GC-20 Geiger Counter, Dosimeter and Radiation Monitoring Station

User Manual

Overview of Hardware

Housing:

The case of the GC-20 is 3D printed from PLA. It is designed to be compact and strong enough to withstand normal use including vibrations or low drops. If your GC-20's housing is damaged, the STL files to 3D print a new one are available on my GitHub page at github.com/pra22/GC20.

The PCB is secured to the housing with the help of three M3 machine screws that thread into brass inserts, providing a strong, metal-to-metal fastening. Repeated disassembly and reassembly won't wear out the threads easily. The back cover is installed using M3 countersunk screws into the same kind of brass threaded inserts.

Electronics:

The GC-20 has a high voltage generation circuit that produces the 400V needed by the SBM-20 Geiger-Muller tube. The circuit is based on a 555 oscillator and an inductor whose output is rectified and smoothed out to generate a constant output voltage.

A D1 Mini microcontroller board functions as the brains of the GC-20. This board is based on the ESP8266 chip by Espressif, and comes with WiFi built-in. All electronic components are soldered onto the main PCB.

CAUTION: THIS DEVICE USES HIGH VOLTAGE. DISASSEMBLY SHOULD BE CARRIED OUT WITH CARE, AND IMPROPER HANDLING CAN CAUSE A MILD (BUT ANNOYING) SHOCK

Power:

Power is provided by a 3.7V Lithium-Ion Polymer battery with a capacity of 2000 mAh. The battery is rechargeable with a standard Micro-USB charging port on the side on the GC-20. The GC-20 consumes an average of 120 mA during normal use without WiFi, giving a battery life of just over 16 hours.
A standard wall USB charger can be used to charge the battery. The power system comes with overcharge, overdischarge, and short circuit protection.

Note: Please make sure that the charger can provide at least 1 A of current at 5 V. Using a lower current (such as the USB port on a computer) might not charge the battery properly.

The battery is connected to the PCB with a standard JST-PH connector with a 2mm pitch. The battery can be easily removed by taking off the back cover, making it possible to carry multiple batteries if a longer runtime is needed and charging is not available.

Software Features Summary

The GC-20 comes with a clean, intuitive user interface with touch controls for ease of use and quick access to all functions. No more navigating clunky, complicated menus with limited input options. The following is a rundown of the major software features that the GC-20 offers.

Home screen:

Figure 1: The home screen of the GC-20

The home screen displays the current effective dose rate, counts per minute, and the cumulative dose since the device was turned on. The integration time can be changed by tapping the "INT 60 s" button and the user can choose between 60, 180 and 5 seconds of integration. A shorter time allows faster response to changing radiation levels at the expense of accuracy. It is useful when measuring higher levels of radiation and a quick response to changing radiation levels is desired. Using 180 seconds results in the least amount of random fluctuation, and is useful for monitoring natural background levels.

The light bulb and speaker buttons can be used to toggle the indicator LED and the buzzer respectively.
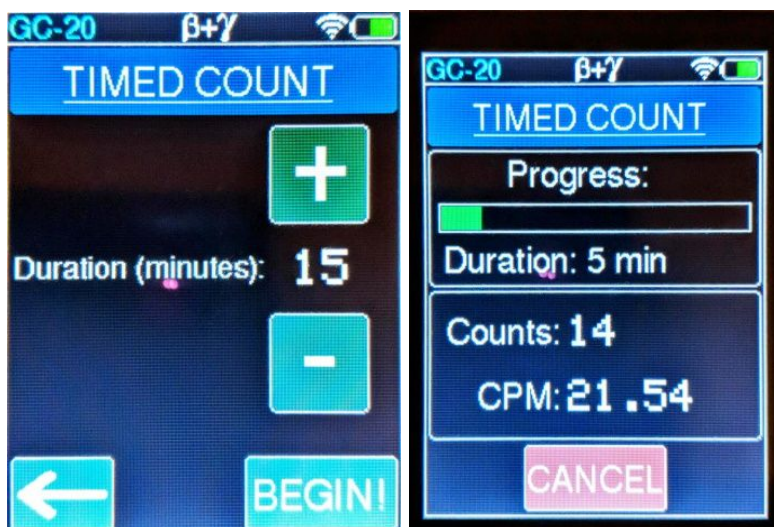
Timed Count Mode:

Figure 2: Timed count setup and running displays

The timed count mode allows for the measurement of low doses of radiation such as the radiation coming from bananas, brazil nuts, or granite. It can also be used to test for high levels of Radon. Select the time interval in five minute increments, hit begin, and the GC-20 starts counting and displaying the accumulated counts over time. It also displays the real time CPM during the timed count. By doing a similar timed count of the natural background, the user can compare and detect small differences in radiation levels.

The WiFi symbol next to the battery level indicator means that the GC-20 is currently in monitoring station mode and is connected to WiFi. More on that below.

Settings:
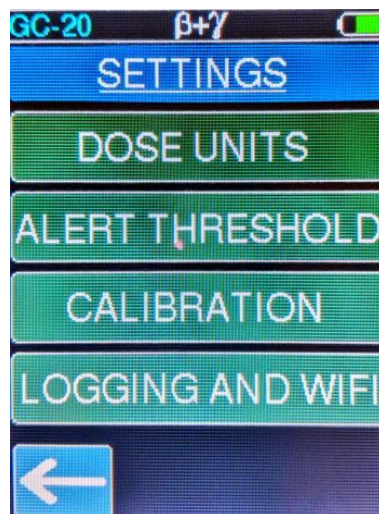
Figure 3: Settings page

The settings menu has four options: Dose Units, Alert Threshold, Calibration, and Logging and WiFi.

Figure 4: The first three settings options

The Dose Units option allows the user to choose between either Sieverts or Rems for the effective dose rate and the accumulated dose.

The user can adjust the threshold at which the home page displays a "High Radiation Level" alert in red, in increments of 1 uSv/hr.

The calibration factor that relates CPM to uSv/hr can be changed using this option. The geiger tube has different sensitivities to different isotopes, so to keep the dose readings reasonably accurate, a default conversion factor of 175 is used. This will accurately report the gamma dose from Cesium-137.

Figure 5: Logging and Wifi setup page with additional options

Finally, tapping the Logging and WiFi button offers a further sub-menu of options related to setting up wifi for the first time, logging data, uploading logged data, and setting the device mode. When data logging is on, an "L" symbol appears on the top bar and the GC-20 begins logging the counts per minute once every 10 minutes. The GC-20 can store upto 150 hours of logs before the memory is full, which is indicated by a "Log Memory Full" message in the page displayed above.

Resetting the device won't erase any logged data since it is stored in permanent memory. The GC-20 will continue logging where it left off when powered up again.

Note: Since the GC-20 doesn't come with a built-in clock, the logged data will contain relative timestamps of 10 minutes.
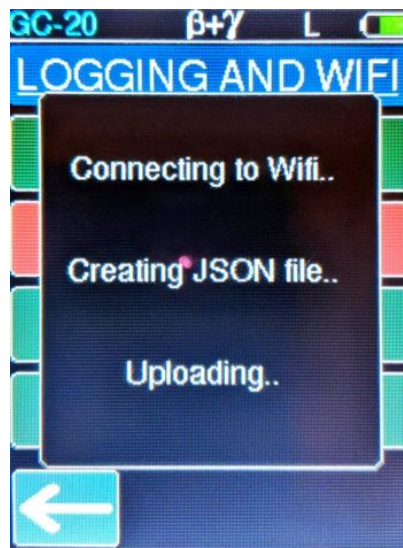
Figure 6: Uploading logged data to ThingSpeak

By tapping the "Upload Data" button, the user can bulk-upload the logged data to their ThingSpeak channel. The uploaded data will populate "Field 1" of the channel. If the data is successfully uploaded, the GC-20 will clear all logs and reset itself.
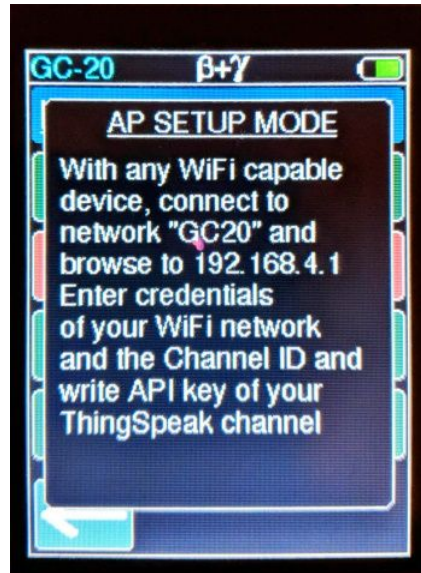
Figure 7: WiFi setup mode.

To use the WiFi features of the GC-20, such as uploading logs and using the device as a radiation monitoring station, the user first needs to set up the WiFi and enter the credentials of their ThingSpeak channel. To do this, tap on the "WiFi Setup" button and the GC-20 will enter Access Point mode. Using any wifi connected device with a web browser, like a phone or a laptop, search local networks and connect to the open network named "GC20". The browser will either automatically take you to the setup page, or if doesn't, enter the url 192.168.4.1. Select your network name from the scanned list or enter the SSID (network name) manually, enter the password, and also enter the credentials of your ThingSpeak channel, i.e. the channel ID and the Write API Key. Once that's done, hit save and the GC-20 will save the settings to permanent memory and reset itself. This only needs to be done once. You can always change the WiFi or channel details at any time by repeating the above.

Before setting up WiFi, create a new free account on ThingSpeak, add a new channel, and find the Channel ID and the Write API Key for the channel.
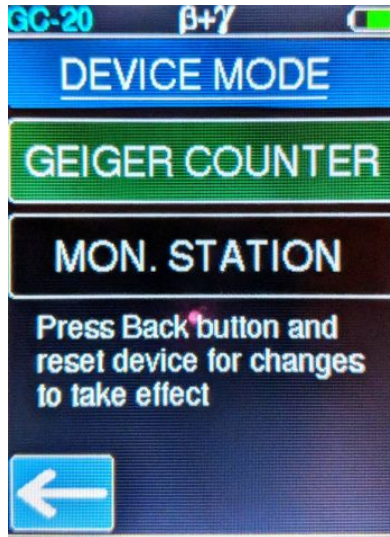
Figure 8: Device mode selection menu

In the Device Mode menu option, the user can choose between the portable Geiger counter mode, or configure the device as a radiation monitoring station. In the monitoring station mode, the GC-20 is always connected to WiFi, and updates the ThingSpeak field every 5 minutes. The uploaded data will populate "Field 2" of the ThingSpeak channel. If it can't connect to WiFi during startup, it waits for 30 seconds before starting in portable Geiger counter mode. In monitoring station mode, the recommended integration time is 180 seconds.

Note: When using the GC-20 as a radiation monitoring station, it is recommended to remove the battery and keep it plugged in to a USB outlet. The top screw in the back can be removed and the hole can be used for mounting the device onto a nail on a wall. If the device is to be stationed outdoors, please use an enclosure that prevents excessive moisture from getting in. To prevent softening of the case in hot weather, the case can be removed and the bare device can be kept in a separate enclosure.

Figure 9: Examples of ThingSpeak data plots for logged data (left) and live upload (right)

The ThingSpeak channel allows the user to customize the appearance of the graphs, change the axis labels, data min and max values, number of data points to display, etc among other options. The user also has the option to save the uploaded data as JSON, XML or CSV (Excel compatible) files.