tBeacon 0.53

User Manual

1. Introduction

The beacon is designed to help search for lost objects. Primary purpose: locating downed R/C planes, multicopters, lost balloons, model rockets, etc. The beacon operates in the UHF radio spectrum, therefore an UHF radio transceiver is required for interaction with the beacon. The transceiver must be capable of operating in the UHF band (LPD, PMR, or FRS) and preferably should be capable of transmitting a Tone burst (acoustic signal of 1750 Hz). Tone burst can be substituted with a CTCSS sub-tone.

Most widespread and affordable models are **Baofeng UV-3R**, **Baofeng UV-5R**, **Wouxun KG-UVD1P** among many others.

Locating the beacon is simply done by navigating to the location (GPS coordinates) which is transmitted from the beacon by means of a voice message. It is also possible to use a Radio Direction Finding (RDF) mode ("fox hunting") in case the beacon was not connected to the location source or it has failed during the flight.

There is also a close proximity search mode which is useful in the case when a GPS location is not precise enough or the lost object becomes covered with snow, grass or other foreign objects. In this mode it is also possible to use light and audible alarming devices connected to the beacon.

It is worth mentioning that if the beacon loses its connection to the GPS receiver during a crash, it will remember the last known good coordinates and will report it to the user.

2. Legal notice

Please familiarize yourself with the regulations of UHF radio spectrum in your country. Perhaps you will need a HAM license to use the beacon in your area within specific bands. Carefully select frequency for your beacon, the default frequency may be illegal in your area. Unlicensed radio bands vary across different countries. If you choosing a frequency from the HAM band, you should report your callsign periodically.

Also your radio may be capable of transmitting on frequencies which you may not have rights to use. Make sure you do not break the law.

It is always a good idea to quickly check the desired frequency by asking a simple question ("is the frequency in use?") in order to avoid interference to other users.

3. Searching basics

3.1. Searching with GPS

Searching for a beacon with GPS is a pretty simple task: upon activation the beacon will report the last location received from GPS. You should enter it into any GPS navigation unit or app and navigate to the crash site. It is possible that the location reported by the GPS is not precise enough; in this case a close proximity search mode could be utilized. It is also possible to use classic RDF mode in case of unexpected troubles.

As a handy navigation tool there are commonly used smartphones with a navigation app. In the simplest case the stock Maps app could be used on most mobile platforms. Some users prefer to use an app showing direction and distance to the target, for example GeoCompass for Android and iArrow for iOS.

More sophisticated mapping apps can also be used, such as Androzic or TwoNav, which support use of offline maps.
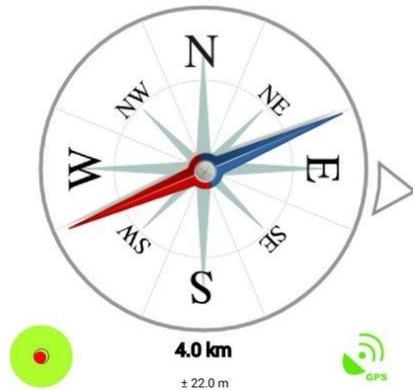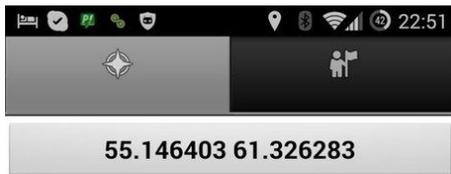
GeoCompass for Android

Please note that coordinate format used by your navigation unit must comply with the format configured for the beacon!
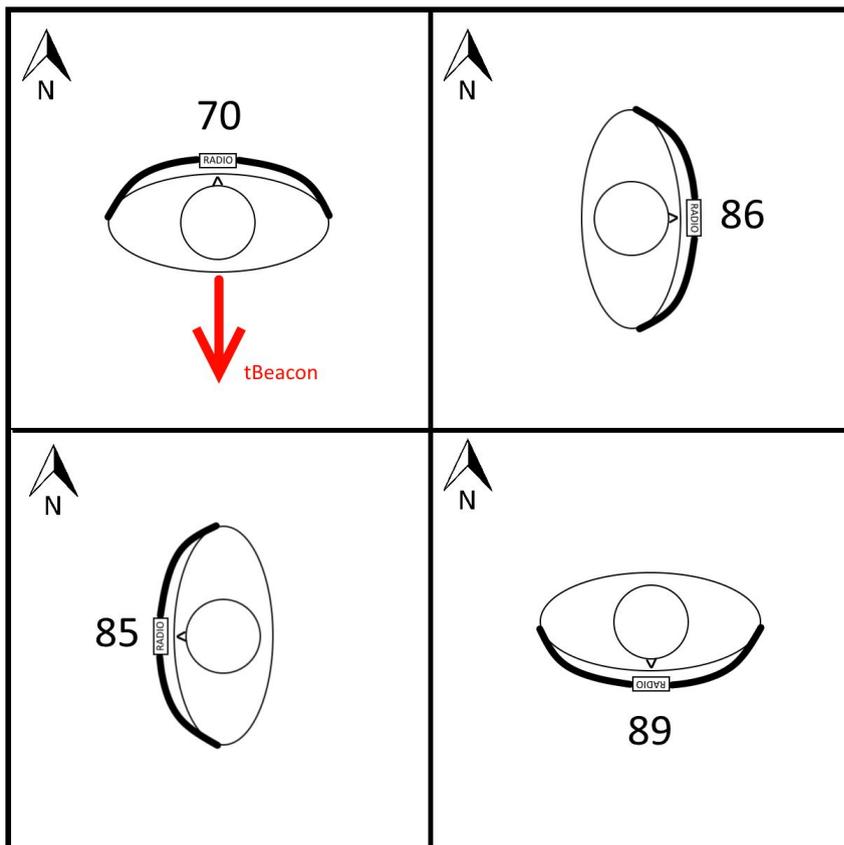
3.2. Close proximity search

This mode is intended for searching within distances of 50-100 meters and represents a form of "inverted" RDF. In this mode the beacon evaluates received signal strength of the calling tone and reports it back to the user by means of a voice message. Signal strength is reported in conventional units from 0 to 99, where 99 represents the strongest signal.

Also this mode enables use of a loud buzzer and bright LED if equipped.

Close proximity search activates if the received signal strength of the calling tone is higher than the value of "**Close proximity threshold**". Then the beacon reports received signal strength and listens for a call again. If the call is received again, the beacon enters a request-response loop. So, if you transmit calling tone immediately after receiving a report for a 0.5-1 seconds duration, then you can make a fast cycle of direction finding. If the beacon detects a single call it emits a three-tone beep and

activates a buzzer and a LED flash several times (determined by a "**Number of transmission after call**" parameter) with minimal delay.

The procedure to locate is as follows. Holding radio close to your stomach and slowly turning around notice the direction of the lowest reported number. The beacon should be behind you.

The close proximity search may make more sense after watching a training video.

3.3. Classical radio direction finding

The method uses the same principle as previous (close proximity search). The main difference is that you will have to determine signal strength by your ears or by your radio's S-meter.

The tone signal transmitted by the beacon consists of three tones of different power and pitch (100mW, 13mw, and finally 1.3mW). Shielding the radio using your body or using a directional antenna you should find a direction to the strongest
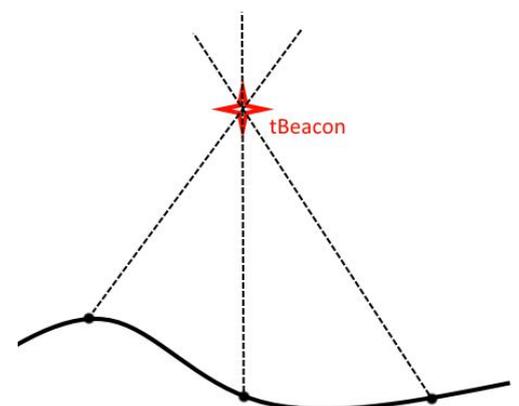
(or the weakest) signal. After taking a reading, move in the determined direction, repeating procedure from time to time. Alternatively you could take several bearings and draw them on a map; the point of intersection is the location of the beacon.

4. Using the beacon

Upon connecting a power supply, the beacon will transmit a "hello beep" (or your callsign if it is set) and announce the voltage of its battery. The beacon then enters the main loop, during which it will enter a deep sleep mode with periodic wakeups for checking for GPS location and for monitoring the frequency for a call.

During normal operation the beacon saves to onboard RAM all locations received from GPS (provided they are correct) and periodically saves it into non-volatile memory. If the GPS source becomes unavailable, the beacon will use the last "known good" location from RAM. In the rare case of a glitch or momentary power failure, it will use info from the non-volatile memory. Since there is a chance this last location is not relevant anymore, the beacon will signal it by a three short bells before reporting coordinates.

To facilitate the preflight checking, the beacon immediately transmits (once and at low power) the first correct location received from GPS.

The three onboard LEDs have the following meaning:
- Yellow: Indicates that charging of beacon's battery is in progress.
- Green: Flashes at one second interval indicating normal operations. Stops flashing after 8 hours of operation to conserve battery power.
- Red: flashes during GPS data collection, RF transmission and frequency monitoring.

The tBeacon performs no autonomous RF transmissions on its own, assuring no interference with avionics and radio control systems.

The beacon can be activated by a call from a radio transceiver or by programmable timer.

4.1. Triggering by a call

Activation by a call is done by transmitting a long enough call on the beacon's frequency. The call itself is a simple sound tone of defined frequency ("**Calling tone frequency**"). It is preferably to use a feature called Tone burst (1750Hz), used by HAMs for interacting with repeaters. If your radio does not support Tone burst (some manufacturers call this "Tone Call") it is possible to use CTCSS sub-tones, by entering it's frequency to the abovementioned parameter. You should enable only Transmission CTCSS on your radio! You may need to disable squelch on your radio if it does not have Transmission CTCSS feature.

Note: you will probably have to recalculate value for a parameter "**Listening duration**". Since increasing of this parameter leads to an increased power consumption it is recommended to stick with higher CTCSS frequencies (240Hz).

Note that the beacon can triggers by transmission with neighboring frequency of CTCSS.

It is not recommended to use CTCSS since there is a chance of false triggering of the beacon because of foreign transmissions on the frequency.

To guarantee activation of the beacon you have to emit a tone signal of duration slightly more than of parameter "Listening interval" (Defaults to 3 sec.).

4.2. Triggering by a timer

When using a transceiver which is incapable of sending calling tone there is only one way to activate the beacon: using timer. Timer is set by a parameter "First-time delay". By default the timer is disabled.

When the specified time elapses the beacon will be activated and starts transmitting three-tone signal with periodical report of current location. Periodicity of location reports is set by a parameter "**GPS periodicity**".

5. Installing the beacon on the craft

First of all you should decide how the beacon will be powered. The power supply should be autonomous and usually it is one lithium-polymer cell (LiPo) battery with capacity of 50-300mAh. Beacon's power supply connection depends on the beacon model. See "**tBeacon model differences**" webpage.

The beacon battery runtime is greatly depends on preset parameters. With default settings, average conditions and with LiPo 1S battery 300мAh beacon can last approximately three weeks.

When installing the beacon on your aircraft it is recommended to choose a location, less prone to deformation in the event of an unplanned landing. The beacon should be isolated from any conductive surfaces, preferably it should be put in heatshrink tube. Also any kind of water protection is recommended (coating, liquid tape, etc).

It is also recommended to place the beacon's antenna vertically and away from metal and carbon parts, if possible.

6. GPS connection

The beacon supports the following protocols:

- **NMEA.** De-facto standard for GPS receivers. Most of them uses this protocol by default;
- **UBX.** Binary protocol of UBLOX receivers that is used, for instance, in APM;
- **NAZA.** Binary protocol of DJI proprietary telemetry bus. Used in DJI NAZA flight controllers for linking GPS module with the main controller or PMU.
- **MAVLINK.** Binary protocol of APM telemetry (ArduCopter, ArduPilot etc.);

Examples and diagrams of connection to GPS receivers or autopilots see in "**GPS connection examples**" webpage.

Connector pinouts and other hints see on "**tBeacon model differences**" webpage.

7. Connecting light and sound alarms

It is possible to connect a buzzer and a LED flash to the beacon to facilitate the search in the tall grass or deep snow. The connection should be made to the AUX pins, which are specific to different version of the beacon. See details on "**tBeacon model differences**" webpage. Pins used to connect are determined by a configuration (default is 5 for a LED and 6 for a buzzer).

When activated the LED pin outputs logic high. The buzzer pin outputs square wave of frequency ~2730Hz. Together they emits SOS signal in Morse code.

Direct connection is permitted only if device current consumption is no more than ~30mA. More powerful devices must be connected via a transistor switch.
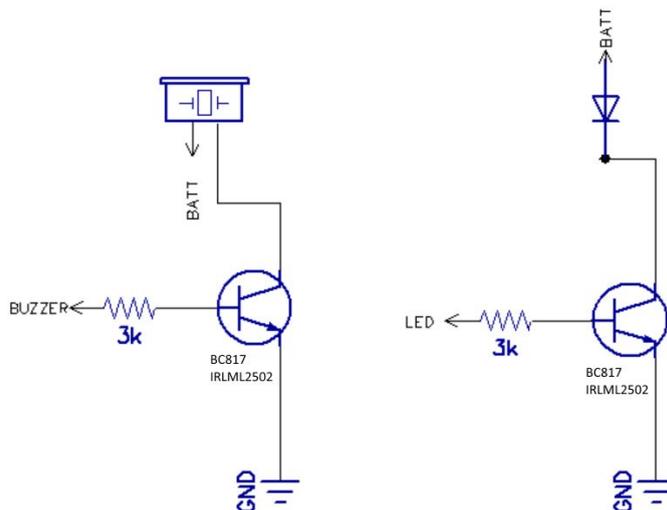
Example of buzzer and LED connection

8. Configuring the beacon

Every service routine is performed with the help of configuration utility. For instance: change settings, frequency calibration, firmware upgrade, bootloader flashing, GPS track download. For the utility to work you need

an USB UART adapter. The utility is currently available only for Windows OS.

Details on connection and power supply for specific beacon's models can be found in "**tBeacon model differences**" webpage.

8.1. UART adapter connection

In order to be able to connect the beacon to your PC, you have to have an UART adapter, preferable the one with DTR output. Connection details and pinouts can be found in "**tBeacon model differences**" webpage

NOTE: RX pin of the beacon should be connected to TX pin of the UART. And vice versa: TX of the beacon to RX of the UART.

Be careful connecting of UART adapter to the beacon. Wrong connection may cause beacon to malfunction!

You should also install the appropriate drivers for your UART adapter. After connection and driver installation there should appear a virtual COM-port in the system. If there are several such ports in the system you should find out its number. This can be done in Devices Manager.
Notice the number of the COM-port, you will need it later.

8.2. Flashing Bootloader

This procedure is needed only for DIY beacons, or for beacons made from Orange OpenLRS receiver.

To flash the bootloader you will need to connect a USBASP ISP to the beacon's microcontroller and press a key sequence CTRL+B in configurator utility.

NOTE: DO NOT USE USBASP WITH 5V LOGIC LEVELS!

8.3. Flashing firmware upgrade

This procedure is necessary for firmware upgrades of pre-made beacons and the initial setup of self-made beacons. The process is initiated by pressing the button "FLASH FW" while the beacon is connected and powered on and the COM-port is chosen correctly. In case you are upgrading without connected DTR signal it is necessary to lower DTR momentarily (connect to GND) immediately after the console window

popped-up. You also might need to discharge the decoupling capacitor by momentarily connecting the DTR pin to Vcc.

8.4. Config mode

In order to change any settings on the beacon it is necessary to put it in config mode. If you use an UART adapter with DTR output, you should choose a correct COM-port, and press the "CONNECT" button. The process goes automatically: the beacon will enter configuration mode and the current settings will be displayed in the window.

If DTR output is not connected you will have to power the beacon immediately after pressing the "CONNECT" button. You may have to retry this process several times.
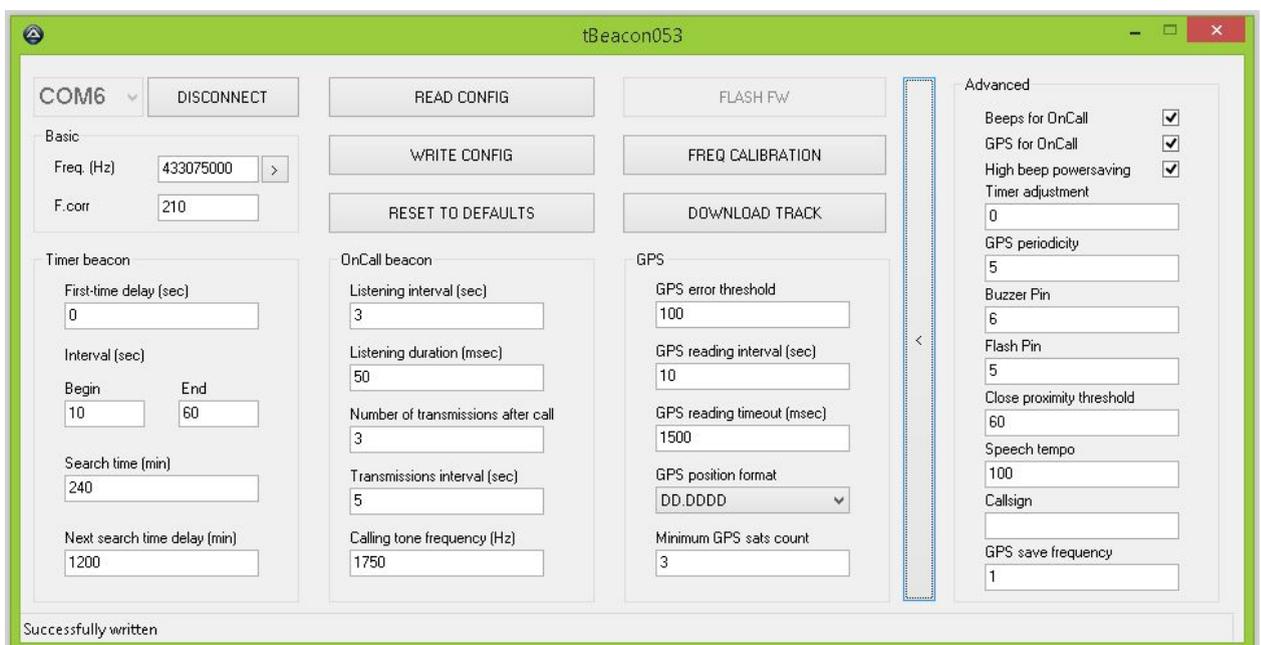
Appearance of the Configurator while the tBeacon is connected

After successful connection all of the service routines become available.

Every changeable parameter of the beacon is presented in the window of configurator utility. A description of each parameter is given in the section "**Parameter descriptions**" below. A short description is also given in a tooltip of every element.

NOTE: Do not forget to press "WRITE CONFIG" after changing settings, or else the new settings will not be saved to the tBeacon.

In order to reset the tBeacon to its default settings, press the "RESET TO DEFAULTS" button on the Configurator and then write the configuration to the tBeacon.

8.5. Frequency calibration

Each beacon should be adjusted according to the reference frequency. This procedure requires a handheld radio with the Tone burst transmission function or CTCSS. Purchased beacons have already been calibrated, but repeating the procedure with your own radio wouldn't hurt.

When the beacon is connected, press the button "FREQ CALIBRATION" and prepare a handheld radio. The handheld radio and the beacon should be set to the same frequencies. Also make sure that radio is in simplex mode.

The utility will warn that the calling tone should be emitted until calibration is finished. Press and keep pressing corresponding buttons on the handheld radio until procedure is finished.

Usually calibration takes 30-40 seconds. However deviations are possible.

NOTE: Do not hold the transmitting handheld radio too close to the beacon, UART adapter and computer. For safety purpose you might want to set the radio to Low Power mode.

8.6. GPS track download

The beacon has the ability to store ~100 last position coordinates, allowing the user to download the tBeacon's GPS track, which could be handy for post-mortem analysis of a crash or just watching where a model aircraft flew. The recording interval of the GPS track is determined by the "**GPS save periodicity**" parameter. For example, with the interval set to 1 and the GPS reading interval set to 10, the track will cover ~16 last minutes of flight.

The track can be saved in a .KML format (can be viewed in Google Earth and many others apps) by pressing "DOWNLOAD TRACK" button.

9. Parameter descriptions

NOTE: Short description of every parameter is provided in a tooltip of a corresponding element.

9.1. Basic

Freq (Hz, 433075000)

Frequency the beacon will be operating at.

For instance, first channel LPD (433.075MHz) is written as: "433075000". First FRS channel is written as 462562500 (462.5625MHz).

For your convenience, basic channels of unlicensed bands can be selected from drop-down menu.

By default, first LPD channel is chosen: 433.075MHz

F.Corr

Frequency correction factor of specific transceiver module. Requires individual calibration, see section **Frequency calibration**.

9.2. Timer based beacon

This section are for the timer-based beacon parameters, the one that is activated in specified amount of time after powering on.

First-time delay (sec, 0)

First-time delay before the beacon activation.

Default is 0, i.e. the timer beacon is disabled.

Time interval in the beginning (sec, 10)

Time interval between transmissions in the beginning of search period of the timer based beacon.

Time interval at the end (sec, 60)

Time interval between transmissions in the end of search period of the timer based beacon.

Search time (min, 240)

Search period within which the timer-based beacon is active.

Default is: 240 min = 4*60, that is 4 hours.

The beacon will be active within this time, increasing time interval between transmissions. In the beginning and at the end of the search

period time interval is defined by corresponding parameters.

Next search time delay (min, 1200)

Delay until next activity cycle.

Default is 1200 min = 20 * 60, that is 20 hours.

Upon completion of search period the beacon goes to sleep for a specified time period.

If the beacon timer is enabled,, then with the default parameters the beacon will wake up after a specified time period since the first power-up, run for 4 hours, and then go to sleep for the next 20 hours. That is: it will wake up every day at the same time for a period of four hours.

9.3. OnCall beacon

This section is for the onCall beacon parameters, which are used when the beacon is activated by a call from a handheld radio.

Listening interval (sec, 3)

Time interval for the beacon to listen to the air waiting for a call.

It is not recommended to set low values due to excessive power consumption. With the default setting, a ringing tone within 3-4 seconds is needed to wake up the beacon.

Listening duration (msec, 50)

Duration of listening on the frequency waiting for a call.

The bigger the value, the more reliable the call recognition and the higher battery consumption.

NOTE: Minimum value is determined by a formula (30000 / (Calling tone frequency in Hz)). For instance, using CTCSS it is recommended to set the parameter to value of 150.

Number of transmissions after call (times, 3)

Number of transmissions (voice and beeps) of the beacon after call.

Default is 3 transmission.

If this type of transmission is enabled in settings, beeps are transmitted first, followed by voice.

Transmissions interval (sec, 5)

Delay between beacon transmissions after a call.

Ignored when in close proximity search mode.

Calling tone frequency (Hz, 1750)

A frequency of a sound tone that is used to activate the beacon.

Note: if changing the parameter you will probably have to recalculate value for a parameter "**Listening duration**". Since increasing of a duration leads to an increased power consumption it is recommended to stick with Tone burst (1750Hz) or higher CTCSS frequencies (240Hz).

9.4. GPS

GPS interaction settings. Protocol type and port speed are determined automatically.

GPS error threshold (times, 100)

Number of errors permitted in the reading of GPS coordinates. In case this threshold is exceeded, GPS interaction is ceased in order to save battery power. Further reading of coordinates is performed 100 times more rarely until normal communication is restored.

GPS reading interval (sec, 10)

Time interval for tracking GPS coordinates (sec).

Default is 10 seconds.

Specifies time interval within which the beacon wakes up and listens to GPS incoming data. The lower the value is, the more accurate data the beacon has and the higher battery consumption is.

GPS reading timeout (msec, 1500)

Timeout of one attempt of reading of GPS data.

This is the period that the beacon has to receive coordinates from the GPS receiver. If the coordinates are received the beacon stores the coordinates and goes to sleep immediately. Otherwise, it waits for the end of the timeout period, consuming additional energy. It is recommended to set a value slightly more than 1000/(GPS transmission frequency), where

GPS transmission frequency is the number of times per second that the GPS receiver transmits a new GPS sentence to its attached devices.

For example, for a 10Hz GPS receiver this value may be safely set to 150 msec. The default value is suitable for slow GPS receivers (1 Hz).

GPS position format (DD.DDDD)

It is possible to choose your favorite format of coordinates (for example, the one that your GPS navigator can support).

Default is DD.DDDD

For instance, Google Maps supports formats 3, 4, 5, 6. For formats 5 and 6 you will have to know additional degrees of longitude and latitude for your location.

When choosing a format one should remember that the more numbers are transmitted, the more energy is consumed.

Different GPS formats and their corresponding location error tolerance:

1. DD MM SS.S   3 meters
2. DD MM.MMM   2 meters
3. DD.DDDDD   1 meter
4. DD.DDDD   10 meters
5. .DDDDD   1 meter
6. .DDDD   10 meters

Minimum GPS sats count

Minimum visible satellites as reported by the GPS receiver for processing by the beacon. The beacon will only store reported coordinates if the number of satellites visible to the GPS receiver is greater than or equal to the parameter. If the parameter set to 0, then the beacon will accept any location from the GPS provided it does have a valid fix and checksum. **NOTE: A minimum of four satellites is required for a reliable 3D fix. A 2D fix can be obtained from three satellites or more.** When using **NMEA RMC** protocol, it should be noted that information of satellites count is not provided in that protocol. When minimum is set to something other than 0, NMEA RMC will be ignored.

Default in minimum 3 satellites.

9.5. Advanced

Advanced parameters. Opens by pressing a reveal button (>). Usually does not require changing.

Beeps for onCall (on)

Determines if it is necessary to transmit beeps after call. Default is on.

GPS for onCall (on)

Determines if it is necessary to report coordinates after wakeup. Default is on.

High beep powersaving (off)

Enabling battery saving at the most powerful beep by using a pulsing tone. Default is off.

NOTE: This type of signal might be inaudible for some handheld radio squelches.

Timer adjustment (msec, 0)

Timer adjustment. If the timer on your beacon is fast or slow, it is possible to introduce a correction.

The value determines difference with a wallclock second in msec. Plus, if the beacon is fast. Minus, if the beacon is slow.

For example, if the beacon went off not in 10 minutes (600 sec), but in 9:30 (570 sec), the correction can be made using the formula 1000 - (1000 * 570/600) = 50.

GPS periodicity (times, 5)

Periodicity of coordinates report for timer beacon (0 – don't report, 1 –every transmission, 5 – every fifth transmission etc.).

Buzzer Pin (pin number, 6)

Pin number for connecting a buzzer. Default is 6.

The pin outputs an SOS signal with a square wave of frequency ~2700Hz.

Flash Pin (pin number, 5)

Pin number for connecting a LED flash. Default is 5.

The pin outputs a discrete SOS signal.

Close proximity threshold (conv. units, 60)

If received signal strength is higher that the configured value, the beacon will enter a close proximity search mode. See "**Close proximity search**". Received signal strength is reported back by voice, and the flash LED and buzzer are activated. The value is in conventional units: 99 - the strongest signal, 0 - weakest or no signal. To disable this mode completely enter 100. To use this mode always, enter 0.

TODO: comments on values meanings

Speech tempo (conv.units, 100)

Tempo of the beacon's synthesized speech. Set in conventional units: the **bigger** value - the **slower** the tempo, 100 - normal tempo.

Callsign (text, "")

You have to report your callsign when rules of particular band require you to do so (ie. all amateur radio bands). The beacon transmits a callsign using Morse code after every call with a probability of ~1/2.

Default is no callsign.

GPS save periodicity (times, 1)

Determines how often GPS coordinates are saved to non-volatile memory.

0 - do not save, 1 - every time, 5 - every fifth time, etc.

NVRAM size allows saving ~100 points.

10. Typical configurations

Default settings were chosen to cover as many use cases as possible. But for some cases there may be need to adjust settings for more convenient use. Below are examples of various configurations for specific use cases.
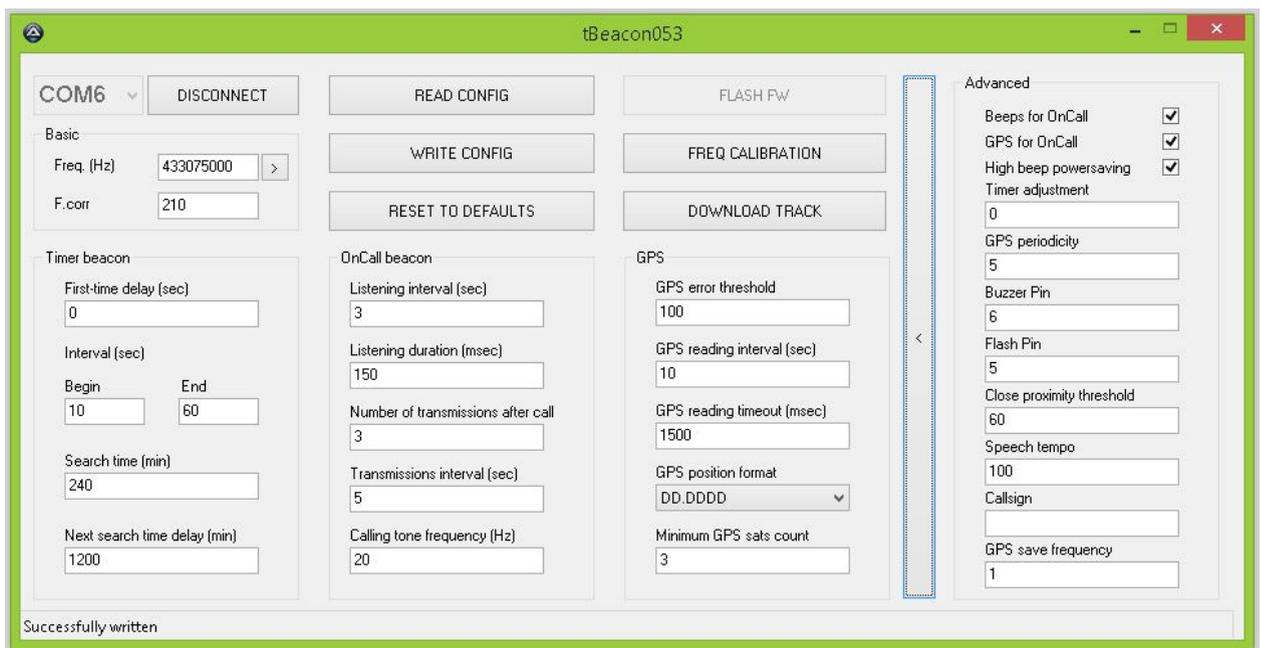
- Very fast plane with GPS. Radio capable of Tone burst.
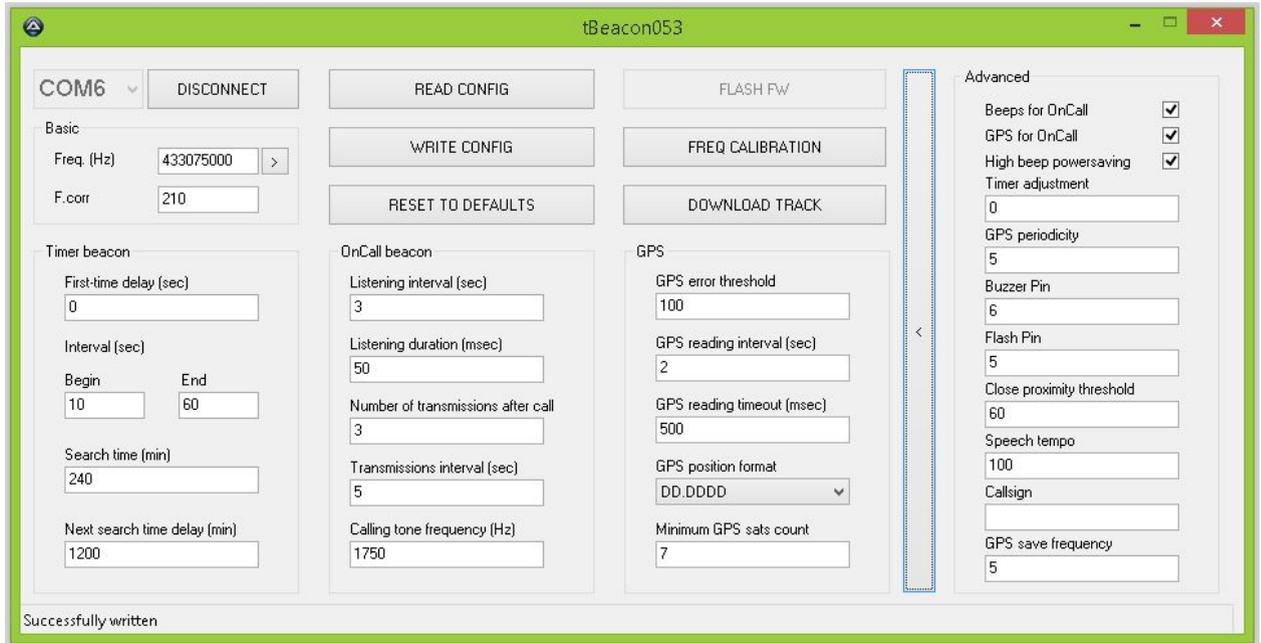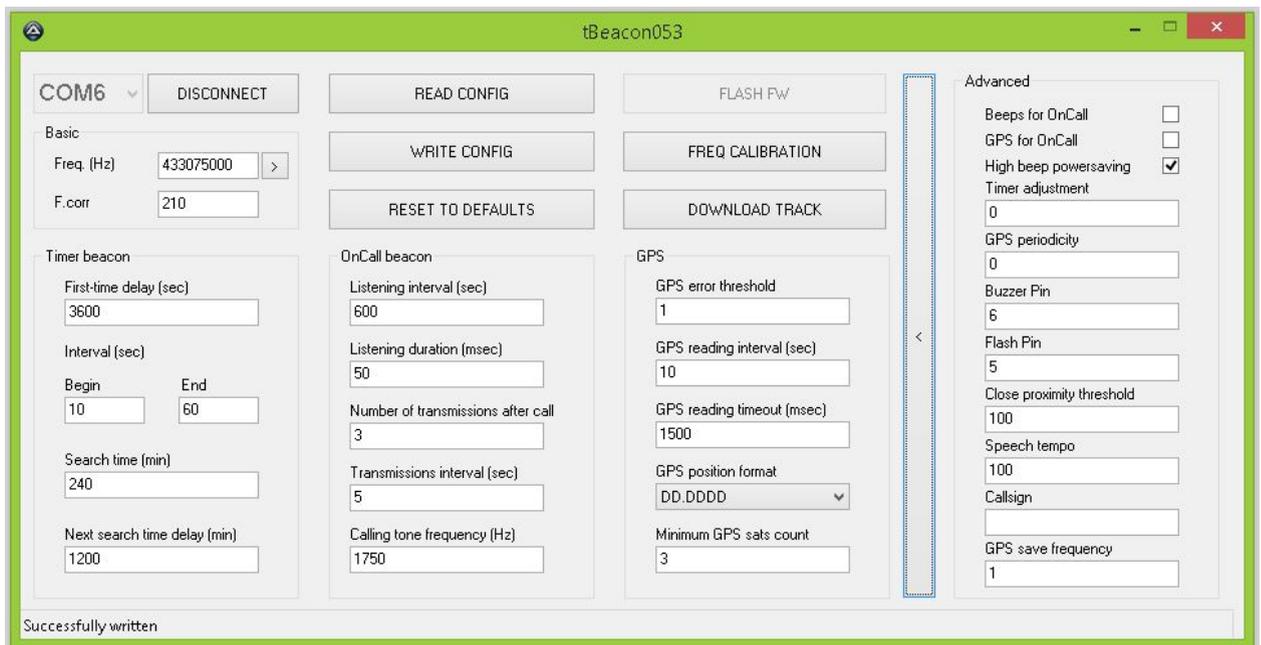

- Plane/multicopter with GPS. Radio capable of Tone burst. The longest beacon's standby time.
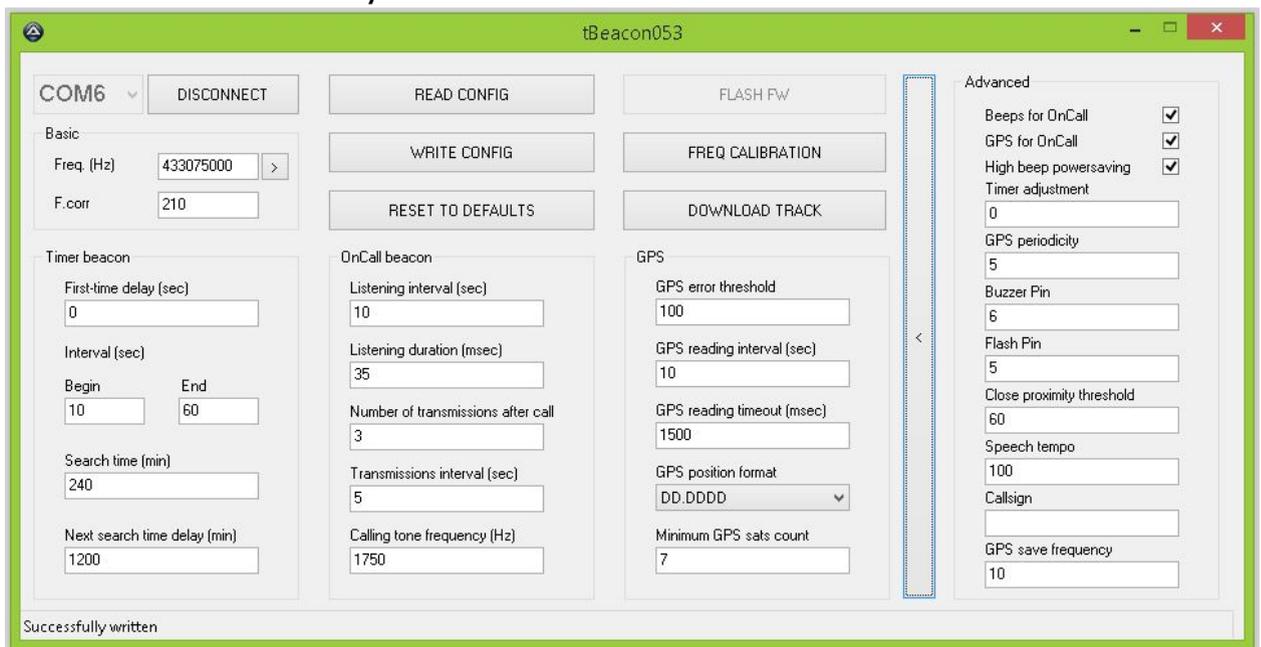
- Plane/multicopter with GSP. Radio with CTCSS only.

- Plane/multicopter without GPS. Radio incapable to emit a calling tone.

- Minicopter without GPS. Radio capable to emit Tone burst.