FRUITY CHUTES
Professional Aerospace Recovery Solutions

Sentinel Automatic Trigger System (SATS-MINI) with VTOL Support – Product Guide

(as of V1.2.0 software, V2.1 hardware)

The SATS-MINI provides unparalleled ability to quickly and reliably detect a drone failure, and at the same time the ability to guard against false triggers making it safe to use with high energy deployment systems that use CO2 or pyro gas ejection. The SATS-MINI supports many configurable features to allow tight integration between the autopilot and the SATS-MINI system.

At the core of the SATS-MINI is a 9-DoF (Degrees of Freedom) IMU employing sensor fusion with absolute orientation capability. The SATS-MINI can be calibrated at any arbitrary position in order to set the Z-axis orientation (primary axis). This means the device can be mounted at any position or orientation on the Drone. The SATS-MINI can discern between Panning rotation along the Z-axis (yaw) being normal, and other rotation along the X and Y-axes being a dangerous rotation. Dangerous rotation detection is based on a rotation of a given number of degrees occurring within a given time period, typically 360 degrees or more in 2 second or less. The IMU can also detect a free fall condition by analyzing accelerometer data to trigger the parachute. The pre-set parameters for the SATS-MINI are optimized for fast detection, while allowing safe handling on the ground to avoid a false trigger. Even with the SATS-MINI armed, casual handling of the drone on the ground before flight will not accidentally trigger the parachute.

NOTE: This document describes the technical details of the SATS-MINI. To program and use the SATS-MINI refer to the User and Programming Guide. Also visit our SATS-MINI Quick Start and Resources page for more information and software downloads..

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Features summary for the SATS-MINI

Core System Features:

- Cortex M0 Core processor
- 9-Dof IMU with sensor fusion
- Altimeter to support auto arm / safety, descent rate trigger
- EEProm and Flash memory for configuration and support black box flight logging
- Bluetooth LE to support mobile app for monitoring and configuration
- Micro USB Connector for charging and configuration by Windows UI
- Real Time Clock for timestamping log file with date and time of the flight (V2.1 Hardware)

Power Management:

- Internal 1S / 500mAh Lipo Battery
- Charge via USB or external input power
- Internal Lipo power charge and management with 5V boost converter
- Channel aggregate power out rated at up to 2.5 amps (12.5W), burst up to 3 amps (15W)
- Automatic option so SATS-MINI can be turned on and off via the Autopilot power control

IO Channels:

- 4 Configurable IO Channels
- Flexible signal pin configuration for PWM or DC levels
- Two channels provide 5V power out, two channels provide external 5V power in
- Expansion port to facilitate Autopilot integration and support add-on modules.

User Interface:

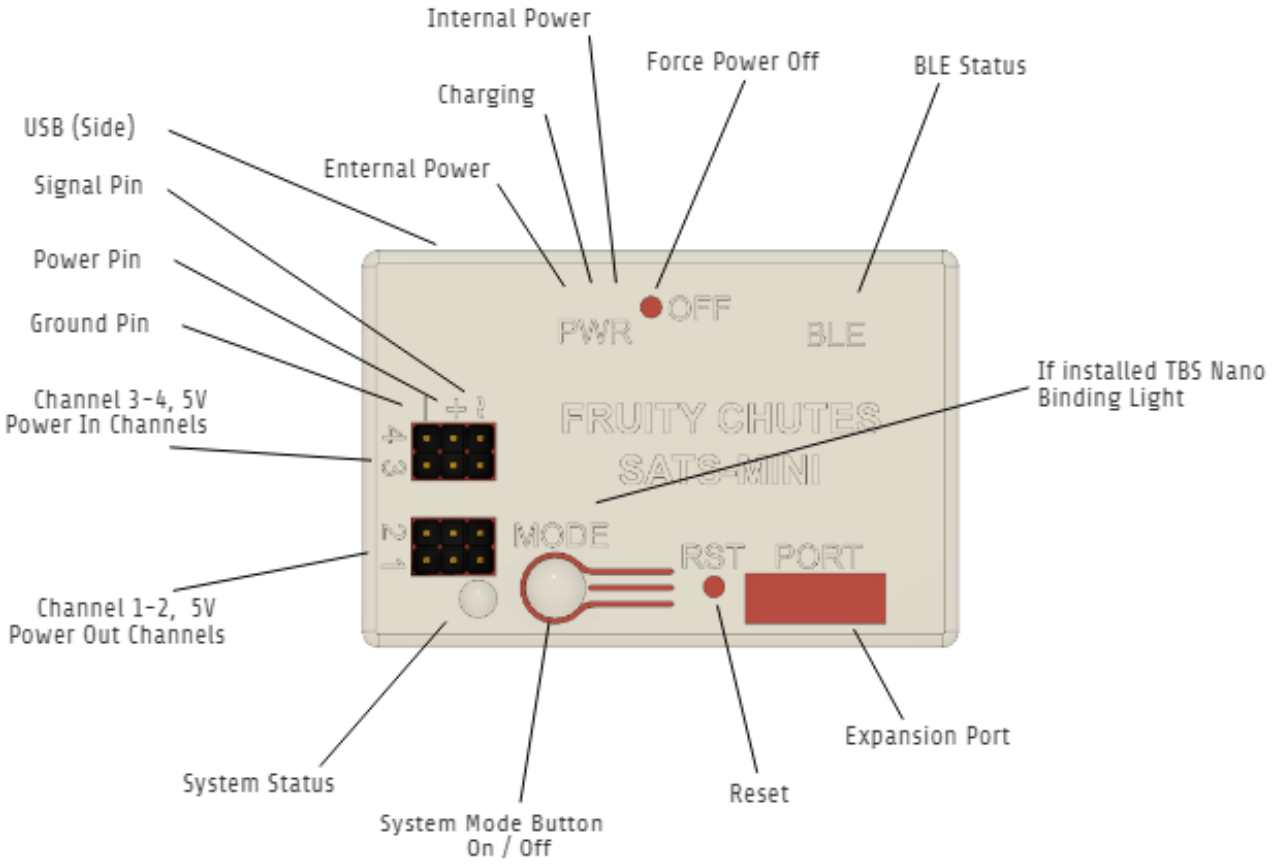
- Single button operation
- Beeper for audible feedback of button operation
- Multi-color LED to display operational state
- Three status LED show power status
- Two LED show Bluetooth LE status

Rescue Radio Support:

- The TBS NanoRX, and the new Nano Diversity RX can be mounted directly to the SATS-MINI PCB to support an external rescue radio to trigger the parachute release.

Physical:

- Case size 2.2”L x 1.46”W x 0.68” H
- Weight 35 grams with battery



SATS-MINI Case Details

SATS-MINI buttons, indicator lights, and I/O pins:

- **System Mode Button, On / Off** – This pushbutton does both the power on / off function and changes the SATS-MINI mode of operation, described later.
- **System Status LED** - This multi-color LED indicates the current system status, described later.
- **Channels 1-2** – These are programmable IO channels and also provide 5V power out to peripherals such as an RC servo.
- **Channels 3-4** – These are programmable IO channels and allow 5V power input.
- **Ground Pin** – Channel ground pin
- **Power Pin** – For CH1-2 this pin provides 5V power out for servos of other devices that need power. For CH3-4 this pin can accept 5V power in to supply the SATS-MINI with operational power and to charge the LIPO.
- **USB (Side)** – The USB connector to both charge the SATS-MINI and for configuration by the PC setup program.
- **External Power** – Green LED when lit indicates that external power is connected via CH3-4, or via USB port.
- **Charging** – Yellow LED indicated the internal LIPO is charging.

- **Internal Power** – Red LED indicating that the SATS-MINI is being powered by the internal LIPO battery.
- **Force Power Off** – Provides a secondary button to force the SATS-MINI to power down. Use a paperclip to reach the push-button on the PCB.
- **BLE Status** – Red and Blue LED's indicate the BLE is active and bound to an external app (under development)
- **TBS Nano Binding Light** – If installed, Green / Red light indicating that the TBS Nano receiver is bound to the transmitter. Green indicates binding.
- **Reset** – Forces a system reset. Use a paperclip to reach the push-button on the PCB.
- **Expansion Port** - 8 Pin Molex Pico Blad connector.

Using the System Mode Button

Pressing the mode button allows the unit to be turned on and off, and to toggle between IDLE and SAFETY / ARMED mode:

1. **Turning on** - Press and hold the Mode button for 2 seconds until the System Status LED turns on solid Red then release. The system will go through a startup sequence and the beeper will chirp and enter the operational status the same as when the unit was last shutdown.
2. **Toggle between modes** – Press and hold the button for 1 second will toggle the system between IDLE and SAFETY / ARMED.
3. **Turn Off** – Momentarily press the button (<0.5 sec) then press and hold for 2 seconds will turn off the unit. Once the light extinguish and the power-off triad sounds, release the mode button immediately. If you continue to hold the button down it will turn the unit back on after holding for 2 seconds. If external power is provided via USB, or via the CH3 or CH4 power pin the Green External Power LED will remain on and the Yellow Charging LED will be on if the LIPO is charging.

   If there is a problem turning off the unit, a paper clip can be used through the hole in the case top and press the OFF button on the PCB board.

ATS Operational States Overview

The ATS has several operational states. These are:

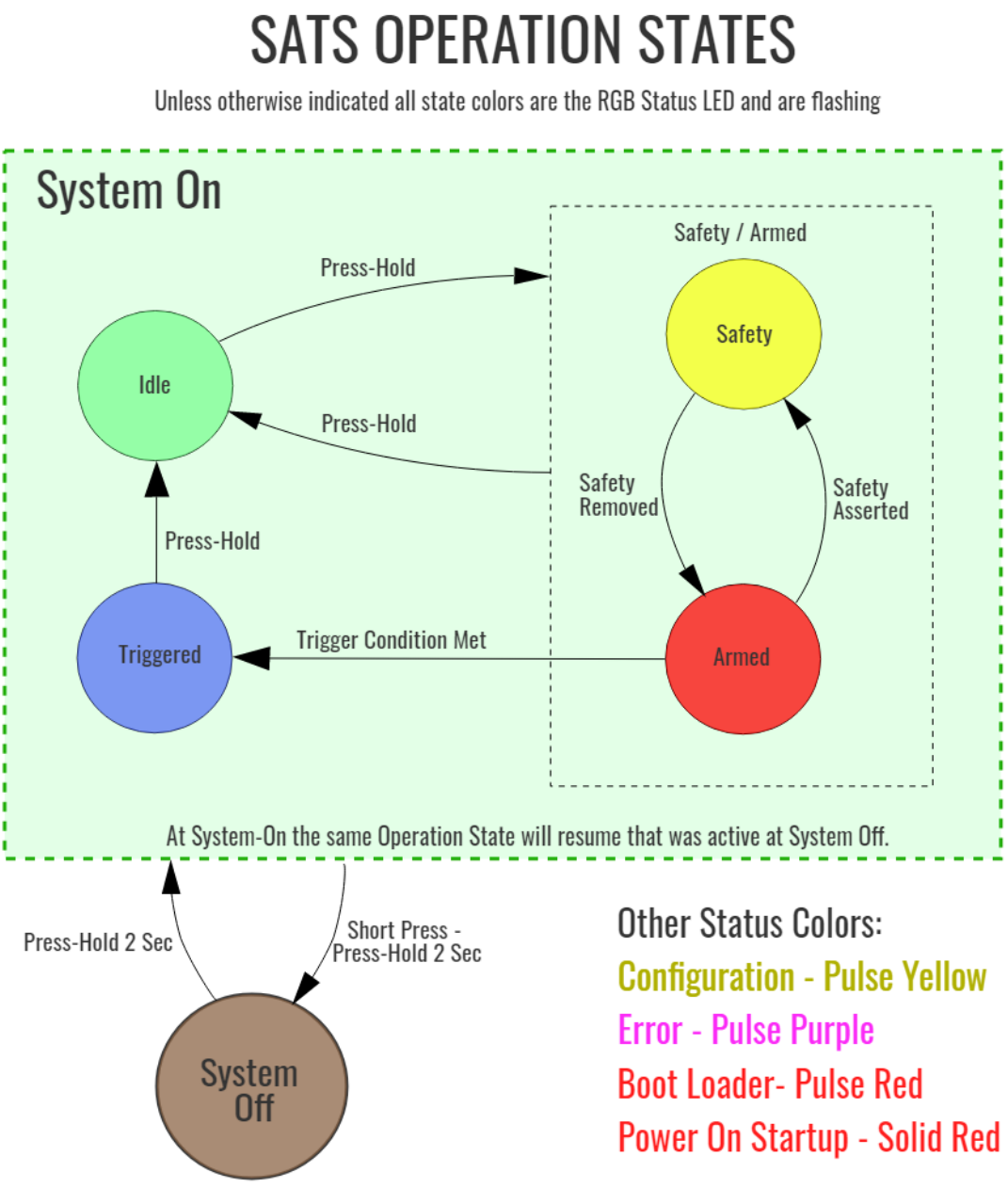
- **IDLE** – In IDLE mode the trigger outputs cannot be activated. The System Status Led is flashing green.
- **SAFETY / ARMED** – This actually has two states possible depending on how the safety is configured. When in Safety the System Status LED is flashing Yellow, when Armed the System Status LED will flash Red. Once entering this state if SAFETY is asserted via altimeter or external control the trigger outputs are held off and cannot activate. If SAFETY is not asserted then the system enters the ARMED mode and the trigger outputs are now active and can be activated. Upon entering SAFETY / ARMED, if SAFETY is not asserted the mode goes directly to ARMED. In ARMED mode, the LED is flashing Red.
- **TRIGGERED** - While the SATS-MINI is in triggered state the System Status LED will flash Blue. The SATS-MINI will remain in the Triggered state until the Mode button pressed to transition the Triggered state to the Idle state.
- **CONFIGURE** – The system will enter this mode when the USB is connected and the device is being configured. The Status LED will pulse Yellow.

- **ERROR** – The System Status LED will pulse purple. This can happen if upon power up the configuration data loaded from EEPROM has some sort of error, or the data signature does not match what the firmware expects.
- **STARTUP** – Immediately after power is applied the system enters the startup mode. The System Status LED will be solid red.
- **BOOT LOADER / Software Update** - If the unit should enter the boot loader mode, then the System Status LED will pulse Red (sometimes solid red). Power cycle the unit to start again. You can enter the boot loader if the Reset signal is asserted twice in a short time (under ½ second).

  While in Bootloader mode if the unit is connected to a USB port to the PC the SATS-MINI will appear as a drive called FEATHERBOOT.. While connected the software release ATS.uf2 file can be dragged into the drive folder to install a new version of the firmware.

Operation State Diagram

The diagram below shows the operational modes of the SATS-MINI and the transitions between different states. Each State ball shows color as the Status LED. In all operational states the Status LED will flash. In non-operational states the LED will pulse.



IO and Other Physical Features

Channels 1 - 4 - The SATS-MINI features four configurable IO channels. The three pin channel connectors have the same format as used with RC receivers with center as power (in and out). RC type servos Receivers and other device types are directly compatible with the connector pins.

Channels Signal Pin (~) - Each channel features a general purpose I/O that can be used as a PWM out, PWM In, DC level output and DC level input depending on the feature assigned to the pin and the interface type used. Pins can be unused (not assigned).

All pins have a 10K pull up to 5V and if not driven the pin be pulled high. When configured as inputs the levels are level shifted down to 3.3V for internal operation. A logic 1 level is 3.0V or higher up to a maximum of the 5.5V.

Channel 5V Power Pins (+) - Channel 1 and 2 provide 5V (5.1 V typically) power out and peripherals like servos, or external receiver. Channel 3 and 4 allows 5V power in capability (4.85V - 5.65V) and can be used to both augment the onboard Lipo power, and also charge the Lipo battery. The SATS-MINI can also be charged via the USB power and internal power path circuitry will select between the two power sources. There is internal over voltage protection for CH3, CH4 and USB power input for up to 24V shutting down the input if the voltage exceed 5.65V. Power input for Channel 3 / 4 and USB are isolated and both can be applied at the same time, power path circuitry will select the optimal power source.

Channel Ground (-) - All ground pins are connected together and provide a return path for external power supplies and I/O signals.

Internal Lipo Battery - The SATS-MINI has an internal 1S / 500mAh LIPO power source that can run the system without any external power. Depending on the peripherals being used the battery life is typically over 6 hours when one servo is connected. Attaching additional servos of the Nono RX receiver can shorten the life and you should characterize the battery life for your particular application. Power supply in and the Lipo supply voltages are recorded into Flash memory while the SATS-MINI is in Armed / Safety state.

Optional TBS Nano Receiver - In internal header is available allowing the TBS Nano receiver to mounted directly on the SATS-MINI board. Then the Nano receiver Channel 1 out is connected to CH4 of the SATS-MINI. To use the Nano the SATS-MINI CH4 is configured as an external trigger input, PWM signal, 2000us trigger width, 10% tolerance. The CH4 signal pin (~) will have the PWM output of the Nano Channel 1. This can be handy for testing. When used with the Nano receiver CH4 is dedicated for the NANO PWM output signal.

Expansion Port - The expansion port allows connection to other hardware without using the 3pin JR RC radio style headers. The connector is an 8 pin Molex Pico Blade connector and a compatible connector should be used. Contact Fruity Chutes to get an expansion port cable.

Connection on the board form Pin 1 to 8 (right to left) are:

Pin 1- I2C SDA - Internal I2C bus Data, 3.3C Level

Pin 2 - I2C SCL - Internal I2C bus Clock, 3.3V level

Pin 3 - GNG - Ground return path

Pin 4 - 5V Power Out

Pin 5 - CH2 IO Pin

Pin 6 - CH3 IO Pin

Pin 7 - 5V Power In

Pin 8 - V Sense External - This pin is used to monitor the drone External battery supply voltage for logging, or for under-voltage parachute trigger function. Voltage range is from 0V - 33.2V.

Virtual Channel Features

These are assignable channel features that can then be attached to any one of the physical Channel 1 - 4. These include:

- Trigger output - Trigger the parachute deployment, and flight termination.
- External trigger input - An external signal can be provided that will trigger the parachute.
- External safety / armed input - Allows external control of the Safety / Armed state.
- System status output - Output signal to indicate when the SATS-MINI is in a given operational state.
- Flight Mode Selector input (1.2.0) - Select which flight more is selected for VTOL, Multicopter, or Fixed

Trigger Output

This virtual feature is used to eject the parachute. The channel can be configured as a PWM output, or a DC level based signal. Configuration Options are:

- **PWM Output**, If selected both the hold and release PWM pulse widths can be specified in degrees of rotation. Typical is 45 degrees (1ms) for hold, 135 degrees (2ms) for release. PWM output frame rate is the RC industry standard of 20ms.
- **Level Output**, If enabled the trigger output DC level can be specified.
- **Trigger Delay**, A delay time can be specified to hold off the trigger output for a set amount of time in mS. This can be used to provide a delay between a channel being used for flight termination, which would have no delay, and a separate parachute channel, which may have a short delay there after of perhaps 0.25 to 1 second delay. This gives time for the rotors to stop. In some applications a longer delay may be needed. Up to 16 seconds delay can be set.

External trigger input

If enabled this input can be used to trigger the SATS-MINI to release the parachute via an external control. Configuration options are:

- **PWM Input**, If PWM signal is selected this is the input pulse width that will cause the trigger event. Pulse width is provided in uS. The Windows UI has a button that can sample and save the current PWM width as the trigger condition.
- **PWM Tolerance**, When PWM is selected this is the allowable tolerance in the detected pulse with. Typical may be 10%.
- **DC Level**, If selected this is the input level that causes the system to trigger.

External safety / armed input

If enabled this input can control if the SATS-MINI is in Safety or Armed State. Configuration options are:

- **PWM Input**, If PWM signal is selected this is the input pulse width that will cause the SATS-MINI to remain in the Safety state. Pulse width is provided in uS. The Windows UI has a button that can sample and save the current PWM signal provided.
- **PWM Tolerance**, When PWM is selected this is the allowable tolerance in the detected pulse with. Typical is 10%.
- **DC Level**, If selected this is the input level that causes the system to trigger.

  NOTE: When the external safety is used with the altimeter based safety, the safety state will be asserted if either the altitude is below the configured altitude, or the external safety input is asserted. Said another way, the SATS-MINI will enter Armed if the altitude is above the configured Safety altitude, and the external Safety input is not asserted. If latching Armed is configured once the SATS-MINI enters the Armed state it will then remain Armed until the SATS-MINI is transitioned into Idle, or if the unit is power cycled. If latching armed is not selected then the SATS-MINI will go back to Safety if the external safety is asserted, or the altitude drops below the configured safety altitude.

System status output

If enabled this output is asserted when the SATS-MINI is in a target operational state. Options are:

- Safety
- Armed
- Safety or Armed
- Disarmed (Idle)
- Error

This can be used to interface to the autopilot to alert the autopilot of the device is in a given operational state. Configurable options are:

- **PWM Output**, If selected the PWM pulse widths can be specified in uS for the configured operational state is active, or is not active. PWM output frame rate is the RC industry standard of 20ms.
- **Level Output**, If enabled the trigger output DC level High or Low can be specified when the configured operational state is active.
- **State Asserted**, This determines the operational state that is being watched and asserted if active.

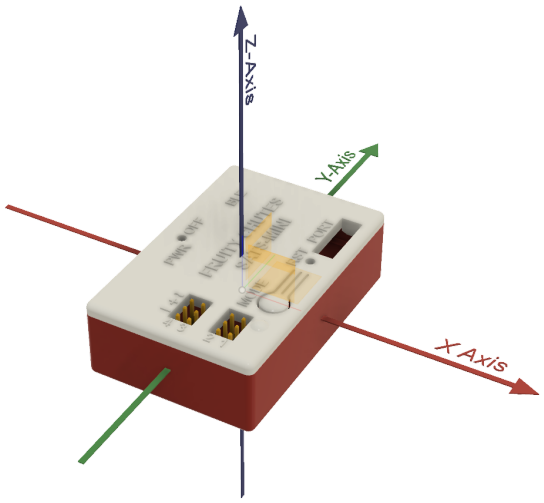
Flight Mode Selector input

As is release 1.2.0 the SATS-MINI supports multiple flight modes of Multi-copter, or Fixed Angle. Generally the current rotation detection (Flipping) is used for Multicopters. Fixed Angle is ideal for Fixed Wing aircraft. This virtual input can be used to switch modes on the fly providing support for VTOL aircraft. Configuration options are:

- **PWM Input**, If PWM signal is selected this is the input pulse width that will cause the SATS-MINI to select the configured flight mode. Pulse width is provided in uS. The Windows UI has a button that can sample and save the current PWM signal provided.
- **PWM Tolerance**, When PWM is selected this is the allowable tolerance in the detected pulse with. Typical is 10%.
- **DC Level**, If selected this is the input level that causes the flight mode selection.

SATS-MINI IMU, System, and Other Programmable Features Overview

The SATS-MINI has many general hardware features and settings that control overall operation. Central to the SATS-MINI is the 9 Dof IMU that constantly monitors the Drones flight while in the Safety and Armed state. The diagram below shows the native IMU orientation of the X, Y and Z axis.



SATS-MINI Native IMU Axis Orientation

Most of the features described below are configurable via the Shooty Chutes UI setup program.

SATS-MINI Primary Axis Calibration

Calibration tells the SATS-MINI which way is up and the primary rotation axis for the Drone (Z axis, or Yaw). This allows the SATS-MINI to discern Yaw rotation which is common for camera panning, from X (pitch) or Y (roll) rotation which should at best be limited in motion. Using calibration the SATS-MINI can be mounted in any arbitrary orientation on the drone and it will work properly. The angular data captured during calibration will allow the translation of the physical IMU angular position and motion into the drones world view orientation for the detection algorithm.

IMPORTANT for 1.2.0: While in Fixed Angle detection mode the SATS MINI needs to be used in the native orientation where the Y axis points to the forward direction of travel, and the Z axis is up. For Tail Sitter VTOL the calibration can be used to set the vertical takeoff orientation of the aircraft. For a tail sitter VTOL the Y axis would be vertical in this case.

SATS-MINI Mounted Native Orientation at X:0, Y:0, Z:0

SATS-MINI Mounted Rotated at X:30 Y:0 Z:90

Once the primary axis is set the SATS-MINI uses two different rotation failure detection algorithms to sense X and Y rotation failures called **Tumble Rotation Detection**, or Z rotation failures called **Yaw (Primary Axis) Detection**. These are configured using the Shooty Chutes UI configuration screens. These are described next.

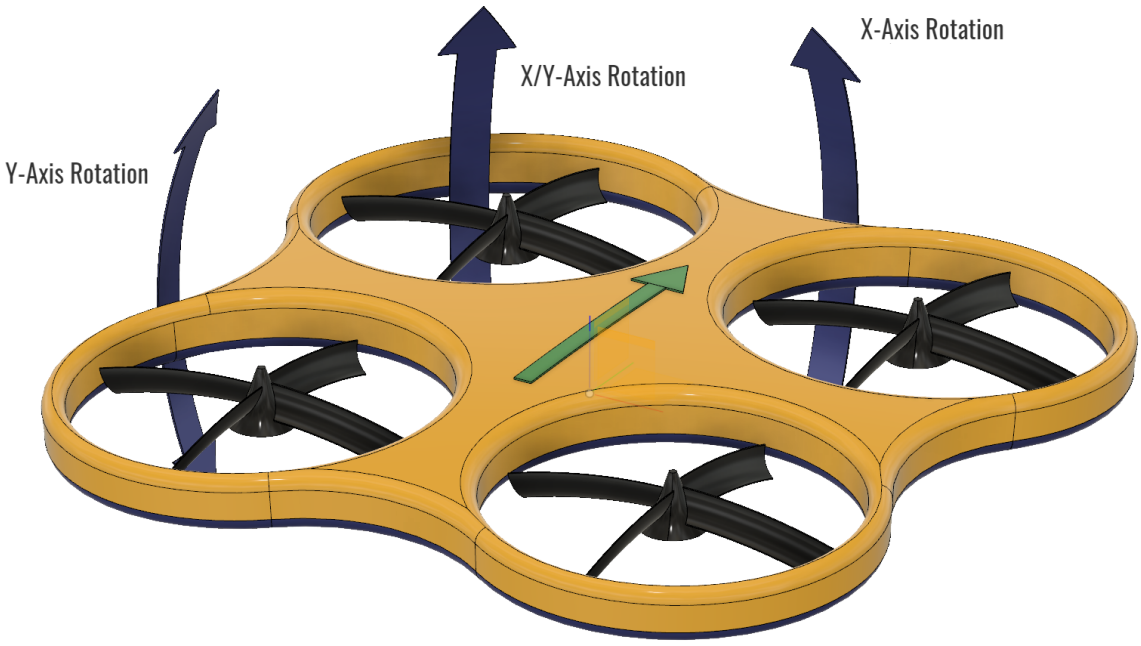
Trigger Setting for Tumble Rotation Detection

This detection looks at rotation of only the X or Y axis, independent of the Z (Yaw) axis. Unless you are flying an aerobatic drone there should never be complete rotation on the X or Y axis. The UI settings for this detection are to specify:

*Rotation of **XXX** degrees in under **Y.Y** seconds*

The default settings is 360 degrees of rotation in under 2 seconds. Degrees can range from 60 to 720 degrees. Time can range from 0.1 to 4 seconds.

Both the X and Y axis are fused together in case the roll is a combination of both X and Y so detection angular rotation is independent the exact axis of rotation. For the default value the trigger will occur as soon at 360 degrees of rotation occurs, and as long as it happens in less than 2 seconds.



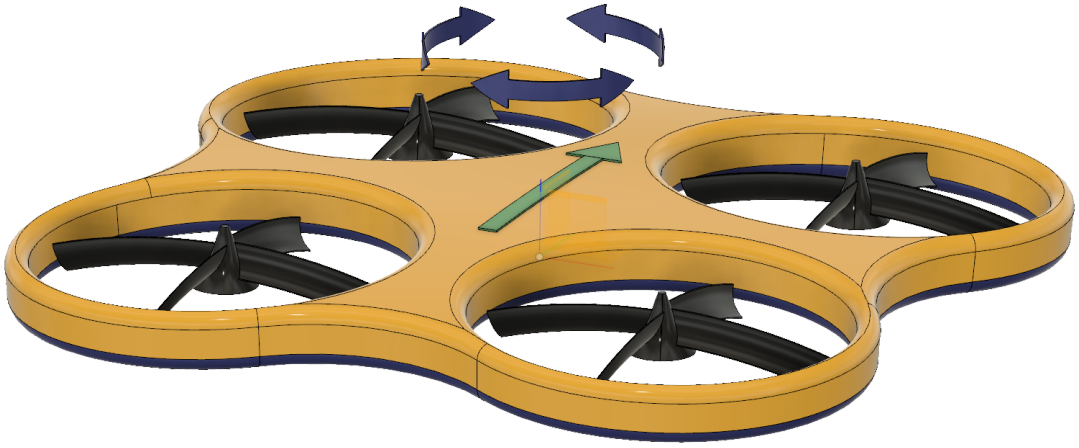
Off Primary Axis Rotation

Trigger Setting for Yaw (Primary Axis) Detection

Given the drone is upright (Z axis pointing up), there is a separate set of detection parameters for Yaw detection. This allows a Drone to have a different detection parameters to allow for camera panning that could be much faster or slower. Again the UI settings for this detection are to specify:

*Rotation of **XXX** degrees in under **Y.Y** seconds*

The default setting is 540 degrees of rotation in under 2 seconds. Also degrees can range from 60 to 720 degrees. Time can range from 0.1 to 4 seconds.



Yaw Rotation

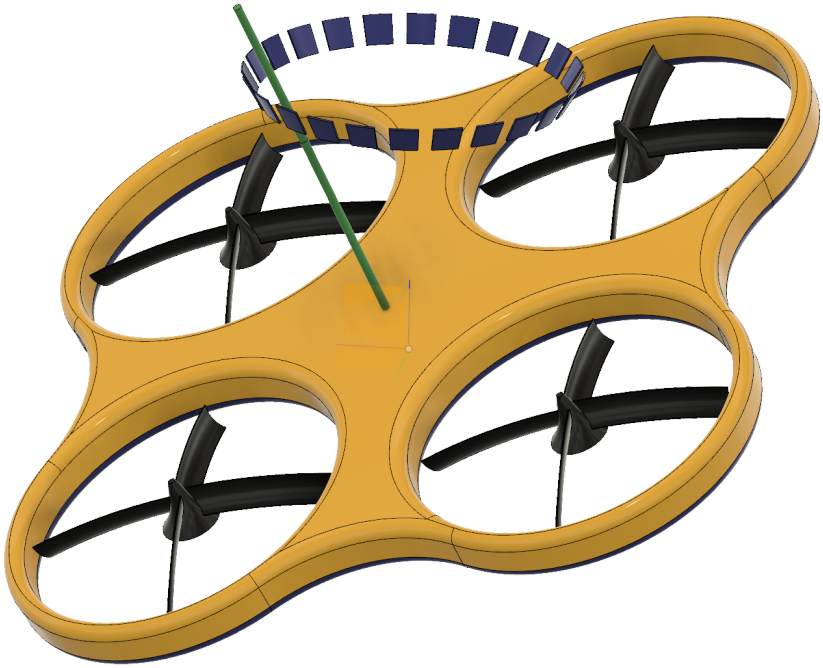
NOTE: Yaw rotation detection is only done when the Primary Axis is within a given number of degrees of vertical, typically 30 degrees. If the Primary Axis is off vertical (e.g. the drone is tipped on its side) then Tumble Rotation is used. For more on this see **Rotation Tolerance** below.

Rotation Tolerances

This setting specifies the Primary Axis tolerances used in the algorithm.

*Primary Axis Tolerance (deg) **XX.X*** (range 10 to 45 degrees, default 30 degrees)

This setting tells the SATS-MINI the acceptable Z axis offset from perfect vertical. Typical is 30 degrees deviation from pure vertical. Minimum value is 10 degrees, maximum is 45 degrees off vertical. For Yaw rotation to be in affect the Z axis must be within this maximum angle off vertical. If the Z axis is off vertical by more than this then the Tumble Rotation Detection parameters are used and all three axis X / Y / Z are fused into an absolute magnitude for detection.



Yaw Rotation Tilt of 27 Degrees Off Vertical, 30 Degrees Tolerance Marked in Blue

Free Fall Detection

This detection uses the three axis accelerometer in order to detect a free fall, for example if the drone has a complete power failure causing the drone to fall from the sky. Setting for free fall are:

Free Fall Threshold (g): ***X.XX*** (range 0.1g to .5g, default 0.3 g)

Free Fall Maximum Time (s): ***X.XX*** (range .1 to 2 seconds, default 0.5 seconds)

Free Fall Reset Count: ***X*** (integer from 1 to 4, default 1)

The Free Fall detection looks at the fused magnitude of all three X / Y / Z accelerometers to compute an absolute magnitude. The trigger condition will happen when the magnitude is less than the threshold for more than the maximum time. For example using the defaults the magnitude of X / Y / Z would need to be under 0.3G sustained for 0.5 seconds. The reset counter comes into play with how many samples are allowed over the threshold that would reset the Free Fall Maximum Time Counter. The default is 1 count over threshold needed to restart the detection time count.

There are some reasons why you may not want a very low Free Fall threshold like 0.1. If the SATS-MINI is mounted off the Drone center of gravity and you have rotation at a higher rate of speed, for example due to a single ESC failure causing fast flipping, this will cause centripetal force to create an apparent “acceleration” that can be greater than the detection threshold. In that case the rotation detection would also catch the failure. But with a proper free fall threshold the free fall detection can trigger the parachute first and possibly faster than a complete rotation might need.

Altimeter Based Automatic Safety

When the SATS-MINI is in the Safety / Armed mode, and if the SATS-MINI Altitude configuration setting is greater than 0, the SATS-MINI will stay in the Safety mode until the drone climbs above the preset altitude. There is a UI option to latch the Armed mode. If this is not set then descending under the altitude will cause the Safety to be reasserted. If the Latch Armed UI feature is set then once the drone climbs above the altitude setting the Drone will stay in Armed until the SATS-MINI transitions back to Idle using the Mode switch, or the SATS-MINI is power cycled.

When the external safety is used with the altimeter based safety, the safety state will be asserted if either the altitude is below the configured altitude, or the external safety input is asserted. Said another way, the SATS-MINI will enter Armed if the altitude is above the configured Safety altitude, and the external Safety input is not asserted. If latching Armed is configured once the SATS-MINI enters the Armed state it will then remain Armed until the SATS-MINI is transitioned into Idle, or the unit is power cycled. If latching-armed is not selected then the SATS-MINI will go back to Safety if the external safety is asserted, or the altitude drops below the configured safety altitude.

Descent Rate Trigger (1.1.2 software or greater)

This monitors the altimeter and watchs for the drone descent rate as being excessive. This is used to detect a drone that is between normal controlled flight and a full out of control free fall. An example might be if your drone has a low or failing battery but the drone is coming down too fast, but under at least some control. Setting include:

Enable: Enable or Disable the feature, default disabled

*Fall of: **XXX** meters in under **XXX** seconds.* (range of 5 to 20 meters, 0.5 - 2 seconds, default is 12 meters in 1 second)

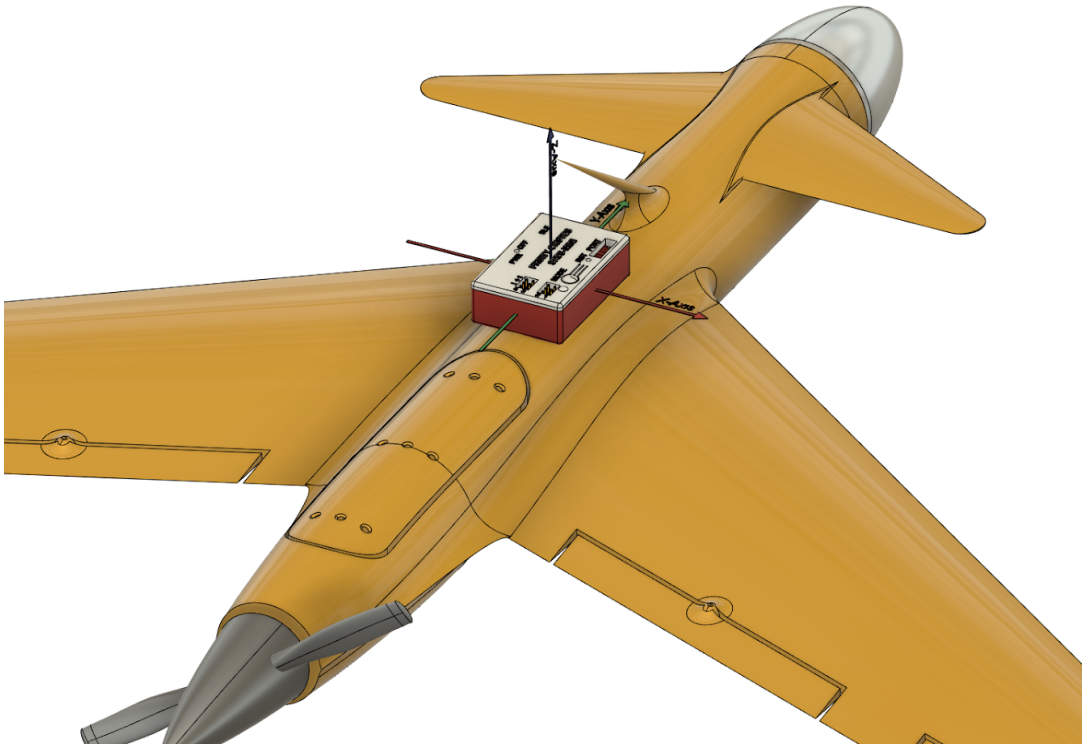
To use this feature we strongly recommend you flight test this your setting on your drone first to check for false triggers. As a point of reference the Mavic 2 drone maximum descent rate is around 5 to 6 meters per second for short times.

Drone External Power Monitor Trigger

This feature, if enabled, will monitor your drone main battery power and trigger the parachute once the battery is under a preset level. (1.1.1 software or greater)

Fixed Angle Detection (1.2.0)

This feature is ideal for fixed wing aircraft. In this mode the acceptable roll, and pitch angles are specified. Also maximum angular rate of change in degrees per second can be configured. If the selected parameters are exceeded then the SATS-MINI is triggered. For Fixed Angle the SATS-MINI must be oriented in its native non-calibrated orientation for this feature (calibration values are X:0, Y:0, Z:0).



SATS-MINI orientation Fixed Angle Detection

Using Flight Mode Input Selector (1.2.0)

Configuring this input allows the SATS-MINI flight mode to be selected on the fly. This is ideal for VTOL support where the drone is operated in two distinct types of flying, Typically the current Tumbling detection is used for multicopters. Absolute Angle detection is ideal for Fixed Wing. When the Flight Mode Input selector is enabled the Device Setup screen has a selector at the top to indicate which features are enabled for each mode. Both flight modes have completely separate selection values for all trigger features. So all trigger settings can be exactly specified for each flight mode.

In either flight mode, Tumble detection or Fixed Angle can be used, but not both. And either of these can be used for both flight modes. For example someone might want to use Absolute Angle the multicopters as well as fixed wing mode. Still the parameters for all detection features can be independently set for each flight mode.

System Logger (Black Box)

The SATS-MINI System Logger performs the same function as the black box on an aircraft. If the parachute should deploy, or there is some other problem, the Flight Logger gives you detailed diagnostic information about what happened. Logging is recorded to the onboard Flash memory.

There are two basic log types that run in parallel. These are the Event Logger, and the Flight Logger.

Event Logger

This logs the high level events like the arming of the SATS, transitions out and into Armed. Also if the parachute is triggered it saves detailed IMU data, the reason for the trigger, and other data at that instant. Below is an example of the Event log entry for a free fall detection:

1	sec	Start Time March 26 2020	7:32:43 PM	*(V2.1 SATS MINI has time stamp feature)*
… detail logging …				
101.26	sec.	Trigger Event	Free Fall	7:35:55 PM
101.26	sec.	X Rotation	7.46	degrees
101.26	sec.	Y Rotation	42.8	degrees
101.26	sec.	Z Rotation	-4.47	degrees
101.26	sec.	Rotation Magnitude	43.67	degrees
101.26	sec.	X Acceleration	0	g
101.26	sec.	Y Acceleration	-0.01	g
101.26	sec.	Z Acceleration	0.15	g
101.26	sec.	Acceleration Magnitude	0.15	g
101.26	sec.	Altitude	34.21	m
… detail logging …				
131.26	sec.	Log Complete	Manually Returned to Disarmed State	7:36:00 PM

Flight Logger

This logs the 9DOF IMU data, current computed angular rotation of all axis, event altitude AGL (above ground level), voltages (V-Lipo, V-Supply, V-External) and other critical information in a spreadsheet like view recorded at a rate of 10 samples per seconds. If you have a 1 hour flight you will have 36000 records saved. Software 1.0.30 allows the logging frequency to be set to 5hz, 10hz, or 20hz.

All log data is time stamped from the time the SATS-MINI was transitioned to an operational state (Safety / Armed). In addition a Log number is assigned at this time. All logs start at 0 seconds and count up. Version 2.1 hardware will also save the date / time the log is started.

Unless erased new logs are appended to the end of the previous log. A maximum of 6.5 total hours of detailed flight logging can be captured (with 10 hz logging). After this only the Event Log will record. If enough Event logs accumulate eventually the Flash will fill up and logging will stop. That could take a long time since the Event Log entries are very small.

The Flight Logs can be downloaded using the Shooty Chutes UI and saved to a CSV file. You can use Excel to view and analyze the logs. After downloading the logs you can also erase the Flash memory keeping the size small and to make downloading fast.

Altimeter Logging

The Altimeter information is included in both the Flight Logger and the Event Logger. The altimeter provides important information about how high the drone is when the parachute is deployed. Altimeter log data is recorded as altitude above ground level and as meters. At the start of the log the current altitude is sampled in order to provide the offset for the AGL computation. Using the Flight Logger altimeter data can also help determine the altitude loss between the SATS-MINI parachute trigger and the parachute being deployed and opened in steady state descent. This information is critical when using the SATS-MINI as part of the ASTM F3322-18 parachute system certification flight testing.

Voltage Logging

Key power sources voltages are logged.

- Battery Voltage - This is the Lipo voltage, which can range from 4.2V high to 3.1V low.
- Supply Voltage - This is 5V supply voltage applied to Channel 3 or 4 center pin, or the USB input.
- External Voltage - This is your drone main battery pack and can range up to 33.2V. This power source is connected to the Expansion Port Pin 8.

Real Time Clock

V2.1 of the SATS-MINI hardware adds a real time clock (RTC) chip that adds date and time stamps to key log events.

Automatic Log Management

As of 1.2.0 several new features are available to alleviate the need to erase the log after 6 to 7 hours of flight time (depending on log speed).

Terse Logging

In this mode only log events are saved to flash memory in real time. However detailed fight data is written to a buffer that saves the last 100 entries. If there is a trigger event the buffer is first dumped to flash memory and then details about the trigger. This typically allows the previous 10 seconds at 10hz log rate of detailed flight data to be logged leading up to the trigger vent. For 5 hz logging it would save 20 seconds previous, at 20 hz only 5 seconds are saved. After the trigger details are saved then the next 30 seconds of detailed flight logging is also written to flash and the log is closed.

With Terse mode enabled, and for normal operation, a typical flight uses very little space (< 50 bytes) so approximately 80,000 flights can be recorded. But in the case of a trigger these details are available for analysis. If you trigger every flight, for example if you use the SATS to initiate a parachute deployment for every flight for landing, there is space for approximately 290 flights before the log is full.

For normal (not terse) logging, once the log space available reaches 30 minutes left, the system forces terse logging so a trigger event now has the flight information leading up to the failure.

Automatic Log Erase as Startup Option

Once the log space available reaches 10 minutes (based on non-terse logging data rate) the Flash can be auto-erased on the next startup. This erases all log data and delays startup by about 35 seconds while the flash memory is erased.

Power Management Features

The SATS-MINI can be powered externally or from the built-in 500 mAh battery. When external power is removed the SATS-MINI will seamlessly switch over to the internal Lipo. While external power is supplied the Lipo will be automatically charged as needed.

Lipo Battery Life

The battery life depends on a number of factors.

- Plan on the maximum battery life being around five and a half hours of operation. This is with single servo being used to eject the parachute or other servo signal decoder board that is low current.
- If you add the Nano receiver the battery life is just a bit over three hours.

In any case we recommend doing a ground test of the battery life for your particular application. You can use the flight log time stamp to record the start of operation at fully charged to automatic turn off.

Lipo Charging

You can charge the Lipo via the USB port. Also if you supply external 5V power into Ch 3 or Ch 4 this will also charge the Lipo. If there is an external power failure the Lipo battery will be fully charged and can still eject the parachute if needed. Charging takes about one hour and fifteen minutes. The SATS-MINI can draw up to 500 mA during the charge process plus enough power to operate the SATS-MINI and any peripherals that may be connected.

Lipo Low Voltage Monitoring

The SATS-MINI monitors the Lipo battery voltage to make sure there is adequate power in order to protect a flight. The Lipo voltage monitoring will also protect the battery from over-discharge. The SATS-MINI beeper will start to “chirp” twice per second when the Lipo has just enough power for one hour of operation.

IMPORTANT: To avoid having the SATS-MINI battery fully discharging during your drone flight we recommend that you *never* start a flight if the SATS-MINI low power warning is chirping.

Below are details how the SATS-MINI monitors the Lipo voltage:

- When the Lipo drops under 3.75V the SATS-MINI will start beeping twice per second to alert the pilot that the Lipo has at least one hour of charge left. **IMPORTANT:** Do not start a flight with the SATS-MINI beeping the low voltage warning.
- When the Lipo drops under 3.6V the SATS-MINI will not turn on. Pressing and holding the Mode button will cause the SATS-MINI to turn on, and then immediately turn off. There is about 15 min of power remaining at 3.6V.
- When the Lipo drops under 3.1V the SATS-MINI will automatically turn off. This is to protect the battery. At 3.1V the SATS-MINI can not reliably provide enough power to trigger the parachute.

We recommend charging the SATS-MINI as soon as you hear it beeping in order to protect your drone at all time.

External 5V Power Auto-Shutdown (1.0.29 or later software)

If enabled this feature will automatically turn off the SATS-MINI power when the external 5V power source is removed and after a two minute delay, or configurable delay (V1.1.1 or later). This lets you power on and off the SATS-MINI by connecting the SATS-MINI Channel 3 or 4 center power pin to your autopilot or other drone 5V power source. For example when the autopilot turns on that will automatically turn on the SATS-MINI (standard feature). Then when the external power is removed the SATS-MINI will detect that and start count down and then turn off automatically.

Other Resources

SATS-MINI Quick Start Guide

SATS-MINI Users and Programmers Guide - Detailed information on how to integrate the SATS-MINI with various drones. ALso using the ShootyChute Windows UI to configure and program the SATS-MINI.

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