

HUVVER-AVI™

ARDUINO COMPATIBLE PROGRAMMABLE AIRCRAFT INSTRUMENT QUICK START GUIDE V7A



1. DESCRIPTION

The huVVer-AVI™ is a general-purpose *customizable* aircraft instrument that uses the Espressif Systems ESP-32 microprocessor. Instrument source code is provided for the popular Arduino platform, ensuring long-term support and enhancements from developers world-wide.

Created for experimental aircraft applications, the huVVer-AVI provides a bright 2.4 inch (61 mm) LCD screen, dual RS-232 serial ports, a CAN bus interface, two relay or lamp drivers, two sensor inputs, a pair of stereo audio outputs, and four front-panel pushbuttons that fits into a standard aircraft 2.25" or 3.125" panel cutout. Operating at input voltages from 8 to 35 volts, and withstanding voltage surges of up to +/- 100 volts, the unit is ideally suited to aeronautical applications.

Arduino (www.arduino.cc) is an open-source hardware/software integrated development environment (IDE), originally created as an educational tool. It has been widely adopted by small to medium sized companies as the platform of choice for quick-turn development of custom microcontroller applications. Developers worldwide support the millions of Arduino users, providing readily available, low cost hardware and open-source software.

The huVVer-AVI family was developed to be *production-ready prototyping systems*. Fully compatible with the Arduino or Espressif IDE development environments, it provides robust power conditioning and multiple levels of protection from electrostatic discharge, over voltages, and short circuits. The units fit into standard aviation 2-inch or 3-inch circular instrument cutouts.

Currently, the huVVer-AVI units require an external Dynon (SkyView, D10A, D100), Garmin (G3X, G5), or OnSpeed system to provide reliable air, system, or engine data. Future enhancement will use other data sources (both wired and wireless) to provide more flexibility. Of note, MakerPlane (<https://MakerPlane.org>) and OnSpeed (www.flyonspeed.org) are developing precision ADAHRS systems that will be supported by the huVVer-AVI units.



Figure 1. More Display Examples

FEATURES:

- Easy to use, open-source Arduino programmable aircraft instrument.
- Bright 850 cd/m² 320 x 240 pixel US-made color display.
- Four front panel programmable buttons.
- High performance Espressif ESP-32 dual-core 240 MHz microprocessor with 520 KB SRAM, and 4 MB Flash memory for programs and data.
- 802.11 b/g/n WiFi and Bluetooth V4.2/LE for wireless connections to external units.
- CAN, dual RS-232 serial, and USB interfaces for wired connections to external devices.
- Operates from 8 to 35 Volts DC with -20 °C to +55 °C ambient temperatures and provides extensive power and I/O conditioning to increase reliability in harsh environments.
- I/O capability
 - Two general purpose (0-5 volt) sensor inputs, with a 5 Volt power output for sensor power.
 - Left and Right stereo audio (8-bit) for alarms and signaling. 300 ohm source impedance.
 - Two 50 Volt open-collector I/O channels for driving external lamps or relays, with on-board coil suppression.
 - Two RS-232 Serial ports.
 - One CAN based Two-Wire Automotive Interface (TWAI, compatible with ISO11898-1)
 - One Universal Serial Port (USB) for program development.

APPLICATIONS:

Complete, general purpose flight-tested instrument libraries are available from www.huVVer.tech.

Version 7 and subsequent libraries includes the following gauges:

- Airspeed Indicator,
- Altimeter,
- Heading Indicator,
- Attitude Indicator,
- AOA indicator,
- OnSpeed Energy indicator,
- Engine Power gauge cluster,
- EGT and CHT temperature gauge cluster,
- Fuel, Oil and Electrical gauge cluster (Fuel Tank Levels),
- Fuel, Oil and Electrical gauge cluster (Fuel Flow and Quantity), and
- Various raw data pages (to assist in installation and program development).

Most instruments are configurable to display supplementary information, to change units, or to configure ranges and thresholds. *Note: For the engine gauges only, setting a negative value for the 'Max' value will turn off an individual gauge.*

Library Versions:

- Version 2 of the library adds Over-The-Air (OTA) wireless updates for downloading new software.
- Version 3 of the library adds configurable WiFi credentials.
- Version 4 of the library adds field-configurable serial port assignment and enhanced screen dimming functions for night-time operation. Instrument graphics have also been updated to improve legibility.
- Version 5 of the library adds multiple protocol recognition on the serial ports, and the ability to select serial ports on-the-fly.
- Versions 6(Beta) and 7 of the library adds four sets of engine instrument clusters.

2. BASIC INSTALLATION

For installation, you will need Mil-spec wire, a number of crimp terminals and at least one connector housing. Appropriate terminal crimper, wire cutter and wire stripper tools are also required.

Crimp Pins: Digikey WM2312-ND. **Note: MakerPlane supplies 10 pins with each instrument.**

Connector Housing: DigiKey WM2006-ND. **Note: MakerPlane supplies two housings with each instrument.**

Wire and wiring supplies: Mil-spec M22759/16-22 (22 AWG single), M27500/20SB1T23 (22 AWG shielded single wire), M27500/22SB2T23 (22 AWG shielded pair), plus a circuit breaker as required. Available from Aircraft Spruce or ProWire USA.



Using the wiring standards defined in FAA publication AC43.13, connect the huVVer-AVI unit to aircraft power. Each unit can draw up to 500 mA of peak current, so 22 AWG wire and a 5 Amp fuse or breaker is adequate. Several units may share one circuit.

Connect Serial Port 2 input (Connector A, pin 4) to any available serial port output from a Dynon SkyView, Garmin G3X, or Garmin G5 EFIS system, using their recommended techniques. Optionally, an another EFIS, or an OnSpeed black box may be connected to the Serial Port 1 input (Connector A, pin 2). For short distance (less than two metres or 6 feet), unshielded wire is acceptable. In addition to power and ground and the optional twisted pair to the CAN port, the RS-232 serial *inputs* are used for to receive EFIS streaming data. The associated serial *outputs* replicate the serial input data or WiFi UDP data, and may be daisy-chained to the inputs of other displays.

The EFIS serial port (if used) must be configured to 115200 bits per second and ADAHRS, (SYSTEM) and EMS output. (Note: Garmin does not support the SYSTEM output mode). The OnSpeed black box is preconfigured to operate at 115, 200 bits per second.

If a WiFi connection to the Dynon SkyView is desired, a Dynon WiFi Adapter(s) must be installed on the SkyView EFIS in your system. Starting with Version 3 of the huVVer-AVI software, the WiFi credentials of your system are entered on-screen using the built-in WiFi Manager, accessible from the System Configuration menu, see **Section 9. WiFi Manager.**

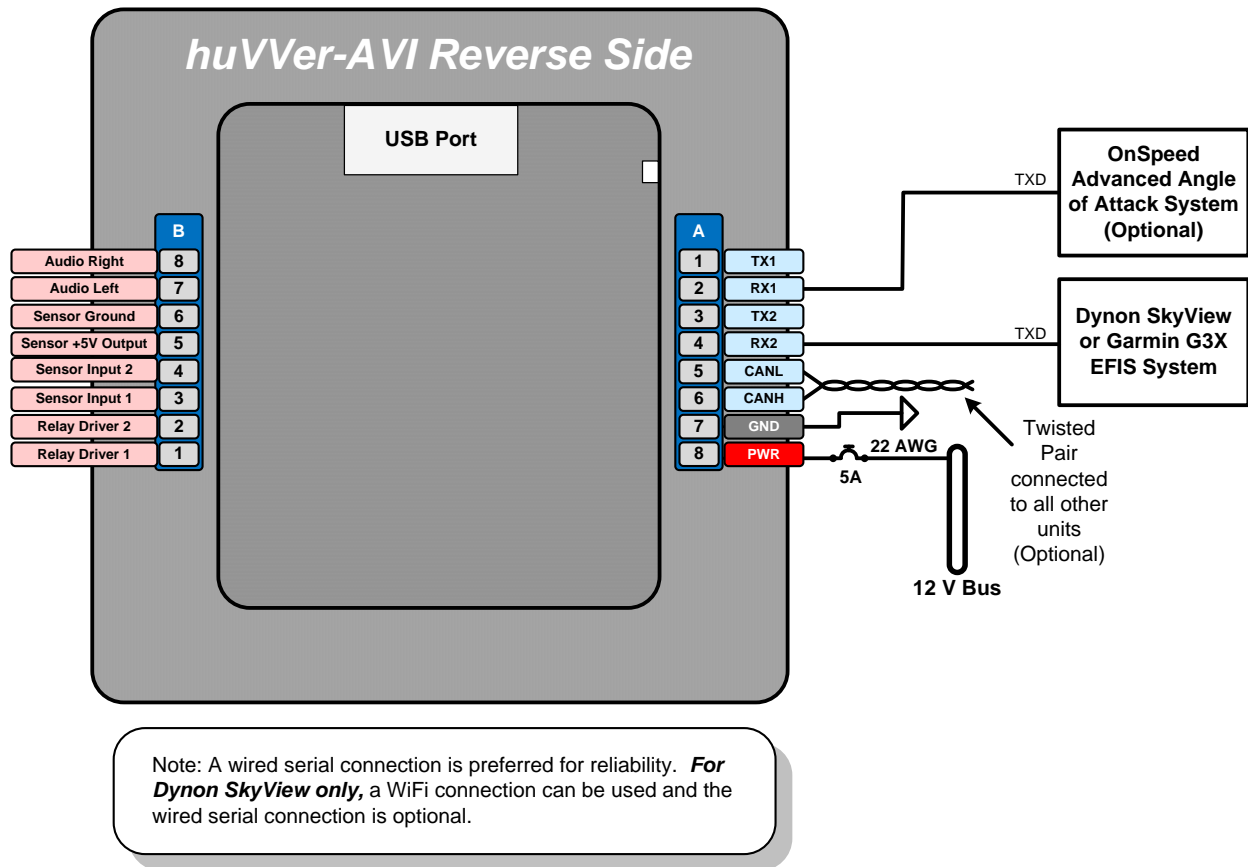


Figure 2

Figure 1. Typical Installation.

3. ADVANCED INSTALLATION

For advanced installation, in addition to the basic power and serial data connections, the following connections are available:

- CAN bus to compatible instruments,
- Audio Left and Right to an audio mixer or intercom system,
- Sensor Inputs to external switches and/or senders,
- Open collector Relay Driver outputs to external lamps or relays.

Some or all of these connections may be required in the future for new features, depending on unit software.

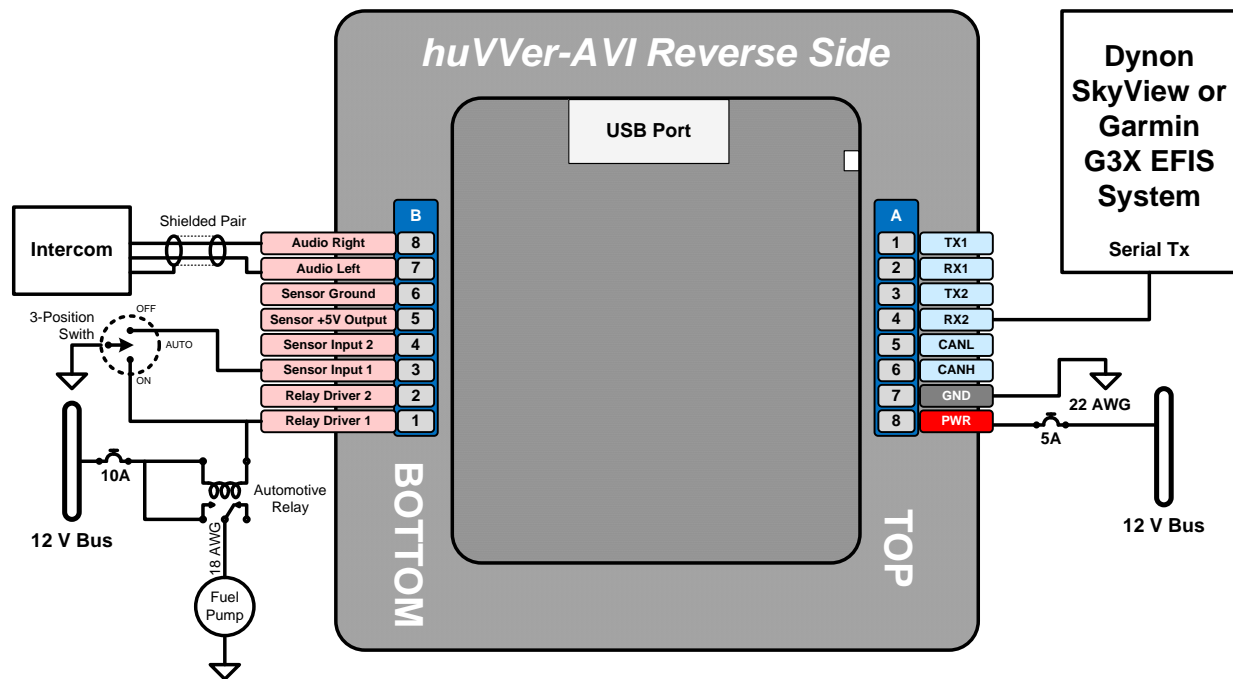


Figure 2. Advanced Installation, Fuel Pump Controller Example

AUTOMATIC FUEL PUMP CONTROLLER

Figure 2 shows an example of how the huVVer-AVI unit may be configured as a general purpose automatic fuel pump controller, in addition to normal display functions such as a fuel computer (tank levels, fuel pressure, flow rate, time remaining, etc.). Note: This example will require customized software development.

The fuel pump switch has Off, Auto, and On positions. Fuel pressure is derived from the information contained in the EFIS EMS data stream. In the On position, the fuel pump switch directly controls the fuel pump relay without software intervention. In the Off or Auto positions, the fuel pump is controlled in software. The software detects when fuel pressure is too low. Then, the pump is turned on by using the Relay 1 (OC1) pin.

Of note, this wiring configuration allows the 3-position switch to override the huVVer-AVI output during engine startup.

4. HARDWARE

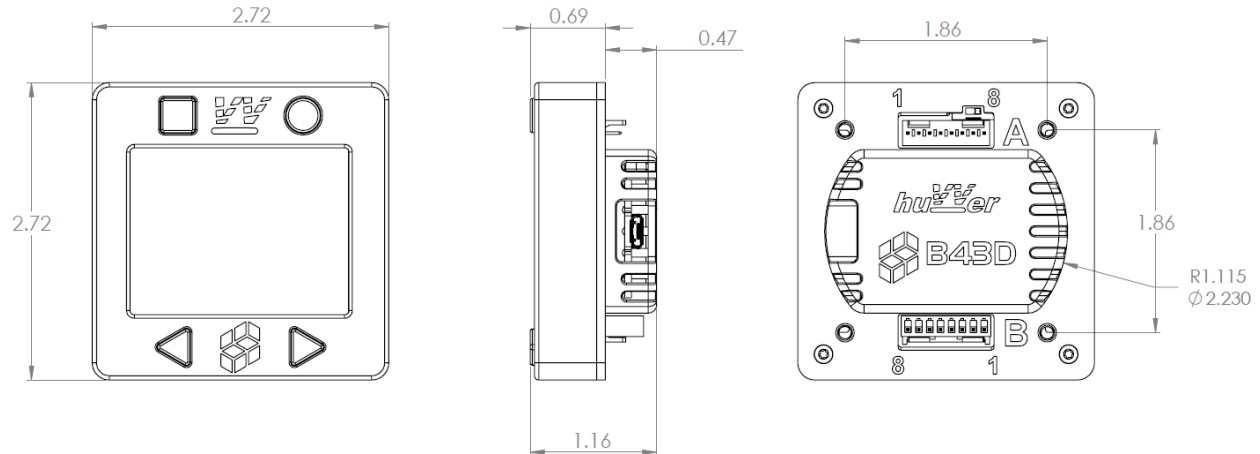
PIN DESCRIPTION

CONNECTOR A			
Pin Number	Pin Name	ESP32 Function	Pin Description
1	TX1	IO22	Serial RS-232 Transmit Port #1.
2	RX1	IO21	Serial RS-232 Receive Port #1.
3	TX2	IO17	Serial RS-232 Transmit Port #2.
4	RX2	IO16	Serial RS-232 Receive Port #2.
5	CANL	IO14 Tx & IO27 Rx	Can bus L pin. Internal ESP32 pin IO22 controls the CAN driver (See Appendix A).
6	CANH	IO14 Tx & IO27 Rx	Can bus H pin. Internal ESP32 pin IO22 controls the CAN driver (See Appendix A).
7	GND	Avionics Ground	Connect to Avionics Ground.
8	PWR	Power	8 to 35 Volt power input.

CONNECTOR B			
Pin Number	Pin Name	ESP32 Function	Pin Description
1	AUDR	IO26	Audio output, right channel, 300 ohm impedance.
2	AUDL	IO25	Audio output, left channel, 300 ohm impedance.
3	GND	Signal Ground	Ground for external sensors.
4	+5V	Sensor bias Voltage	Bias voltage for external sensors (500 mA maximum). Not an input.
5	X2	IO33	External sensor input 2 (0 to 5 Volt range). Pulled up to 5 Volts internally through a 300 ohm resistor.
6	X1	IO32	External sensor input 1 (0 to 5 Volt range). Pulled up to 5 Volts internally through a 300 ohm resistor.
7	OC2	IO12	Relay or Lamp driver 2. Open collector drive.
8	OC1	IO4	Relay or Lamp driver 1. Open collector drive.

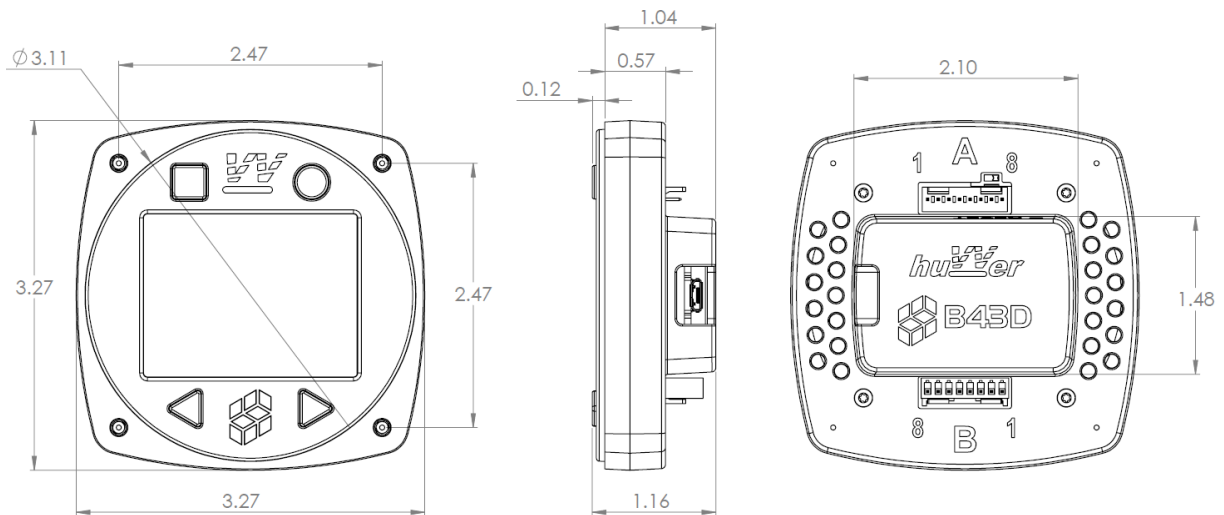
INSTRUMENT INSTALLATION DIMENSIONS

HUVVER-AVI-2 (2.25" AVIATION INSTRUMENT CUTOUT)



Note: The huVVer-AVI-2 is recommended for fascia mounting only.

HUVVER-AVI-3 (3.125" AVIATION INSTRUMENT CUTOUT)



Note: The huVVer-AVI-3 is recommended for flush mounting only. Contact factory for fascia mount option.

5. SOFTWARE

SOFTWARE INSTALLATION

The software for the huVVer family is written in C/C++ on the Arduino software development platform. It is assumed that any developer who wishes to modify the supplied open-source software is familiar with the installation of the Arduino environment, libraries, programming, and debugging. Details are at <https://www.arduino.cc/>

The huVVer-AVI source code is provided at <http://www.huvver.tech/huvver-avi/>. The huVVer.tech website will always be the primary location for product details and support.

To install the program libraries, download the required .zip files to your PC. **Make sure you rename the files to remove the dash number at the end of the file names such as (-1, -2, etc. that computers automatically add if you have multiple copies downloaded).** Open the Arduino main program menu **SKETCH:INCLUDE LIBRARY** then select **ADD.ZIP LIBRARY**, then navigate to the downloads location on your computer to select the renamed .zip file(s). Repeat this procedure as required.

In addition to the *GaugeWidgets* library, you must also have either or both of the *huVVerLink* and *M5Stack* libraries installed.

The following additional libraries are required. Click on the links below, and then click on the green box labeled 'Code' and select Download ZIP. Install as described above.

AsyncTCP.h <https://github.com/me-no-dev/AsyncTCP>

ESPAsyncWebServer.h <https://github.com/me-no-dev/ESPAsyncWebServer>

AsyncElegantOTA.h <https://github.com/ayushsharma82/AsyncElegantOTA> Note, this is also a resident Arduino library and may be enabled from the Arduino **TOOLS: MANAGE LIBRARIES...** menu

SavLayFilter.h <https://github.com/jmderomedi/SavitzkyGolayFilter>

ESP32SJA1000.h <https://github.com/sandeepmistry/arduino-CAN>

Set the **ADDITIONAL BOARDS MANAGER URLS** under the Arduino main menu **FILE:PREFERENCES** to "https://dl.espressif.com/dl/package_esp32_index.json, http://arduino.esp8266.com/stable/package_esp8266com_index.json". **Note: this is not a clickable link. Copy and paste this text inside the quotation marks into the Arduino Preferences field.**

Restart Arduino, then go to **FILE:EXAMPLES** to select the *GaugeWidgets* library and run the *FlightInstruments.ino* sketch in the Examples folder. *We recommend setting the board manager to "ESP32 Dev Module" initially, although some of the M5Stack selections will also work (for the M5Stack only). With any selection, you must turn off PSRAM.*

To switch between the huVVer-AVI or M5Stack units, read the top section of the *FlightInstruments.ino* sketch for instructions.





6. MENU SYSTEM

There are 5 menu levels in the huVVer-AVI software:

1. Boot Menu
2. Default Menu
3. List Menu
4. Action Menu
5. WiFi Manager Menu






BOOT MENU





The *Boot Menu* is not displayed, but some buttons are active during initial start-up of the unit.

- Holding down the Menu  button and the Select  button together will restore the System settings to factory defaults.
- **Important:** When the unit is stuck waiting to connect in WiFi Receive mode, pressing the  button for one second will turn off the WiFi receiver and allow the unit to start up. The WiFi Receive mode must be manually re-enabled on the System Configuration page.
- Holding down the Menu  button alone will enable the WiFi Manager (alternate method).

DEFAULT MENU (TOP LEVEL)





The *Default Menu* is the main operating mode of the unit.

- Pressing the Select  button will ramp up or down through the screen brightness levels. Holding the button for one second will flip the ramp direction. The brightness setting will be automatically written to permanent memory after four seconds of no adjustment and all other instruments connected on the CAN interface will be set to this new brightness. **NOTE:** Pressing and holding the Select  button down will cause the message “Dim Toggle” to flash, then **after four seconds the unit will restart**.
- Pressing the Fwd  button will select the next enabled instrument,
- Pressing the Back  button will choose the previous enabled instrument, and
- Pressing the Menu  button will enter the *List Menu*, where unit configuration options are listed.

Note: The M5Stack units only support three buttons: A - , B -  and C - . There is no Back  button.





LIST MENU


The *List Menu* is where individual settings are listed.

- Pressing the Menu button  will exit and save any modified settings.
- Pressing the Fwd  or Back  button will cycle through the list.
- Pressing the Select  button will select the chosen item for editing and enter the *Action Menu*.

ACTION MENU



The *Action Menu* is for editing the digits of the selected setting.


- Pressing the Select  button while editing will cycle through the available digits within a number.
- Pressing the Fwd  or Back  buttons will cycle through the digit values (0-9 or +/-)
- Pressing the Menu  button will keep the edited value and return to the *List Menu*.

Note: Some settings will automatically restart the unit, and others *will require a manual restart before changes to take effect. If required, the restart is performed by holding down the Select  button for four seconds while in the Default (top level) Menu.*

ALL MENUS (VERSION 5 AND ABOVE)

On-the-Fly WiFi Receive and Serial Port Selection. In normal operation, the following selections are available:

- Running in **WiFi Receive mode**: Holding the Menu  button down for four seconds will disable the WiFi Receive mode and switch to the Serial mode. This selection *is not persistent* and will go back to WiFi Receive mode when the unit is restarted. Note: if the WiFi receiver cannot connect after restarting, hold the Select  button down for one second to persistently disable the WiFi Receive mode. See [Boot Menu](#).
- In **Serial mode**: Holding the Menu button down for four seconds will switch between the two serial ports (Serial 1 → Serial 2 or Serial 2 → Serial 1). This selection *is persistent* and will be preserved when the unit is restarted.

Note: When holding the Menu  button down, the displayed page will change. Keep holding the button down until either the “Serial 1” or “Serial 2” message is displayed.

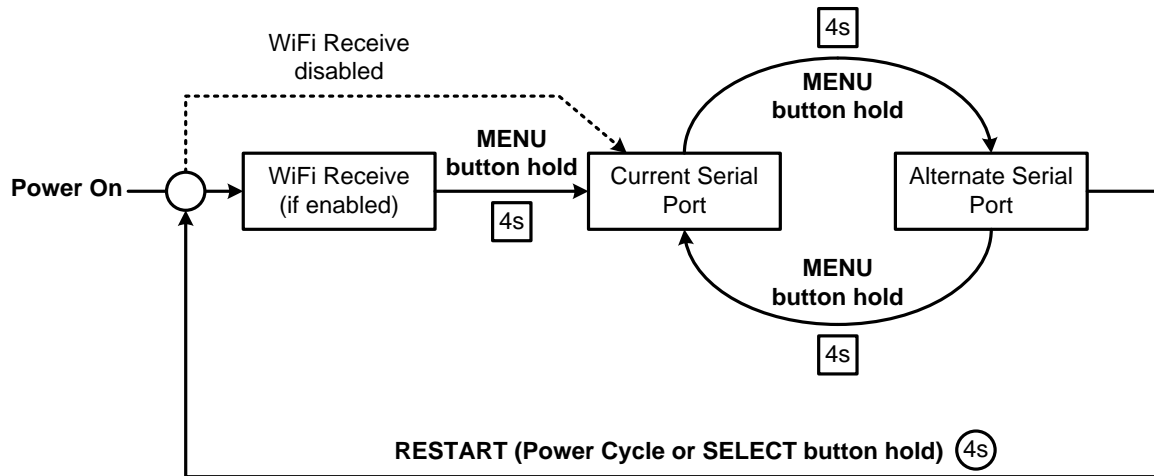








Figure 2 On-the-Fly WiFi Receive/Serial Port Selection

7. WIFI MANAGER MENU (VERSION 3 AND ABOVE)

The *WiFi Manager Menu* is for editing the unit WiFi credentials. It is fundamentally different from the main menu structure.

- Pressing the Select  button will move the cursor down one position.
- Holding the Select  button down for several seconds will exit the WiFi Manager and restart the unit without saving credentials.
- Pressing the Fwd  or Back  buttons will move the cursor right or left, respectively.
- Pressing the Menu  button will enter the key value or execute an action.
- Pressing the Menu  button while the cursor is on SAVE/EXIT will save the WiFi credentials and restart the unit.

8. OVER-THE-AIR (OTA) UPDATES

The following describes how to upload new software using the built-in WiFi capability of the huVVer-AVI units.

If you are provided with an update file (filename ends in .bin), save it in a known location on your portable or handheld device. The file should not be saved in an offline cloud server.

To generate your own .bin file directly from the Arduino IDE, your sketch must not be located in the Arduino libraries folder. From the IDE, select **SKETCH: EXPORT COMPILED BINARY** under the Arduino main menu. This will compile your program and place the object file in your sketch folder. You can move this file to a convenient place, or send it to your portable or handheld device.

UPDATE PROCEDURE


NOTE: some portable or handheld devices assume that whatever network to which they are connected is also linked to the internet, and the following procedure will stall. Try waiting a few minutes for this to clear before proceeding. Make sure your .bin file is located directly in the file system on your device.

1. On the huVVer-AVI, from the System Configuration Menu, set OTA Update to '1', then exit the menu.
2. The unit will automatically restart in OTA Update mode.
3. On your device, connect to the unit's WiFi network, using the OTA ssid and password displayed on the System Configuration page. The defaults are 'huVVer-AVI' for both fields.
4. In a web browser address bar, enter '192.168.4.1/update'.
5. Follow the on-screen instructions to download your .bin file.
6. When the download is complete, the huVVer-AVI unit will restart and execute the updated software. It will be automatically configured to the unit settings in effect prior to the OTA update. You can change the unit settings from the System Configuration menu. Some selections will require a manual restart to take effect, allowing multiple selections to be combined before restart. Certain other selections will automatically restart in order to properly configure the unit.

Note that there is an OTA Update Instructions page on the huVVer-AVI unit. Also, the System Configuration page or the WiFi Manager function both provide the appropriate network ssid and password information needed for OTA updates. If the password information is not visible on the System Configuration page, select the WiFi Manager mode to view the WiFi Credentials.





9. WIFI MANAGER

Beginning with Version 3 of the unit software, the ability for user editing of WiFi credentials is supported. The following describes the operation of the WiFi Manager.

There are two ways to enter the WiFi Manager. The first method is to use the System Configuration menu to set WiFi Manager to '1'. The second method is to hold the Menu  button down during power-on or restart until the keyboard page appears.

EDITING WIFI CREDENTIALS

NOTE: The button operations for the on screen keyboard are different from the main system operation.

1. From the System Configuration Menu, set WiFi Manager to '1', then exit the menu.
2. The unit will automatically restart in WiFi Manager mode.
3. On your unit, four WiFi credentials will be shown (EFIS-ID, EFIS-PW, UNIT-ID and UNIT-PW)* with their associated ssids and passwords. Below these is a keyboard capable of alphanumeric and control function entry.
4. Use the Select , Forward , or Back  buttons to navigate the keyboard. Note: The M5Stack does not have a Back button.
5. Use the Menu  button to make a selection and to edit the highlighted credential.
6. Select the **Enter/Next** key to highlight and rotate through the WiFi credential fields for editing.
7. When done editing, select the **Save/Exit** key. The credentials will be saved in permanent memory and the unit will restart with the new WiFi credentials.

** EFIS-ID & EFIS-PW are normally the WiFi credentials of the upstream EFIS. However, when the huVVer-AVI unit is configured as a WiFi transmitter, these are the credentials used by downstream units. The UNIT-ID & UNIT-PW credentials are used for Over-The-Air (OTA) software downloads.*

9. APPENDIX A. QUICK REFERENCE

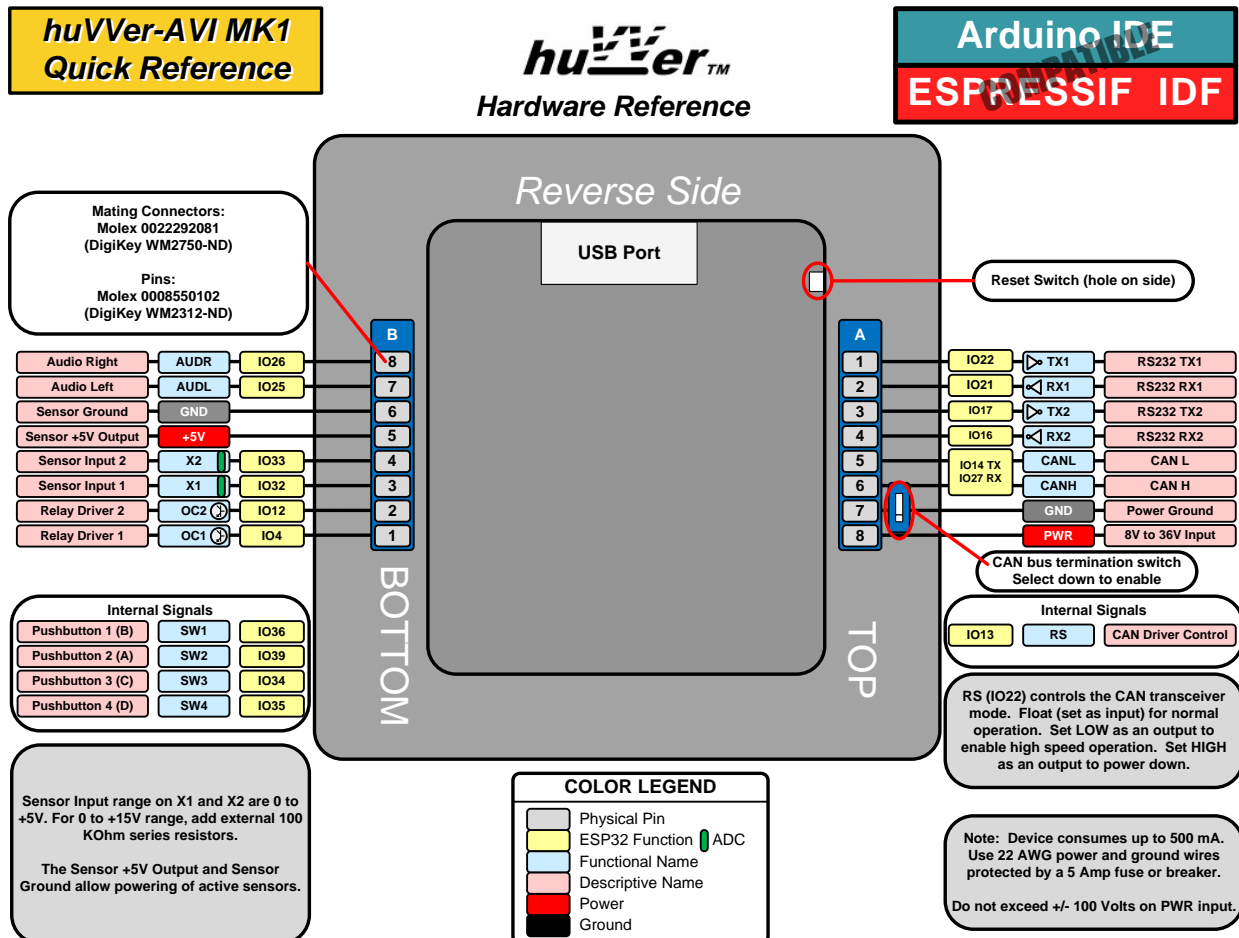


Figure 4. huVVer-AVI Quick Reference Diagram

10. SOURCING INFORMATION

To purchase a fully assembled and tested unit, contact MakerPlane (<https://MakerPlane.org>).

Models available:

huVVer-AVI-3. Fits into a standard 3.125" aircraft instrument hole. Approximately 3.27" square (83.1 mm square). Flush mounting supported. Fascia mounting requires simple modification-- contact factory for more details.

huVVer-AVI-2. Fits into a standard 2.25" aircraft instrument hole. Approximately 2.72" square (69.1 mm square). Only fascia mounting is supported.

11. DOCUMENT REVISION HISTORY

Issue Number	Date	Purpose
VXD-2103001V1A	March 6, 2021	Product Release. Software Version 1.0
VXD-2103001V1B	April 3, 2021	Added documentation for Garmin G5 support
VXD-2103001V2A	April 26, 2021	Restructured Menu system, System Configuration page and added Over-The-Air (OTA) program update capability. Software Version 2.0
VXD-2103001V2B	April 30, 2021	Minor changes to the System Configuration menu to make it compatible with the M5Stack. Improved graphics for pop-up status information. Software Version 2.1
VXD-2103001V2C	May12, 2021	Minor changes to the System Configuration menu to improve legibility and minor changes to this document. Version 2.2
VXD-2103001V3A	November 12, 2021	Addition of WiFi Manager for setting WiFi credentials using an on-screen keyboard. General document cleanup to support new functions.

VXD-2103001V4A	February 28, 2022	Added support for selectable serial ports in the System Configuration Menu. Ports 0 (USB), 1 and 2 (default) are supported. Changed boot selection of WiFi Manager from Select button to Menu button. Added recovery arrow option to Attitude Indicator. Changed operation of dimmer function.
VXD-2103001V5A	June 1, 2022	Add polarity selection (-1, -2) to serial ports (for developers). Added Demo mode indication and copyright notice to bottom of screen. Stream decoder rewritten to OnSpeed and Dynon D10A/D100 and OnSpeed ADAHRS protocols and to support indications of unsupported flight data fields. Added support for on-the-fly selectable serial ports and for on-the-fly switching from WiFi Receive mode to serial port mode.
VXD-2103001V7A	May 1, 2023	Added four types of gauge clusters for Lycoming/Continental engines, up to 6 cylinders. General program adjustments to support new development tools. Minor changes to improve drawing speed and instrument legibility. Enhanced Garmin Airdata support. CAN network now used to synchronize screen brightness settings between instruments. RS-232 ports now can be daisy-chained between units.

Note: Specifications subject to change without prior notice. Images contained herein are copyrighted and represent developmental prototypes. All rights reserved.

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and photos provided courtesy of

