ScienceCube

Wireless Radiation (WL126R)

User Guide

Rev. WL126R-12-2023

This product is to be used for educational purposes only. It is not appropriate for industrial, medical, research, or commercial applications.

KOREADIGITAL

The Science Cube wireless radiation sensor instrument for the detection and quantitative determination of ionizing radiation..

The wireless radiation sensors instrument for the detection and quantitative determination of ionizing radiation such as the alpha and beta rays given off by radioactive minerals and cosmic rays. The ScienceCube radiation sensor uses a Geiger-Müller(GM) tube. The GM counter detects low level beta and gamma radiation. It is possible to detect background radiation, as well as low level radiation, emitted by radioactive sources, like potassium fertilizers or a gas lantern mantle.
You can measure by remotely connecting to a smart device or PC wirelessly or wired.

Suggested experiments

The wireless radiation sensor allows to

- detect the presence of a radiation source.
- monitor the background radiation.
- measure radiation of common radioactive materials such as potassium salts or lantern mantels etc.
- determine the half-life value for short lived nuclides.
  monitor counts per interval (rate) as different thickness of a shielding are placed between the GM Radiation Monitor and a beta or gamma source.

Composition

The ScienceCube wireless radiation sensor *consists of the following.*

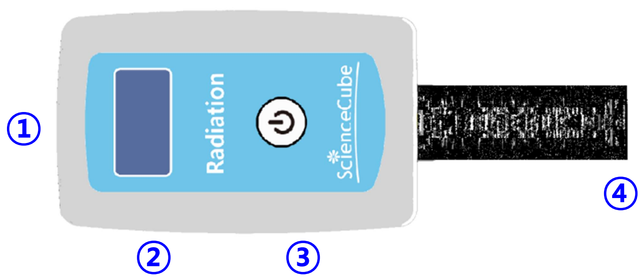
- Wireless radiation sensor(WL126R)
- USB-A/C cable
- Booklet

Feature

- Up to four Science Cube wireless sensors can be connected to a PC or smart device at the same time.
- It supports dual-mode Bluetooth, allowing you to connect not only smart devices but also desktop and laptop PCs to conduct experiments using the **Science#** application.
- It can be connected to a PC through a USB port and experiments can be performed using the **Science#** program.

Function of wireless sensor

Structure



① USB port : Connect the sensor to a PC and use it for experiments or charging.

② OLED Display : Displays measured sensor values, sensor type, sensor ID, and remaining battery level.

③ Power/Function Button : It has functions such as power ON/OFF, measurement sensor change and calibration, etc.

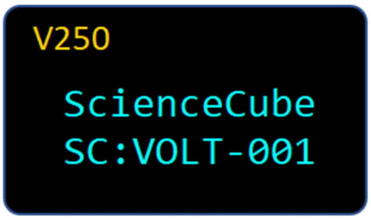
④ Sensing part : Built-in GM counter protected by a non-metallic tube.

> **Caution** : Do not use the sensor near fire or explosive gases. High concentrations of contaminants can permanently damage the sensor.

Power/Function Button

Status	Turn	Action	Description
When the power is off	Click once	■	A short press turns the sensor on.
	Long click	▬▬▬▬	A long press changes the mode and turns on the sensor.
When it's on	Click once	■	Sensor with flip function rotates the screen 180 degrees so text is clearly visible.
	Long click	▬▬▬▬	Turns off.

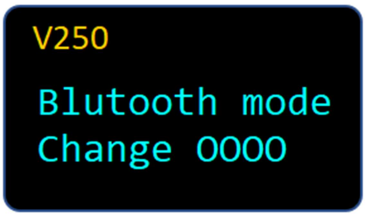
Start screen



V250 : Displays the sensor's firmware version.

SC:OOOO-001 : When you search for a Bluetooth device, the device name will be displayed. (Sensor name and 3-digit serial number)

Mode change



When you press and hold the power button and turn it on, the Bluetooth connection mode changes to **Mobile** or **PC** with the following message.

Measurement screen

①Connection mode	**Mobile** : Connecting Androidor iOS. **PC** : Connecting to Windows PC ※ A long press changes the mode and turns on the sensor.
②Sensor-ID	This is the sensor's unique number and is displayed along with the sensor name in the device name when connected via Bluetooth.
③Battery	Check the battery status, and when charging via USB, the display will change to charging.
④Value	Displays sensor measurement values and units in real time.

How it Works

Radioactivity

Radioactivity is the spontaneous emission of energy from the nucleus of certain atoms. The most familiar radioactive material is uranium.

There are three forms of energy associated with radioactivity; alpha, beta and gamma radiation. The classifications were originally determined according to the penetrating power of the radiation, see Figure 2. Our GM Counter can detect the three types of radiation ; alpha, beta and gamma radiation.

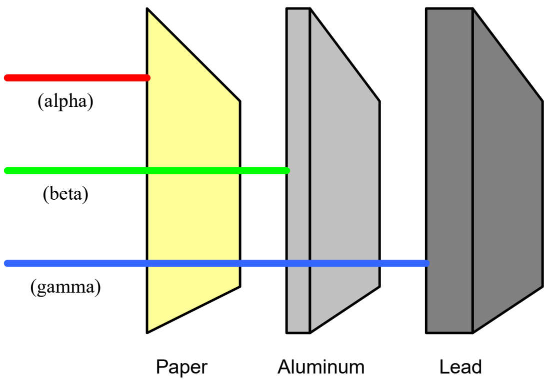


Figure 2. Penetration Power of Radiation

Alpha rays are the nuclei of helium atoms, two protons and two neutrons bound together. Alpha rays have a net positive charge. Alpha particles have weak penetrating ability, a couple of inches of air or a few sheets of paper can effectively block them.

Beta rays were found to be electrons, identical to the electrons found in atoms. Beta rays have a net negative charge. Beta rays have a greater penetrating power than Alpha rays and can penetrate 3mm of aluminum.

Gamma rays are high-energy photons. This has the greatest penetrating power being able to pass through several centimeters of lead and still be detected on the other side. Thick lead is needed to attenuate gamma radiation.

Geiger-Müller Tube

Geiger-Müller tubes are simple devices that detect and measure radioactivity. The original design by H. Geiger and E.W. Müller in 1928 hasn't change very much. The basic sensor functioning remain the same. A cut away drawing of a typical Geiger-Müller (GM) Tube is shown in Figure 3.

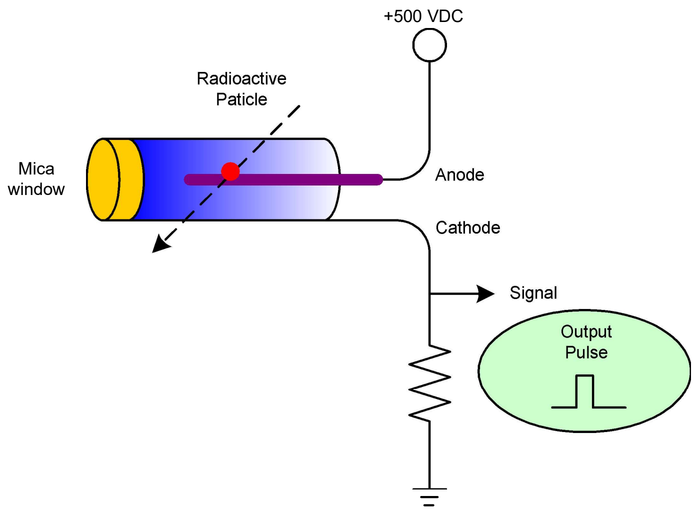


Figure 3. Cross-section and function of typical Geiger-Müller Tube

The wall of the GM tube is a thin metal (cathode) cylinder surrounding a center electrode (anode). The metal wall of the GM tube serves as the cathode of the GM tube. The front of the tube is a thin Mica window sealed to the metal cylinder. The thin mica window allows the passage and detection of the weak penetrating alpha particles. The GM tube is first evacuated then filled with Neon, Argon plus Halogen gas.

GM tube is put into an initial state (ready to detect a radioactive particle), by applying + 500 VDC potential to the anode. A resistor is connected to the metal wall cathode of the tube and to ground. The top of the resistor is where we see our pulse signal whenever a radioactive particle is detected.

In this initial state the GM tube has a very high resistance. However, when a radioactive particle passes through the GM tube, it ionizes the gas molecules in its path and creates a momentary conductive path in the gas. This is analogous to the vapor trail left in a cloud chamber by a particle. In the GM tube, the electron liberated from the atom by the particle, and the positive ionized atom both move rapidly towards the high potential electrodes of the GM tube. In doing so they collide with and ionize other gas atoms, creating a momentary avalanche of ionized gas molecules. And these ionized molecules create a small conduction path allowing a momentary pulse of electric current to pass through the tube allowing us to detect the particle.

This momentary pulse of current appears as a small voltage pulse across the resistor. The halogen gas quickly quenches the ionization and the GM tube returns to its high resistance state ready to detect more radioactivity.

Dead Time

For the short amount of time the GM tube is detecting one particle, if another radioactive particle enters the tube it will not be detected. This is called dead time. The maximum dead time for our GM tube is 90 microseconds (or .00009 seconds). There is a mathematical formula for adjusting a GM counter read out to compensate for the GM tube's dead time. However the adjust is so small that for practical applications it can be ignored. High-end nuclear work will take a tube's dead time into consideration.

Count Rate vs. Dose Rate

Each output pulse from the GM tube is a count. The counts per second give an approximation of the strength of the radiation field. The GM tube has been calibrated using a cesium-137. The chart is shown in Figure 4.

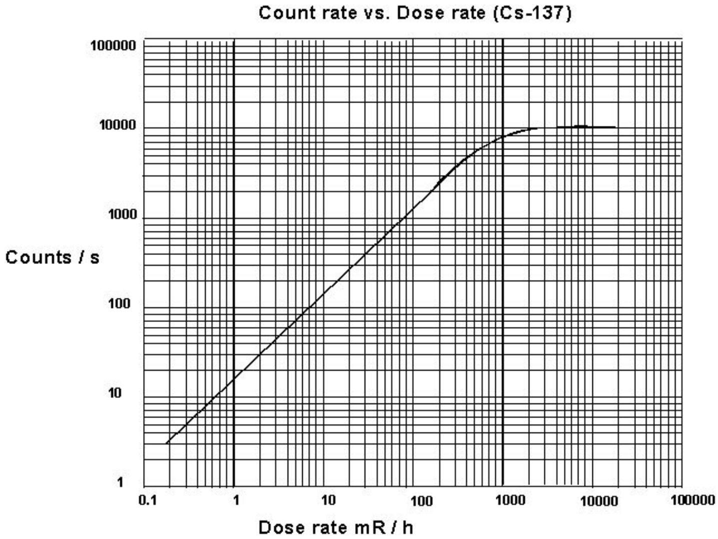


Figure 4. Chart detailing Count Rate vs. Dose Rate

Radioactive decay and half-life determination

The GM Radiation Monitor gives the possibility to measure radioactive decay rate and half-life. Radioactive decay can be expressed with the following formula :

$$N(t) = N_0 e^{-\lambda t}$$

where λ is the decay rate constant. The decay constant is characteristic for a given radioactive species and isotope, and can thus be used to identify the contents of a radioactive sample.

The half-life is the time required for half of the atoms present to decay. A linear plot of the natural log of the decay rate versus time can be used to determine the half-life of an isotope.

$$\ln \frac{N}{N_0} = -\lambda t$$

if $t = t_{1/2}$ then $N = N_0/2$

and $\ln 2 = \lambda t_{1/2}$

Protactinium, with its half-life time of just 72 seconds, makes an ideal radioactive material for this experiment (the source should be strong enough at the beginning).
To improve the quality of the data the background radiation should be subtracted.

Investigation of radiation level at different distances from a source

In this experiment, the radiation level is measured at different distances from a source. The distance from the sensor to the source is determined with a ruler. The radiation values (in counts per interval) at those distances are measured and the distance values are entered via the keyboard. Further one can investigate whether the inverse square law is followed.
Some lantern mantles i.e. those containing Thorium 232 nuclei, can be used as a radioactive source in this experiment. To improve the quality of the data the background radiation should be subtracted.

Radiation level versus shielding

In this experiment the radiation level is recorded as the absorber of different thickness is placed between the GM radiation monitor and radiation source. As absorber an aluminum sheets for beta radiation or a lead sheets for gamma radiation can be used. The intensity of the radiation I diminishes according to the exponential relation

$$I = I_0 e^{-\mu d}$$

where I_0 is the incident intensity, d is thickness of a shielding sheet and μ is a constant known as the 'linear absorption coefficient. During the experiment the radiation (counts per interval) for different thickness' of an absorber (different number of sheets) is detected. The thickness values are entered via the keyboard. To improve the quality of data the background radiation should be subtracted. In this experiment you can also compare the effect of different types of materials to shield beta or gamma radiation.

Conversion of Units of Measurement

Radiation meters measure CPS or CPM, which can be converted to radiation dose using the following unit conversion methods:

The gamma sensitivity of a GM tube is 1000 CPM (18 cps) = 1 mR/hr, which means that 1,000 detections per minute result in 1 mR/hr

R is a unit mainly used in the United States, and the following process is required to convert it to Sv, the International (SI) radiation dose unit. If R units reflect a biological characteristic (the amount of radiation absorbed by the body), they can be converted to rem (roentgen equivalent human) units. Generally, 1 R has a value between 1 and 0.9329 rem depending on biological characteristics, and for convenience of calculation, 1 R is generally considered to be 1 rem.

In the past, rem was used a lot, but now most people use the SI unit Sv, and the relationship between rem and Sv is defined as 1 Sv = 100 rem, so 1 rem is 0.01 Sv.
The relationships between all units are as follows:

18 cps = 1000 CPM
= 1 mR/h
= 1 m·rem/h
= 10 uSv/h

Typically, **1** CPM translates to approximately **0.01** uSv/h.

Reference :

CPM : Count per minutes
mR/h : milli-roentgens per hour
R : Roentgen
Sv : Sievert
rem : Roentgen equivalent human
m·rem/h : milli-rem
uSv/h : micro- Sievert per hour

G-M Tube Specifications

Fill Gas	Ne / Ar + Halogen quenched GM-tube
Cathode	446 Stainless Steel
Recommended Operating Voltage	500 volts
Operating Voltage	450 ~ 650 volts
Minimum Dead Time	90 uS
Cathode Wall Thickness	0.25 mm
Mica Window Areal Density	1.5-2.0 mg/cm2
Effective Window Diameter	9 mm
Gamma Sensitivity (Cs137)	18 cps, 1000 CPM, 1 mR/hr
Max. Background Shielded	50 mmpB = 3 mmAl (cpm) 10

Specifications

Item	Description
Range	0 ~ 20,000 CPM 0 ~ 20 mR/hr 0 ~ 200 uSv/hr
Resolution	1 CPM
Sampling Time	Max. 100Hz (0.01 sec.), (Typical 1Hz)
Condition	0 ~ 50℃, ~85%RH
Wireless Connection	Bluetooth 5.0 or Classic 2.1
Wired Connection	USB-C
Battery	700mAh Li-Polymer rechargeable
Charging Time	within 2 hours
Operating Time	Approximately 6 hours after full charge (depending on usage conditions)
EMC	CE : EN 61326-1, EN 55011, EN 55032, EN 301

CAUTION: Do not use the instrument beyond the measurement range or in conditions that exceed the short-term exposure limits. Prolonged exposure beyond the maximum permissible range can cause serious damage to the sensor.

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