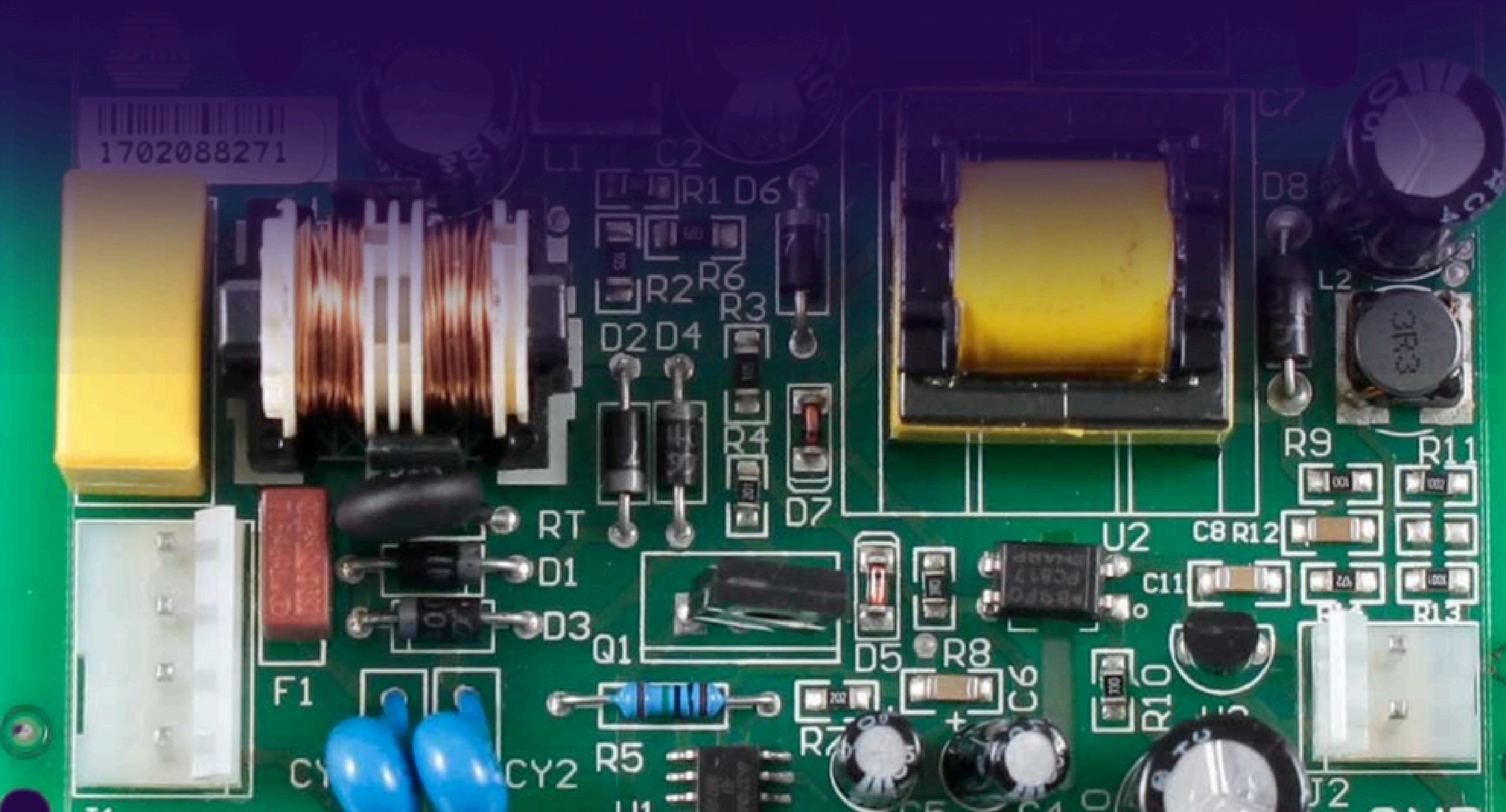
Complete Course

# Switch-Mode Power Supplies

From Basic to Advanced



## 1st CLASS

In the first class of our Switching Power Supply Repair course we will cover the following: following topics:

**1.** What is the main difference between a conventional or linear source and a switching source?

**2.** The generic block diagram of a switching source.

**3.** As duas estruturas básicas das fontes chaveadas: Tipo Série e Tipo Paralelo.

**4.** Exemplos práticos.

**5.** Exercícios nº. 1.

**6.** Avaliação da 1ª aula.

## LINEAR POWER SUPPLY AND SWITCHING POWER SUPPLY

In the past, power supplies were built from a transformer with several taps, and we know that transformers only work with Alternating Current. Depending on the voltage and current values required to supply the loads, this transformer becomes large and heavy. The weight and size of the transformer could be smaller if the frequency of the alternating current applied to the transformer could be higher than the 60 Hz of our electrical grid. However, this frequency cannot be changed because it is defined by the electricity provider and must be standardized throughout the country. On the other hand, working with higher frequencies, although convenient from a theoretical point of view, brought the complication of building transformers for high frequencies and capable of working with relatively high currents, which is why, for many times, power supplies looked like the one shown below:

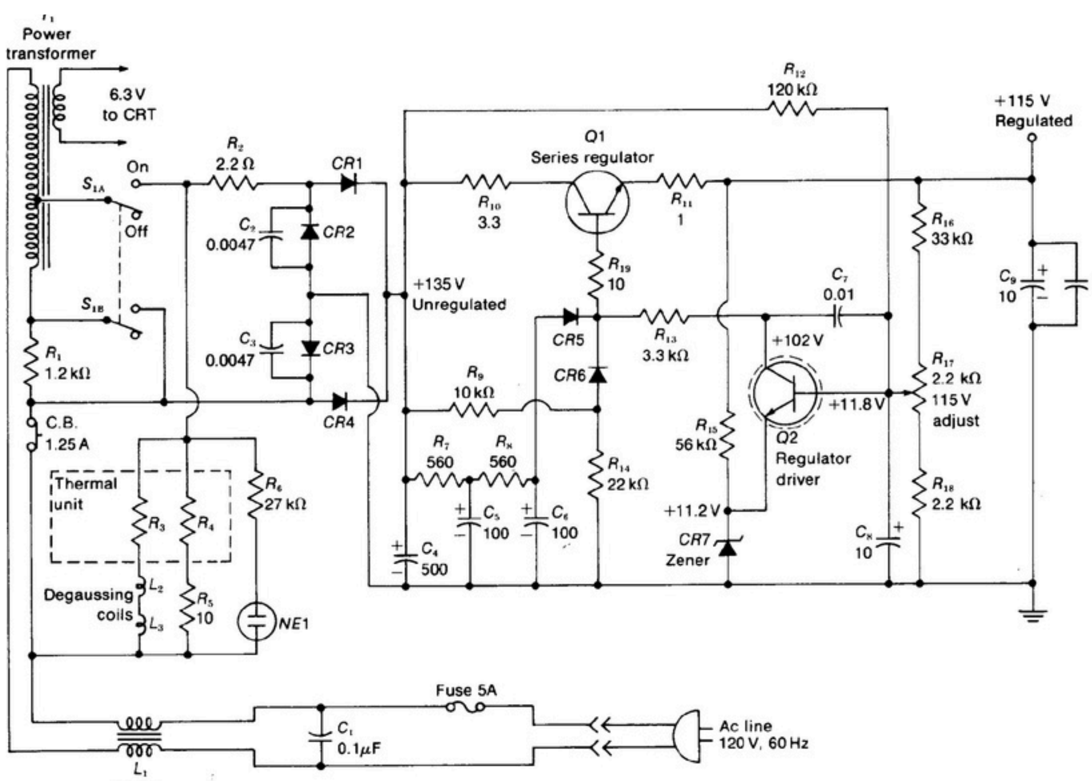


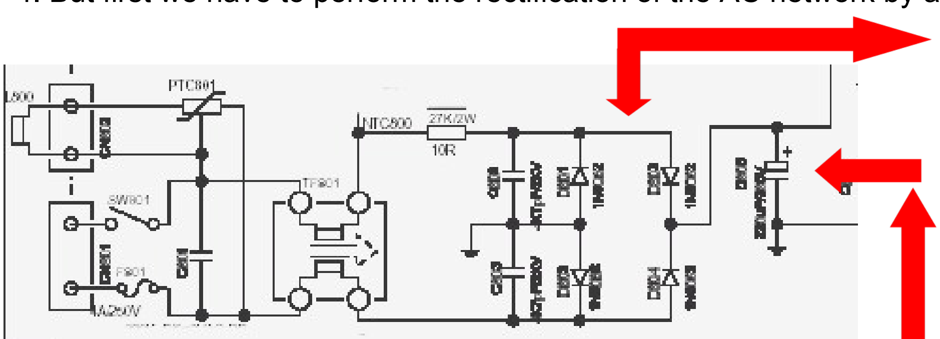

FIGURE 12-30 LOW-VOLTAGE POWER SUPPLY WITH FULL-WAVE BRIDGE RECTIFIER AND SERIES REGULATOR. *C* IN μF. *(SONY CHASSIS KV 1210 U)*

## THE "COMPLICATIONS" OF THE SWITCHING MODE POWER SUPPLY TRANSFORMER

**1.** These "transformers" work differently than a conventional transformer, which is excited by an alternating sinusoidal wave.
**2.** The first difference is that they work with pulses and are therefore often called choppers, an English word that can be translated as "pulse".
**3.** Another issue is that choppers will work with relatively high frequencies compared to the 60 Hz of the electrical grid.
**4.** When we increase the frequency of a circuit or a component of it, issues such as distributed and/or parasitic capacitances need to be taken into account.
**5.** The core must also have characteristics suitable for working with high and pulsating frequencies.
6. Measuring the ohmic resistance of a chopper will certainly not lead you to any conclusion.
**7.** Ohmmeters take measurements on transformers using direct current as a reference, but when a chopper is working it is subjected to relatively high (10kHz to 100kHz) and pulsating frequencies and then everything "changes".

## THE BASIC PRINCIPLE OF A SWITCHING POWER SUPPLY

1. The operating principle of a switching power supply is, in general terms, the same as that of a horizontal deflection circuit.
2. The switching power supply is, in fact, a DC-DC converter.
3. The idea is to produce the switching of a DC voltage in an inductor so that there can be a variable magnetic field and, consequently, the induction of voltages in nearby windings.
4. But first we have to perform the rectification of the AC network by a




**bridge circuit.**

Then we will have the filtering done by a **electrolytic capacitor.**

## SO FAR NOTHING NEW. REALLY?

Up to this point, the power supply behaves like a conventional linear power supply working at the mains frequency, that is, 60 Hz. This is the most widely used format today, although you can find switching power supplies for 110/220 volts with other "expensive" models. We will discuss them later. Before that, however, it is important to clarify that the new automatic power supplies are generally optimized to work between 90 and 240 volts. For this reason, the filter capacitor that comes right after the power supply usually has a working voltage (WV = Work Voltage) of around 400 volts. And speaking of this capacitor, it is important to remember that you should not underestimate it and perhaps it is a good "policy" to start by examining how it charges and discharges. In this case, the good old analog ohmmeter method can help. Another way that some technicians use is to place a capacitor of the same value (or close) and with the same WV in parallel with the original capacitor, but... BE CAREFUL!

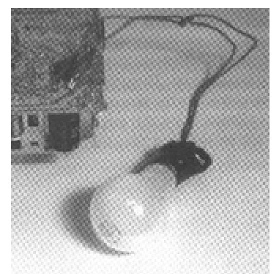
## YOU SHOULD NOT DO THIS!

1. If you want to place a capacitor in parallel with the original one in the power supply, before doing anything else, make sure that it is actually discharged.
2. Turn off the power supply and solder the test capacitor in parallel with the original one and only then turn the power supply back on.
3. NEVER touch the test capacitor to the other one with the power supply turned on.
4. The charge of the “new” capacitor can produce an initial current spike and damage the power supply’s MOSFET.
5. Another thing you should NEVER do is discharge the power supply’s original capacitor by shorting its terminals.
6. If you want to discharge ANY power supply capacitor, use a resistor.
7. The main filter capacitor (the one we saw back there) can also be discharged with an incandescent lamp.

## LAMP TO DISCHARGE CAPACITOR AND TEST THE POWER SUPPLY

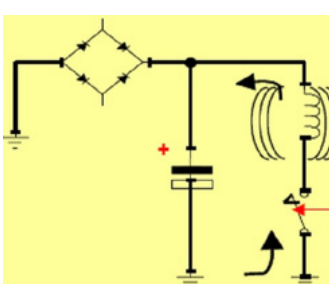
1. The bulb should always be an incandescent type. ELECTRONIC LAMPS WILL NEVER WORK.
2. The bulb's power can be between 25 and 40 watts.
3. The bulb's operating voltage should be 220 volts.
4. You can also use it to check if the power supply is supporting a load.
5. Even without measuring the voltage across the capacitor, you will already have an idea of what is happening by observing the brightness of the bulb.

**NOTE:** Do not confuse this procedure with the Series Lamp that will be studied in the 2nd class.



## STARTING TO UNDERSTAND HOW AN SMPS WORKS

If you were scared by the acronym SMPS, we should tell you that this is how switching power supplies are usually called because of the abbreviation of the English term SWITCHING MODE POWER SUPPLY. It all starts with the discharge of the DC voltage stored in the filter capacitor onto the primary winding of a chopper transformer. The current will begin to flow in the winding and produce a variable magnetic field that will induce voltages in nearby windings. When the current reaches its maximum value, the field will stop expanding and there will be no more induction. At this point, we need to interrupt the path of the current so that the field begins to decrease and produce an induced current in the winding that, in turn, will produce an induction in nearby windings. This entire procedure is what switching consists of and is similar to what happens in flyback.



**Key simulating the transistor.**

## SOME IMPORTANT QUESTIONS

1. This transistor will operate in a conduction and cut-off mode and, in theory, the “faster” it switches from one state to another, the higher the values of the voltages induced in the other windings will be. 2. The “speed” with which the transistor is switched is not the only parameter responsible for the values of the voltages induced; issues such as the number of turns of the windings and the quality of the chopper itself will also contribute greatly.
3. If you are a good observer, you must have noticed that we have highlighted the expression “quality of the chopper transformer”.
4. And here begin the first points that must be observed in the repair, mentioned below:

- Moisture in the transformer.
- Ferrite core in perfect condition.
- Cold solder on the chopper terminals.

## SMPS SWITCHING TRANSISTOR IMPORT PARAMETERS

1. To this day, most repair technicians tend to only worry about two parameters when they need to find a transistor to replace one they can't find for purchase.
2. They only look at the collector current and the collector-emitter voltage.
3. In the days of linear power supplies, this was almost always enough.
4. In other words, you could use a "stronger" transistor and everything would work out fine.
5. With SMPS operating at increasingly higher frequencies, we need to worry about the transistor's switching and recovery times.
6. There is currently a trend toward using MOSFETs instead of bipolar transistors.
7. Another trend is the use of integrated circuits that already have the switching transistor "built-in".
8. We will discuss these issues in more detail in the future.

## COLD WELDING: SOME PEOPLE DON'T BELIEVE IT

Many people confuse cold soldering with cracked soldering. In this case, it is relatively easy to discover a bad soldering with the help of a good lens and good lighting. Sometimes the problem is so obvious that even the naked eye can see a cracked soldering, however, there are situations that are completely invisible to our eyes and could only be discovered if we took an X-ray of the soldering. Micro air bubbles may have originally formed inside the soldering and over time will produce invisible resistances and capacitances, but which can become inconvenient in digital and high-frequency circuits. Don't believe that the soldering is good just because of what you see on the outside. The saying applies here. "You can't see the heart, but you can see the face."

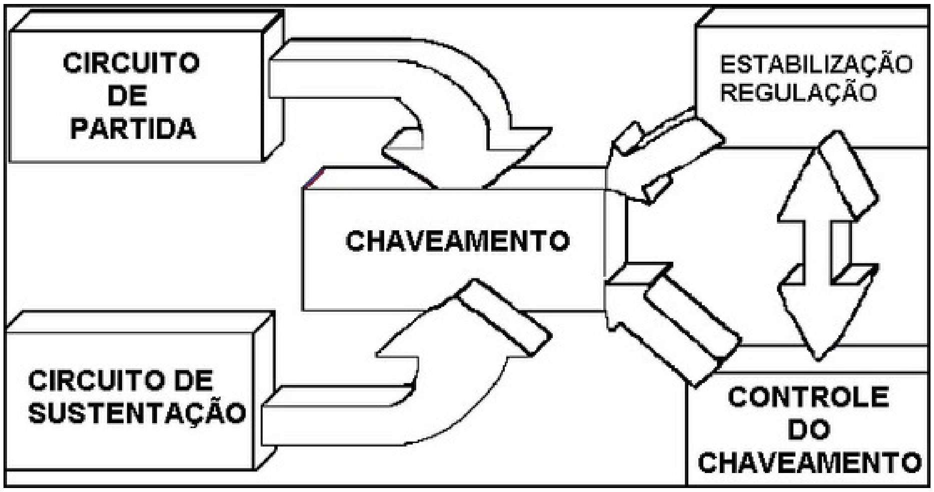
“**NOTE: REMOVE THE OLD SOLDER (REMOVE IT) AND MAKE A NEW SOLDER WITH GOOD QUALITY SOLDER.**

## THE IMPORTANCE OF WELDING QUALITY

1. If you think that all solder is the same, you are completely mistaken.
2. In electronic circuits we should ALWAYS use 60/40 or 63/37 solder.
3. 60/40 solder contains 60% tin and 40% lead.
4. The higher the percentage of tin in relation to the percentage of lead, the better.

## THE BLOCK DIAGRAM

Although we do not intend to go into great depth into the theoretical issues surrounding switching power supplies, since our goal is repair, we cannot avoid the basic points. Viewing an SMPS through blocks will greatly help determine the type of defect and in which area it is occurring. We can divide an SMPS into five basic blocks as seen below.




## THE FIRST STEP TOWARDS SMPS REPAIR

Dividing the source into five blocks will help repair the source because from the blocks we will try to identify what type of problem it is presenting. Every repair must start with a diagnosis, and the diagnosis will be given by analyzing the symptoms. NOTE: Study the following page carefully. It will be useful for the rest of your life.

## GENERAL DIAGNOSTIC GUIDE

**1. THE POWER SUPPLY DOES NOT START.**

Start by finding out which components are responsible for starting the power supply.

**2. THE POWER SUPPLY STARTS, BUT SWITCHING IS NOT SUSTAINED AND, THEREFORE, IT STOPS IMMEDIATELY.**

The big challenge is to understand the difference between not starting or not sustaining the switching.

You will be guided to find out which part of the circuit is responsible for sustaining the switching.

**3. THE POWER SUPPLY STARTS AND SWITCHING IS MAINTAINED, BUT THE OUTPUT VOLTAGES ARE VERY LOW OR NIL.**

When they are low, you can be sure that the power supply is working in terms of starting and sustaining, so the problem must be with stabilization and regulation. And if the output voltages are null? It may be that the power supply is just protecting itself from current overload. You will have to learn to distinguish the difference between a “stopped” power supply and a power supply in protection.

**4. THE POWER SUPPLY HAS ALL ITS OUTPUT VOLTAGES TOO HIGH**. Oh my. This is a serious problem. So, there is no reason to have any doubts, the power supply has a problem in the regulation and stabilization circuit.

## WHY DOESN'T THE POWER SUPPLY BREAK OR STAND AND YOU DON'T FIND ANYTHING DEFECTIVE?

This is a point that usually leaves technicians confused and unsure of what to do. In the last 10 years, SMPS designs have evolved a lot and they have been optimized to not operate with loads above the specified level. In short, what this means is that if there is an overload (overcurrent), _ the power supply can activate a protection system that will stop the switching and there will be no voltage at the power supply outputs, giving the impression, at first glance, that the power supply is not starting or is not holding up. This is one of the important points to be recognized when repairing an SMPS and that can sometimes lead you to a surprising conclusion: THERE IS NO DEFECT, IT IS JUST IN PROTECTION! THE POWER SUPPLY DOES NOT HAVE

## WHAT IF WE TURN OFF ALL LOADS?

The previous question may have led you to this conclusion, that is, if the power supply is "dead" because there is a short circuit in one of its outputs, all you need to do is turn off the loads and the power supply will start working again. Maybe yes, maybe no, but do you know why? Some SPMS do not work
if they are without a load.
In the past, there were power supplies that could not be turned on without a load because they would burn a lot of things. Today, SOME power supplies that cannot work without a load stop switching when there is no consumption.
Since every self-respecting power supply was designed to power a load, it doesn't hurt to put a "phantom" load on at least one of its power lines.

## WHAT ABOUT WHEN THE POWER SUPPLY IS IN STAND-BY?

Another point that we need to draw attention to is the behavior
presented by some SMPS when they are placed in stand-by.
Currently, there is a trend in projects not to turn off the power supply completely.
In other words, the power supply is placed in stand-by (read "istandi bai") or waiting mode.
In this case, the power supply may not reset all of its outputs when it is placed in stand-by,
but only leave them producing voltages of around 50% of the value in normal operation.
Therefore, if you come across an SMPS in which the voltages are low, one thing is certain: it is starting and sustaining the start-up.
The question is to find out whether the fault is in the stabilization or regulation or if there is simply no fault, it is just in stand-by.

## LET'S NOT PUT THE CART BEFORE THE HORSE OR A STOP FOR A COFFEE

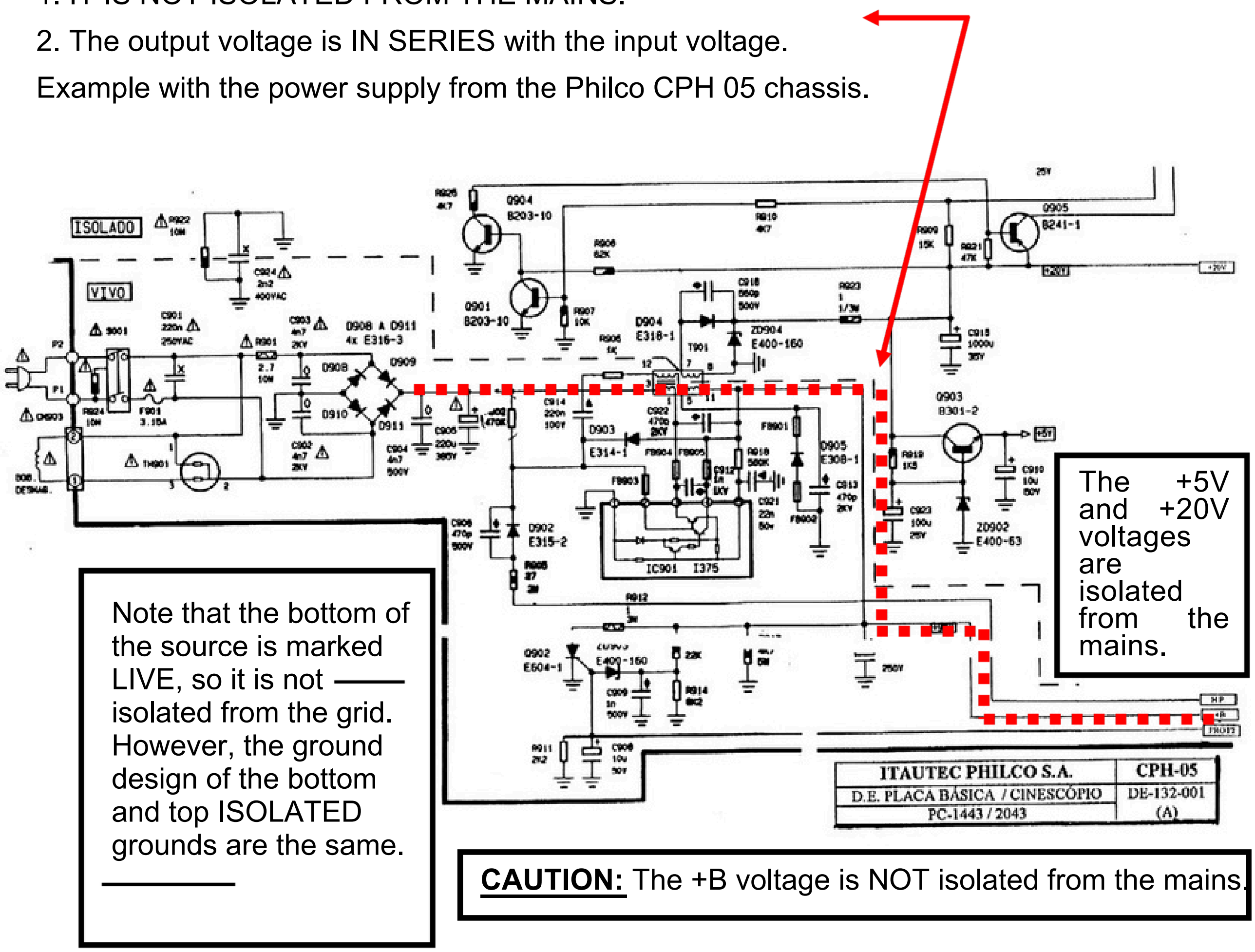
Following the idea that it is necessary to understand how things work in order to be able to repair them, we will deal with something that will be very important when deciding which is the "best
technique" to repair a given SMPS.
From the point of view of the "general structure" of an SMPS, we can divide them into SERIAL TYPE AND PARALLEL TYPE. Formal books on switching power supplies usually talk "everything" about them, but forget to teach you repair methods. In these books, this "general structure" is usually called the TOPOLOGY of the power supply.

# THE SERIAL TYPE FONT

The two main characteristics of a series type power supply are:

1. IT IS NOT ISOLATED FROM THE MAINS.
2. The output voltage is IN SERIES with the input voltage.

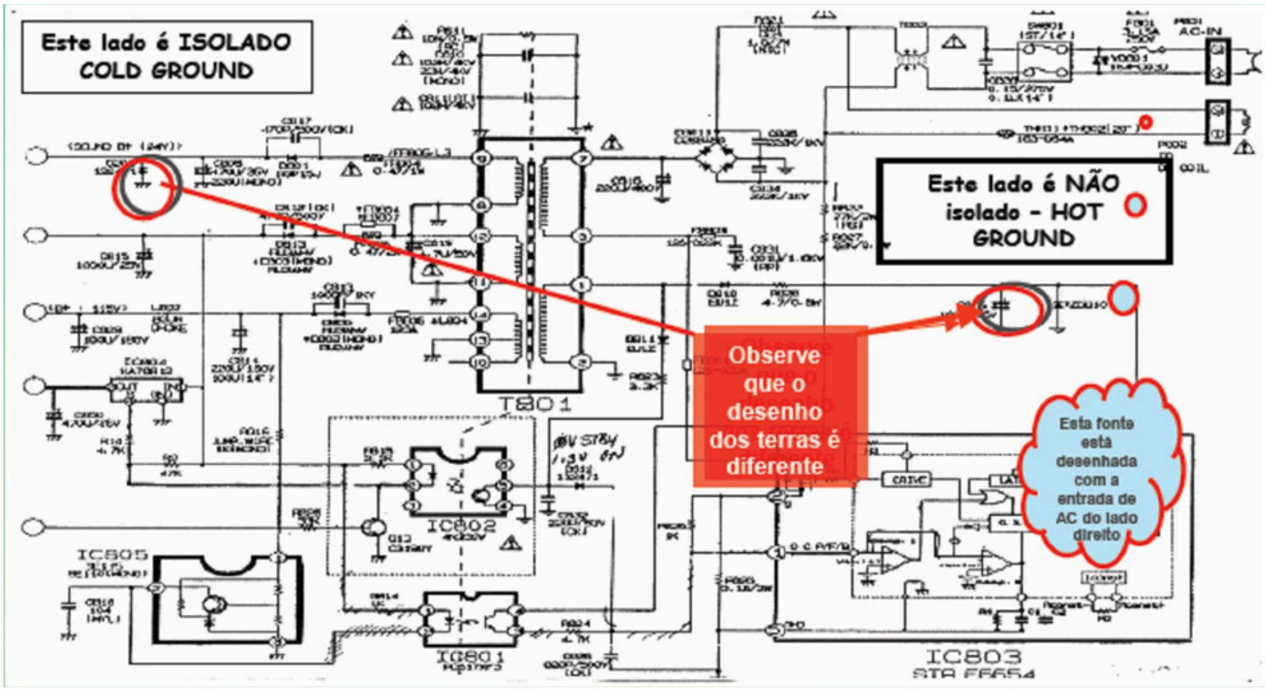
Example with the power supply from the Philco CPH 05 chassis.




## WHY IS IT IMPORTANT TO KNOW THIS?

Two techniques that we will present during this course for SMPS repair are the use of external sources or “jumping”. In order to use these techniques or resources, it is important to know how to recognize whether the source is Series or Parallel. For this reason, we will insist that you learn how to do this recognition. Currently, there is a trend towards using Parallel Sources mainly due to the issue of isolation of the output voltages.

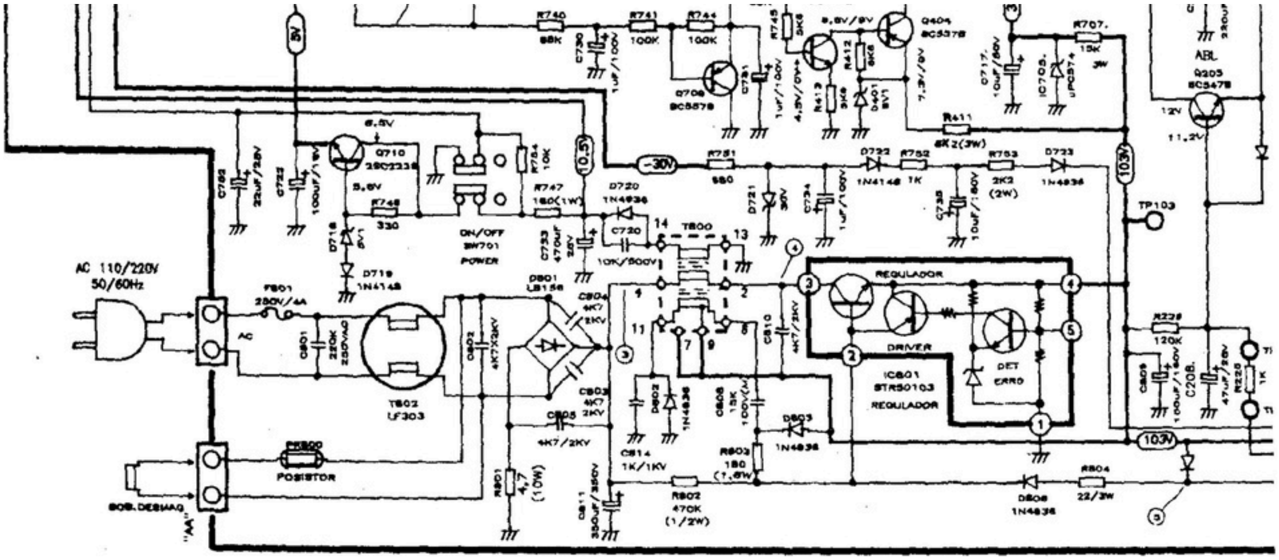
IDENTIFYING A PARALLEL SOURCE



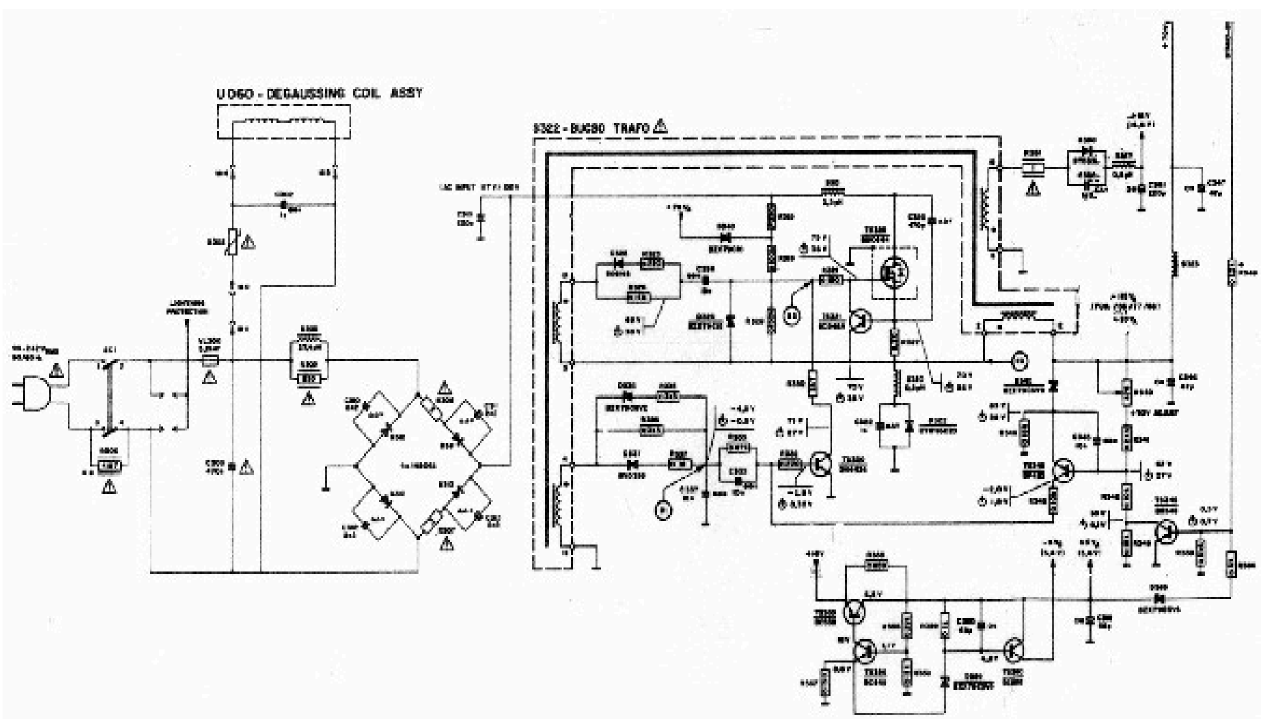

## EXERCISES- 1

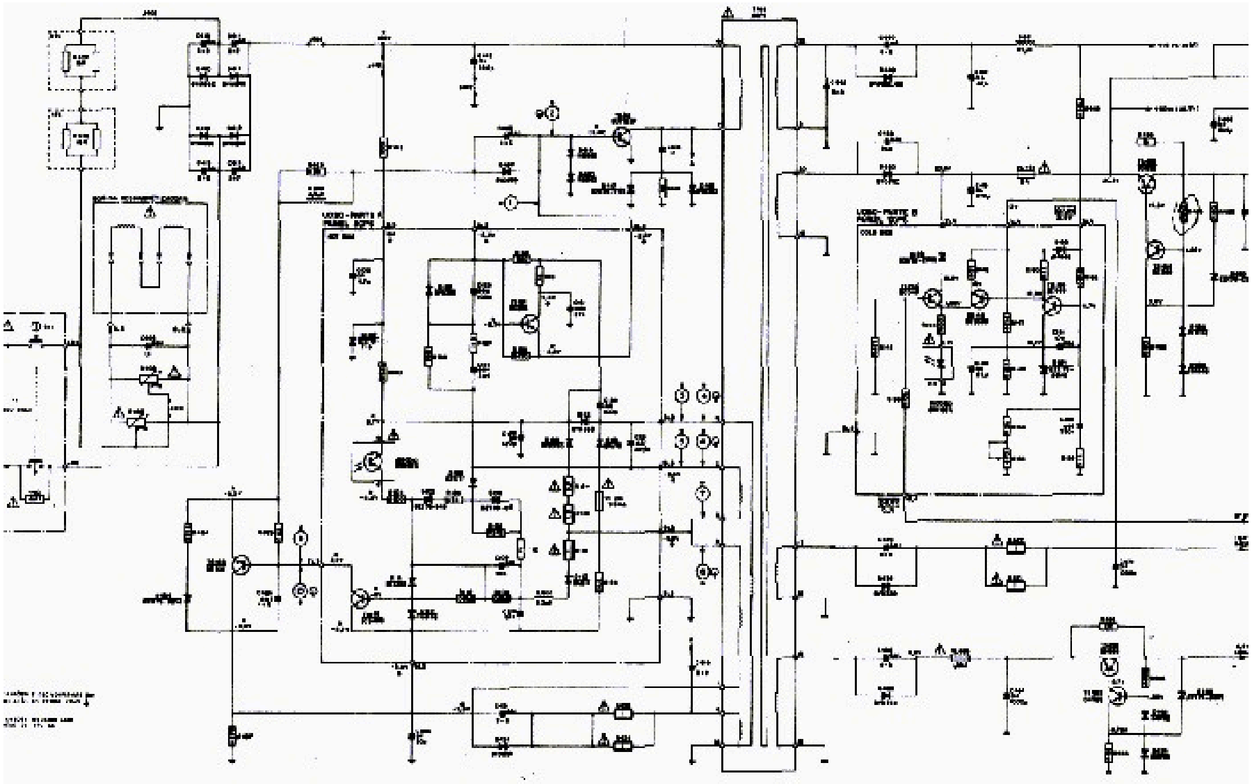
1. Looking at the source on page 8, you would be able to tell how many volts at most should appear on C-905 (Series Type Source).
2. If you do not have the schematic or are in doubt as to whether or not a source is isolated from the grid, what would you do to find out?
3. On pages 10 and 11, you will see the schematic of three sources. Identify which is the series type and which is the type.
4. List the five basic blocks that make up a switching source.
5. List the main defects of a switching source.
6. There are three basic causes for a source not to present any voltage at its outputs. What are they?

# TV POWER SUPPLY CCE HPS 1460 AND OTHERS

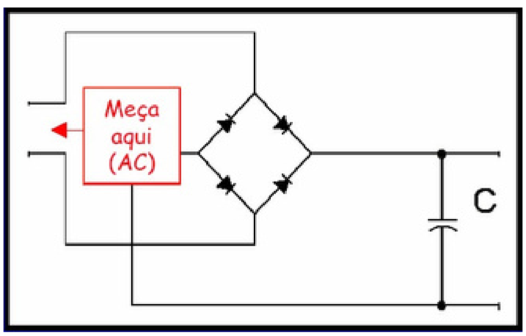



# PHILIPS POWER SUPPLY CHASSIS GR1





HOW TO FIND OUT THE VALUE OF DC VOLTAGE IN THE RECTIFICATION FILTER CAPACITOR




The circuit on the side is a bridge rectifier with a capacitor. If we do not connect any load to the circuit, the mains voltage will peak and maintain this voltage across it. This will be the maximum value that can appear on the capacitor. If we connect a load in parallel with the capacitor, the DC voltage will fall according to the load current. The "new" value of the DC voltage will depend, basically, on the value of the load (consumption) and the capacitance.

**BRIDGE RECTIFICATION WITH FILTER CAPACITOR**

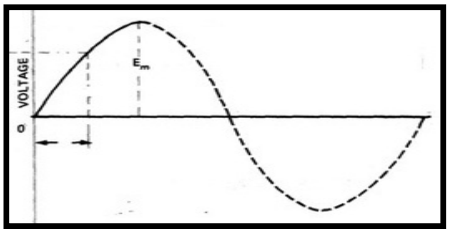
**TO KNOW THE DC VOLTAGE VALUE, DO THE FOLLOWING:**

1. Measure the AC RMS voltage being applied to the bridge rectifier.
2. Multiply the value found by 1.41. This is the DC value across the capacitor if there is no load.

Take any font and try it out.

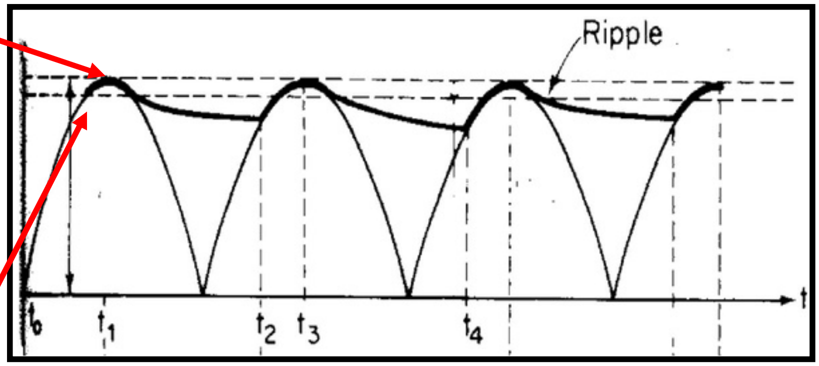
## WAVEFORMS IN FULL WAVE RECTIFIER

When you measure a sinusoidal voltage with your voltmeter, whether digital or analog, you are not measuring the peak value (Vmax in the figure below).




**THE AC SCALE OF VOLTMETERS INDICATES THE AVERAGE VALUE CALLED THE EFFECTIVE VALUE OR RMS.**

**PEAK VALUE = 1.41 XVRMS**




**DC VALUE – WILL DEPEND ON THE LOAD CURRENT AND THE FILTER CAPACITOR VALUE.**

## HOW TO KNOW IF A POWER SUPPLY IS ISOLATED FROM THE GRID OR NOT.

Very simple! With the device disconnected from the power supply, measure the continuity between the negative of the filter capacitor of the input rectifier bridge and the ground of the tuner or another ground where there is contact with the user. If the resistance is close to or equal to zero ohms, the source is not isolated.

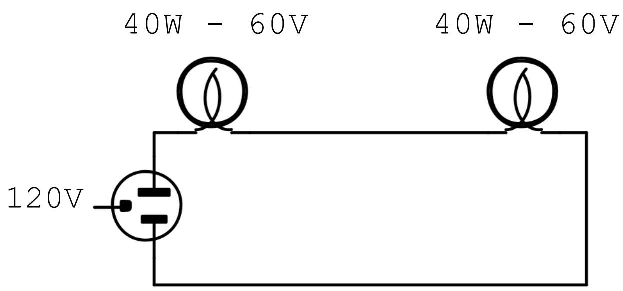
# 2nd CLASS

In the second class of our Switching Power Supply Repair course we will cover the following topics:

1. The importance of the Series Lamp in the repair of Switching Power Supplies.
2. How to build a versatile Series Lamp.
3. The method of repairing Series Power Supplies.
4. How to work with external power supplies.
5. How to build some useful power supplies.
6. The method of repairing Parallel Power Supplies.
7. How to eliminate doubts about whether the defect is really in the power supply.
8. Exercises.
9.Evaluation of the 2nd class.

Switching power supplies have a very different operating principle from the old linear power supplies. This will require new ways of thinking and new working methods that you may not be very familiar with. This is what we will cover in this second lesson. You may be a little scared at first, so we suggest that you take inspiration from what Einstein said a few years ago, which is very relevant to this moment.

**NO NEW PROBLEM CAN BE SOLVED BY THE SAME OLD REASONING THAT CREATED IT. EINSTEIN**




In the example to the side, the voltage in each lamp was equal to half the applied voltage because the two lamps have the same power.

**In the example to the side, the voltage in each lamp was equal to half the applied voltage because the two lamps have the same power.**

## LET'S DEFINITELY UNDERSTAND THE SERIAL LAMP

If the bulbs are of **EQUAL POWER**, they will have the **SAME RESISTANCE** and, therefore, since the resistances are equal, the voltage in each one will be half the applied voltage. Is this what you answered in the question on the previous page? If you are still in doubt, we suggest that you assemble it quickly and take the measurements to prove this important concept in practice.

100 Watts

25 Watts **QUESTION:** Which of the 2 bulbs on the side has the lowest resistance?

## INCANDESCENT LAMPS: POWER AND RESISTANCE RELATIONSHIP

The 100 Watt bulb shines brighter than the 25 Watt bulb. Do you agree? This happens because the current in the 100 W bulb is greater than in the 25 W bulb. Therefore, the 100 W bulb has a lower resistance than the 25 W bulb.

100 Watts

25 Watts

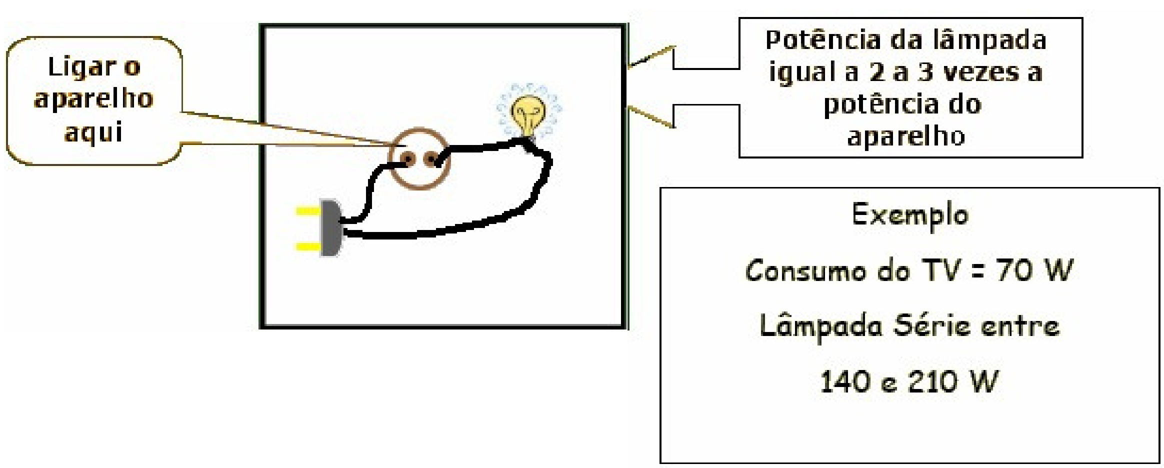
Generally speaking, the higher the power of the bulb, the lower its resistance. It is important to remember that this rule only applies to incandescent bulbs.

## WHY DO YOU NEED TO KNOW THIS?

The main purpose of using a series lamp when repairing electrical equipment is that if the device is short-circuited when connected to the power grid, we will blow the fuse of the device or of our home. In this case, the series lamp will “absorb” this short-circuit and prevent the fuse from blowing. However, in the previous pages we intended to show that it is extremely important to take into account the power of the lamp that will be placed in series with the device. Modern switching power supplies generally work between 90 and 240 Volts, however, the initial consumption at start-up will produce a very large voltage drop and if the lamp has insufficient power, the source will not be able to start because it will be receiving a voltage lower than the minimum required. We must start to think that there must be a criterion for choosing the power of the lamp. It was because this criterion was not used that technicians began to say that series lamps are not suitable for repairing switching power supplies. Pure nonsense!

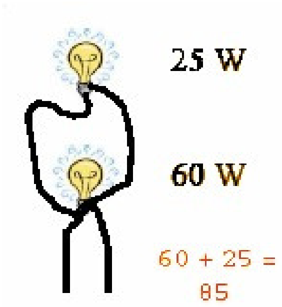
## HOW TO CHOOSE THE POWER OF THE SERIAL LAMP

The purpose of the series lamp is to act as a kind of “brake on the current”, allowing a device to be turned on even if it is short-circuited or has a higher than normal consumption. To be successful, we must use a series lamp whose power is between 2 and 3 times the power of the device we want to test.



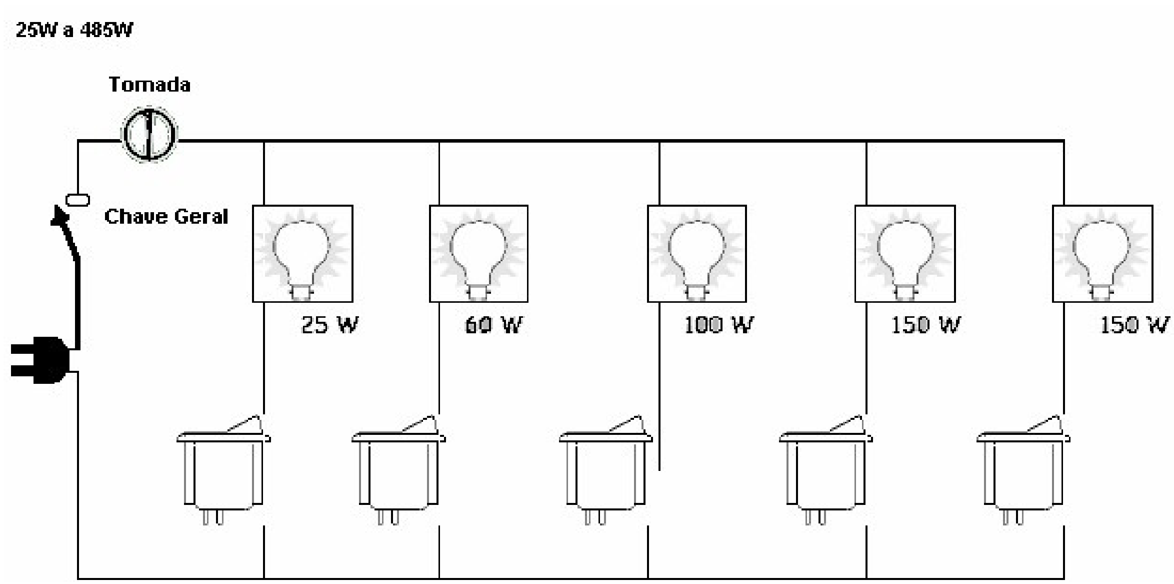
# BUILDING A SERIES LAMP

The wide range of power of the devices we have to work with today leads us to conclude that we will need lamps of various powers. However, we will see that using a small trick we can obtain 22 different powers between 25 and 485 Watts using only five lamps. In the circuit below the two lamps are in parallel and will represent a total consumption of 85 W.




**CONCLUSION!** When we place lamps in parallel, the total power is equal to the sum of the individual powers.

## TCHAN! TCHAN! TCHAN! THE SERIAL LAMP ON YOUR BENCH

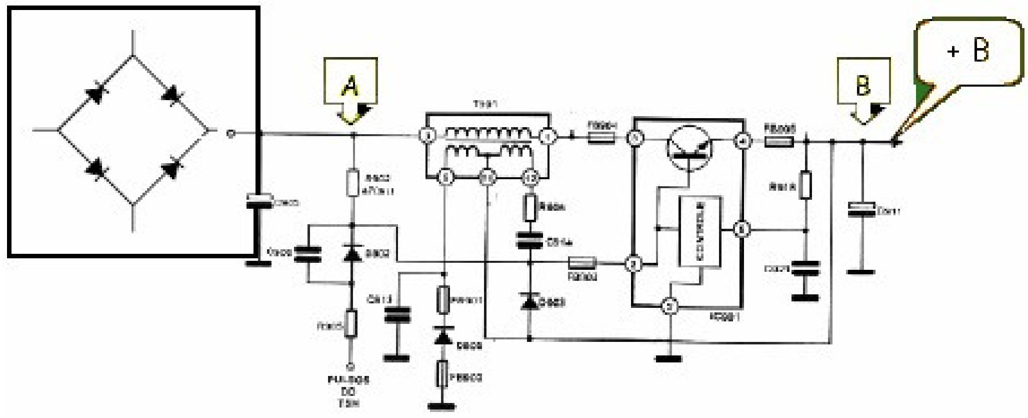



## DON'T BURN TRANSISTORS FOR NO REASON

There are people who still do not believe that the series lamp can prevent losses due to burned-out transistors, especially horizontal outputs. The most important rule you have already learned is to “calculate” the lamp power based on the consumption of the device under test. A few more practical “tricks” need to be observed to improve the efficiency of the lamp use. In the case of televisions and monitors, you may need to turn off the demagnetizing coil so that its high initial current does not produce a very large voltage drop and does not cause the source to break. Some devices may have a relatively high initial current producing intense brightness of the lamps, however, this SHOULD NOT LAST MORE THAN A FEW SECONDS. If everything is fine, the lamps should remain almost off. Pay attention to the brightness of the lamps and KEEP YOUR FINGER ON THE MAIN SWITCH of the Series Lamp. If you notice that the brightness of the lamps begins to increase progressively, TURN THEM OFF IMMEDIATELY before it is too late.

## THE +B OF THE SERIAL SOURCE

By observing the circuit carefully, we can see that the +B of a series source comes directly from the filter capacitor connected to the bridge rectification. To clarify this, here is a simplification of the source of the Philco CPH 05 chassis that appeared in the first lesson. In this source below, the voltage at point B is +95 Volts. What will be the maximum value of the voltage at A if the bridge is being powered by 125 V RMS? If you don't remember, then reread the first lesson.

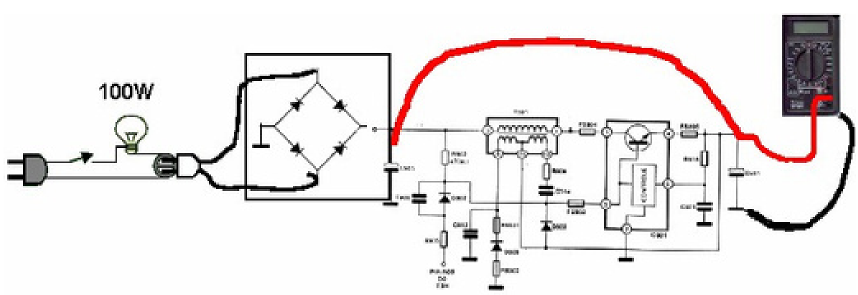



## WHAT HAPPENS BETWEEN A AND B?

In the circuit above, the voltage at A will be a maximum of 176 V DC if the network is at 125 V RMS. However, with the TV working, this voltage will drop to a value between 150 and 160 V because of the current consumption that will not allow the capacitor to remain charged at the peak, which would be 176 V (if the network were at 125 V RMS as in the example). In this chassis, the voltage at B is + 95 V. The voltage drop between A and B from 160 to 95 occurs because of the switching of the transistor internal to IC 801, which is in series in the circuit and interrupts the charge of capacitor C 911 for some time. If this source is not showing any voltage at + B, we can use the trick that we will describe below to try to make the TV work. First, we connect the TV to a lamp in series. We will start with a low power, for example, 100 Watts and you will already understand why in this case we did not use the rule of 2 to 3 times the power consumption as a basis. Next you will connect points A and B with a wire, taking care to keep a multimeter on B to monitor the voltage value.

## THE BRIDGE OR JUMP METHOD IN SERIES SOURCE

When making the "bridge" (jump), it is important to monitor the +B voltage with the voltmeter so that it does not exceed the original value of the circuit.



## WHAT COULD HAPPEN WHEN WE DO THE JUMP

**1.** The series lamp may light up with full brightness. This indicates that the load is shorted (Horizontal Output Transistor, flyback, etc.).

**2.** The series lamp lights up with low intensity and the +B voltage may be a little below or a little above the correct value. In both cases we need to make an adjustment to the lamp power.

- If the voltage of +B is low then the power of the series lamp needs to be increased.
- If the voltage of +B is high then the power of the series lamp needs to be decreased.

Therefore, at this point, we do not use the general rule of 2 to 3 times the power of the device since we are also using the series lamp as an input voltage reducer in order to obtain a certain voltage at the output.

## MAYBE ONLY THE JUMP DOESN'T WORK. WHAT THEN?

What we intend to do with this method that is being studied are basically two things:

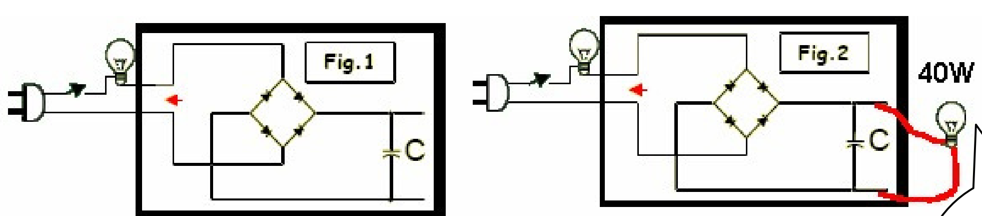
**1.** Check if the source is really defective. Remember that sometimes the source “does not work” because it is protecting itself from an overcurrent.

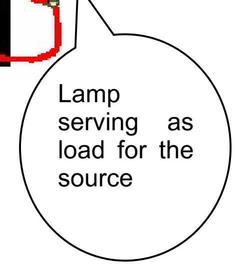
**2.** Make the device work even if its source is defective.

In the case of televisions and monitors, a primary source is the + B that powers the flyback, or rather, the horizontal deflection circuit. However, it is not enough to simply “invent” a source for the + B as previously proposed. In modern televisions (or rather, all current equipment) we need 5 Volts to power the microcontroller and the EEPROM and a source to power the horizontal oscillator block (televisions). If the horizontal oscillator does not work, the horizontal deflection will not work either and, therefore, even if there is a short in this circuit, the source that we improvised with the jump will not “see” any consumption.

## WHAT CAN HAPPEN TO THE +B VOLTAGE WHEN WE MAKE A JUMP IN A SERIES POWER SUPPLY

Observe the two situations below. In Figure 1 we have a bridge rectifier connected to a series lamp, but the source is not supplying any current because there is no load connected to it. In Figure 2 we add a load to the source (40 W lamp serving as a load).




**QUESTION:** If, in both cases, the network is 127 v RMS, what will be the voltage measured at C in fig. 1? Will the voltage measured at C in the circuit in fig. 2 be **GREATER** or **LOWER** than the voltage measured in the circuit in fig. 1?

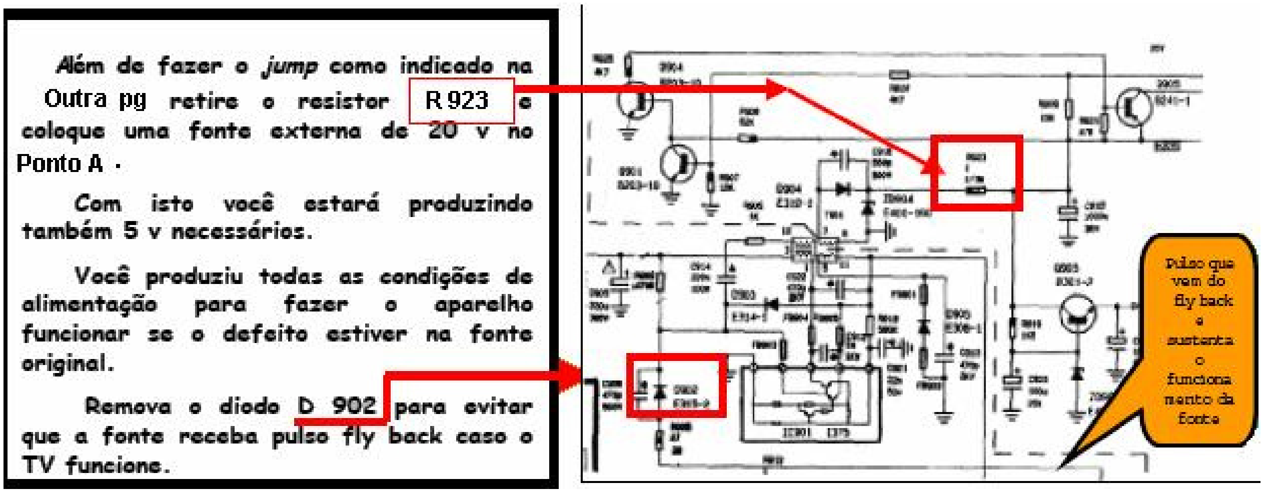
## LET'S SEE IF YOU REALLY UNDERSTAND

In the circuit in Fig. 1, you should measure 179 volts (127 x 1.41) regardless of the value of the series lamp because there is no load and, therefore, no consumption. In the case of Figure 2, the voltage measured at C will be LESS than that measured in the situation in Fig. 1 because a 40-watt lamp was connected as a load. The value of the voltage measured at C in Fig. 2 will depend on two issues:

1. The power of the series lamp.
2. The consumption produced by the load.

## WHAT TO DO IF THE “JUMP METHOD” DOESN’T MAKE THE DEVICE WORK?

In the case of the CPH 05 chassis that we are using as an example for our approach and guidance on how to use the “bridge method” (jump), we can see that the source still produces a voltage of 20 V isolated from the network. The 5 V voltage required for the microcontroller and the EEPROM is obtained from the 20 V source.




## CAREFUL!

**1.** The “bridge method” explained here can only be used in Series Type sources and with the aid of a series lamp.
**2. NEVER** use this procedure in Parallel Type sources.

## EXERCISE NO. 1

**1.** The font on page 10 of the 1st lesson is series type. How would you proceed to use the “bridge method”?
**2.** Could you use the “bridge method” on the other font on page 10 of the 1st lesson? Why?

## BUILDING A POWER SUPPLY FOR + B OF TVs AND MONITORS THAT USE PARALLEL SOURCE.

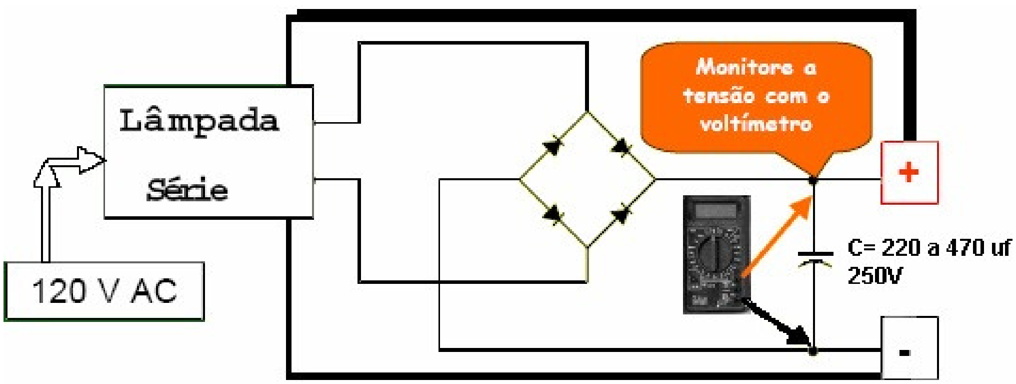
We have already seen that we cannot use the "bridge method" in parallel power supplies. However, we will see that it would be advantageous to be able to eliminate the doubt as to whether or not the device has a faulty power supply by replacing it with conventional linear power supplies. The + B of these devices (TVs and monitors), on average, is usually between 70 and 130 volts approximately. An auxiliary power supply to replace the original + B will be shown below and can be built with parts from your scraps.

## OBSERVATION

It is highly recommended, or rather, mandatory to use the series lamp when using auxiliary sources.

Always keep the voltmeter monitoring the voltage that the auxiliary source is providing.

## THE AUXILIARY +B POWER SUPPLY CIRCUIT.

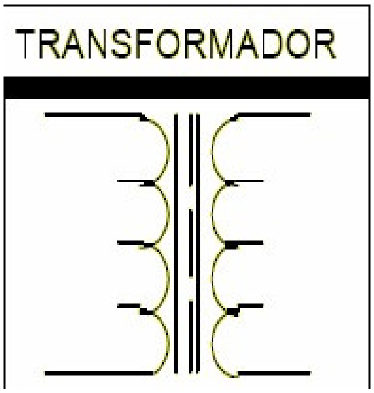


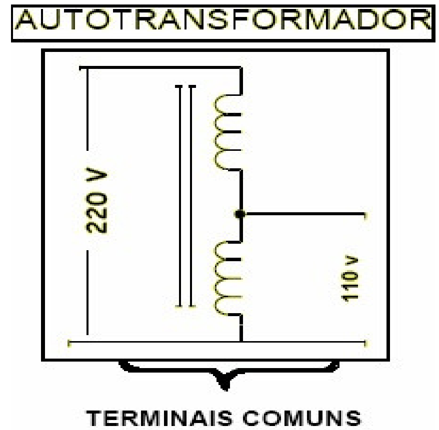

1. The set must not be powered by a 220 Volt network.
2. CAUTION: This source will not be isolated from the network unless you use an isolating transformer.
3. The output voltage value will depend on the load current and must be adjusted with the help of the series lamp power.

## THE PROBLEM OF INTERCONNECTING TWO NON-ISOLATED SOURCES

The input circuit of the switching power supplies consists of a bridge rectifier similar to the one we suggest you build to use as an auxiliary power supply and, as you can see in the device diagrams, this circuit is not isolated from the mains. This means that depending on how we connect the power cable to the socket, we may have the input ground of the device (negative of the filter capacitor) connected to the phase or neutral of the mains. The same problem will happen with the power supply we are proposing that you build to use as an auxiliary + B power supply. To avoid this type of problem, you can use an isolation transformer. This transformer has a turns ratio of 1 to 1. If you are working with a 220V network, you will have to use a transformer to lower it to 120 volts and then the transformer will also act as an insulator. CAUTION: Do not use an auto-transformer because they are not insulators. Most of the 110/220 transformers on the market are auto-transformers.

## ISOLATING TRANSFORMER AND AUTO-TRANSFORMER



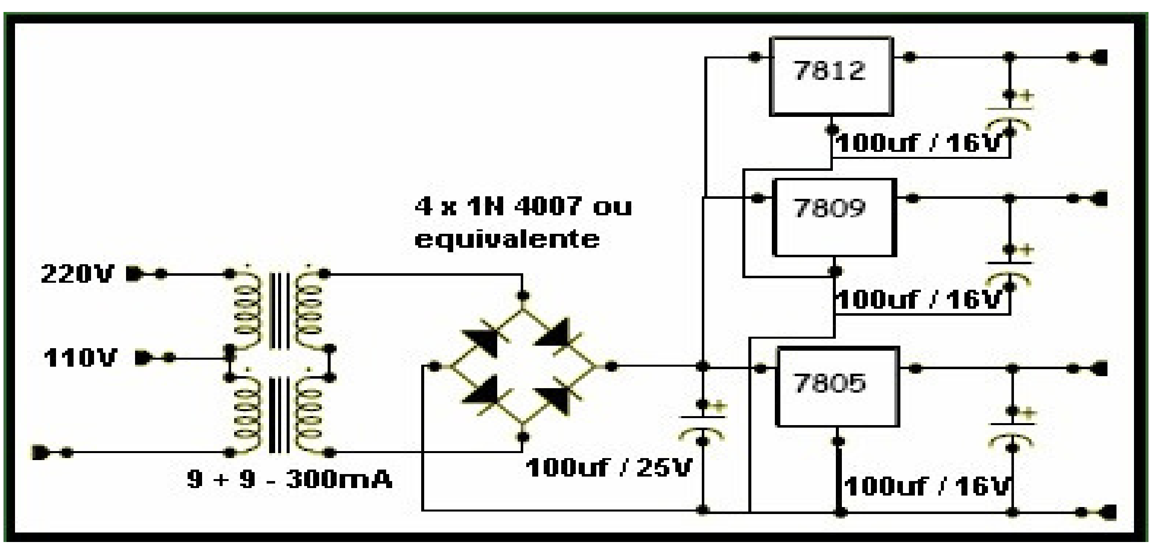




## WHERE DO WE WANT TO GO?

When working with televisions and monitors, the +B power supply is undoubtedly one of the most important, but it is not the only one we should be concerned about. In this 2nd lesson, we are proposing that before trying to repair the device's power supply, you make sure that it is really defective. Therefore, we are suggesting that you build some basic auxiliary power supplies to try to make the device work with them. If the device also does not work with external power supplies, then the defect must not be in its power supply or, at best, it is not only in the power supply. As we saw in the 1st lesson, most switching power supplies go into protection when overloaded and then you may think that the defect is in the power supply when in fact it is not. The auxiliary power supply method will help you eliminate this doubt. Let's see below which other auxiliary power supplies are important.

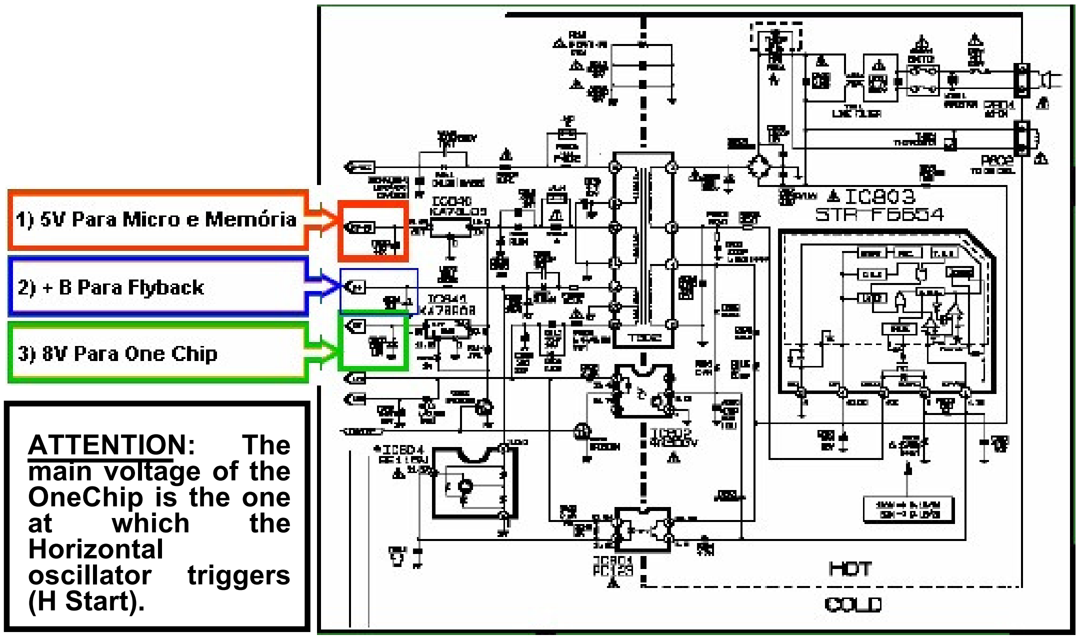
## BUILDING OTHER AUXILIARY SOURCES

Three very important sources in current equipment are: 5V (Microcontroller and EPROM), 9V and 12V. There are several ways to build these sources. Below we present a very simple and inexpensive suggestion.

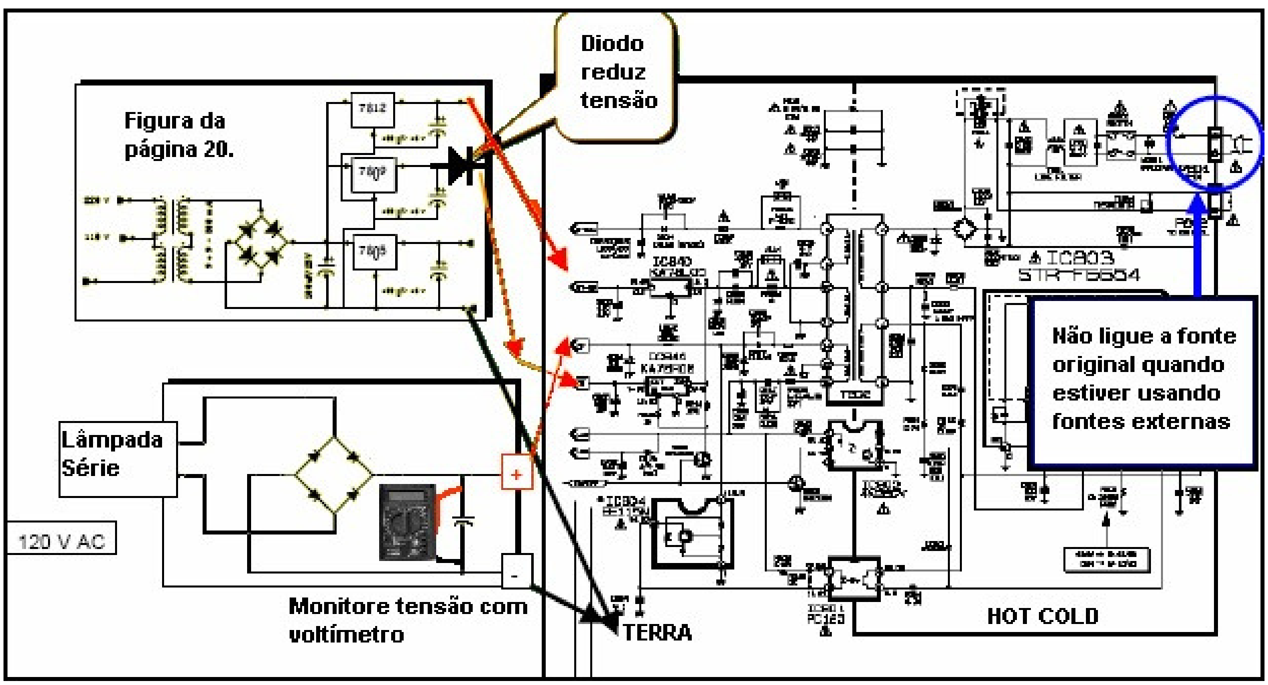


# THE MAIN SOURCES OF A MODERN TV

This is a power supply for an LG TV. The main voltages to make it work are:




# DEMONSTRATING HOW IT'S DONE

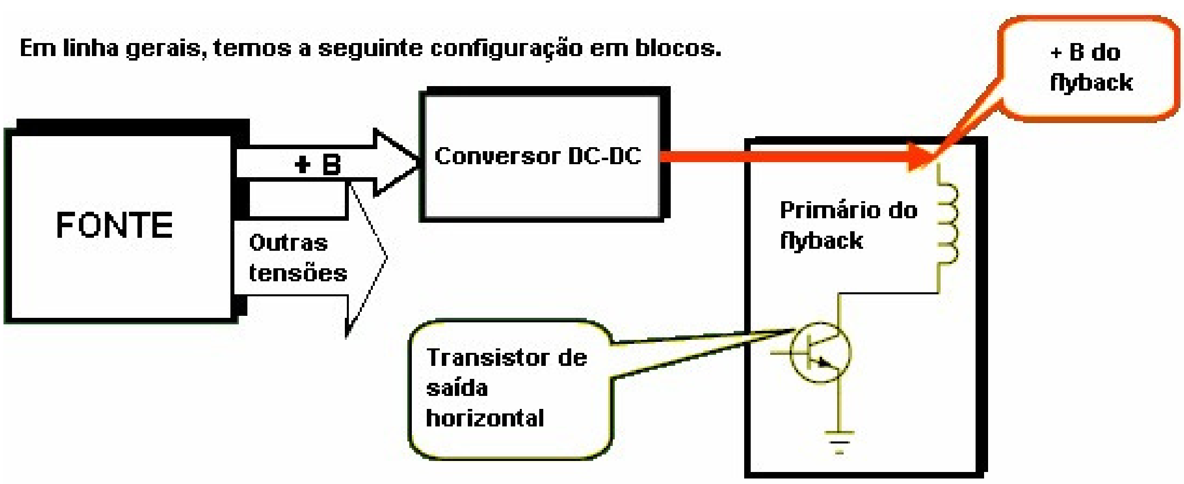


## YOU MAY NOT HAVE THOUGHT ABOUT THIS BEFORE

Switched power supplies usually “protect themselves” when the load is shorted OR consuming more than expected. This is one of the reasons why the fuse does not open even when a load is shorted. When you find a “blown” fuse, it is almost certain that the problem occurred in the primary of the power supply and not in the secondary, especially if the power supply is of the Parallel Type. Using the “bridge method” or the external power supply will help you find out if the defect is in the power supply or in the device (or if you and your client are very unlucky, there may be a defect in the device and the power supply). The example given here was based on televisions, but there is nothing to prevent it from being applied to VCRs, DVDs or monitors with the necessary adaptations that your imagination and creativity will know how to find, while paying attention to safety rules. Speaking of monitors, this method is particularly useful in monitors. Let’s see why in the following example.

## FLYBACK POWER SUPPLY ON MONITORS

Monitors usually have an “intermediate” circuit between the + B of the power supply and the power pin of the flyback. Some manufacturers, such as Samsung, call this circuit “HV Regulator”, while others prefer to call it a DC-DC converter. Regardless of the name, the mission of this circuit is to “adjust and regulate” the voltage of the + B of the flyback, which in monitors tends to vary according to the chosen resolution. In general terms, we have the following block configuration.



## WHERE IS THE DEFECT: IN THE DC-DC CONVERTER OR IN THE FLYBACK?

If the DC-DC converter is defective, the flyback will not work, and if the flyback does not work, the DC-DC converter will stop. In a situation like this, you will be faced with the well-known dilemma: "if you stay, the beast eats you, but if you run, the beast catches you". We will not teach you how to solve the "bug problem" because it is not part of this course, but the monitor problem is simple:

**1.** Turn off the flyback power supply that comes from the DC-DC converter;
**2.** Connect an external power supply (with a series lamp) to the flyback power pin;
**3.** Turn on the monitor normally.

If the monitor works even with a deficiency in the image size, this means that the defect is related to the DC-DC converter. If the defect is related to the flyback, the monitor will not work and the series lamp may light up brightly, indicating that there is a short in the horizontal deflection circuit.

## MAYBE A QUESTION HAS ARISEN

In the previous item we told you to “turn on the monitor normally”, that is, you should use the monitor’s power supplies together with the external power supply that will ONLY power the flyback. However, on page 21 there is a note (in blue) saying not to turn on the original power supply when using the external power supplies. After all, can or cannot the two power supplies “live together” in the same circuit? There is no problem in using the two power supplies at the same time, but we need to be careful about the grounding issue because our improvised + Bi power supply is not isolated from the grid (unless you are using an isolation transformer). If the original power supply is not providing any voltage, there is no way around it, you will have to use several external power supplies. There is no absolute general rule. In each case you have to decide which is the best option. Put your mind to work!

# Volume 2

## From Basic to Advanced

## Part I - Switching Power Supplies in General

### Chapter 01 - Technical Introduction

## Part II – ATX Power Supplies

## Training Opening

Welcome to this new training! You’ve just acquired a material created with great dedication and weeks of intense work. Everything here was made with one goal in mind: to help you truly learn in the easiest way possible. Before creating this material, I worked on a course focused on printer power supplies. Believe me, everything I did there was just a "warm-up" to finally bring to life this work you're studying now, which is about switching power supplies. A large part of what I did there, or maybe everything, is present here. As I mentioned, the material on printer power supplies was just a "warm-up," a way to start shaping the switching power supply training. The goal was always to create this switching power supply course. And here we are. Now, we have a more complete, improved, and precisely structured switching power supply training.

# Chapter 01 - Introduction

I truly hope you enjoy this, as a lot of work and dedication went into it.

## Why do electronic devices use power supplies? And what is the importance of power supplies?

These are two questions. Let's break it down. First, why do electronic devices use power supplies? Electronic devices use power supplies to provide the electrical energy necessary for their operation. Most electronic devices rely on a power supply to convert electrical energy from the power grid into a form that can be used internally in the device. This is because most electronic components, such as transistors and integrated circuits, require specific voltage levels to operate correctly.

# Chapter 01 - Introduction

Regarding the type of power supply, there are mainly two categories:

**Linear Power Supply:**

Linear power supplies are characterized by the use of transformers to convert the electrical grid voltage to a lower voltage. They then use electronic components, such as voltage regulators, to provide a constant output voltage. These supplies tend to be large and less energy-efficient.

**Switching Power Supply:**

Switching power supplies, also known as switch-mode power supplies, use an electronic switching process to convert the grid voltage into a regulated output voltage. They are typically smaller, lighter, and more energy-efficient than linear power supplies. This makes them widely used in modern electronic devices, such as laptops, mobile phones, chargers, and many other portable devices.

**What is the importance of power supplies?**

The importance of power supplies lies in providing the correct voltage to properly power the circuit, ensuring that the electronic components function as expected.

## Chapter 01 - Introduction

A computer, for example, does not operate internally (the motherboard and other devices) with 110V or 220V. The computer's power supply will convert this alternating voltage to direct current and provide (through the motherboard and device power cables) lower voltages, such as 5V and 12V.

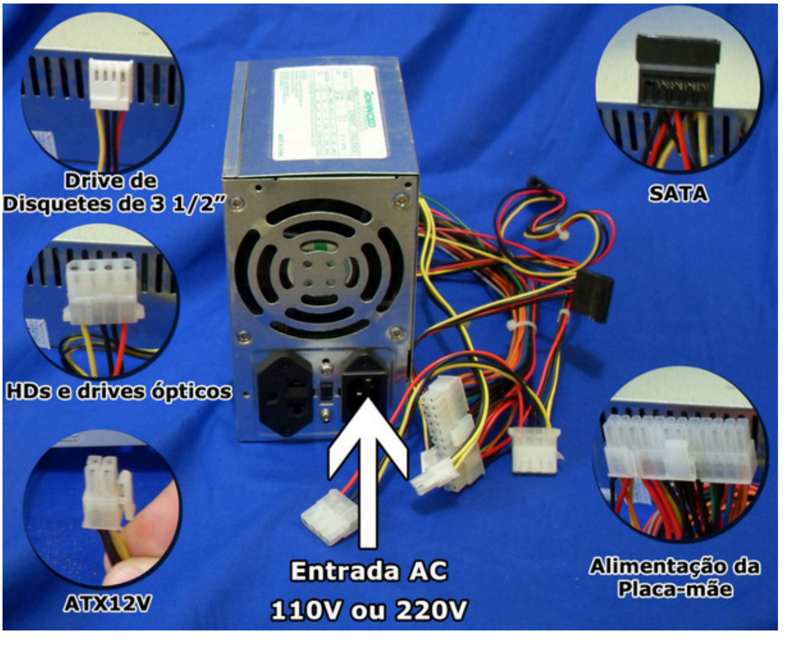



**Figure 01:1:** To illustrate, see this image. It is a computer ATX power supply. We have the AC input (110 or 220V) and the DC outputs.

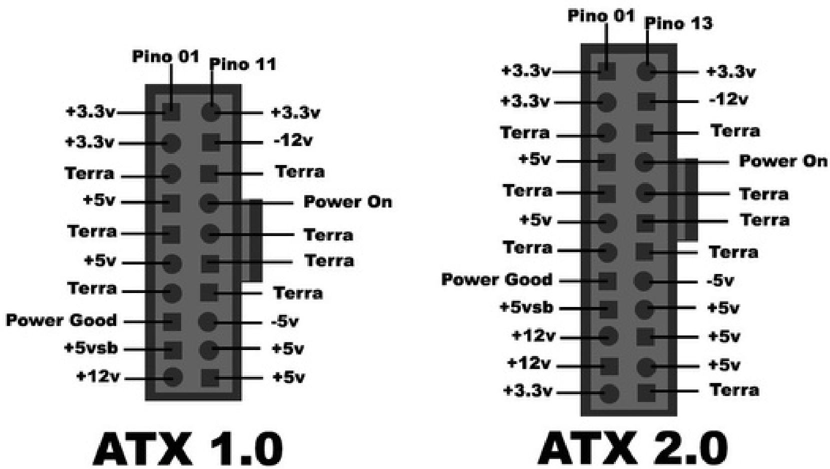


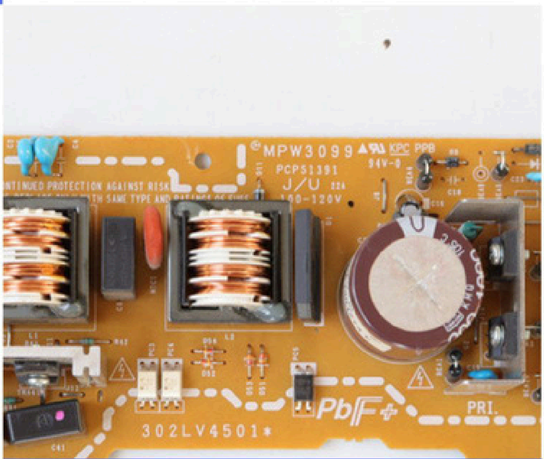

**Figure 01:2:** Now, take a look at this connector. It is the power connector of the motherboard (see the previous image). It provides the motherboard with the appropriate DC voltages.

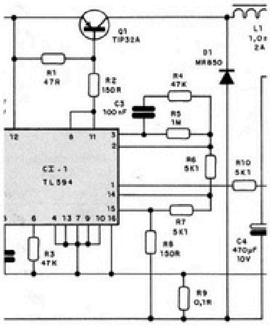
## What knowledge do we need to have before proceeding?

Before proceeding (with the power supplies themselves), we need to study and acquire essential knowledge, such as electrical quantities, direct current, pulsating direct current (among other topics). We will study all of this in the next chapter.

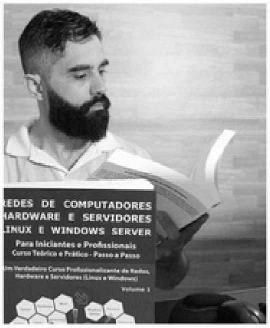
Chapter 02 - Electrical and Electronics

# CAPÍTULO 02




## Elétrica e Eletrônica




## Important to Know

Welcome! I want to tell you that what we will study now is essential for learning about switching power supplies.

If you already have all this knowledge, since it involves basic electrical and electronic concepts, you have two options:

- **Skip this chapter** and go straight to the study of switching power supplies.
- **Do a quick review —** this is what I recommend.

One thing I can guarantee: all the concepts covered here will be necessary. For example, when I talk to you about pulsating direct current, just to name one example, you need to know what it is. I won't be re-explaining what has already been explained here.

So, I ask you to study everything; don't skip any material. Dedicate yourself to truly learning so that you won't get lost later on.

Let's move forward with the content. I guarantee that every minute you dedicate to learning will be well worth it.

## Electricity

The word electricity is a general term and does not apply to just one phenomenon. Instead, electricity is associated with several phenomena arising from the existence and flow of electric charges. Examples include electric current in wires and conductors in general, static electricity, and lightning. However, to gain a deeper understanding, we will study matter, substances, molecules, and atoms, as well as protons, neutrons, and electrons.

## Matter

Matter is anything that occupies space. The term "space" here refers to any place where mass and/or energy can exist. Wood, water, glass, and rock are some examples of matter. It doesn't matter if it is here on Earth, wandering in the universe, or on another planet.

## Substances

Let's take two examples of materials: water and rock. Both are materials, but different from each other. Water has no defined shape, it is colorless and transparent (when clear, of course). The rock is hard, with a defined color and shape (although it can take many different forms). Why are they different? Because all of these (and other) materials are substances with different characteristics.

## Molecules and Atoms

Now comes the most interesting part of all. Substances are made up of molecules, and these, in turn, are composed of atoms. So, what gives a substance its specific set of characteristics are the types and quantities of atoms and the way they are combined to form the molecule.

## Prótons, Neutrons e Elétrons

O átomo não é a menor parte da molécula. Isso porque o átomo é composto por outros três componentes subatômicos principais: prótons, nêutrons e elétrons.

Os prótons, por convenção, possuem carga elétrica positiva (+), os elétrons têm carga negativa (-), e os nêutrons não possuem carga, sendo neutros (●). O núcleo do átomo é formado por prótons (+) e nêutrons (●), e ao redor desse núcleo, os elétrons (-) se movem.

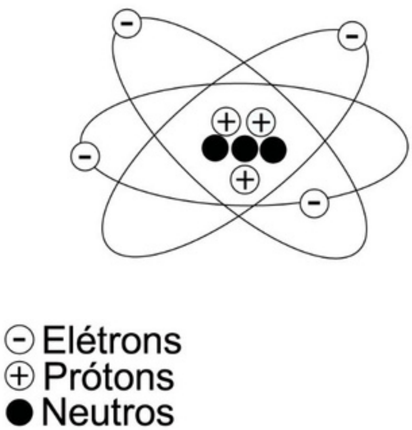



Figura 02.1: O átomo.

When an atom has more electrons (-) than protons (+), it is considered negative. When it has more protons (+), it is considered positive. And finally, if the number of electrons (-) is equal to the number of protons (+), it is considered a neutral atom. The atom can gain or lose electrons, a process called ionization. When this happens, there will be a difference in electric charges in the atom, and the atom will become electrically charged (which is the same as saying it is ionized). An atom can never lose or gain protons. It can gain or lose electrons because protons are located in the nucleus of the atom, while electrons are present in the electron cloud.

**In summary:**

- Neutral Atom: The number of protons and electrons is the same.

- Cation: Positive atom, with more protons than electrons.

## Electrical Quantities

• Anion: negative atom, with more electrons than protons.

In basic electricity, there are some fundamental quantities, which are: voltage, current, resistance and power. Each of them has its own unit of measurement, and this is what we will study in detail now.

Electric current: It is the movement (flow) of electrons (-) in a conductive medium.

For this movement to exist, it is enough to join two bodies with different electrical charges (one positive and the other negative).

Potential Difference (ddp): When there is a difference between the number of electrons at two points, with one point presenting a lack of electrons (-) and the other presenting an excess of electrons (-).

- Condition for electric current: For electric current to exist in a wire or conductive medium, there must be a potential difference between its ends. The movement of the current occurs from the point of greatest concentration of electrons to the point of least concentration.

## Potential Difference and Electrical Voltage

Potential difference and electrical voltage are the same thing. They are the force that moves electrons.

Electrical Voltage: There is voltage in the electrical grid on the street, in our homes, and inside electrical and electronic devices. It is responsible for the flow of electrons through conductors.

Important: Saying "voltage", as in "measuring the voltage" or "voltage that is passing through the wires", is incorrect. The correct term is voltage. Therefore, you should say "electrical tension", "measuring the voltage", or "tension in the wires", among other examples.

**Figure 02.2:** this is the international safety symbol against electric shocks caused by high electrical voltages, according to ISO 3864 standard.

As you may have already understood, the force with which electrons are moved from a “point A” to a “point B” is called electrical tension (or Potential Difference), whose unit of measurement is V --> volt (which is a tribute to the physicist Alessandro Volta). The greater the force, the greater the intensity.

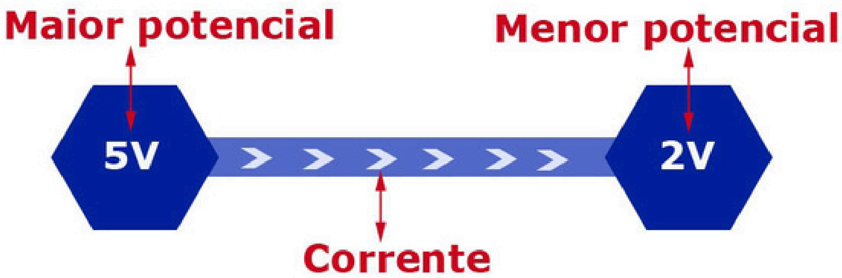



**Figure 02.3:** See an example of potential difference and current. In this example, electrons move from the point of highest potential (5V) to the point of lowest potential (2V).

The intensity of the electric current, that is, the amount of charge that passes through a wire, is measured in a unit called Ampere (A).

The resistance that electrical charges encounter when passing through a given conductor is measured in ohms (Ω). The greater the resistance, the more difficult it will be for the electrical charge to pass through it and the lower its intensity will be. Tip: this little word “ohms” has slight variations in its pronunciation. I have seen different engineers pronounce it slightly differently. It is not up to me to say which universal pronunciation should be adopted. But know that the closest to the correct pronunciation is certainly something similar to “hôlmes” and “hômes”. Finally, I will talk about power: a component needs a certain amount of energy to function. This is what we call power, whose unit of measurement is W - watts (in honor of James Watt). The watt is the amount of energy in joules that is converted, used or dissipated in one second. In other words, one watt is equivalent to 1 joule per second (1 J/s).

## Organized Content:

When we perform physical exercise, we need calories. Without calories, or without them in the necessary amount, we won't be able to perform the exercise, or we will do it with extreme inefficiency. The same applies to electronic components, but instead of calories, they use electrical energy. They need a certain amount of electrical energy to function.

Mathematically speaking, Watt is a unit of power calculated by multiplying current by voltage.
Summary:

- Voltage (Tensão Elétrica): The difference in potential between two points.

- Unit of Measurement: Volt (V)

- Current (Corrente Elétrica): The ordered movement of electrons.

- Unit of Measurement (intensity of current): Ampere (A)

- Resistance (Resistência Elétrica): The opposition (resistance) offered to the flow of electric current.

- Unit of Measurement: Ohm (Ω)

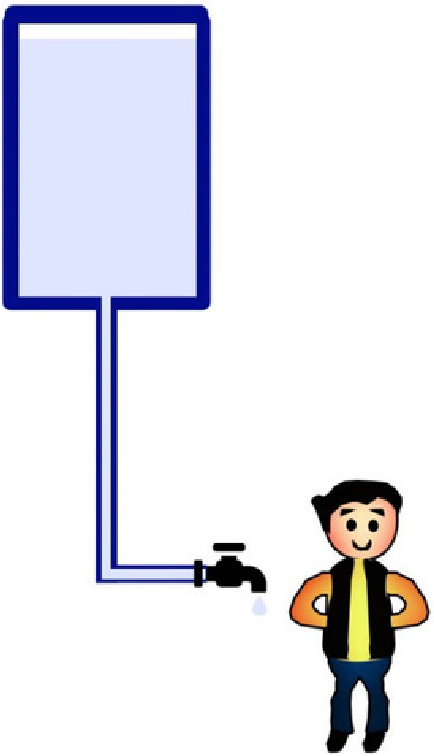


**Figure 02.4:**Hypothetical example.

That example figurative/hypothetical, if compared to electronics we have:

- **Electric wire**: is the pipe; **Electric charge:**it's the
- water; **Voltage:**would be the force of gravity;
- **Electric current:**would be the flow of water;
-

- **Resistance:** he would be provoked for the diameter of the pipe, the pressure reducer and the tap.

Point “A” is the water tank. Point “B” is the faucet. The movement of water from point “A” to the pon In the case of electricity, of electrons from one point **electrical**.

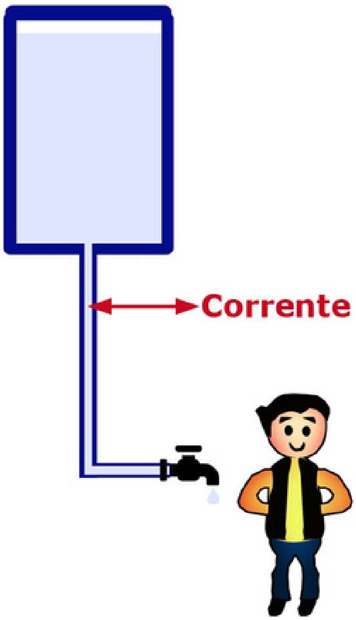



**Figure 02.5:**The movement of water is the current.

We know that**the higher the water tank**in relation to the ground,**the greater the pressure** that pushes this water and**the greater the flow of this water will be**, that is, the amount of water that comes out of the tap will be greater. In this example/comparison, this pressure/force that pushes the water in the hydraulic system is the **voltage (in electricity we say it is the electrical tension or potential difference**).

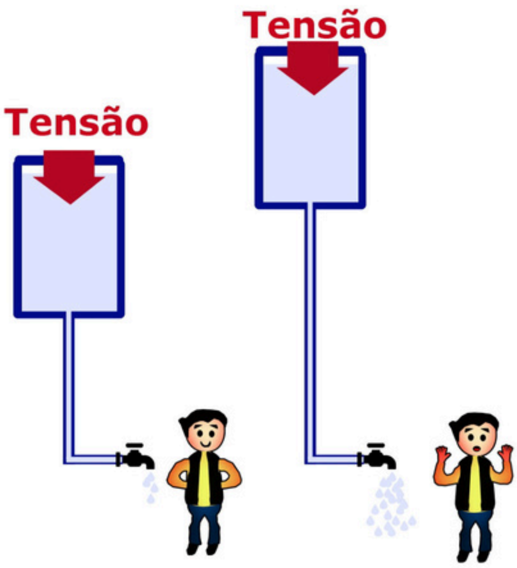



**Figure 02.6:**The higher the voltage, the greater the flow/current of water that will come out of the tap.

The unit of measurement for electrical voltage is the volt (V). If we are going to use the example of a water tank to illustrate this measurement, we have to analyze the height of the water tank in relation to the faucet. However, to make it even easier to illustrate, let's assume that the water pipe starts at the water tank and goes to the**soil**. The soil will be our reference. We can call the soil**Earth**or**GND**(is the abbreviation of GrouND which means earth).

As we know, the higher the box is in relation to the ground, the greater the force of gravity to push the water down. If the box is 12 meters high, we can (in a very simple and hypothetical way) say that 12 meters is the basic reference measurement to calculate this force.

In electronics, we don't use meters. Instead, we use the unit volt (V). If we were to make a hypothetical analogy (very hypothetical indeed!), we could say that these 12 meters would be 12 volts. This is the potential difference between the water tank and the ground.

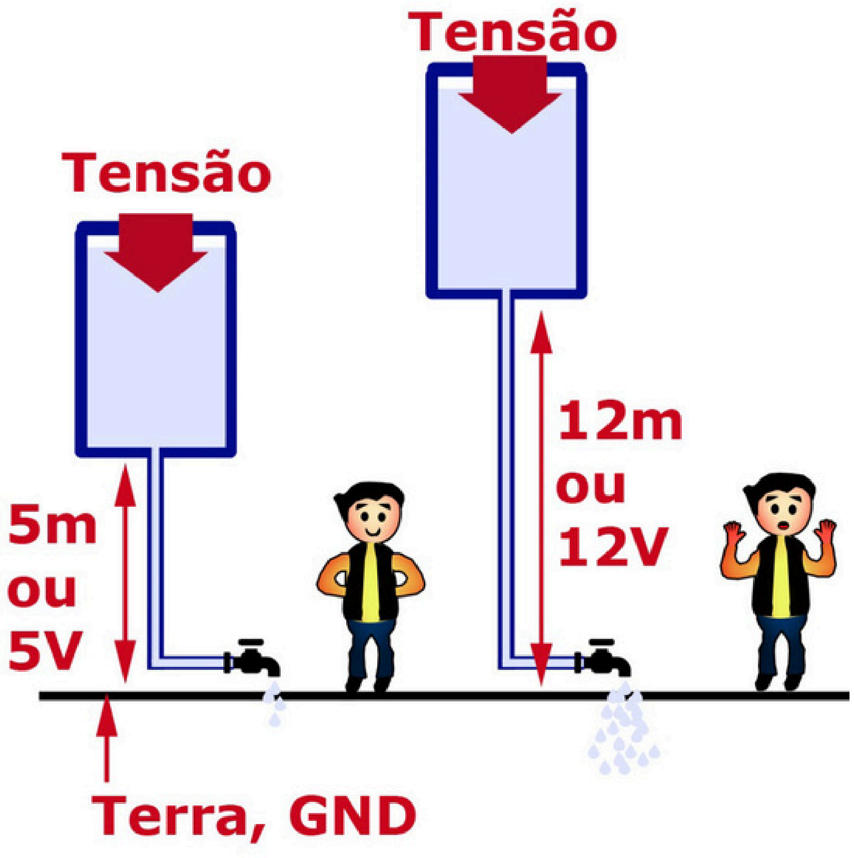



**Figure 02.7:**Meters or volts, the important thing is to understand that the higher the voltage, the more energy can flow (in this example, more water). In other words, the higher the voltage, the greater the current.

**Notice:**Let's remember? Can I use the term "voltage"? Example: the "voltage" of this component is 12V. The ideal is to say voltage. Volts are the unit used to measure voltage. In the same way that meters are used to measure distances. The correct thing to say is the distance in meters from point "A" to point "B", and not the "meters". I'm not saying whether it's right or wrong, I'm just stating what is ideal and most appropriate.

And furthermore it is easy to understand that we need to calculate the diameter of the pipe.

The diameter of the pipe will invariably create a certain **resistance**to the passage of water.
The smaller the diameter of the pipe, the greater the resistance for water to move from the water tank to the tap.
The smaller the diameter, the lower the water flow, i.e. the amount of water that comes out of the tap will be less.
One detail that I need to note is that if the water flow is small in the tap and

we want to increase it, we have two options: increase the height of the water tank (so that the tension is greater) or increase the diameter of the pipes so that the resistance of the water passage is lower.

And when it is necessary to create even more resistance to the passage of water, we can use a pressure reducer.

The pressure reducer will cause the water reaching it to encounter opposition (**resistance**) which will cause the water to continue its flow at a lower intensity.

Finally, the faucet itself is used to control the water output. It can also be used to cause opposition ( **resistance**) at the water outlet.

W

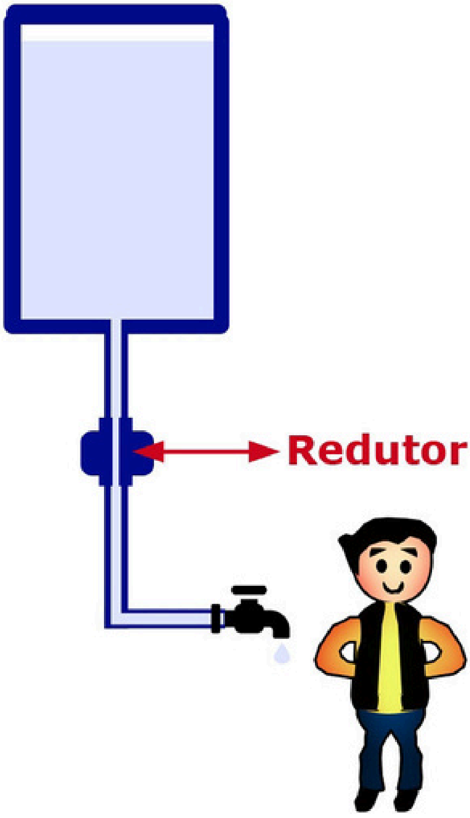



**Figure 02.8:**Reducer. Creates a resistance to the passage of water. In electricity, resistance is the opposition offered to the passage of current.
electrical.

It is worth noting that in the field of electricity and electronics, there are good and bad electrical conductors. Poorly conductive materials (which can be called insulators) are those that present great resistance to the passage of electrical energy. Some are even used as insulators in technical activities. Example: insulating tape.

Examples of bad drivers: Rubber, wood, cork, glass, porcelain, plastic, textiles (wool, silk, etc.), deionized water, highly sugared water, dry air.

**But be careful:**This does not mean that electrical energy will never pass through them. As the voltage increases, the chances of the current being able to pass through poorly conducting materials also increase. Even in materials known as insulators.

To make it clear, let's look at examples of good conductors: metals (such as copper, aluminum, iron, etc.) and some metal alloys, graphite, aqueous solutions (copper sulfate, sulfuric acid, etc.), tap water, water salt water, ionized water (such as that in swimming pools), the human body and humid air.

Finally, where does power come into all this? Using this example, imagine that a water wheel was placed at the end of this pipe. This wheel will turn when water falls on it. The power would be exactly the amount of water needed to make this wheel turn.

**Direct, Alternating and Pulsating Direct Current**

It is of fundamental importance to understand the difference between these three terms. They are widely used in electricity and electronics.

## Alternating Current

Let's start with alternating current, whose acronyms are CA or AC, which comes from English alternating current.
We will have this type of current when the electrons move periodically in the opposite direction.

different. This means that the electrons are constantly changing direction. It does not have a well-defined polarity, as shown in the following image.

This type of current (AC) is ideal for transmission over long distances because it offers lower energy loss and the possibility of easily lowering or increasing its electrical voltage through transformers. The costs involved in these operations are lower when dealing with alternating current.

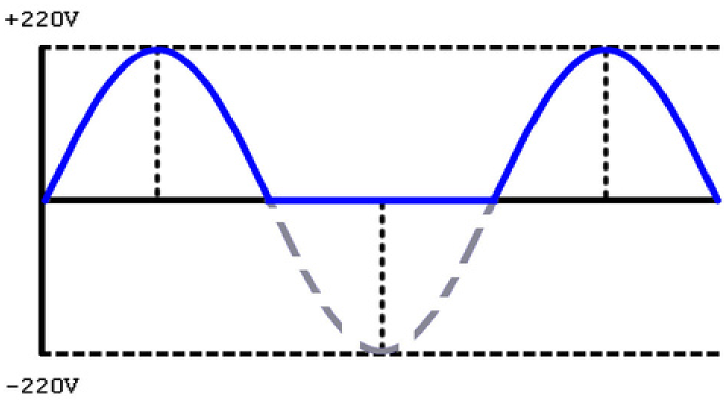



**Figure 02.9:**Alternating Current

## Direct Current

Direct current, whose acronyms are CC or DC, occurs when electrons move in a single direction. It has a defined polarity and there are no variations over time.

We receive alternating current in our homes and the sockets in our homes therefore have alternating current.
A PC, laptop or other computer, works internally with direct current. The power supply of these devices is responsible for converting alternating current into direct current, and provides lower values to the circuits, such as 12V, 5V, 3V, among other values, either higher or lower.

Direct current is more suitable and more efficient in low voltage circuits, such as electronic components in computers, just to give an example.

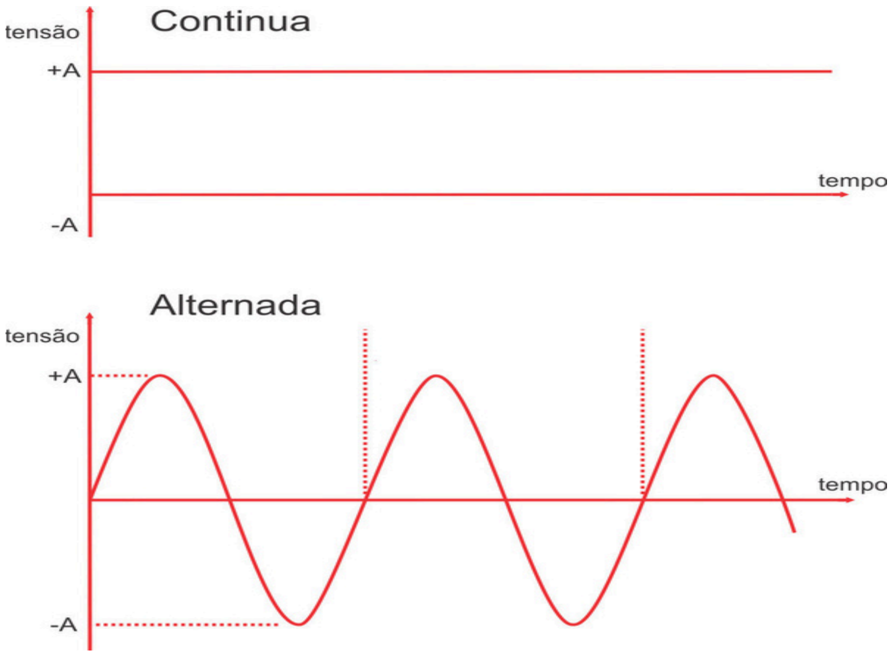



**Figure 02.10:**Direct and Alternating Current over time.

## Pulsating Direct Current

This knowledge here is as important as the previous ones. And to know what a pulsating direct current is, you need to know what a rectifier is.

The rectifier, which can also be called a rectifier circuit, is an electrical voltage circuit that has the purpose of receiving alternating current and converting it into pulsating direct current. And for this to be possible, the circuit will have semiconductor elements, such as diodes and thyristors, in addition to a transformer.

The characteristic of pulsating direct current is that she keeps constant the sense of current. But the value varies over time, passing through maximums and minimums alternately.

Therefore, realize that it is not a completely continuous current. We can say that it is a passing current that will still pass through regulatory circuits to obtain a definitive satisfactory continuous voltage.

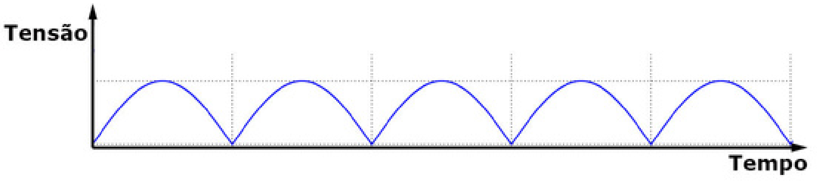



**Figure 02.11:**Pulsating Direct Current

Later on I will return to this subject where I will explain, through a diagram of a simple source, the circuits that receive alternating voltage, transform it into pulsating direct voltage and, finally, into direct voltage.

## Voltage Drop

Now that we know what electrical voltage is, I will explain the basic concept of**voltage drop**.

First, let's understand the basic principles applied to electrical installations. In this sense, voltage drop is a phenomenon that causes a decrease in the voltage of a conductor. This decrease occurs due to the increase in electrical resistance due, for example, to the distance of that conductor.

This is an explanation that applies to electrical installations. In electronics, in electronic circuits, we also have this phenomenon. It can occur due to a defect in some electronic component or because this decrease in voltage is part of the design.

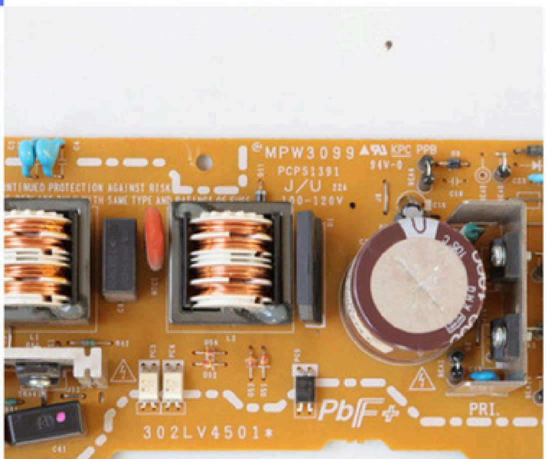
If you are measuring some point in the circuit that should have 12V and it only has 3V, there is a voltage drop caused by some defective component.

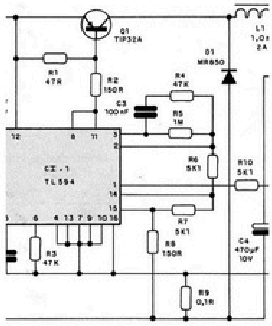
On the other hand, electronic components can be used to cause a voltage drop in a controlled manner.

Later on, we will begin to study schematic diagram analysis. And something extremely important is that when you come across an electronic component in the schematic, you need to recognize the component and know its function. There is no point in understanding that there is a resistor at a certain point, but not knowing its function there.

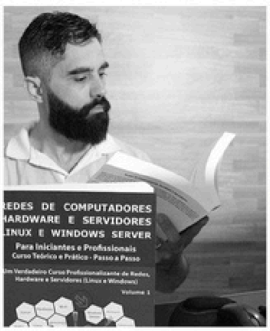
Resistors are widely used in electronic circuits. The name of this component is quite intuitive, as it is reminiscent of “resist”, “resistance”. And that is exactly its role. In a circuit, it causes resistance to the passage of an electric current. As we know, the greater the resistance, the lower the current.

# CAPÍTULO 03




## Segurança e Cuidados




## Introduction


**Figure 03.1:**The best way to start this chapter is with this sign in the image. Observe and memorize what is written on the sign.

**It would be extremely irresponsible to create a course on switching power supplies and not warn about the real and imminent risk: electric shock!**

If your outlet is 110V, you can get an electric shock through the 110V power supply board!

If your socket is 220V, you can get an electric shock through the 220V power supply board!

I'm not warning you about this to scare you. No! But rather to make you work carefully, prudently and professionally. It's that simple.

As we progress through the training, you will learn that there are points on the power supply board where there is the same energy as the outlet. And there are points where there is, for example, a pulsating direct voltage of around 200V!

Working with electronic boards in general (i.e. any electronic board, electronic components, etc.) requires more than just

knowledge technical. Requires also one strict commitment to safety.
The delicate nature of electronic components and circuits, as well as the potential risks involved, make it essential to adopt precautionary measures to protect both the professional and the equipment.

In this chapter, we will explore some of the key safety measures when working with electronic boards.

## Static Energy

Static energy can be a silent threat when handling electronic boards. Static discharges can damage sensitive components, causing irreparable component failure.

To avoid this, a fundamental tip is to use antistatic bracelets and an antistatic magnetic blanket.
Keep yourself grounded throughout the work process and avoid touching components directly.

**Figure 03.2:**standard antistatic wrist strap (with wire).


**Figure 03.3:**wireless anti-static wristband.

**Figure 03.4:**antistatic magnetic blanket. Another form of protection, much more widely used today, is to use appropriate gloves for working with electronics.

**Figure 03.5:**antistatic glove. The one in the photo is just one of the models available. There are others, in different colors.

If you have a busy workshop that maintains and repairs a lot of boards and equipment, especially expensive equipment, I'll give you a personal tip.

All technicians already know that placing a rubber blanket over the entire bench helps a lot.

But did you know that there is a rubber blanket specifically designed to discharge static energy from a person's body as soon as they touch it?

Her name isConductive Antistatic Mat or only Conductive Mat .
This mat is designed to be placed on the floor in the area where a machine operator will step. Its purpose is to drain electrostatic charges from operators as they approach protected work areas by stepping on the mat. When they step on the mat, the expected effect is that all static energy is drained.


**Equipment and measures of Security**

The use of appropriate safety equipment is essential. I have already mentioned anti-static wristbands, gloves and mats.

But there are more equipment and measures, such as the use of adequate lighting, the use of appropriate tools (avoid improvisation), care with ergonomic risks (such as poor posture and repetitive efforts) and control of gases and smoke in the environment.

Be careful not to inhale substances that are harmful to your health.

When welding, the “smoke” that is released, even in a minimal quantity, is not good for your health.

The ideal is to use an extractor fan for electronic soldering fumes. There are several options, but a portable extractor fan that can be placed on the workbench is quite common these days. See it in the image below.

**Figure 03.7:**welding fume extractor electronics.

Those items of protection no just safeguard the operator, but also prevent damage to the board components.

## Completely Disconnect the Power Supply Board

In many situations, the board must be completely disconnected from power sources for the work to be done. For example: soldering or desoldering components, testing with a multimeter that requires the board to be turned off, cleaning the board, etc.

Before starting any interventions such as those mentioned, make sure that the board is completely disconnected from power sources. This includes unplugging the board from the power outlet and removing the batteries, if present.
This also includes discharging capacitors, especially high voltage capacitors. Be very careful with this.

I will address these issues again, regarding the risks of high voltage capacitors, risks of electric shock, etc., at a more appropriate time.

## De-energize the Board (Discharge the Capacitors)

Capacitors store electrical energy even after the board has been deactivated. Discharging capacitors before handling them is essential to avoid electric shocks (even small ones), protect the equipment and prevent interference in measurements.

Perform some process that aims to discharge the capacitors on the board. There are capacitors, like some found on power supply boards, that can store tens and hundreds of volts.
There are a few ways to discharge. For example: disconnect the power supply, remove the batteries and hold down the power button (the button to turn on the device, if the board has one) for a few seconds.

And use the multimeter to check if the discharge has been done.

Another way to discharge the capacitors on the board is to build a small device to discharge capacitors. I teach how to assemble this device a little later in this chapter.

## Suitable Environment

To work in one environment adequate and essential. Avoid places with excessive humidity or high concentrations of dust, gases or smoke, as both can cause harm to the technician's health.

Make sure you have good lighting and ventilation, as well as an organized workbench to reduce the risk of components falling, components “disappearing” in the clutter, wasted time, etc.

## Appropriate Tools

Avoid improvising. Use the right wrenches for each type of screw, avoid pliers without protective rubber on the handles, and so on.

## Proper Handling

Handling electronic boards with care is essential. Hold the boards by the edges and handle them with clean, dry hands to avoid scratching them.

transfer of oil and dirt and the risk of electric shock. And the ideal is to use an antistatic glove that already helps a lot. Even so, you have to know how to handle the plates, know how to work safely.

## Device for discharging capacitors

To conclude this chapter, I teach you how to assemble a small “device” to discharge capacitors.

And even using this device, I will leave my guidance mainly for beginners:
1 - When discharging, especially high voltage capacitors, always be careful;
2 - Discharge, and then check with the multimeter if there is still any energy stored.

Let's go to the device!

**What we will need:**

- 1 resistor 1k5 20w 5% axial;
- 2 multimeter type test leads;
- Cutting pliers;
- Tin and solder paste;
- Soldering iron.

**To assemble, do the following:**

1 - Take the two test leads and cut the connectors that are connected to the multimeter. We don't need them.

2 - Now strip a little of the end of each wire, enough to solder to the resistor.
3 - And solder as shown in the following image.

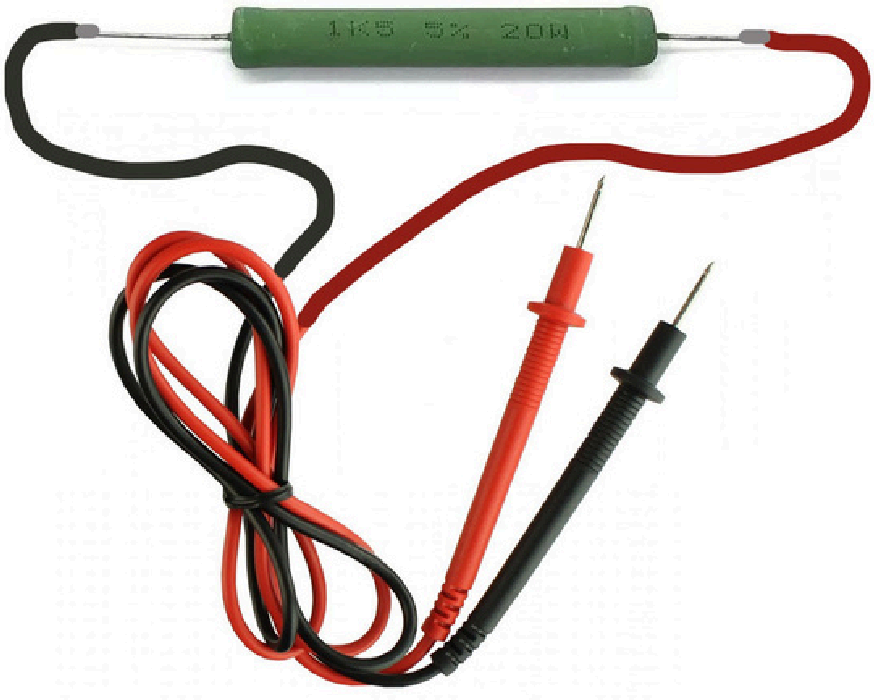
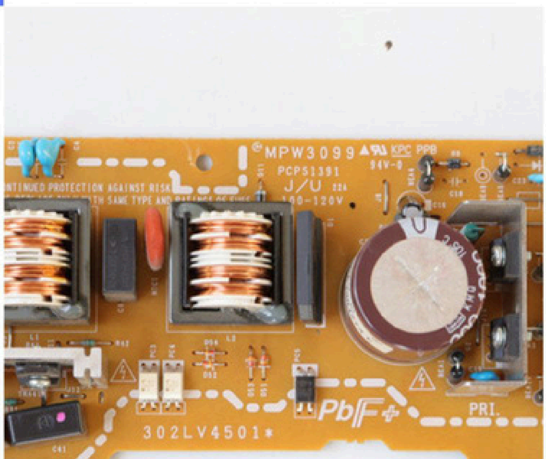


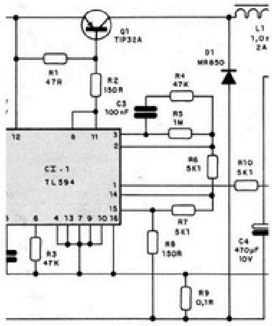

**Figure 03.8:**"device" to download capacitors.

Done! To discharge, simply identify the two terminals of the capacitor and touch each test lead to one terminal.

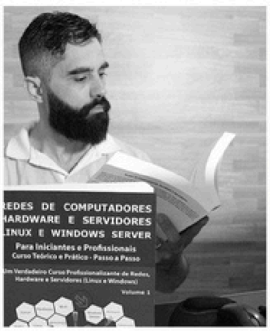
If in doubt, hold for a few seconds and then reverse the test leads.
And as I already left the tip for beginners: does the capacitor have high voltage? 80V, 100V, 200V for example? Test with the multimeter to see if the discharge has actually occurred.

# CAPÍTULO 04




## Ferramentas e Insumos




## Introduction

Welcome to this part of the training. Let's now get to knowtools (and supplies) to work with . I won't cover them all, I believe there will always be many tools that I could mention (and didn't mention). Do you need to buy them all? Not necessarily. There are tools, for example, that are for cleaning dust. You are the one who must decide which one to buy or not to buy.

And work with what? Power supplies? In fact, they are essential tools for working with electronics in general. This material is about switching power supplies, but it is about electronics.

We will see everything from the most basic tools (and supplies) (such as universal pliers) to the essential ones for electronics (such as the soldering iron, solder sucker, etc.) and the most "advanced" ones (such as the soldering and rework station, among others), and so on.

Understand what we are in one point extremely important part of our training, especially if you are a beginner. All the knowledge provided here is essential.

You can now set up your basic workshop by purchasing these tools. Even if you already have knowledge of soldering and desoldering techniques, don't skip this content. I'm sure there's a lot of useful information here for you. If you're already a professional in the field, consider this as a review.

Okay? Then let's get to studying!

**Universal Pliers**

Is this a tool that you will use to repair boards? Not really? But it is one of the most common tools in a workshop. It has its functions. It is very useful for cutting a wire or a cable, for example.

It has four basic functions:*to hold*,*to tighten*, *cut*and *conform*(shape the end of a wire, for example). It consists of*head*, *articulation*and*cables*.

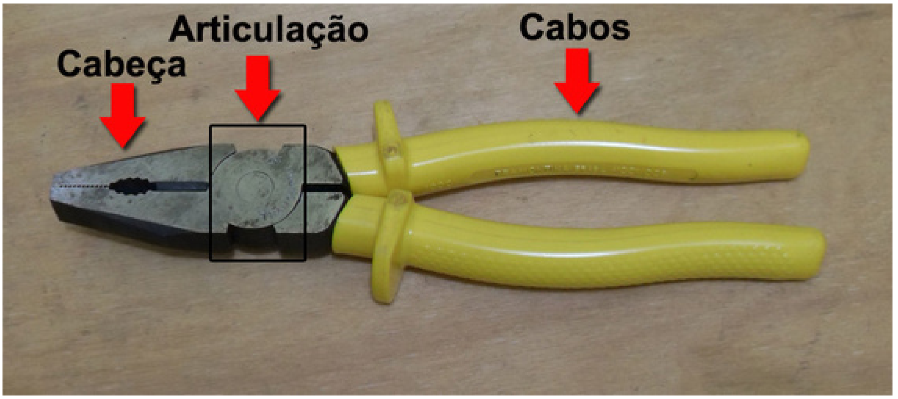



**Figure 04.1:**universal pliers

It has the quality of increasing the force applied to its cables and affecting its head. This means that the result of a force applied to its cables will be greater on the head. This is because the cables act as if they were levers.

**Figure 04.2:**when using pliers, the force applied to the handle is transferred to the head

The handle of the pliers can have different curvatures and sizes and may or may not have some type of coating. The larger the handle, the less pressure is needed to achieve a certain force applied to the head.

The cable coating can be used to provide greater comfort when using it and/or to provide insulation. When the cable has insulation (to allow

tasks performed on energized lines) it must have this information engraved on its cable (in accordance with standard NBR 9699), something like 1000V, which means that it is insulated to withstand voltages of up to 1000 V AC/DC.
The standard universal pliers are 8” (eight inches) in size.

## Cutting Pliers

It is a simple pair of pliers whose basic function is to cut, in general, wires (although, using it, with a little skill, it is also possible to strip wires), pins and terminals (of electronic components), etc.

Yes, you will use the cutting pliers when repairing boards. You will use them to cut off excess terminals when soldering. When you solder a PTH component, the terminal is usually too large and too much, and it is necessary to cut it off to make the service more professional.

It may or may not have some type of coating and may or may not have insulation against electrical energy, as is the case with universal pliers.

**Suggestion:**purchase a 6” (six inch) pliers.

**Figure 04.3:**cutting pliers

**Long and needle nose pliers**
It is an extremely useful pliers for tasks such as connecting wire terminals, removing or fitting jumpers, holding very small components, in short, performing various tasks that would be difficult to do with your fingers.

The fact that it has a thin, long beak also allows us to reach difficult, narrow places, etc.

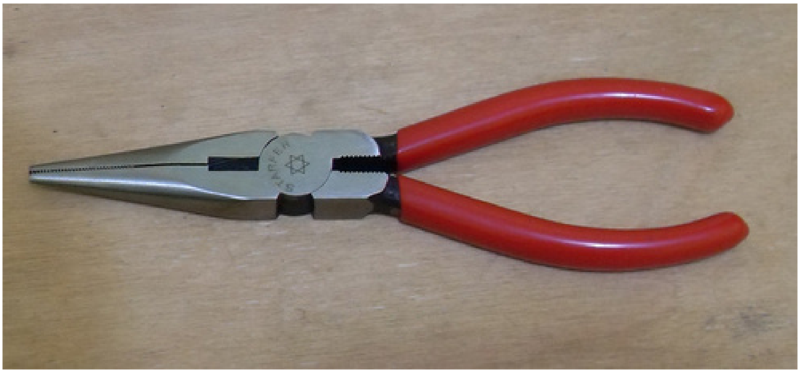


**Figure 04.4:**long needle nose pliers

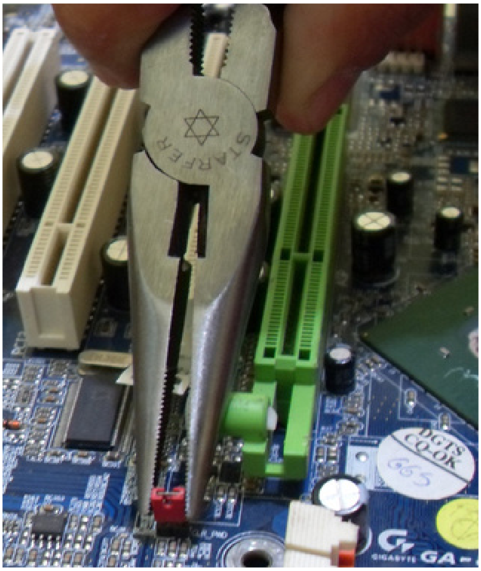



**Figure 04.5:**removing a jumper with long needle nose pliers
**Suggestion:**purchase a 6” (six inch) pliers.

**Screwdriver**
Typical and very useful tool. They are used on screws that have a *crack*. Yours*tip*it is flat and narrow.

A screwdriver is very useful in many cases. One example is installing coolers, which is usually much easier with the help of a screwdriver. In addition, some types of screws, used in computers, power supplies, etc., are designed to accept both a Phillips screwdriver and a flat-head screwdriver.

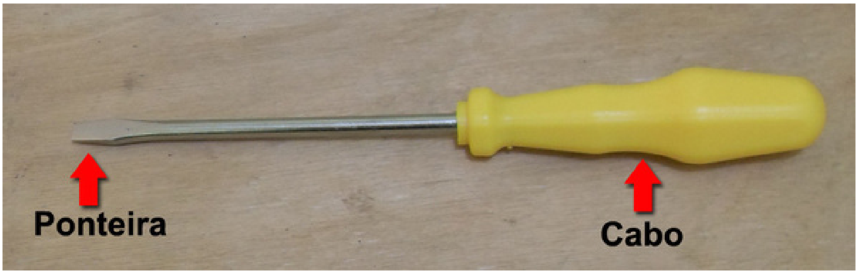



**Figure 04.6:***screwdriver*

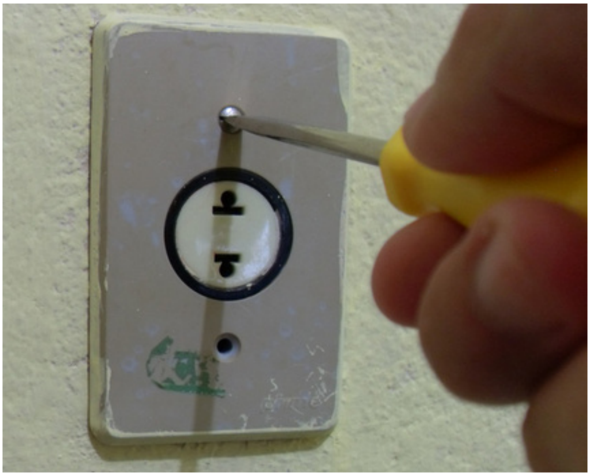


**Figure 04.7:**removing the cover plate (with a screwdriver) from a two-pin socket to change to a three-pin plug

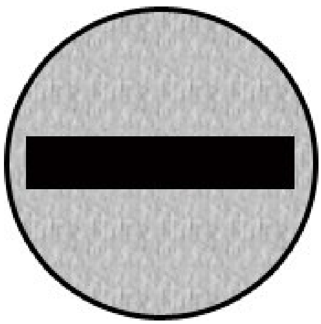


**Figure 04.8:**slotted screw head

**Suggestion:**Purchase a small wrench kit that has at least one wrench that is close to 3/16x4” in size.

## Phillips screwdriver

This is the most commonly used key for maintaining microcomputers, power supplies and all equipment that uses the well-known Phillips-head screws. For this reason, it is indispensable.

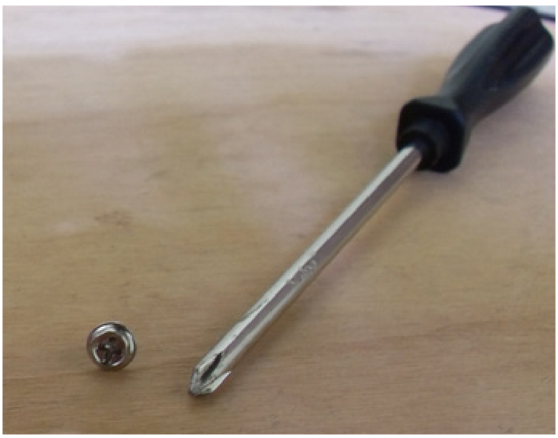


**Figure 04.9:**Phillips screwdriver

The screw head is shaped like a four-pointed star, unlike a screwdriver whose head is just a small, elongated slot. This ensures greater firmness and precision when using the screwdriver. An interesting detail is that the tips of Phillips screwdrivers are designed to “jump” out of the screw slots if tightened too hard, which prevents the socket from breaking.

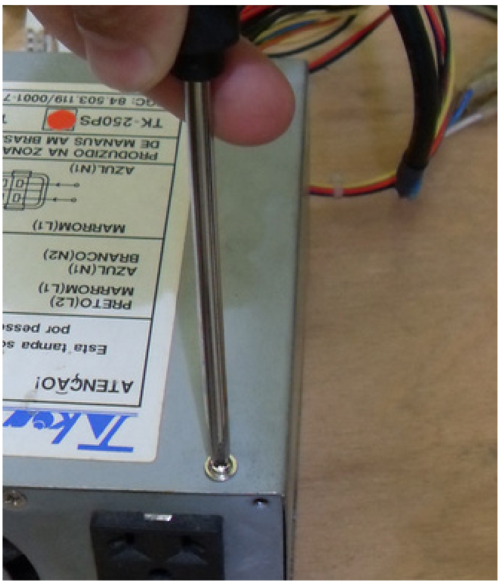



**Figure 04.10:**removing the screw from a source with a Phillips screwdriver.

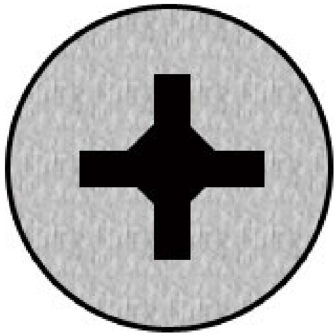


**Figure 04.11:**screw head type Phillips.

**Suggestion:**Purchase a small wrench kit that has at least one wrench that is close to 3/16x4” in size.

## Torx key

There are many who think that this key is not very useful and will not be used much. But just to give you an idea, for those who work with printer maintenance, HD maintenance, video game consoles, etc., it is indispensable.

These keys can be elongated or “L” shaped (or other shapes). In general, they are sold in kits containing several torx keys of different sizes.

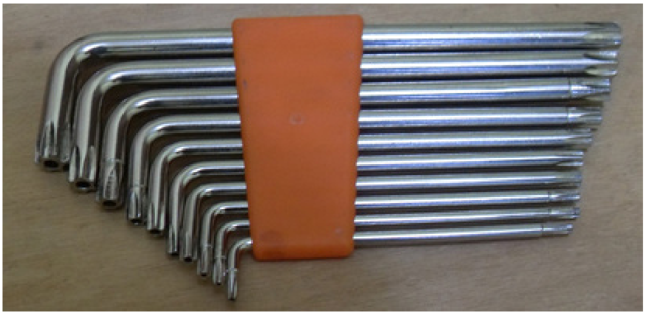


**Figure 04.12:**torx key set.

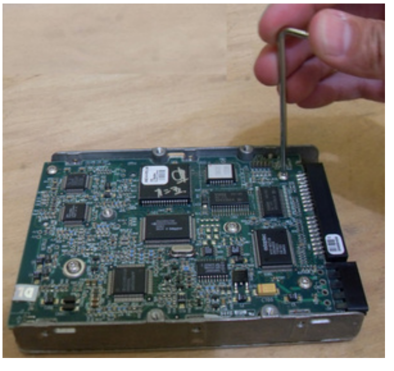


**Figure 04.13:**removing a screw from a HD with a torx key.

The screw head fitting is in the shape of a six-pointed star, which ensures even greater firmness and precision.

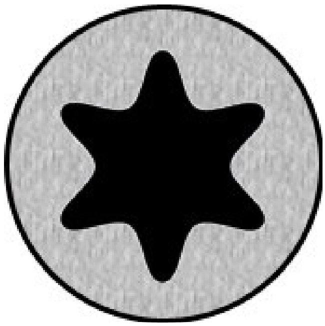


**Figure 04.14:**head of a torx type

**Suggestion:**Purchase a set (kit) of torx keys with approximately the following sizes: T9, T10, T15, T20, T25, T27, T30 and T40.

#### Utility knife

It can be used to open boxes, strip wires and cables, cut cable ties, remove insulating tape from wires, among other functions. It is the type of tool that is “handy”. It helps in countless situations.

**Figure 04.16:**stylus.

**Suggestion:**medium stylus.

## Antistatic brush

They can be used to remove dust from boards or any other component/part of a device/equipment.

They must be soft so as not to damage any components and have antistatic properties (they will not have any metal parts, for example).

If you are going to do a heavy cleaning, use it carefully. It is best to use it as a complement to the cleaning carried out with the vacuum cleaner and air jet.


**Figure 04.17:**brushes

**Suggestion:**antistatic brush set for electronics.

**Soft white rubber**
Used to clean contacts on expansion cards and memory modules in computers, for example.

When dealing with cards that have already been used, and especially those that are already connected to their slot, it may be necessary to clean the contacts. For example: a certain expansion card that has poor contact. A simple cleaning of its contacts can solve the problem.

But understand the following: this is just a temporary resource. Some tests already carried out by technicians and professionals involved with computers and electronics have proven that the use of rubber can wear down the metal layer of the contacts.

In this case, the ideal is to use contact cleaner or isopropyl alcohol.

## Spray clean contacts and alcohol isopropyl


**Figure 04.18:**Contact cleaner spray and alcohol isopropyl.

Contact cleaner spray and isopropyl alcohol are common products used in electronics for cleaning and maintaining electronic components and circuits. Both can perform more specific functions:

- **Contact Cleaner Spray:**Contact cleaner spray is a product designed to remove dirt, dust, oil residue and oxidation from electrical contacts, etc. It is very useful when there are problems with poor contact or when electronic components do not work properly due to dirt or oxidation on the contacts. To use, you simply apply the spray to the contacts or the affected area, let it dry and then reassemble the equipment.

- **Isopropyl Alcohol:**Isopropyl alcohol is a highly effective and safe alcohol-based cleaner for use on electronics. It is used to clean printed circuit boards, electronic components, connectors, and other electronic devices. Isopropyl alcohol is preferred because it evaporates quickly and leaves no residue.

residue, making it ideal for cleaning moisture-sensitive components. It is useful for removing dirt, grease, soldering fluxes, and even for disinfecting electronic surfaces.

## Vacuum cleaner and air blower

It is a device specifically designed to clean dust using *air blasting*or*dirt suction*.

It cleans boards, the inside of cases, keyboards, printers, etc.
There are models that only blast air and there are vacuum models.

**Figure 04.19:**Air blower

**Suggestion:**An air blower is usually cheaper than a vacuum cleaner and is enough to get you started..

**Magnifying glass**

Mainly used to read lowercase letters engraved on electronic components in general. Mainly for those who work with electronics, a magnifying glass is very useful to help when reading information contained in small electronic components.

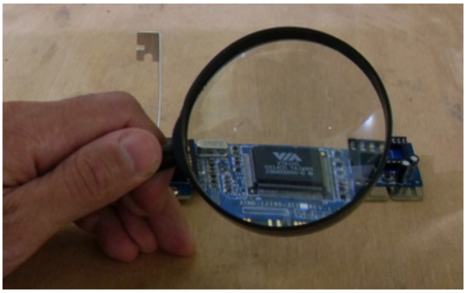


**Figure 04.20:**performing the reading of a chip a network card

**Suggestion:**magnifying glass with 75 or 90 mm lens.

## Digital test key

This switch makes simple measurements in direct current (DC) or alternating current (AC).


**Figure 04.21:**digital test key.

Alternating current is the current that reaches our homes. It is a type of electric current that undergoes variations (in magnitude and direction) over time. This type of energy cannot be used internally by the computer. Therefore, the computer's power supply transforms it into direct current (which can also be called Direct Current - DC), which is a stable energy that does not undergo variations over time.

A test switch performs measurements in the range of 12 to 220V. Information on the minimum and maximum voltage range that the switch supports will be engraved on the packaging and/or on the key itself. Therefore, pay close attention to this information.


**Figure 04.22:** minimum voltage information and maximum in the key

In general, measurements can be taken in two ways: *direct*(not to be confused with direct current) and *indirect*(the same as*Inductive*). We make a direct

measurement when we place the tip of the key directly on an exposed wire, circuit points, screws where wires are connected, socket pins, etc. In inductive mode, the tip of the key is placed on insulated wires (and there is circulation of electrical energy).

The key has two buttons:*Direct Measurement*and *Inductive Test*. To make a direct measurement, place the tip of the key on the bare wire (for example) and press the button*Direct measurement*. And to make an indirect measurement, place the tip of the key on the insulated wire and press the button.*Inductive Test*.

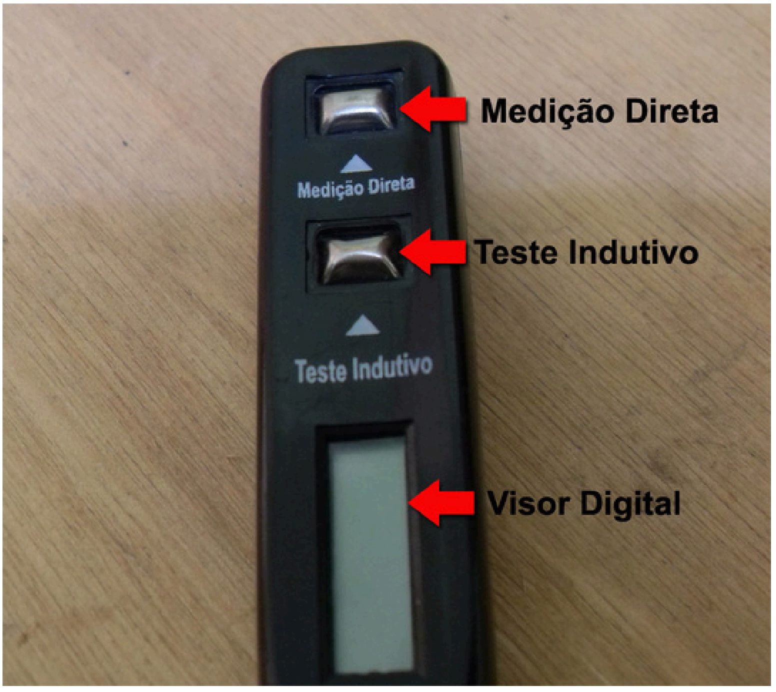



**Figure 04.23:**buttons and display

This key is very useful for locating the phase wire in an outlet. Simply touch the tip of the key to a wire (or outlet pin) and press the Direct Measurement button. If a small lightning bolt symbol appears on the digital display, this means that this wire is the phase wire. Any wires that do not appear are neutral or ground. It is important to note that in 110V networks, outlets will have only one phase wire, while in 220V networks, outlets have two phase wires.


**Figure 04.24:**phase wire located

## Flashlight

To the to do one maintenance (between others situations) in darker environments, a flashlight is essential, especially when the technician needs to open the case just to read and/or check a part.

**Figure 04.25:**a small flashlight

## Cotton swabs for electronics

It is also very useful, it helps with cleaning in different situations, both in preventive cleaning and in cleaning for some technical service that is being carried out.

**Figure 04.27:**Industrial cotton swab rod
Wood and Cotton Tip

**Antistatic wristband**
For basic protection. It is placed on the wrist and connected to a grounded point. There is also a wireless model, which does not require connection to a grounded point.


**Figure 04.28:**Antistatic wristband

## Antistatic glove

Also used to work more safely, especially when handling components that are sensitive to static energy.


**Figure 04.29:**antistatic gloves.

**Thermal Paste**

Indispensabletowhoit workswith
computers for example. There are white thermal pastes (which are cheaper), silver (which are
what


**Figure 04.30:**thermal paste

**Suggestion:**Thermal paste is generally a relatively low-cost product. Get one of each (white and silver, in a jar, tube and syringe) if possible, and never let your workshop run out of stock.

**Multimeter**

Device extremely important in electronics. With it we can make measurements such as *voltage*,*current*and*resistance*. They can be divided into two models:*analog*and *digital*.

The analog model is characterized by a display containing a pointer. This means that the measurement results are indicated by a mechanical pointer. It operates electromechanically.

The digital model has a digital display (liquid crystal display), where the measurement results are all given digitally on this screen, showing the exact result. Its operation is completely electronic.

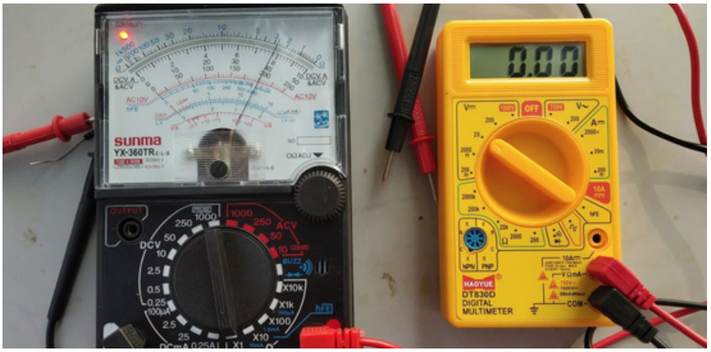



**Figure 04.33:**analog and digital model.

And among the digital models, there are still three types: Manual Digital Multimeter, Automatic Digital Multimeter and Intelligent Digital Multimeter.

## Manual Digital Multimeter

<u>Represents the first generation of digital multimeters.</u>

It contains a digital display and a rotary switch (selection switch) that is used to set the measurement value range. And you are the one who will set this value range that you are going to measure. You will turn the switch and position it on the closest and highest scale.

Let's use the example of measuring the continuous voltage of a battery. If a battery has 1.2V and a battery has 9V (for example), then set the selection switch to 20 (DCV), as it is the closest scale and above these values. That's why it is manual.

This model is best suited for students. That is exactly why this is the model we will use in this course.


**Figure 04.34:**digital manual model.

## Automatic Digital Multimeter

They represent the second generation of digital multimeters.

It has a digital display and a rotary switch. The difference is that it is not necessary to choose a scale closer to and above the value to be measured.

In the example I gave earlier, measuring the direct current of a battery, simply set the switch to DCV (DC). In the case of the Hikari HM-2090 model that we see, we must select the Direct Current symbol. It automatically selects a range (scale) suitable for the measurement.

Most models have the option of manually setting the range using a specific button and the display. However, it comes factory-set to “Auto”, meaning it will detect and set a range suitable for the measurement. This model is only recommended for professionals, precisely because you will not learn how to select the scales with this model.

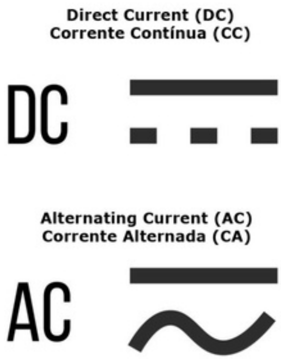




**Figure 04.35:**automatic digital model.

## Smart Digital Multimeter

They represent the third generation of digital multimeters.
It has a digital display and does NOT have a rotary switch.

THE difference screaming and this equipment
it achieves to recognize the signal measured

automatically, without the need of select measurable functions.

This model and indicated only to professionals, simply because you will not learn how to choose functions and scales correctly with this model.

**Figure 04.36:**smart digital model

**Which model is recommended for beginners?**

I will recommend using a manual digital multimeter, as it is the best for learning. With it, we must select the functions and scales correctly using the rotary switch. It is essential learning.

And to be more specific, I recommend the Minipa ET-1002 multimeter. It is an excellent multimeter and has a relatively low price. With it we can measure DC Voltage, AC Voltage, Resistance, DC Current, Continuity Test, Diode Test and Transistor hFE Test.

I don't like to talk about equipment prices, because this can change a lot depending on when you are studying this material. But, at the exact moment I am creating this material, the price of this model is more or less R$100.00.

## Soldering iron

It's very obvious, but I need to "say" something to start the subject. It is used to solder or desolder electronic components.
Common models used are 30, 40 and 50W. In this case I am talking about soldering irons purchased separately, that is, they are not soldering station soldering irons.

Which one should you buy? You can buy two models: one with 40W and one with 50W.
For soldering small components in general: a soldering iron with a power in the range of 40 watts is sufficient. This allows you to quickly heat the soldering points without overheating or damaging the components.

For soldering larger components: You can opt for a soldering iron with a slightly higher wattage, in the range of 40 to 50 watts.

Your own bench experience will guide you. Mainly because it is not only power that should be evaluated. You have to know how to use the right tips, there is the issue of cleaning the tips that directly affect the quality of the welding, etc.

For example, I work on printed circuit boards with a 40W soldering iron, always with a tip in good condition, always clean and tinned. You have to use everything correctly: good quality tin, solder flux, solder paste, solder paste, mesh.

desoldering, chip saver, etc. And know the soldering and desoldering techniques.


**Figure 04.37:**soldering iron.

## Solder Sucker

It is used, together with the soldering iron, to remove solder from some point of a given circuit.

Let's suppose that you have soldered a transistor into a circuit, and now you need to remove it. To do this, you need to melt the solder that is on its terminals and use the solder sucker to suck it up. This is what the solder sucker does, it “sucks” the melted solder.

Using it is simple. It has a plunger that must be pressed all the way down. Once this is done, press a button, which will lock it. Finally, bring its nozzle (tip) right up to the molten solder and press the button again, which releases the plunger, which quickly returns to its original position. The sudden upward movement of the plunger causes the molten solder to be sucked into it.

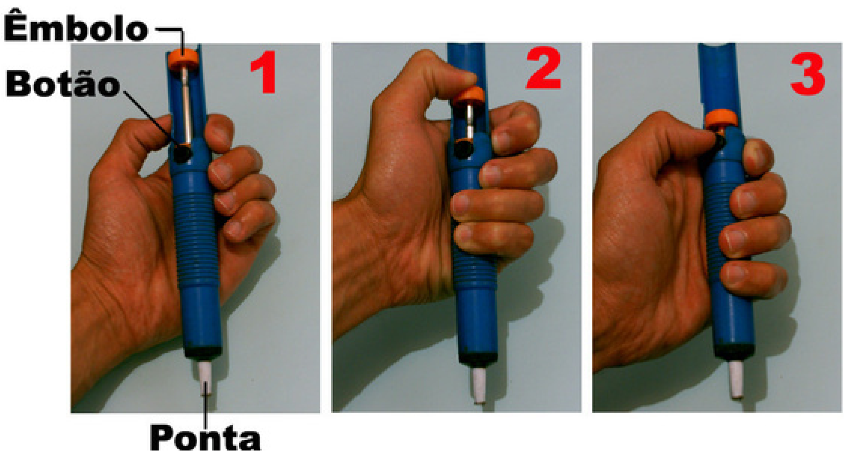



**Figure 04.38:**how to use solder sucker.

**Soldering Station, Rework, Soldering and Rework**

This equipment is extremely useful on a bench, especially on benches of professionals who work a lot with electronics.

See that I mentioned here “Soldering Station, rework, Soldering and Rework”. This is because there is the Soldering Station, there is the Soldering Rework and there is Station Station and Rework.

And just to give you an idea of how much this can complicate the lives of beginners, know that there are several very specific pieces of equipment, such as infrared soldering stations, desoldering stations, digital soldering stations and analog soldering stations.

And to help, I've simplified this issue quite a bit. From now on, you'll have an exact idea of what to buy to start your studies and set up your workshop.

## Types of Stations

The first thing to learn is to differentiate the main types of equipment. I will not list all the types of equipment that exist here, as this is not necessary. However, I will make the following distinctions:

- **Soldering station:**It consists of a soldering iron connected to a control unit. This control unit provides temperature control. It may or may not have a digital panel that displays and controls the temperature. When it does not have a digital panel (temperature control is done through an analog rotary knob), it is an analog station. When it has a digital panel composed of buttons and an LCD, it is a digital soldering station.


**Figure 04.39:**analog soldering station.


**Figure 04.40:**digital soldering station.

- **Station of rework:** AND one Equipment that has a heat gun connected to a temperature control unit. The function of this equipment is to desolder components more safely. Just as I explained when talking about the soldering station, there are analog and digital rework stations. The concept is the same as already explained. Using the right technique, it is also possible to solder using this equipment.


**Figure 04.41:**analog rework station.


**Figure 04.42:**digital rework station.

- **Soldering and rework station:**Finally, this equipment consists of a soldering iron and a heat gun, both connected to a control unit where we can control the temperature. And once again, there are analog and digital models. The name of this station may be slightly different depending on the manufacturer and/or store, but it has the same function. For example: some manufacturers and/or stores call this equipment a soldering and desoldering station, a combined station, etc.

But understand what the purpose of team


**Figure 0** the


**Figure 04.44:**soldering and rework station digital.

## Station power

These devices are sold in different brands and models. There are also different power options, and the higher the power of the device, the higher the price you will have to pay. But don't buy equipment with very low power just because it's cheaper. If the power is too low, it may not meet your needs.

There are stations ranging from very small ones with around 18W (for very delicate soldering and desoldering) to stations with 300W (or more) that can handle heavier work such as soldering and desoldering large gauge electrical wires and cables.

Also, if it is a rework and soldering station, the equipment will have the total power, the heat gun power and the soldering iron power.

**Temperature Variation**

It is essential to purchase equipment that can work with a good temperature range. It is quite common to find models on the market that work with temperatures ranging from 150ºC to 500ºC. This is a good option, as you will be able to work on everything from more delicate soldering and desoldering to more robust work. And the issue of temperature variation is different between a soldering iron and a heat gun.

## Air Blower Nozzles

The air blower will come with a set of nozzles that can be used according to the air flow requirement. The nozzles are measured by the diameter of the nozzles. The number of nozzles and the nozzle diameters vary according to each manufacturer. However, the variation ranges from around 2 or 3 mm to 9 or 12 mm. You can also buy nozzles separately, as long as they are accepted by the make and model of your equipment.

Cap s

**Fig n.**

**Which Station Do You Indicate?**

Which station do you recommend for beginners? I recommend the Yaxun 902+ 110V.

- Some Features:
  - Hot air blower:
    - Hot air temperature: 150ºC - 500ºC;
    - Power consumption: 350W;
    - 5 Nozzles of different sizes.
  - Soldering iron:

- Welder temperature: 200ºC - 480ºC;
- Power consumption: 50w.

You can purchase the equipment of your choice. Do not understand this as an “obligation to purchase” but rather as a reference.

## Soldering Iron Tips

The soldering iron has a tip that is used for soldering and desoldering.
And this tip can be changed according to the need.

Most soldering irons, soldering stations or soldering and rework stations will only come with one type of tip (usually the conical type), leaving it up to the technician to purchase a separate tip kit.

The main types are:

- **Conic:** It is the most common type and is included with the soldering iron when purchased. Can be used in virtually all types of services;
- **Needle:** This tip is thin and long. It is suitable for delicate work, such as soldering SMD, resistors and capacitors;
- **Crack:** This tip is recommended for welding robust components, such as large gauge electrical wires, among other services.

- **Other tips:** There are also other tips for a wide range of applications, such as knife, beveled and curved tips.


**Figure 04.46:**examples of tips

You have to purchase tips according to your equipment. Just research, check the recommended equipment and there will be no mistakes.

## Tip Cleaner

The essential care that must be taken with the soldering iron is its cleaning, especially the tip. As a soldering iron is used, tin builds up, and excess tin must be removed whenever possible. This removal should be done with a metal sponge or vegetable sponge.

You can even buy a Metal Sponge with Support that allows you to clean it constantly while in use. There are several options available on the market. In the image below you can see a Hikari HSE-20 Small Metal Sponge with Support.

**Figure 04.47:**Metal Sponge with Support Small Hikari HSE-20.

## Little Fork

When desoldering some components such as the MOSFET transistor, you can use a tool called a “fork”. It should be inserted under the Gate and Source terminals. Yes, there is a space there that allows you to inserting the fork. It is used to apply a small force to the transistor, causing it to jump out as soon as the solder melts. Be careful not to let the transistor “fly away”.

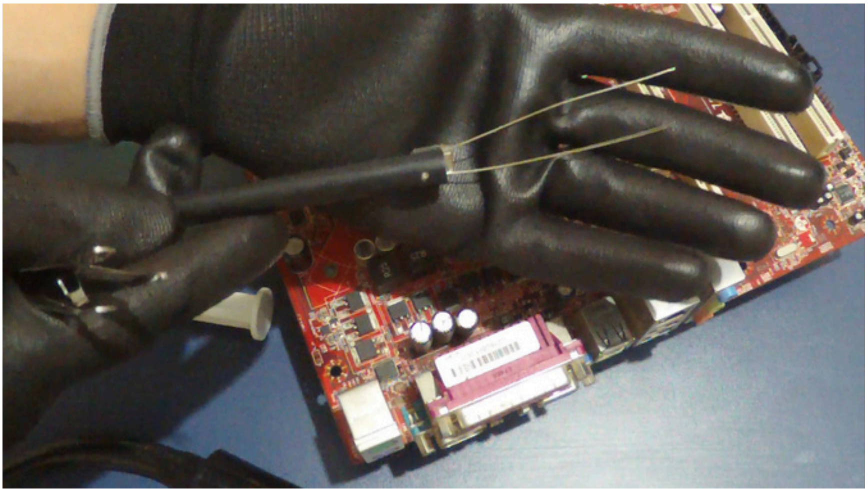


**Figure 04.48:**here is the “little fork”.

**Tweezers**

Tweezers have a variety of functions, such as picking up components that have fallen into a difficult place, extracting jumpers, removing chips, etc. And

Mainly: it helps a lot in soldering and desoldering processes. And to make this possible, there are tweezers with different shapes. So get a small set of tweezers.


**Figure 04.49:**set of tweezers.

## Tin, Types and Characteristics

Solder, also known as tin solder or tin solder, is used for soldering. Tin is composed of a combination of tin (Sn) and lead (Pb). The more tin the alloy has, the lower the melting point will be, that is, the more tin, the lower the temperature required to melt the solder.

There are several tin (Sn) and lead (Pb) alloys on the market and this can be a bit confusing. Let's look at some alloys:

- **Alloy 63% Sn + 37% Pb:**One of the most suitable for electronics and usually the hardest to find. This alloy is called a eutectic alloy and has the lowest melting temperature. They are sold in the form of wires with a diameter of 1 mm. Melting point: 290 °C. If this is not available, use the 60% Sn + 40% Pb alloy.

- **Alloy 60% Sn + 40% Pb:**Widely used in electronics. They are sold in the form of wires with 2 mm and 1 mm in diameter.
  The packaging is standardized in blue color.
  Melting point: 310 °C.
- **Alloy 50% Sn + 50% Pb:**suitable for welding high gauge electrical wires and cables and protective covering in

copper busbars. They are generally sold in the form of bars or wires. The packaging is standardized in yellow. Melting point: 350 °C.

- **Alloy 40% Sn + 60% Pb:**Suitable for heavy welding. Examples: copper pipes and metal gutters. They are generally sold in the form of bars or thick wires. The packaging is standardized in green. Melting point: 450 °C. Most suitable soldering irons: high-power electric or gas-powered irons.

**Figure 04.50:**Tin solder.

## Solder Paste

Attention, I will give you a warning: solder paste and solder paste are not the same thing. I am now talking about solder paste.

Solder paste is nothing more than tin for soldering, but in a paste form. It can be used, for example, in situations where precision is required. For example: cell phone boards, soldering where we need to use a microscope, soldering very small components, small tracks, SMDs, reballing, etc.


**Figure 04.51:**solder paste.

## Solder balls

These are the spheres used in the BGA chip. There is no universal sphere. Each chip uses a specific sphere depending on its size. The sizes are in mm. In a workshop, it is ideal to have a set of spheres. Example: 0.30mm, 0.35mm, 0.40mm, 0.45mm, 0.50mm, 0.60mm and 0.76mm. But be careful: spheres have an expiration date, so be aware of this.


**Figure 04.52:**solder ball set.

## Solder Paste and Solder Flux

You have just learned about solder paste. As I just said, solder paste is a different product from solder paste. Pay close attention.

Other components used in soldering processes are solder paste and solder flux, which serve to prevent oxidation, provide a greater “alloy” and avoid corrosive residues and/or rosin resins. Solder paste can also be called soldering paste.


**Figure 04.53:**soldering paste.

Soldering flux can be liquid or paste-like. In other words, you will find “paste flux” and “liquid flux” for sale. Its purpose is the same as that of soldering paste.


**Figure 04.54:**pasty flow.


**Figure 04.55:**liquid flux for soldering.

## Other inputs

From the same form what occurs with to the tools, there are also many other inputs, of which I will mention two:

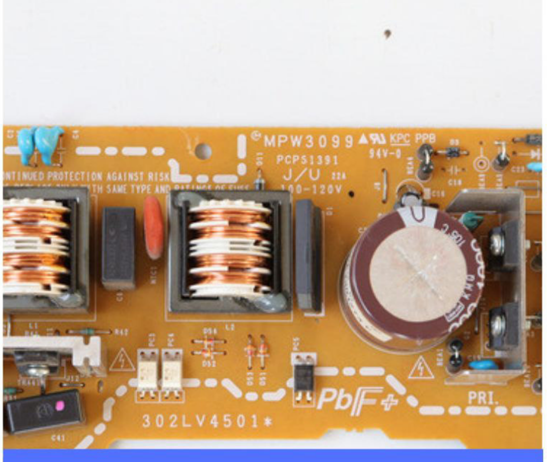
- **Desoldering mesh:** Also known as desoldering tape. A sheet of 1.5m x 2.5mm tape is sufficient for this exercise below;

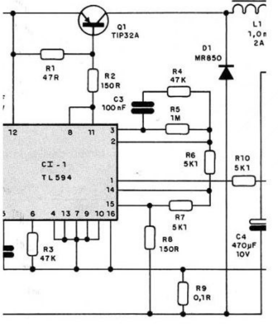
**Figure 04.56:** desoldering mesh.

- **Thermal Tape:**It is an aluminum tape that is used in various jobs, such as reballing and reflow. We use it to insulate components that we want to protect from heat.

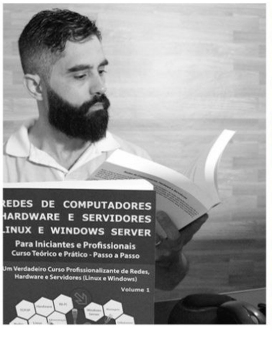
**Figure 04.57:**aluminum thermal tape.

# CAPÍTULO 05




## Princípios de Funcionamento




## Introduction

I will finally address switching power supplies. And know that this is a very broad subject. There are many details to study.

And we will find many switching power supplies on the market of all levels of complexity. There are power supplies with very small and reduced boards, as well as power supplies with very large boards and many electronic components. It all depends on the project.

And there is no way to simply study all existing source boards.

The good news is that it is possible to learn the essence of switching power supplies, which will help you a lot in dealing with the most varied sources.

The goal from this point on is to allow you to learn all of my teaching methods so that you are able to master switching power supplies. We will do this step by step and in detail.

**Linear and Switching Power Supplies**

Now let's understand these two extremely important terms. The terms "linear power supply" and "switching power supply" mainly refer to the operating characteristics of power supplies.

I will say in advance that printer power supplies, notebook power supplies, PC power supplies (ATX power supplies), cell phones, current TVs (in fact, TVs from the color tube onwards already came with a switched circuit), current video games, and all current equipment use switched power supplies.

I emphasized the term “current” here because it will be difficult to give examples using equipment from the past, very old equipment, and so on.

Switching power supplies are “high-tech power supplies”, they are more compact, they use smaller transformers, etc.

I will explain this in the following paragraphs.

“Linear power supply” and “switching power supply” describe how these power supplies convert input electrical energy into an output voltage suitable for powering electronic devices.

We will detail each term below.

## Linear Power Supply

- **Operating Characteristics:**A linear power supply works by providing a voltage output that is directly proportional to the input voltage, but regulated and filtered to remove fluctuations and noise. It uses components such as transformers, voltage regulators, and heat sinks.

- **Basic Principle:**Electrical energy is transformed directly, in a continuous process, without interruptions or switching.
The output voltage is regulated by actively adjusting the input voltage to keep the output stable.

Linear power supplies have the ability to transform the voltage of the electrical current (110 or 220V), using a transformer to reduce the “voltage” to a specific level, such as 12V.

In this procedure, the voltage, which is still alternating, passes through a rectifier circuit made up of a series of diodes.

These diodes convert alternating voltage into a pulsating form.
Subsequently, through the filtering process, this pulsating voltage is transformed into an almost constant voltage.

To ensure stability, an extra regulation phase is usually required, often carried out with the help of a power transistor.

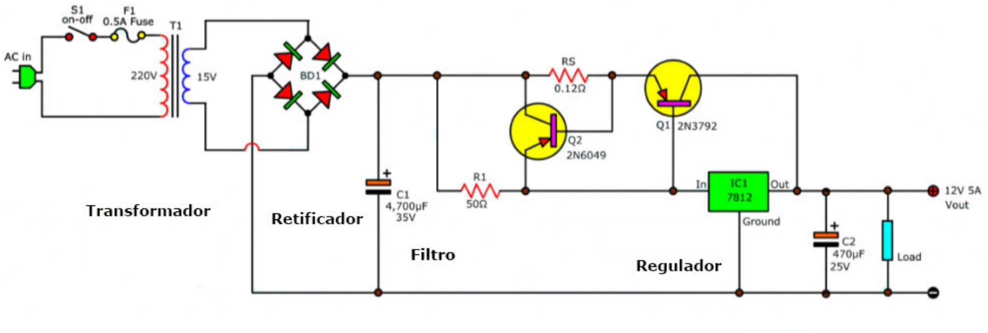



**Figure 05.1:**See an example schema electrical from a 12V 5A linear source.

Linear power supplies demonstrate remarkable effectiveness in low-power scenarios, exemplified by cordless phones.

However, when dealing with higher power needs, linear power supplies often become too bulky for the application.

This is due to the inverse relationship between the frequency of the alternating voltage and the size of the components:*the lower the frequency, the larger the dimension of the components involved.*

Such sources are not suitable for portable devices, as they would be too bulky and heavy for convenient transportation.

The solution found for this issue was the implementation of high-frequency switching, which resulted in the development of switching power supplies.

## Switching Power Supplies

- **Operating Characteristics:**A switching power supply operates using a switching process, where electrical power is rapidly turned on and off in cycles. It uses components such as power transistors and inductors.

- **Basic Principle:**Electrical energy is converted into electronically controlled pulses, alternating between on and off, and then filtered to obtain the desired output voltage.

In high-frequency switching power supplies, the input voltage undergoes a frequency boost before entering the transformer.

This increase in frequency makes it possible to significantly reduce the dimensions of the transformer and electrolytic capacitors.

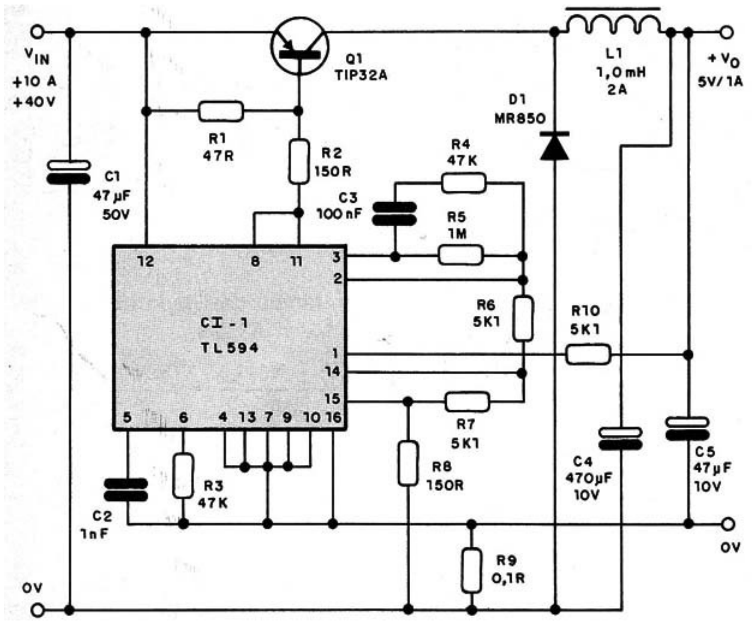



**Figure 05.2:**5 V x 1 A switching power supply. The basis of the circuit is the TL594 integrated circuit and a power supply 10 to 40 V input.

This type of source is widely used in computers and many other compact electronic devices.

OK to remember, or highlight, what they exist There are essentially two techniques used to regulate voltage in conventional sources: analog regulators, also called linear, and switched regulators, often called keyed.

As I have already explained, linear regulators require rectification and filtering stages, which include the use of bulky transformers and diodes whose dimensions are determined by the required power.

Those regulators no present one remarkable efficiency, which becomes a challenge when designing high power sources.

And here we come to the switching power supplies: *sources that adopt switching regulators do not depend on such bulky transformers.*

After rectification, a high-frequency transistor and an inductor can perform filtering in a highly effective manner.

## Understand this once and for all: the secret of fonts!

What I teach now I will explain again in a more practical way, shown step by step on a real switched power supply board. But it is necessary to understand it in theory first.

An electronic board of a switched-mode power supply will be composed of several well-defined circuits. Each circuit will be composed of one or a set of electronic components.

When we took one plate with one
The huge number of components can be a bit scary. But the secret is being able to distinguish these circuits.

I will say in advance that a power supply board can be divided into two large sectors: primary power supply and secondary power supply.

**And in summary, the primary source may have these circuits:**

- **Input circuit:**receives power which can be 110V or 220V for example.
- **Filters:**This input energy will pass through a series of filters. The electrical energy will pass through inductors, suppressor capacitors, etc.

- **Rectification:**alternating energy is transformed into pulsating current through the rectifier source.

But I'm talking very briefly about the primary source only! So let's take it easy so as not to get confused. There's still a lot to study.

## Understand a Linear Source

Let's get down to the basics. Take a look at the image below. We have a block diagram of a linear power supply. It's a very simplified diagram.

When analyzing this diagram, we see that there are no arrows used, but rather simple lines. This is because it is a simple diagram, where it is conventional to read the flow of current from left to right. We already have an idea that the reading should be done, or ideally it should be done, from left to right, from the AC input to the DC output. Not that it is a mandatory rule. I am not saying that.

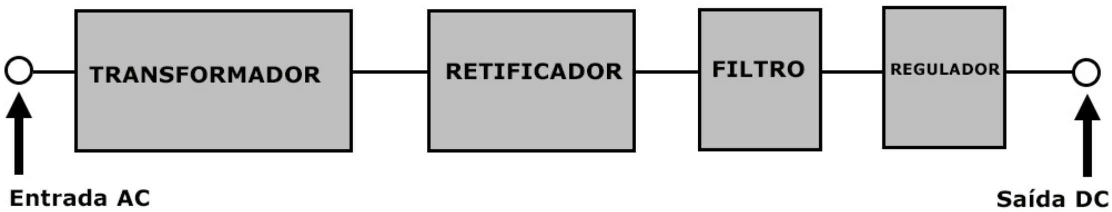



**Figure 05.3:**block diagram of a power supply simple power supply.

When it is necessary to indicate the direction of current flow, arrows will be used. See the following image of the same diagram, now with the use of arrows that indicate the flow of current.

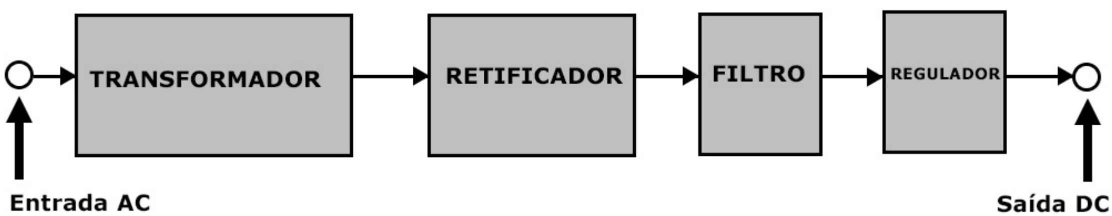



**Figure 05.4:**block diagram of a power supply simple feeding, with the use of arrows.

In this linear power supply diagram, regardless of whether there is an arrow or not, we can analyze:

- **AC Input:**As an example, I can mention the 110 or 220V in our homes. This is where the electric current enters this circuit. We are talking about alternating current;

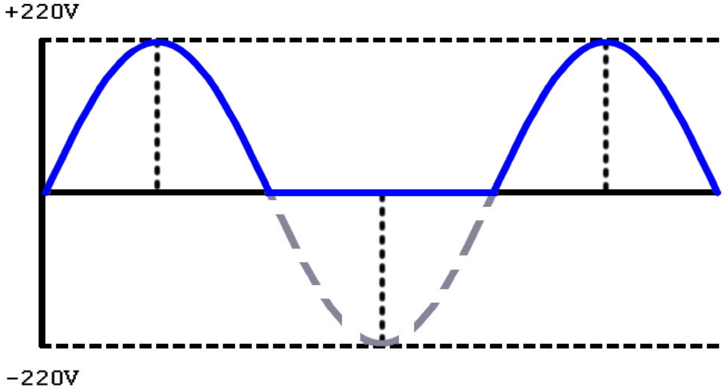



**Figure 05.5:**Alternating Current

- **Transformer:**the current will pass through the Transformer and the voltage level can be changed. It can be, for example, reduced to 24V. If it is reduced to different values than expected, for example 50V instead of 24V (in our example), we conclude that there is a problem in this block/ stage. And here we are still dealing with alternating current;

- **Rectifier:**This reduced voltage is still alternating, it will be transformed into pulsating voltage. The value of the pulsating voltage can also be measured. Values outside the design standard indicate problems in this block/stage;

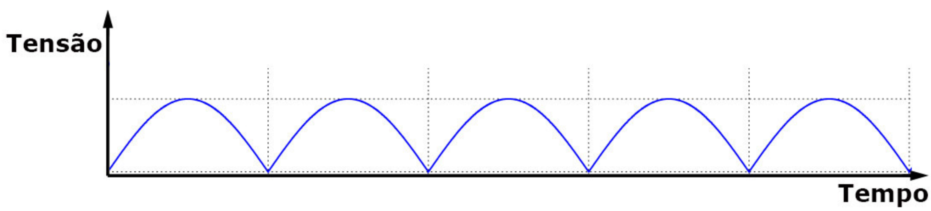
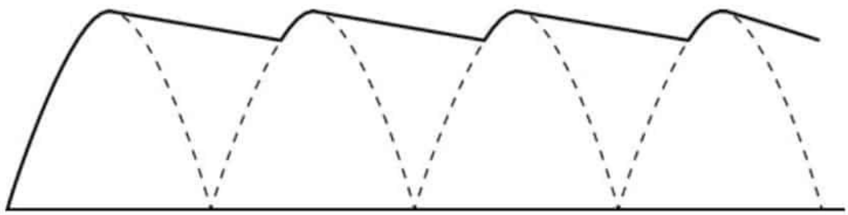



**Figure 05.6:**Pulsating Direct Current.

- **Filter:**in this voltage block/stage The pulsating voltage will be filtered, thus obtaining a continuous voltage, but which still suffers oscillations. The function of this filter is to make the output waveform as close as possible to a pure continuous voltage. This circuit can be composed, for example, of an electrolytic capacitor. And I will show you this in practice in the following chapters. Therefore, the wave still has a small

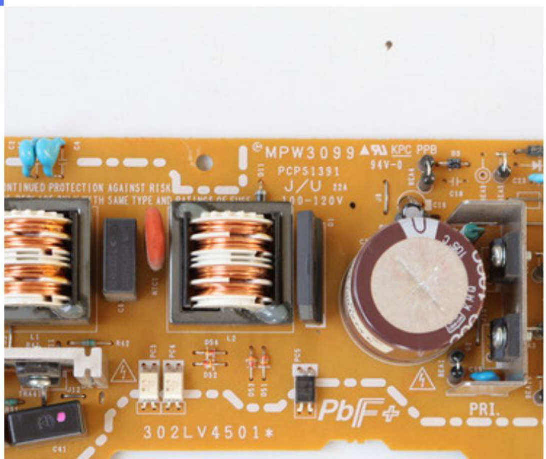


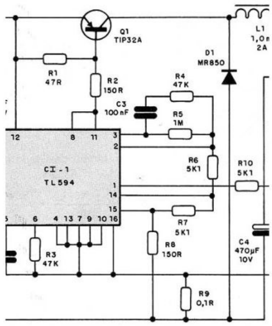
pulsating direct current.

- **Regulator**: finally, the voltage obtained in the previous block/stage will be fully regulated to obtain satisfactory continuous voltage.

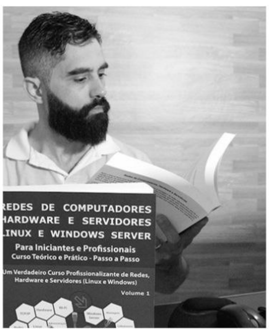

project. Values different from what is expected may indicate a defect in the block/stage in question or in blocks/stages prior to these.

# CAPÍTULO 06




## Fonte Primária e Secundária





## Primary and Secondary Source, High and Low Voltage

Let's start with more basic principles. And understanding that the source, the source board, is divided into “two main sources” is one of those principles.

From today onwards you will never again analyze a power supply board as “a single source”.

There are two main circuits. Knowing how to identify these two circuits is also a matter of safety.

It's a circuit you can literally get a big shock from. The same shock, the same electric shock that you would get from your home's electrical outlet.

In the other circuit, this risk no longer exists because it works with lower voltages, such as 5V, 12V, among other examples. But this can vary! It depends on the project. Therefore, always work carefully, use PPE and take care of safety. Do not work barefoot, with wet hands, etc.

Now let's understand what a primary and secondary source is:

- **Primary Source:**is where the power from your property's outlet arrives. This is where the power comes in first. You will deal directly with**high voltage**, which is the same as the outlet, and may have slightly lower voltages, but it is still considered high. The primary source will have, for example, a voltage of 110V/120V, 22A. This is enough to give you a tremendous shock. Therefore, use PPE, use a workbench with some protective rubber or blanket to work with electronics, do not work barefoot, with wet hands (use gloves for electronics), etc.

- **Secondary Source:**the secondary source will receive energy from the primary source. However, the voltages it works with are**low voltages**. The value of these voltages will vary according to each project, but can be voltages such as 12V, 5V, among others, more or less. The purpose of the secondary source is to power the equipment's logic board.

Very good: we have already learned about:Primary and Secondary Source, High and Low Voltage. So far we have learned the theoretical concepts.

Now let's learn to recognize Primary and source Secondary on the plate.

## Primary and Secondary Power Supply on the Board

As important as understanding the theoretical foundations is understanding them in practice. And that is the goal now.

Now you will learn to definitively recognize the primary and secondary sources on the board.

In this topic I will not explain how it works. Later on you will have access to the topics "How the Primary Source Works" and "How the Secondary Source Works".

THE**primary source**It is easily identified by the main power connector, which is where the electrical energy from the socket will enter.

It could be a power connector, where you plug the cable that is connected to the socket, or it could be a cable soldered directly to the board (the cable that you connect to the socket).

And the**secondary source**It is also easily identified through the power connector that will supply power to the equipment's logic board. This connector has several pins and provides low voltages (12V, 5V, etc.) to the logic board.

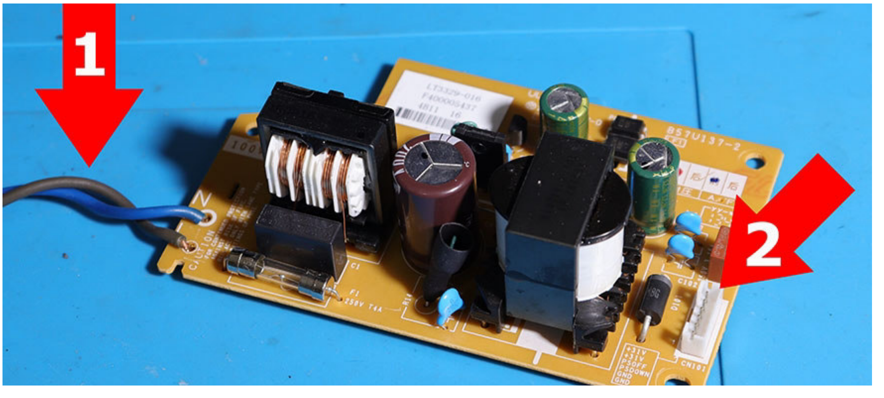



**Figure 06.1:**Look at this image. We have the main power connector (1) and the logic board power connector. Primary power supply (1) and secondary power supply (2). And in this example the cable (1) is soldered to the board.

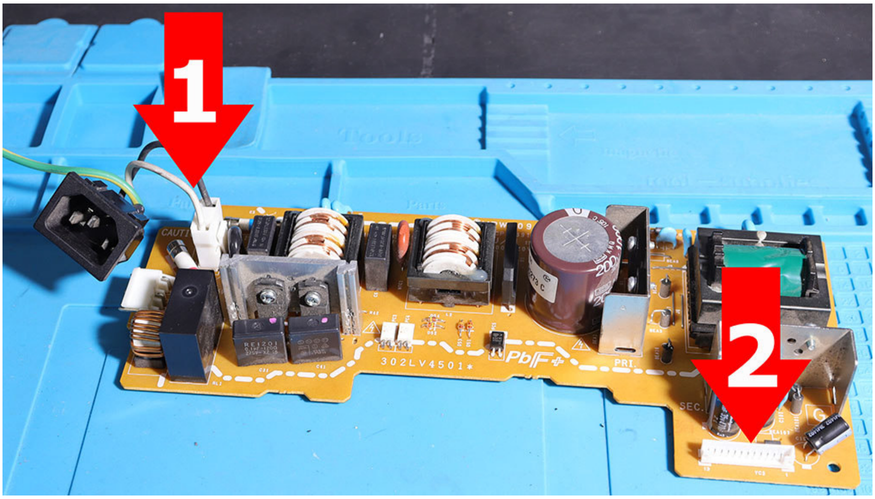



**Figure 06.2:**Here's another example. Here we have the main power supply (1) and the logic board power connector (2). The main power supply is a three-pin connector where the power cable goes. Therefore, the cable is not soldered to the board. In fact, this connector (1) that you see in the photo is plugged into two pins on the board through a white plug/connector.

Okay, that's the basics. There's more information we can absorb.

## Screen printing on plate - Basic

There is a silkscreen print on the plate made up of symbols, lines and texts.

Some signs have a lot of silkscreen printing, including descriptions and warnings. Other signs have less silkscreen printing.

The most basic screen printing is the letters that identify each component, which can be called “reference designators” or “reference designation prefixes”.

**Some common ones are:**

- **BD:**Rectifier bridge.
- **W:**Capacitor.
- **CON:**Connector.
- **D:**Diode.
- **F:**Fuse.
- **HS:**Heat sink.
- **IC:**Integrated circuit.
- **L:**Inductor (Coil).
- **LED:**Light Emitting Diode (LED).
- **J:**Jumper (Piece of wire connecting two points).

- **MOV:**Varistor.
- **PH:**Photo coupler.
- **Q:**Transistor.
- **Q, TR, TRA:**Transistor.
- **A:**Resitor.
- **RL:**Relay
- **T:**Transformer
- **U:**Integrated circuit.
- **Y:**Crystal.

The technician must be attentive and know how to interpret the information. There may be certain situations that can confuse beginners, but it is just a matter of analysis. For example:

It can happen that a**oscillator**(let's use as an example a **555**) and a**Photo coupler** be identified on the plate by the letter**U**or**IC**.

"Hey", in the case of the Photo Coupler I usually see the identification on some plates**PH**, which is easier to deduce as Photo (**Photo – PH**).

However, the oscillator and the photocoupler are integrated circuits. Therefore, it may happen that in a given project it is identified by the letter U or IC (Integrated Circuit). It is just a matter of paying attention to the analysis.

Look at another situation: it may happen that someone has the indication**PRAÇA**on the board. You know that it is a photo coupler, you have no doubt about the component. But take a look: Photo Coupler in English is Photo Coupler.

So the conclusion is simple: the designer can sometimes use different letters to identify the same component. It all depends on the board and

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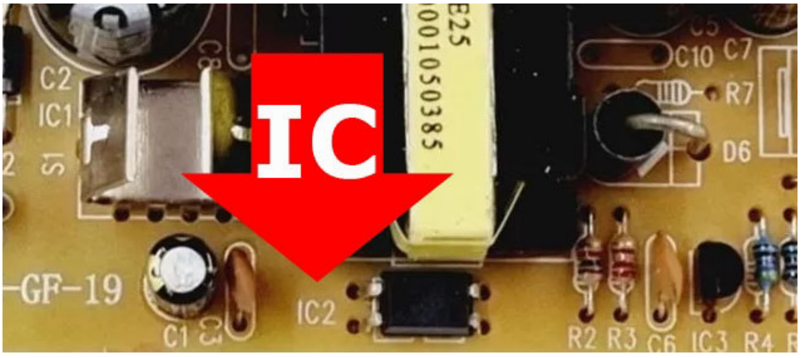



**Figure 06.3:**IC – The component is a Photo coupler.

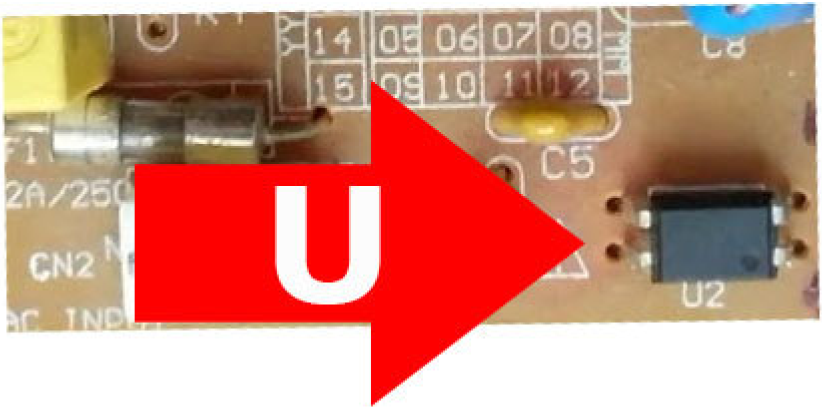
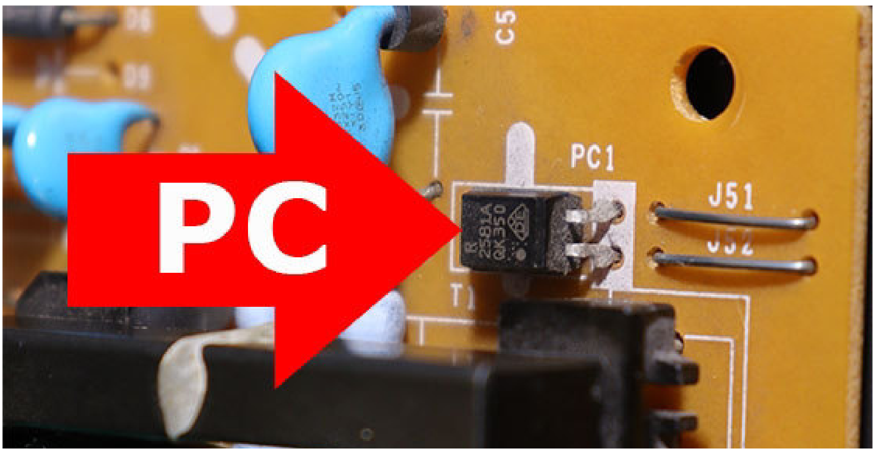



**Figure 06.4:**U – The component is a Photo coupler.



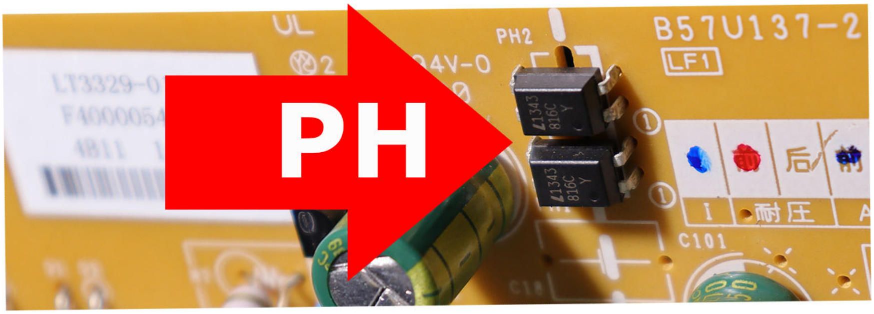



**Figure 06.6:**PH – The component is a Photo coupler.

## Screen Printing on Plate – Information and Alerts

Ready, already we overcome the silkscreen more elementary.

Let us turn our attention to the subject of this chapter: primary and secondary sources.

**Specifically in the primary source**, there will be very important information very close to the fuses.

“Caution
For Continued protection Against risk of fire, replace
Only with same type and ratings of fuse.”

"Careful
For continued protection against fire risk, replace only
with fuses of the same type and rating.”

The relevant information regarding each fuse will be
printed. For example: F1 T6 3AH 250V.

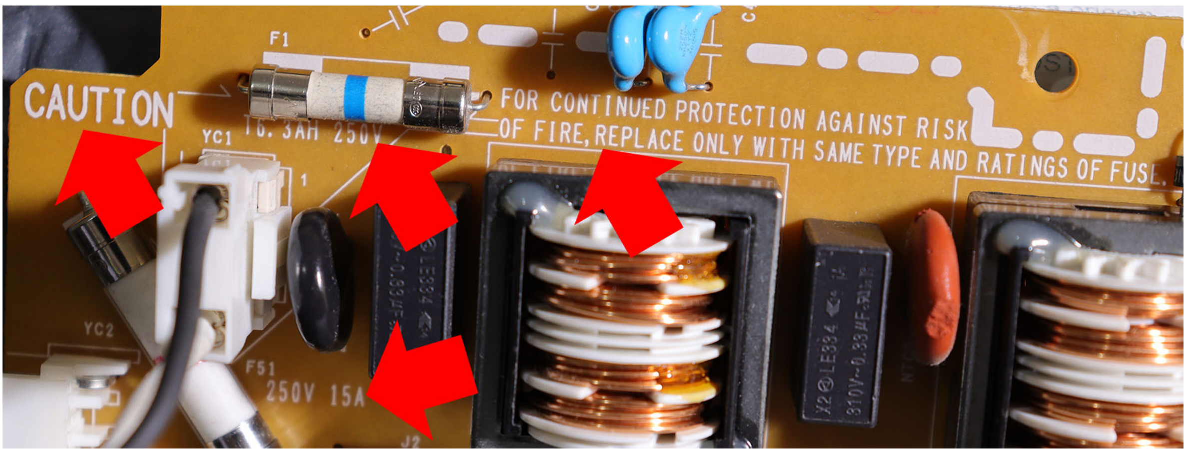



**Figure 06.7:**Important Alert and Information
each fuse.

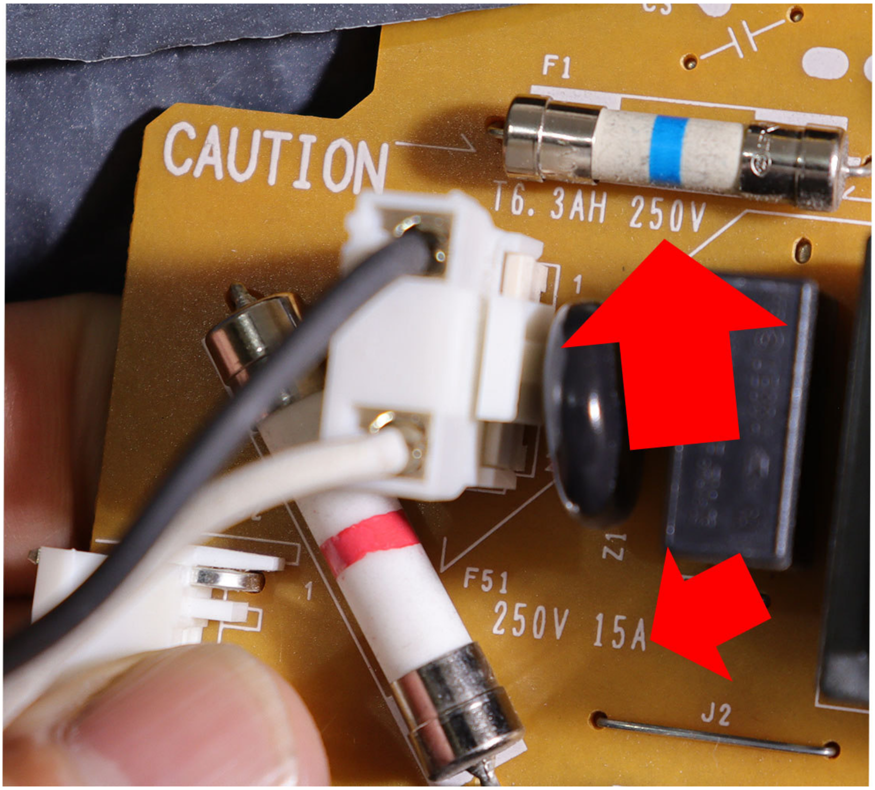



**Figure 06.8:**information for each fuse. Above we have a T6 3AH 250V and below 250V 15A.

AND**specifically in the secondary source** we can find information about the voltages of each pin of the logic board connector. But this is not a rule. Some boards have a table with this information, and some boards do not.

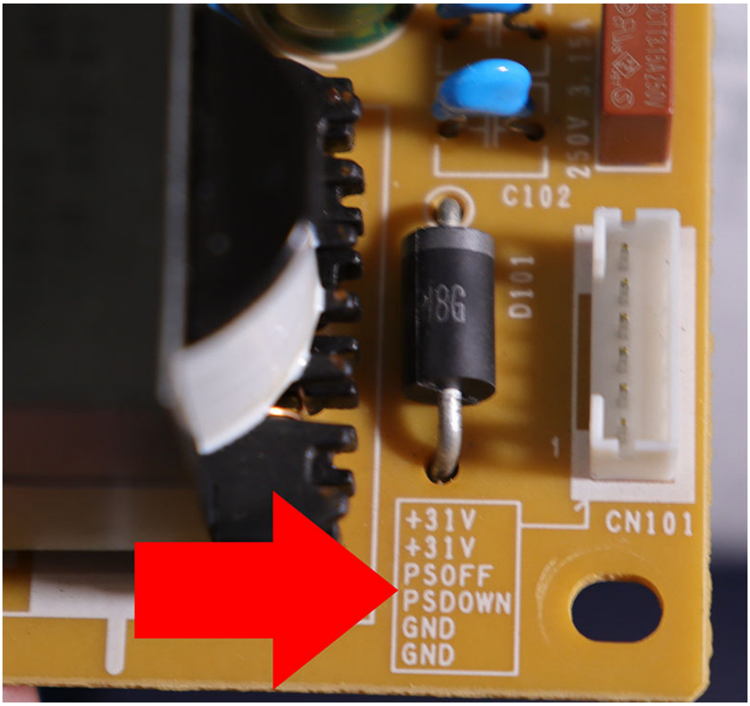



**Figure 06.9:**table with voltages of each pin from the logic board power connector.

## Screen printing on the plate – Font division

Now I will address a question that is of utmost importance. How do you know which source is primary and which is secondary?

Perhaps you would soon answer:

“Primary where there is the connector that receives power from the socket” which is where the high voltage will originate, and secondary where there is the connector that powers the logic board”.

But you have only identified the connectors. The question is: which area on the board comprises the primary source and which area on the board comprises the secondary source.

Is it possible to distinguish? Yes, it is possible to distinguish and it is our obligation (as a technician) to make this distinction.

One way to distinguish is through your own experience, where you will recognize the electronic components. You already know how the source works (I will teach you this in topics ahead) and will look at the source and understand where the primary source begins and ends and where the secondary source begins and ends.

But you will be able to do this when you understand how the source works. Maybe you don't know it yet.

But there are other ways to identify it: through the silkscreen on the plate and through the tracks, mainly on the back of the source.

Both methods are relatively easy. However, screen printing is much easier for those starting from scratch.

I will explain first through silkscreen printing and then we have another topic where I explain precisely the issue of the board's tracks.

Manufacturers usually help us a lot in this matter of distinguishing the primary source from the secondary source. If you observe, you will notice a **dashed or solid line**dividing and separating the source into these two large blocks: primary and secondary.

If you notice, this line will go around the components, creating this separation from the primary source to the secondary source.

This line, which can be dashed or continuous, can be white or black.

And to help, within the group of components that make up the primary source you may find the word PRIMARY or just PRI.

And whatever is on the side of this group is the secondary source, and can be identified by SECONDARY or just SEC.

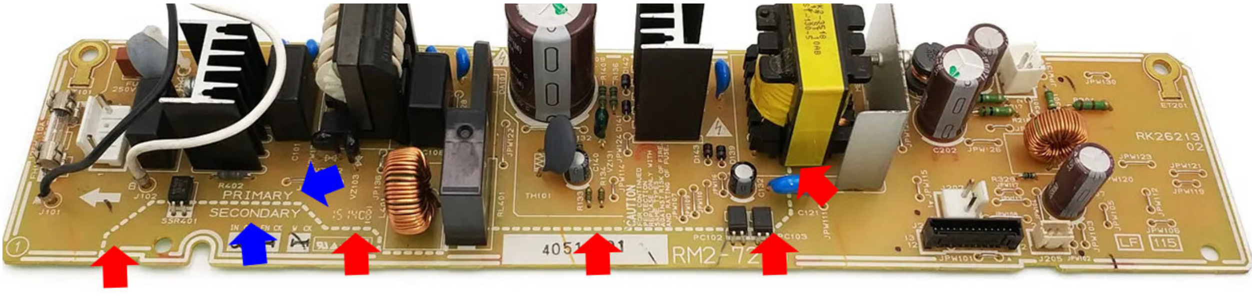



**Figure 06.10:** notice the dashed line. And notice the blue arrow. We have the word PRIMARY within that area. And we have the word SECONDARY on the other side.

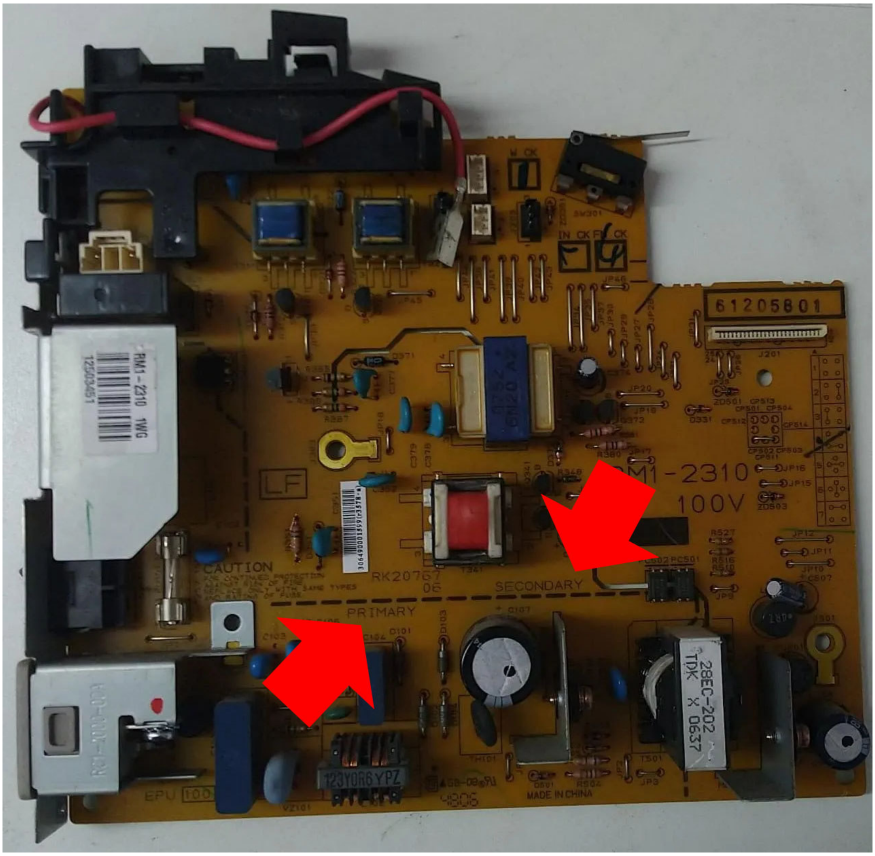



**Figure 06.11:**take a look at this example. Here I highlighted for you only the words PRIMARY and SECONDARY. The dashed line is there, only the color is different. Can you identify what is within the group that make up the primary source?

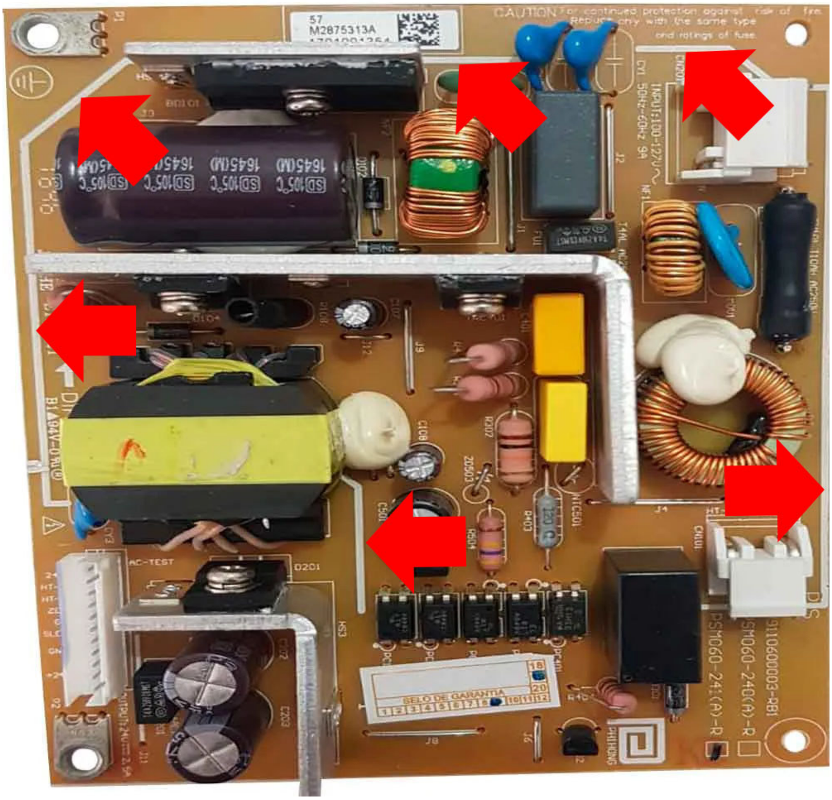


**Figure 06.12:**Look at this interesting example. The line is NOT dashed. It is continuous. It goes around all the components.
that make up the primary source. Note the connector (bottom left) that powers the logic board. It was on the "outside" of this
selection.

## Source Division across Plate Tracks

By understanding the division created by the dashed or solid lines, it becomes easy to see the division through the plate tracks.

If you look at the two large groups, primary source and secondary source, and turn the board over and look at the opposite side where the electronic components are arranged, what will you notice?

You will clearly notice these two divisions through the tracks on the plate. It is possible to perceive a group of tracks that form and/or are part of the primary source and a group of tracks that form and/or are part of the secondary source.

To illustrate this in an extremely easy-to-learn way, I will use the source board in the following image. It is a small board and easy to study.

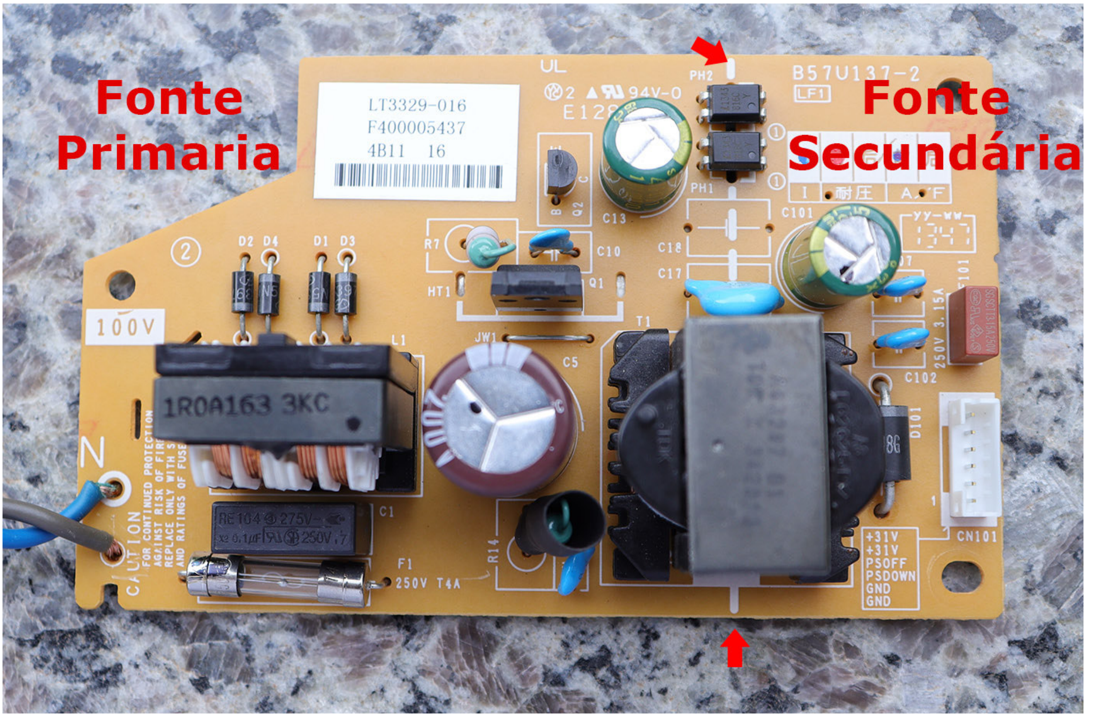



**Figure 06.13:**Look at this example, the top of the board - Note the primary source and the secondary.

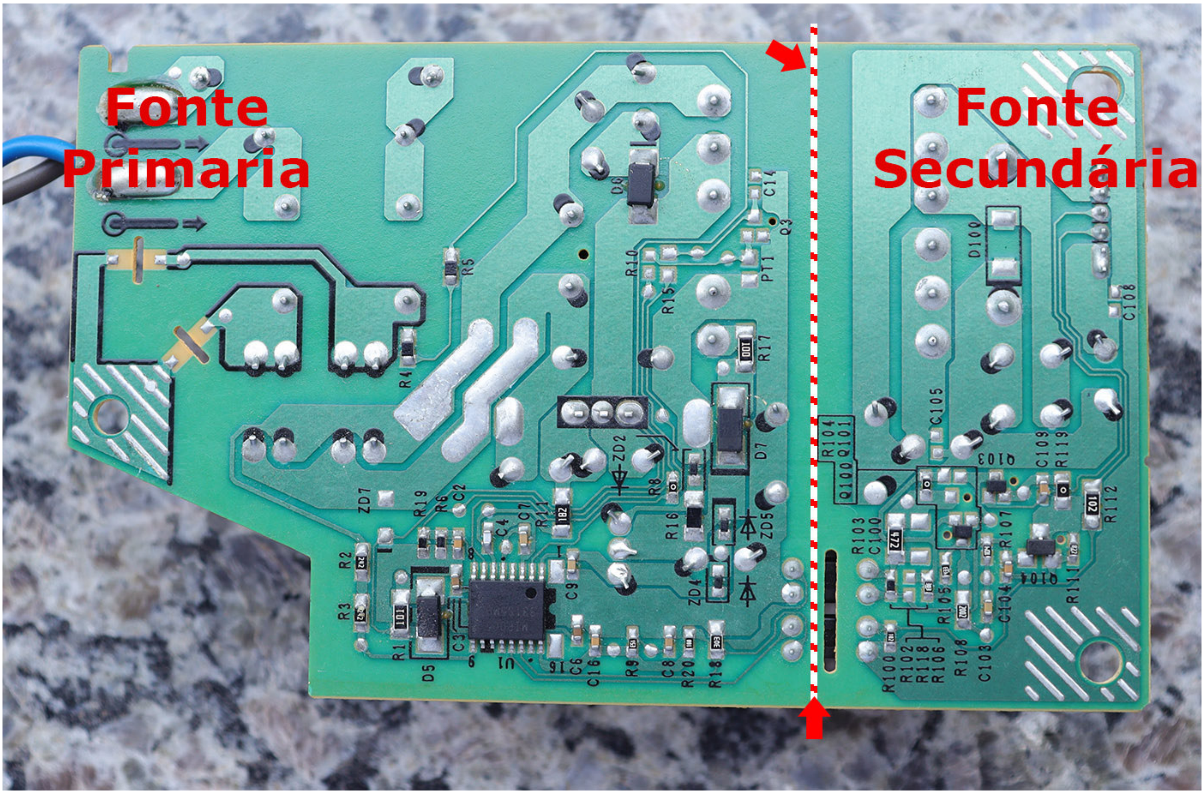
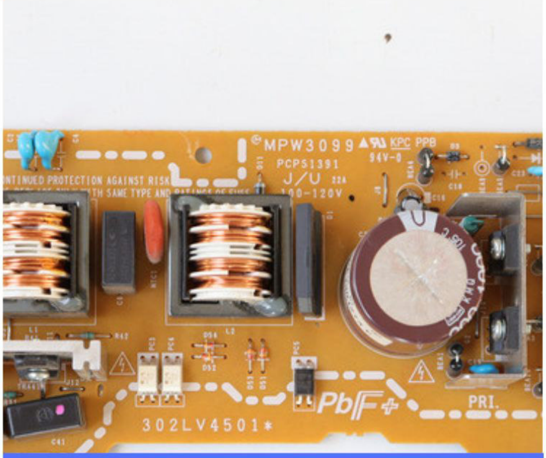
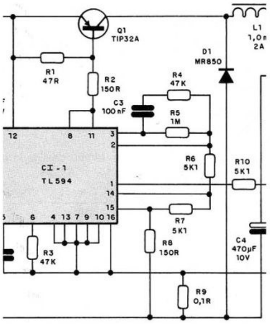


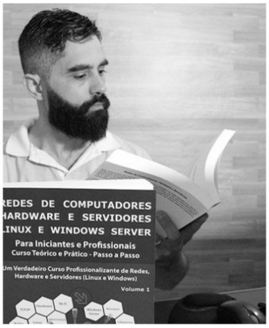

**Figure 06.14:**the same source. Note the trails.

# CAPÍTULO 07




## Fonte Primária




## Primary Source Operation

The primary source is directly connected to the input power grid, providing the main power to the device or system. It plays a key role in voltage conversion and current regulation to provide reliable and safe power to downstream electronic components.

**In summary, the primary source:**

- It receives power which can be 110V or 220V for example.
- This input energy will pass through a series of filters.
- Electrical energy will pass through inductors, suppressor capacitors, etc.
- Alternating energy is transformed into direct energy through the rectifier source.

**Here are some key aspects of the primary source:**

- **Connection to the Power Grid:**The primary source is connected to the incoming AC (alternating current) power grid, which typically operates at voltages such as 110V, 220V, or others, depending on the region and electrical standard. It is responsible for receiving power from the power grid and preparing it for use by the device or system.

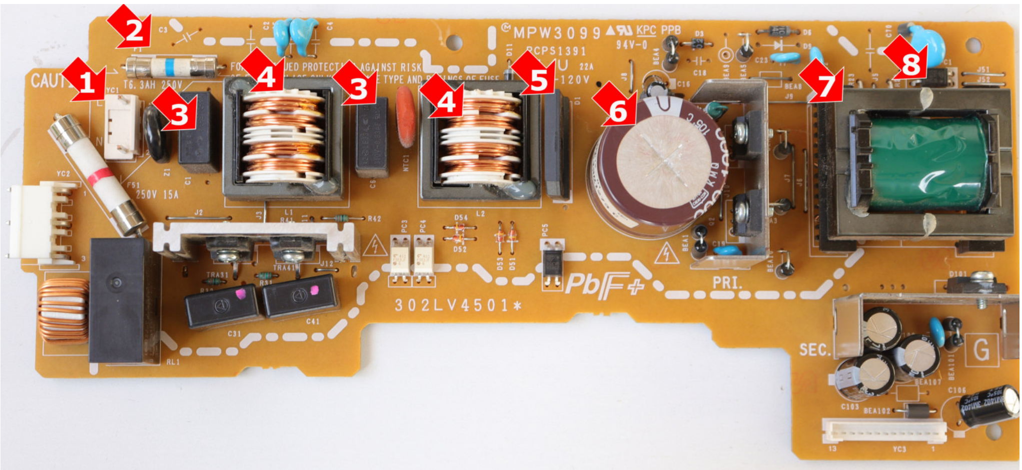
- **Rectification and Filtering:**Mains power is often supplied as alternating current (AC) that oscillates between positive and negative values. The primary source incorporates rectifier diodes to convert the AC into a pulsating direct voltage (DC). Filtering circuits, such as capacitors, are then used to smooth out this pulsating voltage, making it more stable.

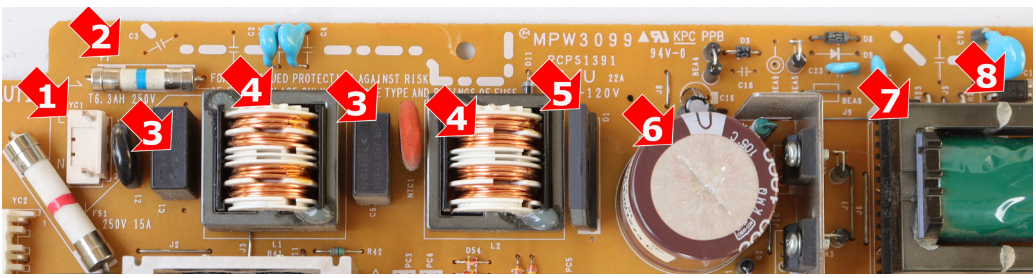
- **Protection and Regulation:**The primary source usually includes protection circuits such as fuses and protection devices.

overload shutdown, to protect the device against abnormal conditions such as short circuits or current spikes. In addition, voltage regulation is often performed on the primary source to ensure that the output voltage is maintained within acceptable limits regardless of fluctuations in the mains input voltage.

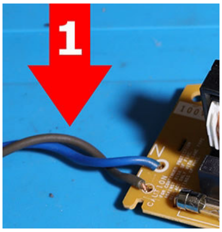
- **Insulation:**There is isolation between the primary source and the secondary source. Energy is transmitted from one source to another through transformers and photocouplers.

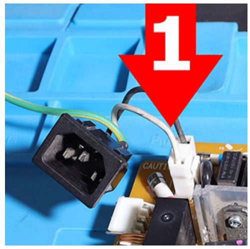
# Chapter 07 - Primary Source



**01 – Power input:**This is where the power cable (AC) goes. It can be soldered to the board or not.




**02 – Fuse:**identified by the letter F. Test: is the current passing from one side to the other?

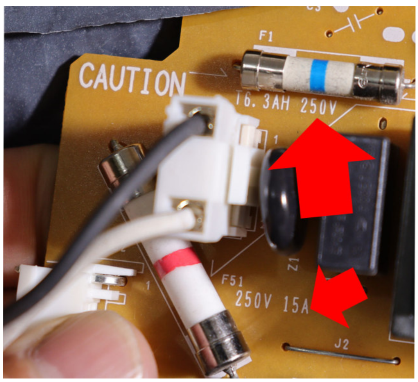



**Figure 07.3:**fuse.

**03 - Suppressor capacitor**for filtering AC current. It can break, it can short circuit.

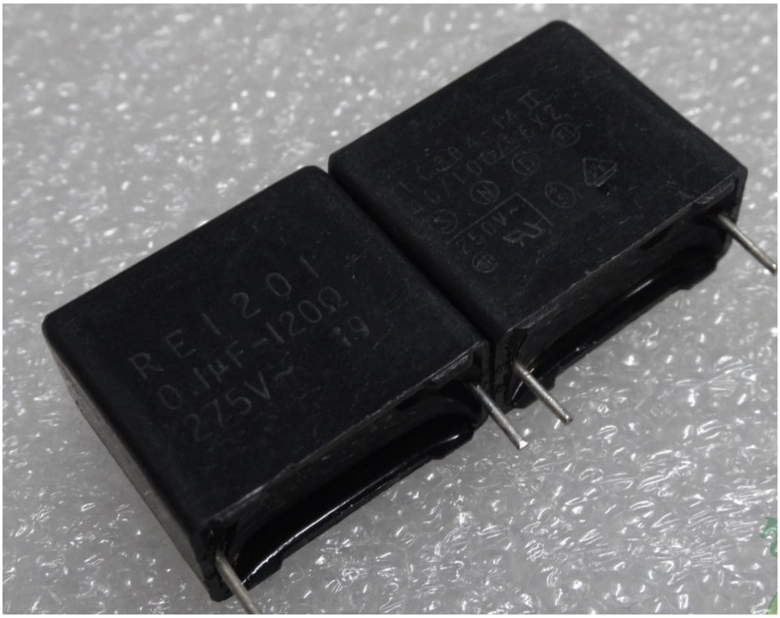



**Figure 07.4:**REI capacitor 201 o.1uF - 120ohm.

A suppressor capacitor, also known as an interference suppression capacitor, is an electronic component designed to minimize electromagnetic interference and radio frequency interference in circuits.

electrical and electronics. They they are used mainly in electronic devices to meet electromagnetic compatibility standards and ensure that the device does not cause harmful interference to other equipment or is susceptible to external interference.

Here are some common characteristics and uses of suppressor capacitors:

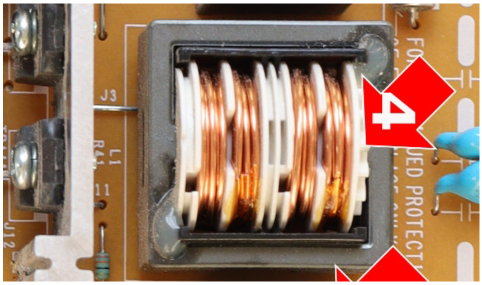
Interference Suppression: Suppressor capacitors are used to reduce electromagnetic interference generated by electronic devices such as power supplies, electric motors, switches, and other devices that generate electrical noise. They also help shield devices from external interference.

- **Construction:**Suppressor capacitors are usually constructed with special dielectrics, such as zinc oxide, to provide adequate suppression characteristics. They may also include coatings or encapsulations to meet safety and isolation requirements.

- **Filtering:**In addition to suppressing interference, suppressor capacitors can be used in filtering circuits to attenuate high-frequency signals and ensure that only the desired frequencies are transmitted or received.

- **Security:** Those capacitors play a fundamental role in protecting electronic devices and preventing safety problems, such as fires or electric shocks, which can be caused by transient voltage surges.

It is important to select and use appropriate suppression capacitors for a specific application, taking into account electromagnetic safety standards, circuit characteristics and electromagnetic compatibility requirements. The correct selection of these capacitors helps ensure reliable operation and compliance with applicable regulations and standards.



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electrical device, power surges, noise in the electrical network, among others. Transients can be undesirable in many electronic circuits, as they can damage sensitive components. Therefore, transient filtering is an important step

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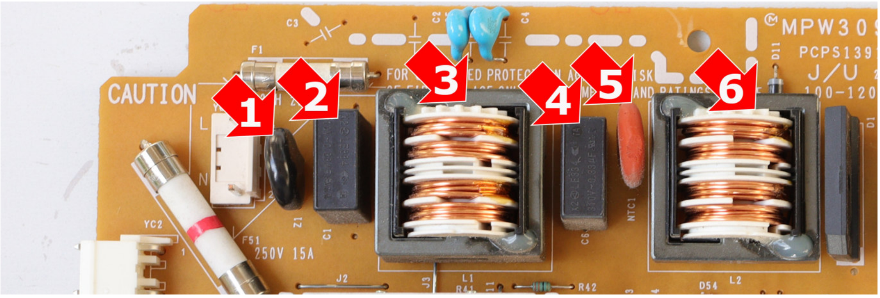


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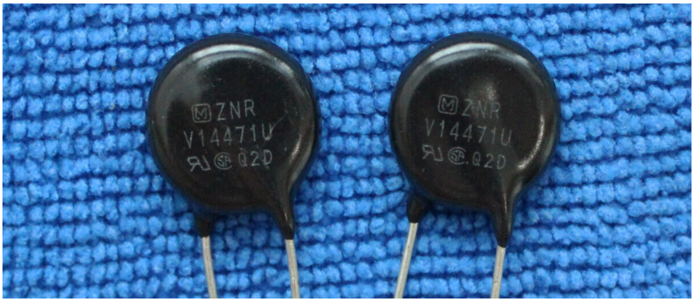


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Just ahead we find a thermistor (5). Basically it is a resistor that changes its resistance according to the temperature.


**Figure 07.8:**thermistor 5R1.

**05 – Rectifier bridge**, where it converts alternating energy into pulsating direct energy;

A bridge rectifier, also known as a bridge rectifier, is an electronic device used to convert alternating current (AC) into pulsating direct current. It plays a crucial role in many electronic devices and circuits that require DC power to operate, such as electronics power supplies, battery chargers, and more.

The rectifier bridge is made up of four semiconductor diodes connected in a specific way to perform this conversion. The diodes allow current to flow in only one direction through the circuit, blocking reverse current.

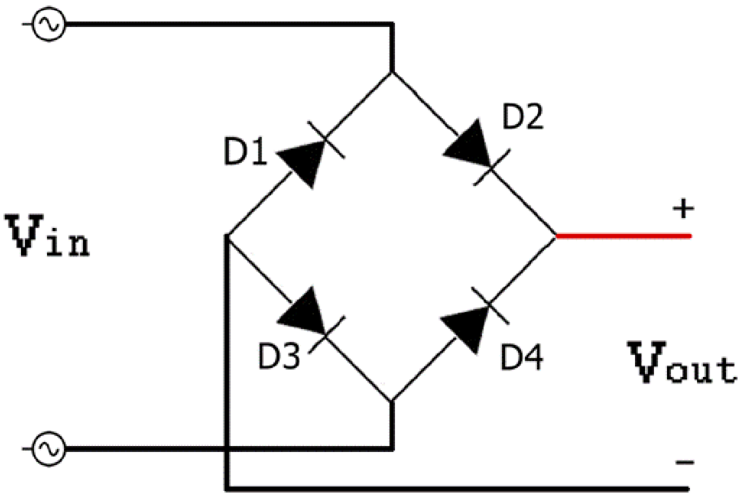


**Figure 07.9:**basic bridge diagram rectifier.

**THE operation basic from the bridge rectifier is as follows:**

When the input voltage is positive at one of the AC terminals, the corresponding diode conducts, allowing current to flow.

When the input voltage reverses (becomes negative), another diode in the rectifier bridge conducts, allowing current to flow in the same direction.

This is repeated for the other two diodes in the bridge, so that regardless of the polarity of the AC input voltage, there will always be a path for current to flow in the same direction at the bridge output.

The bridge rectifier then rectifies the AC voltage, producing a pulsating DC voltage at the output. This pulsating DC voltage still needs to pass through a filtering stage to smooth out any unwanted ripples and produce a more stable DC output. The combination of bridge rectifiers and filtering capacitors is often used in linear power supplies for electronics.


**Figure 07.10:** rectifier bridge – here we have an IC.

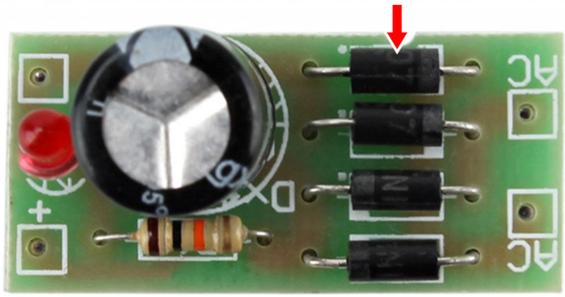


**Figure 07.11:** rectifier bridge with diode 1N4007.

Can the power supply be rendered useless? Yes. It can break, leak or short circuit.

Something common happens: when any of the diodes short-circuits, the fuse breaks. You change the fuse and it breaks!

**06 – Filter capacitor (also known as link capacitor):** The energy will be filtered in the previous components (suppressor capacitor, coil, rectifier bridge) and will pass through this capacitor to stabilize the pulsating direct voltage. As I have already explained in this material, in this block/stage the pulsating voltage will be filtered, thus obtaining direct voltage, but which still suffers oscillations. The function of this filter is to leave the output waveform as close as possible to a pure direct voltage.


**Figure 07.12:**filter capacitor.

**07 - MOSFET transistors:**right after the filter capacitor we find another important element: two MOSFET transistors (in this case). On the board in our example they are identified by Q1 and Q2, and both are screwed onto an aluminum heatsink. They are transistor K8A50D.

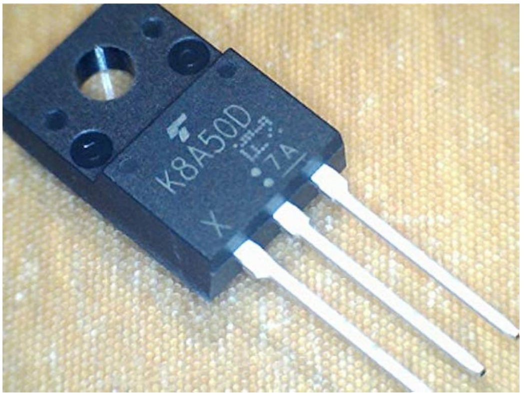


**Figure 07.13:**transistor K8A50D.

You transistors MOSFET (Metal-Oxide-Semiconductor Field Effect Transistor) in the The primary part of the power supply plays a crucial role in its operation. These MOSFETs are used to control the flow of electric current in the primary part of the power supply circuit, especially in the switching stage.

These MOSFETs are used as controlled electronic switches to rapidly switch the electrical current in the coil of the main power supply transformer.

Fast switching controlled by MOSFETs allows the power supply to regulate the output voltage.

Through the duty cycle of the MOSFETs, the power supply can adjust the amount of energy

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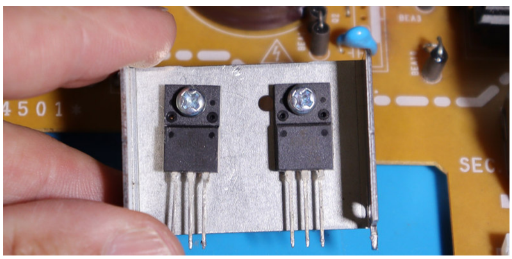



**Figure 07.14:**transistors K8A50D.

**08 – Transformer (transformer chopper)**: it is from this transformer that low voltages such as 24V, 12V and 5V will be generated. The voltage obtained in the previous block/stage will be fully regulated to finally obtain a satisfactory continuous voltage. In this case there are three windings, one for each voltage. Note that this transformer interconnects the primary source with the secondary

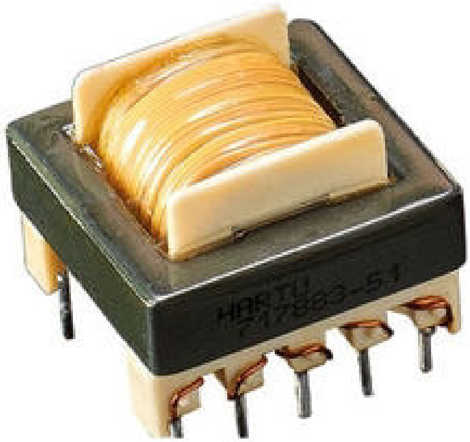


**Fig.**

Power is generated through induction. Induction, in the context of electronics and physics, refers to the generation of electric current or electromotive force (EMF) in a circuit due to variations in the magnetic field that passes through it. This phenomenon is fundamental in many devices and operating principles of electrical and electronic circuits. There are two main types of induction:

**08.1 - Electromagnetic Induction:**Faraday's Law of Electromagnetic Induction: This law states that a change in magnetic flux through a circuit induces an electric current in that circuit. The magnitude of the induced EMF is directly proportional to the rate of change of the magnetic flux. This is essential in electric generators, where the rotation of a coil in a magnetic field creates an alternating current.

**08.2 – Transformer:**Transformers are devices that use electromagnetic induction to increase or decrease alternating voltage in a circuit. They consist of two closely spaced windings (or coils), usually called the primary and secondary, that are separated by an iron core. When an alternating current is applied to the primary winding, it creates a changing magnetic field in the core, inducing a current in the secondary winding.

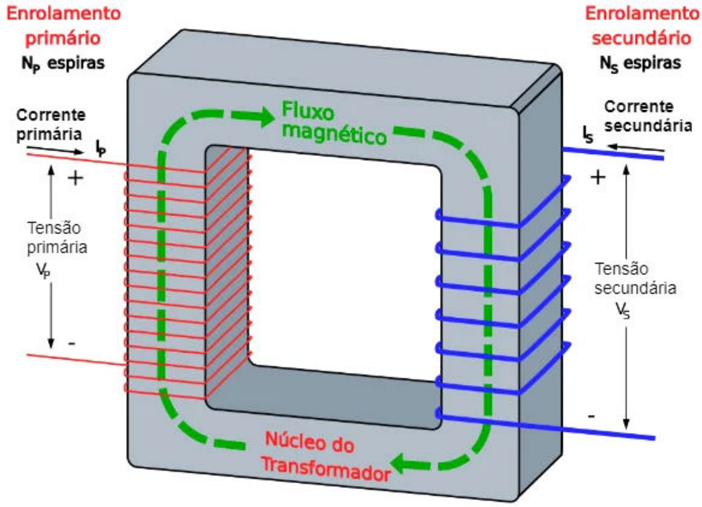



**Figure 07.16:**schematic of a transformer simple.

**08.3 - Self-induction:**Self-induction occurs when an electric current in a circuit creates a magnetic field that in turn generates an EMF in the same circuit. This effect is especially important in coils or inductors. When the current in a coil changes, the magnetic field generated by the coil itself induces an EMF that opposes the change in current. This is described by Lenz's Law.

**08.4 - Induction plays**a key role in a variety of devices electromagnetic, as engines electrical, generators, transformers, solenoids and ignition coils, among others. In addition, it is an important basis for understanding concepts in electricity and magnetism.

**09 - Photo coupler:** plays a role important in protecting and controlling the transfer of power between these two sources. The photocoupler is used to control the switching on and off of the primary source. When a control circuit activates the photocoupler, it closes a path to the primary circuit, allowing power to flow from the primary source to the transformer. This allows power to be supplied to the secondary source. If you notice, there is no “direct” path for the power from the secondary source to the primary source. There is no direct physical path.

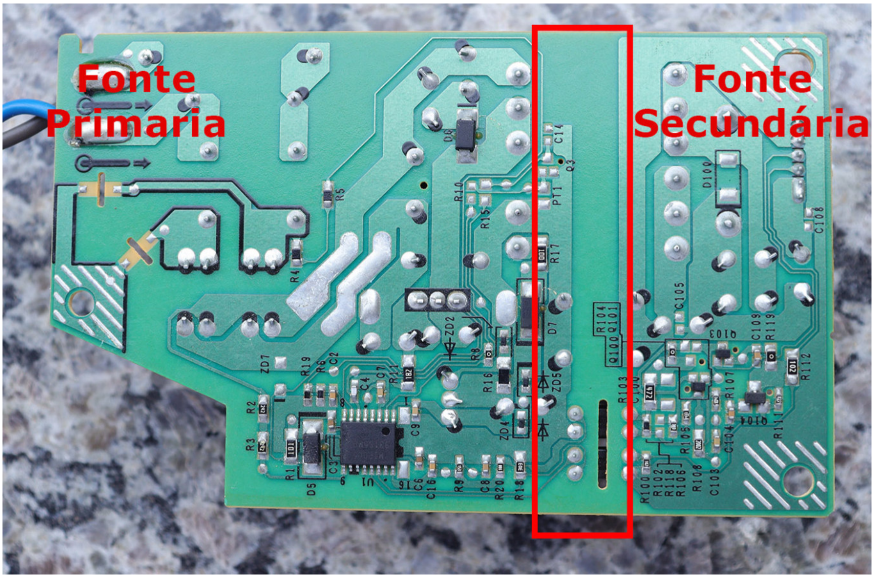



**Figure 07.17:** energy has no “direct” path from the secondary source to the primary.

## Controller IC - PWM Control

We are now in the final stretch of this chapter, and to close with a flourish I need to explain this CI to you.

During your studies on power supplies you will read and see a lot about PWM control.

In a switching power supply there is a transformer called a chopper switched by one or more MOSFET transistors that receive a PWM signal that will control the operation of the source.

The PWM (Pulse Width Modulation) IC (integrated circuit) is used in switching power supplies to control the power output of the source.

The main function of the PWM IC in a switching power supply is to control the width of the power pulses delivered to the transformer or switching circuit of the power supply.

This is done by varying the width of high-frequency energy pulses, typically in the kHz to MHz range.

This variation in pulse width allows control of the output voltage and source current, which is essential for regulating the output voltage and maintaining the efficiency of the switching source.

PWM (Pulse Width Modulation) and chopper transformer are often related in power electronics systems, especially in switching power supplies and DC-DC converters. I will explain the relationship between them.

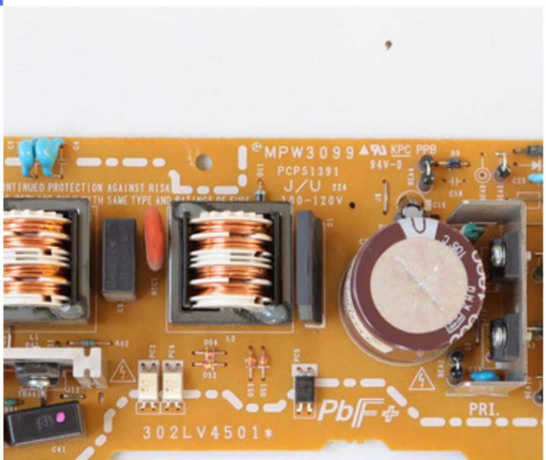
The relationship between the PWM and the chopper transformer occurs as follows:

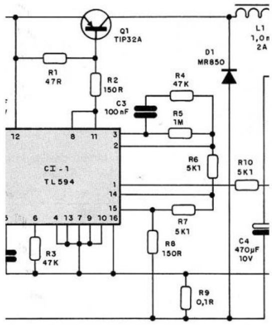
PWM is used to control the width of the power pulses delivered to the primary of the chopper transformer in a switching power supply.

Varying the width of the pulses controls the amount of energy transferred to the transformer.

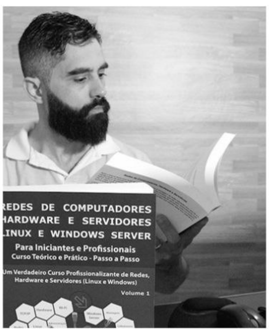
The chopper transformer, operating at high frequency, allows energy to be transferred efficiently to the secondary, where it can be adjusted and rectified to provide the desired output, which may be a controlled voltage or current.

# CAPÍTULO 08




## Fonte Secundária





## Secondary Source Operation

In the previous chapter we had an important study of **primary source**, which is where we find the **high voltage**. In many materials this area of the plate (primary source) is treated as**“hot area”**, from English**“hot”**, or even**“high font plate”**.

Let's study now the**secondary source**, which is where we will find the**low voltages**. In many materials this area of the plate (secondary source) is treated as**“cold area”**, from English**“cold”**, or even**“low power supply board”**.

Learn all these terms, as many materials on the web, text materials, videos, etc., use these terms.

The secondary source, in a power supply system, is the part of the power source that provides the final, regulated electrical power to the electronic components or device loads.

She**receives the energy already processed and converted by the primary source**, adapting it yet more to to meet to the requirements specific to the components of the device or system.

And here I mentioned a key point, and it is from this point that we will continue our analyses and studies.

I just mentioned that the**secondary source**receives energy from whom? From**primary source**?

Let's remember a little bit what I taught in the previous chapter? There I taught that*energy has no “direct” path from the secondary to the primary source*.

And if you are studying everything step by step, you will be able to do this analysis now. Just take a source board and observe.

Look at the main face, which is where all the electronic components are. See the separation of the two sources: primary and secondary.

Turn the board over. Look at the bottom, see the printed tracks on the board. You can see the two sources and how they are not directly “connected”.

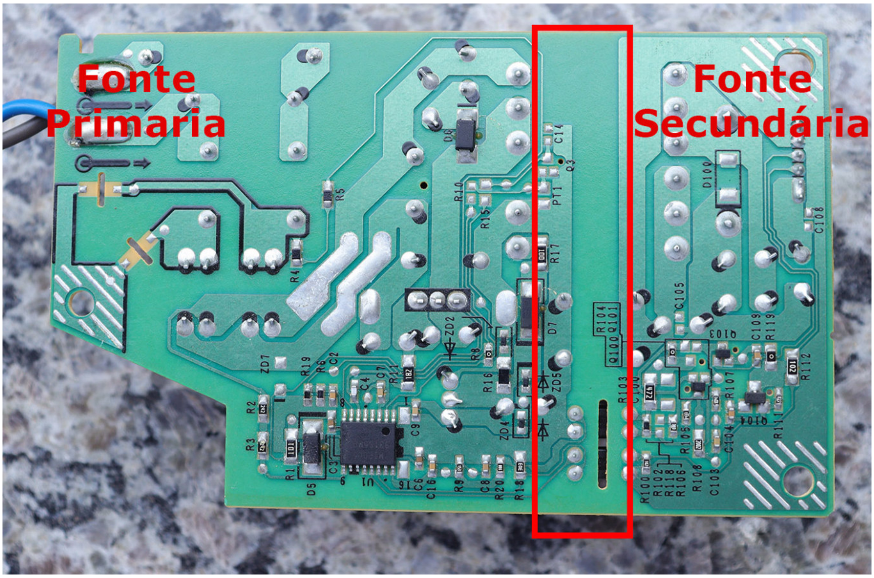



**Figure 08.1:**see the division of the two sources.

Why is this observation important? Because it helps us understand the source completely and will help us in future diagnoses.

What connects these two sources? What allows the energy from the primary source to reach the secondary source?

There are two electronic components responsible for this "bridge" between one source and another:

- **Transformer (transformer chopper)**: This transformer will generate low voltages, such as 24V, 12V and 5V. In this case, there are three windings, one for each voltage. Note that this transformer interconnects the primary source with the secondary source.

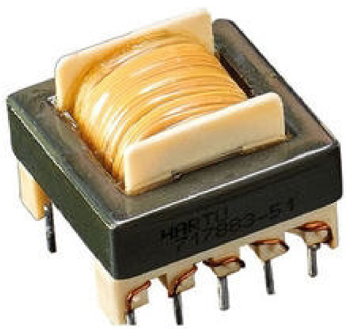
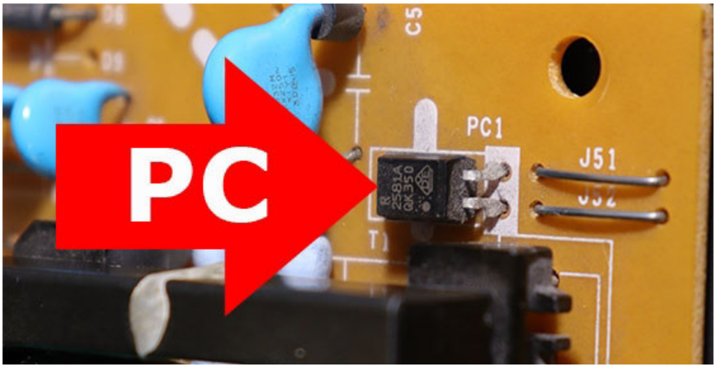


**Figure 08.2:**chopper transformer.

- **Photo coupler:** plays a role important in protecting and controlling the transfer of power between these two sources. The photocoupler is used to control the switching on and off of the primary source. When a control circuit activates the photocoupler, it closes a path to the primary circuit, allowing power to flow from the primary source to the transformer. This allows power to be supplied to the secondary source.




**Figure**

Let's go remember again? *Already I taught also that, it can happen that a **coupler**be identified on **Photo** the plate by the letter**U** or**IC**.*

*Another way of identifying the photocoupler on some plates is through the letters**PH**, which is easier to deduce as Photo (**Photo – PH**).*

*The photocoupler is an integrated circuit. Therefore, it may happen that in a given project it is identified by the letter U or IC (Integrated Circuit). It is just a matter of paying attention during analysis.*

*Look at another situation: it may happen that you have the indication**PRAÇA**on the board. You know that it is a photo coupler, you have no doubt about the component. But take a look: Photo Coupler in English is Photo Coupler.*

*Therefore, the conclusion is simple: the designer can sometimes use different letters to identify the same component. It all depends on the board and the project. Here alone I have already mentioned four ways that* *one**photo coupler**can be identified on the plate: U, IC, PC or PH.*

There you go, I made a small summary (of some topics) of what I taught in chapter 02. If you have any questions, go back to chapter 02 and study again.

**Continuing...**

**Here are some key aspects of the secondary source:**

- **Receiving Processed Energy:**The secondary source receives the power already rectified, filtered and possibly regulated by the primary source. This power has already been converted from the AC (alternating current) mains input voltage to a direct current (DC) voltage more suitable for use by electronic components.

- **Regulation and Fine Tuning:**The secondary supply may include additional regulation circuitry to ensure that the output voltage is maintained within strict limits, even under variations in load or at the input voltage. This is critical for providing stable and accurate power to electronic components.

- **Voltage Conversion:**In some cases, the secondary source also performs additional voltage conversion, adjusting it to specific levels needed to power different parts of the device. This may involve additional transformers or DC-DC converters.

- **Power Distribution:**From the secondary source, power is distributed to the various parts of the device, such as digital and analog circuits, motors, displays, etc.
  The secondary supply can have multiple outputs to meet these different voltage and current needs.

- **Protection and Security:**The source
  The secondary may also include additional protection circuits to ensure the safety of the electronic components. This may include protection against overload, short circuit, and other adverse events that may occur in the load.

- **Energy Efficiency:**The efficiency
  Energy efficiency is an important consideration in the design of the secondary source, since the conversion of electrical energy can result in losses. Designing an efficient secondary source helps reduce energy waste and unwanted heating.

- **Electrical Insulation:**In some cases, especially in sensitive applications, the secondary source may include electrical isolation devices, such as isolation transformers, to ensure that there is no direct electrical connection between the secondary source and the primary source, increasing safety.

The secondary power supply is essential for providing controlled and regulated electrical power to the electronic components of a device or system. It plays a crucial role in ensuring a reliable power supply that is adequate for the specific operations and functions of the device. Through the secondary power supply, the power is adapted to meet the needs of each component, ensuring the proper functioning of all aspects of the device.

## Voltage rectification

This is an important aspect that you need to learn. We are now studying the secondary source. And I have already explained in detail about the transformer and the photocoupler.

The fact is that the outputs of the main transformer are rectified and supplied there to the power connector of the logic board. And this logic board will power the entire system that is connected to it.

But there is a process here. There are several electronic components involved, such as electrolytic capacitors and coils (usually for filtering). But the ones that act directly in the rectification of negative and positive voltages are the diodes.

In general, and I'm not saying this is a rule, conventional diodes can be used to rectify negative voltages (-5V and -12V).

for example) and power Schottky diodes for rectifying positive voltages (+3.3 V, +5 V and
+ 12 V).

Power Schottky diodes are easily identified and widely used because they look similar to power transistors.

But on the board they are identified, by silkscreen printing, with the “D” for diode.

But I'm explaining it in a very general way. It all depends on the board design. Some boards will have the Schottky diode, and some won't. Some boards will only have the common diode being used, and some boards will have both.

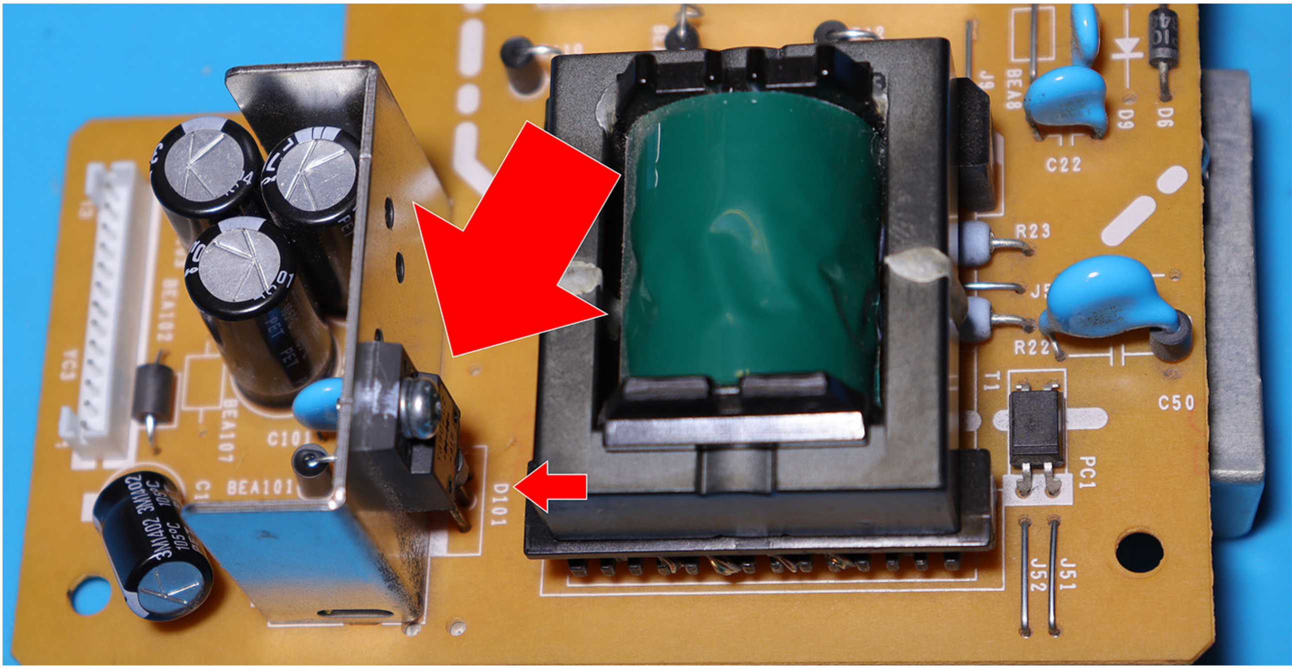



**Figure 08.4:**Schottky diode.

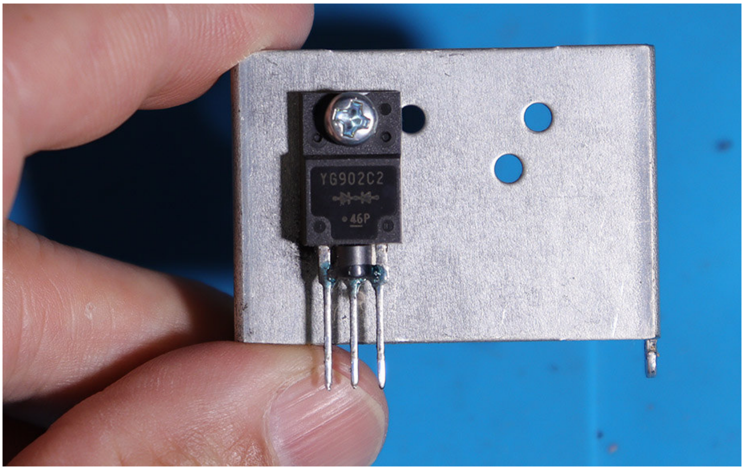



**Figure 08.5:**Schottky diode.

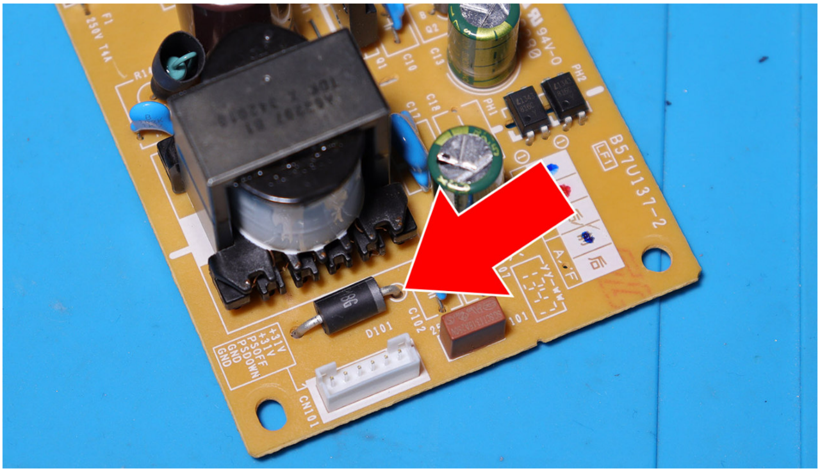


**Figure 08.6:**two-terminal Schottky diode.

I will address this subject again, where I will teach you how to test common and Schottky diodes, including teaching you how to differentiate between common and two-terminal Schottky.

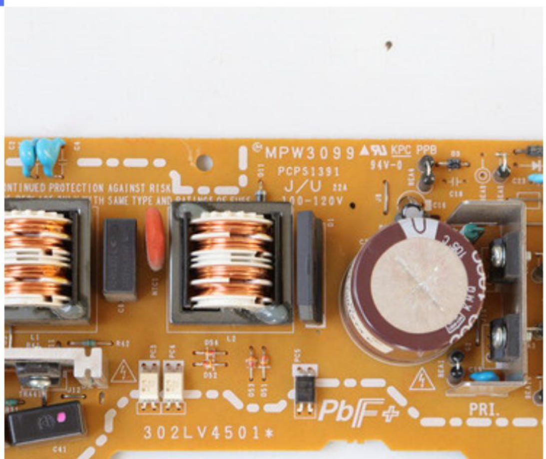
For more information, see the next chapter (see the summary).

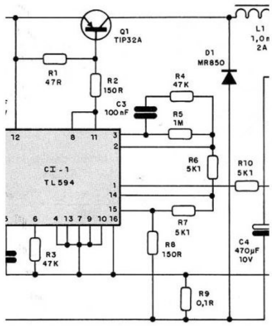
## Voltage Regulator Integrated Circuit

Important quote that component, mainly because it resembles a transistor, but it is a voltage regulator integrated circuit. It will be identified on the board by U, CI or IC.

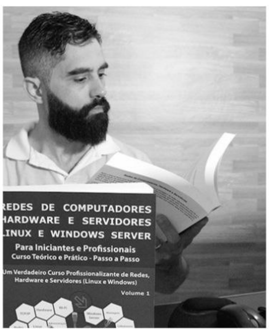
**Figure 08.7:**integrated circuit regulator voltage.

# CAPÍTULO 09




## Análise de Esquema Elétrico




## Introduction

The best way to start this chapter is by being completely honest with yourself. Under no circumstances am I here to “try to deceive you”.

Let's say what needs to be said: you will not become an expert in analyzing electrical diagrams through this material. Nor is that the goal here.

Electrical diagram analysis is an extremely complex subject. It could easily be the subject of a book of over 800 pages.

And here we don't have space to create an electrical diagram analysis course. The content would be extremely dense, tiring and discouraging.

So keep this in mind:This chapter is not a course in electrical schematic analysis.

**What I'm going to do here is give you simple guidelines.**that can help you understand the circuits of a power supply, if you can get an electrical diagram of your power supply in question and decide to analyze it. And I will, in fact, try to simplify all explanations. Otherwise I run the risk of getting lost in the explanations and everything ends up being confusing.

So, I'll start right away with some important instructions.

## Instructions for beginners

- **First point:**Never look at a diagram and despair. Many beginners get scared when they see a large and complex diagram. Just start observing, analyzing calmly and you will start to identify the symbols, elements and sectors. The symbols you studied are used. And if there is one that you do not know, review the study materials and search on Google. It is that simple.

- **Second point:**You will not graduate from this course as an engineer (and that is not the goal here). The learning must continue after this course. Continue analyzing more diagrams, study and research.

- **Third point:**I will not analyze this diagram (which I will use as a reference) in its entirety. Imagine how much written content this would generate, I will simplify it to help you. Don't forget, my friend, I have the difficult task of transcribing all the knowledge that is possible into text format. It is not easy at all.

- **Fourth point:**When you get a schematic diagram, it is not necessary to study it all. You can do a quick study and locate the main and most important components. But the most important thing, after doing this initial analysis, is to identify and study the block/stage that has a defect. You will not always need to test the entire board. Generally, you will test, locate and fix the points that have problems, in the affected sectors.

- **Fifth point:**the goal here is to help you understand how to analyze and help you be able to “think for yourself”. The goal here is to make you know where to analyze according to the problem in question. If a board has a problem with some component in the AC voltage input sector, would it make sense to try to find a defect in the DC voltage output connector? Would that make sense? Do you understand the importance of learning to think?

- **Sixth point:**It is a job that requires patience. Calmly, you analyze and study the diagram, locate the block/stage that requires testing and analysis and work on it.

- **Seventh:**there will be smaller or larger blocks/ stages, less or more complex, with a smaller or larger amount of lines that you must follow and a smaller or larger amount of components that you must test.

- **Eighth:**The analysis consists of putting into practice everything you have learned so far.

## Primary and secondary source

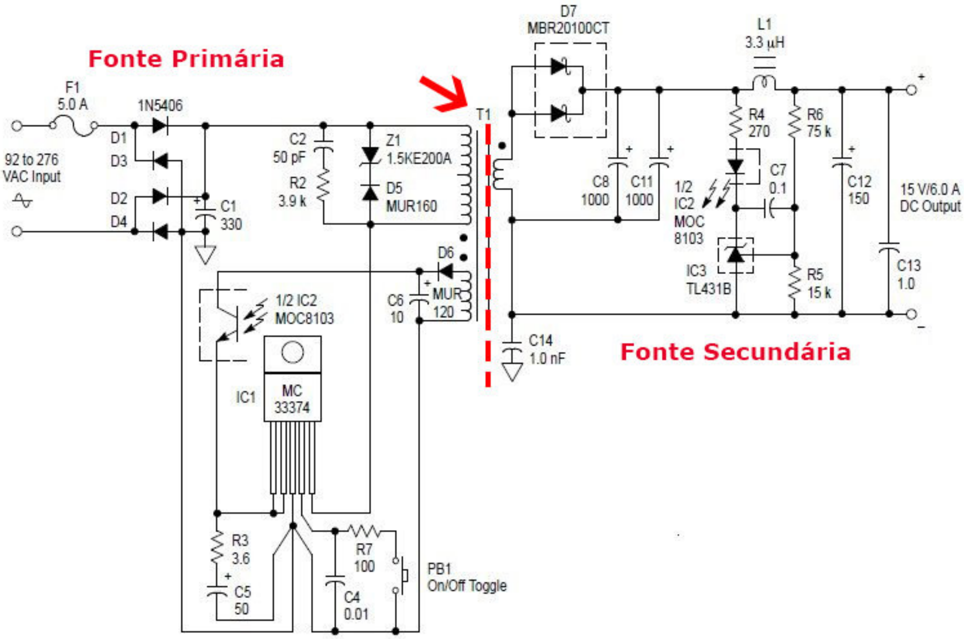



**Figure 09.1:**primary and secondary source.

Look at the division of the primary and secondary sources there, exactly as I have already taught. These two sources are not interconnected by tracks. Note the "T1" identifying the chopper transformer. Therefore, we have also identified the primary and secondary of the chopper transformer.

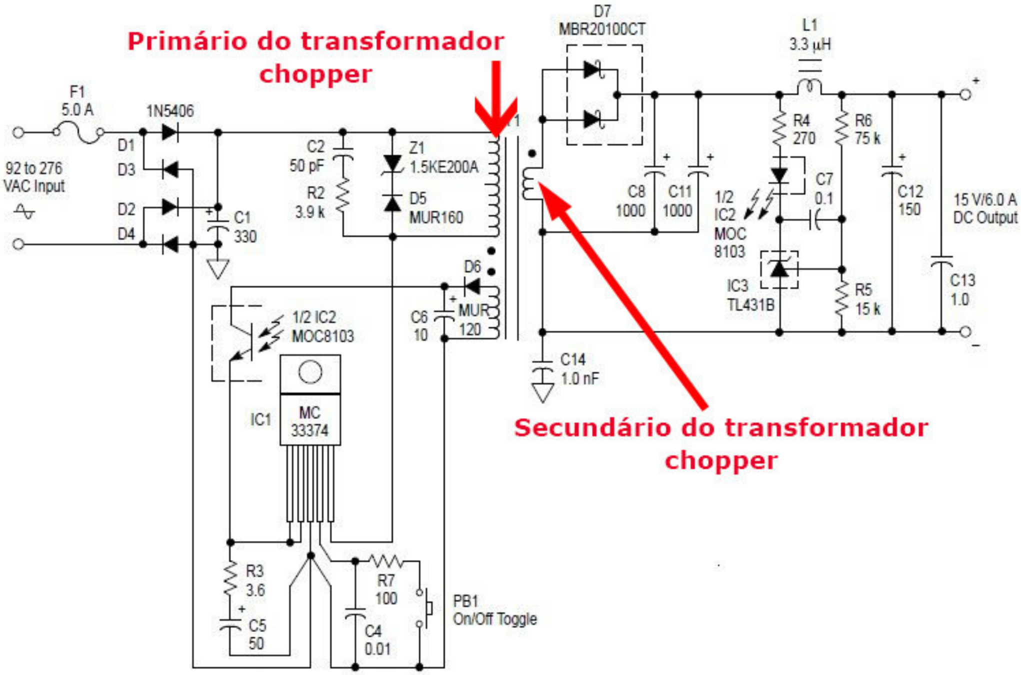



**Figure 09.2:**primary and secondary chopper transformer.

## AC input and fuse

On the far left we see two dots/tracks that indicate the AC input, that is, where the alternating voltage comes in. We can see the identification VAC Input.

And we easily notice a 5 amp fuse (F1 5.0A).

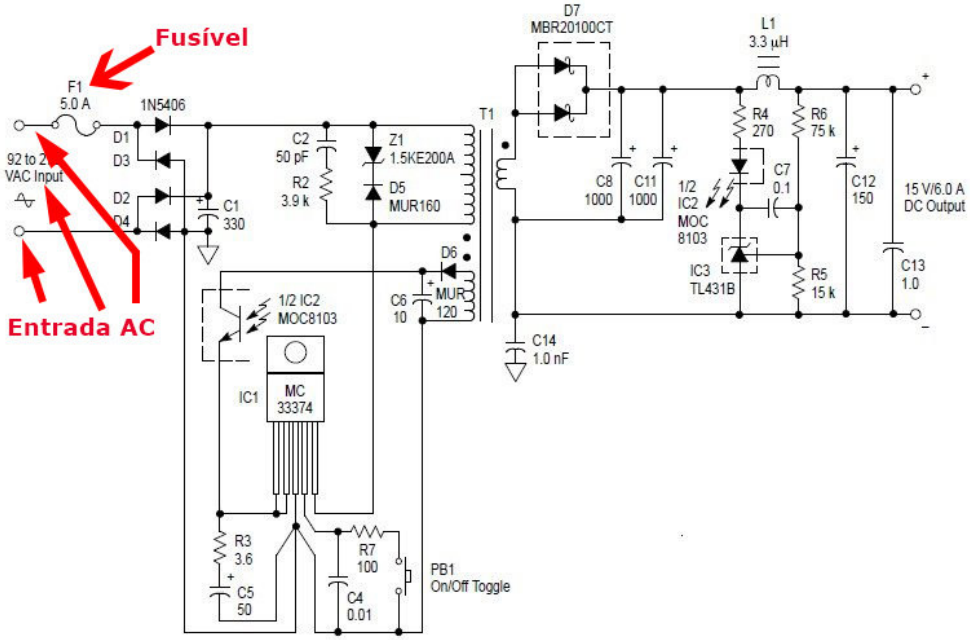



**Figure 09.3:**AC input and Fuse.

## Rectifier bridge

When analyzing we can verify four 1N5406 diodes identified. It is the circuit that forms the rectifier bridge.

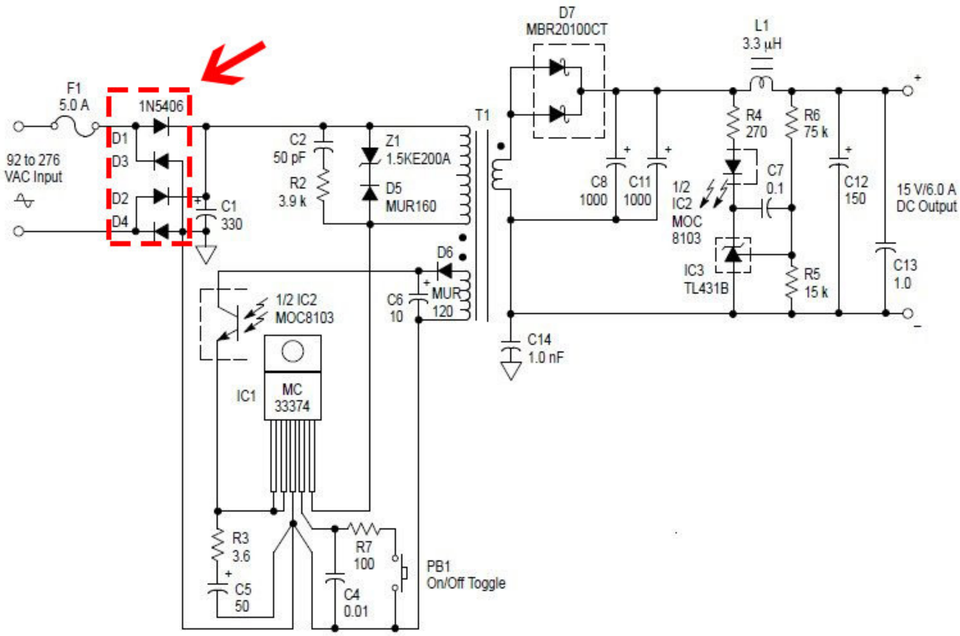



**Figure 09.4:**rectifier bridge.

## Filter Capacitor

Right after the rectifier bridge we have the filter capacitor. The energy will pass through the rectifier bridge where it will be converted into pulsating direct current. And it will pass through this capacitor to stabilize the pulsating direct voltage.

pulsating voltage will be filtered, thus obtaining continuous voltage, but which still undergoes oscillations.

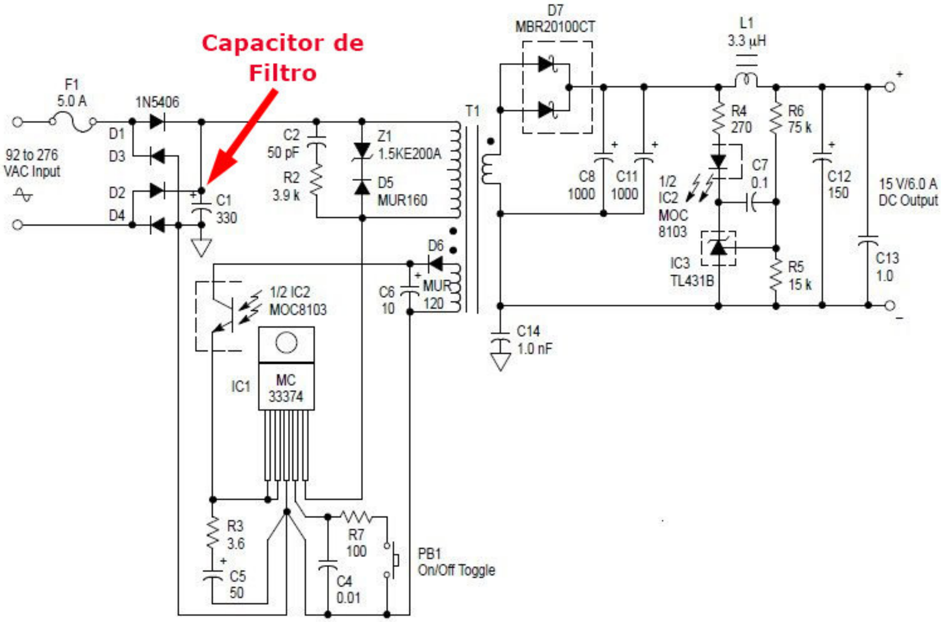



**Figure 09.5:**filter capacitor.

## Rectification Block and Filter

And with this we can identify a block/sector that we can call the “rectification and filter block”.

And what is its function? Very simple: this block receives alternating energy from the socket and “transforms” it into direct voltage. And as I already explained, this voltage still fluctuates.

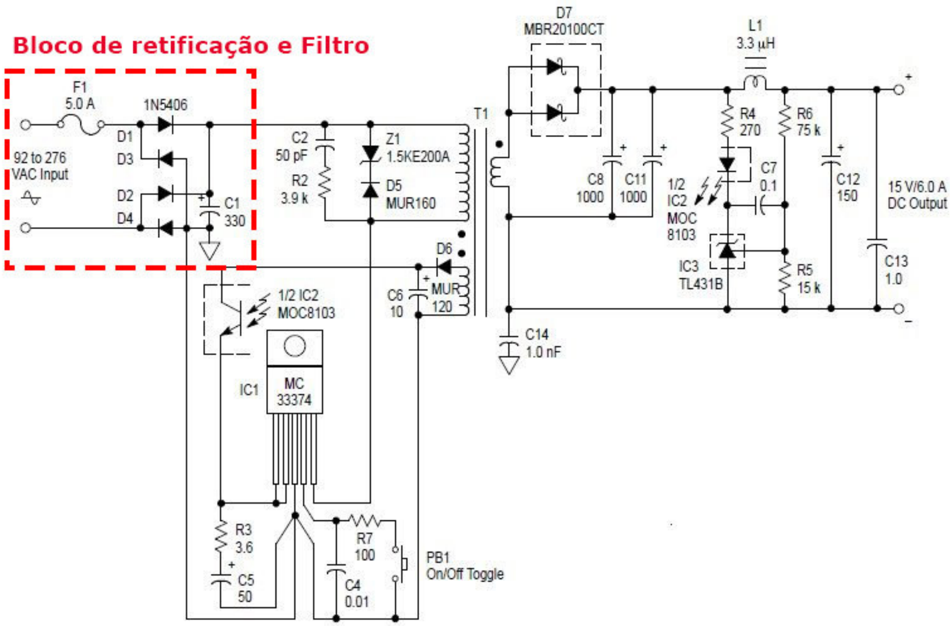



**Figure 09.6:**rectification block and Filter.

## Primary block of the transformer chopper

See how everything makes sense through a simple analysis! So far I'm only using what I've already taught.

Have we identified the correct transformer chopper primary yet?

The voltage from the filter capacitor will arrive at the primary of the chopper transformer, which is generally a higher voltage than the voltage coming from the socket.

For example: if 110V enters the board, the filter capacitor can be 200V.

And these 200V will be sent to the primary of the chopper transformer.

We can consider the entire area marked in the following image as a block, the primary block of the chopper transformer.

There will be some components involved in this block, such as backflow protection diodes.

current, and capacitor and resistor that act as filters.

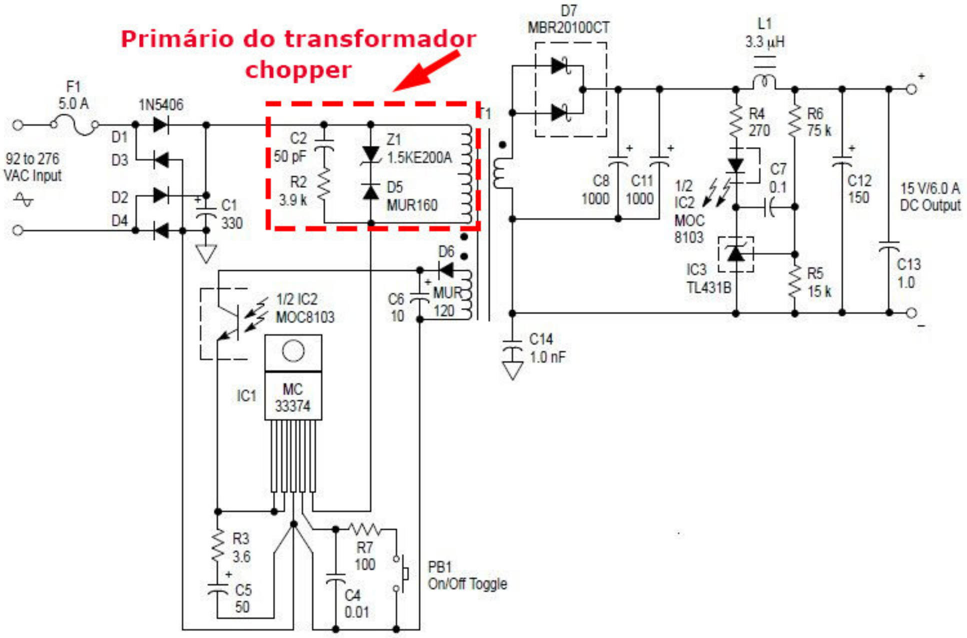



**Figure 09.7:**transformer primary block chopper.

## Switch IC

Just below we have the MC 33374 switching IC very clearly. It has a MOSFET internal, and its function is what we have already studied: to control the flow of electric current in the primary part of the power supply circuit, especially in the switching stage. It will generate pulses in the primary of the chopper transformer so that it is possible to induce voltages in the secondary of the chopper transformer.

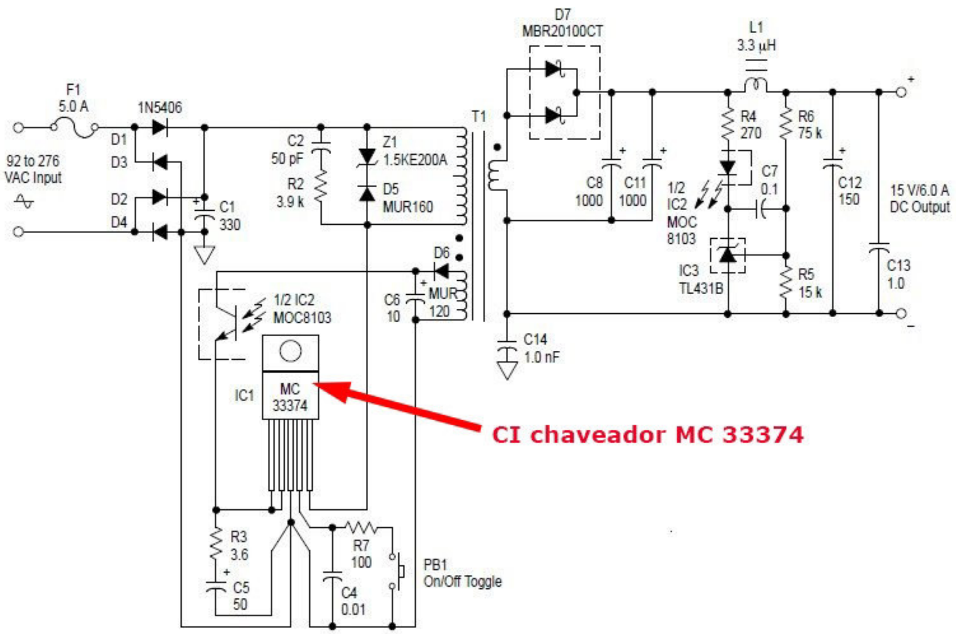



**Figure 09.8:**Switch IC.

## Feedback Loop

In this diagram we can verify the presence of the Feedback circuit, which is the photo coupler (phototransistor).

In that case it is about of phototransistor MOC8103.

It plays an important role in protecting and controlling the transfer of energy between these two sources (primary and secondary).

It can read the voltage in the secondary source and sends feedback to the switching IC so that it increases or decreases its switching frequency.

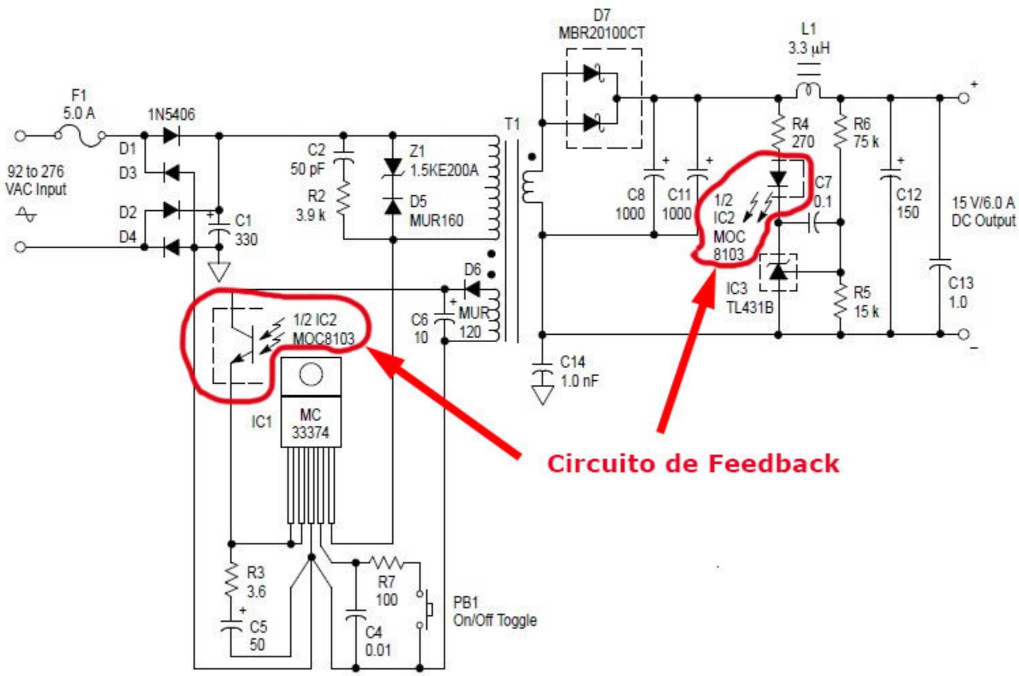



**Figure 09.9:**Feedback circuit.

## Feedback block

And all the electronic components that are there performing auxiliary and essential functions are part of this feedback circuit, such as resistors R4, R5 and R6, coil/inductor L1, capacitor C7 and integrated circuit IC3 TL431B.

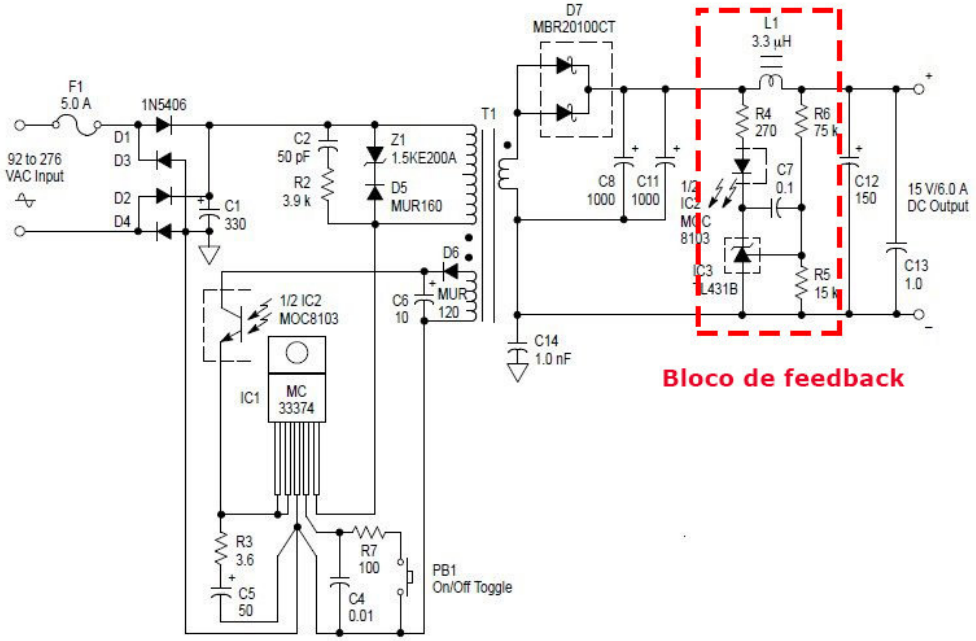



**Figure 09.10:**Feedback block.

## Switching block

And based on these explanations we can close another block: switching block. Within this block we can include by convention the feedback circuit and the other electronic components present: resistors and capacitors.

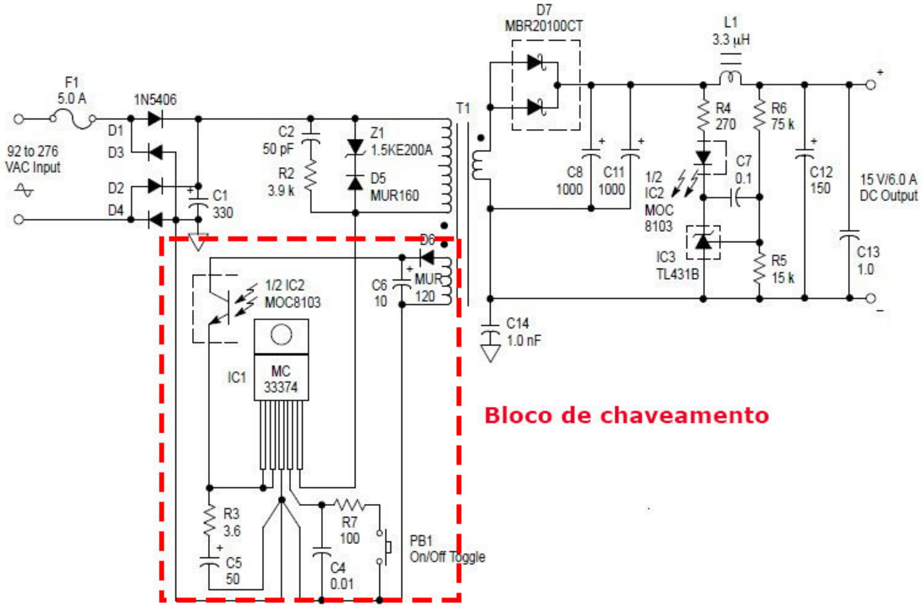



**Figure 09.11:**switching block.

## Secondary block of the transformer chopper

As we have already studied, the switching IC will generate pulses in the primary of the chopper transformer so that it is possible to induce voltages in the secondary of the chopper transformer.