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VERY HIGH FREQUENCY SWITCHING POWER SUPPLY WITH HIGHS PERFORMANCES

Jamal Boukherouaa*[1] A. Belfqih[2] A. Hmidat[3] F. El Mariami[4] A. Berdai I.Elkhaloufi[5] A.Aquadoh[6] Bensassi[7] A. Lekbich[8]
[1*]Ecole Nationale Supérieure d'Electricité et de Mécanique (Université HassanII Ain Chock) ENSEM - Oasis, Route d'el Jadida - BP : 8118 - Casablanca - Maroc.
*Correspondence Author: **Jamal Boukherouaa**

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Abstract
In this research paper, we try to demonstrate that it is currently possible to achieve very high frequencies in the forced switch-mode power supplies (the conventional switching power supplies) without performances degradation and preserving the qualities required in the field of power supplies. This thanks to the use of the new generation of magnetic and electronic components and an appropriate design.
We have made these investigations, through experimental tests performed on a prototype operating at an extremely high frequency (2,6MHz with a current which can reach 20A). The performance quantification tests have concerned mainly: the signals quality, the static behavior, the dynamic behavior, the residuals and the energetic efficiency.

Introduction
In the power supply systems, the high frequency operation is a highly sought advantage because of the multiple benefits it offers: miniaturization, weight reduction, size reduction, improvement of dynamic performance...
However, it is often said that the conventional switching power supplies are not suited to the high frequencies, due to the sharp deterioration of the performances of these power supplies when it is exceeded the barrier 1MHz. For these high frequencies, we then use the resonant power supplies which show, among others, the drawback of operating at variable frequency.
In this context, we try to demonstrate, through this modest research paper, that it is currently possible to achieve very high frequencies in the forced switch-mode power supplies without performances degradation and preserving the qualities required in the field of power supplies. This thanks to the use of the new generation of magnetic and electronic components and an appropriate design.
We have made these investigations, based on experimental tests performed on a prototype operating at an extremely high frequency (2,6MHz with a current which can reach 20A). Performance quantification tests were mainly concerned: the quality of the voltage and current signals, the static comportment, the dynamic comportment and the energetic efficiency.

Prototype presentation
The overall circuit diagram of the power supply is presented in the figure1. It is a prototype for an operation with an input voltage: 48V DC, an output voltage: 12V/20A DC and a switching frequency: 2.6MHz.

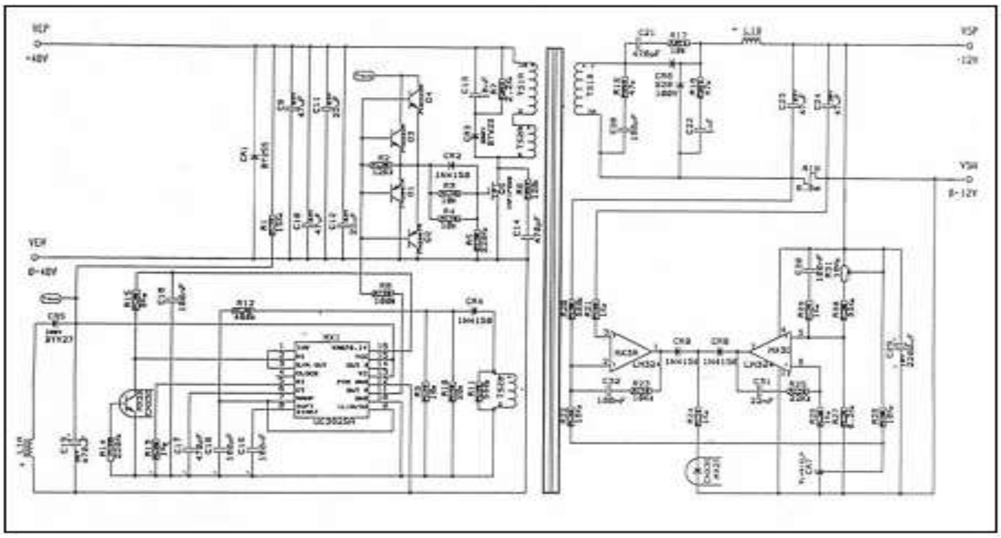

Figure1: Global circuit diagram

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This global circuit diagram especially includes:
- An output voltage control loop to maintain this value constant even if we vary the load or the input voltage. This loop also includes a correction circuit to control the excesses of the output voltage and the system response time. The output voltage can be set to a value different from that chosen for the prototype.
- A control loop of output current for the protection against overruns of the maximum current set by the user. This loop also includes a correction circuit. The passage of the voltage control loop to the current control loop is done automatically to protect the switching power supply.
- A fast electronic protection against the short circuits and the brutal overcurrent. This protection permits to impose instantly the output voltage to 0 without waiting for the current control loop.
- A Protection against reverse polarity.

The switching power supply presented in figure1 uses the latest generation of electronic and magnetic components. The transformer, the inductances, the filter capacitors, the electronic switches and their control circuits are particularly suited to high frequencies and are chosen meticulously. For this, we performed several simulations and several preliminary tests to arrive at the final prototype.

Test results (signals quality tests)

The prototype has been the subject of several tests. In figures 2 and 3 we measured at nominal point, the shape of voltages: Vds, Vgs, Vlc and Vs; respectively drain-source voltage of the power transistor, the control voltage of this transistor, the input voltage of secondary filter and the output voltage.

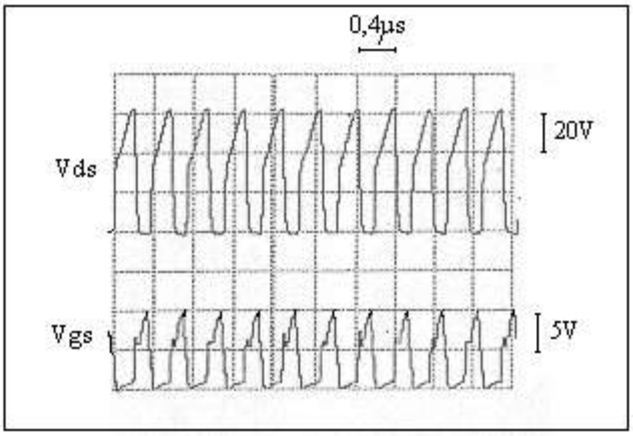

Figure2: Drain-source Voltage Vds and Gate-source Voltage Vgs

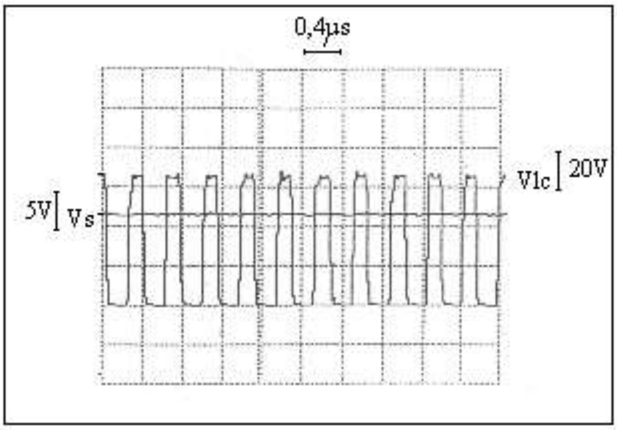

Figure3: Secondary Voltage Vlc and Output Voltage Vg

These gaits show that the switching power supply is working properly with a very good quality of signals and that the switching is done in good conditions (absence of peaks, very few parasites, stable operation ...).

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Test of dynamic behavior

-To test the dynamic behavior of the system, we measured, in a first time, the response to a voltage echelon (figure3).

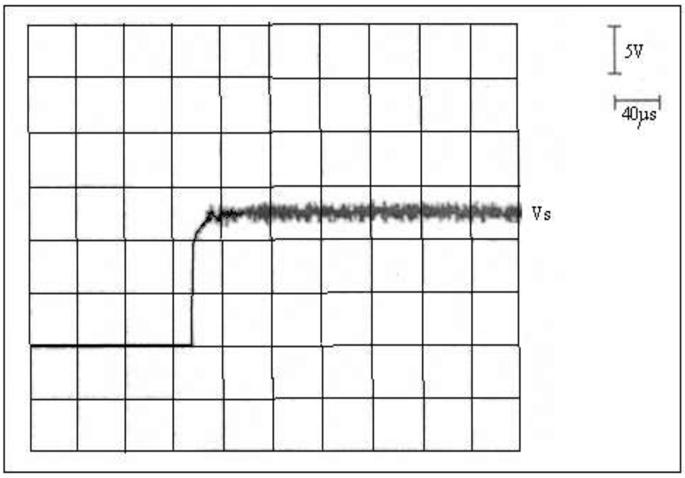

Figure4: Response to a voltage echelon

This test allows us to see the reaction of the prototype to the start or when restarting after tripping of an integrated protection systems (current control loop, reverse polarity, primary current protection ...). The figure4 shows us that the response time is very low (due to the high frequency) and overtaking is almost zero.

-Then we measured, in a second time, the response to a pulsed output current with peaks reaching 20A at a frequency 65 KHz.

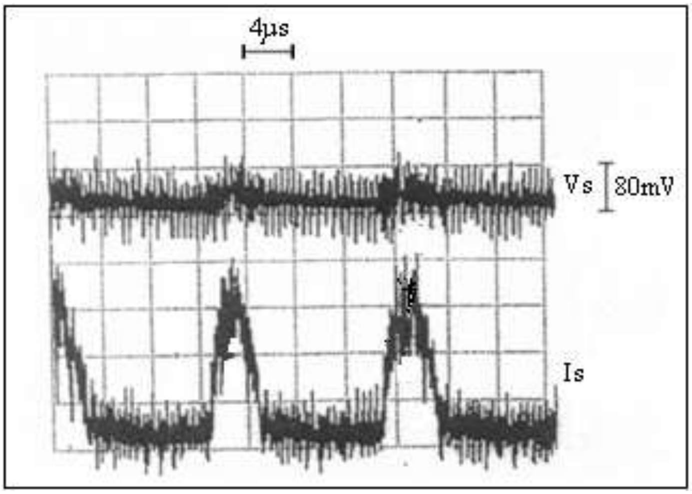

Figure5: Response to a pulsed current

We get extremely low response times and barely detectable overruns (figure4).

Test of static behavior

Regarding the static behavior, we measured, at first, the output voltage Vs when there is change in the load (variation of output current Is). Then we did the same thing when the input voltage Ve varies in the ascending and descending direction.

Ve = 48V :

Vs (V)	11,88	11,95	11,97	12,00	12,00
Is (A)	0	2	7	13	16

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Is = 16A :

Vs (V)	12.00	11,98	12.00	12.01	12.03
Ve (A)	30	40	48	52	60

We can notice that the output voltage is not very affected by these variations.

Energy efficiency

In the seventh experimental test, we did an energy audit ; this by measuring the yields of the prototype obtained for different values of the load and by a qualitative control of the echauffement of the power circuit components (in particular the switching transistor and the transformer).

Ve = 48V :

Yields	87	88	88	89	90	91
Is (A)	1	4	7	10	13	16

So we get very high yields (given the high switching frequency); and these values compete with the resonant power supplies reputed to have good yields. Therefore, we can deduce that the power dissipation in the power circuit components are weak; which justifies the moderate echauffement of the latter.

Residuals test

Finally, in the last test, we measured the peak to peak ripple of the output voltage, called residuals, by the standard method CNET.

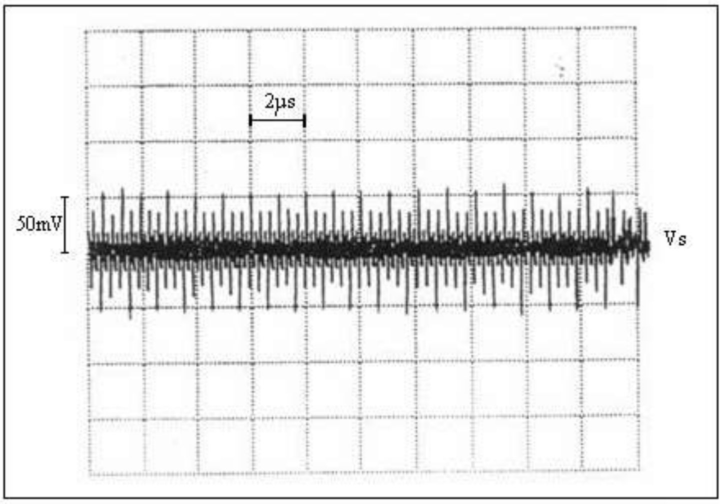

Figure6: Residuals test

We get a maximum ripple of 120mV (figure6) that means residuals about 0.9%. This value is very low and is even comparable to that of stabilized power supplies.

Conclusion

The results of tests performed on the realized prototype show that we can use the forced switch-mode power supplies (the conventional switching power supplies) at very high frequencies without performances degradation. The prototype also allowed to highlight the benefits of the high frequency operation in the field of power supplies; namely: miniaturization, flat form, weight reduction, size reduction, improvement of dynamic behavior...

Currently we are working on improving EMC interference and especially the electromagnetic disturbances of these switching power supplies to make them conform to international standards even at very high frequencies (unfortunately, this is not the case in the

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current prototype). We believe, indeed, that it is possible to design specific filters which can significantly reduce the parasites injected to the network due to the forced-switching essentially.

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