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# ABSTRACT

*High frequency arging, renewable energy, fuel-cell, power factor correction, LED lighting applications, due to their low response time, easy controlling and high power density. However, switching easy controlling and high. In this paper, properties of soft switching methods named as zero voltage transition, zero current transition (ZCT), and zero voltage zero current transition (d zero current switching (ZCS) are studied and discussed, simulations of soft switching DC to DC boost converters including these methods are accomplished for 500W and 1kW power at switching frequency of 100 kHz. Zero voltage zero current transition. However, by increasing frequency of the converter, switching losses and EMI noises increase accordingly.*

**Keywords:** *Switched-mode Zero Current Transition (ZCT), Zero Voltage Zero Current Transition (ZVZCT).*

# MAKALENİN TÜRKÇE BAŞLIĞI

# ÖZ

*Yüksek frekanslı anahtarlamalı DC-DC dönüştürücüler, kontrol kolaylığı, süratli tepki verme ve yüksek güç yoğunluğu avantajları nedeniyle endüstride; batarya şarj istasyonları, yenilenebilir enerji sistemleri, yakıt pili, güç faktörü düzeltme, LED aydınlatma, gibi uygulamalarda yaygın olarak kullanılmaktadır. Ancak, anahtarlamalı DC-DC dönüştürücülerde anahtarlama frekansı arttıkça güç yoğunluğunun daha da artmasına rağmen anahtarlama kayıpları, elektromanyetik girişim gürültüleri ve düşük verim sorunları ortaya çıkmaktadır. Bu sorunların üstesinden; dönüştürücünün sert anahtarlama ile çalıştırılması yerine, dönüştürücüye hücreleri gerilimde birleştirilmesiyle geliştirilen sıfır gerilim ve akımda geçiş ekniği ile sıfır akımda anahtarlama ve sıfır gerilimde anahtarlama (Zero Voltage Switching-ZVS) tekniklerini içeren aktif bastırma hücreli DC-DC dönüştürücüler incelenmiş, 500W-1kW güçlerinde ve 100 kHz anahtarlama frekansında yükseltici DC-DC dönüştürücülerin simülasyonları yapılmıştır.*

**Anahtar Kelimeler:** *Anahtarlamalı DC-DC Dönüştürücüler, Sert Anahtarlama (HS), Yumuşak Anahtarlama (SS).*

## 1. INTRODUCTION

The switched-mode DC-DC converters are widely used in the industry. They possess higher power density, faster transient response are derived and sizes of transformer, inductance stresses, the converter need to be operated with soft switching instead of hard switching In soft-switching techniques have been proposed (Bodur, Aksoy & Akın, 2002; Hollstein, Halgamuge & Glesner, 1996; Okamoto, 1999, p. 20).

The switching losses in converter occur during semiconductors are turning off and on. When the semiconductors are turning on, its voltage decreases and it current increases at the same time. On the contrary, during the semiconductors are turning off, its voltage increases and its current decreases at the same time. In process of transition (ZVT), zero current transition (ZCT) methods are commonly used for soft switching techniques.

## 2. HEADING-1

The active this snubber cell contains one or more an auxiliary switches to operate the main switch with soft switching. In last years, it has been improved and proposed, and moreover boost DC-DC converter including ZVZCT technique which obtained by combining ZCT T, and has been studied in the literature for about thirty years ZCT, two different ZVZCT active snubber cells are studied two different ZVZCT active snubber cells analyzed and simulated respectively (Kodama et al., 2001).

### 2.1. Subheading-1

In ZCT technique, it is aimed to make the main switch turn off when a current the snubber cell is consist of an auxiliary switch, resonant inductance and capacitor and an auxiliary diode. The general features of the converter are as follows (Hollstein et al., 1996).

It is very difficult to realize the avoidance of this short circuit causing losses and EMI problem increases cost of the converter (Okamoto, 1999, p. 35).

***Figure 1.*** *The basic ZCT converter circuit (Hollstein et al., 1996).*

As is subjected to zero by the snubber cell in Figure 2 just before the main switch is in turn off position. And after that, switching shown in Figure 3, the main switch current signal converter, the main diode turns on of the main switch is removed. Thus, the main switch turns off without switching losses. In with ZVS whereas an auxiliary switch turns on with ZCS. Both of them turn off with HS (Okamoto, 1999; Kodama et al., 2001).

### 2.2. Subheading-1

As seen in Figure 4, the basic ZVT converter has a snubber cell including resonant, an auxiliary switch and two an auxiliary diodes connected in parallel to the main switch. The waveforms in Figure 5 show that the snubber cell in Figure 4 makes the main switch turns on with ZVT, without losses and any voltage and current stress. Furthermore, the main switch turns of the converter other than the acceptable current stress on the auxiliary switch (Hollstein et al., 1996; Okamoto, 1999).

***Figure 2.*** *The basic ZVT converter circuit (Okamoto, 1999).*

Figure 5. Switching signal of the main switch (S), switching signal of the auxiliary switch (S1), the main switch voltage (VS), the main switch current (IS) and Lr inductance current (ILr), the main diode voltage (VDF), the main diode

### *2.2.1. Subheading-2*

The circuit in Figure 6 is designed in order to overcome most of the problems of the snubber cell that is connected in parallel to the main switch consists of a snubber inductance Ls , a snubber capacitor Cs and an auxiliary switch which are connected in serial to each other.

The capacitor urns on with ZVT and turns off with ZCT and all the other semi-conductors turns on and off with soft switching.

### *2.2.1.1. Subheading-4*

As is subjected to zero by the snubber cell in Figure 2 just before the main switch is in turn off position. And after that, switching shown in Figure 3, the main switch current signal converter, the main diode turns on of the main switch is removed.

## 3. METHODOLOGY

As seen in the main switch is the sum of the parasitic capacitor of the main switch and the other parasitic capacitors. The auxiliary switch turns on and off with ZCS. The converter decreases EMI noise and operates even at a wide range of load and high frequency (Okamoto, 1999).

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### 3.1. Sub Heading-1

A comparison of the modern soft switching techniques studied in Chapter 2 is given in Table 1.

It is deduced from Table 1 that the ZVZCT techniques are more advantageous than the other soft switching techniques mentioned in Chapter 2.

***Table 1.*** *The features of soft switching techniques (Bodur et al., 2002; Hollstein et al., 1996; Okamoto, 1999).*

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Feature** | **Basic ZCT** | **Basic ZVT** | **ZVZCT-1** | **ZVZCT-2** |
| The main switch’s turning on | HS | ZVT | ZVT | ZVT |
| The aux. switch’s turning on | ZCS | ZCS | ZCS | ZCS |

## 4. SIMULATIONS

The results are obtained by performing simulation of the boost DC-DC converters including the ZVZCT techniques, which featured in the soft switching techniques studied in Chapter 2.

### 4.1. Sub Heading-1

In Figure 10, the model of a 1 kW converter operating at 100 kHz frequency is demonstrated. The switching signal of the auxiliary switch S1 is applied before about.

Similarly, the switching signal of the auxiliary switch is applied before about 300 ns and removed after about 300 ns considering the turn off signal of the main switch (Okamoto, 1999).

### *4.1.1. Sub Heading-2*

Output voltage of the boost converter is 400 V, because of the duty cycle of the main switch is 0.5. As seen in Figure 11, the main switch turns off with ZCT and turns on with ZVT. The fall time of the main switch is 125 ns.

## 4. CONCLUSION

Although size of the circuit elements become smaller when the converter operates at high frequencies, power losses and EMI noises increase. According to the results of the comparison in Table 1, the ZVZCT converters have many advantages so that the simulations of these converters are implemented.

In simulation of the first converter the main switch turns on with ZVT and turns off with ZCT. The second converter, the main switch turns on with ZVT and turns off with ZCT and a voltage stress about 1.5 times of the output voltage occurs on the auxiliary switch. The main diode turns off with ZCS and turns on with ZVS.

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The author(s) declare(s) no conflict of interest.

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