TECHNOLOGY

BEHIND

TRANSFORMER SOFTWARE

A

COMPUTER PROGRAM

ON

TRANSFORMERS

WITH SPECIFIC COVERAGE ON TRANSFORMER SELECTION
POWER FACTOR IMPROVEMENT AND CAPACITOR BANK SELECTION

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CONTENTS

FORM FACTOR

Definitions:

The ratio $\frac{rms\_value}{average\_value}$ is called the *Form Factor* of an alternating wave.
Form Factor for a pure sine wave,

$$
\begin{aligned}
Form\_Factor &= \frac{rms\_value}{average\_value} \\
&= \frac{0.707 \times \max imum\_value}{0.637 \times \max imum\_value} \\
&= \frac{0.707}{0.637} = 1.11
\end{aligned}
$$

The Form Factor is an indication of more peaked or flatter than a pure sine wave. If the wave is more peaked the Form Factor will be more than 1.11 while it is less than 1.11 for flatter wave like trapezoidal etc.

Average value of a sine wave is defined as:

1. $$average\_value = \frac{Area\_under\_half\_wave}{Base\_length}$$
$$= 0.637 \times Maximum\_height$$
2. $$average\_value = \frac{2 \times Maximum\_value}{\pi}$$
$$= 0.637 \times Maximum\_value$$

RMS value of a sine wave is defined as:

RMS value or Effective value of an alternating current or voltage is the effective value of DC voltage, which produces equivalent heat in the same time.

Mathematically, dividing the curve into number of small tiny sections and then taking square root of the sum of each square for determining the effective or RMS value of the alternating curve.

$$
\begin{aligned}
RMS\_value &= \sqrt{\left(i_1^2 + i_2^2 + i_3^2 + i_4^2 + \ldots\ldots\right)} \\
&= \frac{1}{\sqrt{2}} \times I_m \\
&= 0.707 \times I_m
\end{aligned}
$$

NO LOAD LOSS (CORE LOSS)

Core Loss of Transformer comprises of two parts viz.:

a. Hysteresis Loss and
b. Eddy Current Loss

Both these losses take place in the core (made of laminations) of the transformer and thus depend on the type of core material and its magnetic quality. Core materials like Dynamic Sheet Steel, Steel Alloy and Lohys are used for better performance and high efficiency of transformers.

Hysteresis Loss is given by the formula:

$$Loss\_hyst = K_h \times B^{1.6} \times f \quad \text{Watts/cc of core volume}$$

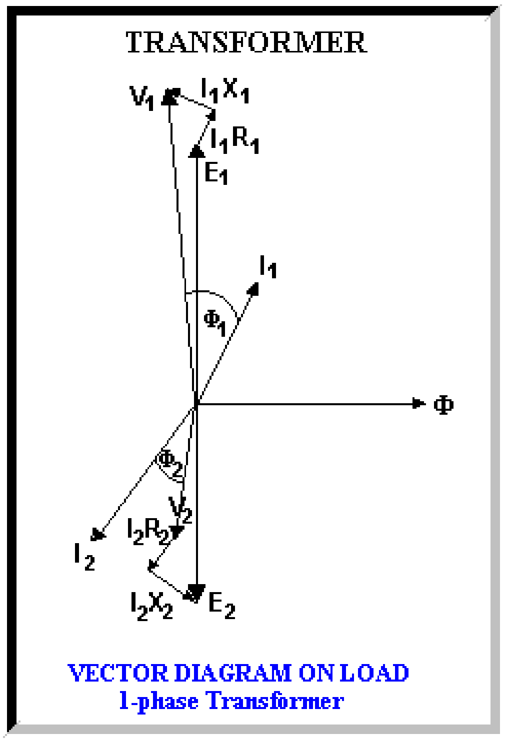
Where K_h = Material constant for Hysteresis
= 0.002×10^{-7} (For Dynamic Sheet Steel)
= 0.001×10^{-7} (For Steel Alloy)
B = Magnetic Flux Density in Lines/ cm^2
= 9000 Lines/ cm^2 (Normal value)
f = Frequency of the Supply System

Eddy Current Loss is given by the formula:

$$Loss\_eddy = K_e \times B^2 \times f^2 \times t^2 \quad \text{Watts/cc of core volume}$$

Where K_e = Material constant for Eddy Current
= 1.36×10^{-11} (For Dynamic Sheet Steel)
= 0.33×10^{-11} (For Steel Alloy)
B = Magnetic Flux Density in Lines/ cm^2
= 9000 Lines/ cm^2 (Normal value)
f = Frequency of the Supply System
t = Thickness of each lamination in cm

VECTOR DIAGRAM OF 1-PHASE TRANSFORMER ON LOAD



DIVERSITY FACTOR:

Normally, all the loads of a plant do not run simultaneously at a time. Consider the case of a township. The lighting loads increases as the sun-sets. When this lighting load is maximum, it is not advisable to run the water supply pumps, which could be run at lean hours. This type of diversification of loads is taken up by the Diversity Factor, which may be defined as:

D.F. = (Working demand at any time + Available capacity)
/ (Maximum Demand)

⇨ Always more than 1.00

$$D.F. = \frac{Working\_demand\_at\_anytime + Available\_capacity}{Maximum\_demand}$$

In practice, it is presumed that available capacity of about 20% of Maximum Demand Power is obtained, for both Active and Reactive Powers, in Diversification of loads due to their inherent work schedule.

SUPERPOSITION FACTOR:

Superposition Factor is Diversity Factor defined in a different way i.e. it indicates the amount of Active & Reactive Powers that are saved due to superposition of loads.

Superposition factors for active and reactive powers are defined as under:

S.F.(Act) = (Active Power) /(Active Power
3
+ Saving in Active Power due to diversification)
=> Less than 1.00
S.F.(React) = (Reactive Power)/ (Reactive Power
+ Saving in (React. Power due to diversification)
=> Less than 1.00

$$S.F.(Act) = \frac{Active\_power}{Active\_power + Saving\_activepower\_dueTo\_diversification}$$

$$S.F.(\mathrm{Re}act) = \frac{\mathrm{Re}active\_power}{\mathrm{Re}active\_power + Saving\_reactivepower\_dueTo\_diversification}$$

Referring to the definition of Diversity Factor, the available capacity in a given demand may further be increased beyond 20% by proper planning and rescheduling of working hours of different category of loads. This type of management is known as Load Management or Demand Management.

Moreover, if the count of individual loads is very small, then Diversity Factor is much lesser than 1.2 i.e. Available Capacity as defined above is much below 20%. A correct judgment of Diversity Factor is, therefore, necessary based on the following factors:

1. Count of individual loads
2. Size of loads
3. Normal working schedule of loads

The following curves obtained through years of practical experience give the values of Active Power SF ‘p’ and Reactive Power SF ‘q’ corresponding to given Active Power ‘P’ and Reactive Power ‘Q’.

Mathematically, the values of SF for Active Power ‘p’ and SF for Reactive Power ‘q’ are given by the following empirical formulae:

p = 0.2 x (8 - log(P))

q = 0.08 x (15.5 - log(Q))

Er. M.Z. Ali, C. Eng.(I), F.I.E. of CMPDI has suggested the above empirical formulae.

MAXIMUM DEMAND:

Maximum Demand is the maximum value of Apparent Power Demand in kVA during a given time span, normally over a period of one month. Maximum Demand Indicators are used to measure this value.

CONTRACT DEMAND:

Contract Demand is the Apparent Power Demand in kVA that a consumer makes through contract with the power supply company, that, so much power is required for their establishment.

Normally, power supply companies impose heavy penalty on those consumers whose Maximum Demand exceed their Contract Demands. Contrarily, billing by Supply Company is made, based on the Contract Demand, even if the consumer's Maximum Demand is less than its Contract Demand.

DEMAND FACTOR:

Demand Factor of an Electrical Load/ Equipment/ System is an indication of its actual power consumption irrespective of its rating.

Consider the case of a 415V, 3-phase, 45kW rated capacity motor. The rating 45kW is indicative of the power that this motor will consume at its full load.

Normally motors do not run at their full load capacity. If there is no load on the motor then it will simply run at 'No Load' and consume power just to compensate for the core losses, friction & windage losses and stray magnetic losses. These losses comprise only a very small fraction of the rated full load capacity of the motor. Thus, the power demand of the motor under no load is very small.

Demand Factor may be defined as under:

Demand Factor = (Actual Power being consumed by the motor or load) ÷ (Rated Capacity of the motor or Load)

Normally, the value of Demand Factor is less than 1.00. However, in case of overloaded motors the Demand Factor may go above 1.00.

LOAD FACTOR:

Electrical Load factor is a measure of the utilization rate, or efficiency of electrical energy usage. It is the ratio of total energy (kWh) used in the billing period divided by the possible total energy used within the period, if used at the peak demand (kW) during the entire period.

If your Contract Demand is kVA and energy consumption in a month kWh units then the Load Factor of that month will be:

$$Load\ Factor = \frac{\text{kWh}}{\text{kVA x 24 x number of days in the month}}$$

Load Factor is a positive value less than one. If your load factor ratio is above 0.75 your electrical usage is reasonably efficient. If the load factor is below 0.5, you have periods of very high usage (demand) and a low utilization rate.

TESTS

General Requirements for Type, Routine and Special Tests:

Tests shall be made at any ambient air temperature below 50^{o} and with cooling water (if required) at any temperature not exceeding 30°C.

Tests shall be made at the manufacturer’s works, unless otherwise agreed between the manufacturer and the purchaser.

All external components and fittings that are likely to affect the performance of the transformer during the test shall be in place.

Tapped windings shall be connected on their principal tapping, unless the relevant test clause requires otherwise or unless the manufacturer and the purchase agree otherwise.

Test basis for all characteristics, other than insulation, is the rated condition, unless the test clause states otherwise..

Where it is required, test results shall be corrected to a reference temperature of 75°C.

*1. **Type Tests** – The following shall constitute the type test:*

a) Measurement of winding resistance;
b) Measurement of voltage ratio and check of voltage vector relationship;
c) Measurement of impedance voltage/short-circuit impedance (principal taping) and load loss;
d) Measurement of no-load loss and current;
e) Measurement of insulation resistance;
f) Dielectric tests;
g) Temperature-rise and
h) Test on-load tap-changers, where appropriate.

2. *Routine Tests* *– The following shall constitute the routine tests:*

a) Measurement of winding resistance;
b) Measurement of voltage ratio and check of voltage vector relationship;
c) Measurement of impedance voltage/short-circuit impedance (principal taping) and load loss;
d) Measurement of no-load loss and current;
e) Measurement of insulation resistance;
f) Dielectric tests and
g) Test on-load tap-changers, where appropriate (16.9).

3. Special Tests *– The following tests shall be carried out by mutual agreement between the purchaser and the supplier:*

a) Dielectric tests;
b) Measurement of zero-sequence impedance of three-phase transformers;
c) Short-circuit test;
d) Measurement of acoustic noise level;
e) Measurement of the harmonics of the no-load current and
f) Measurement of the power taken by the fans and oil pumps.

Measurement of Impedance Voltage/Short-circuit Impedance (Principal Tapping) and Load Loss – The impedance e voltage/short-circuit impedance (principal tapping) and load loss shall be measured at rated frequency by applying an approximately sinusoidal supply to one winding, with the other winding short circuited, with the windings connected on the relevant tapping. The measurements may be made at any current between 25 percent and 100 percent, but preferably not less than 50 percent, of the rated current (principal tapping) or tapping current. Each measurement shall be performed quickly and the intervals between them shall be long enough to ensure that temperature rises do not cause significant errors. The difference in temperature between the top oil and the bottom oil shall be small enough to enable the average temperature to be determined with the required accuracy. If necessary the oil may be circulated by a pump.

The measured values of the load loss shall be corrected by multiplying them by the square of the ratio of rated current (principal tapping) or tapping current to test current. The value so derived shall be corrected to the reference temperature given in 16.1 taking the l^2 R loss (R=de resistance) as varying directly with resistance and all other losses as varying inversely with resistance. The resistance shall be determined as specified in 16.2.

The measured value of the impedance voltage (principal tapping) shall be corrected by increasing it in the ratio of rated current to test current. The value of impedance voltage so derived shall be corrected to the reference temperature given in 16.1.

The measured value of a short-circuit impedance voltage/short-circuit impedance (principal tapping) and the load losses shall be measured between windings taken in pairs as shown below:

a) Between winding 1 and winding 2}
b) Between winding 2 and winding 3} the other winding being open-
c) Between winding 3 and winding 1} circuited.

For transformers with more than three windings, the windings shall be taken in pairs and the principle of the method specified for three winding transformers shall be followed.

NOTE – The resistance of the test connections should be sufficiently low not to affect the measurement. If it is impracticable to employ connections to which the loss may be neglected in relation to the load loss of the transformer; allowance should be made for such losses.

16.5 Measurement of No-Load Loss and current – The no-load loss and the no-load current shall be measured at rated frequency at a voltage equal to rated voltage if the test is performed on the principal tapping or equal to the appropriate tapping voltage if the test is performed on another tapping. Other winding(s) shall be left open-circuited and any windings, which may be connected in open-delta, shall have the delta closed.

For all transformers, the voltage shall be measured with a voltmeter responsive to the mean value of voltage but scaled to read the rms value of a sinusoidal wave having the same mean value. The voltage U indicated by this voltmeter shall be taken as the required value of line-to-line voltage and the no-load loss P_m shall be measured at this voltage.

At the same time, a voltmeter responsive to the value of voltage shall be connected in parallel with the mean-value voltmeter and its indicated voltage U shall be recorded.

If the voltages U and U are not the same, the measured value of no-load loss is corrected according to the formula:

$$P = \frac{P_m}{P_1 + kP_2}$$

Where
P = corrected value
P_1= Ratio of hysteresis losses to total iron losses,
K = $(\frac{U}{U^2})^2{}_1$ and
P_2 = Ratio of eddy current losses to total iron losses.
NOTE – For flux densities normally used at 50 or 60 Hz the following values should be taken :

	P_1	P_2
Oriented steel	0.5	0.5
Non-oriented steel	0.7	0.3

The no-load current of all the phases shall be measured by rms ammeters, and the mean of their readings shall be taken as the no-load current.

16.2 Measurement of Winding Resistance

16.2.1 General – The resistance of each windings, the terminals between which it is measured and the temperature of the windings shall be recorded. Direct current shall be used for the measurement.

In all resistance measurements care shall be taken that self-inductive effects are maintained.

During these cold-resistance measurements, the time for the measuring current to become steady should be noted and used for guidance e when making hot-resistance measurements following a temperature-rise type test.

16.2.2. Dry-type Transformers – The temperature recorded shall be the average reading of several (at least three) thermometers placed on the winding surface.

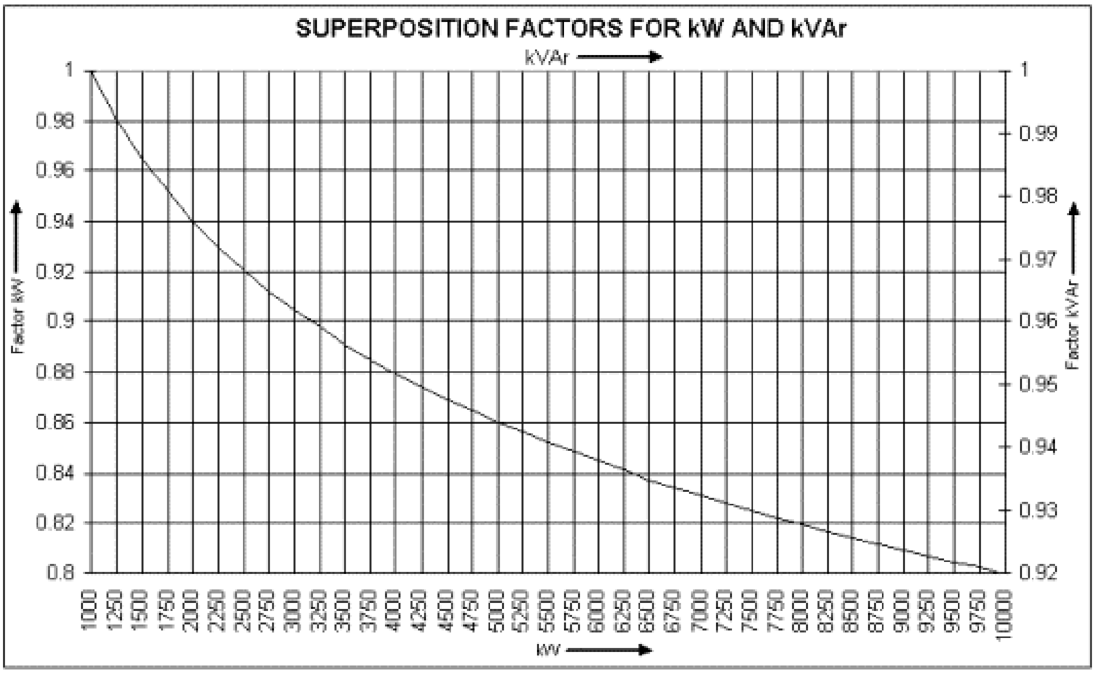
Winding resistance and temperature shall be measured simultaneously, and the temperature of the winding, as measured by thermometer, should approximately equal the temperature of the surrounding medium.

16.2.3 Oil-Immersed Type transformer – After the transformer has been under oil without excitation for at least 3 hours, the average oil temperature shall be determined and the temperature of the winding shall be deemed to be the same as the average oil temperature. The average oil temperature is taken as the mean of the top and bottom oil temperatures.

In measuring the cold resistance for purposes of the temperature rise test; special efforts shall be made to determine the average winding temperature accurately. Thus the difference in temperature between the top and bottom oil shall be small. To obtain this result more rapidly, the oil may be circulated by a pump.

DERIVATION OF EMPIRICAL FORMULAE FOR kW & kVAr FACTORS DUE TO SUPERPOSITION

INTEGRATED SUPERPOSITION FACTORS CURVE:



Consider the Superposition curve sown in Fig.(i). We may divide the curve into two parts:

(a) Lower portion of the graph between kW and Superposition factor for kW and

(b) Upper portion of the graph between kVAr and Superposition factor for kVAr.

On inspection, it is quite clear that the x-axes of both the curves are not linear but having the same scale values for kW as well as kVAr. However, the y-axes are different for both the curves except a common maximum value of 1.0 for the factors for kW and kVAr. The difference is clearer if we interpret them as under:

I. Superposition factor for kW varies from 0.8 to 1.0 or in other words the value of kW (summation) varies from a minimum of 80% to a maximum of 100% due to Superposition of loads i.e. a total variation of 20%.

II. Superposition factor for kVAr varies from 0.92 to 1.00 or in other words the kVAr (summation) varies from a minimum of 92% to a maximum of 100% due to Superposition of loads i.e. variation of only 8%.

We will, now, try to find an empirical relation between the kW (summation) and the Superposition factor for kW. If an empirical relation is established at all then the same method will be applied in the similar way to find a factor for kVAr for a given value of kVAr (summation).

Consider the part of the Superposition curve shown in the next page (Fig.2):

In the x-axis the curve starts from x = 1000, which may also be written as $x = 10^3$, and reaches to an approximately steady value at x = 10000, which may also be written as $x = 10^4$. The curve shows practically no change after x = 10000.

In the y-axis the curve has a steady minimum value of y = 0.8 (i.e. 80 percent) and reaches to a maximum value of y = 1.0 (i.e. 100 percent).

The origin of the curve is (0, 0)

From the nature of the curve it is evident that the curve is an exponential curve in which both the values of x and y are varying on linear scales along their axes.

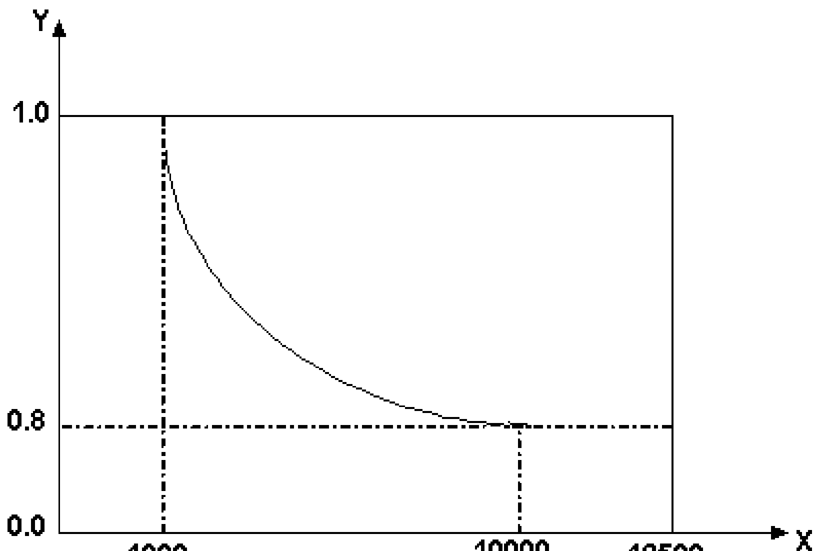


Fig.-2

The exponential variation of the curve will change to a linear variation, if either one of the axes scale is changed from linear to exponential or from exponential to linear variation. From the given scales of x and y it is observed that the conversion of x-axis scale to an exponential scale or rather a logarithmic scale to the base 10, will be very much preferred as because in that case the x-axis scale, to cover the entire curve, will range from 3 i.e. (log 1000) to 4 i.e. (log 10000).

Let us assume that the curve reduces to a straight line AB, as shown in Fig.3. Now, for the sake of simplicity, we will transform the origin from O (0, 0) to O', point which has co-ordinate of x=3 and y=0.8. (It should be noted that x is now on logarithmic scale to the base 10).

For deriving an equation for the line AB, we will now refer to the new origin O' (3, 0.8) and let this new

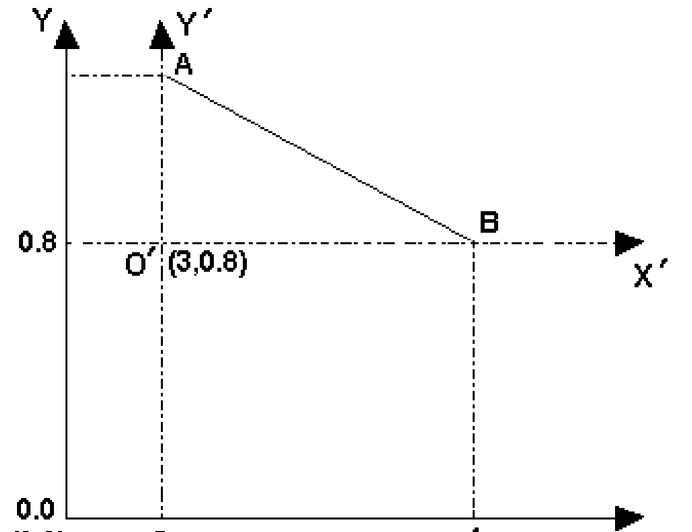


Fig.- 3

Origin be represented by O' (0, 0). Then the new scales of x'-axis and y'-axis will be B (1.0) and A (0, 0.2) respectively.

From the geometry of the line, the equation of the line AB is given by:

$$y_1' = mx_1' + C \qquad \text{..............(i)}$$

Where m is the gradient of the line AB and is given by:

$$m = \frac{\left(y_2' - y_1'\right)}{\left(x_2' - x_1'\right)}$$

$$= \frac{(0-0.2)}{(1-0)}$$
$$= -0.2$$

And C is the intercept of the line AB on y'-axis and is given by:

C = OA

= 0.2

Putting the values of m and C to the equation of the straight line, we get the following equation for any point M (x', y') on the line AB:

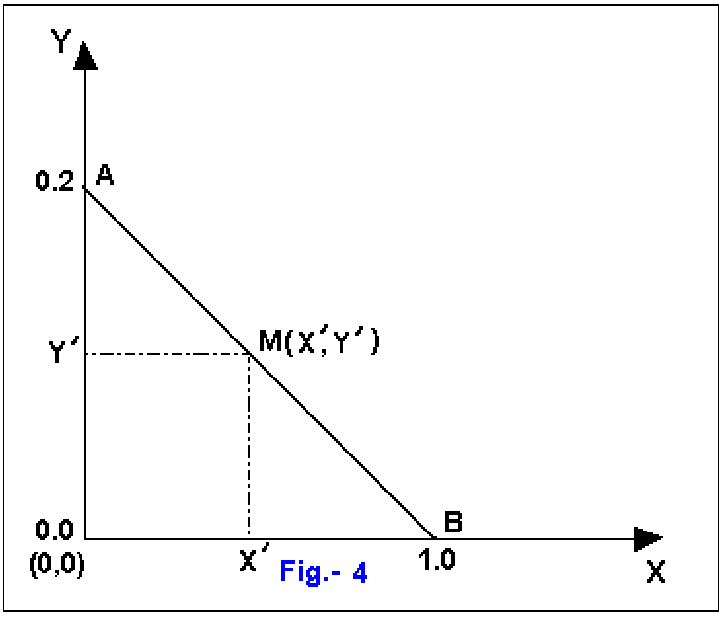


Fig.- 4

$$y' = (-0.2)x' + (0.2)$$

$= 0.2(1 - x')$ ....(ii)

The above equation of the line AB is with respect to the transformed origin O' (3, 0.8) assumed as O' (0, 0).

We will, now, again transform the new origin to the original origin O (0, 0). To do this transformation, we have just to put for the following:

$$x' = x - 3$$
$$y' = y - 0.8$$

Then the equation no.(ii) reduces to the form :

$$y - 0.8 = 0.2 \times (1 - (x - 3))$$

$$= 0.2 \times (4 - x)$$

or $$y = 0.8 + 0.8 - 0.2x$$

$$= 1.6 - 0.2x$$

or $$y = 0.2 \times (8 - x)$$

…………………………….. (iii)

But, as per our assumption, x is on a logarithmic scale to the base 10. Converting x again to the linear variation, the equation (iii) becomes:

$$y = 0.2 \times (8 - \log(x))$$ …………………………. (iv)

This is the required equation of the Superposition curve taken earlier. For direct application to the Superposition factor for kW and the corresponding kW (summation), the equation (iv) may be written as:

This is the required equation of the Superposition curve taken earlier. For direct application to the Superposition factor for kW and the corresponding kW (summation), the equation (iv) may be written as:

$$p = 0.2 \times (8 - \log(P))$$ …………………………. (v)

Where P = kW (summation) and

p= Superposition factor for kW

In a similar way, the equation for finding out Superposition factor for kVAr can also be derived. It should be noted in this case that the variation of Superposition factor for kVAr is from 0.92 (i.e. 92%) to 1.00 (i.e. 100%), whereas the variation of Superposition factor for kW, as discussed earlier, was from 0.8 (i.e. 80%) to 1.00 (i.e. 100%).

Following the procedure adopted for finding out kW factor, the equation derived for kVAr is as under:

$$q = 0.08 \times (15.5 - \log(Q))$$ …………………………. (vi)

Where Q = kVAr (summation) and

q = Superposition factor for kVAr

The Superposition factors for kW and kVAr that are based on a long practical experience of the giants of the filed are related with each other as under:

The best suited power factor for a power supply system is between 0.92 (lagging) and 0.93 (lagging), because lowering the power factor will mean higher kVA demand which has multiple impacts on economics, line currents, voltage regulation and the system balance. On the other hand the power factor should be well below unity to avoid leading power factor which may cause instability in the power supply system. Hence, the most economic power factor considered for all practical purposes is from 0.92 (lagging) to 0.93 (lagging).

If we observe the variations of kW and kVAr on Superposition, it will be found to vary from 80% to 100% for kW and 92% to 100% for kVAr respectively or in other words, it can be stated that overall variations of 20% in kW and 8% in kVAr result due to Superposition of loads.

OPTIMUM POWER FACTOR FOR A SYSTEM:

Now, consider the vector diagram shown above in (Fig.5):

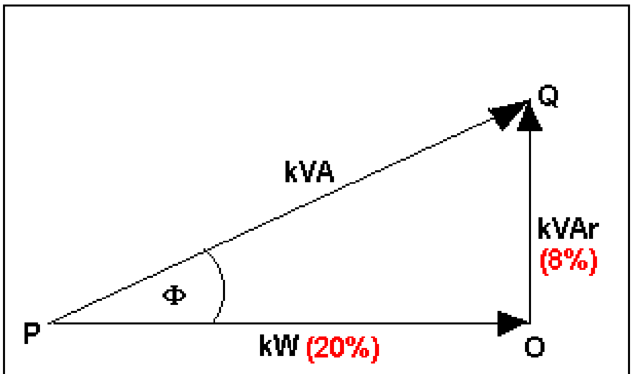


Fig.- 5

The resultant kVA variation is given by:

$$kVA = \sqrt{(kW^2 + kVAr^2)}$$

$$= \sqrt{(20^2 + 8^2)}$$

$$= 21.54$$

And the power factor is given by:

$$\cos\Phi = \frac{kW}{kVA} = \frac{20}{21.54} = 0.928$$

Thus, we see that the variation in Superposition factors for kW and kVAr are also related with the most economic power factor of the power supply system.

USE OF POWER BALANCE TABLE

In this age of modern and sophisticated technology nearly all the industries whether small, medium or large scale, are based on Electrical Power supply. One of the major reasons for the failure of an industry is the poor Power Supply system. Moreover, most of the medium and large-scale projects use electrical power in the range between 1000 kW and 10000 kW. Use of power in the range specified above need proper supply arrangement in addition to some additional precautions, which are essential for the stability of the supply system.

Thus, prior planning for the Electrical Power Supply pays proper return in turn.

Preparation of Power Balance table is the first step in this process. The Power Balance table provides the following information's to the planner:

1. Total connected and working loads.
2. Average demand factor
3. Maximum demand
4. Annual Energy consumption and specific energy consumption
5. Capacity of the Power Transformer
6. Capacity of the capacitor bank required for power factor improvement etc. etc.

Planning is such a job, which varies from person to person. Experience is one of the major factors in this job. Another vital point in its perfection is the correct judgment in selection of Superposition factors. How much the entire Electrical loads can be diversified? These factors depend on the type of industry, its environment and other relevant factors. A slight deviation in selection of proper values of Superposition factors may lead to an immediate uneconomical results alongwith a continued extra economic burden.

In view of above, it is essential to take every possible necessary precaution to make the Power Balance table as practical as possible.

POWER BALANCE TABLE:

While planning and preparing the electrical Power Supply chapter of a project the first and foremost task is to prepare a Power Balance Table for the project. The preparation of a Power Balance Table needs the following data as input:

1. Specification of various categories of loads
2. Daily working hours of different loads
3. Annual working days of the project
4. Annual production of the project

On the basis of the data supplied, the planner starts his work. The Power Balance Table is prepared at the first instance to get the salient Electrical features of the project. The Power Balance is prepared in a tabular form significantly with the following columnar headings:

1. Load Specification
2. Working Load
3. Demand Factor
4. Power Factor
5. Active Power
6. Reactive Power
7. Apparent Power
8. Annual energy consumption and
9. Specific Energy consumption

After summing up the various columns of the table the effect of Superposition of loads or in other words diversification of loads is considered for various reasons which we will not discuss here.

We will restrict our discussion to the effect of superposition and the Power Balance.
The following a norms being followed by the European Experts for planning the Electrical Power Supply System are used.

The norms followed for finding out superposition factors for kW and kVAr is in the form of graphical curve known as Superposition Curve. The Superposition Factors are just read from the graph for various values of kW (summation) and kVAr (summation). The superposition Factors thus obtained are directly taken into account in the Power Balance Table to account for the effect of Superposition of loads of the project.

Finally, the impact of power factor improvement is taken into account and accordingly, the value of additional capacitor is calculated that is required for power factor improvement.
The transformer capacity is selected on the basis of the Maximum Demand thus obtained. Normally, two times the 60% of Maximum Demand is selected as the Transformer capacity. However, the nearest standard capacity of transformer is also taken into account.

NOTE: TO GET RESULTS PRESS 'Ctrl+d' TO RESET PRESS 'Ctrl+r' .

Table - I

POWER BALANCE KANIAH II PROJECT

Sl. No.	Description	Connected Load in kW	Working Load in kW	Demand Factor	Power Factor (cos ø)	tan ø	Apparent load in kW	Reactive load in kVAr	Maximum Demand in kVA	Running Hours/ day	Annual Working days	Annual Consump. In MkWh
1	Vertical Transport	400	200	0.80	0.85	0.62	160	99	188	10	300	0.4800
2	Pumping	1200	1000	0.80	0.85	0.62	800	496	941	16	365	4.6720
3	Vertical Transport	400	200	0.80	0.85	0.62	160	99	188	12	300	0.5760
4	Surface Lighting	300	100	0.90	0.90	0.48	90	44	100	12	365	0.3942
6	Surface Lighting	300	100	0.90	0.90	0.48	90	44	100	12	365	0.3942
7	Underground lighting	200	200	0.90	0.90	0.48	180	87	200	24	365	1.5768
8	Colony	750	500	0.80	0.85	0.62	400	248	471	10	365	1.4600
9	Direct Haulage	800	600	0.80	0.80	0.75	480	360	600	15	300	2.1600
10	Endless Haulage	70	35	0.80	0.80	0.75	28	21	35	15	300	0.1260
11	Belt Conveyor	100	70	0.80	0.75	0.88	56	49	75	15	300	0.2520
12	CHP	200	150	0.80	0.80	0.75	120	90	150	12	300	0.4320
13	Compressor	200	100	0.60	0.70	1.02	60	61	86	10	300	0.1800
	Sub-Total	**4920**	**3255**	**0.81**	**0.84**	**0.65**	**2624**	**1698**	**3125**			**12.7032**
Taking Diversity factor for kW and kVAr as	**1.23**		3255	0.66	0.84	0.65	2133	1380	2541			
Improving PF upto	**0.95**		**3255**	**0.66**	**0.95**	**0.33**	**2133**	**701**	**2246**			

Capacitor Bank required for power factor improvement in kVAr	**230 x 3 kVAr**
Required Transformer Capacity in kVA	**1347 x 2 kVA**
Selected Transformer Capacity in kVA	**1600 x 2 kVA**
Percentage Voltage Impedance of the Selected Transformer	**6.25 %**

NOTE: TO GET RESULTS PRESS 'Ctrl+s' TO RESET PRESS 'Ctrl+r'.

Table - I

POWER BALANCE KANIAH II PROJECT

Sl. No.	Description	Connected Load in kW	Working Load in kW	Demand Factor	Power Factor (cos ø)	tan ø	Apparent load in kW	Reactive load in kVAr	Maximum Demand in kVA	Running Hours/ day	Annual Working days	Annual Consump. In MkWh
1	Vertical Transport	400	200	0.80	0.85	0.62	160	99	188	10	300	0.4800
2	Pumping	1200	1000	0.80	0.85	0.62	800	496	941	16	365	4.6720
3	Vertical Transport	400	200	0.80	0.85	0.62	160	99	188	12	300	0.5760
4	Surface Lighting	300	100	0.90	0.90	0.48	90	44	100	12	365	0.3942
6	Surface Lighting	300	100	0.90	0.90	0.48	90	44	100	12	365	0.3942
7	Underground lighting	200	200	0.90	0.90	0.48	180	87	200	24	365	1.5768
8	Colony	750	500	0.80	0.85	0.62	400	248	471	10	365	1.4600
9	Direct Haulage	800	600	0.80	0.80	0.75	480	360	600	15	300	2.1600
10	Endless Haulage	70	35	0.80	0.80	0.75	28	21	35	15	300	0.1260
11	Belt Conveyor	100	70	0.80	0.75	0.88	56	49	75	15	300	0.2520
12	CHP	200	150	0.80	0.80	0.75	120	90	150	12	300	0.4320
13	Compressor	200	100	0.60	0.70	1.02	60	61	86	10	300	0.1800
	Sub-Total	**4920**	**3255**	**0.81**	**0.84**	**0.65**	**2624**	**1698**	**3125**			**12.7032**
	Superposition factors											
	0.916	For kW										
	0.960	For kVAr	3255	0.74	0.83	0.68	2404	1631	2905			
	Improving PF upto **0.95**		**3255**	**0.74**	**0.95**	**0.33**	**2404**	**790**	**2531**			

Capacitor Bank required for power factor improvement in kVAr	**280 x 3 kVAr**
Required Transformer Capacity in kVA	**1518 x 2 kVA**
Selected Transformer Capacity in kVA	**1600 x 2 kVA**
Percentage Voltage Impedance of the Selected Transformer	**6.25 %**

D:\02 SofexIndia\Trans Elect\Power Balance\[Power Balance.xls]DataBank 24-04-2018