

Chapter 1

Optimum Cost of Voltage Sag through proper bus assignment

1.1 *Introduction*

1.2 *Objective and formulation of the problem*

1.2.1 Downtime cost estimation

Let us denote the cost of downtime for a bus for one process trip by

$$C_j^{d1}, \quad j = 1, 2, \dots, n$$

where j is the bus index, and n is the number of buses. So, if a process trips m times, the total cost of downtime would be

$$C_j^d = m * C_j^{d1} \quad (1.1)$$

Thus, for n buses, we will end up with a cost of downtime vector

$$C^d = [C_1^d \quad C_2^d \quad \dots \quad C_n^d] \quad (1.2)$$

Now, let us consider that a process has trip probability of p_i corresponding to voltage sag

point $V_i^p = \{t_i, V_i\}$. The the probable number of trips can be estimated as the number of sag points for which $p_i \geq 0.9$ (we consider this for safety factor). Thus

$$m = \sum_i i \quad \forall p_i \geq 0.9$$

This value of m can now be included in equation 1.1 to find out C_i^d .

1.2.2 Running Cost of Process

Each process in a plant has a fixed power that it needs to consume to run itself. This introduces cost of procuring that power. We consider the following cost function for estimating the cost

$$C_i^r = a + b * p_i + c * p_i^2 \quad (1.3)$$

where

$a = \text{Fixed Cost}$

$b = \text{Coefficient of cost due power consumption}$

$c = \text{Coefficient of cost due power loss}$

$j = \text{Process index}$

1.2.3 Optimum Cost problem

With the above foundation at hand, we can now define the optimum cost problem as follows :

$$\text{Min } C = \sum_{j=1}^n \sum_{i=1}^p (C_j^d + C_i^r) \quad (1.4)$$

Where,

$j = \text{bus index}$

$i = \text{process index}$

$n = \text{number of buses}$

$p = \text{number of processes}$

Our problem is to assign process to proper buses such that the total cost can be minimized.

1.3 Algorithm for Solution

We begin by considering that if process j is assigned to bus i , then the cost for this combination is given by

$$c_{ij} = C_i^d + C_j^r \quad (1.5)$$

Considering for all such combinations, we will end up with a cost matrix

$$C = \begin{bmatrix} c_{11} & c_{12} & \dots & c_{1n} \\ c_{21} & c_{22} & \dots & c_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ c_{p1} & c_{p2} & \dots & c_{pn} \end{bmatrix} \quad (1.6)$$

To find the optimum bus assignment, we note that row elements correspond to cost,

when a particular process is connected to the n buses. Thus, to find the best bus assignment, we need to find the index of minimum value along each row, which will give us the least cost that the process will yield, when connected to that bus.

Thus, we find the optimum bus index j for process i such that

$$c_{ij} = \min[c_{i1} \quad c_{i2} \quad \dots \quad c_{in}] \quad (1.7)$$

This can be achieved easily with matlab function

$$[c, I] = \min(C')$$

where I gives the bus index vector, and C gives the minimum cost vector. Thus, we will need to assign process i to its corresponding bus index $I(i)$, to achieve minimum cost of $c(i)$.

The minimum cost will thus be $C_{min} = \sum_j c_j$, and can be calculated in matlab as

$$\text{min_cost} = \text{sum}(c)$$

1.4 Results