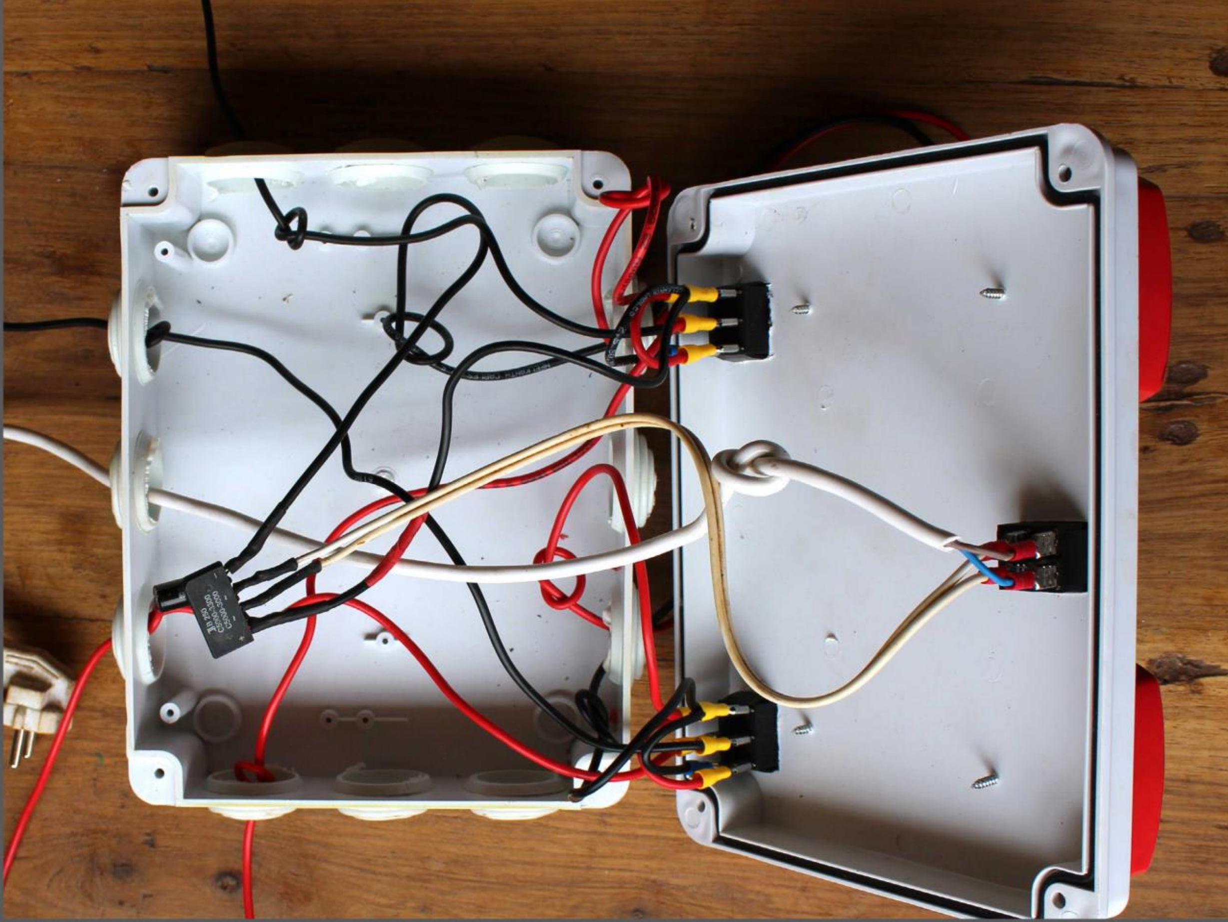
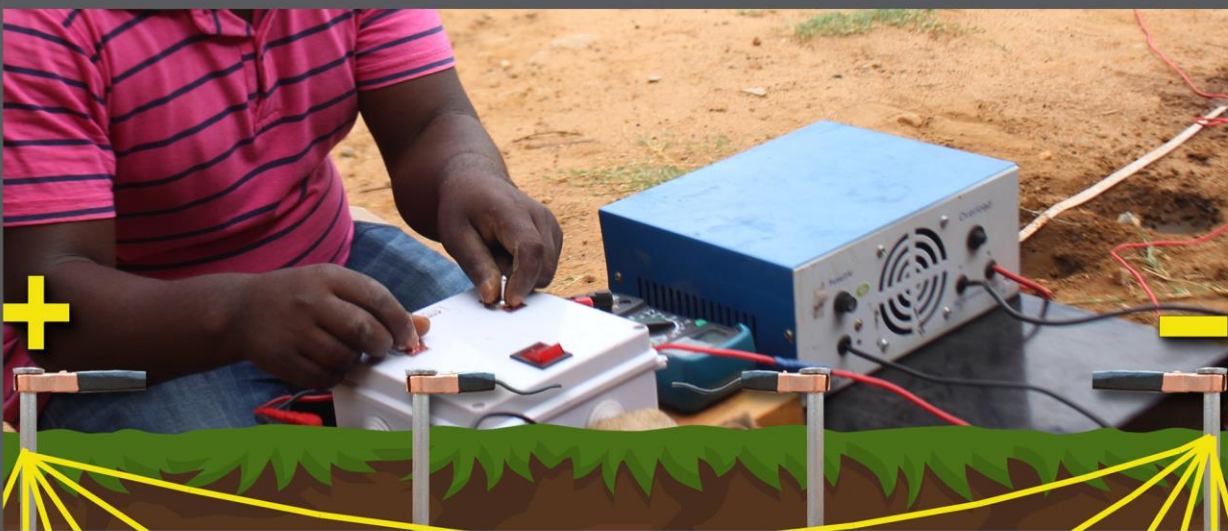
SMART Centres



Making VES equipment



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The **SMART** Centre Group

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It is highly recommended to use this manual in combination with practical hands-on training that can be provided by a SMART Centre. Please feel free to contact us via www.smartcentregroup.com

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1 Introduction

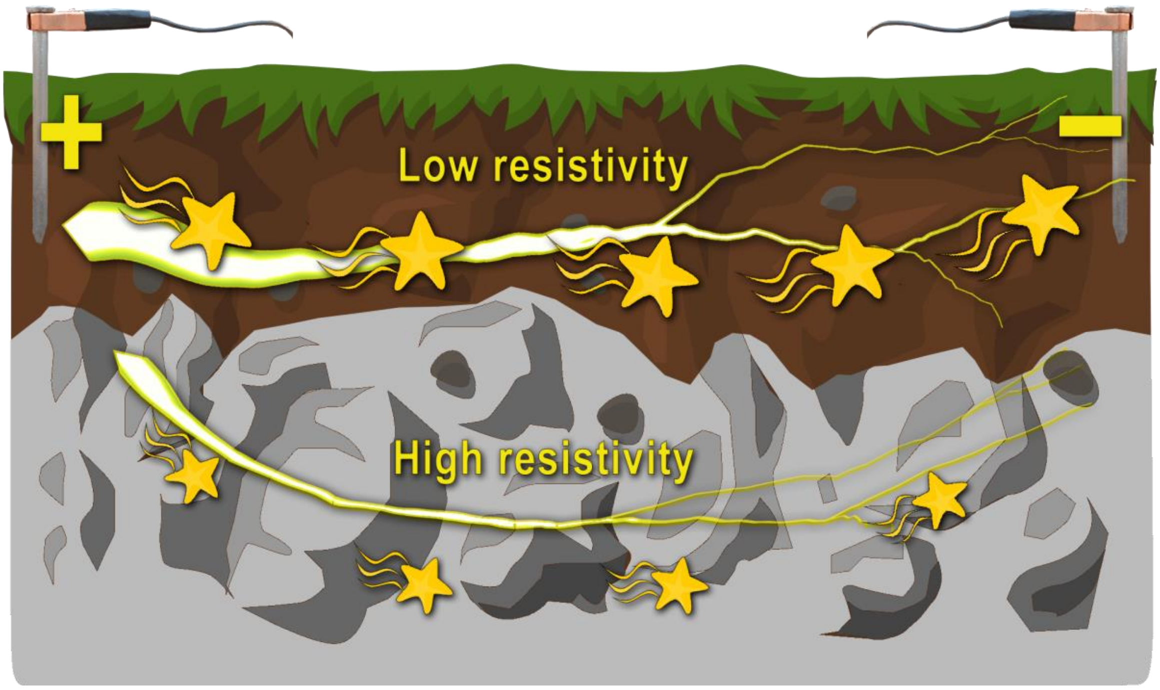
The construction of a borehole is a complicated process. Before drilling starts, a good drilling site can be selected by detecting the depth to bedrock with Electric Sounding Equipment.

This manual explains how to make Electric Sounding equipment with local available materials (€ 300) in common African context. This affordable equipment uses the same method as professional (€ 3000) equipment and is therefore just as accurate. It only takes more time to do the measurement. The use of this equipment is explained in the manual "Borehole siting".

2 Theory of electric sounding

Electricity travels easy through some soil types while it encounters more “resistance” in other soil types. For example wet sandy soil allows electricity to flow easily (low resistivity) while massive rock makes it difficult for electricity to pass through (high resistivity). By measuring the “resistivity(*)” of soil layers, we can say something about the type of soil. In general hard soils have high resistivity and soft soil types have low resistivity.

But how can we determine deep soil layers without drilling? We can only apply electricity at the ground surface by sticking probes in the ground and connect them to a power source. Luckily electricity flows in curves (see illustration). The farther apart we put the probes, the deeper these curves will reach.

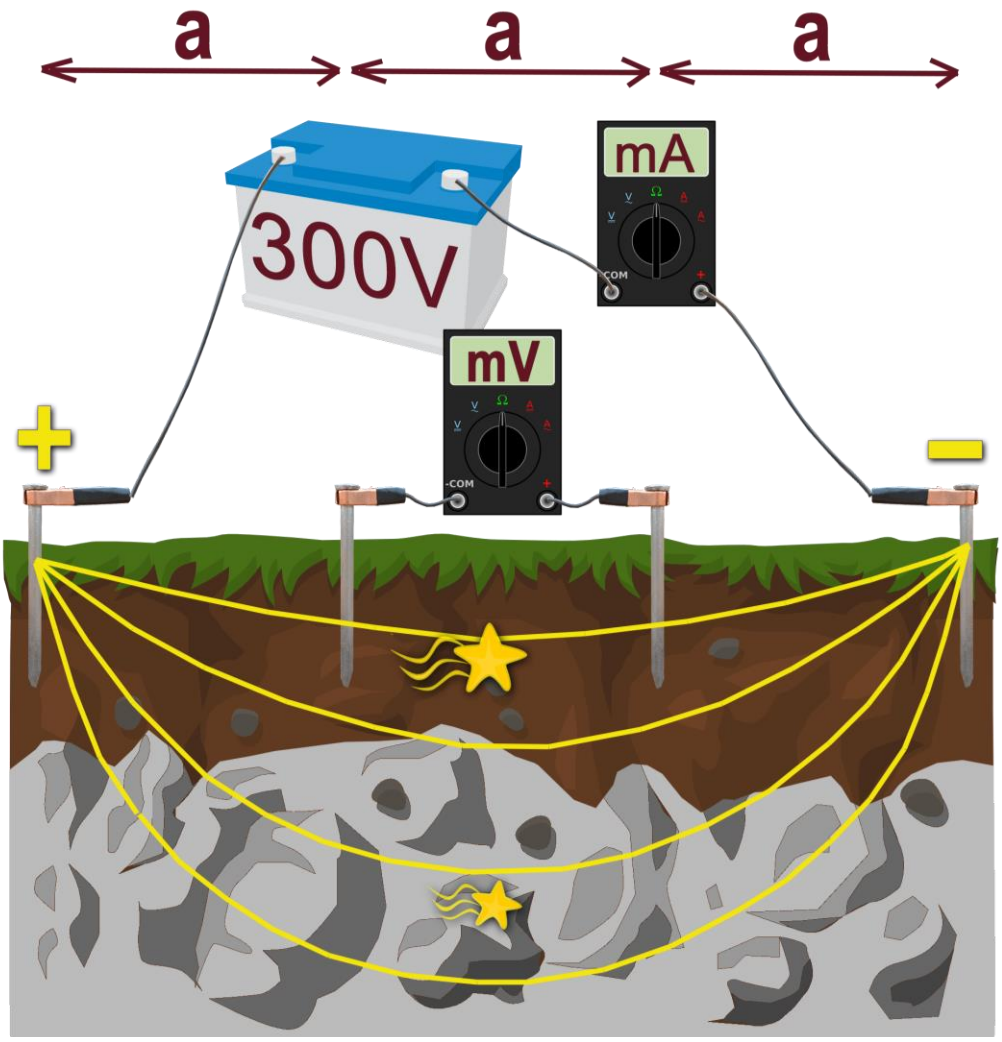


To calculate resistance (in Ohms or Ω), we use the formula Ohms = Volts / Amps. So we need to measure how much current (Amps) is flowing through the soil and we need to measure the difference in Voltage between two points in the soil.

> You can compare electricity as a flow of electrons just like a flow of water molecules in a pipe.
>
> - The current (Amps) is like with the amount of water that is flowing through the pipe.
> - The Voltage is like the water pressure.
> - Resistance (Ohm or Ω) is like the friction that slows water flow down when passing through a narrow pipe. A narrow pipe would have higher friction (Ω) compared to a wider pipe.

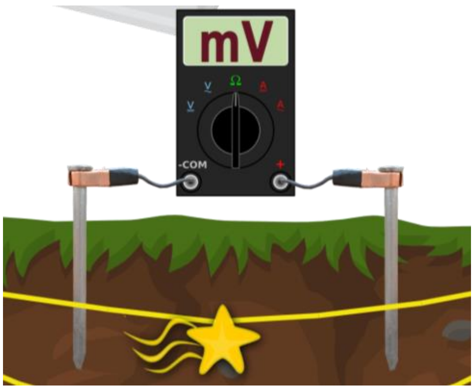
(*) *Electrical resistance (in Ω) depends on the material and the distance electricity has to travel (long distances have higher resistance). Resistivity (in Ω.m) is electrical resistance of a specific material and does not depend on distance. It only depends on the type of material.*

Inventor Mr. Wenner discovered that the following setup combined with some calculations (software) gave good results: He put 2 probes far apart and connected them to a high voltage DC power supply and measured the current (Amps) flowing through it. He also used two other probes which are closer together and measured voltage between these probes. The distance (let us call it “a”) between the 4 probes must always be equal and that “a” is also the approximate depth that you are targeting. If you want to measure deeper, simply increase distance “a” and move all 4 probes farther apart.



Note: this is a theoretical sketch; in reality, we will use a normal 12V battery with an inverter and a rectifier to generate 300V DC.

2.1 God’s voltage



You will notice, when you stick two probes in the ground without applying power anywhere that you can already measure some mili-Voltage between them. This is the natural earth potential or God’s voltage. It would influence our measurement if we would not compensate it.

2.2 Compensating for God's voltage

Let's say you measure God's voltage of 75 mV. Now you swap the wires connected to the multimeter and measure again. You will notice is will say -75 mV. Only the sign has changed. So if we now take an average of these two measurements (75 + - 75)/2 = 0/2 = 0 mV both measurements eliminate each other.

That is exactly what we do when using the VES equipment. We measure each point 4 times:

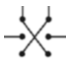
- 2 times in one direction
- And 2 times in the other direction

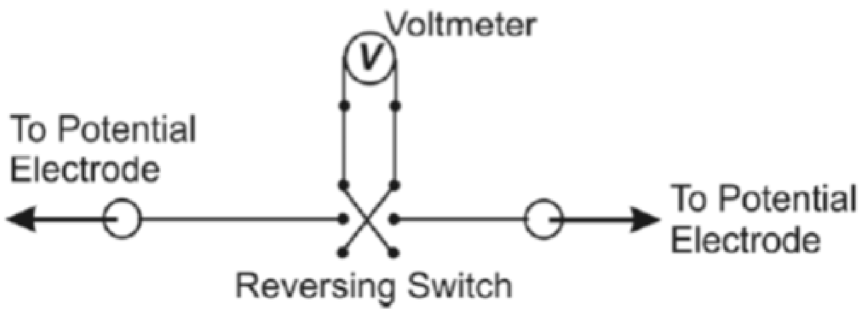
We than take the average and use it to calculate resistivity.

3 Electrical diagram

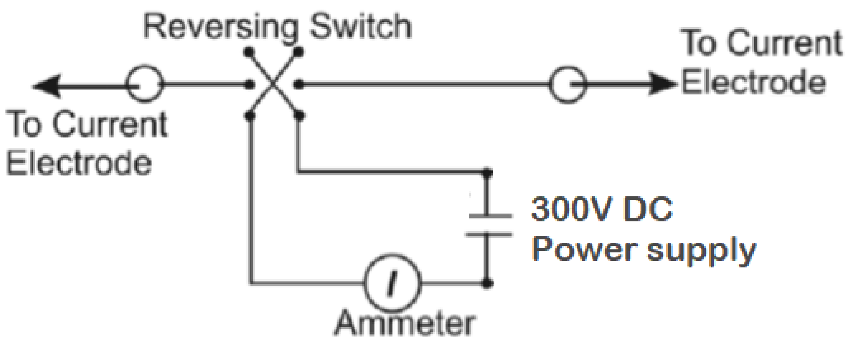
3.1 Reversing or toggle switches

So we could simply swap the wires after each of these 4 measurements. But it might be easier to have a switch do that for us.

Reversing or toggle switch  always have 6 connectors. If you buy one with a light, then open it and remove the light.



Also the wires to the current (Amp) probes need to be swapped so that current mAmp always flows in the same direction as we are measuring the mVolt.



It is good to remember when you are in the field and a switch fails, you can always swap the wires and have the same effect.

3.2 Making 300 Volt DC

For our measurements we need a high Voltage DC power source. Preferably 300 Volts but also 240 V DC could do.

DC is direct current and normally comes from batteries or solar panels and is of low voltage.

In our equipment we use normal a 12 Volt DC car battery. When buying a car battery, you don't need a big one, but make sure it is closed and maintenance free otherwise you will spill acid when transporting it. Also keep the plastic pole protectors they are useful when transporting it.

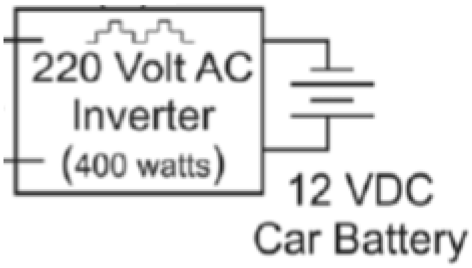
To make 300 Volt DC from 12 Volt DC we use an standard Chinese inverter which inverts 12 Volt DC in 240 Volt AC (alternating current).

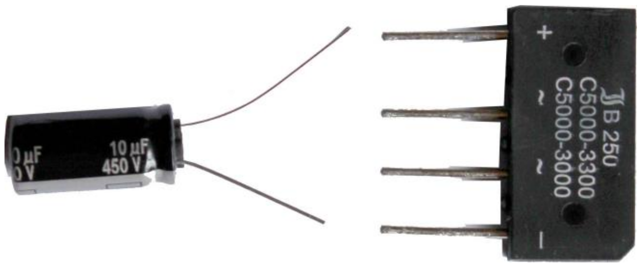
When you are buying such an inverter get one for 400 Watt (Watt=AV) or more and make sure you test the output and choose the one with the highest output voltage.

The inverter should have a fuse, buy a few spare fuses. In this example the inverter has also a charging mode so you can charge your battery when you are back from the field.

Also the inverter needs to be of an old generation using a coil and not mush electrical components because they are more robust for our type of work. Some of these inverters have a high out put switch, good for us.

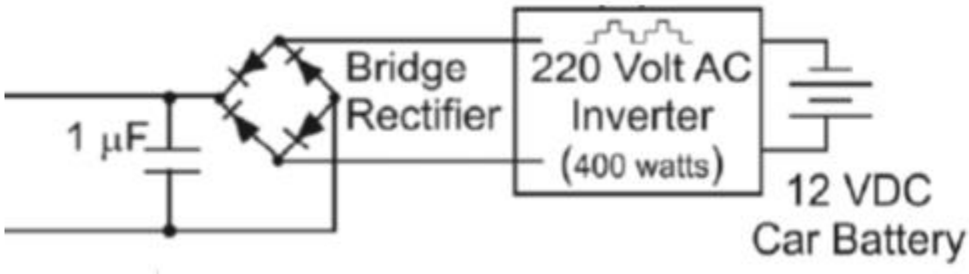
But now we have 240 or 300 Volt AC alternating current and we need DC direct current of the same voltage.





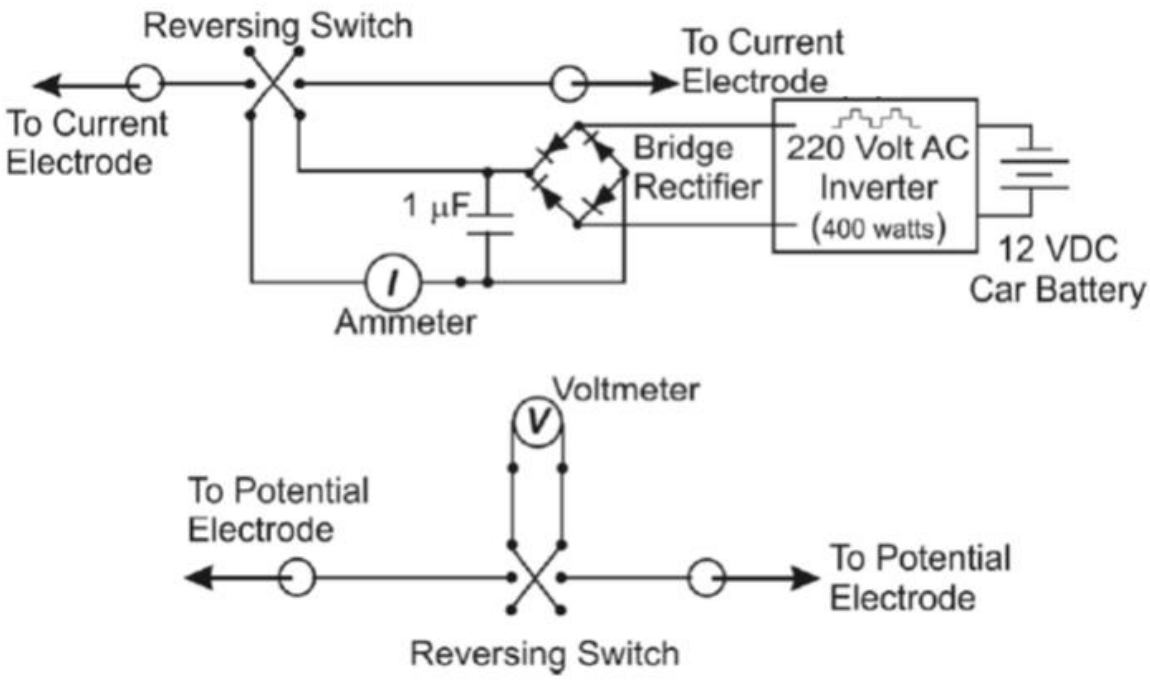
To make DC from AC, use a bridge rectifier (4 pins) and a capacitor of 1 µF suitable for 400 Volt or more. These components can be found in old heavy TV's or buy them online.
Connect capacitor's negative - to the - on the rectifier and the other to the +.

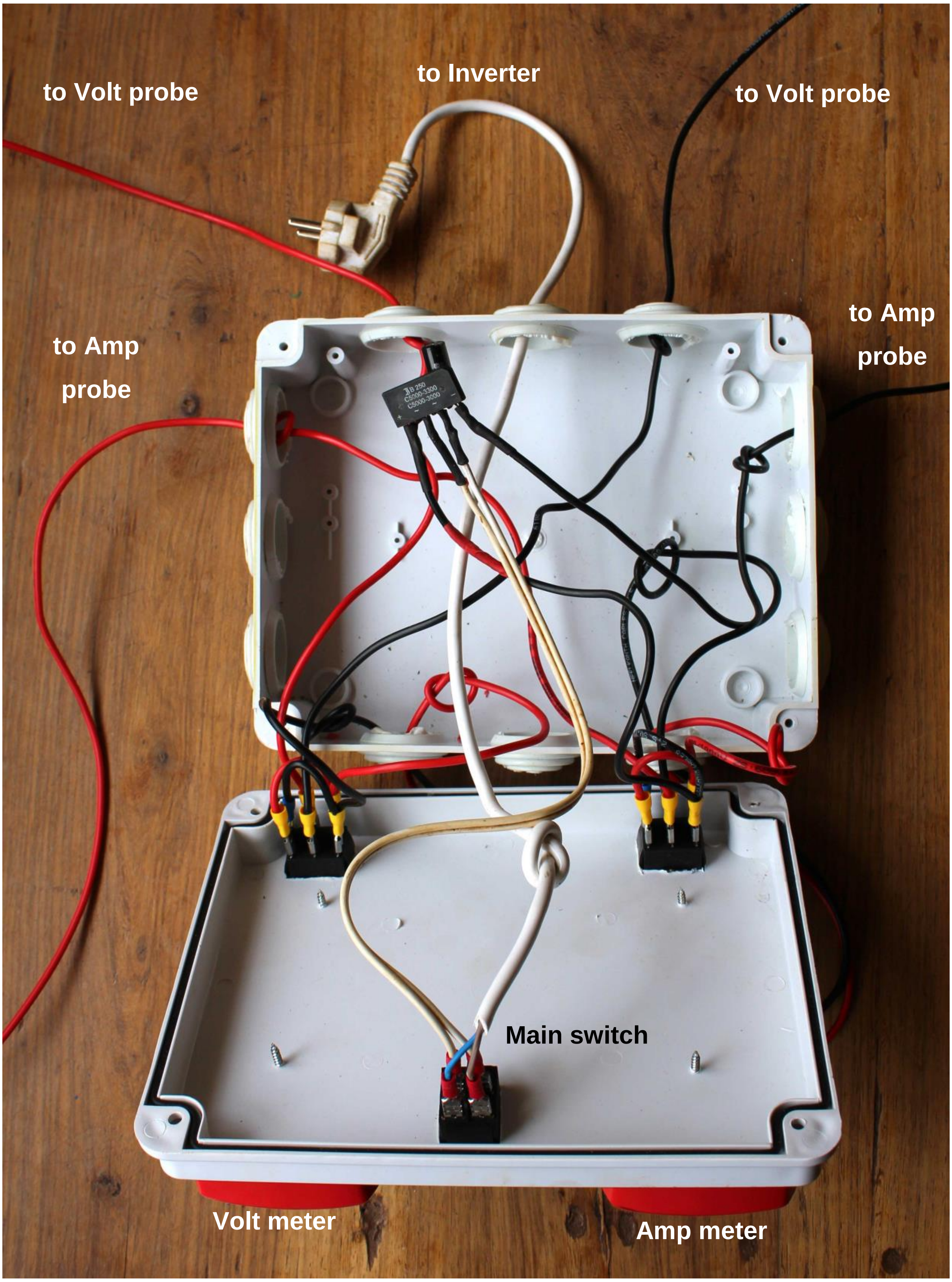
Make sure you insulate all connections to these small components very well because there are under high voltage.

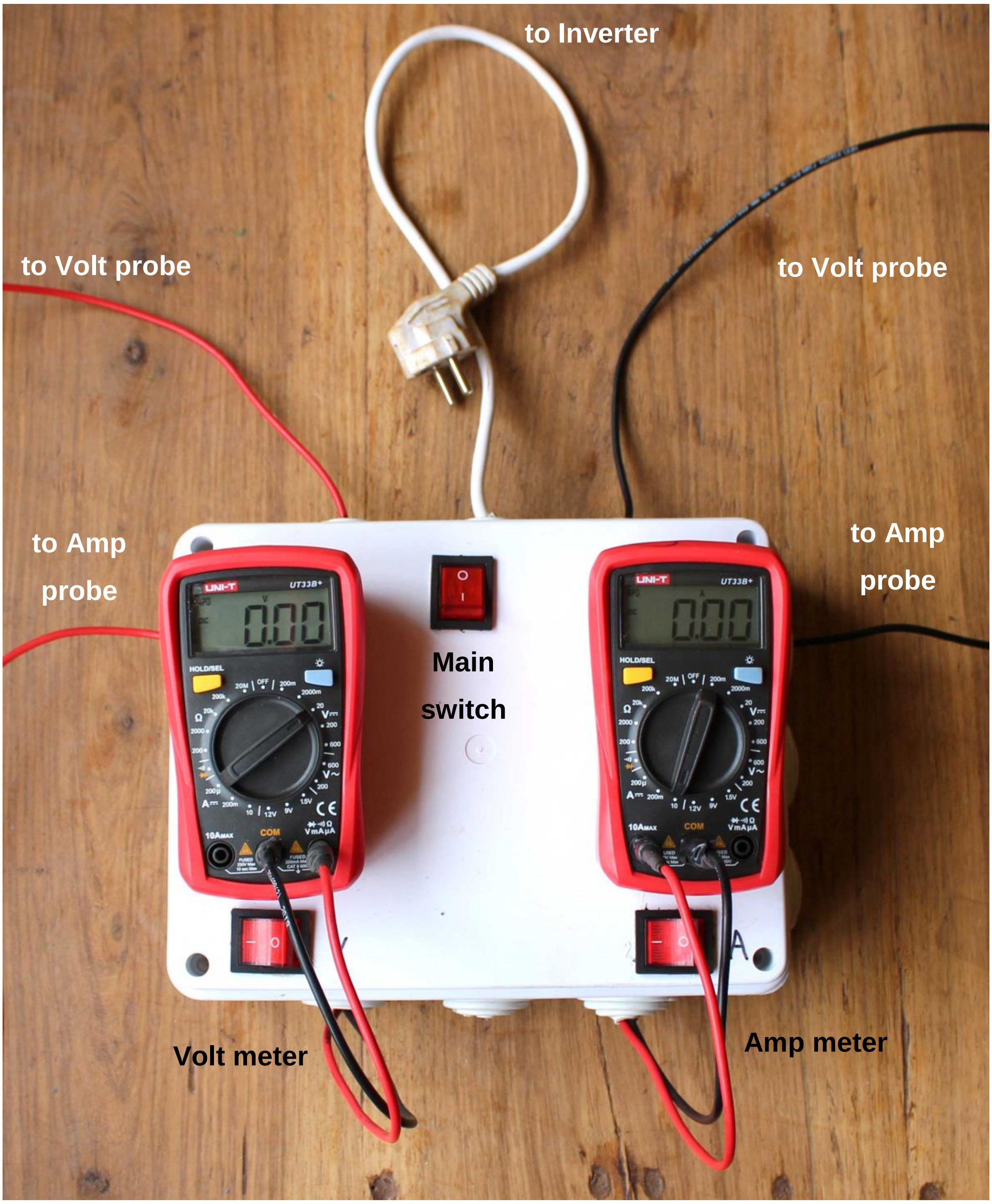


3.3 Overall electrical diagram

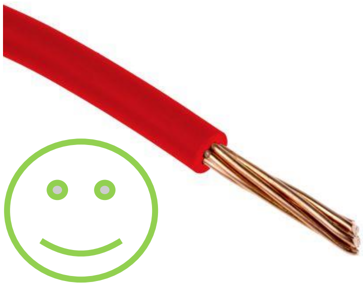
We have discussed all parts of the electrical diagram in the paragraphs above. Combined it looks like:




to Volt probe
to Inverter
to Volt probe
to Amp probe
to Amp probe
Main switch
Volt meter
Amp meter


to Inverter
to Volt probe
to Volt probe
to Amp probe
to Amp probe
UNI-T
UT33B+
UNI-T
UT33B+
Main switch
Volt meter
Amp meter

4 Connection cable reel to switch box



When buying cable, make sure to get stranded wire of 2.5mm² (=1.6mm or 14gauge). Wire that has one single core will break easily.

An item which we could not find in Zambia was a useful cable reel.

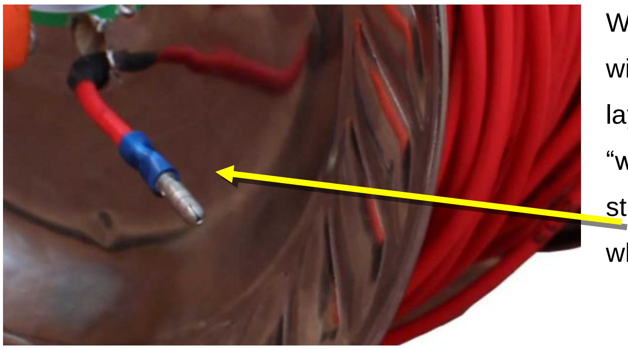
It is important to have a reel because rolling the cable by hand will cause kinks in the wire and will wear it out quickly. Rolling the cable by turning the cable reel will prevent kinks.

We had to make a reel using two plates (which we normally eat from), a piece of wood, a pipe, a bolt, a few nuts and washers. A screwdriver is used to hold the reel and the bolt to turn it.

Please let me know if you have a better solution.

To connect the cable from the reel to the switchbox we used Male and Female insulated wire Bullet crimp connector terminals. The blue type is suitable for our 2.5mm² wire.

To avoid confusing when connecting cables from the probes to the box; we made sure the Amp cable at the box was female (also to avoid touch it by accident) and the wires for the volt probes would be male at the side of the switch box. Of course it would be just the other way around on the side of the cable reel: at the reel with the long cable we have male connectors and on the short cables are female connectors.



We made relatively long wires sticking out of the witch box. This is done so that the reels can be laying on the ground while the switch box is on the “working table” or suitcase. There is no long wire sticking out of the reel because it will be in the way when rolling it.

5 Concluding

Making the VES equipment is simple but using it requires some exercise. We recommend you ask your SMART centre to train you in borehole siting and at least study the manual “Borehole siting” well.

Good luck.