STUDY FOR THE SYNCHRONIZATION OF CEB (COMMUNAUTE ELECTRIQUE DU BENIN) ELECTRICAL NETWORKS: CASE OF THE VOLTA RIVER AUTHORITY (VRA) AND THE TRANSMISSION COMPANY OF NIGERIA (TCN)

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CEB is the only common structure for Benin and Togo, which provides electricity to these two countries. The optimization of its power transmission network is very important. Thus, the synchronization of its major sub-networks, namely Volta River Authority (VRA) and Transmission Company of Nigeria (TCN), aim not only to facilitate the network operation, but also to optimize and to reduce the inconvenience for people in Togo and Benin. This synchronization depends on the electrical parameters of the TCN and VRA networks. We studied the feasibility of this synchronization by providing a High Voltage Direct Current (HVDC) system that we have simulated in Matlab / SimPowerSystems software.

Key words: Power, synchronization, optimization, HVDC, electrical network.

The demand for electric power in Africa and African western area in particular is rising and this tendency increases with the industrialization and the fast growth of the population. Then, electricity constitutes integral part of our life. It provides power for domestic machines, supports our vast communication and information networks, lights our cities and it is used considerably in many large companies. Providing reliable and economic electricity is then essential for the population wellbeing and the company development.

The companies of electrical energy production must thus ensure the regular provision of this request without interruption, through an inter-connected network in order to prove reliability of the service.

It is the aim of the Benin Electric Community (CEB), charged to ensure self-sufficiency in electric power of Togo and Benin. There are several interconnections with CEB; between them, we have the Transmission Company of Nigeria and the CEB which allowed the creation of the Station at Sakété where we can have simultaneously the presence of the Volta River Authority (VRA_Ghana) network TCN. The coexistence of these two networks, TCN and VRA at the Sakété Station should have as advantage, through their pooling, optimal management and stability of the electrical supply network of CEB; but such is not the case because of the permanent fluctuation (variation of frequency and phase) of the Nigerian network making impossible the synchronization of the two networks since the exploitation of numerical interconnection post 330/161/20 Kv–412.5 MVA in Sakété (Benin) by February 2007. The consequence of this dysfunction is the division of CEB network in two great parts: the first part supplied by the VRA and the second one by the TCN. Moreover, for certain Post of the CEB, we note decrease of the voltage which can reach 11.29% (example of the loop 161 Kv of Cotonou-Vêdoko Station in Benin). It becomes imperative then to synchronize networks TCN and VRA in order to improve the level of stability of the CEB network.

MATERIALS AND METHODS

Study of electric parameters (frequency and tension) of TCN and VRA networks

Evolution of tensions TCN and VRA at the Sakété Station

A respective follow-up of TCN tension on the set of bars and VRA tension on the L200 lines and L210 of network enabled us to plot with Excel the variation curves of tensions. Through these curves, we note that the network tension is not fixed in any point. It is necessary to undertake some actions to maintain constant this tension.

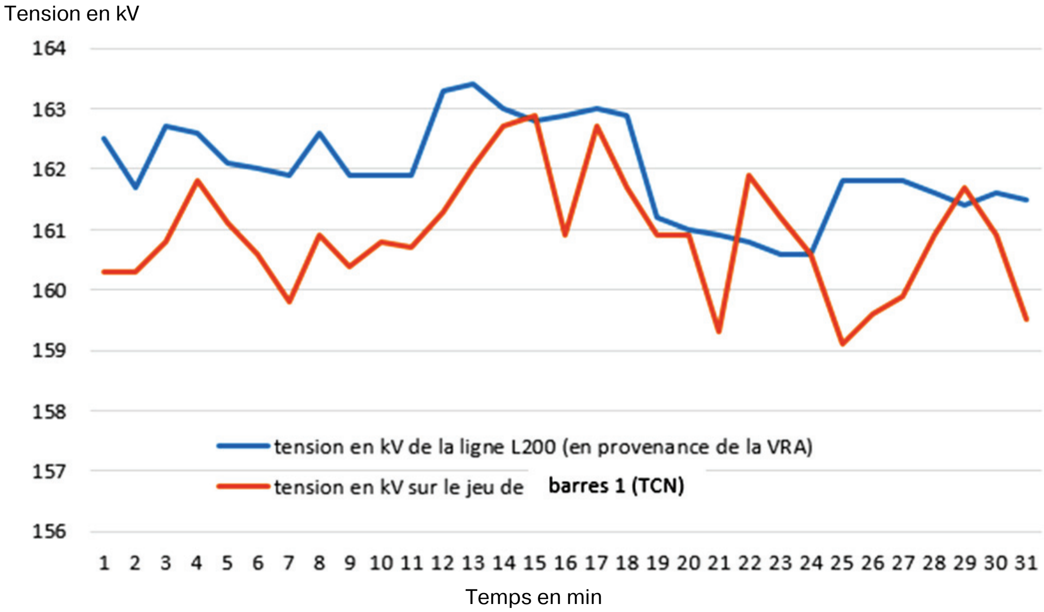

Fig. 1. Variation c¶|urves of TCN and VRA networks at the Sakété Station

Evolution of the frequency of TCN and VRA networks at the Sakété Station

A ground study, more precisely on the secondary of auto-transformers and on the lines L200 and L210 enabled us to collect data which helped us to plot with Excel the variation curves of the frequencies over time; it is what we draw on figure 2.

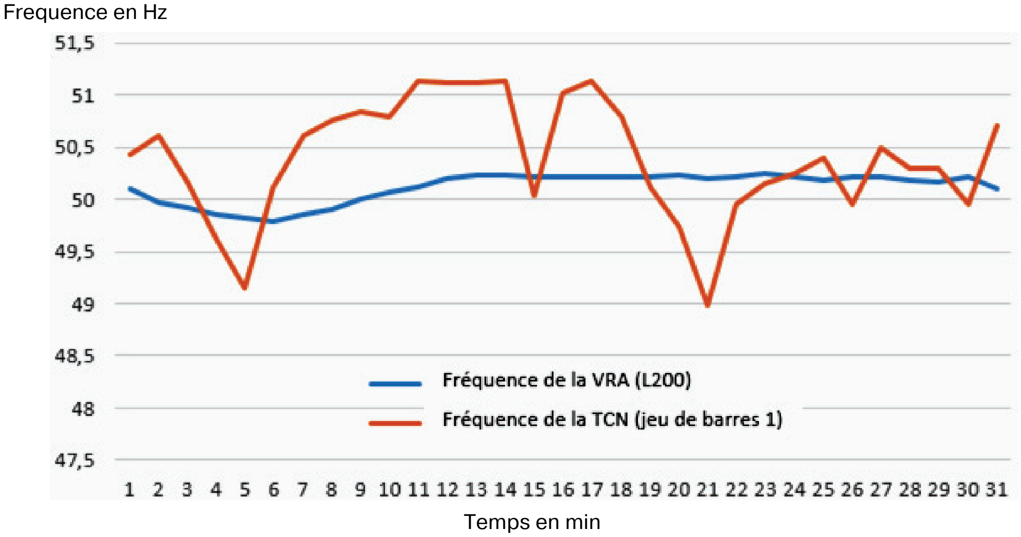

Fig. 2. Frequency curves of TCN and VRA networks at the Sakété Station

Starting from figure 2, we can note that the frequency of the CEB network especially in Sakété is unstable; it fluctuates very quickly and some times that of TCNC network fluctuates between 48.5 Hz and 51.5 Hz.

Problems and insufficiencies of the network of the CEB

The major problem of energy insufficiency, for the consumer satisfaction, led the CEB to make recourse to importation of the electric power, coming from the countries of the West African countries. However, far from satisfying this increasing need of electric power, the CEB is also confronted with the problem of synchronization between the VRA and TCN network, representing its principal suppliers.

Synchronization is the technique which should make it possible to pool the two electrical supply networks to form only one inter-connected network, requires the respect of more essential conditions defined and implemented in the brackets calculators of Sakété by AREVA with knowing [5]:

— the difference of effective tensions between the two networks must have as margin 2%;

— the difference of the frequency between the two networks must be equal at most, to 50 MHz;

— the difference of phase between the two networks must be equal to 20 degrees;

— and all these conditions must be met during 200 ms.

These requirements are often not met, since VRA and TCN networks impose from their characteristics, frequencies and phases making impossible the synchronization. Indeed this impossibility of synchronization creates many difficulties to the CEB, namely:

— exploitation of CEB network in two pockets (VRA pocket and TCN pocket);

— repeated power cuts registered by customers: these cuts are due to the change of suppliers through the operations on the transformation post; this does not ensure continuity of the service and makes the network unreliable;

— enormous losses online due to the transport of the energy of TCN towards the North of the two countries through a very long route knowing, Sakété-Onigbolo-Bohicon-Nangbéto-Atakpame-Kara-Djougou and Parakou.

Presentation of HVDC systems

Defined in English as High Voltage Direct Current the principle of this system is summarized as follows: the alternative power provided by one (or several) energy source (s) is initially transformed into a continuous power; a energy converter CA/CC (rectifying) ensures the operation. The continuous power transits, thereafter by a line or a continuous transmission cable; another energy converter CC/CA (inverter) transforms this continuous power into an alternative power.

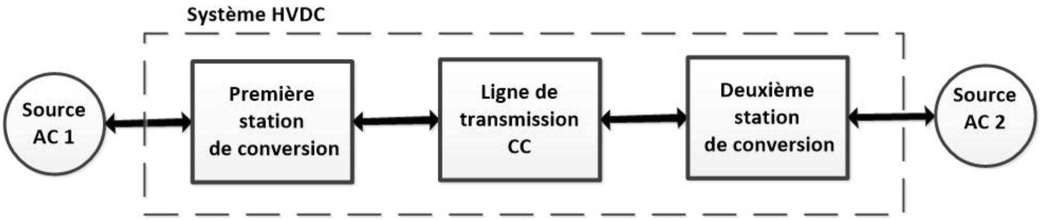

Fig. 3. Simplified scheme of a HVDC system configuration

Advantages of a transmission system with high voltage continuous power (CCHT)

The establishment of a energy transport connection for long distance with alternate has some difficulties due to the "reactances" of lines and it is essential, the more the line is long, to achieve compensations at different points. Continuously, until 1950, it was impossible to reach significant tensions. From 1960, with the static inverters, passing from alternate high voltage to the high voltage continuous power became possible, as well as the opposite way.

For certain applications, CCHT system is more effective than that of CA; this evaluation is based on the following data [4; 5]:

— underwater connection by cables for energy supply of some nonproducing islands;

— connection between two production networks for different frequencies (two networks of 50 Hz and 60 Hz for example);

— interconnection of two networks with the same frequency. All obligation of synchronism disappears when energy is transmitted by a connection with continuous power;

— optimization of drivers: two drivers for the bipolar system and one driver for the mono polar system;

— energy exchange at the peak hours between two networks not located in the same time zone;

— energy exchange, when difference in climatic conditions.

The interconnection of alternate networks requires the same frequency, the synchronism, the equal tensions and the phases to the interconnection. The interconnection between two alternate networks must be able to count on the stability of the whole in the event of defect. In the same way, maintaining the synchronism of two powerful networks poses problems which do not accommodate with a simple interconnection. These difficulties disappear with internetwork connection of continuous power, since such of connections do not transmit the disturbances between networks from one to the other [5].

HVDC back-to-back systems

Another interesting configuration of the HVDC systems that we study is called HVDC back to back. This configuration does not have a continuous power line connecting the conversion stations. The two stations of conversion are located at the same place. This category of system is used to inter-connect two asynchronous CA systems, being able to operate at different nominal frequencies, or on mode without synchronization, by coupling two networks of the same nominal frequency.

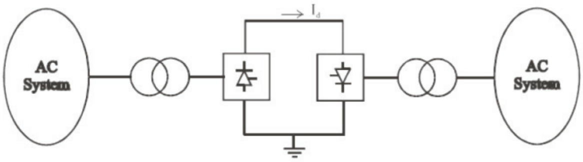

Fig. 4. HVDC back to back system [4]

HVDC system components

The components of the HVDC system are as follows [6]:

— the power switches are associated to form valves. Those realize conversion AC-DC and they are the principal element of any HVDC converter. Each single valve includes a certain component (thyristor for example) connected by series;

— the transformers which modify the level of tension;

— the smoothing inductance whose principal functions are:
 limitation of power with continuous defections;
 prevention of resonance in the circuits of continuous power;

— the harmonic filters, on the AC side of a HVDC conversion station, which have two principal functions:
 absorbing the harmonic powers generated by HVDC converters HVDC;
 providing reactive power.

— lightning protector which the principal task is to protect equipment from overtensions;

— transmission circuit DC, which includes the line of transmission DC;

— system of control and protection.

RESULT

Simulation

The simulation circuit includes mainly:

— the sources with alternate power: AC system by the rectifying side (AC1) is parameterized to 50 Hz, 330 Kv nominal and that on the inverter side (AC2) to 50 Hz / 161 Kv;

— the converters: the rectifying blocks and inverter include a transformation part and converter with thyristors (rectifying or inverter). The transformer on the rectifying side is parameterized with values 412.5 MVA as nominal power, frequency of 50 Hz and tension of 330 kV/100 Kv, while that on the inverter side is parameterized with 278 MVA, 50 Hz and 161 Kv/100 Kv.

— filters of harmonic for a total of 120 MVAr.

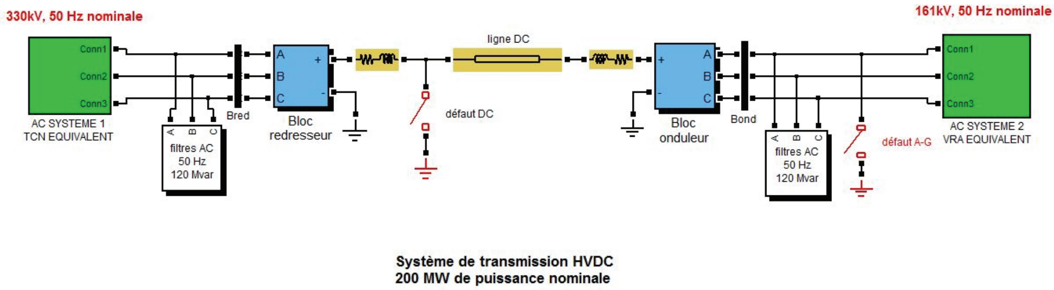

Fig. 5. Diagram of simulation block

Results of simulations and analyzes

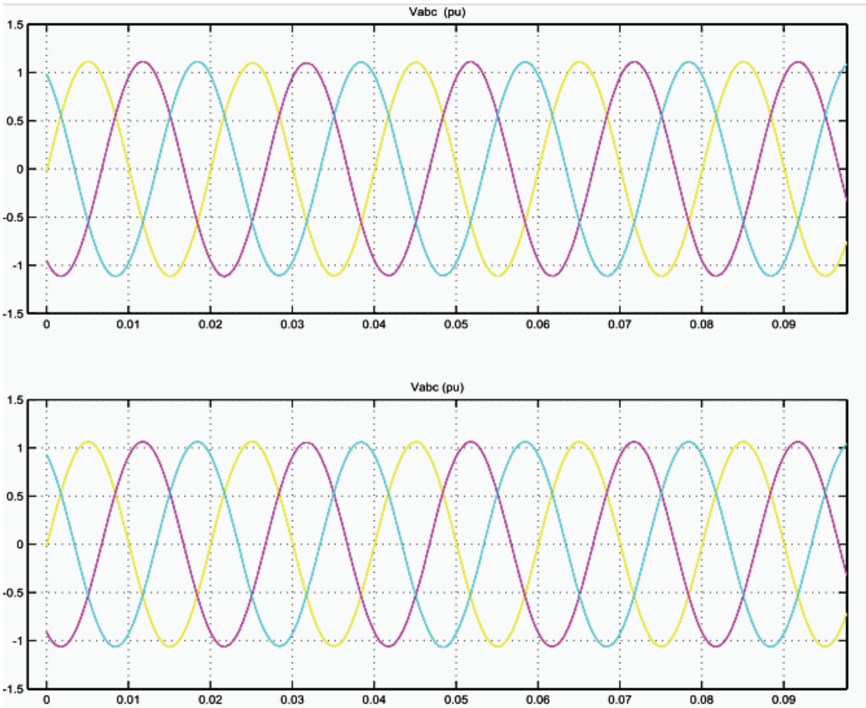

Fig. 6. Evolution curves of the alternating voltages at the entry of the rectifier and outside of the inverter respectively

Figure 6 makes it possible to visualize the initial conditions by supposing AC1 configured to 330 Kv 50 Hz with angle phase A set to 0 degree and AC2 configured to 161 Kv 50 Hz with phase A set to 0 degree.

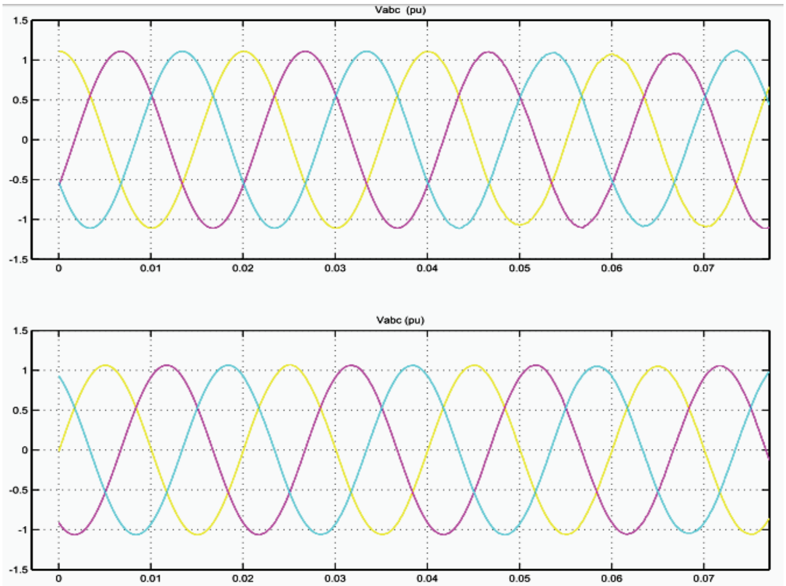

Fig. 7. Evolution of curves of alternating voltage rectifying side with a phase of 90° and alternating voltage side inverter

With figure 7: We suppose AC1 configured to 330 Kv 50 Hz with angle phase A set at 90 degree and AC2 configured to 161 Kv 50 Hz with the angle phase A set to 0 degree. The finding is that there is no change at the exit of the system despite the change at the entry.

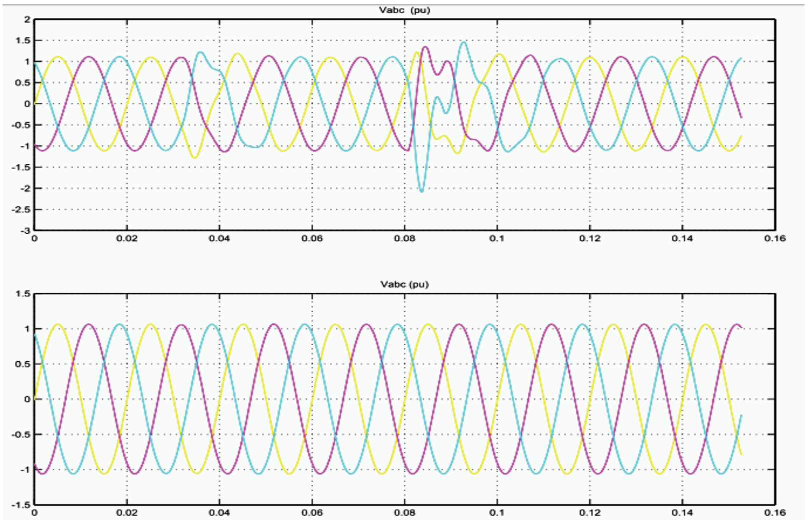

Fig. 8. Evolution curves of the alternating voltages rectifying side and inverter with variation of phase on the rectifying side

With figure 8: We set AC1 to 330 Kv 50 Hz with angle phase A at 0 degree, 20 degree, 90 degree at different moments and AC2 set to 161 Kv 50 Hz with angle phase A fixed at 0 degree. We note through simulation that the variations of tension phase of source AC1 do not have any influence on the output signals on the side AC2.

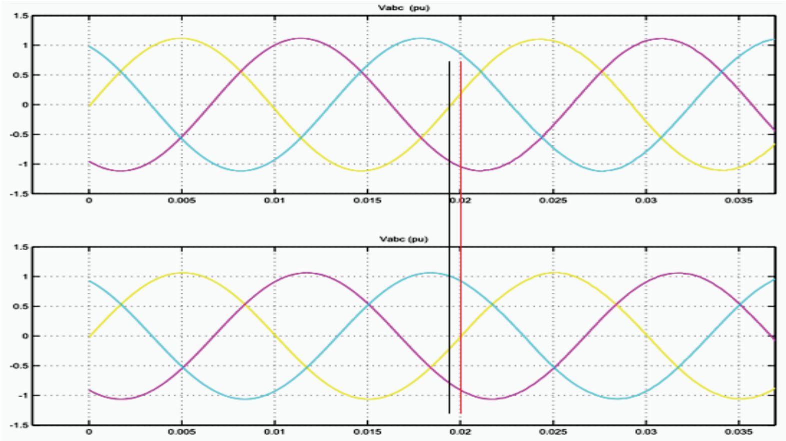

Fig. 9. Curves of evolution of the alternating voltages on the rectifying side and inverter with 51.5 Hz of frequency on the rectifying side

We assume AC1 set at frequency of 51.5 Hz and AC2 with 50 Hz. The objective of this configuration is to see the impact of the variation of frequency on HVDC back to back system. After simulation, no change is observed on the output signal AC2 and this, whatever the variation of frequency.

DISSCUSSION AND CONCLUSION

The permanent fluctuations of the electrical supply network of the TCN due to variations of tension (figure 1), of frequency (figure 2) and the angle of phase prevent the respect of the synchronization conditions defined and implemented in calculators of Sakété section by AREVA. What makes it impossible the synchronization of electrical networks of both TCN and VRA.

The results of simulations obtained confirm the effectiveness of HVDC system in pooling the two non synchronous networks.

Since the system is well regulated, the fluctuations due to the variations of phase, of frequency and of tension coming from the TCN electric network which we simulated through figures 7, 8 (variation of phase) and figure 9 (variation of frequency), are corrected through HVDC back to back system and make it possible to obtain a stable electric power which is pooled with VRA network.

The establishment of this system by the CEB, will not only allow him, to avoid the losses of energies due to the permutations of VRA and TCN sources and to optimize its electrical supply network but also to reduce as possible the nuisances caused to its customers.

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ИЗУЧЕНИЕ СИНХРОНИЗАЦИИ ЭЛЕКТРИЧЕСКИХ СЕТЕЙ БЕНИНА (ЭСБ): СЛУЧАИ ВЗАИМОДЕЙСТВИЯ АДМИНИСТРЦИИ РАЙОНА РЕКИ ВОЛТА (РРВ) И ПЕРЕДАЮЩЕЙ КОМПАНИИ НИГЕРИИ (ПКН)

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ЭСБ — единственная структура в Бенине и Того, обеспечивающая электроэнергией эти две страны. Оптимизация мощности транспортирующих сетей — очень важная задача. Таким образом, цель синхронизации работы ее главных подстанций, а именно района р. Волта и передающей компании Нигерии — это не только облегчение работы операционных сетей, но также и оптимизация и снижение трудностей для народа в Того и Бенине. Эта синхронизация зависит от параметров электросетей ПКН и РРВ. Мы изучили возможные пути этой синхронизации с использованием высоковольтной передающей системы, которую мы смоделировали с помощью компьютерных программ (Mathlab / Sim Power Systems soft ware).

Ключевые слова: электрическая мощность, синхронизация, оптимизация, высоковольтная система, электрическая сеть.