STEP-DOWN VOLTAGE CONVERTER FOR STUDENTS STUDY

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REZUMAT. În cadrul lucrării s-au studiat diferite metode de comandă a tranzistorul comutator, partea practică constând în realizarea a două convertoare cc – cc (coborâtoare de tensiune) unul dintre acestea având generatorul de comandă al tranzistorului realizat cu elemente discrete, iar altul fiind comandat de către un circuit specializat. Între cele două modalităţi de comandă se face o comparaţie şi se evidenţiază pentru fiecare în parte avantajele si dezavantajele.
Convertorul realizat cu elemente discrete permite reglarea tensiunii la ieşire, reglarea frecvenţei şi modificarea în trepte a bobinei, a condensatorului de filtrare şi a sarcinii, fapt ce permite observarea influenţei fiecărui element de circuit asupra funcţionării convertorului.

Cuvinte cheie: convertor. limitare current, MOSFET, PWM

ABSTRACT. In this paper have studied different methods of control transistor switch, the practical realization consisting of two converters DC - DC (descending voltage) one of which has generator control of the transistor realized with discrete elements, and another being ordered by a special circuit. Between the two control methods are compared and highlights the advantages and disadvantages of each.
Converter realized with discrete elements allows the output voltage regulation, frequency regulation and changes in steps of the coil inductance, filter capacitor and load, allowing observation of the influence of each element on the operation of the converter circuit.

Keywords: converter, limiting current, MOSFET, PWM

1. INTRODUCTION

The issue of static power converter circuits and power electronics is an issue of particular interest in light of developments in the electronics industry and upgrading equipment in this area. Functioning circuits and electronic devices require DC power for energy supply. Huge progress made by the power electronics and microelectronics in recent years have led to the creation of a DC voltage source with high reliability, good performance, lightweight and low volume.

Another category of variable-voltage switching, subject of this paper, is switching power converters made with specialized integrated circuits, including control functions, control and protection.

2. MOSFET TRANSISTOR

Unipolar transistors used in switching power converters are FET Transistors (field effect) with the gate (grid) isolated in the literature known as MOSFET. They are induced or initial channel N. The transistor has the advantage that it can operate without damage with gate voltages (from source) positive and negative.

Symbol that is represented MOSFET transistor with N channel is presented in Fig.1. The three terminals of the transistor are: G= gate or grid, D = drain, S = Source

Output static characteristic of transistor is presented in Figure 2. It shows how the variation of drain current I_D depending on drain-source voltage U_{DS} for several voltages applied between gate and source U_{GS}.

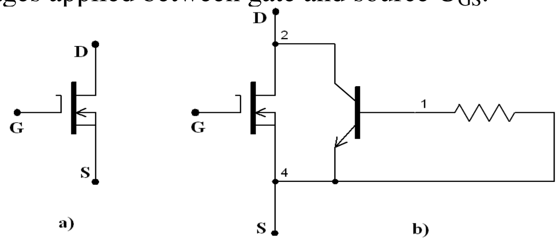

Fig. 1. MOSFET transistor with N channel.
a), b), representation of transistor.

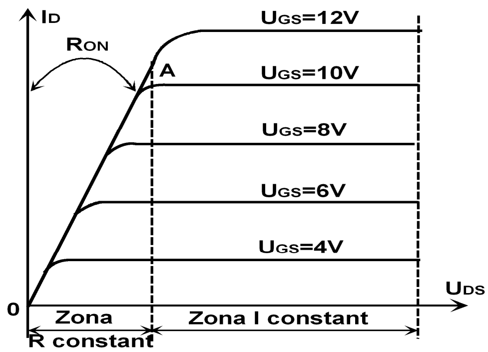

Fig. 2. Output characteristic of MOSFET transistor with N channel

3. ADVANTAGES AND DISADVANTAGES OF SWITCHING MOSFET TRANSISTOR.

Switching MOSFET transistor used in switching, compared with high voltage bipolar transistor has the following advantages and disadvantages:

•**Advantages:**

•small stroke leading to reduced switching losses and higher switching frequency of converter up to 200kHz;

•control circuit must not debit a high active power as a result it is easier to realize;

•because there is no time storage transistor, the danger of saturation of the converter transformer's symmetrical magnetic core is practically suppressed.

•**Disadvantages:**

•maximum allowable voltage between drain and source lower (up to 1000V);

•greater losses during the conduction TON due to the resistance value RON through the circulating of drain current ID linear ascending (transistor in the converter have inductive load); The more breakdown voltage UDS is higher so the RON increase.

4. PWM GENERATOR REALISED WITH DISCRETE CIRCUITS

Triangular and rectangular voltage generator was made to the oscillator consists of two operational amplifiers LM741 under one integrator and one comparator with hysteresis (Fig. 3). Triangular voltage obtained in the first operational amplifier output will be applied to a comparator LM339 performing modulation in duration. In this way was made rectangular voltage generator to control the power transistor switch converter.

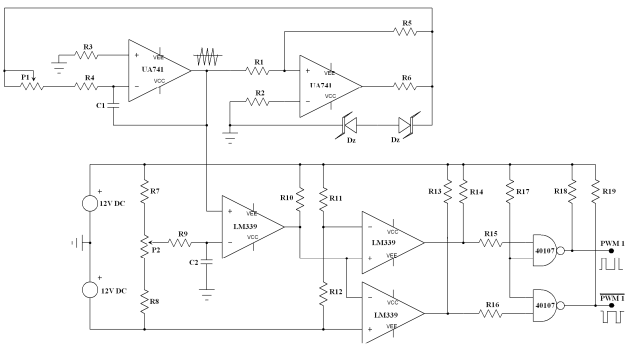

Fig. 3. PWM signal generator developed by LM339 and UA741

By changing the value of the potentiometer P1 shall be made the output pulse frequency changes and through the modifying the value of potentiometer P2 is impulse change as a positive duration.

The output voltage of this type of PWM signal generator is connected to the power switch transistor gate in voltage step-down converter BUCK or step-up voltage converter BOOST.

Scheme of creating a converter DC - DC step-down voltage, which uses as a switching element MOSFET transistor controlled to a PWM signal generated by the circuit in figure 3 is shown in figure 4.

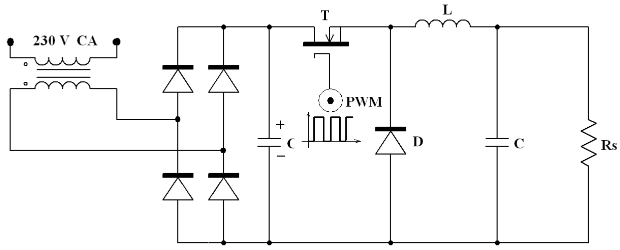

Fig. 4. Step-down CC-CC voltage converter BUCK

5. SPECIALIZED CIRCUIT UC384X

The fundamental challenge in implementing supply sources is to achieve simultaneously two conflicting objectives: good electrical performance and low price. UC384X integrated circuit is a pulse duration modulator that was designed with two objectives considered above. This integrated circuit makes it possible to design a controller that can get inexpensive to all the advantages of performance adjustable voltage switching sources. In addition UC384X series circuits are used for DC-DC converters for control MOSFET transistors type or bipolar transistors.

Circuits of the family UC384X permit the construction of CC-CC converters at fixed frequency with a minimum of external components, and providing protection from low voltage, with a starting current below 1 mA.

Internal wiring diagram of the integrated circuit can be studied in Figure 5.

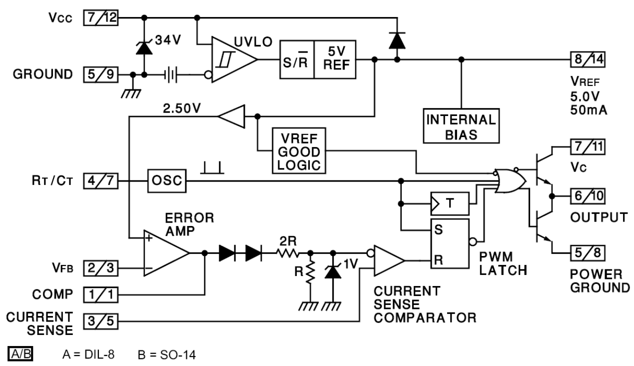

Fig. 5. Block diagram of the integrated circuit UC384X

CURRENT SYSTEM CONTROL OF SPECIALIZED CIRCUIT UC384X

In Figure 6 is presented current system control with two loops in a typical application BUCK regulator. In this circuit a clock signal initializes the transistor control pulses at a fixed frequency. End of each pulse signal occurs when the current reaches the limit of the error signal. Thus, the error signal actually controls peak inductor current. This working contrasts with the conventional schemes in which the error signal directly controls the pulse length regardless of the current through the coil. By using current control converter performance increase. Control circuit corrects input voltage variations directly without using an error amplifier. Because of this error amplifier can be used only to correct variations in load. For converters in which inductor current is continuous peak current control is almost equivalent to the current control environment. Therefore, when converters in current mode control, inductance can be treated as a current source controlled by the error voltage.

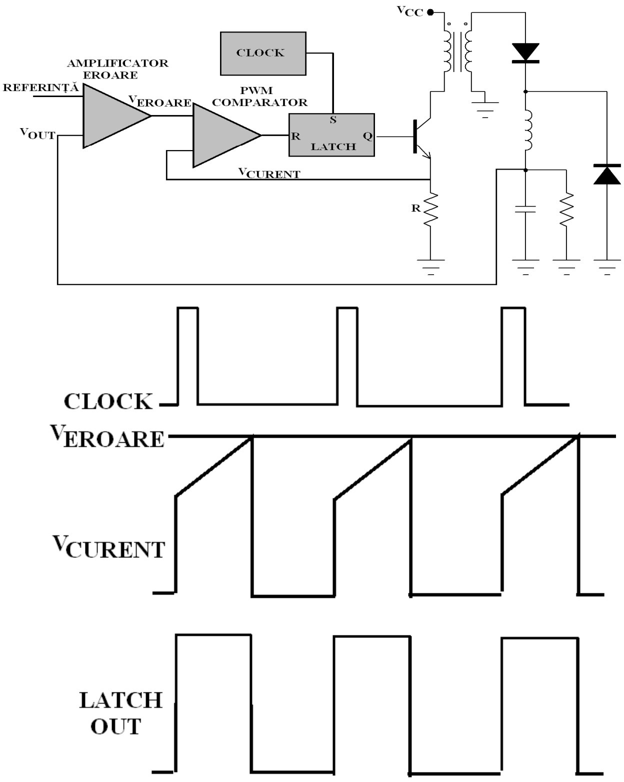

Fig. 6. Current system control of the integrated circuit UC384X

BLOCKED IN CASE OF LOW VOLTAGE OF THE INTEGRATED CIRCUIT UC384X

Blocking circuit in case of low voltage is necessary to ensure that the supply voltage circuit can be fully operational. Figure 7 shows that control voltage in case of low voltage is fixed internally between some voltage limits.

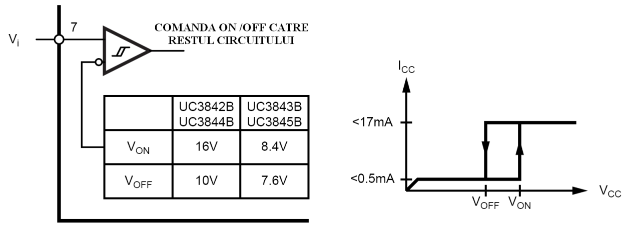

Fig. 7. Blocking in case of low voltage

OSCILLATOR OF SPECIALIZED CIRCUIT UC384X

Oscillator circuit is determined through the resistor R_T and capacitor C_T as shown in Fig. 8.

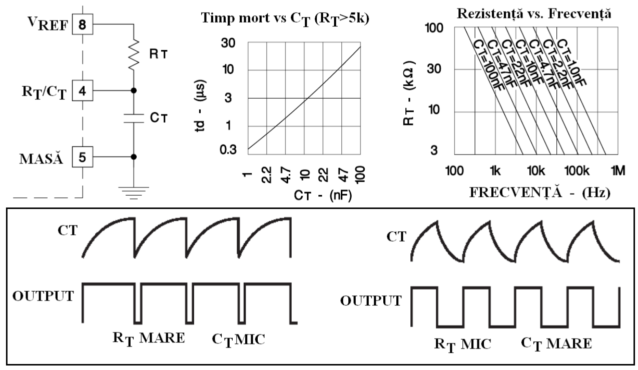

Fig. 8. Oscillation circuit and characteristics of their values

Capacitor C_T is charged by the reference voltage Vref=5V through the resistor R_T and discharged through the internal current source. The first step in the selection of oscillator components is required to determine the dead time circuit. Once set dead time is used to obtain the closest standard value of C_T. The value of R_T is obtained by interpolation using the value of C_T and oscillator frequency.

Resistor can be calculated using the following equation:

$$F_{OSC}[kHz] = \frac{1,72}{R_T[k\Omega]\cdot C_T[\mu F]}$$ for $R_T>5k\Omega$

CURRENT SENSING AND CURRENT LIMITATIONS

UC384X's input current is configured in Figure 9.

Conversion current - voltage is made with an external reference resistor R_S with respect to ground. Under normal operating peak voltage is controlled through the R_S according to the following relationship.

$$I_{pk} = \frac{V_{(pin1)} - 1{,}4}{3 \cdot R_S} \cdot \left(\frac{N_S}{N_P} \right)$$

R_S resistor can be connected directly to the power circuit or through a current transformer as shown in Figure 9.

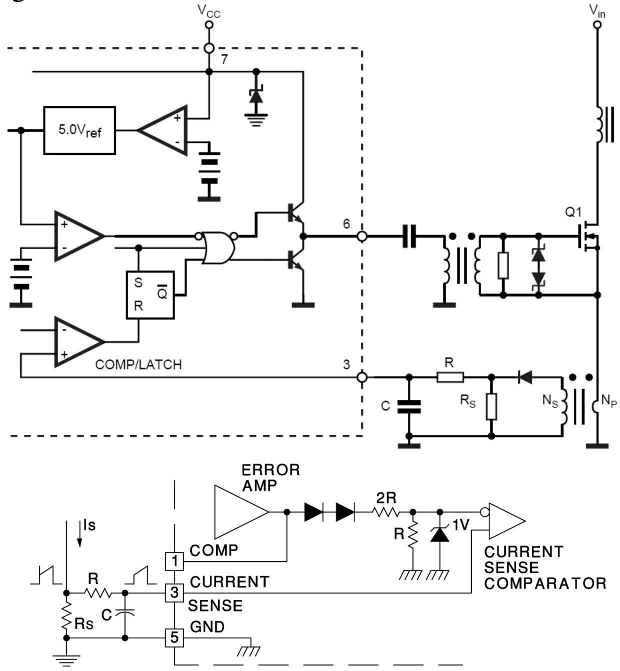

Fig. 9. Current sensor.

Even if a direct connection would be simpler the transformer can reduce power dissipation in R_S and errors.

When the current sensing circuit is in series with transistor output, as shown in Figure 9, the current waveform will have a high peak on the rising edge. As shown, a simple RC circuit it is used to mitigate the peak. RC time constant of the circuit should be approximately equal to the duration of peak current (typically a few hundred ns).

6. EXPERIMENTAL RESULTS

The following experimental data was taken from the basically electrical scheme of the DC - DC step-down voltage converter, with adjustable output voltage, without overload protection. Wiring diagram is shown in Fig. 3.

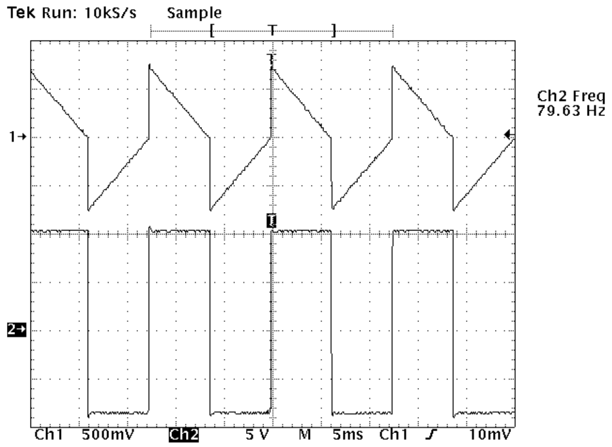

Fig. 10. Mode of generating the pulses

Waveform measured with 1 test lead represents voltage across the load resistance and the waveform measured with the 2 test lead represents voltage command of the MOSFET transistor.

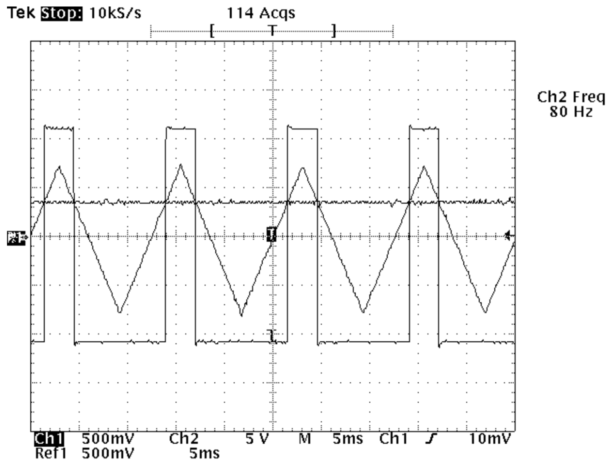

Fig.11. Pulse width modulation control with the integrated circuit LM339

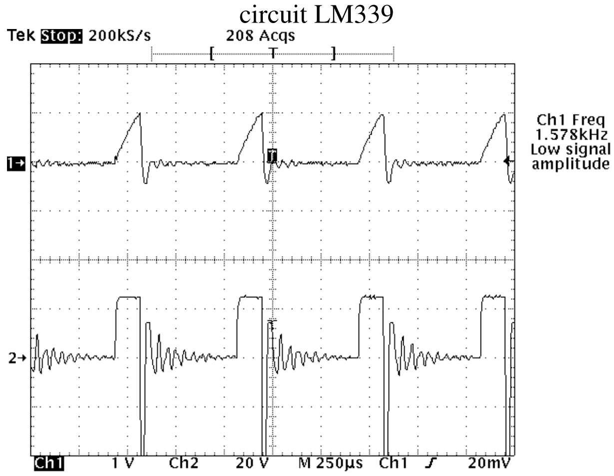

Fig. 12. Influence of the coil L from converter circuit at a fixed value of load resistance when in circuit is not connected diode and filter capacitor

The following experimental data was taken from the basically electrical scheme converter DC - DC step-down voltage, with adjustable output voltage and with overload protection (Figure 15).

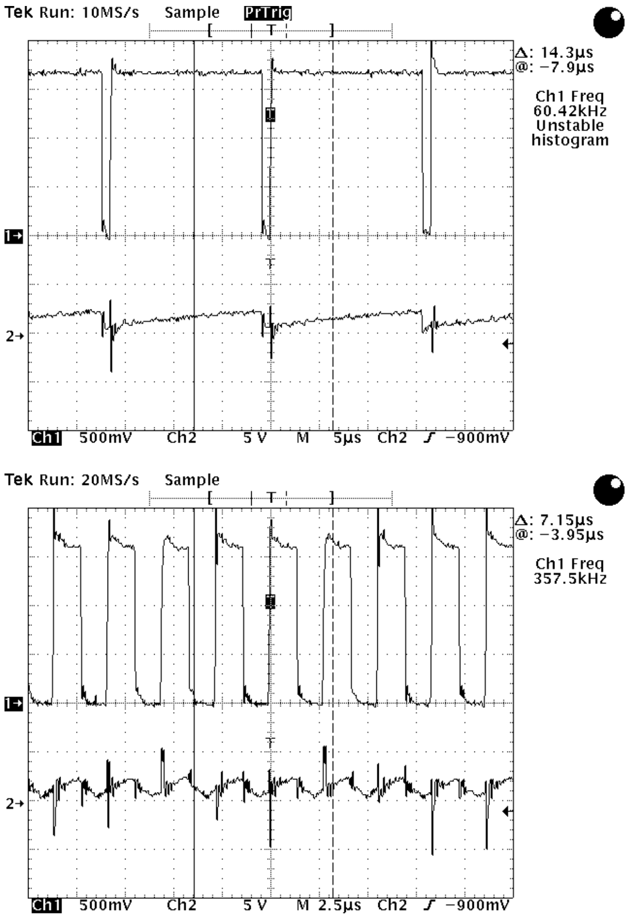

Fig. 13.: Changing the operating frequency of the circuit UC3843 from the group R_T - C_T

Waveform measured with 1 test lead represents voltage command of the MOSFET transistor and the waveform measured with the 2 test lead represents oscillating voltage produced by R_T-C_T group and applied to pin 4 of integrated circuit UC 3843.

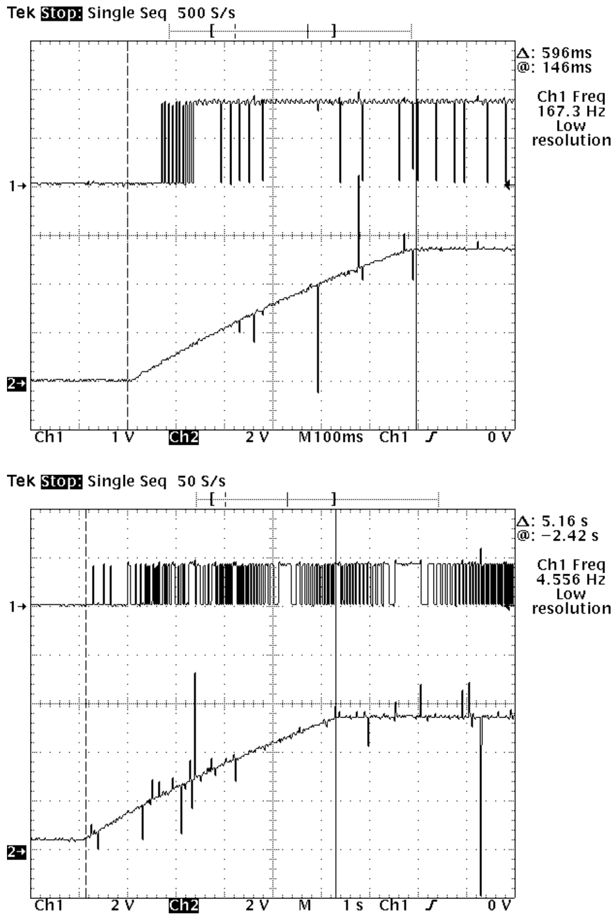

Fig. 14. Change duration of slow start

7. CONCLUSIONS

From the study the following conclusions can be drawn:

- circulated power is high
- output voltage can be adjusted
- output voltage is stabilized
- operating frequency can be set in a wide range
- because it can operate at a frequency of hundreds of kHz, coil and filtering capacitance are small
- overall dimensions are reduced
- radiator for cooling of the transistor switch is not large
- converter can be protected against overload and short circuit
- is made a slowly increase through the load current at startup circuit
- current and voltage ripple is reduced because the operating frequency is high
- converters are much lighter than the linear converters
- production costs are lower

DC - DC step-down voltage converter, with adjustable output voltage, without overload protection, can be used to demonstrate how work the converter and to observe the influence of each circuit element within it.

DC - DC step-down voltage converter, with adjustable output voltage, with overload protection which is controlled with dedicated circuit can be used to demonstrate the facilities offered by UC 3843 PWM controller, and for its use as a adjustable voltage source, stabilized, with the possibility to limit the current through the load

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