Handmade Geiger Counter with GM tube

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As you know, there was nuclear crisis in Japan. People need to keep away from radiation. Geiger counter is a radioactive detector.

Section 1 Introduction

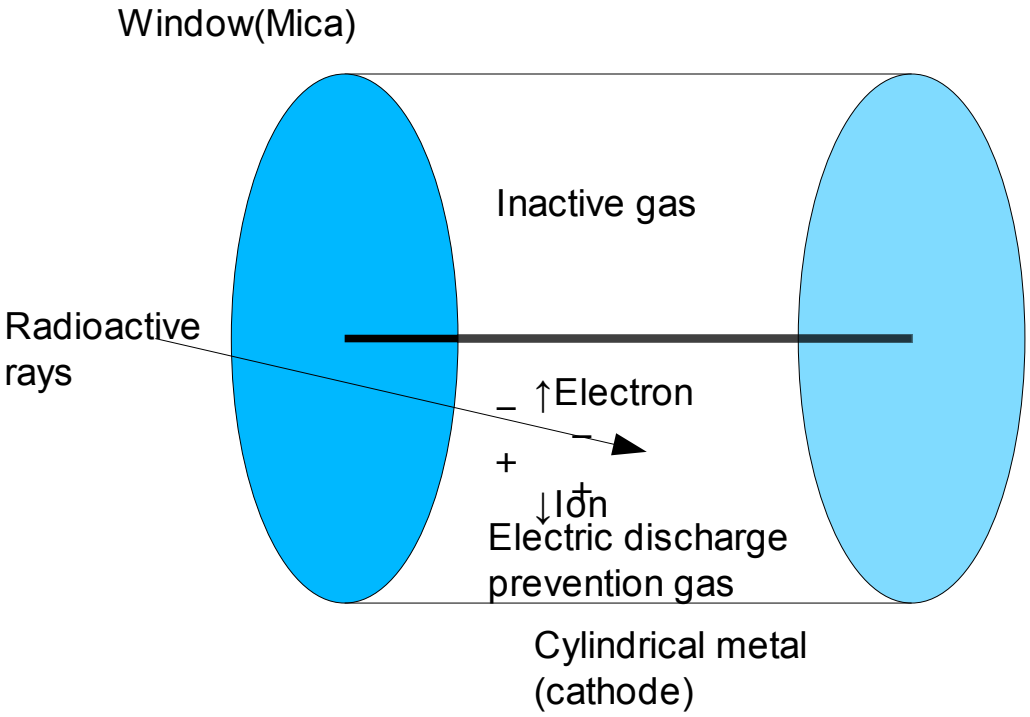
There is radioactivity. The radioactive rays are invisible. We are suffering from it. The sun is a nuclear fusion reactor. Are the radioactive rays dangerous? How far do we take a distance from radioactive obstacle for our safety?
I had lots of questions. First, I had wanted to measure radioactivity to understand the effect from the field.
Geiger counter, dosimeter, is a measurement device. But it is very expensive. I made it with low cost. And I had success to count it.

Caution:
Use this document at your own risk!
Danger high voltage in the Geiger counter.

Section 2 Geiger Muller tube

In 1925, Johannes Wilhelm Geiger who was a physicist in German and Walter Muller who was a student, invented a sensor to detect radioactive rays. In short, GM tube.
Although the high voltage is needed for the center of cylindrical metal (negative pole) by what has arranged metal stick (anode), radiation is measurable one by one. The intensity (speed) of radiation cannot be measured. Quantity (number) is measured. Sensitivity can be comparatively made high. It is fit for detection of alpha rays and a beta ray. Although a gamma ray is also detectable, it is said that the detection probability is about several %.

The Geiger Mueller counter is decompressed by 0.1 atmospheric pressure, and it fills up with inactive gas (Ar, helium) and halogen gas (bromine) as continuation electric discharge prevention.
Voltage from DC 500V to 700V necessity. The voltage region suitable for this measurement is called Plateau voltage.



Geiger muller tube device

Work theory of GM tube.

1. Radiation (alpha, beta, gamma) carries out incidence. It collides with a gas molecule (inactive gas), and gas is ionized (ionization).
2. The generated electron is accelerated by high voltage field.
3. Further, an acceleration electron collides gas and is excited.
4. When the excited gas return to a base state, ultraviolet rays are generated.
5. Ultraviolet rays ionize gas and cause an electronic avalanche.
6. An electronic avalanche reaches the anode and is detected as a pulse.
7. On the other hand, plus ion gas reduces voltage field.
8. Thereby, the electronic avalanche ceases.
9. Plus ion gas moves to the negative pole(Since it is a molecule, movement takes time).

10. Current flows, and an electronic avalanche is promoted.

11. An electronic avalanche does not stop. Then, electric discharge prevention gas is put in.

12. Electric discharge prevention gas receives a plus electric charge.

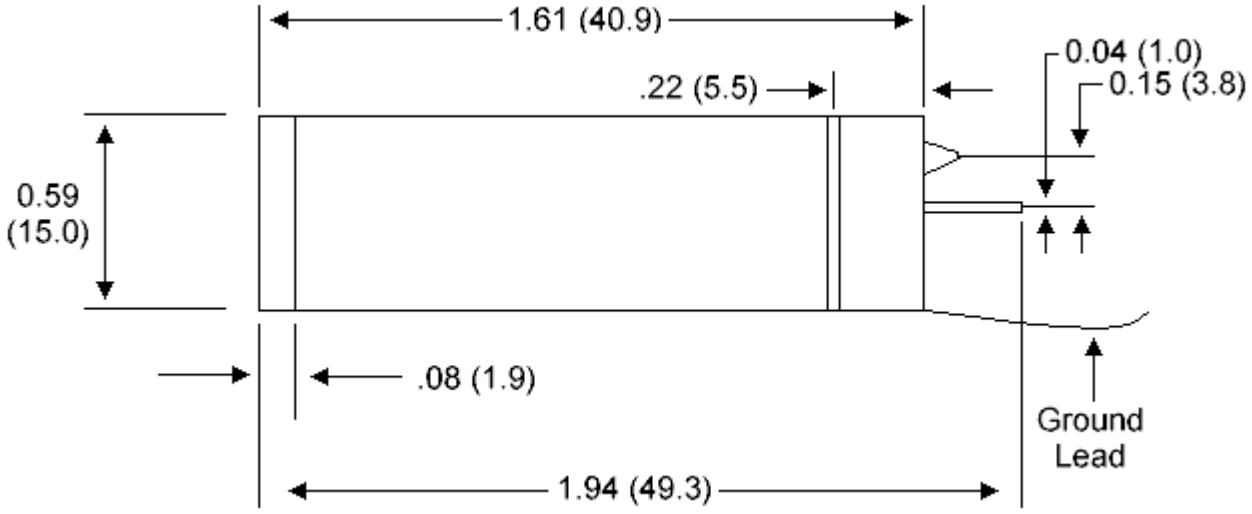
13. Although electric discharge prevention gas reaches the negative pole, an electronic avalanche is not promoted at this time.

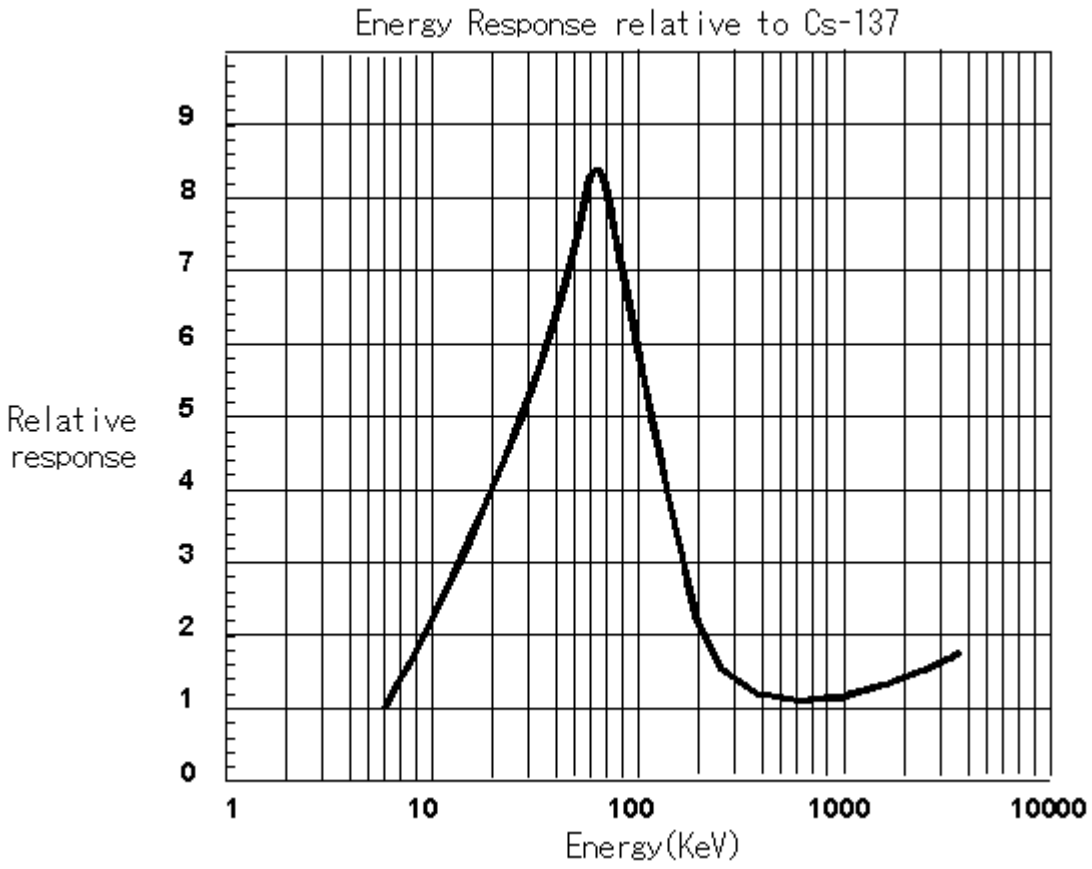
14. Electric discharge prevention gas returns to a molecule.

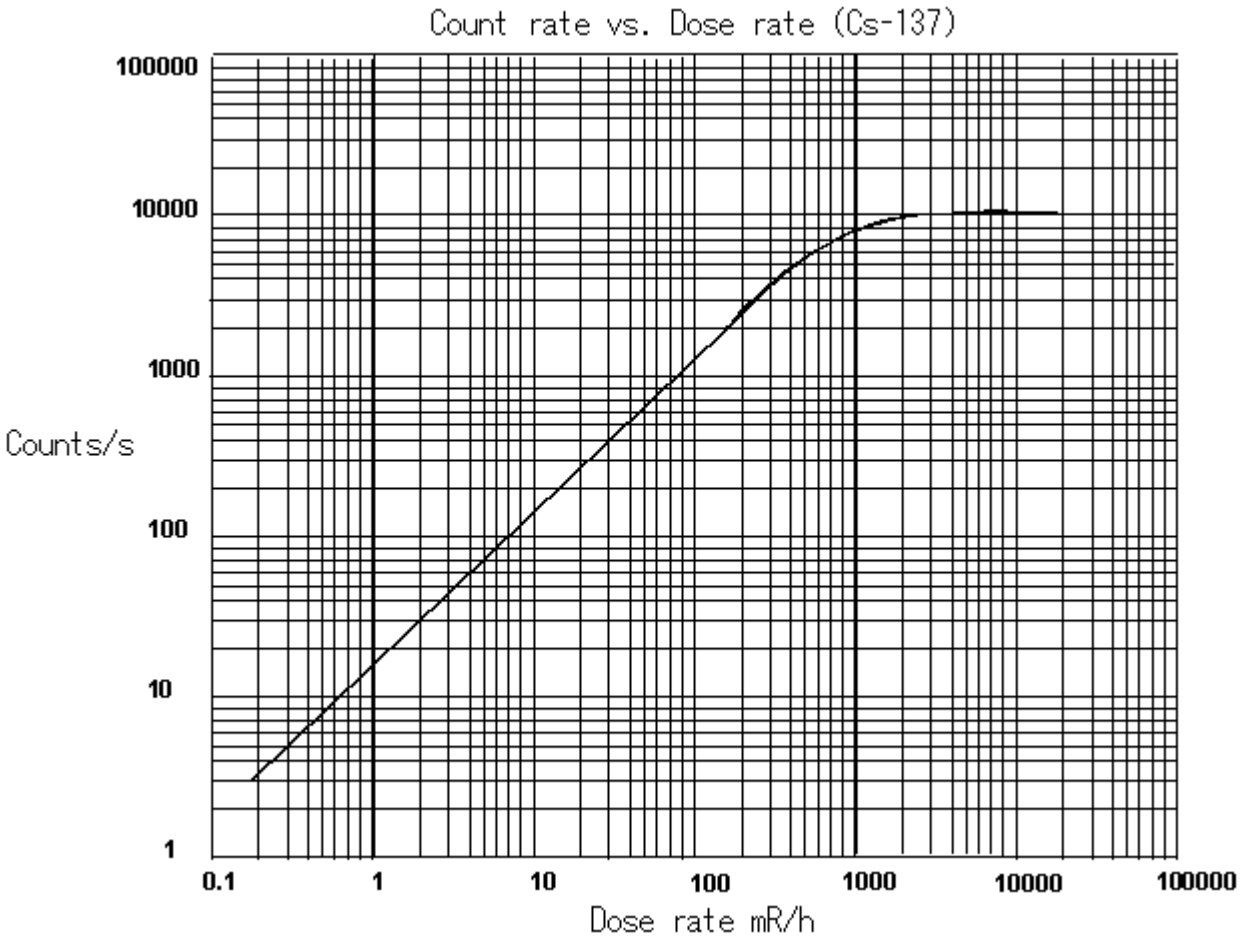
Section 3 Geiger Muller tube

I got a Geiger Muller tube. The model number is GMT-01. LND 712 is same specifications.

Size unit inch(mm)







Electrical Characteristics

Maximum Starting Voltage (volts)	325
Recommended Operating Voltage (volts)	500
Operating Voltage (volts)	450 - 650
Minimum Dead Time (u sec)	90
Maximum Plateau Slope (% / 100 volts)	6
Recommended Anode Resistor (M ohms)	10
Gamma Sensitivity Cs137 (cps / mR / hr)	18
Max. Background Shielded 50 mmpB = 3 mmAl (cpm)	10
Tube Capacitance (pF)	3
Weight (grams)	8

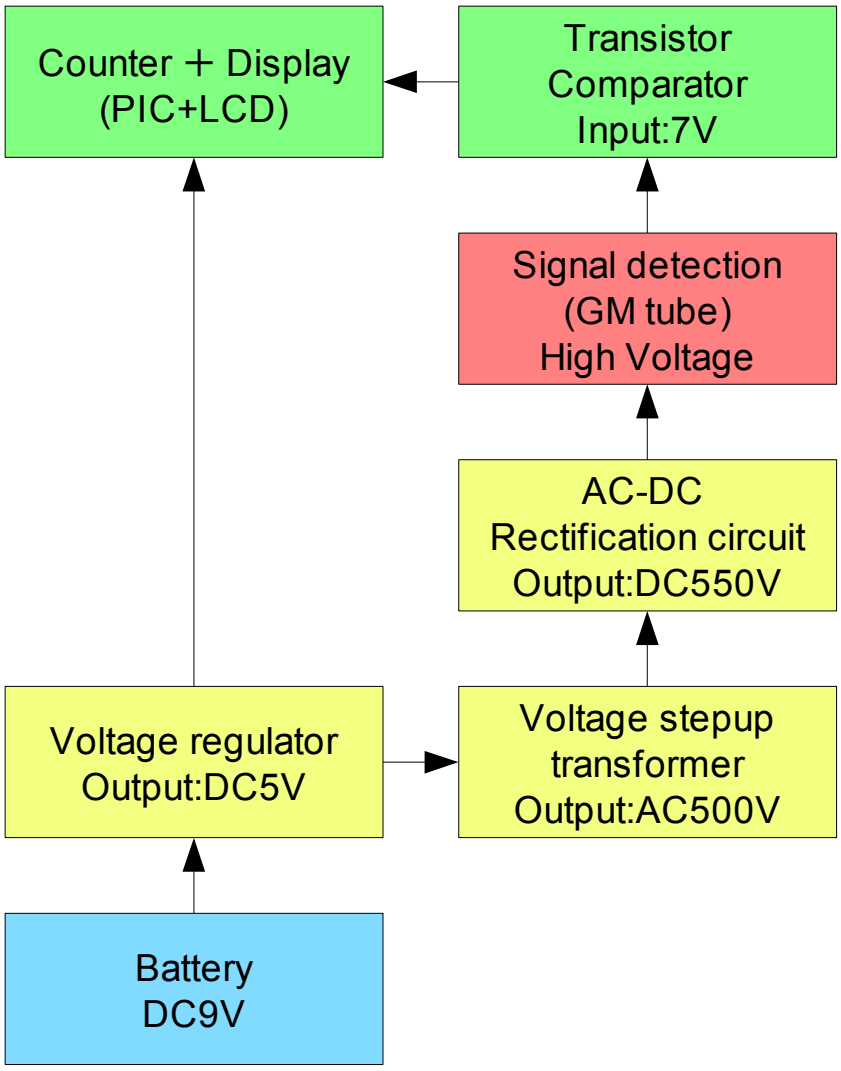
Mechanical Characteristics

Active Length (inch / mm)	1.53 / 39.0
Active Diameter (inch / mm)	0.354 / 9.0
Cathode Material	446 Stainless Steel
Cathode Wall Thickness (inch / mm)	0.010 / 0.25
Mica Window Areal Density (mg / cm2)	1.5-2.0
Effective Window Diameter (inch / mm)	0.354 / 9.0
Fill Gas	Ne / Ar + Halogen
Operating Temperature Range (ºC)	-40 to +75
Type of Connector	Pin

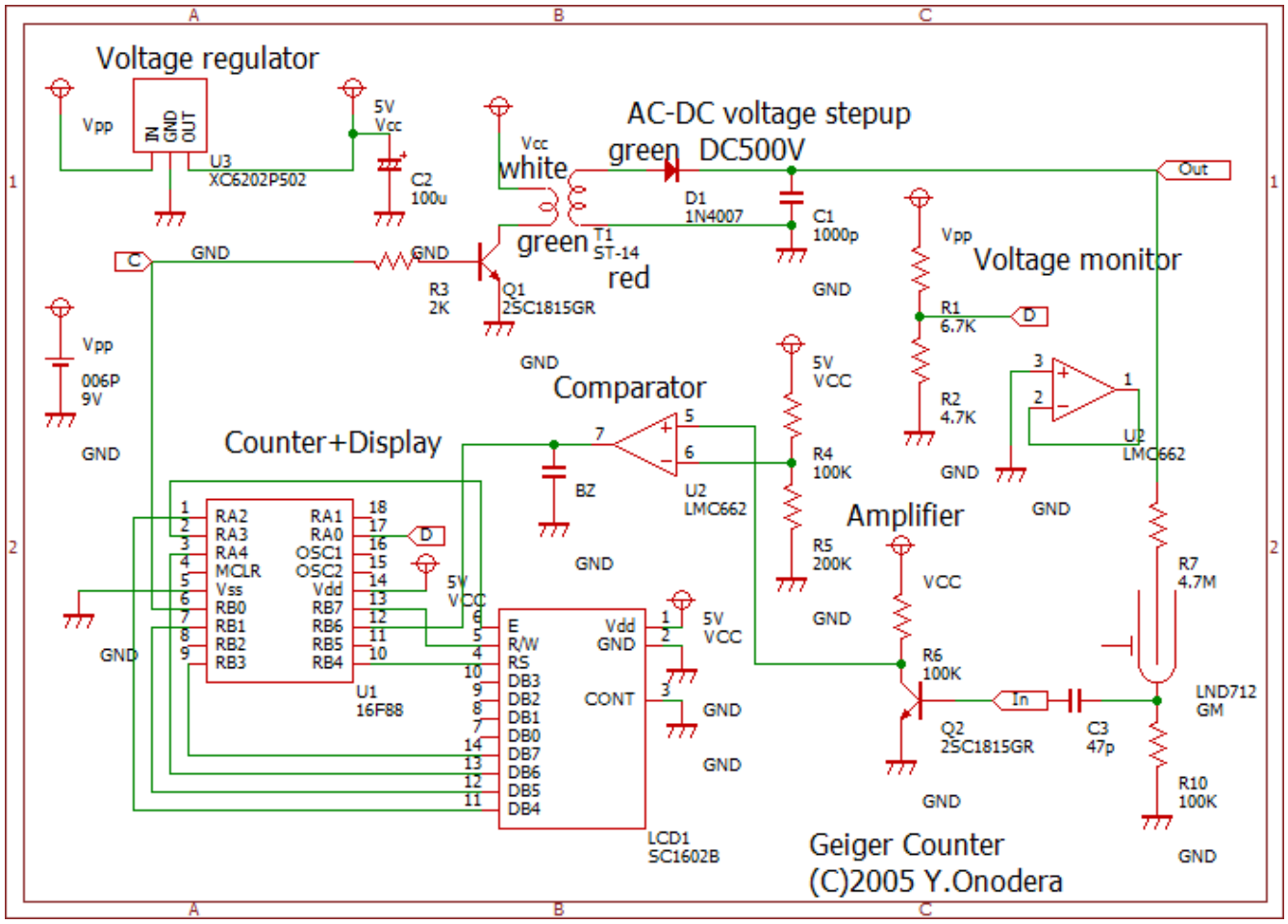
Section 4 Geiger Counter specifications

Detective radiation	alpha, beta, gamma and X-rays
Measurement range	0.000 - 9.999[uSv/h] 1 minute interval 10.00 – 99.99[uSv/h] 1 minute interval 100.0 – 999.9[uSv/h] 1 second interval 1.000 – 9.999[mSv/h] 1 second interval Over 5.555[mSv/h] will be saturated.
Display range	0-65536[cps], 0-65536[cpm], Over 10000[cps] will be saturated. The remaining measurement time:0-59[sec], Battery voltage:0.0-9.9[V]
Size	W117xD84xH41[mm]
Weight	120[g]
Monitor	Detection sound, Battery voltage
Battery	006P 9V Alkaline
Current consumption	approximately 2.8[mA]
Battery life	approximately 178hours with Alkaline

Section 5 Function block diagram



Section 6 Circuit



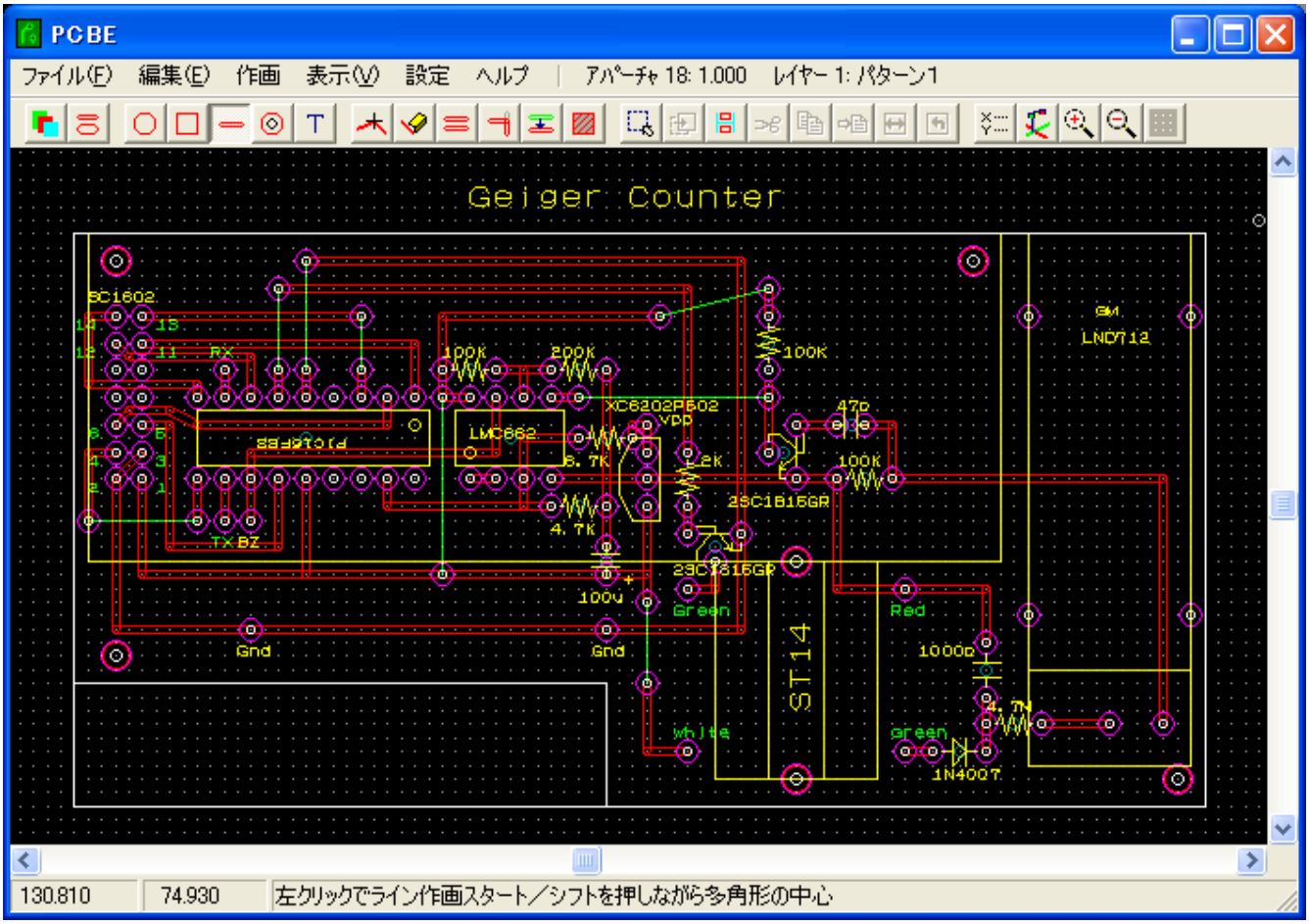
Section 7 Parts table

Part value	quantity	Part number	Note
1000p	1	C1	Ceramic capacitor,Voltage-proof 1KV
100u	1	C2	Chemical capacitor,Voltage-proof 16V
47p	1	C3	Ceramic capacitor
1N4007	1	D1	power diode,Voltage-proof 1KV
SC1602B	1	LCD1	16 rows 2 lines LCD, with HD44780
2SC1815GR	2	Q1,Q2	NPN general purpose transistor, hfe range:200-400, compatible 2PC1815GR, Not pin compatible 2N3904
6.8K	1	R1	Carbon resistance 1/4W
4.7K	1	R2	Carbon resistance 1/4W
2K	1	R3	Carbon resistance 1/4W
100K	3	R4,R6,R10	Carbon resistance 1/4W
200K	1	R5	Carbon resistance 1/4W
4.7M	1	R7	Carbon resistance 1/4W
ST-14	1	T1	SANSUI Transformer (impedance 500K:1K)
16F88	1	U1	PIC(Microchip)
LMC662	1	U2	CMOS Operational amplifier
XC6202P502TB	1	U3	Voltage regulator 5V, same as 78L05
9V	1	006P	Alkaline battery, Nickel hydrogen battery is good.
BZ	1	BZ	A piezo-electric element
GMT-01	1	GM1	Geiger Muller tube
Case	1	Case	Case 117x84x41mm

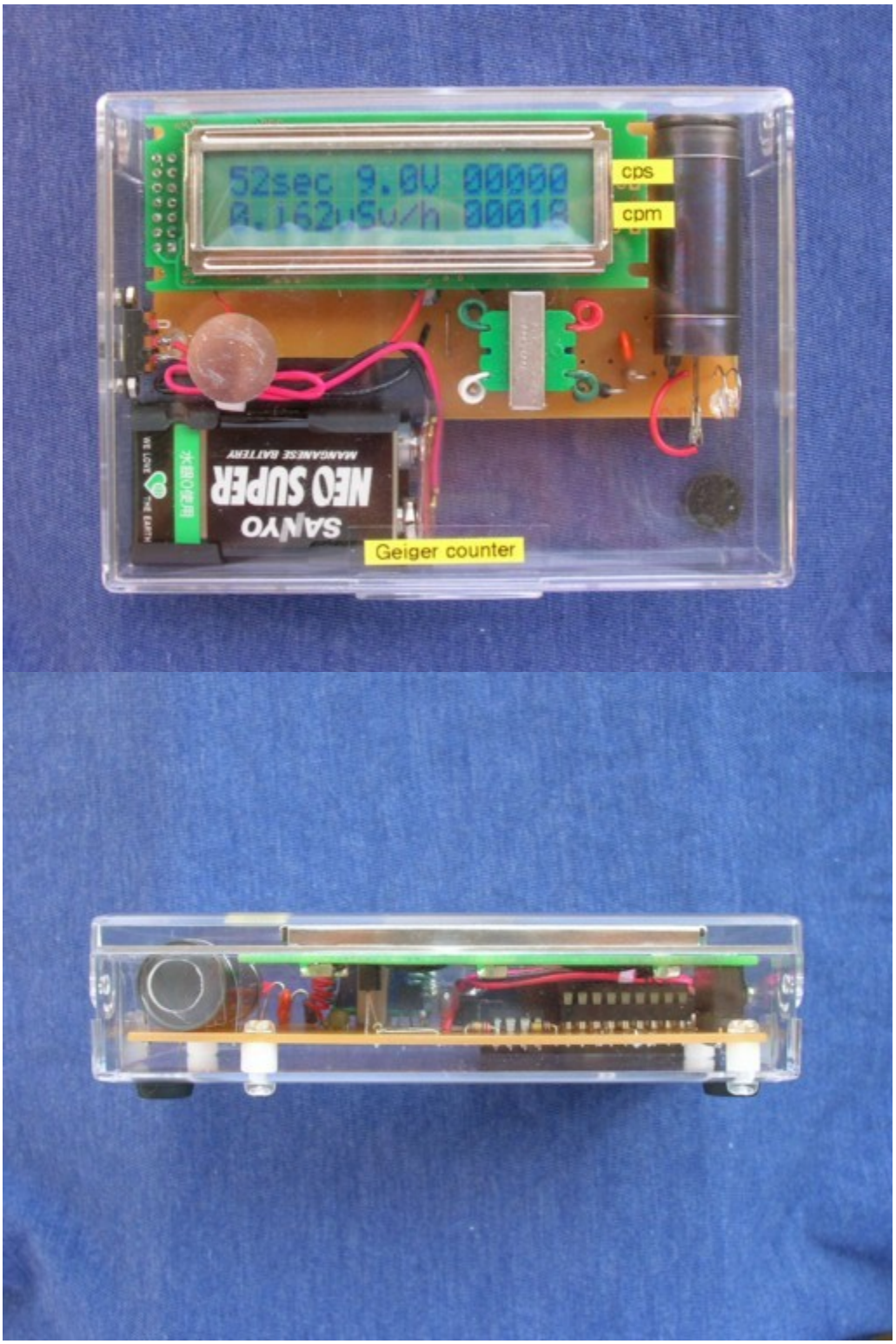
- LMC662 is CMOS and Rail-to-Rail type.
- 78L05 has about 2mA of self-consumption current.

Section 8 PCB

PCB was designed with electronic CAD.



Section 9 Photos



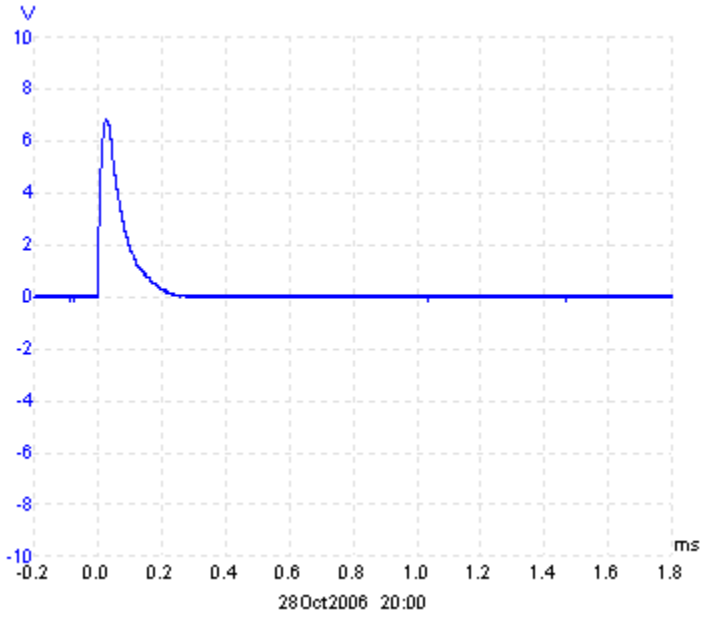
Section 10 Firmware

I made a firmware for PIC16F88 with HI-TECH C.

- 18cps/mR/h = 1.8cps/uSv/h = 108cpm/uSv/h
- uSv/h=CPM / 108 = CPM x 0.00926

Section 11 Detected pulse

A detection pulse is about 7 V, 200us.

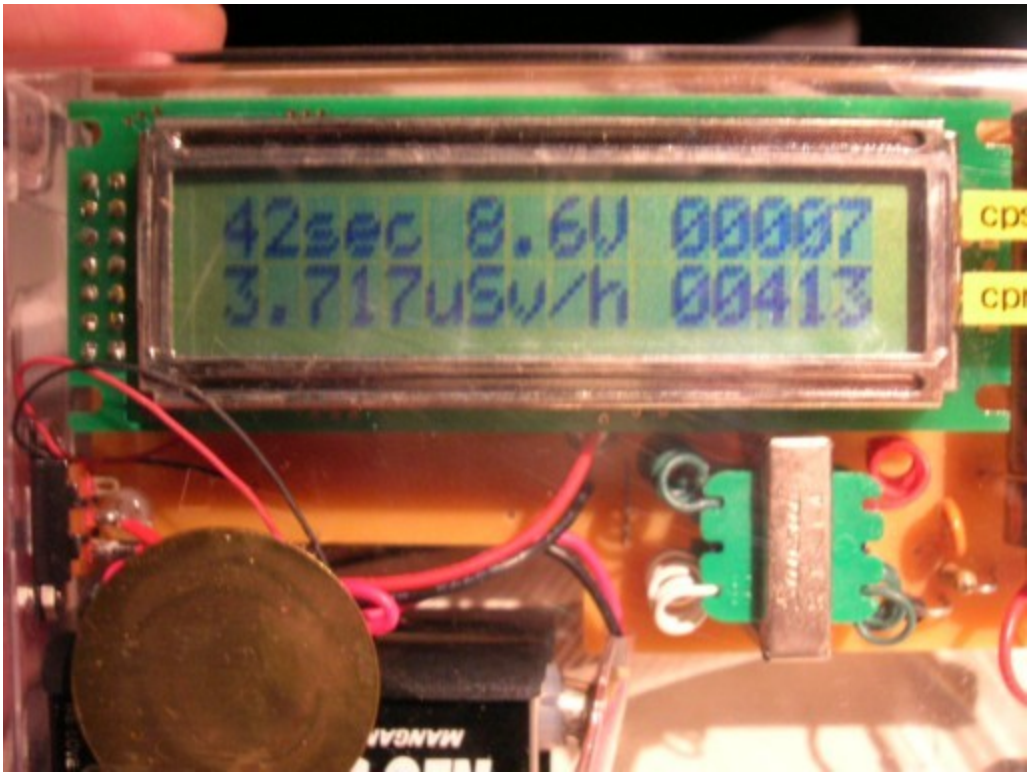


Section 12 Background

20[cpm] = 0.194[uSv/h]

Section 13 In flight radiation

3.7[uSv/h] at 11,277[m](37,000[feet])



Section 14 Uranium grass

0.594[uSv/h]

Section 15 Conclusion

It was at 14:46 11 Mar. 2011. Big earthquake had damaged Fukushima Daiichi nuclear power plants. There were three active reactors and three nonactive reactors. All active reactors went to shutdown automatically. But all power plants had lost power to control themselves. Tsunami had broken them. So cooling system couldn't work after shutdown to go safe mode. Uncontrolled hot fuel rod had lead to three hydrogen explosions.

I could detect a radiation at 15 Mar. 2011 in Tokyo Japan. Tokyo is located 250km south side of the nuclear power plants. It was north wind. Radioactive fog was moving in Tokyo. This Geiger Counter was very useful for us.

Time	[uSv/h]
2011-03-13,12:20	0.185
2011-03-14,12:20	0.203
2011-03-15,09:00	0.444
2011-03-15,12:00	0.314
2011-03-16,08:00	0.361
2011-03-16,12:10	0.212
2011-03-17,09:30	0.240
2011-03-17,12:30	0.231
2011-03-18,12:10	0.212
2011-03-19,12:20	0.185
2011-03-20,14:20	0.212
2011-03-21,14:00	0.203
2011-03-22,12:30	0.296
2011-03-23,14:20	0.222
2011-03-24,14:20	0.250

