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Graphical User Interface for A Risk Assessment Against Lightning Protection System in Malaysia

Full Paper

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Abstract

This paper presents the general risk assessment calculations based in Malaysian Standard, Protection against lightning-Part 2 (MS IEC 62305-2:2007) using MATHLAB - Graphical User Interface (GUI). A GUI application was developed to calculate the general risk assessment concerned and compare it with the tolerable risk. All parameters' values and calculation techniques used in (MS IEC 62305-2:2007) are available to the user. The parameter value used to calculate the risk assessment was guided in the program. This paper also provides the capability to evaluate new risk assessment after selecting the appropriate class of lightning protection system. The selection of the protection level would result in reducing the risk assessment, thus protecting the structure, power line and telecommunication lines.

Keywords: - Malaysian Standard, Graphical User Interface (GUI)

1. Introduction

Lightning is a natural occurrence which can be fatal to humans and destroy service and property. In nations like Malaysia that have a high number of lightning flashes, the effect is more noticeable (Abulaban & Siow, 2021). Malaysia witnessed 100 to 140 days of lightning on average of each year with 600000 to 1300000 of lightning strikes (Rahim et al., 2016). Lightning flashes may cause fatalities, injuries, damage to the structure and connected service as well as failure in electrical system due to over voltages. Besides that, there have been documented losses of RM250 million in Malaysia because of communication failure, structural and equipment damage, and system downtime (Ab-Kadir, 2016). Hence there is a risk assessment against lightning protection system. Assessing the danger lightning to structures is the main goal of lightning risk assessment (Abulaban & Siow, 2021). Furthermore, risk assessment findings can confirm the adequacy of the lightning protection level used by considering the building's installations and various parameters (Kasza & Kovacs, 2019).

The risk assessment present in this paper is based on the Malaysian standard of protection against lightning (MS IEC 62305-2:2007). This paper implements the general risk assessment of MS IEC 62305-2:2007 determining the necessity of protection measures and evaluates the risk components concerning the structure, power line and telecommunication line. Furthermore, the aim of this study is to devise a system that can aid users in conducting risk assessment by allowing them to input the necessary parameters through MATLAB -Graphical User Interface (GUI). Once the user has entered these parameters, the proposed system will carry out the risk calculations in accordance with the standard guidelines. This paper suggests the use of MATLAB- Graphical User Interface (GUI) to assist users in comprehending and evaluating risk assessment of buildings with the intention of raising awareness of the risk faces by the user.

2. Literature Review

Graphical User Interface (GUI) in MATLAB have surpassed all other types of user interfaces for engaging with computing system (Oulasvirta et al., 2020). It helps the user to determine the risk of building by entering the parameters needed. It is important to build user friendly risk assessment against lightning to evaluate the total risk concern.

The current lightning risk assessment technique is based on IEC62305-2, which is a comprehensive and practical lightning risk assessment system. Lightning risk assessment is a type of assessment technique that includes a comprehensive risk calculation for casualties (Yu & Ren, 2014).

As per MS IEC 62305-2:2007, the choice to safeguard the structure or service and the selection of protection measures must be made by the following subsequent procedure:

- Identification of the object that requires protection along with its specific characteristic.
- Identification of all forms of loss associated with the object and assessment of corresponding risk.
- Evaluation of risk.
- Comparison of the evaluated risk with the tolerable risk to determine the necessity of the protection.

The lightning current is the primary source of damage. The sources of damage on lightning affect are the flashes to the structure, near a structure, to the service and near a service. The type of loss that may appear depends on both the physical and content properties of the thing. Along the way to protect the structure, power line and telecommunication line, there are many criteria's concerns to complete the calculation of risk assessment. The length, width and height of the building are very important to calculate the collection area for the structure. The length of the cable in power line and telecommunication line is also important to define the collection area to the power line and telecommunication line.

Lightning protection is built into buildings as part of the development process (Syakura et al., 2019). It is a system function to reduce the effect of lightning strikes especially to the power lines and telecommunication lines. There are two types of lightning protection systems, which are the air termination system and down-conductor system.

An arrangement of sacrificial conductors called an "air termination system" is put up to serve as a preferred attachment point to lightning strikes, protecting the protected structure (Adekitan & Rock, 2020). The air-termination system of a lightning protection system is function to prevent uncontrolled lightning strikes to the structure to be protected. The appropriate dimensioning of the air-termination systems can reduce the effect of lightning strike. The rolling sphere method is the universal method to determine the arrangement and the sitting of the air-termination systems.

Table 1. Classification of the lightning protection system and radius of the rolling sphere

Max building height		
LPS	**Radius of the rolling sphere (r)**	**Mesh size (M)**
Class I	20m	5 x 5 m
Class II	30m	10 x 10 m
Class III	45m	15 x 15 m
Class IV	60m	20 x 20 m

The down conductor system is a part of external Lightning Protection System (LPS) which directs the current from the lightning strike to the ground when lightning hits the structure (Ariffen et al., 2019). The quantity of down conductors required is contingent upon the perimeter of the external edges of the roof and its projection on the ground surface.

Table 2. Typical values of the distance between down conductors and between ring conductors according to the type of lps

Class of LPS	Typical distance (m)
I	10
II	10
III	15
IV	20

3. Methodology

The aim of this paper is to provide an easier way to perform risk assessment against lightning that are outlined by MS IEC 62305-2:2007. This is achieved by employing a MATLAB – based Graphical User Interface (GUI) which allows users to access all the relevant parameters, values and calculation method specified in the standard. This tool provides the capability to evaluate the total risk components concerned and compare it with the recommended tolerable risk. Furthermore, this project also would recommend solving the problem regarding the total risk components higher than tolerable risk.

a. Risk Assessment

The destruction caused by lightning can be confined to a section of the structure or it may affect the entirety of the structure. In addition, it may impact the internal system that is linked to the structure's service. The resulting loss from each type of damage may vary depending on the object being protected. A lightning flash may cause damage depending on the characteristics of the object to be protected. The risk, R1 is the value of a probable average annual loss. The pertinent risk components must be defined and calculated to assess risk. However, this project only considers the risk component for a structure due to flashes to the structure, power line and telecommunication line.

Step 1

The computation of pertinent quantities entails determining the collection of area structures and lines. The calculation area is defined as the region of intersection between the ground surfaces and a straight line having a slope of 1/3 which passes through the upper portions of the structure (touching it there) and rotates around it.

The calculation of collection area involves the structure, Ad, power lines, AI(P) and telecom line, AI(T). The collection area to the structure, Ad, power line, AI(P) and telecom line, AI(T) can be calculated by using this formula (Malaysia & Standard, 2012):

$$Ad = \left[Lb \times Wb + 6Hb \times (Lb + Wb) + \pi \times (3Hb2) \right] \quad (1)$$

$$Al(P) = \sqrt{\rho \times [Lc \times 3\,Hb]} \quad (2)$$

$$Al(T) = 6\,Hc \times [Lc - 3\,Hb] \quad (3)$$

Where *Lb* is the length of structure, *Lc* is the length of cable, Wb is the width of structure and *Hb* is the height of structure.

Step 2

The average yearly count of perilous incidents caused by lightning strikes on a safeguarded object is reliant on two factors which is the physical characteristics of the object and the level of thunderstorm activity in the area where it is situated. To derive the numerical value of this count N it is commonly practiced multiplying the lightning ground flash density Ng by collection area of the structure. The value of lightning flash density is fixed to 20 per km2 per day and it is suitable value for the condition of lightning occurrences in Malaysia (Malaysia & Standard, 2012). Additionally, the location factor, Cd will be considered to adjust for the relative position structure whether it is situated in an exposed area or surrounded by other objects.

The number of flashes due to the structure, ND, power line, NL(P) and telecom line, NL(T) can be calculated by using this formula:

$$Ad = ND = Ng \times Ad \times Cd \times 10-6 \quad (4)$$

$$NL(P) = Ng \times AI(P) \times Cd(P) \times Ct(P) \times 10-6 \quad (5)$$

$$NL(T) = Ng \times AI(T) \times Cd(T) \times 10-6 \quad (6)$$

Where *Ad* is the collection area to the structure, *Al*(*P*) is the collection area to the power line, *Al*(*T*) is the collection area to the telecommunication line, *Ng* is the lightning flash density, *Cd* is the structure location factor, *Cd*(*P*) is the power line location factor, *Cd*(*T*) is the telecommunication line location factor and *Ct*(*P*) is the transformer factor.

Step 3

The pertinent risk components need to be specified and calculated to assess the risk calculation to be made on the need for protection. The risk to the structure, RB is the component related to the physical damage caused by dangerous sparkling inside the structure triggering fire or explosion, which may endanger the environment. On the other hand, the risk to the line, RV pertains to the physical damage (such as fire or explosion caused by hazardous sparking between external installations and metallic components usually at the point of entry of the line into the structure) resulting from the lightning current transmitted through the incoming services.

The number of risks to the structure, RB, risk to the power line, RV(P), risk to the telecom line, RV(T) and total risk, R can be calculated by using this formula:

$$RB = ND \times PB \times hz \times r\rho \times rf \times Lf \quad (7)$$

$$RV(P) = NL(P) \times Pv \times hz \times r\rho \times rf \times Lf \quad (8)$$

$$RV(T) = NL(T) \times Pv \times hz \times r\rho \times rf \times Lf \quad (9)$$

$$R = RB + RV(P) + RV(T) \quad (10)$$

Where *R* is the total risk, *RB* is the risk to the structure, *RV*(*P*) is the risk to the power line, *RV*(*T*) is the risk to the telecommunication line, *ND* is the dangerous event to the structure, *NL*(*P*) is the dangerous event to the power line, *NL*(*T*) is the dangerous event to the telecommunication line, *hz* is the special hazard, *rρ* is the reduction factor, *rf* is the risk of fire and *Lf* is the loss by physical damages.

The tolerable risk, Rt use in this project is 10^-5. So, when the total risk is greater than tolerable risk, the system needs protection. There are four levels of Lightning Protection Level (LPL) which is class 1, 2, 3 and 4. The maximum values of lightning parameter relevant to LPL must not exceed with a probability of 99%, they are reduced to 75% for LPL 2 and to 50% for LPL 3 and 4. The minimum peak current respectively for LPL 1(3kA), LPL 2(5kA), LPL 3(10kA) and LPL 4(16kA) lead to the rolling sphere radius equal to 20, 30, 45 and 60 m (Malaysia & Standard, 2012).

Every level of lightning protection system will result in a different value of probability of physical damage to a structure, PB. The values of probability PB depends on the protection measures to reduce physical damage of the structure. Furthermore, the protection measures also would reduce the value of probability of physical damage to the power line and telecommunication line, PV. Table 3 shows the new values of PB and PV after selecting the level of lightning protection. The structure not protected with lightning protection system will have value of PB and PV as 1. In a country with high lightning flash density, the suggestion of the best lightning protection level was LPL 1. LPL 1 can protect the smaller zone of the structure. In fact, LPL 1 has the lowest minimum peak current which is more secure compared with others. When there is a lightning strike, LPL 1 could require at least 3kA to protect the structure and the system.

Table 3. Values of PB and PV depending on the protection measures

Characteristic of the structure	Class of LPS	P_B & P_V
Not protected by LPS	-	1
Protected by LPS	IV	0.2
	III	0.1
	II	0.05
	I	0.02

The process in calculating the risk assessment of the building is clearly explained in Fig. 1. The tolerable risk, Rt for this work is 10-5.

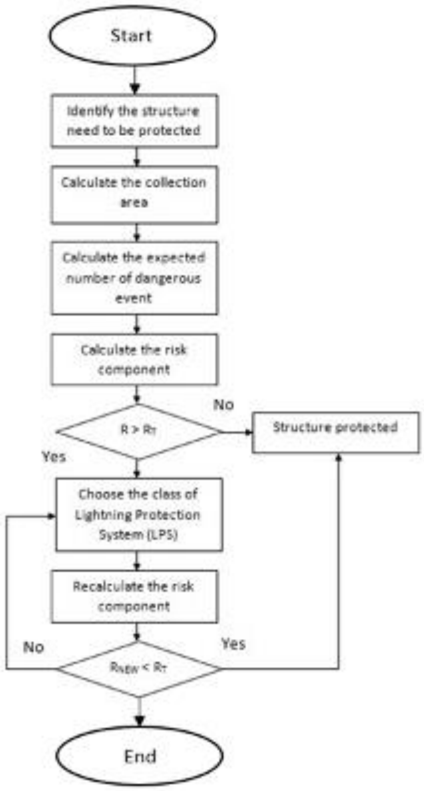

Fig. 1. Flowchart of risk assessment

b. Graphical User Interface (GUI)

Graphical User Interface (GUI) in MATLAB is an illustrative interface to a program which can generate progress that easy to use by proffering them with a consistent appearance and with intuitive controls like pushbutton, edit text, static text and many more. There are four components that are required in creating this GUI project. The elements are:

i. Pushbutton

Push buttons are a function to generate an action when clicked. For example, the calculate button might calculate the equation written in the programming language. When the users click a push button, it will calculate and show the answer in the edit text.

ii. Edit Text

Edit text is the component that enables users to enter or modify text strings. These edit texts also function to act as display for the push button.

iii. Static Text

Static text controls display lines of text. Static text is typically used to label other controls, make a description, or indicate equations associated. Users cannot change static text interactively.

iv. Axes

Axes enable your GUI to display graphics such as graphs and images. Like all graphics objects, axes have properties that you can set to control many aspects of their behavior and appearance.

Fig. 2 shows the development in calculating risk in MATLAB-GUI. At the end of the program, if the risk assessment is higher than tolerable risk, the user will choose the level of lightning protection system to reduce the risk and protect the structure against lightning.

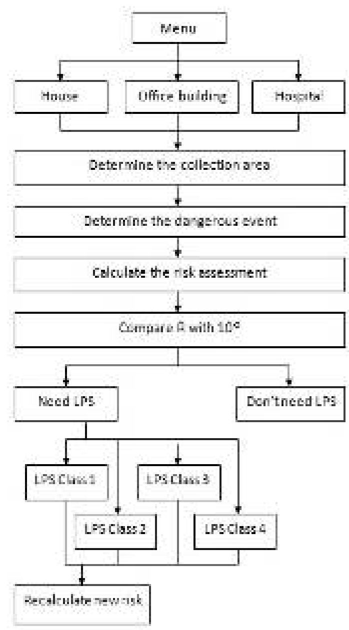

Fig. 2. Block diagram for whole structure in GUI

4. Result and Discussion

It was clearly stated in the previous session that risk assessment should be done to determine whether the building need protection or not. If the risk component concern is higher than tolerable risk, the building needs protection. Fig. 3 shows the menu for this project. The user needs to enter the name of the building and choose the type of building correctly. Fig. 3 shows that the user enters "BAIT AL-HUSNA" as the name of the building and chooses "HOUSE" as the type of the building.

Fig. 3. Main menu

The next slide is called Collection area calculation which the user will see the "Step 1". There is the collection area calculation to the structure, power line and telecommunication line. The details of the input data from the user were shown in Fig. 4. The user enters the length, width, and height to the structure as 15, 20 and 6m. The answer of collection area to the structure, Ad is 2578.01 m2. The user also enters the length of power line as 1000 m and the answer is 21957.5 m2. Then, the user fills the length of telecommunication line and height as 1000 m and 6 m and the answer is 35352 m2. The results of the calculation were saved in m-file. The saved data then imported to the next slide which the expected annual number of dangerous events slides.

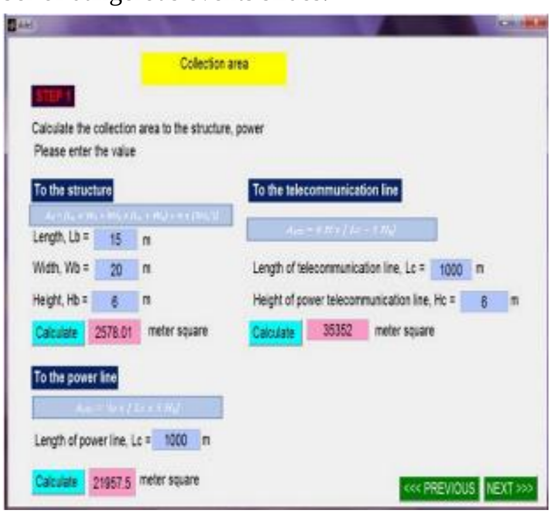

Fig. 4. The collection area calculation

Fig. 5 below shows the calculation of dangerous events to the structure, power line and telecommunication line. For the structure, the user enters the location factor, Cd as 1 and the result of the calculation is 0.0386701 per year. The selection of the location factor was detailed when the user clicks "Table Cd." In calculation of power line, the user enters the location factor, Cd(P) and transformer factor, Ct as 1 and 1. The answer for the power line is 0.329363 per year. For the telecommunication, the user enters as 1 for the location factor, Cd(t) and the result is 0.53028 per year. All the answers were also saved in m file and the answer was imported to the next slide which is the slide of step 3.

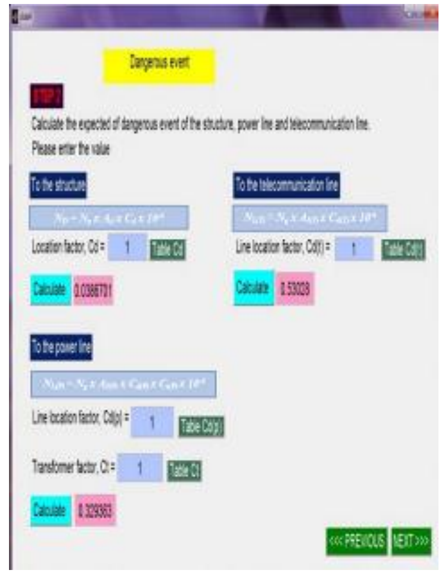

Fig. 5. Calculation of dangerous event

Fig. 6 below shows the calculation of risk assessment. In this slide, the user needs to decide whether the protection of the building is necessary. If the total risk assessment is higher than tolerable risk (0.00001) then the user is recommended to get the protection of the building. All the input parameters for special hazard, fire protection, risk of fire and loss by physical damage are 1, 1, 0.001 and 0.1. The value of the input parameter is the same for the structure, power line and transmission line. From Fig. 6, the total risk component is 8.9631^10-5. This condition does not comply with the tolerable risk, Rt. So, the building needs protection. The user must click "YES" to continue.

Fig. 6. Calculation of total risk

The last slide of this project is shown in Fig. 7 which is the slide for selection of protection level. When the user clicks each of the classes of LPS, the message box will appear to show the characteristic of each class. Each of the classes would result in a different value of probability of physical damage for the structure, power line and telecommunication line. From Fig. 7, the user chooses class 2 of LPS which gives the new value of probability of physical damage of 0.05. Thus, the user can recalculate the new risk assessment which is 0.00000449. The new risk assessment now is less than the tolerable risk. So, the building now is protected which reduces the damage and loss due to lightning flashes.

Fig. 7. Selection of LPS

5. Conclusion

In conclusion, the use of MATLAB - Graphical User Interface (GUI) facilitates the risk assessment process for lightning protection systems in buildings. By providing users with a mean to input relevant parameters, the proposed system can calculate the level of risk associated with lightning strikes and suggest appropriate protection measures to mitigate the potential damage and loss. Adhering to the Malaysian Standard on protection against lightning is crucial in ensuring the safety and protection of structures, power lines and telecommunication lines. Implementing such standards can aid Malaysian users in assessing and reducing the risk of lightning strikes on buildings.

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