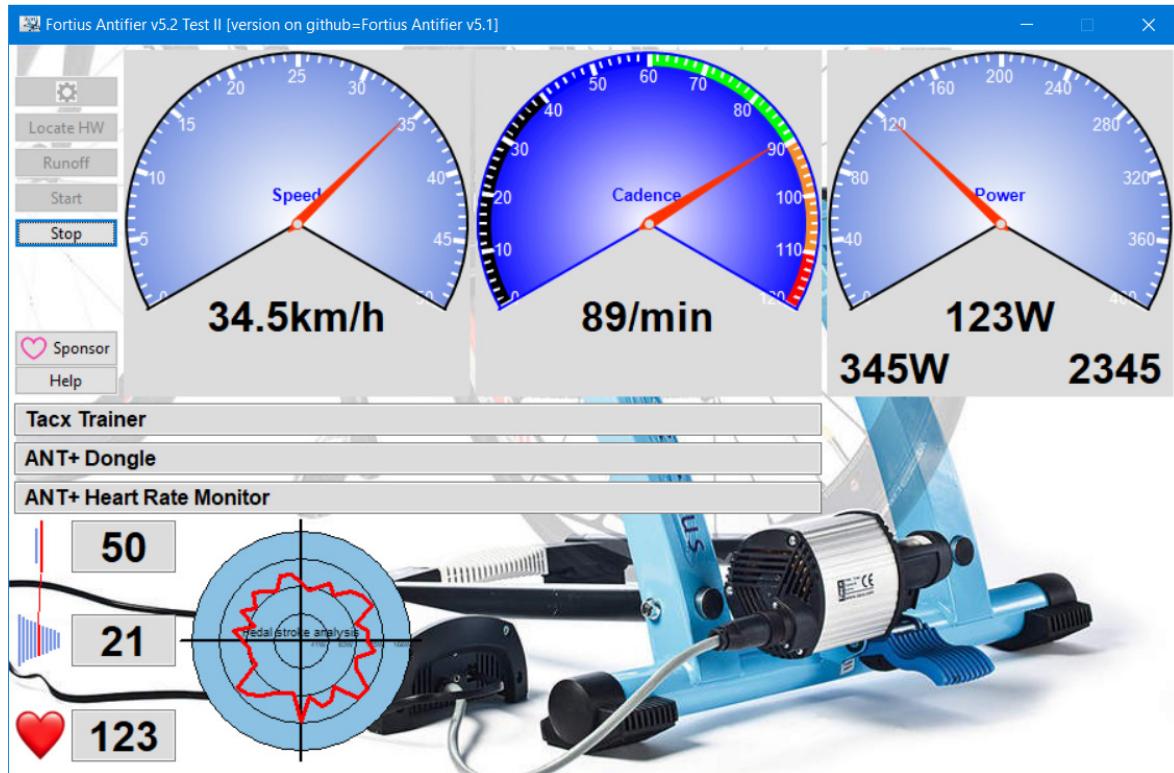




## Fortius ANT User Manual

*Author and copyright: Wouter Dubbeldam*  
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# 1. Introduction

## 1.1 Summary

Tacx created trainers and provided software (Tacx Training Software, TTS) to enable users to do structured training or ride in a virtual world. Trainer and TTS were sold in a package and the interface was not available for other manufacturers.

Based upon these initial products, open standards were defined. ANT+ defines the way how CTP's (Cycling Training Programs) and FE-C's (Controllable Fitness Equipment) communicate with each other. This open standard enables that software (CTP) and hardware (FE-C) can be created by different manufacturers.

Known CTP's are Zwift, Trainer Road, Rouvy, Sufferfest, Golden Cheetah, RGT, TTS and many others. Programs have their own specialty domain: Zwift provides the possibility to train together in a virtual world, Trainer Road has structured training programs and Rouvy allows to ride in augmented reality – and of course each product also provides functionality in the competitive area.

Trainers are provided by hardware manufacturers, like Tacx, Wahoo, Elite and others.

The open ANT+ standard allows the CTP's to communicate with FE-C's.

BUT: old Tacx trainers are left behind – the proprietary Tacx-interface is not supported by the modern CTP's and we understand that the current version of TTS does not support the old trainers anymore.

This is where FortiusAnt has its place: **FortiusAnt enables users of old Tacx Trainers (like Fortius, Magic, Flow, Vortex, Bushido, Genius and others) to use modern Cycling Training Programs, [CTP] (like Zwift, Trainer Road, Rouvy, Sufferfest, Golden Cheetah, RGT, TTS and many others as mentioned above).**

**Important: only one computer (laptop or desktop) is required to run FortiusAnt and a [CTP].**

## 1.2 Thanks

FortiusAnt is based upon the methods and architecture from **[Antifier]** and uses the interface description from **[TotalReverse]** and without their work, FortiusAnt would not have existed. Same is valid for Golden Cheetah for i-Magic's resistance formulas.

Thanks to **@darkpotpot** and **@iepuzaaur** for testing the i-Vortex, **@yegorvin** for testing the iMagic power curve, **@ElDonad** for cracking the CYCPLUS dongle issue and **@mattipee** for enthusiasm on programming, correctness and testing as well as valuable github- and vsc-lessons. Thanks to **@switchabl**, **@cyclingflow**, **@bikebeppe64**, **@mikeherriman**, **@mk2mark** and **@jurgen-iflow** for developing and testing the Flow/Magic trainer on T1932, **@cyclingflow** for parameterizing the runoff procedure and **@MarcoVeeneman** for the Bluetooth support. 2021 starts with the release of Bushido and Genius support, thanks to the efforts of **@switchabl**. Of course, thanks to all who have reacted and

added to FortiusAnt improvements.

If you use FortiusAnt, let me know and add yourself to the map!

FortiusAnt has matured in 2020's corona era and continues to expand in 2021 with ANT- and Bluetooth support. It shows where github code-sharing and joint effort can bring us; a new and inspiring experience for myself.





If you use FortiusAnt, let me know and you add stars on the map! See github issue #14.

### 1.3 The structure of this manual

After the introduction you are now reading; the manual has the following chapters

- Background information; explaining concepts
- Installation instructions; how to install FortiusAnt
- Operating instructions; how to run FortiusAnt
- Questions and special situations; to describe anything else
- The section on Power curve validation is moved to the end of the manual

I hope the manual helps in operating FortiusAnt and I'm always happy to hear from you @github!

### 1.4 The story in a picture:





Legacy Tacx with FortiusANT bridge can be used with ANT+ Software



## 1.5 References, abbreviations, and terminology

Term	Explanation	See also
[Antifier]	The predecessor of FortiusAnt, created by "John".	<a href="https://github.com/john-38787364/antifier">https://github.com/john-38787364/antifier</a>
[ANT+]	ANT+ is a wireless technology that allows devices to talk to each other. The following documents are most interesting to study when digging into the python code:	<a href="http://www.thisisan.com">www.thisisan.com</a>
	<ul style="list-style-type: none"><li>• D00000652_ANT_Message_Protocol_and_Usage_Rev_5.1.pdf</li><li>• D00001198_-_ANT+_Common_Data_Pages_Rev_3.1.pdf</li><li>• D000001231_-_ANT+Device_Profile-Fitness_Equipment-Rev_5.0(6).pdf</li><li>• D00000693_-_ANT+Device_Profile- Heart Rate Rev 2.1.pdf</li></ul>	
[BLE]	Bluetooth Low Energy	
[CTP]	Cycling Training Program, such as Zwift, Trainer Road, Rouvy, Sufferfest, Golden Cheetah, RGT, TTS and many others	
[FE]	Fitness Equipment, like legacy Tacx trainers	
[FE-C]	Controllable Fitness Equipment, the ANT+ name for an indoor trainer.	
	A [FE] + [FortiusAnt] becomes an FE-C.	
[FortiusAnt]	FortiusAnt enables a usb-connected Tacx trainer to communicate with [CTP]s through ANT.	<a href="https://github.com/WouterJD/FortiusAnt">https://github.com/WouterJD/FortiusAnt</a>
[HRM]	ANT+ Heart Rate Monitor profile	See [ANT+]
[PWR]	ANT+ Power Meter	See [ANT+]
[Python]	Python is a high-level programming language	<a href="http://www.python.com">www.python.com</a>
[SCS]	ANT+ Speed and Cadence Sensor	See [ANT+]
[TotalReverse]	Invaluable source of information regarding Tacx USB interfaces.	<a href="https://github.com/totalreverse/ttyT1941">https://github.com/totalreverse/ttyT1941</a>



## Fortius ANT - User Manual

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[TTS]

Tacx Training Software; proprietary [CTP] connecting  
to Tacx trainers only.



## 1.6 Revision History

Date of this revision: February 3rd, 2021

Version: v5.2 Published

Version	Revision Date	Summary of Changes
5.1	February 3 <sup>rd</sup> , 2021	<ul style="list-style-type: none"><li>- Revision of the manual</li><li>- User-interface changes effectuated</li><li>- Documentation-suggestions from github</li><li>- Section 3.8 Start FortiusAnt extended with some details on starting FortiusAnt and the location of logfiles etc.</li><li>- Bluetooth added</li></ul>
5.1	January 8 <sup>th</sup> , 2021	<ul style="list-style-type: none"><li>- Typo in description of -p command-line parameter.</li><li>- Note added to install libusb as Administrator, if so required.</li><li>- Gear switching is extended to front/rear</li><li>- Power can be adjusted in ERGmode</li><li>- Settings can be modified interactively and saved</li></ul>
5.0	January 4 <sup>th</sup> , 2021	<ul style="list-style-type: none"><li>- Tacx Bushido and Genius support added</li></ul> <p>Note that the -t option for i-Vortex is changed into -t Vortex. Detailed remarks for Bushido and Genius are written in the appendices 5.11 "Detailed notes on Tacx Genius" and 5.12 "Detailed notes on Tacx Bushido".</p>
4.1.a	December 27 <sup>th</sup> , 2020	<ul style="list-style-type: none"><li>- Start-up sequence added to 4.1 "The main functions of FortiusAnt and the head unit."</li><li>- Table added to 3.2.2 "Hardware"</li></ul>
4.1	December 22 <sup>nd</sup> , 2020	<ul style="list-style-type: none"><li>- Bluetooth Low Energy supported (-b).</li><li>- ANT remote control button implemented (-C).</li><li>- Main program can only closed from the GUI, so that it cannot be stopped from the head unit by mistake.</li><li>- Minor functional improvements.</li></ul>
3.i 3.h 4.0	December 11 <sup>th</sup> , 2020	<ul style="list-style-type: none"><li>- Supported tacx trainertypes described in more detail (see 2.3)</li><li>- Power calculations implemented for magnetic brakes</li><li>- Documentation improvements based upon some issues</li><li>- Command line parameter -r (resistance) introduced; to send TargetPower directly to brake for test-purpose</li><li>- Command line parameters -D (antDeviceID)</li><li>- -G (ModifyGrade) and -c CalibrateRR introduced.</li><li>- -H described with some examples</li><li>- -u uphill removed (replaced by -G/0)</li></ul>
3.h	November 15 <sup>th</sup> , 2020	Debugging section added
3.g	November 5 <sup>th</sup> , 2020	In manual power/grade mode, a tcx file is created. Sections added: <ul style="list-style-type: none"><li>- 6 Power curve validation</li><li>- 5.6 Fortius without cadence sensor</li><li>- 5.7 Two ANTdongles – disturbed communication</li></ul>
3.f	October 21 <sup>st</sup> , 2020	i-Vortex and -P option added
3.e	October 16 <sup>th</sup> , 2020	Command line parameter -u uphill added Section added: 5.5 Tacx head unit with firmware to be loaded. Minor textual modifications
3.d	October 5 <sup>th</sup> , 2020	Section Requirements added
3.c	October 2 <sup>nd</sup> , 2020	Only ONE computer is required to run FortiusAnt and a [CTP], two computers are drawn in the pictures to explain the concept.
3.b	October 1 <sup>st</sup> , 2020	First version published
3.a	June, 17 <sup>th</sup> 2020	First version



## 2. Background information

### 2.1 FortiusAnt Sensor- and Monitor devices

ANT+ Master devices are Heartrate monitor, Powermeter, Speed- and Cadence sensor and [FE-C]'s. "Master" could be replaced by "Sensor": they measure and transmit the results through ANT+.

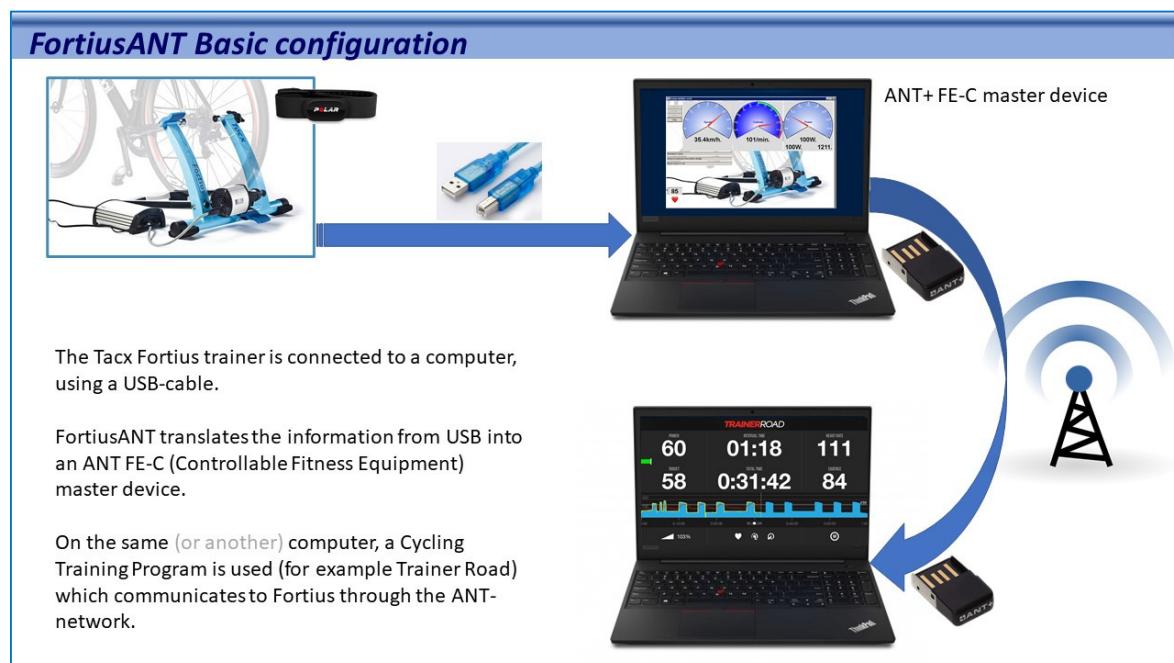
ANT+ Slave devices receive the transmitted signals and display the results, like a speed/cadence/power display on a bicycle; they may also send commands to the sensor – for example a [CTP] sends commands to a [FE-C]. "Slave" could be replaced by "Display": the display/monitor/control what the sensor does.

FortiusAnt follows ANT+ terminology also when the terms Master and Slave are replaced in future.

To understand "what we are doing"; the following pictures explain at a high level what happens "under the hood".

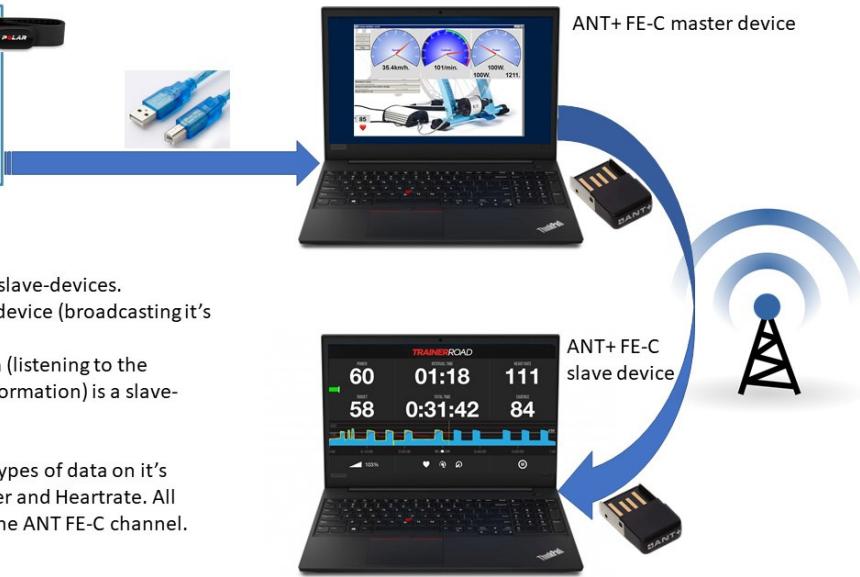
**Important:** only one computer (laptop or desktop) is required to run FortiusAnt and a [CTP]. Two computers are shown to explain the concept. One computer with three USB-connections will do the job: (1) the USB-cable to the Tacx Trainer, (2) the ANT+ dongle for FortiusAnt and (3) the ANT+ dongle for the [CTP]. And indeed: the two programs on one computer (FortiusAnt and [CTP]) communicate with each other externally and wirelessly, using two ANT+ dongles.

See also section 3.2 "Requirements".

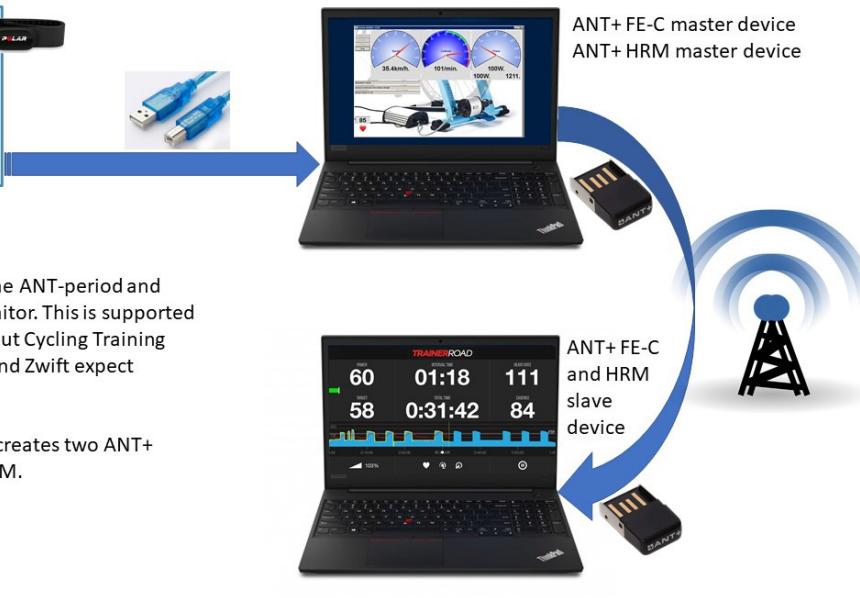




### ANT master and slave devices



### FortiusANT creates two ANT+ master devices (FE-C and HRM)





### FortiusANT can also listen to an independent ANT+ HRM strap



ANT+ FE-C master device  
ANT+ HRM slave device



Although the basic purpose of FortiusANT is to translate Fortius to ANT+ FE-C, the following option is implemented. A little gadget in fact.

Imagine, you use an ANT+ coded Heartrate monitor; the Tacx Fortius does not recognize the HRM and no data can be displayed or broadcasted.

Therefore the `-H` flag tells FortiusANT to listen to a master HRM-device and display the heartrate. In that case, no master ANT+ HRM device is created.



ANT+ FE-C  
and HRM  
slave  
device



### Zwift works slightly different



ANT+ FE-C master device  
ANT+ HRM master device



As explained, FortiusANT creates two master devices



ZWIFT shows the following devices that can be paired individually:

- ANT+ Heartrate monitor
- ANT+ Controller
- ANT+ Cadence sensor
- ANT+ Power meter

The latter three can all be paired to the FortiusANT FE-C device, but if your bicycle has an own powermeter, you could choose to connect to that device instead.





## 2.2 Description

A [CTP] (Cycling Training Program) send commands to the [FE-C] (Controllable Fitness Equipment) through [ANT+] (or [BLE]). There are two modes: Power- or Ergo-mode and Resistance- or Slope-mode.

### 2.2.1 Resistance

It is important to understand that an [FE-C] only knows 'resistance' which is the torque to turn the braking axle. From physics we know that power (Watt) = torque (Nm) \* speed (km/hr). For a given resistance, the power required is linear with the speed (=cadence), provided you do not change gears. Also, for a given resistance and cadence, the power required is linear with the gear-ratio.

PS. This is especially valid for the older trainers; Tacx i-Vortex can be set natively to a defined Power.

### 2.2.2 Power- or Ergo-mode

In Powermode the [CTP] sends the required power to the [FE-C] and regardless gear or cadence, the requested power is constant. FortiusAnt calculates the resistance = power/speed (with some constants applied). Note that, if you change gears and/or cadence, the required power will remain equal because the resistance is adjusted.

### 2.2.3 Resistance mode

In resistance mode, FortiusAnt receives the required grade from [CTP]. Grade may vary from -20% (downhill) to +20% (uphill). FortiusAnt calculates the resistance to be sent to the [FE].

The power required to ride up a hill is based upon the given grade with a weight of 90 kg (rider + bike) at a given speed'. Input parameters are grade and weight (from [CTP]) and speed (as measured by [FE]). Result is Power and conversion to resistance is described above.

## 2.3 Tacx trainers

Tacx has created a large variety of trainers with commercial names like Magic, Flow, Fortius, Vortex, Bushido, Genius, with or without i-. Technically, you will find three numbers: one for the configuration, one for the head unit, one for the brake and then for other optional equipment parts. For more information see [**TotalReverse**], "Tacx product number overview" where the T-numbers describe the part they represent.

FortiusAnt is developed for the configuration I own: a **T1930** Tacx Fortius Multiplayer bundle with **T1941** brake, **T1932** PC-head unit and **T1905** steering unit.

FortiusAnt converts the USB-interface to an ANT+ interface. In this USB-mode, FortiusAnt only "knows" the head unit, not what "commercial name" is used. The head unit comes in two flavors: T1902 head unit (the so-called USB legacy interface) and all other USB head units. FortiusAnt also knows the type of brake used: magnetic or motor and adjusts automatically to the required characteristics.

Bundle	Brake	Head unit	Remarks
T1930 Tacx Fortius	T1941 Motor	T1932	USB interface tested, see 6.2
T1900 Tacx i-Magic	T1901 Magnetic	T1902	Legacy USB interface tested, see 6.3
T2250 Tacx Flow	T1901 Magnetic	T1932	Magnetic Brake interface tested, see 6.4. Issues: #102 #128 #143 #153

When directed to do so (using the -t flag), FortiusAnt does not look for a USB-trainer, but tries to pair with a proprietary ANT+ Tacx trainer. FortiusAnt then communicates with the brake and optionally with the head unit.



FortiusAnt supports the following trainers, connecting to the **USB head unit**:

- Head unit T1902: Old "solid green" iMagic head unit (with or without firmware)  
This head unit uses a so-called legacy-USB protocol, the others the New-USB-protocol.
- Head unit T1904: New "white, green" iMagic head unit (firmware inside)
- Head unit T1932: New "white, blue" Fortius head unit (firmware inside)
- Head unit T1942: Old "solid blue" Fortius (firmware inside)
- Head unit 0xe6be: Old "solid blue" Fortius (without firmware)  
This head unit requires software to be loaded when FortiusAnt is started.  
See also section 5.5 "Tacx head unit with firmware to be loaded".

FortiusAnt supports the following trainers (-t flag), connecting to an **ANT+ brake**:

- -t Vortex: T1961 brake and T2172 head unit are supported (see issue #46)
- -t Bushido: Head unit T1982 is required (see issue #117)
- -t Genius: Head unit T2020 is optional (see issue #101)

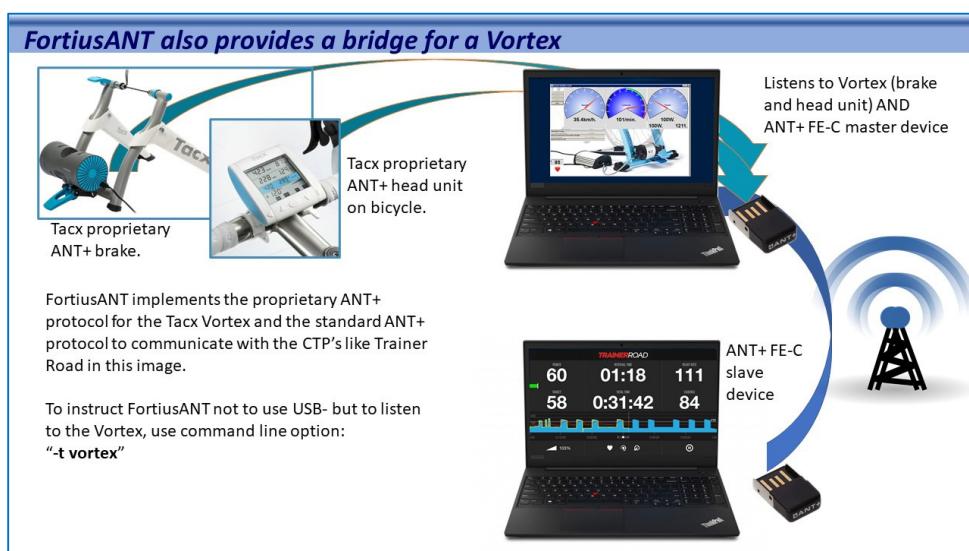
## 2.4 Tacx proprietary ANT trainers

The ANT-interface was initially used to connect a heartrate monitor to a watch and from there developed into a low-energy wireless protocol in the sport-environment. For more info, refer to [www.thisisant.com](http://www.thisisant.com).

When the whole world went wireless, the USB-connection became obsolete. ANT+ enabled to connect trainers with a variety of computers: windows, tablet, smartphone, etc. Tacx followed and built trainers with an ANT-connection but decided to keep the interface between trainer and software proprietary.

And hence Bushido, Genius and Vortex were created, communicating with an ANT+ protocol, but not following the standard regarding transmission details and data. (And perhaps, giving some credit to Tacx, the standard followed the proprietary tacx-developments).

FortiusAnt can communicate with those trainers. Functionally you may see it that instead of a USB-cable, the ANT-dongle is used. Further there are no functional differences.





### 2.5 Bluetooth Low-energy

#### FortiusANT with Bluetooth Low-energy



#### 2.5.1 Introduction

ANT+ is designed as low-energy protocol so that sensors can communicate with a sports-watch. "Bluetooth Low Energy" [BLE] can simple be seen as a competitive protocol. Many smartphones support BLE but not ANT and ANT-dongles are hard to find and tend to be more expensive than BLE-dongles. Sensors (power-meters and FE-C's) tend to support both protocols, and therefore there are many reasons to support Bluetooth Low Energy.

Unfortunately, there is no direct connection available between FortiusAnt and an installed BLEdongle; and the node.js server is required to make the connection.

FortiusANT was originally designed to provide an ANT+ interface to a Tacx Fortius. This requires the user to use ANT+ dongles in order to connect to applications such as Zwift, Trainer Road, Rouvy, Sufferfest, Golden Cheetah, RGT, TTS and many others.

On request of several users of FortiusANT support for BLE (Bluetooth Low Energy) has been added. When using the BLE interface the use of an ANT+ dongle is not mandatory anymore if you have supported BLE hardware.

If you have a tacx-proprietary ANT trainer (Bushido, Genius, Vortex), want to pair with an ANT+ heartrate monitor or transmit power data to a Garmin Edge (power- or speed/cadence sensor) then the ANT-dongle remains required.

#### 2.5.2 Design

The BLE support for FortiusANT is implemented in NodeJS, unlike FortiusANT itself which is written in Python. The implementation makes use of the very well working Bluetooth LE library see abandonware/bleno on <https://github.com/abandonware/bleno>.

Using this library FortiusANT is advertising the following services which can be discovered:

- FTMS (Fitness Machine Service)
- HRS (Heart Rate Service)

Communication between FortiusANT and the BLE server happens internally via a local http server where FortiusANT acts as the client and the BLE server as the server.



## 2.6 Calculations

### 2.6.1 Power mode

When the [CTP] is in power-mode, a required number of Watts is sent to [FE-C], in our case FortiusAnt. The [FE] requires a resistance to be set and hence a function TargetPower2Resistance(Power, Speed) is used to convert. The function is different for legacy- and new-USB trainers.

So, if you want to ride with a power of 100Watt and the bicycle wheel runs at 10kmh, the [FE] needs to receive another required resistance than when the wheel is rotating at 40kmh.

Similarly, the [FE] returns the currently realized resistance and a function is used to calculate the realized Actual Power.

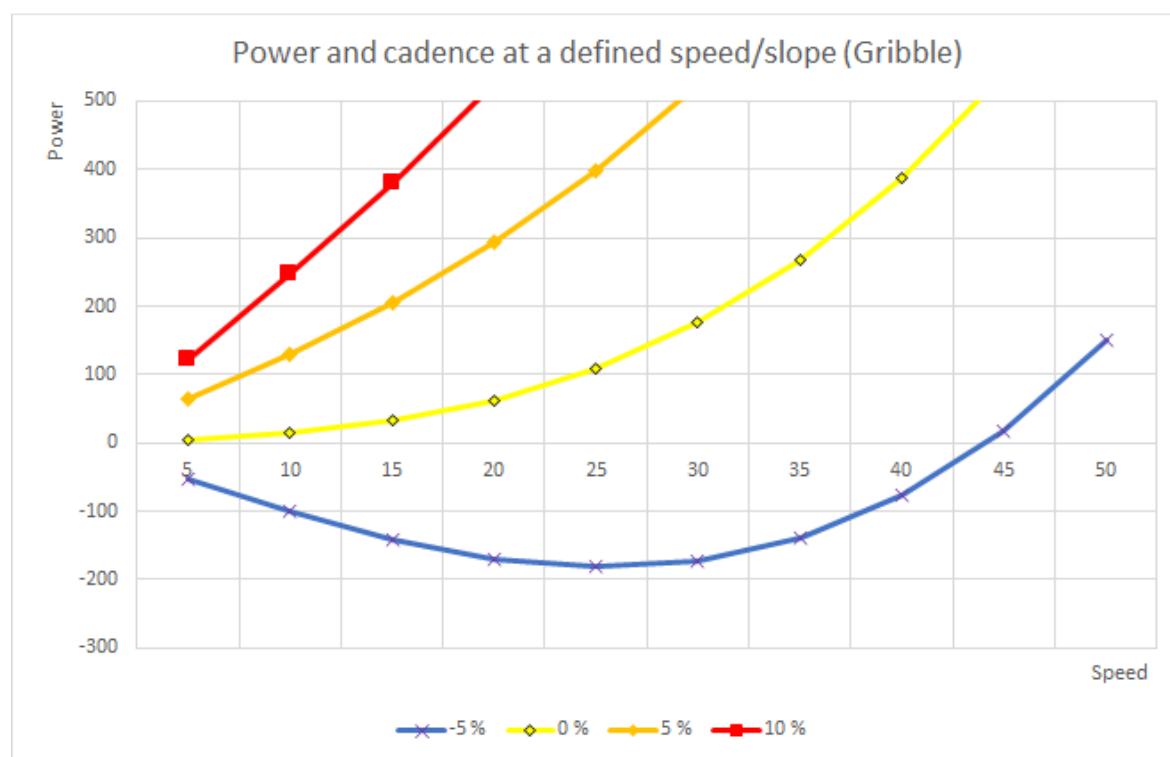
### 2.6.2 Grade mode

In Grade mode, the [CTP] communicates the slope where you are riding: flat = 0%, up hill (e.g. 10%) or downhill (e.g. -10%).

An additional step is required, using function Grade2Power(Grade, Speed, UserAndBikeWeight). First the Grade is converted to power and then the same applies as described in the previous paragraph.

The function also depends on RollingResistance, WindResistance, WindSpeed and DraftingFactor. Constants are used if [CTP] does not explicitly specify these parameters. The default value for UserAndBikeWeight is 85kg.

The formula results in the power curve as shown below. Note that, on a flat surface (yellow curve) you need 100Watt to ride 25km/hr. On a hill of 5% (orange curve) you need 300Watts at 20km/hr. And if you ride downhill -5% (blue curve) you would ride around 44 km/hr without adding additional power.





## 3. Installation instructions

### 3.1 Introduction

FortiusAnt is written in **[Python]** and can be run on any computer for which a python runtime environment is created. For Windows, FortiusAnt is also available as an executable, containing the python runtime environment. Windows users can therefore decide which version to use.

FortiusAnt communicates with the Tacx Trainer through a USB-interface, which needs some special care. And at the other side, FortiusAnt communicates with a **[CTP]** using an ANTdongle.

### 3.2 Requirements

#### 3.2.1 You, the Tacx Athlete

Getting the Tacx connected to Zwift, Trainer Road, Rouvy, Sufferfest, Golden Cheetah, RGT, TTS and many others – **[CTP]** in short – needs some knowledge:

- Download documentation and software from <https://github.com/WouterJD/FortiusAnt/>
- Be able to connect Tacx and ANT+ dongles
- Be able to install drivers on your computer
- Be able to start an executable
- Understand basic concepts, this manual only explains the FortiusAnt specifics

If this is complex, ask a friend to assist!

#### 3.2.2 Hardware

Before installing, decide what hardware you want to use:

Tacx trainer	Hardware	Connections	Software	Description
USB connected: Fortius, Flow, Magic...	One computer <sup>1)</sup>	USB 1a - Tacx Trainer	FortiusAnt	FortiusAnt communicates with Tacx Trainer (USB 1a) and with <b>[CTP]</b> (USB 1b ↔ USB 1c)
		USB 1b - ANT dongle 1		
		USB 1c - ANT dongle 2	<b>[CTP]</b>	
	Two computers <sup>1)</sup>	USB 1a - Tacx Trainer	FortiusAnt	FortiusAnt communicates with Tacx Trainer (USB 1a) and with <b>[CTP]</b> (USB 1b ↔ USB 2a)
		USB 1b - ANT dongle 1		
		USB 2a - ANT dongle 2	<b>[CTP]</b>	
	One computer <sup>1)</sup> One smartphone <sup>2)</sup>	USB 1a - Tacx Trainer	FortiusAnt	FortiusAnt communicates with Tacx Trainer (USB 1a) and with <b>[CTP]</b> (USB 1b ↔ ANT interface)
		USB 1b - ANT dongle 1		
		ANT interface	<b>[CTP]</b>	
	One computer <sup>1)</sup> One smartphone <sup>2)</sup>	USB 1a - Tacx Trainer	FortiusAnt	FortiusAnt communicates with Tacx Trainer (USB 1a) and with <b>[CTP]</b> (USB 1b ↔ BLE interface)
		USB 1b - BLE dongle 1		
		BLE interface	<b>[CTP]</b>	
ANT+ connected: Bushido, Genius or Vortex	One computer <sup>1)</sup>	USB 1a - ANT dongle 1	FortiusAnt	FortiusAnt communicates with Tacx Trainer (USB 1a) and with <b>[CTP]</b> (USB 1a ↔ USB 1b)
		USB 1b - ANT dongle 2	<b>[CTP]</b>	
	Two computers <sup>1)</sup>	USB 1a - ANT dongle 1	FortiusAnt	FortiusAnt communicates with Tacx Trainer (USB 1a) and with <b>[CTP]</b> (USB 1a ↔ USB 2a)
		USB 2a - ANT dongle 2	<b>[CTP]</b>	
	One computer <sup>1)</sup> One smartphone <sup>2)</sup>	USB 1a - ANT dongle 1	FortiusAnt	FortiusAnt communicates with Tacx Trainer (USB 1a) and with <b>[CTP]</b> (USB 1a ↔ ANT interface)
		ANT interface	<b>[CTP]</b>	
	One computer <sup>1)</sup> One smartphone <sup>2)</sup>	USB 1a - ANT dongle 1	FortiusAnt	FortiusAnt communicates with Tacx Trainer (USB 1a) and with <b>[CTP]</b> (USB 1b ↔ BLE interface)
		USB 1b - BLE dongle 1		
		BLE interface	<b>[CTP]</b>	

<sup>1)</sup> Computer: May be running Windows, Linux, MacOS or Raspberry.

<sup>2)</sup> Smartphone: or tablet

<sup>3)</sup> FortiusAnt cannot receive heartrate from HRM since BLE/HRM is not supported



### 3.3 Download FortiusAnt from github

Goto <https://github.com/WouterJD/FortiusAnt/>

In section <code> click on [↓Code] and download the code as a zipfile.

Create a folder on your computer called C:\Github\FortiusAnt (windows) or .../Github/FortiusAnt (unix). From now on, this folder will be referred to <**the FortiusAnt folder**>.

The downloaded file contains a folder called **FortiusAnt-master**. Copy the contents into <**the FortiusAnt folder**>. <**the FortiusAnt folder**> now contains sub-folders **pythoncode**, **WindowsExecutable**, etc.

### 3.4 Install python

Note: Python is NOT required when you use the Windows executable.

- Goto <https://www.python.org/downloads/>
- Follow the installation instructions for your system. It's impossible to handle all operating systems specific instructions. For Windows it's easiest NOT to install for "All users".
- Noted by @msjnaessens: "If you installed python 3.9, you cannot install numpy. I chose to install python version 3.7.9 instead."

Note that, Python version 3 is required. If you have multiple instances of python installed, mind the PATH settings!

If the python path is NOT specified there, next commands may give the error "command not found". On windows the PATH settings can be checked using Computer, Properties, Advanced, Environment variables.

After installation, the python version can be checked with the following commands:

```
python --version  
pip --version
```

You can check whether the most recent pip is installed with the command:

```
pip install --upgrade pip
```

As soon as python is installed correctly, the modules that are required for FortiusAnt can be installed as follows:

```
pip install -r requirements.txt
```

the requirements file is available in <**the FortiusAnt folder**>/pythoncode.

### 3.5 Install USB-driver

#### 3.5.1 Windows – prepackaged drivers

The installation from libusb is explained in the next paragraph. For FortiusAnt a prepackaged installation is available:

Goto [https://github.com/switchabl/t19xx\\_usb](https://github.com/switchabl/t19xx_usb)

And follow the installation steps as explained there:

- Download the all-in-one package from [https://github.com/switchabl/t19xx\\_usb/releases/download/v1/libusb-win32\\_T19xx.exe](https://github.com/switchabl/t19xx_usb/releases/download/v1/libusb-win32_T19xx.exe)
- Run libusb-win32\_T19xx.exe as Administrator.
- Click "Next", then "Finish".



### 3.5.2 Windows – from libusb

You can skip this step if you have installed the prepackaged drivers from @switchabl as explained in the previous section.

On the system where FortiusAnt is running, the easiest is that TTS is not installed, since the two programs require different USB-drivers which may be conflicting. There are studies to have both programs installed, for sake of simplicity of this installation instruction will describe a FortiusAnt-only installation. **Refer to** 5.4 "Can TTS4 and FortiusAnt coexist?" for more information!

You have to (re)install your trainer as a libusb-win32 device.

#### Download the libusb driver

- Download software from <https://sourceforge.net/projects/libusb-win32/>
- Read the wiki, sections download and Device Driver Installation
- Download libusb-win32-bin-1.2.6.0.zip from files/libusb-win32-releases/1.2.6.0/
- Unzip the file
- Note: when Windows does not allow to install, installing the libusb driver as Administrator (rightclick, Run as Administrator when adding) may help.

#### Uninstall TTS-driver (refer to **section** 5.4 "Can TTS4 and FortiusAnt coexist?" first)

- Open device manager.
- Right click on the device and click "Uninstall". It may be listed as a "Jungo" device (see <http://www.tacxdata.com/files/support/Windows10driverissues.pdf> - DO NOT RUN TacxDriversSetup.exe!)
- Unplug the trainer, wait 5 seconds, and plug it back in again

#### Install option 1

- Find it again (usually under other devices>VR-interface)
- Right click and select "update driver software"
- Select "Browse my computer for driver software"
- Select "Let me select from a list of device drivers on my computer"
- Select libusb-win32 devices
- Select ANT USB Stick 2, then OK in the warning, then close Your USB-trainer is now installed as "ANT USB Stick 2" which works, but perhaps is not a very clear name.

#### Install option 2

- Go to the ..\libusb-win32-bin-1.2.6.0\bin folder
- Start inf-wizard.exe, click next
- Select "VR-Interface" (which is the USB-device you plugged in again), click next
- Specify the name for Manufacturer (Tacx) and Device (VR-Interface), click next
- Store the results in the same folder; this creates a file like VR-Interface.inf
- Complete the installation

Now the USB-trainer is installed as "VR-Interface" (you could have chosen for "Fortius Virtual Trainer").

Technically, it is the same as option 1, but especially if you have two ANT sticks and one Tacx Trainer a named device is nicer. The names will only show up in device manager and ExplorANT and have little significance for the end-user.

### 3.5.3 MacOS

Hints:

- libusb can be installed using brew install libusb.
- Get brew if you don't have it already: <https://brew.sh/>.



### 3.5.4 Linux – General

Hints:

- Root required
- Refer to AntBridge installation instructions for hints (<https://github.com/pepelkod/AntBridge>).
- Instructions supplied by FortiusAnt users, since I have no linux environment to test.

### 3.5.5 Linux Ubuntu 20.04

As provided by [@msjnaessens](#); thanks.

Fresh install of Ubuntu 20.04; installed in Oracle VM VirtualBox 6.1; 2048 MB ram; 4 cpu cores (i7 8750H); 16 MB video memory; installed on MSI GV62 8RC laptop.

```
sudo apt install git
git clone https://github.com/WouterJD/FortiusAnt
sudo apt upgrade python3
sudo apt install python3-pip
pip3 install --upgrade pip
sudo apt-get install python3-pygame
```

```
sudo apt install make gcc libgtk-3-dev libgstreamer-gl1.0-0 freeglut3 freeglut3-dev python3-gst-1.0 libglib2.0-dev ubuntu-restricted-extras libgstreamer-plugins-base1.0-dev ubuntu-dev-tools
```

```
sudo apt install python3-wxgtk4.0
pip3 install -r ./FortiusAnt/pythoncode/requirements.txt
pip3 install --upgrade wxpython
```

```
git clone https://github.com/pepelkod/AntBridge
LOC=/lib/modules/`uname -r`/kernel/drivers/usb/serial/
sudo mv $LOC/usb-serial-simple.ko ~/Documents
sudo mv $LOC/usbserial.ko ~/Documents
sudo rmmod usb_serial_simple usbserial
sudo apt install libusb-dev
sudo apt install libgoogle-glog-dev
sudo apt install libusb-1.0-0-dev
sudo apt install pkg-config
```

Open terminal in AntBridge folder

make; make;

```
sudo make install
```

```
git clone https://github.com/Tigge/openant
git clone https://github.com/Tigge/antfs-cli
```

```
open terminal in openant folder:
sudo python3 setup.py install
open terminal in antfs-cli folder
sudo python3 setup.py install
```

Now run FortiusAnt:

```
sudo python3 ./FortiusAnt/pythoncode/FortiusAnt.py
```

Done!



### 3.6 Install ANTdongle

ANTdongles are a lot easier to use than the Tacx-USB-interface, since they are plug&play; insert the dongle in your computer and the required drivers will be installed automatically.

Dongles from manufacturer=CYCPLUS are reported not working well with FortiusAnt, refer to github FortiusAnt issues (#61, #45 and #65).

### 3.7 Using Bluetooth Low Energy

#### 3.7.1 Supported Hardware

Since BLE support in FortiusANT depends on the bleno library, hardware support is also limited to what bleno supports.

On macOS, on-board bluetooth is used, no need for an external dongle.

On Windows a bluetooth dongle is required, there is a limited set of supported hardware. It is important that your bluetooth dongle has one of the supported chipsets. See node-bluetooth-hci-socket on <https://github.com/noble/node-bluetooth-hci-socket#windows>.

#### 3.7.2 Installation on macOS

- Install Xcode: App Store see <https://apps.apple.com/nl/app/xcode/id497799835?l=en&mt=12>
- Install NodeJS: brew install node
- Install dependencies: cd node and npm install

#### 3.7.3 Installation on Windows

- Install Git for Windows (<https://git-scm.com/downloads>)  
Only needed if not installed yet.
- Install NodeJS LTS version (<https://nodejs.org>)
  - During installation: **check the box** which installs the necessary tools for native modules.
  - After NodeJS installation completes, a command prompt will appear which will install the necessary tools. This will take a while, grab a drink in the mean time.
- Install Zadig (<https://zadig.akeo.ie>)
- Insert the bluetooth dongle
- Replace the driver for your bluetooth dongle using Zadig

Note that you cannot use the bluetooth dongle for windows itself when you perform this step.  
Using the exact same steps as mentioned below you can restore the old driver if you want.

1. Start Zadig
  2. Select options, list all devices
  3. Select the bluetooth dongle  
Note: It may be difficult to know which device is the correct BLE dongle in case your machine also has BLE on-board. Disable the on-board BLE device before inserting the BLE dongle so Zadig will see only one.
  4. Remember the current driver, in case you want to restore the driver later on.
  5. Check if WinUSB driver is set as target driver, this should be the default. (Choose the old driver when reverting)
  6. press Replace Driver
- Install dependencies
    1. Start the windows command prompt and type:  
`cmd <enter>`
    2. Go to the FortiusANT folder and type:  
`cd <the FortiusANT folder>\node <enter>`
    3. Install node.js and type:  
`npm install <enter>`



### 3.7.4 Run FortiusANT with BLE support

To start FortiusAnt with BLE support add the ` -b` option.

When [Start] is pressed the BLE interface will be started until [Stop] is pressed. FortiusANT will start advertising as 'FortiusANT Trainer' on Windows and Linux systems. On macOS, it will start advertising as your computer name.

A [CTP] can then connect to FortiusAnt in the usual way, selecting the Bluetooth device.

## 3.8 Start FortiusAnt

**Now FortiusAnt is ready for use. To start (or run) FortiusAnt:**

- Double-click FortiusAnt.exe from Windows explorer (compiled version)
- Double-click FortiusAnt.py from Windows explorer (python version)
- Execute the FortiusAnt.exe or FortiusAnt.py command from the command-prompt
- Create a script, command-file, shortcut or menu-entry to do the same
- Use any of the sample-scripts in <the FortiusAnt folder>/StartUp  
Note that these are called xxx.bat for usage in the windows-environment.  
When made executable, the same scripts can be used in MacOS or Linux environment (after making them executable).

Windows, Linux, MacOS all use the same concept of giving a command, but in slightly different ways. Further explanation is beyond the scope of this manual.

If you start FortiusAnt without additional command-line options, FortiusAnt will use the default (best-practice) settings.

After starting FortiusAnt using one of the described methods, a "console" is opened and then the FortiusAnt user-interface is started. The pause command in the sample scripts is present, so you can see messages in the "console" in case of an abnormal end.

See section 4.2 "Command line" for information on parameters that can be passed on the command-line.

Note that logfiles, training-files and data-files (.log, .tcx or .json) are created in the 'current directory' where the FortiusAnt is started (not where it is located!).

Therefore, mind the difference between

```
cd <the FortiusAnt folder>/pythoncode  
FortiusAnt.py -a -g
```

and

```
<the FortiusAnt folder>/StartUp  
./pythoncode/FortiusAnt.py -a -g
```

In the first example, the files are created/expected in the pythoncode directory, in the second example those files are created/expected in the StartUp directory.

## 3.9 Settings in the JSON-file

Instead of using a command-line to start FortiusAnt, settings can also be stored in a JSON-file; a sample is available in folder "<the FortiusAnt folder>/StartUp Json".

The settings in FortiusAntSettings.json may be modified with an editor or using FortiusAnt (click the settings button).



### 3.10 Check FortiusAnt

When FortiusAnt is started without additional command-line parameters, the following text is displayed in the console:

```
Hello!  
You have started FortiusAnt without command-line parameters.
```

```
Therefore, we start with a best practice setting:  
FortiusAnt.exe -a -g -H0 -A
```

```
If you want to start without the graphical user interface:  
FortiusAnt.exe -a
```

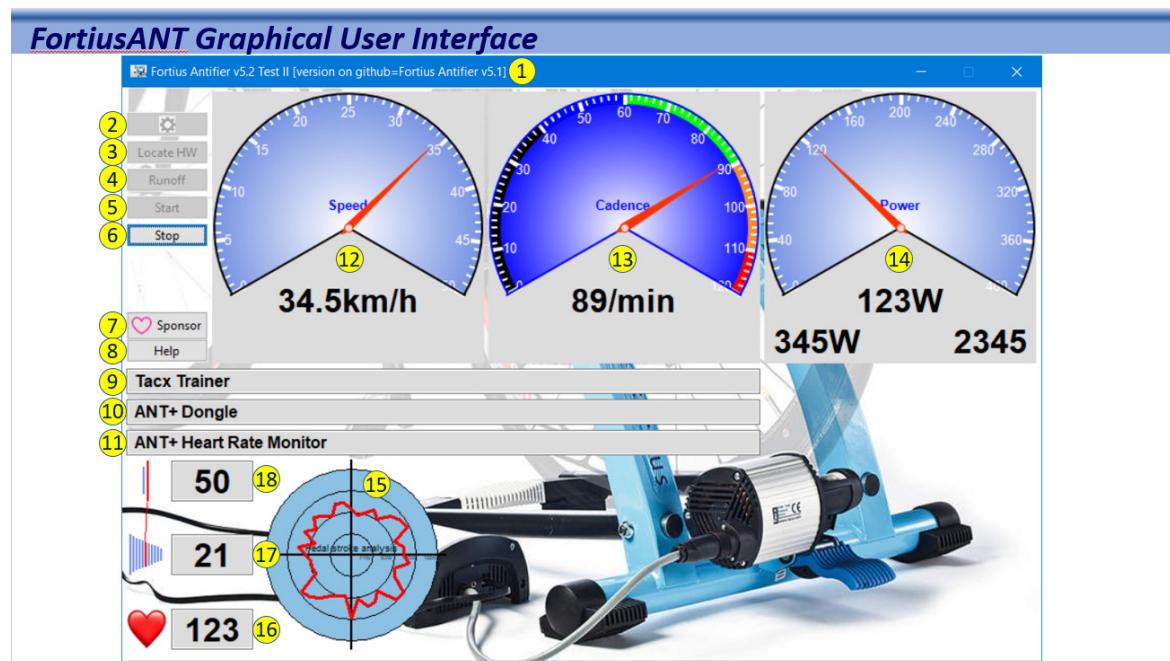
```
For more info, please refer to the wiki on github.  
Succes!
```

```
FortiusAnt is open source and can be used freely.
```

```
Just for the fun of knowing where you all are training,  
put yourself on the FortiusANT map by making yourself known  
by leaving a message with name/location/trainer on  
https://github.com/WouterJD/FortiusANT/issues/14
```

```
or visit the sponsoring page https://github.com/sponsors/WouterJD
```

And then the graphical user interface appears:



When the GUI is shown, you know that FortiusAnt is installed correctly.



The user interface contains the following elements:

1. The window title displays name and version of the software you run and the actual version as available on github.
2. <Settings> is a button to open a dialogue to modify and/or save the settings of FortiusAnt.
3. <Locate HW> is a button and when pressed, FortiusAnt will search for a Tacx USB-device and an ANT-dongle. When found, the result is displayed in (5) and (6), the button is disabled and <Runoff> and <Start> are enabled.
4. <Runoff> activates the user-driven calibration
5. <Start> activates FortiusAnt to bridge USB data to ANT+ and vice-versa; then <Start> is disabled and <Stop> enabled.
6. <Stop> stops the FortiusAnt bridge.
7. <Sponsor> opens the sponsoring page on github.
8. <Help> opens the manual on github.
9. Shows what USB-trainer is found
10. Shows what ANT-dongle is found
11. Shows what heartrate is used
12. Displays the speed of the bicycle wheel (returned by the Tacx trainer)
13. Displays the cadence of the pedals (returned by the Tacx trainer)
14. Displays the power as returned by the Tacx trainer.  
Also, the target is displayed as requested by the CTP.
15. Displays the Pedal Stroke Analysis, as calculated by FortiusAnt.
16. The heartrate.
17. and 18 show the virtual gearbox.



## 4. Operating instructions

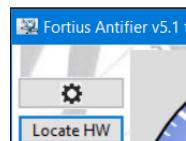
### 4.1 The main functions of FortiusAnt and the head unit.

After that FortiusAnt is started (see 3.8 Start FortiusAnt) you see the user interface with the buttons **Settings**, **Locate HW**, **Runoff**, **Start** and **Stop**.

The correct start-up sequence is:

- Setup environment (trainer, computer, bicycle, connections) and connect heartrate monitor
- Start FortiusAnt
- Press Locate HW to connect to USB-devices (Tacx trainer and/or ANTdongle)
- Execute runoff-procedure (magnetic brake trainers)
- Press Start
  - complete Calibration – motor brake trainers only
  - wait that Bushido, Genius or Vortex trainer are paired to FortiusAnt
- Start [**CTP**] and pair with FortiusAnt
- Start Training or Virtual Ride

#### 4.1.1 Settings



Since version 5.1 settings can also be modified interactively, clicking the button above "Locate HW". This button is enabled when FortiusAnt is not active.

See section 4.3 "Modify settings" for more info.

#### 4.1.2 Locate HW

Checks for the presence of USB-trainer and ANT-dongle. If successful, results are displayed and the button is disabled. For more info read section 4.4 "Locate HW". Note that, when successful, FortiusAnt is not yet discoverable by a [**CTP**]; see **Start**.

#### 4.1.3 Runoff test

To ensure comparable training sessions, the trainer should provide the same relative resistance each time

1. Aim for about 7 bar (100psi) in tire when cold
2. Warm up for 2-3 minutes to warm tire
3. Increase speed and pass the 40 km/hr speed, then stop pedaling and let wheel slow down
4. Ideally, the wheel should stop after 7 seconds from 40kph

If the rundown is too short, the role may be too tight and if the rundown is too long, the role may be too loose. In that case, adjust the role and retry the rundown test.

Using the -R command-line parameter, the procedure can be customized:

- maxSpeed = the speed that must be reached, default = 40 km/hr (allowed = 20...50)
- dip = the speed under maxSpeed when the runoff timer starts, default = 2 km/hr (allowed = 0...5)
- minSpeed = when the runoff-timer stops, default = 1 km/hr (allowed = 0...10)
- targetTime = runoff target time, default = 7.2 seconds (allowed = 0...10)
- power = the power during the runoff, default 100W (allowed = 0...500)



### 4.1.4 Start

FortiusAnt starts to calibrate the trainer (if supported and -n is not specified). Calibration means that the brake rotates the wheel at 20 km/hr and returns the resistance found. As soon as the resistance is constant, the calibration stops. The calibration time is at least 30 seconds (warming up the tire) and stops when the resistance value is constant.

Note that the calibration starts when you turn the pedal as if starting to cycle, which is the only physical action to take. Note that, starting the motor automatically would be a risk for physical injury, therefore the confirmation with a pedal-kick is required.

When calibration is started, **do not pedal**, the process completes automatically.

After calibration, the Fortius is ready for training and will listen to the FE (Tacx USB-trainer) and **[CTP]** and exchange info between them. Also, information is received from **[HRM]** and **[CTRL]** and information is broadcasted as **[PWR]** and **[SCS]**.

### 4.1.5 Stop

Pressing this button stops the currently running process (runoff, calibration or operational mode).

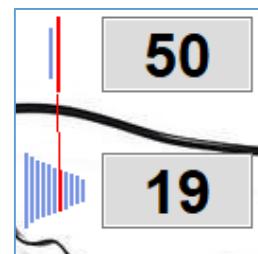
### 4.1.6 Buttons on the Tacx head unit



There are four buttons: Cancel, Enter, Up, Down.

- If not in an active mode, **Up/Down** navigate through the menu, **Enter** activates the selected button. You cannot use **Cancel** anymore to stop FortiusAnt; the "Stop"-button must be used.
- In runoff or manual mode, **Up/Down** modify the required power with ±50Watt. **OK** \*) resets the power to the initial value of 100Watt. **Cancel** stops the runoff.
- In manual grade mode, **Up/Down** modify the slope with ±1degree. **OK** \*) resets the slope to the initial value of 0 degrees.
- In resistance and ERG mode, **Up/Down** and **Cancel** modify the resistance of the Fortius using the virtual gear; **Up/Down** controls the cassette and **Cancel** the front gear. **OK** \*) resets the resistance to the initial value of 100%. The standard transmission = double 50-34 x 11 speed 11-34. The virtual gear is displayed to represent the reduction.

\*) Tacx has a variety of trainers with different head units, not all head-units have an OKbutton.





#### 4.1.7 ANT+ Remote Control



It may be useful to use an ANT+ Remote control instead of the head unit. Not all Tacx configurations have a head unit, sometimes the head unit does not fit the bike or the buttons are experienced as impractical.

Any standard ANT+ Remote Control can be used to command FortiusAnt acting as Up / OK / Down as described in the previous paragraph.

No configuration required; you can pair the control with FortiusAnt as described in the related manual.

## 4.2 Command line

FortiusAnt is started with a command (see 3.8 Start FortiusAnt). In addition to the examples shown there, parameters can be passed on the command-line:

```
usage: FortiusAnt.py [-h] [-a] [-A] [-b] [-c CALIBRATERERR] [-d DEBUG] [-D ANTDEVICEID] [-g]
                     [-G GRADEADJUST] [-H HRM] [-m] [-M] [-n] [-p FACTOR] [-P] [-r] [-R RUNOFF] [-s]
                     [-T TRANSMISSION] [-t] [-x]
```

### Basic arguments:

- h show this help message and exit
- a Automatically start; “Locate HW” and “Start” if the required devices were found.
- b Advertise FortiusAnt as “FortiusAnt Trainer” on a Bluetooth Low Energy dongle.
- g Run with graphical user interface.
- t TACXTYPE Specify Tacx Type; if not specified, USB-trainers will be detected automatically. Allowed values are: Bushido, Genius, Vortex, Magneticbrake, Motorbrake.

### Power curve adjustment:

- c CalibrateRR Calibrate the rolling resistance for magnetic brake. See section 6.4 “PowerCurve for i-Flow (T1901-T1932)”. Default is 15. If the power, displayed by FortiusAnt is higher than your power-meter, specify -c 14 to reduce the RollingResistance by 1 Newton.
- G GradeAdjust Modify the requested grade with a factor/factorDownhill; see section 6.4 “PowerCurve for i-Flow (T1901-T1932)”. Note that GradeAdjust is not active in manual mode.
  - FortiusAnt -a -g → the default value: targetGrade = 100% of requested Grade
  - FortiusAnt -a -g -G50 → recommended when using Rouvy: targetGrade = 50%
  - FortiusAnt -a -g -G50/50 → targetGrade = 50% (uphill) and 25% downhill
  - FortiusAnt -a -g -G100/0 → targetGrade = uphill only (replaces former -u flag)
  - FortiusAnt -a -g -G0/0 → targetGrade = always flat
- p FACTOR Adjust target Power by multiplying by this factor for static calibration.  
If the power, displayed by FortiusAnt is always 10% higher than your power-meter, specify -p90 to reduce resistance with 10%.

### Advanced arguments:

- A Pedal Stroke Analysis.
- D antDeviceID Select one specific antDongle (perhaps with a non-standard deviceID). The following types are known: 4104 = Suunto, 4105 = Garmin, 4100 = Older.
- H HRM Pair this Heart Rate Monitor (0: any, -1: none). Tacx HRM is used if not specified.
  - FortiusAnt -a -g → will use Tacx heartrate monitor (analog HRM paired to Tacx)
  - FortiusAnt -a -g -H-1 → no HRM is used at all
  - FortiusAnt -a -g -H0 → FortiusAnt will pair with first HRM found
  - FortiusAnt -a -g -H1234 → FortiusAnt will pair with HRM with ID=1234
- m Run manual power (ignore target from ANT+ Dongle).
- M Run manual grade (ignore target from ANT+ Dongle).  
When -m or -M is specified, a .tcx file will be created for every exercise.
- n Do not calibrate before start.



- P Power mode has preference over Resistance mode (for 30 seconds).  
Run Zwift or Rouvy to ride a route, the target is transmitted as a grade and you see where you ride. In parallel run Trainer Road to do a structured training, the target is transmitted as power. FortiusAnt "listens" to TR and transmits power and cadence to both. Now you can do a structured TR-training in the virtual world of Zwift or Rouvy.
- R RUNOFF The runoff procedure can be customized: maxSpeed/dip/minSpeed/targetTime/power. Refer to 4.1.3 "Runoff test".
- T TRANSMISSION Transmission, default value = 34-50\*x34-30-27-25-23-21-19\*-17-15-13-11
- x Export TCX file to upload into Strava, Sporttracks, Training peaks.  
-x is implicit in manual (grade) mode.

### Developer arguments:

- d DEBUG Create logfile with debugging data (see section 4.11 "Debugging FortiusAnt").
- r Target Resistance = Target Power (to create power curve)
- s Simulate trainer to test ANT+ connectivity.

### Examples:

FortiusAnt.py	FortiusAnt is started without user-interface, -g -a -A -H0 are assumed.
FortiusAnt.py -g -a	FortiusAnt is started with user-interface and starts automatically.
FortiusAnt.py -g -m	FortiusAnt is started with user-interface. No [CTP] is required, power can be set using the console. Although intended for interface testing, you could do a manual ride this way.
FortiusAnt.py -g -M	Same as -m but now the slope-grade can be adjusted.
FortiusAnt.py -g -s	FortiusAnt is started with user-interface. No [FE] is required, automatic response to [CTP] is generated. This is intended for interface testing.
FortiusANT.py -a -g -H0 -t Bushido	
FortiusANT.py -a -g -H0 -t Genius	
FortiusANT.py -a -g -H0 -t Vortex	

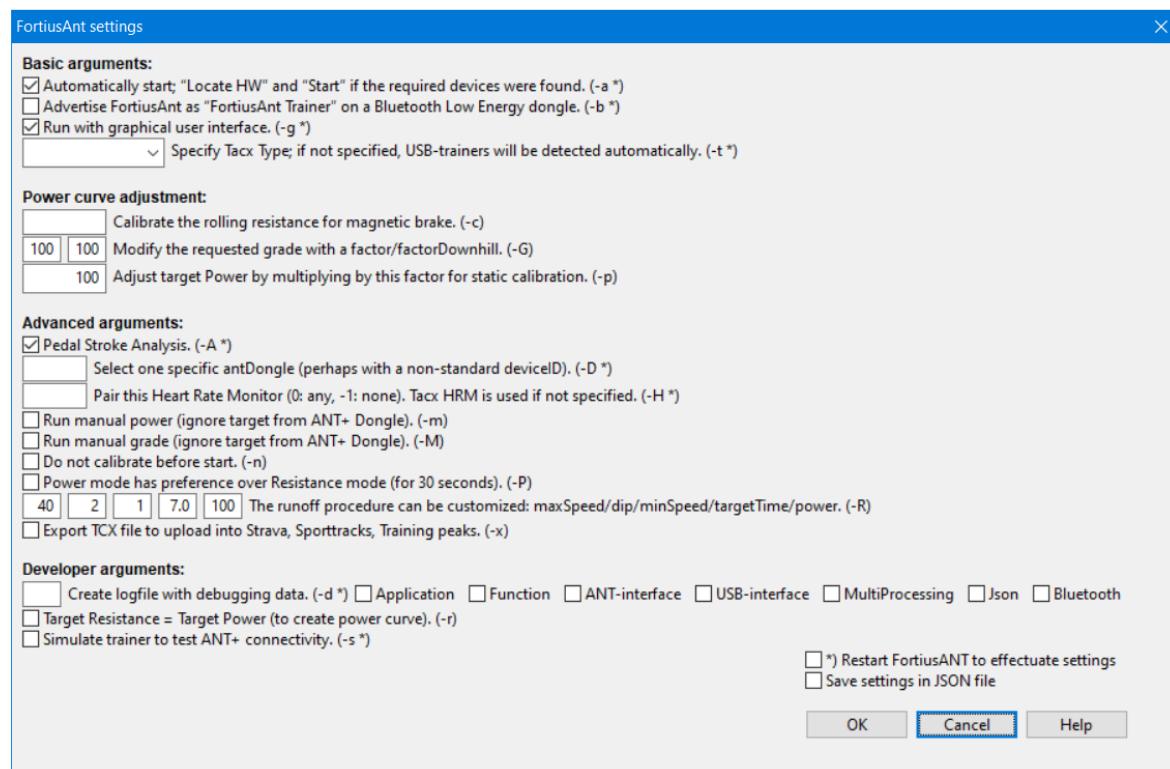
### Values for parameters:

DEBUG	Is a binary flag list what to write to the logfile, 0=nothing, 127=everything. The values below can be added together. No = 0 Application = 1 Function = 2 antDongle = 4 usbTrainer = 8 multiProcessing = 16 jsonFile = 32
FACTOR	Correction factor 0.9 ... 1.10
HRM	The device ID of the Heart Rate Monitor to be used. 0: pair with first found, -1 do not pair at all.



## 4.3 Modify settings

When pressed, the following dialogue appears. The dialogue contains the settings that are currently active.



All settings are described in the previous section, please note the following:

- All settings can be saved in a JSON-file, which is stored in “the current directory”.
- “The current directory” is the directory that is active when the .py or .exe file is started.
- Settings marked with \*) will cause a restart of FortiusAnt after clicking the OK button. The restart will be done automatically.
- The restart can be suppressed by de-selecting the appropriate checkbox above the OK-button, but then only the options that are not marked with \*) are in effect. The marked options will be in effect during the following session if saved to the JSON file.

The precedence of settings is: **default values ← command-line ← JSON-file**.

The reason for the latter is that, -if you change the settings, save in the JSON-file and execute the same command, the settings in the JSON-file are in effect.

Recommendations:

- if you use a JSON-file, do not use command-line options.
- If you want to use a command-line, note that the JSON-file takes precedence.

Because of the variety of systems used (Windows, Linux, Raspberry, ...) no special rules are (yet) defined for system-standard locations of a JSON-file.



### 4.4 Locate HW

When the “Locate HW” button is pressed, the following happens:

#### Find ANT+ dongle

A check is done whether an ANT+ device with DeviceID 4100, 4104 or 4105 is found. If found, an attempt is made to use the dongle, if in use another dongle will be searched for.

FortiusAnt always needs an ANT-dongle, unless -m or -M is specified in that case you can set power or slope with the trainer's head unit buttons.

The following messages can be displayed:"

No (free) ANT-dongle found

Using <manufacturer> dongle

or messages indicating what interface-error occurred.

#### Find Tacx Trainer

Then a check is done whether a Tacx device is used with one of the DeviceID's as listed in section 2.3 “Tacx trainers”.

The following messages can be displayed:"

No Tacx trainer found

Connected to Tacx Trainer T<DeviceID>

or messages indicating what interface-error occurred.

Note that, when the -s command-line parameter is specified, the following message is displayed:

Simulated Tacx Trainer to test ANT-interface

Note that, when the -t i-Vortex command-line parameter is specified, the following messages are displayed:

Pair with Tacx i-Vortex and Head unit (pairing can take a minute)

Tacx i-Vortex paired: %s, Head unit: %s

#### Heartrate monitor

Old Tacx trainers paired with a heartrate monitor (HRM) and passed the heartrate through the USB-interface to **[TTS]**. Even though this option is supported on the **[FE-C]** ANT+ interface, it is not used by **[CTP]** since this software pairs with a HRM itself.

The FortiusAnt display shows the heartrate and therefore the following options exist:

- No command-line option: use the heartrate from the Tacx trainer
- -H0: pair with an ANT+ HRM”, use the first HRM that is found
- -Hnnnnn: pair with the ANT+ HRM with DeviceID=nnnnn
- -H-1: no HRM.

The following messages can be displayed:"

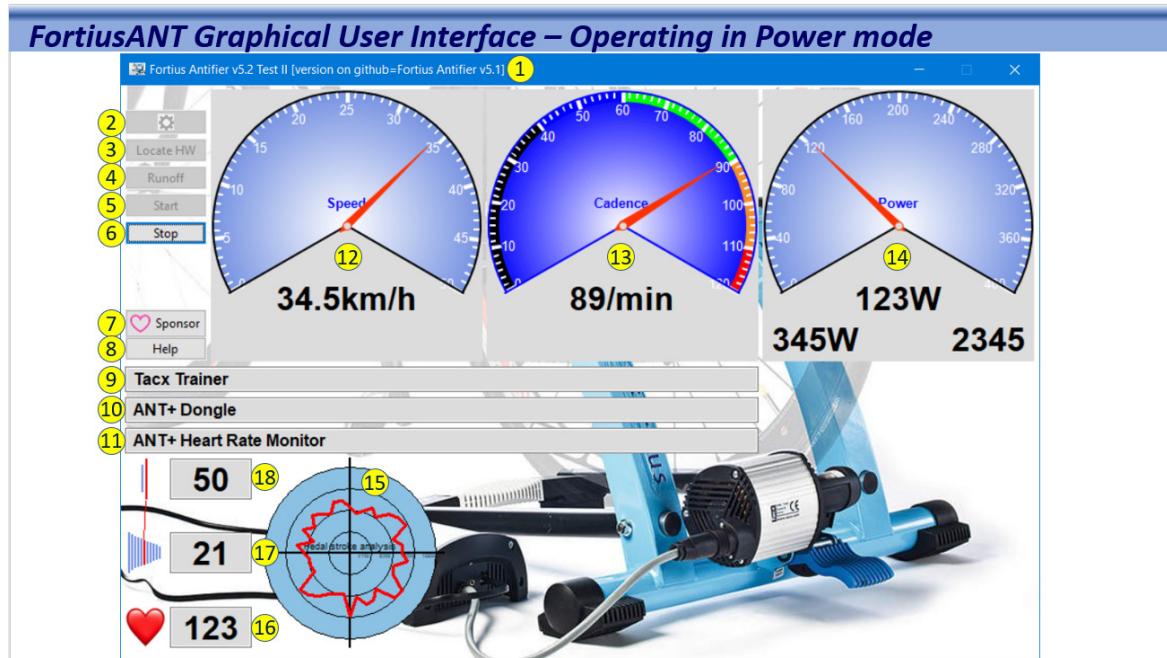
Heartrate expected from Tacx Trainer

Heartrate expected from ANT+ HRM

Heart Rate Monitor paired: <DeviceID>



## 4.5 The FortiusAnt display in power mode



This display means that, the [CTP] requires 345Watt, which results in a resistance of 2345.

The athlete currently cycles with 89 revs/minute, resulting in 123Watt at a wheel speed of 34.5 km/hr.

The cycling athlete can modify the requested grade (→ power and resistance) using the virtual gearbox; up/down change the rear gear and the cancel button changes the front gear.

(Note that all figures in this graphic are fictitious and do not represent an actual training).

## 4.6 The elements on the screen are explained in section 3.8 “Start FortiusAnt

**Now FortiusAnt is ready for use. To start (or run) FortiusAnt:**

- Double-click FortiusAnt.exe from Windows explorer (compiled version)
- Double-click FortiusAnt.py from Windows explorer (python version)
- Execute the FortiusAnt.exe or FortiusAnt.py command from the command-prompt
- Create a script, command-file, shortcut or menu-entry to do the same
- Use any of the sample-scripts in <**the FortiusAnt folder**>/StartUp  
Note that these are called xxx.bat for usage in the windows-environment.  
When made executable, the same scripts can be used in MacOS or Linux environment (after making them executable).

Windows, Linux, MacOS all use the same concept of giving a command, but in slightly different ways. Further explanation is beyond the scope of this manual.

If you start FortiusAnt without additional command-line options, FortiusAnt will use the default (best-practice) settings.

After starting FortiusAnt using one of the described methods, a “console” is opened and then the FortiusAnt user-interface is started. The pause command in the sample scripts is present, so you can see messages in the “console” in case of an abnormal end.

See section 4.2 “Command line” for information on parameters that can be passed on the command-line.

Note that logfiles, training-files and data-files (.log, .tcx or .json) are created in the ‘current directory’ where the FortiusAnt is started (not where it is located!).



Therefore, mind the difference between

```
cd <the FortiusAnt folder>/pythoncode  
FortiusAnt.py -a -g
```

and

```
<the FortiusAnt folder>/StartUp  
./pythoncode/FortiusAnt.py -a -g
```

In the first example, the files are created/expected in the pythoncode directory, in the second example those files are created/expected in the StartUp directory.

## 4.7 Settings in the JSON-file

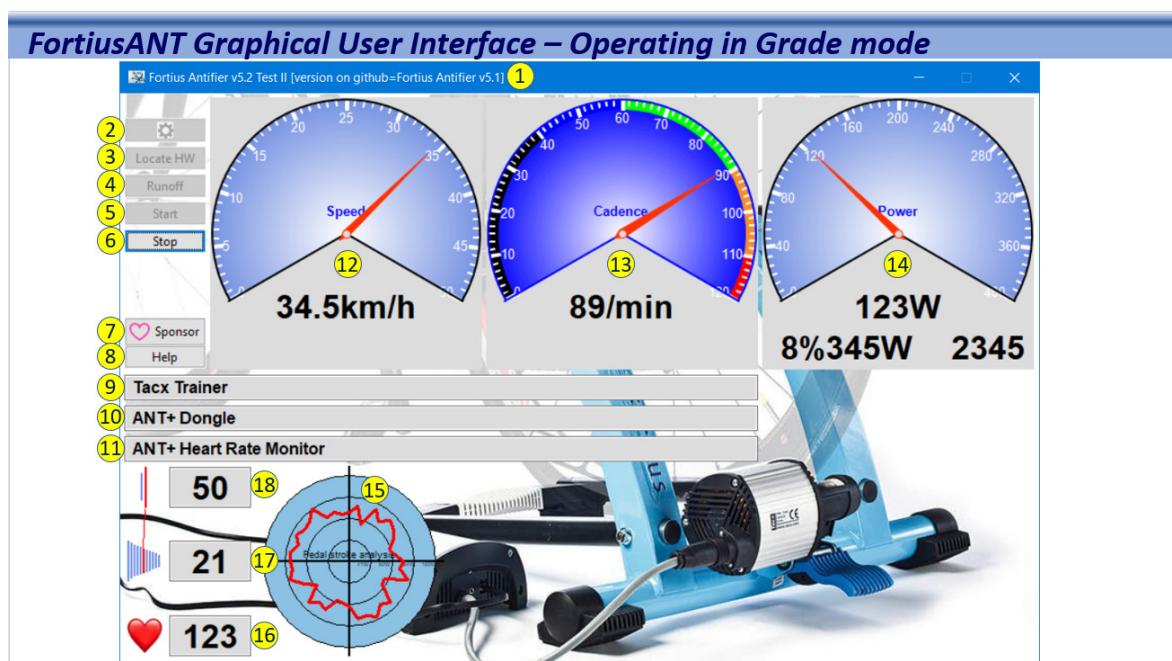
Instead of using a command-line to start FortiusAnt, settings can also be stored in a JSON-file; a sample is available in folder “**<the FortiusAnt folder>/StartUp Json**”.

The settings in FortiusAntSettings.json may be modified with an editor or using FortiusAnt (click the settings button).

Check FortiusAnt”.

In addition to the standard display, under the power gauge (11) the actual power (99W), the requested power (100W) and the resistance set in the trainer (2345) are displayed.

## 4.8 The FortiusAnt display in grade mode



This display means that, the [CTP] requires a slope of 8% which (using speed and user/bike weight) results in a requested power of 345Watt and a resistance of 2345.

The athlete currently cycles with 89 revs/minute, resulting in 123Watt at a wheel speed of 34.5 km/hr.

The cycling athlete can modify the requested grade (→ power and resistance) using the virtual gearbox; up/down change the rear gear and the cancel button changes the front gear.

(Note that all figures in this graphic are fictitious and do not represent an actual training).



### 4.9 The elements on the screen are explained in section 3.8 “Start FortiusAnt

Now FortiusAnt is ready for use. To start (or run) FortiusAnt:

- Double-click FortiusAnt.exe from Windows explorer (compiled version)
- Double-click FortiusAnt.py from Windows explorer (python version)
- Execute the FortiusAnt.exe or FortiusAnt.py command from the command-prompt
- Create a script, command-file, shortcut or menu-entry to do the same
- Use any of the sample-scripts in <the FortiusAnt folder>/StartUp  
Note that these are called xxx.bat for usage in the windows-environment.  
When made executable, the same scripts can be used in MacOS or Linux environment (after making them executable).

Windows, Linux, MacOS all use the same concept of giving a command, but in slightly different ways. Further explanation is beyond the scope of this manual.

If you start FortiusAnt without additional command-line options, FortiusAnt will use the default (best-practice) settings.

After starting FortiusAnt using one of the described methods, a “console” is opened and then the FortiusAnt user-interface is started. The pause command in the sample scripts is present, so you can see messages in the “console” in case of an abnormal end.

See section 4.2 “Command line” for information on parameters that can be passed on the command-line.

Note that logfiles, training-files and data-files (.log, .tcx or .json) are created in the ‘current directory’ where the FortiusAnt is started (not where it is located!).

Therefore, mind the difference between

```
cd <the FortiusAnt folder>/pythoncode  
FortiusAnt.py -a -g
```

and

```
<the FortiusAnt folder>/StartUp  
./pythoncode/FortiusAnt.py -a -g
```

In the first example, the files are created/expected in the pythoncode directory, in the second example those files are created/expected in the StartUp directory.

### 4.10 Settings in the JSON-file

Instead of using a command-line to start FortiusAnt, settings can also be stored in a JSON-file; a sample is available in folder “<the FortiusAnt folder>/StartUp Json”.

The settings in FortiusAntSettings.json may be modified with an editor or using FortiusAnt (click the settings button).

Check FortiusAnt”.

In addition to the standard display, under the power gauge (11) the actual power (257W), the requested grade (0%) and resulting required power (274W) and the resistance set in the trainer (2345) are displayed.

Here you also see the “digital gearbox”. In addition to the gears on your bicycle imagine you have a second drive train with a 15x15 ratio. So, the displayed situation is neutral. When you press Up/down the ratio is changed with ±10%, increasing and decreasing the required resistance on the bike. The digital gearbox shows the number of teeth on your digital cassette.

If your [CTP] requires to ride uphill with a slope of +10% and you have a high wheel-speed (because that is how the Fortius works well, see section 5.1 “Low cadence on Fortius”) you would need a high power. If that required power is higher than you can produce, you can reduce the required power using the down-button without reducing speed. If you are using Zwift you will see that the difference in Speed in Zwift (based upon power) and the speed displayed by FortiusAnt will increase).



The digital gearbox is not active in power-mode, because if 100W is required, 100W you must give. At a high wheel speed, the resistance is already calculated accordingly.

Thanks to Erik OT for the magnificent suggestion!

### 4.11 Debugging FortiusAnt

FortiusAnt has a debugging flag -d specifying what output must be written to the logfile.

The options are defined as a decimal number, being the sum of the options desired:

No logfile	= 0x00	= 0
Application	= 0x01	= 1
Function	= 0x02	= 2
antDongle	= 0x04	= 4
usbTrainer	= 0x08	= 8
Multiprocessing	= 0x10	= 16
JSON	= 0x20	= 32
Bluetooth	= 0x40	= 64

If you want all options activated, -d127 will do the job.

To log the ANT+ calls: -d4 and if you want ANT+ and the USBtrainer to be logged -d12 does the job.

If -d32 is specified, a JSON file will be created with the relevant data from FortiusAnt. This may be helpful for further analysis.

Although books could be written to explain the content of logfile and JSON file, I leave it to the user's creativity to understand the content. If you want to interpret the JSON file, "FortiusAnt JSON Analysis.xlsx" in the supportfiles section on github may be helpful.



## 5. Questions and special situations

### 5.1 Low cadence on Fortius

One of the limitations of the Fortius is the resistance at low wheel-speed, which implies a low rotational speed of the brake.

If you have a high wheel-speed, the Fortius can realize a resistance of 1000Watt. This works fine and is good to train your power.

At a low wheel-speed however, the brake does not work very fine and therefore it needs some thinking to train "Uphill training at 20%", requiring high power and low speed. You would be inclined to reduce gears as you would do in real world.

What I do is always use a high gear, causing a high wheel-speed, and drop the cadence without shifting. For example, if you want to simulate a steep uphill, requiring 500Watt you still go in the highest gear and use a cadence of 50 rpm.

FortiusAnt will reduce resistance for the trainer and the result is that you ride at 30km/hr with 500Watt and 50 rpm. Just ignore the wheel-speed!

Note that modern trainers have a direct drive and no wheel; there the wheel is ignored completely.

### 5.2 Zwift speed does not match Garmin

If you ride your bicycle on your trainer; the speed that Zwift displays does not match Garmin's speed.

Your Garmin receives the speed from the bicycle and displays the real speed of the wheel on the trainer. (Probably you realize, with the same effort, you would not achieve that speed in the real world)

Zwift receives the realized power from the trainer and uses its own algorithms to conclude what speed you are riding: If riding on a flat surface, without headwind, the simple formula would be:  
speed=power/resistance. But when you ride uphill and you take air-resistance into account, the formula is far more complicated.

Interested in the power you need to ride?

- <https://www.fiets.nl/2016/05/02/de-natuurkunde-van-het-fietsen/>
- [https://www.gribble.org/cycling/power\\_v\\_speed.html](https://www.gribble.org/cycling/power_v_speed.html)

The gribble formulas are used by FortiusAnt to convert grade to power, see also section 2.6.2 "Grade mode".

### 5.3 Average speed in Trainer Road

Jerome uses TrainerRoad and notices that during a ride his average speed is 20km/hr and his friend is going at 40 km/hr. How is that possible?

Imagine that TrainerRoad requires to ride with a Power of 200Watt, the two riders have the same bike and the same trainer and have selected the same gear-ratio.

If Jerome chooses to ride with 50 rpm, his speed will be low, and the trainer will increase the resistance so that the required power of 200Watt is realized.

If his friend rides at 100 rpm, his speed will be higher than yours and the trainer will decrease the resistance so that the required power of 200Watt is realized.

Note that power = resistance \* speed! Jerome rides at half speed of his friend, but with a higher resistance and hence both athletes produce the same power at a different speed and different distance. Note therefore that, on a [FE] speed and distance are irrelevant, time, power and cadence are the deciding factors.



For you it's a pity that your Strava statistics for the end-of-year applause run behind; but having read the explanation - that would be a lesser issue.

The situation in real world is different; if you go for a ride together time, speed and distance will be the same and therefore you will come home with the same average power. Difference choice in gears will change the resistance and cadence which is less observed in the Strava results.

Why would you ride at 50rpm or 100rpm?

When TrainerRoad demands 200Wattt it may instruct you (through the displayed texts) to ride at a high or a low cadence, depending what purpose is intended. It is not correct to say that the speed is not relevant: it may be that either you or your friend did not do the intended training (high power or high force).

### 5.4 Can TTS4 and FortiusAnt coexist?

[**TTS**] is Tacx' own training software which uses it's own USB-driver and/or ANT+ interface. The installation instruction suggests to de-install (for simplicity), see 3.5 "Install USB-driver".

The following information is of interest for everybody who would like to work with [**TTS**] and other [**CTP**]'s.

**iepuzaur:** I am running on Windows10 TTS4 and FortiusAnt, at first I also thought I have to uninstall the Jungo driver TTS uses, but then I noticed you can have both drivers installed and there is no issue on my system.

Of course, you cannot use them concurrently, if you start TTS4 it will use the Jungo driver, while when you start FortiusAnt the libusb drive will be selected.

So as long as you do not intent to use them at the same moment, the drivers shall not conflict (at least this is my case). (Thanks to @iepuzaur, june 2020).

**Note however:** If your TTS4 software is already installed and registered then that should work. If it isn't, it won't as the registration servers have been switched off. The only software that works without registration is Fortius v2.02.

Never uninstall TTS4 if you have a working registered copy as there is no way to reinstall it and re-register it. (Thanks to Shaun Murray, @aegisdesign, sept 2020).

**frenkse8:** I have been using FortiusAnt for 2 months now in combination with the Tacx Desktop App (Windows 10). It works fine! The Tacx Desktop App connects via ANT with ANT-ID 57591 (identified as Tacx Neo2T!).

Incidentally, I also own the 4iii Viiiva HRM with ANT to BT bridge, but I expect the bridge to work in one direction only, so not from BT to ANT. So, using BT via the 4iii HRM is unlikely to provide a solution, I failed. However, this is not necessary, because FortiusAnt can work directly via ANT with the Tacx Desktop App.

By the way: I'm using FortiusAnt and Tacx App on two different laptops, because I sometimes want to use Tacx TTS4 (installed on the same laptop as Tacx Desktop App). I failed to get FortiusAnt and TTS4 to work on the same laptop.

Note that, TTS4 and Tacx Desktop App are 2 different applications. TTS 4 is outdated software, but like the Tacx Desktop App. A few years ago, Tacx replaced TTS4 with the Desktop App and they changed the revenue model: with the Desktop App they introduced the subscription model (monthly / annual fee). TTS4 uses real life videos that had to be purchased separately.

FortiusAnt also works with TTS4 (with 2 laptops), but that is not necessary, because TTS 4 also works via the USB connection of the Fortius trainer (with the Jungo USB driver that is installed by TTS4). It is **tricky to uninstall the jungo driver** (to try to run TTS4 and FortiusAnt on 1 laptop), because Tacx has ended the support of TTS4 and reinstallation of TTS4 is therefore no longer easily possible (because Tacx servers for authentication are out of operation). (Thanks to @frenkse8, August 2020)

**Github;** read issues #99, #168, #180

**TTS/ANT+**; TTS can successfully pair with FortiusAnt and then the Tacx USB driver is not needed anymore. Of course, then two ANTdongles are required.



### 5.5 Tacx head unit with firmware to be loaded

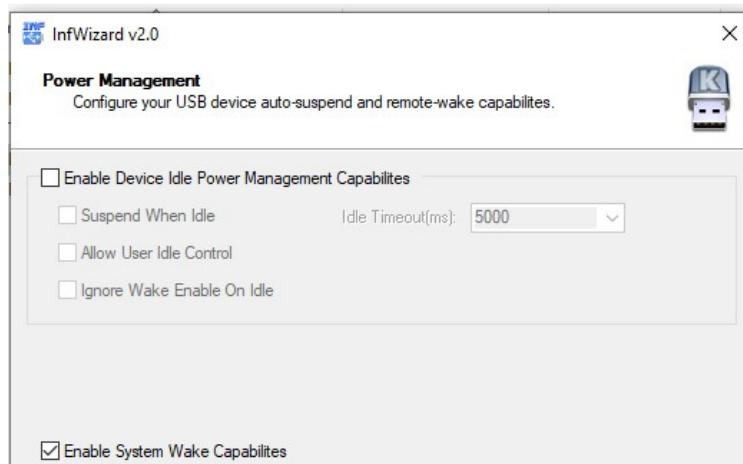
Some head units (0xe6be, Old "solid blue" Fortius) do not have firmware; the firmware must be loaded.

When FortiusAnt discovers a 0xe6be head unit, the firmware is loaded automatically and (after a wait time of 5 seconds to let the head unit reboot) a 1942 head unit is expected to be present. The following messages will be displayed, before/after loading the firmware:

....Stop CPU

....Start CPU

Some users have reported that the head unit is not found after the reboot and tell that this can be resolved with the following settings in the Power Management Options of the libusbK inf wizard:



#### 5.5.1 *Unable to load firmware" on 1942 head unit*

In other cases the head unit was not found because old TTS-drivers were still available. It seems that the head unit (without software) is detected by the libusb-driver but not after the reboot (#158)!

@BrRoBo reports through issue #155 see also #101:

I seem to have had the exact same issue as @bradyap, but found a quick solution to my case. Brady's screenshots of his issue are identical to what I was seeing and we had the same head unit... T1942. The install is on a clean version of Windows 10 64bit, no prior TTS or other Tacx software installed.

What I think happens is that we do the lib32 USB driver install and successfully see the Fortius unit listed under libusb-win32 devices along with how-ever-many Ant USB stick 2 are connected. Then when we run the FortiusAnt.exe application, it seems to be looking for a different device or registration, causes the Fortius to unload from the list of "libusb-win32 devices" and then there is a new "Tacx Fortius" listed under "Other devices". This unregistration, re-registration cycle is reproducible over and over by disconnecting the Fortius USB, then plug it in to load the lib32 driver and see it properly listed, then use the FortiusAnt "Locate HW" which again will cause the Fortius to get re-registered under "Other devices".

The simple solution at this point is to open the properties for the "Tacx Fortius" listed under "Other devices", then "Update drivers", select "libusb-win32 devices", then "Tacx", then select whatever name you used ("VR-Interface", "Fortius Virtual Trainer", etc. FWIW, I used the latter "Fortius Virtual Trainer" as my device name). Bingo, the Fortius head unit is reloaded into the correct list of "libusb-win32 devices". Issue fixed for this USB port. If the Fortius USB plug is moved to a different port, this library/device driver fix must be performed once per each port to correct the issue, and then will no longer occur if the Fortius USB plug is moved around to different ports.



### 5.6 Fortius without cadence sensor

Although it appears that the cadence sensor is for information purpose only, the Fortius (and perhaps other Tacx trainers as well) does not work if no cadence sensor is connected and/or no cadence is measured. Note that the magnet must be well placed compared to the sensor.

In a downhill ride, the brake will drive your bike (negative power) provided that you keep pedaling. If you stop pedaling, the motor will stop. Also in normal mode, usually after 4 seconds or so, if the unit detects no cadence, it will "stop" the motor.

If you do NOT have a cadence sensor, you will experience a high resistance – because the brake is in stop-mode. Therefore, operation without the standard cadence sensor is not possible.

### 5.7 Two ANTdongles – disturbed communication

Two laptops are used:

- The left laptop is connected to Tacx Fortius, is running FortiusAnt and has the ANTdongle at the left side.
- The right laptop is running Zwift and has the ANTdongle at the right side.

Sometimes the connection is lost and FortiusAnt does not display the required grade as transmitted by Zwift or Zwift appears not to receive the power from FortiusAnt.

After exchanging the dongles, so that these are close to each other, the transmission errors were gone.

Perhaps the presence of two computers between the two dongles disturb the ANT-transmission; note that ANT is low-power.

So in case of transmission errors; check whether there may be interference.

### 5.8 Tacx returns insufficient data

This error can be displayed and has different reasons:

- FortiusAnt reads too often from the head unit and therefore the head unit is not ready to provide the next buffer
- Loose or faulty cabling
- Other hardware errors

The following message is given

Tacx returns insufficient data, len=XX

To resolve, try to run without Pedal Stroke Analysis

When pedal stroke analysis is active (-A flag), FortiusAnt reads more often from the head unit and this MAY cause the error.

Or Tacx returns insufficient data, len=XX

To resolve, check all cabling for loose contacts

FortiusAnt is developed, using a 1932 head unit on a Tacx Fortius. In that environment, the message is given very seldomly and the built-in retry (4 times) appears to works. Some systems, even without PDA, show the short message error more often which needs further investigation.



### 5.9 Sudden drop of requested power

If you are experimenting with multiple CTP's (for example Zwift on one system and Trainer Road on another) it may occur that multiple CTP's send commands to FortiusAnt. FortiusAnt listens to both and changes behavior as requested. If one CTP asks to perform 100Watt and the other sends Grade=-20% the required power will bounce between the two requestors.

This can be intended, for example you ride a structured training in Trainer Road and entertain yourself with a virtual ride in Zwift. In that case specify -P so that the ERGmode commands from Trainer Road prevail over the grade-mode requests in Zwift.

Of course, if two CTP's both send ERGmode requests (100Watt and 200Watt) then you'd better switch off one of the CTP's 😊.

### 5.10 Zwift on Android does not pair with FortiusAnt

Check Zwift whether your Android/ANT hardware is supported; that is not always the case.

Reference: <https://forums.zwift.com/t/ant-update/195323/119>

Please understand I do not further describe Zwift (or others) hardware compatibility list.

### 5.11 Detailed notes on Tacx Genius

- Installing t19xx USB drivers is not required
- Turn Genius brake on
- Run FortiusAnt with '-a -g -H0 -t Genius'
- Pairing to the Genius is automatic (may take a minute)
- Calibration is initiated automatically after pairing
- When requested, nudge the wheel forward by hand (or give the pedals a light kick)
- The brake spins up the wheel automatically, DO NOT PEDAL DURING CALIBRATION
- After calibration is complete, a calibration value will be shown
- A value between -15 and 15 is good
- A value lower than -15 indicates that the roller pressure is too low, should increase using knob on the trainer
- A value lower than +15 indicates that the roller pressure is too high, should decrease using knob on the trainer
- To re-do calibration, turn the brake off and on again, then restart FortiusAnt
- For consistent results, warm up for ~5 minutes before starting FortiusAnt is recommended
- Calibration (and warm-up) can be skipped by adding the '-n' command-line option
- The brake remembers the last calibration value
- This should be fine if the last calibration is recent and nothing was changed/tyre pressure is the same
- FortiusAnt will show 'UNCALIBRATED' to remind you the calibration is not fresh

Known issues:

- Cadence estimation by the brake is not always reliable and often seems to read 3-5rpm high
- In ERG mode the wheel sometimes takes a while to stop spinning after you stop pedaling
- Downhill simulation slows down after a few seconds if you stop pedaling completely (built-in safety limitation)
- The Genius remote control (T2022) is not supported (yet)
- Virtual shifting is currently not implemented for the Genius



### 5.12 Detailed notes on Tacx Bushido

- Installing t19xx USB drivers is not required
- Bushido support is experimental (consider leaving feedback in #117)
- The Bushido head unit (T1982) is (currently) required
- Head unit needs to be turned on and paired to the brake (see Tacx manual)
- Calibration is done on the head unit (see Tacx manual)
- Run FortiusAnt with '-a -g -H0 -t Bushido'
- Pairing to the Bushido is automatic (may take a minute)
- Head unit buttons can be used to control FortiusAnt (keymap is the same as Vortex)

Known issues:

- If power is not transmitted properly, it may help to reset the head unit:
- Settings -> Info -> 10x right arrow (suggested by @tinusvee)
- Virtual shifting is currently not implemented for the Bushido



## 6. Power curve validation

### 6.1 General

As explained [CTP]'s require a Power or Grade and either requirement is translated into a required resistance as explained in the previous section. While developing the calculations were validated and it may be useful to check for your own trainer whether the calculations are correct.

"The Power Curve" is the relation between requested Power and the resistance set on the trainer.

The formula basically is: Resistance =  $c * \text{Power} / \text{Speed}$ ; the resistance of the brake goes up with increasing power and reduces with increasing speed (of the bicycle wheel).

Overall conclusion from the tests is that the algorithm does what it should do, which is confirmed by users who are happy how their trainer works. Individual situations are reported however (e.g. issue 102) that the power curve is not satisfactory. This section can be used to validate your own trainer.

### 6.2 Test for Tacx Fortius (T1932)

The algorithm is tested on a Tacx Fortius with a T1932 head unit, using a bicycle with power-meter. FortiusAnt is started in manual mode (-m flag) so that power can be selected.

Test protocol.

Select gears for 10, 20, 30, 40, 50 km/hr at reasonable cadence (e.g. 90 rpm).

For each speed perform the following test:

Manually select power 50Watt (up/down button on head unit).

Ride until reading from FortiusAnt and Power Meter is stable.

Write down power from Power Meter (46 in table).

Increase power on head unit 100, 150, 200, 250, 300 Watt and repeat test.

Test Results (Target Power in column header, result power in the table)

	50W	100W	150W	200W	250W	300W
10 km/hr	46	97	145	194	245	285
20 km/hr	50	100	145	197	245	290
30 km/hr	63	102	154	196	245	295
40 km/hr	105	120	160	210	260	305
50 km/hr	123	130	165	210	250	310

With the assumptions:

- Attempts to improve the algorithm may be useless, since it should not be more exact than the Tacx Fortius (was designed for).
- Changing the algorithm remains giving an empirical result since the technical specs from Tacx are not available to validate

**The conclusions are:**

- 50Watt at 50km/hr gives odd readings but that is not too strange.
- Overall measured power corresponds with Target Power.
- Multiple measurements give different results within 5%

Tests are done intermittently and hence have different brake and tire temperatures.



### 6.3 Test for i-Magic (T1901-T1902)

@yegorvin has performed a performance calibration test using his iMagic with T1901 magnetic brake, T1902 head unit and a power meter. Note that the T1902 head unit is different from (all) other head units [TotalReverse].

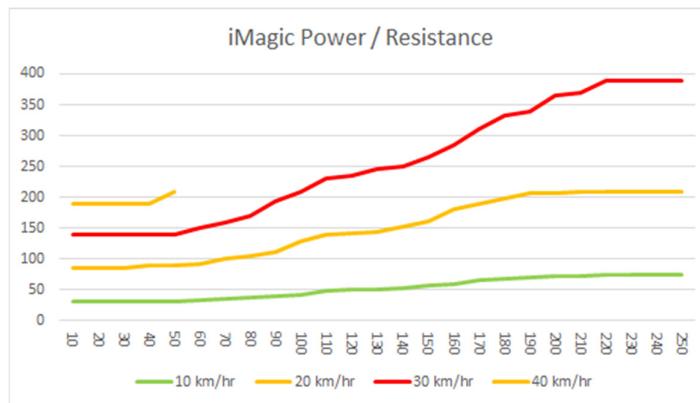
The test is performed as follows:

- FortiusAnt is operated in manual mode (-m flag), modifying the power from 10...250 in 10 Watt steps.
- The power as selected is transferred directly to the iMagic (Resistance = TargetPower) without intermediate formula. (The python code is changed for this)

Results of the test are:

Res	10km/hr	20km/hr	30km/hr	40km/hr
10	32	85	140	190
20	32	85	140	190
30	32	85	140	190
40	32	89	140	190
50	32	89	140	210
60	34	93	150	
70	35	100	160	
80	38	105	170	
90	40	112	193	
100	42	128	210	310
110	48	139	230	
120	50	142	235	
130	50	145	245	
140	52	152	250	
150	58	162	265	~410
160	60	180	285	
170	65	190	310	
180	68	198	332	
190	70	207	340	
200	72	207	365	~550
210	72	210	370	
220	75	210	390	
230	75	210	390	
240	75	210	390	
250	75	210	390	

The power curve of the iMagic is as shown below, where the range R=50...200 seems quite linear.





### Convert Resistance to Power formula's

The assumption is that  $P = a * R + b$ , when using the target resistance of 50W we have three formula's, one for each speed:

$$\text{Speed} = 10: 32 = 50 a + b$$

$$72 = 200 a + b \implies P_{10} = R * 0.27 + 19$$

$$\text{Speed} = 20: 89 = 50 a + b$$

$$207 = 200 a + b \implies P_{10} = R * 0.78 + 50$$

$$\text{Speed} = 30: 140 = 50 a + b$$

$$365 = 200 a + b \implies P_{10} = R * 1.50 + 65$$

And with this, we could create the function as follows:

```
Function Resistance2PowerLegacy(Resistance, Speed) As Double  
If Speed = 30 Then  
    Resistance2PowerLegacy = Resistance * 1.50 + 65  
ElseIf Speed = 20 Then  
    Resistance2PowerLegacy = Resistance * 0.78 + 50  
ElseIf Speed = 10 Then  
    Resistance2PowerLegacy = Resistance * 0.27 + 19  
End If  
End Function
```

But of course, this would work for three distinct speeds only.

A good formula for the constants 65, 50 and 19 is  $2.2 * \text{Speed}$  and validation shows that it's good enough.

But there is no linear solution for 1.50, 0.78 and .27, so let's go for  $F = ax^2 + bx + c$  (where  $x=\text{Speed}$ )

$$0.27 = 100 a + 10 b + c$$

$$0.78 = 400 a + 20 b + c$$

$$1.50 = 900 a + 30 b + c \implies F = 0.001543 \text{Speed}^2 + 0.0001848 * \text{Speed} + 0.1058$$

$$\implies \text{Speed}^2 / 648 + \text{Speed} / 5411 + 0.1058$$

and the final formula then becomes:

```
Function Resistance2PowerLegacy(Resistance, Speed) As Double  
    Resistance2PowerLegacy =  
        Resistance * (Speed * Speed / 648 + Speed / 5411 + 0.1058) + 2.2 * Speed  
End Function
```

To check:

$$S = 10, R = 50; P = 50 * (10 * 10 / 648 + 10 / 5411 + 0.1058) + 2.2 * 10 = 35$$

$$R = 200; P = 200 * (10 * 10 / 648 + 10 / 5411 + 0.1058) + 2.2 * 10 = 74$$

$$S = 20, R = 50; P = 50 * (20 * 20 / 648 + 20 / 5411 + 0.1058) + 2.2 * 20 = 80$$

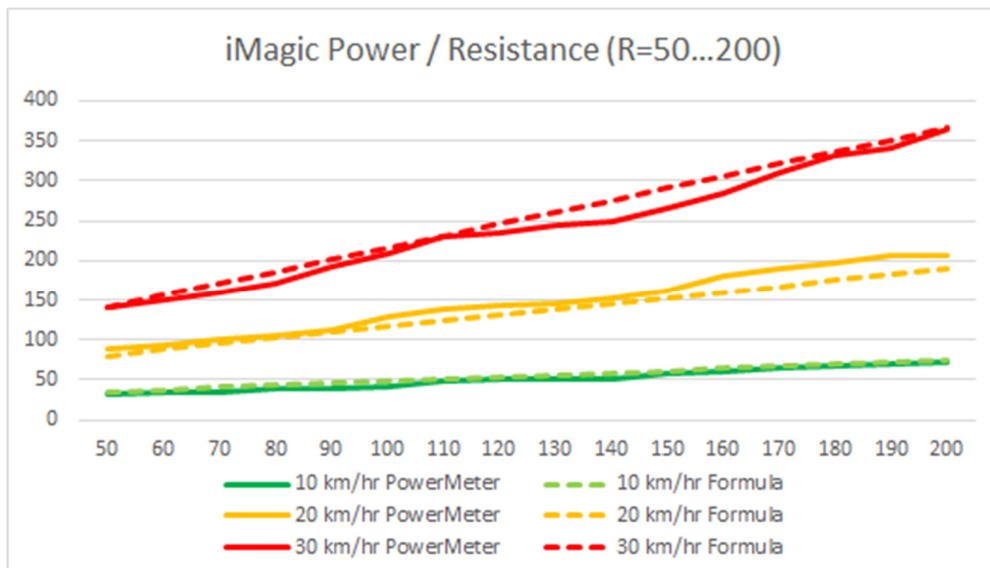
$$R = 200; P = 200 * (20 * 20 / 648 + 20 / 5411 + 0.1058) + 2.2 * 20 = 190$$

$$S = 30, R = 50; P = 50 * (30 * 30 / 648 + 30 / 5411 + 0.1058) + 2.2 * 30 = 141$$

$$R = 200; P = 200 * (30 * 30 / 648 + 30 / 5411 + 0.1058) + 2.2 * 30 = 366$$



With the Powermeter-measured and Formula-calculated values into one graph, the result is as shown and close enough to be used (or at least tested):



#### Conclusion:

The formula based upon @yegorvin's measurements can be used by the 6 known Tacx i-Magic T1902 users at this moment.

## 6.4 PowerCurve for i-Flow (T1901-T1932)

At first, FortiusAnt was developed for the Fortius, using the T1932 head unit and the T1941 motor brake. Then the so-called Legacy USB interface was explored (see previous paragraph) using the T1901 magnetic brake and T1902 head unit.

Tacx also sold combinations of the “new” T1932 head unit and the “old” T1901 brake; so that Magnetic brake users could use Virtual reality. This combination has a special behavior: instead of a resistance that can be set with a value from 30...226 (magnetic brake) or -5000...+10000 (motor brake) this configuration supports 14 distinct levels.

Experiments show that the following levels are supported (thanks @bikebeppe64 for the tests and @antifier for the table).

	0	1	2	3	4	5	6	7	8	9	10	11	12	13
ResistanceLevel	1039	1299	1559	1819	2078	2338	2598	2858	3118	3378	3767	4027	4287	4677
ResistanceSend	1900	2030	2150	2300	2400	2550	2700	2900	3070	3200	3350	3460	3600	3750

The power of the magnetic brake is:

$$\text{Speed} * (\text{ScaleFactor} * \text{Resistance} * \text{Speed} / (\text{Speed} + \text{CriticalSpeed}) + \text{RollingResistance})$$

Where ScaleFactor = 0.013 N, CriticalSpeed = 4.67 m/s and RollingResistance = 15N

Note that:

- **Power = Speed \* ScaleFactor \* Resistance** is: the braking force due to the magnetic brake: this depends on the resistance setting and the speed. (This is just basic physics, you might even say it is just the definition of power). The ScaleFactor translates the resistance value from the head unit into units of force (unit N = Newton).
- The factor **+ Speed \* RollingResistance** is the rolling resistance of the tire, due to the tire deforming continuously as it turns: this would be there even if we removed the magnets in the brake and turned it off. It is largely independent of speed, but can vary a lot with different tire material, size and pressure and the knob setting on the trainer. It is different for everyone and may be different today than it is tomorrow if you forget to pump up your tire.
- The factor **(Speed / (Speed + CriticalSpeed))** the brake cannot deliver the same braking force at all speeds. We assume that as you pedal faster, it increases linearly at first and eventually reaches a constant value (this is an approximation). That is what the factor Speed / (Speed + CriticalSpeed) does. The CriticalSpeed determines where the (gradual) change from linear force to constant force happens. For speeds significantly higher than the critical speed, the factor becomes = 1, so at high speeds the brake force is just ScaleFactor \* Resistance value.

These two parameters depend on the geometry of the eddy current brake, the strength and positioning of the magnets,



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the electric current in the coils, the head unit firmware, and so on. We assume they are fixed and more or less the same for all brakes.

This formula has been established by @switchabl and @cyclingflow based upon tests performed by @bikebeppe64, @jürgen-iflow, @mikeherriman and @mk2mark.

Since the Rolling Resistance of the bike depends on external factors (type of bicycle, tire, etc) the Rolling Resistance can be customized with -c CalibrateRR. A figure from 12...18 is probably a reasonable value.

As you know, the environment can operate in PowerMode or GradeMode.

### PowerMode

In PowerMode, the requested power is calculated using the formula above. If a required power is known, the resistance is established by searching the appropriate value in the table above. Funny (at least because we do not know why) is that the ResistanceSend is sent to the trainer and then the ResistanceLevel is set.

	0	1	2	3	4	5	6	7	8	9	10	11	12	13
ResistanceLevel	1039	1299	1559	1819	2078	2338	2598	2858	3118	3378	3767	4027	4287	4677
ResistanceSend	1900	2030	2150	2300	2400	2550	2700	2900	3070	3200	3350	3460	3600	3750
0 km/hr	0 W	0 W	0 W	0 W	0 W	0 W	0 W	0 W	0 W	0 W	0 W	0 W	0 W	0 W
10 km/hr	57 W	61 W	65 W	69 W	73 W	77 W	81 W	85 W	89 W	93 W	98 W	102 W	106 W	112 W
20 km/hr	129 W	141 W	152 W	164 W	175 W	187 W	198 W	210 W	221 W	233 W	250 W	261 W	273 W	290 W
30 km/hr	207 W	227 W	247 W	268 W	288 W	309 W	329 W	349 W	370 W	390 W	421 W	441 W	461 W	492 W
40 km/hr	286 W	316 W	346 W	376 W	406 W	436 W	466 W	496 W	526 W	556 W	601 W	631 W	661 W	706 W
50 km/hr	368 W	408 W	447 W	487 W	527 W	567 W	607 W	647 W	687 W	726 W	786 W	826 W	866 W	926 W

In the table above, you can see that, when the 2550 is sent to the trainer, the resistance is set to 2338 and the power required is 77, 187, 309, 436, 567 Watt at respectively 10...50 km/hr.

According this table, the trainer can require a resistance of 57W ... 926Watt.

### GradeMode

In GradeMode, FortiusAnt first calculates the power that is required to ride the requested grade at the actual speed:

CTP (Swift, Rouvy)	FortiusANT	5 km/hr	10 km/hr	15 km/hr	20 km/hr	25 km/hr	30 km/hr	35 km/hr	40 km/hr	45 km/hr	50 km/hr
-10 %	-10,0 %	-80 W	-195 W	-303 W	-403 W	-491 W	-565 W	-621 W	-657 W	-669 W	-656 W
-7 %	-7,0 %	-43 W	-121 W	-193 W	-256 W	-307 W	-344 W	-363 W	-363 W	-338 W	-288 W
-4 %	-4,0 %	-7 W	-47 W	-82 W	-109 W	-123 W	-123 W	-106 W	-68 W	-7 W	80 W
-1 %	-1,0 %	30 W	26 W	28 W	39 W	61 W	97 W	152 W	226 W	324 W	448 W
2 %	2,0 %	67 W	100 W	138 W	186 W	245 W	318 W	409 W	520 W	655 W	816 W
5 %	5,0 %	104 W	173 W	249 W	333 W	429 W	539 W	667 W	815 W	986 W	1183 W
8 %	8,0 %	140 W	247 W	359 W	480 W	613 W	760 W	924 W	1109 W	1317 W	1551 W
11 %	11,0 %	177 W	320 W	469 W	627 W	796 W	980 W	1182 W	1403 W	1648 W	1919 W
14 %	14,0 %	214 W	394 W	580 W	774 W	980 W	1201 W	1439 W	1698 W	1979 W	2287 W
17 %	17,0 %	251 W	468 W	690 W	921 W	1164 W	1422 W	1697 W	1992 W	2310 W	2655 W
20 %	20,0 %	288 W	541 W	801 W	1069 W	1348 W	1643 W	1954 W	2286 W	2641 W	3023 W

And using the resulting power, the related resistance is calculated (see previous section):

CTP (Swift, Rouvy)	FortiusANT	5 km/hr	10 km/hr	15 km/hr	20 km/hr	25 km/hr	30 km/hr	35 km/hr	40 km/hr	45 km/hr	50 km/hr
-10 %	-10,0 %	1039 R	1039 R	1039 R	1039 R	1039 R	1039 R	1039 R	1039 R	1039 R	1039 R
-7 %	-7,0 %	1039 R	1039 R	1039 R	1039 R	1039 R	1039 R	1039 R	1039 R	1039 R	1039 R
-4 %	-4,0 %	1039 R	1039 R	1039 R	1039 R	1039 R	1039 R	1039 R	1039 R	1039 R	1039 R
-1 %	-1,0 %	2078 R	1039 R	1039 R	1039 R	1039 R	1039 R	1039 R	1039 R	1039 R	1819 R
2 %	2,0 %	4677 R	4027 R	2858 R	2338 R	2338 R	2598 R	2858 R	3118 R	3767 R	4027 R
5 %	5,0 %	4677 R	4677 R	4677 R	4677 R	4677 R	4677 R	4677 R	4677 R	4677 R	4677 R
8 %	8,0 %	4677 R	4677 R	4677 R	4677 R	4677 R	4677 R	4677 R	4677 R	4677 R	4677 R
11 %	11,0 %	4677 R	4677 R	4677 R	4677 R	4677 R	4677 R	4677 R	4677 R	4677 R	4677 R
14 %	14,0 %	4677 R	4677 R	4677 R	4677 R	4677 R	4677 R	4677 R	4677 R	4677 R	4677 R
17 %	17,0 %	4677 R	4677 R	4677 R	4677 R	4677 R	4677 R	4677 R	4677 R	4677 R	4677 R
20 %	20,0 %	4677 R	4677 R	4677 R	4677 R	4677 R	4677 R	4677 R	4677 R	4677 R	4677 R

Here you can see that, given the nature that negative required power is not possible and that the maximum power is quickly reached, you will get a real feel only between -1% and 5%.

To realize a "real feel" the requested slope can be reduced. By specifying -G50 (Grade = Grade \* 50%) the requested grade is reduced to the half and the resistance table becomes:



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CTP (Zwift, Rouvy)	FortiusANT	5 km/hr	10 km/hr	15 km/hr	20 km/hr	25 km/hr	30 km/hr	35 km/hr	40 km/hr	45 km/hr	50 km/hr
-10 %	-5,0 %	1039 R	1039 R	1039 R	1039 R	1039 R	1039 R	1039 R	1039 R	1039 R	1039 R
-7 %	-3,5 %	1039 R	1039 R	1039 R	1039 R	1039 R	1039 R	1039 R	1039 R	1039 R	1039 R
-4 %	-2,0 %	1039 R	1039 R	1039 R	1039 R	1039 R	1039 R	1039 R	1039 R	1039 R	1039 R
-1 %	-0,5 %	3378 R	1039 R	1039 R	1039 R	1039 R	1039 R	1039 R	1039 R	1559 R	2078 R
2 %	1,0 %	4677 R	2338 R	1559 R	1299 R	1559 R	2078 R	2338 R	2858 R	3378 R	
5 %	2,5 %	4677 R	4677 R	3378 R	3118 R	2858 R	3118 R	3378 R	3767 R	4027 R	4677 R
8 %	4,0 %	4677 R	4677 R	4677 R	4677 R	4677 R	4677 R	4677 R	4677 R	4677 R	4677 R
11 %	5,5 %	4677 R	4677 R	4677 R	4677 R	4677 R	4677 R	4677 R	4677 R	4677 R	4677 R
14 %	7,0 %	4677 R	4677 R	4677 R	4677 R	4677 R	4677 R	4677 R	4677 R	4677 R	4677 R
17 %	8,5 %	4677 R	4677 R	4677 R	4677 R	4677 R	4677 R	4677 R	4677 R	4677 R	4677 R
20 %	10,0 %	4677 R	4677 R	4677 R	4677 R	4677 R	4677 R	4677 R	4677 R	4677 R	4677 R

And with -G25:

CTP (Zwift, Rouvy)	FortiusANT	5 km/hr	10 km/hr	15 km/hr	20 km/hr	25 km/hr	30 km/hr	35 km/hr	40 km/hr	45 km/hr	50 km/hr
-10 %	-2,5 %	1039 R	1039 R	1039 R	1039 R	1039 R	1039 R	1039 R	1039 R	1039 R	1039 R
-7 %	-1,8 %	1039 R	1039 R	1039 R	1039 R	1039 R	1039 R	1039 R	1039 R	1039 R	1039 R
-4 %	-1,0 %	2078 R	1039 R	1039 R	1039 R	1039 R	1039 R	1039 R	1039 R	1819 R	
-1 %	-0,3 %	4027 R	1039 R	1039 R	1039 R	1039 R	1039 R	1039 R	1299 R	1819 R	2338 R
2 %	0,5 %	4677 R	1559 R	1039 R	1039 R	1039 R	1299 R	1559 R	1819 R	2338 R	2858 R
5 %	1,3 %	4677 R	2858 R	1819 R	1559 R	1559 R	1819 R	2078 R	2598 R	3118 R	3378 R
8 %	2,0 %	4677 R	4027 R	2858 R	2338 R	2338 R	2598 R	2858 R	3118 R	3767 R	4027 R
11 %	2,8 %	4677 R	4677 R	3767 R	3378 R	3118 R	3378 R	3767 R	4287 R	4677 R	
14 %	3,5 %	4677 R	4677 R	4677 R	4027 R	4027 R	4027 R	4287 R	4677 R	4677 R	4677 R
17 %	4,3 %	4677 R	4677 R	4677 R	4677 R	4677 R	4677 R	4677 R	4677 R	4677 R	4677 R
20 %	5,0 %	4677 R	4677 R	4677 R	4677 R	4677 R	4677 R	4677 R	4677 R	4677 R	4677 R

In the examples above, the white area represents the “dynamic area”: at a requested slope of 2% the resistance varies for a speed of 5...50km/hr; at 50km/hr the resistance varies from -10%...+11%.

It is also possible to define an extra reduction for downhill: -G25/50; the grade is then additionally reduced by an extra 50% for grades < zero.

The default is -G100/100 because Zwift has already a standard reduction (similar to -G50, which may be modified in the Zwift settings) and Rouvy has not. It seems that -G50 is a good start when training with Rouvy.



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### Tests

When -c 16 (Rolling Resistance) is specified, the curve quite nicely fits the measured figures from [@jurgen-iflow](#):

Power according @switchabl:			Power as measured by @jurgen-iflow			Ratio		
			tcxWatts	(Multiplication terms)				
			Avg.tcxWatts	SpeedKm/h(33.5)				
			CurrentResistance	23	33,5	23,0 km/uur	33,5 km/uur	
Rolling Resistance	16							
	23 km/hr (sw)	33,5 km/hr (sw)						
1039	158 W	244 W	1039	177 Watt	265 Watt	90%	92%	
1299	173 W	267 W	1299	176 Watt	269 Watt	98%	99%	
1559	187 W	291 W	1559	180 Watt	276 Watt	104%	106%	
1819	201 W	315 W	1819	183 Watt	270 Watt	110%	117%	
2078	215 W	338 W	2078	200 Watt	295 Watt	107%	115%	
2338	229 W	362 W	2338	211 Watt	319 Watt	108%	113%	
2598	243 W	386 W	2598	231 Watt	319 Watt	105%	121%	
2858	257 W	409 W	2858	257 Watt	380 Watt	100%	108%	
3118	271 W	433 W	3118	268 Watt	379 Watt	101%	114%	
3378	285 W	457 W	3378	293 Watt	392 Watt	97%	116%	
3767	306 W	492 W	3767	317 Watt		96%		
4027	320 W	516 W	4027	332 Watt		96%		
4287	334 W	540 W	4287	347 Watt		96%		
4677	355 W	575 W	4677	365 Watt		97%		

#### @switchmcblade

I've been following the thread with interest and as it seemed like you were nearing the end I downloaded this branch 3.9e version to try it out with Zwift.

I don't have a power meter to be sure if it is accurate, but TBH that doesn't bother me as much as being repeatable so I can at least directly compare myself from ride to ride. Previously even a few % change up and down I was having to fiddle with the virtual gearbox to try and get the resistance in an area that I can actually put power down. So I could never be sure from ride to ride if I'd gone up or down the same amount on the virtual gearbox at the same point in the ride.

The new version is so much better, at no point did I feel the need to touch the virtual gearbox. The resistance changes felt natural and I could happily feel like I could manage the resistance changes using the bike gears alone. I'm definitely happy with the experience of installing and riding without worrying about flags or anything else.

Thank you so much to everyone who worked in any way for this improvement, you've transformed my old Flow back into a useful trainer from an ornament in the garage.

And when -c 13 (Rolling Resistance) is specified, the curve quite nicely fits the measured figures from [@mk2mark](#):

Power according @switchabl:			Power as measured by @mk2mark			Ratio		
			tcxWatts	SpeedKm/h				
			Avg.tcxWatts	SpeedKm/h				
			CurrentResistance	12	23	37	12,0 km/uur	23,0 km/uur
Rolling Resistance	13							
	12 km/hr (sw)	23 km/hr (sw)	33,5 km/hr (sw)	37 km/hr (sw)				
1039	64 W	139 W	216 W	242 W	1039	65 W	155 W	264 W
1299	70 W	153 W	239 W	269 W	1299	62 W	151 W	261 W
1559	75 W	167 W	263 W	296 W	1559	64 W	154 W	260 W
1819	80 W	181 W	287 W	323 W	1819	68 W	157 W	284 W
2078	85 W	196 W	310 W	350 W	2078	70 W	173 W	300 W
2338	91 W	210 W	334 W	377 W	2338	71 W	191 W	314 W
2598	96 W	224 W	358 W	404 W	2598	81 W	209 W	310 W
2858	101 W	238 W	381 W	431 W	2858	86 W	228 W	
3118	106 W	252 W	405 W	458 W	3118	92 W	246 W	
3378	112 W	266 W	429 W	485 W	3378	94 W	297 W	
3767	120 W	287 W	464 W	526 W	3767	107 W	318 W	
4027	125 W	301 W	488 W	553 W	4027	116 W	339 W	
4287	130 W	315 W	512 W	580 W	4287	121 W	345 W	
4677	138 W	336 W	547 W	620 W	4677	120 W	281 W	

#### @mk2mark

Just to add to the general mood of positivity, and following my successful Zwift Slope mode ride yesterday:-

Today I created a custom workout (ERG mode) testing increasing power levels from 80-450W.

Zwift was driven entirely from FortiusAnt with "-c11.6" set as recommended - power, cadence, speed etc.

I connected bike sensors to Garmin only.

Firstly the Power output followed the target really well - significantly better than it used to with TTS4 - GREAT RESULT.

The power as measured by Garmin was also close - really good up to about 270W then it started to flatline until I realized that since 200W I had been using a constant gear & cadence and had reached the limit of the brake at that speed. I was surprised at how quickly I hit this limitation of the hardware, so worth keeping in mind that the T1901 brake needs high wheel speed to get the higher power outputs.

Once I upped the wheel speed the power then tracked ok - started to underread from 410W as opposed to over yesterday so I may need to tweak the -c flag a bit. However, in my practical 'working' range of 150-350W it was really good.

I am a very happy user. Thanks so much everyone for what you have achieved.

**Conclusion:** The purpose of FortiusAnt is to enable "old" Tacx trainers to be used with CTP's like Zwift and Rouvy providing a more or less real experience. And for that purpose, +/- 10% is considered acceptable. For more details; check <https://github.com/WouterJD/FortiusAnt/issues/153>