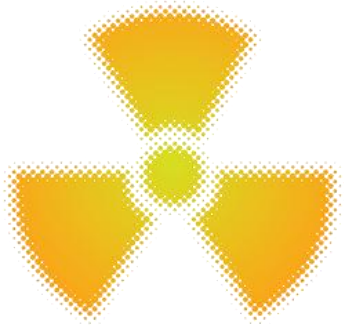


“W-GM Project - *IoT*”

Wireless Geiger-Müller Counter
for Radioactivity level long term monitoring

ENGLISH:	The manual is only available in English.
FRANÇAIS :	Le manuel n’est disponible qu’en Anglais.
中國語文：	用戶手冊僅提供英文版本。
日本語：	このマニュアルは英語でのみ利用可能です
РУССКИЙ:	Данное руководство доступно только на английском языке.
Last update:	December 22, 2018

AD'novea

FOREWORD

The **W-GM Counter** based on an ESP32 chipset (*Heltec WIFI kit-32 with OLED*) is a fork of the Ethernet C-GM Counter that costs about half price of the C-GM Counter

Our design has been drastically optimized to reduce as much as possible to the minimum number of components and enable users to wire the hardware on a piece of Veroboard without requiring specific material.

NOTE: The W-GM Count uses fragile components that can be easily destroyed and makes it assembly a little more complex. You have been warned! During the development, I had one ESP8622 destroyed while powered by a DC pack on USB and two Heltec ESP-32 Wifi Kit-32 out-of-order due respectively to 3V3 and I2C failures with no clear reason. This will drastically increase the final cost of the DIY device. I cannot be blame for this.

Please, pay lot of attention to the remarks related to the risks and read the '*IMPORTANT Recommendations*' section.

NOTES, REMARKS AND WARNING

ⓘ Note related to use.

➲ Important remark for avoiding failures or damages.

△ Critical note to avoid major injury or death.

RECYCLING

Please dispose electronics devices in an environmental friendly manner.

COPYRIGHTS

IMPORTANT

Lethal conditions might occur when human bodies are in contact with high voltage. Therefore, under no circumstances persons unskilled, not familiar or unaware of electrical risks are discouraged to get involved.

Operating the device is under the entire, whole and sole responsibility of the user.

This project has been provided for educational purpose only and is not aimed for commercial applications neither it has been approved for any kind of uses.

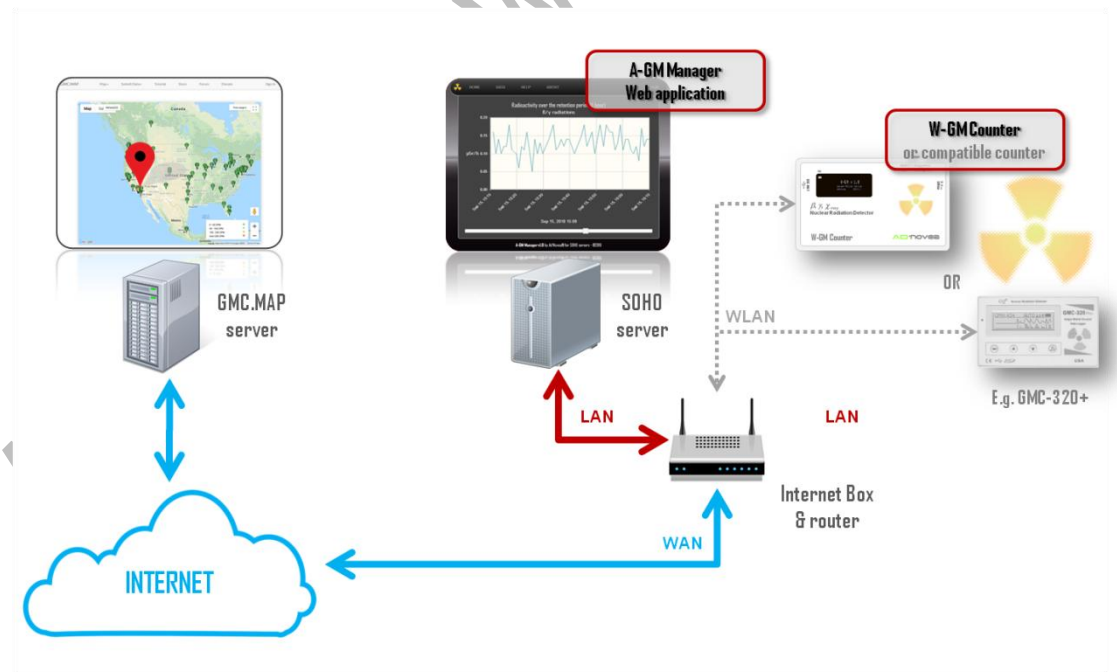
TABLE OF CONTENTS

OVERVIEW

The overall project is aimed for providing a **continuous measurement of the radioactivity level**. It is made of an open-source Web application (*A-GM Manager*) running on a SOHO server (*e.g. QNAP sells Small Office Home Office servers*) connected to a DIY *W-GM or C-GM Counter device* or a compatible GMC-320 Geiger-Muller Counters from GQ Electronics LLC. This project has been developed and is provided AS IS by AdNovea®.

This document will make references to:

- **A-GM Manager** — A **web application** for long-term continuously monitoring and storage of the Beta/Gamma radiation levels acquired from Geiger-Muller Counters on local servers. Data can be redirected to the GMC.MAP website for worldwide radiation data sharing using a user account.
- **C-GM Counter** — An open-source **hardware** and **firmware** for a Connected (*Ethernet*) G.M. counter device developed by Ad'Novea® able to run with the A-GM Manager application.
- **W-GM Counter** — An open-source **hardware** and **firmware** for a Wireless (*WIFI*) G.M. counter device developed by Ad'Novea® able to run with the A-GM Manager application.
- **GMC-320 device** — GMC-320/5xx/6xx devices are sold by GQ Electronics LLC© and allow the redirection of measures to the GMC.MAP website directly from the device using a WiFi connection. A-GM manager also support these devices to log the radiation measure on local server as well as the redirection to the GMC.MAP website.

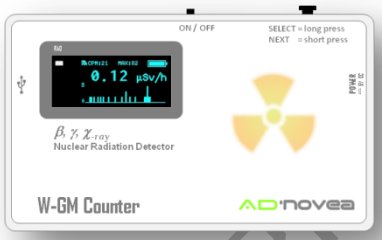


Project architecture

***IMPORTANT**: This project is provided for training or education and in no case for commercial or professional purposes. It has not been approved for any kind of applications.*

W-GM COUNTER

ⓘ *Information required for assembling the W-GM Counter device hardware and firmware can be found and downloaded from* https://sourceforge.net/u/adnovea



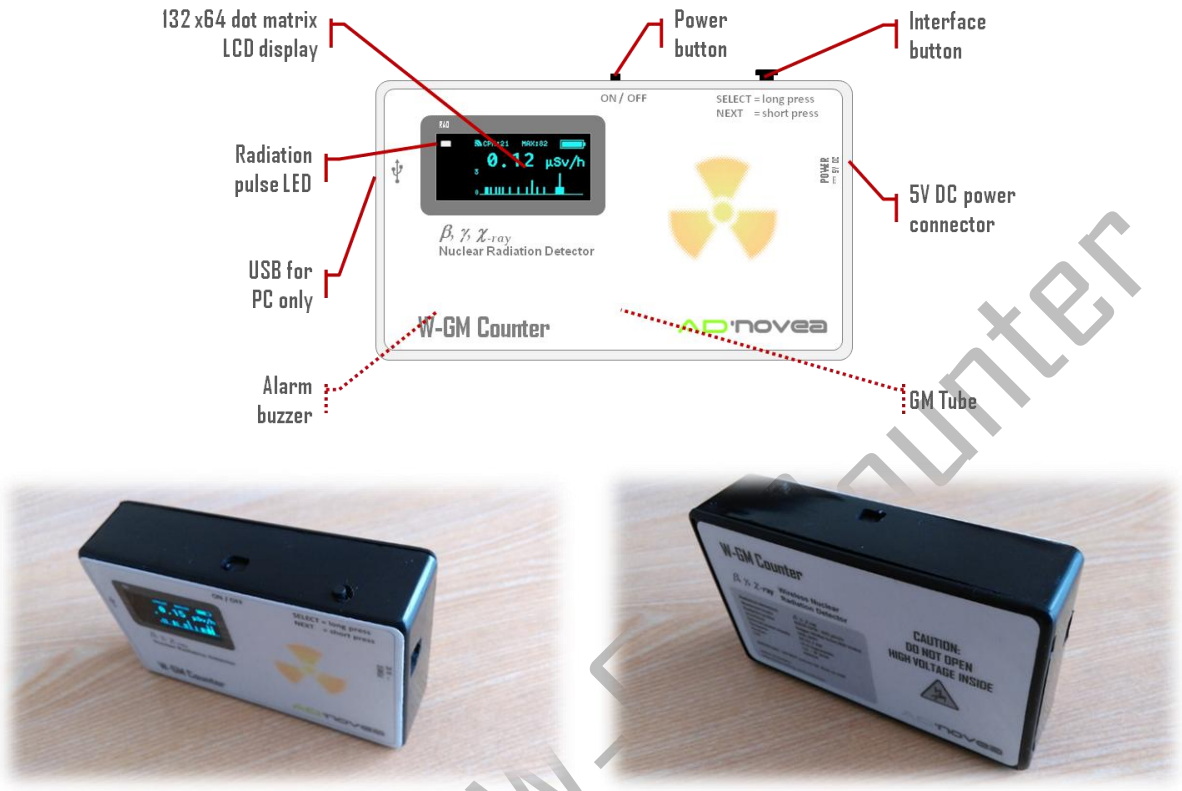
FEATURES

- Radiation detection : β, γ, χ-ray
- GM tube : STS-5 (*CTC-5*) / SBM-20 (*400 V operating voltage*)
- Language support : English only
- Maximum value: 65 535 CPM / 425 µSv/h (*theoretical*)
- Display values :
  - Current CPM
  - Current µSv/h
  - Maximum µSv/h since startup
  - Average µSv/h since startup
  - Elapsed time since startup
  - History and level bar graph
- Alarm
  - User defined threshold
- LED for radiation pulses
- Audio sound
  - Beep for each beta/gamma radiation pulse
  - Audible sound alarm
- Device control from :
  - Device internal menu
  - USB (*require a serial console such as Termite*) or Wifi (*using a web browser*)
- WIFI network connection using DHCP
- Support for A-GM Manager web interface
- User defined parameters (*from Menu or through web interface*)
  - GM tube conversion factor (*CPM to µSv/h*)
  - Alarm threshold in CPM
  - Buzzer On or Off
  - Display timeout
  - Enable Wifi for communication to A-GM Manager
  - A-GM server IP address (*through USB or A-GM Manager*)
  - Internal battery and H.V. voltmeter calibration (*through USB or A-GM Manager*)
  - Parameters can be permanently saved into EEPROM

USAGE

Don't power directly the USB ESP32 with a 5V DC pack power supply,
these power supplies may be destroying the CP2102 (USB) chip.

The W-GM Counter device counts the number of radiation pulses (CPM) over a one minute period (*shifting window*), and convert this count into a micro Sievert per hour (*µSv/h*) value using the G.M. tube conversion factor (*see Geiger-Müller Counter / Conversion factor section*).

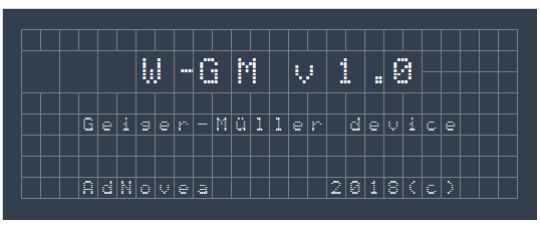


W-GM Counter device

IMPORTANT Recommendations

- When the battery is flat, SWITCH OFF the device to avoid completely draining of the Lipo battery because it will impair the cells (**Battery LiPo cells should NEVER be discharged below 3.0V**).
- Powering the device from a 5V DC pack MUST USE the micro-USB socket and never the ESP-32USB.
- Use the Wifi ONLY with an external 5V DC pack powering the device.
- Device must be switched off while recharging the battery to shorten the recharging time.
- Device (ESP-32 USB) connection to a PC requires the battery to be charged, no DC pack connected and the device switched on.

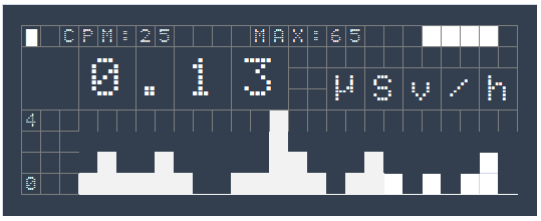
Available screens



At start-up, the splash screen displays the version and copyrights of the W-GM counter device firmware.

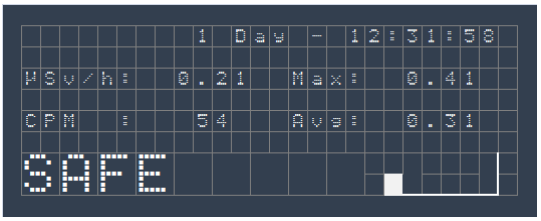
Check the website for the latest firmware version if needed.

The splash screen can be closed by pressing the tack button

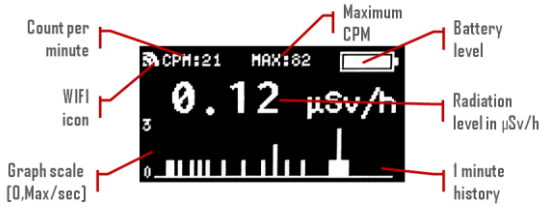


About 5 seconds after the power-up, the splash screen closes and the counter starts the radiation measurement. The current CPM, µSv/h 1-min history and battery level are displayed.

When connected, the WIFI icon shows on the top left side.



To navigate between information screens, short press the tack button. The following screen is the Detail information screen.



Radiation screen

Details screen

The **Detail information** screen displays:

1. The elapsed time since power-up.
2. The Current radiation level in µSv/h and the Maximum µSv/h since start-up.
3. The Current radiation level in CPM and the Average µSv/h since start-up.
4. The radiation status (risk) and the bar graph.

The Bar graph has 6 divisions with 6 messages corresponding to preset radiation levels set as below:

BAR GRAPH		RADIATION LEVEL	MESSAGE	COMMENT
_____	none	< 30 CPM (0.2 µSv/h)	Normal	Very low level
_____	none	> 30 CPM (0.2 µSv/h)	Safe	Medium level
_▉____	1 bars	> 75 CPM (0.5 µSv/h)	Warning	Warning level
_▉▉___	2 bars	> 150 CPM (1.0 µSv/h)	HIGH LEVEL	Check environment
_▉▉▉__	3 bars	> 400 CPM (3.0 µSv/h)	CRITICAL	Abnormal level
_▉▉▉▉_	4 bars	> 1000 CPM (6.5 µSv/h)	EMERGENCY	Evacuation level
_▉▉▉▉▉	5 bars	> 2000 CPM (13 µSv/h)	DANGER!	Extreme danger level

LED indicators

The **white LED** on the left side of the OLED display flashes on each radiation pulse. If the radiation level equals 0 at start or because the GM tube is defective, the white LED toggles.

The **orange LED** belongs to the ESP-32 battery charger circuit. It turns on when the ESP-32 built-in USB socket is connected to a PC USB port. The orange LED stays still while the battery will be charging, turns off when the battery will be fully charged and blinks if the battery is defective or disconnected.

There a **green and red LED** on the TP4056 module. The red LED is on while the battery will be charging and the green turns on when the battery will be fully charged. These two LEDs are not visible with our casing proposal.

Keyboard

The user interface was made very simple with only one tack switch for controlling both screens and menu.

According to the duration of the button push, there are two possible actions:

1. **Short press = SELECT** User depress the button less than half second.
2. **Long press = NEXT** User depress the button more than half second and less than two second

ⓘ *A very long press (> 5 seconds) allows to display the battery level. Press again the tack button during 1 second to exit and return to normal operation.*

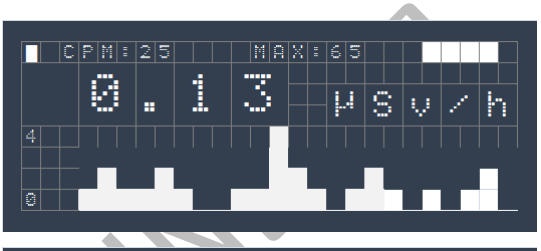
To **ENTER** the Menu or **VALIDATE** a menu entry, make one **long press**.

To jump to **NEXT** screen or menu entry, make one **short press**.

HINTS: For returning to the default RADIATION screen, long press to enter the Menu and long press to exit.

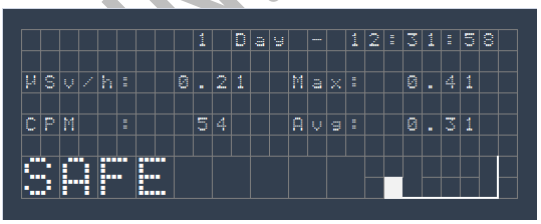
Info screens

The information's screens can be toggled using the **NEXT** button (*short press*).



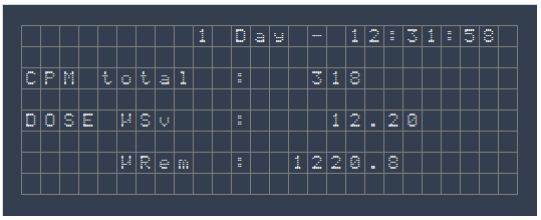
RADIATION SCREEN

This default information screen displays the current radiation values such as the radiation level in µSv/h, the current CPM value, the battery level, Wifi connection status and the last minute history graphic.



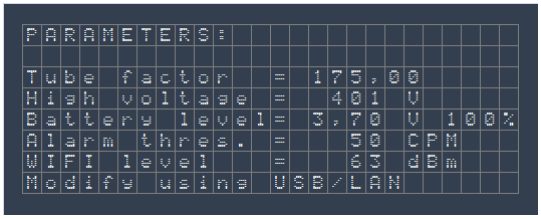
DETAILS SCREEN

The Details screen displays the current radiation values in µSV/h, the maximum µSV/h value since power-up, the current CPM value and the average µSV/h since power-up. Messages are displayed on bottom line.



DOSIMETER SCREEN

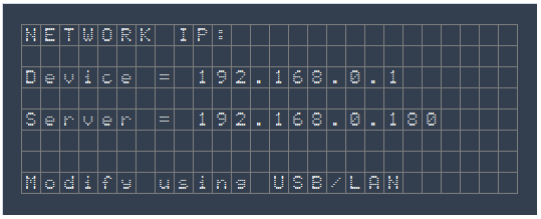
This screen displays values since power-up including the elapsed time, the total number of counts and the equivalent dose expressed both in micro-Sievert and micro-Rem.



PARAMETERS SCREEN *

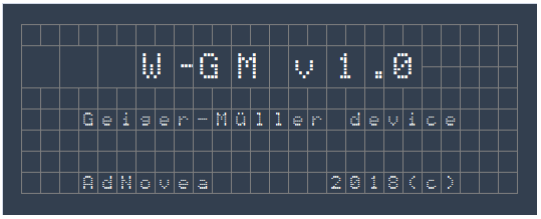
Display the GM tube conversion factor CPM to µSv/h, the current high voltage value (*read from internal voltmeter*) and the Alarm threshold (*in CPM*).

Wifi level is displayed only when the Wifi is enabled.



NETWORK SCREEN *

Display the device (Dev) IP address (*allocated by the DHCP service*) and the A-GM remote server (Svr) IP address.



CREDITS SCREEN

Display the firmware version and date as well as the copyrights.

* *For modifying GM tube factor, alarm threshold or IP addresses, see Commands and GM tube's conversion factors sections.*

ⓘ *Button actions can be inefficient or delayed during Wifi network initialization.*

Radiation alarms

Radiation level alarm threshold value can be checked from the device Menu and must be set using the USB/LAN interfaces.

➲ Alarm threshold CANNOT BE MODIFIED directly from the Menu using the serial connection or from the A-GM web interface (*see Network connection section*).

Alarms cannot be masked and will be active even when the sound is off.

During Radiation alarm, the Details screen displays a message (*left-bottom*) and the level (*bar graph*). Alarms are active while the alarm threshold is exceeded and stops when the level returns below the threshold.

Details screen Max value gives the maximum level that has been reached during the alarms.

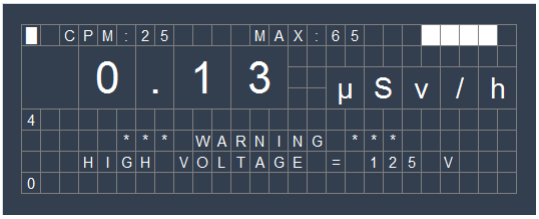
Entering the Menu stop the alarm.

Current values can be clear using the CLEAR COUNTERS command from the Menu.

GM tube failure alarms

The **white LED** on the left side of the OLED display flashes on each radiation pulse. If the radiation level equals 0 at start or because the GM tube is defective, the white LED toggles.

If the GM tube High Voltage drops below 360V or exceed 440V, the history on the Radiation screen is replaced with a warning message:



WIFI network connection

When using the Wifi, ensure your W-GM device is powered by an external 5V DC pack. The Wifi requires more current and a minimum voltage to operate that USB may not necessary be able to provide correctly.

The W-GM Counter device can be connected to a LAN (*Local Area Network*) using a WIFI connection for remote control or to broadcast radiation measures.

In order to connect to the network, both SSID and KEY must be set. Using a terminal (*baud rate 115000*), enter the SSID and KEY using respectively the 'SSID' and 'KEY' commands and save to the EEPROM using the 'EEPROM' command.

The WIFI ACTIVATION should be enabled (e.g. from the Menu). The DHCP allocated IP address can be found from the INFO screens.

ⓘ

- *The device must be powered using a 5V DC pack plugged on the mini-USB not the ESP-32 micro-USB.*
- *The Wifi router must be running BEFORE the Wifi activation of the W-GM device.*
- *The device network connection takes about 20 seconds. The Wifi icon is displayed once the connection has been successfully done.*
- *The first connection from a Web browser can take several (2-3) minutes before reaching the device.*

Commands

The W-GM Counter device can be controlled from the **Serial communication port** (*through the USB*) using a terminal application (*e.g. Termite application or Arduino IDE monitor*) or from the **WiFi communication port** (*through the LAN*), using the A-GM Manager interface. The available commands are listed below:

FACTOR=xxx.x	Set the conversion factor for the GM tube installed in the W-GM device. Factor for SBM-20 is about 175.00 and 153.80 for STS-5 tubes. *See "GM tubes' conversion factors" section.*
PWM=freq,duty	Configure the PWM signal for the High Voltage power supply. Set the frequency in Hertz and the duty cycle in percent. Default is 4000,818 (4kHz / ~80%).
CAL=low,max,HV	Battery level calibration and High Voltage conversion factor. Set the lowest and max *battery level* (*voltage for full ADC range*). Default values are 3400,7200,153. HV set the ADC conversion level to Voltage, multiplied by 100 within

	the range [0-255]. This value is given by : $$HV = \frac{R1}{(R1 + R2) \times Vref} \times 1023$$ Where R4=2.2MΩ, R9=3.3kΩ, VRef=3.3V*. With the values above HV = 139 and for a 400 Volts high voltage the ADC outputs level=556 (1.39 x 400) ** 3.3V for NodeMCU version and 1.1V for other ESP32 versions*
ALARM=xx	Set the alarm threshold in CPM. Default value is 50 CPM.
RESET	Clear all counters: elapsed time, maximum and average values.
BEEP=ON or OFF	Enable/disable the audible beeps for each radiation pulse. Default value is ON.
TIMEOUT=xxx	Set the menu timeout in seconds (0= disable). The maximum is 240 seconds. If disabled, the menu stays on. Default value is 10.
BRIGHT=xxx	LCD brightness value in the range [0,255]. Default value is 100.
WIFI=ON or OFF	Enable/disable the network support. If disabled, the W-GM counter works as a standalone device. Default value is ON.
SSID=xxxxx	Wifi network name (max 32 characters).
KEY=xxxxx	Wifi password (max 32 characters).
SERVER=xxx.xxx.xxx.xxx	Set the A-GM Manager remote server IP address. Default value is 192.168.0.180
URL=/xxx/xxx.php	A-GM Manager server URL. Default is /A-GM/agm.php
MEMORY	Display the free memory space.
JSON	Output the JSON formatted data and parameters compatible with IoT standards.
OPTIONS	Display the values of the parameters.
EEPROM	Save permanently the parameters values into the EEPROM. Saved values are restored at device start-up.
VERSION	Return the W-GM Counter device version, date and credits.

ⓘ *For clearing completely SSID and KEY information from EEPROM, save 32 character's long strings.*

Remote control from web browser

ⓘ When the Wifi connection is active, commands can be sent directly to the W-GM Counter device using a standard Internet Web Browser and entering the command against the following URL format:

http://<device IP addresse>**/?**<commmand>**=**<value>

E.g. http://192.168.0.120/?BEEP=ON

The server web page returns '*OK*' or '*Invalid*' if the command is incorrect. When JSON command is requested, the page returns the whole list of parameters and data values.

Data Output

Every second, the W-GM Counter sends over the Serial communication ports (*through the USB*) the radiation data values as:

CPM=0 MAX=0 TOT=0 AVG=0 ELP=0

Where respectively are the Current count in CPM, the Maximum count in CPM, the Total number of counts since power-up, the Average count in CPM since power-up and the Elapsed time since power-up.

When Wifi is enabled, the same pieces of information are sent to the A-GM Manager server IP address as:

?CPM=0&MAX=0&TOT=0&AVG=0&ELP=0

ⓘ *If the High Voltage is out of range, the CPM value is set to '0'. CPM values equal to '0' are managed by the A-GM Manager web application as GM tube failure and will sent an e-mail to the administrator address. CPM=0 is not possible in normal condition because of the background radiation which is about 0.041-0.081 µSv/h and will continuously generate 6 – 13 CPM.*

CONFIGURATION

Menu navigation is operated through the single tack button.

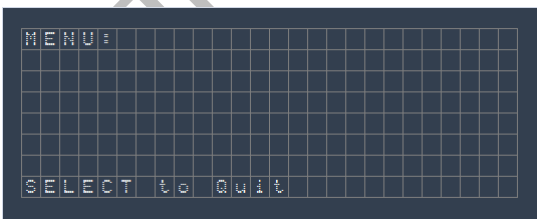
To ENTER the Menu, make one **long press** (SELECT).

Press **NEXT** (*short press*) to jump to the next menu entry.

Press **SELECT** (*long press*) to change an option.

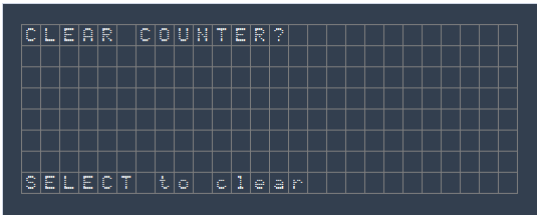
➲ When the Network support is enabled, the button action can be heavily delayed after the power-up due to the network connection retries.

ⓘ Menu automatically exits after the TIMEOUT set by the user. The '0' value disables the Timeout.

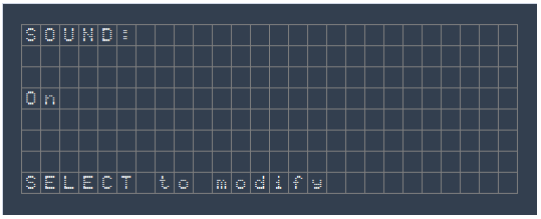


Press SELECT for returning to the radiation values default screen.

Release the button when the display blanks.

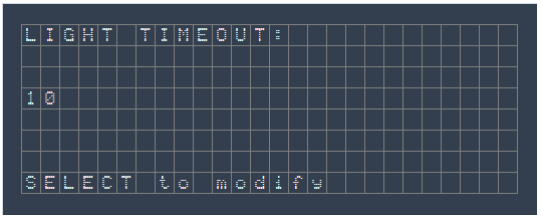


Press SELECT for clearing all counters. Maximum and Average µSv/h, CPM and Elapsed time will be reset.

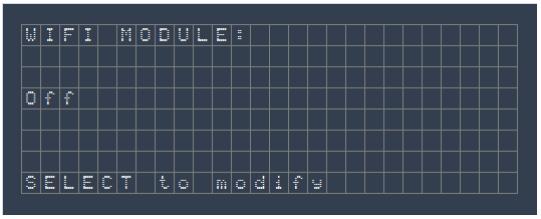


Press SELECT for enabling (On) or disabling (Off) the beeps when radiations are detected.

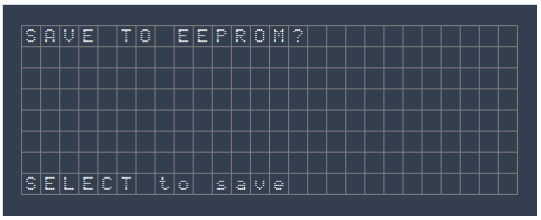
Alarm sound cannot be disabled.



Press SELECT for setting the display timeout. Each press increases the value by 10 seconds until 240 seconds (4 minutes). If equals to 0, the timeout is disabled.

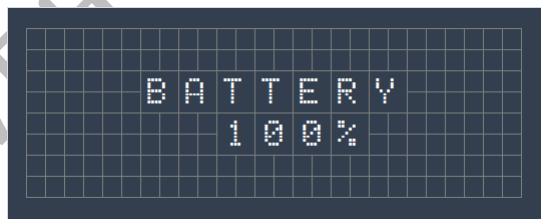


Press SELECT for enabling (On) or disabling (Off) the Network management.



Press SELECT for saving permanently the current parameters into the device EEPROM memory.

During battery charging, you may want only to monitor the progress. Long press (> 5 seconds) the tack button and the display will read the battery percentage. Press again during 1 second the tack button for exiting and returning to normal operating mode. Because the device is running, it will slow down the battery recharging.



Battery charge information

GEIGER-MÜLLER TUBES

Conversion factors

The G.M. tube CPM to µSv/h conversion factor (*µSv/h = CPM / Factor*) depends on the Geiger-Muller tube model. There are some values given below for different models of GM tubes.

TYPE	FACTOR (CPM per µSv/h)	HIGH VOLTAGE (Volts)	LOAD (Ohms)	DEAD TIME (µs)	MANUFACTURING (year)
M4011	158.35	380-450 (380)			
SBM-20	158.0 - 175	350-475 (400)	~5.1 MΩ	100-190µs	1970-1990
STS-5 (CTC-5)	150.02	360-440	5-10 MΩ		mid 1960-1970

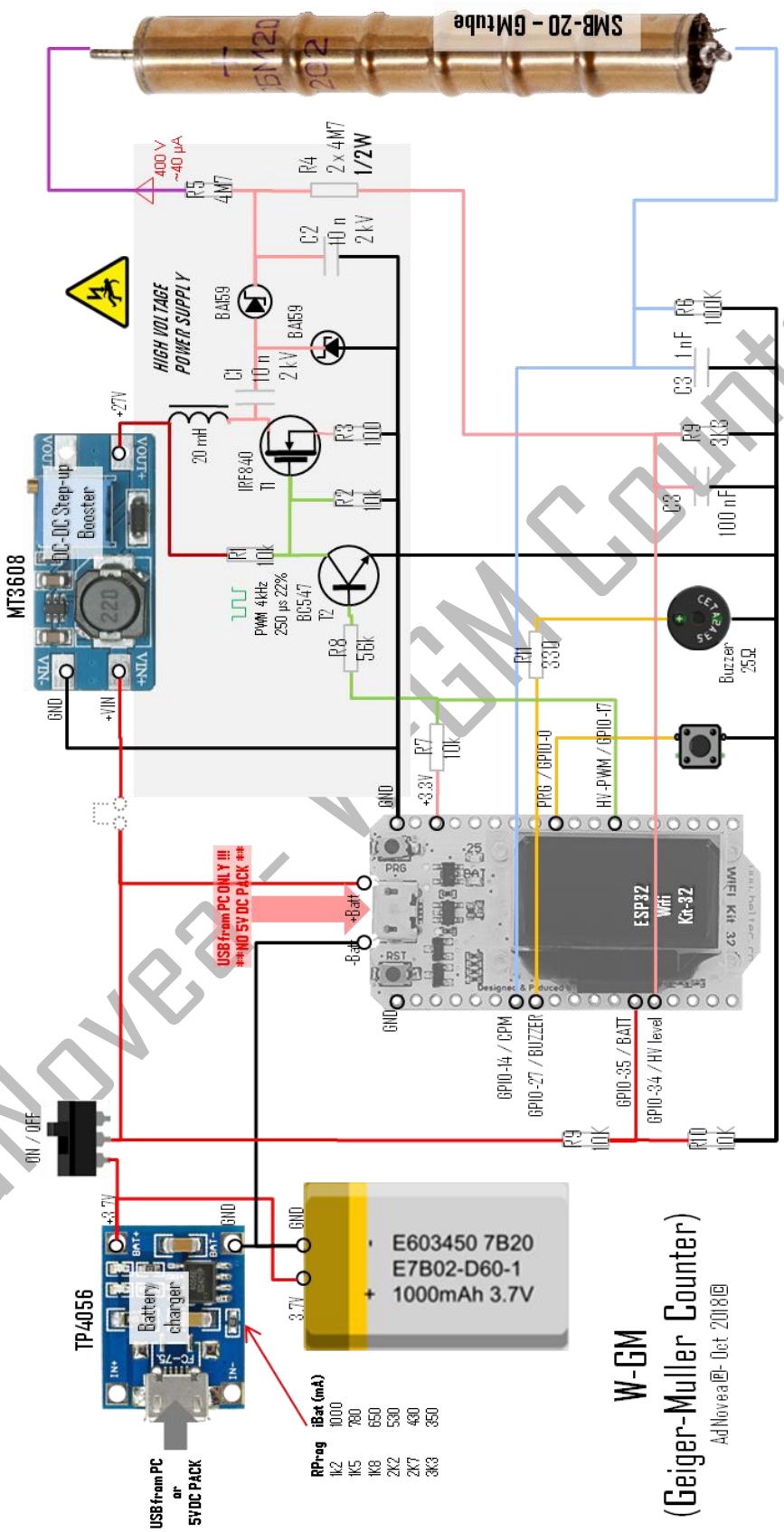
- Some GM tubes are very sensitive to background radiation which can be seen as a pseudo uniform emission source of particles whereas they become much less sensitive to radiation sources that are multiple point sources.
- Some GM tubes such as the M4011 are reported to be also light sensitive.
- GM tube conversion factor can depend of the isotopes (*type of radiation's source*). For example, the SBM-20 is reported with a conversion factor of 1/150 (0.00664) for a Cobalt 60 (^{60}Co) sources, 1/171 (0.00584) for a Cesium 137 (^{137}Cs) sources and 1/197 for the Radon (^{226}Ra) sources. Most of the time, the SBM-20 factor is given for 158.3 or 175.43.
- The Anode load resistor in series with the GM tube prevents the tube to enter into constant avalanche. The resistor value is given in the GM tube datasheet.
- Cathode sensing that is used in the W-GM Counter device is the preferred method but does not provide cathode at ground level.
- Dead time is the time after an event in which the tube will not register a count. It's like the tube is resetting. Most specs on tubes list the dead time (in µS). The SBM-20 has a dead time of 190 µS. The Dead time impact is very low at low count but becomes significant at higher rates. For example a 200µs dead time allows theoretically 5 000 pulses/second or 300 000 pulses/minutes or 1 950µSv/h. In addition to the Dead time, one must also consider the overall Recovery time including the Dead time where pulses appearing after the Dead time with lower amplitudes than normal could be missed. The dead time may also be impacted by the high voltage.
- When radiation increases, the high voltage drop, the dead time increases and there is a saturation. Over 10 000 CPM (~70 µSv/h with our GM tubes) the device measures are probably no longer relevant!
  ➔ *In NO CASE the W-GM Counter can be used for accurate measurement but is aimed for educational purpose only*.

ⓘ NOTE: for avoiding multiple detections on one single radiation pulse, the system must ignore any signals during the dead time period. The default delay for the W-GM Counter has been set to 300µs, about 1.5 the standard SBM-20 dead time to take into account the impact of the high voltage on multiple detections.

➲ **IMPORTANT**: Most of STS-5/CTC-5 Geiger-Müller tubes sold over the Internet have been manufactured at the end of the cold-war and are date 1969/70 (*e.g. CTC 5 marking on the photo is VI○69 for manufacturing in June 1969*). Therefore these GM tubes are half-century old and have been exposed during about 50 years to background radiation.

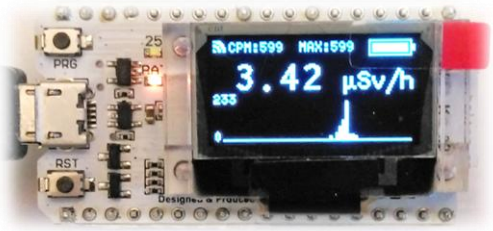
Saturation during the tests with a radioactive source

SCHEMATIC



Hardware details

The W-GM Counter is based on an ESP32 module from Heltec (Wifi Kit-32) that costs about 10$. Main advantages of this module are the built-in OLED 128x34 display, in-board Wifi 802.11b/g/n and a large amount of memory regarding an Arduino Nano for example. The battery charging circuit also available on this module will not be used but replaced by an additional TP4056 battery charger module.



Heltec WIFI kit-32

The ESP32 I/Os are allocated as follow:

	Name	I/O Pin	Signals
•	PIN_BUTTON	0	Button/PRG has internal pull-up (GPIO-0)
•	PIN_SDA	4	OLED I2C SDA (GPIO-4)
•	PIN_GM	14	Signal GM tube #1 (GPIO-14)
•	PIN_SCL	15	OLED I2C SCL(GPIO-15)
•	PIN_RST	16	OLED I2C RESET(GPIO-16)
•	PIN_PWMHV	17	PWM signal to drive HV power supply (GPIO-25)
•	PIN_LED	25	LED detection GM tube #1 (GPIO-17)
•	PIN_BUZZER	27	Audible radiation detection (GPIO-27)
•	PIN_HV	34	High Voltage measurement (GPIO-34)
•	PIN_BATT	35	Battery level (GPIO-35)

ⓘ *GPIO allocations requires to take into account all the constraints on GPIO pins during boot and limitations when some features are enables such as the WIFI.*

The **MT3608** module is a DC-DC Step-up (booster) able to deliver up to 2A with a 28V maximum output voltage. The input voltage can be set between 2V and 24V. In our design, we use the battery output (3.6-4.2V). The step-up will be adjusted for providing a 27V output voltage. This module ensures having a very stable voltage within the range of the battery voltage. Moreover it steps up the voltage to be used for the high voltage power supply.

The **high voltage power supply** is made of a switcher (IRF840) that hashes the 27V and increases the voltage up to 400-450V. The MOSFET IRF840 is driven by the PWM (Pulse Wide Modulation) signal delivered by the ESP32 at about 4 kHz. The PWM duty cycle must be adjusted to enable the current in the self to provide overvoltage when cut-off. The diode and capacitance rectify and increase the high voltage. HV capacitance must support at least 1kV. The R4 is made of two 4M7 and the power to dissipate is 68mW.

ⓘ *An optional jumper at the booster input insulates the HV stage from the power supply when doing the adjustment. Indeed, the booster may be destroyed if the PWM duty cycle is too wide and enable high current in the switcher stage.*

The use of a **TP4506** module for charging the battery was motivated after the destructions of ESP32/ESP8266 module CP2102 USB converters while powered by a 5V DC pack. Therefore we have decided to not use the

micro-USB for powering the device and neither its battery charging circuitry. The TP4506 module has been added to enable the battery charging and device powering. The battery can be charged from a DC pack whereas the power switch is off. According to the battery capacity, the RProg resistor on the TP4506 module must be changed (*see the Battery Charging Current Setup section*).

The radiation LED is the LED built-in on the ESP32 module. It is connected to GPIO-25. The buzzer can be a piezo or a small loudspeaker. Keep in mind that the maximum output current delivered by an I/O is 12mA.

The device consumption has been measured as follow:

- ESP alone ~40mA and ~80mA with Wifi activated
- Booster alone ~10mA (27V) plus ~15mA for High Voltage stage (400V)

ⓘ *When battery goes low, the booster may become noisy. It's time for recharging the battery. The device must be switched off as soon as the battery low icon blinks. Lipo batteries can be impaired if their voltage drops too low.*

CHARACTERISTICS

- Radiation detection types: β, γ, χ-ray
- Detector: Geiger-Müller tube STS-5 / SBM-20 (400 V)
- Maximum values: 65535 CPM / 425 µSv/h (*theoretical*)
- Display: OLED dot matrix 132x64
- Keyboard: 1 tack switch
- Sound: Buzzer piezo
- Indicator: LED white
- Connectivity: USB
  WIFI 802.11b/g/n, DHCP only
- Interface language: English only
- Dimensions: W : 100mm x H: 60mm x D: 25mm
- Weight: ca 95g w/o cables and power supply
- Power supply: 5V USB DC pack / 2 Watts
- Accessories: USB cable, 5V DC pack

EEPROM content

W-GM parameters are stored into the ESP-32 EEPROM. 128 bytes maximum have been allocated for the storage.

ⓘ *To overwrite the parameters with default values, set the CPM input (GPIO-14) at High level (3V3) during power-up, then save parameters into the EEPROM.*

Default values:

ID
0x55 or 0xAA | 0

SSID
Empty | 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33

KEY
Empty | 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66

URL
/A-GM/agm.php | 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98 99

Remote Server
192.168.0.180 | 100 101 102 103

Net Enable
0 (off) | 104

Sound
1 (on) | 105

LCD timeout
10 (seconds) | 106

PWM [0] Freq. | **PWM [1] Duty cycle**
4000 (Hz), 820 (75%) | 107 108 | 109 110

CAL [0] Min | **CAL [1] Range** | **CAL [2] HV**
3350(3V35), 7200(max), 153(HV) | 111 112 | 113 114 | 115 116

GM Factor
175.00 | 117 118 119 120

Alarm val
50 (CPM) | 121 122 123 124

BILL OF MATERIAL

The cost of our W-GM Counter device hardware is less than **22 USD** or **27 EUR**.

Supplier	Reference / ASIN	Designation	Qty	P.U.	Price €
Amazon / TOOGOO	159019/ B07FZXGMY2	NodeMCU ESP32 WIFI Kit-32	1	11,03 €	11,03 €
Amazon / Baoblaze	075503327000C355374190 / B07G5NDN3P	MT 3608 booster	1	1,18 €	1,18 €
Amazon / TOOGOO	041695 / B00YGPU46K	TP 4056 battery charger	1	0,50 €	0,50 €
eBay / Arthur Bernard UK	172971837532	G.M. Tube STS-5 / CTC-5 Soviet Army	1	9,35 €	9,35 €
Amazon / LHWY	B07DVY9HC5	Battery 800mAh	1	0,51 €	0,51 €
Ebay / 9-hk353	223084318182	Buzzer piezo	1	0,10 €	0,10 €
Amazon	STK0151001508 B01FJUOEFW	Tact Switch Micro 6x6x16mm	1	0,02 €	0,02 €
Amazon / SODIAL	041662 / B00YO8QOCM	Power switch SPDT	1	0,02 €	0,02 €
Amazon	STK0114008663 / B00IDWUADY	MOSFET IRF840	1	0,67 €	0,67 €
Amazon	STK0114006054 / B00CYYMPN0	NPN BC547	1	0,01 €	0,01 €
Amazon / Sourcingmap	a13070600ux0401 / B00EZ74FIC	20mH self	1	0,25 €	0,25 €
		Diodes (3)	3	0,02 €	0,06 €

Supplier	Reference / ASIN	Designation	Qty	P.U.	Price €
		Resistors (11)	11	0,01 €	0,11 €
		Capacitances (4)	4	0,02 €	0,06 €
Amazon / Pinzhi	gm-2tiq-l9tw / B01CUAX3QK	Black plastic casing 100 x 60 x 25 mm	1	1,29 €	1,29 €
eBay / Tiny Heaven	391791911461	Veroboard 95 x 55 mm	1	0,89 €	0,89 €
		Miscellaneous (veroboard, screws, wires, …)	1	0,50 €	0,50 €
				TOTAL	**26,54 €**

Resistors: R1/2/7/9/10=10kΩ, R3=100Ω, R4(2x)/5=4.7MΩ, R6=100kΩ, R7=56kΩ, R9=3.3kΩ, R11=330Ω

Capacitances: C1/2=10nF/2kV, C3=1nF, C4=100nF

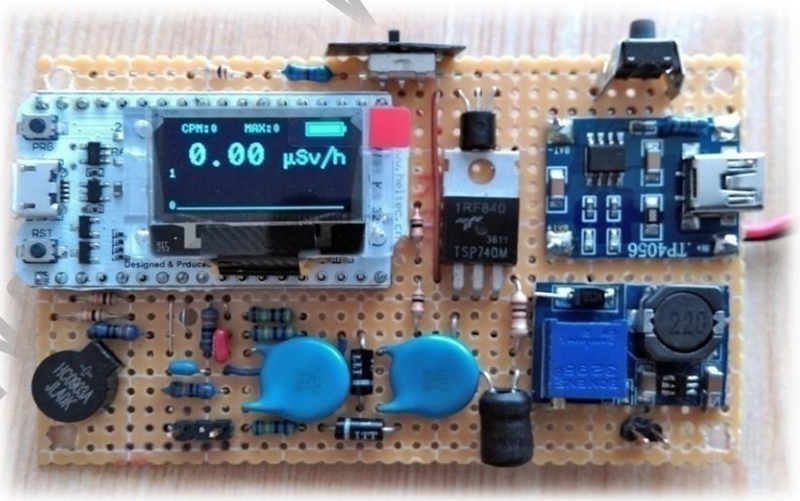
Diodes: 2x BA159, 1N4001

Transistors: T1=IRF840, T2=BC547

Modules: NodeMCU ESP32 WIFI Kit-32, MT3608 (booster), TP4056 (charger)

BUILDING THE W-GM COUNTER HARDWARE

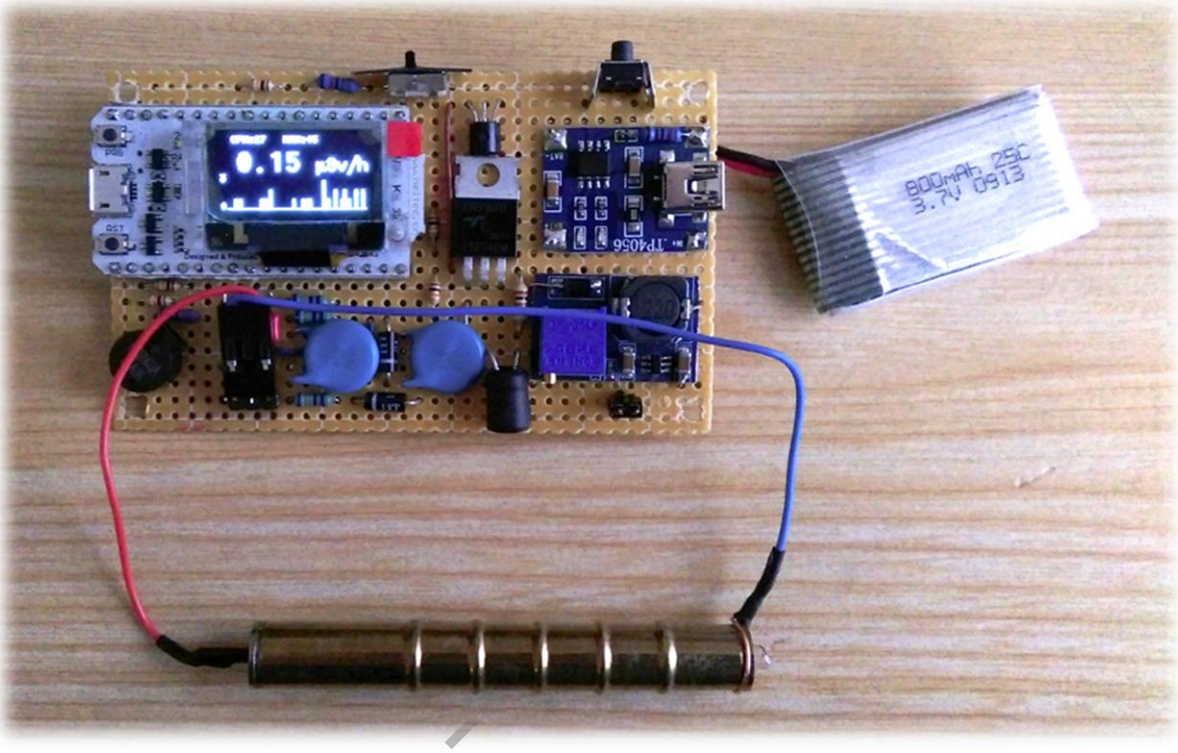
The assembly of the W-GM counter hardware has been made the simplest as possible using minimum components available from the selves (*e.g. Amazon or eBay*) and the minimum of wiring. There is no dedicated printed circuit board (*PCB*) but instead an inexpensive single face dot board (*aka Perfboard*) with solder pad for each hole (*Veroboard*).



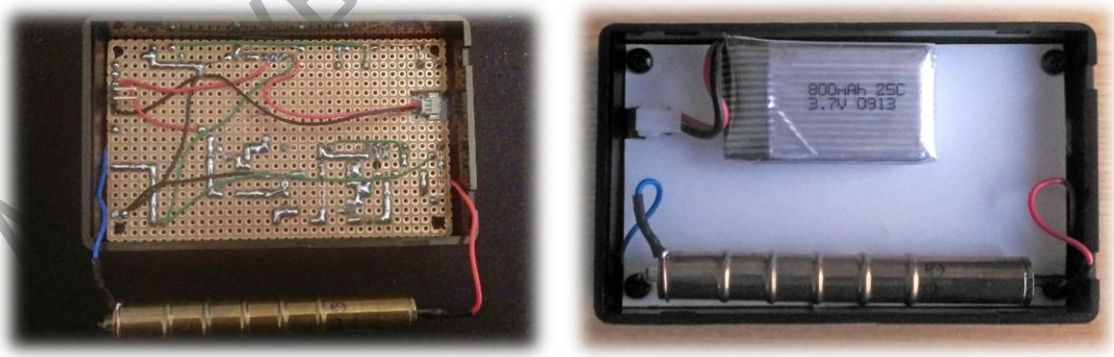
The Perfboard receives the modules, resistors, capacitances, diodes, switch and piezo.

- TP4056 and MT3608 modules are sold directly on the Perfboard.
- The 20mH self is placed as far as possible from the ESP-32 module WIFI antenna.
- The ESP32 module is weld on the Perfboard.
- The size of the Booster (MT3608) had its pads removed for freeing more space.

BC547 PNP transistor and IRF840 MOSFET pinouts



The W-GM assembled and running with the SBM-20 GM tube.



W-GM backside with GM tube and battery

It does not required to be very skilled for wiring the W-GM Counter hardware because the number of wires is very limited. The component's positions are very important for optimizing the wiring. The photos above show the Perfboard wiring and the final assembly with the battery.

HARDWARE ADJUSTMENTS

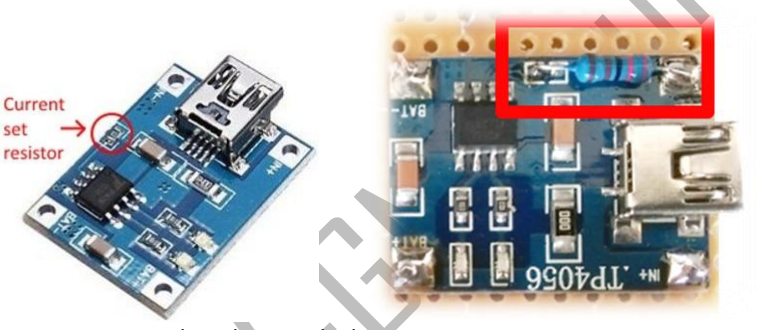
Battery charging current setup

The Heltec WIFI kit32 on-board charging circuit is not used because the default charging current is limited to 100mA. The resistor between pin 2 and 5 of the MCP73831which is 10kΩ may be replaced for increasing the charging current. In no case should the resistor value be below 2.1kΩ for a charge current of 470mA. 500mA is the absolute maximum charge current allowed for the MCP73831 charger chip. The micro-CMS components are not simple to replace and requires the correct resistor value for its replacement.

Moreover, using the Heltec USB port connected to a 5V DC pack for powering the module may be dangerous if the DC pack voltage slightly exceed 5V (*I destroyed an ESP8266 powering it from a 5V DC pack*). Therefore we have made the choice to implement a dedicated module for the battery charging.

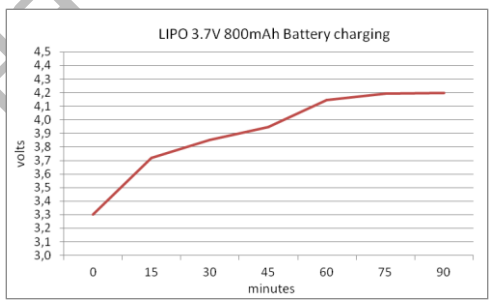
The TP4056 is a well known and robust module for Lipo battery charging. According to the battery capacity, the built-in 1.2K *RProg* resistor (*set for 1A current*) must be changed to setup the charging current.

R_{PROG} (k)	I_{BAT} (mA)
10	130
5	250
4	300
3	400
2	580
1.66	690
1.5	780
1.33	900
1.2	1000



RProg value along with charging current

The charging current is said to be set between 0.36 and 1 times the capacity of the battery. For our 800mAh battery we have chosen a 2K2 resistor allowing a 550mA charging current. With the device switched off, the battery is fully charged after 1h25 (*see graphic below*).



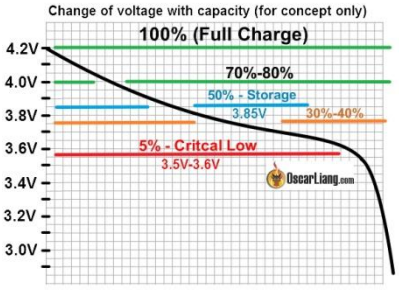
800 mAh Lipo charged after 85 minutes

Battery voltage calibration

The W-GM device will stop working when the voltage drops below 3V. Hopefully, the booster module is able to maintain stable output voltage (27V) all over the Lipo battery discharging voltage range.

When the battery reaches 3.35V, the voltage decrease accelerates and got within less than 10mins down to 3.0V where the device stops working. The icon will be set blinking when the battery voltage reaches 3.35V.

Lipo battery discharge occurs while the output voltage drops from 4.2V down to 32V as shown on the graphic below:



0%	3,00V
5%	3,30V
10%	3,60V
20%	3,70V
30%	3,75V
40%	3,79V
50%	3,83V
60%	3,87V
70%	3,92V
80%	3,97V
90%	4,10V
100%	4,20V

Lipo battery discharge

The battery indicator and voltage can be calibrated using the 'CAL' command and its 3 parameters.

- The 1st parameter of the CAL command sets the minimum battery level before battery empty blinks. The default value is 3.35V or 3350mV.
- The 2nd parameter is used for the battery voltmeter calibration and depends of the resistor values used to build the battery voltage divider. This parameters corresponds to the theoretical voltage to be applied on the resistor divider for a full scale ADC reading. The default value is about 7V or7000mV
- The 3rd parameter concerns the high voltage voltmeter calibration (*see the Commands section*)

Our default 'CAL' command values are: **CAL=3350,7200,153**

The accuracy of the internal battery voltmeter is not very good because we extrapolated the discharge curve by a linear function. The most critical value is the 3.35V position where the battery is flat and low battery message shall be displayed. We adjusted the battery voltmeter to be accurate on lower values and optimistic on fully charged values. The CAL command parameters must be set according to your voltmeter calibration.

High voltage calibration

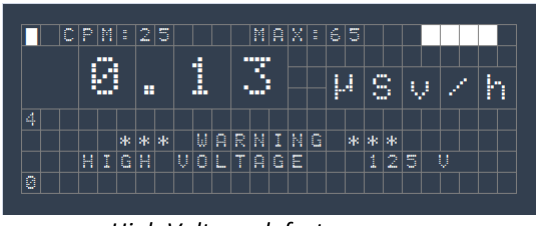
ⓘ *Due to the important internal output impedance of the high voltage power supply, there is a tradeoff to find between the current delivered by the module and the maximum voltage output. Moreover, output voltage measurement will be affected by the multimeter internal impedance.*

The GM tube anode (+) must be connected to +400V.

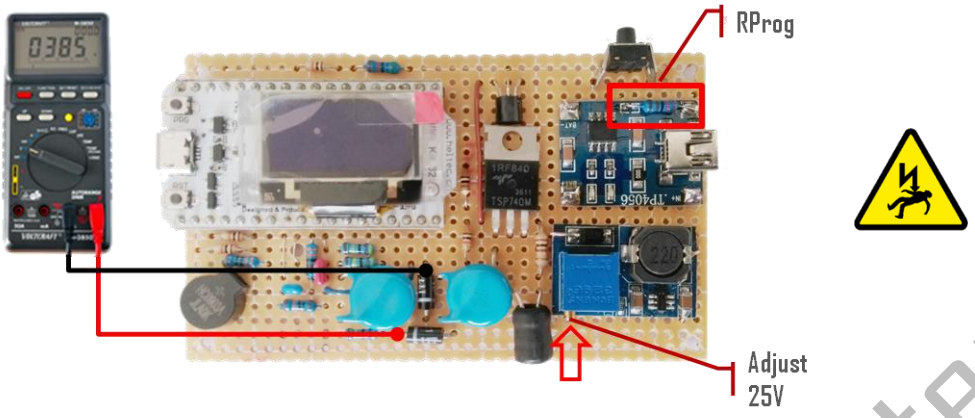
High voltage adjustment shall be done with the W-GM Counter powered from a 5V DC pack and using a multimeter (*position: voltmeter DC ⎓*).

The high voltage value can be adjusted according to the GM tube specification (*e.g. ~400V for SBM-20 tube*). We setup the high voltage at about ~390V/400V.

The GM tube high voltage tolerances are set between 360V and 440V (*suitable for SBM-20/STS-5 tubes*). If the High Voltage gets out of this range, the history is replace with a warning message:



High Voltage defect message



WARNING: Multimeter impedance affects the voltage reading.
Module must be connected to the W-GM circuitry.

Building procedure and first power-up

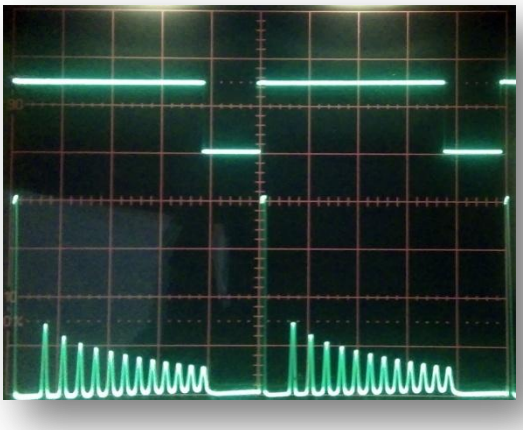
WARNING: Incorrect High Voltage adjustment leads to high current consumption and risk of burns and component destructions (especially the Booster and MOSFET).

***WHY**: because when the MOSFET is always ON, the current through the self is only limited by the 100Ω resistor and could impaired both the MOSFET and/or the Booster not to mention the risk of burns due to the hot temperature of the resistor.*

1. First remove the jumper to insulate the Booster/HV from power supply.
2. Power the device using the mini-USB (*not the micro-USB from the ESP32*)
3. Ensure the PWM signal (GPIO-17) is correct with a duty cycle of about 75%. This determines when the current passes through the self and may lead to high destroying current. Do not connect the PWM yet.
4. Ensure the R7 (10K) resistor is connected to a 3.3V. This will disable the HV when there is no PWM or during start-up.
5. While the PWM is NOT connected and the R7 set to 3.3V disable the HV, replace the jumper.
6. Adjust the booster voltage to 27V using the potentiometer. Read the voltage on a multimeter and set the booster voltage to a stable value.
7. Connect the PWM signal. Then, using the PWM parameters, adjust the frequency and duty cycle. DO NOT increase to much the '*Duty Cycle*' because it increases the current and may destroy components.
8. Calibrate the internal high voltage voltmeter using the 3rd parameter of 'CAL' command (e.g. **CAL=3350,7200,153**). Adjust the matching of the internal voltmeter reading with the reading of an external multimeter connected C2 capacitor and the cathode of the 2nd diode.
9. Remove the external multimeter and readjust the high voltage to 400V using ONLY the internal voltmeter thanks to the 2nd parameter of 'PWM' command (e.g. **PWM=4000,820**). This last step is required because the high impedance of the high voltage power supply made the external multimeter impedance lowering the actual HV value.

Do NOT exceed 400/410V otherwise the Dead time increase leads to multiple detection for one single pulse.

On the oscilloscope screenshot below, the GPIO-17 PWM signal (*upper signal*) is inverted by the BC547 transistor before driving the MOSFET. The duty cycle must be modified to adjust the high voltage. See the picture above where the higher peak reaches 400V when the MOSFET switches off (*lower trace*).



4 kHz PWM signal (GPIO-17 – 1V/div) and IRF840 Drain signal (100V/div)

W-GM COUNTER RADIACTIVITY CALIBRATION

The easiest way for the W-GM counter calibration is to use a radioactivity source (*e.g. fluorescent clock with radium-226, smoke detector with americium-241*) and already calibrated GM counters. Expose the two counters to the source at the same distance and match the **µSv/h** value from the W-GM counter with the calibrated counter reading by modifying the **FACTOR** parameter using the USB or Ethernet connection.

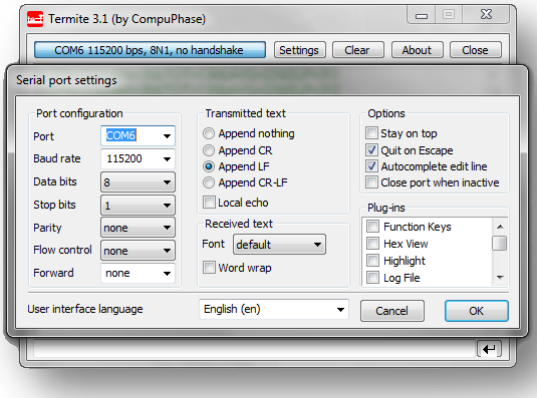
ⓘ *CPM depends of the GM tube sensitivity whereas the µSv/h is a tube independent unit thanks to the GM tube Factor. CPM depends of the nature of the radiation type.*

We have calibrated our W-GM counter against a GMC-320+ counter using respectively M4011 and SBM-20 tubes. The M4011 conversion factor is given for **153.80** and our test results for the SBM-20 were slightly different so we have selected the value of **160.00** for our SBM-20.

DEBUGGING USING THE USB PORT

To debug the W-GM Counter hardware and firmware, you can connect the ESP-32 micro-USB of the device to an USB port of your PC and run a Terminal console such as the "Termite" application. Select the **COM** port corresponding to the W-GM device and set the baud rate to **115200**.

Debugging information will be displayed and command (*see Commands section above*) can be sent.



TERMITE terminal settings

Don't power the ESP32 with a 5V DC pack power supply connected to the USB port, these power supplies will be destroying the CP2102 (USB) chip.

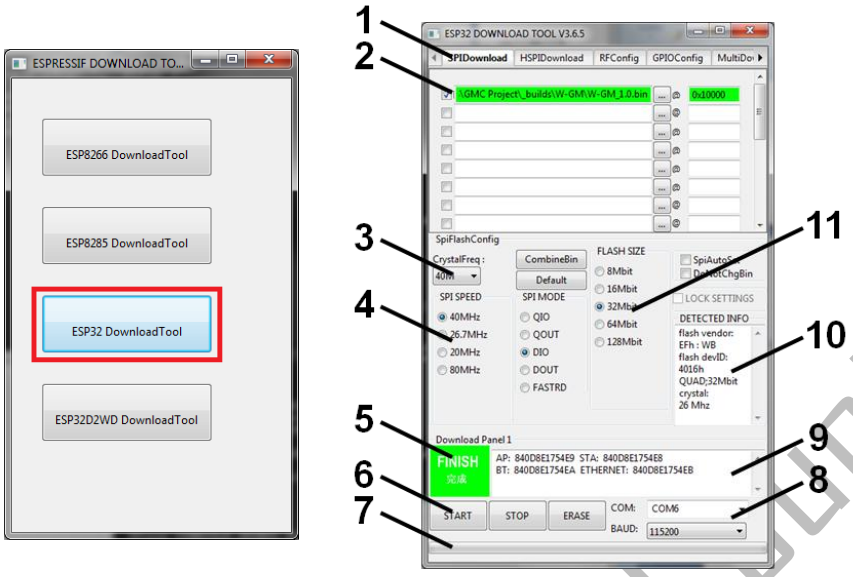
FLASHING THE W-GM COUNTER FIRMWARE

The W-GM Counter Device programming can be done using the W-GM Counter device **BIN file** and the **Flash Download Tools** utility. The "*Flash Download Tools*" application can be downloaded from the constructor website at https://www.espressif.com/en/products/hardware/esp32/resources.

Launch **flash_download_tools_v3.6.5.exe**. A DOS box opens and a menu is displayed. Select **ESP32 DownloadTool** from the menu.

1. Select a particular tab to find related options. Select HSPI tab for HSPI flash download. In general, you should use **SPI download** mode.
2. **BIN files** to be downloaded (**W-GM_vx.x.x.bin**). The checkbox must be checked and the file and address (**0x10000**) must be valid for a file to be successfully opened by program for download.
3. Crystal Frequency should be the frequency of the crystal connected to your ESP32 module (**40M**).
4. SPI Flash speed. You may switch to 80MHz with fast flash chips but **40MHz** will be fine. The default SPI MODE is **DIO**. *However, the Integrated Development Framework ESP-IDF v.1.0 seems to be having issues with this higher than 40MHz*.
5. Tells about the current operation status. Whether the download tool is idle or running, etc.
6. **Start**/Stop button to start or stop programming.
7. Progress bar to indicate firmware download program.
8. **COM port** settings such as baud rate (115200) and port number.
9. PHY MAC IDs for Wifi, BLE, Ethernet, etc.
10. Information on the flash chip. This is acquired by low level API and this information is necessary for evaluating flash map, etc at runtime.

11. Flash memory size. Most modules will contain the ESP32 hooked to a Winbond **32MBit** flash memory. You may change accordingly if your hardware differs.



Flash Download Tool interface

Binary Download Locations

As in ESP32 ESP-IDF v.1.0 with no modified "ld" script files, the locations should be as follows for normal applications:

```
0xe000:  boot_app0.bin
         ...\packages\esp32\hardware\esp32\1.0.0\tools\partitions\boot_app0.bin
0x1000:  bootloader.bin
         ...\packages\esp32\hardware\esp32\1.0.0\tools\sdk\bin\bootloader_dio_40m.bin
0x4000:  partitions_singleapp.bin

0x10000: .bin
         See your sketchbook folder
```

The system only consists of a bootloader, a data partition table and the main user application BIN (*generated by you by compiling your code*).

Downloading the Program

- Pull GPIO0 LOW by pressing the "**PRG**" button on your development board.
- Reset the ESP32 by pressing the "**RST**" button momentarily while holding down the "**PRG**" button.

Next press the **Start** button to continue and flash the **BIN files** into your ESP32 module!

Make sure that the **COM port** has been correctly selected. The download tool would typically automatically detect an USB-UART converter.

> ***WARNING:*** *Incorrect settings can 'bricks' your ESP. Check your ESP version and procedure for flashing the BIN file. We decline responsibility for direct or indirect damages.*

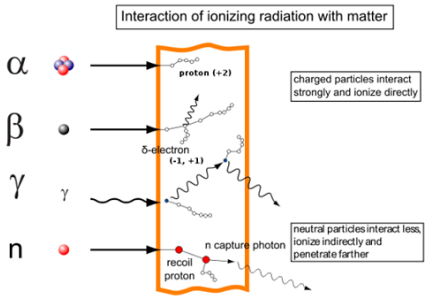
ANNEXES

GLOSSARY

The list below contents abbreviations and acronyms.

µRem	The roentgen equivalent man (Rem) is an older CGS unit. **1 Rem = 100 Sv**
µSv/h	Micro-Sievert per hour – The Sievert (Sv) is a derived unit of ionizing radiation dose in the International System of Units (SI) and is a measure of the health effect of low levels of ionizing radiation on the human body.
Alpha particles (α)	Alpha particles have a typical kinetic energy of 5 MeV and a speed of about 15,000,000 m/s, or 5% of the speed of light. They can be stopped by few centimeter of air, a piece of paper or the epidermis
Beta particles (β)	Beta particles have medium energy and most can be stopped by a few millimeters of aluminum. Beta radiations are in the range of 0.25 to 3.5.
CPM	Count Per Minute.
Gamma particles (γ)	Gamma particles have very high energy and require shielding by dense material such as lead or concrete to be stopped. Gamma radiations are in the range of 0.1 to 1.25 MeV.
GM	Short for Geiger and Muller who are the inventors of the vacuum tube with low pressure gas able to detect ionizing radiations from X-Ray, alpha, beta and gamma particles.
GM Counter	Device able to count the number of radiation impulses per minute (CPM).
GM Factor	Each GM tube manufactured type has its own sensitivity to radiation and a specific factor to convert the number of impulse (CPM) into micro-Sievert per hour (µSv/h).
GUI	Graphic User Interface includes the display and keyboard systems.
Ionizing radiations	Radiation carrying enough energy to liberate electrons from atoms or molecules, thereby ionizing them (Alpha, Beta, Gamma or X-Ray radiations)
LAN	Local Area Network: private network installation
LCD	Liquid Crystal Display is a dot-matrix display for text and semi-graphic characters.
QPKG	Packaged application module compatible with QNAP servers
Sv (Sievert)	Unit of ionizing radiation dose in the International System of Units (SI) measuring the health effect of low levels of radiation on the human body.
Tack switch	Push button made of micro-switch system.
WIFI	Ensemble de protocoles de communication sans fil des normes IEEE 802.11
X-Ray	X-ray radiations are in the range of 30 keV to 3.0 MeV.

TYPES OF RADIATIONS



Alpha:

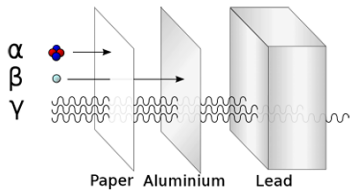
Alpha radiation are positively (+2) charged particles emitted from atom nucleus in the process of decay. These particles are also very dense and their strong positive charge precludes them from penetrating more than an inch of air or a sheet of paper. Alpha particles are not a serious health hazard, except when they are emitted from within the body as a result of ingestion, for instance, when their high energy poses an extreme hazard to sensitive living tissue. This weak form of ionizing radiation is only detectable by some models of Geiger counters equipped with Geiger-Muller tubes having a thin mica window at one end.

Beta:

Beta radiation are negatively charged (-1) particles emitted from an atom in the process of decay. These relatively light particles can penetrate deeper than Alpha particles, though still only through a few millimeters of aluminum at best. If ingested, Beta radiation can be hazardous to living tissue. This relatively weak form of ionizing radiation is detectable by many Geiger counters.

Gamma:

Gamma radiations are one extreme of the electromagnetic spectrum, particularly that radiation with the highest frequency and shortest wavelength. (*That same spectrum also includes the more familiar X-rays, ultraviolet light, visible light, infrared rays, microwaves, and radio waves, listed in order of decreasing frequency and increasing wavelength from Gamma rays*.) Gamma rays can pass through virtually anything, and are effectively shielded or absorbed only by materials of high atomic weight such as lead. Gamma rays are produced naturally by the sun and other bodies in outer space, their transmission to earth being known as "*cosmic radiation*". A very powerful and potentially very dangerous type of ionizing radiation detectable on virtually all Geiger counters.



Background radiation:

Certain earth's minerals contain the radioactive elements such as Uranium and/or Thorium which also emit Gamma rays. This radiation along with the cosmic radiation (*Gamma rays which come from the sun and other stars*) combine to produce the "*background count*" of a Geiger counter. This might typically be in the range of 15 to 60 counts per minute, but will vary depending upon your location on the earth, your altitude, and also

the efficiency (*sensitivity*) of the Geiger counter tube. The background count should always be factored in or "subtracted" from the overall reading derived from a specific radioactive source.

Common background radiation goes from 0.041µSv/h to 0.081µSv/h (3650 - 7200µSv/year).

DOSE RATE EXAMPLES

All conversions between hours and years have assumed continuous presence in a steady field, disregarding known fluctuations, intermittent exposure and radioactive decay. Converted values are shown in parentheses.

Source Wikipedia.

<1 mSv/a	< 0.1 µSv/h	Steady dose rates below 100 nSv/h are difficult to measure
1 mSv/a	0.11 µSv/h avg*	ICRP recommended maximum for external irradiation of the human body, excluding medical and occupational exposures.
2.4 mSv/a	0.27 µSv/h avg	Human exposure to natural background radiation, global average
3.7 mSv/a	0.42 µSv/h avg	.Average radioactivity level at the entrance of the Chernobyl exclusion zone.
24 mSv/a	2.7 µSv/h avg	Natural background radiation at airline cruise altitude
41 mSv/a	4.6 µSv/h avg	Radioactivity level at the Chernobyl memorial near the nuclear plant before the new sarcophagus.
130 mSv/a	15 µSv/h avg	Ambient field inside most radioactive house in Ramsar, Iran. Radioactivity level in sewer drain in Pryp'yat', Ukraine.
(800 mSv/a)	92 µSv/h	Natural radiation on a monazite beach near Guarapari, Brazil
(9 Sv/a)	1 mSv/h	NRC definition of a high radiation area in a nuclear power plant, warranting a chain-link fence
	2–20 mSv/h	Typical dose rate for activated reactor wall in possible future fusion reactors after 100 years. After approximately 300 years of decay the fusion waste would produce the same dose rate as exposure to coal ash, with the volume of fusion waste naturally being orders of magnitude less than from coal ash. Immediate predicted activation is 90 MGy/a
(1.7 kSv/a)	193 mSv/h	Highest reading from fallout of the Trinity bomb, 32 km away, 3 hours after detonation
(2.3 MSv/a)	262 Sv/h	typical PWR spent fuel bundle, after 10-year cool down, no shielding
(4.6–5.6 MSv/a)	530–650 Sv/h	The radiation level inside the primary containment vessel of the second BWR-reactor of the Fukushima power station, as of February 2017, six years after a suspected meltdown

**avg The equivalent average dose over one year (1y = 8766h).*

TROUBLESHOOTING

Problems	Solutions
W-GM COUNTER	
WIFI enabled but no icon displayed	• Network or A-GM server cannot be found. Check the SSID/Key and A-GM server IP address.
LED blinks every second	• No pulse is detected. This is normal at startup until the first radiation pulses are detected otherwise the GM tube is defective. Check High Voltage value with very high impedance (>100MΩ) multimeter (voltage must be 400V)
High Voltage value is wrong and/or always displayed on Radiation screen	• There is an internal voltmeter inside the W-GM counter. Its accuracy requires a calibration because of the tolerances on the divider bridge used by the voltmeter. Check if the displayed value matches the actual high voltage value measured with a multimeter. • The High Voltage circuitry can be defective. Check HV voltage.
Button does not work at start-up	• When the network feature is enabled, the device tries and retries to connect. Each try introduce lag in the button's action processing.
Normal or safe is displayed but alarm is audible	• The Alarm threshold is probably too low. Check the Alarm threshold against the different messages in the USAGE section.
Display does not return to Radiation screen when timeout is reached	• Check if Timeout is > 0 (0=disabled).
Device cannot connect to network. No icon displayed.	• Wifi router must be running BEFORE activation of the Wifi on the device. Start Wifi router, switch device Wifi off and on. • Check SSID/KEY values. • Check Menu configuration. • Check for potential IP address conflicts. • Switch off and On the power supply to reset the ESP32. • DHCP tries during about one minute to connect.
Slow to connect from web browser and/or cannot be pinged correctly.	• If the Wifi network is connected and an IP address allocated but there is no correct connection, check your password. • The connection to the device from an Internet browser may take 2-3 minutes or more the first time.
Display freezing or lag	• The LCD looks like it is freezing at start-up when the network is enabled and no connection can be performed. You can disable the network connection using the USB connection or Wait until the network timeout expire. The display will return to normal. • When the network is enabled in the menu and no network connection is possible, the display lags and is inaccurate. Fix the network issue or disable the network. • The LCD can display a warning message about the high voltage whereas the voltage is correct. Wait until the network timeout expire. The display will return to normal.
An orange LED is on	• The orange LED belongs to the ESP-32 battery charger circuit. It turns on when the ESP-32 USB is connected to a PC. The LED stays still while the battery will be charging, turns off when the battery will be fully charged and blinks if the battery is defective or disconnected.

LICENSES

We are proud to release our project under free licenses. Feel free to use it the way you like in accordance with the licenses below.

A-GM Manager Web application	*License : GPL v3 (open-source)* https://www.gnu.org/licenses/gpl-3.0.en.html
W-GM Counter Firmware	*License: Free to use for personal application only* No source code released

SUPPORT

This project is provided “AS IS” and is not committed to provide support of any type.

Nevertheless you may find some helpful pieces of information and exchanges from the SourceForge repository.

https://sourceforge.net/u/adnovea