UNDER PEER REVIEW

Original Research Article

Design standardized program to calculate the related data from single load on single feeder

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ABSTRACT

The feeder construction type adopts π—type (nominal π) transmission mode. The total feeder impedance value makes up of feeder impedance and load impedance, and then the feeder impedance value is derived from the hyperbolic function of mathematical formula, and the wire diameter parameter and length by a computer program to calculate. The load impedance composition is divided into two types: resistance parallel reactance or resistance series reactance, and the difference analysis of the feeder current obtained after being connected in series with the line impedance. The impact of voltage changes on the load end, load impedance and adjustment capacitors are deeply analyzed and discussed, and their differences are shown graphically. At the same time, the relationship between the load power factor and the resistance and inductance ratio of the adjusting capacitor and the load impedance are analyzed. Based on the frequent changes in the test data of related equipment parameters during design, the above calculation steps are been complied for a computer programming, the program has been tested for excellent performance. So that it is a powerful tool for designers to improve the accuracy of repetitive computer programming calculations.

Keywords: Single diagram of power system, Nominal π transmission, Feeder current, Power factor.

1. INTRODUCTION

A sole feeder voltage 13.8kV supplies single load with being delivered in π type (nominal π). The feeder is known to be 10km long, its wire diameter with The resistance value (0.045 ohm (Ω)), the inductance value (0.4 ohm (Ω)), and the parallel admittance value (4/1000000 Siemens (S)) of per kilometer. This feeder supplies a single device, which impendence is made up of a resistance value of 30 ohms parallels an inductance value of 40 ohms. The added equipment is shown in the red line of Fig. 1.

To find the loss value of the feeder line and the power factor of the load. When a set of capacitors are installed in parallel at the load end with a value of 40 ohms to adjust the line loss value, how does the above-mentioned data change?

A standardized computer program was developed to replace manual calculations for the purpose of this article, following referring to related power system books and journal articles. During the calculation, its ancillary equipment such as circuit breakers and relay protection system equipment will be ignored.

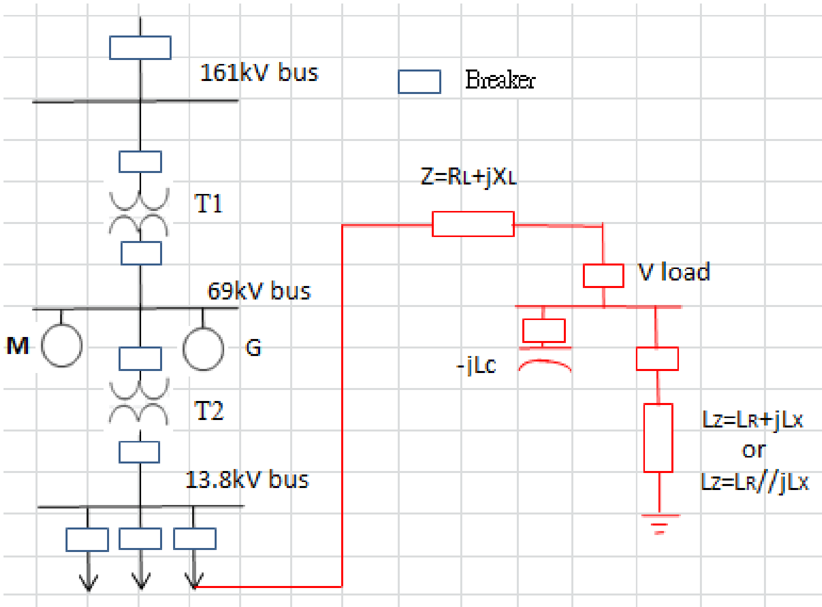

Fig 1 Power system single diagram

2. LITERATURE REVIEW

The effect of power system was from new equipment added into the system which those related document has been described in related textbooks and journals articles. In particular, the loss of the line caused by the change of the load current and the calculation of the electricity bill due to the change of the power factor, etc., Its articles and textbooks are too numerous to list. This article only mentions two books on power system and several representative journal articles as evidence for literature review.

Literature [1] explains the theorems and application notes for the basic textbooks of academic theory. Literature [2] and [3] describe the pros and cons of feeder line structure types. In particular, the impedance value of the π-type line structure is introduced, which is the parameter and length of the wire, which is calculated by the hyperbolic function. However, the literature [4] states that Taipower's contract capacity for user equipment is at a fixed limit and its load power factor value must be above 80%.

If it is lower than this value, a fine will be imposed, otherwise the electricity fee will be given preferential treatment; it also mentions the influence of adjusting capacitors on improving power factor. Literatures [5] and [6] are the benefits of parallel capacitors on line loss and power factor and technical application improvements; As for [7], [8], [9], and [10], they are based on the integration of academic theory and applied to the publication of articles in the journals of the actual power system.

The content is the relationship between the three-phase wiring of the first and second side coils of the power system transformer equipment and the neutral point grounding of the generator to the change of the system impedance value, then connect the transmission line impedance to draw the "Thevenin equivalent" impedance value of the power system.

Finally, use MATLAB software to program the computer to perform the calculation of the "clear time" when the power system fails, the calculation of the feeder fault current and the calculation of the line short — circuit current by the capacity method. Integrate the above literatures and use the specifications and parameters of the equipment components of the distribution substation (including the impedance value between the equipment wiring).

Find the relevant data when adding a single feeder and a single load to the feeder bus. Especially in the combination of load impedance-resistance and inductance are connected in parallel or series.

Another important point is the relationship between the power factor and the adjustment capacitor to achieve the best economical and safe design. The above [1] literature calculation process is too cumbersome and easy to make clerical errors if it is manually performed, so this article starts to develop and replace the written calculation with a program. The development process steps are described as follows.

3. DESIGN PROGRAM

Continuing the summary and collation described in the literature, after conducting related tests and checking calculations, a computer program is developed to replace artificial calculations.

This chapter focuses on programming skills, as for the details of the artificial calculation steps, readers are advised to refer to the literature to avoid repetition and take up space. The execution of computer programs highlights its advantages, such as maneuverable operation, rapid calculation, and repeated parameter changes.

3.1 ARTIFICIAL CALCULATIONS

A single diagram of power system equipment in a certain distribution substation, now a dedicated feeder line is added to supply a single load and a set of regulating capacitors, as shown in the red part in Fig. 1. The algorithm steps are as follows:

- **Calculate the total impedance of the feeder**

The schematic diagram of the feeder π-type transmission circuit is shown in Fig. 2. The line impedance value is calculated by mathematical formula as follows: From the literature [3], it is known that the line impedance is derived by interactively derived from Thevenin and Norton's theorem, the ABCD constants for the nominal π model are given.

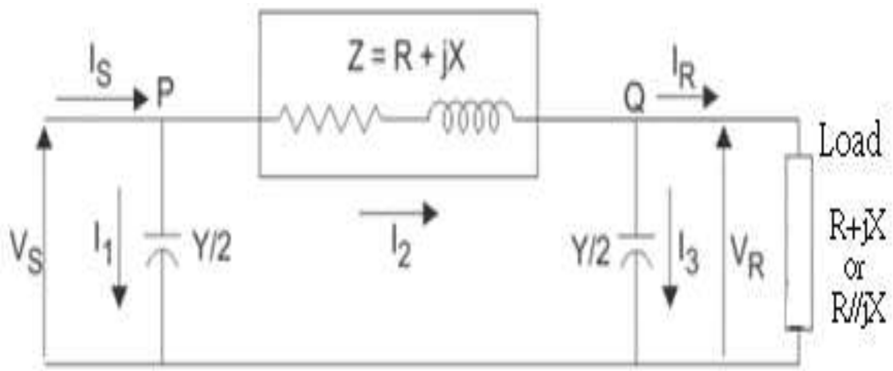

Fig. 2 Schematic diagram of feeder π－type transmission circuit [2]

$$\begin{bmatrix} V_S \\ I_S \end{bmatrix} = \begin{bmatrix} A & B \\ C & D \end{bmatrix} \begin{bmatrix} V_R \\ I_R \end{bmatrix} \tag{1}$$

$A = D = \cosh \gamma l$;B = $Z_C \sinh \gamma l$; C = $1/Z_C \sinh \gamma l$

The criterion of the above formula 1 are A = D ;

AD – BC =1 .

z is the parameter of series impedance per kilometer －resistance value of 0.045 ohm (Ω), inductance value of 0.4 ohm (Ω), y is parallel admittance value of 4/1000000 Siemens (S). l is the line length, γ is the square root of z*y, the parallel capacitive reactance of the line Z_C is the square root of z/y, sinh, cosh, and tanh are triangular hyperbolic functions. The total impedance of the line series (Z) is equal to B = $Z_C \sinh \gamma l$，the total parallel admittance of the line (Y) is equal to B = $2/Z_C \tanh \gamma(l/2)$.

The calculation results for each period and different voltages under fixed total impedance and different load impedance structure are summarized as shown in Table 1. At the same time, it is presented as a curve graph, as shown in Fig. 3, the blue line is the voltage of the power supply terminal, and the red line is the series type load impedance of the voltage of the load terminal and the green line is the parallel type load impedance of the voltage of the load terminal.

Table 1 the results for each period and different voltages under fixed total impedance and different load impedance structure are summarized

Hour	Feeder Voltage kV	Feeder Impedance (Z)	Load Impedance		Load voltage (kV)	
			Series	Parallel	Series	Parallel
1	13.5	0.450+j3.999	20+j40	20//j40	7.20	7.55
2	13.5				7.20	7.55
3	13.4				7.15	7.49
4	13.4				7.15	7.49
5	13.4				7.15	7.49
6	13.5				7.20	7.55
7	13.6				7.25	7.61
8	13.7				7.30	7.66
9	13.8				7.36	7.72
10	14.0				7.47	7.83
11	14.1				7.52	7.89
12	14.2				7.57	7.94
13	14.2				7.57	7.94
14	14.2				5.57	7.94
15	14.2				7.57	7.94
16	14.2				7.57	7.94
17	14.1				7.52	7.89
18	14.0				7.47	7.83
19	13.8				7.36	7.72
20	13.8				7.36	7.72
21	13.7				7.30	7.66
22	13.5				7.20	7.55
23	13.5				7.20	7.55
24	13.5				7.20	7.55

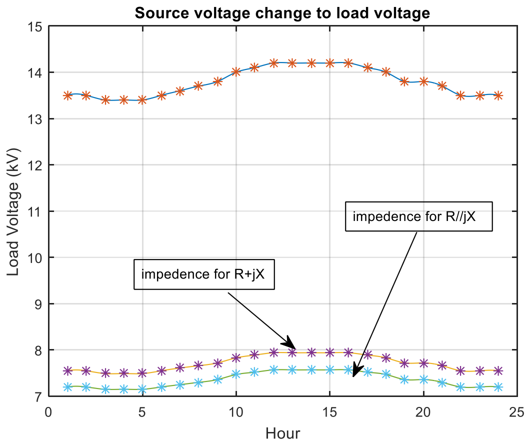

Fig 3 Corresponding curve of voltage between power supply terminal and load terminal in each period

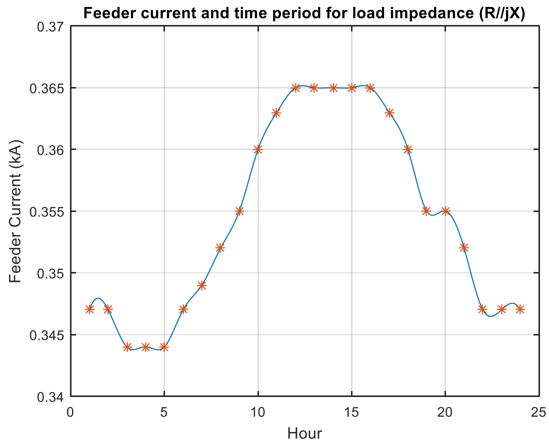

Fig 4 Feeder current and time period for load impedance (R//jX)

- **Discussion on load impedance**

This paragraph discusses what the load impedance constitutes — resistance and inductance in parallel or in series to analyze the calculation data changes in the under the same parameter values.

➢ **Resistance and inductance in parallel**

First, the total feeder impedance is obtained by connecting the load impedance in series with the resistance and inductance in parallel to the feeder impedance. From the above formula (1), it is calculated that the feeder impedance value is 0.45Ω+j3.99Ω and the load impedance is connected in series to 16Ω+j8Ω, and the total feeder impedance value is 16.45Ω+j11.99Ω.

The corresponding load current data generated by the voltage during the varying period of time is calculated according to formula (2), as shown in Fig. 4. At this time, the adjustment capacitor is not put in, and the total impedance of the feeder is calculated as the following formula 2.

As for the rest of the relevant calculation steps and techniques, please refer to the literature [1] and will not repeat them.

$$Z_{total} = R_{line} + jX_{line} + 1/(1/R_{load} + 1/jX_{load}) \quad (2)$$

However, the "apparent power" data corresponding to each time period of the equipment load is calculated and sorted, as shown in Fig. 5, the blue line represents the apparent power of the source end, and the red line is the apparent power of the load end.

As for the corresponding curve of the apparent power of the load side when the unused or used the adjusted capacitor bank , as shown in Fig. 6, the "apparent power" data for the corresponding time period of the device, the red line is the source end, and the blue line is the load end.

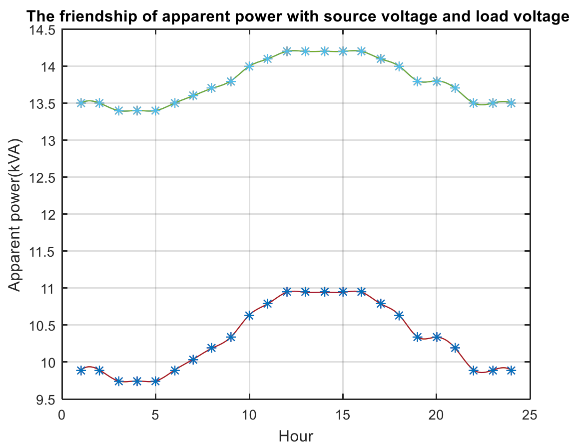

Fig 5 the friendship of apparent power with source voltage and load voltage

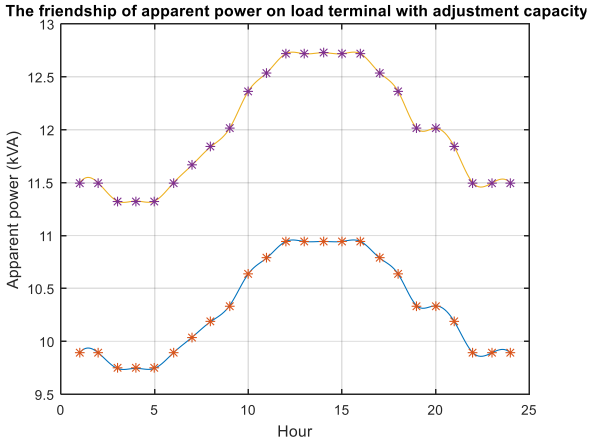

Fig 6 the friendship of apparent power on load terminal with adjustment capacity

- **Resistance and inductance in series**

When the load impedance is composed of resistance and inductance in series, the calculated feeder impedance value is 0.45Ω+j3.99Ω and the load impedance is formed in series to 20Ω+j40Ω, and the total feeder impedance value is 20.45Ω+j43.99Ω. After varying the voltage in each period, calculate the corresponding load current data according to formula (3) and then draw the graph, as shown in Fig. 7. Comparing the corresponding curve from Fig. 4 and Fig. 7, the load impedance of the feeder current formed by the series connection of resistance and inductance is relatively reduced.

$$Z_{total} = R_{line} + jX_{line} + R_{load} + jX_{load} \quad (3)$$

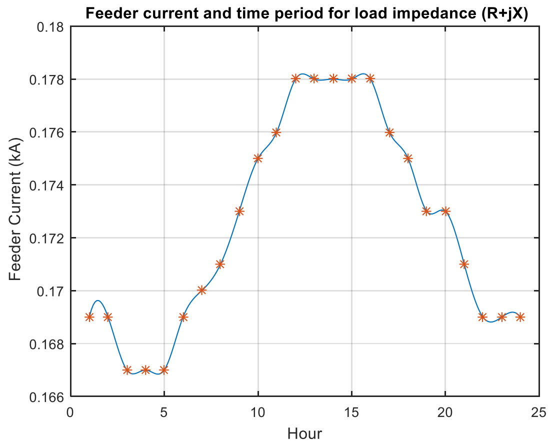

Fig 7 Feeder current and time period for load impedance (R+jX)

Regardless of whether the resistance and inductance are connected in series or in parallel, the calculation data of load impedance is summarized as shown in Table 2. Among them, the most prominent point is that the power factor is unaffected, which is also the advantage of a single load on the feeder.

Table 2 Load impedance by R+jX or R//jX data comparison table

Series	Parallel
X= [13.8 20 40 -40 0.045 0.4 4 10];	X= [13.8 20 40 -40 0.045 0.4 4 10];
$Z_{total} = Z_{line} + Z_{load(R+jX)}$	$Z_{total} = Z_{line} + Z_{load(R//jX)}$
$I_{line} = V_{sln}/Z_{total}$	$I_{line} = V_{sln}/Z_{total}$
$V_{load} = V_{sln} - Z_{line} * I_{line}$ (kV): 7.72	$V_{load} = V_{sln} - Z_{line} * I_{line}$ (kV): 7.36
$L_{loss\,(R)} = 3 * I_{line} * I_{line} * R_{line}$ (MW): 0.04	$L_{loss\,(R)} = 3 * I_{line} * I_{line} * R_{line}$ (MW): 0.23
$L_{loss\,(X)} = 3 * I_{line} * I_{line} * X_{line}$ (Mvar): 0.36	$L_{loss\,(X)} = 3 * I_{line} * I_{line} * X_{line}$ (Mvar): 2.03
$Load_{app} = (R_{app} + X_{app})$.^0.5 (MVA): 10.19	$Load_{app} = (R_{app} + X_{app})$.^0.5 (MVA): 10.34
$p.f = \cos(R_{app}/Load_{app})$ (factor): 0.89	$p.f = \cos(R_{app}/Load_{app})$ (factor): 0.89
With the adjust capacity	With the adjust capacity
$Z_{total} = Z_{line} + Z_{load(R+jX)}$	$Z_{total} = Z_{line} + Z_{load(R//jX)}$
$I_{line} = V_{sln}/Z_{total}$	$I_{line} = V_{sln}/Z_{total}$
$V_{load} = V_{sln} - Z_{line} * I_{line}$ (kV): 8.50	$V_{load} = V_{sln} - Z_{line} * I_{line}$ (kV): 8.04
$L_{loss\,(R)} = 3 * I_{line} * I_{line} * R_{line}$ (MW): 0.012	$L_{loss\,(R)} = 3 * I_{line} * I_{line} * R_{line}$ (MW): 0.22
$L_{loss\,(X)} = 3 * I_{line} * I_{line} * X_{line}$ (Mvar): 0.108	$L_{loss\,(X)} = 3 * I_{line} * I_{line} * X_{line}$ (Mvar): 1.94
$Load_{app} = (R_{app} + X_{app})$.^0.5 (MVA): 10.85	$Load_{app} = (R_{app} + X_{app})$.^0.5 (MVA): 10.10
$p.f = \cos(R_{app}/Load_{app})$ (factor): 0.89	$p.f = \cos(R_{app}/Load_{app})$ (factor): 0.89

- **Adjustable capacitor**

➢ **The load impedance formed a resistor parallel a reactance**

Improve the load side system voltage during the time period ((9~20) to enable (input) the capacitor (inductance-j40Ω). The data curve of the voltage change in each time period of the single user and the loss of the feeder line when the capacitor is used, as shown in table 3 to select the relationship curve between the line loss of the important item and the adjustment capacitor and load impedance formation method (R//jX) from Table 3, as shown in Fig. 8. The brown curve in the Fig. is the capacitor used curve, but the total impedance of the feeder line is calculated when the capacitor is switched on, as shown in the following formula 4. The apparent power calculation data is shown in Fig. 9, the brown curve is been the capacitor used (9~20).

$$Z_{total} = R_{line} + jX_{line} + 1/(1/R_{load} + 1/jX_{load} - 1/jX_c) \quad (4)$$

Table 3 friendship of feeder and load voltage and capacitors (load impedance (R//jX))

hour	Feeder voltage kV	Load Voltage kV	Load Voltage kV+SC	Line Loss (R)MW	Line Loss +SC(R)MW	Load apparent	Load Apparent +SC	Lie Loss (MVar)	Lin Loss +SC(MVar)
1	13.5	7.198	7.864	0.218	0.208	9.891	9.66	1.943	1.855
2	13.5	7.198	7.864	0.218	0.208	9.891	9.66	1.943	1.855
3	13.4	7.145	7.806	0.215	0.205	9.745	9.52	1.914	1.828
4	13.4	7.145	7.806	0.215	0.205	9.745	9.52	1.914	1.828
5	13.4	7.145	7.806	0.215	0.205	9.745	9.52	1.914	1.828
6	13.5	7.198	7.864	0.218	0.208	9.891	9.66	1.943	1.855
7	13.6	7.252	7.923	0.222	0.212	10.038	9.81	1.972	1.883
8	13.7	7.305	7.981	0.225	0.215	10.187	9.95	2.001	1.911
9	13.8	7.358	8.039	0.228	0.218	10.336	10.10	2.030	1.938
10	14.0	7.465	8.155	0.235	0.224	10.637	10.39	2.089	1.995
11	14.1	7.518	8.214	0.238	0.227	10.790	10.54	2.119	2.024
12	14.2	7.572	8.272	0.242	0.231	10.944	10.69	2.149	2.053
13	14.2	7.572	8.272	0.242	0.231	10.944	10.54	2.149	2.053
14	14.2	7.572	8.272	0.242	0.231	10.944	10.54	2.149	2.053
15	14.2	7.572	8.272	0.242	0.231	10.944	10.54	2.149	2.053
16	14.2	7.572	8.272	0.242	0.231	10.944	10.54	2.149	2.053
17	14.1	7.518	8.214	0.238	0.227	10.790	10.54	2.119	2.024
18	14.0	7.465	8.155	0.235	0.225	10.637	10.39	2.089	1.995
19	13.8	7.358	8.039	0.228	0.218	10.336	10.10	2.030	1.938
20	13.8	7.358	8.039	0.228	0.218	10.336	10.10	2.030	1.938
21	13.7	7.305	7.981	0.225	0.215	10.187	9.95	2.001	1.911
22	13.5	7.198	7.864	0.218	0.208	9.891	9.66	1.943	1.855
23	13.5	7.198	7.864	0.218	0.208	9.891	9.66	1.943	1.855
24	13.5	7.198	7.864	0.218	0.208	9.891	9.66	1.943	1.855

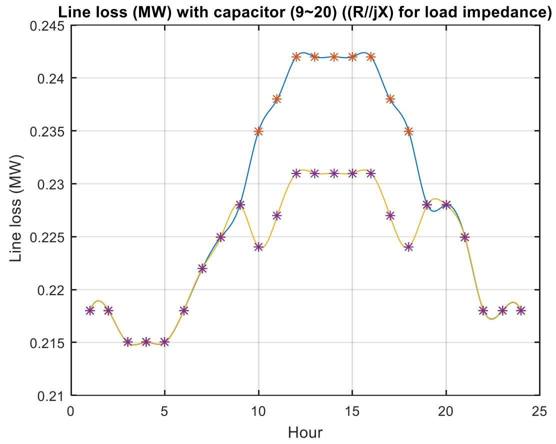

Fig 8 Line loss (MW) with capacitor (9~20) ((R//jX) for load impedance)

➢ **The load impedance formed a resistor series a reactance**

When the load impedance constitutes a resistance and inductance in series (R+jX), the formula for calculating the total impedance of the feeder is as shown formula 5, and the related data is been calculated , as shown in Table 4.

The data curve of the voltage change in each time period of the single user and the loss of the feeder line when the capacitor is used, as shown in Fig.10.

The brown curve in the figure is the capacitor used curve, but the total impedance of the feeder line is calculated when the capacitor is switched on. The apparent power calculation data is shown in Fig.11, the brown curve is been the capacitor used (9~20).

$$Z_{total} = R_{line} + jX_{line} + 1/\left(\left(R_{load} + jX_{load}\right) - 1/jX_c\right) \quad (5)$$

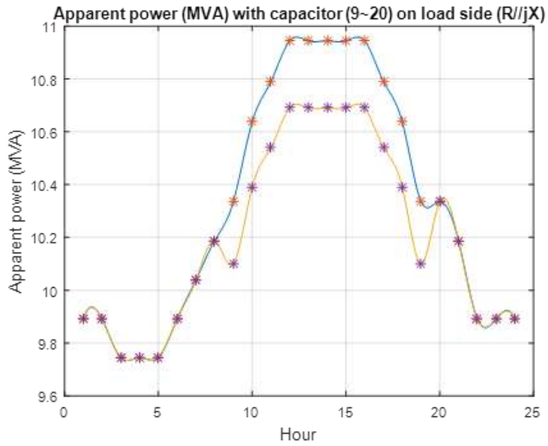

Fig 9 Apparent power with capacitor (9~20) load side ((R//jX) for load impedance)

Table 4 friendships of feeder and load voltage and capacitors (load impedance (R+jX))

hour	Feeder voltage kV	Load Voltage kV	Load Voltage kV+SC	Line Loss (R)MW	Line Loss +SC(R)MW	Load apparent	Load Apparent +SC	Lie Loss (MVar)	Lin Loss +SC(MVar)
1	13.5	7.55	8.32	0.038	0.012	9.76	10.38	0.342	0.104
2	13.5	7.55	8.32	0.038	0.012	9.76	10.38	0.342	0.104
3	13.4	7.50	8.25	0.038	0.012	9.61	10.23	0.337	0.102
4	13.4	7.50	8.25	0.038	0.012	9.61	10.23	0.337	0.102
5	13.4	7.50	8.25	0.038	0.012	9.61	10.23	0.337	0.102
6	13.5	7.55	8.32	0.038	0.012	9.76	10.38	0.342	0.104
7	13.6	7.61	8.38	0.039	0.012	9.90	10.54	0.347	0.105
8	13.7	7.66	8.44	0.040	0.012	10.04	10.69	0.352	0.107
9	13.8	7.72	8.50	0.040	0.012	10.19	10.85	0.358	0.108
10	14.0	7.83	8.62	0.041	0.012	10.49	11.17	0.368	0.112
11	14.1	7.89	8.68	0.042	0.013	10.64	11.33	0.373	0.113

12	14.2	7.94	8.75	0.043	0.013	10.79	11.49	0.379	0.114
13	14.2	7.94	8.75	0.043	0.013	10.79	11.49	0.379	0.114
14	14.2	7.94	8.75	0.043	0.013	10.79	11.49	0.379	0.114
15	14.2	7.94	8.75	0.043	0.013	10.79	11.49	0.379	0.114
16	14.2	7.94	8.75	0.043	0.013	10.79	11.49	0.379	0.114
17	14.1	7.89	8.68	0.042	0.013	10.64	11.33	0.373	0.113
18	14.0	7.83	8.62	0.041	0.012	10.49	11.17	0.368	0.112
19	13.8	7.72	8.50	0.040	0.012	10.19	10.85	0.358	0.108
20	13.8	7.72	8.50	0.040	0.012	10.19	10.85	0.358	0.108
21	13.7	7.66	8.44	0.040	0.012	10.04	10.69	0.352	0.107
22	13.5	7.55	8.32	0.038	0.012	9.76	10.38	0.342	0.104
23	13.5	7.55	8.32	0.038	0.012	9.76	10.38	0.342	0.104
24	13.5	7.55	8.32	0.038	0.012	9.76	10.38	0.342	0.104

From Fig. 8 and 10 above, it is known that the line loss load impedance series type is better than the parallel type. In addition, Fig. 9 and 11 shows that the apparent power improvement of the load impedance series type is better than that of the parallel type. Of course, whether the capacitor is used or not will not affect its load power factor value, but only reduce the loss of the feeder line and increase its apparent power. Those data obtained from the test when the capacity of the adjustment capacitor is larger, the apparent power is larger. Another experience is that the resistance of the load impedance formed in series or parallel with the resistance and the inductance do not affect the power factor.

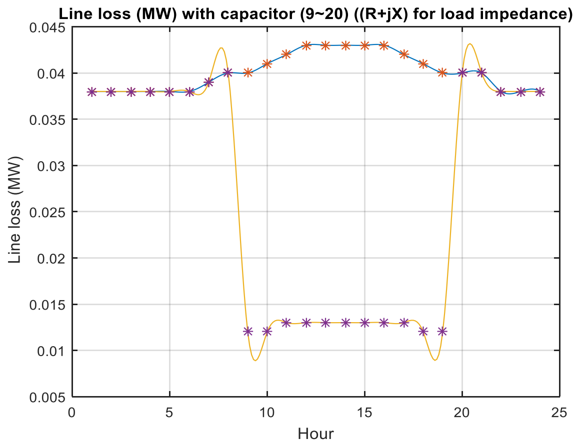

Fig 10 Line loss (MW) with capacitor (9~20) ((R+jX)

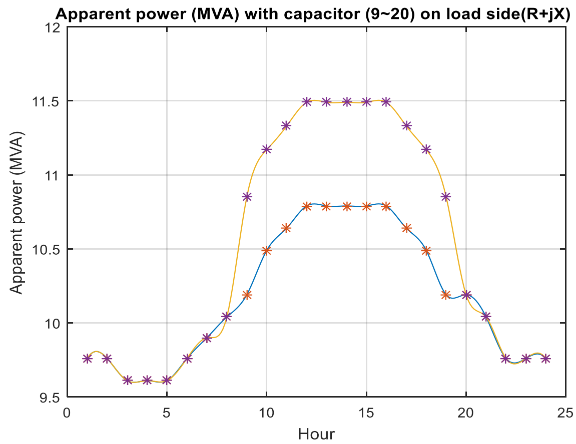

Fig 11 Apparent power with capacitor (9~20) load side ((R+jX)

- **Load power factor**

The power factor of a single feeder and a single load is discovered in the calculation process, regardless of the composition of the load impedance—resistance and inductance are connected in series or in parallel and the result is the same.

The power factor value will vary with the change of resistance and inductance values. If the resistance value is fixed, the power factor becomes smaller when the inductance value is smaller, and vice versa, the power factor becomes larger, shown in Table 5.

Table 5 Relationship between power factor and load impedance

Load volt	Load R	Load XL	Adjust XC	Line XL	pf
13.8kV	20Ω	j20Ω	-j40Ω	0.45+j4	0.707
		j25Ω			0.780
		j30Ω			0.832
		j35Ω			0.868
		j40Ω			0.894
		j45Ω			0.913
		j50Ω			0.928

3.2 Design Program

After the above-mentioned artificial calculation steps, the process is very cumbersome and easy to cause clerical errors and affect accuracy, leading to errors in the design of equipment specifications. In order to prevent the shortcomings of artificial calculations, a maneuverable programming algorithm was developed to replace manual work, thereby shortening design time and efficiency and reducing operating costs. Import the artificial algorithm into the MATLAB application software through the grammar and then only need to enter the relevant parameters to perform accurate calculations.

The design of the program in this article only discusses the related data of the line loss, power factor and adjustment capacitor on single feeder and single load. When inputting "feeder voltage, load impedance value, adjusted reactance value, the related diameter parameters of feeder line and line length," the relevant data information of the load equipment can be accurately calculated.

The program of the load impedance for parallel type, the execution result is shown in the Fig.10. As for The program of the load impedance for series type, the execution result is shown in the Fig. 11. The detailed program steps see the attachment program 1 and program 2.

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The load impedance is the resistance parallel inductance with line to find the line loss value and
power factor: Sample X=[VL|RL|XL|Xd|Zr|Zi|Y|L];    X=    [13.8 20 40 -40 0.045 0.4 4 10];

The load voltage (kV): x41 = 7.3584
The Real line loses (MW): x51 = 0.2284
The Reactive line loses (Mvar): x52 = 2.0304
The apparent power delivered (MVA): x55 = 10.3360
The load power factor (factor): x8 = 0.8944
The load voltage with SC (kV): x111 = 8.0391
The Real line loses with SC (MW): x121 = 0.2181
The Reactive line loses with SC (Mvar): x122 = 1.9388
The apparent power delivered with SC (MVA): x125 = 10.1000
The load power factor with SC (factor): x15 = 0.8944

*****************************************************************
```

Fig10 the result for load impedance with a resistance in parallel an inductance

****

The load impedance is the resistance series inductance with line to find the line loss value and power factor: Sample X=[VL|RL|XL|Xd|Zr|Zi|Y|L]; X= [13.8 20 40 -40 0.045 0.4 4 10];

The load voltage (kV): x41 = 7.7200
The Real line loses (MW): x51 = 0.0402
The Reactive line loses (Mvar): x52 = 0.3576
The apparent power delivered (MVA): x55 = 10.1953
The load power factor (factor): x8 = 0.8944
The load voltage with SC (kV): x111 = 8.4998
The Real line loses with SC (MW): x121 = 0.0122
The Reactive line loses with SC (Mvar): x122 = 0.1084
The apparent power delivered with SC (MVA): x125 = 10.8496
The load power factor with SC (factor): x15 = 0.8944

****

Fig11 the result for load impedance with a resistance series an inductance

4. CONCLUSION

The method of calculating the total impedance of the feeder in this design computer program, if the result obtained by multiplying the relevant parameters of the line diameter by the length of the feeder is consistent with the total impedance value of the feeder derived from the mathematical formula of the hyperbolic function of the π－type transmission. Load impedance composition type－ resistance and reactance are adopted for being in series or parallel, the calculation result is the same as the value of the power factor.

The influence power factor is determined by the change between the resistance and the inductance in the load impedance. The load impedance adopts resistance and inductance series connection. The advantages include a small amount of line loss, small feeder current, and large apparent power at the load end.

Another feature of this article is presented with pictures and descriptions that are easy to understand. According to the above calculation steps, use MATLAB application software technology to compile the [Design standardized program to calculate the related data from single load on single feeder,] In order to accurately calculate the data which parameters is been changed after.

By choosing the best parameters to comply with power equipment regulations and economical and safe, it is used by designers and maintenance personnel.

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APPENDIX

Executive program

Case 1 (parallel)

```
clear;
fprintf('***************************************************************
**\n')
fprintf (' The load impedance is the resistance parallel inductance with line to find
the line loss value and power factor')
fprintf (' : Sample X=[VL|RL|XL|Xd|Zr|Zi|Y|L]; \n X= ')
X=input (' ');
C=X(1);
A=X(2);
B=X(3);
D=X(4);
V4=X(5);
V5=X(6);
V6=X(7);
V7=X(8);
z=V4+V5*i;
y=V6*i/1000000;
l=V7;
g=sqrt(z*y);
Zc=sqrt(z/y);
E=cosh(g*l);
F=Zc*sinh(g*l);
G=1/Zc*sinh(g*l);
H=E;
EFGH=[E F;G H];
Z=F;
Y=2/Zc*tanh(g*l/2);
x1=(A*(B*i))/(A+(B*i));
x2=Z+x1; % the total impedance
x3= (1.05*(C/1.73))/x2; % the feeder current
x31=abs(x3);
x4= (1.05*(C/1.73))-(x3*Z); % the load voltage
fprintf ('The load voltage (kV)')
x41=abs(x4)
```

```
x5=abs(x4)*1.73; % load voltage line-line
fprintf ('The Real line loses(MW) ')
x51=3*(x31.^2)*real(Z) % Real line loses
fprintf ('The Reactive line loses(Mvar) ')
x52=3*(x31.^2)*imag(Z) % Reactive line loses
x6=3*(x41.^2)/A; % the real power delivered to the three-phase load
x7=3*(x41.^2)/B; % the reactive power delivered to the three-phase load
x53=x6+x51;
x54=x7+x52;
fprintf ('The apparent power delivered (MVA)')
x55=sqrt((x53.^2)+(x54.^2)) % apparent power delivered
fprintf ('The load power factor (factor)')
x8=cos(atan(x7/x6)) % the load power factor
x21=(x1*(D*i))/(x1+(D*i));
x9=Z+x21; % the total impedance
x10= (1.05*(C/1.73))/x9; % the feeder current
x101=abs(x10);
x11= (1.05*(C/1.73))-(x10*Z); % the load voltage
fprintf ('The load voltage with SC (kV)')
x111=abs(x11)
x12=abs(x11)*1.73; % load voltage line-line
fprintf ('The Real line loses with SC(MW) ')
x121=3*(x101.^2)* real(Z) % Real line loses
fprintf ('The Reactive line loses with SC(Mvar) ')
x122=3*(x101.^2)* imag(Z) % Reactive line loses
x13=3*(x111.^2)/A; % the real power delivered to the three-phase load
x14=3*(x111.^2)/B; % the reactive power delivered to the three-phase load
x123=x13+x121;
x44=3*(x111.^2)/D; % the reactive power delivered to the three-phase load with SC
x124=x14+x44+x122;
fprintf ('The apparent power delivered with SC(MVA) ')
x125=sqrt((x123.^2)+(x124.^2)) % apparent power delivered
fprintf ('The load power factor with SC(factor)')
x15=cos(atan(x14/x13)) % the load power factor
fprintf('****************************************************************
**\n')
```

Case 2 (Series)

```
clear;
fprintf('****************************************************************
**\n')
fprintf (' The load impedance is the resistance series inductance with line to find the
line loss value and power factor ')
fprintf (' : Sample X=[VL|RL|XL|Xd|Zr|Zi|Y|L]; \n X= ')
X=input (' ');
C=X(1);
A=X(2);
B=X(3);
D=X(4);
V4=X(5);
V5=X(6);
V6=X(7);
V7=X(8);
z=V4+V5*i;
y=V6*i/1000000;
l=V7;
g=sqrt(z*y);
Zc=sqrt(z/y);
E=cosh(g*l);
F=Zc*sinh(g*l);
G=1/Zc*sinh(g*l);
H=E;
EFGH=[E F;G H];
Z=F;
Y=2/Zc*tanh(g*l/2);
x1=A+(B*i);
x2=Z+x1; % the total impedance
x3= (1.05*(C/1.73))/x2; % the feeder current
x31=abs(x3);
x4= (1.05*(C/1.73))-(x3*Z); % the load voltage
fprintf ('The load voltage (kV)')
x41=abs(x4)
x5=abs(x4)*1.73; % load voltage line-line
fprintf ('The Real line loses(MW) ')
x51=3*(x31.^2)*real(Z) % Real line loses
```

```
fprintf ('The Reactive line loses(Mvar) ')
x52=3*(x31.^2)*imag(Z) % Reactive line loses
x6=3*(x41.^2)/A; % the real power delivered to the three-phase load
x7=3*(x41.^2)/B; % the reactive power delivered to the three-phase load
x53=x6+x51;
x54=x7+x52;
fprintf ('The apparent power delivered (MVA)')
x55=sqrt((x53.^2)+(x54.^2)) % apparent power delivered
fprintf ('The load power factor (factor)')
x8=cos(atan(x7/x6)) % the load power factor
x21=(x1*(D*i))/(x1+(D*i));
x9=Z+x21; % the total impedance
x10= (1.05*(C/1.73))/x9; % the feeder current
x101=abs(x10);
x11= (1.05*(C/1.73))-(x10*Z); % the load voltage
fprintf ('The load voltage with SC (kV)')
x111=abs(x11)
x12=abs(x11)*1.73; % load voltage line-line
fprintf ('The Real line loses with SC(MW) ')
x121=3*(x101.^2)* real(Z) % Real line loses
fprintf ('The Reactive line loses with SC(Mvar) ')
x122=3*(x101.^2)* imag(Z) % Reactive line loses
x13=3*(x111.^2)/A; % the real power delivered to the three-phase load
x14=3*(x111.^2)/B; % the reactive power delivered to the three-phase load
x123=x13+x121;
x44=3*(x111.^2)/D; % the reactive power delivered to the three-phase load with SC
x124=x14+x44+x122;
fprintf ('The apparent power delivered with SC(MVA) ')
x125=sqrt((x123.^2)+(x124.^2)) % apparent power delivered
fprintf ('The load power factor with SC(factor)')
x15=cos(atan(x14/x13)) % the load power factor
fprintf('****************************************************************
**\n')
```