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POWER FEEDER CALCULATIONS

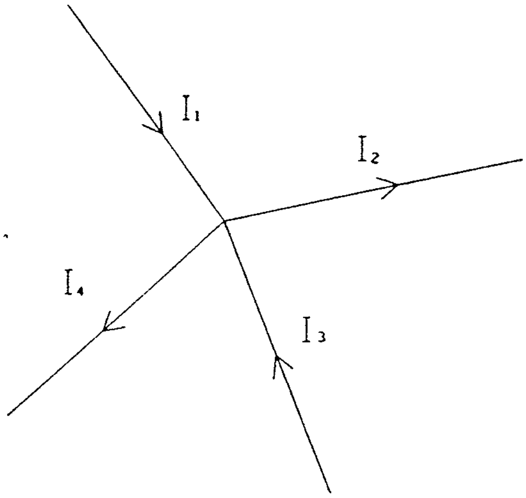
Cable A-B V = 2amps x 1.58ohms

Cable A-B V = 3.16volts

Cable B-C V = 6.46amps x 1.26ohms

Cable B-C V = 8.14volts

"the voltage drop to the farthest point from the feed voltage must never be greater than 10% of the feed voltage."

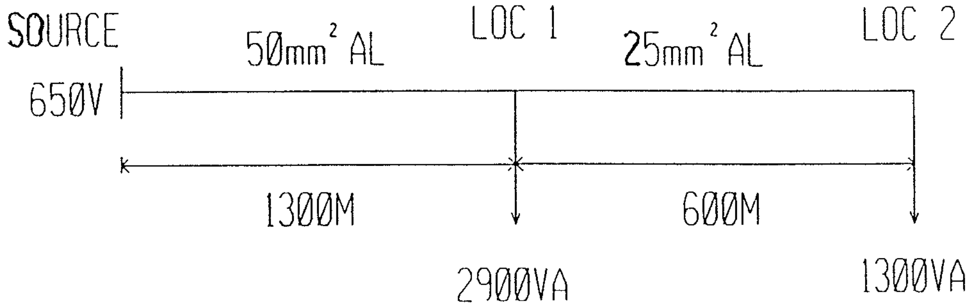


KIRCHOFF'S FIRST LAW

$$I_1 - I_2 + I_3 - I_4 = 0$$

Figure 1 is an example of a power feeder.

FIGURE 1



Current Flowing in C - B = 2 amps + 4.46 amps

Current Flowing in C - B = 6.46 amps

POWER FEEDER CALCULATIONS

INTRODUCTION - CABLES USED FOR POWER FEEDERS

Two types of cable are in use for railway signalling power schemes. These are:-

(a) Stranded Copper and

(b) Solid Aluminium.

Aluminium cable schemes are far cheaper than their equivalent copper and so aluminium cables are generally used these days. Resistance and current ratings vary with temperature but these effects are negligible when calculating sizes of cable for a scheme.

Maximum current rating also depends on the method of cable laying (ie. ducting, burying or in the air). This is not a critical factor when choosing cables, as signalling feeders invariably use cables well below their current rating simply to conserve voltage drops.

When calculating a cable scheme the critical factor must be that

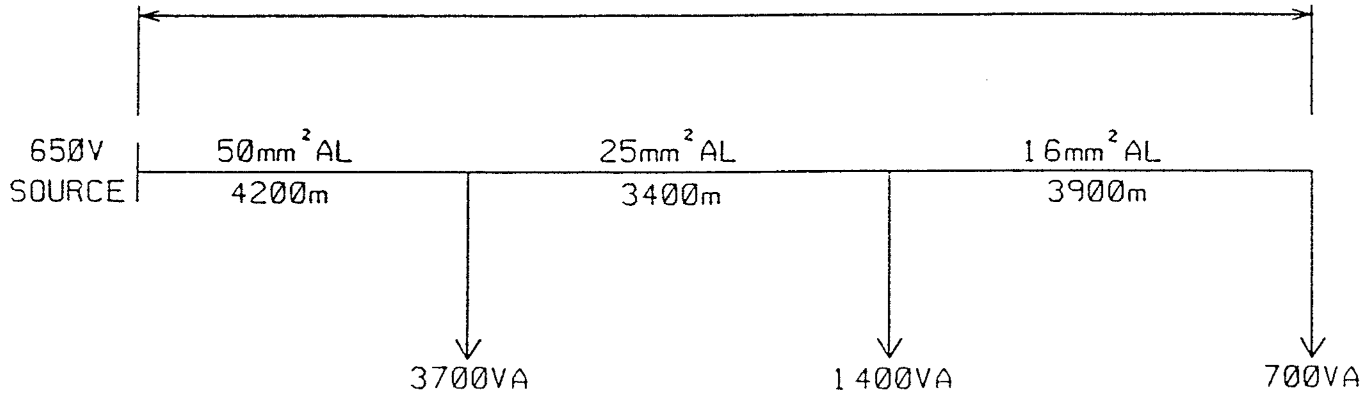
> **"the voltage drop to the farthest point from the feed voltage must never be greater than 10% of the feed voltage."**

All equipment is designed to work to this tolerance.

For example the diagram below is unacceptable as we have a volt drop at the farthest end of the feeder of greater than 10% of our feed voltage, which is 650 volts.

The loads quoted include the 10% excess normally applied.

VOLTAGE DROP IS 99VOLTS APPROXIMATELY. THIS EXCEEDS THE 10% TOLERANCE.



continued

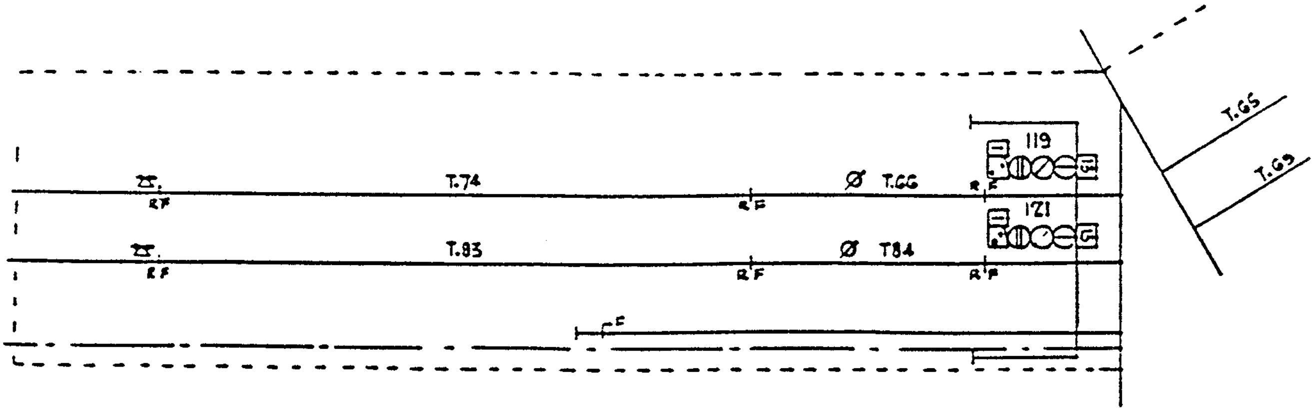
DESIGNING A POWER FEEDER

As we said previously the maximum volt drop to the farthest point from the feed voltage must never exceed 10% of the feed voltage. This is always calculated for the worst case, when there is the greatest load.

In railway signalling terms this is when the most complicated route is being set at the most remote interlocking.

You can decide the worst case by referring to the Signalling Location Plan. The Location Plan also contains information about which location case each piece of signalling apparatus is contained within and also where these are physically positioned relative to the running lines.

Attached below is a diagram showing an extract from a typical Location Plan.



From the information contained on a Location Plan, location loadings can be evaluated. For somebody to be able to do this requires a certain degree of Railway Signalling circuitry knowledge.

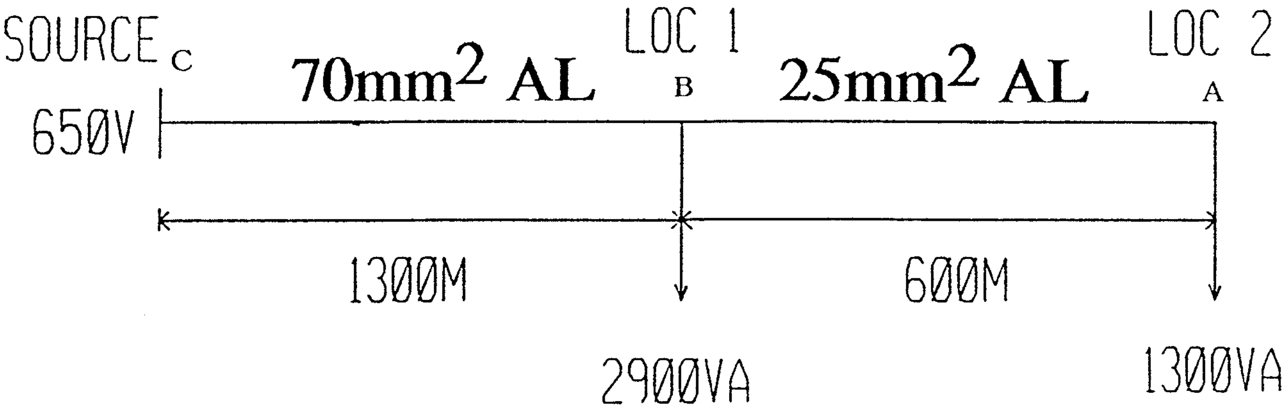
continued

In this module we have assumed the trainee does not have this knowledge and in the example that is used to explain how to design a power feeder all location loadings are given.

Figure 1 is an example of a power feeder.

The loads quoted include the 10% excess normally applied.

Figure 1.



We have a source of 650 volts A.C, and two locations each with a load. The cable size has been decided for us and we know the distance the cable's have to be run. At this point there is one important piece of information we do not know. That is the resistance values of the cables.

We need to know these values, in order to calculate the voltage dropped in the cable.

Attached is a ready-made table, (TABLE No. 1) showing various sizes of copper and aluminium cables complete with their resistive values and maximum current rating.

continued

Table No. 1

CABLE RESISTANCE/MAXIMUM CURRENT RATING

Copper Cables			
Conductor Size	Resistance Per Km in Ohms	Resistance Per Kyds in Ohms	Current Rating in Amps
9/0.30 mm	30	27.43	
16/0.30 mm	17	15.54	
50/0.25 mm	7.7	7.04	24
1/0.85 mm	30.7	28.07	
1/1.53 mm	9.76	8.92	
7/0.67 mm	7.41	6.78	24
7/1.35 mm	1.81	1.65	42
19/1.53 mm	0.52	0.47	90
19/2.52 mm	0.25	0.23	170
9/0.012"	28	25.6	
16/0.012"	15.8	14.45	
1/0.036"	26.7	25.41	
1/0.044"	18	16.46	11
1/0.064"	8.5	7.77	
7/0.029"	5.9	5.39	26
7/0.036"	3.8	3.47	26
7/0.044"	2.56	2.34	34
7/0.064"	1.21	1.11	56
19/0.064"	0.45	0.41	81
Aluminium Cables			
16 sq mm	1.89	1.73	60
25 sq mm	1.20	1.10	94
35 sq mm	0.868	0.79	115
50 sq mm	0.641	0.57	135
70 sq mm	0.443	0.41	165
95 sq mm	0.32	0.29	200

continued

Let us now work through Figure 1 as an example, to calculate the amount of voltage dropped at the end of the power feeder, ie. Location 2.

STEP 1

Give each point at which there is a load an alphabetical letter using the letter "A" at the load farthest from the feeder.

Check 10% excess has been included in the load.

STEP 2

Calculate the amount of current taken by each load. For example the current at Loc 1 will be:-

I = VA/V,

(LOC 1) I = 2900/650

(LOC 1) I = 4.46 amps.

and the current taken by Loc 2 will be:-

I = VA/V,

(LOC 2) I = 1300/650

(LOC 2) I = 2 amps.

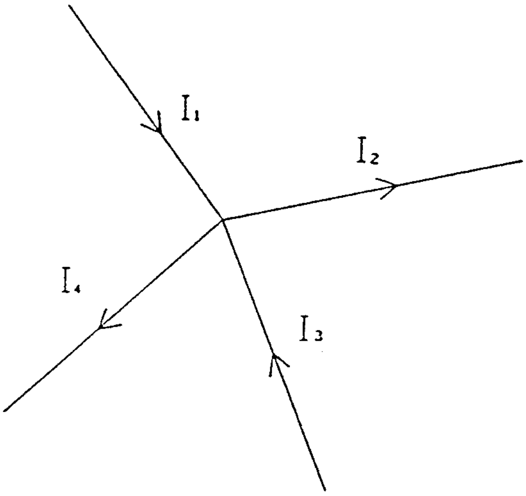
continued

STEP 3

Now we have calculated the current taken by each load we can apply Kirchoff's First Law to calculate how much current is flowing between points C - B and B - A. Kirchoff's First Law states:-

> **"The total current flowing into any node in a circuit is equal to the total current flowing away from that node."**

See the diagram below:-



KIRCHOFF'S FIRST LAW

$$I_1 - I_2 + I_3 - I_4 = 0$$

So in Figure 1 if there is current of 2 amps being taken by Loc 2 then the current flowing in B - A must be 2 amps. Using Kirchoff's First Law if there is 2 amps flowing in B - A and Loc 1 is taking 4.46 amps then we have:-

Current Flowing in C - B = 2 amps + 4.46 amps

Current Flowing in C - B = 6.46 amps

continued

STEP 4

Calculate the resistance of the cable between each load (location in this case). An important point to remember when dealing with twin conductor cables, is to **double** the resistance value to cater for the loop. So remember

> **"to calculate the resistance of a cable,
> (2.2 x distance) is used to take into
> account the return conductor and 10% errors."**

Taking our example, the Cable A - B, we know it is a 25 sq mm aluminium cable. So referring to Table 1 we can see that it has a resistive value of 1.20 ohms per kilometre. Therefore by applying this information we acquire the following:-

Resistance Value of Cable A - B = 2.2 x resistance of cable per Km x Length of Cable.

Resistance Value of Cable A - B = 2.2 x 1.20 ohms x 0.60 Km

Resistance Value of Cable A - B = 1.58 ohms

Following the same procedure for Cable B - C we will get:-

Resistance Value of Cable B - C = 2.2 x 0.443 ohms x 1.3 Km

Resistance Value of Cable B - C = 1.26 ohms

STEP 5

Having calculated the current flow in Cables A - B and B - C, and also the resistance of cables A - B and B - C we are now able to calculate the volt-drop in each of the cables by applying "Ohms Law, V = I x R."

Therefore:-

Cable A - B V = 2 amps x 1.58 ohms

Cable A - B V = 3.16 volts

and also

Cable B - C V = 6.46 amps x 1.26 ohms

Cable B - C V = 8.14 volts

continued

STEP 6

In order to calculate the voltage at the farthest end of the feeder we must now add up the individual volt-drops and subtract the total from the source voltage.

Therefore:-

Voltage at the end of the feeder = 650 - (3.16 + 8.14) volts

Voltage at the end of the feeder = 650 - 11.30 volts

Voltage at the end of the feeder = 638 volts

638 volts is within the limits that we laid down at the beginning of the module. These limits were

> **"the voltage drop to the farthest point from the feed voltage must never be greater than 10% of the feed voltage."**

If it had been greater than 10% then we would have a problem. What do you think we could do to overcome the problem as Signal Design Engineers?

You should now be able to attempt some similar examples (loads given) of varying complexity.

A more realistic example is shown in Figure 2 where you are given the Signalling Location Plan and you need to evaluate the location loadings. As was said previously you really need to have some circuitry knowledge to do this.

The greatest load in Figure 2 will be taken when a route is set through 101 points reverse.

continued

POWER FEEDER CALCULATIONS

When this has been decided then evaluate the load taken by each location. Attached is Table 2 which gives a comprehensive list of individual pieces of equipment and their VA rating.

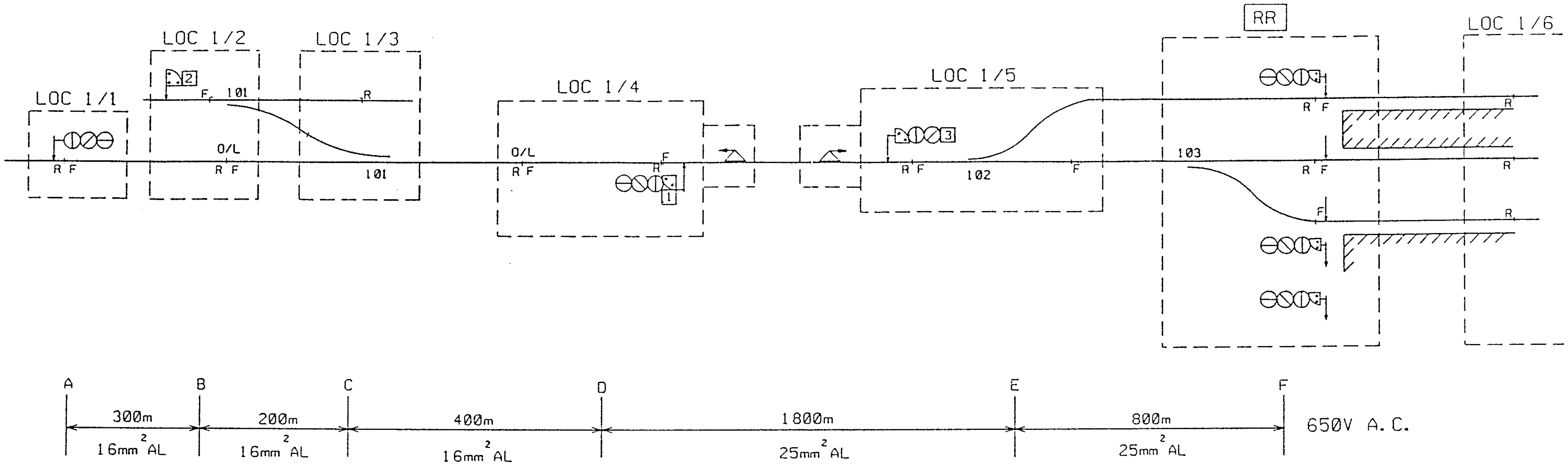
The procedure for calculating the power feeder volt-drop is exactly the same as given for the example in Figure 1. The only point to remember is that when the location load is calculated an extra 10% is added to that number.

Table 2

LIST OF LOCATION POWER LOADINGS			
1. SIGNALS	VA	4. DC TRACK CIRCUITS	VA
SINGLE ASPECT	40	NON IMMUNE DC	15
DOUBLE ASPECT	70	IMMUNE	35
SEARCHLIGHT	40		
SUBSIDIARY	50		
SHUNT (GROUND)	70		
BANNER	55		
SIGNAL MOTOR	70		
2. ROUTE INDICATORS	VA	5. ASTER TRACK CIRCUITS	VA
POSITION LIGHT JUNCTION	140	TRANSMITTER	70
THEATRE TYPE	300 (MAX)	RECEIVER	30
STENCIL - SINGLE	140		
STENCIL - DOUBLE	300		
3. POINT MACHINES	VA	6. MISCELLANEOUS	VA
RELAYS ONLY (Battery fed)	30	AWS	50
SINGLE ENDED	1000	AWS SUPPRESSED	80
DOUBLE ENDED	1800	RELAYS	5
CLAMPLOCKS - SINGLE ENDED	750	LOC/POINT HEATER	20
		HOT BOX DETECTOR	250
		AHB MACHINE	1100
		4 BARRIER MACHINES	1100
		CCTV	1000

end

POWER FEEDER CALCULATIONS



NOTE:- TRACK CIRCUIT RELAYS TAKE NO POWER FROM A SUPPLY, SO LOC 1/6 CAN BE IGNORED. C.M. & E.E. SUPPLY AT RELAY ROOM. WORST CASE SETTING A ROUTE ACROSS 101 POINTS. D.C. TRACK CIRCUIT (IMMUNISED).

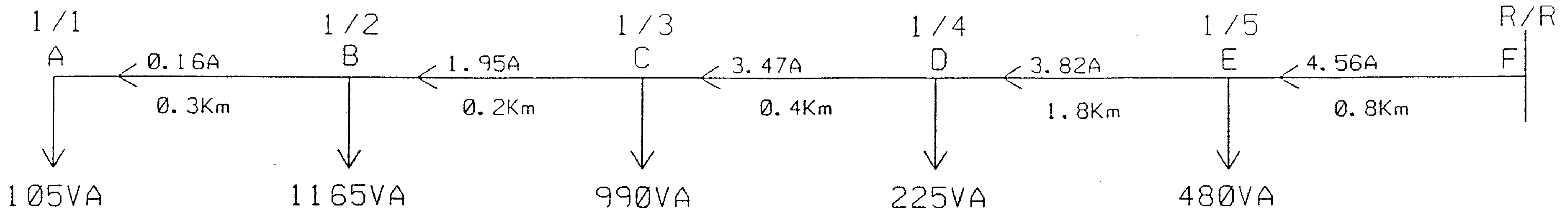
LOCATION LOADINGS (VA)

	1/1	1/2	1/3	1/4	1/5
SIGNALS & INDS	40	70	-	40	340
AWS	-	-	-	80	-
TCdc	35	70	-	70	70
RELAYS	20	20	-	15	25
POINTS	-	900	900	-	-
TOTAL	95	1060	900	205	435
TOTAL + 10%	105	1165	990	225	480

FIGURE 2.

continued

POWER FEEDER CALCULATIONS



$VA = V \times I$

$$\therefore\ I = \frac{VA}{V} = \frac{105}{650} = \underline{0.16A} \quad \frac{1165}{650} = \underline{1.79A} \quad \frac{990}{650} = \underline{1.52A} \quad \frac{225}{650} = \underline{0.35A} \quad \frac{480}{650} = \underline{0.74A}$$

N.B. TO CALCULATE RESISTANCE OF CABLE (2.2 X DISTANCE) IS USED TO TAKE INTO ACCOUNT RETURN CONDUCTOR AND 10% ERRORS.

RESISTANCE OF CABLE PER KM

CABLE A-B	CABLE B-C	CABLE C-D	CABLE D-E	CABLE E-F
2.2 X 1.89 X 0.3	2.2 X 1.89 X 0.2	2.2 X 1.89 X 0.4	2.2 X 1.2 X 1.8	2.2 X 1.2 X 0.8
=1.247	=0.832	=1.663	=4.75	=2.11

LENGTH OF CABLE

VOLT DROP DUE TO CABLE RESISTANCE CAN NOW BE CALCULATED i.e. V=I X R

CABLE A-B	CABLE B-C	CABLE C-D	CABLE D-E	CABLE E-F
0.16 X 1.247	1.95 X 0.832	3.47 X 1.663	3.82 X 4.75	4.56 X 2.11
=0.2	=1.662	=5.77	=18.15	=9.62

∴ VOLTAGE AT END OF FEEDER= 650-(0.2+1.622+5.77+18.15+9.62) = 650-35.362= 614.64 VOLTS

i.e. WITHIN THE ACCEPTABLE 10% OF SOURCE VOLTAGE

FIGURE 3.

end