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Comparative Analysis of Asymmetric Bridge Converter and R-Dump Converters in Switched Reluctance Motor Drive

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Abstract : Switched reluctance motor (SRM) is becoming popular because of its simple construction, robustness and low-maintenance. Converter is one of the important elements in SRM drive which plays a very crucial role. In this paper asymmetric and R-dump converter topologies for 6/4 switched reluctance motor are designed and discussed..The converter topologies are simulated by using MATLAB/SIMULINK. Converters are compared with speed control of switched reluctance motor. Conventional Pi controller is used in speed control of SRM drive in both converter topologies

Keywords : Switched reluctance motor, Asymmetric, R-dump, speed control.

1. INTRODUCTION

The functionality of Switched Reluctance Motor is already known for more than 150 years, but only some vast improvements of the power electronics drive technologies have made a great success of adjustable speed drives with Switched Reluctance Motor. Due to enormous demand for variable speed drives and development of power semiconductors the conventional reluctance machine has been come into picture and is known as Switched Reluctance Machine Switched word comes into picture because this machine can be operated in a continuous switching mode. Secondly reluctance word comes into picture because in this case both stator and rotor consist of variable reluctance magnetic circuits or we can say that it have doubly salient structure. A SRM has salient poles on both stator and rotor [3] The operation of SRM is sort of straightforward due to its ability to control with efficiency from unidirectional winding currents, just one switch per phase is enough for yielding a really economical brushless drive however in ac motor drives a minimum of 2 switches per phase are needed. However the windings aren't asynchronous with switches in ac drives that result in irreparable harm in shoot-through faults. With the case of a shoot-through fault, the phase inductance limits the speed of rise in current and provides time to initiate protective relaying to isolate the faults. The SRM phases are independent and, in the case of one winding failure, uninterrupted operation of the motor drive operation is still possible although with reduced power output

Switched reluctance motor equations are as follows

$$v = ri + \frac{d\psi}{dt} \tag{1}$$

$$\psi = L = N\phi \tag{2}$$

For $r = 0$

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$$v = L.\frac{di}{dt} + i\left(\frac{dL}{d\theta}\right)\left(\frac{d\theta}{dt}\right)$$

From these equations we can say that developed torque depends only on magnitude of current and doesn't depends on current direction.

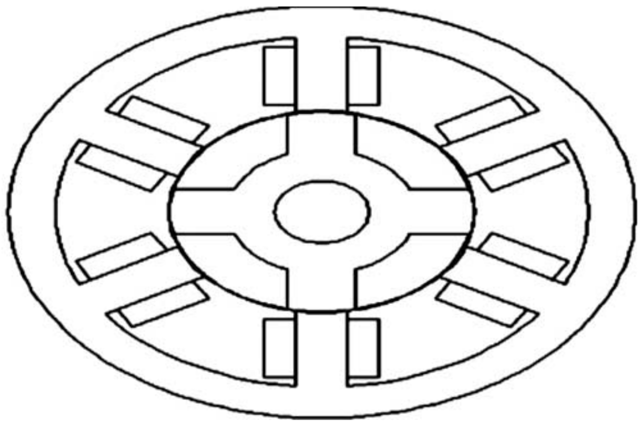

Fig. 1. Structure of 3 phase 6/4 switched reluctance motor.

The torque production in SRM can be explained using the elementary principle of electro-mechanical energy conversion. The general expression for the torque produced by one phase at any rotor position is

$$T = \left[\frac{\partial W}{\partial \theta}\right] i \rightarrow \text{const} \tag{4}$$

Where T is the torque

W' is the co-energy

Δ is the displacement of the rotor

The power converter is the heart of the motor drive. The execution, size, and the expense of the motor drive are principally relied on the converter kind of the power converter circuit. [3][6]

In this paper, presents an examination between various converter topologies used with 3-ph 6/4 SRM. In order to achieve the smooth rotation and optimal torque output the phase-to-phase switching in the switched reluctance motor drive is required with respect to rotor Position. The phase-to-phase switching logic can only be realized by using the semi Converter device. We can also say that the power semi converter device topology put a Great impact on switched reluctance motor's performance

2. POWER CONVERTERS

A main drawback in bound application is that the choice of converter topology. The SRM converter has some essential requirements [6], they are: Minimum one switch is capable to conduct freely in every phase of the motor.

The converter would be capable to excite the phase before it enters the generating or demagnetizing region. The converter has to satisfy several different requirements so as to extend the converter performance; such as Fast demagnetization time, quicker excitation time, high power, higher efficiency, and fault acceptance. They are[4], [7] The converter should be ready to permit phase overlap control as a result of the converter energy will be provided to at least one phase whereas at an equivalent time it's off from the other phase

2.1. Asymmetric Bridge Converter

With a specific end goal to have a fast generation of the excitation current, high switching voltage is required; asymmetric bridge converter is used. Fig. 2, demonstrates the single phase of asymmetric bridge converter for SRM drive. The unique switching technique can be accomplished by that converter which comprises of two power switches and two diodes for every phase. In every phase, the upper switch is utilized to play out the switching control, while the lower one is used as a part of charge of substitution. Every stage can be controlled autonomously. three modes of operation takes place in asymmetric bridge converter, characterized as magnetization, freewheeling, and demagnetization mode. In inner current control loop of the drive system we will get better frequency response and less current ripple because of this unipolar switching methodology

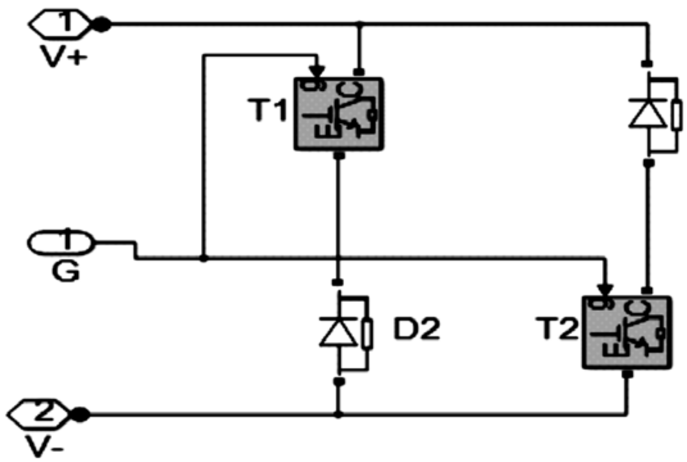

Fig. 2. Asymetric Bridge Converter.

2.2. R-dump Converter

In Srm converter topologies some of them have a single switch per phase. R-dump converter is One among them and is the least complex one The R-dump converter type is shown in Figure 3 is the converter configuration with one switch and one diode per phase. At the point when the switch T1 is turned off, the current freewheels through diode D1, charging Cs, and later flows through the external resistor R which partially dissipates the energy stored in the energized phase. The design contemplations, the turn-off transient voltage must be incorporated into rating of the switch T1 [3]

On the off chance that the current goes under the negative slope locale of the phase inductance, negative torque will be created, which reduces the average motoring torque. The value of resistance R decides the power dissipation furthermore the switch voltage. The stress on the switch increments with higher value of resistance R[2], and with lower value of resistance the suitable fall time of the current increments. This converter has the disadvantage that the current in any of stages will take more time to smother contrasted with recharging the source. Likewise the energy dissipated in a resistor decreases the efficiency of the motor drive

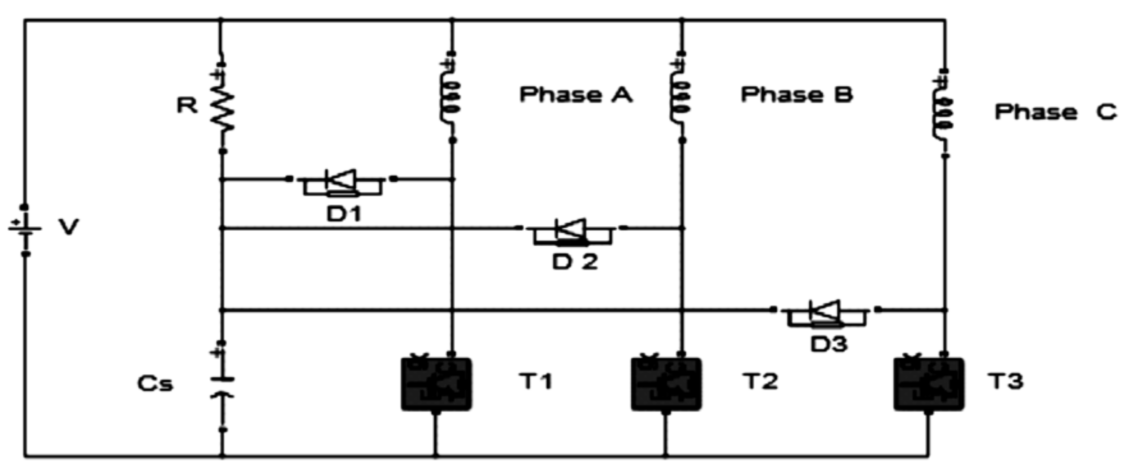

Fig. 3. R-dump Converter.

3. SWITCHED RELUCTANCE MOTOR DRIVE SIMULATIONS:

Speed control of switched reluctance motor Fed with asymmetric and R-Dump converters are carried out using conventional PI controller. The simulink models designed for PI controller individually and their performance result's compared. The Switched Reluctance Motor is an electrical motor that runs by reluctance torque. For industrial application very high speed of 40,000 revolutions per minute motor is used..The PI Controller (proportional integral controller) could be a special case of the PID controller within which the derivative of the error isn't used.

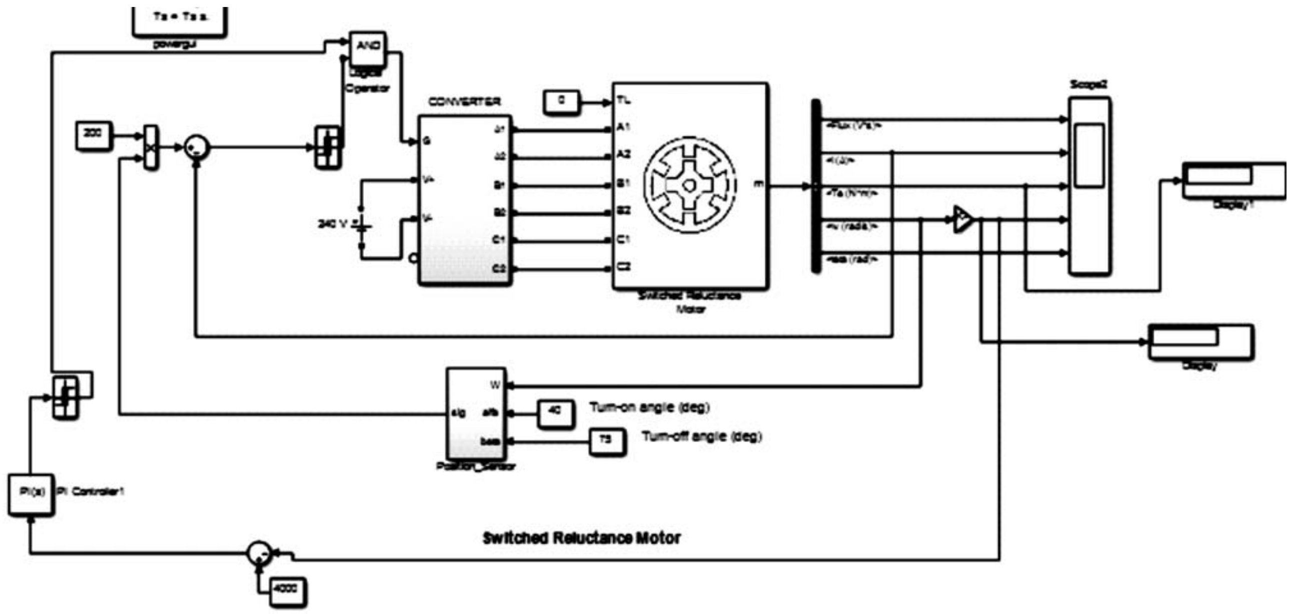

Fig. 4. Simulink model of srm drive.

4. RESULTS AND DISCUSSION

Speed measurement

In the below fig 5(*a*), it shows the graph of speed of motor . If set speed is 4000, the actual speed displayed is 4001 and the settling time is 0.24 seconds.

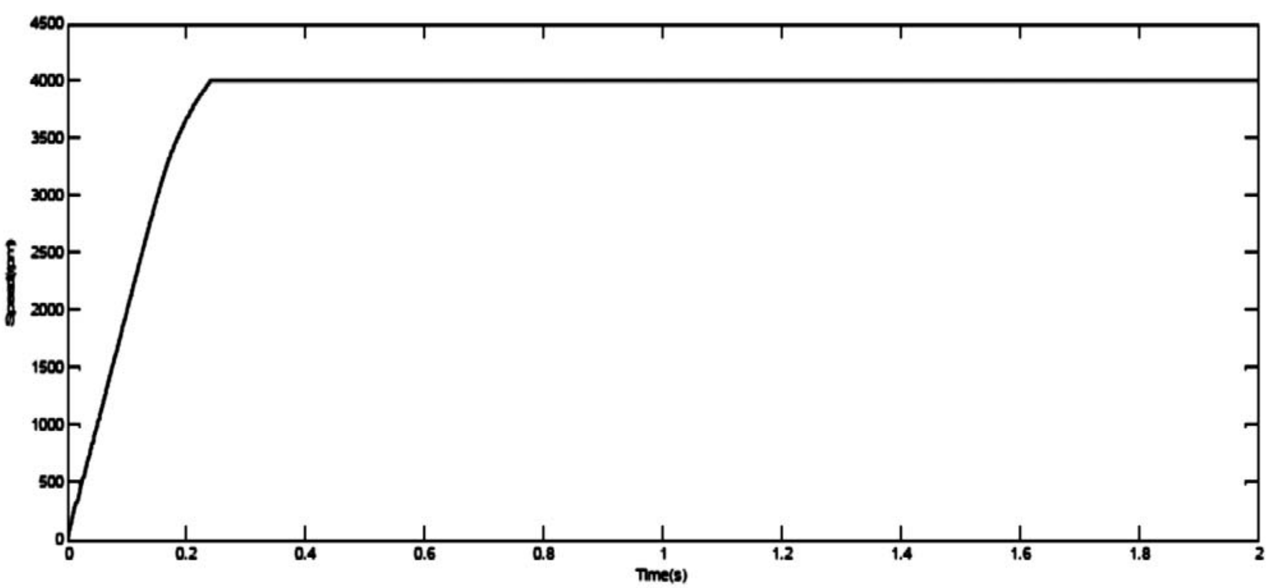

Fig. 5.(*a*) speed response for Asymmetric Bridge converter.

In the fig 5(*b*) the actual speed displayed is 4003 and the settling time is 0.265 seconds. Compared to asymmetric converter r-dump converter takes more time to reach steady state

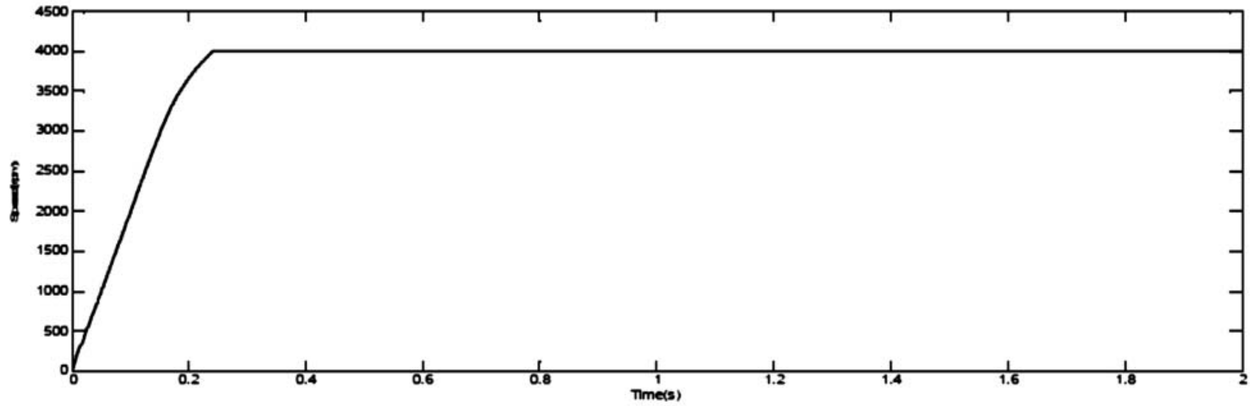

Fig. 5.(*b*) Speed response for R-dump converter.

Current :

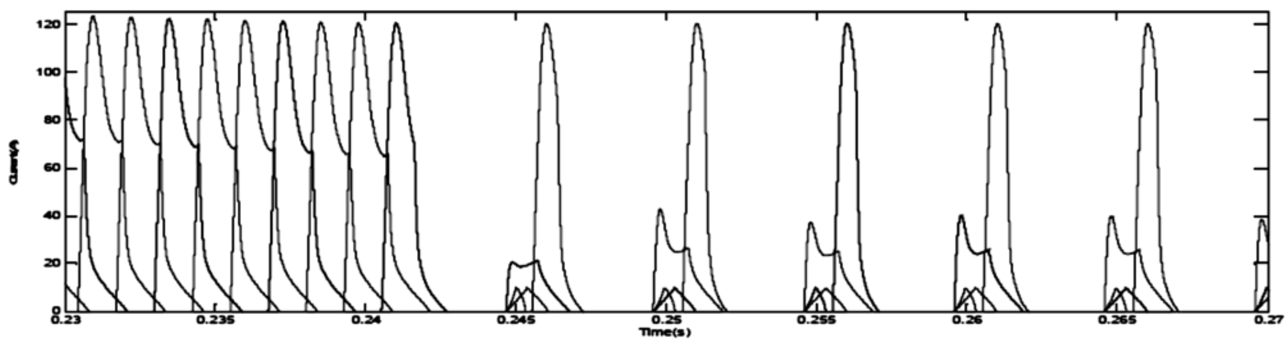

Fig. 6.(*a*) Current response for Asymmetric Bridge converter.

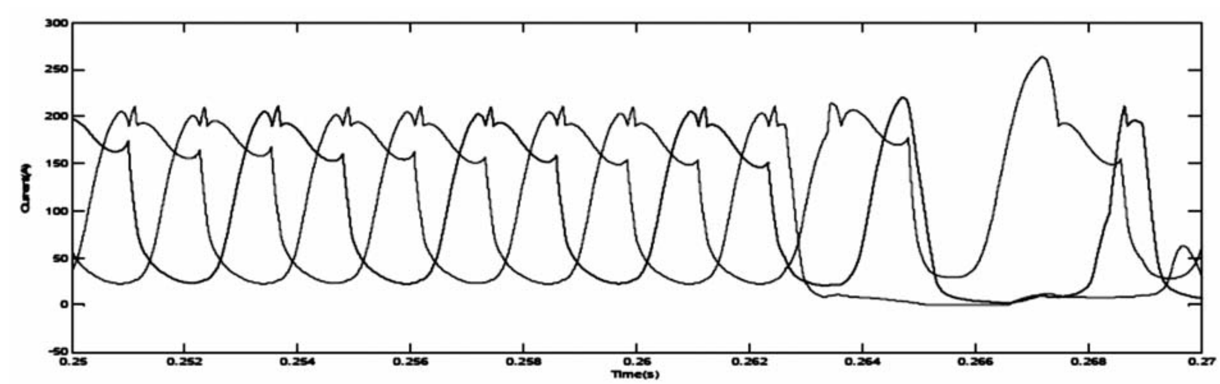

Fig. 6.(*b*) Current response for R-dump converter.

Flux :

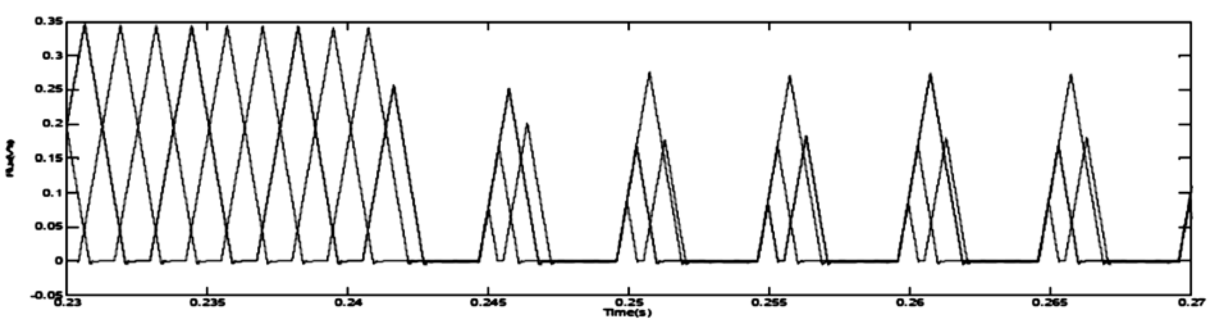

Fig. 7.(*a*). Output flux for Asymmetric Bridge converter.

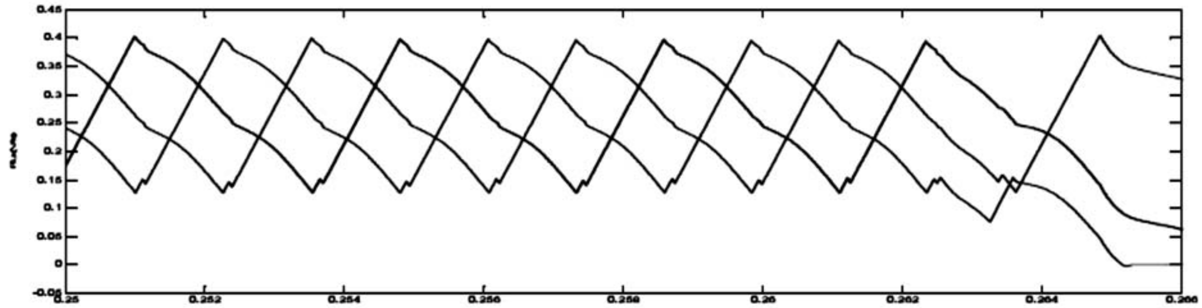

Fig. 7(*b*) output flux for R-dump converter.

Torque:

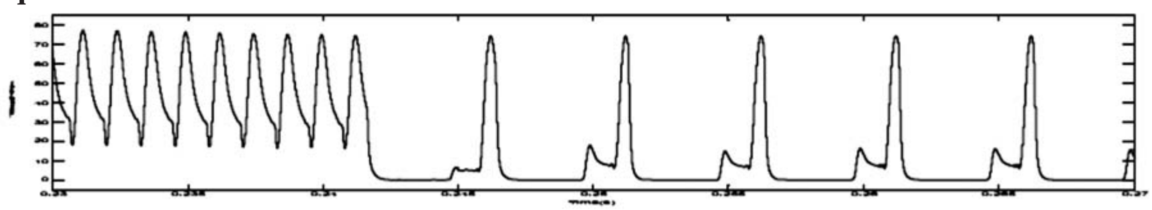

Fig. 8.(*a*) Output Torque for Asymmetric Bridge converter.

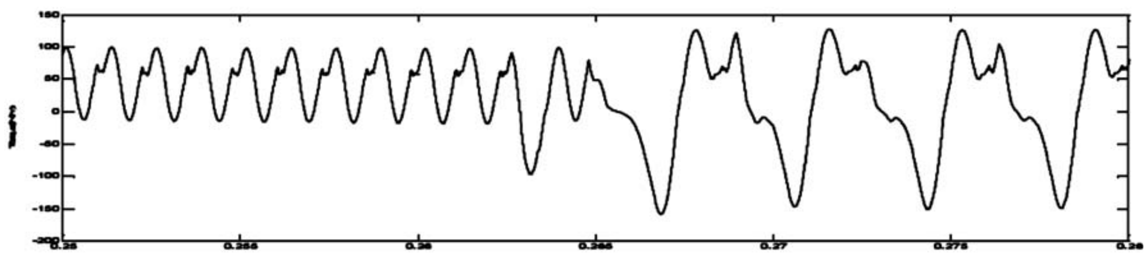

Fig. 8.(*b*). Output Torque for R-dump converter.

5. CONCLUSION

From the results analysis asymmetric bridge converter is most suitable converter compared to *r*-dump converter. In asymmetric converter analysis it is found that time taken to reach steady state is less compared *r*-dump. Also it is observed that *r*-dump drive got high current and torque ripples. Asymmetric converter has the flexibility of fault tolerance; continuous operation with reduced power output of the motor drive also can be obtained just in case of failure of one winding.

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