

# **wiFred documentation – Documentation for WiFi throttle with withrottle interface and wireless clock driver**

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WIP

This document describes the usage and configuration of the wiFred – a very simple wireless throttle to connect to withrottle servers like JMRI – and the wireless clock driver used to drive a simple wallclock to the timing of JMRIs FastClock system. It also contains schematics and BOMs for both devices as well as programming instructions and assembly tips, and also an overview of options for the server side of things.

The most recent version of this document can be found at:

<https://github.com/newHeiko/wiFred/raw/master/documentation/docu.pdf>  
and

<https://github.com/newHeiko/wiFred/blob/master/documentation/docu.tex>.

Skip right ahead to section 2 or 3 if you are not interested in the why and more into the how.

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## **1 Background for wiFred development**

As of the writing of this document, JMRI [1] has a long track record of offering a server for using smartphones as wireless model railroad throttles, along with apps like with throttle [3]<sup>1</sup> and EngineDriver [4]. This server will enable WiFi throttles to control locos any model railroading layout to which JMRI can build a connection [2]. In addition, Digitrax [9] and MRC [8] offer specific hardware solutions to enable the connection of the abovementioned smartphone apps to their DCC systems through a WiFi network.

The Fremo [5] is a European modular model railroading club whose unique requirements on it's DCC throttles led to the creation of the throttles FRED and FREDI [6] – a series of LocoNet®-throttles which started their life as hobbyist projects with large numbers in circulation but were also commercially available from Uhlenbrock [7].

### **1.1 Specification wishlist**

In modular railroading events, particularly of the Fremo-americaN-group [5], some people have evaluated the smartphone throttle solutions and found them lacking a nice, haptic feedback. But the idea of wireless control without locking into a specific vendor and their necessarily expensive equipment found great approval. So a wishlist was compiled to define the requirements for a wireless throttle:

- Same form factor as the FRED [6] with similar controls
- Option to control at least two, better four locomotives for double/triple traction (similar to the double FRED)
- Battery runtime of at least six hours
- Exchangeable batteries, so when the battery runs down, they can be quickly exchanged for a charged set or cheap primary cells
- Easy configuration, but not too easy to prevent operators from accidentally selecting other locomotives
- As little change to the existing Fremo Loconet® network as possible
- Use of with throttle protocol, so the server side of the communication can be assumed to work and does not have to be developed as well

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<sup>1</sup>with throttle is also the name JMRI uses for the protocol and the server.

## **1.2 Wireless clock**

During the development of this wiFred another topic came up in the americaN group of the Fremo, namely wireless clocks with adjustable clock rate for Timetable & Trainorder operations. Contrary to other Fremo groups, the americaN group standard does not call for any cabling for fast clocks and the group does not have the equipment for setting up a fast clock network, so first trials were done with regular Quartz clocks at 1:1 rate which had to be adjusted to timetable starting time every timetable morning. So a new solution was required, adding the following to the specification above:

- Battery runtime of at least eight hours to have some backup for long days
- Able to control cheap Quartz clocks
- Clock rate adjustable centrally in small increments in case the timetable planner has misjudged the capacity of the layout or operators
- Re-use existing systems as much as possible – in the case of the clock system, use JMRI's fast clock server

## 2 wiFred Wireless throttle

### 2.1 Quickstart Guide

Follow these steps for a new throttle (see later chapters for more explanation or if you run into trouble)

- 3. Use PCB to determine positions of holes and cutouts in housing
- 2. Make said cutouts and glue little pieces of 3mm thick plastic or wood underneath PCB screw holes
- 1. Solder components to PCB
- 0. Flash firmware to ESP and to AVR
- 1. Test fit PCB into housing, removing plastic parts of housing as required
- 2. Fit PCB into housing, insert three screws to fix PCB to housing
- 3. Make sure communication jumpers are set correctly, close housing and fix back cover with two screws
- 4. Add throttle knob
- 5. Insert batteries
- 6. Using any WiFi client (laptop, smartphone, tablet...), find and connect to network *wiFred-configXXXX*
- 7. Using any web browser, navigate to *http://192.168.4.1*
- 8. Enter your WiFi configuration (and a throttle ID if you like – highly recommended to easier tell them apart) **and hit the *Submit*-Button**
- 9. Click on Loco configuration subpage
- 10. **Make sure to enable the checkbox on top next to Enabled?** and also enter your wiThrottle server settings
- 11. For every loco you want to control with this throttle, enter the appropriate details below
- 12. Finish by **hitting the *Submit*-Button**
- 13. Configure function settings for each loco on the respective sub pages if required
- 14. Restart the throttle by navigating back to the main configuration page and clicking on **Restart system to enable new WiFi settings**

Your throttle should now be ready to use and connect to your wiThrottle server on startup. Refer to the chapters below if it does not or contact the author of this document.

## 2 wiFred Wireless throttle



Figure 1: Controls and features of the wiFred-throttle

### 2.2 Usage

Figure 1 shows the controls of the wireless throttle. They consist of the following:

- Four loco selection switches (loco 1 on the left, loco 4 on the right, move towards speed potentiometer to enable)
- Speed potentiometer (Counter-clockwise endstop: Stop, clockwise endstop: Full speed)
- Direction switch – move right for forward movement, left for reverse movement
- Black function keys F0 to F4
- Two yellow shift keys to trigger F5-F8 (SHIFT1, lower key), F9-F12 (SHIFT2, upper key) and F13-F16 (both shift keys)
- Red emergency stop key
- Two green direction indicator LEDs
- One red status LED

- Battery compartment (on the rear) for two AA cells, 1.2 V to 1.5 V nominal voltage

As soon as a pair of batteries is inserted into the battery compartment as the symbols inside the battery compartment show, the throttle will boot up and try to connect to a wireless network. The throttle will not be damaged if batteries are inserted wrongly, but it will not work either. Use NiMH- or primary AA cells with 1.2 V to 1.5 V nominal voltage, low self discharge NiMH cells like Eneloop® or similar are recommended. Do not insert 3 V or 3.6 V AA size lithium batteries as this may damage the throttle.

If no connection to the network configured into the device can be established within 60 seconds, the throttle will create its own wireless network named *wiFred-config* plus four hex digits taken from the MAC address of the throttle WiFi interface, for example *wiFred-config0CAC*, to enable configuration as described in the next section.

Four different locos with long DCC addresses can be assigned to the four loco selection switches. Commands derived from the speed potentiometer, the direction switch and the function keys will be transmitted to all selected locos (near) simultaneously, with a certain translation table enabling some locos to go backwards when others go forwards and also limiting function keys to some of the four locos only – this is described in more detail in sections 2.3.3 and 2.3.4.

Pushing the red emergency stop key will cause the throttle to send an emergency stop signal to all four locos attached. After an emergency stop, turn the speed potentiometer to zero to re-enable control of the locos.

Pushing the red emergency stop key while holding down either of the shift keys will place the device into configuration mode (as well as issuing an emergency stop to all attached locos). See section 2.3 for more details on how to access the throttle to do the configuration.

Any change in the loco selection switches will cause the throttle to send a stop (zero speed) command to all attached locos. This makes sure that any loco that is deselected will stop on the layout and avoids newly selected locos suddenly taking off at speed. The same is true for a change in the direction switch, to avoid high-speed reverse maneuvers. Turn the speed potentiometer to zero to re-enable control of the locos.

When all four loco selection switches are set to the disabled state, the throttle will send a stop (zero speed) command to all four locos attached and – after a wait time of 30 seconds – it will disconnect from the network and go into low power mode. To reconnect, re-enable any loco selection switch.

The same happens when the batteries are empty, but the throttle will not reactivate before changing the batteries. Expected runtime with a pair of 2500 mAh-NiMH-batteries is around 8-10 hours of full time operations, more if the throttle is placed in low power mode when the locos are not running.

During startup and operation, the LEDs will show the patterns explained in table 1.

Table 1: LED patterns and their meaning on the wiFred throttle

Red LED	Green LED (Left)	Green LED (Right)	Status
Slow Blinking (0.5 Hz)	Off	Off	Trying to connect to WiFi network
Fast Blinking (2 Hz)	Off	Off	Successful WiFi connection, trying to connect to wiThrottle server and acquire locos
Off	Off	On	Regular operation, forward direction
Off	On	Off	Regular operation, reverse direction
Off	Flashing	On	Emergency stop, forward direction. Also happens when switching direction with speed potentiometer not at zero
Off	On	Flashing	Emergency stop, reverse direction. Also happens when switching direction with speed potentiometer not at zero
Off	Off	Blinking	Battery low, regular operation, forward direction
Off	Blinking	Off	Battery low, regular operation, reverse direction
Off	Flashing	Blinking	Battery low, Emergency stop, forward direction
Off	Blinking	Flashing	Battery low, Emergency stop, reverse direction
Short flashes	Off	Off	Throttle in low-power mode
Off	Off	Off	Battery empty or no battery inserted
On	Off	Off	No connection to existing WiFi network. Created internal configuration WiFi network
On	On	On	Configuration mode enabled while connected to existing WiFi network. All locos emergency stop to avoid runaways. Push SHIFT + ESTOP again to exit configuration mode

To recover from an emergency stop, turn speed potentiometer to zero to re-gain control.

## 2.3 Configuration

Before using the device, it must be configured. At the very least, the General Configuration 2.3.2 and Loco Configuration 2.3.3 pages have to be submitted once to be saved to non-volatile memory. If no valid configuration is detected at startup, the device will start with a default configuration with no locos enabled and trying to connect to a network named “*undef*” with a key named “*undef*”, which will probably fail.

### 2.3.1 Entering configuration mode

There are two ways to enter configuration mode:

1. Power up the throttle when the configured WiFi network is not in range (or when there is no valid configuration – the first startup of a new throttle will fall into this category)
2. Press SHIFT (either key) and ESTOP together when the throttle is connected

In the first case, the throttle will create a wireless network named *wiFred-config* plus four hex digits taken from the MAC address of the throttle WiFi interface, for example *wiFred-config0CAC*. Any WiFi device with a web browser can connect to that network and open a web browser to point to <http://192.168.4.1>.

In the second case, the throttle will change the last tuple of its IP address to .253 – so if the wireless network is configured with IP addresses in the *192.168.100.x*-range as highlighted in figure 2, any web browser can access the configuration at <http://192.168.100.253>.

If the IP address of the throttle during normal operation is known, the configuration page can also be accessed by pointing a web browser to it at any time while it is connected. Note that this is untested and therefore not recommended while the throttle is running locos.

### 2.3.2 General configuration

Figure 3 shows the first page you will see when you point a web browser at your wiFred throttle. It has some general configuration settings for the following items:

Throttle name: This is a free-form identification string of the throttle. It shows up in the wiThrottle window of JMRI as shown in figure 2 and can be used to identify the throttle during configuration.

WiFi SSID: The name of the wireless network the throttle shall connect to.

WiFi PSK: The so-called password<sup>2</sup> for the wireless network.

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<sup>2</sup>Technically correct term: Pre-Shared Key

## 2 wiFred Wireless throttle

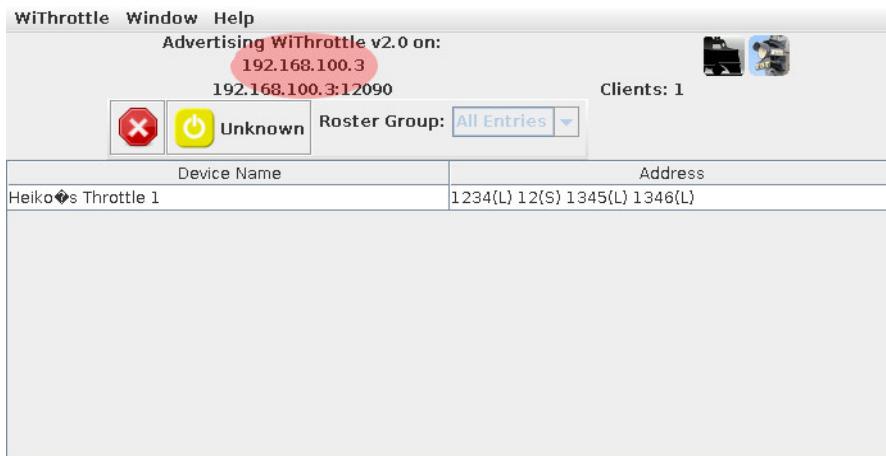
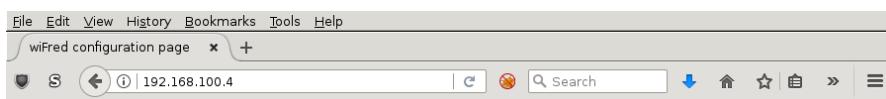


Figure 2: Screenshot of wiThrottle screen showing one throttle connected



### General configuration

Throttle name (max 20 chars):   
WiFi SSID (max 20 chars):   
WiFi PSK (max 20 chars):

Clock configuration

[Clock configuration subpage](#)

Loco configuration

[Loco configuration subpage](#)

Restart system to enable new WiFi settings

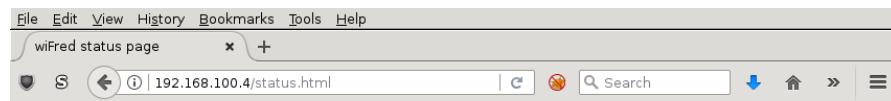
[Restart system to enable new WiFi settings](#)

Status page

[wiFred status subpage](#)

Figure 3: Screenshot of wiFred main configuration page

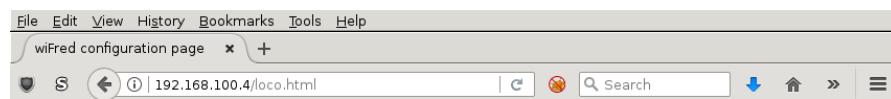
## 2 wiFred Wireless throttle



### wiFred status

Battery voltage: 2577 mV  
System time: 05:30:00  
Network time: 05:30:00  
Clock rate: 1.00  
[Back to main configuration page](#)

Figure 4: Screenshot of wiFred status page



### Loco configuration

Enabled?   
Loco server and port: 192.168.100.3 :12090  

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Loco 1 DCC address: (-1 to disable) 1234 Long Address?   
Reverse?  [Function mapping](#)  

---

Loco 2 DCC address: (-1 to disable) 12 Long Address?   
Reverse?  [Function mapping](#)  

---

Loco 3 DCC address: (-1 to disable) 1345 Long Address?   
Reverse?  [Function mapping](#)  

---

Loco 4 DCC address: (-1 to disable) 1 Long Address?   
Reverse?  [Function mapping](#)  

---

[Submit Query](#) [Back to main configuration page \(unsaved data will be lost\)](#)

Figure 5: Screenshot of wiFred loco configuration page

**Reminder:** Changes are saved using the “Submit Query” button which may look different in different web browsers (firefox shown).

A new device will not read a saved configuration at startup unless both the main page and one of either the loco configuration subpage or the clock configuration subpage has been saved at least once.

This page also includes links to the configuration sub pages for locos and clock settings as well as a link to the status page shown in figure 4 which gives information about the current clock settings and battery voltage and may be enhanced in the future.

### 2.3.3 Loco configuration

On this page, shown in figure 5, the (up to four) locomotives to be controlled with this throttle and some settings for all locomotives are available.

Right on top, the checkbox next to **Enabled?** determines if the wiFred is to be used as a throttle. All the configuration settings are available if it is not, but it will not connect to the withrottle server and several other features described in this document may not work either unless this checkbox is enabled.

Next the server settings can be found. The correct settings can be read from the JMRI withrottle server screen, as highlighted in figure 2. Normally the port does not need to be changed, as 12090 is the default setting.

Following the server configuration, there are four identical sections assigned to the four different locomotives which can be controlled with this throttle. Each section consists of the following settings:

**DCC address:** Can be a short address between 1 and 127 (also used for consists) or a long address between 0 and 10239. Note: Short addresses between 1 and 127 are not the same as long addresses between 1 and 127. If this is set to -1, the corresponding loco is disabled.

**Long address?:** Checkbox to change the behaviour of the DCC address input field described above.

**Reverse?:** If checked, the corresponding loco will invert it's travel direction. Mainly intended for back-to-back consists without decoder reconfiguration.

**Function mapping:** Link to the function mapping subpage for the corresponding loco, as described in section 2.3.4. Clicking this link will lose all information entered on the current page and take the web browser to a different subpage.

**Reminder: Changes are saved using the “Submit Query” button which may look different in different web browsers (firefox shown).**

### 2.3.4 DCC function configuration

By default, if a function key is pressed, the throttle will send the appropriate commands to every loco under control. Under certain circumstances, this may not be desired – the obvious example being a loco in the middle of a multi-unit consist, which should not have lights or ditchlights. So this page – shown in figure 6 – offers the option to chose between three different settings for every function on each of the four locomotives (one page per locomotive):

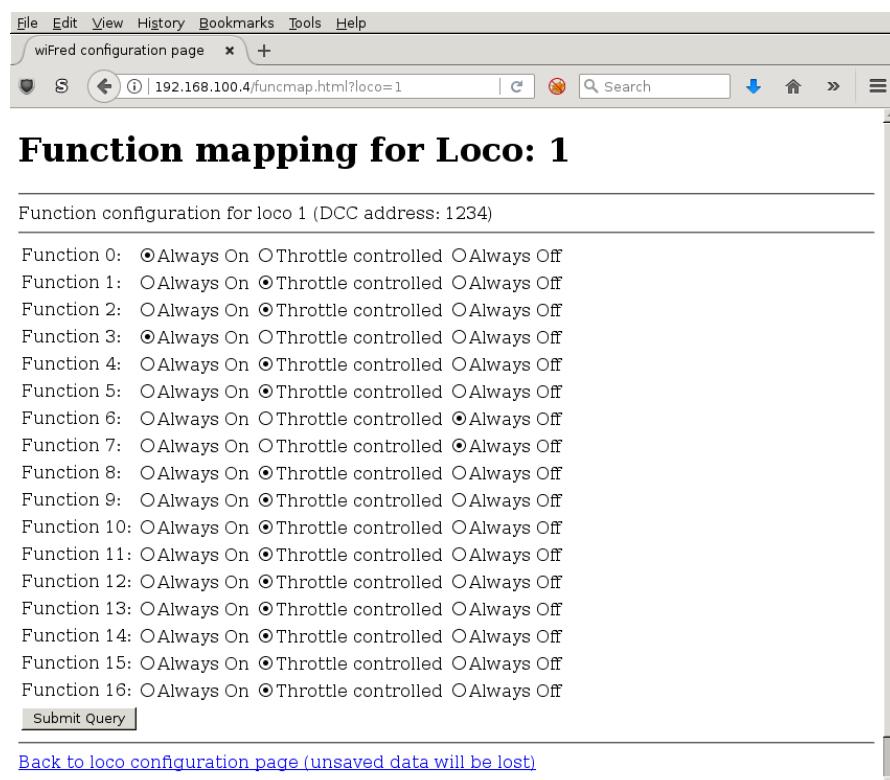


Figure 6: Screenshot of wiFred function handling config page

### 3 Wireless clock driver

Always Off: When the loco is enabled by moving the selection switch to the “selected” position, the current status of the function is queried. If the function is on, a function key press will be simulated to turn it off. No other function key events will be sent to this loco for this function.

Throttle controlled: When the first loco is enabled by moving the selection switch to the “selected” position, the current status of the function is queried and saved. When selecting the next loco, the status is queried. If it does not match the first loco, the function status is changed by simulating a function key press. Afterwards, key presses are handed through to the loco.

Always On: Similar to the “Always Off” setting, but the throttle will attempt to enable the function when the locomotive is selected and ignore any further function key presses. This will probably not work with so-called momentary functions that are only active as long as the function key is pressed.

**Reminder:** Changes are saved using the “Submit Query” button which may look different in different web browsers (firefox shown).

#### 2.4 Hardware description

#### 2.5 Programming instructions

### 3 Wireless clock driver

#### 3.1 Usage

#### 3.2 Configuration

For general configuration (WiFi etc.) see section 2.3.2, as it’s the same.

#### 3.3 Hardware description

#### 3.4 Programming instructions

### 4 Options for server setup

### References

- [1] JMRI: A Java Model Railroad Interface, <http://www.jmri.org>
- [2] JMRI: Hardware Support, <http://www.jmri.org/help/en/html/hardware/index.shtml>

## Revision History

- [3] WiThrottle, <http://www.with throttle.com/html/home.html>
- [4] Home | EngineDriver, <https://enginedriver.mstevetodd.com/>
- [5] Home - FREMO - Freundeskreis Europäischer Modelleisenbahner e.V.,  
<https://www.freemo-net.eu/en/home/>
- [6] Throttle, <http://fremodcc.sourceforge.net/throttle/throttle.en.html>
- [7] Uhlenbrock | FRED, der Handregler für die Intelli-box,  
[https://uhlenbrock.de/de\\_DE/produkte/prodarch/I62AD172-001.htm!ArcEntryInfo=0004.41.I62AD172](https://uhlenbrock.de/de_DE/produkte/prodarch/I62AD172-001.htm!ArcEntryInfo=0004.41.I62AD172)
- [8] Prodigy WiFi, <http://www.modelrectifier.com/Prodigy-WiFi-s/332.htm>
- [9] LocoNet WiFi interface, <http://www.digitrax.com/products/wireless/lnwi/>

## Revision History

Revision	Date	Author(s)	Description
0.1	WIP	Heiko Rose-mann	Setup first document structure.