Career Episode 1

Introduction

CE 1.1

The preset career episode describes my understanding about the Doppler tolerant waveform and radar ambiguity function. I have completed this project in a group as a part of my course requirement. As I have completed the project as a group member, the division of work was there. My role was to develop theoretical knowledge about the radar frequencies and waveforms.

Chronology:

Location:

Name of the Organization:

Post:

Project Name: Doppler tolerant waveform and radar ambiguity function

Background:

CE 1.2

A radar system indentifies the incoming wavelengths within its working range. The radar receives a wavelength and analyzes the wavelength to identify the message or any incident within the target groups. The wavelength receiving and sending from radar depends on two very sophisticated mechanisms. One is the technical specification of the radar and the other thing is the angular direction of the radar. The subliming factor, which plays a major role in the radar-working mode, is the environmental anomalies of the locality.

CE 1.2.1

Detection

While working on the project I have learnt about the fundamental working principal of the radar. I have learnt that for a particular provided range or Doppler or angle a radar takes the decision whether the target object is present or not present.

CE 1.2.2

Estimation

The estimation is the detection of the live object's nature within the radar range. The best example what I have experienced is the working mode of the SAR – Synthetic aperture radar. I have learnt about the fundamental working chronology of the radar during the estimation.

Personal Activity

CE 1.3

Through my working experience within the group, I have learned the following things from the theoretical aspects. The things are overview about the radar frequencies, radar waveform taxonomy, CW: Measuring range, Ambiguity function, FM and PM pulse compression waveforms and the coherent pulse trains. The knowledge on these topics have helped me to apply the theoretical knowledge in this project.

CE 1.3.1

Radar Frequencies and radar bands

The radar frequencies and the radar bands are totally interrelated to each other. The radar band ranges from HF band to mm (V&W). The frequency of the radar varies according to the band. The frequency ranges from the 3 MHz to the 1000 MHz. The following table will illustrate the different band and the related frequencies with it.

Radar band	Radar Frequency
HF	3- 30 MHz
VHF	30- 300 MHz
UHF	300-1000 MHz
L	1-2 GHz
S	2-4 GHz
C	4-8 GHz
X	8-12 GHz
KU	12-18 GHz

KA	27-40 GHz
Mm(V &W)	40-300 GHz

CE 1.3.2

Continuous Wave v/s Pulsed

I have seen that the major difference between the continuous wave and the pulsed wave is that the continuous wave transmits and receives the frequency simultaneously. Whereas, the pulsed wave transmits and receives through a given period of interval. This interval was prefixed.

The other thing what I have learnt is that for the continuous wave radar it requires separate transmitting and receiving antennas whereas for the pulsed wave one single antenna works as a sender and the receiver. In case of continues wave radar the isolation requires limiting the power supply whereas the in case of pulsed wave radar the time-multiplexing technique allows the isolation, in this case the power requirement remains very high.

The major advantage for the continuous wave radar I have found that it does not have any blind ranges. However, the pulsed wave radar has blind rage. The main reason behind this is the eclipsing manner during the time of transmitting events.

CE 1.3.3

Modulation

I have learnt that the modulation is a major factor for the pulsed wave radar. The modulations have different classification. The following table will illustrate the classes of modulation.

Amplitude	"ON-OFF" Amplitude Modulation
Phase	Frequency Modulation
Frequency	Frequency Modulation
Polarization	Phase Modulation

CE 1.4

CW Doppler Processing

The continuous wave radar processing follows the following steps.

DFT Processing

During my work, what I have found is that during the DFT processing the sample continuous wave returns to the receiver in a discrete manner with an applied timing. It develops a working spectrum through Fourier analysis. The result displayed through a sincshaped response. The sign curve represents the analyzed result.

Weighting can be applied to reduce Doppler sidelobes

To weighting of the wave has been calculated through considering the two factors. One is the SNR loss and the other one is the Resolution degradation.

Sampling of DFT response

The sampling of the received DFT response is a function of two factors. One is the frequency and the other one is the bin spacing. I have found that these two are the most important factor for the sampling of the received DFT response.

The one thing I have found while I worked in this project is that the, if we use the zero padding then it reduces the bin spacing. However, the zero padding does not improves the resolution under any circumstances.

CE 1.5

Measuring range with a single pulse

$$s(t) \triangleq \left\{\sqrt{P_{TX}}\sin(2\pi f_c t), for\ t\epsilon\right]0, T_p\left[\ and\ 0, for\ t\ does\ not\ \epsilon\right]0, T_p\left[\right\}$$

In this equation P_{TX} defines the peak transmit power, f_c denotes the center frequency and the T_p defines the width of the pulse. The resultant of this equation helps in the determination of the range.

CE 1.6

The Matched Filter

To match the filter the first stage is the observation of the known signal. The observation of the known signal is followed by the following equation.

$$y(t) = As(t) + n(y)$$

s(t) defines the known signal.

I also followed the following formula to apply the matched filter to increase the signal-to-noise ratio. This is called SNR ratio.

$$z \triangleq \int_{-\infty}^{\infty} y(t)s*(t)dt$$

= A + $\int_{-\infty}^{\infty} n(t)s*(t)dt$

SNR = $\frac{A2}{\sigma 2_n}$

To calculate this equation I assumed the signal is having unit power and which is:

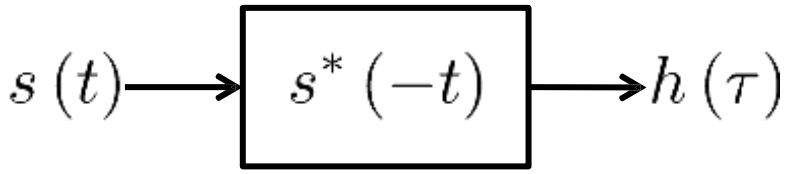
$$\int_{-\infty}^{\infty} |s(t)|^2 \, dt = 1$$

CE 1.7

Waveform range Response

It is an auto correction function for the transmitted signal from the object and the radar. To calculate this I have followed the following equation

If the matcher filter is



Then

$$h(\tau) \triangleq \int_{-\infty}^{\infty} s(t-\tau)\, s^*(t)\, dt$$

CE 1.8

Ambiguity Function

Through working in this project, I have found that the ambiguity function is the characterization of the filtered response while the received signal comes with an uncompensated Doppler shift. I have followed the following range response and the ambiguity function.

The range response formula that I have used is

$$h(\tau) \triangleq \int_{-\infty}^{\infty} s(t-\tau)\, s^*(t)\, dt$$

The Ambiguity function that I have used is

$$\chi(\tau, f_{\mathrm{D}}) \triangleq \int_{-\infty}^{\infty} s(t-\tau)\, e^{i2\pi f_{\mathrm{D}} t} s^*(t)\, dt$$

CE 1.9

The Limitations of the Un-modulated Pulse

I have seen during the project is that for any of the un-modulated pulse an wrapping of the waveform energy and the range resolution

To evaluate the limitation I have considered the following formulas

$$\mathrm{SNR} = \frac{P_{\mathrm{TX}} T_{\mathrm{p}} G^2 \lambda^2 \sigma}{k T_0 \left(4\pi\right)^3 R^4}$$

$$\Delta_{\mathrm{R}} = \frac{c}{2} T_{\mathrm{p}}$$

CE 1.10

Doppler Designing Considerations

While considering the Doppler programming I have considered the following aspects

The Ambiguities: I considered the Doppler and the range ambiguities

The Blind Zones: I have found that the blind zones in Doppler happen only when clutter and the target Doppler becomes same. The other reason for the occurrence of the blind zone is the eclipsing. Eclipsing is the nature of the radar. It defines that it is impossible to transmit and receive the signal at the sometime.

CE 1.11

Pulsed Doppler waveform modes what I have found while working within this group has been illustrated through the following table.

High PRF	Doppler unambiguous
	Range Ambiguous
Low PRF	Doppler unambiguous

	Range Ambiguous
Medium PRF	Doppler unambiguous
	Range Ambiguous
Processing of multiple PRFs	Moving range and Doppler blind zones
	Range resolving and the Doppler ambiguities

Summary

CE 1.12

Throughout this entire project, I have developed critical thinking about the radar working modes, blind zones and the Doppler working model. Working in a group also helped me to learn about the USP of the group activity and the division of work according to the competency of the group members. The entire coding of the solution has helped me to understand how the practical application of the theoretical knowledge can be done through the coding. The main thing what I have Learnt throughout the project is that how the blind zone in the Doppler can be resolved through proper theoretical knowledge and practical coding.

Therefore, throughout this project what has been learnt is that how the Doppler tolerance works in the real life scenario. Through doing this project the different radar frequencies and their nature has been learnt. Furthermore, the modulation for the radar and the Doppler processing through different modes also been learnt. The most important thing that has been learnt is that how the fitter matching is done and how it helps in the case of the Doppler tolerance. In case of the ambiguity functions it has been learnt that how this function can be implemented in solving the real life case scenarios.

Career Episode 2

Introduction

CE 2 .1

In this career episode the main thing, what I have tried to illustrate is the critical understanding about the inductive charging. I have completed this project alone, as it was a sole performance project. The wireless charging is the most recent trend in the mobile phone market. Especially Nokia and Microsoft have used it as a marketing tool. The main reason for doing this project is that to develop a critical understanding about the wireless charging.

Chronology:

Location:

Name of the Organization:

Post:

Project Name: Wireless Charging of Mobile phones

Background:

CE 2.2

The concept of mobile charging has been changed in very recent days with the introduction of the Lamia series from Nokia and Microsoft. The inductive charging was a theoretical concept till date and has been practiced within the laboratory only. However, Nokia successfully applied it and commercialized this concept. Therefore, through this project I tried to understand and illustrate the theoretical application of the wireless charging concept.

CE 2.3

Functioning of the Wireless Charging

The wireless charging is totally based of the wavelength distribution from the source. I have observed that the wavelength of an electromagnetic distribution can range from one millimeter to the one meter. The main advantage of using this technology is that it is very much suitable to

develop portable point to pointcommunication. To transmit and to receive the microwave both the node usagesanantenna with a very specific size.

In mobile phonechargerit is not possible to use the antenna of different size. Therefore, to develop the wireless mobile charger the rectennahas been used. The main feature of this device is that it directly converts the collected microwave energy to the required DC- Direct Current. I found that the internal elements of the rectennahave been arranged through following the mesh pattern. I found that the simplest rectennacould be developed through using Schottky diode. This diode needs to be placed within the two dipoles of the antennas.

However, while working on this project I have found that the conversion off the microwave energy into the Direct current through the rectenna is very much efficient. Within the laboratory condition,the efficient of the rectennahas been ranked higher with the 90% score. I also found that the rectenna configuration through the diodes in the both the dipoles remained able to absorbing the microwaves and converting it into the required DC current.

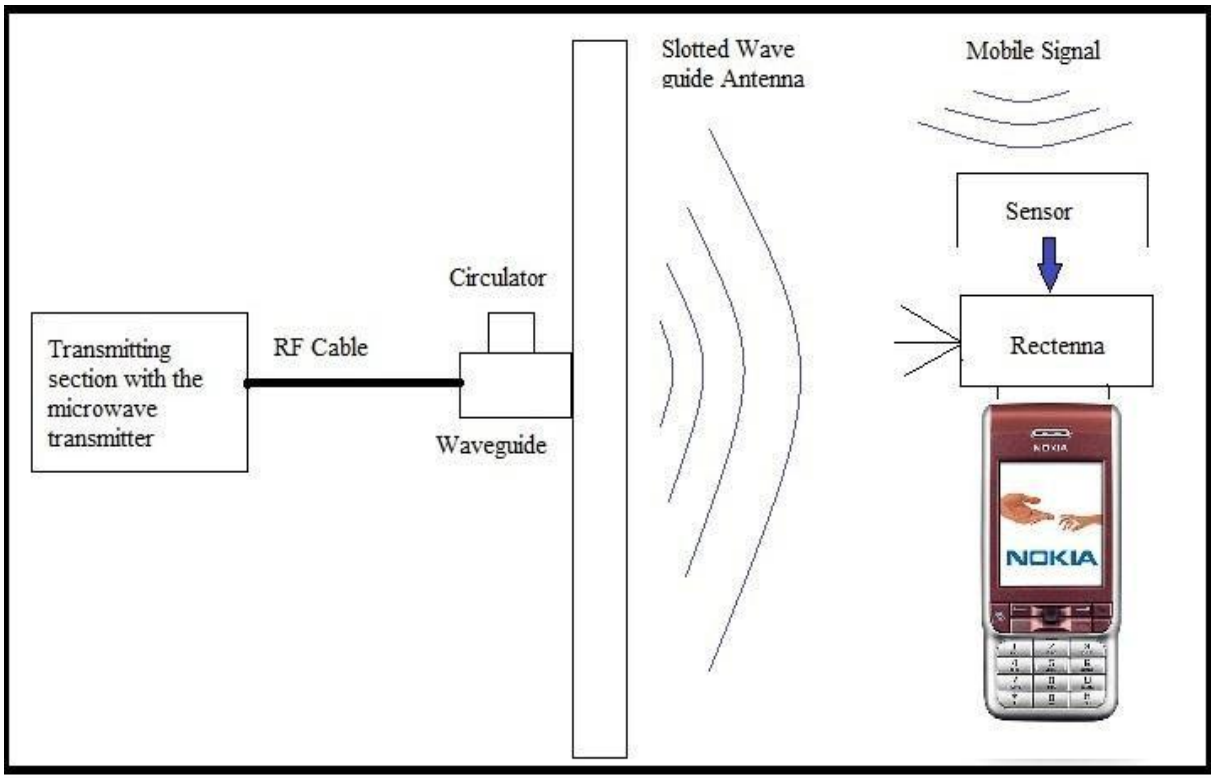
I have observed that the modern day rectennashas been developed through the nanotechnology.In the laboratory conditions, an inverse result has been found. Theoretically the efficiency of the this type of rectenna should be higher but while testing the product in the laboratory condition it has been found that the efficiency of the product is just 1% while it has used infrared light.

CE 2.4

Recent Development

In very recent times, it has been found that the rectenna has been developed using the sensor technology. I found that Nokia used a simple sensor to connect between the mobile and the changing slot. I found that the sensor used the mobile phone wave to charge the mobile phone.

The following block diagram will show the rough working mode of the newly developed rectenna.



While working in the working procedure of the sensor I found that the simple F 2 V connector would serve the purpose. In most of the countries, I have found that the GSM mobile companies are using the 900 MHz to the 1800 MHz frequency. Newly developed sensor is also using the same frequency band. Throughout the study on the development of the sensor, I found that the development of the sensor within this frequency helps the companies to keep the cost within the considerable range. On this context, I have found that this sensor has the capacity to generate larger amount of power directly from the microwave beam. To generate the higher amount of power wed can use the SPS satellites.

CE 2.5

Limitations in using this technology in the Mobile handsets

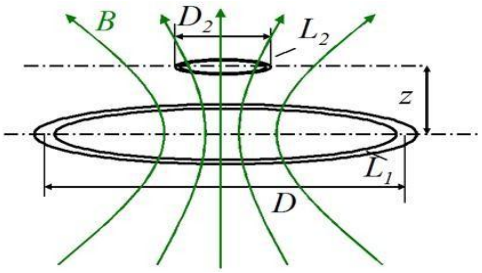
The rectenna that is using the most advanced technology in recent days is much bulky in size. Therefore, using this in the mobile phone will hamper the mobility of the product due to the increment in the size.

However, the main disadvantage of this technology is that lower efficiency and the overheating nature of the charging product. Throughout my experience while working with the wireless charging in the laboratory and in real life situation I found that, the charging material gets over heated very soon. This overheating within a short operational time is a major drawback of this system. Moreover, it there is no as such either theoretical or practical solution is available to reduce this heatingissue in the wireless charging. In most recent development, it has been found that this heating is resistive in nature. This heating over the higher operational time reduces the efficiency of the product.

The other limitation of this product what I have found that the incompatibility of the product with the older phones. I found that if this wireless charging is usedwith the older mobile phones it takes higher time to get charged and the heating becomes more rapid than the latest handsets. The other limitation of this charging method is that as the efficiency is very low if the power supply and the output becomes equal then the charging takes higher than normal time.

CE 2.6

The Inductive charging working procedure



I found that some of the mobile phone makers are providing the wireless charging technology. However, the provided and the theoretical solution is not the same. The mobile phone manufacturers are providing a charging plate or a charging plate to charge the mobile phone. This charging mechanism is called as the inductively couples power transfer system.

This charging system follows the mechanism illustrated in the figure. In this figure, the L1 defines the transmitter coil and the L2 defines the receiver coil.The position of these two coils will be the L1 will be placed at the bottom of the device and the L2 will be top of the device. The charging will happen through the L2 plate. I found through some of journals that some of the

companies have coupled these two plates in different ways. I found that Nokia itself have used this technology in two different ways. In Lumia 920, they have used thee charging bed and in Lumia 822, they have used the charging plate. The major problem what found in this application is that the charging bed is being overheated very frequently and it is taking the more than normal charging time. I found that some of the companies like JBL and HTC are claiming that the heating issue is much more controllable than the charging bed. However, this has not been experienced in the controlled laboratory conditions. In recentdays,all the companies are trying to resolve the issue with the microwaves.

Summary

CE 2.7

Wireless charging is the most innovative idea evolved in the recent days. I found that this technology is still in the very basic development stage. There is a many scopes are available for the theoretical develop on this technology before it gets the successful deployment. The other thing what I have found that there is a large disparity between what theory says and what happens in practical condition. Theory says that the efficiency is much higher but in practical found that the efficiency is much lower than the theoretical explanations.However, I found that this could be a great innovation in some days through the theoretical and the practical advancements.

Therefore, throughout this project the theoretical aspect of the wireless charging. The application of the theory through the application by Nokia has helped to experience the difference between the theoretical claims and the practical experiences. This project helped to learn the transformation of the microwave into the power for charging the mobile devices. However, the size and the efficiency of the charging in present scenario is not that much bright. Through more advanced study and development on this area may create a bright prospect for the wireless charging. Moreover, the development of the rectenna and the associated sensors will provide scope for the development in the inductive charging research.

Career Episode 3

Introduction

CE 3.1

This career episode will illustrate my practical understanding about the optical fiber networks and the positioning of the non-standard optical payloads. This career episode will also illustrate my application knowledge on the optical fiber network and the positioning of the non-standard optical payloads. This project has not only given me the knowledge about the starbugs but also made me aware about the different aspects of the starbugs.

Chronology:

Location:

Name of the Organization:Starbucks

Post:

Project Name: Positioning of non-standard optical payloads.

Background:

CE 3.2

The concept of starbugs is based on the concept of focus plane positioning. This is fast and accurate positioning of the optical fibers. The positioning of the optical fiber is done through the miniature piezoelectric robot. The formation of the starbugis a complex structure. It consist of two piezo ceramic tube actuators joined from different legs.

The motion of Starbugs can be different direction. It can be moved backward, forward, right and left. It usages a 300 Hz frequency. It also can have rotational motion. A starbug device is made up of the piezo materials. The piezo materials are the multilayered materials especially developed for the micro and nano positioning. The bending of the device completely depends on the implication of the voltage into it.

While working on this project I found seven distinctive advantage of starbugs. Those are:

1. Positioning different mass and size
2. Micro tracking facility within dynamic field configuration
3. Active payloads and the passive payloads
4. Scalable
5. Redundancy
6. Vacuum and cryogenic
7. Field configuration time

These are main reasons why most of the scientific experiments prefers using this device.

CE 3.3

Payloads

The payloads offer a better opportunity for the development of the future generation telescopes. I have seen that it provides a smarter focal plane for the future generation telescopes like GMT-Giant Magellan Telescope.

I found that there are few non-standard payloads during my working tenure. Those are:

1. Wave front correctors
2. Wave front sensors
3. IFU- large integral field unit
4. Local image correctors
5. Pick off mirrors
6. FADC- Fluid atmospheric dispersion corrector

The following table will provide a explanatory view about the mentioned payloads

Wave front Sensors	Wave front correctors	Local image correctors	IFU- large integral field unit	FADC	Pick off mirrors
Light	Heavy	Moderate	Heavy	Moderate	Moderate
Image aberration	This technology is	This is used as a corrector for	Provides 2D spatial field to	Fluid used as dispersion	A D-shaped mirror mainly

measuring.	applied to improve the performance through reducing the wave front distortions.	the aberrations happed locally over a wide field.	each of the single spectrum elements.	corrector.	used to differentiate the closely spaced beams.
Used in adaptive optics with Starbug	Deformable mirror	3dF corrector for HECTOR	Used in KOALA IFU for AAT	Used in Fluid ADC for GMT	Used in MOMSI

CE 3.4

Problems associated with different payloads

I have learnt about some of the very common problem associated with the payloads. The most common problem that I have found is that the X-Y and R-theta robot faces problems due to the different weights and different sizes of the material. However, I found that this problem could be resolved through the positioning of the multiple starbugs and with the harness payload.

CE 3.5

Conceptual designing

Through the project work, I have learnt that designing can be done in six different reasons. The designing differences are:

1. Triangular
2. Square format
3. Rectangular format
4. Circular format
5. Linear format (Harness)
6. Linear format (Metrology maker)

The main features that I have learnt on these models are displayed through the following table:

Designing	Main Features
Triangular format	• It provides better solution • The designing of this format is very much simple and incurs lower development cost
Square format	• It provides a better synchronization among all other types of designs • The development cost for this kind of model incurs lower development cost
Rectangular format	• Provides best in class result • Positioning of the vectors is very much difficult in the same direction
Circular format	• Very difficult to synchronize with a specific direction • Higher designing complexity • The development cost for this kind of device is very much high
Linear format with Harness	• Highly reliable positioning • Easy to position the vectors to a specific point • Designing for this kind of device having lesser complexity • The development cost is much lower than the other devices
Linear format with Metrology maker	

CE 3.6

The steps in designing of Hoverboard

- It is very much necessary to develop a design before the development starts. I have designed the 2D model of the device through using Microsoft Visio software package.
- Once the 2D design is ready the 3D model of the designed through the Autodesk inventor and sent for painting to the corresponding painting experts.

- Once the design is delivered, the surface was rough and uneven. Due to this design, the suction was lower. Therefore, it required a higher pressure to bring the hover effect into the newly designed device.
- Through using the P1000 and P600 hoverboard was polished. This polished device provided a better result than the earlier times. The adhesion to the field was improved more through using the hover holes. Through doing this the 0 to 90 degree tilt was achieved very smoothly.

CE 3.7

Positioning of the Hoverboard on the field plate

The positioning on the field plate has been done through following steps:

1. Firstly, need to place the hoverboard with the payload and the Starbug on the telescope's field plate. To ensure the proper air supply the device is connected with the inlet which is hover hole.
2. Turning on the air supply with a power specification approx 220kpa on the hoverboard. The main reason for applying this power is that it will remain able to lift the hoverboard by a considerable height.
3. Putting the starbug in any one of the four holes and calibrating it.
4. Once it reaches the desired position shut down the air supply and turn on the vacuum. The main reason behind doing this is that the vacuum will stick the position of the device in the desired location.
5. Once the hoverboard is stick with the field plate, we can tilt it to the required angle ranging from 0 to 90 degree slowly.
6. If any repositioning is required needed then we need to perform the step 1 to 5. Before we do the repositioning, we need to bring down the plate to the zenith position.

CE 3.8

Identifications on the Vacuum Ring and vacuum Nozzle in the laboratory condition

Properties	Vacuum Nozzle	Vacuum Ring

Performance	Excellent	Good
Sucking force of the vacuum	Moderate	High
Air pressure on Hover	Lower	High
Complexity	Higher	Lower
Development Cost	Less The main reason behind this is that it can be developed without doing the 3D printing.	More The main reason behind the higher cost is that it requires separate vacuum ring system.

CE 3.9

Application of the Device

I found it has been applied in the following projects:

- GMT for MANIFEST project
- UKST for TAIPAN
- Cleaner concept in both the GMT and UKST project

Summary

CE 3.10

This project has helped me in understanding the different aspects of the payload and starbugs. This project also illustrated that the AAO hoverboard is prototype that usages the starbugs for the positioning and tilting the telescope from 0 degree to 90 degree. I also learnt that though there are two designs available for this. One is TAIPAN and the other is MAINFEST. This project also helped me to learn about the cleaner concept and this concept looks like a very much interesting concept for the future development.