Design Multi input Single output DC to DC converter for Mobile Devices

Gözde GÜMÜŞ[1,*], Hakan GÜMÜŞ[2], Okan GÜMÜŞ[3]

[1]Institute of science, Engineering Faculty, Electrical and Electronic Department, Çankırı Karatekin University, Ankara, Turkey

[2]Institute of science, Engineering Faculty, Electrical and Electronic Department, Çankırı Karatekin University, Ankara, Turkey

[3]Institute of science, Engineering Faculty, Electrical and Electronic Department, Çankırı Karatekin University, Ankara, Turkey

Abstract

In today's world. We have been able to find more than one way to generate energy. Also, humanity wants to store then use this energy. Based on this situation, we need to change our perspective on energy. Our electricity always falls short of consumption. So, we synthesize several generation methods. If we want to give an example, some plants have wind turbines and PV or PV and hydroelectric power plants. As you know turbines generate AC but PV systems generate DC. That can be a solution to energy shortage, but it can be not easy to transmit. On the other hand, this DC energy is using many areas but we haven't any good quality solution to store DC electricity. According to this, our work is about how to take different types of inputs and regulate energy for charging mobile devices. Regulating, methods are very different and they have also some methods. In this study, we are talking about multiple DC/DC converters. This study has Multiple input DC/DC converter topology. This type of converter has some production methods. Also, we are discussing some methods applications and their specification. In addition to this, we search about how to safely charge mobile devices.

Keywords: *DC,AC,PV,Converter .*

1. Introduction

Smooth converting and transmission system is very important at these days. Cause of this reason, this study is researching methods about multiple input DC/DC converters.

These are three main types of switching power supplies: boost, buck, and buck boost. The first is responsible for raising the input voltage, the second is responsible for lowering it and the. third is a mixture of the previous two. All these configurations work in a non-isolated way, that is, they share a common ground and the output voltage variation depends on the duty cycle applied to the switching component. [1]

This time we worked with the voltage reducer (Buck), this configuration is commonly used because the output voltage is lower than the input voltage and its efficiency can reach very high values compared to the configuration. The simplest configuration is that of the voltage divider, which dissipates most of the energy as heat through the semiconductor devices. [2]

In Figure 1 you can see the circuit, which is composed of:

- A diode, this allows current to flow through the circuit when the switch is on.
- opened.
- A power switch which is usually an N-type Mosfet transistor.
- An inductance and a capacitor, which are responsible for filtering the output signal
- of the circuit.
- A resistor, which is the load of the output in the power stage [1].

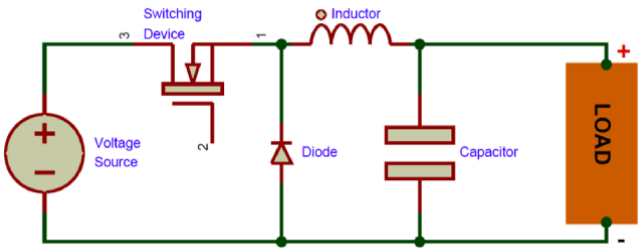

Figure 1. DC/DC converter

2. Problem Definıtıon

In this part we are talking about the challenges for the developing circuit for mobile devices the first challenge is electricity type they should be all convert to DC. As you know we are using energy for mobile devices. Then how to charge mobile devices safety

A converter with a buck-help design is used in one of the first isolated multi-input converters. The separation transformer's two components are designed to act as an inductor for the converter and to make absolute motions for certain data sources. This converter has three modes of operation. Switch S1 is on, S2 is off, and V1 charges the inductor L in the principal state. In the consequent state, S2 is on, S1 is off, and V2 charges the inductor, hence the inverse is true for switches. Because there is no ability transfer from the data stage to the outcome stage during the underlying two modes, the pile is provided by the outcome capacitor. The two switches are off in the third working condition, and neither V1 nor V2 loads the inductor. Along these lines, the inductor passes limit on to the pile. For this converter, the outcome voltage, V_{out} is given as:

$$V_{out} = \frac{D_1}{N_1(1 - D_1 - D_2)} V_1 + \frac{D_2}{N_2(1 - D_1 - D_2)} V_2$$

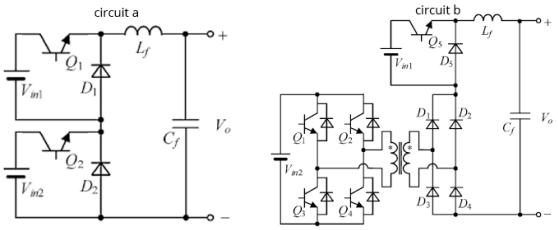

Figure 2. Multi-input full bridge converter [3] [4]

In this figure, you can clearly two circuits connected by pulsating current-source cell for generating energy. In these two circuits give ideas to multi input single output DC to DC converter. If I have to mention about pulsating current-source cell, simply it is pulsing energy to circuit with periodic square pulses outputs. As you see in circuit a there is two DC inputs. Also, we are talking deeply about AC and DC sources to circuit topology. if you need to compare our circuit to these two circuits. Circuit a is simply converting two DC sources to single output. In

circuit b, there is one AC source which is called V_{in2}. This source is generating AC energy. Depend on this, we need to convert this electricity AC to DC.

.

3. Results and Discussion

Today's world had to use mobile devices for a glorified life. As you know we must to charge these devices. In that condition we have some methods. To give an example, using power banks, strong capacity Li-Ion batteries or using fast chargers.

If you are designing good quality chargers for mobile devices, you must notice to the features. Voltage and amperage values must be in accordance with the value specified in mobile devices. If any of these values is low, the device may be damaged due to low power supply. In addition, the minimum power requirement required by each mobile device differs. In order to prevent this, we saw that it would be appropriate to give 5V 2.1 Amps as a result of our research. In addition, it should be considered that the voltage and current value can be changed by adding a potentiometer to the output.

To design mobile charger you must know power suplly. If we want to explain detailly, we must examine to schematic design for mobile charger.

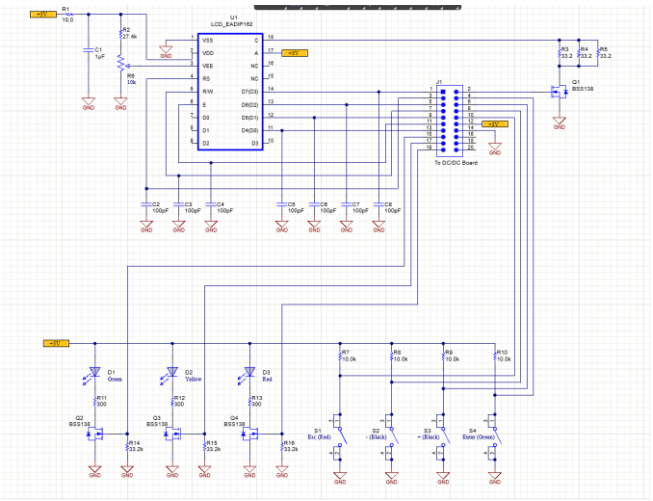

Figure 3. Reference design for mobile devices [5]

As you see in the figure 3 you can clearly see the mobile charger reference design for our project. That is PMP8740. This component is using for industrial devices. This circuit has 2-kW AC/DC battery charger with %92 efficiency. That is the critical point because ıf we try to design a multiple input we must have a good efficiency. That efficiency value is about loss energy. Also, we have to design an efficiency circuit for a good engineering design. In addition, this circuit has 0V between 32V output voltage. If we are examining to output current, it has 62,5 maximum currents. If it is a qualified point to controlling with microcontroller. To finalize that it has 90 VAC between 264 VAC input voltage. Also, if we want to explain in order:

- 93.5% peak efficiency optimizes thermal management of the module
- Serial interface gives users the ability to easily parallel up to 10 hardware modules

- Two raw displays and four pushbuttons simplify configuration
- Pre-defined levels for li-ion, lead-acid and gel batteries
- Primary/Secondary or stand-alone
  configuration for battery charging or standard power supply unit

Output voltage options	PMP8740.1	PMP8740.2	PMP8740.3	PMP8740.4	PMP8740.5
Vin (Min) (V)	90	90	90	350	10
Vin (Max) (V)	265	265	265	420	14
Vout (Nom) (V)	390	12	32	32	5
Iout (Max) (A)	3.9	.05	62.5	62.5	.3
Output Power (W)	1521	.6	2000	2000	1.5
Isolated/Non-Isolated	Non-Isolated	Isolated	Isolated	Isolated	Non-Isolated
Input Type	AC	AC	AC	DC	DC
Topology	PFC- Boost	Flyback- Quasi Resonant	Flyback- Quasi Resonant	Full Bridge- Phase Shifted	Buck-Synchronous

Figure 4. Different versions of PMP8740

As you see in figure 1.5 you can see differences model by model of PMP8740.

DESIGNING MULTIPLE INPUT DC/DC CONVERTER

Also, we must to examine to DC/DC converter topology for our studying. To understanding DC/DC converter we must look into this; DC-DC converters are widely used to generate an efficiently regulated voltage from a well-controlled or uncontrollable source to a load that may or may not be stable.

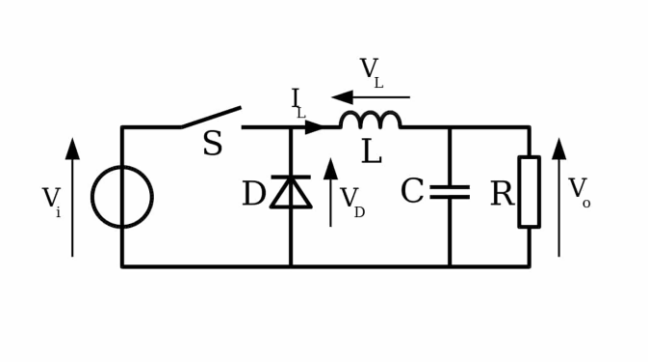

Figure 5. Basic DC/DC Converter

In line with this information according to figure 1.6, These DC/DC converters will store energy that goes into a temporary storage and then delivers it to an outlet of a different voltage. For this to be possible, magnetic field storage like inductors or electric field storage like capacitors must be used. Also known that before the chapter “TYPICAL DC/DC CONVERTERS” so we are studying about DC/DC converter types.

DC DC BUCK CONVERTER

Buck converter or DC to DC converter, as name suggests, is a voltage adjustable converter at the output that reduces a DC voltage to a DC voltage again.

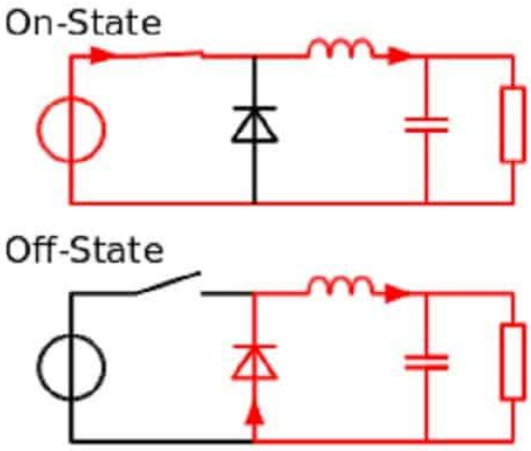

Figure 6. On and off state for buck converter

The state we call on-state here is the state where the switch is closed and the current is flowing. Off-state is when the switch is open. Here, Mosfet is usually used as a switch. The reason why it is preferred over BJT causes less power loss in power electronics.

DC/DC BOOST CONVERTER

In DC circuits where high voltages are required, the desired voltage value can be achieved by creating battery packs, but even if this is a solution that provides sufficient parameters in theory, the structure to be created provides disadvantages in many respects such as material, usage area and weight. At this point, DC-DC converters are designed in order to obtain the desired voltage values. Boost Converter is one of the structures that has an important place among DC converters. The design of the circuit is carried out to obtain the output voltage by increasing the voltage applied to the input. The schematic of a basic boost converter circuit is given in the figure below.

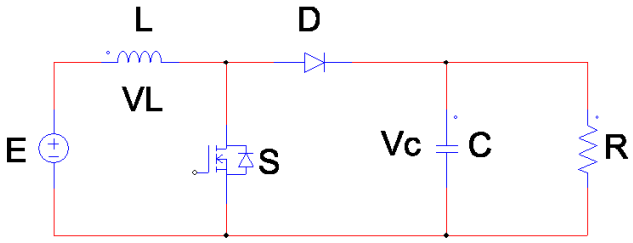

Figure 7. Basic boost converter circuit

Also, in this range the diode is reverse polarized. The capacitor provides current to the load and iC is negative. The inductor current must decrease for the current to be the same as the current at the output when the switch opens. For the inductor current to be reduced, With the switch closed, the voltage VC must be larger than E. The equation gives the derivative of the inductor current when the switch is open.

$$\frac{d_{i_l}}{d_t} = \frac{E-V_c}{L} \quad (1)$$

Since IL should be equal to the increase in on-time with the switch closed; The chopper voltage relationship can be determined:

$$I_{max} - I_{min} = \frac{E}{L} DT(2)$$

$$I_{max} - I_{min} = (\frac{E - v_c}{L})(1\text{-}D)T(3)$$

DC TO DC BUCK BOOST CONVERTER

Buck boost converters circuit, like other switched converters, are examined in two stages according to the conduction/off state of the switching element. First of all, we will examine the case where the switch is transmitting. When the switch is on, the circuit is divided into two parts. The first of these is the circuit formed by the source and the coil providing the input voltage, and the second is the circuit consisting of the load and the capacitor. These two circuits can be seen in detail in the figure below.

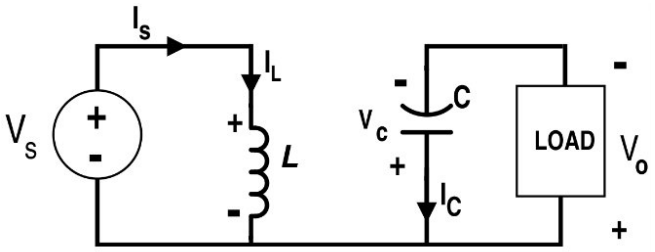

Figure 8. Initial State, Switching Element In Transmission

In switch transmission, the coil in the circuit is energized by the energy coming from the source. On the right side, the energy on the capacitor is transferred to the load. In this case, the D diode in the circuit is on. In direct current circuits, the average voltage of the coil and the average current of the capacitor are both zero., the voltage of the coil will be reverse induced and the current of the capacitor will flow in the opposite direction in the other when the switch is in the cut condition of the circuit.

In the second switch-off state of the circuit, the coil energized through the input source in the previous state discharges its energy on C and the load. The capacitor, which transfers its energy to the load in switch transmission, is re-energized with the energy coming from the coil in the second case. The circuit diagram of the second state, that is, when the switching element is in cut-off, is given in the figure below. In this case, since the input source will be completely disconnected from the circuit, the circuit is fed through the coil. In the circuit below, current flows through the D diode until the energy of the coil is depleted, and with this current, the capacitor and the load are fed.

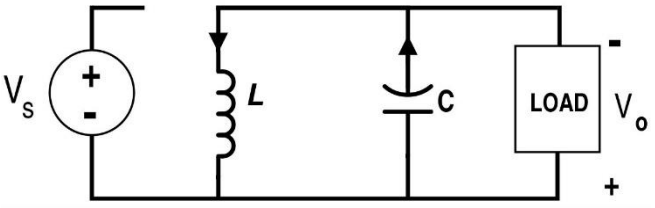

Figure 9. Second Case, Switching Element Cut-off

In the second (in the switch cut) state of the circuit, the coil energized over the input source in the previous state discharges its energy on C and the load. The capacitor, which transferred its energy to the load in the previous case (Key conduction), is re-energized with the energy coming from the coil in the second case. The circuit diagram of the second state, that is, when the switching element is in cut-off, is given in the figure below. In this case, since the input source will be completely disconnected from the circuit, the circuit is fed through the coil. In the circuit below, current flows through the D diode until the energy of the coil is depleted, and with this current, the capacitor and the load are fed.

Also, there are some DC/DC converter types they are

- Full Bridge
- Half Bridge
- Forward

These converter types their explanation does not quite cover the content of this thesis topic. About this topic we can analyze the DC converter design.

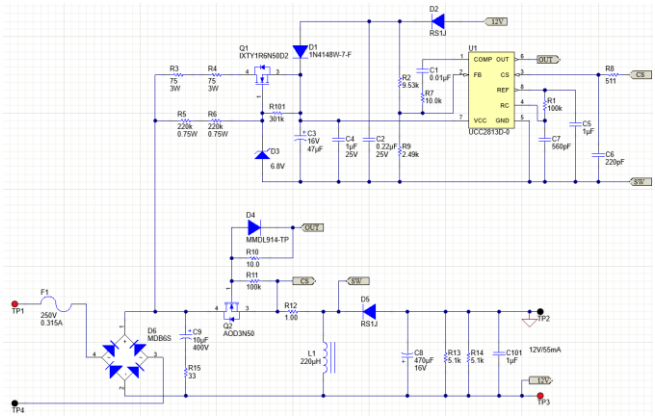

Figure 10. DC-DC converter schematic design [5]

As you can see in the figure 1.11 the schematic of DC/DC converter. It is using UCC2813d-0. This component made by TI for wide input converters. As you see in the schematic the input of circuit has max input 250V 0.315A. Also, thanks to UCC2813d-0 we 12V 55mA output. This design can be holding the light this thesis.

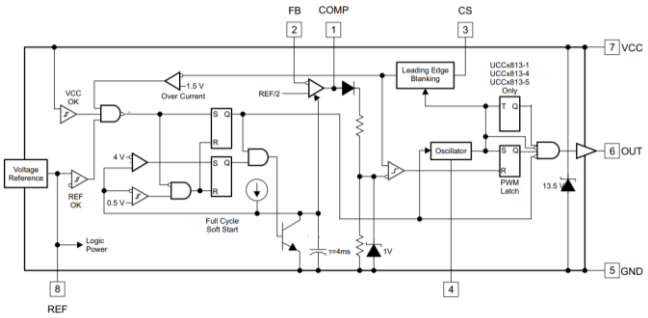

Figure 11. Block diagram of UCC2813d-0

Figure 1.12 is clearly showing the block diagram of UCC2813d-0. This diagram shows us how to work DC/DC converters work generally. In this diagram There is two voltage reference. Depend on that, this component regulating voltage using these references.

4. Developed Or Applied Approach

As we said before, different types of voltage inputs can be added to the diagram of the circuit to be established, and a power output will be obtained by regulating all of these voltages separately from each other. If we examine the input voltage part of the circuit to be made, I have realized that it will be risky for alternators producing direct current to operate on a single circuit. As a solution to this, the desired power will be obtained by using IGBT type MOSFETs instead of using ordinary quad diode gates, by providing the power regulation of the circuit in a controlled and safe manner. These features of the circuit here are similar to wide-input DC converters, but with a few differences. Another issue to be considered in the circuit planned to be designed is the different behavior of different types of voltages on the circuit. These behaviors cause factors such as temperature, noise and harmonics that we all know. In addition, the precaution we will take against the risk of alternating current jumping on the circuit will be to reduce this risk by placing transformers in safe places in the circuit. Another point to be considered while this electricity is regulated is that the output electricity is suitable for mobile devices. In order to ensure the compatibility condition, different phones, tablets and other similar smart devices used in today's world were examined and it was understood that an output of 5 volts and 2 amps would be suitable for almost all devices. In addition, it is aimed to move this circuit to the next level by using digital type current and voltage sensors in order to see the input and output voltages and detect possible problems. The reason for this type of sensors is to control the production of the input voltages of the circuit to be made and to prevent the circuit from being damaged. It is aimed to show in detail whether the power obtained by using 7-segment LEDs will be dangerous for the circuit and the device so that the sensors at the voltage input can clearly show data to the user. In addition, this excess power will be prevented by using mosfets in case of a possible overproduction, and there will be a manual switching system. These features will take the circuit to the next level while making it safe.

5. Results And Discussion

In this part, we will discuss the outputs of the circuit that decided to make it as a result of the researches. When you look at the circuit, it is a great difficulty to have more than one voltage type behind, but it is not a type of circuit made for the first time. When this difficulty is examined in general, it is seen that various restrictions and current dividers are used. When the diagram of the circuit we will make is examined, the voltage sensors that are planned to be used are digital, and each input and output power is controlled in isolation, as well as being able to be followed, which includes great differences and innovations. From another point of view, the battery control unit, which is designed to charge mobile devices appropriately, will be used as new type components. Transistors appear to be common in ordinary charge control circuits. This can be shown as another innovation. The controlled charging of the battery and the isolation of the battery's outgoing voltage also emphasize the importance of this control system once again.

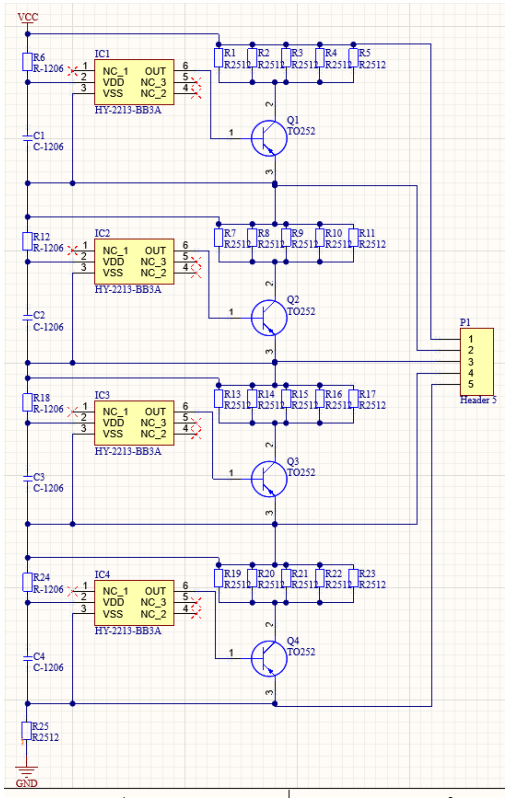

Figure 12. Battery management circuit (BMS)

Figure 5.1 clearly shows us how to charge a 4-cell battery. Unlike standard battery control units, the HY-2213 component is used. The suitability of the planned circuit for telephone batteries has been tested before and is shown in the datasheet of the product.

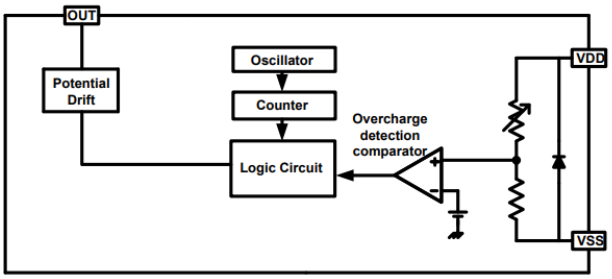

Figure 13. HY-2213

5. Conculsions

In this study is detailly explained to how to works DC/DC converter and their applications. Today's world, we must to change our vision to converters. If we have to many ways for generating energy, we must to need multi-inputs for DC/DC converters. After we understanding this two main idea, we must combine with battery charges. To easily understand the main idea which is multi-input DC/DC converter design for mobile devices. In addition to these, when the circuit to be made is examined from a different angle, both the entrance controls and the battery control units differ from the products that have been studied in the market, and another point of view has been brought. Since the circuit contains alternating and direct current due to its structure, Safety has been tried to be kept at the highest level as explained in chapter 5.

References

[1] Marzo, Understanding Buck Power Stages in Switchmode Power Supplies, T. Instruments, 1999 .

[2] J. C. A., C. Restrepo, «A noninverting buck-boost dc-dc switching converter with high efficiency and wide bandwidth,» *IEEE Transactions on Power Electronics, vol. 26*, September 2011, p. 2490 2503.

[3] L. Y. F.-Y. Chen Yaow-Ming, « Multi-input DC/DC converter based on the multiwinding transformer for renewable energy applications.,» IEEE Trans Ind Appl , 2002, p. 38:1096–104.

[4] A. L. a. J. A. P. L. Solero, «Design of multiple-input a dc dc power converter for hybrid vehicles,» *IEEE Trans. Power Electron.*, Oct. 2005., pp. vol. 20, no. 5,1007–1016.

[5] Available: https://www.ti.com/tool/PMP8740 . [Acces: 04 20222].

[6] S. Furbo, «Thermal destrafication in small standart solar tanks due to mixing during tapping,» *Proceeding of ISES Solar Wolar Congress*, Jerusalem,Israel, 1999.