Wireless Electrical Power Transmission Via Microwave Link

Mushreq Abdulhussain Shuriji, Wedian Hadi Abd AL Ameer

Abstract-Wireless communication technology has changed and expanded within these few years at an incredible rate, in particularly wireless power transmission. The aim of this research is to carry out a proposed system design to transmit the electrical power wirelessly using microwave link. In conclusion, wireless power transmission system has been presented and discussed. Furthermore, the proposed system can transmitted the electrical power optimally within 200-300m wirelessly. Besides, the results from the proposed system design provides a guideline for engineers to design a wireless power transmission system between the substations.

Index Terms: Microwave Link, Wireless Power, Wireless Power Transmission, Witricity.

I. INTRODUCTION

The transmission and distribution of electrical energy has been started with direct current (DC) in the late of 19th century, but it was inefficient due to the power loss in conductors [1]. Furthermore, Alternating current (AC) offered much better efficiency, since it could easily be transformed to higher voltages, with far less loss of power AC technology was soon accepted as the only feasible technology for generation, transmission and distribution of electrical energy [1,2]. However, high-voltage AC transmission links have disadvantages and engineers were engaged in the development of a technology for DC transmissions as a supplement to the AC transmissions. The invention of mercury arc rectifiers and the thyristor valves, made the design and development of line-commutated current sourced converters possible [1]. In a HVDC system, electricity is taken from an AC power network, converted to DC in a converter station and then transmitted to the receiving point by a transmission line or cable. In addition, it is then converted back to AC using another converter station, and injected into the receiving AC network.HVDC enables the power flow to be controlled rapidly and accurately. Also, it improves the performance, efficiency and economy of the connected AC network [2].

Nowadays, wireless communications is regarded as the fastest growing segments in the communication industry [3]. Even though the Wireless communications were invented almost 200 years ago, Wireless power transmission, in recent years, has attracted the attention and imagination of both, public and the researcher alike. However, in the design of wireless transmission, there are many technical challenges that could be contributed to the promising emerging applications. Furthermore, Wireless power transmission can be define as a system that uses radio frequency (Microwave) instead of wires as a transmission medium for transmitting the electrical power wirelessly. Moreover, it is noted that, wireless power transmission has many benefits, for example, replacing the complexity of the wire network system, providing mobility and flexibility to consumers also reducing the installation and maintenance costs. While, the drawback of the wireless power transmission is the amount of the energy loss due to the path loss within free space channel as well as the process in the devices. In this research, we carried out a new approach of wireless power transmission system. Starting with the transmission line system connected the main power plant to the substation plant which is called high voltage. Transmission line and its components represents by A.C or D.C which is depends on the system design. Then connected to a microwave generator with 200MW output power operates on 3GH radio frequency. Moreover, the microwave generator will supplied with a switch mode device which is used as a converter, to convert the A.C signal applied from main station to the switch into a D.C signal [4,5,6]. Then, the electrical signal can be sent using a microwave transmitter with high power gain antenna [7,8,9] . Furthermore, the electrical signal is transmitted wirelessly in free space within distances of (100-1000M). Finally, at the receiver side the D.C received electric power will convert back into A.C using high power inverter. The proposed wireless powertransmission system design is provided and discussed extensively in later sections.

II. CONSTRUCTION OF MAIN POWER SOURCE AND MICROWAVE GENERATOR

A. MAIN POWER SOURCE

The first step to build the system starts from power generation station, or the main generation station. This station could be thermal or gas or renewable station. In fact, it depends on the type of the fuel, which are coal, oil and natural gas. Moreover, the power capacity of the main generation plant started from 500MW and straight on, which depends on the power generation efficiency for the power plant and its capacity design.[10].

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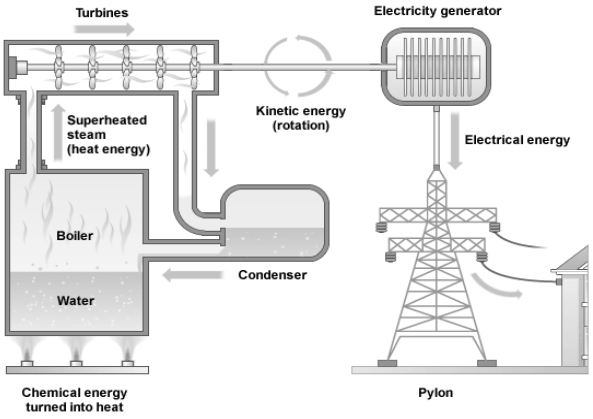

Fig .1 Thermal power plant [11].

B. POWER PLANT WITH HIGH POWER MICROWAVE GENERATOR KLYSTRON TYPE

As we mention earlier, there are several types of power stations. In this proposed system, a thermal type is selected to be the main power station, which is been deployed and used widely due to its reliability and cheap price tag for maintaining and installation [10].The maximum capacity of the selected plant is 500MW. The output of the power plant is supplied to the microwave switch mode device to convert the AC input voltage to a low ripple adjustable DC current. The primary advantages of switch-mode power supplies are their compact size, stability and low current ripple, which produces a high quality, narrow bandwidth output spectrum. Additionally, the output D.C switch microwave device is supplied to the microwave generator. [12,13].

Microwave generators are designed to provide a stable and controllable microwave power, as a result KLYSTRON type. The klystron is a significant microwave power source, which is been used in advanced radar and wireless communication as well Typically, staggered tuning is used in the klystron to obtain a wide range of bandwidth, and high resonant frequency for enhancing beam-wave conversion efficiency [14,15].

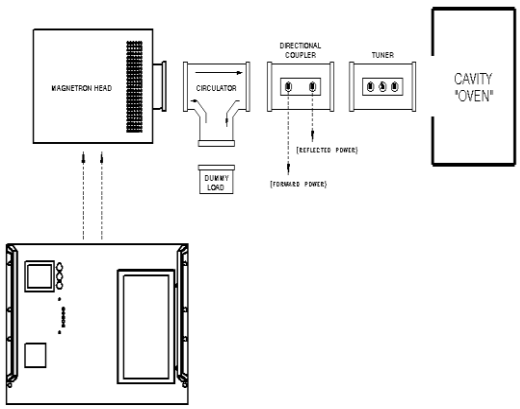

Fig .2 Typical Microwave generator system [12].

The maximum output power for the (KLYSTRON) type is within (150-200 MW).In addition, the D.C output of the klystron system is transmitted using a very high power gain microwave antenna, which is equal to 38dB. The electrical power transmission distance is been demonstrate start from 100m up to 1Km. The effective radiated electrical power is captured by a receiving high power gain directive antenna with gain equal to 38dB as well. The transceiver of the microwave link system is presented comprehensively in later section. Finally, the received electrical power is fed into the inverter to convert the D.C to A.C and then supplied the converted power to another substation power plant or consumers. The proposed system design is presented in figure (3) shown below.

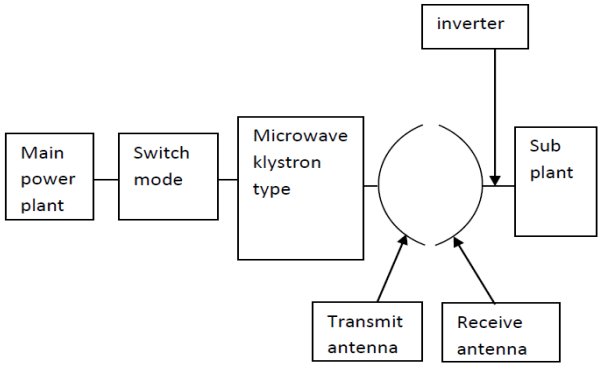

Fig .3 the proposed system construction.

III. CONSTRUCTION OF THE WIRELESS POWER TRANSMISSION SYSTEM USING MICROWAVE LINK

The wireless power transferring system operates on the microwave band of the RF spectrum. Moreover, a microwave link is a wireless communication system that uses a beam of radio waves in the microwave frequency range (3GHz-300GHz) to transmit the electrical signal from just a few feet or meters to several miles or kilometers apart [15]. In addition, the properties of using microwave link is as follows [15]:

- Involve line of sight (LOS) communication technology.
- Affected greatly by environmental constraints, including rain fade.
- Have very limited penetration capabilities through obstacles such as hills, buildings and trees.
- Signals can be degraded during solar proton events.

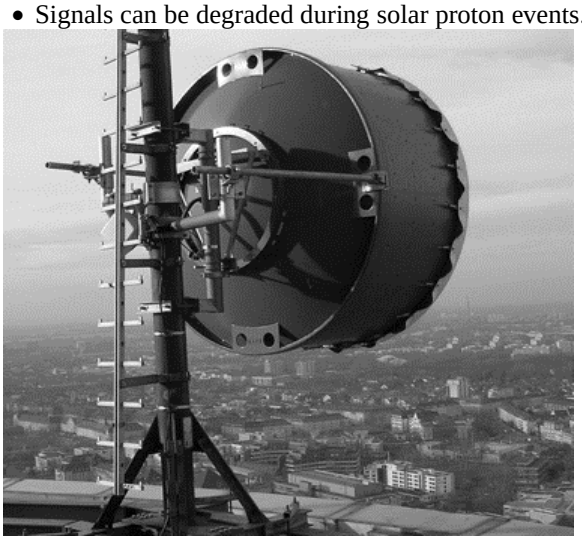

Fig .3 Microwave link [15].

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In this proposed system, the wireless power transmission system will operates on 3Ghzand the microwave link are transmitted between the two separated locations using directional antennas, forming a fixed radio connection (microwave link) between the two points. The requirement of a line of sight limits the distance between stations to 30 or 40 miles. Because the radio waves travel in narrow beams confined to a line-of-sight path from one antenna to the other, they don't interfere with other microwave equipment, and nearby microwave links can use the same frequencies. Antennas used must be highly directional (High gain); these antennas are installed in elevated locations such as large radio towers in order to be able to transmit across long distances. Typical types of antenna used in microwave link installations are parabolic antennas, dielectric lens, and horn-reflector antennas [9]. Highly directive antennas permit an economical use of the available frequency spectrum, despite long transmission distances.

IV. CALCULATION OF THE WIRELESS RECEIVED ELECTRIC POWER USING THE PROPOSED MICROWAVE LINK SYSTEM

The proposed wireless transmission system has the following specification:

- 500MW AC Power source.
- 200MW DC Microwave generator.
- 3GHz operating frequency.
- Two high directional power gain microwave antennas (38dB).

The following table .1 shown below illustrate the received power at the receiver over various wireless communication distance.

Table .1 Received Power over various distance.

Distance (m)	Received Power (W)	Received Power (dBm)
100m	50420862.100	77.026
200m	12605215.550	71.005
300m	5602318.020	67.483
400m	3151303.886	64.984
500m	2016834.487	63.046
600m	1400579.505	61.463
700m	1028997.187	60.124
800m	787825.971	58.964
900m	622479.780	57.941
1Km	504208.621	57.026

The Fig .5 (a, b) shown below are reveal the received electrical power in dBw and W respectively over various wireless communication distance.

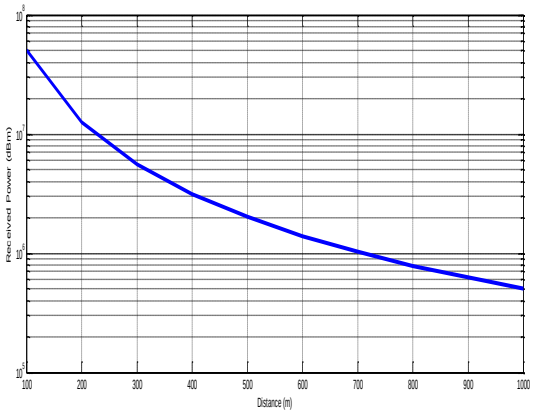

Fig.5 (a) Received electrical power in dBw versus distance in m.

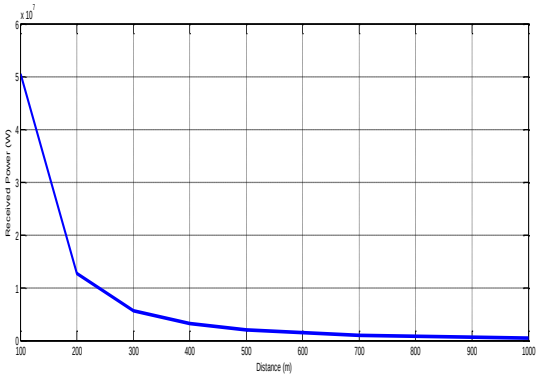

Fig.5 (b) Received power in W versus distance in meter.

V. CONCLUSION

In conclusion, wireless power transmission system has been presented and discussed. Furthermore, the proposed system can transmitted the electrical power optimally within 200-300m wirelessly. Besides, the results from the proposed system design provides a guideline for engineers to design a wireless power transmission system between the substations. In addition, increasing the distance between the transmitter and the receiver will eventually increases the amount of energy lost.

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Mushreq Abdulhussain Shuriji was born in Baghdad, Iraq, in 1984. He received the B.Sc. degree in electrical engineering from Al-Musatansiriyah University/ College of Engineering, Baghdad, Iraq, in 2006, and the M.Sc. degree in electrical engineering \ Wireless communications, University Tenaga Nasional, Selangor, Malaysia, in 2013. Since, 2008, he has joined the Department of Electrical Engineering, College of Engineering, Al-Mustansiriya University as a lecturer. His current research interests include Wireless communications, modulation technique for wireless communications, Binary-CDMA design and investigation, Mat-lab Simulink for wireless communications system design, Li-Fi wireless technology, wireless power transmission and Witricity technology.

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