

INTEGRATION OF GIS DATA INTO A PSS SINICAL ELECTRICAL MODEL

James Dooley
ESB International, Ireland
james.dooley@esbi.ie

Stephen Hunt
ESB International, Ireland
stephen.hunt@esbi.ie

Philip White
ESB International, Ireland
philip.white@esbi.ie

ABSTRACT

Planning of Distribution Systems is a complex task and may be optimised by the use of software tools such as GIS (Graphical Information Systems) and an electrical model of the system. Simultaneous use of these two packages is not ideal and can be problematic, especially if both are not updated with exactly the same information.

PSS Sincal is a distribution and planning software package developed and maintained by Siemens. This paper details an algorithm developed by ESBI to integrate GIS data into a working PSS Sincal electrical model. PSS Sincal has an open database structure which provides the ability to integrate the software with other programs, such as GIS.

However, the software does not have ready built modules to carry out this task. In order to enable this integration between PSS Sincal and GIS, all functionality must be derived by the user.

INTRODUCTION

For optimised planning of distribution systems and to produce the most cost efficient and quality solution possible, the planner must simultaneously consider three aspects of the distribution configuration – system layout, switching and conductor size.[1]

In order to do this, a detailed electrical model of the system is required in addition to a geographical mapping tool such as GIS. The electrical model of the system is used for calculation of short circuit levels using IEC 60909 [2] and a power flow solution. The GIS model is required for planning of new feeder routes and substation sites.

Using both of these packages independently can become time consuming and can lead to possible data discrepancies, as both need to be simultaneously kept up-to-date with the most accurate information.

In order to streamline the planning process and obtain the optimum solution from both an economical and practical standpoint, ESBI has developed an automated algorithm to incorporate GIS Data into a PSS Sincal electrical model of the system.

For the purpose of calculating short circuit levels and power flow using a PSS Sincal system model, a standard SLD (single line diagram) which contains horizontal/vertical lines and busbars is a sufficient graphical display to perform and display these calculations. A sample horizontal/vertical busbar SLD is provided in Figure 1.

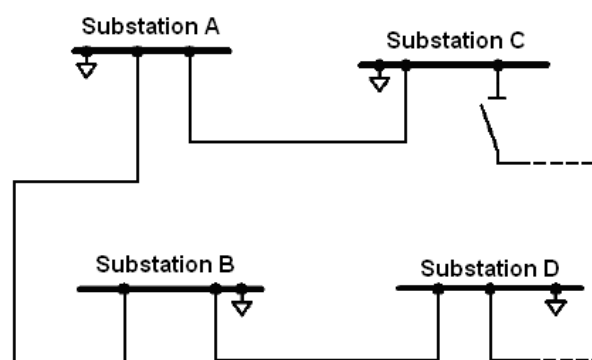


Figure 1 - Horizontal/Vertical SLD structure

However, substations in a GIS enabled SLD system model are located in their actual geographical location. The precise underground cable and overhead line routes that join adjacent substations are also displayed. This information is superimposed on a GIS map in PSS Sincal which illustrates the relative position of substations & feeder routes from roads, buildings, railways and rivers for the entire system.

By using this optimised geographical PSS Sincal model, the planner now has all required information in one consolidated package.

This graphical interface, combined with the ability to perform electrical calculations such as short circuit and load flow in a fully functional PSS Sincal electrical model, provides a very valuable and powerful planning and maintenance tool.

A sample geographical SLD was modelled in PSS Sincal and is provided in Figure 2 below. Parameters for feeders can be displayed, such as length, resistance, reactance, capacitance etc. In addition, short circuit and load flow calculations can be undertaken with results displayed in a similar manner.



Figure 2 – Geographical SLD in PSS Sincal

PSS SINCAL MODEL STRUCTURE

One of the benefits of PSS Sincal is that the software employs an open database structure, which means that records can be modified manually using a suitable program, such as Microsoft Access.

With this feature of the software, processing of data can be undertaken outside the PSS Sincal environment and processed data can then be embedded directly into the relevant database tables.

The ultimate aim of this algorithm is to consolidate both packages (PSS Sincal and GIS) into the PSS Sincal environment. Therefore, it is required to restructure the data from the GIS System to fit the PSS Sincal format.

In order for successful implementation of this algorithm, a common bus numbering system must exist between the GIS model and the PSS Sincal model.

In the PSS Sincal model, busbars are positioned on the diagram using (x,y) coordinates and feeder routes have a series of points to define them. These properties are stored in tables in the PSS Sincal database which contain this graphical information. The table that contains substation coordinates is known as the GraphicElement table and the other table which contains feeder routes is called the GraphicBucklePoint table.

Electrical parameters, such as Positive Phase Sequence (PPS) and Zero Phase Sequence (ZPS) values and also feeder lengths are stored in separate tables in the database.

For conversion of a standard horizontal/vertical busbar and feeder structure SLD into a geographical SLD, it is essential to ensure that the electrical information in the model remains intact after the conversion. The graphical part of the database model is only considered; therefore the GraphicElement and GraphicBucklePoint tables are only modified.

ALGORITHM FUNCTIONS

GIS mapping provides detailed information for substation locations, precise feeder routes, lengths and the relative position of these assets from roads, buildings and rivers etc.

The algorithm deals with the following objectives:

- (1) Extract coordinates for each substation on the system from the GIS model and incorporate this geographical information into the PSS Sincal model.
- (2) Assign geographical data to each feeder on the system so that its precise route is displayed in the PSS Sincal model.

Transposition of coordinates

In order for the GIS map to be displayed as a background image in PSS Sincal it is imported as a .dwg file. As PSS Sincal has a size limitation for this background image, suitable transposition values must be used.

Once these transposition values are determined, only

transposed coordinates can be used for substation positions and feeder routes in PSS Sincal.

In order to obtain these transposition values, the GIS map of the entire system must be imported into PSS Sincal as a background image. The entire system must be centred and use as much of the page as possible.

The next step is to select a specific point on the system using the GIS package and note the (x,y) coordinates. Using PSS Sincal, the exact same point is found and its (x,y) coordinates are also noted.

By subtracting the PSS Sincal coordinates from the GIS coordinates transposition values (a & b) can be obtained, as shown below:

$$a = x_{GIS} - x_{PSS} \qquad b = y_{GIS} - y_{PSS}$$

Values of a,b can either be positive or negative which is dependent on the range of coordinates in the GIS system.

Objective 1 - Substation Repositioning

Objective 1 involves extracting substation name, number and (x,y) coordinates from the GIS Model. All coordinates exported from GIS must be transposed using transposition values a & b, in order to be displayed in PSS Sincal.

Using the substation bus number as a unique identifier, the transposed (x,y) coordinates of each substation in the GraphicElement table is updated.

Once all substations have been re-located to their geographical position in the PSS Sincal model the next objective is to deal with the feeders that connect adjacent substations. This task is much more complicated than the first objective.

Objective 2 - Geographical Feeder Routing

The connectivity of the system is defined by the database tables that contain all the feeder information. For each feeder, it must have a start and end substation. Therefore, if Feeder 1 is connected to Substation A (Bus No. 1234) and Substation B (Bus No. 5678), the feeder will typically be called 1234_5678.

In order to assign a feeder, say feeder 1234_5678 with the data that defines its geographical route, (series of points) all feeder data was extracted from the GIS model to a suitable drawing package, such as Microstation which is developed and maintained by Bentley.

Feeder data provided in the GIS model will typically have several line segments to define an entire feeder route between two substations and this will be reflected in the converted Microstation drawing file. An example of a feeder in this format is provided in Figure 3.

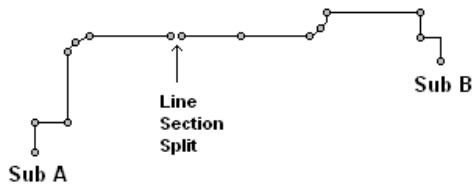


Figure 3 – Sample Feeder Route

In order for this algorithm to work, each feeder in the Microstation drawing must be a single element as the algorithm uses the start and end point of each line segment to search for the closest substation.

In Figure 3 above, there are two line sections that define this feeder route. If the algorithm was to analyse these line sections, it would use both points at the line section split and search for their closest substation.

Therefore, with this feeder split into two line sections, the algorithm does not produce useful results.

To solve this problem and ensure that each line segment represents a single feeder across the entire system, an additional algorithm was derived and was run within the Microstation environment.

Taking the example shown in Figure 3 and applying this algorithm in Microstation, the following can be observed as shown below in Figure 4.

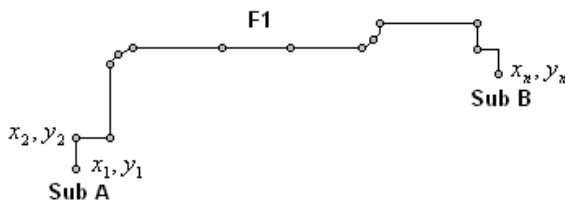


Figure 4 – Sample Feeder Route with joining

In order to analyse every feeder on the system, all joined line segment data was extracted from the drawing file to a raw data output. This raw data file contains a series of points for each line segment that is extracted and takes the format shown in Figure 5.

$F1(x_1, y_1)$	Feeder 1 is defined by set of points, x_1, y_1 being the first point and x_n, y_n being the last point of the line segment. A space indicates the start of the next feeder, i.e. Feeder 2.
$F1(x_2, y_2)$	
$F1(x_n, y_n)$	
$F2(x_1, y_1)$	
$F2(x_n, y_n)$	

Figure 5 – Raw Feeder Data output

The algorithm uses the start x_1, y_1 and end x_n, y_n

coordinates of each feeder in order to find the substation that each end is connected to.

As the geographical coordinates for each substation are known, the algorithm searches for the closest substation and assigns the relative substation number to the start and end point of each feeder.

The percentage of total feeders recognised by this algorithm is dependent on the quality of the input data and also the amount of substations that have the same bus number between the PSS Sincal and GIS model. Therefore, prior to running this algorithm an assessment of all substation names and their bus numbers should be undertaken to ensure that they align between both packages. Cases where the data differs between the two packages, will have to be investigated and rectified.

After the algorithm has been run, there may possibly be feeders that have not been assigned start and end substation numbers. Reasons may include mismatched bus numbers between packages that were not identified originally or data discrepancies between packages. When further investigation of these possible issues is complete and resolved, the algorithm can be re-run. A process chart for the algorithm is shown in Figure 6 and definitions for each stage are given in Figure 7.

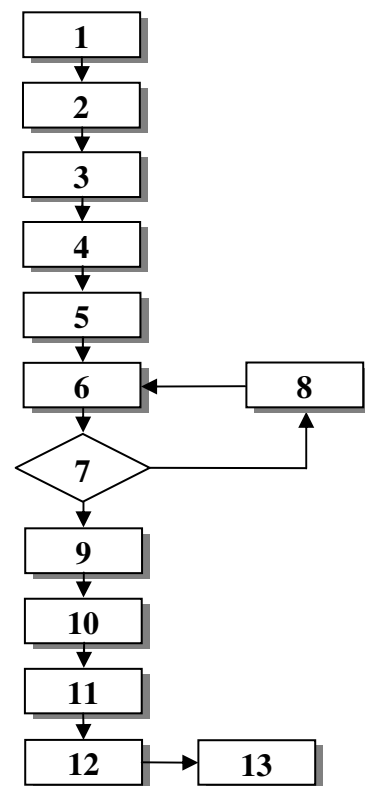


Figure 6 – Algorithm Process Chart

1	Extract busbar names and numbers from PSS Sincal and GIS.
2	Identify and amend bus numbering mismatches and discrepancies between packages
3	Extract substation geographical coordinates from GIS Model
4	Extract feeder routes to a drawing package - Microstation
5	Join all line sections to ensure that each feeder is represented as one line section.
6	Search the start and end point for each feeder in order to find its to and from substation.
7	Check to see if all feeders were assigned start and end substations. If there are feeders that were not identified proceed to step 8.
8	Identify feeders that were not assigned start and end substations. Ensure that feeders were joined correctly as per step 5.
9	Calculate transposition values a & b.
10	Apply transposition to substation coordinates and all feeder coordinate data.
11	Update PSS Sincal GraphicElement table with transposed geographical coordinate data to reposition all substations.
12	Update PSS Sincal GraphicBucklePoint table with transposed geographical feeder route data.
13	Finish

Figure 7 – Algorithm Process Chart Definitions

GEOGRAPHICAL PSS SINCAL MODEL

The algorithm now has assigned a bus number in the raw data file to the start and end point of every feeder that was detected.

Using an additional algorithm, this data was processed to ensure compatibility with the PSS Sincal database format and then embedded directly into the GraphicBucklePoint table.

Using this geographical SLD, network planners can accurately select the shortest cable routes, identify constraints in cable corridors and select the optimum locations of reinforcements when relieving bottlenecks.

Switches that represent Normally Open (N.O.) points are also visible in the geographical model. These can be turned on or off to analyse standby feeding arrangements.

In addition, locations of new build substations, proposed feeder routes for supplying new customers can also be visualised, which streamlines the planning process and helps the network planner optimise their time and resources for the project.

Short Circuit Levels and Load flow calculations can be performed in the usual manner and results are superimposed on the GIS SLD.

This algorithm can also be run on a regular basis to ensure that the most recent GIS Data, such as new substation positions and feeder routes are incorporated into the PSS Sincal electrical model.

CONCLUSIONS

This paper outlines an algorithm that illustrates how geographical data can be incorporated into a PSS Sincal electrical model of the system.

With this optimised geographical model, the network planner now has a very powerful planning tool at their disposal.

The network planner can now visualise existing and potential feeder routes in PSS Sincal while being able to simultaneously apply short circuit faults and run load flow calculations to ensure that proposed feeder routes are acceptable.

This is a much more efficient approach for network planning and maintenance, as undertaking this work using two separate packages would take considerably longer as input data from both packages has to be cross referenced and validated for every feeder proposal.

ACKNOWLEDGEMENTS

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