

AN-1174 Battery Powered Portable Geiger Counters

This application note describes two implementations of portable, battery powered Geiger counters. Version 1 uses two SLG46533V GreenPAK™ IC chips and has a two-digit 7-segment display, while Version 2 is even lower power, uses just one SLG46533V chip, and has an 8-bar indicator display. Both versions feature a speaker which beeps when a gamma or alpha particle is detected.

Version 1

In Version 1, functionality is divided between two chips. The first chip is responsible for pumping high voltage (around 400V) to bias a SBM-10 Geiger tube, as well as counting the particle impulses and transferring the result to the second chip every 250 seconds using an internal 25kHz generator with a divide by 64 configuration. The second chip drives the two digit 7-segment display. Photos are shown below in Figure 1.

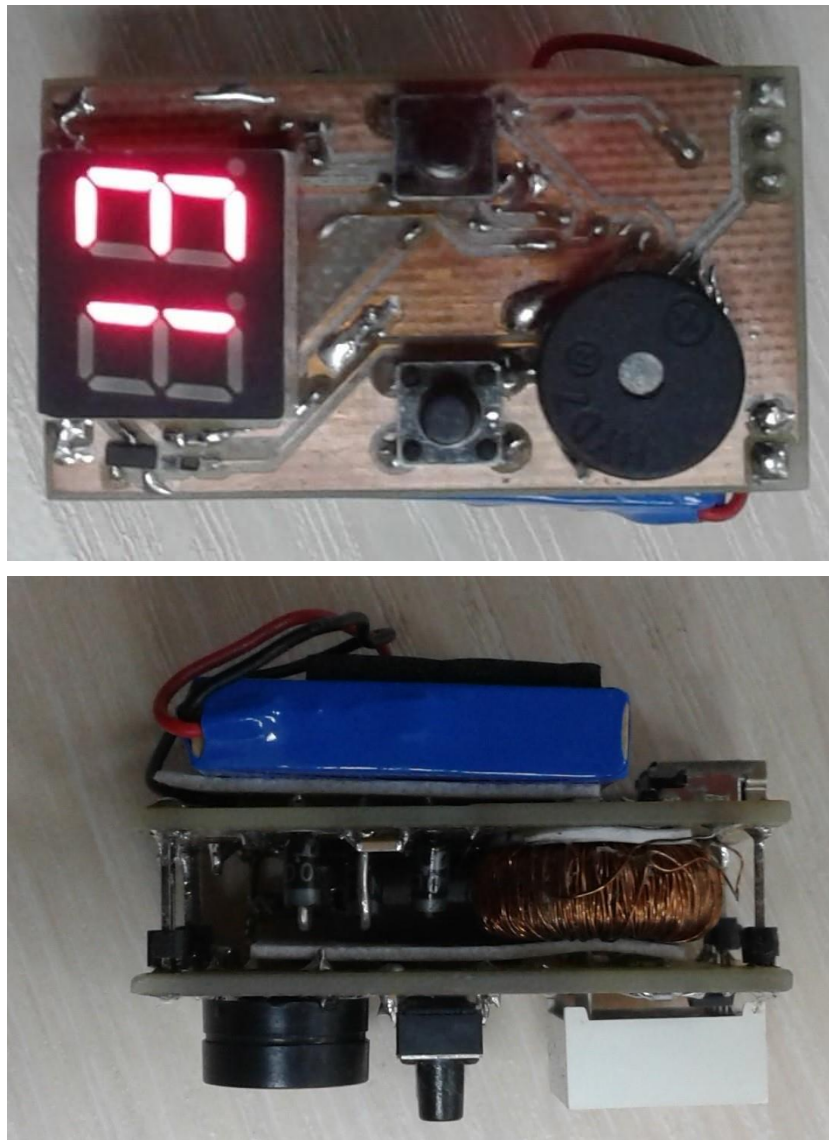


Figure 1. Version 1 Photos

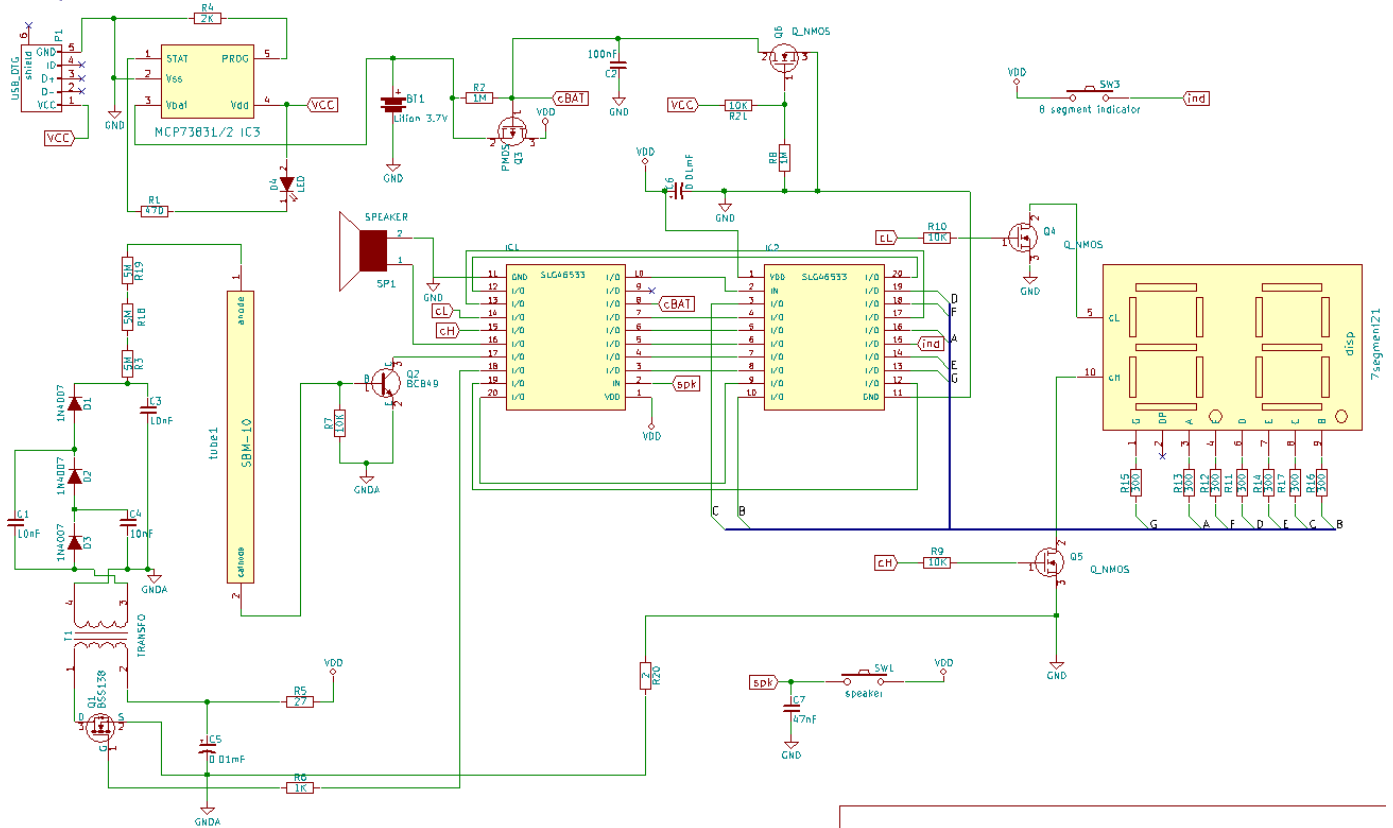


Figure 2. Version 1 Schematic

Version 1 Schematic Analysis

The device has two buttons. One is for showing the value on display for 10 seconds and the other turns the speaker on/off. Also, it has an automatic protection system for the battery cell. When the battery voltage goes below 3.6V, the first chip disconnects the battery. The battery is monitored by an internal comparator which is only awake <1ms every 250 seconds, thus saving a lot of power. When the battery drops below 3.6V, pin 8 lets go of the gate of PMOS Q3 to be pulled up, thus shutting off current to VDD. The battery can also be charged through a USB connector. During charging, Q6 is turned on, which forces Q3 on to power VDD.

Q1 is used to pump high voltage through the transformer. The circuitry comprised of D1, D2, D3 and C1, C3, C4 is using for multiplying the output voltage of transformer. Voltage on C3 = 3 x C4. C3 transfers this voltage to the SBM-10 tube. Working range of the tube is 320 – 480 volts. When a gamma or alpha particle penetrates the tube, the voltage lowers 20 – 50 volts. This causes current flow through Q2. In this case C3 gives it's energy to equalize the voltage on the tube. SBM-10 tube has only around 2pF capacitance and C3 has 10 nF, so there is only about 0.01% loss of C3 energy from one radioactive particle. So, during equalizing of voltage on tube and C3, Q2 creates an impulse on its collector, which is connected to the main chip and pulled up through an internal 10K resistor. The resistors R3, R18, R19 determine the impulse delay on collector. R7 is used to protect the base emitter junction of Q2. The coil ratio is 1:20.

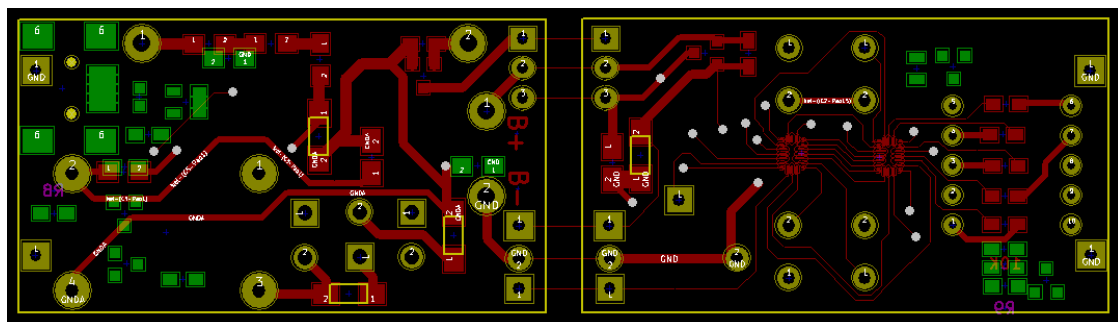


Figure 3. Version 1 PCB layout

This device has four time modes and an 8 bar indicator. There are 6 buttons. First button to turn the device on/off, a second button to turn the indicator on/off, and 4 buttons for time modes. Like Version 1, there is a speaker that beeps from radiation events. If the event frequency gets so high it is out of range for a certain mode, you will hear continuous beep and, and also the 8th bar will blink, indicating that the quantity of particles in this range is overloaded. You need to switch to a shorter time range mode or wait a few (depends on mode) seconds. If the overload is still indicated, that means the radiation level is too high for this mode, and the time mode should be switched to a shorter time-interval mode.

1st mode: 9sec. interval collection of particles, means impulse has 4 $\mu\text{Rhs}/\text{hour}$. Max 32 $\mu\text{Rhs}/\text{hour}$.

2nd mode: 4.5sec. interval collection of particles, means impulse has 8 $\mu\text{Rhs}/\text{hour}$. Max 64 $\mu\text{Rhs}/\text{hour}$.

3rd mode: 2.25sec. interval collection of particles, means impulse has 16 $\mu\text{Rhs}/\text{hour}$. Max 128 $\mu\text{Rhs}/\text{hour}$.

4th mode: 1.125sec. interval collection of particles, means impulse has 32 $\mu\text{Rhs}/\text{hour}$. Max 256 $\mu\text{Rhs}/\text{hour}$.

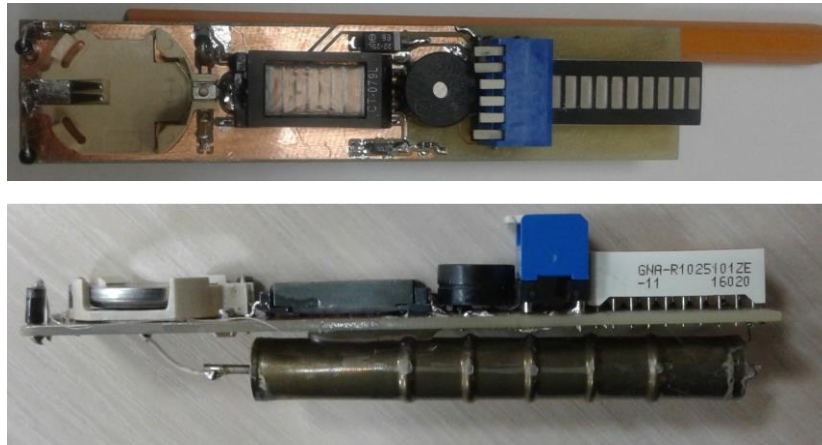


Figure 4. Version 2 Photos

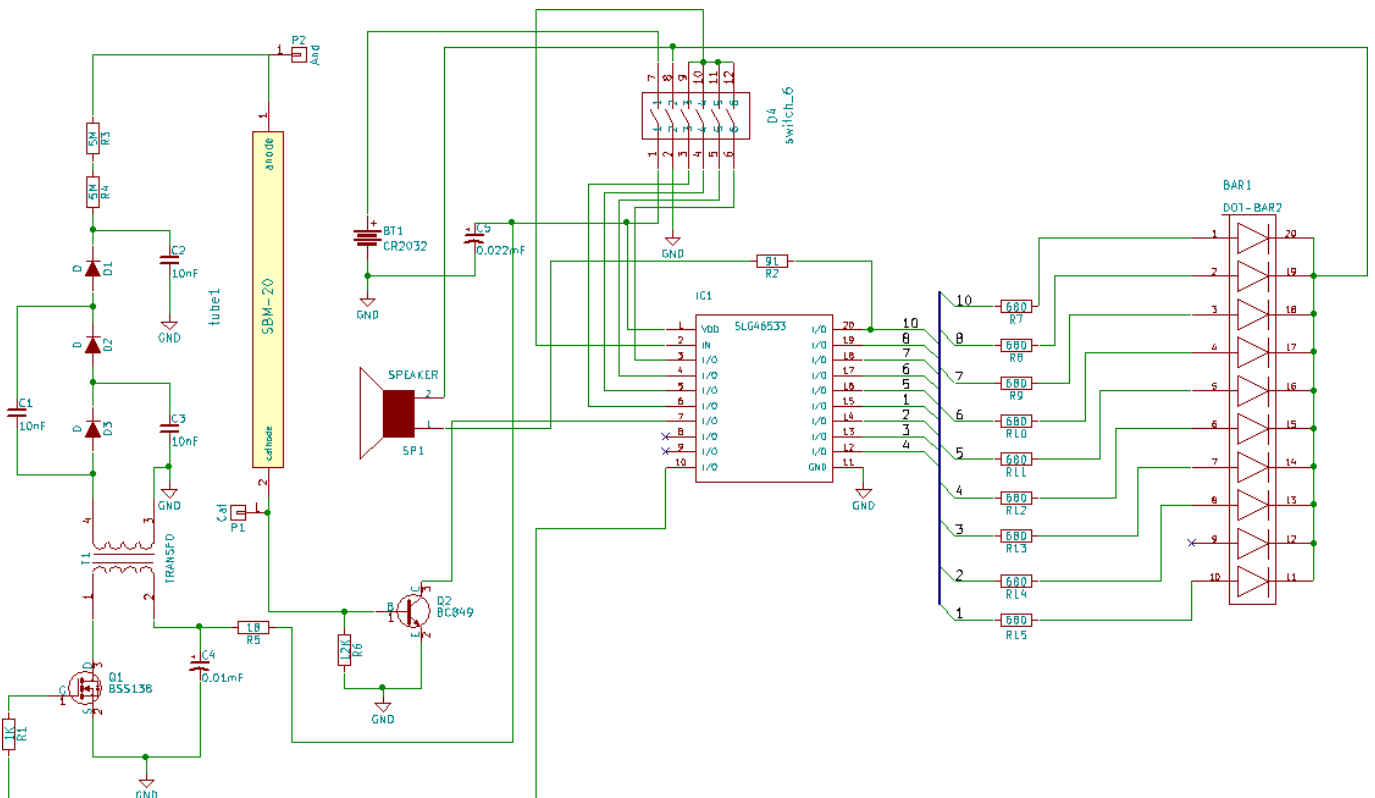


Figure 5. Version 2 Schematic

Version 2 Schematic Analysis

Only one GreenPAK IC chip is used, which integrates the controller of the high voltage pump (around 400V) for the SBM-20 tube. Q1 is used for pumping high voltage through the transformer. The circuit with D1, D2, D3 and C1, C2, C3 is using for multiplying output voltage of the transformer. Voltage on C2 = 3 x C3. C2 transfers this voltage to a SBM-20 tube. Working range of the tube is 320 – 480 volts. When a gamma or alpha particle penetrates the tube, the voltage lowers 50

-100 volts. This causes current flow through Q2. In this case C4 gives it's energy to equalize voltage on tube and itself. SBM-20 tube has only around 4pF capacitance and C2 has 10 nF, only about 0.03% energy is lost at C2 from one radioactive particle. So, during equalizing voltage on tube and C2, Q2 creates an impulse on its collector which is connected to main chip and pulled up through an internal 10K resistor. The resistors R3, R4 determine impulse delay on collector. R6 protects the base emitter junction of Q2.

The 4 modes above show different interval times that collect impulses of SBM-20 and show it on the display and refresh the result again after a certain time (mode). The standard collection time of SBM-20 is 36sec. It means that impulses during this time equal the quantity of μRhs per hour. The transformer was taken from an LCD inverter. If the voltage does not exceed 400V then we can tune it with higher C4 capacitor.

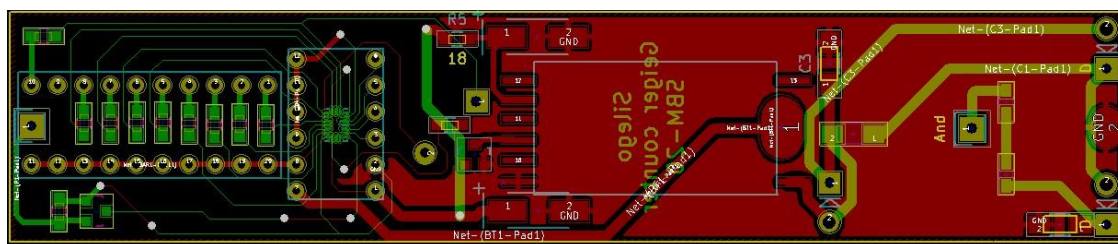


Figure 6. PCB layout

Results and Conclusion

Both devices have the advantage of low current consumption, and were implemented in portable sizes. Version 1 draws ~100 microamperes with display turned off, and has dimensions 45 x 25 x 20mm. It was designed with a 450mAh rechargeable battery, with which the device can last ~6 months. Version 2 is 108 x 22 x 25mm, draws ~50 microamperes (with display turned off), and uses a standard CR2032 coin cell battery, which at 240mAh can last ~6 months. These projects demonstrate how GreenPAK ICs can be used in portable high-voltage systems.

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