LV Design

Frequently Asked Questions

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1 Background

LV Design was developed by Western Power specifically to help its engineers; network designers and operations staffs quickly calculate the voltage drops, line currents, kilowatt losses and costs in both underground and overhead low voltage networks

LV Design FAQ was written to address technical questions asked by users from time to time. The document will be updated continuously when a new question arise.

2 Designing street lights

2.1 Example of SL design using 3-phase cable connected to a 3-phase network

The example below shows SL circuits terminated at a pillar that supplies power to 9 streetlights on a freeway. The lamps, rated at 0.375 kVA, are evenly distributed over the three-phase cable and staggered equidistantly across the cable.

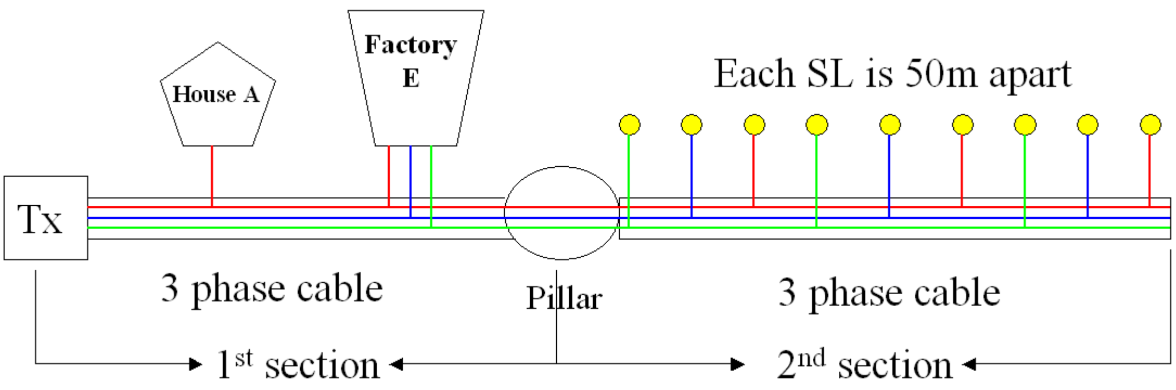

Figure 2.1: shows the physical layout out of SL circuit

As can be seen in Figure 2.1, the longest phase, which has the lamp at the end, is the red phase. Hence, we only need to be concerned about the voltage drop (VD) of the red phase and if this VD is within the acceptable limit, then the other two phases will also be within limits.

2.2 How to calculate the worst VD in this example

To calculate the voltage drop (VD) along the circuit from the transformer to the farthest lamp, it is necessary to break the circuit into two sections:

- Section one is from transformer to the pillar supplying the SL circuits
- Section two is from the pillar to the phase conductor (red phase) that has the lamp that is farthest away.

2.2.1 Section One

In this section the lamps on each phase need to be aggregated (3x0.375 = 1.125 kVA), as shown in Figure 2.2a, and treated as a balanced 3-phase discrete load (E loads). They are discrete because the lamps are either all fully on or fully off and the neutral currents would cancel at the pillar because they all flow through a common neutral.

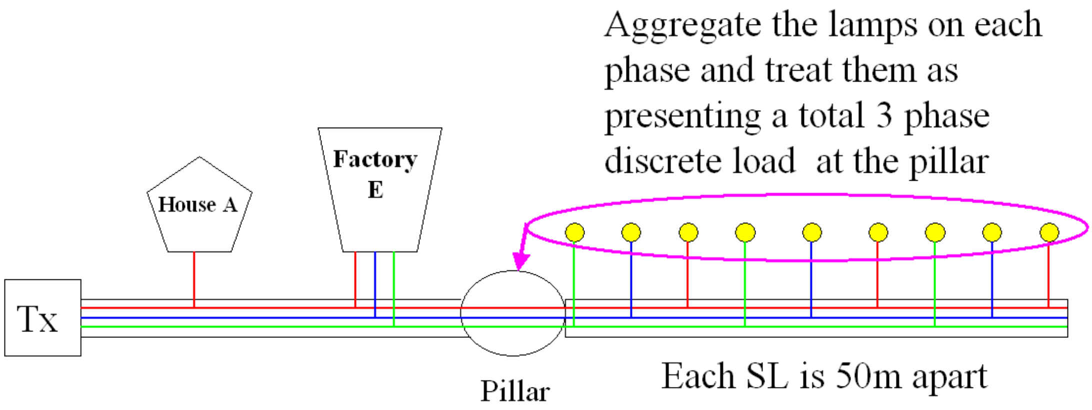

Figure 2.2a.

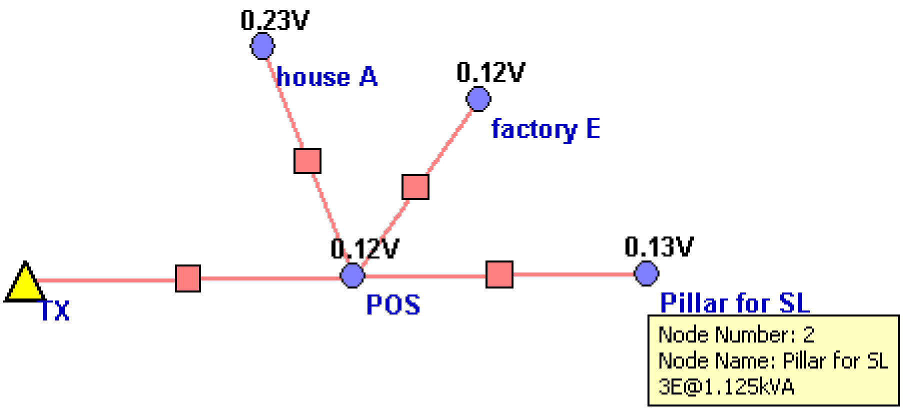

Figure 2.2b. How to model figure 2a in LV Design.

Run "Solve Network" to calculate the VD from the Tx to the pillar and call it **VD1**. This takes into account all the other loads on the 3-phase circuit caused by other customers as well as the total load from the SL. This will give the voltage at the pillar under the load conditions presented by the customer loads and the streetlights.

NB: The voltage level appearing at the pillar may be less in practice than indicated by LV-Design because the customer loads may not be as high during the night when the lights are on.

2.2.2 Section two

Next, you need to calculate the VD from the pillar to the farthest SL which is on the red phase conductor of the 3-phase cable. However, for the purpose of accurately calculating the volt drop by the SL, this cable needs to be treated as a single-phase cable and modelled in LVD with D Loads of only three lamps, 150 metres apart as shown below:

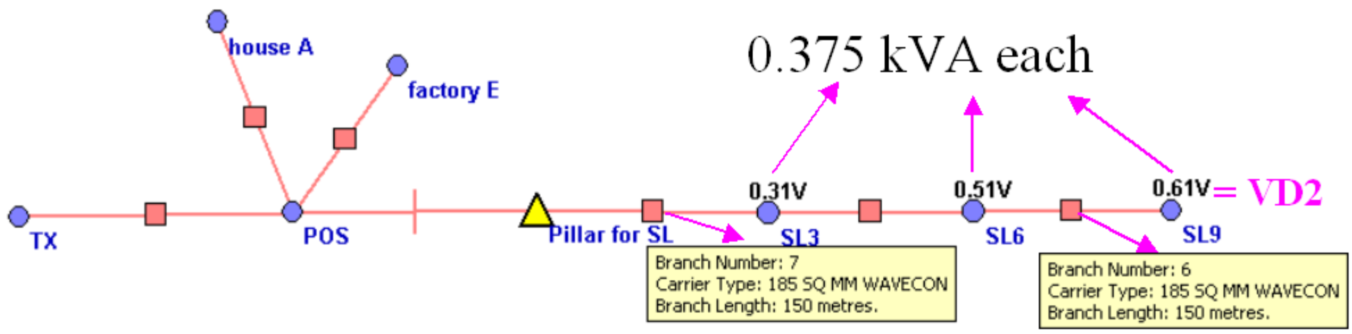

Figure 2.3

The red phase conductor produces the "worst-case scenario" and if the total VD (VD1 + VD2) from the transformer to the farthest lamp is acceptable, then the total VD over each of the other two phases will also be acceptable.

To commence running LVD to calculate VD2, it will be necessary to isolate the 3-phase circuit from the calculation by creating an "open point" and move the Tx to the Pillar position as shown in Figure 2.3. In this example, the largest VD will be on the red phase. By using D type loads on the second section, LVD algorithm will treat the cable as a single-phase cable. The reason why modelling was done as a single-phase cable is because there is no capability in LVD for modelling single-phase discrete loads on a 3-phase cable.

The resultant VD will be double of what it would be on a 3-phase system because the calculation allows for a return current in the neutral. To correct this VD2 needs to be halved.

Therefore, the total VD from the Tx to the furthest SL would be: VD = VD1 + (VD2/2)

2.3 Example of SL design mixed with residential/ commercial loads connected together on a 3-phase network

For streetlights that are mixed with the residential or commercial loads on a 3 phase network as below:

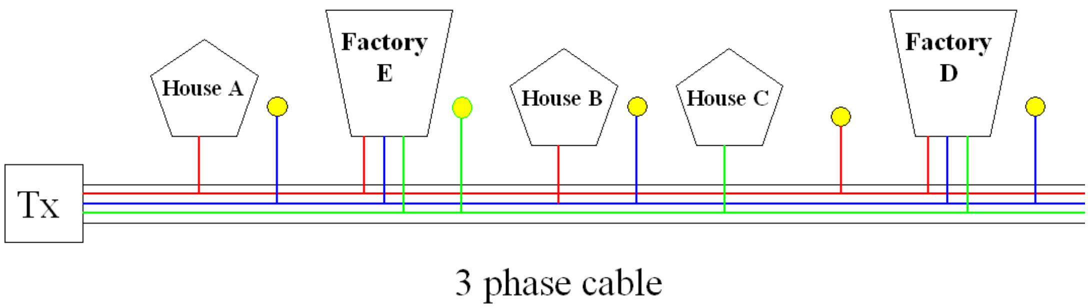

Figure 2.4

In this example, the appropriate load type to model the lamps (SL) is single-phase diversified load (A or B type). With this arrangement, the SL lights are treated no differently to the residential loads or factory loads on the circuit. This is because the lamp, rated at 0.375 kVA, is relatively small compared to a household electricity demand with an average ADMD of 3 kVA.

2.4 SL design using one or two phases of a 3-phase cable connected to a 3-phase network

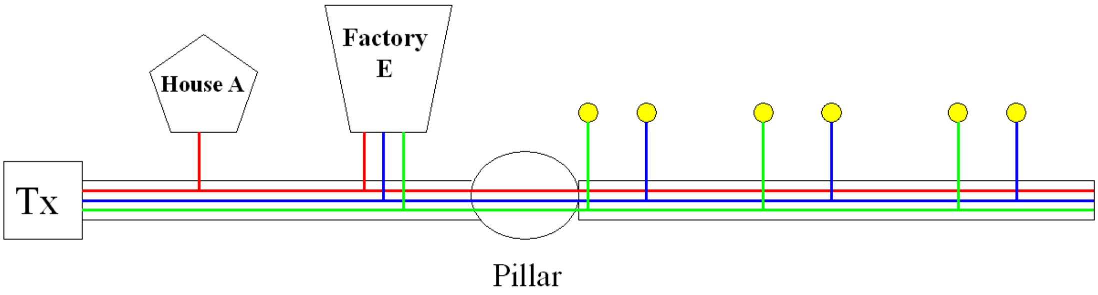

Figure 2.5

For streetlights that are designed over one or two phases of a 3-phase cable such as Figure 2.5 above, D loads should be used to simulate the network.

3 Single phase network (SPUD, SPURS TX)

For rural or semi rural areas, if single phase Tx is used at the network the customer loads should be modelled as "D" type load. The kVA allocated should be the Maximum Demand (MD) as shown in the Figure 3.1 below.

The MD can be estimated from the ADMD value or the maximum demand measured from the customer meter.

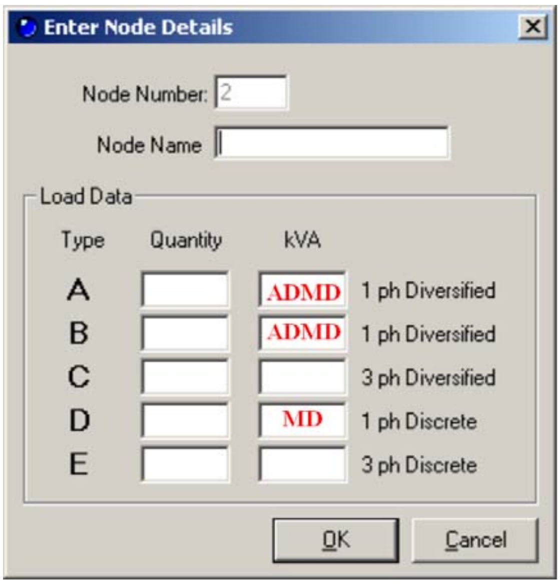

Figure 3.1

4 LV Design voltage drop algorithm for A, B loads

The calculation algorithm in LV Design started from the Tx and moves toward an end node of a branch (in this example, the end node is J as seen in Figure 4.1 below). Besides, LV Design also uses the stages approach. In other words, while moving toward an end node, the calculations are repeated every time it detects a node. Hence, a new Diversity Factor (DF) is calculated each time it passes through a node as the number of nodes (N) increases such as below:

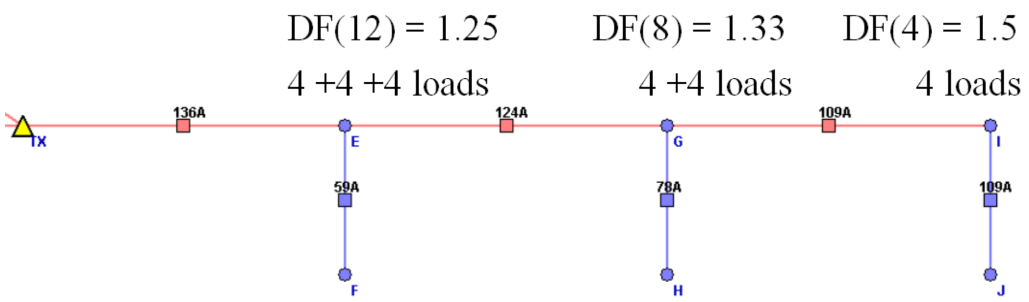

Figure 4.1. Node F has four loads at 4.7 kVA each, Node H has four loads at 8.7 kVA each, Node J has four loads at 6.2 kVA each

4.1 Detailed calculations

The DF formula for A,B loads is:

$$DF(N) = 1 + \frac{1}{n} = \frac{n+1}{n}$$

Where N is the total number of A, B loads at each segment n is the round up value of (N/3)

The formula LV Design uses to calculate the Current (for A,B loads) is:

$$I^{A,B}{}_{segment} = \overline{ADMD} * n^{A,B} * \left(\frac{1000}{V_{1\phi}}\right) * DF_{1\phi}(N^A + N^B)$$

By using the stage approach:

At node E:

Number of loads can be seen down stream is 12 loads:

DF(12) = 1.25

$\overline{ADMD}$ = [(4.7*4) + (8.7*4) + (6.2*4)]/12 = 6.53 kVA

$$I^{A,B}{}_{Tx\_E} = \overline{6.53} * 4 * \left(\frac{1000}{240}\right) * DF_{1\phi}(12) = 136A$$

At node G:

Number of loads can be seen down stream is 8 loads:

DF(8) = 1.33

$\overline{ADMD}$ = [(8.7*4)+(6.2*4)]/8 = 7.45 kVA

$$I^{A,B}{}_{E\_G} = \overline{7.45} * 3 * \left(\frac{1000}{240}\right) * DF_{1\phi}(8) = 124A$$

At node I:

Number of loads can be seen down stream is 4 loads:

DF(4) = 1.5

$\overline{ADMD}$ = [(8.7*4)/4 = 8.7 kVA

$$I^{A,B}{}_{G\_I} = \overline{8.7} * 2 * \left(\frac{1000}{240}\right) * DF_{1\phi}(4) = 109A$$

In addition, the values of 136A, 124A or 109A are the current values of the worst phase in a 3-phase network. This is because LVD assumes the residential network (A or B loads) is a balanced 3-phase network, thus it will try to distribute all the loads onto the three phases as evenly as possible. It will then pick the phase with the heaviest loads to calculate the current.

5 DFIS connectivity issues

When users export LV network data from DFIS to LV Design, they might encounter the problem below:

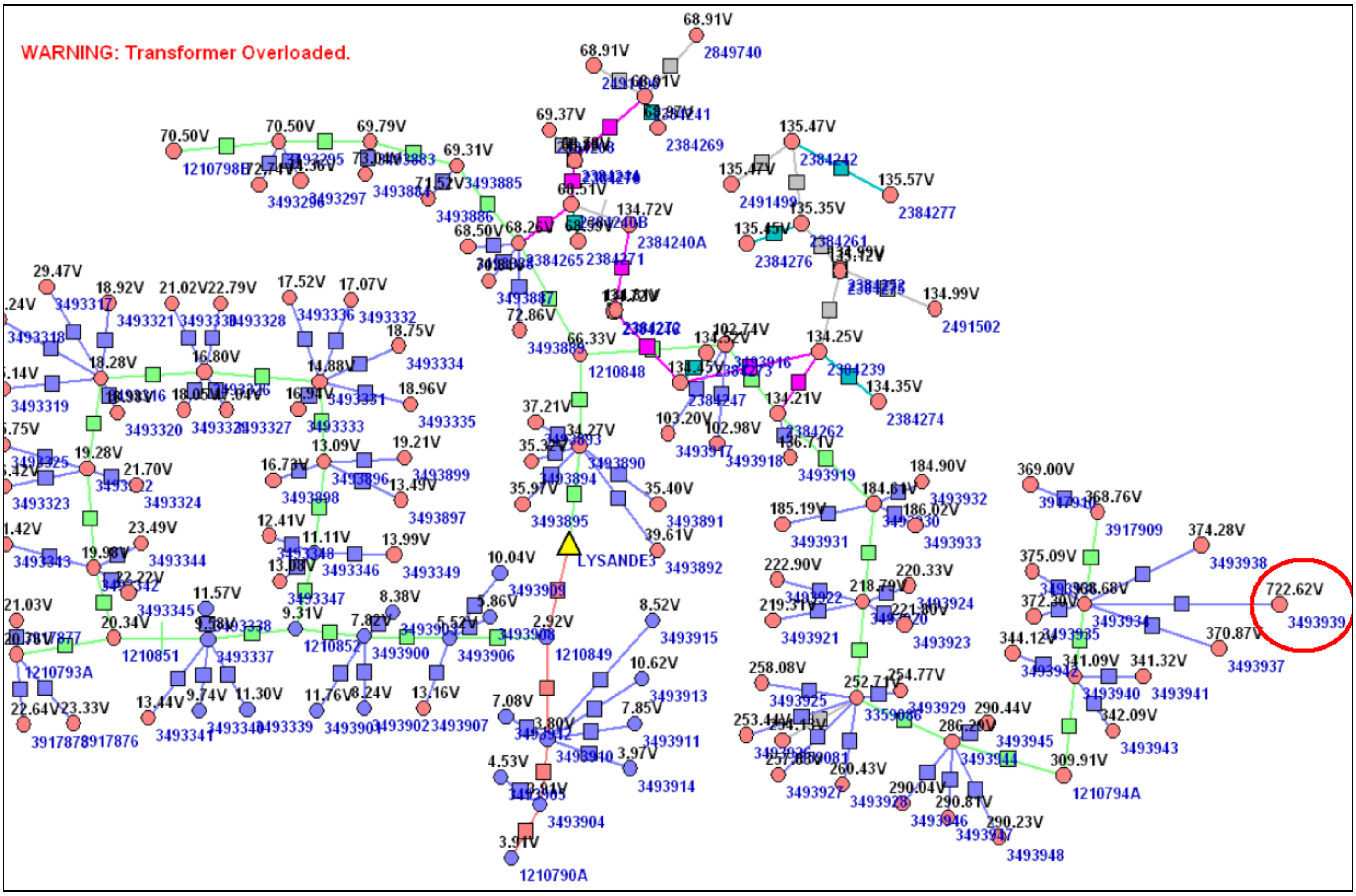

Figure 5.1

As can be seen above, the Voltage Drop is extremely high in this LV network. This can be explained by one of the DFIS connectivity issues where a few meters are not connected to the right network. Consequently, when LV Design imports data from DFIS, it will take in all the meters data (kVA/ADMD), including the wrong ones.

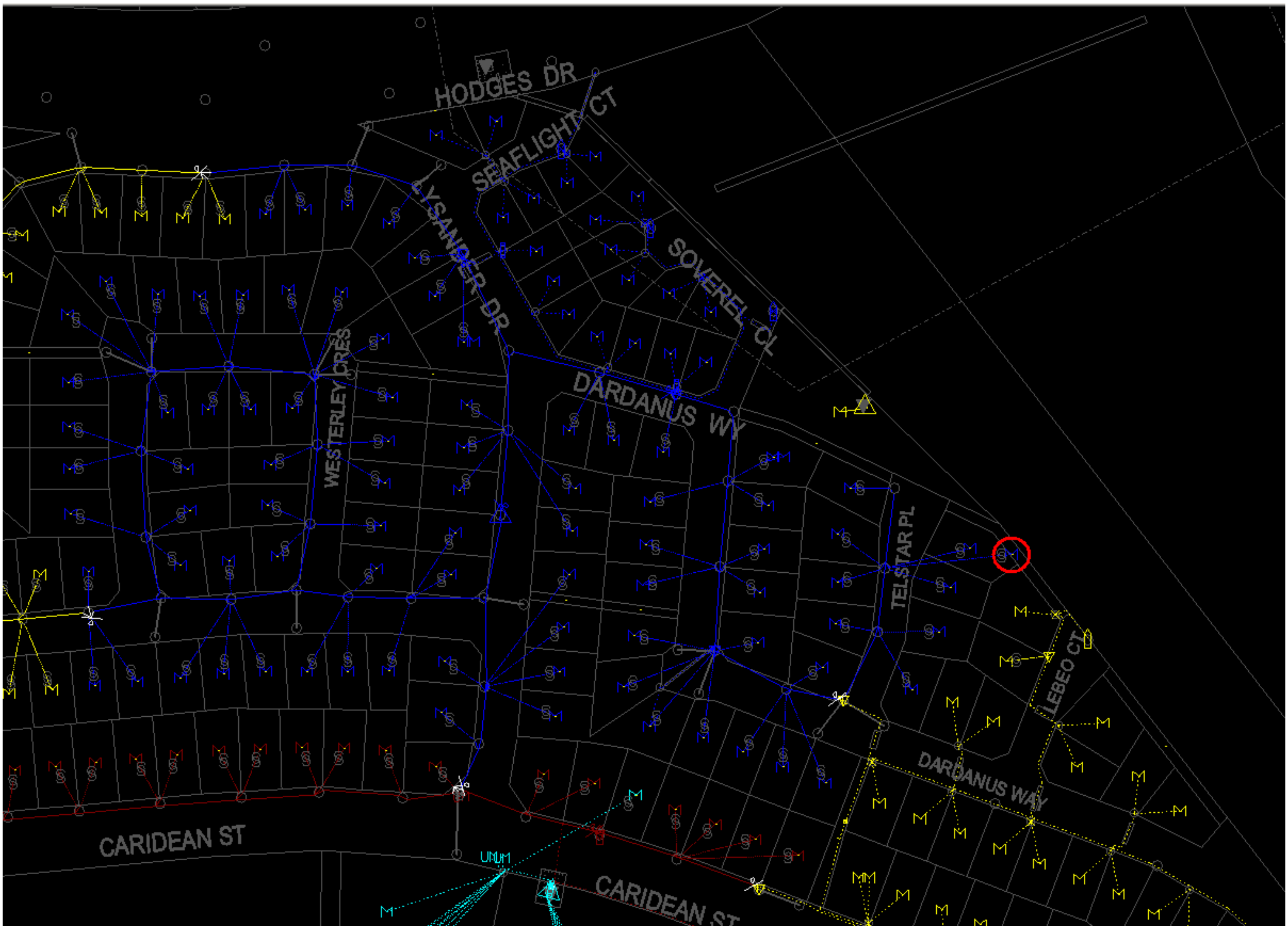

Figure 5.2: Now take a look at the DFIS network where the data was exported.

In this example, the circled meter in red should not be in the Lysande3 network (in blue) because the meter type is not the same as the other ones in the Lysande3 network.

These connectivity issues should be checked to fix the nodes on LV Design and forwarded to DFIS group so that they can correct the data error.

6 The effects of Diversity factor in LV Design algorithm

6.1 Problem description

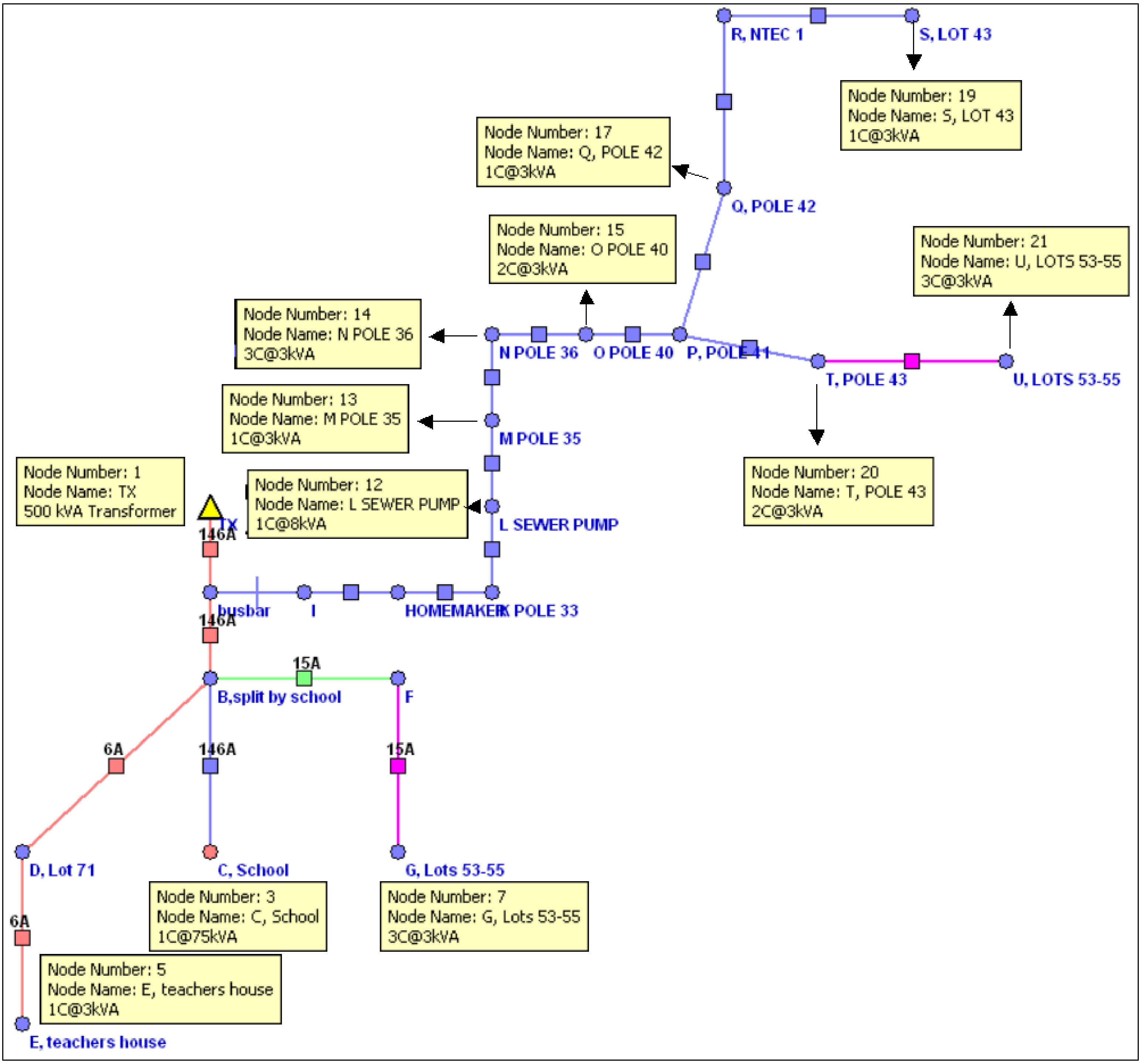

Figure 6.1

The problem here is that the sum of the currents in the bottom three branches (teacher's house, school and Lots 53-55) does not add up to that coming from the transformer. The branch off to the right (blue) is an open point so it doesn't contribute.

If you put an open point in the school branch it works correctly (taking into account rounding), but if you have an open point in the Lots 53-55 branch the current from the transformer is less (136A) than that into the school (146A). If you put an open point in the teacher's house branch then the transformer current doesn't include that to Lots 53-55.

6.2 Explanation

Figure 1 shows the *maximum currents* that could be drawn by node E, C and G are 6A, 146A and 15A respectively, where there is very little diversity or none between the loads within a dwelling. In other words, maximum current is used when one might demand more electric power than usual. For example, all the electrical appliances in the house are turned on at the same time.

When it comes to the upper level of the network (node B), the current drawn will now be calculated with the diversity factor among dwellings taken into account. This means the current drawn from node B will not equal the total current drawn by node E, C and G because it is based on the assumption that not everyone uses their maximum demand at the same time. For example, you might decide to cook dinner but your neighbour decides to eat in a restaurant that night.

This happens again when calculating the Transformer's current where there is a greater diversity among the loads within the network. For example, majority of the Transformers in the commercial area would not work as hard as the Transformers in the residential area in the evening.

In conclusion, the current displayed on the cable can be used to design the cable rating and the current draw from the transformer can be used to determine the transformer size for the network.