VOL. 11, NO. 10, MAY 2016 ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences

www.arpnjournals.com

VALIDATION OF MOBILE PHONE RADIATION EFFECTS ON ACTION POTENTIALS BASED ON ROBOTIC ARM EXPERIMENT

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ABSTRACT

This study is a continuity of previous research done by the author which is to validate the simulation results. As the simulation results has shown disturbance in the action potential (AP) signal when electromagnetic radiation (EMR) appear, therefore, it is essential to undertake an experiment to validate those results. As using life specimen will lead to ethical issues, the author has choose robotic arm experiment setup because the main concern in this study is the disturbance on the signal which is measurable through the robotic arm signal. GSM phones are placed really closed to copper wires connecting the robotic arm at certain degree of orientations. The results show significant displacement of matchbox by 0.2 to 1 cm from specified region when radiation source appear. There is also significant voltage increment of 0.4 V on DC signal of robotic arm when phones at 225^0 orientation. The GSM phone radiation is possible to interfere with harmonious function of APs.

Keywords: action potential (AP), robotic Arm, phone orientation.

INTRODUCTION

Unawareness of long term pollution from EMR to the human body is a critical issue nowadays as the EMR is produce from daily wireless communication devices such as mobile phones and base stations. The EMR can easily penetrate into a human body and thus disturb the harmonious flow of APs. Simulation work from author previous research has shown that the EMR propagating the human body will induce currents and voltages which can interact with APs by introducing interference spikes riding on the original signal [1]. The interaction of the interfering currents and voltages with APs over long period of exposure can create havoc or confusion to the delicate nervous system. This might be the starting of potential health hazards. There are several studies mostly involving mobile phones at GSM 900 band as the source of EMR towards the APs in nervous system.

Bolashakov and Alekseev [2] found that non-continuous 900 MHz pulsed wave radiation increased bursts of firing of Lymnea (freshwater snail) neurons. This result correlates with finding from Hao *et al.* [3]. 47 rats exposed to 916 MHz, 10 W/m2 mobile phone EMR; 6 hours a day, 5 days a week for 10 weeks. The neuron signals of one exposed rat and one control rat in the maze were obtained by the implanted microelectrode arrays in their hippocampal regions. The hippocampal neurons of exposed rat showed irregular firing patterns and more spikes with shorter interspike interval during the whole experiment period. Furthermore, results from rats searching for food in an eight-arm radial maze show the average completion time and error rate of the exposure group were longer and larger than that of control group. It indicates that the 916 MHz EMR influence learning and memory in rats to some extent in a period during exposure. Razavinasab, Moazzami and Shabani [4] did a study on electrophysiological properties of CA1 pyramidal neurons which exposed to GSM radiation. 8 rats were exposed to 900 MHz pulsed EMR for 6 hours per day. Whole cell recordings in hippocampal pyramidal cells did show a decrease in neuronal excitability. Mobile phone exposure was mostly associated with a decrease in the number of APs fired in spontaneous activity. There was an increase in the amplitude of the after hyperpolarization (AHP) in AP of exposed rats compared with the control. The results of the passive avoidance and Morris water maze assessment of learning and memory performance showed that phone exposure significantly altered learning acquisition and memory retention in exposed rats compared with the control rats. Therefore, the study confirmed that exposure to mobile phones adversely affects the cognitive performance of rats.

Meanwhile study by Partsvania *et al*. [5] show that after acute exposure of 900 MHz mobile phone radiation on single neurons of mollusk, average firing threshold of the action potentials was not changed. However, the average latent period was significantly decreased. This indicates that together with latent period the threshold and the time of habituation might be altered during exposure. However, these alterations are transient and only latent period remains on the changed level.

As several studies produce different behavioural and physical changes towards the AP with appearance of EMR, the main concern here is the EMR do alter the AP which is the electrical signal in a human body. Therefore, the used of robotic arm is also possible to validate the effect of EMR as indirect comparison. This due to robotic arm signal itself is an electrical signals which possible to interfere by the EMR. It is just difference in type of signal as the AP signal is an AC signal while the robotic arm signal is a DC signal. Furthermore, the setup of robotic arm experiment is easier to accomplish, while the use of life specimen need consideration on ethical issues which can drag the time taken to overdone the experiment. Therefore, the author considered to use robotic arm experiment to validate the effects of the EMR towards the APs.

OWI-535 ROBOTIC ARM EXPERIMENT SETUP

As to be stressed, the purpose of using robotic arm setup is not by comparing in physical means to the nervous system, but to compare what will happen to the signal inside the wires of robotic arm when there is radiation source placed near to the robotic arm. It is just the same like situation in simulation circuit where the result is observed on signal behaviour when radiation source appear [1].

A robotic arm model known as OWI-535 Robotic Arm Edge is one of the device used along with LabVIEW software and National Instruments hardware in constructing robotic arm experiments setup. The robotic arm setup is used to model the mechanism of the interruption of the important functions of the AP. The AP in this robotic arm setup is assumed as DC source despite of their difference in waveform shape. This is because; the OWI-535 model only can be operated by using DC signal. As said earlier, the concern of this study is only about the consequences of radiation signal towards a device signal.

Creation of DC source of robotic arm involved a combination of LabVIEW software and NI 9263 module in NI cDAQ-9178 hardware. Figure-1 shows setup to produce DC signal by using LabVIEW. The square wave generator is used to create the DC signal of 5V in amplitude as shown in Figure-2. The Elapsed Time block diagram is used as limiter on how long the DC source is supplied to the robotic arm. The created DC signal is directed to DAQ Assistant block diagram in order for NI 9263 module in NI cDAQ-9178 as shown in Figure-3 to take the DC as its output. The output will eventually become the input for the OWI-535 Robotic Arm Edge.

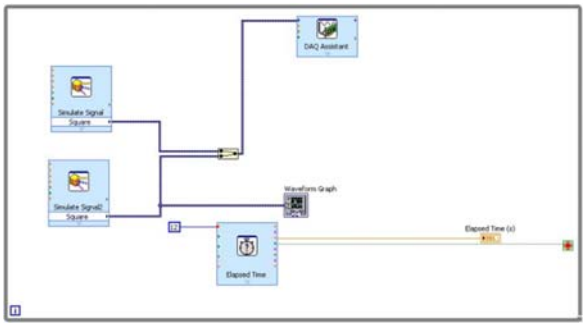

Figure-1. Creation of DC signal in LabVIEW.

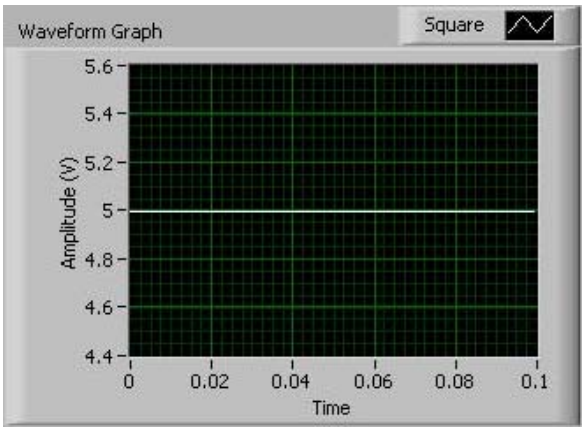

Figure-2. DC source produced by LabVIEW.

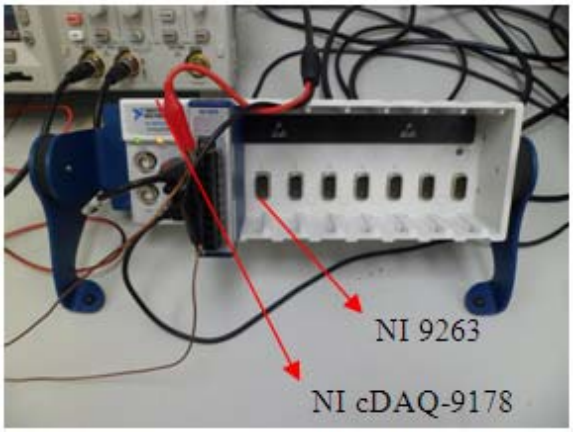

Figure-3. NI 9263 module in NI cDAQ-9178.

Figure-4 shows an experiment setup with all GSM phones in 0º orientations are placed on a pair of copper wire which act as transmission line between the DC source from NI hardware and robotic arm with load. All phones are suing same network which is Maxis. The Maxis network is operate at GSM 900 band. Those phones also have been set to preferred 2G network only to make sure all of them only operated in GSM 900 band during the experiment.

The usage of six mobile phones as shown in Figure-4 is very crucial in this experiment as those six mobile phones are on silence ongoing call state during the whole time of experiment. Silence ongoing call state means those phones are on established call connection with no voice tone transmitted through those phones. The radiation power of one GSM 900 phone during silence ongoing call state will be set to the lowest power level by the base station which is at 5 dBm (3.16 mW) [6, 7]. That means, if six phones in silence ongoing call state are used, the net radiated power will be 6 times of one phone radiated power which is 18.96 mW. During common ongoing call with voice, the phone will conserve its power to a level that it still can maintain an acceptable signal quality which is usually near to 0.02 W [8]. Therefore, the

net power of 18.96 mW from those phones at silence ongoing call mode is enough to imitate the actual ongoing call with appearance of human voice in term of its output power level.

This setup is realized in order to know if GSM phones radiation which the phone is in silence ongoing call condition can influence the robotic arm movement in placing a matchbox which is the load that been grip by the robotic arm to its required location. The matchbox will be moved from point A to point B as shown in Figure-4. The electrical signal of the robotic arm is also analyzed to know any possibilities of signal distortion. The phones orientation in the experiments can be changed to eight different styles from 0^o to 315^0 which will be shown in the experiment results.

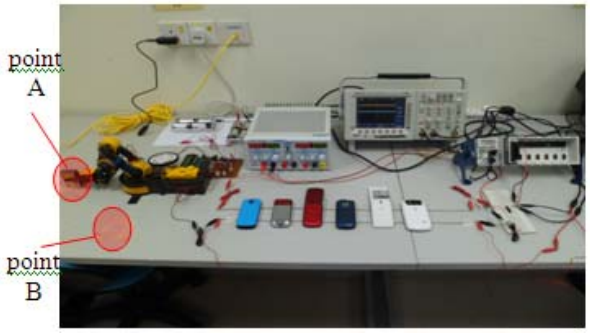

Figure-4. Robotic arm experiment setup with GSM phones.

Variations of phone orientations during the robotic arm experiments are very important as antenna location inside the phone can determine which phone orientation can transfer maximum radiation power to the copper lines. As orientations are changing, there is one approximate phone orientation where radiated wave from the phone antenna is in parallel with the receiving monopole antenna as shown in Figure-5. This parallel formation can lead to maximum wave absorption by the monopole antenna and hence introduce maximum radiation effect towards the copper wires. Meanwhile, other phone orientation has produced non parallel formation as shown in Figure-6 and therefore the radiated wave is not absorbed fully.

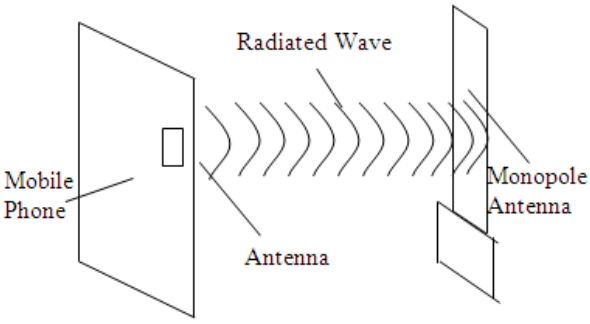

Figure-5. Radiated wave in parallel with the antenna.

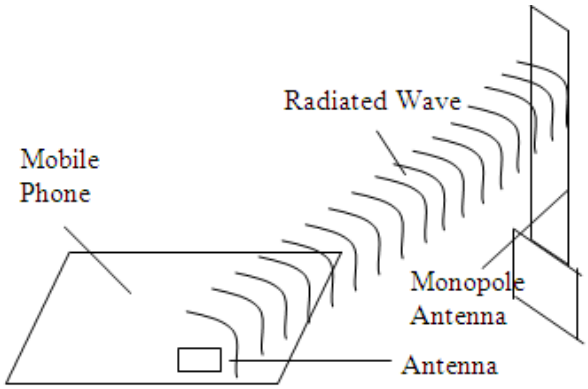

Figure-6. Radiated wave not in parallel with the antenna

Therefore, before conducting the experiment as shown in Figure-4, other pre-experiments have been done to identify the phone orientation that introduces maximum radiation effect towards the copper wires. The setup of the experiment is as shown in Figure-7. The mobile phone is placed at distance of 3 meters facing the monopole antenna which attached to spectrum analyzer that is used to measure the received voltage in dBmV unit.

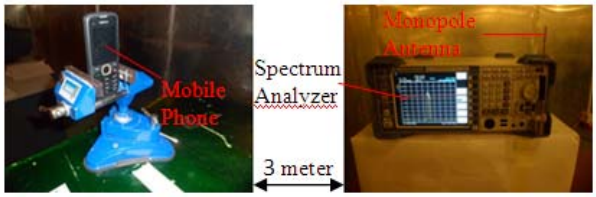

Figure-7. Setup to determine propagated wave position.

The purpose of this experiment is to identify propagated wave position from mobile phone. Distance of 3 meter between antennas is not critical as long as it remains fixed throughout the measurement for coupling of wave to take place at the monopole antenna. Furthermore, the distance is suitable as the wave radiation power is reduced as it travels through distance and lead to easier identification of phone orientation with biggest radiation magnitude. However, instead of changing the mobile phone orientation, it is easier to change orientation of the monopole antenna as it can be rotated at the 50 Ω port of the spectrum analyzer. The received voltage is measured three times for each phone orientation.

PREVIOUS SIMULATION RESULT ON AP

Figure-8 shows the effects of EMR towards the AP with mobile phone power level at 0.02 W. In the figure, the waveform of original source AP from the brain (blue solid traces), original load AP without any radiation effects at the muscle finger (red dash traces) and load AP with EMR effects (green dot traces) [1]. The result clearly shown that with appearance of EMR, there will be interference spike appears riding on the original load AP. Therefore, in this paper, the author will proved that the robotic arm signal in the experiment setup has similar

effect such as burst of voltage at some interval of time in the robotic arm signal when there is EMR source near to the robotic arm experiment setup.

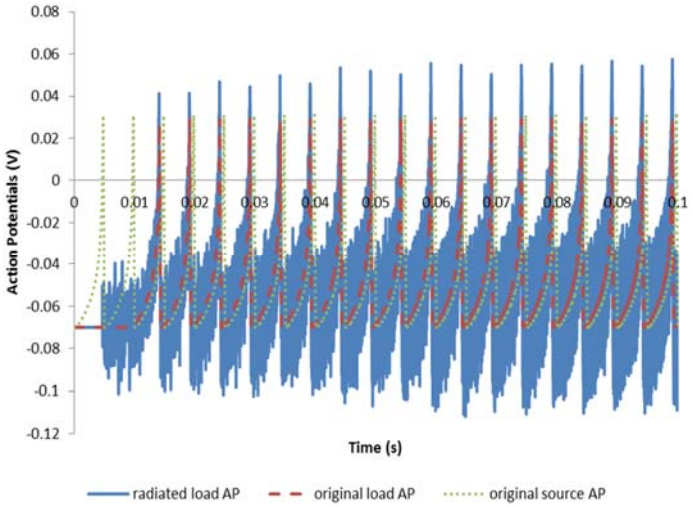

Figure-8. Interference of EMR in APs signal

EXPERIMENTAL RESULTS

Table-1 shows the measured received voltages from a Nokia phone model at all eight phone orientations. Tabulated results show that monopole antenna at 225^0 orientation has the highest received voltage. Therefore it is suspected that phone orientation at 225^0 during robotic arm experiment will introduce the highest radiation magnitude to the robotic arm signal. The other phone models such as Samsung, U-com and Sony Ericsson also show 225^0 orientation as the dominant factor in introducing high radiation magnitude.

Table-1. Received voltage from Nokia phone.

Orientation	Received Voltage (dBmV)			
	1st reading	2nd reading	3rd reading	Average reading
0^0	**38.94**	**35.35**	**37.92**	**37.40**
45^0	37.80	38.14	36.78	37.57
90^0	39.90	39.44	38.33	39.22
135^0	38.56	36.11	39.20	37.96
180^0	40.80	32.09	35.44	36.11
225^0	44.55	44.53	44.98	44.69
270^0	43.54	42.81	43.32	43.22
315^0	37.13	38.69	40.44	38.75

Observation from the robotic arm experiment has produced some promising results as there is significance distortion in robotic arm movement as six mobile phones placed near to copper wires in the experiment. Furthermore, there is also interference introduced on the robotic arm signal when those six phones are at same certain orientation.

The usage of six mobile phones is very crucial in this experiment as those six mobile phones on silence ongoing call state will produced the net radiation power which is approximately at 0.02 W as per discussed in sub-topic 2. Furthermore, the simulation results of AP signal shows that 0.02 W radiated power from a mobile phone can introduced interference spike on the AP signal [1]. Therefore, it is a strong indication to use six mobile phones as source of radiation for the robotic arm experiment. The net power of 18.96 mW from those six phones on silence ongoing call state is enough to introduce radiation effect on the robotic arm signal.

As for accuracy in placing matchbox at point B from point A, when there is no radiation, the match box is perfectly placed on the specified region at point B. Somehow for other cases when there is radiation source appearing near to copper lines at different orientations, the

box placement is deviated a little bit from its specified region. The range of displacement for all cases is from 0.2 cm to 1 cm. The only differ is either it deviated to the left or to the right. 0° and 315° orientations show deviation to the right while other orientations show deviation to the left. These observations proved that the radiation has some slight effect on the robotic arm movement and hence might have distortion effect on human arm movement too.

In order to strengthen the displacement of match box observations, the signal used to move the robotic arm is also being analyzed in its radiation effect such as spike or slight increase in supplied voltage can be detected at presence of radiation source nearby.

Figure-9 shows the robotic arm signal when matchbox placement process is in progress with phone radiation source introduce at 0° orientation for all of six phones on the copper wires. Even though the movement of match box has deviation when radiation source of 0° orientation is introduced, somehow the robotic arm signal in Figure-9 did not show any significant interference on the signal. This might happened due to the transmitted wave from the phone is not in parallel with the copper lines and hence very small portion of radiated wave has been absorbed. Thus the absorbed wave only show small magnitude of radiation on the robotic arm signal and could not be visibly maintained as when the motor in robotic arm moves. Other phone orientations that have similar results as shown in Figure-9 are 45°, 90°, 135°, 180°, 270° and 315°.

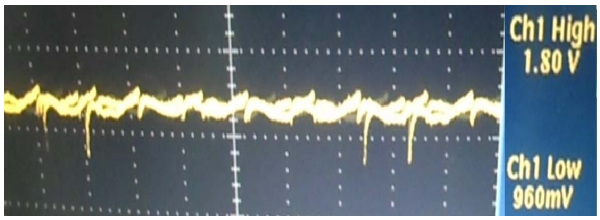

Figure-9. Robotic signal in movable state with phone at 0°.

Figure-10 shows the robotic arm signal when matchbox placement process is in progress with phone radiation source introduce at 225° orientation for all of six phones on the copper wires. The voltage increment can be observed clearly which is about 0.4 V. This results has further strengthen the fact that phone orientation at 225° has introduced a significant radiation effect on the robotic arm signal in its moveable state and thus validate the pre-experiment results as shown in Table-1. Therefore, when there is a mobile phone near to human body, the mobile phone must not be in orientation where the radiated wave is in parallel with nerve fibre tract inside the body. It may cause a severity to AP inside the nerve fibre and hence will interrupt the normal human voluntary system.

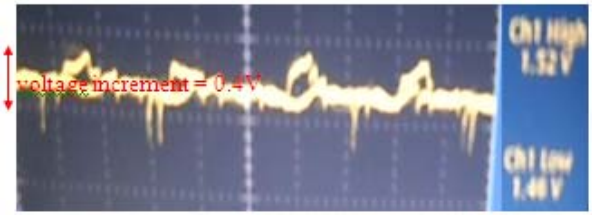

Figure-10. Robotic signal in movable state with phone at 225°

CONCLUSIONS

The experimental results show the robotic arm DC signal is interfered by the appearance of GSM phone radiation, but only 225^0 phone orientation show significance interference by voltage increment of 0.4 V in short interval on the robotic arm signal. This due to antenna radiation wave in the phone is in parallel with copper lines feed to the robotic arm during the 225^0 phone orientation. Furthermore, location of match box placement on the required region shows deviation when radiation source exist near to the copper lines. At a glance, the GSM phone radiation is possible to interfere with harmonious function of APs that maybe become hazardous threats in long period of time.

ACKNOWLEDGMENTS

The authors would like to thanks UniversitiTeknikal Malaysia Melaka (UTeM) and Ministry of Education, Malaysia for the financial supports given through Research Grant (PJP/2013/FKEKK (48C)/S01277). A high appreciation to Center of Electromagnetic Compatibility (EMC) at Universiti Tun Hussein Onn Malaysia (UTHM) for the facilities provided to conduct this study.

REFERENCES

[1] Othman, M.Z.M.Jenu. 2015. Mobile phone radiation effects on action potentials in brain-arm nerve fibres of human. International Journal of Applied Engineering Research (IJAER) Vol. 10. No. 17. pp. 38177-38182.

[2] M. Bolshakov and S. Alekseev. 1992. Bursting responses of Lymnea neurons to microwave radiation. Bioelectromagnetics. Vol. 13. No. 2. pp. 119-129.

[3] D. Hao, L. Yang, S. Chen, J. Tong, Y. Tian, B. Su, S. Wu and Y. Zeng. 2013. Effects of long term electromagnetic field exposure on spatial learning and memory in rats. Neurological Sciences. Vol. 34. No. 2. pp. 157-164.

[4] M. Razavinasab, K. Moazzami and M. Shabani. 2014. Maternal mobile phone exposure alters intrinsic electrophysiological properties of CA1 pyramidal

neurons in rat offspring. Toxicology and Industrial Health. 0748233714525497.

[5] Partsvania, T. Sulaberidze, L. Shoshiasvili and Z. Modebadze. 2011. Acute effect of exposure of mollusk single neuron to 900-MHz mobile phone radiation. Electromagnetic Biology and Medicine. Vol. 30. No. 3. pp. 170-179.

[6] European Telecommunication Standards Institute (ETSI). 1999. Digital cellular telecommunications system (Phase 2+); Radio transmission and reception (3GPP TS 05.05 version 8.20.0). ETSI. Sophia Antipolis, France.

[7] E. Calabro and S. Magazu. 2013. Measurement of output power density from mobile phone as a function of input sound frequency. Journal of Microwave Power and Electromagnetic Energy. Vol. 47. No. 4, pp. 270-279.

[8] M. Kahabka. 2013. Pocket Guide for Fundamentals and GSM Testing. Wandel and Goltermann GmbH, Eniugen u. A.