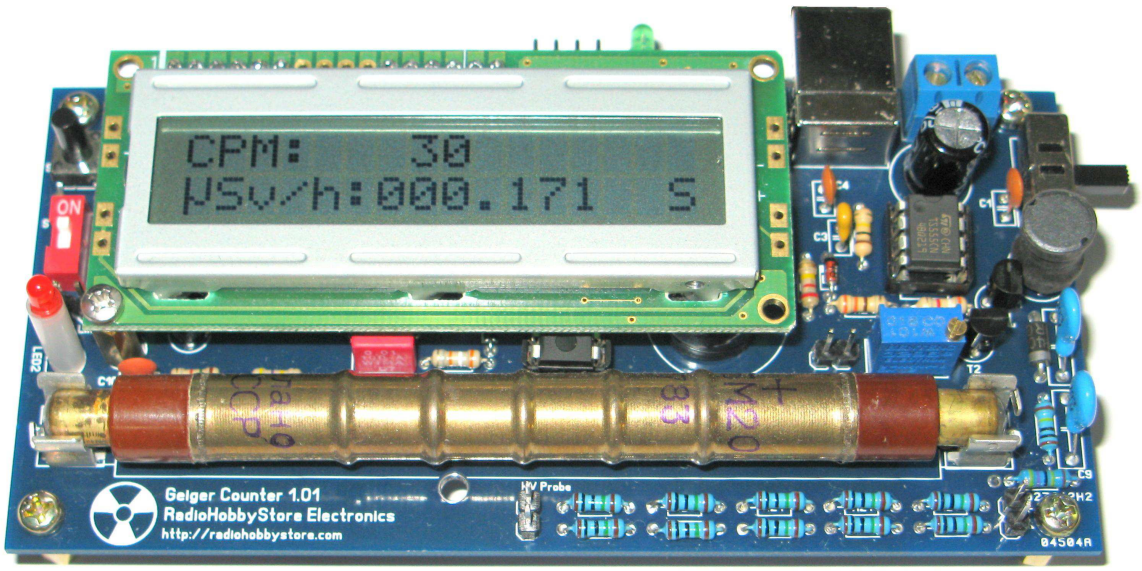
Geiger Counter DIY kit

ver. 1.02



http://radiohobbystore.com

Components List:

Resistors:

R1 – Carbon Film Resistor 220K (red, red, yellow, gold)
R2 – Carbon Film Resistor 330R (orange, orange, brown, gold)
R3 – Carbon Film Resistor 3.9K (orange, white, red, gold)
R4, R15 – Carbon Film Resistor 100K (brown, black, yellow, gold)
R5, R12 – 1% Metal Film Resistor 1M (brown, black, black, yellow, brown)
R6 – 1% Metal Film Resistor 4.7M (yellow, violet, black, yellow, brown)
R7, R11 Carbon Film Resistor 10K (brown, black, orange, gold)
R8 - Carbon Film Resistor 1.5K (brown, green, red, gold)
R9, R13 – Carbon Film Resistor 470K (yellow, violet, yellow, gold)
R10 – Carbon Film Resistor 27K (red, violet, orange, gold)
R14, R29 – Carbon Film Resistor 1K (brown, black, red, gold)
R17– Carbon Film Resistor 39K (orange, white, orange, gold)
R19,R20,R21,R22,R23,R24,R25,R26,R27,R28 – 1% Metal Film Resistor 10M (brown, black, black, green, brown)
R16 – Carbon Film Resistor 36-100 Ohm (optional)
P1 – Variable Resistor Potentiometer 3296W 100 ohm
P2 – Variable Resistor Potentiometer 10K (103)

Capacitors:

C1, C4, C8, C11, C14 – Ceramic Disc Capacitor 100nF (104)
C2 – Electrolytic Capacitor 470uF 16V
C5, C7 – Electrolytic Capacitor 470uF 10V or 220uF 10V
C3 – Multilayer Ceramic Capacitor 1nF (102)
C6, C9 – Multilayer Ceramic Capacitor 10nF 1KV (103)
C10 – Ceramic Disc Capacitor 330pF (331)
C12, C13 – Multilayer Ceramic Capacitor 22pF (220)
C15 – Film Box Capacitor 10nF (103)

Semiconductors:

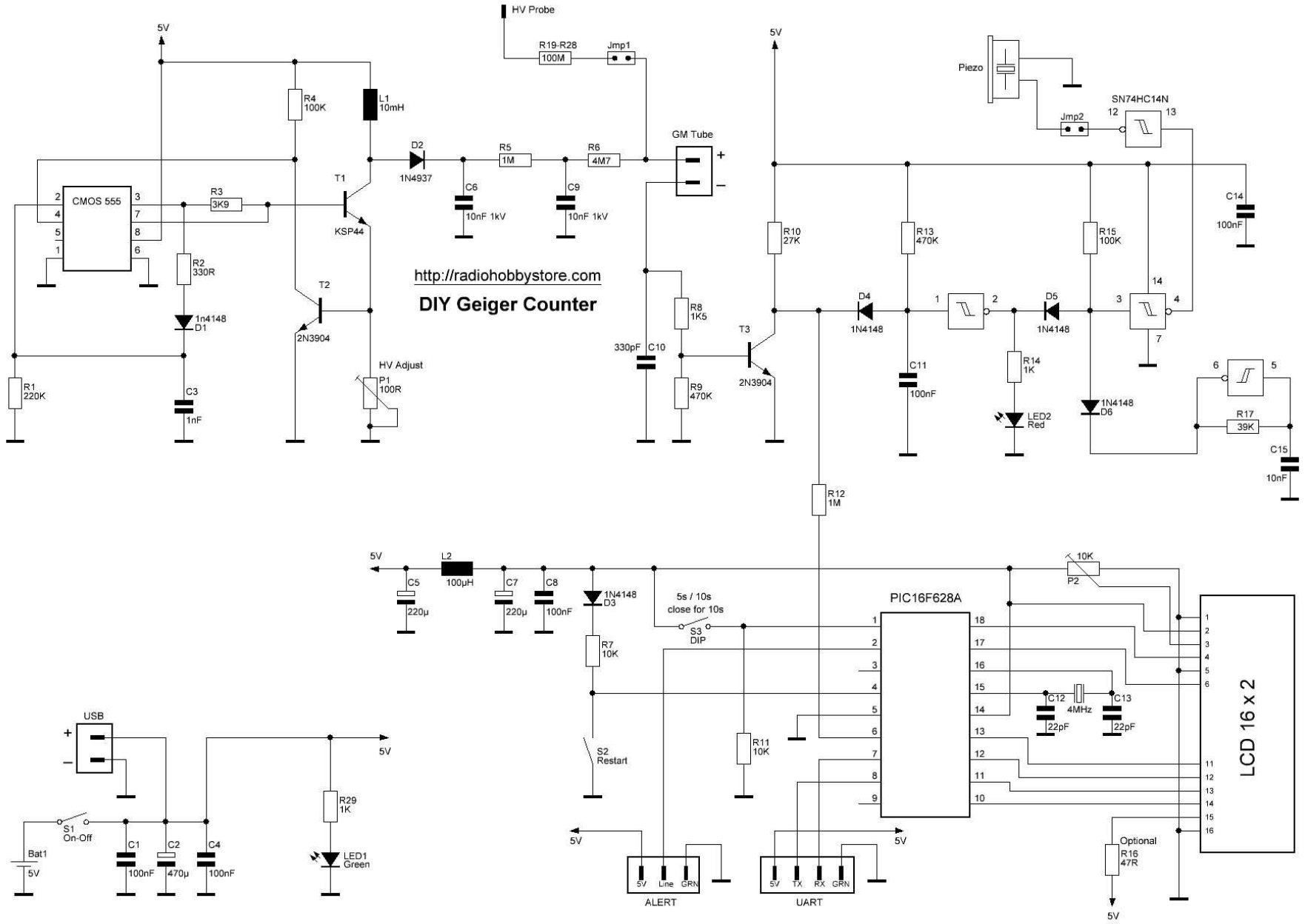
D1, D3, D4, D5, D6 – 1N4148 Small Signal Diode
D2 – UF4007 (can be replaced with 1N4937 or FR157)
T1 – KSP44 High Voltage NPN Transistor
T2, T3 – 2N3904 Generic NPN Transistor
TS555CN – CMOS 555 Timer IC
SN74HC14N – HEX Inverting Schmitt Trigger IC
PIC16F628A – Microchip MCU with last filmware
LED1 – 3mm Green Led
LED2 – 3mm Red Led

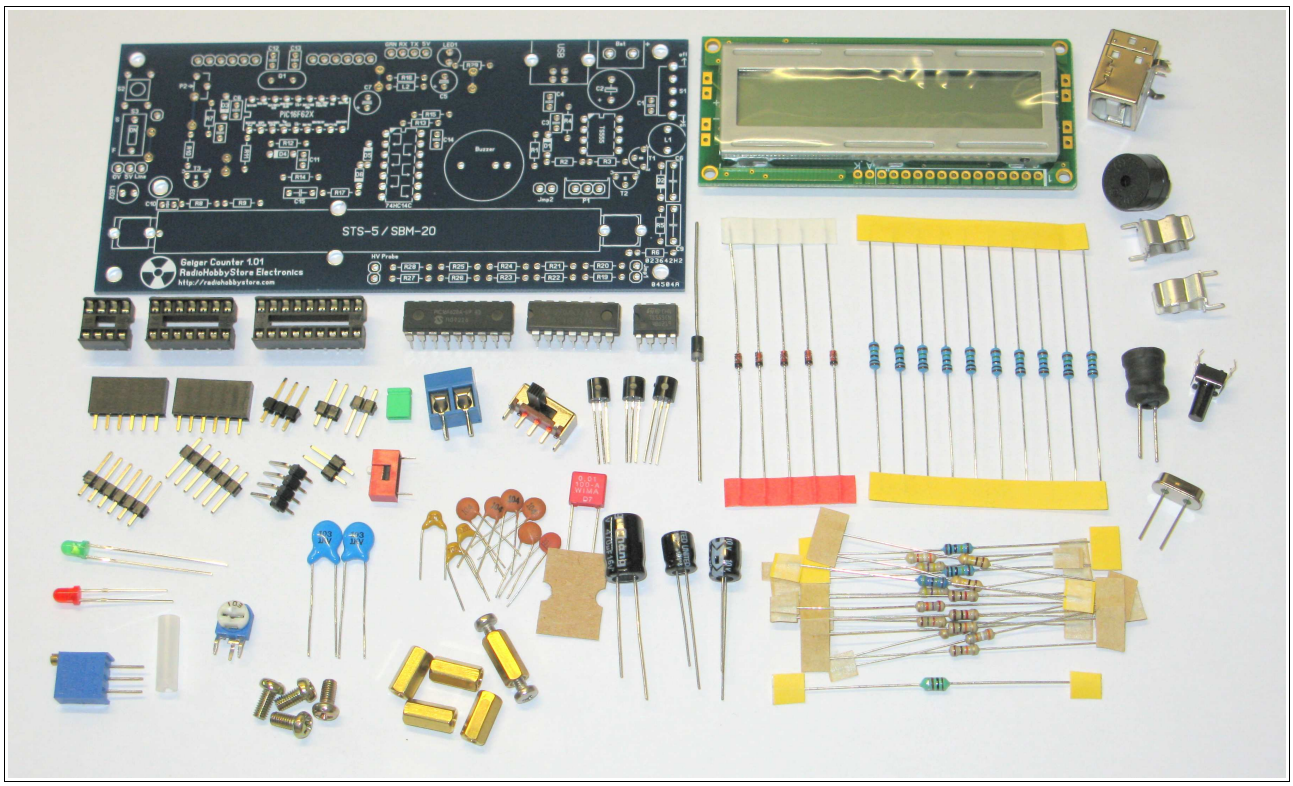
Inductor:

L1 – 10mH Inductor
L2 – 100uH Axial Inductor (green)

Other:

4.000 MHz Crystal
1x Buzzer
2x Tube Holder Clips
1x 8 Pin DIP IC Socket
1x 14 Pin DIP IC Socket
1x 18 Pin DIP IC Socket
1x Slide Switch On/Off
1x Terminal Block 2 Position
1x USB PCB Socket Type B
1x Led Holder
1x Tact Switch Button
1x Dip Switch Button 1 Position
21x Male Pin Header Pins (6+6+3+2+2+2)
4x Male Pin Header Right Angle Pins
2x 6Pin Female Header
1x Jumper Cup
2x M2.5 Screw
1x M2.5 Standoff 11mm
4x M3 Standoff
4x M3 Screw
1x LCD 16x2 HD44780 (optional)


http://radiohobbystore.com
DIY Geiger Counter
5V
HV Probe
R19-R28
100M
Jmp1
R4
100K
L1
10mH
D2
1N4937
R5
1M
R6
4M7
GM Tube
T1
KSP44
CMOS 555
R3
3K9
C6
10nF 1kV
C9
10nF 1kV
R2
330R
1n4148
D1
T2
2N3904
HV Adjust
P1
100R
R1
220K
C3
1nF
330pF
C10
R8
1K5
R9
470K
T3
2N3904
Piezo
Jmp2
SN74HC14N
C14
100nF
R10
27K
R13
470K
R15
100K
D4
1N4148
D5
1N4148
C11
100nF
R14
1K
LED2
Red
1N4148
D6
R17
39K
C15
10nF
R12
1M
L2
100µH
C5
220µ
C7
220µ
C8
100nF
1N4148
D3
R7
10K
5s / 10s
close for 10s
S3
DIP
S2
Restart
R11
10K
PIC16F628A
10K
P2
C12
22pF
4MHz
C13
22pF
LCD 16 x 2
USB
S1
On-Off
Bat1
5V
C1
100nF
C2
470µ
C4
100nF
R29
1K
LED1
Green
5V
Line
GRN
ALERT
5V
TX
RX
GRN
UART
Optional
R16
47R



Technical Specifications:

- Geiger Tube PCB Compatibility: STS-5, SBM-20
- MCU can be pre-flashed for any Conversion Factor (0.0057 by default for SBM20)
- Supply Voltage: 5V (USB, 4x 1.25V Ni-Cd Battery, 3x 1.5V Alkaline Battery)
- Supply Current: 8.5mA - 25mA
- PCB Dimensions: 125 x 60 mm
- LCD 16x2 HD44780
- CPM Counting and uSv/hr Calculation
- 5 or 10 Seconds Measure Period, selected with DIP Switch
- Sound and Led Events Indication
- Alarm Threshold (1000 by default)
- Arduino Compatibility
- UART Data CPM sending
- Freeware Windows Software for monitoring on your PC
- Easy High Voltage Adjustment with a regular 1M/10M Multimeter

DIY Geiger Counter Kit include electronics to drive GM Tube with high voltage, it also include electronics to detect events from the tube and provide visual and sound indication of ionization radiation. The MCU part of the project produce CPM and radiation dose calculation.

The original high voltage circuit stage was published in “Nut's and Volt's” January 2004 by Tom Napier.

The kit is supplied without Geiger Tube! The tube, batteries, enclosure and TTL USB module should be purchased separately! It's possible to purchase the kit without LCD if you have your own and want to save some money, so please choose right package for you during checkout. We also can supply GM Tube for additional cost.

This is not ready to use device! You need to solder and calibrate it. You also will need to install it into enclosure. Assembly of the kit require good soldering skills.

When you are buying DIY Kit you are agree that you have certain skills to solder it by yourself. We are not responsible if you damage the PCB or other kit's parts due to wrong assembling or handing. If you do not have enough soldering skills please add to your cart our "DIY Kit Assembling Soldering Service" and we'll send you fully soldered and calibrated kit.

We can accept return for the kit only if you not started to solder it.
To power the Geiger counter you can use USB port of your PC / COM-USB Module / 4x Ni-Cd Batteries / 3x Alkaline 1.5V Battery. Please turn the power switch OFF or disconnect the batteries when using USB! The board do not include over-voltage and reverse voltage protection. Stay below 5.5V supply voltage.

Take note: this is amateur and educational purpose project. The radiation level calculation may be not accurate! Avoid using this device in high radiation area where you can be exposed to dangerous levels of ionizing radiation.

Why radiation level calculation maybe not accurate? There is several reasons for it. For example is necessity to use beta-filter during measuring gamma radiation sources. Lack of proper beta-filter can lead to a significant increase in readings. Another reason is +-20% GM Tube tolerance.

MCU Software:
By default the MCU pre-flashed with Conversion Factor 0.0057 for SBM20/STS5 tube and Alarm Threshold of 1000cpm. Before you buy you can contact support if you need other values pre-flashed or you can modify the asm file by yourself. If you do not have experience with PIC's programming we advise to use the default filmware.

The software has 2 time period : Fast (5 sec) and Slow (10 sec) for radiation measuring. Time period can be selected with S3 DIP Switch. Slow period is better for background radiation level.

Firmware 1.02: Maximum counting ability now is 175000 cpm. The SBM-20 tube has 180000 cpm theoretical limit.

Firmware 1.01 only (old): Firmware has limitation to 65535 cpm.

Arduino Compatible:
The MCU can communicate with Arduino. It generate external interrupts that can be used in your Arduino based projects. For example, you can connect the kit to Cosm. Use pin “Line” for the connection (please refer Arduino connection manual pdf for more technical details).

UART Communication:
Geiger Counter send CPM data via UART every 5/10 seconds. It can be used with our Windows software for monitoring radiation level on your PC. Actually you can use any COM-Terminal program or other MCU to receive the data. Please refer “Radiation Logger” software manual for more technical details and UART settings.

High Voltage Circuit:
Most popular Geiger tubes needs 350-450V DC anode voltage. There is several ways to produce a HV. First, is step-up transformer with a blocking generator and voltage multiplier. Many factory made dosimeters has a transformers. Second options is a step-up converter circuit without a transformer, that we use in our DIY kit.
For normal operation the high voltage do not need to be stabilized, so several volts drifts will not

affect the results because of tube plateau. CMOS 555 timer generate 30uS on and 3ms off frequency, something about 3.5KHz. It drive KSP44 transistor to produce high voltage over 10mH inductor. Ultra fast diode rectifier the AC voltage. Since Geiger tube consume only several uA, it do not need large capacitors. Two accumulative 10nF capacitors will supply the required current for the tube. You can install even two tubes in parallel to increase the sensitivity. P1 potentiometer allow to adjust the HV.

Pulse registration circuit stage is build with T3 transistor and logic 74HC14N IC.

LCD Backlight:
If you purchased our kit without LCD, you can use any HD44780 compatible 16x2 display. Additional R16 resistor need to be installed for backlight (10 ohm-100 ohm).

Assembling and Soldering:

Please follow our assembling and soldering instruction steps. Print the circuit and put it in front of your eyes during the soldering. All components is marked on the pcb silkscreen. Take your time to perform a solder work. It can take about two hours to complete the kit.

Remember do the clean solder work and install right components in the right place, because it always hard to unsolder the parts from the PCB. Color bands of the resistors may be hard to distinguish, and you need to check each resistor with a meter before soldering.

We cannot be responsible if you'll overheat your PCB or will damage the kit components during wrong soldering with a mistakes. So please double check yourself before you solder. Remember to use a solder with Rosin Core Flux. Some industrial flux has several Mega-ohms resistance and they require a special cleaning that cannot be performed at home.

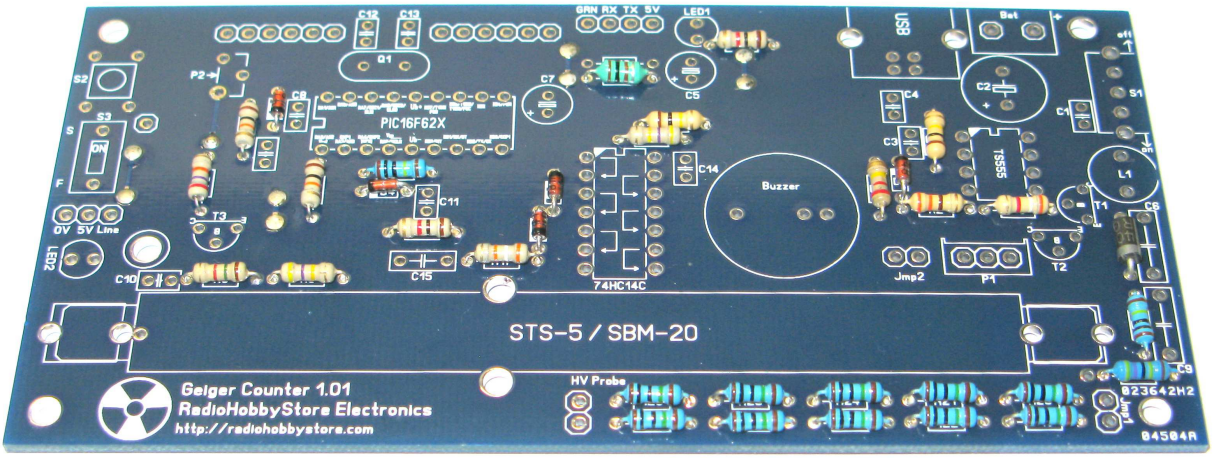
Do not apply too much solder. Extra flux can be cleaned with soft brush and isopropyl alcohol. A good joint should look like:

We advice you to use 0.8mm or 1.00mm thickness lead solder wire with low melt point:

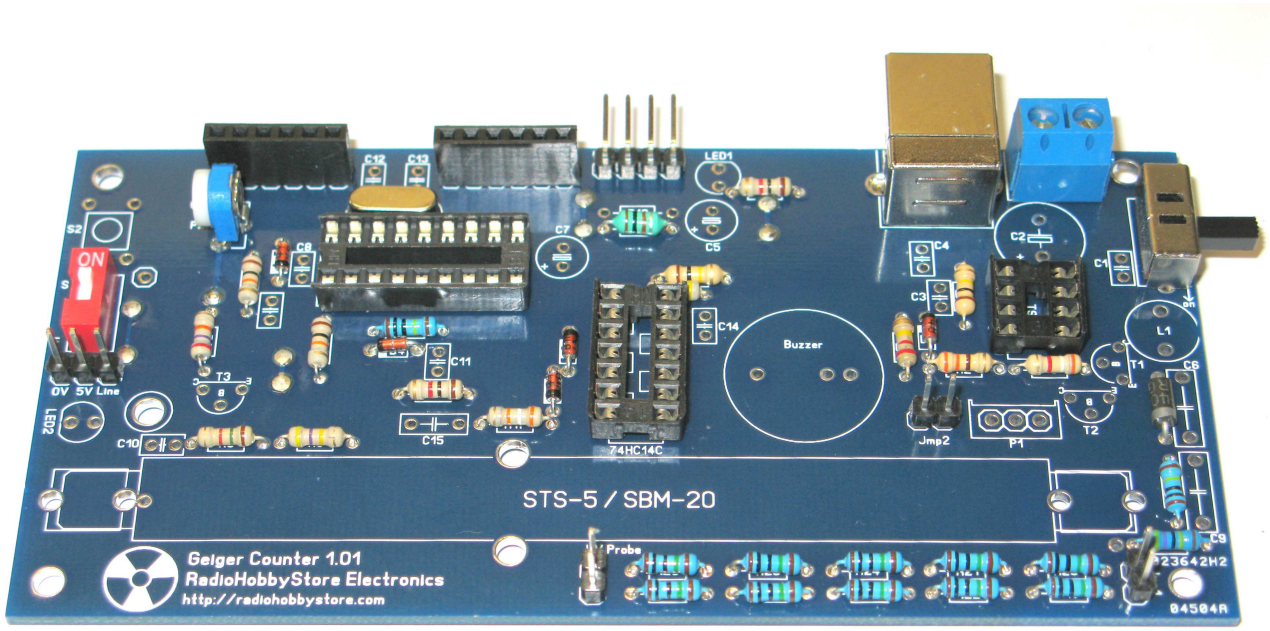
60/40 – 186 Celsius (386 Fahrenheit)
63/37 – 183 Celsius (361 Fahrenheit)

We do not recommend to use lead free solder for the kit! Lead free solder need very high temperature for good flow and it can destroy the pcb pads if you'll need to do some repair. Its very hard to unsoder components from the pcb if lead free solder was applied. We cannot accept kit for the repair if you used lead free solder.
If you'll need to remove excess solder from the pad, use right desoldering tools (braid wick or small pump).

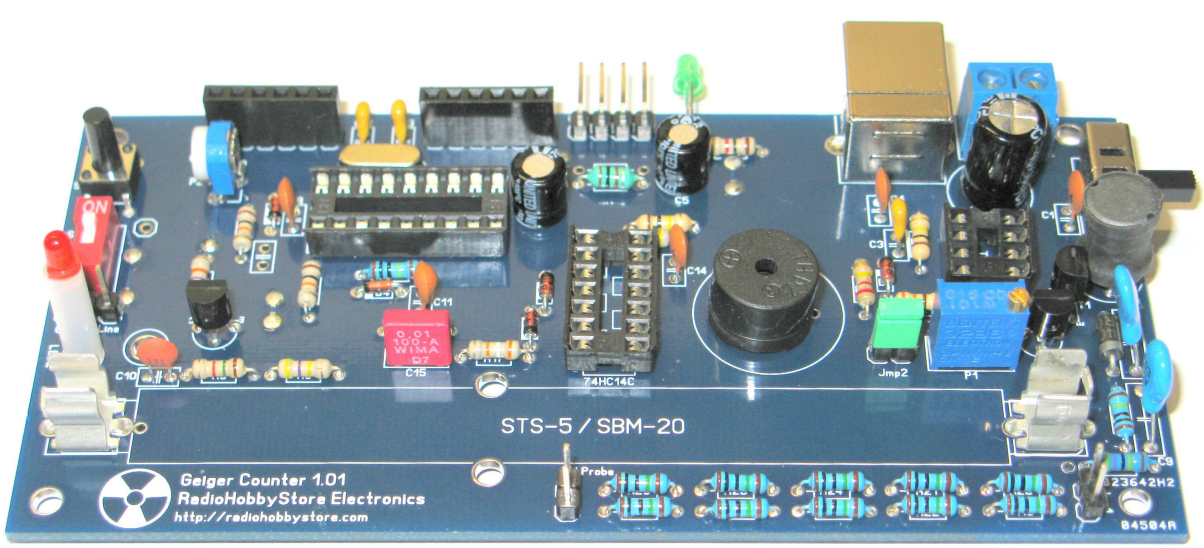
Its better to start soldering with horizontal placed components : resistors, diodes, L2 coil



Then place electromechanical components, 4.000MHZ crystal and P2 potentiometer.

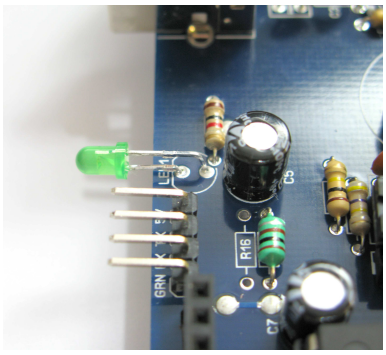


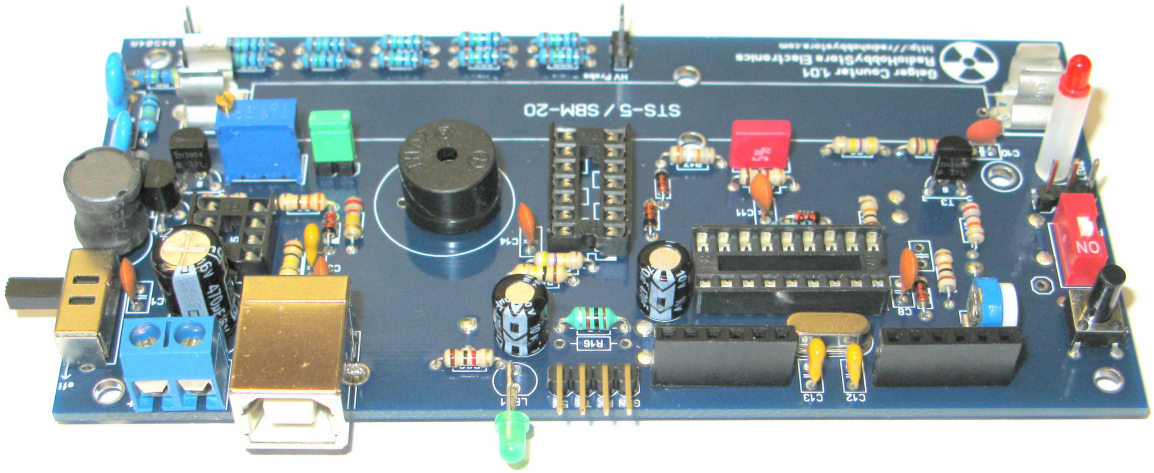
The holes for the buzzer are little wider than it necessary, so be sure to install the buzzer as close to



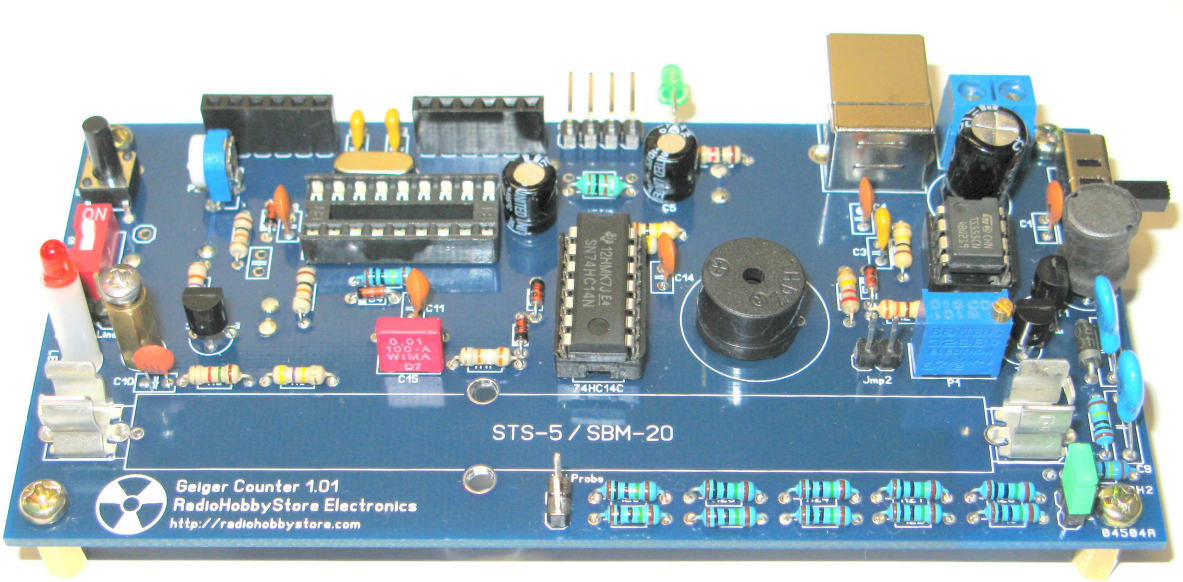
the board as it possible. Put attention to led's, diodes, electrolytic caps and transistors direction.

Power indication LED-1 installed in right angle position. LED-2 plastic holder is necessary when using enclosure.





Insert 74HC14 and CMOS555 IC's in theirs sockets. Put attention to IC's direction! Install 4x M3 standoff and one M2.5 LCD standoff.



To avoid simple problems please check now with continuous tester all 5V and GND points on the PCB:

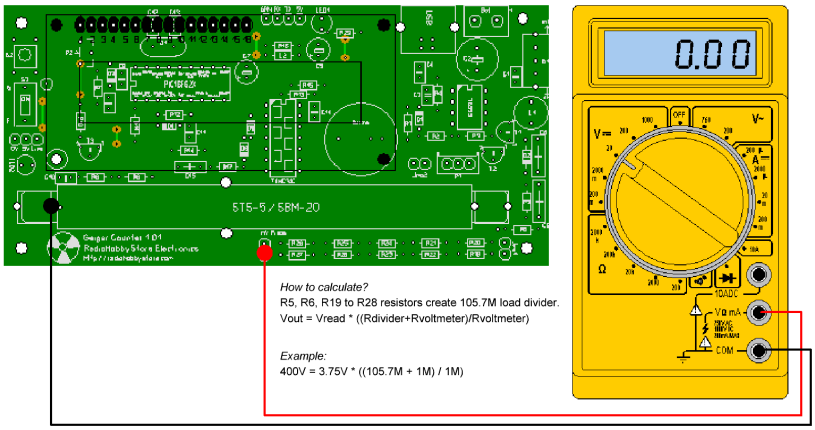
PIC16F628A : VDD pin 14; GND pin 5
TS555: VDD pin 8; GND pin 1,6
74HC14N: VDD pin 14; GND pin 7

High Voltage Calibration:

You need to calibrate the high voltage **BEFORE** installing Geiger tubes, PIC16F628A and LCD! At first step check if all components are in their right place and direction. Check your solder work for shorts or “cold” joints. You can use multimeter continuously test. Compare your board with the pictures in the manual.

The HV calibration steps is:

1. Remove Jumper Cup **jmp2**
2. Install Jumper Cup **jmp1**
3. Trim multiturn P1 to approximately 30 ohm
4. Connect multimeter red probe to R28 Pin Header
5. Connect multimeter black probe to tube cathode clips (R8, C10 test point)
6. Sure your multimeter is on 20V/200V DC range
7. Power on the device with 4x Ni-Cd batteries or USB
8. Adjust voltage with P1 to 3.75-3.78V if you use 1M multimeter or adjust the voltage to 34.5V if you use 10M multimeter
9. Power off the device. Remove **jmp1** and install back **jmp2**



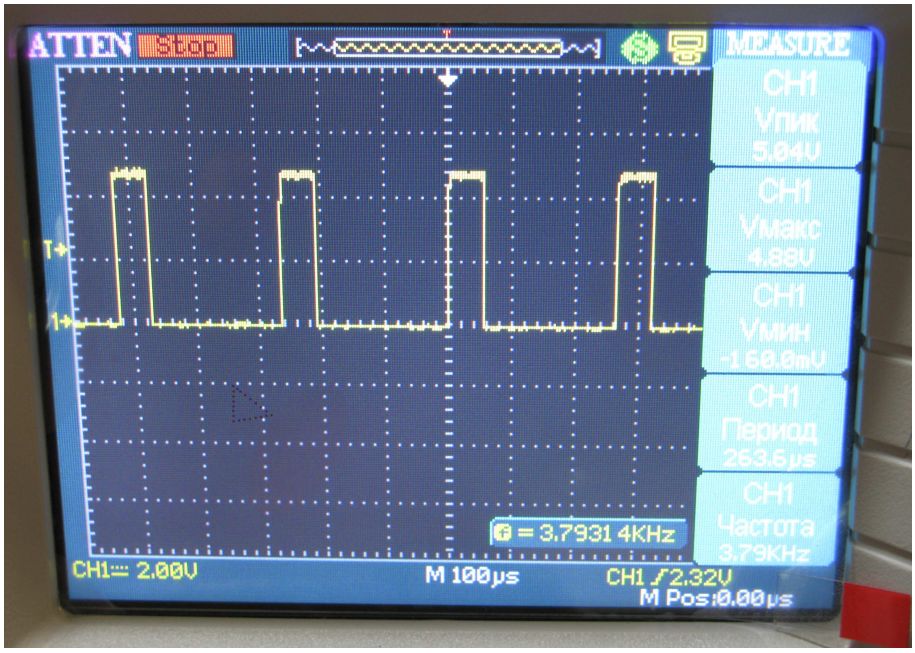
Vout = Vread * ((Rdivider + Rmeter) / Rmeter

Rdivider = 105.7M
Rmeter depend on multimeter type you use. A cheap one like DT832 has 1M internal resistance.
Vout is 400V

So we need **Vread = 3.75V** for 1M multimeter and **Vread = 34.5V** for 10M multimeter.

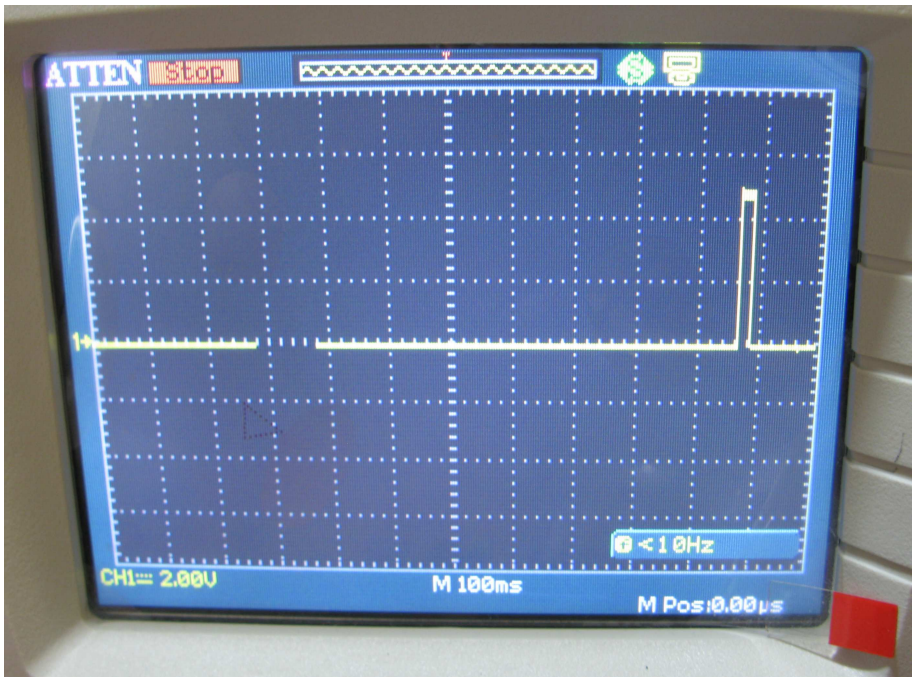
You can also measure HV without 100M divider on D2 cathode, but it overload the circuit because of low internal resistance of your multimeter and you'll read much more lower voltage than 400V! Please do not spin multiturn P1 potentiometer to much if you do not get right voltage readings when it was trimmed to 25-30 ohm.

If you have scope please test on pin#3 of the CMOS 555. It's will oscillate with 3.5KHz approximately.



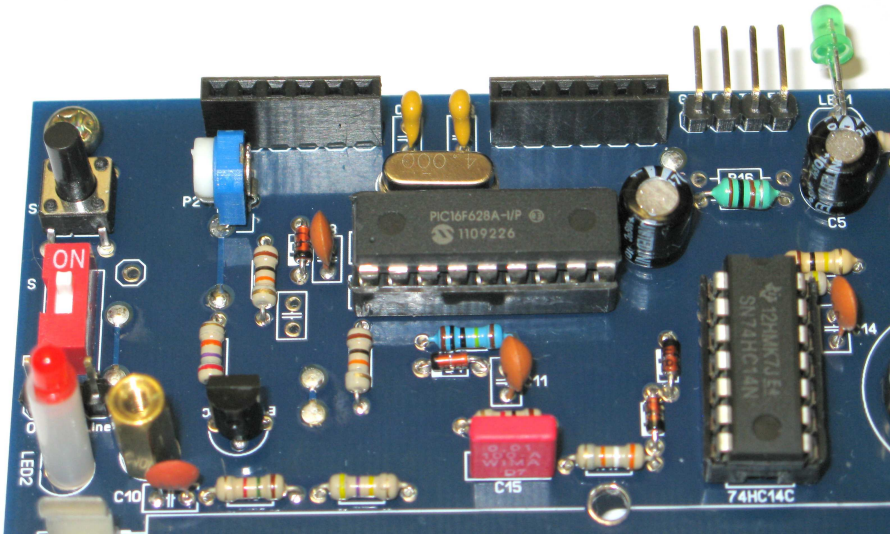
Tubes Installation:
Geiger tubes are very fragile items. Handle it with care!
The tube has anode (+) and cathode (-) sides. Anode side is marked on tube body and it connected to R6 resistor. SBM20 is shorter than STS-5 in 4mm, but the PCB allow installation of both. During device testing and using remember about high voltage 400V presented! Do not touch the tubes clips. Depend on your skin resistance and humidity you can feel the bite if touch, so please avoid touching with your hands or any metal items.

Registering event from GM Tube on the pin#2 of the 74HC14N

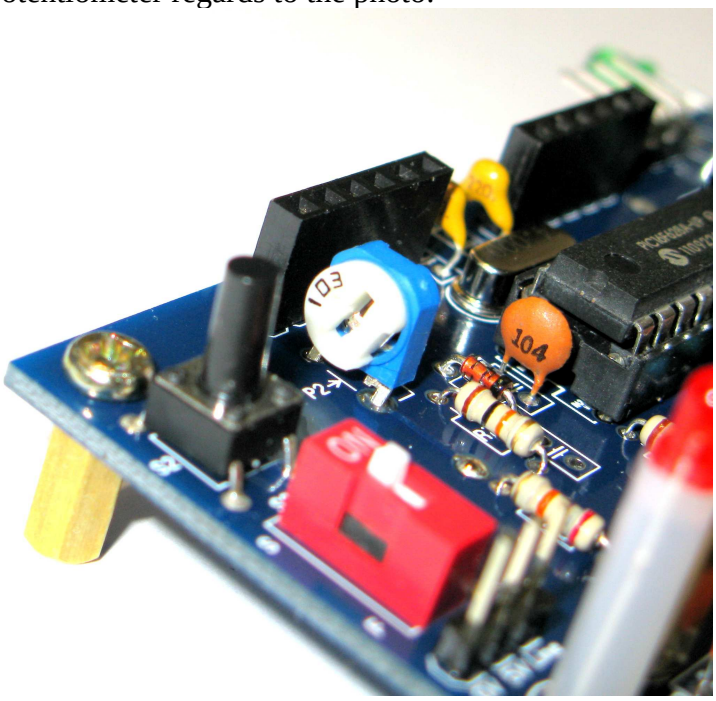


PIC16f628A and LCD installation:

After you have successfully calibrated high voltage and you got visual and sound events indication you can power off the device and install MCU with LCD. Install pre-flashed PIC16f628A chip in right direction (see photo).



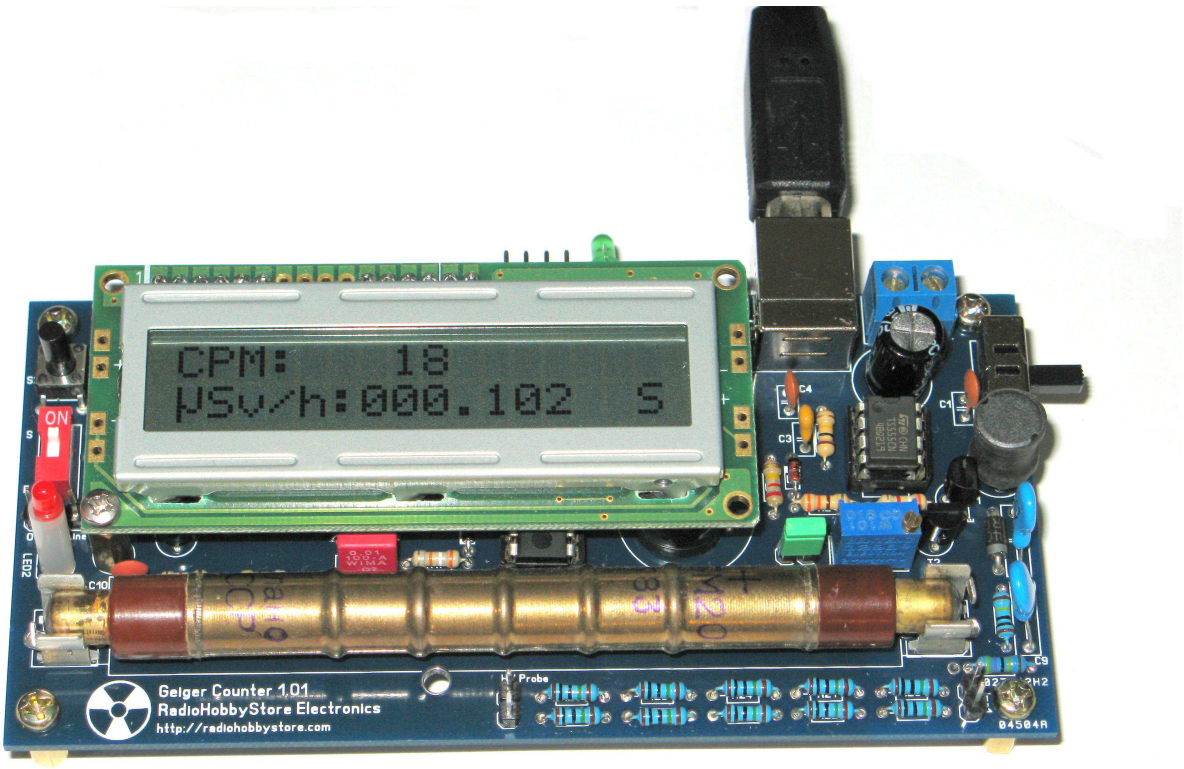
Trim P2 LCD contrast potentiometer regards to the photo:



You can re-adjust P2 potentiometer a little later, when LCD is connected. LCD Male pins (6+6) are inserted into 2x 6Pin Female Header. If you purchased the kit without LCD please use 16x2 HD44780 compatible. R16 can be installed for LCD backlight.

Now the device is fully assembled and ready to work. S3 DIP switch control measure period. ON for 10 seconds and OFF for 5 seconds. 10 seconds is better for background radiation level.

Each time you change time period you should restart MCU with S2 tact switch. Time period is indicated on LCD with F or S letter. **F** for fast 5 seconds and **S** for slow 10 seconds.



Take note of the batteries wires polarity because the circuit do not have reverse polarity protection!

If using USB or USB-TTL converter please disconnect the batteries or switch S1 to OFF position to avoid batteries explosion.

How to test GM tube?

When you buy NOS GM Tube ask your seller to test it. If you order the tube from our store we test it before shipping.

Do the visual test. It must to be free of cracks or dents. Shake the tube and check is there any sounds inside. It's should not be!
Clean rust from tube terminals for good electrical contact.

Where to find radiation source?

Visit this page for commonly available radioactive materials:
http://www.kronjaeger.com/hv/rad/src/list/index.html

Troubleshooting:

High voltage problems:

- Double check D1, D2, T1, T2, CMOS555 direction and position. If 555 IC was inserted in wrong direction then it probably have to be replaced with a new one. Be sure you get CMOS555 and not Bipolar. Transistors Collector-Emitter direction are also critical.
- Test L1 coil with ohm-meter, it should be about 16 ohm DC resistance.
- Test with a voltmeter all 5V PCB points.
- When kit power is off check with continuous test all ground PCB points.
- If you have scope compare with our oscilloscope screenshots.
- 555 timer oscillation can also be tested with a small speaker or piezo: connect speaker wire to pin#3 of the IC, you should hear 3.5-3.8KHz sound. This method are not perfect, but can help in some circumstance.

No counts problems:

- Check 74CH14N IC direction.
- Check LED2 and Buzzer direction.
- Check GM Tube polarity (anode-cathode direction).
- Short tube clips to see it you get clicks and led reaction
- Try another GM Tube

No beeps:

- Check with ohm meter the buzzer terminals. It should be about 45 ohm.
- Check if you installed Jmp2

LCD and MCU issue:

- Test if you get 5V readings on MCU and LCD VDD test points.
- Adjust LCD contrast with P2.
- Check with the scope or frequency counter if 4MHz crystal has oscillation.

UART Communication issue:

- Install drivers and configure software, please refer “Radiation Logger” software manual.
- RX and TX pins can be inverted on TTL module, so try to swap.

Need help with the DIY Kit you purchased?

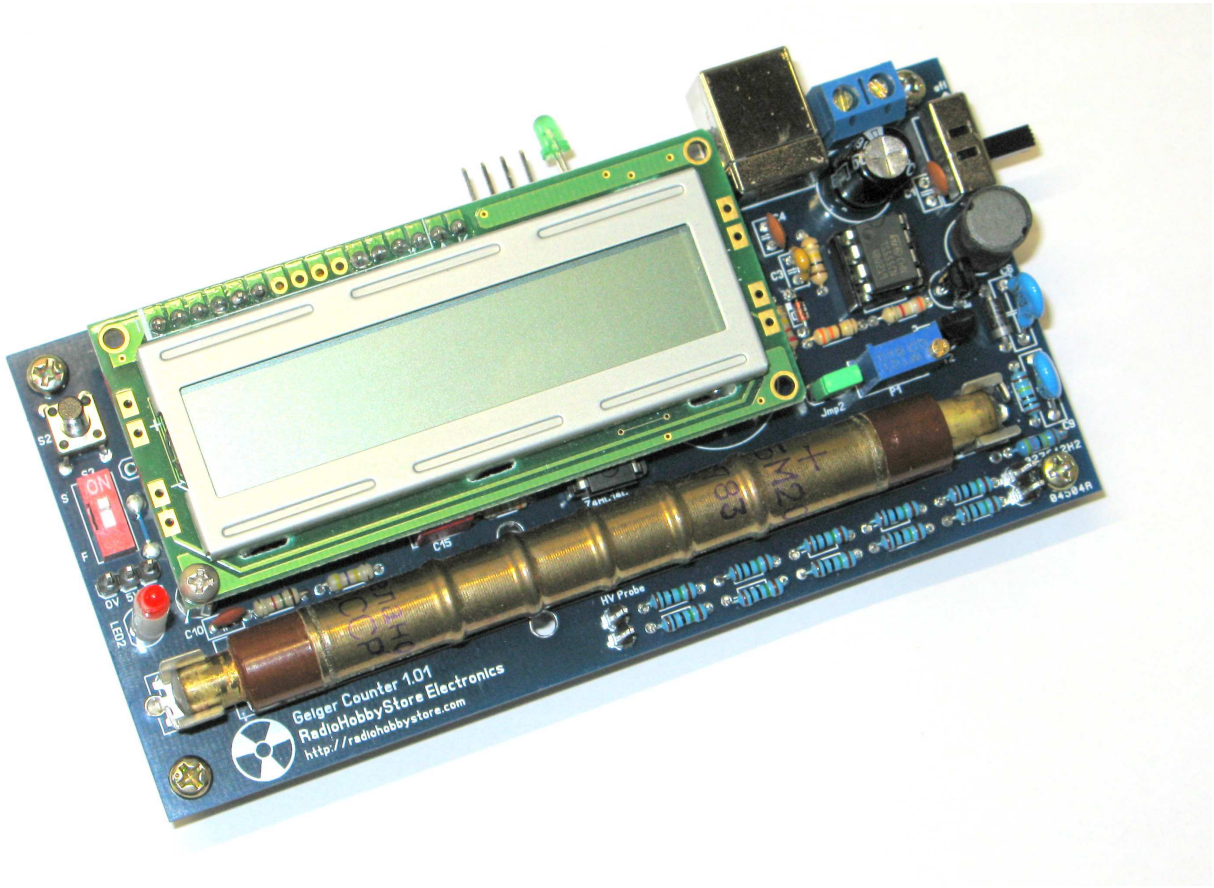
If you soldered the kit regarding the circuit and manual, but it's not operate, at first, recheck if the right components are in the right place and direction. In case you cannot recognize a problem please send us support request to support@radiohobbystore.com

Support request requirements:

- Please describe your problem, attach screenshots or pictures and tell what you already tried to do for resolving the problem.
- Attach two clear focused photos of your soldered kit, from both sides of the PCB.
- Please wait up to 24 hours for the response.
- Please follow our support instruction because we can help you only if you'll work with support team. If you'll not provide a information for support team we'll not be able to resolve the problem.

Several advices for successful kit assembling:

- Print a circuit schematic page from user manual and put it in front of your eyes during soldering.
- Follow user manual for assembling and calibration.
- Take your time! Please do accurate soldering.
- Use only Rosin Flux and Solder with low melt point.
- Clean the PCB after soldering with rubbing alcohol and soft brush.
- Discover kit components datasheets.



Copyrights:

PCB Design:
You cannot duplicate PCB design of the kit for commercial use.

MCU Software:
The author of this code allow to use this program with any non-commercial dosimeters projects, but WITHOUT ANY WARRANTY from his side! Please post link to RadioHobbyStore if you are going to use this code, or part of this code, in your own educational projects. You can't use this source code or hex/asm file for producing similar DIY kits for sale!

PC Software:
“Radiation Logger” Windows Software is freeware for non-commercial use! If you find this program useful you can donate to author via PayPal.

Primary sources for circuits and information about building DIY Geiger Counters: This sources was used during working on the kit.

1. “Simple Geiger counter” by MarkusB http://letsmakerobots.com/node/18220
2. “Pocket Geiger Unit” by Tom Napier http://ru.scribd.com/doc/41802301/Nuts-Volts-25-01-Jan-2004
3. “DIY Geiger Counter compatible with Arduino” by John Giametti https://sites.google.com/site/diygeigercounter/home
4. “Geiger Counter - Radiation Sensor Board for Arduino” by Libelium http://www.cookinghacks.com/index.php/documentation/tutorials/geiger-counter-arduino radiation-sensor-board

5. “One Gigaohm high voltage probe” by EA4EOZ http://ea4eoz.blogspot.co.il/2012/09/onegigaohm-high-voltage-probe.html

6. “Commonly available radioactive sources” by Jochen Kronjaeger http://www.kronjaeger.com/hv/rad/src/list/index.html
7. “Geiger Counter Page” http://einstlab.web.fc2.com/geiger/geiger3.html (japanese)
8. “Geiger Counter Circuit” http://www.rlocman.ru/shem/schematics.html?di=51856 (russian)

High Voltage Inverter: I'm not the author of high voltage inverter stage! There is many sources you can find online where similar 555 timer circuit is used, and not only for Geiger Counters, but also for producing high voltage for other goals. I would to thank all authors for their great work and information shared online.

My other DIY Geiger Project: http://mygeiger.org