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Design and Simulation of Solar Battery charger for Charge Quality Using Pulse Width Modulation Method

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Abstract

In this study, an attempt to design a high-efficiency charger to achieve parameters such as localizing the solar charger technology in the country, using a new method, and converting voltage and current (power) was closer to the maximum transmission power. Also, solar systems will be used more day by day; therefore, such systems can help to replace solar systems with fossil energies. The main goal of this study was to achieve high efficiency in charging to optimize solar systems. It can be achieved high efficiency by this method. The goal is to achieve the highest efficiency with the lowest cost, which in the forthcoming study was reached to efficiency over 80% versus 5.65% with a lower cost than the existing systems in the market.
Keywords: Solar Charger, Power Transmission, Pulse Width Modulation, Solar Photovoltaic Panel and Battery Proper Charging Parameters

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Introduction

Photovoltaic phenomenon is a phenomenon that generates electricity through light irradiation without the use of stimulus mechanisms and photovoltaic system is a system that uses this phenomenon. Photovoltaic systems are one of the most widely used new energy application. Various systems with varying capacities (0.5 watts to several megawatts) have been installed around the world and, given the reliability and performance of these systems, the number of its applicants is added each day.

In Iran, an average of 5.5 kilowatt hours of solar energy per square meter radiates from Earth's surface, and there are 300 sunny days in 90% of the country. The total area of Iran is approximately 1,600,000 square kilometers, which is about 1012 × 1/6 square meters. The amount of solar energy radiation in Iran is equal to: 1/6×5/5 ×1012. The total amount of sunlight per day for Iran is roughly 9,000000000 megawatts per hour. If only of 1% of Iran is absorbed solar energy and the efficiency of the energy supply system is only 10%, it can still receive 9000000 megawatts of energy per day from the sun.

Studies on solar energy in Iran began about 35 years ago and roughly simultaneously at Shiraz and Sharif universities. One of the important projects in these centers was the 10 MW solar power plants at Shiraz University and the project to develop and build photoelectric cells in the center. Photovoltaic system components include:

Solar panels: This part is in fact a solar energy converter into mechanical energy without any mechanical interference. It should be noted that the current and output of these panels are dc (direct).

Desired power generation or control section:

This section actually controls all system features and injects and controls input power of panels in accordance with the design and user requirement for the load or battery. It should be noted that in this section, the characteristics and constituent elements, depending on the needs of the electrical load and the consumer, as well as local weather conditions changes.

Consumer or electric charge:

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According to the output of the DC, the photovoltaic panels of the consumer can be from two types of DC or AC. Different types of photovoltaic panels also provide the need of different consumers with different capacities.

Photovoltaic systems have many uses, including astronaut, solar lighting, feeder system of a residential unit, a solar pump system, feeder system of telecommunication stations and seismotectronic system, a calculator, a clock, a radio, a tape recorder, children's play equipment and Photovoltaic power plants, solar fridges, portable feeder system, etc.

Solar Charger

Battery charger is a device for recharging energy into rechargeable batteries by inserting an electric current into the battery. The charging current depends on the manufacturing technology as well as the volume of battery to be charged. Important factors are involved in the construction of a battery charger, including the efficiency, cost, battery life, and construction capability in the country. The efficiency of the chargers available in the market, which can be used in different places, is due to a maximum voltage conversion of 65.5%, but the system presented in this thesis can increase efficiency by at least 90%, which according to the efficiency of existing systems in the market, this is a significant improvement.

Battery

Batteries store electrical energy chemically. In photovoltaic systems, batteries have the task of supporting overnight and on cloudy days. Since the power output of photovoltaic panels varies throughout the day, a storage battery can be a relatively stable source for power generation to compensate changes light shined to the panels. Another advantage of using the battery in solar systems is supplying the electric motor startup current. On the other hand, batteries are not accessories with 100% efficiency and lose some energy in the form of heat in chemical reactions during charging and discharging. In order to compensate for this waste of energy, they should consider battery efficiency in solar system design.

2. Background

In 2011, Mr. Mark Paster and his colleagues have worked on the issue of solar charging by tracking the maximum power point that has provided an ASIC solar charger for lithium-ion and nickel-based batteries. The system is a DC converter to DC that acts on a solar panel at its maximum

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power point by tracking it using a courier tracking algorithm. Only an inductor and an external diode are necessary. The circuit is made in a process of 0.5 μm and a voltage of 5 volts. The system has low power consumption with 84 micro-amps.

In 2012, Mr. Burk Akin worked on the issue of a solar charge with USB output that portable charging system by a solar energy Boost DC to DC converter is presented. The fast and efficient charging system is also developed in the PowerSim simulation program. At steady state conditions, the efficiency is 92.6% that is achieved for the solar charging system. In this system, solar energy charge is designed for Universal USB output. The system consists of a solar cell, a lithium ion battery, a conventional boost converter DC to USB output. The solar system has efficiency 92.6% for 1.35 watt with a switching frequency of 100 kHz without a lithium-ion battery.

In 2013, Ms. Patti AR and her colleagues reached 59.1% efficiency using the PWM technique but without converting power. The PIC16F873's programmable IC has been used to make this charger. A photocopier declares the battery voltage to the IC as feedback. The pulse brightness depends on the amount of battery charge. In the design circuit, all battery charging parameters were well observed and the battery charge quality was more than 90%, but the basic forms of the system need is to the voltage setting of the charger circuit and its low efficiency.

In November, 2014, Mr. Ishtyak Ahmad Karim and his colleagues studied the design of a solar charging controller for a PV 100 WP system. In the PRO Magazine at Dahka University made the Charger using ATmega8 programmable ICE and Ferrite core for power conversion, but due to the lack of intelligent feedback, the efficiency of the system had some errors in different conditions of battery voltage.

2. Method

Battery of charger is a device for reaching the voltage required to the battery with the condition of not damage the battery and maintain a battery voltage that the more its efficiency is higher, it is better for the consumer. High efficiency is not important in some cases. For example, in the construction of a battery charger for car, because of the electrical energy consumed is provided by urban electric power, the consumer considers the most important thing in the absence of damage to the battery and low price of the device. But in the solar energy structure, which is paid a lot for every watt and the volume of production is limited, the efficiency of all voltage converters,

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including the battery charger, inverter, etc., is very important. That's why it seeks designing techniques that can do battery charge process with the lowest losses.

One of the best ways to convert a voltage is to convert power. This means that the input power to the system is equal to the output power of the system, but the voltages and currents in the system are converted to each other.

The best converters can be called transformers. It should be noted that the more the frequency of the system's operation is more, the conversion efficiency is higher, and also the size of the transformer will be smaller (i.e. reaching the ferrite core). However, switching operations at high frequencies are more complicated in terms of orbital design, and are becoming more numerous in terms of equipment used.

The function of the system is that the voltage obtained from the photovoltaic plates, which is DC with 21 volt voltage, using a smart oscillator, we reach to two square pulse waveforms with time difference. These two waveforms are applied to one head of the Trans by amplifier, and the middle head of Trans is fed to the voltage. In the Trans output, the wiring is wired at a voltage of 14 V, that this voltage remain the same value according to the square of the input pulse after DC. This DC voltage goes directly to the battery and charges the battery.

From battery voltage, a sample is sent to IC as a feedback which reduces the applied pulse width to the Trans, ie, the effective voltage applied to the battery, until the battery is fully charged. In Figure 1, the block of diagram shows the performance of this system:

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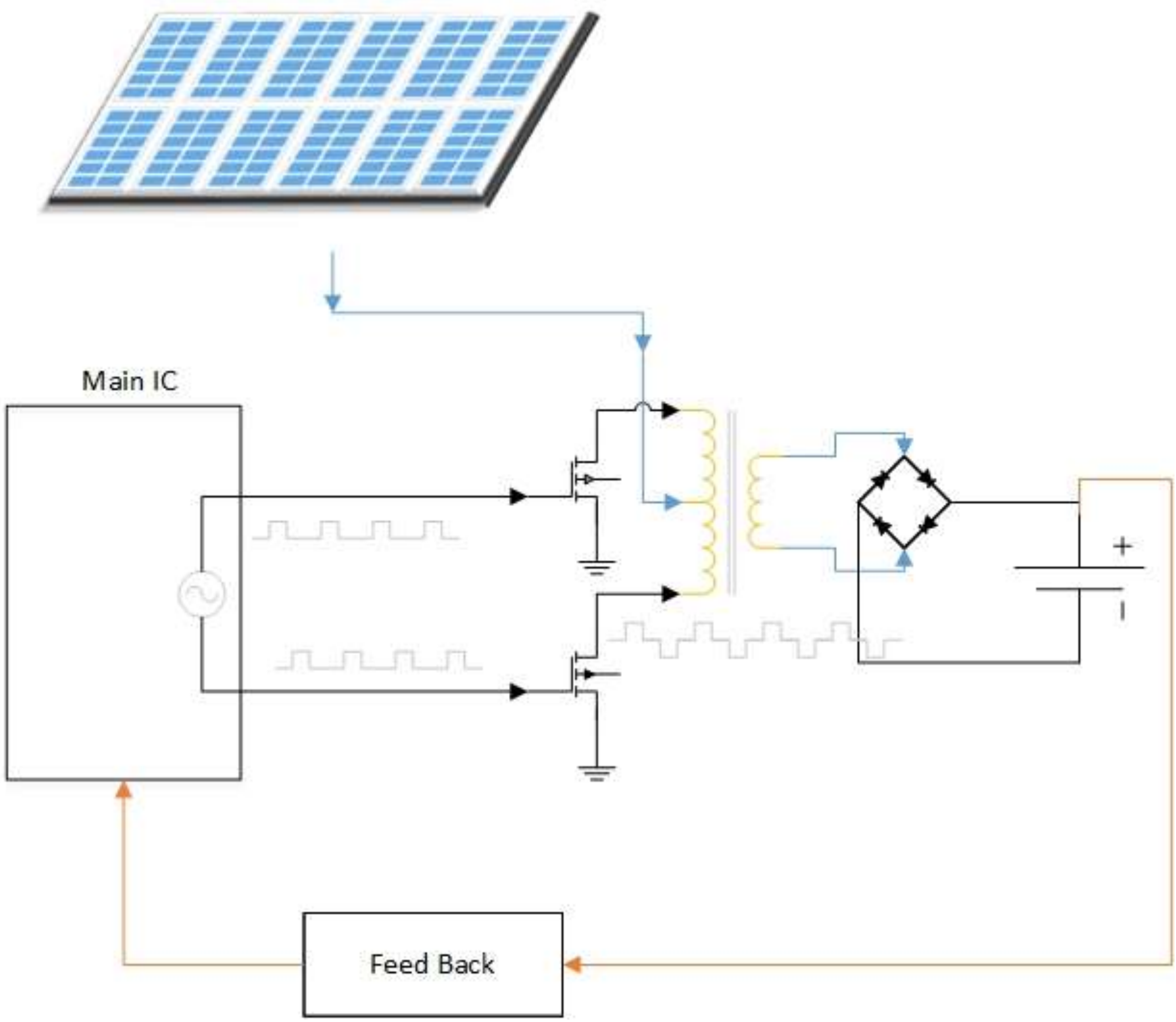

Figure 1. Diagram block of function of circuit

The system, which has a voltage feedback, by sampling the battery voltage and its applying helps to the input to apply the amount of current required by the battery to it. This issue will lead to the correct charge of the battery because the cause is detected in many battery crashes, improper charging, and applying current more that needed.

Given the fact that the charger is designed for 100 watt and 21.5 volt and 4.8 Amp for photovoltaic panels, as well as a maximum voltage of battery is 13.8 volts, we have

$P_{in}=P_{out}$

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$V_{in}*I_{in}=V_{out}*I_{out} \rightarrow I_{out}=(V_{in}*I_{in})/V_{out} \rightarrow I_{out}=7.2A$

Therefore, Trans calculations that require multi-stage calculations are as follows:
Calculating the coefficient K (area of the inner cross-section of the reel):
$K=L*W$

There is a condition for choosing a reel. The K value obtained to power 2 divided by 1.28 must be greater than the Trans power required.
$K^2/(1.28) > Max_p$

Calculate Sfe:
$S_{fe}=K*\sqrt{P_{out}}$

Calculation round-volt (this parameter shows us that for each coil round, the multi volts is induced in this coil.):
$N_v=375/S_{fe}$

Calculation of the number of primary and secondary rounds:
$N_1=N_V*V_{in}$
$N_2=N_V*V_{out}$

Calculation of primary and secondary wire diameter:
$d_1=1.13*\sqrt{I_1}(mm)$
$d_2=1.13*\sqrt{I_2}(mm)$
The circuit is related to the voltage sampler and the pulse width modulator, using a transformer, transmits the voltage and current of the photovoltaic panel according to the battery value. The completed circuit is shown in Fig. 2. This circuit is charger completed and, by increasing number

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of MOSFETs output, can charge very high powers of the battery and solar panel with a high efficiency.

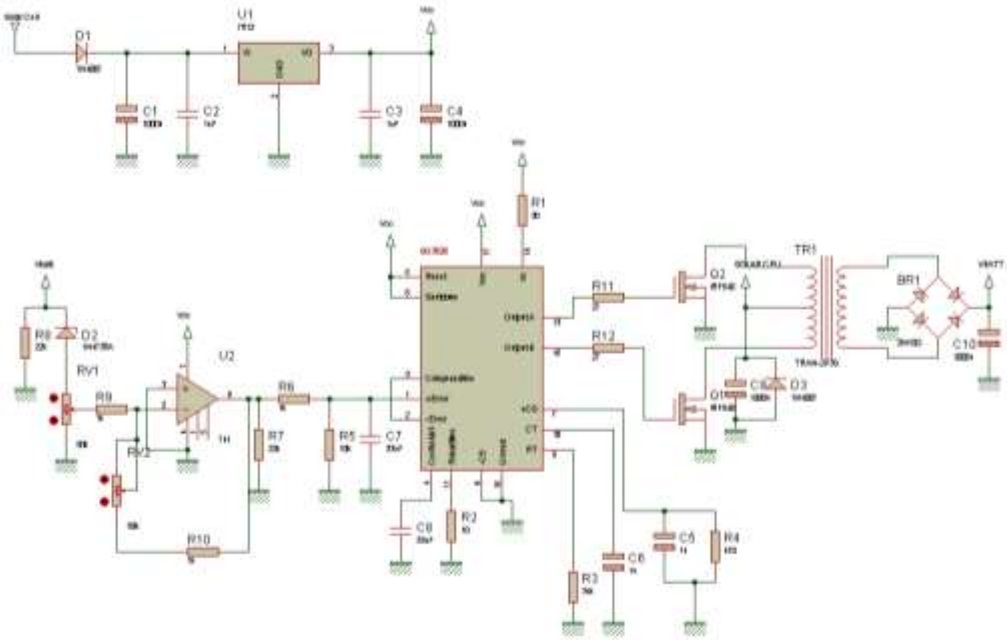

Figure 2. Completed map of circuit

In measuring the charger values, two important parameters, ie input power and output power, are very important, and their ratio specifies the efficiency of the charger. These two parameters are obtained by measuring the voltage and the input and output current. Therefore, the input voltage and current, and the voltage and output current are measured and multiplied using a multimeter.

3. Findings

In the calculation of the transformer used in this transformer, according to the length and width of the reel, which is 4.5 and 6.2 cm, the area of the reel is 11.7 cm^2 and the maximum power of the reel is 106.94 watts, which is well met the circuit requirement.

Also, the value of the Sfe parameter is 117 and the value of the round on voltage equals to 3.2. Therefore, the number of initial rounds is 67 rounds and the number of secondary rounds is 44 rounds.

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The central core of the charging circuit is in fact a pulse width controller. The goal is to increase the pulse width by reducing the battery voltage so that the battery can be recharged in maximum power and by increasing battery voltage, the pulse width will decrease and only the remaining charge will be transferred to the battery. The best operating conditions of this circuit are that if the input voltage from the battery to the circuit at the Vbatt point is at its maximum range, the positive output pulse width should be at its lowest value and increase the positive pulse width by decreasing the voltage of the battery. In Figures 3 and 4, and Graphs 1 and 2, the output pulses are observed at the lowest and highest values of the battery voltage.

Graph of pulse width in full charge mode

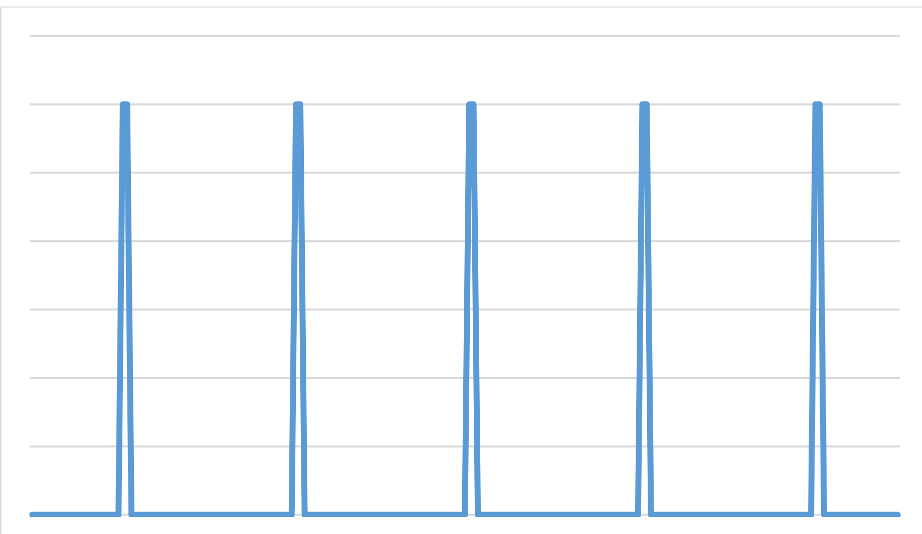

Figure 3. An output pulse at the lowest value of battery voltage

Graph of pulse width in charge mode less than 10 v

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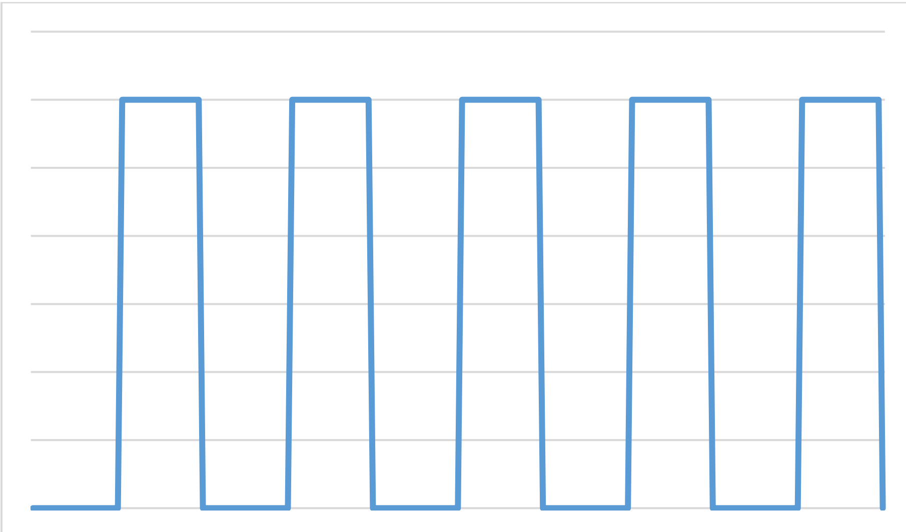

Figure 4. Two output pulses in the highest amount of battery voltage

4 - Conclusion

The maximum charging efficiency was at 10 and 11 o'clock in the morning, during which hours the output power of the charger was in the range of 70 to 95 watts. Therefore, it can be said that in order to improve the performance of the system, it is necessary to design circuit of charge smarter for measuring the pulse width produced. However, with a review of other values obtained from the average efficiency, the achieved efficiency throughout the day has been 91.1%, which is a very large number.

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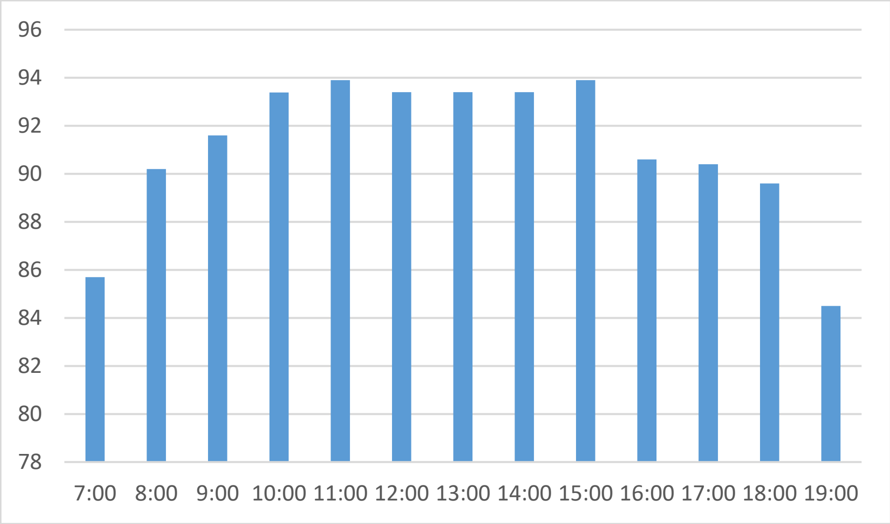

Figure 5. Function of solar charger

In the case of the cause of decreasing efficiency of the system at lower powers, it can be said that the loss of core and copper wire is the most important factor because the wave produced is square, which has positive effect in increasing the efficiency in high powers due to the edge of wave (shown in Fig. 6, where the square wave is compared with the sinusoidal wave). And in low powers, it reduces the efficiency that can be used ferrite core to increase efficiency in this range. To use the ferrite core, circuit does not change. It is only enough to increase the frequency of the circuit operation to as much as possible and in multi-kilogram or multi-MHz ranges by varying the capacitor values and the frequency setting resistance, and instead of using the ferrous core trans, corresponding to the operating frequency use ferrite core.

The reason for not using the ferrite core in the project is the desirability of localizing the system, and because these cores are not manufactured or wired in the country, ferrous Trans is used.

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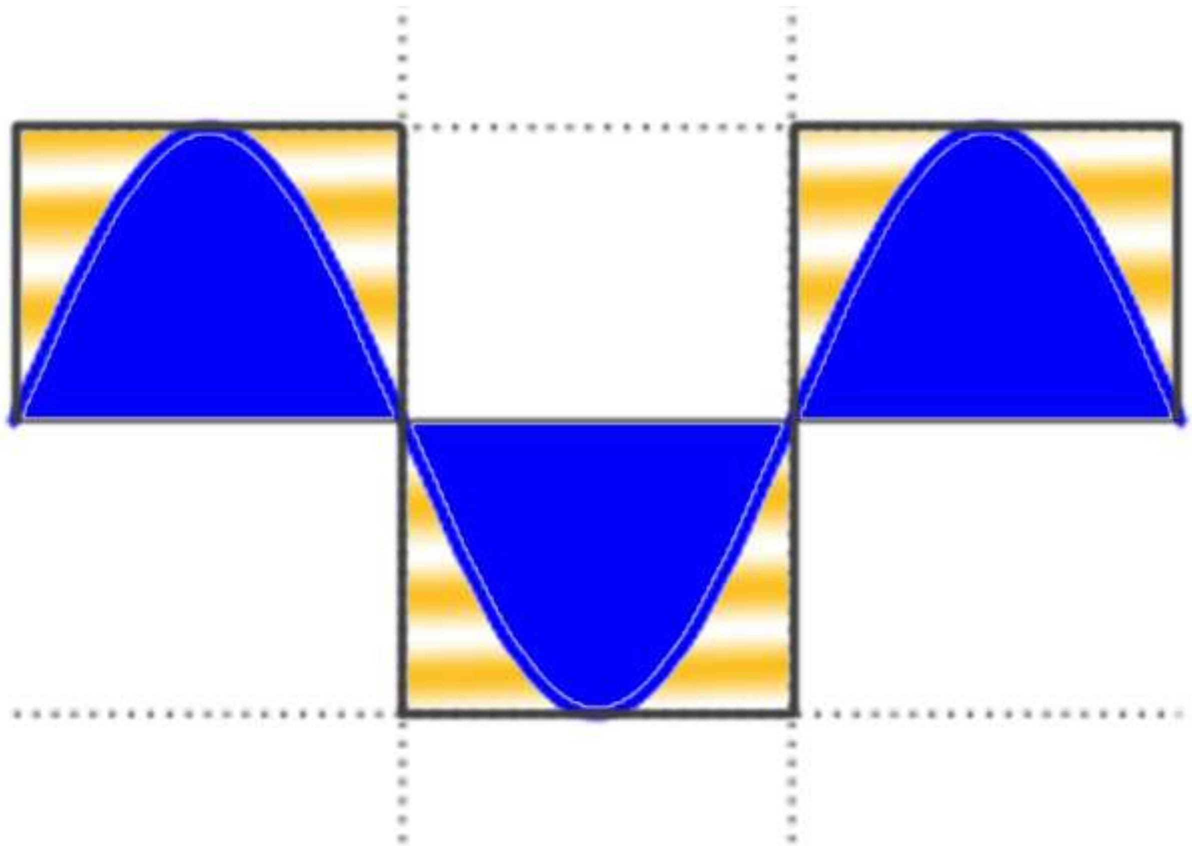

Figure 6. Amount of losses in the sinusoidal circuits

Figure 6 shows the amount of loss power loss in sine waveform converter systems designed with bipolar transistors. The orange hawked parts, which occupy about 37% of the space, turn into losses in transistors. Therefore, making circuits with ferrous core and square wave transformers will have fewer losses.

5. Comparison

It is very difficult to achieve efficiency over 90% and so far this issue has been occurred for low power chargers. It should be noted that the chargers examined in the previous chapter differ greatly from the solar chargers in the market. Powerful chargers in the market for these powers have up to 67% efficiency.

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