Benefits of using LT capacitors over HT Capacitors

Power factor compensation can be provided on either LT or HT side of the distribution transformer for the loads at LT side. Often compensation is done on the HT side as the electricity board measures power factor on HT side for penalty calculation. Also, HT capacitors involve low initial investment as compared to LT capacitors. However, compensation achieved by HT capacitors does not provide the benefits offered by the use of LT capacitors, as discussed in this article.

Consider two cases with compensation provided on HT and LT side respectively as shown in figure 1 and 2.

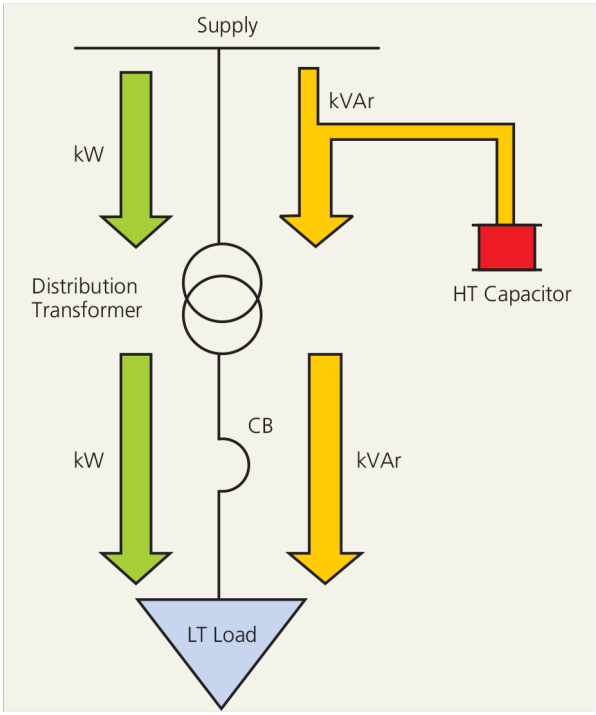

Fig 1: Compensation on HT Side

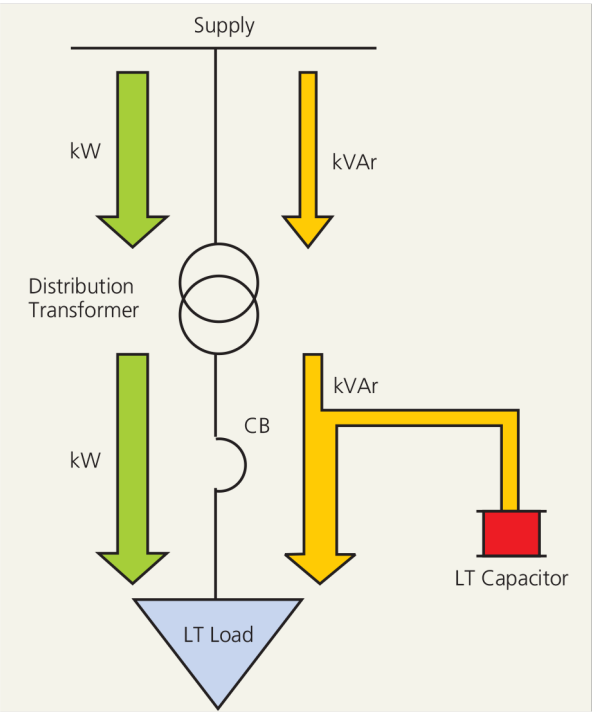

Fig 2: Compensation on LT Side

As seen in fig 1, with the capacitor connected on the HT side, the compensated reactive power flow through the transformer does not reduce and hence there is no change in current flow. Although the HT side power factor is improved, the LT side power factor remains same. However, as seen in fig 2, connecting capacitor on LT side reduces the reactive power flow through the transformer and we get improved power factor and reduced current flow on both LT and HT sides.

1. Reduction in Transformer Copper Losses

Consider a load of 1200 kW connected to a transformer of 2000 kVA. The typical full-load copper losses in a 2000 kVA transformer are 25000 W.

When compensation is provided on HT side, operating power factor of the transformer is 0.75 (same as uncompensated), denoted by $\cos\phi_1$.

When compensation is provided on LT side, operating power factor of the transformer is 0.98 (compensated), denoted by $\cos\phi_2$.

$$\text{Power Saving} = W_f * K * \left(\frac{1}{\cos\phi 1} - \frac{1}{\cos\phi 2} \right)$$

Where,

W_f = Full Load Copper Losses = 25000 W

$$K = \frac{\text{Load in kW}}{\text{kVA rating of transformer}} = 0.6$$

Power Saving (in W)	=	25000*0.6*(1/.75-1/.98)	=	4694 W
Monthly Energy Savings (in kWh)	=	4694 *24*30/1000	=	3380 kWh
Typical Energy Charge (in Rs/kWh)	=	Rs. 6 per kWh		
Monthly Cost Saving (in Rs)	**=**	**6*3380**	**=**	**Rs. 20278/-**
Yearly Cost Savings (in Rs)	**=**	**20278*12**	**=**	**Rs. 243330/-**

Thus, LT compensation provides monthly savings of Rs. 20,278/- for a 2000 kVA transformer. Additionally, the operating temperature of the transformer is relatively less because of reduced copper losses. Hence, apart from monetary benefits, LT compensation also ensures longer life of the transformer.

2. Capacity Release in Transformer

Consider a 2000 kVA transformer connected to a load.

Cast 1: When compensation is provided on HT side, operating PF of transformer = 0.75

Maximum load that can be connected = 2000*0.75 = 1500 kW

Cast 2: When compensation is provided on LT side, operating PF of transformer = 0.98

Maximum Load that can be connected = 2000*0.98 = 1960 kW

Additional load that can be connected under the same transformer = 460 kW

LT compensation allows release of capacity of 460 kW with the same transformer. Thus, additional load can be easily connected to the system without any additional investments in new transformers.

3. Optimized Main Incomer Switchgear Rating

LT side capacitor, when connected after the main incomer reduces the current drawn by the same set of loads. Hence incomer switchgear rating can be optimized and the investment cost of the main incomer can be reduced.

Apart from those mentioned above, LT compensation also offers other advantages, such as

- Maintenance of LT capacitors and panels is easier and does not require complex safety measures
- Spares and accessories for the same are easily available and relatively cheaper

Thus, for a factory with all LT loads, power factor compensation with LT capacitors proves to be a better option, with its relatively smaller payback period.