



SmartSim

SmartSim System

User's Manual

V1.0

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1. Introduction

1.1 Description

SmartSim is an advanced automation system composed of several automation boards designed to integrate and enhance the Open VetSim simulator. It facilitates the dynamics of teaching and learning in veterinary simulation scenarios, making the experience more immersive and closer to real clinical practice. The AirDose module manages the pneumatic system in the mannequin, replicating vital parameters such as respiratory and heart rates. The VitalHub module acts as the central hub, detecting sensors and sending commands to the simulator via WiFi. The TCS module assists in the simulation of chest compressions.

1.2 Target Audience

SmartSim was developed for professors, instructors, and veterinary professionals who seek to elevate the quality of teaching in simulations. It is ideal for training in areas such as emergency care, anesthesia, and vital monitoring, allowing students and graduated veterinarians to practice in realistic environments with the Open VetSim.

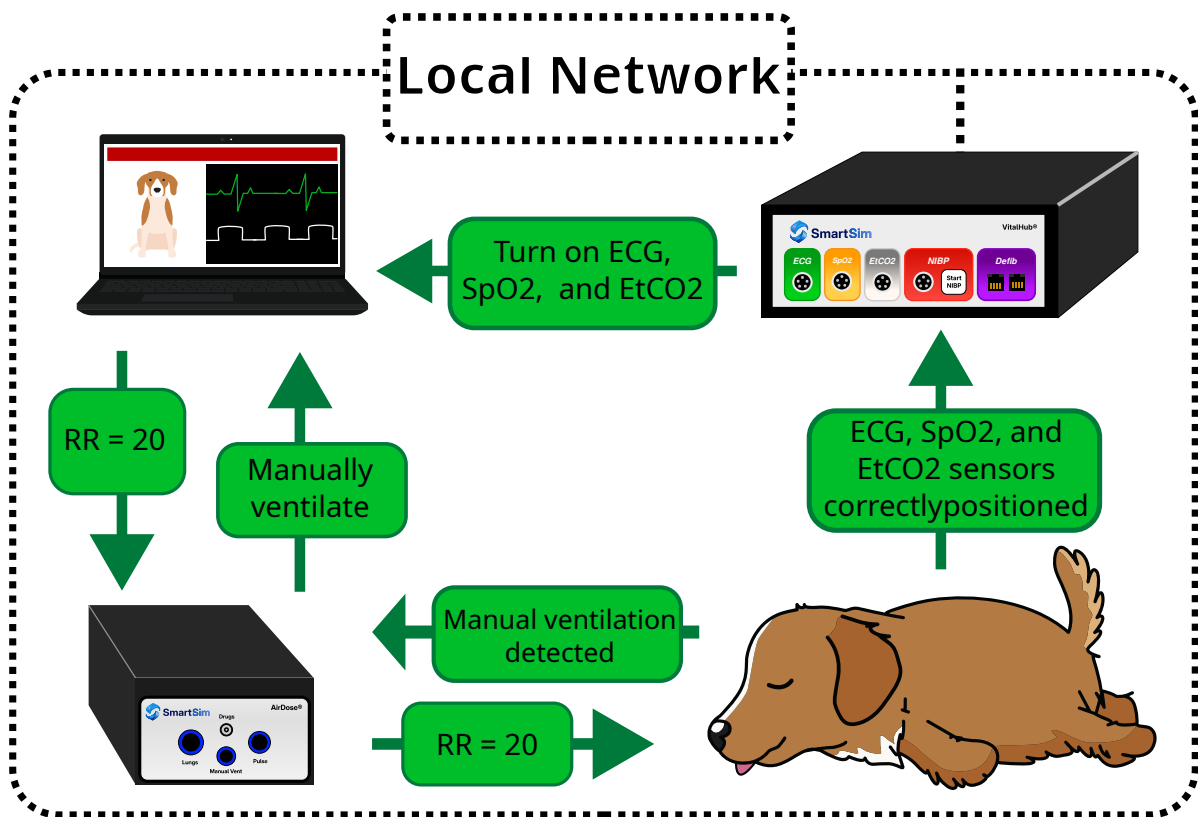
1.3 Benefits

The main benefit of SmartSim lies in the intelligent automation of parameters generated by the simulator, whether in pre-programmed scenarios or manual instructor configurations. The system automatically recognizes the correct positioning of simulated sensors (such as ECG, SpO₂, ETCO₂, NIBP, and defibrillator) and sends signals to the Open VetSim to enable vital signs on the monitoring screen, promoting immediate and realistic responses. Additionally, it obtains parameters such as heart rate (BPM) and respiratory rate (RR) from the simulator and applies them to the mannequin's pneumatic system, accurately simulating pulse and breathing.

Designed with an emphasis on flexibility, SmartSim offers extensive configuration via a web interface, including adjustments to thresholds and WiFi networks, allowing full customization to meet the specific needs of each educational environment.

2. Theory of Operation

The SmartSim system operates by connecting the VitalHub module, the AirDose module, and the computer running Open VetSim on the same local network. For the system to function correctly, the computer running Open VetSim must have the mDNS service enabled and routing policies configured (see section X). When all these components are connected to the same network, the interaction between the boards occurs mainly through HTTP commands and JSON data retrieval.



3. Overview

3.1. Dimensions

3.1.1 VitalHub

Width x Height x Length (cm): 19.5 x 7 x 17.5

Weight:

Power Supply: 5 volts and 2 Amperes.

Because it operates at 5 volts, the VitalHub can be powered by a power bank or smartphone chargers, provided that these devices do not use fast charging modes such as Power Delivery, TurboPower, and Quick Charge found in modern devices.

3.1.2 AirDose

Width x Height x Length (cm):

Weight:

Power Supply: 12 volts and 4 Amperes.

3.1.3 TCS

Width x Height x Length (cm):

Weight:

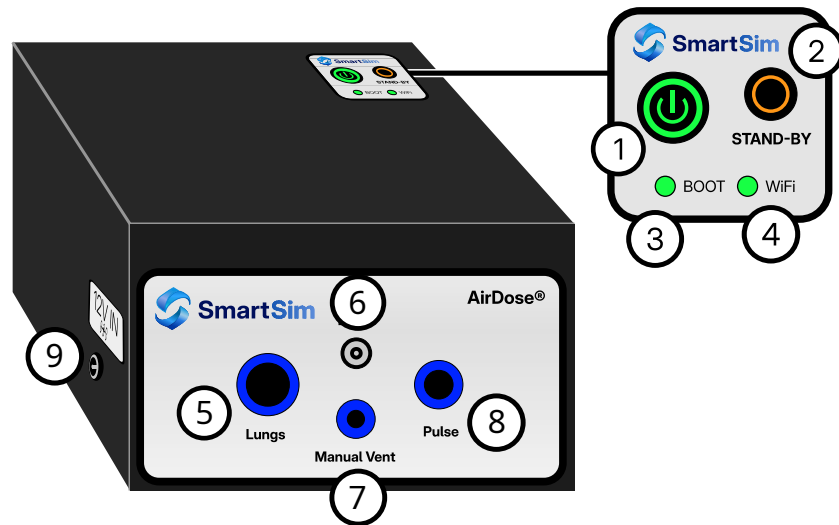
Power Supply: Built-in Battery.

3.2 VitalHub



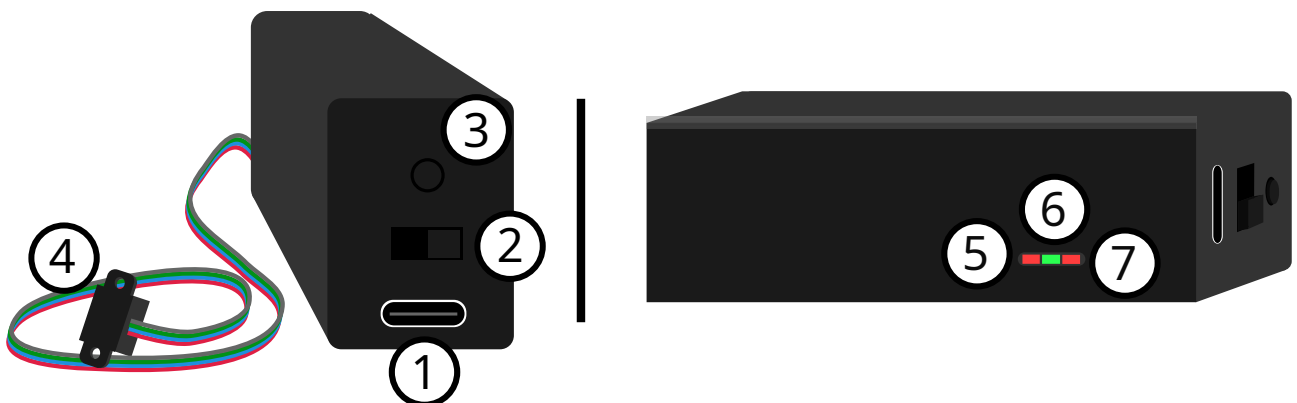
1. ON/OFF button.
2. Boot LED.
3. WiFi LED.
4. PC / AirDose LED.
5. Electrocardiogram detection cable input.
6. Peripheral oxygen saturation detection cable input.
7. Capnography detection cable input.
8. Non-invasive blood pressure cuff position detection cable input.
9. Button to trigger non-invasive blood pressure reading.
10. Defibrillator paddles input.
11. Power selector and selector button.
12. Display.

3.3 AirDose



1. ON/OFF button.
2. Stand-By button.
3. Boot LED.
4. WiFi LED.
5. 8 mm hose input.
6. Drug detection cable input.
7. 4 mm hose input.
8. 6 mm hose input.
9. 12 V power input.

3.4 TCS



1. USB-C charging input.
2. ON/OFF switch.
3. Reset button.

4. Accelerometer.
5. ON/OFF status LED.
6. Fully charged battery LED.
7. Charging LED.

3.7 Included Items

- 1 VitalHub module;
- 1 5V 2A charger;
- 1 defibrillator function screen;
- 1 ECG simulation cable;
- 1 SpO2 simulation cable;
- 1 EtCO2 simulation cable;
- 1 NIBP simulation cable;
- 2 defibrillator paddles with coiled wires;
- 1 AirDose module;
- 1 12V 4A charger;
- 1 long 8 mm hose;
- 1 short 8 mm hose;
- 1 8 mm female-to-female connector;
- 1 long 6 mm hose;
- 1 short 6 mm hose;
- 1 6 mm female-to-female connector;
- 1 long 4 mm hose;
- 1 short 4 mm hose;
- 1 4 mm female-to-female connector;
- 1 22 mm male-to-female connector with integrated 2.4 mm connector;
- 1 6 mm quick-connect Y-connector;
- 2 latex hoses with 6 mm converter connector;
- 1 6 mm Y-connector;
- 2 nylon cuffs;
- 11 labeled syringes;

- 1 TCS module;
- 1 RGB LED lamp.

4. Mannequin Preparation

To facilitate transport and installation of the pneumatic system connections, the hose inputs on the mannequin feature quick-connect pneumatic connectors of different sizes. Ensure that your mannequin has a passage large enough to allow the three hoses to pass through, but small enough to prevent the connectors from passing when attached to the hoses. This keeps the connectors outside the mannequin at all times and prevents the hose ends from entering the mannequin.

To correctly connect the hoses to the quick-connect fitting, simply push the hose all the way into the connector. Pull to check that the hose is secure. To release the hose, push the blue ring and pull the hose.

4.1 Respiratory Rate Simulation

Place the two rubber cuffs supplied with the SmartSim system below the rib cage reproduction on your mannequin. For better fixation of the cuffs, double-sided tape may be used to prevent the cuff from shifting out of the desired position. Test without any fixation aid to determine whether the internal structures of your mannequin are sufficient to hold them in place. Pass the 8 mm hose through the mannequin passage and attach the 8 mm female-to-female connector.

4.2 Pulse Rate Simulation

Similar to the cuffs, position the latex hoses that simulate the femoral arteries at the desired location. Pass the 6 mm hose through the mannequin passage and connect the 6 mm female-to-female connector to the end of the hose from the outside.

4.3 Manual Ventilation Simulation

Connect the adapter with the 4 mm hose between the trachea and the ventilation bag. Pass the 4 mm hose through the mannequin passage and attach the 4 mm female-to-female connector. The connector is designed for 22 mm male and female ports compatible with the trachea and bag of respiratory systems used in mechanical ventilation and anesthesia equipment. THESE TWO ITEMS ARE NOT INCLUDED with the system.

[foto]

4.4 Syringe Identification

Make a small hole in one of the arms of your choice on the mannequin, large enough to pass the connector wire through. Route the wire through the mannequin's hose passage. Make two additional small holes to pass the Hellermann ties for secure fixation of the connector to the mannequin's arm. To conceal the connector in the arm, we recommend applying self-adherent compression bandage (3M Vetrap) to simulate a real venous access.

[foto]

4.5 ECG_iD Installation

The ECG_iD is an important component for correct detection of ECG lead positioning. It consists of three parts: the external part with the magnetic connector, the nut for threading on the inside of the mannequin, and the case containing the electrical circuit.

To install it, make a small hole at the position where the lead will be located on the mannequin, large enough to pass the thread of the magnetic connector. Pass the wire through the nut, tighten until secure, and connect the wire terminal to the ECG_iD case in the correct position according to the sticker. Repeat the procedure for the other four leads.

[foto]

4.6 TCS Installation

The installation of the chest compression sensor is simple. Simply attach the accelerometer at the point where pressure should be applied with the fists. The angle and position of the sensor do not matter, as the sensor calibrates to zero on every startup.

5. System Preparation

5.1 Assembling the VitalHub

5.1.1 Mounting

The VitalHub system has two suction cups on the lower rear side. They serve to prevent the module from being dragged, mainly by the defibrillator cables, since the device is very light. Ensure that the table where the device will be placed is clean and smooth so that the suction cups attach correctly.

5.1.2 Power Supply and Cables

Connect the power supply to the rear USB-C input using the supplied charger. The green LED on the connector will light up. Plug the cables for each parameter into their respective inputs on the VitalHub module.

5.2 Assembling the AirDose

5.2.1 Hoses and Cables

Connect the 12 V power supply to the “12V IN” input. The AirDose module has three hose outputs: 1. Lungs (8 mm); 2. Pulse (6 mm); 3. Manual Vent (4 mm). They have different sizes precisely to facilitate correct assembly of each function. Also connect the connector responsible for drug syringe detection. Make the same hose and cable connections to the available inputs on the mannequin.

6. Startup and Pre-configuration of SmartSim

6.1 Pre-configuring the Computer with Open VetSim

The SmartSim system can connect to any WiFi network, whether a conventional router or an Access Point created by a smartphone. Device identification is performed by the Multicast Domain Name Service (mDNS). For the service to work correctly with your computer, go to Settings/Network and Internet/Status/Properties (below the name of the connected network) after connecting to the network that will be used by the SmartSim system, and select the “Private” option so that local network device discovery services are enabled.

Run the program “SmartSim_Setup.exe” as Administrator and note the name that appears below CURRENT HOSTNAME. This name will be used for the SmartSim modules to communicate with your computer over the network, therefore this name must be configured inside the modules (see sections X, Y and Z). When clicking “SET UP SMARTSIM”, the message “SUCCESS: Configured with [your_hostname]” should appear.

6.2 Configuring WiFi on the Modules

The modules come with blank WiFi settings. To configure them, simply power on the module to be configured and a password-free WiFi network will become available with the names VitalHub_Config, AirDose_Config, and TCS_Config for each respective module. After joining the configuration network, access <http://192.168.4.1> and a page with an SSID field and a Password field will appear. Fill in the fields correctly and click the “Save and Restart” button. The module will restart automatically and, if configured correctly, will join the specified network. If any field was configured incorrectly, to clear the data simply perform the WiFi reset procedure: press and hold the reset button of each module (see list below) while powering it on. Keep the reset button pressed for 5 seconds and release it. The configuration network should become available within a few seconds.

Reset buttons:

- VitalHub: Start NIBP;
- AirDose: Stand-By;
- TCS: Button above the ON/OFF switch.

6.3 Connecting the VitalHub

Press the POWER ON/OFF button on top of the module and wait for the “BOOT” LED to turn on and the “WiFi / TX” LED to stay lit, indicating that the module has connected

correctly to the configured network (see section X for WiFi configuration). After connecting to the local network, the module will attempt to recognize the accessory modules and the computer hosting the simulator on the network. For diagnostic assistance, the “PC / AirDose” LED will stay lit when the computer and AirDose are recognized. If only the AirDose is connected, the LED will blink rapidly; if only the PC is recognized, the LED will blink slowly. If no device is recognized, the LED will remain off. This status can also be monitored via the VitalHub status page (see section X).

6.4 Connecting the AirDose

Press the “POWER ON/OFF” button; the green LED on the button should turn on, and the module will automatically connect to the configured WiFi network. The “WiFi / TX” LED will light up, indicating correct module connection. The AirDose module starts in Stand-by mode with the button LED pulsing intermittently. To start the simulation, press the “Stand-by” button or the “Turn ON/OFF” button on the AirDose Status page (see section X). The LED should stay lit and the pneumatic pumps will begin operating automatically, synchronized with Open VetSim.

6.5 Connecting the TCS

To power on the TCS, after correct WiFi network configuration, simply turn on the ON/OFF selector switch. The ON/OFF LED should light up. During module startup, there is an attempt to connect to the RGB LED lamp. To connect the lamp to the module, first turn on the lamp and then the module. When connected correctly, the lamp will flash with blue pulses. If you want to connect the lamp after the TCS has already started, it will be necessary to restart the module. The connection between the module and the lamp is made via Bluetooth signal. To avoid interfering with the same radio signal as WiFi, the search is performed only during module startup. To check if the connection between both devices was made correctly, simulate movements with the accelerometer; the lamp should display the same color as the efficiency bar on the TCS status page (see section X).

7. Simulation of Parameters

The SmartSim system is capable of simulating the following parameters and functions:

7.1 ECG

Only when the electrodes are connected in the correct positions does the module send the signal that the parameter has been activated. If any electrode becomes disconnected, the module sends the signal that the parameter has been deactivated. To facilitate electrode placement, the connection between the electrode and the mannequin is magnetic.

7.2 SpO₂

To send the signal of correct parameter positioning, the module reads the signal from a small switch located in the cable clip. Although it is a low-resistance switch, if the surface where it is placed is very soft or spongy, the material may deform and fail to activate the switch. If this occurs, modify the surface to make it more rigid (for example, change the padding).

7.3 EtCO₂

Inside the tracheotube connection input there is a small switch. When activated, the module sends the signal of correct parameter positioning. When the switch is released, the module sends the signal to deactivate the parameter. Activation of this switch is millimetric, so perform tests with the tracheotubes to be used to evaluate the force required to insert and remove the tracheotube and whether the switch is correctly activated. If excessive force is required to insert and remove the tracheotube, sand the tracheotube adapter to reduce its diameter and facilitate the procedure.

7.4 NIBP

To enable NIBP in Open VetSim, simply place the cuff around one of the mannequin's limbs with adequate pressure. Inside the cuff there is a pressure sensor, and when the required value is reached, the module sends the signal to the computer to enable the parameter. When the cuff is removed, the module sends the signal to disable the parameter.

7.5 NIBP Reading

The "Start NIBP" button is only enabled after the module detects correct cuff positioning. With the cuff correctly placed, pressing the button causes the module to send the signal to simulate the NIBP value reading.

7.6 Defibrillator

The defibrillator simulation system consists of the paddles and the screen. After passing the module's initialization screen, the energy selector screen should appear. Turning the selector knob clockwise increases the energy value. The selector is sensitive to rotation speed: slow rotation changes the values by +1 or -1, while fast rotation changes the values by +10 or -10.

After selecting the desired energy, press the selector button. The screen will flash the message "PRESS CHARGE". If no action is taken within 10 seconds, the screen will return to the energy selector. Pressing the Charge button (yellow button) will switch to the "Charging" screen and a charging sound will be emitted by the module. After 3 seconds, the message "Ready!" should appear on the screen and a constant high-frequency audible alert will be emitted by the module. Pressing the shock buttons simultaneously will cause the module to send the shock command and the screen will display the message "Shocked!". After the shock, the energy selector screen will appear again. If the shock buttons are not pressed within 30 seconds, the screen will automatically return to the energy selection screen.

7.7 Chest Compressions

After correctly positioning and adjusting the TCS (see section X), the signal for the start of chest compressions is sent automatically to the computer hosting Open VetSim. Read the sensor calibration settings carefully for the best user experience.

7.8 Drugs

Currently, the AirDose module is capable of simulating the administration of 11 different drugs using the labeled syringes. When the syringe is attached to the connector and the plunger is pressed all the way in, the tip of the plunger will press a switch and the module will send the signal for administration of the corresponding drug. In future software versions, the drug names and ADC values will be fully configurable.

7.9 Pulse Rate

When the AirDose module is correctly connected to the computer hosting Open VetSim, exiting Stand-By mode causes the pulse rate to be simulated in real time according to the simulator values. The values must be changed via the Instructor Interface of the program.

7.10 Respiratory Rate

When the AirDose module is correctly connected to the computer hosting Open VetSim, exiting Stand-By mode causes the respiratory rate to be simulated in real time according to the simulator values. The values must be changed via the Instructor Interface of the program.

8. WebServer

The SmartSim system features a Web Server to unify the telemetry, configuration, calibration, and firmware update interfaces.

8.1 Status and Telemetry

8.1.1 VitalHub

To access the VitalHub Status page, open your web browser and enter the address <http://vitalhub.local> (the browser may request confirmation due to the absence of a digital certificate. Simply confirm that you wish to proceed). In the upper left corner there is a menu to access the other Web Server pages, and in the upper right corner there is a button to switch between dark and light themes.

8.1.1.1 WiFi Network

The first card displays the network name (SSID) to which the module is connected, the IP address assigned by the router, and a bar showing the WiFi signal strength of the device. The fuller the bar, the better the signal.

8.1.1.2 Modules

This card shows the network availability status of the modules and the computer hosting Open VetSim. For the computer status to be displayed correctly, the hostname must be properly configured on the module's configuration page (see section X). If the computer's hostname was not resolved correctly during system startup, the "Refresh" button performs a new resolution attempt.

8.1.1.2 ECG Leads

When the electrodes are connected to the mannequin, the lead status is updated in real time. If the connection is made to the correct lead, the text in the "Status" column will turn green with the word "OK". If an electrode is in the wrong position, a red text will appear indicating which electrode is occupying that lead. When all electrodes are in the correct positions, all columns should display "OK" and the signal will be sent to Open VetSim to show the electrocardiogram on the simulator's "Vitals" screen. To facilitate electrode placement, the connectors are magnetic.

To the right of the lead status is the ADC field. The ADC value is essentially a number that the board uses to “measure” the intensity of a variable signal — in this case, the voltage passing through the circuit. Each lead has a maximum ADC value, but this value can suffer interference, causing the value generated by an interfered electrode to exceed the configured maximum limit, resulting in incorrect lead reading by the board. These limits can be configured on the configuration page (see section X).

8.1.1.3 Sensors and Status

The Sensors and Status card shows in real time how the board is detecting each sensor.

8.1.1.3.1 NIBP Pressure

The value shown on this line is the voltage passing through the flexible sensor inside the cuff. The more the sensor is pressed, the less voltage passes through it and the value should drop to zero. With no pressure on the sensor, the value should be 3.3 V; when pressed, the value should be zero.

8.1.1.3.2 ETCO2

The displayed value should be ON when connected to the tracheotube or OFF when no tracheotube is connected.

8.1.1.3.3 SpO2

The displayed value should be ON when the clip is correctly positioned on the mannequin and OFF when the clip is not on the mannequin.

8.1.1.3.4 Defib Charger

The value should be ON while the yellow button on the defibrillator paddles is pressed and OFF when it is not pressed.

8.1.1.3.5 Defib Shock

The value should be ON when the red button on the defibrillator paddles is pressed and OFF when it is released.

8.1.1.3.6 NIBP Button

The value should be RELEASED when the button is not being pressed and PRESSED when it is pressed.

8.1.1.4 Maintenance Buttons

8.1.1.4.1 TEST BUZZER

This button is used to test the buzzer. When pressed, the board’s buzzer should emit a sound.

8.1.1.4.2 LED Test

For this test to work, maintenance mode must be enabled. When you click the button for the LED you want to test, the LED should flash rapidly.

8.1.1.4.3 Maintenance Mode

Clicking this button will turn it red with the text “MAINTENANCE MODE: ENABLED” and the WiFi and PC / AirDose LEDs will turn off. While this mode is active, no commands will be sent to the simulator, but the status in the card will continue to update. This mode allows testing of the sensors without affecting the operation of Open VetSim.

8.1.1.5 Virtual Switches

The Virtual Switches card allows commands to be sent to Open VetSim more quickly in case a sensor fails. Clicking a button sends the command to the simulator, enabling or disabling the parameter or delivering the defibrillator shock.

8.1.1.6 Log Events

The Log Events card records the last 30 actions performed by the VitalHub. It serves as an additional redundancy to verify what was executed and how the board is communicating with the simulator, showing whether commands were sent or received correctly.

8.1.2 AirDose

To access the AirDose Status page, open your web browser and enter the address <http://airdose.local> (the browser may request confirmation due to the absence of a digital certificate. Simply confirm that you wish to proceed). In the upper left corner there is a menu to access the other Web Server pages, and in the upper right corner there is a button to switch between dark and light themes.

8.1.2.1 WiFi Signal

This card displays the SSID of the connected local network, the IP address obtained by the AirDose, and the WiFi signal strength bar.

8.1.2.2 Pressures

The first bar shows in real time the pressure from the sensor responsible for detecting pressure generated by manual ventilation through the Ambu bag. The scale of this bar goes up to 60 mmHg, which is sufficient to display variations satisfactorily.

The second bar shows in real time the pressure read by the sensor in the cuffs that simulate spontaneous breathing.

8.1.2.3 Virtual Standby Control

This card allows control of the AirDose standby mode without pressing the physical button. Clicking “Turn ON/OFF” will make the unit enter or exit Standby mode, and the status will change between ON and OFF next to the text “Current Status” on the line below.

8.1.2.4 Detected Syringe

This card shows the name of the syringe plugged into the connector on the mannequin’s arm and the detected ADC value. The mechanism is the same as for the ECG leads. The names and ADC values can be configured on the AirDose configuration page (see section X).

8.1.2.5 Other Parameters

This card displays the respiratory rate and pulse rate values obtained by the AirDose through requests to Open VetSim. The value is updated in real time but does not update if the AirDose is in Standby mode. If this value differs from the value configured in the simulator, there is likely a communication error between the AirDose and the computer running Open VetSim.

8.1.3 TCS

To access the TCS Status page, open your web browser and enter the address <http://tcs.local> (the browser may request confirmation due to the absence of a digital certificate. Simply confirm that you wish to proceed). In the upper left corner there is a menu to access the other Web Server pages, and in the upper right corner there is a button to switch between dark and light themes. The TCS status page displays the following data in real time:

8.1.3.1 Battery

The first data line shows an icon with the current battery capacity along with the real-time percentage and voltage of the battery. As this is a calculated value, there may be a small difference between the displayed value and the actual battery level.

8.1.3.2 Accel Z

This is the real-time value of the accelerometer's Z-axis. Since the compression movement is downward, the Z-axis value is the most affected by this type of movement. With the accelerometer at rest, this value should be very close to zero. When powering on the TCS with the mannequin in the position that will receive the compression movements, if the Accel Z value does not show a value close to zero, calibrate the sensor using the calibration button (see section X).

8.1.3.3 Frequency

This value shows the total number of movements per minute detected by the accelerometer.

8.1.3.4 Status

Shows the simulation status sent to Open VetSim. When the status changes to "Active", the module sends the signal to the simulator to activate the chest compression trace. When the status changes to "Stopped", the module sends the signal to end the chest compression trace.

8.1.3.5 Valid Compressions

Number of movements characterized as valid according to the limits defined on the configuration page.

8.1.3.6 Invalid Compressions

Number of movements characterized as invalid according to the limits defined on the configuration page.

8.1.3.7 Total Compressions

Sum of valid and invalid movements.

8.1.3.8 Efficiency

Efficiency of valid movements calculated from the total of the last 10 overall movements.

8.1.3.9 “Calibrate Offset” Button

Button used to calibrate the accelerometer to zero after startup. If, after powering on the module with the mannequin in the desired position for compression movements, the Accel Z value does not show a value very close to zero, keep the mannequin completely still, press the calibration button, and wait 10 seconds with the mannequin in the same position. At the end of the button countdown, the value should be very close to zero.

8.2 Configuration

8.2.1 VitalHub

To access the VitalHub module configuration, click **Menu / Configuration / VitalHub** or enter <http://vitalhub.local/config> in your browser.

8.2.1.1 WiFi Settings

If it is necessary to change routers, this card allows you to change the network name in the “SSID” field and the network password in the “Password” field.

8.2.1.2 mDNS Settings

In the “Target Hostname” field, enter the hostname of the computer hosting Open VetSim. Communication between the module and the simulator is performed using this name.

8.2.1.3 ECG Thresholds

In this section, the ADC values for each ECG electrode can be configured. Each electrode has a maximum ADC limit to be recognized by the system. When all electrodes are correctly connected, the ADC value of each electrode must be below the configured value. If two electrodes fall within the same configured ADC range for a lead, the system will interpret that two electrodes are occupying the same lead and the correct ECG positioning trigger will not be sent to the simulator.

For example: If the ADC configured for the RA electrode is 100 and for the LA electrode is 200, but when connecting the RA electrode the system reads an ADC value of 110, when

both electrodes are connected the system will show that the LA electrode is connected in the RA position and the LA electrode is correctly connected.

The ADC values must be configured based on the values shown on the status page with all electrodes correctly connected, as interference may affect the displayed value if any electrode is not connected.

8.2.1.4 NIBP Settings

The NIBP Threshold field shows the ADC threshold value of the sensor inside the cuff, which is responsible for the trigger that indicates to the simulator that non-invasive blood pressure is enabled and unlocks the “Start NIBP” button. The lower this value, the more sensitive the trigger. In other words, at values very close to zero, any manipulation of the sensor inside the cuff will activate the trigger. At high values, the sensor must be pressed with greater force to activate the trigger and display the values on the simulator’s Vitals screen.

8.2.1.5 “Save and Restart” Button

Click this button to save the desired changes whenever any configuration is modified.

8.2.2 AirDose

To access the AirDose module configuration, click **Menu / Configuration / AirDose** or enter <http://airdose.local/config> in your browser.

8.2.2.1 WiFi Settings

Similar to the VitalHub settings, the first card contains the local network name and password settings.

8.2.2.2 mDNS Settings

In the “Target Hostname” field, enter the hostname of the computer hosting Open VetSim. Communication between the module and the simulator is performed using this name.

8.2.2.3 Ventilation Parameters

8.2.2.3.1 AMBU Threshold

This is the pressure value read by the pressure sensor responsible for triggering spontaneous breathing in the simulator. The value is in mmHg. At very low values, the trigger

may activate due to mannequin movement or sensor interference. At very high values, a very high Ambu ventilation pressure will be required to activate the trigger, resulting in undetected manual ventilations.

8.2.2.3.2 Target PIP

This is the pressure value in mmHg at which the pump responsible for simulating respiratory movements stops operating at the end of the inspiratory phase. At very low values, inspiratory time may be too short and no visible chest expansion movement will occur. At very high values, there may be undesirable wear on the air bag due to excessive pressure.

8.2.2.3.3 PWM Minimum Duty Cycle

The power of the pneumatic pump responsible for respiratory movements can be adjusted. This value ranges from 0 (off) to 255 (full power). The value set in this field is the power level when the pump is turned on. At very low values, the pump may take longer to reach peak pressure. At very high values, the sensor may turn the pump off too early.

8.2.2.3.4 PWM Maximum Duty Cycle

In this field, the maximum power of the pneumatic pump responsible for respiratory movements can be set. As in the previous item, the value ranges from 0 to 255 and must be equal to or greater than the minimum value. At very low values, the pump may not fully inflate the air bags. At very high values, insufflation time may be too short.

8.2.2.3.5 PWM Step Increment

This value defines the steps for power adjustment from minimum to maximum. These steps create a power ramp so that pump acceleration is smooth and without jolts.

8.2.2.4 Ventilation Parameters

8.2.2.4.1 Breathing Sensor Offset

Voltage value of the sensor when it is under atmospheric pressure (real zero mmHg). If the sensor value on the status page fluctuates between zero and 1–2 mmHg when the sensor is not under pressure, this value can be adjusted to achieve true zero. The lower this value, the higher the value shown on the status page when the sensor is not pressurized. In the example above, the offset value should be increased to avoid fluctuation on the status page.

8.2.2.4.2 Breathing Sensor Span

Voltage value that marks the end of the sensor's measurement scale. This value is used to calibrate the maximum pressure measured by the sensor and adjust the actual scale. Positive pressure calibration of the sensor can be performed from this value.

8.2.2.4.3 AMBU Sensor Offset

Similar to item 8.2.2.3.1 but applied to the pressure sensor responsible for measuring Ambu ventilation pressure.

8.2.2.4.4 AMBU Sensor Span

Similar to item 8.2.2.3.2 but applied to the pressure sensor responsible for measuring Ambu ventilation pressure.

8.2.2.5 Syringe Names

The SmartSim system has 11 registered syringes for interaction with Open VetSim. In this field, it is possible to change the syringe names, although it is not possible to change the URL sent to the computer running the simulator. The order in which the names are displayed in this field is the same order as the URLs are arranged in the code. Therefore, if the second name is changed, the URL for the drug “Analgesic” will be sent to Open VetSim. URL modification will be available in future firmware versions.

8.2.2.5.1 ADC Thresholds

This field contains the comma-separated ADC threshold values for each syringe. These values determine which URL will be sent to the simulator.

8.2.3 TCS

To access the TCS module configuration, click **Menu / Configuration / TCS** or enter <http://tcs.local/config> in your browser. On this page, the module’s network parameters and accelerometer variation thresholds are configured. Correct configuration of these thresholds is essential for the accelerometer to accurately display the number of real movements. Before placing the mannequin into use, perform tests by adjusting these values until the desired calibration is achieved.

8.2.3.1 Network

8.2.3.1.1 WiFi SSID

WiFi network name for the module to connect to. This field can be changed to update the network name without resetting the module.

8.2.3.1.2 WiFi Password

WiFi network password for the module to connect to. This field can be changed to update the network password without resetting the module.

8.2.3.1.3 Target Hostname

Hostname of the computer hosting Open VetSim.

8.2.3.2 Accelerometer Parameters

8.2.3.2.1 Start Threshold

Threshold required for the accelerometer to begin reading. The closer to 0, the more sensitive the initial reading. It is not recommended to set the value to 0, as any minimal variation or noise may start the accelerometer reading.

8.2.3.2.2 End Threshold

Threshold at which the accelerometer will stop reading the movement. The closer to zero, the more complete the movement must be to be computed. This value is used to analyze the recoil of the chest compression movement.

8.2.3.2.3 Min. Movement Variation

Minimum accelerometer variation to count as a movement. If the movement reaches this value but does not reach the valid movement threshold, it will be classified as invalid. The closer to zero, the smoother the movement can be while still being counted as invalid.

8.2.3.2.4 Valid Movement Threshold

Threshold required to compute a valid movement. The closer to zero, the more sensitive the movement can be while still being counted as valid.

8.2.3.2.5 Start Debounce

Tolerance time in milliseconds between movements. This value is important to avoid double or ghost movements. Very low values cause multiple movements, while very high values may cause failure to detect true movements.

8.2.3.2.6 Movements to Start Detection

Number of valid movements required before the chest compression start signal is sent to the simulator. A very low number may send erroneous signals to the simulator, while a very high number may cause a delay in sending the signal.

8.2.3.2.7 Timeout Inactivity

Time in milliseconds of tolerance for inactivity of total movements before the module sends the signal to the simulator to stop the chest compression trace. A very low value may send the signal during small accelerometer reading glitches. Very high values cause delays in sending the signal, causing the simulator to show the trace without chest compression movements and reducing simulation accuracy.

8.2.3.2.8 "Apply Configuration" Button

After making the desired changes, click the “Apply Configuration” button. The values will be saved to the module’s memory and the page should return to the module’s Status page.

8.3 Firmware Update

All modules support remote software update (*Over-the-Air Update*), and new features that do not require hardware changes can be added at any time. The procedure is very simple and fast. To access the module’s update page, click on the Web Server Menu, go to “**OTA Update**”, and click on the name of the module to be updated. On each page there is a “Browse...” button. Select the supplied .bin file. After selecting the correct file for each module, click “**UPLOAD FIRMWARE**”. The module should restart automatically within a few seconds.