INTERFERENCE STUDY ON DUAL CHAMBER DEMAND PACEMAKER

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Abstract: **The growing generation has great improvement in telecommunications and other related technologies that have changed the entire healthcare environment to increasing amounts of electromagnetic radiation that can cause interference with other electrically controlled devices. This paper suggests that electromagnetic interference may occur between pacemakers and wireless handheld (cell) phones, a potential public health concern. If the pacemaker is exposed to an electromagnetic field generated by a mobile phone, electromagnetic interference may occur and this may be resulting in affecting of pacemaker. Any medical device that uses on-board electronics can be affected by EMI, but implantable devices (pace makers) are particularly vulnerable to the effects of EMI because people are constantly surrounded by electronics. It is necessary to understand how EMI can affect them and proactively protect them from interference or damage. This article describes methods and means for effectively controlling EMI in (CIED) Cardiac Implantable Electronic Devices.**

Keywords: **Electromagnetic interference, pacemaker, CIEDs, Electromagnetic compatibility, EMI shielding**

1. INTRODUCTION

EMI is an electromagnetic field generated by electrical devices which causes interruption to other electronic device in its vicinity. EMI depends on several factors on several factors including the duration of interference, the field strength and the frequency spectrum of the source. A research has indicated that interference may be caused by holding a mobile phone within 150mm of the implanted device, or with direct contact between the phone antenna and the user's skin. Electronic device which emits electromagnetic energy (EMC) or EMI, which can affect the normal operation of your implanted heart device, in most of these cases, energy fields are not enough to affect the heart devices, but electrical devices with strong energy fields could alter the therapy delivered by your implant. There are some of the pacemakers where EMI can potentially interfere, ICD, CRT-P, or CRT-D. Cause the ICD or CRT-D to falsely detect an irregular heart rhythm and deliver a shock that is not needed. Although the EMI cannot be completely reduced but we can control or reduce the amount of EMI.

2.LITERATURE SURVEY

CIED manufacturers have responded to this EMI problem with improved device protection from abnormal or unwanted influences, special circuitry designed to filter out signals from EMI sources at commonly used frequencies, and specialized algorithms designed to distinguish between noise and true intracardiac signals. Juna Misiri MD, Fred Kusumoto MD, and Nora Goldschlager MD also explains about EMI in CIEDs in a non-medical setting.

The overall risk summary for clinically significant related hostile events of EMI in CIED recipients is very low. Therefore, no special precautions are required when using household appliances. Environmental and industrial sources of EMI are relatively safe if the exposure time is limited and the distance to the CIED is maximized. The risk of events due to EMI is highest in the hospital environment. It is ensured that doctors are aware of possible interactions and ways to minimize them. This paper was described by Roy Beinart and Saman Nazarian.

The EMI measurement techniques and the types of them includes emissions and immunity. Emissions and Immunity testing also includes his two subtypes, his EMI radiation techniques such as electromagnetic shielding, his EMI filters with material efficiency, circuit topologies and spread spectrum techniques for the electromagnetic spectrum. This content was proposed by Phalguni Mathur and Sujith raman.

EMI shielding and filtering are an effective way to remove EMI. If such an EMC is implanted in the medical devices it can withstand the daily exposure of the EMI to ensure stable and well grounded operation in the implanted medical device such as Pacemaker. Ting wei wang and Ting Tse lin has displayed EMC methods for implantable medical devices.

The patients who are using implantable pacemaker in daily life can experience vulnerable effects due to the multiple source of EMI. Patients should be aware of the problems and need to take precautions in order to prevent the effects of EMI. This content was proposed by Okan Erdogan.

Mobile phones and wireless communication play a major role in healthcare because of that electromagnetic interference (EMI) is produced. This EMI can cause malfunction of medical devices. However, if the transmitting device is kept above 1 m, the possibility of medical device failure may be rare. This conetnt was proposed by Stephen E.Lapinsky and Anthony C.Easty.

Electromagnetic compatibility (EMC), has the ability to make a device function well. It is considered to be important in the construction or design of equipment. They use a wide variety of equipment in hospitals where electrosurgery produces high levels of EMI. Other devices such as EEG and ECG are sensitive to EMI. Understanding EMC allows us to prevent interference problems and protect critical systems. In hospitals, EMI was often considered a minor nuisance, some equipment failures caused by EMI resulted in death or injury. This topic was proposed by Catalina luca Gheorghe Asachi and Alexander Salceanu Gheorghe Asachi .

The Symbiotic cardiac pacemaker model based on an implantable triboelectric nano generator explains that how the self-powered implantable medical electronic devices collects biomechanical energy from cardiac motion, respiratory motion, and blood flow. The symbiotic pacemaker corrects sinus arrhythmia and prevents its worsening successfully. The voltage of the implantable triboelectric nanogenerator reaches up to 65.2 V. This content are proposed by Han Ouyang, Zhuo Liu, Ning Li, Bojing Shi, Yang Zou, Feng Xie, Ye Ma, Zhe Li, Hu Li, Qiang Zheng, Xuecheng Qu, Yubo Fan, Zhong Lin Wang, Hao Zhang & Zhou Li.

The electromagnetic interference (EMI) is having a negative effect in the performance of medical devices. Any medical device that uses on-board electronics will get affected by EMI, mainly implantable devices such as pace makers are particularly vulnerable to the effects caused by the EMI. The implantable devices are not easily replaceable and are often life-sustaining. It is necessary to understand how EMI affects the medical devices and protect them from interference or damage. The objective of this article is to control or reduce EMI in the hospital environment and (CIED) Cardiac Implantable Electronic Devices. This was explained by Y. David, Abdul R.S. Bhukari , W. David paperman.

The EMI causes impact on the implantable cardiac devices such as pacemakers and implantable cardioverter- defibrillator. Electrosurgery is a technique that can be most affected by EMI. The doctors and surgical team should take special care for the Pacemaker Implanted patients by choosing proper device and surgery. Even though MRI is not used for patients with CIEDs it should have some guidelines. The other sources for EMI in medical devices are Physiotherapy devices such as TENS and Ionizing radiation. This topic was offered by Juna Misiri , Fred Kusumoto, Nora Goldschlager.

3. RELATED WORK

3.1 Electromagnetic Interference

Electromagnetic Interference (EMI) is an interference of a external electromagnetic field or electromagnetic waves while it is contact with the electronic circuits, it can cause malfunction in the circuit and it doesn’t work properly. The source of emi it can be either a natural or manmade.

EMI cause a dangerous effect on the implantable medical devices due to the continuous contact with the emi sources while travelling. Wherever the electric current flows, the magnetic field Is produced around in a perpendicular direction.

3.2 Electromagnetic Compatibility

Electromagnetic compatibility is ability of an electronic devices having the immunity to withstand electromagnetic interference in an electromagnetic environment. In medical devices the EMI effects are very severe, so the medical equipment must having a electromagnetic compatibility test.

EMC tests are done for the production model of an equipment till it is attaining the level of frequency.

EMC is achieved by making the frequency level that does not interfere with the electromagnetic fields either it may be higher or lower than that fields.

3.3 EMI Shielding

EMI shielding is defined as the covering of an equipments or device with a material that does not conduct the electromagnetic fields through it. The advantages of EMI shielding is reduce the electromagnetic interference in the medical equipments and work in a proper way, it also increase the life span of device. The EMI shielding materials are namely platinum, gold, copper, nickel etc.

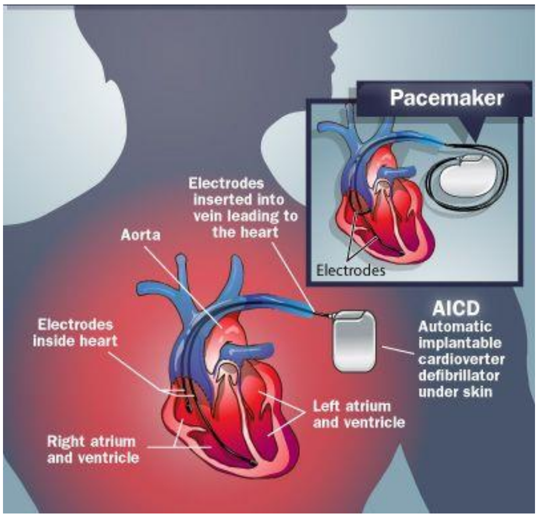
The thin layer of these materials are coated over the devices to reduce EMI effects and it is corrosion resistant. These materials are used in the implantable medical devices to withstand from liquids and acids inside the body.

3.4 EMI Filter

It is defined as the filtering of electromagnetic frequency that are interfere with the electronic devices. The EMI filters are having a low pass filters, when the electromagnetic frequency pass through the low pass filter it only passes the low frequency and the higher frequency are reflected back. In medical equipment it has a medical grade EMI filter to meet the requirements of medical applications.

3.5 EMI In Pacemaker

Current generation pacemaker are capable to withstand the electromagnetic interference, but due to the advancement in the technologies there are so many electronic devices we are using in our day to day life. The devices like mobile phones, headphones, TV , radio etc, are mostly interfere with the pacemakers regularly . It may cause a dangerous effects for patients using pacemaker due to malfunction, affects signals and stop working etc.The patients are very careful with the surrounded electronic equipments and place them in a 50cm apart from the body. These are the effects of EMI in pacemaker.



4. Methodology

The objective is to design a Printed circuit board (PCB) using Easy EDA software and to analyze the amount of radiation emitted from the pacemaker by providing various types of frequency ranges using HFSS software. The block diagram of the pacemaker is given in Figure 3.6 and it describes that, In accordance with the principles of the demand pacemaker design, a sense amplifier is provided to detect intrinsic ventricular activity.

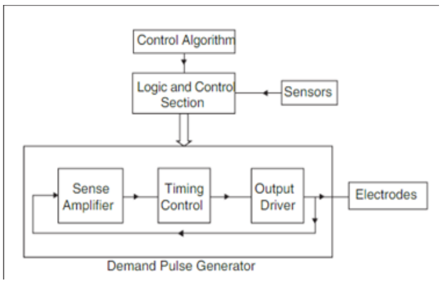


Fig 4.1: Block diagram

The timing control circuits determine both atrial and ventricular time-out stimulating period. However the atrial-stimulating impulse is generated first, and, after a predetermined time interval (200 ms), the ventricular-stimulating impulse is generated. Three electrodes are provided: a neutral electrode, an electrode for atrial stimulation, and an electrode for ventricular pacing and sensing. The field-effect transistor **(**FET) switch (S FET) is inserted in the feedback path of the ventricular electrode in order to avoid erroneous detection because of the atrial con- traction. The S FET is normally conducting. The negative pulse generated at the atrial electrode is transmitted through the diode Da, charging the capacitorCa, and turning off the switch. When the atrial-stimulating terminates, Ca dischargesthrough resistor Ra and turns on the switch again. In this manner, thesense amplifier is disabled during each atrial stimulation and for a short interval thereafter. The Schematic diagram of pacemaker and PCB diagram of pacemaker are shown in figure 4.2 and figure 4.3 respectively.

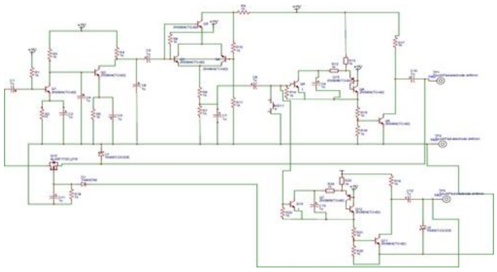


Fig 4.2: Schematic diagram of pacemaker

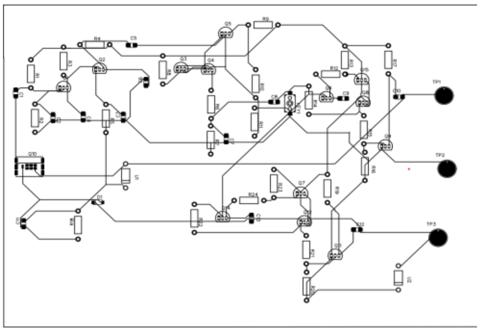


Fig 4.3: PCB diagram of pacemaker

5. Results and Discussion

This paper discuss about how to control or reduce EMI which are affecting CIEDs like Pacemaker and implantable defibrillators. The overlapping of the signals occurs because, the frequency range of the electromagnetic radiation (10-60 Hz) and the frequency of the cardiac signals are same. Thus, the EMI may affect the CIEDs. So, the patient may affect by irregular heart beat(arrythmia) or pausing of the heart beat and it leads to fainting. The pacemaker implanted patients should maintain a minimum range of 6 inches from the electronic gadget. By maintaining a distance, it may reduce the effect of EMI on CIEDs. In other ways using EMI shielding, it can reduce the coupling of radio frequency waves or electromagnetic field. The redesigning of pacemaker with the added filters can be a alternate solution for reducing EMI. Traces are the conductive paths that carry current from the driver to the receiver on the PCB. When these traces come across any bend or cross, they form fully radiating antenna. The graph below shows the impedance matching network which we simulate. Here, the goal is to determine the frequency for optimal impedance matching by extracting the S-parameters. The frequency dip is the representation of impedance mismatch, impedance matching guidelines do not explicitly mention the input impedance of an interconnect, which will determine the S-parameters (specifically return loss). Impedance mismatch shows that the radiation is exciting at different frequencies. From fig 5.1 we can determine the trace width is inversely proportional to the radiation, Higher
the trace width will cause low amount of radiation. The various frequency data values for trace width with 1.5mm and 3mm given below in table 5.1. Here, the source is set to 5GHz, and frequency sweeps will be used to determine the insertion loss and return loss. The way to proceed further is to iterate through different values using parameter sweeps.

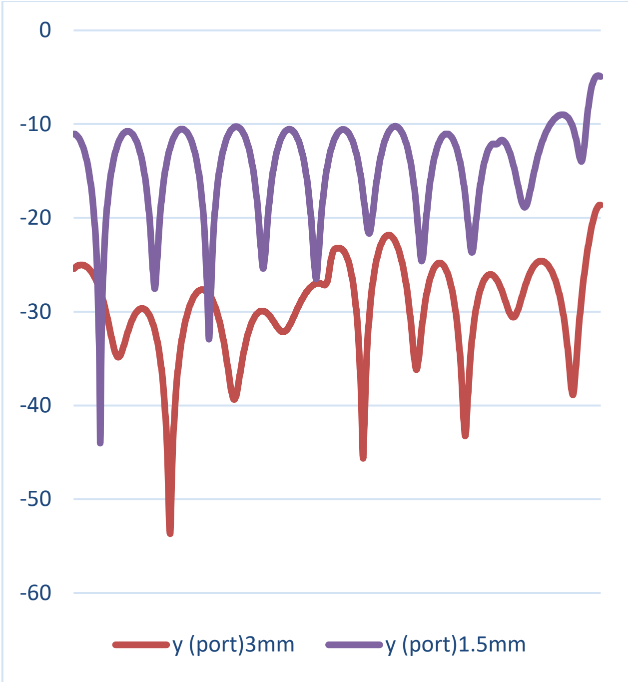


***Fig 5.1** frequency data chart for s parameter*

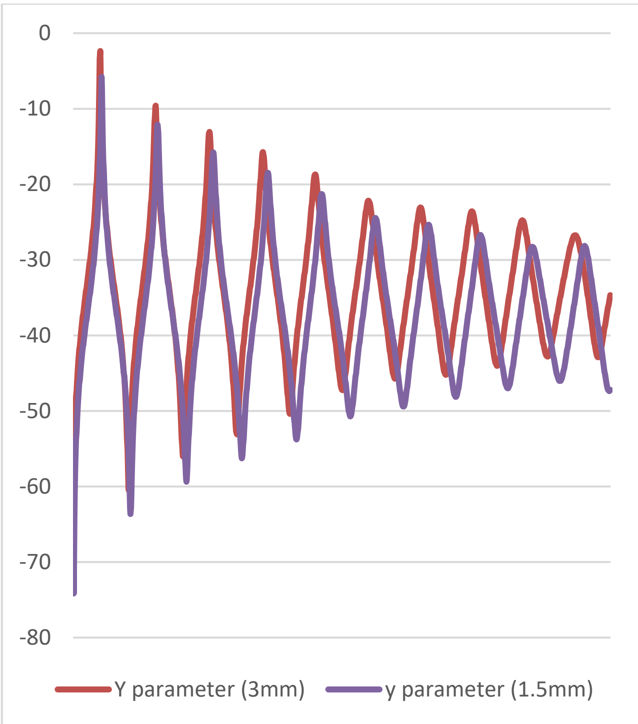


***Fig 5.2** frequency data chart for y parameter*

	TRACE WIDTH 1.5MM	TRACE WIDTH 3MM
x (freq)	Y1(port)	y2(port)
1	-11.0347606	-25.42989474
2	-32.98220254	-28.22484299
3	-10.79489508	-31.71095865
4	-24.8176261	-32.98503022

5	-10.63094045	-31.38252115
6	-23.6984664	-28.76340562
7	-10.47402159	-36.54756736
8	-20.01092761	-30.23194377
9	-11.10115691	-30.10837099
10	-17.58461489	-27.12137944
11	-11.42559829	-25.78260838
12	-14.60617482	-23.55103999
13	-12.14472852	-27.30921804
14	-13.68266456	-25.324154
15	-15.12599755	-37.84394217
16	-12.4529693	-26.03891263
17	-16.24305656	-29.97490921
18	-11.08752743	-24.74644953
19	-10.31993728	-38.87713526
20	-4.934161926	-18.63134486

Table 5.1 *Frequency data table*

6.CONCLUSION

This paper talks about the electromagnetic interference in pacemaker. The electromagnetic interference are produced by the cosmic noises, high current fluctuations, communication gadgets, magnets etc. The electromagnetic interference in pacemaker can affect the patients and cause arrythmia, ventricular tachycardia, dizziness etc. By maintaining a specific range with the electronic gadgets such as mobile phones, air pods the interference will be reduced. Applying a metal coating (EMI shielding) is a common technique to reduce EMI. Metals such as platinum, copper, nickel, gold are used for reduction of EMI. Designing of a pacemaker circuit with filters will reduce the electromagnetic interference.

7.REFERENCES:

1. Juna Misiri ; Fred Kusumoto ; Nora Goldschlager(2012), “Electromagnetic Interference and Implanted Cardiac Devices: The Nonmedical Environment (Part-I)”
2. Roy Beinart and Saman Nazarian (2013),” Effects of External Electrical and Magnetic Fields on Pacemakers and Defibrillators”
3. Phalguni Mathur and Sujith Raman (2020), “Electromagnetic Interference(EMI): Measurement and reducing techniques”.
4. Ting Wei wang and Ting Tse lin(2021), “Electromagnetic Compatibility issues in Medical Devices”
5. Okan Erdogan (2002), “Electromagnet Interference on Pacemaker”
6. Stephen E.Lapinsky (2006), “Electromagnetic Interference in Critical care”
7. Catalina luca, Gheorghe Asachi, Alexandru Salceanu (2012), “Study upon Electromagnetic Interferences inside an Intensive Care unit”
8. Han Ouyang, Zhuo liu, Ning li, Bojing Shi, Yang zou, Feng xie, Ye ma, zhe li, Hu li, Qiang Zheng, Xuecheng Qu, Yubo Fan, Zhong Lin Wang, Hao Zhang& Zhou li (2019), “Symbiotic Cardiac Pacemaker”
9. Y. David, Abdul R.S.Bhukari, W.David Paperman (2002),” Management of Electromagnetic Interference in Hospital”
10. Juna Misiri ; Fred Kusumoto ; Nora Goldschlager (2012), “Electromagnetic Interference and Implanted Cardiac Devices: The Nonmedical Environment (Part-II)”