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Human Machine Interface for Step-up DC-DC Converter

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ABSTRACT

Step-Up DC-DC converter, also known as a boost converter, is a series of power electronics that can raise a DC voltage source to remain a variable DC voltage source. This power converter This includes the type of switching-mode power supply (SMPS). The change in output voltage controlled by adjusting the power switch of pulse width modulation (PWM) on the boost converter. This article discusses the design and manufacture of a regular boost converter that can be controlled by a computer. This boost converter has an interface with a computer using Visual Studio software to create a human-machine interface between computer and boost converter. And MOSFET as a power switch to boost converter, an ATMega328 microcontroller as a signal processor. The resulting prototype can produce a higher and varied output voltage when the duty-cycle is varied.

Key words: Boost Converter, MOSFET, Gate Drive, Visual Studio 2012.

1. INTRODUCTION

Non-conventional electricity generation is increasingly available near consumers like photovoltaic and wind turbine. The energy produced by non-conventional power plants is usually stored or directly used. But it requires a process to be more efficient and standard achieves, so that it can be used safely. The output voltage from renewable energy generators is usually relatively small, so a boost converter is needed to increase voltage. Boost converter is a converter that can control voltage following the input voltage or become higher by increasing the width of the PWM pulse (duty-cycle width) [1], [2].

Previous DC / DC boost converter studies such as maximizing renewable energy by modifying the boost converter circuit to improve photovoltaic efficiency[3], [4], modifying switching, capacitor, input, and interleave boost converter [5]–[8]conducted a full-bridge dc-dc converter simulation[9] , an ac-dc boost converter design [10]and a dc-dc converter study at high voltage[11]–[13].

The role of devices in the age of the Internet of Things (IoT) aims to obtain real-time data from the real world and provide services to users. For this reason, power electronic devices have also developed using the human-machine interface to facilitate measurement and control following the user needed. [14]. the use of interfaces on recently power electronics study is to modify pulse width modulation[15], and interface in the desalination process using renewable energy sources[16].

This article discusses the design and implementation of a dc-dc boost converter circuit with an output voltage that can be controlled by a microcontroller as a switching controller, analyzes the efficiency of the boost converter design, and uses the human-machine interface as the acquisition of voltage and current measurement data.

2. TOPOLOGY BOOST CONVERTER

2.1 Boost Converter

The boost converter converts variable DC voltages to higher and fixed output voltages used for various applications. The boost converter uses a switching component that regulates the size of the duty cycle. Some examples of commonly used switching components are IGBT, thyristor, MOSFET, etc. The form of the basic circuit of a boost converter consists of only a few components such as a DC source, an inductor, a diode, a capacitor and a resistor shown in Figure 1[3], [4].
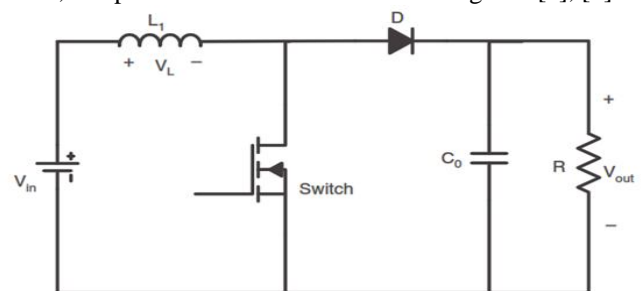

Figure 1: DC / DC converter circuit schematic[4].

MOSFET switching component as a duty cycle size control for current counters. For open and close MOSFET is using a control circuit. When MOSFET is closed, energy will be stored in the inductor and will be released when it opens. Performance of the DC Chopper type Boost can be divided in 2 main work:

A. When the MOSFET is on (closed)

The diode turned off. Current will flow clockwise from the source to the inductor (current is charging in inductor). The polarity inductor on the left side is more positive than the right side. Shown by Figure 2.
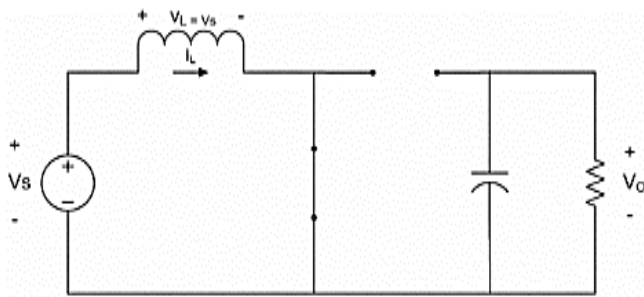
Figure 2: MOSFET Boost Converter ON[17].

B. When the MOSFET is off.

The diode is on. The current stored in the inductor will decrease because of a higher impedance. The reduced current at the inductor causes the inductor to reverse polarity (more negative on the left side). Thus, current flow on diode and load is sum current at the source and inductor (series). At the same time, the capacitor will also store energy in the form of voltage. That is why DC Chopper Type Boost has a higher output compared to the input.
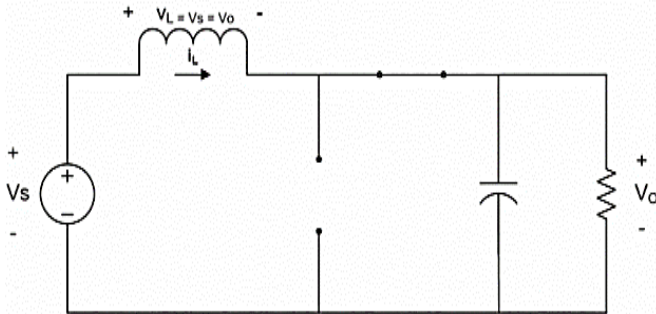

Figure 3: MOSFET Boost Converter OFF[17].

The ideal transformation of the input and output voltage of the DC-DC boost converter is:

$$\frac{V_o}{V_i} = \frac{1}{1-D} \quad (1)$$

The On-Off MOSFET condition controller uses Pulse Width Modulation (PWM) and widely used for research in controlling the output voltage of a static power converter. PWM is a modulation technique that changes the pulse width with a fixed frequency and amplitude value [15], [18]. PWM can be considered as the opposite of ADC (Analog to Digital Converter) that converts Analog to Digital signals. PWM is used to produce analog signals from digital devices (as an example from microcontrollers) pulse width modulation is a digital signal that is the square wave in width can be adjusted as needed by changing the duty cycle. To get a variable output voltage, the duty cycle of a square wave can be changed[19], [20].

2.2 Human Machine Interface

The human machine interface (HMI) is a communication mechanism between users with a system. The user interface can receive information to help find problems and solutions as well[16].

Visual Basic is a Programming language to create graphical Windows-based applications or Graphical User Interface. Visual Basic is object-oriented programing, meaning that the program waits for the user to respond to certain events. Visual Basic provides many conveniences for Windows-based program designers to make the display as attractive as possible following the programmer needed. The development Visual Basic program can also use the Windows API (Application Programming Interface), but require additional external function declarations. Visual Basic is very suitable to be used as a tool to help develop database-oriented applications.

3. METHODOLOGY

The boost converter circuit design is purpose to increasing input voltage of 12 VDC to output voltage 12VDC to24VDC. The gate drive circuit functions as the driver of the MOSFET used on the boost converter circuit, potentiometer function as control size of the duty cycle to produce the voltage as desired. Arduino Uno functions as a regulator of the working system to generate PWM signals, as well as sending and receiving data to a PC as a human-machine interface. The design is illustrated on Figure 4.
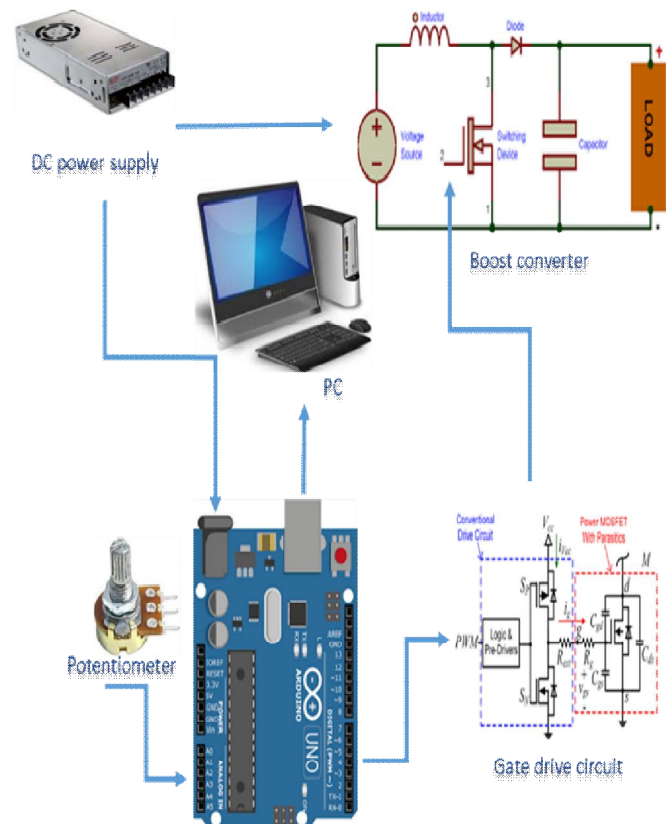

Figure 4: Block Diagram Design

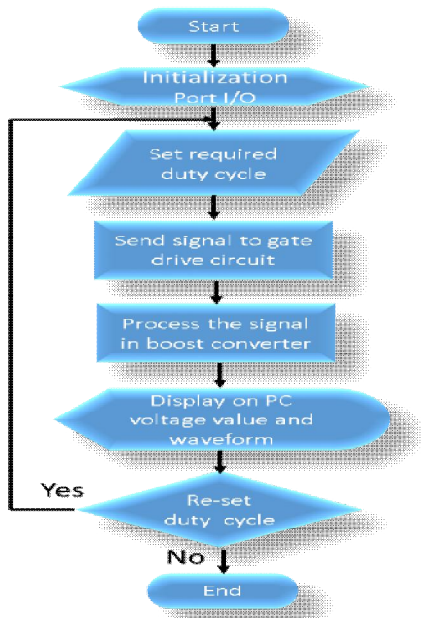Flowchart design of boost converter with the human-machine interface is shown in Figure 5.

Figure 5: Flowchart Design

4. RESULT AND DISCUSSION

The implementation design of the boost converter integrated with the human-machine interface based on the block diagram is shown in Figure 6 and overall appearance of the human-machine interface as monitoring of the boost converter circuit has shown in Figure 7.
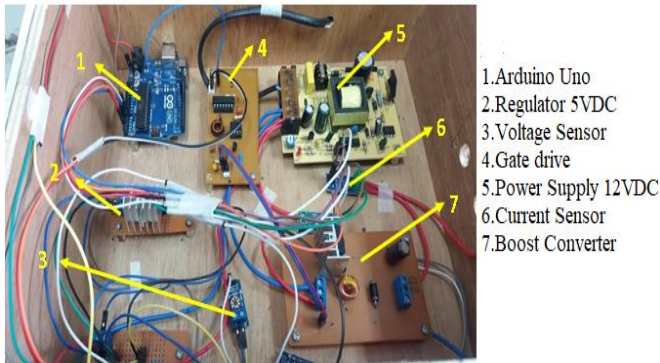

1.Arduino Uno
2.Regulator 5VDC
3.Voltage Sensor
4.Gate drive
5.Power Supply 12VDC
6.Current Sensor
7.Boost Converter

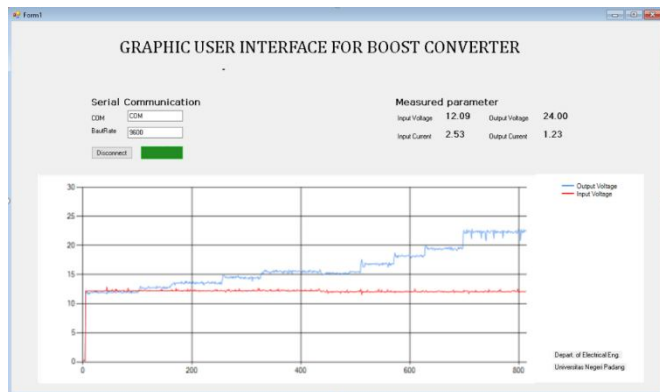**Figure 6:**Implementation of boost converter integrated with HMI

Figure 7: HMI measurement of voltage and current

In Figure 7, there are three parts to the interface. The top left is the serial communication section. There are two textboxes displaying COM and baud rate, a connect button, and one connectivity indicator. And the upper right is the result of the voltage and current sensor from the boost converter circuit.The lower part is a graphic of input and output voltage of the boost converter circuit.
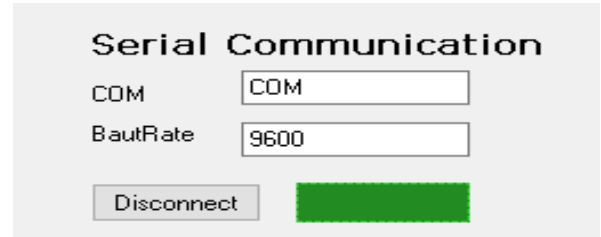

Figure 8: Serial communication.

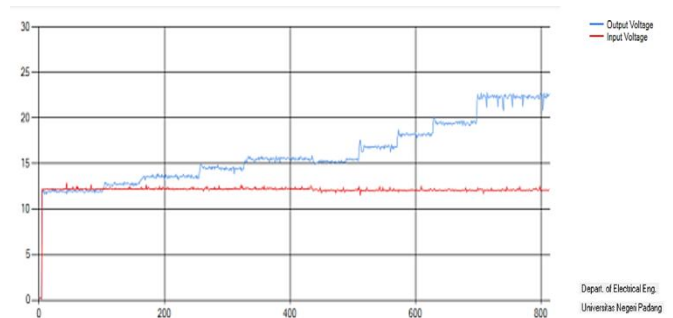**Figure 9:** Measured parameter voltage and current.

Figure 10: Graphic of Input and output Voltage.

4.1Power Supply Testing

Testing the power supply to find out the power supply circuit can work well. So it can supply Arduino Uno power, gate drivers, potentiometer, and boost converter circuits. The power supply measurement table shown in table 1.

Table 1: Power supply measurement

Measurement Parameter	Value
Source Voltage	220 VAC
Power supply Voltage Output 12 V	12.18V DC
Regulator Voltage Output 5V	4.96VDC

From the measurements, the 12 VDC power supply output voltage is 12.18 VDC, and 5 VDC regulator output voltage is 4.96 VDC. Deviations in the measured output voltage are still tolerance limits. It can be concluded that generated voltage by the power supply and regulator works well.

4.2 Gate Drive.

The gate driver circuit test is connecting the gate drive circuit to the 5 VDC power supply, the PWM output signal generated by the ATMega328 Microcontroller connects to the signal input section of the gate drive. The output signal generated by the gate drive can be seen using an oscilloscope, location of the measuring point for testing the gate drive circuit at the gate drive circuit output. The shape of the PWM signal output from the gate drive with a duty cycle of 10% is shown in Figure 11-13.
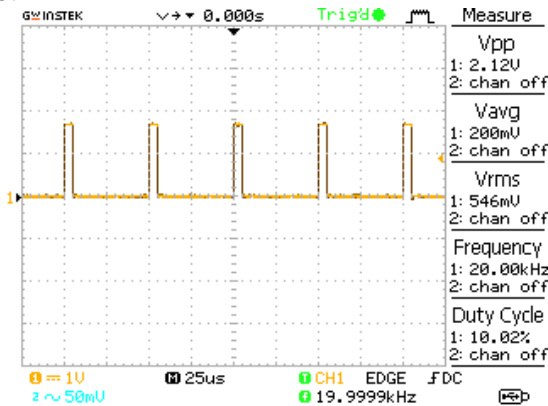

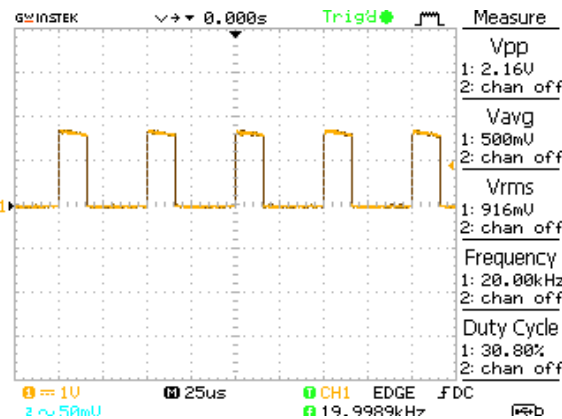**Figure 11:**Output signal of Gate Drive with Duty Cycle 10%

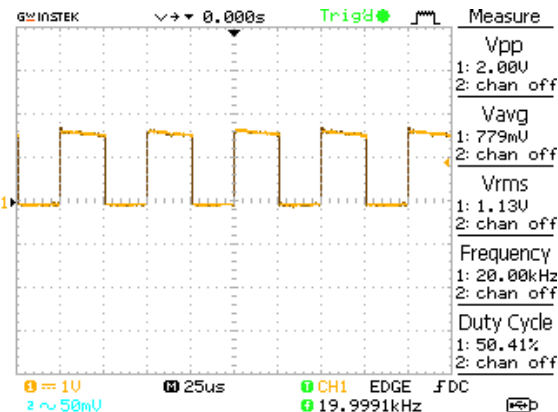**Figure 12:** Output signal of Gate Drive with Duty Cycle 30%

Figure 13: Output signal of Gate Drive with Duty Cycle 50%

4.3 Boost Converter

Boost converter testing by applying a 12VDC voltage to input boost converter circuit and duty cycle setting are 10%, 15%, 20%, 25%, 30%, 35%, 40%, 45%, and 50%. The load used is 70Ω resistor. The measurement results of the boost converter in Table 2.

Table 2: Measurement of Boost Converter with Load 70 Ω

Duty Cycle (%)	V_{in}	I_{in}	V_{out}	I_{out}
10	12.12	0.29	13.34	0.26
15	12.10	0.30	14.24	0.25
20	12.10	0.32	15.14	0.26
25	12.10	0.34	16.29	0.25
30	12.07	0.36	17.39	0.25
35	12.10	0.37	18.57	0.24
40	12.15	0.39	20.12	0.24
45	12.12	0.42	21.97	0.23
50	12.07	0.43	24.95	0.21

From the measurements, it can be seen that increase output voltage is proportional increase of the duty cycle. The graph of the output voltage shown in Figure 14.
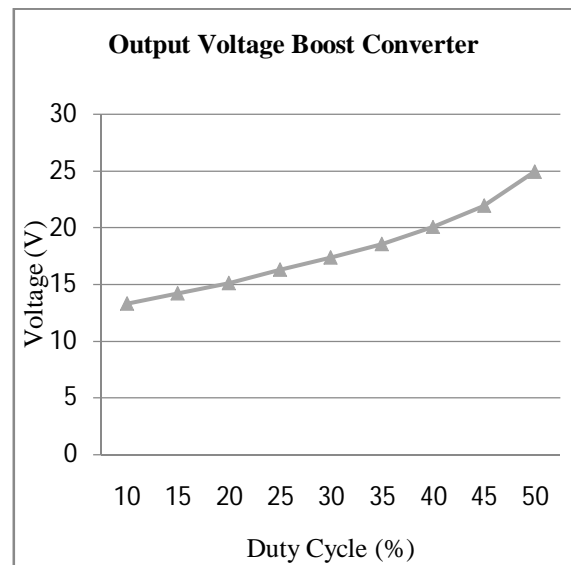

Figure 14: Output Voltage vs Duty cycle.

5. CONCLUSION

In this paper, the design of the boost converter using the human user interface can be done. The HMI can display graphs of input and output voltages, current data, and input-output voltages. With the graphical interface and the data displayed will make it easier for users to control the output voltage needed. Based on measurement results, that increase in output voltage is proportional to the increased duty cycle.

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