# Development of Radiation Protective Mobile Case

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**Abstract**

The Radiation protective mobile cover is a product that blocks or reflects radiation emitting from a communication device. These gadgets are continually processing data, thus they are always active. Different components tend to generate and emit microwave radiation while processing this data and most of the radiation is emitted through the display unit. In this study, the flip cover has been designed in a systematic approach of concurrent engineering to obtain a higher overall shielding from radiation generated by the display unit as well as the other components. The cover is made of low-cost materials (aluminum foil, rubber) in order to be both economical and healthy for all clients. The developed protective cover can protect the customer effectively by filtering 96.07% of the generated radiation. This study designed a cover that protects against dangerous energy released by mobile phones. Other sorts of dangers, such as fire, chemical, biological, and projectile hazards, can be protected using the principles of the present invention.

## Keywords
Radiation, Smartphone, Protection, Human skin, mobile cover.

## 1.Introduction
This research aims to discover how a mobile case can protect humans against Electromagnetic Field (EMF) radiation. Smartphones emit radiation mostly when it is transmitting data over cellular networks like texting, calling, internet browsing, etc. The majority of mobile phones use frequencies of 850-1800MHz or 900-1900MHz. A mobile cover that shields or reflects radiation emitted by a communication device is known as a radiation protection mobile cover. Mobile phones are evolving as per customer needs; therefore, mobile phones are getting more attention from the customers, manufacturers, and to researchers. Different technologies are employed in a single phone to gain additional functionality. Thus, smartphones nowadays contain millions of small semiconductors, network modules, etc. that emit microwave radiation while processing data. These microwaves have the ability to penetrate semi-solid substances (human skin) and increase temperature. Besides increasing the temperature, these microwaves also cause cellular malfunction affecting the self-healing capability of the body cells. Moreover, many users also complain about headaches, fatigue, tiredness, blur vision, eye burning, etc. due to the use of mobile phones for prolonged hours. The study demonstrates how to overcome these problems by introducing a specialized cover.

## 2.Literature Review
Smartphones are becoming part of everyday life for people. We cannot think of a day without smartphones. With the technological advancement in making more user-friendly and effective cells, the smartphone industry is changing rapidly. However, with that advancement, some degradation is shown in health issues over the last two decades. It has been shown that radioactive frequency (RF) radiation has the ability to cause biological damage through heating effects (Bonaldi et al., 2014). In a cell, there are seven clusters and each of them has different frequencies. Cells are interlinked next to each other to create the cellular network (Webber et al. 1995). Electric field of 1 V/cm can introduce disturbance of the thermal equilibrium inside a cell of 10 $\mu$m radius, which is equivalent to disturbance produced by a temperature rise of 1 K (Hinrikus et al., 2005). Research shows that there is an effect of radiation on male fertility. (Agarwal et al., 2008) An experiment on rats shows that continued use of cell phones permanently damages tissues. (Yan et al., 2009) Another study shows continuous use of cell phones over 10 years increases acoustic neuroma disease. (Christensen, 2004). On the other hand, some studies show negative or no relation with cancers or such kinds of disease. One of them found rare incidents with cancer but they suggest it might show headaches, fatigue

sleeplessness. (ICNIRP (International Commission for Non-Ionizing Radiation Protection) Standing Committee on Epidemiology: et al., 2004) In one paper there suggests no risk for glioma or meningioma. (Christensen, 2004). Good news against these protective policies is also found in some papers. Such as a paper, showing electromagnetic shielding is done by limiting the flow of electromagnetic fields between the two areas by applying a protection medium. The electromagnetic radiation can be blocked if the barrier has a high conductivity or dielectric constant or high magnetic permeability (Bonaldi et al., 2014). Another proposal of using stainless steel yarn and the copper yarn was found applicable to protection from microwave radiation (Rashid et al., 2020). Enhanced radiation protection can also be achieved by nanomaterials (DeMeo et al., 2020.).

## 3.Methodology

i. Our research question: Firstly, how could we protect ourselves from radiation emitting from mobile phones. Secondly, what material should we use for radiation blockage?

ii. Our hypothesis: For the first question, we hypothesized that we should go for a protective cover with special features for radiation blockage. For the second question, we hypothesized that Aluminum or Lead be chosen for radiation blockage. (B1. Aluminum be chosen. B2 Lead be chosen)

As per our research question and hypothesis, we will conduct our research study. We will conduct a survey to collect customer requirements for radiation protective cover and based on that survey we will take preferences for the cover. Those preferences will help us to choose materials for our radiation protective cover and build the body parts.

### 3.1 Survey

We performed a survey based on our research question and hypothesis. We gathered replies from a variety of persons in that survey, the majority of them were teenagers. There are 55 percent men and 45 percent women among them. Surveys have been conducted through Google forms, emails, and personal interviews. The question is given in the appendix. After the survey, we collected data in percentage values for each option. Then multiplied each option by the question's related importance, which is indicated by weight (1 to 100). This weighing method has given us a way to choose preferences for Quality Function deployment.

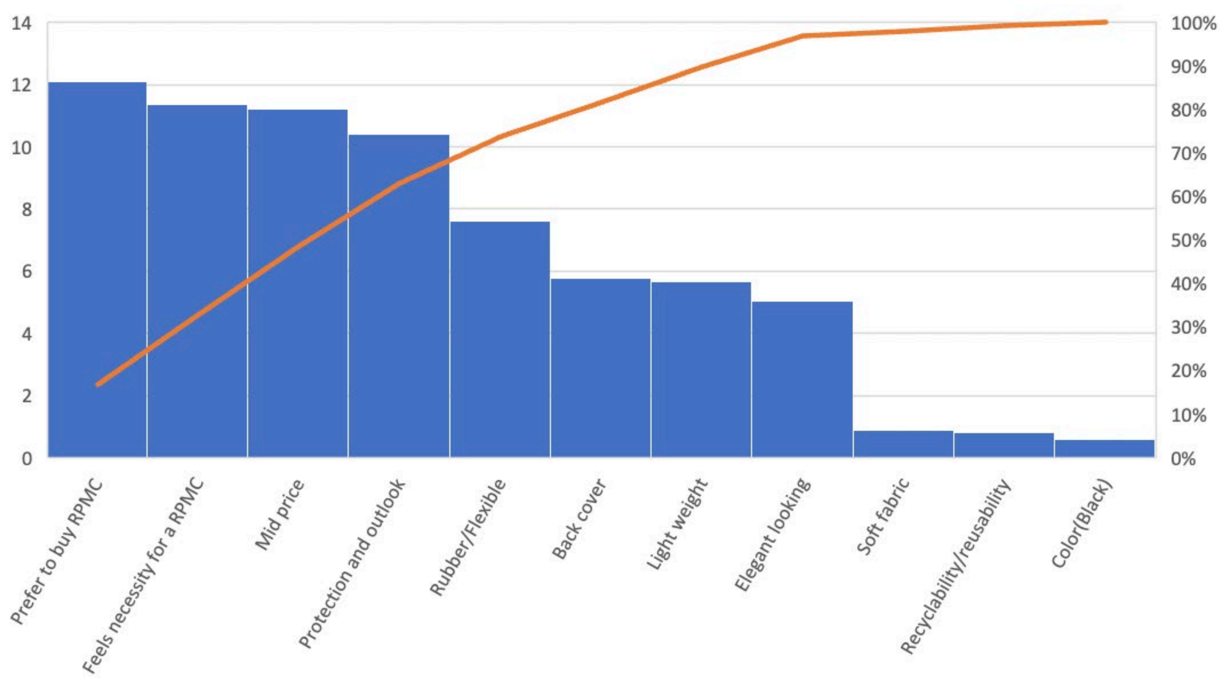



Figure 1. Pareto chart of customer preferences showing the weighted value and cumulative percentage.

Here we can first four preferences cumulates around 80% so we take these as a high preference then the next four as medium preferences and the rest as low preferences. In the survey, 64%, of people choose a back cover. Therefore, it

has a high value after weighing but we have to choose a flip cover as a medium preference instead of a back cover. Because for blocking radiation from the front side we need a flip cover (Figure 1, figure 2 and figure 3).
All the preferences from the weighing method are categorized below:
1. High Preference: Protective advantages (from fall), medium price (Budget Cover), radiation protection, build quality
2. Medium Preferences: Rubbery/Flexible Material, flip cover, lightweight, out-look
3. Low Preferences: Color, fabric usage in cover, recyclability.

### 3.2 Quality function deployment

As we have customer preferences now, we need to convert them into technical requirements. For that, we are going to apply QFD or Quality function deployment. Quality function deployment is a process and set of tools used to effectively define customer requirements and convert them into detailed engineering specifications and plans to produce the product that fulfills those requirements. Many successful organizations are using QFD to produce products that satisfy their customers' needs. Here in QFD after categorizing the customer requirements, one must interpret the customers' voices into related technical requirements. There are two kinds of relationships: one between customer requirements and technical requirements and another between technical requirements themselves. The relationships are indicated through several signs, which are shown in the tables below (1-13). In the relationship between customer requirements and technical requirements after allocating a sign, one must calculate values for each technical requirement by multiplying preference weight with the sign value shown in the table 1-2.

Table 1. Correlation signs

| **Correlations** | **Sign** |
|---|---|
| Highly Positive | ++ |
| Positive | + |
| Highly Negative | - - |
| Negative | - |

Table 2. Relationship indicator between customer preferences and technical preferences.

| | | |
|---|---|---|
| High Relation | ● | 5 |
| Medium Relation | ○ | 3 |
| Low relation | ▽ | 1 |

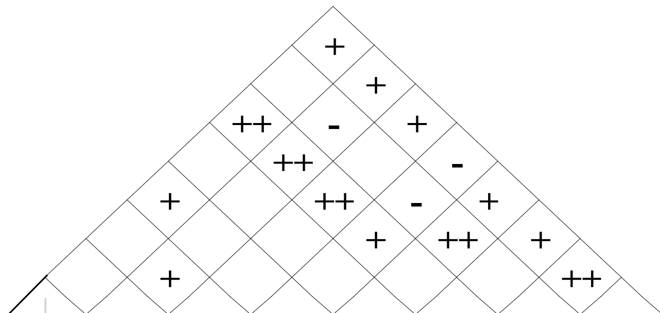
For our radiation protective mobile cover, we choose some technical preferences based on customer preferences and product type. Build material with radiation coverage, durability, longevity, body weight, gripping ability, strength, ease to use, and design are chosen for technical preferences. Then we allocate the relationships among them. These relationships are described below.

First, brainstorming has been done about the relationships. The high relationship we get: Damage protection has high relation to building material, durability, and strength. Radiation protection has high relation with build material. Build quality has high relation to building material, durability, longevity, and strength. Medium price has high relation with build material. Flexible material has high relation with gripping ability. Lightweight has high relation with build material and body weight. The flip cover has high relation to body weight. Outlook has high relation with design. The fabric has high relation to building material and design. Recyclability has high relation with build material.

The medium relation we get: Damage protection has medium relation with longevity and design. Build quality has medium relation with the gripping quality. Medium price has medium relation with durability, longevity, body weight, design, and easy to use. Flexible material has medium relation with strength. Lightweight has medium relation with strength. Outlook has medium relation with build material. The fabric has medium relation with gripping ability and strength. Color has medium relation with build material and design.
The low relation we get: Damage protection has low relation with body weight. Radiation protection has low relation to longevity and body weight. Build quality has low relation with easy to use. Flexible material has low relation with durability and longevity. Lightweight has low relation with durability. Outlook has low relation with gripping ability. The fabric has low relation to durability and longevity. Color has low relation with longevity. Recyclability has low relation with build design.

Now the relationship between Different Technical Requirements is identified -

Highly positive correlations are Strength has highly positive correlations with longevity, durability, and building material. Easy to use has highly positive correlations with design and gripping ability.




| Preference Scale | Technical Preferences / Customer Preferences | Build Material with Radiation Coverage | Durability | Longevity | Body weight | Gripping Ability | Strength | Easy to Use | Design |
|---|---|---|---|---|---|---|---|---|---|
| High Preference(5) | Damage protection | ● | ● | ○ | | | ● | | ○ |
| | Radiation protection | ● | | | | | | | |
| | Build Quality | ● | ● | ● | | ○ | ● | | |
| | Medium Price | ● | ○ | ○ | ○ | | | ○ | ○ |
| Medium Preference(4) | Flexible material | | | | | ● | ○ | | |
| | Light weight | ● | | | ● | | ○ | | |
| | Flip cover | | | | ● | | | | |
| | Out-look/Design | ○ | | | | | | | ● |
| Low Preference(3) | Fabric | ● | | | | ○ | ○ | | ● |
| | Color | ○ | | | | | | | ○ |
| | Recyclability | ● | | | | | | | |
| Our Importance Rating | | 171 | 76 | 70 | 65 | 48 | 83 | 20 | 77 |

Figure 2. Relationships between customer requirements and technical requirements with House of Quality

Positive correlations are Design has positive correlations with strength, gripping ability, longevity, durability, and building material. Bodyweight positive correlations with strength and build material. Durability has positive correlations with longevity.
The negative correlations we get: Bodyweight has negative correlations with design and is easy to use. Easy to use has negative correlations with durability.
From the house of quality matrix, we observe that building material with radiation coverage gets the high priority as per customer requirements followed by strength, durability, design, etc. Apart from that, we also get relationships between technical requirements.

### 3.3 Selection of material:

Now we will select materials, which will fulfill our demand for radiation and fall protection. For that, we first selected the criterion for body parts. Then followed a digital logic method to get relative emphasis co-efficient. Here we first define a number of positive decisions through combinatory and assign values (0 or 1) for two criteria that we considered. Between the two considered criteria, we gave 1 that has relatively high importance and 0 for the second one. Then we summed the value to the right and calculated relative emphasis co-efficient using the simple averaging technique. After that, we collected different properties for our material preferences. For cost and availability, there is not enough reliable data, so we used a certain value to indicate relative importance, which is given below in table 3.

Table 3. Numerical Value (Rating)

| | |
|---|---|
| Very High | 5 |
| High | 4 |
| Medium | 3 |
| Low | 2 |
| Very Low | 1 |

Then in the performance index, we first calculated scaled property based on two formulas given below.
For goals of availability, young's modulus, ultimate tensile strength and impact loading, radiation protection

Scaled property, B= $\frac{\textbf{Numarical value of property}}{\textbf{Maximum value in list}} * \mathbf{100}$

For goals of cost and water absorption, health hazard,

Scaled property, B= $\frac{\textbf{Minimum value in list}}{\textbf{Numarical value of property}} * \mathbf{100}$

Then we calculated weighted property from the scaled property and relative emphasis property/weighed factor. Our radiation protective cover has two main parts. 1) Back Part 2) Front Part.

#### 3.3.1Back Part:

Table 4. Determination of Relative Importance of criterion Using Digital Logic Method

| Selection Criteria | Number of Positive Decision (6C2) = 15 | | | | | | | | | | | | | | | No. of Positive Decision | Relative Emphasis Coefficient. α |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | | |
| Cost | 1 | 0 | 0 | 1 | 0 | | | | | | | | | | | 2 | 0.133 |
| Availability | 0 | | | | | 0 | 0 | 1 | 0 | | | | | | | 1 | 0.067 |
| Young's Modulus | | 1 | | | | 1 | | | | 1 | 1 | 0 | | | | 4 | 0.267 |
| Ultimate Tensile Strength | | | 1 | | | | 1 | | | 0 | | | 0 | 1 | | 3 | 0.199 |
| Water Absorption | | | | 0 | | | | 0 | | | 0 | | 1 | | 0 | 1 | 0.067 |
| Impact Loading | | | | | 1 | | | | 1 | | | 1 | | 0 | 1 | 4 | 0.267 |
| Total Number of Positive Decisions | | | | | | | | | | | | | | | | 15 | ∑α=1.00 |

Here we first brainstorm for selection criterion of basic cover then allocates decisions value (1 or 0) as per relative importance (table 4-5).

Table 5. Our preferred material's properties and selection criteria

| **Properties** \ **Material** | **Rubber** | **Denim Fabric** | **Selection Criteria** | **Rubber** | **Denim Fabric** |
|---|---|---|---|---|---|
| Young's Modulus (MPa) | 1.9 | 2.91 | Cost | 3 | 4 |
| Ultimate Tensile Strength (MPa) | 19 | 3 | Availability | 5 | 4 |
| Water Absorption (% 24 hours) | 0.20 | 0.45 | | | |
| Impact Loading (KJ/m$^2$) | 320 | 115 | | | |

Here we collected value of properties for our two choices of materials. However, for cost and availability we found no authentic data, so we used relative numerical rating. (Table 6)

Table 6. Material Performance Index for Back Part

| Selection Criteria | Weighted Factor, α | Rubber | | Denim Fabric | |
|---|---|---|---|---|---|
| | | Scaled Property, B | Weighted property,αB | Scaled Property, B | Weighted Property, αB |
| Cost | 0.133 | 100 | 13.3 | 75 | 9.98 |
| Availability | 0.067 | 100 | 6.7 | 80 | 5.36 |
| Young's Modulus | 0.267 | 0.65 | 0.174 | 100 | 26.7 |
| Ultimate Tensile Strength | 0.199 | 100 | 19.9 | 15.79 | 3.14 |
| Water Absorption | 0.067 | 35.94 | 2.41 | 100 | 6.7 |
| Impact Loading | 0.267 | 100 | 26.7 | 35.94 | 9.6 |
| Material Performance Index, γ | | | 69.18 | | 61.48 |

Previously we described about how scaled property is calculated. After multiplying with weighted factor and scaled property, we get weighted property.
Result: Material performance index is "Greater" for Rubber, so Rubber was chosen.

### 3.3.2 Front part Shielding Material:

The back part will be made of rubber for a better hand holding comfortability and to provide better shock resistance if the phone falls. Our main target is to use the front part as a barrier for the microwave emission. Whenever we use the mobile phone for calling, we put the screen side of the phone to our ear. The phone got direct contact with skin of the skull region. When calling, the front part of the cover will be in between of skin and mobile device, so it will be able to block and reflect the microwaves. For that, we are going to combine aluminum foil with two layer of rubber (table 7).

Table 7. Determination of Relative Importance of Goals Using Digital Logic Method

| Selection criteria | Number of positive decisions N=n(n-1)/2=6(6-1)/2=15 | | | | | | | | | | | | | | | Positive decision | Relative Emphasis coefficient, α |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | | |
| Cost | 1 | 0 | 1 | 0 | 1 | | | | | | | | | | | 3 | 0.2 |
| Availability | 0 | | | | | 0 | 1 | 0 | 0 | | | | | | | 1 | 0.07 |
| Young's Modulus | | 1 | | | | 1 | | | | 1 | 1 | 1 | | | | 5 | 0.33 |
| Ultimate Tensile Strength | | | 0 | | | | 0 | | | 0 | | | 1 | 1 | | 2 | 0.13 |
| Water Absorption | | | | 1 | | | | 1 | | | 0 | | 0 | | 1 | 3 | 0.2 |
| Impact Loading | | | | | 0 | | | | 1 | | | 0 | | 0 | 0 | 1 | 0.07 |
| | Total Number of Positive Decisions | | | | | | | | | | | | | | | 15 | ∑α=1.00 |

Here we first brainstorm for selection criterion of front part then allocates decisions value (1 or 0) as per relative importance (Table 8-12).

Table 8. Our preferred material's properties and selection criteria

| Material / Properties | Rubber | Denim Fabric | Selection Criteria | Rubber | Denim Fabric |
|---|---|---|---|---|---|
| Young's Modulus (MPa) | 1.9 | 2.91 | Cost | 3 | 4 |
| Ultimate Tensile Strength (MPa) | 19 | 3 | Availability | 5 | 4 |
| Water Absorption (% 24 hours) | 0.20 | 0.45 | | | |
| Impact Loading ($KJ/m^2$) | 320 | 115 | | | |

Here we collected value of properties for our two choices of materials. However, for cost and availability we found no authentic data, so we used relative numerical rating

Table 9. Calculation of the performance index

| Selection criteria | Weighting Factor,α | Rubber | | Denim Fabric | |
|---|---|---|---|---|---|
| | | Scaled Property B | Weighted Score αB | Scaled Property B | Weighted Score αB |
| Cost | 0.2 | 100(3) | 20 | 75(4) | 15 |
| Availability | 0.07 | 100(5) | 7 | 80(4) | 5.6 |
| Young's Modulus | 0.33 | . 65 | .21 | 100 | 33 |
| Ultimate Tensile Strength | 0.13 | 100 | 13 | 15.79 | 2.05 |
| Water Absorption | 0.2 | 35.94 | 7.19 | 100 | 20 |
| Impact Loading | 0.07 | 100 | 7 | 35.94 | 2. 52 |
| Material Performance Index, ϒ | | | 54.4 | | 78.15 |

Previously we described about how scaled property is calculated. After multiplying with weighted factor and scaled property, we get weighted property.
Decision: Material performance index is "Greater" denim fabric. Therefore, we should select Denim fabric for front part.

### 3.3.3 Material selection for Core material

Table 10. Determination of relative importance of goals using digital logic method

| Selection criteria | Number of positive decisions, (4C2) | | | | | | Positive decision | Relative Emphasis coefficient ,α |
|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | | |
| Cost | 1 | 0 | 0 | | | | 1 | 0.17 |
| Availability | 0 | | | 0 | 0 | | 0 | 0 |
| Radiation protection | | 1 | | 1 | | 0 | 2 | .33 |
| Health hazard | | | 1 | | 1 | 1 | 3 | 0.5 |
| Total number of positive decisions | | | | | | | 6 | ∑α=1.00 |

Here we allocate decisions values for selection criterion of core material then as per relative importance (table 10, table 11).

Table 11. Numerical Value for Cost & Availability

| Selection Criteria | Aluminum (Al) | Lead (Pb) |
|---|---|---|
| Cost | 3 | 4 |
| Availability | 5 | 4 |
| Radiation protection | 2 | 4 |
| Health hazard | 3 | 5 |

Here we used relative numerical rating, as we have no authentic data in table 12.

Table 12. Calculation of the performance index

| Selection criteria | Weighting Factor,α | Aluminum | | Lead | |
|---|---|---|---|---|---|
| | | Scaled Property B | Weighted Score αB | Scaled Property B | Weighted Score αB |
| Cost | 0.17 | 100(3) | 17 | 75(4) | 12.75 |
| Availability | 0 | 100(5) | 0 | 40(2) | 0 |
| Radiation protection | 0.33 | 50(2) | 16.5 | 100(4) | 33 |
| Health hazard | 0.5 | 100(3) | 50 | 60(5) | 30 |
| Material Performance Index, ϒ | | | 83.5 | | 75.75 |

Previously we described about how scaled property is calculated. After multiplying with weighted factor and scaled property, we get weighted property.
Decision**:** Material performance index is “Greater” for Aluminum.

### 3.4 Body Parts

Functional decomposition is a technique for dividing a larger task into smaller tasks. We applied different ways like making a black box diagram and dividing all Component Hierarchy and cluster functions for specifying how we were going to build the protection case. All of the studies are below in figure 3:

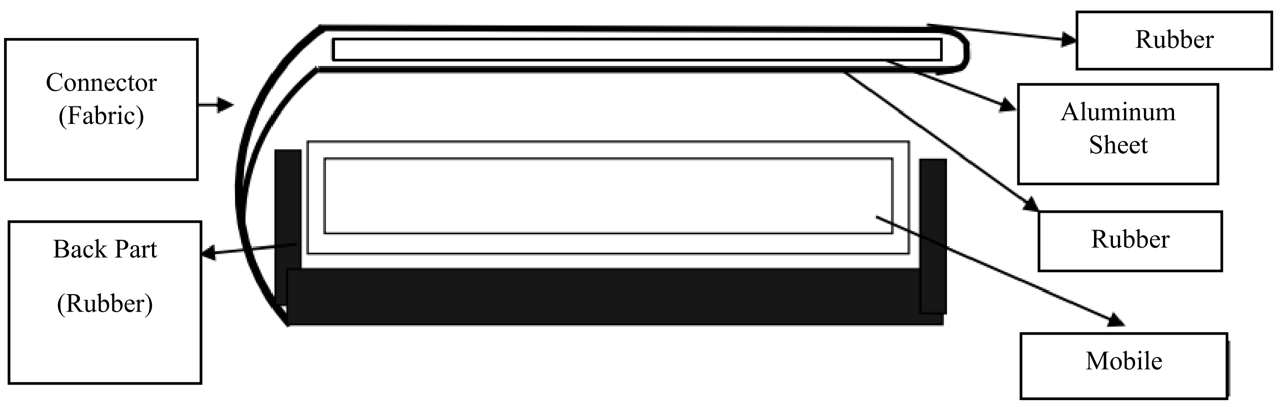



Figure 3. Illustration of Radiation Protective Mobile Cover showing its basic parts.

**Front Part**: For the front part there are several ways to lessen the radiation, we are going to use Aluminum Sheet between two layers of rubber. As per need and cost. We are going to fuse aluminum with those two layers of rubber.

**Front-Back Connector**: For the connecting front and back part we are going to use fusing and pressing technique. Here Flexible strong fabric will be used for connecting two parts.

**Back Part**: Back part should be strong. For that, we are going to use rubber and cast it in molds for desired shape according to different mobile, so that it can be useful for damage protection.

### 3.5 Functional Decomposition of Radiation Protection Mobile Cover

Functional decomposition is done to know the product's functions with respect to energy and information. Here we can figure out the product’s input and output. Our black box diagram is given below. Our product will take radiation and mechanical (impact force) energy and output will be in radiation and mechanical energy in lesser quantity. If we measure input and output radiation level output will be lower (Figure 4-6).

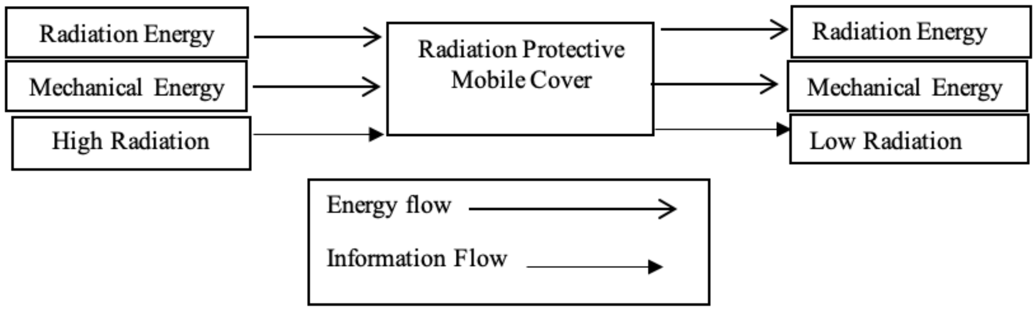



Figure 4. Black box diagram of Radiation Protective Mobile Case showing the transition of energy and information flow through the product.

From the black box diagram, we can identify that our objective is to lessen the radiation. We cannot fully block the radiation otherwise; the data transmission will be stopped. So, we have to maintain the balance of keeping the radiation as low as possible without losing network communication.

### 3.6 Cluster Function of Radiation Protection Mobile Cover

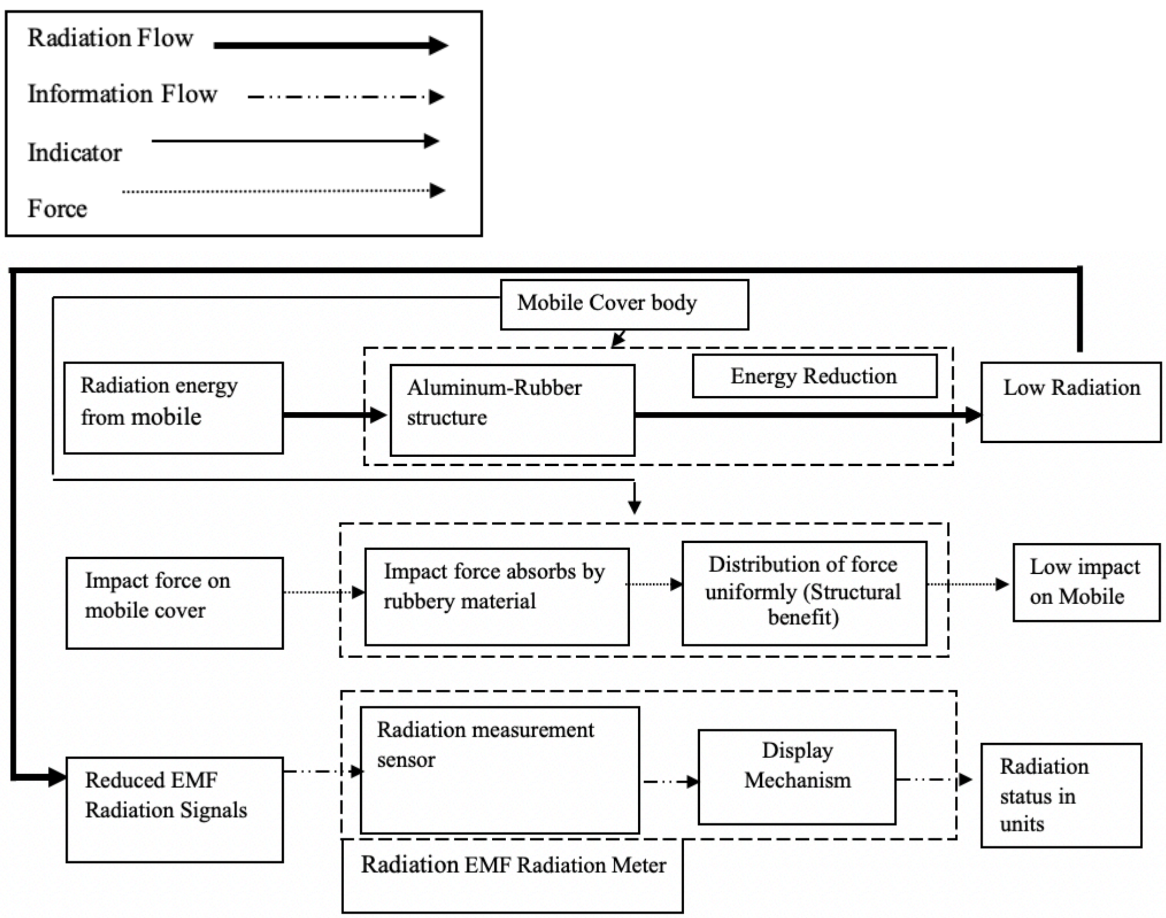



Figure 5. Cluster Function Structure for Radiation Protective Mobile Cover showing its basic functions

In this cluster function, we show that radiation energy from mobile lessens while passing through an aluminum-rubber structure. This low radiation can be shown in the EMF radiation meter. Apart from that, a generic cover should also protect the mobile from damage. Which is also shown in between. Impact force is absorbed as the main structure is made of rubber.

### 3.6 Stress Analysis of back part

We need to analyze fall stress, as fall protection is a very basic feature for our mobile cover. For that, we are going to use the solid works stress analysis feature. We only choose the back part for the fall test as the main falling stress is acted on this. The analysis is done on the 1m falling height parameter. From analysis, we can see lowest stress is induced in the charging section. In addition, the highest stress is induced in the middle of the back part. Edges get moderate stress.

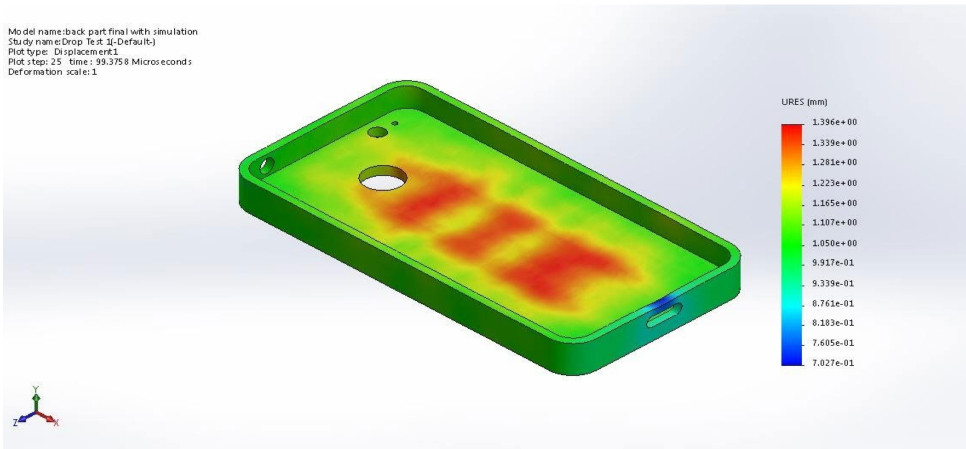



Figure 6. Stress analysis for the back part of our mobile cover.

## 4 Result

After completing these procedures, we finally made a sample prototype of the radiation protective mobile cover. We found that a significant amount of radiation is reduced after the application of the protective cover. It is also found that it slows down the rising temperature. With the protective case, we discovered the maximum raise of temperature was 2ºC. We tested the prototype several times with KMOON GM3120 EMF Radiation tester. In addition, the reading we have found is given below Table 13:

Table 13. EMF meters' reading showing the reduction of E-field and H-field.

| No. of Experiment | Before Applying Shield | After Applying Shield | % Reduction of E-Field (V/m) | Before Applying Shield | After Applying Shield | % Reduction of E-Field (V/m) |
|---|---|---|---|---|---|---|
| | E-Field (V/m) | E-Field (V/m) | | H-Field (µT) | H-Field (µT) | |
| 1 | 454 | 11 | 97.577 | 1.85 | 0.08 | 95.675 |
| 2 | 570 | 16 | 97.192 | 2 | 0.06 | 97.000 |
| 3 | 575 | 18 | 96.869 | 1.95 | 0.08 | 95.897 |
| 4 | 575 | 26 | 95.478 | 2.1 | 0.12 | 94.286 |
| 5 | 610 | 22 | 96.393 | 2.1 | 0.16 | 92.381 |
| 6 | 595 | 30 | 94.957 | 2.25 | 0.06 | 97.333 |
| 7 | 525 | 10 | 98.095 | 1.75 | 0.05 | 97.143 |
| 8 | 550 | 13 | 97.636 | 2.25 | 0.12 | 94.667 |
| 9 | 580 | 32 | 94.482 | 2.5 | 0.18 | 92.800 |
| 10 | 510 | 10 | 98.039 | 1.9 | 0.03 | 98.421 |
| 11 | 570 | 36 | 93.684 | 2.1 | 0.1 | 95.238 |
| 12 | 600 | 25 | 95.833 | 2.5 | 0.04 | 98.400 |
| Mean reduction percentage | | | 96.07067 | | | 95.46093 |

## 4.Discussion

Our research shows that a flip cover embedded with rubber and aluminum saves us from a significant amount of EMF radiation-emitting directly from the mobile phone. We measured the radiation using KMOON GM3120 EMF Radiation tester. We took 12 readings of the E-field and H-field. A physical field that surrounds electrically charged particles and exerts a force on all other charged particles in the field, either attracting or repelling them, is known as an electric field. It can also refer to a system of charged particles' physical field. Electric fields are created by electric charges or magnetic fields that change over time. On the other hand, the magnetic influence on moving electric charges, electric currents, and magnetic materials is described by a magnetic field, which is a vector field. In a magnetic field, a moving charge receives a force that is perpendicular to both its velocity and the magnetic field. The magnetic field of a permanent magnet attracts or repels other magnets, as well as ferromagnetic elements like iron. Furthermore, a varying magnetic field exerts a force on a variety of non-magnetic materials by changing the mobility of their outer atomic electrons. Electric currents, such as those employed in electromagnets, and electric fields that fluctuate in time create magnetic fields that surround magnetized things. Our radiation meter measures E-field in the V/m unit and H-field in the µT unit. When the phone is covered and the screen is off, the E-field is reduced by 96.07%, and the H-field is reduced by 95.46%. As we keep our phones in the pocket of our pants or shirt, which can make an adverse effect on our body parts. Long time usage can affect our reproductive organs, heart, and lungs. From our experiment, we showed that radiation protection cover could reduce a significant amount of radiation. However, while we work on our phone, we cannot use the cover, or we should say its flip side on the screen. During that time, we are at risk of an ampule amount of radiation directly emitting from screens.

## 5.Conclusion

A mobile cover with radiation protection blocks or reflects radiation emitted by a communication device. These devices are always active because they are always processing data. While processing this data, several components generate and emit microwave radiation, with the display unit emitting the majority of the radiation. Our main goal is to make human being safe from the harmful EMF radiation that mobile phone emits through their screens and other parts. Through a customer survey, we defined customer preferences first. Then after applying QFD or Quality Function

Deployment, we get technical preferences. Then we used the digital logic method to get relative weight and after that, we get the weighted score from relative weight and scaled property. From the calculation, we decided to take aluminum and rubber. We chose aluminum for radiation protection and rubber for core material. Both are cost-efficient and widely available in the market. In the reduction of direct exposure to radiation, our product makes a huge leap in the reduction of 96.07 % in E-field and 95.46 % in H-field. Cover design can also withstand impact force in a limited range. As our cover only focuses on blocking the radiation emitting from the back of the mobile. However, in front, while the mobile is off flip cover will protect but when we work on a mobile screen the cover cannot protect the user from radiation. In the future, we should focus on developing a way to defend against radiation emitted directly from screens while using mobile phones. We should also focus on developing its design to make it more effective against potential damage. Apart from that, we can also work on sustainability, as the world is moving toward a more sustainable future.

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## Biography

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## 6. Appendix:

### Survey Questions:

**Public Opinion on Radiation Protective Mobile Cover**

1. Which type of mobile cover do you use?

Plastic Cover Metal Cover
Rubbery Cover Composite Cover

2. Why do you use a mobile Cover?

For good outlooking To protect mobile from damage
Both good out looking & protection I never thought about using

3. Which type of cover do you prefer?

Flip cover Back cover

4. What is the current price of your phone?

Below 200 taka 200-400tk
400-800 taka above 800 TK

5. Did you know that mobile phones emit harmful radiation?

Yes No

6. Every day our phone emits harmful radiation. Have you ever felt the necessity for a radiation protective cover?

Yes No I never thought about it

7. If there comes a radiation protective cover on the market, would you prefer to buy it?

Yes No

8. How much money (BDT) would you spend on such a cover?

Below 1000 1000-1500
1500-2000 won't buy one

9. How do you expect the outlook of the cover to be?

Normal mobile cover Elegant looking Look's doesn't matter

10. What is your opinion about the weight of this cover?

Lightweight Medium weight Heavyweight

11. Your Choice of color?

12. Do you want this will be reusable & recyclable?

Yes No

13. Do you want any additional features in this cover? Explain this.