Project Report –Wireless Charging

Wireless communication and mobile networking
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1. OVERVIEW

In this semester, I joined in to the system group. In the medical field, deaf people need to live with artificial cochlear. The common power is rechargeable battery but it's not convient for them.

So The aim of our group is going to build a circuit to solve the power problem of Bluetooth cochlea. To achieve this, we have to use antenna to capture the energy of WIFI signal to convert it into the power of our artificial cochlear.

In the first half of the semester. The work of mine mainly focused on the current we need to power the Bluetooth device.

Then in the other half of the semester, I worked to build the circuit to capture the energy of WIFI signal to convert it into the power. After that, because of the fact that we cannot improve the energy we capture, I begin to find the way to improve the voltage we can get.
In the following parts, I will explain what I have done in this project in detail. Because I mainly worked on physical layer structures, I don't have any code.

2. Blue-tooth power consumption

The chip we use for Bluetooth cochlea is CC2541, it support the protocol of Bluetooth-Low-Energy. So we mainly focused on the BLE consumption.

Firstly, I have found the current of the blue-tooth in the protocol book named Specification of the Bluetooth System. I find the current consumption for different way of Bluetooth.
In the TX mode, which is used for sending message, the current is 16.8mA.
In the RX mode, which is used for receiving message, the current is 17.9mA.

Then, I have to find the time of sleeping for Bluetooth and the time of sending or receiving message. I find there are four types of physical channel.
1 basic piconet channel is used for two device which have connected.
2 adapted piconet channel is used for two device which have connected.
3 inquiry scan-channel is used for finding blue-tooth device.
4 page scan-channel is used for connecting blue-tooth device.

The define of slot is the following equation.

The average timing of packet transmission shall not drift faster than 20 ppm relative to the ideal slot timing of 625 µs. The instantaneous timing shall not deviate more than 1 µs from the average timing. Thus, the absolute packet transmission timing t_k of slot boundary k shall fulfill the equation:

$$t_k = \left(\sum_{i=1}^{k} (1 + d_i) T_N \right) + j_k + \text{offset}, \qquad \text{(EQ 1)}$$

For Piconet physical channel timing, there are only 3 packet types: 1,3,5 slots.

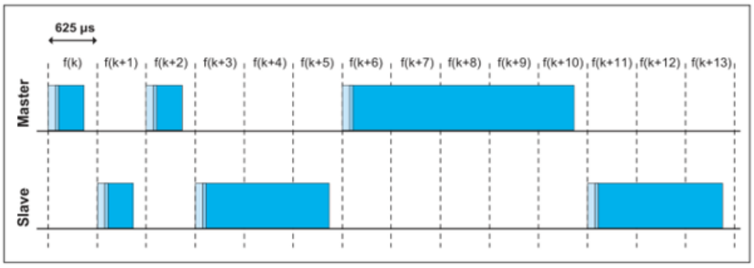


Figure 2.1: Multi-slot packets

I find that for each slot, the time of broadcast for Piconet physical channel is less than 426 µs. The time share of broadcasting in total is 68.16% The adapted piconet channel and basic piconet channel are the same about the time slot and time share.

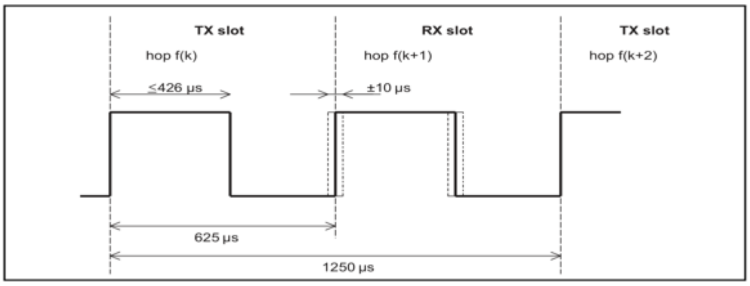


Figure 2.3: RX/TX cycle of master transceiver in normal mode for single-slot packets

For inquiry scan-channel, I find that the time of broadcast for inquiry scan-channel is less than 68 µs. The time share of broadcasting in total is 21.76%

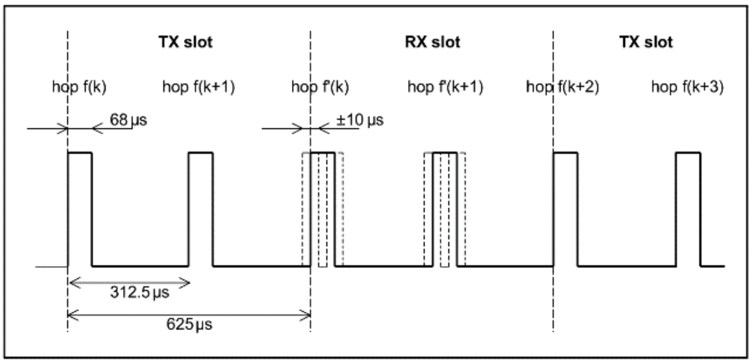


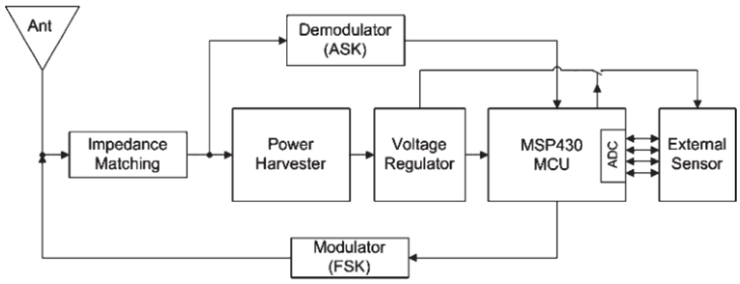
Figure 2.7: RX/TX cycle of transceiver in PAGE mode

And the time share and time of broadcast of page scan-channel is as same as inquiry scan-channel.

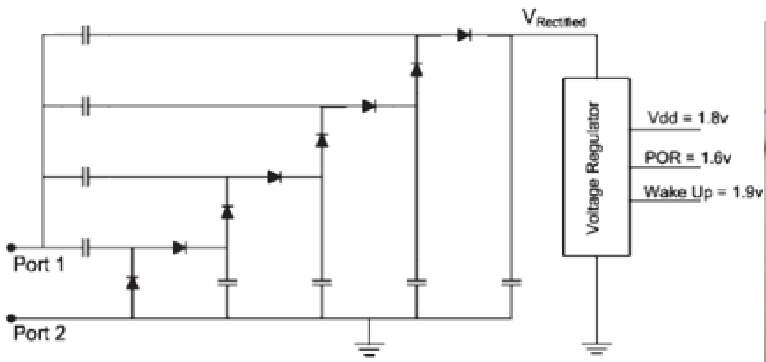
3. **Antenna energy harvesting**

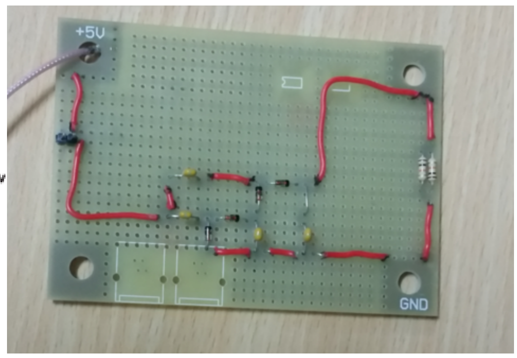
After calculating and asking some engineer in factories, we knew that we should harvest at least 400 mV from the WIFI signal in the air. So two students and I build the circuit for antenna energy harvesting.

The name of the circuit is named the Wireless Identification and Sensing Platform(WISP) which is a battery-free programmable RFID sensor device. The architecture of WISP allows the measurement of virtu-ally any low-power sensor, which is also wirelessly powered by the RFID reader.
The block diagram of the WISP platform is:



The circuit of WISP and what we build are the following:





We can see that our circuit uses only two capacitor. That means, we can amplify the voltage we get from the antenna by four times. So by now we have captured WIFI signal so that the voltage can be 260 mV.

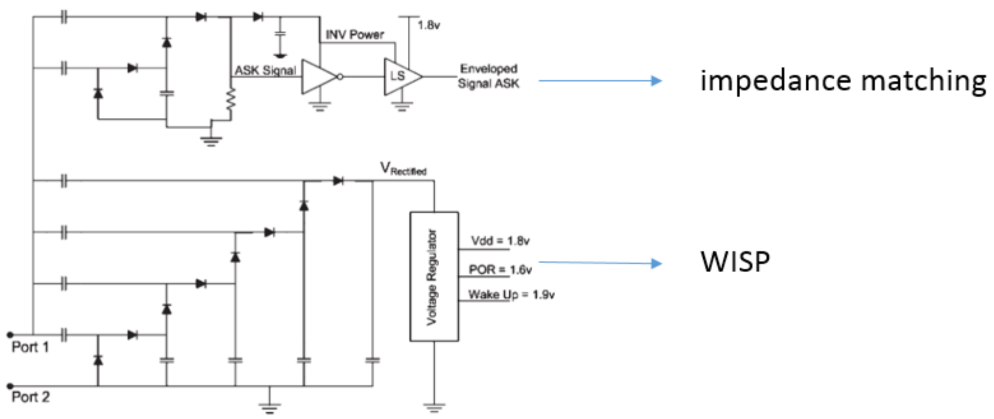
However, we found 400 mV is different to get. So our mini-group aimed to find ways to improve the voltage we can get and problems about the situation of our current work.

4. **Finding problems for harvesting energy**

We begin to find problems for our circuit so that we can improve the voltage we can get later.
1.I find there is one problem that we cannot find the theoretical value we can get at most. Because we have tried to get close to the antenna for sending WIFI. But the value is still under 400mV. If the antenna for sending WIFI cannot give energy with 400mV, then we can never get the voltage value unless the WIFI router is changed. The problem may not be solved. But we can test other WIFI router to find whether it's anything do with the WIFI router.

2.The antenna we are using now is single-polarity antenna which is not designed for WIFI capture. So we have bought the double dipole antenna.

3.Impedance matching is a way to improve the voltage by adding to the circuit of WISP.



The question is if we touched the antenna, the voltage value is changing swiftly. So by now we have not added impedance matching. If we can solve the problem, it is easy to get the voltage of 400mV.

4.As we sey above, the antenna is not stable. That is, if we touched the antenna, the voltage value is changing swiftly. So we have to find how to using energy to locate the direction of antenna and make the antenna more stable and not decrease quickly when the direction of antenna is changed.

5. **Thinking**

The wireless charging project is interesting and challenging. I'm very pleased to solve many problems we faced and get the result by now. And I gained much knowledge about the WISP, BLE and so on. It may be useful for later research of mine.

In the part of finding problems for harvesting energy, students in our group and me have raised many questions that restrict the improvement of the energy harvesting. These questions are need to be solved, however we have not found the way to solve. I think the circuit need to be changed to make the circuit more stable.

So the project still have a long way to go. After overcome a series of problems, I'm sure

that we can achieve an antenna energy charged artificial cochlear and it will be helpful for deaf people.
Finally, thanks for teachers and other students in the group!

6. Reference

BLE HW training
cc2541_Datasheet
Specification of the Bluetooth System
Design of an RFID-Based Battery-Free Programmable Sensing Platform
倍压整流电路参数分析与设计
倍压整流电路电容参数的优化设计