GC-20 Geiger Counter, Dosimeter and Radiation Monitoring Station
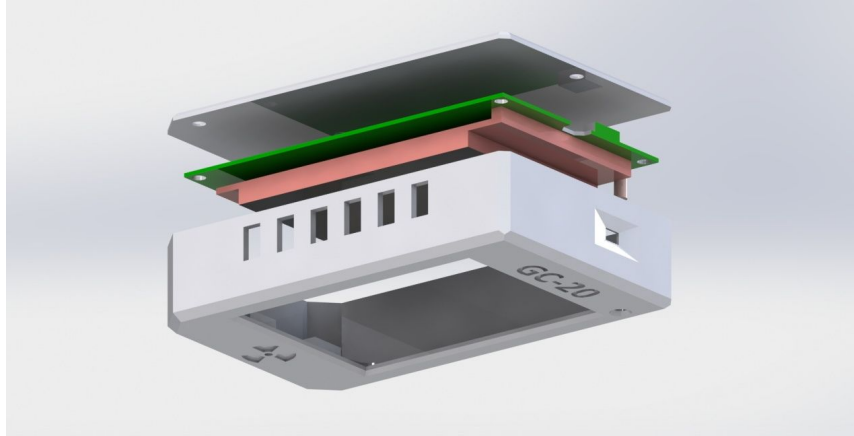
Build Guide

Figure 1: Rendering of the CAD model

All hardware design files for the GC-20 are available at my GitHub page at github.com/pra22/GC20. This includes the Solidworks CAD assembly, STL files for 3D printing, Gerbers for the PCB, and a PDF schematic of the circuit that contains the part numbers of all electronic components as purchased from LCSC. The passive components are all of size 1206. Most components are SMT, with the exception of the JST connector, LED, D1 Mini, TFT LCD display, the battery charger board, and the connections to the Geiger tube.

The GC-20 uses the Russian SBM-20 Geiger tube. This tube is capable of detecting hard beta and gamma radiation. To keep the size compact, I opted to use the kind with both ends taken off, as shown in the figure below.

Figure 2: SBM-20 tubes with exposed leads. The protruding rod is the anode and the tube body is the cathode
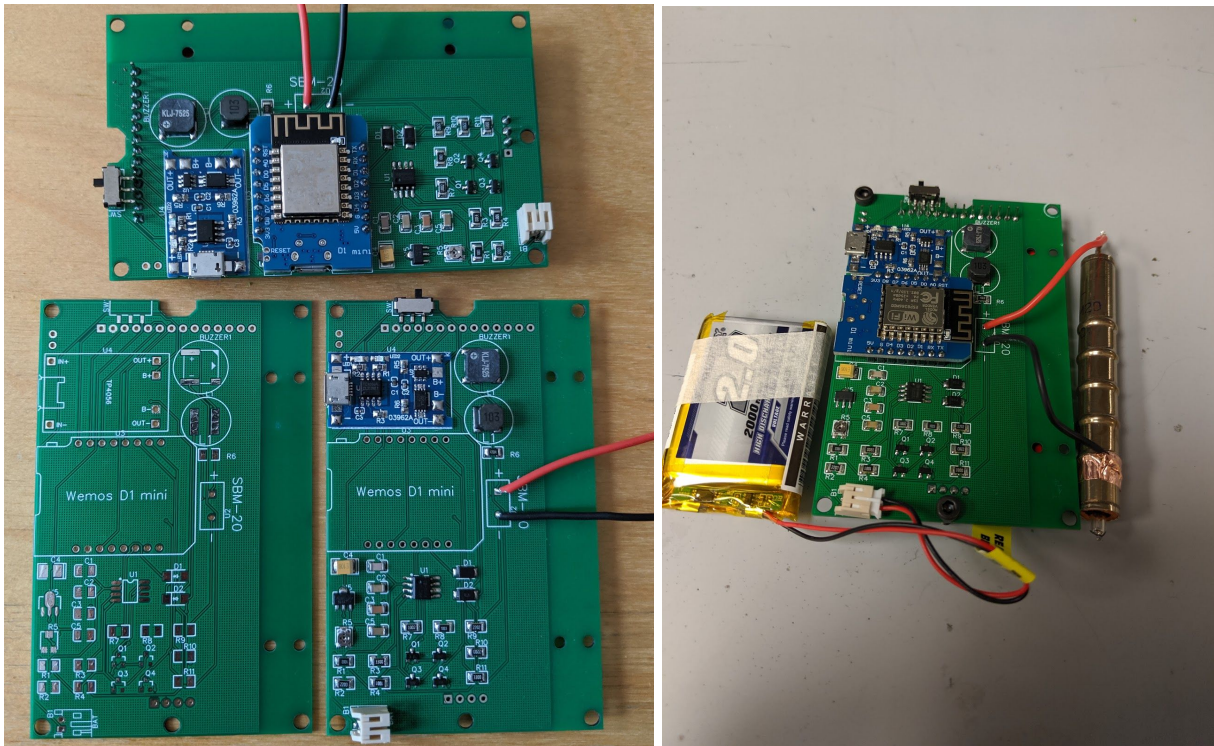
Figure 3: PCBs at various stages of assembly

I used a toaster oven and a stencil to solder the SMT components and found that this method works well. All parts are labeled and correctly represent the schematic part numbers.

Note: The battery charger board should be soldered like an SMD component by placing it over the pads and flowing solder into the holes. Their hole spacing is odd and won't fit standard 0.1 in male headers.

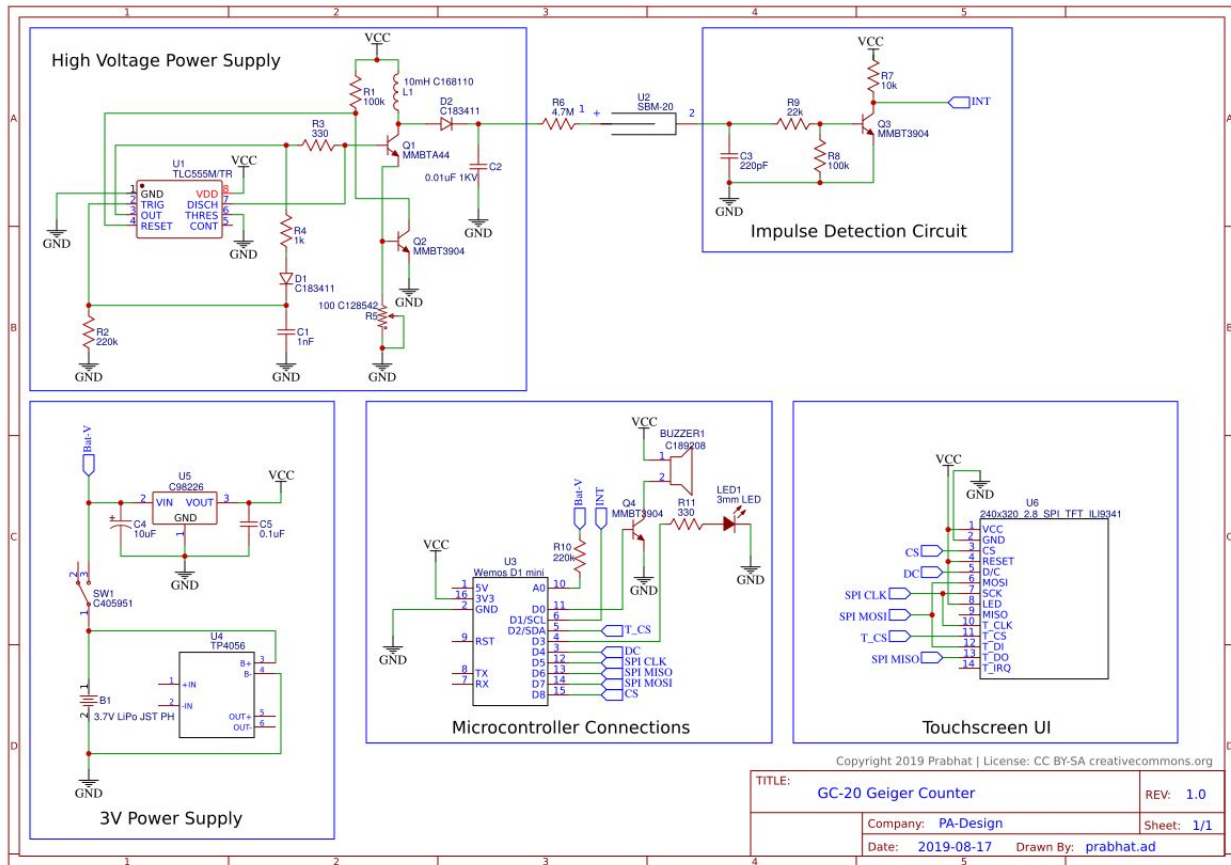The circuit is based on the following schematic diagram:

Figure 4: Complete Circuit Schematic

The part labels for each component in the schematic are either the manufacturer's part number or the LCSC product number. Find them by searching on LCSC's website. If you prefer to use a different supplier such as Digikey, the equivalent parts can be found by first reading the product description at LCSC. There are no rare or special components, but I had some trouble finding a 10 mH Ferrite core inductor that worked. The PDF version of this schematic can be found in my GitHub page for a clearer view of the circuit.

The order list from LCSC is as follows:

LCSC order information for electronic components for the GC-20			
Reference Designator	Value/Description	LCSC Part Number	Footprint
U1	CMOS 555 timer	C383061	SOP-8
U5	3V LDO linear regulator	C98226	SOT-89
C1	1 nF MLCC 50V	C1885	1206
C2	10 nF 1000V	C107192	1206
C3	220 pF MLCC 500V	C106036	1206
C4	10 uF Tantalum	C119050	CASE-B_3528
C5	100 nF MLCC	C82601	1206
R1	100K	C17900	1206
R2	220K	C17956	1206
R3	330	C104763	1206
R4	1K	C4410	1206
R5	100 Ohm Variable Resistor	C128542	Custom
R6	4.7M	C37800	1206
R7	10K	C140407	1206
R8	100K	C17900	1206
R9	22K	C25830	1206
R10	220K	C17956	1206
R11	330	C104763	1206
D1	Fast recovery 600V diode	C183411	SMAF
D2	Fast recovery 600V diode	C183412	SMAF
Q1	NPN Transistor 200mA 400V	C181174	SOT-23
Q2	NPN Transistor 200mA 40V	C111113	SOT-23
Q3	NPN Transistor 200mA 40V	C111113	SOT-23
Q4	NPN Transistor 200mA 40V	C111113	SOT-23
L1	10 mH Power Inductor	C168108	Custom
BUZZER1	Magnetic Buzzer	C189208	7.5*7.5*2.5mm
SW1	Power switch SMD	C405951	Custom
B1	JST PH battery connector	C265016	TH, 2mm pitch
LED1	Red LED 3mm	C330752	TH

The following table lists the components used to make the full assembly, NOT including the discrete electronic components to be ordered from LCSC or a similar supplier.

| Part Name	Quantity	Link
PCB	1	Order from any manufacturer using the Gerber files
Wemos D1 mini	1	https://www.amazon.com/IZOKEE-NodeMcu-Internet-Development-Compatible/dp/B076F53B6S/ref=sr_1_5?keywords=D1+mini&qid=1569094374&s=gateway&sr=8-5
2.8" TFT LCD Touchscreen with SPI interface	1	https://www.amazon.com/HiLetgo-240X320-Resolution-Display-ILI9341/dp/B073R7BH1B/ref=sr_1_3?keywords=tft+lcd+touch+spi&qid=1569094450&s=

		gateway&sr=8-3
SBM-20 Geiger Tube with ends off	1	Many sellers on ebay and other sites. Goes in and out of stock at various online stores.
3.7 V LiPo Charger board	1	https://www.amazon.com/Makerfocus-Charging-Lithium-Battery-Protection/dp/B071RG4YWM/ref=sr_1_5?keywords=3.7v+battery+charger+board&qid=1569094608&s=gateway&sr=8-5
Turnigy 3.7V LiPo battery and JST connector	1	https://hobbyking.com/en_us/turnigy-2000mah-1s-1c-lipoly-w-2-pin-jst-ph-connector.html
M3 x 22mm Countersunk screws	3	https://www.mcmaster.com/91294a137
M3 x 8mm hex head machine screws	3	https://www.amazon.com/M3-0-50-Socket-Stainless-Machine-Quantity/dp/B01L0E1TAY/ref=sr_1_14?keywords=m3+8mm+machine+screws&qid=1569095687&s=gateway&sr=8-14
M3 brass threaded insert	6	https://www.amazon.com/Uxcell-a16041800ux0824-Knurled-Threaded-Embedment/dp/B01IYWTCWW/ref=sr_1_3?crid=2HA0QXKNMSBWV&keywords=m3+brass+insert&qid=1569095827&s=gateway&sprefix=m3+brass+ins%2Caps%2C151&sr=8-3
Conductive copper tape	1 roll	https://www.amazon.com/gp/product/B07R8QBSZ3/ref=ppx_yo_dt_b_asin_title_o01_s00?ie=UTF8&psc=1

Other miscellaneous parts, equipment and supplies include:

- Soldering Iron
- Hot Air soldering station (optional)
- Toaster Oven for SMD reflow (optional, either do this or the hot air method)
- Solder wire
- Solder paste
- Stencil (optional)
- 3D printer
- PLA filament
- Silicone-insulated stranded wire 22 gauge
- Hex keys

Steps:

1. Solder all SMD components to the PCB first, using your preferred method
2. Solder the battery charger board to the pads SMD-style
3. Solder male leads to the D1 Mini board and to the bottom pads of the LCD board
4. Solder the D1 Mini board to the PCB
5. Cut off all protruding leads from the D1 Mini on the other side
6. Remove the SD card reader from the LCD display. This will interfere with other components on the PCB. A flush cutter works for this
7. Solder through-hole components (JST connector, LED)
8. Solder the LCD board to the PCB AT THE END. You won't be able to de-solder the D1 Mini after this
9. Cut off the bottom-side protruding male leads from the LCD board on the other side of the PCB
10. Cut two pieces of stranded wire around 8 cm (3 in) long each and strip the ends
11. Solder one of the wires to the anode (rod) of the SBM-20 tube
12. Use the Copper tape to attach the other wire to the body of the SBM-20 tube
13. Tin and solder the other ends of the wires to the through-hole pads on the PCB. Make sure the polarity is correct.
14. Upload the code to the D1 mini with your preferred IDE; I use VS Code with PlatformIO. If you download my GitHub page, it should work without needing any changes
15. Attach the battery to the JST connector and power on to see if it works!
16. 3D print the case and the cover
17. Insert the brass threaded inserts into the six hole locations in the case with a soldering iron
18. Install the assembled PCB to the case and secure with three 8mm screws. Two on top and one on the bottom
19. Place the Geiger tube on the empty side of the PCB (towards the grill) and secure with masking tape.
20. Insert the battery over the top, sitting over the SMD components. Guide the wires to the gap at the bottom of the case. Secure with masking tape.
21. Install the back cover using three M3 x 22 mm countersunk screws. Done!
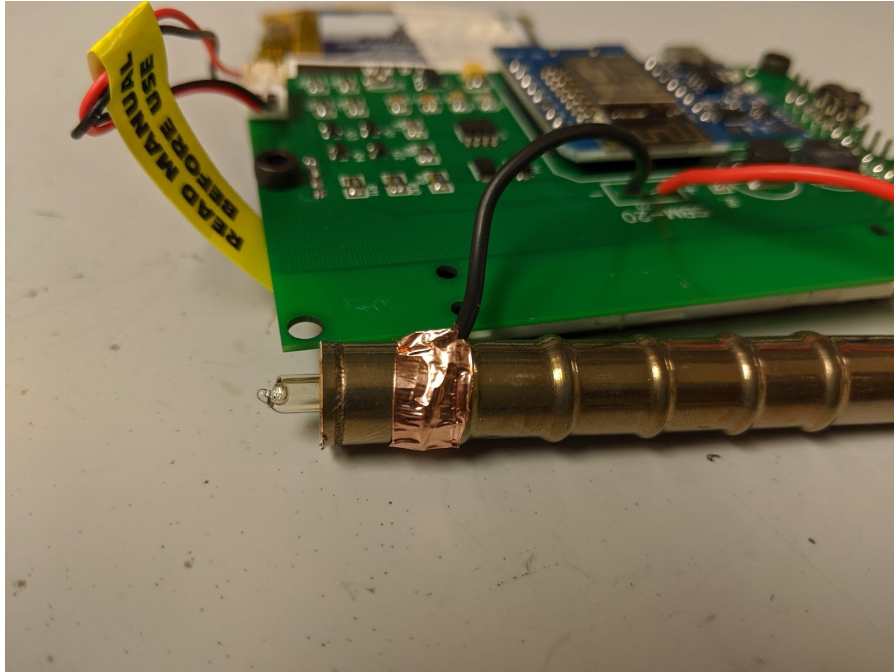
Step 12: Closeup of the copper tape

Steps 19 and 20: Everything tucked in
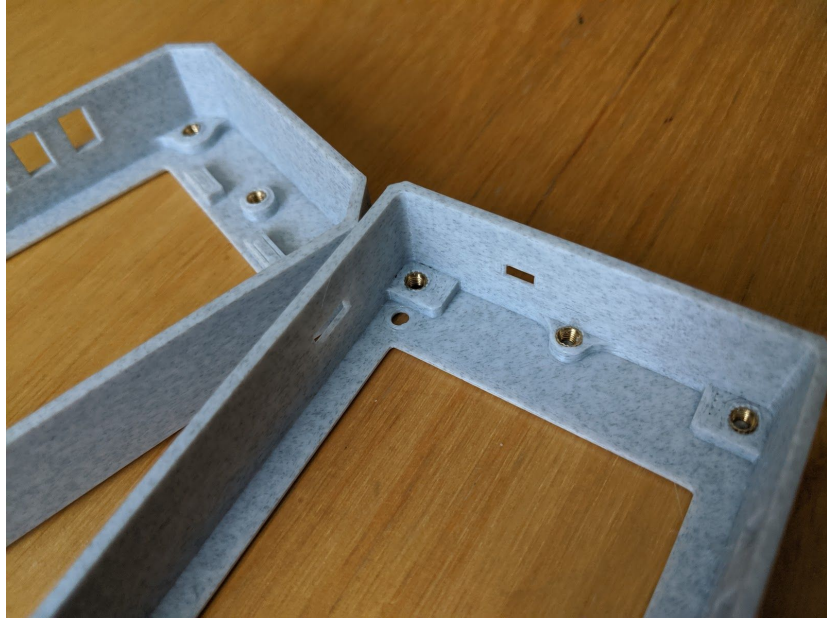
Step 17: Brass inserts soldered into holes

The result!