LapRF Personal Timing System

Operator's Manual

Rev 1.2 - August 2017

Specifications

5.8GHz RF Detection	
Frequency	5.3-6.0GHz
Programmable Attenuation	0-32dB
Threshold	Programmable to fine tune (but not normally required)
Antenna	Custom linearly polarized (Suitable for LHCP, RHCP, Linear use)
Channels	Arbitrary (defined by connected app.)
Pilots	1-8, depending upon required precision and gate speed
Mechanical	
Dimensions	L =100mm, W = 100mm, H = 25mm
Weight	121g
Battery	
Cell	18650, 2600mAh, 3.7V nominal
Consumption	~300mA @ 3.7V
Bluetooth	
Standard	BLE, Bluetooth Smart
Antenna	Internal CE-compliant, or external dipole for extra range (up to 50m)
App Support	
Mobile	iOS and Android
Compatibility, iOS	iOS devices require BLE, iPhone 4s or later, iPad 3rd Gen. or later *See here for more details: http://www.iphonefaq.org/archives/973945*
Software Interface	
Ports	Bluetooth Wireless, and USB Wired
Protocol	LapRF Comms Protocol (available upon request for developers)
PC Software	LiveTime scoring engine (Beta 2.8.1, Available)

WARNING: To avoid problems with charging the 18650 battery via USB, be extremely careful with battery polarity when inserting the cell. The spring terminal must be connected to the negative (-) terminal of the battery.

Introduction

The LapRF Personal Edition is the first in a family of race timing systems from ImmersionRC.

LapRF technology uses the emitted 5.8GHz RF from race quadcopters (or fixed wing aircraft) to detect a passage through the start-finish gate.

Different from other offerings on the market, the LapRF uses custom timing receivers with specially designed antennas to ensure that only quads which pass through the 'beam' are timed, and other sources of interference are ignored.

All that is required to use the LapRF in a race is to program the band, and channel that each pilot will use, place the timer in the start/finish gate, and go fly! No transponders required.

Getting Started

Charging the Battery

Using a standard USB Micro cable charge the timing puck for at least 3 hours before use.

Ok, so nobody actually wants to do this… the battery is delivered approx. 70% charged, and won't be damaged if the timer is powered up, and a few laps flown. Do not run it for long though before charging it to prevent permanent damage to the battery.

App. Download

Search for the term 'LapRF' in either the iOS App. store, or the Google play store.
Download the free app. and install.

Powering On

To power on the LapRF, press and hold the power button, located on the underside of the timer, for about 4 seconds until the LEDs light up, and the LapRF beeps.

To power off, repeat this procedure.

Connecting to the LapRF

Take note that despite the fact that there's a 'bind' button on the bottom, and the LapRF is a Bluetooth device, you do not need to pair it with your phone or tablet. The LapRF won't show up as a Bluetooth device either.

Instead you start the app and click on 'Race Setup' and subsequently on the 'Select Timing System' in the top left corner. This will list all available timing systems, check on the bottom of yours to see how it is called, for example 'TidyLawn' and select it, refer to the below noted image for an impression of what the 'Race Setup' page looks like, note the 'Select Timing System' top left.

Subsequently the 'Start Race' icon on the Race page should go green to indicate a good connection.

Timing System Address
Select Timing System

Race Start Delay
| None | 5 seconds | 10 seconds |

Start Time From
| Start Tone | First to Gate |

Race Type
| Lap Count | Fixed Time | Practice |

Number of laps
8   − +

Race time
3m 0s   − +

Race!   LapRF Setup   **Race Setup**   Diagnostics

Configuring the Bands/Channels

Once the LapRF is connected, click on the 'LapRF Setup' icon and configure your bands and channels.

The switch on the left enables/disables each pilot slot, be sure to disable unused slots for maximum accuracy.

Once the band and channel have been selected, the frequency is displayed.

Use the power switch to select the power level that you will be running.

Click the 'Write Settings to LapRF' button to program the time. Note that once these are programmed, the settings will persist even when the timer is power cycled.

Finally, Race!

Click on the Race button, and then 'Start Race'.

'Goggles Down, Thumbs up'
Joe Scully - Some time in 2015

Battery Charging

The internal 18650 li-ion battery may be charged by simply connecting the puck to a USB power source using a standard micro-B cable.

The maximum charge current is approx. 800mA, which results in a charge time of a little more than 3 hours.

For extended use, the 18650 may be easily swapped out and replaced with a fully charged pack.

⚠️ **WARNING: 18650 batteries can be extremely dangerous if mishandled. Keeping unprotected batteries in your pocket, especially with other metallic objects, can result in an explosion, and severe burns.**
Always use a protective carrying case when transporting these cells.

⚠️ **WARNING: To avoid damage when charging the 18650 battery via USB, be extremely careful with battery polarity when inserting the cell. The spring terminal must be connected to the negative (-) terminal of the battery.**

When purchasing batteries, name-brand cells from reputable sources are highly recommended. Many of the 'budget' cells available from online resellers may not be as safe as genuine cells.

Battery Life

The supplied 2600mAh cell should suffice for approx. 8 hours of racing. As the cell voltage reduces, the gate will automatically turn off, after beeping to warn the user approx. 5 minutes before.

iOS Application for iPhone and iPad

Main Screen

The main screen shows the lap times, including average, best, and total times, for each active pilot.

Times in green are the best lap times for each pilot.

Note: When a timing system is not connected, touching the large pilot number on the left side of the screen will create a manual time, and can be used to evaluate the app.

The color if the 'Start Race' button currently indicates a valid connection to the lapRF. Red for no connection, Green for a good connection.

				Race Clock 069:7											
Start Race	Stop Race	+		Lap 1	Lap 2	Lap 3	Lap 4	Lap 5	Lap 6	Lap 7	Lap 8	Avg	Best	Total	#
1 Pilot 1				2.87	19.24	1.71	-	-	-	-	-	7.94	1.71	23.82	3
2 Pilot 2				0.97	15.32	-	-	-	-	-	-	8.14	0.97	16.29	2
3 Pilot 3				-	-	-	-	-	-	-	-	-	-	0.00	-
4 Pilot 4				16.24	-	-	-	-	-	-	-	16.24	16.24	16.24	1
5 Pilot 5				1.40	12.57	-	-	-	-	-	-	6.98	1.40	13.97	2
6 Pilot 6				16.97	3.80	-	-	-	-	-	-	10.38	3.80	20.77	2
7 Pilot 7				-	-	-	-	-	-	-	-	-	-	0.00	-
8 Pilot 8				-	-	-	-	-	-	-	-	-	-	0.00	-
			Race!		LapRF Setup		Race Setup		Diagnostics						

On the race screen, the pilot icon shows Red when the app is in 'First to Gate' mode, and the pilot hasn't reached the first gate to start timing yet.
Once the pilot does reach the gate, it will turn Green, and times will start appearing.
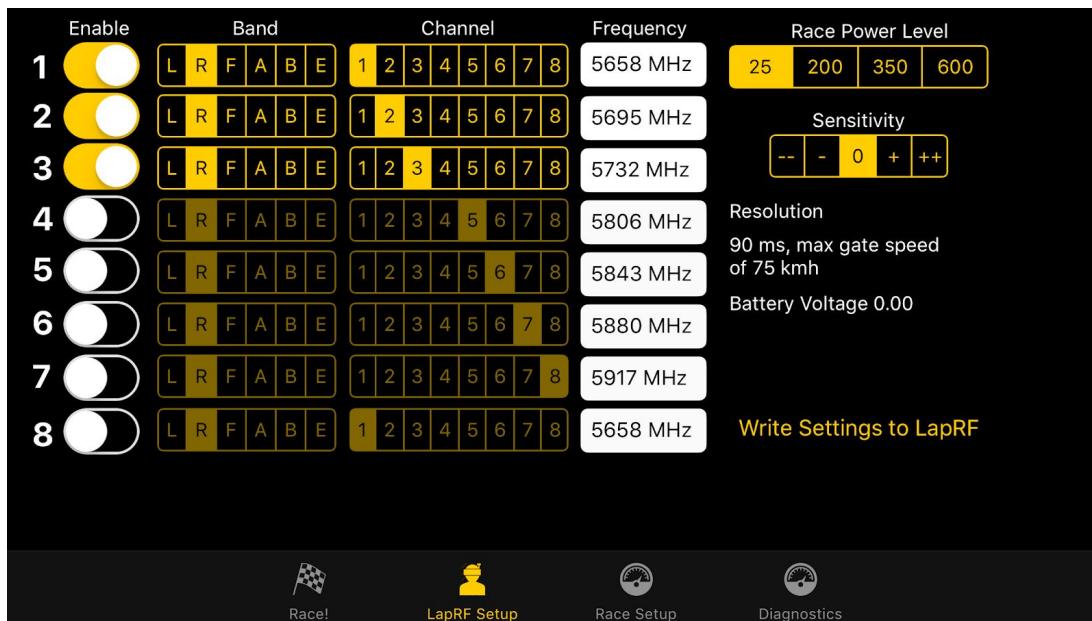
LapRF Setup

The lapRF setup page is where the number of active pilots is set, plus the band and channel that each pilot is using.

In addition, the power level used for the race (all pilots should ideally use the same vTx power) is set here, along with a 'sensitivity tweak' which works a bit like the exposure correction on most high-end cameras.

If you are missing laps, increase sensitivity, if you are getting false hits, decrease it.

This is a good time to talk about pilot count, and its effect on resolution/accuracy/gate speed.

The personal time has a single timing module, which scans each of the active channels.

When a single pilot is enabled, the RF signal is 'sampled' at the maximum rate, and supports quads flying through the start/finish gate at over 160km/h.

When a second pilot is enabled, the timing module has to toggle between the two channels, reducing the accuracy of each channel, and decreasing maximum gate speed.
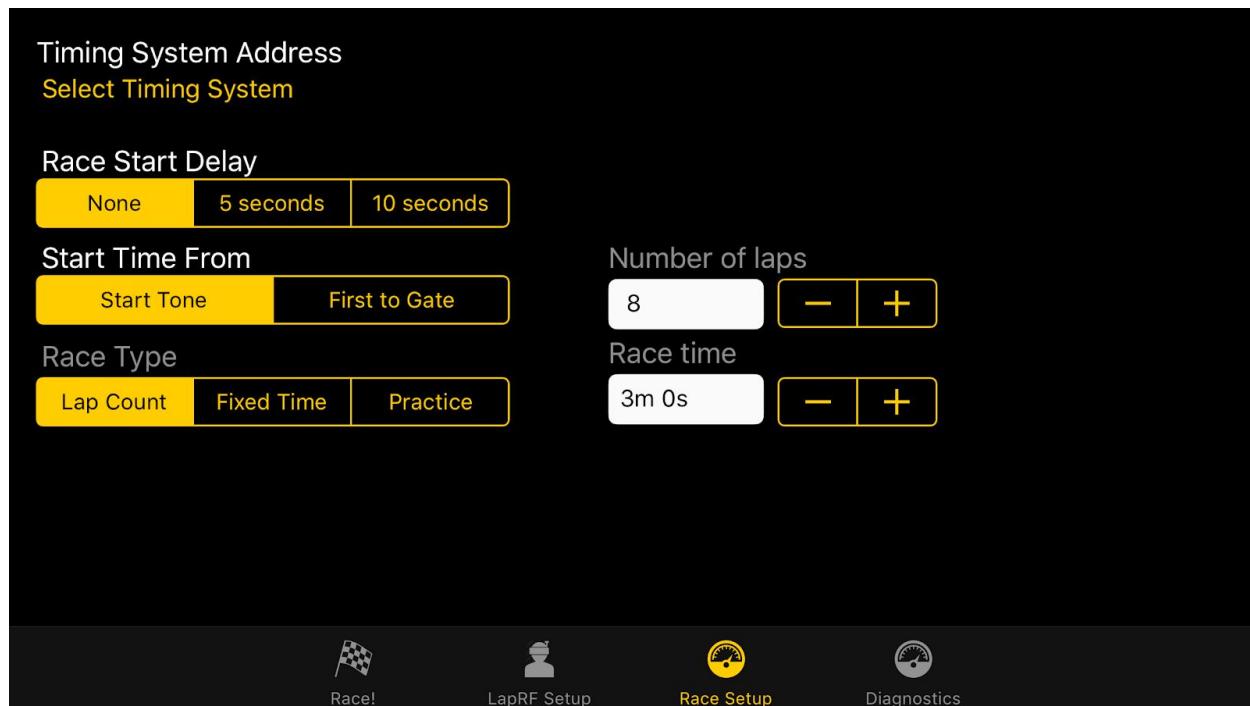
In practice, for 250 sized quads, with pilots of typical skill level, 4 pilots can easily share a single lap timer.

For slower quads, tiny-whoop class for example, even more pilot slots may be enabled.

For the best accuracy at 200km/h+ gate speeds, and up to 16 pilots, the lapRF Event system is a better choice, and should be used for larger events. *Availability July 2017.*

Race Setup

The Race Setup page is where miscellaneous race settings/preferences are configured.

Select Timing System

Click this to select the LapRF. If the device doesn't appear in the list, ensure that bluetooth is enabled, and that no other mobile device is using it (even in the background).

Race Start Delay

Configure the delay between hitting the 'Start Race' button and the race starting. Use it to give time to get your goggles on before flying.

Start Time From

FPV races are usually either configured to start from the tone (start grid is positioned after the Start/Finish gate), or from 'First to Gate', where the start grid is positioned before it.

With the latter, lap times are for full laps, including the first lap.

Race Type

For races with a fixed number of laps, select 'Lap Count', and set the number of laps to be raced.
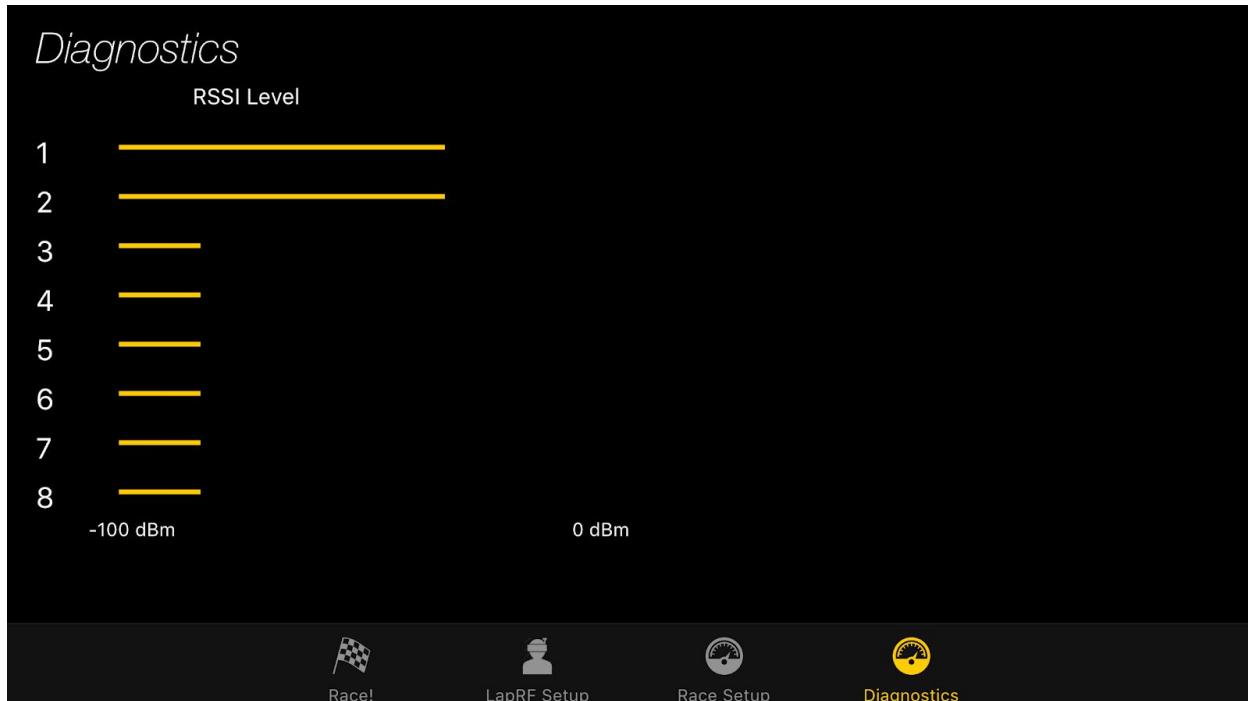
For races which are fixed-time, select 'Fixed Time' and be sure to enter the Race time.

For Practice events, select 'Practice', the race will continue to run and record lap times until your LiPos croak. *Note that only the first 8 times will be shown on the Race page.*

Diagnostics

The diagnostics page shouldn't normally be required, but can be a useful tool during debugging.

The RSSI level of each configured pilot slot is shown. Power on video transmitters and walk them through the gate to ensure correct configuration of the lapRF, and the video transmitter itself.

Android Application

Main Screen

		#	Lap 1	Lap 2	Lap 3	Lap 4	Lap 5	Lap 6	Lap 7	Lap 8	Avg	Best	Total	Lap
1	Pilot 1	3	10.13	71.84	81.91	41.26	123.0	40.67	-	-	61.47	10.13	368.8	6
2	Pilot 2	6	133.3	51.59	40.79	-	-	-	-	-	75.23	40.79	225.7	3
3	Pilot 3	1 🏆	20.42	20.44	10.38	51.51	61.41	102.5	-	-	44.44	10.38	266.6	6
4	Pilot 4	4	92.24	61.55	40.95	61.59	10.36	-	-	-	53.34	10.36	266.7	5
5	Pilot 5	8	246.3	-	-	-	-	-	-	-	246.3	246.3	246.3	1
6	Pilot 6	2 🥇	10.43	30.37	41.50	81.94	61.51	51.19	-	-	46.16	10.43	276.9	6
7	Pilot 7	7	103.0	-	-	-	-	-	-	-	103.0	103.0	103.0	1
8	Pilot 8	5	215.6	20.22	30.87	10.31	-	-	-	-	69.27	10.31	277.0	4

The main screen shows the results of the race in progress. For each enabled pilot the individual lap times are shown, along with the Total, Best, Avg, and number of laps.

The fastest lap per pilot is shown highlighted in green.

The status of the connection to the LapRF is also shown, along with the Bluetooth signal strength (RSSI) and the battery voltage.
Each field will change color to indicate a problem (Green = all is ok, Red = problem).
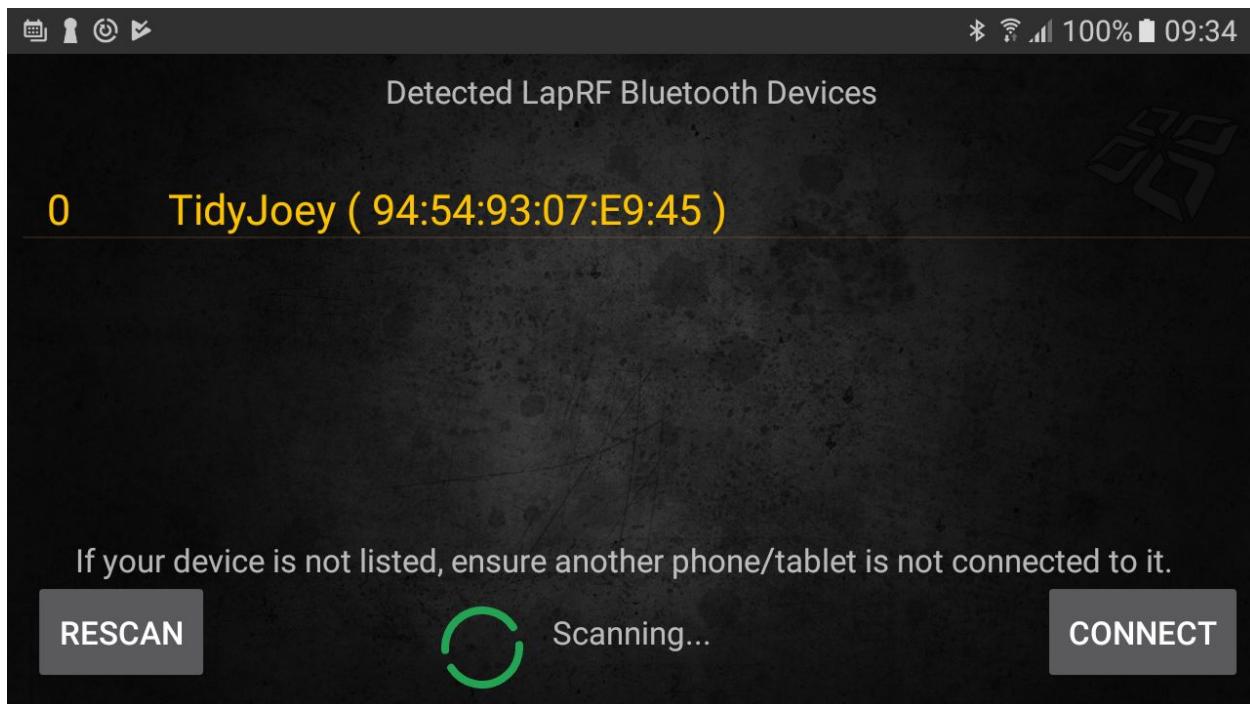
Note: When a timer is not connected, starting the race will create a number of random lap times in order to demonstrate the results display.

Bluetooth Detected Devices

When first running the application, or when selecting 'Select Device' from the context menu, the list of all detected LapRF devices is presented.

Note: If your device does not appear here, ensure that Bluetooth is enabled, and that no other mobile device is using the connection to the LapRF, even in the background.
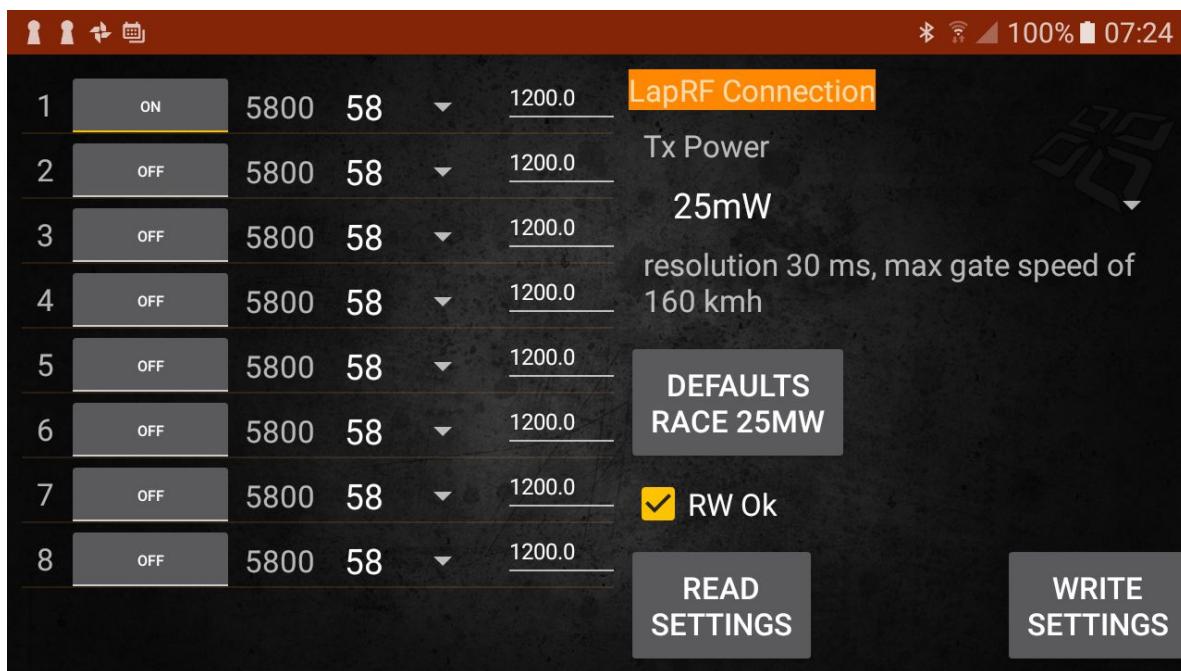
LapRF Setup

Before starting a race, the 5.8GHz band and channel of each pilot must be provided.
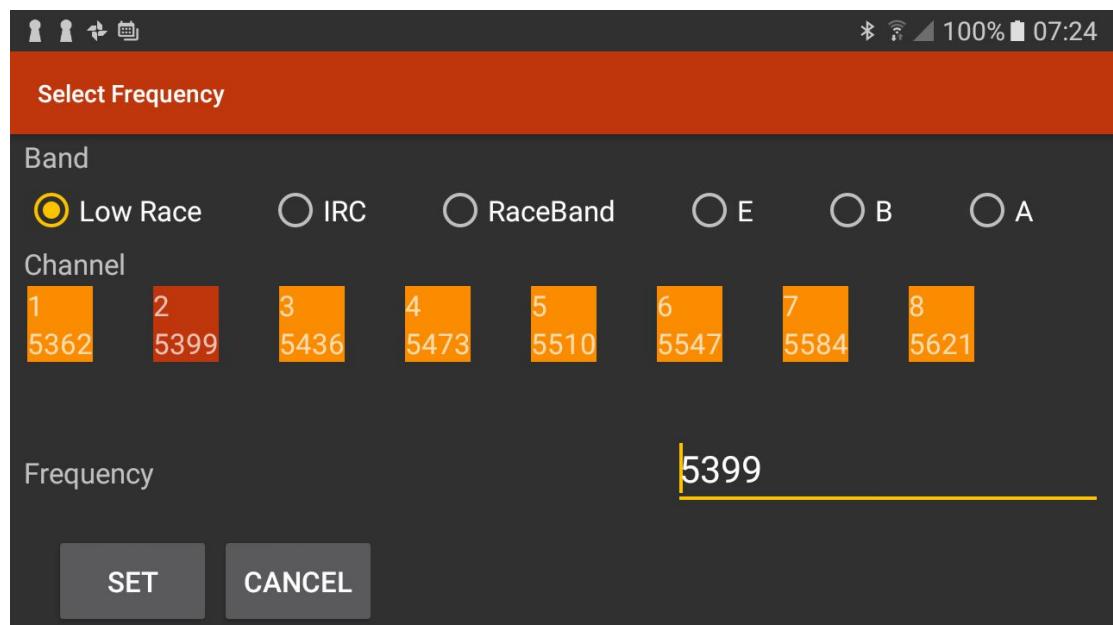
In the LapRF setup screen enable pilots, and then click on the frequency value to display the band/channel picker.

Select also the race transmitter power in the drop-down to the right.

When you are happy with the settings, don't forget to click the 'Send' button to send them to your LapRF.
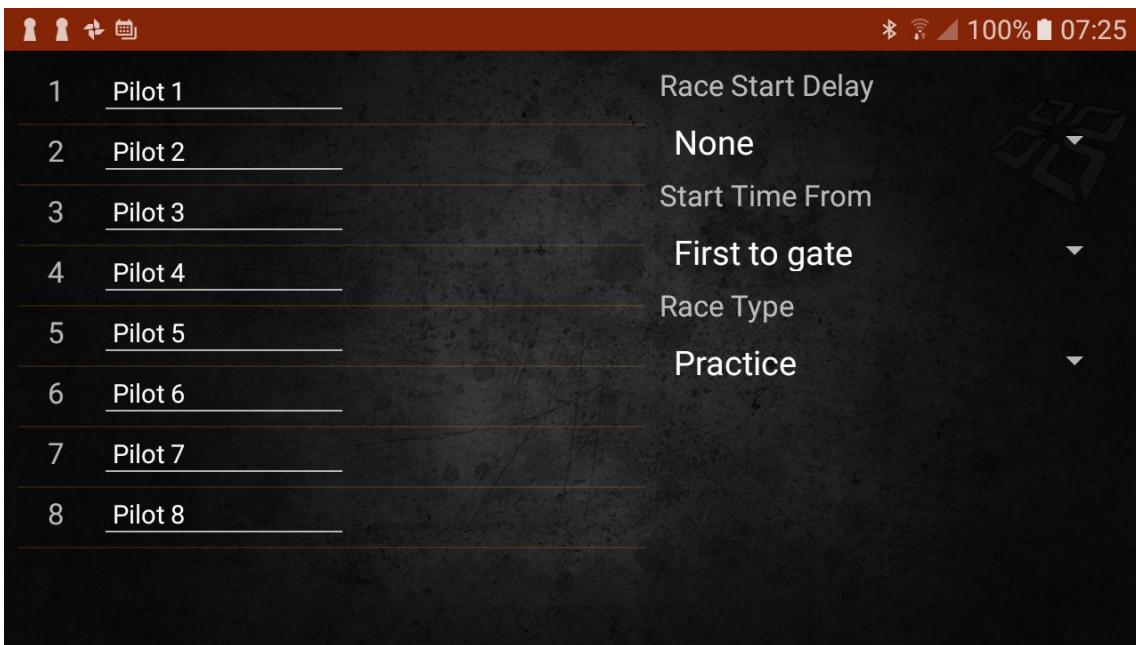
Note that when selecting band and channel the frequency is automatically displayed. For custom frequencies (for example, for the Connex digital frequencies), simply type the value into the frequency control.

General Settings
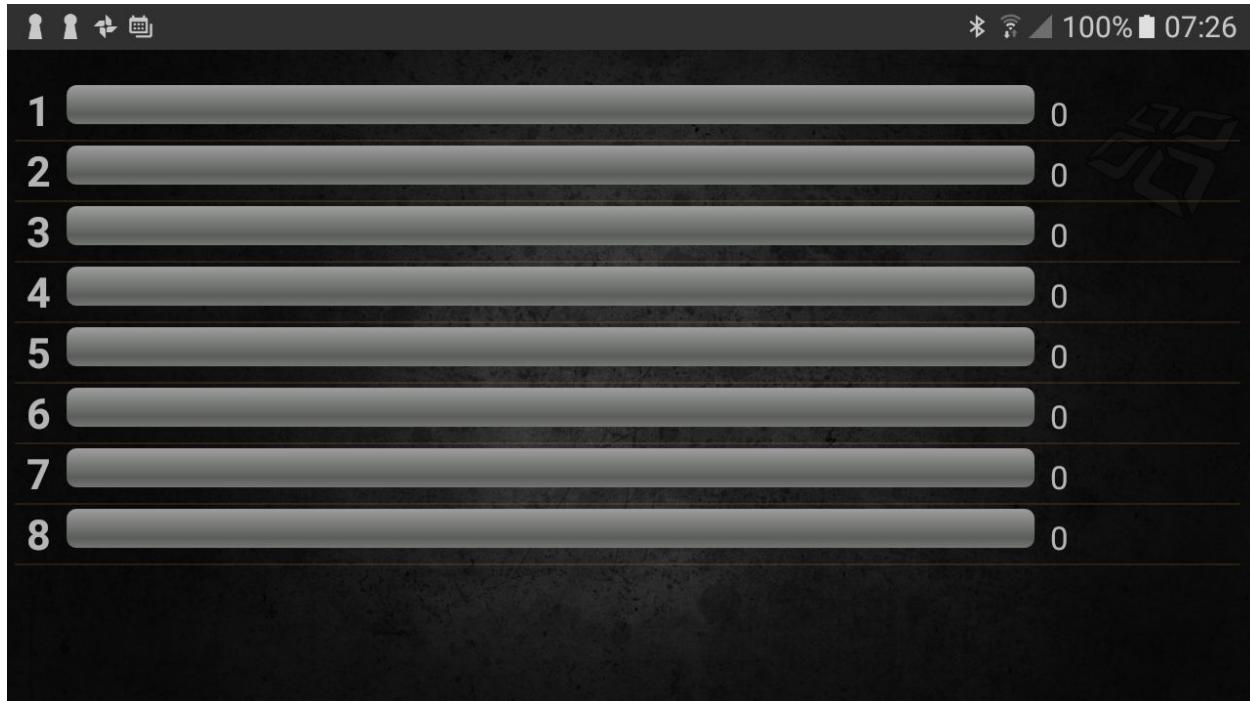
The general settings page enables names to be entered for each of the pilots, along with the various race modes.

Diagnostics

The diagnostics page shouldn't normally be required, but can be a useful tool during debugging.

The RSSI level of each configured pilot slot is shown. Power on video transmitters and walk them through the gate to ensure correct configuration of the lapRF, and the video transmitter itself.

Placement

The lapRF's integrated patch antenna forms a beam which emits from the top of the product.

Ideal placement is in the center of the gate, but that does expose it to strikes from low-flying (high speed) racers.
A small hole in the ground works well to protect it for grass tracks, or where this is not possible, either protect the timer from strikes placing a solid object in front of it, or place the timer at a 45 degree angle from one corner of the gate.

When laying out tracks for RF timing, avoid parts of the track which come close to the timing gate to prevent false readings.

For start grid positioning, place it at least 5m from the gate to ensure that the first crossing is registered.

Fire Up

The most obvious installation of the LapRF is in the bottom-center of the gate, firing up.

The disadvantage of this installation method is that the LapRF is vulnerable to strikes from low-flying, high-speed quads.
A small hole in the ground, or a non-conductive object placed in front of the timer to protect it works well.
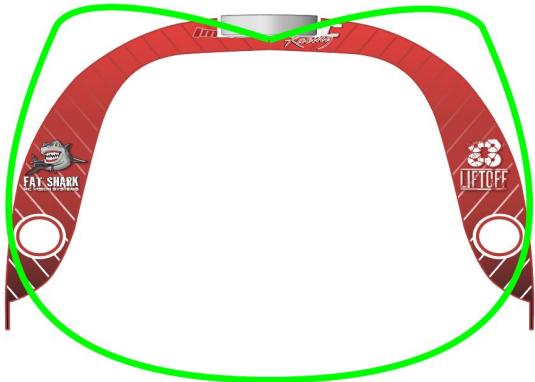
Fire-Down

An alternative, keeping the timer centered in the gate, is to fire down towards the ground. This achieves much better bluetooth range, but is a little more difficult to mount.

The radiation pattern of the antenna can fill the gate better than the up-firing alternative.

45-Degree Firing

A solution that works well when other parts of the track get close to the start/finish gate is to place the LapRF at 45 degrees on one side of the gate.

This has the advantage of making it easier to protect the timer from quad-strikes also.

Bands, Channels, and Frequencies

The applications which support the lapRF define the bands and channels that are available for a race.

All of the commonly used bands are present.

	1	2	3	4	5	6	7	8	
L	5362	5399	5436	5473	5510	5547	5584	5621	Low Band*
F	5740	5760	5780	5800	5820	5840	5860	5880	IRC/FS
R	5658	5695	5732	5769	5806	5843	5880	5917	RaceBand
E	5705	5685	5665	5645	5885	5905	5925	5945	Band E
B	5733	5752	5771	5790	5809	5828	5847	5866	Band B
A	5865	5845	5825	5805	5785	5765	5745	5725	Band A

⚠ **Note: The band that we refer to as 'Low Band' is not legal in most countries worldwide without an appropriate license. In many countries a special event license may be obtained for official races in areas where interference may be minimized.**
Please check with your local radio-communication authority before using this band.

Increasing Bluetooth Range

The internal bluetooth module uses a self-adhesive dipole antenna, fixed to the inside of the product.

This antenna uses a standard U.FL connector, which may be removed, and replaced with an external antenna, by means of a 10cm U.FL to bulkhead SMA cable.

When disassembling the case, a small plastic 'blanking plate' may be removed after opening the case of the LapRF, to open up the hole through which to secure the SMA connector.
Do not try to remove this with a knife from the outside of the box!, the part slides out easily when the box is opened.

For the antenna, the FatShark 2.4GHz dipole works well:
http://www.getfpv.com/2-4-ghz-2-5-dbi-antenna-tested.html

And for the required cable, U.FL to SMA:
https://www.digikey.com/product-detail/en/amphenol-rf-division/336313-12-0150/ARF2362-ND/5417988

Note: ImmersionRC will be supplying a kit with the required antenna and cable in the near future, but in the interest of speed to market, the above combination will work well.
Another Note: We know of no issue/damage if the puck is powered up without the external bluetooth antenna connected.

Certification

The CE, FCC, and other certificates for the integrated Bluetooth module are available from here:

https://www.immersionrc.com/fpv-products/laprf/
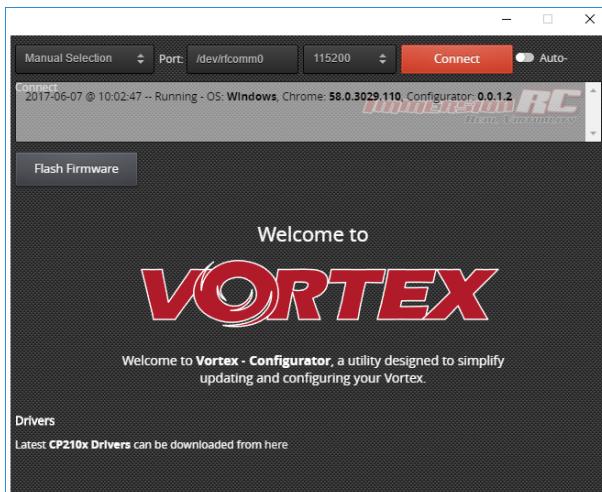
Note that these certificates only apply when the internal antenna is used.

For resellers, or anyone who has to ship the device, the documents required by shipping services for battery safety are also provided at the link above.

Firmware Update

- Install a fully charged battery
- Ensure that the timer is turned off
- Press and hold the **Bind** button, while pressing the **Power** button. The status led will blink rapidly.
- Connect the timer to a PC with the USB cable.
- Run the ImmersionRC 'Vortex Configurator' Chrome application
- Press the **Flash Firmware** button, and point to the firmware file downloaded from the ImmersionRC website product page for the LapRF.

Battery Charging

While charging, the 'Charge' LED under the puck acts as a 4 level battery gauge.

One short flash indicates a battery that is below 25%, two for 50%, three for 75%, and a solid indicator indicates a battery that is fully charged.

Indicators, and LED Colors

The two RGB LEDs on the top of the unit will change color to indicate the pilot slot of the last pilot that crossed the gate.

These colors are:

Slot 1	Red
Slot 2	Yellow
Slot 3	Green
Slot 4	Light Green
Slot 5	Cyan
Slot 6	Blue
Slot 7	Pink
Slot 8	Magenta

(Yes, seems cool, but in practice, it is of little value, pilots should concentrate on the FPV feed, and audible lap times are all that pilots need to know what is going on).

What are the Gain and Threshold numbers for?

Firstly, these values are generally ok at their default settings. The 'robustness' of the hardware and software used in the LapRF results in a high tolerance to settings which are not hand-tuned.

If you really want to understand more about how to tweak this values (for those of you who get a kick out of PID tuning), please read on, if not, just set default values, and go fly, in the vast majority of cases, you will not need to understand them.

Gain *(this gets a bit technical, jump down to the part in the box if you want to get to the point, fast)*

Gain is a value that you will not see on the multitude of 'DIY', or even most (if not all) commercial trackers. This control is similar to the 'gain' on a microphone mixing desk. Turn it up, and things get loud, turn it down, and things get real quiet.

It is a parameter which controls a piece of hardware unique to the RF Timing modules used in all LapRF systems.

For 25mW races, with the tracker close to the gate, a value of around 59 is suitable. This corresponds to a 'gain' of 29.5 dB (one gain code = 0.5dB).

Maximum value is 63, for a gain of 32.5dB.

If you want to use higher power, 200mW (23dBm) for example, you need to 'turn the volume down'. Since 200mW is approx. 10dB more power than 25mW (13dBm), the gain value should be 20 codes lower, 59 - 20 = **39**.

For 600mW (27dBm), this is 14dB more power, so the gain value should be approx. 28 codes below the default, 59 - 28 = **31**.

Why do you care?, because this parameter lets you reduce the crosstalk from adjacent channels, something that all other RSSI based timing systems all suffer from. It lets you run races with 200mW, or even 600mW transmitters, without pilot 1 being captured on 3 other channels.

> So to tweak it, start with the default setting, 59 for 25mW, 39 for 200mW, 31 for 600mW, and if you are getting crosstalk from other channels, decrease it. If you are not sensitive enough, and missing laps, increase it.

Threshold

This one is a little more difficult to explain exactly what it does, because it ties into some pretty fancy software, which runs on-the-fly in the LapRF systems.

Basically it is the size of the RSSI peak, above the noise base-line, which is required to trigger a detection (lap).

The higher the value, the closer the quad has to be to the timer to register a lap.
Set it too low, and you will be recording the laps of the dude 2 miles down the road, flying in his local bar. Set it too high, and a 10 Gigawatt transmitter hung off the side of a time-travelling car wouldn't be recorded.

800 appears to be the magic value for most cases. This was what we used for the multiGP IO event for all 8 LapRF 8-Way trackers, even the one pointing at the gate which was hovering 12 feet above the ground.

Real Practical, Tried-and-Tested Values

Most gates, with the tracker positioned close to the gate, 25mW Transmitters:

Gain = **59**, Threshold = **800**

Elevated gates, with the tracker firing up to the bottom of a gate 12 feet in the air (MultiGP IO Team track for example)

Gain = **63**, Threshold = **800**

Now, if you are pushing the limits a bit, and you are using a single personal tracker to time 4, 5, 6, or more quads, the threshold may need decreasing a bit.

Troubleshooting

Problem: LEDs are white on power-up

Solution: Indicates an issue with the programming of the unique device ID, please contact support.

Problem: Quad passings are being missed when multiple quads selected

Solution: Take note that additional pilots are added to the personal tracker, the accuracy, and ability to capture high speed quads decreases. For faster quads, consider arranging gates and flags so that the start/finish gate crossing speed is much lower.
For larger events, consider using the LapRF Event Timing System.

Problem: My LapRF doesn't appear in the list of devices

Solution: First thing to check is that another device is not currently connected to the LapRF. Another phone (iOS or Android), tablet, etc. For both iOS and Android ensure that the app is well and truly closed, and is not still running in the background.

Also ensure that your phone/tablet supports BLE. For iOS this started with the iPhone 4c, and the iPad 3rd Generation (1st and 2nd generations will not work).

http://www.iphonefaq.org/archives/973945

Problem: My LapRF flashes red and turns off when I power it on

Solution: Battery is drained!, recharge before using. .