

# UVC Sanitize Box

**ultraviolet C (UVC, 200 to 280 nm)** light disrupts DNA base pairing, causing formation of pyrimidine dimers, and leads to the inactivation of bacteria, viruses, and protozoa. It can also be used to produce ozone for water disinfection.

UVC is highly disruptive for live organisms because it is strongly absorbed by proteins (principally 210 nm to 230 nm) and the nucleic acids of DNA and RNA (principally 250 nm to 280 nm). The latter wavelength range is commonly referred to as the “**germicidal UVC range**.”

*UVC radiation can cause severe burns (of the skin) and eye injuries. Avoid direct skin exposure to UVC radiation and never look directly into a UVC light source.*



# UVC Sanitize Box

## Facts of ultraviolet C

1. UVC cannot inactivate a virus or bacterium if it is not directly exposed to UVC. In other words, the virus or bacterium will not be inactivated if it is covered by dust or soil, embedded in porous surface or on the underside of a surface.
2. UV exposure increases the risk of potentially blinding eye diseases, if eye protection is not used
3. Over exposure to UVC may cause serious health issues including cancer.

## How UV Disinfection Works

When bacteria, viruses and protozoa are exposed to the germicidal wavelengths of UV light, they are rendered incapable of reproducing and infecting. UV light has demonstrated efficacy against pathogenic organisms, including those responsible for cholera, polio, typhoid, hepatitis and other bacterial, viral and parasitic diseases. In addition, UV light (either alone or in conjunction with hydrogen peroxide) can destroy chemical contaminants such as pesticides, industrial solvents, and pharmaceuticals through a process called UV-oxidation.

Microorganisms are inactivated by UV light as a result of damage to nucleic acids. The high energy associated with short wavelength UV energy, primarily at 254 nm, is absorbed by cellular RNA and DNA. This absorption of UV energy forms new bonds between adjacent nucleotides, creating double bonds or dimers. Dimerization of adjacent molecules, particularly thymine, is the most common photochemical damage. Formation of numerous thymine dimers in the DNA of bacteria and viruses prevents replication.

Content source: <https://www.trojanuv.com/uv-basics>

## Effectiveness of UV

A significant body of scientific research has proven UV light's ability to inactivate an extensive list of pathogenic bacteria, viruses and protozoa. UV offers a key advantage over chlorine-based disinfection, due to its ability to inactivate protozoa that threaten public health – most notably *Cryptosporidium* and *Giardia*. The release of these harmful microorganisms into receiving lakes and rivers by wastewater facilities utilizing chlorine disinfection increases the potential of contamination in communities that rely on these same bodies of water for their drinking water source and recreational use. Drinking water treatment plants can benefit by using UV since it can easily inactivate chlorine-resistant pathogens (protozoa), while reducing chlorine usage and by-product formation.

Content source:  
<https://www.trojanuv.com/uv-basics>

# UVC Sanitize Box

## Regulation

Ultraviolet lamps intended for medical purposes, such as products that disinfect other medical devices or irradiate part of the human body, that meet the definition of medical device under section 201(h) of the Federal Food, Drug, and Cosmetic Act also typically require FDA clearance, approval, or authorization prior to marketing. When a UVC lamp is regulated only as an electronic product, there are currently no specific FDA performance standards that apply

Content source: CDC/FDA USA

## UVC light has been shown to inactivate the novel coronavirus in experiments.

Ultraviolet (UV) light is produced by the sun and by special lamps. There are three types of UV light—UVA, UVB, and UVC. UVC light includes wavelengths of light from 200 to 280 nanometers. These UVC wavelengths have the most energy of the three types of UV light. Energy from UVC wavelengths is absorbed by, and quickly destroys, the genetic material inside viruses and other microbes, rendering them inactive.

In a few laboratory experiments, UVC light has been found to destroy the ability of the SARS-CoV-2 virus to infect a host (for example, a mouse or a person), another indication that it is effective against germs. UVC light has also been shown to inactivate the genetic material in other coronaviruses.

Content source:

<https://www.nationalacademies.org/based-on-science/covid-19-does-ultraviolet-light-kill-the-coronavirus>

## Human Coronavirus Types

Coronaviruses are named for the crown-like spikes on their surface. There are four main sub-groupings of coronaviruses, known as alpha, beta, gamma, and delta.

Human coronaviruses were first identified in the mid-1960s. The seven coronaviruses that can infect people are:

### Common human coronaviruses

229E (alpha coronavirus)  
NL63 (alpha coronavirus)  
OC43 (beta coronavirus)  
HKU1 (beta coronavirus)

### Other human coronaviruses

MERS-CoV (the beta coronavirus that causes Middle East Respiratory Syndrome, or MERS)  
SARS-CoV (the beta coronavirus that causes severe acute respiratory syndrome, or SARS)  
SARS-CoV-2 (the novel coronavirus that causes coronavirus disease 2019, or COVID-19)

People around the world commonly get infected with human coronaviruses 229E, NL63, OC43, and HKU1.

Sometimes coronaviruses that infect animals can evolve and make people sick and become a new human coronavirus. Three recent examples of this are 2019-nCoV, SARS-CoV, and MERS-CoV.

Content source: National Center for Immunization and Respiratory Diseases (NCIRD), Division of Viral Diseases

# UVC Sanitize Box

Is it easy to DIY a UVC sanitize box?

The answer is “YES”

The key components we need is:

1. A suitable box or container
2. UVC light or light bulbs

For other components like power cord, timer switch etc. are easy to get in the market.

What is safety concern of building a DIY UVC sanitize box?

The only safety concern of a DIY sanitize box is the operator cannot expose to the UVC light during operation.

So, here are some points:

1. The box/container is light sealed.
2. The UVC light must be stopped when the box/container open.
3. Should have some kind of timer or auto stop device to make sure UVC light will be OFF after a certain period of time of operation.
4. Safety device of power supply

# UVC Sanitize Box

Show time

Let's DIY a UVC sanitize box



# UVC Sanitize Box

## What do we need ?

1. A box – I use a soft flexible portable cold container with size of 14 (D) X 17 (W) X 14 (H)
2. Wood stick – 1 X 2 inches wood stick (actual size is 0.75 X 1.5 inch)
3. Steel rod –  $\frac{1}{4}$  inch diameter steel rod
4. Steel wire mesh – any type BBQ steel mesh or similar
5. UVC light bulb and socket
6. Over temperature protection switch
7. Electrical wire
8. Slide switch (for 110V AC use)
9. Micro switch (for 110V AC use)
10. Over current protection breaker
11. AC to DC converter (for timer use)
12. Timer module, adjustable up to 60 minutes (for 110V AC control)
13. Current limiter and starter for UVC light bulb
14. Indicators for UVC ON, AC ON and Timer ON
15. Electrical wires
16. Aluminum sheet
17. Plastic sheet
18. Brass hooks

# UVC Sanitize Box

## The box

Advantages:

1. Portable flexible
2. Good size 14 (D) X 17 (W) X 14 (H)
3. Has silver reflective surface inside
4. Double layer wall
5. Water leak prove
6. Has handle for transportation

Disadvantage:

Soft and flexible, thus we need some kind of bone structure to support it.



# UVC Sanitize Box

## Wood stick

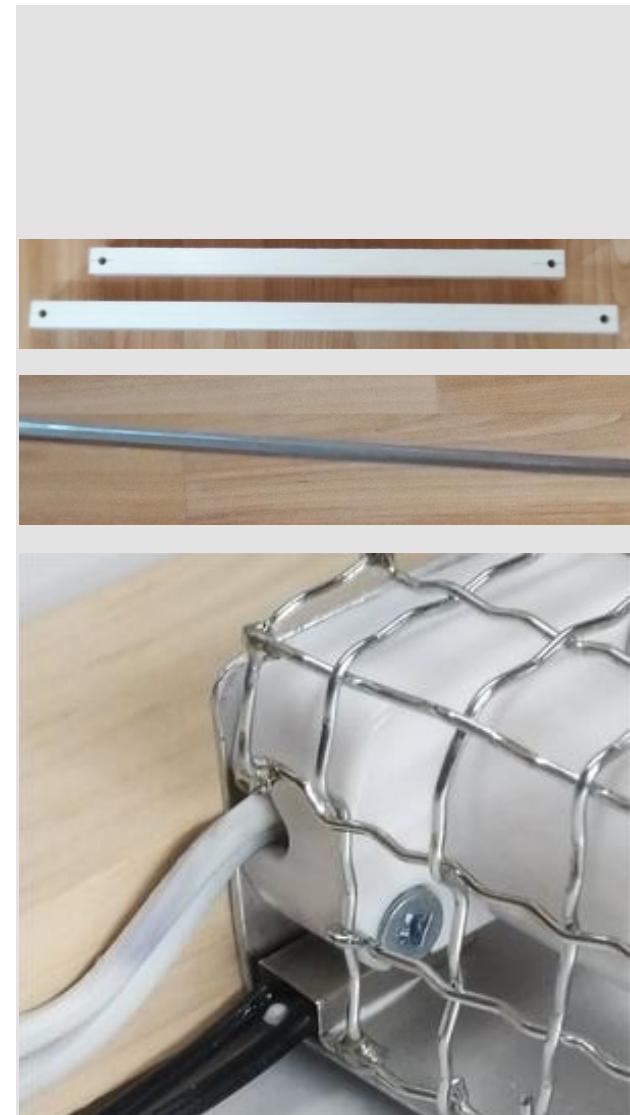
1 X 2 inch wood stick (actual size is 1.5 X 0.75 inch)  
17 inches length – 2 pcs  
14 inches length – 2 pcs

## Steel rod

¼ inch diameter steel rod - 12 inches length – 4 pcs

## Steel wire mesh

Any type of BBQ steel mesh or similar is good for use. About 3X12 inches



# UVC Sanitize Box

## UVC light bulb and socket

UVC light bulb – 10 to 12volts 3watts

UVC light bulb socket – match with UVC light bulb, E17 shown

## Over temperature protection switch

Normal closed over temperature thermostat, 250Vac 5A 40°C

## Slide switch (for 110Vac use)

Any suitable SPST switch is ok



# UVC Sanitize Box

Micro switch (for 110V AC use)

250V 3A normal open or similar is OK

Over current protection breaker

Normal closed over current circuit breaker, 250V 1.5A shown

AC to DC converter (for timer use)

AC 110V to 12V 400 mA AC/DC module is shown



# UVC Sanitize Box

Timer module, adjustable up to 60 minutes

0.1 to 60 seconds adjustable, 125V 10A relay control, normal open or similar

Current limiter and starter for UVC light bulb

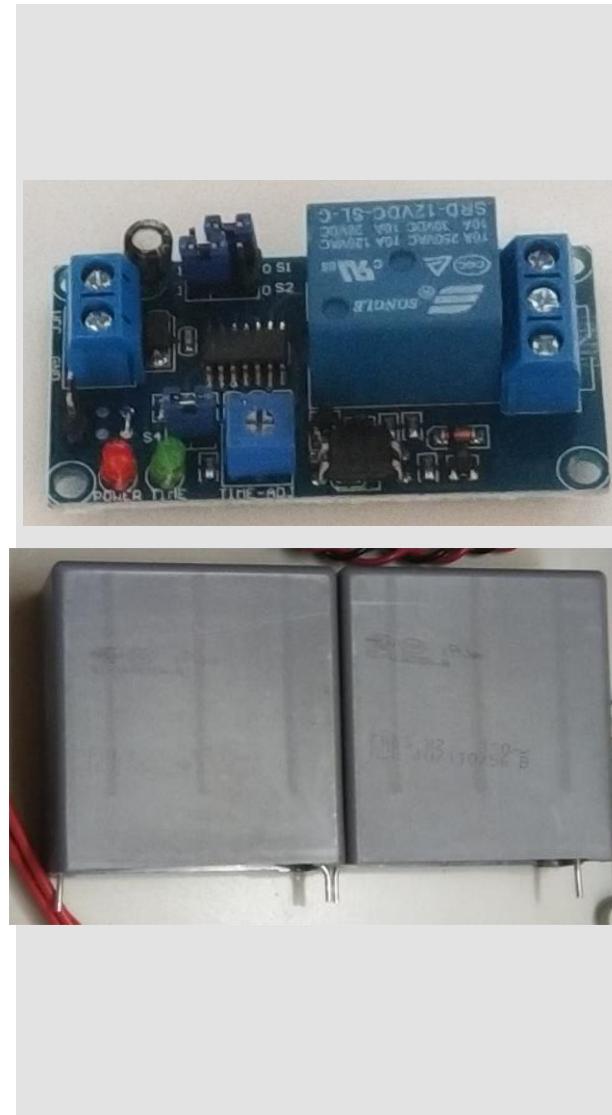
Film capacitor, 6.8 uF 10% 310Vac (F863RR685K310Z by KEMET or similar

Indicators for UVC ON, AC ON and Timer ON

LED red indicator – AC ON

LED yellow – Timer ON

Neon Red – UVC ON



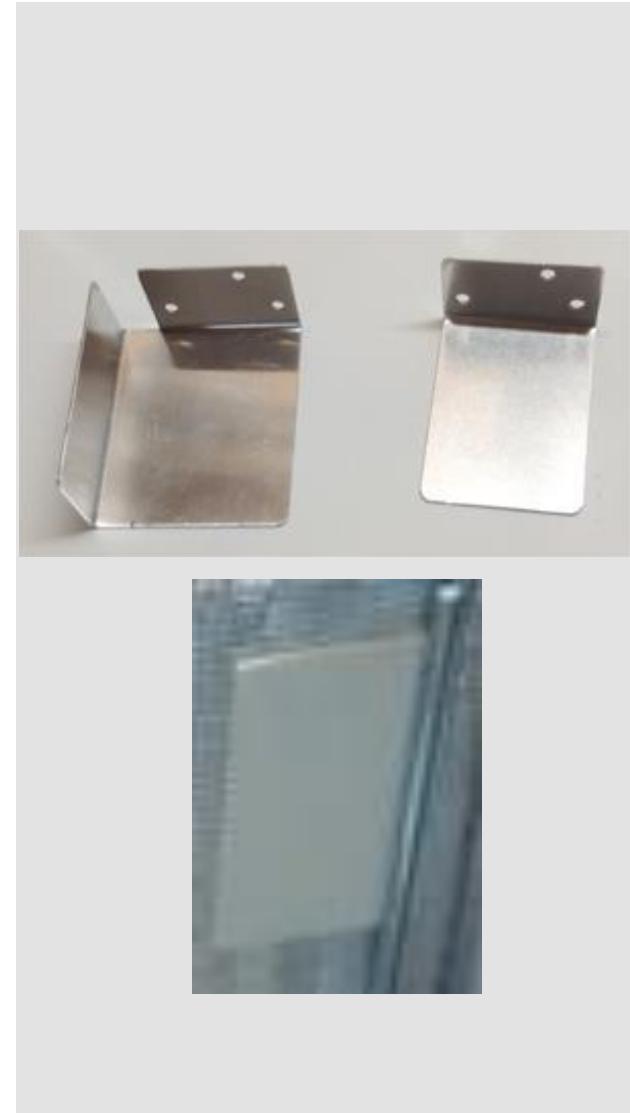
# UVC Sanitize Box

## Aluminum sheet

Any about 1MM thickness aluminum sheet

## Plastic sheet

Any about 3MM thickness plastic sheet



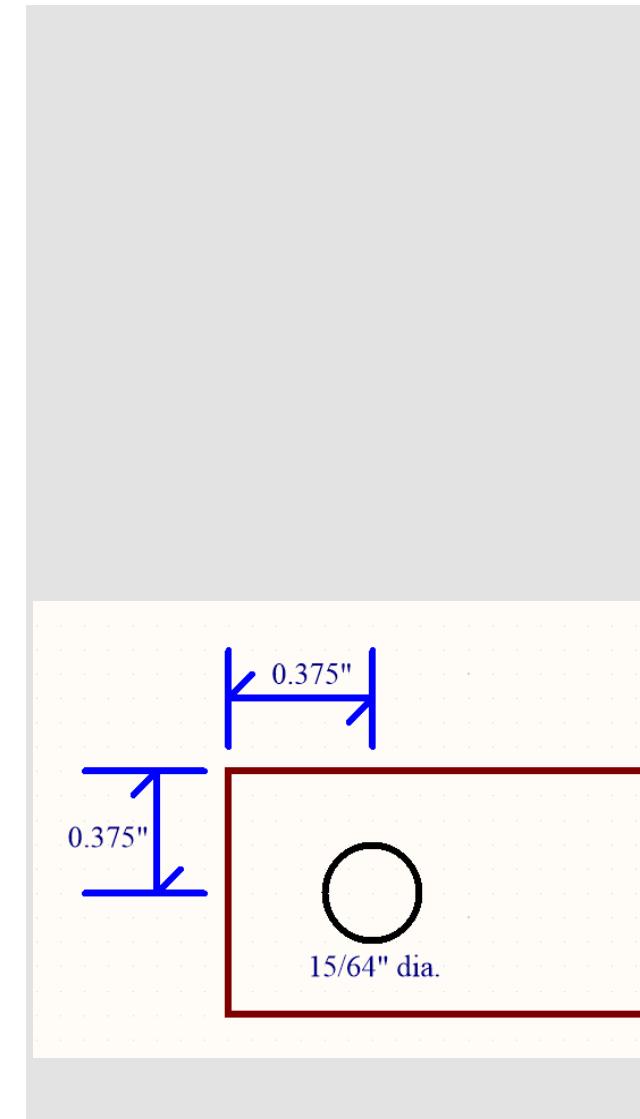
# UVC Sanitize Box

## step 1

1. prepare wood sticks  
cut 2 pcs each of 14 inches and 17 inches



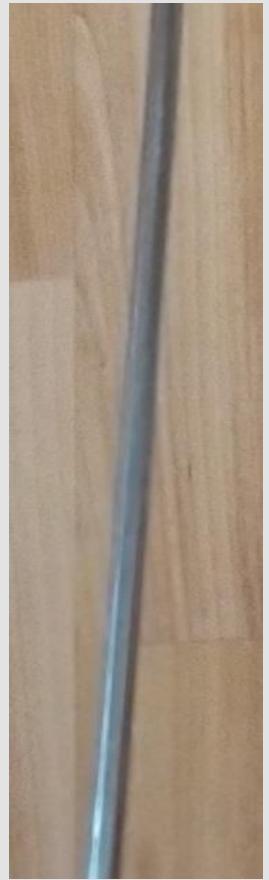
2. Drill holes at both ends of each stick by  $15/64$  inches  
drill bit with depth of 0.75 inches



# UVC Sanitize Box

## step 2

1. prepare steel rod  
cut 4 pcs rod with 12 inches length
2. cut one pc with 2 inches length and drill a 0.1 inch diameter holes at one ends about 0.2 inch to the end

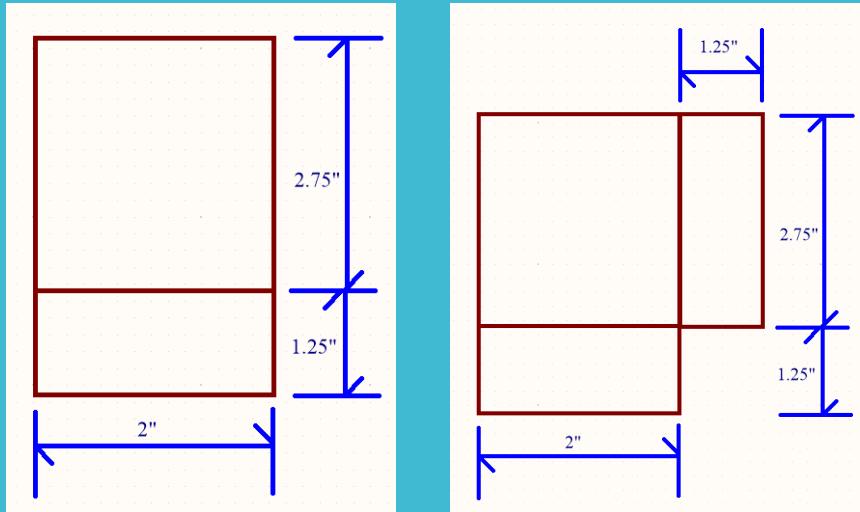


# UVC Sanitize Box

## step 3

### Prepare aluminum sheets

1. Cut Al sheet
2. Bend the Al sheet
3. Drill holes according to socket and mounting
4. Drill holes at edge according to steel mesh



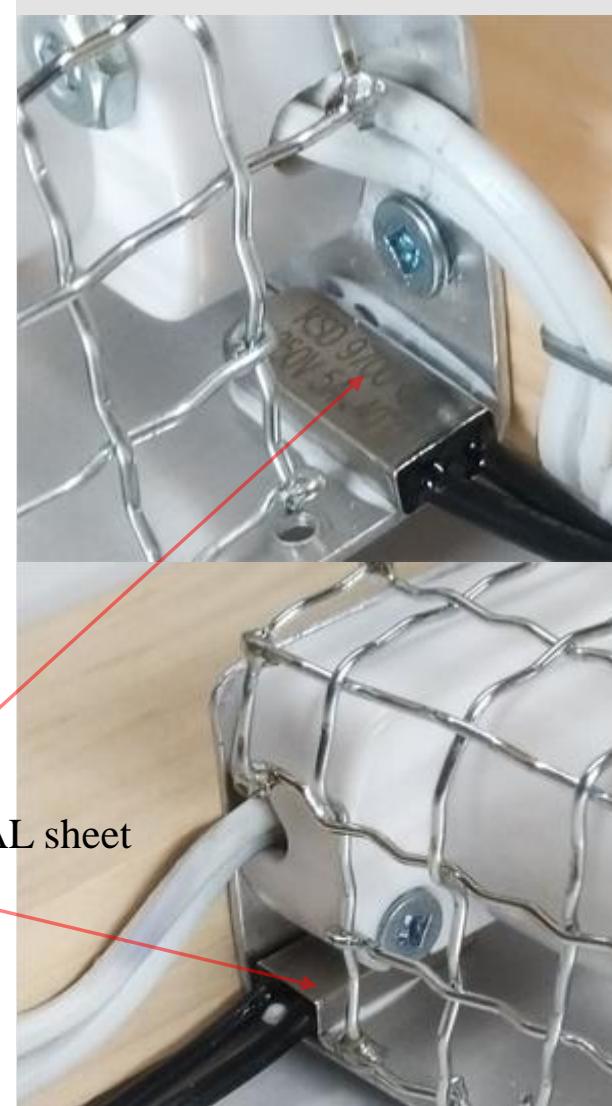
# UVC Sanitize Box

## step 4

Install over temperature thermostat to aluminum sheet

Use thermos glue to glue the thermostat on

Glue thermostat to AL sheet  
by thermo glue

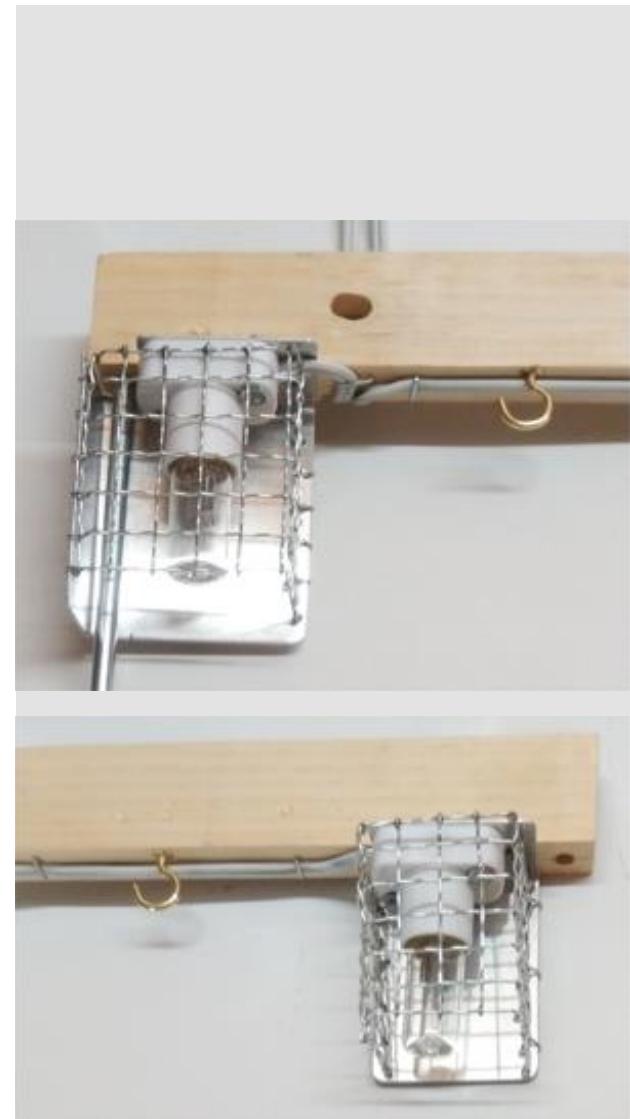


# UVC Sanitize Box

## step 5

Install socket, Al sheet to wood stick

1. Connect thermostat in series with the socket by electrical wire
2. Install socket, aluminum plate to wood stick as shown
3. Install steel mesh to the aluminum plate as shown

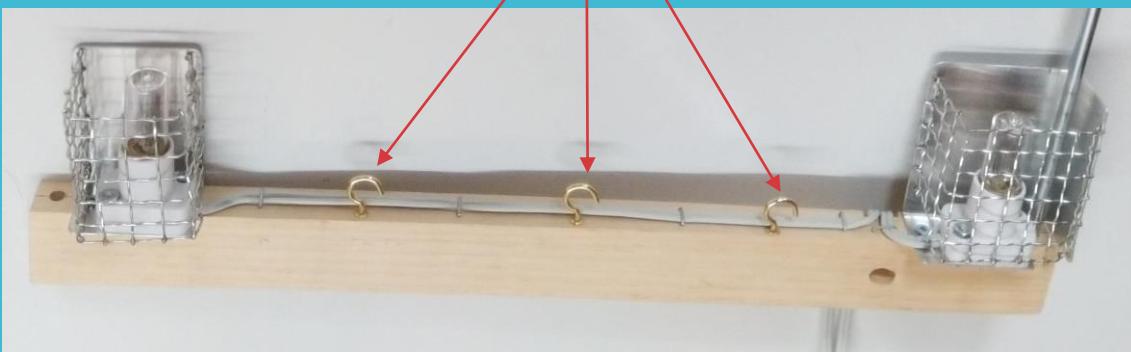


# UVC Sanitize Box

## step 6

Install brass hooks to the wood stick as shown

Brass hooks, as required



# UVC Sanitize Box

## step 7

Build the bone structure

Insert steel rods to wood sticks as shown  
glue the plastic plates to bag as shown  
Install structure into cooler bag as shown

Wala ! Box done !



# UVC Sanitize Box

## step 8

Connect the control box

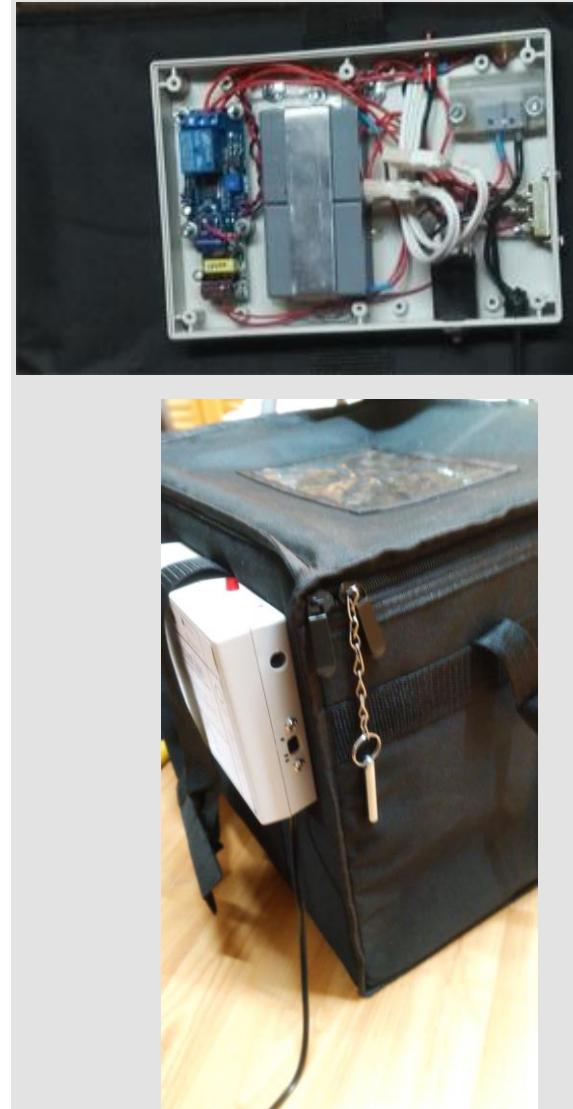
Insert wires into the control box and plug to sockets

Screw the box to wood stick by wood screws

Install wood screws to hold the bag to wood stick

Install steel rod for power control

*Hurray ! Finished !*



# UVC Sanitize Box

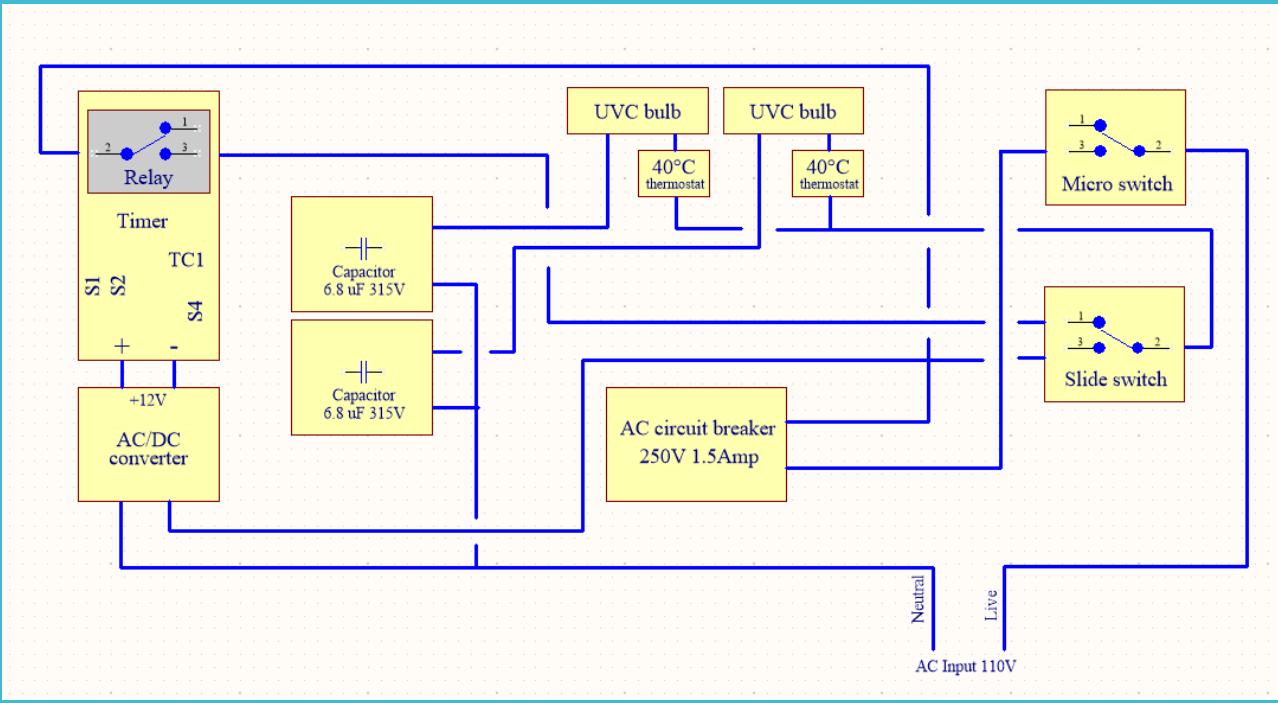
# Tips of UVC bulb

1. The UVC bulb emit 254 nm UVC light when lights up.  
This type bulb is used in brand name air cleaning system for air cleaning
  2. The bulb generate about 77°C on bulb surface when lights up. That is why steel mesh is installed to avoid touch by human.
  3. The heat radiated to the aluminum plate is low as about 32°C  
Purpose of the aluminum plate is to block direct heat to the bag surface.
  4. Purpose of glued plastic plates are act as separator between aluminum plate and bag to make sure they are not direct contact just in case.  
32°C will not harm the plastic bag and seems there are no safety concern at all.
  5. Two bulbs connected as separated circuit is to make sure at least one will lights up even the other one is not.



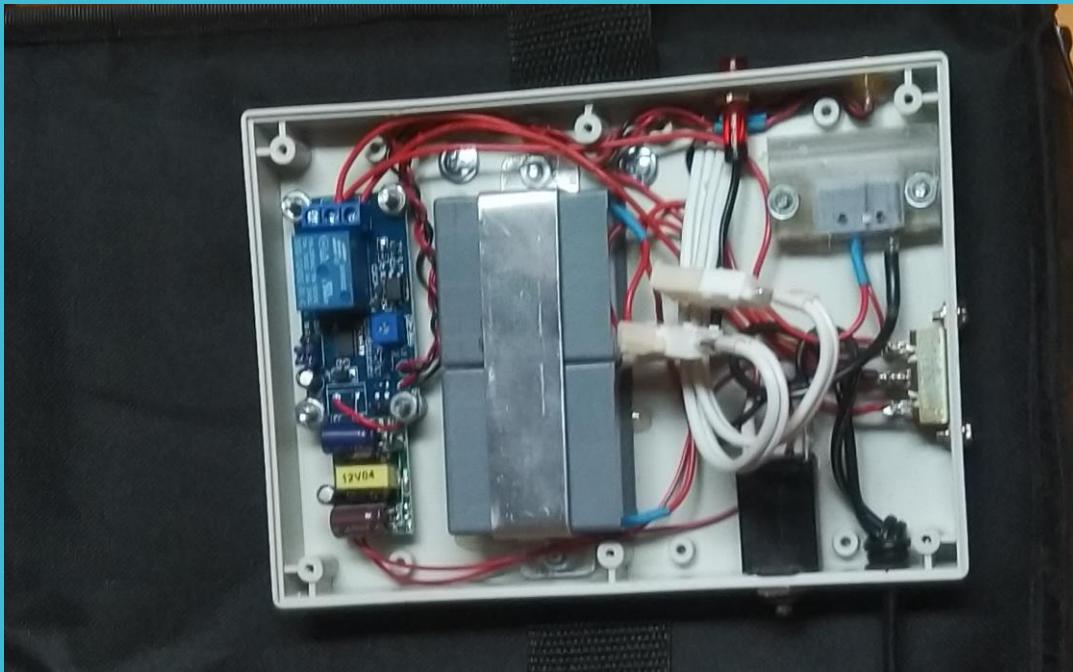
# UVC Sanitize Box

## Circuit of connection



# UVC Sanitize Box

## Control Box



### Control Box

Basically, only one component is custom built and all other components are off shelf ready buy.

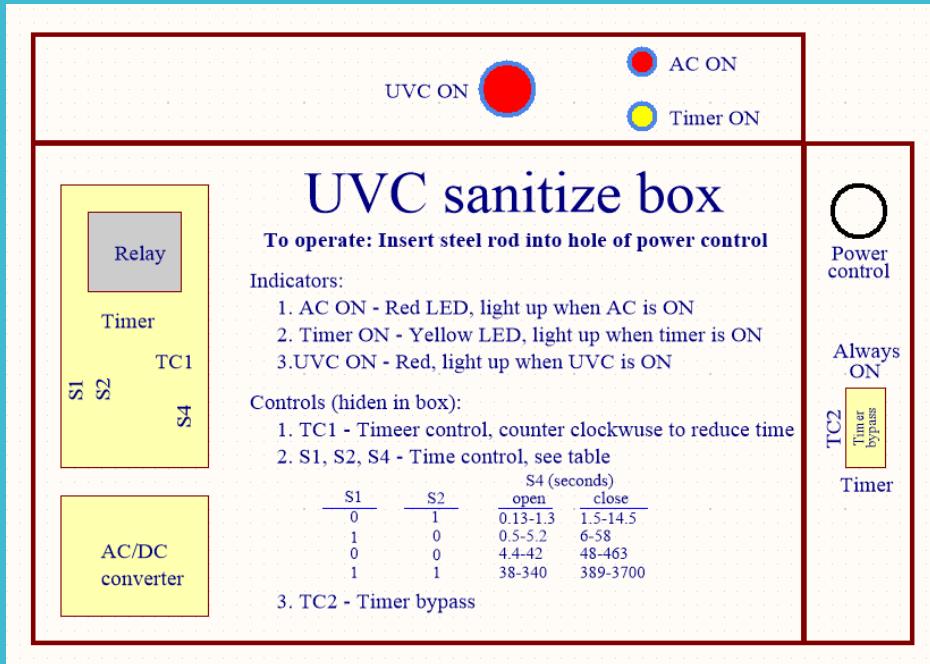
Building the box is just mechanical work of components installation.

Of course, you need some soldering skill and basic electronics knowledge for connecting all the components.

Following slide will explain how to build the custom micro switch for power control.

# UVC Sanitize Box

## Control Box



## Control Box Label

Print a label as shown or at your preference then glue it to the top of the control box as operating guide.

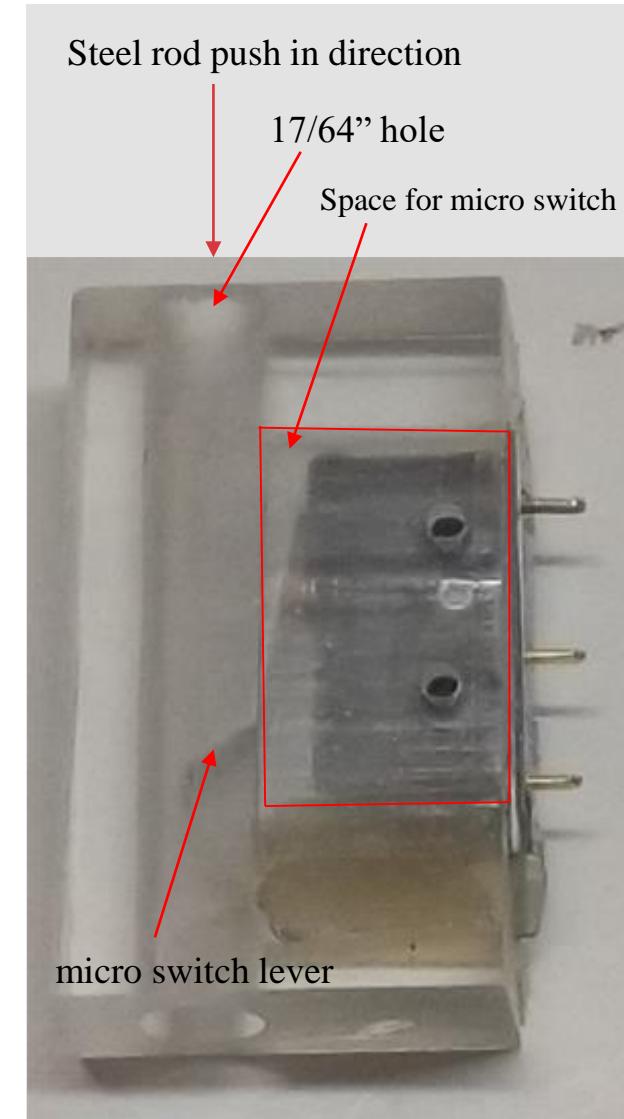
# UVC Sanitize Box

## Build the custom micro switch

Plastic block or any ways for you to build a plastic housing easily.

Here is what I did:

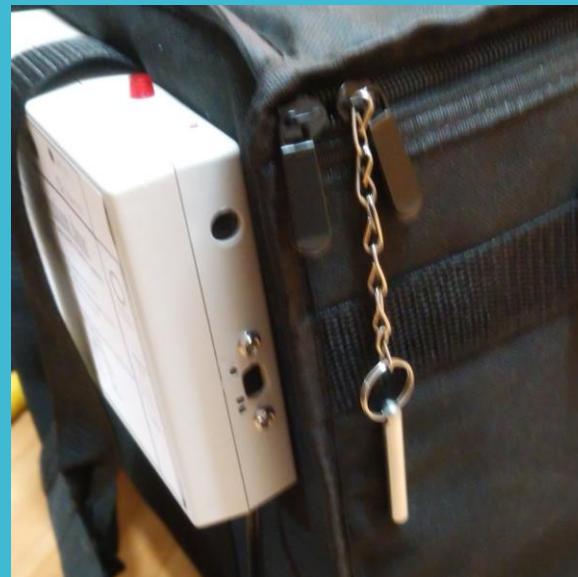
- 1 Get a plastic block with size can house the micro switch
- 2 Cut out an empty space to house micro switch
- 3 Drill a 17/64" hole through as shown  
Note that the space intersect with the 17/64" hole for the micro switch lever to go in
- 4 Use screws to mount the micro switch to plastic block.  
Note: I used hot melt glue to glue the switch and worked fine for me.
- 5 Drill two holes at free space for plastic block mounting to the box
6. Get the 2" steel rod, put a chain and key ring to it as micro switch activation tool
7. tie the chain to the zipper handle of the cooler bag



# UVC Sanitize Box

Build the custom micro switch cont.

6. Get the 2" steel rod, put a chain and key ring to it as micro switch activation tool
7. tie the chain to the zipper handle of the cooler bag



# UVC Sanitize Box

## All Done

### Verification:

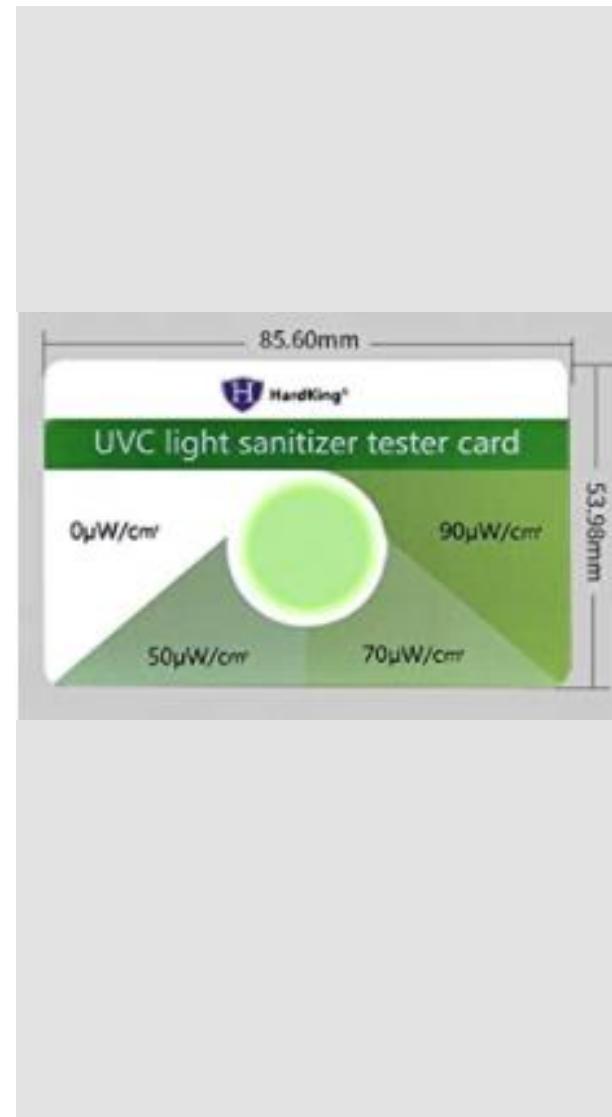
UVC test cards are used to verify the UVC light bulbs do emit UVC light.

### Support:

Please feel free to contact me via contact page for any information  
You also can have Q&A from the forum

### Disclaimer:

1. All components are purchased off shelf from market
2. There are no endorsement of any purchased components in any kind
3. You are responsible of your own risk and safety.
4. We are not liable of any of your safety, damage whatsoever



# UVC Sanitize Box

## Effectiveness of UVC

UV effectiveness is estimated by calculating the UV dose which will be delivered to the microbial population. The UV dose is calculated as follows:

$$\text{UV dose } (\mu\text{W}\cdot\text{s}/\text{cm}^2) = \text{UV intensity } (\mu\text{W}/\text{cm}^2) \times \text{exposure time (seconds)}$$

Dosages for a 90% kill of most bacteria and viruses range between 2,000 and 8,000  $\mu\text{W}\cdot\text{s}/\text{cm}^2$ . Larger parasites such as cryptosporidium require a lower dose for inactivation. As a result, the U.S. Environmental Protection Agency has accepted UV disinfection as a method for drinking water plants to obtain cryptosporidium, giardia or virus inactivation credits. For example, for a 90% reduction of cryptosporidium, a minimum dose of 2,500  $\mu\text{W}\cdot\text{s}/\text{cm}^2$  is required based on the U.S. EPA UV Guidance Manual published in 2006.

Content from: [https://en.wikipedia.org/wiki/Ultraviolet\\_germicidal\\_irradiation](https://en.wikipedia.org/wiki/Ultraviolet_germicidal_irradiation)

# UVC Sanitize Box

## Update

UV sanitize box had been verified by using test cards and proved that UVC light exist and has expected strength.

First: A test card as shown was used to check UVC light do exist.

The card showed a light green when UVC light exist. It is expected to be a lighter green than 50 uW color because the specification of UVC bulb is 35 uW only.



# UVC Sanitize Box

## Update cont.

Another test card is used to check the energy generated by the UVC bulbs. The center of the card showed yellow when not exposed to UVC light.

The card changed to color similar to orange after about 30 minutes and changed to similar red color about 40 minutes.

Here is the calculation:

$$\text{Energy} = \text{Power} \times \text{Time (Second)}$$

So, for 35 uW power at 30 minutes  
the generated energy is

$$\text{Energy} = 35 \times 1800 = 63000 \text{ uJ}$$

or 63 mJ (63000 / 1000)

