Radial Relay Coordination Tool - User Manual

A -MATLAB based tool that can assist users to find the relay coordination parameters. Also, It can find the maximum fault current.

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1. Introduction

The Radial Relay Coordination Tool is designed for people with background knowledge in relay protection who are new to this specific tool. It simplifies the coordination of relays in a radial power distribution system by calculating the Time Dial Setting (TDS) and Pickup Current (IP) for each relay along the radial feeder. The tool employs user-entered data and pre-established relay characteristics to perform coordination calculations.

1.1 Objective

- Find optimal TDS and IP values for each relay to allow coordination during faults.
- Calculate trip times (tr) from relay curves (CO-8, CO-7, etc.)
- Consider the coordination time intervals between relays to prevent mis operation.

1.2 Key Features

1. Selection of relay curve depending on the relay type (e.g., CO-8, CO-7).
2. Calculation of maximum fault current
3. Calculate Pickup Current (IP) and pickup (M) multiples.
4. Selection of TDS from a given value depending on coordination intervals.
5. Calculation of the trip times for each relay.

1.3 Prerequisites

- MATLAB has to be installed on the system.
- The user has to be familiar with the fundamental concepts of relay coordination principles.
- Input data for each relay, i.e., including line-to-line voltage, fault currents, and impedance data (if the tool should calculate the maximum fault current).

1.4 User Interface

The tool includes a graphical user interface (GUI) that takes input data from the user. The GUI requests the following inputs:

- Line-to-line voltage (V_ll)
- Relay type selection (CO-8, CO-7, etc.)
- Fault current values(User can ask the tool to calculate it)
- Impedance values (R, X) (if the tool should calculate the maximum fault current).

1.5 Input Data Format

The input data should be organized in two tables:

- Table 1: Load and Fault Data
  - Column 1: Bus ID

- Column 2: Load in MVA
    - Column 3: Fault Current (A)
- Table 2: Relay Data
    - Column 1: Bus ID
    - Column 2: CT Ratio (primary/secondary)
    - Column 3: Impedance Ratio
    - Column 4: Relay Type (e.g., 8 for CO-8)

2. The Algorithm

Below flow chart summarizes the work of the algorithm.

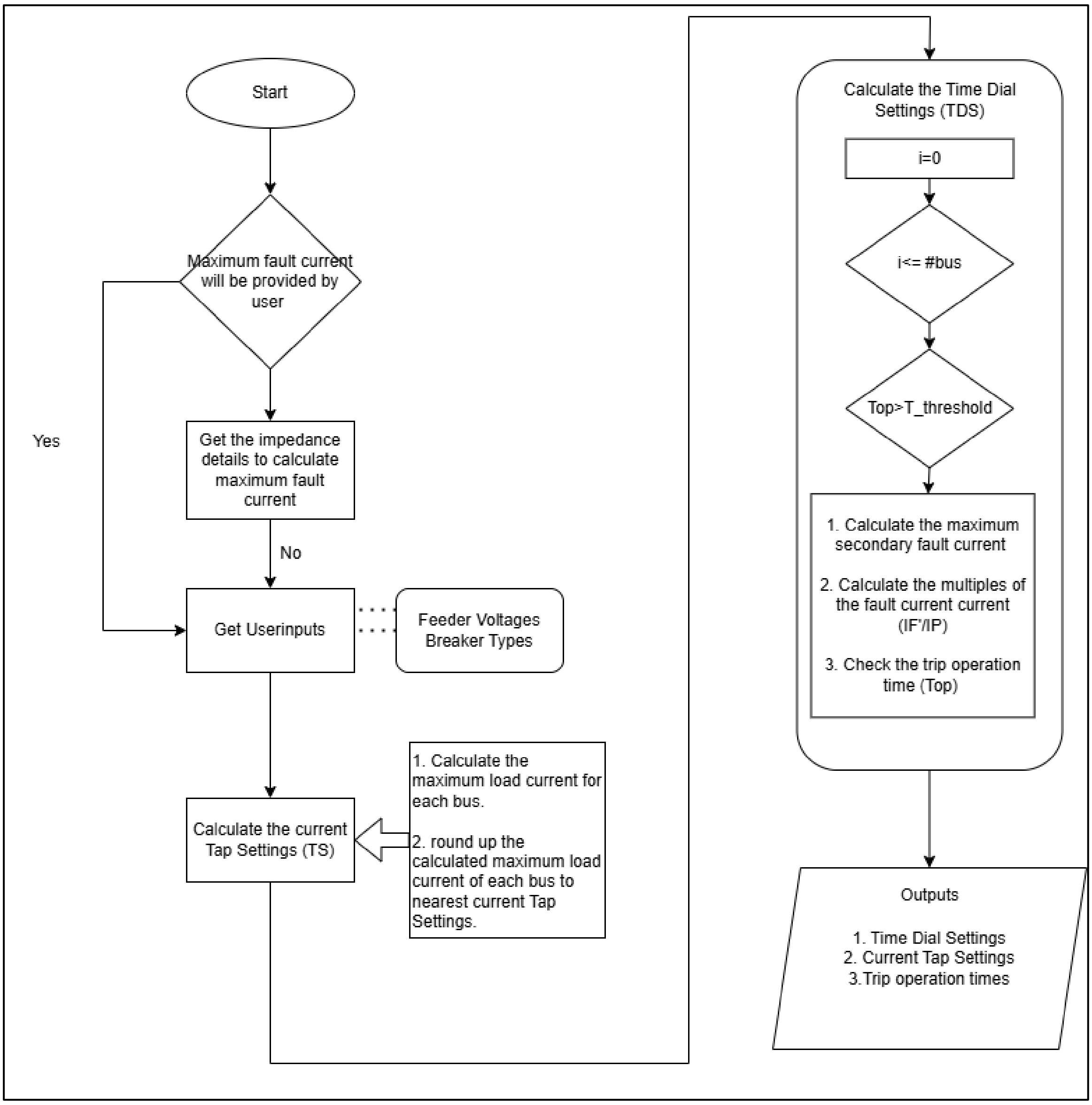

Figure 1 : Flowchart of the developped tool.

As you can see in the above flow chart, first the tool will ask the user whether they want the tool to calculate the maximum fault current or the user will input them. User can choose one of the options. If the user, ask the tool to calculate the maximum fault current then in the next steps the tool will get the impedance details so that it can calculate the maximum fault current.

Then the tool will get the user inputs such as line-to-line voltage, breaker type, power consumption at each bus. In the next stage it calculates Current Tap Settings. Then in the next stage Time Dial Settings are estimated. The time dial settings are estimated in such a way to ensure that unwanted customer interruption will be avoided. At the same time, it will try to operate as fast as it can.

3. Example Case study (Getting started!)

Step-by-step guide for an example:

For this example, we use example 10.4 in the reference textbook. The following figures provide the system information.

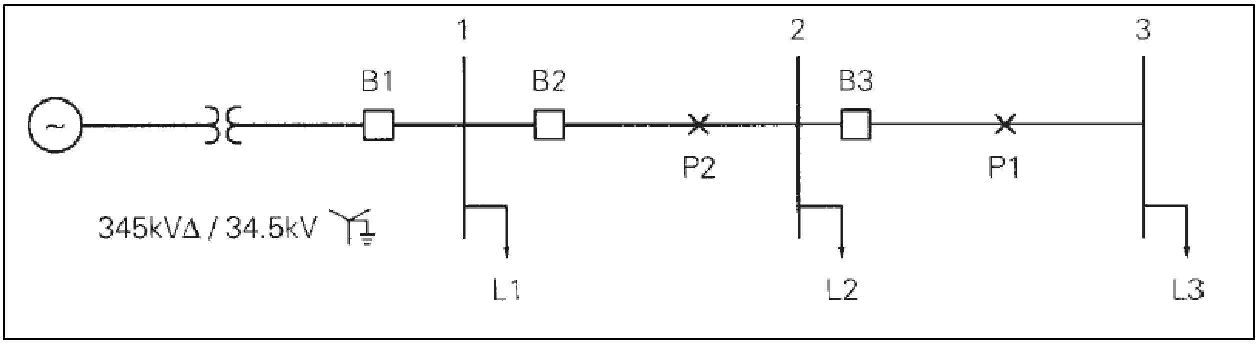

Figure 1 : A sample system used in this study to evaluate the proposed tool [textbook fig 10.16]

Bus	S MVA	Lagging p.f.
1	11.0	0.95
2	4.0	0.95
3	6.0	0.95

TABLE 10.3
Maximum loads—Example 10.4

Bus	Maximum Fault Current (Bolted Three-Phase) A	Minimum Fault Current (L–G or L–L) A
1	3000	2200
2	2000	1500
3	1000	700

Figure 2: The data for the test system used in this study[text book tables 10.3-5]

- Unzip the zip folder that contains the developed tool. Open the main script with the MATLAB tool.
- Open the script and run it.
- A pop-up will ask for the feeder voltage. Enter the value (it should be in voltage, not in kilovolts) as shown in the following figure.

```
Enter the line to line voltage(V,not kV):
```

- Then the tool will ask whether you will provide the maximum fault currents, or the system should determine it. If you ask the system to calculate, then it will ask for the line and source impedances
- Enter the voltage: 34500

Step 2

Then it asks:

```
Do you wnat the system to calculate maximum fault current? Enter 1 for yes 0 for no
```

By picking 1, the user commands the system to calculate the maximum fault current.

1. GUI interface

An interface will open, which will have two tables as shown in the figure below. In the first table, you should enter the load bus numbers and their MVA powers. You don't have to enter the maximum fault current if you asked the system to calculate it. If you asked the system to calculate the maximum fault currents, then you can enter them in this stage. A pop-up will appear and ask for individual line impedances.

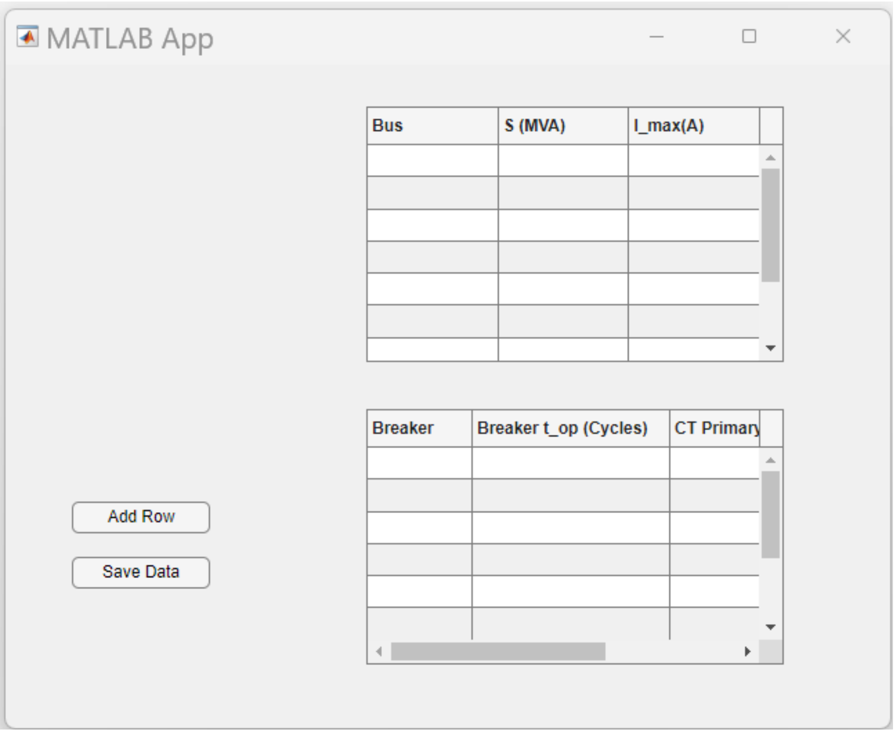

Figure 3 : The GUI of the developped tool where the user can enter the data

The interface after entering the data is shown below. The maximum current data wasn't entered. We can leave it blank since we want the system to calculate this for us.

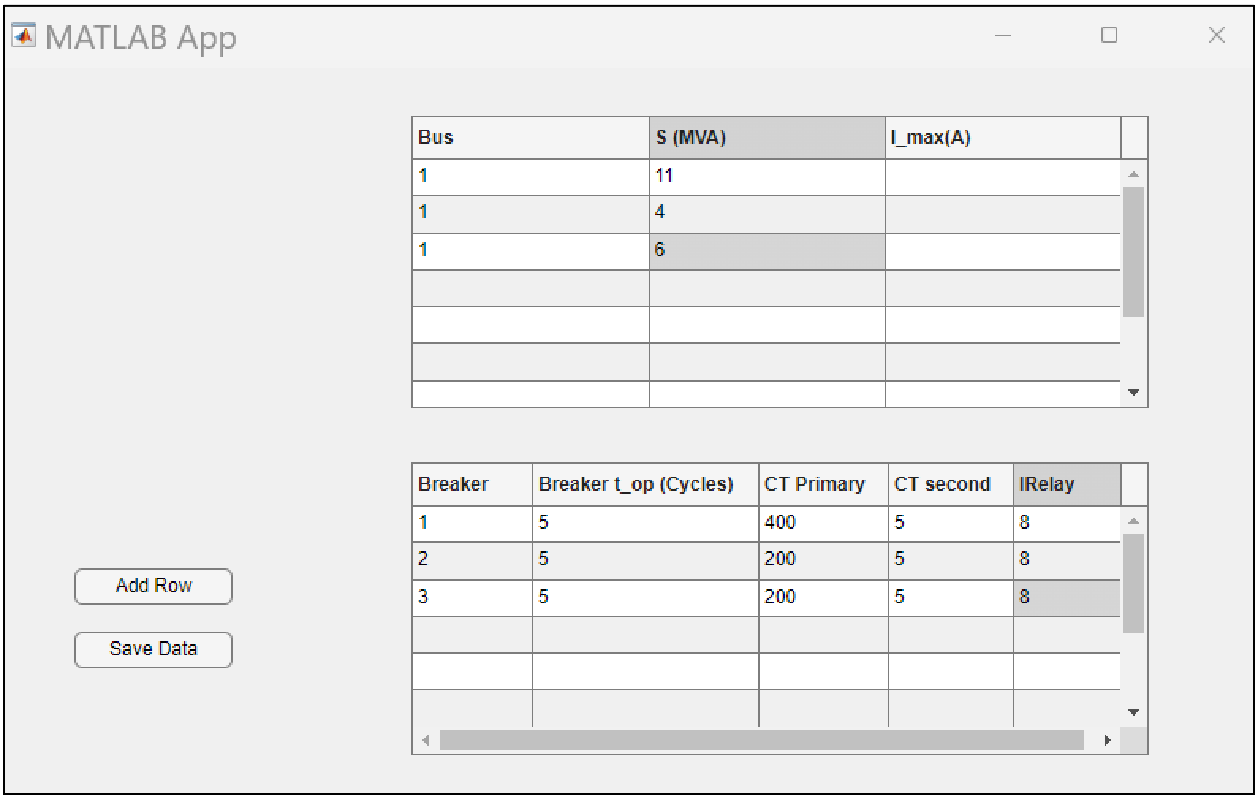

Figure 4 : GUI after entering the data

- Once the user enters the data, the save data button in the app is required to be pressed.
- Then the system asks for the source and line impedances to calculate the maximum fault currents.

```
Enter the sum of the source and transfromer positive seq impedances... 6.647
what is the impedance between busses 2 and 3: 7.43i
what is the impedance between busses 3 and 4: 11.372i
```

- The calculated fault currents are given as:

```
I_fault =

   1.0e+03 *

    2.9966    1.9980    0.9988
```

Finally, the system provides the answer as in below.

Breaker	Tap Settings	Time Dial Settings
1	5	4
2	9	2
3	9	0.5

Figure 5 : Results for the sample test system study.

Troubleshooting

- If the relay type is not included, the tool will display a warning and skip calculations for that relay. relay curve characteristics can be modified in the 'curves.m' file to include additional relay types or custom settings.

- Ensure all input values are correctly formatted and provided before executing the tool.

Limitations of the tool

- The Tool is suitable to be used only with radial type of systems.Bus voltages are assumed to be equal to the feeder voltage.
- Only three types of relay curves are included, namely CO-5,CO-7 and CO-8.

4. Results Comparison

The answer from the tool was compared with hand calculations provided in the book. Below table.

Breaker	Example Calculation			Tool Calculation			Time Error
	TS	TDS	T(i) ..i=1,2,3	TS	TDS	T(i) ..i=1,2,3	
1	5	5	0.76	5	5	0.9048	0.1448
2	5	5	0.43	5	5	0.4632	0.0332
3	3	0.5	0.05	3	0.5	0.0752	0.0252
							0.15068

The tool accurately finds the TS and TDS calculations. However, there is total of 0.15068 sum of squared error in the coordination time calculations.

Contributions:

The contribution of the group members are as follows:

Member	Tap Setting calc.	Time Dial Setting Estimation	Data Input Method	Relay Curve Digitization	Bonus (Fault Current estimation)	Report
Mukomene,Pascal						
Shanthanam,Sangar						

References

Textbook: Power system analysis by glover and Sharma

Clas notes, Power system analysis II, ECE597

Matlab