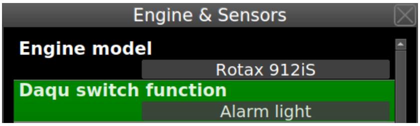

Figure 14: Illustration of Alarm light function activation on Nesis and Aetos.

5 RPM Signal

This section gives installation details for RPM output signal. Most engines with ECU transmit the engine RPM value over digital communication bus (CAN bus, RS-232). This works well with Kanardia instruments. However, some third party instruments may require classical RPM signal as it was created on engines without ECU in order to operate properly. Daqu can solve this problem.

Daqu reads the engine RPM value from ECU and creates digital pulses on the pins 5 and 9 of the Kanardia CAN bus connector. See Figure 3 and Table 2 . It creates one digital pulse per RPM. Third party instrument can connect to these pins and detect pulses in order to obtain RPMs.

5.1 Connection

Inside Daqu, an opto-isolator is used. Collector is routed directly to RPM out+ pin and emiter is routed directly to RPM out- pin. This allows different connection schematics. The most often used one is given on Figure 15.

Here some positive voltage V must be connected via a 10kΩ resistor to the RPM + pin and RPM - pin must be grounded externaly. A rectangular signal appears between the pins. The signal will oscillate between GND and supplied voltage V.

5.2 Configuration

No special software configuration is required. By default the RPM-out signal is 1 pulse per rotation with a 50% duty cycle.

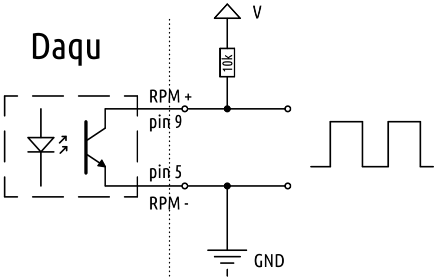

Figure 15: An example of RPM output connection.

6 Rotax iS

This section gives some specific installation tips for the Rotax iS engines. Rotax has two iS models, 912 iS and 915 iS. Although the engines are different, the ECU and connection principles are the same for both engine types.

6.1 ECU CAN Bus Connection

Rotax iS engines are equipped with ECU that has two CAN bus outputs, referred to them as Display CAN Lane A and Display CAN Lane B. Please refer to the Rotax Installation Manual documentaiton for more details.

Both lanes are connected to the Daqu Engine ECU connector, see section 2.2. Lane A comes from Rotax HIC A connector and Lane B comes from Rotax HIC B connector. Figure 16 illustractes connections. In principle, only two wires from each lane are connected. Ground is usually not connected.

Please note that Rotax iS ECU data is available only when *ECU start switch* is active or engine is running.

6.2 Configuration

Daqu must be correctly configured to read data from the ECU. When configuring Daqu correct Engine model must be selected. Select Rotax 912iS. Example of configuration dialog is ilustrated on Figure 18.

6.3 Automatic Start Power Switch

This topic is experimental.

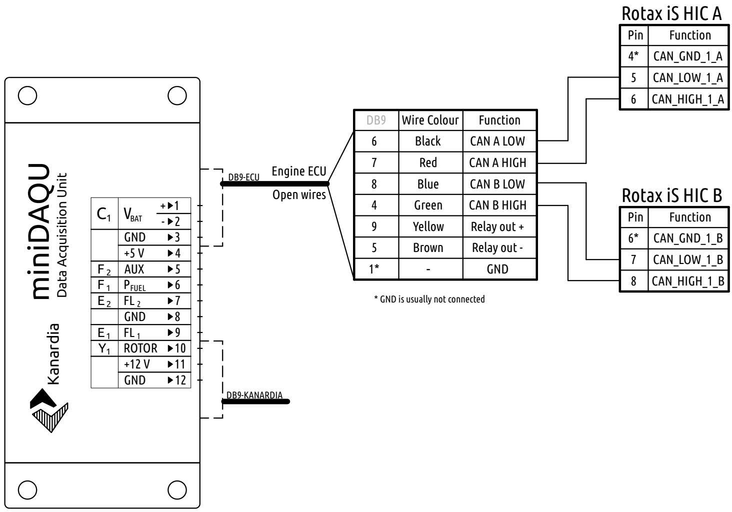

Figure 16: Schematics for Daqu Engine ECU connector. Open wire ends are connected with Rotax HIC A and HIC B connectors.

Rotax iS engines require so called *Start Power Switch*. This switch is turned on during the engine startup procedure. The role of the switch is to provide startup power for engine ECU. Once engine runs, the switch must be turned off, as engine provides its own power for ECU.

This means that two additional operations are required in the engine start sequence comparing to carbureted Rotax engines: turning the start power switch on to start the ECU and once the engine runs, turning the switch off.

6.3.1 Installation

This process can be also automated with a relay (Start Power Relay) and a signal sent from Daqu. Schematics is shown on Figure 17. The part which is added to existing Rotax schematics is drawn inside dotted rectangle.

The relay is connected in parallel to existing start power switch. In the case of relay or Daqu failure the engine can be still started using start power switch. The relay must be a double pole type and rated equally as start power switch. See Rotax installation manual for details. One such relay is Finder, P/N: 66.82.9.012.0000, but many others can be used as well.

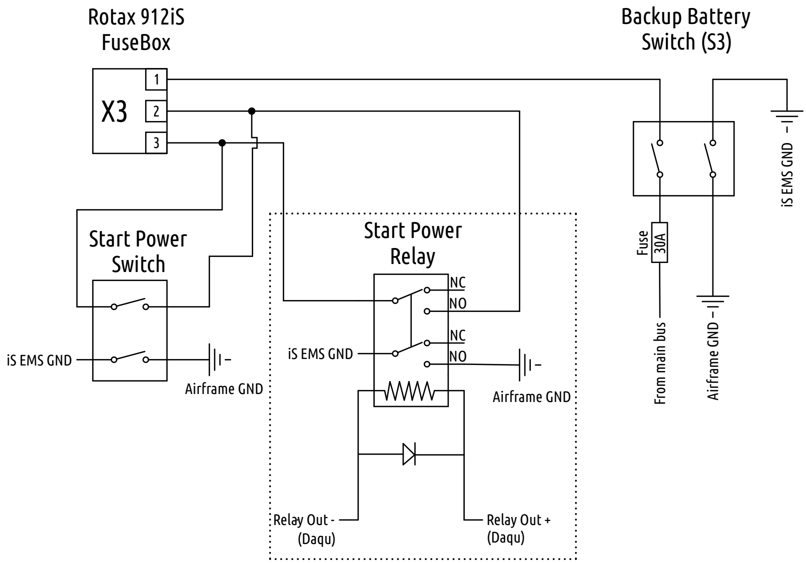

Figure 17: Automatic start power switch with a relay and connection from Daqu.

The signal from Daqu comes from the *Engine ECU* connector, pins 5 and 9. See section 2.2. When signal is high, it will energize the coil inside the relay and in turn, relay connects ECU to GND (first pole) and power (second pole).

The signal lines must be protected with a flyback diode, unless such diode is already built in the relay. Use a diode, which reverse voltage V_R is rated higher than the system voltage.

6.3.2 Configuration

Automatic start power switch option is turned off by default. The switch in Daqu can be uses for several purposes. In order to activate the automatic start power switch function, the *Daqu switch function* must be set to *iS ECU start*. In addition, the *iS start switch RPM threshold* must be set. The later defines engine RPMs, which must be reached to disconnect the relay.

At the time of the writing only Nesis and Aetos support this option. Figure 18 illustrates settings for Rotax 912 iS engine.

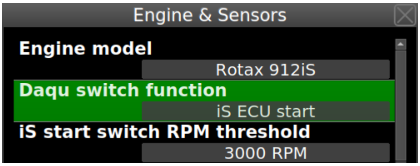

Figure 18: An example of automatic start power switch configuration for Rotax iS engine.

6.3.3 Operation

Check that parallel Start Power Switch is turned off. This switch shall be always off, when Automatic Start Power Swtich option is used.

When Daqu gets power (usually when avionics is turned on) and if engine RPMs are zero, Daqu holds Start Power Relay *on*. This means that Rotax iS ECU is also powered automatically and ready for engine start.

Once engine gets started and engine PRMs reach the value specified in the configuration, Rotax iS ECU becomes powered from its internal source and Daqu switches the ECU relay *off*.

Important: Daqu will keep relay off even after engine is stopped – it will not reengage the relay on engine stop. Avionics must be turned off and then back on in order to activate automatic start relay again.

If Daqu fails to engage relay (due to some malfunction) and you can't start the engine, turn the parallel Start Power Switch on – follow the stadard Rotax iS engine start procedure. Once engine starts, turn the parallel Start Power Switch off.

7 ULPower Engines

This section gives some specific installation tips for the ULPower engines. These engines are equipped with ECU that has a CAN and serial RS232 output. The ECU can be directly connected to the Daqu either using CAN or RS-232 protocol. Furthermore, some ULPower engines can also two ECUs. In case of two ECUs, Daqu must be connected over CAN bus with both ECUs – RS-232 protocol can't be used in this case.

ULPower engines may also use an AUX box for reading various sensors not directly related to ECU. This AUX box is connected directly to one ECU or to both ECUs (when two ECUs are used). The ECU combines data from AUX box with its own data and outputs the combined data over CAN or RS-232.

Figure 19 illustrates an example with one ECU connected to Daqu using RS-232 serial communication. The AUX box is optional.

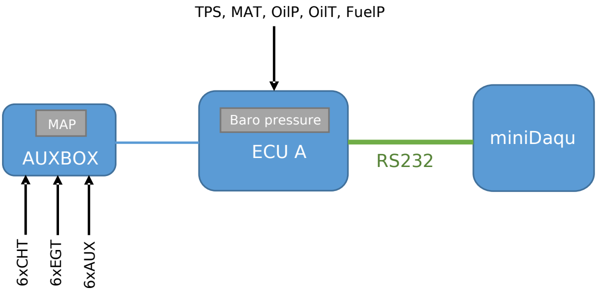

Figure 19: Block view of ECU connection over RS-232 protocol.

Figure 20 illustrates an example with one ECU connected to Daqu using CAN bus. The AUX box is optional.

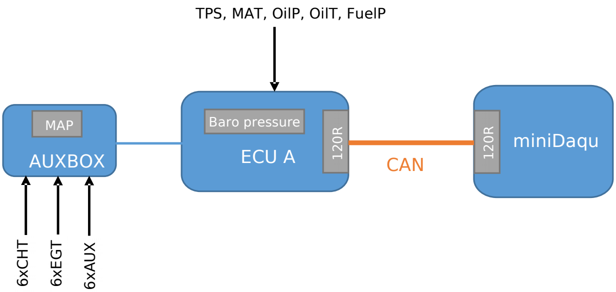

Figure 20: Block view of ECU connection over CAN bus.

Figure 21 illustrates an example with two ECUs. In this case only CAN bus can be used. The AUX box is optional.

7.1 ECU and AUX Parameters

According to ULPower documentation the ECU provides the following parameters: RPM, throttle position, engine compartment ambient pressure, air(box)

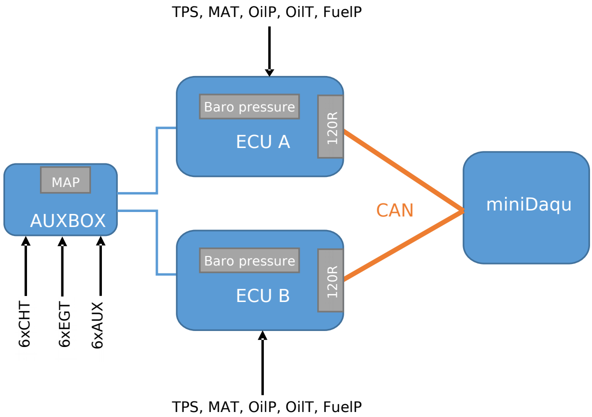

Figure 21: Block view of dual ECU connection CAN bus.

temperature, oil pressure, oil temperature, fuel pressure, fuel flow, ECU temperature, ECU supply voltage, engine hours, ignition status and sensor status.

Optional AUX box provides the following additional parameters: manifold pressure, EGT 1-6, CHT 1-6 and some auxilary values.

Daqu can utilize all parameters provided by ECU and AUX box with exemption of auxilary values.

Please note that some additional sensors can be connected to Daqu, too.

7.2 ECU CAN Bus Connection

Please note that GND is not connected to prevent ground-loops. We assumed that the engine and Daqu are both connected to the common aircraft ground. The CAN connection differs regarding the number of ECUs used.

7.2.1 One ECU

When only one ECU is used, a terminator resistor must be also installed on Daqu side (usually inside the DB9 connector between pins 4 and 8). In the connector, which we provide, the resistor in not installed by default. You have to install it yourself. Please refer to table 4 for correct connection of Daqu to ULPower ECU.

Table 4: Connection table for CAN bus.

DB9-ECU	Function	ECU
Pin 6	CAN A Low	ECU1 CAN Low
Pin 7	CAN A High	ECU1 CAN High
Pin 8	CAN B Low	connect pins 8 and 4
Pin 4	CAN B High	with 120 Ω resistor
Pin 1	GND	N/C

7.2.2 Two ECUs

When two ECUs are used, they are already terminated and no additional resistor is needed. Table 5 summarizes connections.

Table 5: Connection table for CAN bus.

DB9-ECU	Function	Dual ECU
Pin 6	CAN A Low	ECU1 CAN Low
Pin 7	CAN A High	ECU1 CAN High
Pin 8	CAN B Low	ECU2 CAN Low
Pin 4	CAN B High	ECU2 CAN High
Pin 1	GND	N/C

7.3 ECU RS-232 Connection

The serial port interface can be connected to only one ECU. Daqu receives data stream from ECU, decodes data and send it over Kanardia CAN bus protocol. Please refer to Table 6 for connecting ULPower ECU to Daqu via serial protocol. Please note that GND is usually not connected to prevent ground-loops. In this case the engine and Daqu must be connected to the common aircraft ground. But if the GND line is also connected, there should be no harm.

ECU does not listen to Daqu TX and nothing is sent from Daqu anyway. So connection of Pin 3 is not required.

Table 6: Connection table for serial RS-232 bus.

DB9-ECU	Daqu Function	ECU
Pin 2	RS232 RX	RS232 TX
Pin 3	RS232 TX	RS232 RX (connection not required)
Pin 1	GND	N/C

7.4 Configuration

When configuring Daqu, correct Engine model must be selected. An example of configuration dialog is illustrated on Figure 22.

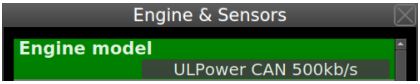

Figure 22: An example ULPower engine selection.

Select one of the following options:

`ULPower RS-232` when ECU is connected using RS-232 serial connection.

`ULPower CAN 125 kb/s` when ECU is connected using CAN. The communication speed is 125 kb/s. This speed was used ECUs delivered until 1.11.2018. Please check your ECU.

`ULPower CAN 500 kb/s` when ECU is connected using CAN. The speed 500 kb/s is used in latest ECUs. Please check your ECU.

When additional Daqu channels are used, they must be properly configured. A function selected by Daqu channel will override same function provided by ECU or AUX.

7.5 Fuel Pressure - MAP Sensor Is Required

Fuel pressure indication will not be correct without knowing the manifold pressure. Either ULPower AUX box or a MAP sensor connected to Daqu is required.

ULPower ECU provides fuel pressure information. According to our experiences ULPower is using a vented-gage type fuel pressure sensor. This means the ECU sends fuel pressure measured in the fuel rail line relative to the ambient pressure in the engine compartment.

However, the fuel injectors *feel* the fuel rail pressure on one side and the manifold pressure on the other side. This pressure difference across the injectors is what it should be displayed on the screen. But there is a small catch. ULPower ECU does not provide manifold pressure information by default. This can be solved in one of two ways:

- Use ULPower sensor AUX box. The AUX box does provide the manifold pressure to the ECU and the ECU forwards it to Daqu. Daqu detects this and the difference is calculated automatically.
- If you do not use the AUX box, you shall connect external manifold pressure sensor directly to Daqu. This is detected and the difference calculation is again automatic. Refer to the section 9.9 for more details.
- If there is no manifold pressure information, Daqu will provide the absolute fuel pressure in the fuel line. This value will be probably out of the valid range as the pressure was not compensated with MAP.

8 MWfly Engines

> CAUTION: This section is preliminary!
> The content is not verified!

This section gives some specific installation tips for the MWfly engines. MWfly engines are equipped with ECU that has a CAN output. However, Daqu can not be directly connected to this ECU and an interface is needed. This interface is called *CC-m* CAN to CAN module and it is provided by MWfly.

8.1 CC-m Module

The module is equipped with a D-SUB 9 male connector. Please refer to the CC-m module documentation for proper pin out and details.

CAN Aerospace low and high pins from the CC-m connector shall be connected to the Daqu ECU connector. Ground is usually not connected. Figure 23 shows connection schematics.

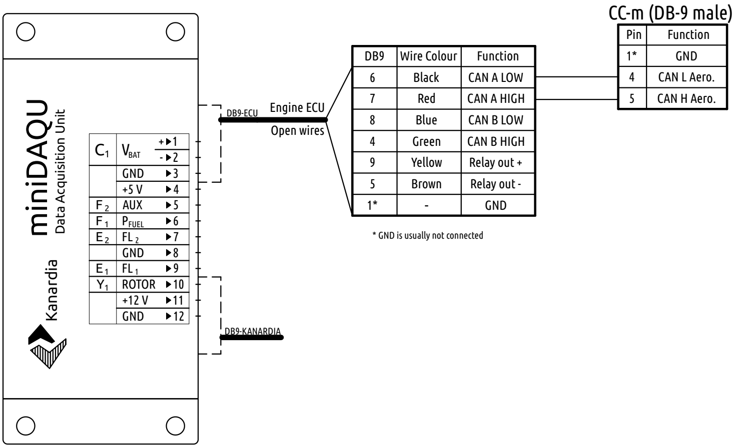

Figure 23: Schematics for Daqu Engine ECU connector. Open wire ends are connected with MWFly CC-m module connector.

9 Additional Sensors

Most of engine data is transmitted ECU. However, some additional sensors may be connected to mini Daqu, which either supplement or override information from ECU.

When a sensor is connected and activated on Daqu and engine ECU already provides such sensor, the sensor connected on Daqu takes priority and overrides values from ECU.

9.1 Fuel Pressure

In most cases, ECUs do not have fuel pressure information. In order to get it, a fuel pressure sensors must be connected to Daqu.

Rotax iS is a bit special here and it is explained in a separate section 9.2.

9.1.1 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.
- In vented gage type, the 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.

IMPORTANT: Daqu supports mostly *vented gage type* pressure sensors. Absolute types can be also used in specail cases.

9.1.2 Installation

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.

9.1.3 Configuration

Various sensor configurations are given in tables listed next. The *Max value* or sometimes *Ref val.* must be always set in *bar* unit. If the sensor limit is specified in PSI, convert this to bar and set this the value in bars into channel configuration. 1 PSI equals to 0.06894757 bar. The following table lists some common conversions.

PSI	bar
7	0.48
15	1.03
35	2.41
70	4.83
100	6.89
150	10.34

Table 7: Conversion table of PSI to bar for commonly used pressures sensors. Always enter bar value during channel configuration.

9.1.4 Variable Voltage

Sensors with variable voltage output were described in section 3.5.1. Connection example is given on Figure 6. It shows an active sensor with 0.5 – 4.5 V output. The sensor in example requires 5 V to operate.

The sensor configuration is shown on Table 8. Because this sensor is a generic one, max value (or reference value) must be also specified. This value is sensor specific.

Option	Selection/Setting
Channel	Any E or F
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)	10 (depends on sensor)

Table 8: An example of active pressure sensor with 0.5 – 4.5 V output. Max value is set to 10 bar.

9.1.5 Variable Current

A connection example for current varying sensor is given. The sensor from example requires 12 V for power. Signal output is currect between 4 and 20 mA. Sometimes these sensors are grounded via engine block, so GND lead is not connected. Figure 7 shows connection schematics.

Corresponding configuration is shown in Table 9. Only F 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.

Option	Selection/Setting
Channel	Any F
Function	Fuel pressure
Sensor	4-20 mA Int Res
Report time	0.5 – 1.0 s
Filter	2.0 s
Max value (at 20 mA)	10 (depends on sensor)

Table 9: Typical fuel pressure configuration for sensors with current output. Max value is set to 10 bar.

9.2 Fuel Pressure - Rotax iS

Rotax ECU does not have a fuel pressure sensor. In order to measure and indicate fuel pressure a sensor must be connected to Daqu. Reference fuel pressure is about 3 bar. Example on Figure 24 shows the most often used solution with a 10 bar sensor. The sensor has a voltage output in 0.5 to 4.5 V range.

9.2.1 Configuration for Vented Gage Sensor

The channel used for this sensor must be also properly configured. Table 10 shows example.

Note that *Fuel P. cmp* is used for the function. This abbreviation stands for *Fuel Pressure Compensated*. This means that fuel pressure is calculated in a special way from three different values: fuel pressure measured by sensor S, fuel pressure in manifold M and fuel pressure in engine compartment E. M and E are obtained from ECU. The indicated fuel pressure F is then calculated as:

$$F = (S + E) - M$$

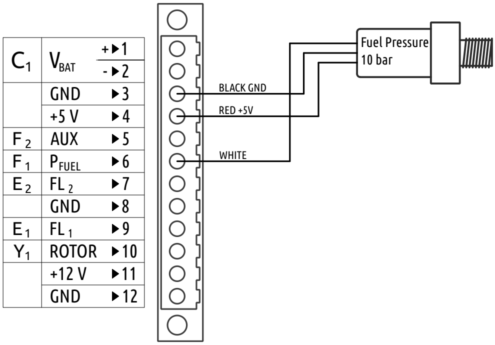

Figure 24: Schematics for fuel pressure sensor with voltage output. Here we assumed a sensor which requires 5V to operate. Your sensor may be different and it may require 12V to operate. Check the sensor datasheet.

Table 10: Rotax iS engine with vented gage fuel pressure sensor.

Option	Selection/Setting
Channel	Any E or F
Function	Fuel P. cmp.
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

The $S + E$ term gives absolute fuel pressure. The resulting pressure is difference between absolute fuel pressure and absolute manifold pressure, as it is required by Rotax manual.

9.2.2 Configuration for Absolute Sensor

Absolute sensor option is available since software version 3.7.

When compared to vented gage sensor, the only difference is in the *Function* settings. Table 11 shows the configuration.

Note that *Fuel P. cmp abs* is used for the function. This abbreviation stands for *Fuel Pressure Compensated, Absolute*. The fuel pressure is difference between the absolute fuel pressure detected on the rail S and manifold pressure

Table 11: Rotax iS engine with absolute fuel pressure sensor.

Option	Selection/Setting
Channel	Any E or F
Function	Fuel P. cmp abs
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

M. The indicated fuel pressure F is then calculated as:

$$F = S - M$$

9.3 Voltage

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

Some engines, Rotax iS, for example, transmit their own system voltage, which is obtained from engine ECU. When a voltage is connected and activated on Daqu C channel, this voltage will override the voltage transmitted by ECU.

9.3.1 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 25 illustrates an example.

9.3.2 Configuration

The table 12 shows correct channel settings.

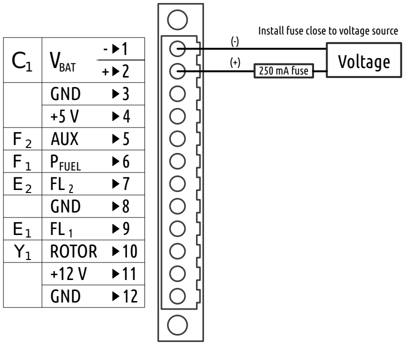

Figure 25: System voltage measurements. A 250 mA (or less) fuse is required close to the system bus source.

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

Table 12: Channel C configuration for system voltage.

9.4 Current

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

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

9.4.1 Installation

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

Sensor has three wires. Red wire provides power for the sensor operation and connects to +5 V pin. Black wire provides sensor ground and connects to GND pin. White wire provides signal and connects to one of E or F channels. See Figure 26 for proper connection schema.

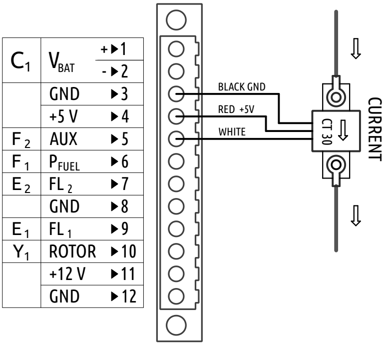

Figure 26: CT-30 sensor connection schematics.

9.4.2 Configuration

The table 13 shows possible channel settings. Alternatively, *El. current 2* can be also selected for the second current sensor.

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

Table 13: Connection of -30 to +30 A electrical current sensor.

9.5 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.

9.5.1 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 9.5.2.
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 9.5.4 and 9.5.3 for more details.
4. Daqu channel configuration: Use Nesis/Aetos/Emsis/Blu to enter Daqu channel configuration values. Consult values given in tables 14 and 15. 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.

9.5.2 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.

9.5.3 Resistive Fuel Level Sensors

Connection principles for resistive sensors were already given in section 3.3, starting on page 15.

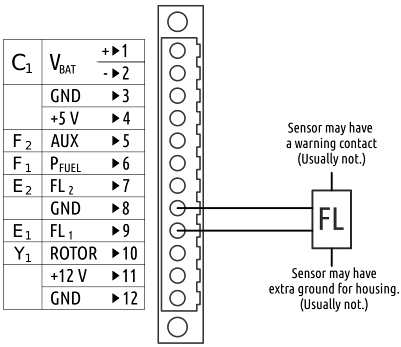

Figure 27: An example of resistive fuel sensor. Usually it has only two connections. But it can have more. Please refer to the sensor manual for more details.

Typical configuration for a sensor from Figure 27 is shown in Table 14. 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.

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.

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 14: Typical fuel level configuration.

9.5.4 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 28 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 15.

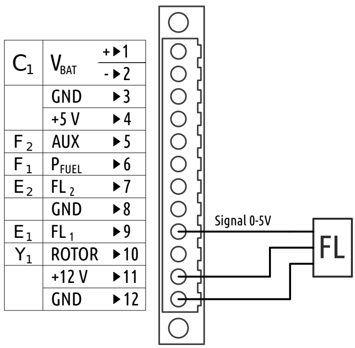

Figure 28: An example of capacitive fuel level probe connected to the +12 V power source. Some probes require 5 V, be careful.

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 15: Typical fuel level configuration for a capacitive sensor.

9.5.5 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.

9.6 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 3.6 starting on page 18. Here, configurations are shown for both cases.

9.6.1 Variable Resistance

Figure 8 shows typical schematics for the variable resistance. The corresponding channel is configured something like shown by Table 16.

Option	Selection/Setting
Channel	Any E or F
Function	Pitch trim
Sensor	Res 400 Ohm / 5 kOhm / 10 kOhm
Report time	0.2 – 0.5 s
Filter	about 0.5 s

Table 16: An example configuration for pitch trim resistive sensors.

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

9.6.2 Variable Voltage Divider

Figure 9 shows typical schematics for the variable voltage divider. The corresponding channel is configured something like shown by Table 17.

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

Table 17: An example configuration for pitch trim sensor connected as variable voltage divider.

9.6.3 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.

9.7 Rotor RPM

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

Connection schematics were already given in section 3.7. Two schematics were given, one for NPN sensor, Figure 10 and the other for PNP sensor, Figure 11.

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 18 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 18: An example for rotor RPM connected to Y channel. Sensor is in rotor head, hence the reduction ratio is set to 1.0. Your case will be different.

See also section 1.5.2 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 19: 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. Your case will be different.

9.8 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.

Almost all sensors are NPN type (FlosScan, FT-60). Connection schematics is given on figure 10. Refer to the sensor documentation for proper connection and operating voltage.

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.

9.8.1 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.

9.8.2 Configuration

Example configuration is made for FT-60 fuel flow sensor, a.k.a. *Red cube.* This sensor connects to 12 V. Figure 10 shows connection schematics for this sensor (NPN type). The sensor has 68000 pulses per US gallon. This equals to $68000/3.7854 \approx 18000$ pulses per liter. Table 20 shows configuration details.

9.9 Manifold Pressure

Manifold pressure information is usually provided by ECU. But there are cases where this information is not available and here a MAP sensor is connected to Daqu.

Option	Selection/Setting
Channel	Y only
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 20: An example for rotor RPM connected to Y channel.

9.9.1 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 29 illustrates the sensor and connector.

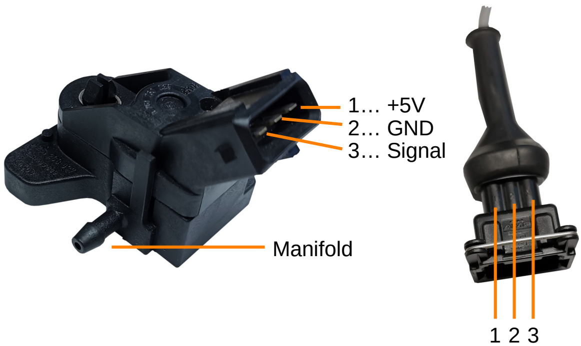

Figure 29: External manifold pressure sensor, Bosch 0 261 230 037.

The sensor can be connected to any E or F channel. When purchased at Kanardia, the sensor comes equipped with a cable. The connection schematics is given on Figure 30.

An example of channel configuration is shown in Table 21.

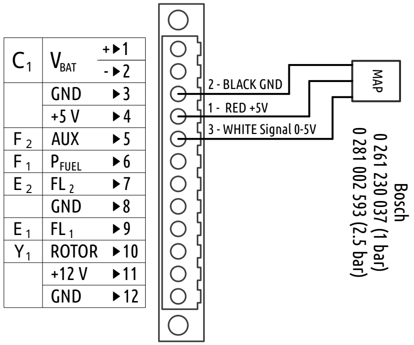

Figure 30: External MAP sensor from Bosch, connection schematics.

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

Table 21: Configuration example for external Bosch MAP sensor.

9.9.2 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 9.9.1 apply here. The only difference is the part number in the configuration table.

10 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.

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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.

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

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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.