

# **600KV Van de Graaff Generator High Current Model**



[www.physicsplayground.com](http://www.physicsplayground.com)

# 600KV Kit Model

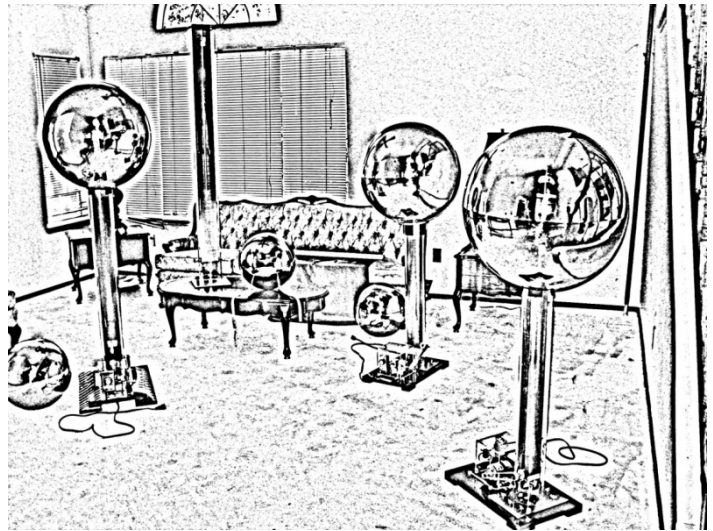


# Table of Contents

<b>Introduction and Materials</b>	<b>4</b>
<b>How a VDG Works</b>	<b>5-6</b>
<b>Video Overview (Youtube)</b>	<b>7</b>
<b>VDG Specifications</b>	<b>7</b>
<b>Building the Base</b>	<b>8</b>
<b>Prepping the Tubing</b>	<b>8-10</b>
<b>Rollers and Charging System</b>	<b>11 -14</b>
<b>Quick Start</b>	<b>15</b>
<b>Operation Instructions</b>	<b>15</b>
<b>Trouble Shooting</b>	<b>16</b>
<b>Maintenance and Safety</b>	<b>17</b>
<b>Experimenter Ideas</b>	<b>17-18</b>

# Introduction:

Welcome to perhaps what will be your first VDG build. This manual is designed to give you a very straight forward streamlined set of instructions so that you will be finished and shocking your friends in no time. To start the build, below



you will find a list of materials, tools and general adhesives that are necessary for completion. I encourage that you take your time in order to ensure a kit that will achieve at its maximum performance.

During the process of constructing the VDG, there are a few things that are imperative to be mindful of. The first item is to never get oil on any of the parts, primarily the belt and rollers, because this will hinder the device from producing a charge. Secondly, never clean the VDG with acetone or other alcohols because it will react and crack the acrylic, furthermore, acrylic is very fragile so be extremely cautious while handling. With these tips in mind, let's get busy.

## Tools:

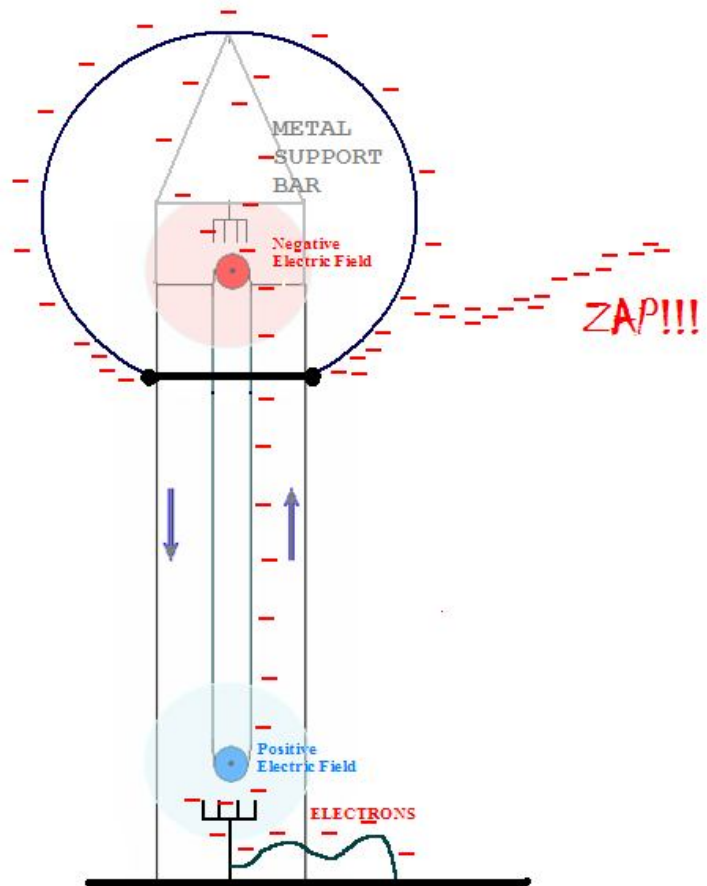
- Sand paper (fine grit)
- Screw Driver
- Needle Nose Pliers
- Scissors
- Drill (for sanding axles)
- Razor blade
- (optional) 5 minute 2 part epoxy or Loctite

## Materials:

- Gorilla Super Glue **(now included)**
- Electrical Tape
- Fishing String

# How a VDG Works:

The VDG works by taking electrons from the bottom grounded comb and transferring them to the top comb, where they are then distributed to a dome where they are trapped and accumulated to produce a very large electric field. The heart of this charging process is dictated by two physical principles. The first principle is that opposite charges attract and like charges repel such as in magnets. The second physical principle is that many objects develop either a positive or negative charge when



rubbed. This process of charging is often done on a daily basis such as when you rub your feet on the carpet and accidentally shock the cat or when you pull your clothes from the drier and feel the clinging sensation from the charge that built upon the clothes while drying. As found in the **triboelectric series**, some materials develop a stronger + or – charge than others.

With these physical principles in mind, let's now look more closely at how the VDG dome receives the charge that makes our hair stand up. When the latex belt runs across the bottom nylon roller it develops positive charge which then produces a positive electric field. The free roaming electrons on the bottom metal grounded comb begin to feel the attraction from the positive electric field, causing them to fling toward the roller. However, since insulating latex belt is between the comb and the roller, the electrons get stuck to the latex belt surface, where they are then transported to the top to be flung right back off.

During this process the top roller develops a negative charge that emits a negative electric field. As the electrons on the latex belt begin to approach this roller, they start to feel its repulsive negative charge, where they are flung to the closest conductor they can find, which so happens to be the top comb. The electrons are then pushed through the metal support system, to the stainless steel discharge dome where they accumulate to produce the hair standing electric field. As the belt rounds the top roller, now approaching the bottom, it will have a neutral charge due to the excess electrons expelled to the dome. If the top roller can develop a large enough negative charge, it will produce a returning positive charge belts, which in turn will be advantageous to attracting even more electrons from the bottom comb.

The dome is one of the most crucial parts of the VDG, which accounts for at least 80% the generator's final output voltage. So that a maximum voltage can be achieved, it is essential to understand conceptually how the electrons interact with the metal sphere. Once the electrons make it to the dome, they are now roaming around and cramming against each other due to their individual repulsive electric fields. Essentially they are looking for a way out, which consist of any edge or point on the surface that offers a path of least resistance. By referring to the illustration, there is a high concentration of electrons located at the discharge sphere's bottom edge because this is a region where the electrons feel the lowest resistant and will try to prematurely leak off (**leakage**), hence creating a lower voltage. To prevent this from occurring, the dome has an insulation that lines the bottom edging.

Not only will the electrons try to leak off from the bottom location, but from any protruding scratch or even dust/dirt particles. Because insulators become conductors at high voltages, mostly any material on the dome such as dust or debris could create a point of leakage. If there are no points of leakage present, the electrons will build to such great numbers that they will arc to surrounding objects or even down the acrylic tower. Just wait and you will see!

# **Overview of VDG Building Process Video**

Below are two links to You Tube videos that have been made for a similar model that gives a brief overview of building the VDG. These videos will soon be updated to fit the new 600KV model.

*Please note: The videos below show the original 350 KV model that the 600KV was designed after. The video is being updated as there are a few design changes relative to the mechanics of the system.*

## **Part 1:**

<http://www.youtube.com/watch?v=XqAPI43UluY>

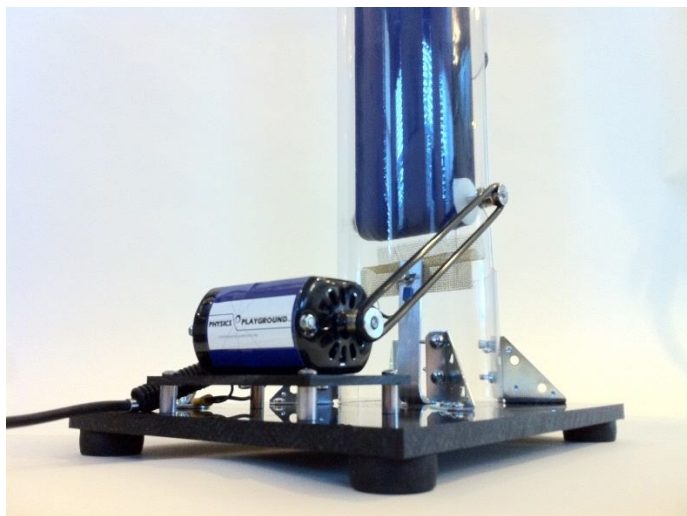
## **Part 2:**

<http://www.youtube.com/watch?v=toScKk0dWAw>

# Part 1: Setting the base (30 minutes)

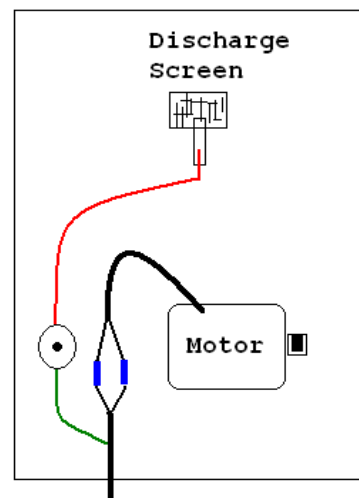
## Motor and Drive system:

- 1) Connect the motor to the small black motor base plate using two metric 4Mx.7mm-8m machine screws. After attaching, if the motor shows signs of interference with the screws, add a few washers to offset the distance the screws enter the motor base plate.
- 2) Connect the motor plate to the main base using the larger 10-24x1.25 machine screws and 4 aluminum standoffs as seen in the illustrations below.



**Wiring:** *(Warning: This section should only be completed by those who are familiar with AC wiring)*

- 1) Cut the end off of the 10 ft 3 prong cord to expose the wires. Peel off 7 inches of the black insulation of the cord and then cut the black and white wire to 2 inches long and 4 inches long for the green wire. Strip the ends of each wire.



- 2) Cut the wire leading from the motor to 5 inches. Split the wire and then very carefully strip the ends. The copper in these wires are very thin so make sure that wire has not been removed from the stripping process. If so, cut the copper ends off and repeat this process until correct. Connect the wires from the motor to the black and white wires of the power cord using the two blue crimp terminals.
- 3) There will be a long 1.5 ft black wire included in the kit. Strip on end of the back wire and connect it along with the green ground wire to the larger yellow o-ring terminal and then connect it to the main base using the  $\frac{1}{4}$ -20x 1.24 inch machine screws, large fender washer, and wingnut as seen in the illustrations. Cover the wire with the insulation when finished.





## **Part 2: Charging System and Rollers (30 minutes)**

*(Prior to starting, please note that the bottom roller will be **WHITE** and the top will be **GRAY**)*

**CAUTION:** This is the most difficult part of the building process and if not pursued with care, the builder will bend the racers in the bearings making them difficult to spin.



**Bearings:** The bearings will be pressed onto three 1.25 inch axles and one 2 inch axle. The smaller axle may have the bearings pressed on by placing the bearing on a metal or concrete surface and then **very gently tapping** the axles in by using a hammer.

When prepping the larger 2 inch axle it is best to sand it down enough so that the bearing will slide across it with just a slight amount of tension and then use a two part epoxy or Loctite to hold it in place. The bearing should only slide down about 3/4 of an inch, just enough so that the pulley may fit on.

**Axles:** The axles may now be pressed in. Please take your time on this part. To press in the axles, use either a vice press or tap in the axles with a hammer however if you use a hammer, you cannot directly hit the bearings and must use a pointed metal object so that you are only striking the axle. When the bearing seem to be close, place them into the tube insertion holes to check the length. When finished, they should have a snug fit that slightly pries out on the tube.

**Wool Coating:** On the rollers are coatings that will significantly enhance the VDG's performance. The nylon roller has a wool coating. This wool coating should first be cut to size relative to the length. The wool has been precut to the correct width and should touch at the locations where the rollers crowning begins.

The wool is applied by quickly spreading a **very light** amount of super glue on the nylon roller and then pressing on the wool. If too much super glue is applied, it will override the charging properties of the wool and will cause the VDG to operate very poorly. Next, wrap the wool in **nylon** fishing string to further support the wool. To fasten the nylon, use super glue or melt the string using a match or lighter.

**Combs:** . To connect the combs, you will have to press a small hole through the material and then connect the comb to the top and bottom braces as seen In the illustrations. The most important item about the combs is that they **do not touch the belt** and the combs have exposed points to produce the ions jets that spray electrons on to and from the belt. To expose the points, just pull a wire from the brass screen. The top and bottom combs assemblies should be braced with the 10-24 x 5/8 machine screws.

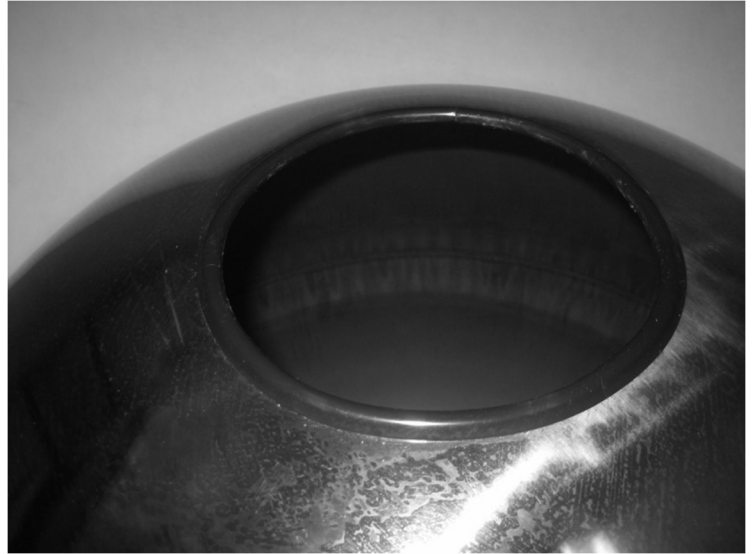
### **Dome support System:**

- 1) Connect the large support system to the outside of the tube using the four 10-32 nylon machine screws and wing nuts or thumb nuts provided.
- 2) On the support system is a 4 inch arm that will be used to hold the top comb. Attach the arm using the flathead 10-24 x 5/5 machine screw and wing nut.
- 3) Place a hole in the brass screen and attach it to the bottom of the arm. This screen should bent so that it does not touch the roller belt material



## **Dome Preparation:**

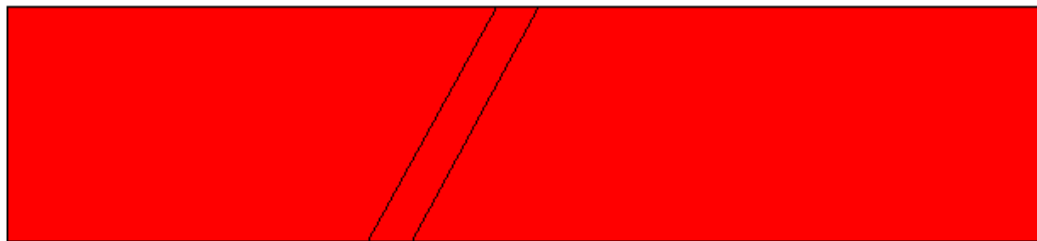
- 1) Attach the edge trim to the metal sphere so that is very tightly applied. To avoid a gap at the location where the ends meet, cut a small angle at the beginning end and walk the trim around. Next, use a large amount of force to push in the trim and cut the other end so that it is flush with the beginning. Should there still be a gap, cover it with either a 2 part epoxy or a small piece of electrical tape.
- 2) Once the insulation is attached, place the sphere on the VDG tubing with the aluminum support system already connected. With the sphere resting on the aluminum support system, place a mark on the tubing at the bottom of the sphere. This is the location where the foam edging will be placed in order to fill the gap between the insulation and the tubing.
- 3) To secure the foam edging, it is advisable to place a wrapping of white electrical tape around it. White tape has better insulative properties.



## **Mending the Belt Material:**

- 1) To mend the belt material, you will have to cut the ends of the 48 inch belt with a sharp pair of scissors to create a 30 to 45 degree lap joint. Next, mend the belt ends with Gorilla Super Glue only. To mend the ends, create a .375 to .5 inch lap joint and then lay a piece of paper between the joint and the belt below to prevent unnecessary

USE A 45 DEGREE LAP-JOINT WITH A .25 TO .5 INCH OVERLAY



ONLY USE GORILLA SUPER GLUE TO MEND

adhesion.

- 2) When applying the glue, pick up on one side of the lap joint and then spread the super glue using a Q-tip. Next, press the lap joint together where glued for about 1 minutes. Do the same for the other side of the lap joint.

## **VDG Operation Instructions**

### **VDG Assembly for Test Run:**

- 1) Before placing on the belt and rollers, **rewash the belt and both rollers using dish soap**. Try to avoid getting water on the bearings. When finished, dry a paper towel.
- 2) **Warning: These belts are deigned to create a very high tension system to avoid harmonics at high RPMs.** To assemble the belt and rollers, it is easiest to first place the belt on the top roller and then feed the belt material down the tube. Next, reach up with your left hand and place it through the loop of the belt and then pull down. With your right hand, insert the bottom roller and then release the belt with you left. Please note that it is important that your left hand is through the loop and not just pulling with your fingers.
- 3) Attach the drive belt form the motor to the bottom Pulley.
- 4) Space the top and bottom combs from .25 to .5 inches.
- 5) Turn the generator on without the dome attached and feel the top support system for sparks. If there are no sparks, blow a hair dryer through the bottom opening until it develops a charge. This may take up to 5 minutes. Under optimal conditions, there should be a continuous stream of sparks consisting of 2 inch arcs coming from the support system when touched. A majority of the time the VDG will start right up, however if it is still lagging, rewash the belt and rollers and allow is to run for about 10 minutes. You will find the more you use the VDG, the stronger it will operate.
- 6) Gently place the dome on top of the support system and screw the nylon bolt through the top dome insertion hole.
- 7) The sparks should average about 12 inches, with max sparks at 30 inches. If you are not getting 12 inch arcs, it could be due to a variety of reasons such as high humidity levels or

sharp pointed grounded objects in the vicinity that create ion jets and pull the electrons from the dome, hindering the VDG from building a charge. *Please refer to trouble shooting.*

## **Trouble Shooting:**

- 1) Problem: Humid day or working in large crowded auditoriums. This will decrease the voltage by half. That is why they say we have good VDG weather and bad VDG weather.

Solution: Blow a hair dryer through the bottom of the VDG roller entrance hole.

- 2) Problem: Dust particles on dome that cause leakage.

Solution: Clean the dome after each hour of use. Even small dust particles will cause points of leakage. To see the points of leakage, run the VDG with the lights out and look for small blue ion jets. Brush the ion jet away and the VDG will produce rather large arcs. Be very careful while trying this technique

- 3) Problem: Oil on belt and rollers. This will shut the VDG off.

Solution: Wash the top and bottom roller with soapy water.

- 4) Problem: Belt is not dry enough after washing. This will shut the VDG off.

Solution: Blow hot air up through the bottom of the tower while running.

- 5) Problem: Pointed metal objects around the VDG will cause it leak.

Solution: The VDG cannot be around pointed objects because they will prematurely pull charge from the dome and not allow it to build to its maximum potential. Keep the VDG located in open space.

- 6) Problem: Belt begins to rub on the combs at very high speeds.

Solution: Once the belt develops a large amount of wear, it will loosen and possibly brush the combs during operation. This will indicate that it is time to change the belt. These belts are made from a latex material and will break down in UV light, therefore when finished using the VDG, take off the belt and place it in a dark location. These belts should last a very long time if stored correctly.

## VDG Maintenance:

- 1) Do not allow the belt to come in contact with the combs during operation in order to maximize the belts life.
- 2) Latex will oxidize when in the presence of ozone or UV light. The ozone is inevitable due to the voltage produced, however the UV will inflict a significant amount of damage over time, therefore **always store the belt as removed and in a dark place when not in use.**
- 3) Never clean with alcohol or acetone due to sever cracking of the acrylic or CAB tubing.
- 4) The VDG belt and rollers may be cleaned with dish soap and water. Try to avoid water contact with the bearings.
- 5) All parts of the VDG charging system (dome, belt and rollers, and tower should be cleaned every 2hours of run time.

## VDG Safety:

- 1) VDG's should not be used around people with heart condition or pacemakers.
- 2) Participants with nervous disorders may be very sensitive to the VDGs such that the VDG may cause heightened levels of anxiety. This is not a well-documented and support fact in the education or health care community, however there have been situations inquired about that eluded to this being a possibility.
- 3) Be careful not to make items that will act as high voltage capacitors. The current from the VDG's are safe, however when the current is allowed to be stored at such high capacitances, they can become lethal when discharged.
- 4) Larger VDGs can produce welts from prolong exposure to arcs.
- 5) Keep away from all electronics and do not use in the same circuit that is used for other electronics
- 6) Operate in well ventilated areas due to the ozone produced.
- 7) Avoid making human chains.
- 8) Keep the speed control away from VDG while in operation. Never touch the speed control while standing closer than 6 feet from the VDG.

## Warranty and Replacement Parts:

**Warranty:** Physics Playground generators and high voltage equipment are covered under a one year warranty except for static belts and speed controls. Sign of rough use, such as dropping, over tightening hardware, and exposure to caustic chemicals will dismiss the equipment from eligibility of the warranty.

Prior to sending a replacement part, the buyer must email a photo of the damaged part to frederickgraff@hotmail.com for verification. All replacement parts will be shipped within 4 business days.

**Consumable Parts:** Please visit Physics playground for replacement parts. Both belt material and pre-made belts will be sold on the website. For those who wish to mend their own belts, the belt sizes are listed below.

- 400KV VDGs:  
(2 in x 32 in)
- 500KV to 700KV High Current VDGs:  
(4.5 in x 48 inch)

**Warning: Van de Graaff generators are not a toy and should only be used by those familiar with high voltage devices. Physics Playground does not hold responsibly for the use or misuse of the purchased high voltage equipment. Use at your own risk.**