Indoor “GPS”

(with ±2cm precision)

Autonomous copter setting manual

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Description

- The manual gives basic and practical recommendations for setting up of Indoor “GPS” system for usage with autonomous copters/drones indoor and outdoor, with focus on indoor

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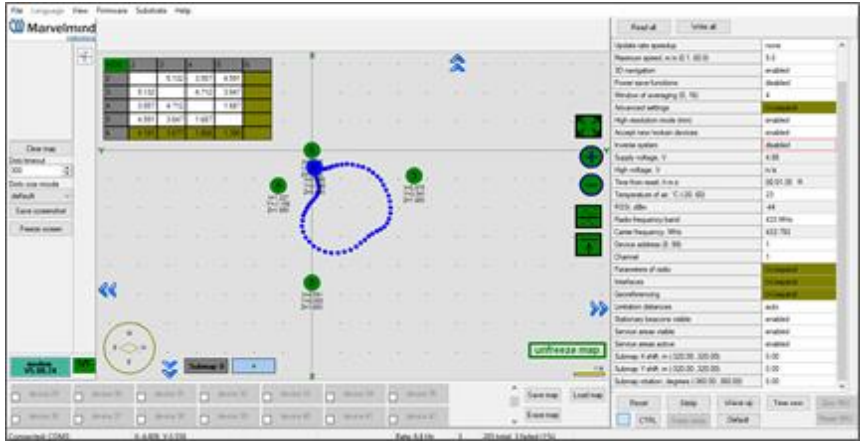
Step 1: Get basic tracking of beacon

- First of all, reach good basic tracking of beacon prior attaching to any drone. Use Starter Set or Starter Set with IMU with default settings
- Don’t yet try to fly remotely controlled or even fly autonomously until you have good tracking of a mobile beacon in hands. Otherwise, it will be very difficult to distinguish where the issue coming from – tracking instability in Marvelmind Indoor “GPS” or ArduPilot or other systems settings
- Follow step-by-step recommendations in the Operating Manual and YouTube channel

Dashboard view



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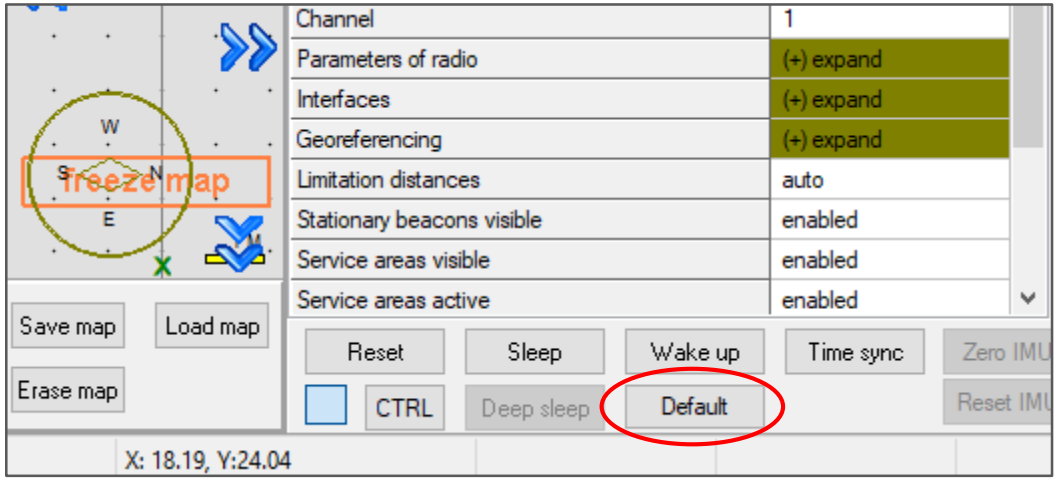
Step 1.1: Use default settings

- Set everything in default, at the beginning. Later on, you may use optimized settings (higher order Radio Profile, faster update rate, etc.). But now, use only default settings
- Press Default button in the Dashboard to guarantee the default settings in all beacons and modem, when either modem or beacon connected over USB (from the step-by-step guide in the Operating Manual)

Dashboard view



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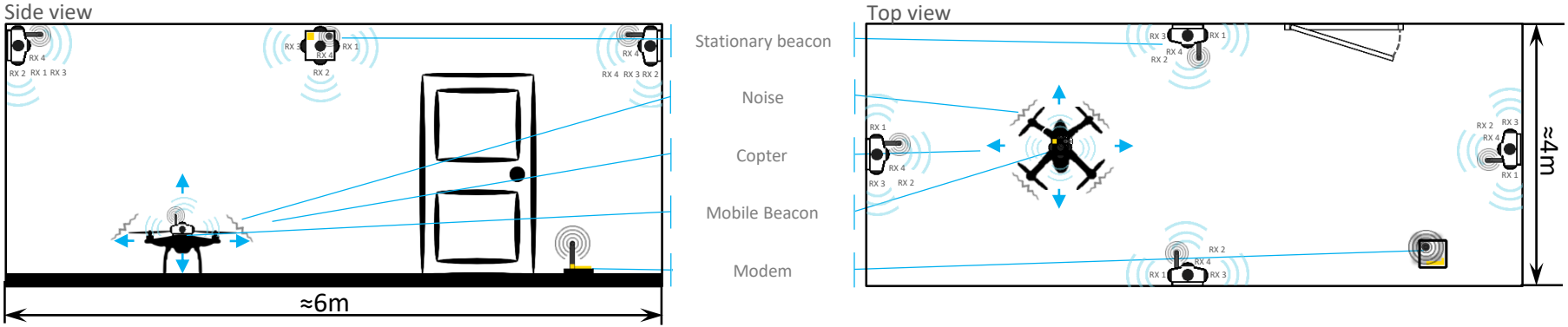
Step 1.2: Place beacons correctly

- Choose a mid-size area, for example, 6x4m or 10x10m or so
- It is recommended to put stationary beacons at the same height and above the fly area and farther from the sources of noise, such as copter
- Enable only needed sensors (RX1-RX5) – not all of them. But make sure they are enabled at all



Step 1.3: Reaching good “Z” axis

- To have good Z tracking, remember to fly always either significantly below the plane of stationary beacons and significantly above the plane. Otherwise, Z precision will suffer. Rule of thumb, the angle between the mobile beacon and the plane of stationary beacons must not be less than 15-20 degrees: https://www.youtube.com/watch?v=19lUp-ADD3Y&t

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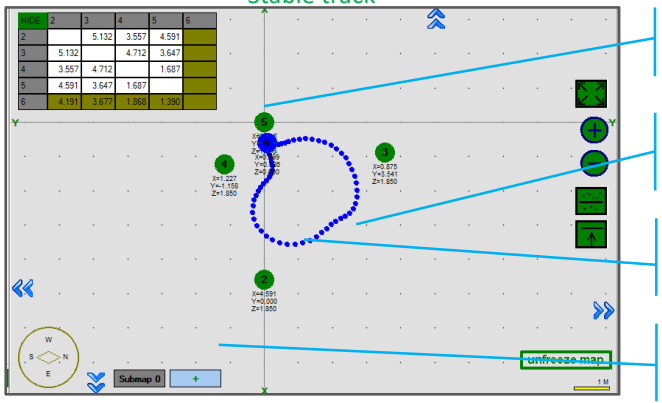
Step 1.4: Reach stable tracking

- Reach good and stable tracking of a mobile beacon over the whole map, where the drone will fly. The beacon shall be still separate from a copter - just regular tracking over the whole area with mobile beacon in hands or installed on a tripod, etc.

  *If necessarily, and that is strongly recommended, to minimize unnecessary noise and to increase range, disable sensors on each beacon that are not needed: [How to enable/disable sensors on beacon]

Stable track



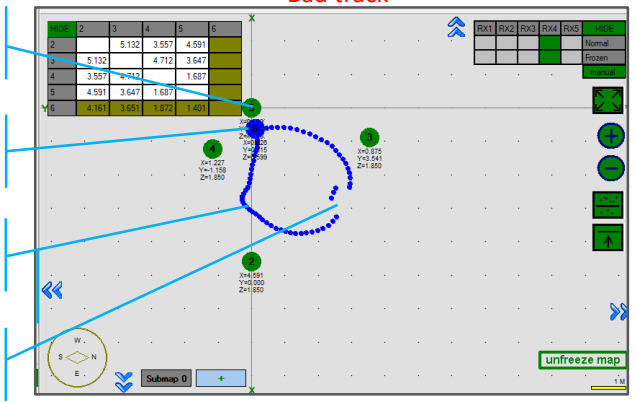
Stationary Beacon

Mobile Beacon

Track

Jumps

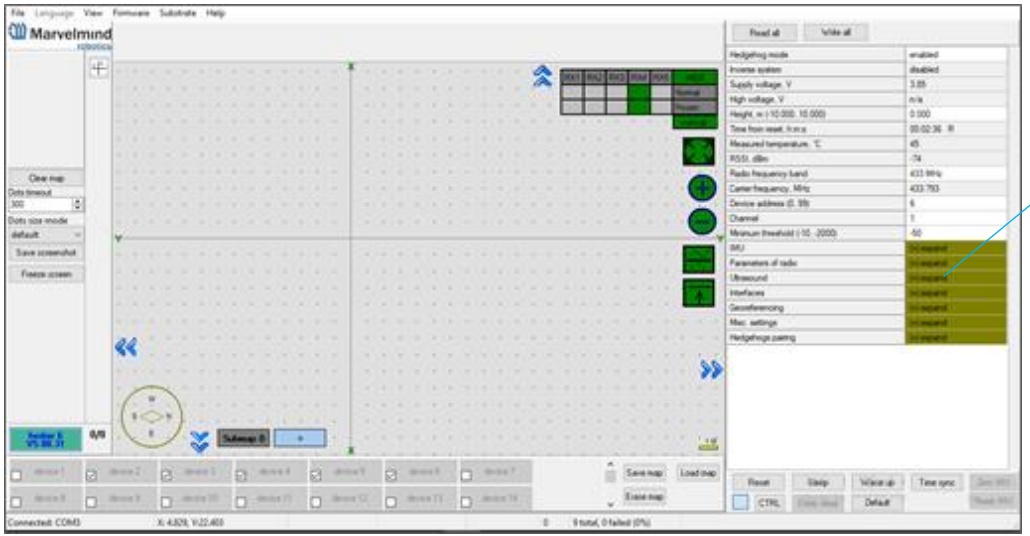
Bad track



Step 1.5: Set recommended number of periods

- For distances larger than 10m or so, use 50 periods in ultrasonic instead of the default (5 for Beacon HW v4.9, 20 for Super-Beacon) (**Dashboard => Choose beacon => Ultrasound** => **Number of periods**). This gives stronger ultrasonic signal and better signal to noise ratio

Dashboard view



Ultrasound Tab

Ultrasound	(-) collapse
Mode of work	TX+RX normal
High voltage TX settings	(+) expand
Analog power in sleep	disabled
Power after transmission	not turn off
Transmitter mode	PWM
Frequency, Hz (100..65000)	31718
Duty, % (1..99)	50
Number of periods (1..100)	5
Amplifier limitation (calibrated)	4000
Amplification	manual
Receiver amplifier (0..4095)	4000
Time gain control	disabled
Mode of threshold	automatic
Minimum threshold (-10..-2000)	-50

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Step 1.6: Number of periods

Ultrasound Tab

Ultrasound	(-) collapse
Mode of work	TX+RX normal
High voltage TX settings	(+) expand
Analog power in sleep	disabled
Power after transmission	not turn off
Transmitter mode	PWM
Frequency, Hz (100..65000)	31718
Duty, % (1..99)	50
Number of periods (1..100)	5
Amplifier limitation (calibrated)	4000
Amplification	manual
Receiver amplifier (0..4095)	4000
Time gain control	disabled
Mode of threshold	automatic
Minimum threshold (-10..-2000)	-50

Ultrasound Tab

Ultrasound	(-) collapse
Mode of work	TX+RX normal
High voltage TX settings	(+) expand
Analog power in sleep	disabled
Power after transmission	not turn off
Transmitter mode	PWM
Frequency, Hz (100..65000)	31718
Duty, % (1..99)	50
Number of periods (1..100)	50
Amplifier limitation (calibrated)	4000
Amplification	manual
Receiver amplifier (0..4095)	4000
Time gain control	disabled
Mode of threshold	automatic
Minimum threshold (-10..-2000)	-50

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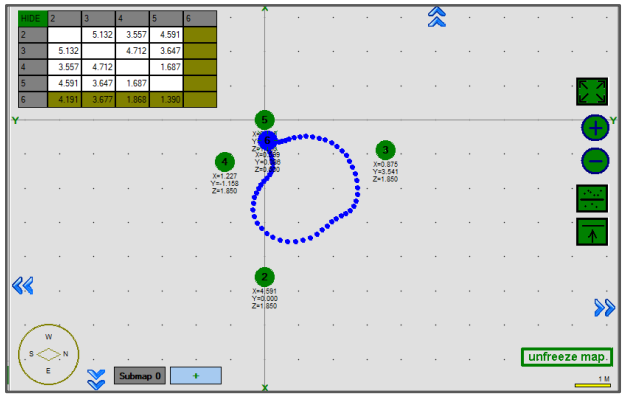
Step 2: Onboard tracking - rotors not active

- In Step 2, repeat the Step 1, but place the beacon on the copter exactly how it will be placed in real life. Power everything on the drone, except rotors. Check, for example, that drone's telemetry, power, etc. doesn't affect tracking of the mobile beacon. Get the stable track

Stable track



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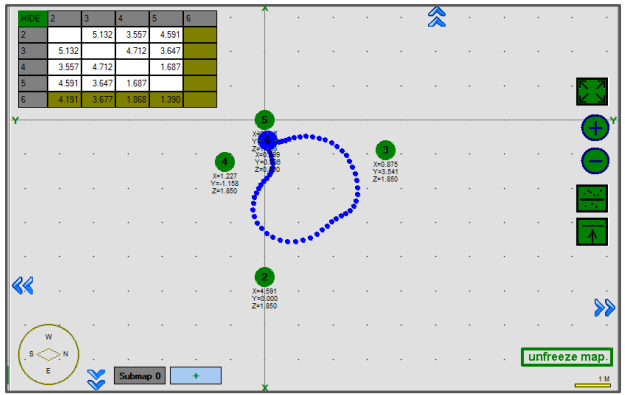
Step 3: Onboard tracking – rotors active

- Now, put the copter on the floor where it is supposed to fly and apply 80-90% of taking off power to the rotors. If the tracking is stable (no jumps, etc.), move to the Step 4
- If you have any problems related to the noise of rotors, adjust ultrasonic and other settings

Stable track



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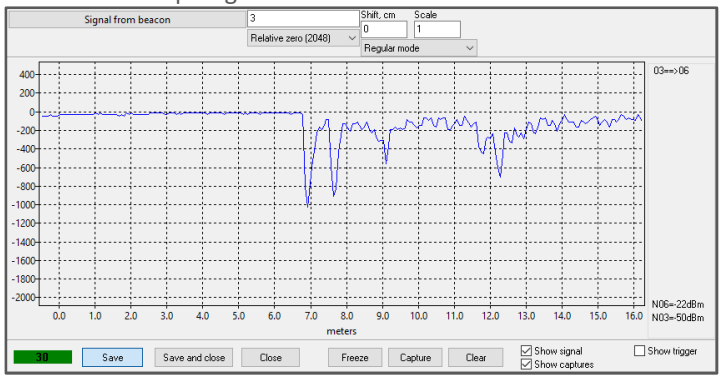
Step 3.1: Overcome the noise

- If tracking becomes unstable, when motors are powered, use **Dashboard** => **View** => **Oscilloscope** to monitor signal from the mobile beacon to all stationary beacons one by one.

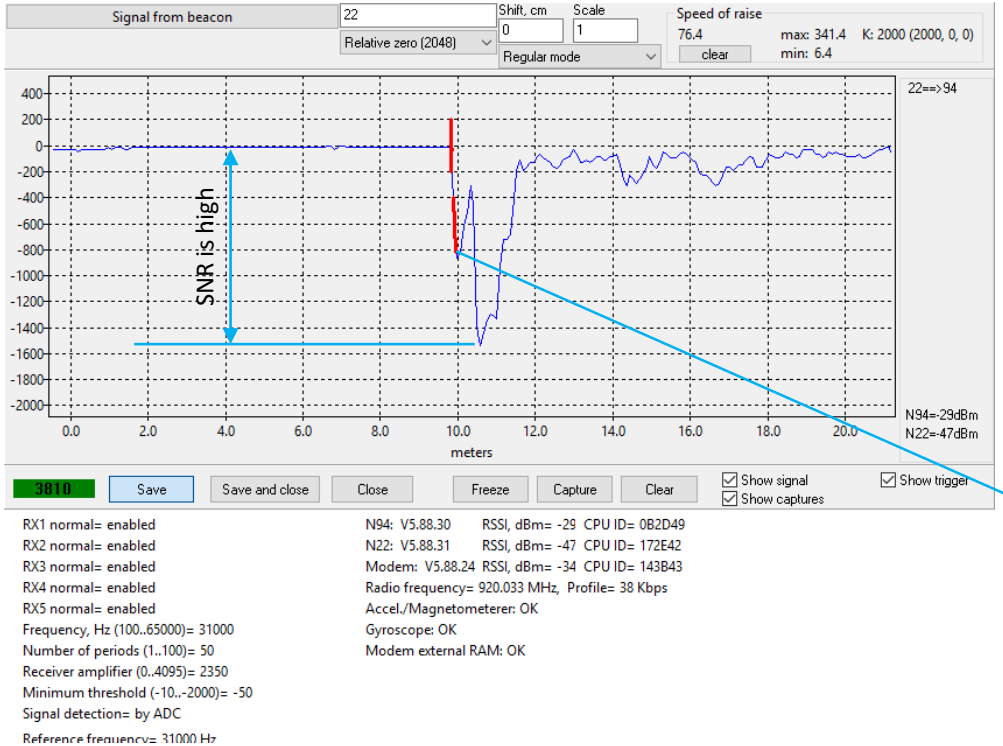
[Help Video: how to use embedded oscilloscope]

- If necessary, set **gain** settings to manual in beacon ultrasonic settings and adjust the gain optimally and manually. Do it by changing the gain and monitoring the ultrasonic signal using oscilloscope. The task is to have signal from the mobile beacon strong, but not overloaded - in **500-1500** range. That would prevent the ultrasonic amplifier from saturation and signal/noise degradation
- Check several points this way on the map
- See Operating Manual for more details

Good oscilloscope signal



Step 3.2: AGC without noise - example



- AGC is ON
- Noise is very low
- Trigger works correctly
- Signal to noise ratio (SNR) is high

Trigger (works correctly)

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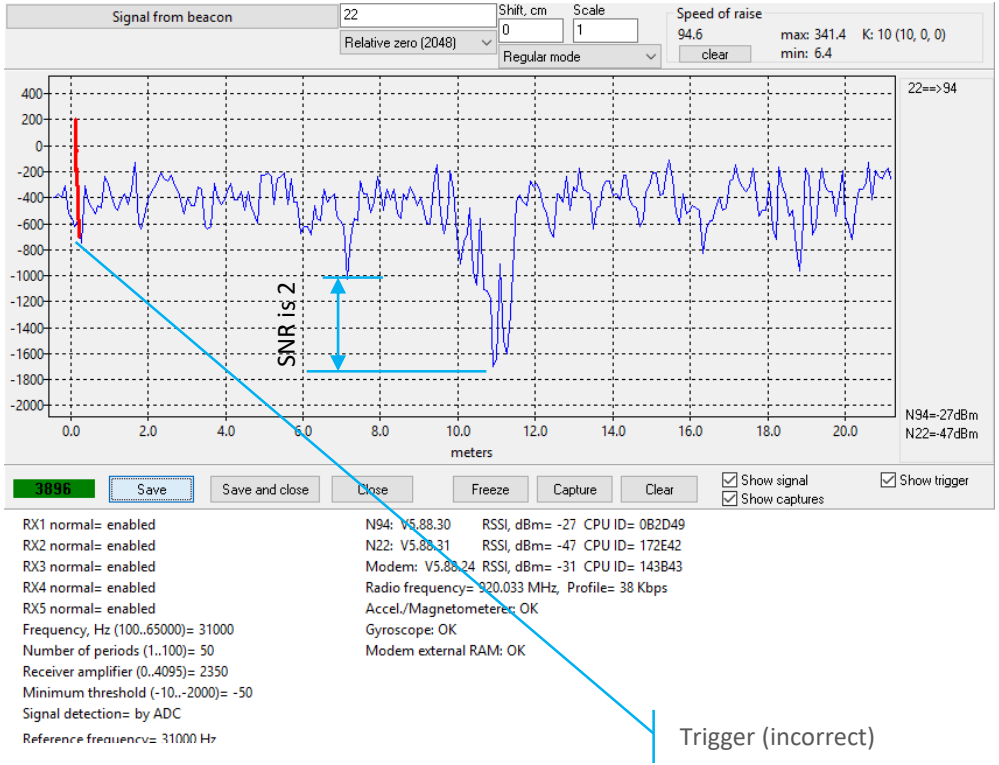
Step 3.3: AGC with noise - example



- AGC is ON
- Strong external noise, for example, copter's noise
- Trigger works incorrectly (real distance is 10m, but it triggers at 0.2m)
- Signal to noise ratio is low

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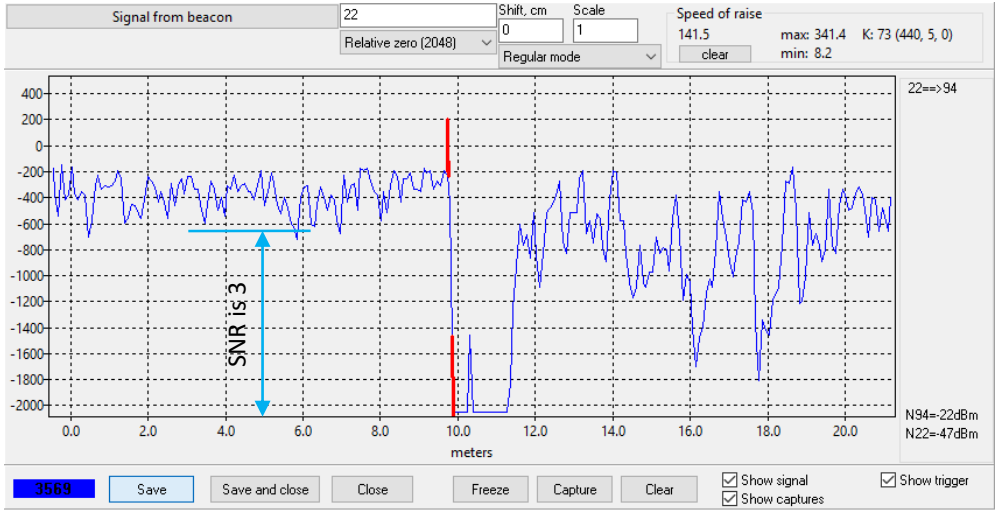
Step 3.4: Manual gain – overloaded signal



- Manual amplification is ON
- The same level of noise as in the previous example
- Receiver amplifier = 4000
- Too big amplifier value (Gain) **=>** SNR is already good enough and triggers at the right place, but still SNR is suboptimal

=> Make gain lower to improve signal to noise ratio

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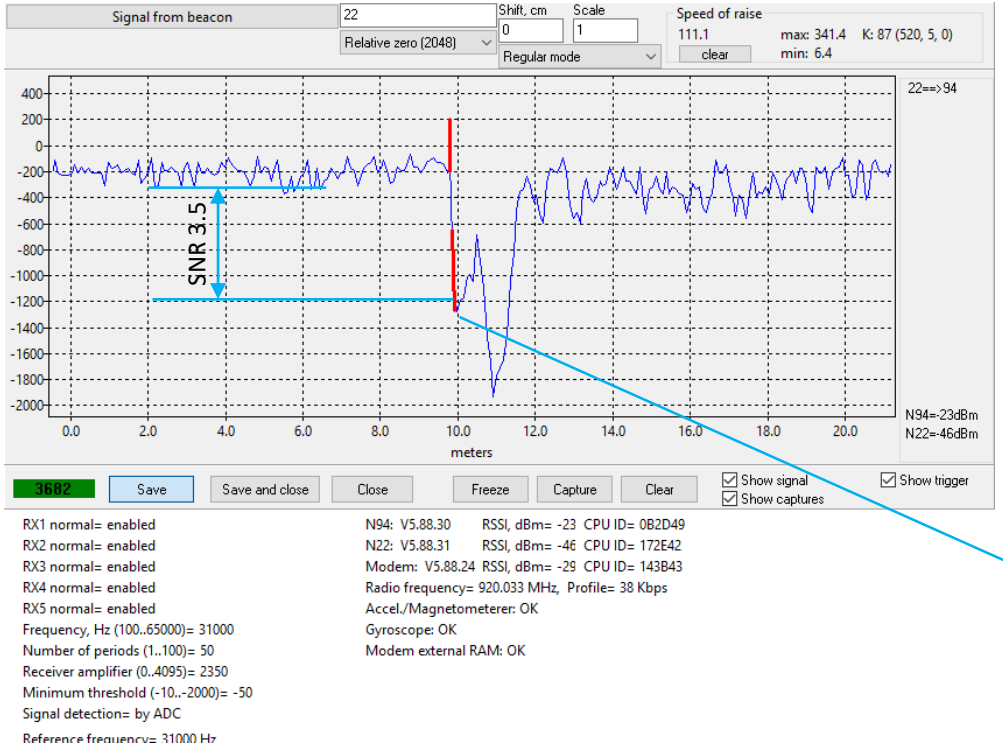
Step 3.5: Manual gain – correct values



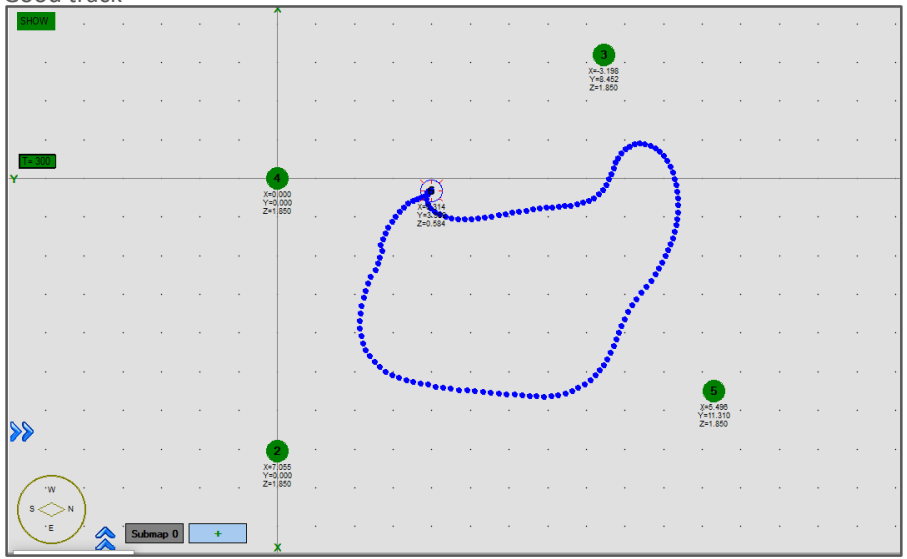
- Manual amplification is ON
- The same level of noise as in the previous example
- Receiver amplifier = 2350
- Signal is not overloaded
- Solid signal to noise ratio
- Trigger works correctly

Trigger (works correctly)

Step 4: The manual flight

- Now, starts flying the drone in manual mode and track the copter over the whole area. If tracking is good , the copter is ready for automatic mode. Move to the Step 5
- If something is incorrect, see next page…

Good track



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Step 4.1: If something is wrong

- Please, re-check the previous steps and Operating Manual and our YouTube channel. Try also:
  - Check that only correct sensors (RX1-RX5) are enabled
  - Fly farther from stationary beacons, i.e. place them 15m apart and fly only within the central 5 meters spot, etc.

- If everything is really correctly done, then, probably, the copter is simply too noisy, range is too big or something more fundamental:
  - Reduce the range between beacons to increase signal/noise ratio
  - Use less noisy drone or perform other similar operations to increase signal/noise ratio

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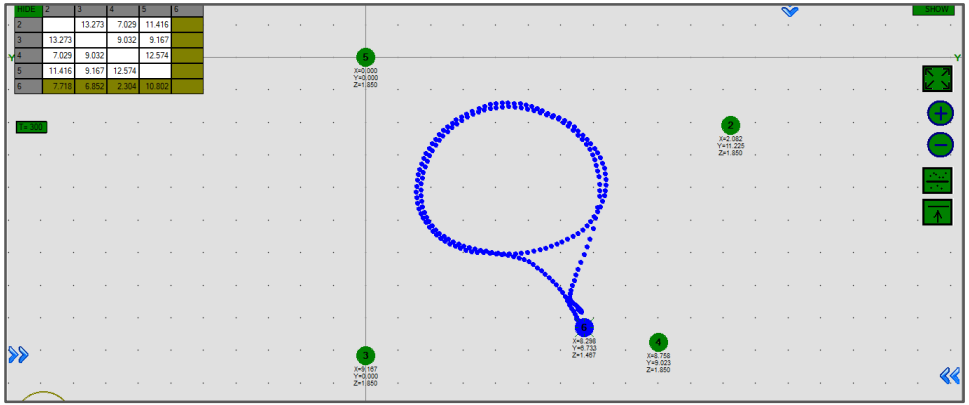
Step 5: Autonomous flight

It is time to fly in automatic mode now. It is advised to monitor the tracking via Dashboard to identify the cause for issues - whether it is an issue with tracking or with the drone's onboard SW:

https://www.youtube.com/watch?v=e8eHhUhc0Z4 – fully autonomous flight

Dashboard view



Notes

- In order to get fully autonomous flight, you shall do step by step settings and do not jump over to the end without verifying that underlying layer works as supposed to. For example, don't jump to tracking or flying autonomously a copter, if your basic tracking with beacon in hand is not stable
- Clearly distinguish between issues with tracking from issues with misconfiguration of ArduPilot or effect of barometer or compass on the system, for example. Make sure that tracking is good, monitor tracking all the time via Dashboard.
- If tracking is good and drone is not flying well, pay attention to configurations, coefficients in flight controller, etc. For example, usually, GPS is less precise than barometer, but not in our case. And readings from barometer or onboard compass may conflict with data from Indoor "GPS"
- Radio/telemetry may impact on each other. Make sure you know the frequencies and bands. Choose different bands and frequencies, if possible. If not, minimize the output powers, separate antennas, etc.

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Contacts

For additional support:

- Site: https://marvelmind.com/
- Selected video demos: https://marvelmind.com/#watch_demo
- Selected customers: https://marvelmind.com/#customers
- Email: info@marvelmind.com

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