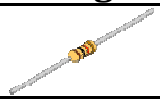
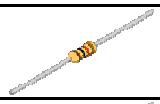
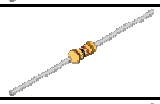
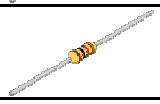
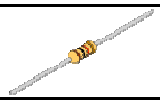
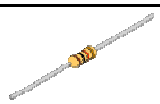
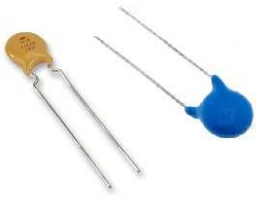
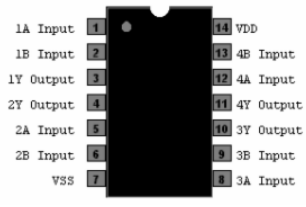
Radiation Detector DIY Kit

Arduino Compatible

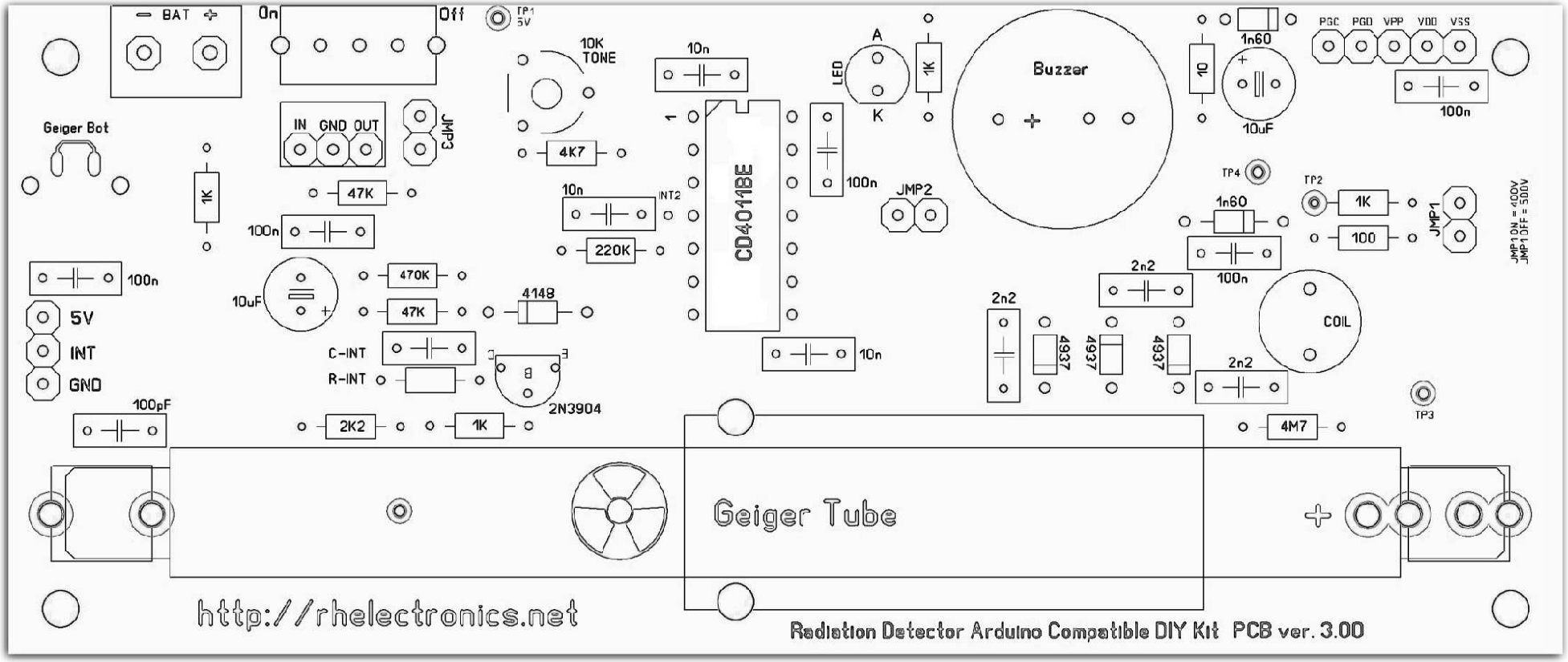
ver. 3.00

http://rhelectronics.net

Image	Quantity	Value	Description	Notes
	1	10 ohm	¼ W Resistor, Brown, Black, Black, Gold	Recommended to verify resistance with multimeter
	1	100 ohm	¼ W Resistor Brown, Black, Brown, Gold	Recommended to verify resistance with multimeter
	4	1K ohm	¼ W Resistor Brown, Black, Red, Gold	Recommended to verify resistance with multimeter
	1	2.2K ohm	¼ W Resistor Red, Red, Red, Gold	Recommended to verify resistance with multimeter
	1	4.7K ohm	¼ W Resistor Yellow, Violet, Red, Gold	Recommended to verify resistance with multimeter
	3	47K ohm	¼ W Resistor Yellow, Violet, Orange, Gold	Recommended to verify resistance with multimeter
	1	220K ohm	¼ W Resistor Red, Red, Yellow, Gold	Recommended to verify resistance with multimeter
	1	470K ohm	¼ W Resistor Yellow, Violet, Yellow, Gold	Recommended to verify resistance with multimeter
	1	4.7M ohm	¼ W Resistor Yellow, Violet, Green, Gold	Recommended to verify resistance with multimeter
	1	10K	Tone Trimmer	103 marking
	2	1N60	Diode	Polarity: Cathode side has strip
	1	1N4148	Diode	Polarity: Cathode side has strip
	3	1N4937	Fast Rectifier Diode	Polarity: Cathode side has strip
	1	Red LED	Tube Event Indicator	Polarity: Cathode side is short
	4	10nF (103)	Multilayer Capacitor	103 marking
	5	100nF (104)	Multilayer Capacitor	104 marking
	1	100pF (101)	Multilayer Capacitor	100 or 101 marking
	3	2.2nF (222)	HV Capacitor	222 marking

	**2**	**10uF**	**Electrolytic Capacitor**	Polarity: Minus side has strip
	**1**	**HV Coil**	**Radial Inductor**	Check DC resistance
	**1**	**Terminal Block DG301**	**Battery Connector**	Has screws for fixing battery wires, check wires polarity
	**1**	**Slide Switch**	**On/Off Button**	See On/Off direction on PCB silkscreen
	**2**	**Metal Connector**	**Geiger Tube Clips**	For SBM-20/STS-5 Tube
	**1**	**Buzzer**	**Clicker Sounder**	Polarity: Plus side has marking
	**10 Pins**	**Male Pins 2.54mm**	**Connectors, Jumpers**	Breakable Pins
	**3**	**Jumper Cup**	**HV Control / Buzzer Control / Step-Up Module Connector**	JMP1 – switch HV range JMP2 – connect Buzzer JMP3 – Step-UP configuration
	**4**	**M3 Screw**	**Mounting Screw**	Plastic or Metal
	**4**	**M3 Standoff**	**Mounting Standoff**	Plastic or Metal
	**1**	**14 Pin IC Socket**	**Socket for installing CD4011 IC**	Polarity
	**1**	**2N3904**	**Transistor**	
	**1**	**CD4011BE**	**IC**	

Geiger tube is not included!


BAT
On
Off
TP1
5V
10K
TONE
10n
LED
A
K
1K
Buzzer
1n60
10
10uF
PGC
PGD
VPP
VDD
VSS
100n
Geiger Bot
IN GND OUT
JMP3
1K
47K
100n
4K7
10n
INT2
220K
CD4011BE
100n
JMP2
TP4
1n60
100n
TP2
1K
100
JMP1
JMP1 ON = 400V
JMP1 OFF = 500V
2n2
2n2
4937
4937
4937
2n2
COIL
100n
5V
INT
GND
10uF
470K
47K
4148
C-INT
R-INT
2N3904
10n
100pF
2K2
1K
4M7
TP3
Geiger Tube
http://rhelectronics.net
Radiation Detector Arduino Compatible DIY Kit PCB ver. 3.00

Technical Specifications:

- Geiger Tube PCB Compatibility: SBM-20, STS-5, J305, LND-712
- Geiger Tube Voltage Compatibility: 400V and 500V tubes
- Supply Voltage: 4.0V-5.5V
- Supply Current: 30uA-60uA (0.03mA-0.06mA) at background radiation
- High Reliability up to 1mSv/h (1000uSv/h)
- Arduino, PIC, AVR compatible
- Audio Output Connector for "Geiger Bot" IPad / IPhone
- Radiation Logger Compatible (require Arduino UNO or similar)
- Sound and LED Geiger Event Indication
- PCB Dimensions: 120 x 50 mm

This is third edition of RH Electronics Arduino Compatible DIY Radiation Detector kit. It has several improvements in compare to previously sold editions. The kit comes with high quality silkscreened PCB and all components you need to build nuclear radiation detector electronics. Geiger Tube is not included with default package, but you can supply your own or purchase Geiger Tube for additional cost.

Why choosing this edition over other radiation detectors kits?

Previously sold edition, as many others hobby Arduino compatible DIY Geiger Kits from the market, had high voltage electrical circuit based on 555 timer IC. Even 555 HV converters are easy-to-build for beginners, it has several drawbacks: large power consumptions, high voltage drops under load, no limiting of high voltage spikes. These were the reasons to refuse using 555 timer and redesign our electrical circuit for better specifications.

Benefits of original third edition:

- Kit consumes **less than 0.06mA** at background, usually **0.035mA**
- **Improved HV stability** up to 1000uSv/h radiation load
- More supported tubes, **400V and 500V** range select
- Tube over voltage protection, **limiting HV spikes**
- Wide **compatibility with different MCU** for software developers
- TRRS socket for **direct connection to Apple devices** for "Geiger Bot"
- **Only DIP components to solder**, SMD already installed
- **Simple assembling**, no need to read electrical circuit

Battery Type	5V Step Up NCP1402	Operation Time at Background
 4xAA Ni-MH	not require Step-UP	1 year
 2xAAA	require Step-UP 	45 days
 1xAAA	require Step-UP 	20 days

* Operation time can be less if high radiation continuous load presents, or if other type of Step-Up module used.

The kit can be used for pocket radiation detector build with configurable power source. For example, you can use 4xAA Ni-MH or 2xAAA Alkaline with step-up module. At background radiation 0.1uSv/h – 0.45uSv/h the kit has very tiny power consumption that allows long continuous operation on one battery set.

Jumpers Configuration:

JMP1 – select tube voltage, close for 400V, open for 500V.

JMP2 – configure buzzer connection, can be replaced with external switch.

JMP3 – configure Step-UP module connection. Close JMP3 jumper if 4x1.2V batteries are used. If Pololu Step Up module http://www.pololu.com/product/798 is used then you can solder the module directly to PCB (IN, GND, OUT). Other modules can be wired to the PCB.

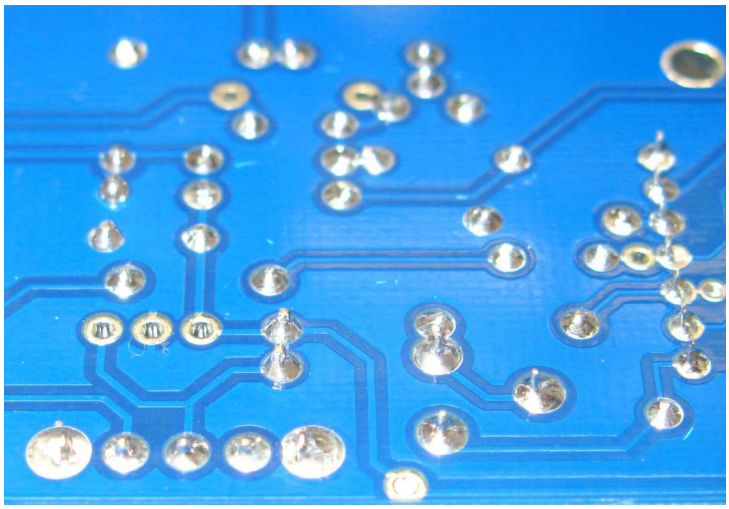
Be sure to remove JMP3 if Step-UP is used!

Soldering Tips:

1. Use only 60/40 lead solder with low melt point. Others lead-free solder require very high temperatures for good flow that can overheat the components if you need to desolder parts.
2. Print PCB silkscreen and keep it in front of you during soldering.
3. Take your time; it may take up to 2-3 hours to complete whole kit, depend on soldering experience.
4. Use desoldering braid or pump in case you made a mistake and need to change component position.
5. The kit has HV converter with very low current load capability. That's why it's very important to wash the PCB with isopropyl alcohol to remove all flux after soldering. Even your flux can be marked as "non-washable" you have to clean the PCB! Flux creates current leaks that cause HV drops.
6. How to wash PCB correctly? C**lose buzzer hole with little piece of insulating tape, it will help to keep buzzer membrane clean and prevent from liquid alcohol to destroy the buzzer**. Uninstall CD4011 IC from the socket. Use small brush to clean flux remains with isopropyl. This liquid is safe for most components; rub it on all solder points on your board. Dry the PCB properly at least 30 minutes with hot air or fan. If you still see flux remains, repeat washing again.

The PCB has electrostatic sensitive smd componets on the bottom side! Be sure your workspace and soldering tools are safe for sensitive devices. Flux or moisture can cause HV leaks and destroy FET. Wash the PCB with flux remover and dry it properly with hot air!

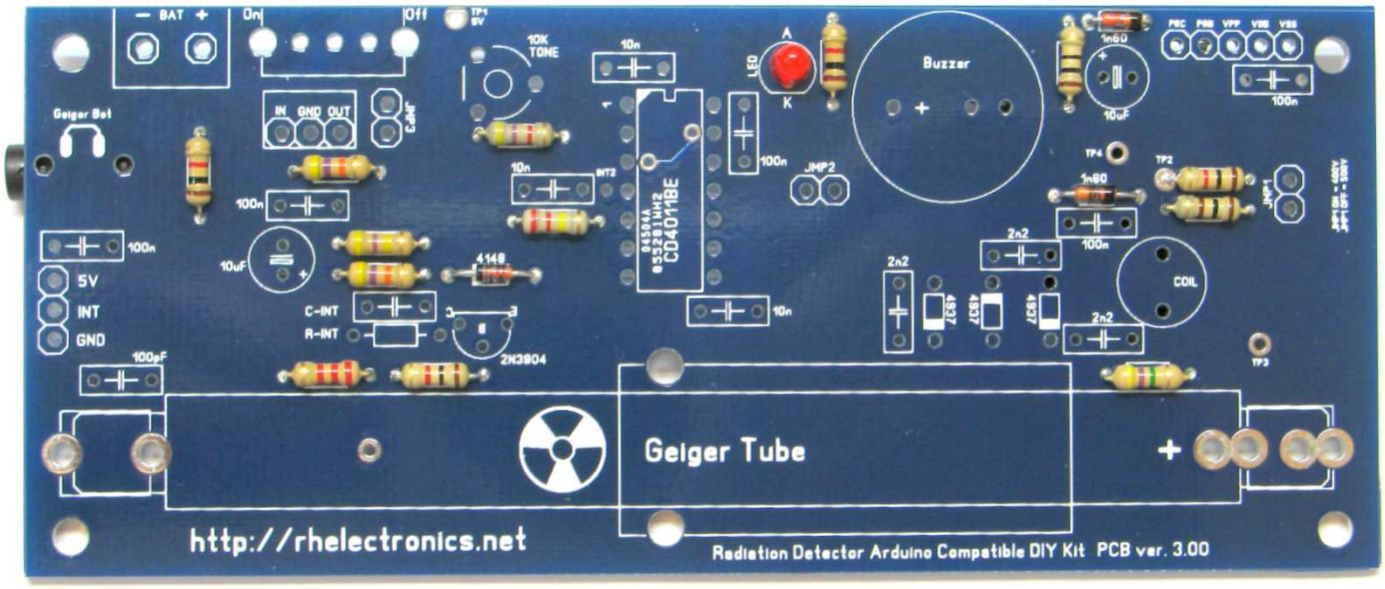
Put special attention to polarity of diodes, transistor, electrolytic capacitors, LED, buzzer and CD4011 IC



Assembling Notes:

Before you start soldering, please check parts list, installing diagram and PCB silkscreen. On the bottom side of the PCB you have already installed SMD components. Be careful not to overheat these small parts when soldering DIP components closely. Because all kits components are electrostatic sensitive, please do not touch the tube or the board in high voltage area when the kit is powered.

Start soldering with the resistors and horizontal placed diodes. Check diodes and LED polarity! The short lead of the LED is a cathode side, marked as “K”.



We strongly recommend you to check all resistors values with a multimeter and not rely on the color code.

Next solder all ceramic capacitors; 100nF = 104, 10nF = 103, 100pF = 101.

C-INT and R-INT allows more flexibility when connecting the kit to your microcontroller. Depend on your MCU type and internal pull-up resistors configuration, you can select if using R-INT or C-INT. **Default values for R-INT is 47K and for C-INT is 10nF (103)**. Arduino can be used with C-INT installed when internal pull-up activated. PIC can be used with R-INT connected to microprocessor INT0 input.

Do not install <u>both</u> R-INT resistor and C-INT capacitor, please read your MCU datasheet and select a proper method to capture interrupts.

By default our example shows C-INT soldered for Arduino and you need to turn-on internal pull-up resistor through software. This capacitor is 10nF, marked as 103.

Put special attention to 1N4937 diodes, CD4011 and 2N3904 transistor polarity. We recommend you to solder 14 Pin IC Socket for the CD4011, even the photo below is missing the socket.

IC Socket will allow you to replace the IC easily in case you'll have any issue. Check the polarity direction of the IC. CD 4011 can be burned fast if you installed it in wrong direction.

Before you'll wash the board, please close the buzzer hole with small piece of insulating tape and uninstall CD4011 from the socket. You can use antistatic tweezers to carry the IC.

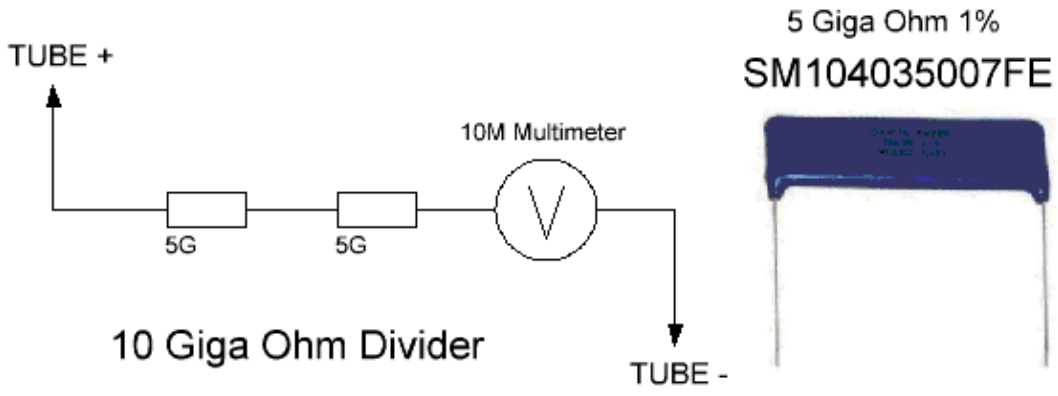
Calibrating of the kit:

When the kit was soldered correctly and washed, it should start working properly since you connect the batteries. Check TP1 and TP4 on the PCB read the battery voltage. Use jumper JMP1 to configure tube voltage: open for 500V; close for 400V.

All you need to do is to trim buzzer frequency with 10K potentiometer. The resonant frequency of the piezo buzzer is about 4000Hz. Connect power rail to the minus clip of the tube, you'll hear the sounder and the red led will flash. Turn 10K potentiometer a little to the left direction for the loudest sound.

HV probe (for general information):

1. If you really interested to check HV then we recommend you to use 10 Giga ohm divider that can be build with two 5Giga ohm 1% OHMITE resistors SM104035007FE in series with 10M multimeter. 400V will read as 400mV on the display if the divider is applied. When building this type of divider please make all probe connection as short as possible because some multimeters starts oscillate with such high impedance input. 10 Giga ohm impedance does not apply significant load on the circuit and allows you to measure the HV correctly.
2. If you have an oscilloscope, then you can check HV with 10M scope probe. Apply it to the TP3 on the PCB and you should see the HV spikes as it exist before multiplier. For 400V the spikes are about 200V height and for 500V are about 250V.

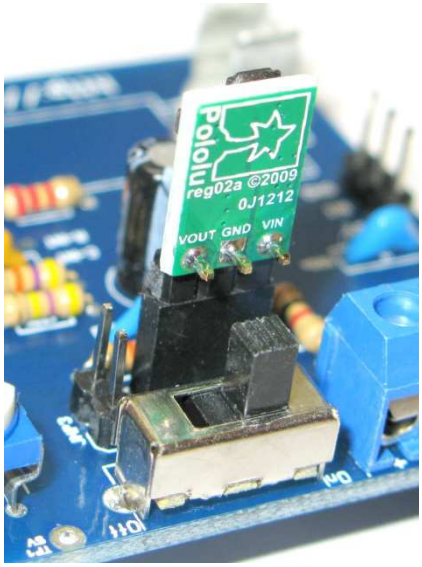


Step Up Module Mode:

Adding 5V step-up module will allow you to run the kit even with one AAA 1.5V alkaline battery. We recommend Pololu Step Up module based on NCP1402, but any other will also can be wired to the PCB.

You can use 3 Pin Female Socket if you want your kit to stay configurable for different batteries, or just solder the module to the PCB directly. The board has clear marking of the module VIN, GND and VOUT direction.

Be sure to remove JMP3 if Step-UP is used!



The mode can be very resonable if your enclosure is small and not allows you to use 4x1.25V Ni-MH. Different types of 5V step-up modules from Pololu, Sparkfun or eBay can be wired to the PCB. It's important to know that step up module can use the battery down to 0.8V that its not recommendable for Ni-MH discharge. That’s why when using step-up its better to use alkaline batteries.

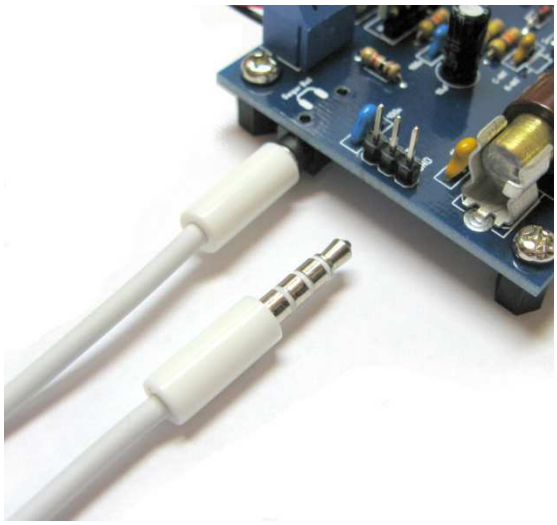
Linear Voltage Regulator:

For those who want to power the kit with 9V 6F22 type battery, we suggest to solder 78L05, or LM2936, or LP2950 LDO 5V linear voltage regulator. 78L05 its not recommended because of low efficiency and high stand by current. With 78L05 the total current can be about 1.5-2.0mA. LP2950 has much more better specifications and only 75uA quiescent current. Be sure to check regulator IC pinout and polarity before you solder it into VIN,GND,VOUT. **Remember to remove JMP3 if voltage regulator is soldered.**

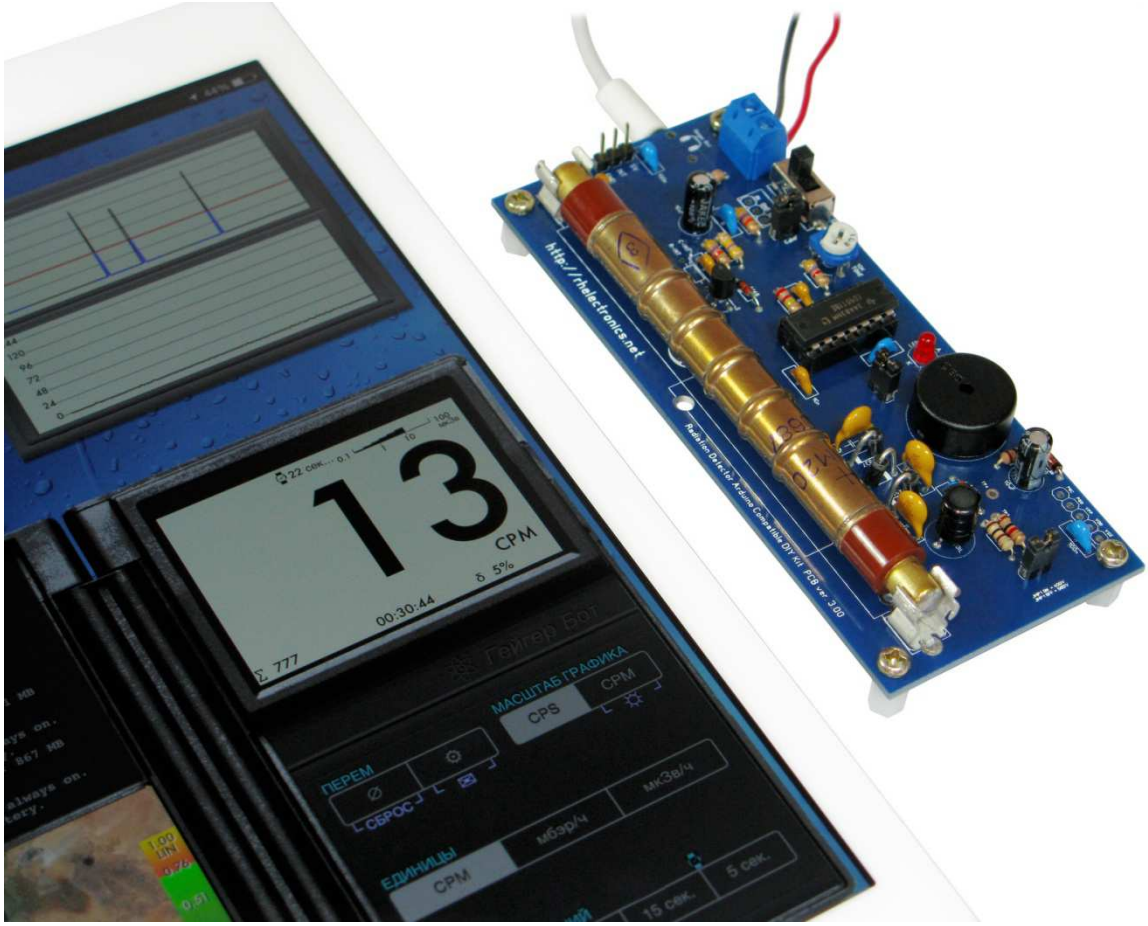
Geiger Bot:

The PCB has ready to use socket for ipad cable. To connect the kit to Apple devices use 4 strip audio cable. You can download freeware Geiger Bot application through iTunes or here:

https://sites.google.com/site/geigerbot/



Since audio output has fixed 1ms pulse duration, we recommend to use Geiger Bot for monitoring background and testing low radiactive sources only. For high speed count please use Arduino with INT connection as described below in “Connection to MCU” section of the manual.



Geiger Bot Software Settings:

Geiger Counter->Custom GM tube-> I/O settings

Auto-Adjust: OFF

RMS Window: 1

Delay Window: 18

Volume Threshold: 10000

Sample Rate: 22050

Disable Measurement Mode: OFF

Hysteresis Filter: 0

Input Polarity: Negative Only

Wavelet Filter: OFF

Input Gain Control: 0.50

Ultrafast Rates: OFF

Radiation Logger:

"Radiation Logger" it's freeware Windows application from RH Electronics that allows you to log radiation data on your computer, Xively or RadMon.org

http://www.rhelectronics.net/store/radiation-logger.html

However, to use the kit with Radiation Logger you need to add a microcontroller and UART interface. The simplest way to do it for this kit is to use Arduino UNO development board. The UNO board can be programmed directly from Arduino IDE via USB and also has installed UART chip for connecting to Radiation Logger.

As before, you need to use 3 jumper wires for connecting the kit to Arduino UNO. It has same pinout as it was in second edition: 5V, INT, GND, please read more technical details below in "Connection to MCU" section of the manual.

Connection with MCU:

With your favorite microcontroller added, the kit can be turned into Radiation Monitoring station or into Dosimeter with display. If you are software developer, then you can write MCU program to capture Geiger tube events from INT or INT2 point on PCB. We provide a basic Arduino example for counting radiation and sending data to Radiation Logger through Serial Port, but you need to know more about microcontroller programming if building your own devices, **we are not provide support for programming**.

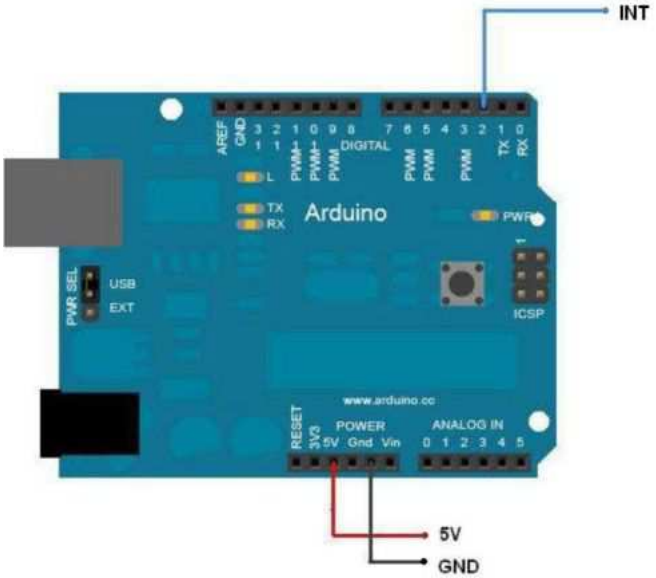
C-INT and R-INT allows more flexibility when connecting the kit to your microcontroller. Depend on your MCU type and internal pull-up resistors configuration, you can select if using R-INT or C-INT. **Default values for R-INT is 47K and for C-INT is 10nF (103)**. Arduino can be used with C-INT installed when internal pull-up activated. PIC can be used with R-INT connected to microprocessor INT0 input.

Do not install <u>both</u> R-INT resistor and C-INT capacitor, please read your MCU datasheet and select a proper method to capture interrupts.

By default our example shows C-INT soldered for Arduino and you need to turn-on internal pull-up resistor through software. This capacitor is 10nF, marked as 103.

The kit produce HIGH-LOW-HIGH interrupts on INT pin and INT2 point. However INT2 point already used for Apple devices output and has fixed 1ms duration. INT pin has about 10uS interrupt duration. By default microcontroller can be connected to INT pin.

The PCB has 3 pins for communication with MCU: **INT, GND, 5V**. You can power the kit from 5V Arduino board or, if you use batteries for Geiger Kit, you have to connect only 2 pins to Arduino: INT and GND. Put the slide On/Off switch to OFF position if batteries are connected when you are using computer 5V rail connected to 5V pin!

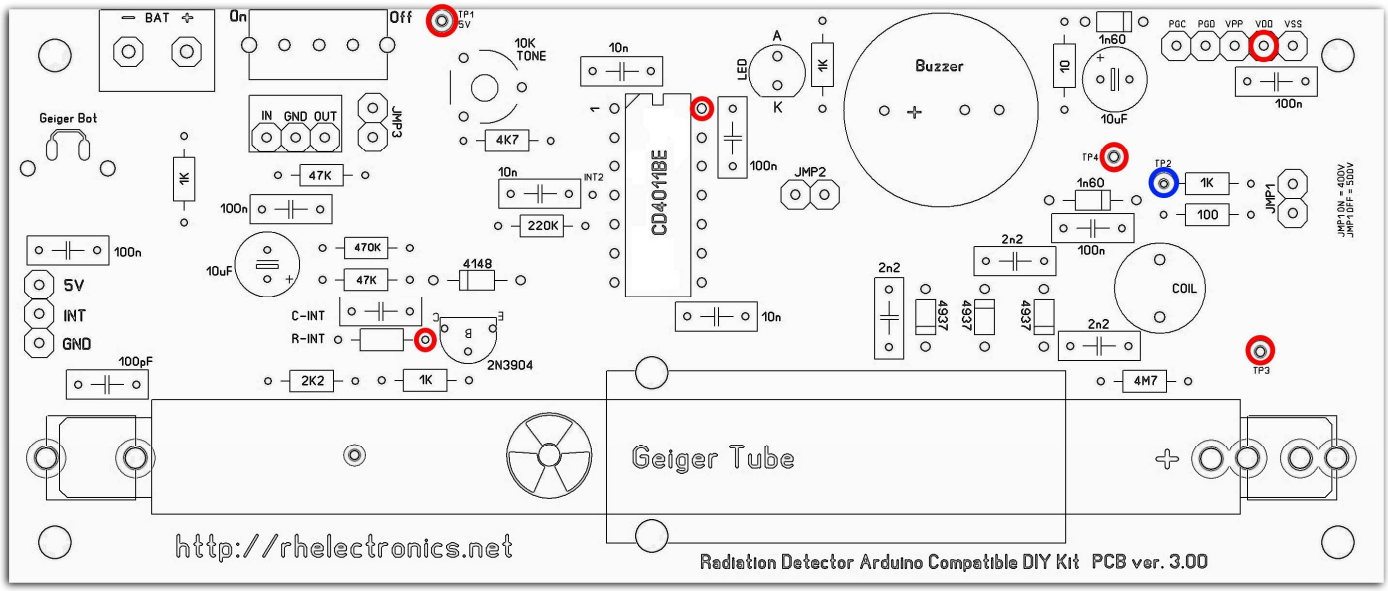


```
#include <SPI.h>
#define LOG_PERIOD 15000    //Logging period in milliseconds, recommended value 15000-60000.
#define MAX_PERIOD 60000  //Maximum logging period
unsigned long counts;             //variable for GM Tube events
unsigned long cpm;                //variable for CPM
unsigned int multiplier;          //variable for calculation CPM in this sketch
unsigned long previousMillis;  //variable for time measurement

void tube_impulse(){            //procedure for capturing events from Geiger Kit
  counts++;
}

void setup(){                     //setup procedure
  counts = 0;
  cpm = 0;
  multiplier = MAX_PERIOD / LOG_PERIOD;     //calculating multiplier, depend on your log period
  Serial.begin(9600);             // start serial monitor
  pinMode(2, INPUT);              // set pin INT0 input for capturing GM Tube events
  digitalWrite(2, HIGH);          // turn on internal pullup resistors, solder C-INT on the PCB
  attachInterrupt(0, tube_impulse, FALLING); //define external interrupts

}
void loop(){                      //main cycle
  unsigned long currentMillis = millis();
  if(currentMillis - previousMillis > LOG_PERIOD){
    previousMillis = currentMillis;
    cpm = counts * multiplier;
      Serial.print(cpm);  // send cpm data to Radiation Logger
      Serial.write(' ');    // send null character to separate next data
    counts = 0;
  }
}
```

Troubleshooting:

Most of the problems caused by incorrect soldering or flux. If the kit does not operate please perform several standard tests before you contacting support.

1. Wash the board with flux remover liquid as described in the manual! The board with flux or grease = no high voltage! Be sure the board is dry after washing. Flux remover liquid under components can create leaks.
2. Inspect your solder quality! https://learn.adafruit.com/downloads/pdf/adafruit-guide-excellent-soldering.pdf
3. Check all components installed in right position and right direction. Use installation diagram from the manual.
4. Check all resistors. Sometime, if too much heat or mechanical pressure applied, the resistor may have internal break.
5. Check all diodes. A diode conducts in one direction only! If a diode conducts in both directions, or not conducts at all, then it needs to be replaced.
6. Check HV radial coil has DC resistance.
7. Check jumpers configuration, check your battery is OK.
8. Check you can read app. Battery DC voltage on **red points** on the diagram.
9. If you have oscilloscope, then you can check **TP2** and **TP3** AC signals.



By shorting tube clips with wire you shall get one short led flash and buzzer beep. By connecting battery + to tube minus clip you shall get continuous beep.

Test board current consumption with ammeter. Increased than 60uA current tells about shortcuts, flux or other problems on the board.

WARNING!

The board has high voltage presented on tube clips! If you buy the kit you are fully responsible for any possible injury caused during assembling or using this device. Never touch the PCB or GM tube during operation. Place finished kit into plastic case to prevent touching high voltage elements.

Need help with the DIY Kit you purchased?

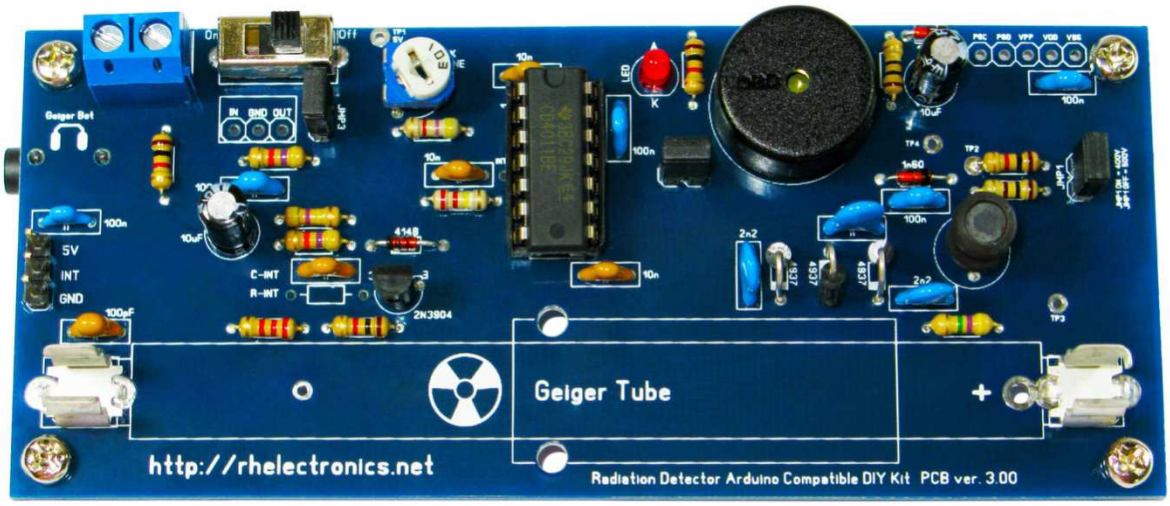
Please send a support request to us at: support@rhelectronics.net

Support request requirements:

- Include your order number or eBay ID
- Please describe your problem fully; attach screenshots or pictures and tell what you already tried to do for resolving the problem.
- Attach high resolution 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 or you'll drop out from communication we'll not be able to resolve the problem.

Several advices for successful kit assembling:

- Use PCB silkscreen and diagram to solder all components in right place and direction.
- Follow the user manual PDF for assembling and calibration.
- Take your time! Please do accurate soldering.
- Use only Rosin Flux and Solder 60/40 with low melt point.
- Clean the PCB after soldering with flux removal.
- Locate and download components datasheets for reference.



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