INDU COMBO
Manual

Kanardia d.o.o.

November 2018

Revision 1.0

Contact Information

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

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Revision History

The following table shows the revision history of this document.

Rev.	Date	Description
1.0	November 2018	Initial release

Contents

1 Introduction

First of all, we would like to thank you for purchasing our device. Indu Combo is an electronic device, which mimics classical construction and combines it with the state of the art electronics. This results in the best of both worlds; a perfect and intuitive analogue reading combined with high precision of modern electronics.

This manual describes the technical description of the unit, installation and operation.

CAUTION: Indu Combo is not TSO approved as a flight instrument.

1.1 General Description

Combo is an electromechanical device. It consists of high precision electronic differential pressure sensor and altitude pressure sensor, which provide dynamic and static air pressures in digital form. The electronics reads the sensor and drives stepper motor turning a needle, which shows airspeed an a scale.The scale has markings specific to an aircraft.[1] Altitude, rate of climb and QNH informations are also shown on a colour LCD display. When connected to a CAN bus Combo outputs airspeed, altitude, static pressure, QNH and standard altitude data which can be used by other Kanardia devices.

The QNH (baro-correction) units can be changed. You can choose between:

- hPa in the range of (590 – 1080) with one hPa step.
- inHg in the range of (17.42 – 31.89) with 0.01 inHg step.

[1] Markings must be specified at the time of order.

1.2 Technical Specification

Table 1 shows some basic technical specification.

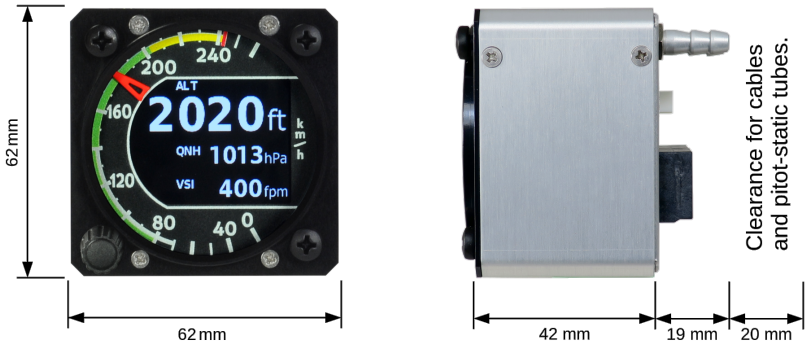
Description	Value
Weight	57 mm: 200 g
	80 mm: 210 g
Size	57 mm: 62 x 62 x 45 mm
	80 mm: 82 x 82 x 45 mm
Operational voltage	6 $\sim$ 32 V
Power consumption	1.26 W
Current	105 mA at 12 V 53 mA at 24 V
Operating temperature	-30 $\sim$ +85 °C
Humidity	30 $\sim$ 90 %, non condensing
Airspeed sensor	12 bit, 0 $\sim$ 69 hPa, 381 km/h (205 kt), resolution $<$ 0.1 km/h
Barometric sensor	24 bit, 10 $\sim$ 1200 hPa, 20 cm resolution
QNH range	590 $\sim$ 1080 hPa, (17.42 $\sim$ 31.89 inHg)
Internal logger storage	more than 50 h, 1 s interval
Communication	CAN bus, 29 bit header, 500 kbit, Kanardia protocol

Table 1: Basic technical specifications.

1.3 Options

1.3.1 Scale

The instrument can be delivered with different scales. Basically, there are no standard scales and you have to define the scale units and scale



(a) 57 mm

(b) 80 mm

Figure 1: Front and side view with its principal dimensions.

markings at the time of order. Scale is then custom made for each individual order. Scale holds color-coded markings in order to give the pilot immediate reference. The following markings are possible:

- V_{NE} – **Red line on the top of yellow arc.** This designates

never exceed speed limit. This is a speed, which should never be exceeded due to the risk of structural failure.

- V_A – **Top of green and bottom of yellow arc.** This designates the design maneuvering speed. This speed is limited by aircraft structural characteristics at full control inputs deflecton.
- V_{FE} – **Top of white arc.** This defines maximal extended flap speed. Note that a different speed limit may be defined for partial extended flap.
- V_{REF} – **Yellow triangle.** The triangle defines the reference speed. This defines the landing reference speed or threshold crossing speed.
- V_{S1} – **Bottom of green arc.** Stall speed or minimum steady flight speed for which the aircraft is still controllable in a specific configuration. This is usually a clean configuration with flaps retracted. Note that bottom of green arc usually starts at 10% higher value.
- V_{S0} – **Bottom of white arc.** Stall speed or minimum flight speed in landing configuration. Note that bottom of white arc usually starts at 10% higher value.

1.3.2 Display

The standard LCD display indicates baro corrected altitude on the top, QNH settings in the middle and vertical speed at the bottom. Figure 3 shows the display.

If you want a different LCD display layout, you can configure it yourself with our Customizer desktop application.[2] This option requires

[2] Available from April 2020

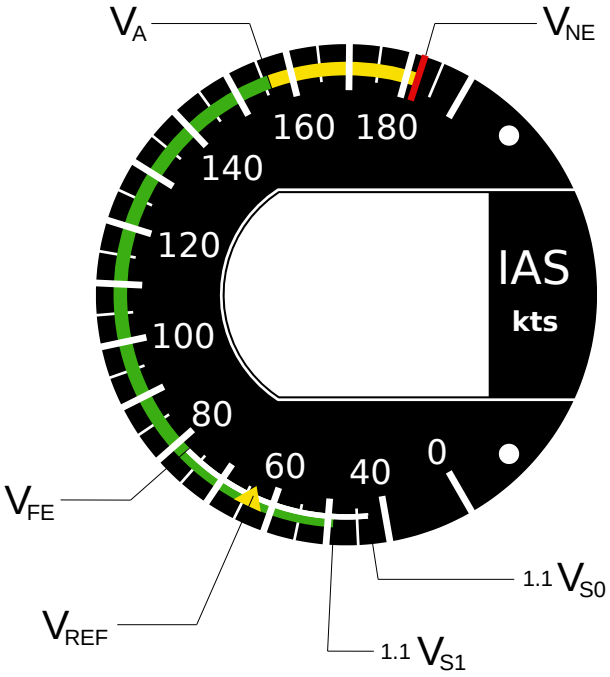


Figure 2: A scale example with the markings.

Figure 3: Combo display example.

Kanardia's Blu device for transfering the configuration from your android device to your Indu Combo. Please read our Customizer Manual for more information.

2 Installation

The instrument requires a standard size 57 or 80 mm hole in the instrument panel. The position of the hole must ensure that the instrument is always visible from the pilot's perspective.

2.1 Mounting & Dimensions

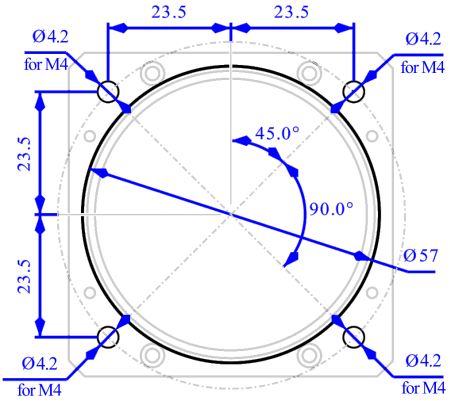
The mounting screw holes are located on a circle of 66.5/89 mm diameter. The instrument is mounted using three screws type M4. To prevent internal stresses, please make sure that the instrument panel is flat.

Remove the mounting screws from the instrument and then remove the knob. Use finger nail or sharp knife to remove the cap from the knob, but be careful not to cut the cup away. Once the cap is removed, use flat screwdriver and loosen the screw. Slide the knob from its axle. Figure 4 shows an example of the knob with its cap removed.

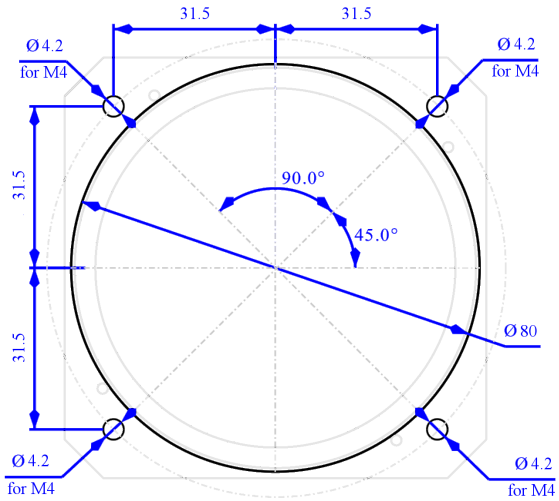
Figure 4: Photo of the knob with its cap removed.

It is highly recommended that the instrument panel is mounted using rubber shocks, which reduce the vibrations. Figure 5 illustrates the mounting hole for both sizes of instrument.

Bottom left hole is used for the push button strut.



(a) 57 mm



(b) 80 mm

Figure 5: Instrument panel cutout and mounting hole. Note: Figure is not in scale.

2.2 Connections

Figure 6 illustrates all connections at the back side of the instrument.

(a) 57 mm

(b) 80 mm

Figure 6: Back view of the instrument with connections.

2.2.1 Static Pressure - `Pst`

Indu Combo must be connected to the static pressure source. Static pressure source is usually obtained from pressure sources located on the fuselage side surfaces or from the static port on the pitot tube.

Locate the existing tube, cut it at an appropriate place and insert a T junction. Install a new tube from junction to the instrument.

It is highly recommended to keep the static tubing as short as possible. The tubing must avoid sharp bends and twists. The tubing must be airtight. Water must not be allowed to enter the tubing.

It is strongly recommended to label each tube before connecting to Indu Combo. This will help a lot if you ever have to remove and re-install the instrument.

2.2.2 Total Pressure - `Ptot`

Indu Combo must be connected to the total pressure source. Total pressure source is obtained from the total port on the pitot tube.

Same principles as with the static connection apply.

2.2.3 CAN Bus - `CAN`

Connection to the CAN bus is optional and is not required for the normal operation.

Use standard RJ45 ethernet cable to connect it with other Kanardia equipment.

When connected to the bus, airspeed, dynamic pressure, standard atitude, baro corrected altitude, baro correction and static pressure data will be transmitted to the other units connected on the bus.

2.2.4 Illumination

LCD display brightness level can be adjusted. Here are two options: new instruments have a push-rotate knob, while older instruments have only rotating knob. When Indu Combo is connected to the CAN bus, the knob adjusts brightness of all instruments connected to the bus.

On instruments with a push knob, simply push the knob, adjust the brightness and push the knob once more.

For instruments with only rotation knob, an optional external illumination knob can be connected to the back of the instrument. Illumination knob part number is I-ALT-ILLUM and it must be ordered separately. Please refer also to section 3.3 on page 16 for the activation procedure.

2.2.5 Power - POWER

Connect supplied connector at the back of Indu Combo. The connector has a notch on one side, which protects from wrong orientation.

Connect blue lead to negative (ground) terminal and red lead to positive (+12-24 V) terminal.

3 Calibration Adjustments

The knob is used to perform some adjustments.

3.1 Altitude Adjustment - Static Sensor Offset

1020 → 999 → 1013 for hPa or 30.12 → 29.50 → 29.91 for inHg.

A minor sensor offset may be required in order to adjust Indu Combo according to some other reference instrument. Please, follow the steps given below in order to make the adjustment. A precise reference instrument is needed in this procedure.

1. Set both the reference instrument and Indu Combo to 1013 hPa and compare the readings. Write down the altitude shown by the reference.

2. Turn the knob on Indu Combo to indicate 1020 hPa (30.12 inHg) and wait for about 3 seconds for a short cyan line to appear on the top of LCD display.

3. Quickly turn the knob to indicate 999 hPa (29.50 inHg). A moment later a longer cyan line appears on the top. You must reach 999 hPa before cyan line disappears.

4. Turn the knob to select 1013 hPa (29.91 inHg) and wait for a moment. Again, you have to reach this value before cyan line disappears.

5. Now a full cyan line appears and the LCD display is slightly altered. It shows the offset and the altitude. Turn the knob until Indu Combo shows the same altitude as the reference altimeter. Wait for cyan line to disappear.

   This completes the sensor offset procedure.

3.2 Toggle QNH hPa – inHg

1020 → 1025 → 1013 for hPa or 30.12 → 30.27 → 29.91 for inHg.

Part of the LCD display is also a QNH value. This value can be shown in hPa or in inHg units. You can change the units using next procedure:

1. Turn the knob until it shows 1020 hPa (30.12 inHg) and wait for about three seconds for a short cyan line to appear on top of LCD display.

2. Quickly turn the knob to indicate 1025 hPa (30.27 inHg). A moment later a longer cyan line appears.

3. Turn the knob to 1013 hPa (29.91 inHg) to complete the procedure. Observe the units and values next to QNH. They changed from hPa to inHg and vice versa.

3.3 Toggle Illumination Knob

1020 → 1035 → 1013 for hPa or 30.12 → 30.56 → 29.91 for inHg.

This section applies only to instruments without push/rotate knob.

If the external illumination knob does not work – screen does not react on the knob, try the following procedure. This procedure enables remote illumination knob if it was not enabled or disables illumination knob, if it was enabled.

1. Turn QNH until it shows 1020 hPa (30.12 inHg) and wait for about three seconds for a short cyan line to appear on top of LCD display.
2. Quickly turn the knob to indicate 1035 hPa (30.56 inHg). A moment later a longer cyan line appears.
3. Turn the knob to 1013 hPa (29.91 inHg) to complete the procedure.
4. Finally, you need to turn off Indu Combo and then back on in order to activate the change.

4 Maintenance & Repair

No special maintenance is required.

The instrument has no serviceable parts inside. In the case of malfunction, it must be sent to factory for a repair.

5 Troubleshooting

5.1 Freeze During Engine Start

In certain aircraft installations instrument freezes and then reboots itself, when some large current consumers are switched on. This is caused by a very short voltage drop as a consequence of the consumer's power demand.

A simple electronic circuit illustrated on Figure 7 may help in this case. The circuit consist of two elements.

- The diode prevents reverse flow from the capacitor. We recommend Schottky Diode 1N5818G. You can also use some other diode, which has a low voltage drop, 1 A forward current and at least 20 V of blocking voltage.

- The capacitor serves for a very short energy reserve. Use an aluminium electrolytic capacitor with about 1000 µF, at least 25 V and at least 100 °C working temperature.

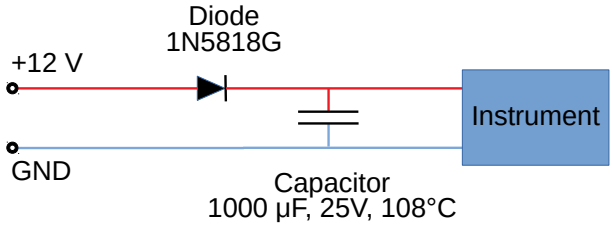


Figure 7: Circuit that may prevent sudden voltage drops in certain installations.

6 Sensor Calibration & Altitude Calculation

6.1 Calibration Procedure

Each unit is factory calibrated against reference barometer at different pressure points. In standard calibration range we calibrate in following pressure sequence: 1100, 1000, 900, 800, 700, 600, 500, 400, 280, 550, 650, 750, 850, 950 and 1050 hPa. These measurements are then repeated at different temperatures ranging from -10 to 60 °C in 7 °C steps.

Please note that FAA Part 43, Appendix E does not require calibration/verification at different temperatures. But temperature calibration is essential for any electronic sensor.

This means that each instrument is calibrated against $13 \cdot 11 = 143$ different temperature - pressure pairs. The least squares method is then applied on this results in order to obtain corrections coefficients. A two dimensional, third degree polynomial is used for the correction model.

You can't change calibration parameters, but you can adjust the altitude. Please refer to the section 3.1 for more details.

6.2 Pressure Altitude Calculation

Pressure altitude is calculated according to the ISA 1976 model of athmosphere. First two athmosphere layers are used; throposphere and thropopause. The throposphere is modeled by equation (1) up to 11000 meters of geopotential altitude. The thropopause layer is modeled by equation (2) up to 20000 meters of geopotential altitude.

As the pressure sensor is calibrated down to 100 hPa (about 16000 meters) altitudes above 16000 meters are not reliable.

$$p = p_0 \left[\frac{T_0 + T_0' \cdot z}{T_0} \right]^{\frac{-g_0}{RT_0'}} \quad (1)$$

$$p = p_1 \exp \left[-\frac{g_0(z - z_1)}{RT_1} \right] \quad (2)$$

The equations converts geopotential altitude into pressure. Here z means geopotential altitude, $g_0 = 9.806645$ m/s^2 is gravity constant, $R = 287.0528$ N $\cdot$ m/kg $\cdot$ K. is gas constant for dry air, $p_0 = 1013.25$ hPa is standard pressure at sea level, $p_1 = 226.321$ hPa is standard pressure at throposphere/thropopause limit, $z1 = 11000$ m is geopotential altitude of the limit, $T_0 = 288.15$ K is temperature at sea level, $T_1 = 216.65$ K is temperature at limit and $T_0' = -0.0065$ K/m is temperature gradient in throposphere.

Besides the equations given below, their inverse and derivatives of inverse are also used.

6.3 Altitude Derivative

Altitude calculated from pressure is numerically derived to get rate of altitude change – vertical speed. The derivative is mathematically correct and as such does not introduce any error. We are using multiple point numerical derivation.

7 Limited Conditions

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

7.1 Warranty

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

Warranty Coverage

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

Kanardia d.o.o. warrants the Kanardia-branded hardware product will conform to the published specification when under normal use for a period of twenty-four months (24) from the date of retail purchase by the original end-user purchaser ("Warranty Period"). If a hardware defect arises and a valid claim is received within the Warranty Period, at its option and as the sole and exclusive remedy available to Purchaser, Kanardia will either (1) repair the hardware defect at no charge, using new or refurbished replacement parts, or (2) exchange the product with a product that is new or which has been manufactured from new or serviceable used parts and is at least functionally equivalent to the original product, or, at its option, if (1) or (2) is not possible (as determined by Kanarida in its sole discretion), (3) refund the purchase price of the product. When a refund is given, the product for which the refund is provided must be returned to Kanardia and becomes Kanardia's property.

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

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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

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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.