<u>**Can DC pass through Transformers?**</u>

Question: In a three-phase half-wave converter, (Fig 1) the current in each winding of the secondary of the supply transformer is a series of rectangular pulses. (Fig.2)

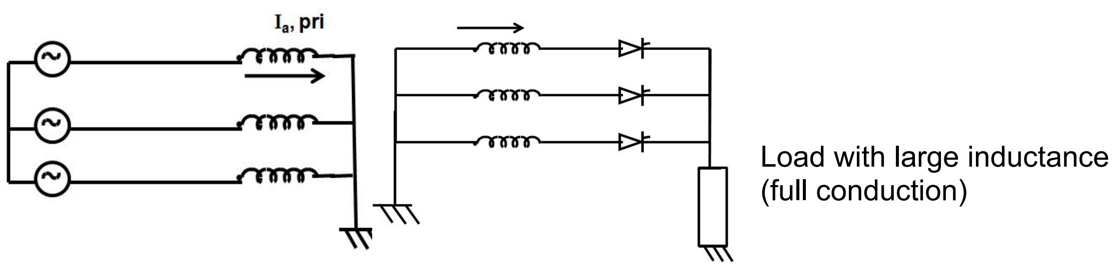


Fig 1: 3-Ph Half wave converter.

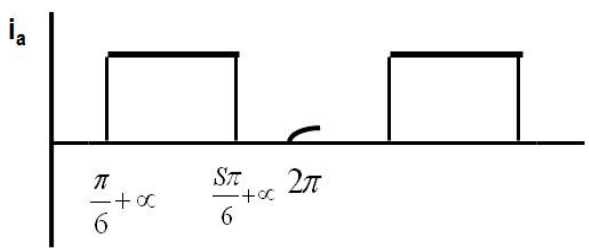
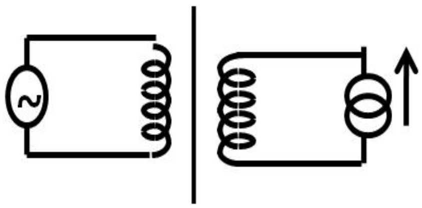


Fig 2: Current in Ph ‘a’ of Secondary.

What is the waveform of current in the primary? Also, since by Fourier analysis, we can see that there is a DC component in the secondary, will it not be absent in primary? After all, DC cannot pass through a transformer!

Answer: Let us take the last comment first. “*DC cannot pass through a transformer*”. This statement is one of those half-truths, which is misleading. Let us go through a series of simple, idealized scenarios.

Scenario:1 The primary of an ideal transformer (see Fig 3) is connected to an ideal ac voltage source. The secondary is connected to an ideal dc current source. Find the currents in the two windings.



Unidirectional constant dc current source.

Fig. 3: Scenario 1.

Answer to Scenario:1

The voltage across primary is AC of constant amplitude. Hence the flux has to be AC of constant amplitude and same frequency as voltage source. $\left(v_1 \propto \frac{d\Phi}{dt}\right)$ If the secondary were open, the primary current would have been zero (ideal transformer, infinite permeability etc.)

The current in the secondary is dictated by the dc current source. So, the secondary current is dc.

Note that the primary voltage is dictated by the AC source. The secondary current is dictated by the DC source.

The flux is dictated by the AC source since Φ has always to be such that $\frac{d\Phi}{dt} = K_1V$ all the time. This is possible only if the dc flux (and AT) set up by the secondary is counteracted by a dc in the primary. (AT balance is valid around any closed flux path). But we should remember that, here the direct current in secondary will result in a balancing direct current in primary, *because of the requirement of a sinusoidal flux of constant amplitude and not because of the principle of amp-turn balance.*

Of course, here also AT balance is valid in the sense that -

$(\phi_{ac,new} + \phi_{dc,sec} - \phi_{dc,pri})\mathcal{R} = \phi_{ac,old}\,\mathcal{R}$ And since $\phi_{ac,new}$ has to be equal to $\phi_{ac,old}$, the result is that $\phi_{dc,sec} = \phi_{dc,pri}$

All this is strictly true under ideal conditions, i.e. no leakage, no resistance etc. In big power transformers, this is true mostly.

Conclusion: In Fig 1, if transformer ratio is 1:1 the secondary current will be identically equal to primary current. *Yes, the DC can cross the transformer, so to speak*.

Now, consider scenario 2 in Fig.4. Here, the direct current in primary will be zero during steady state. In this case also, during the initial switching transient, there will be dc in the primary, which will die down due to the resistance. So, in this case, the DC "cannot cross the transformer" in steady state.

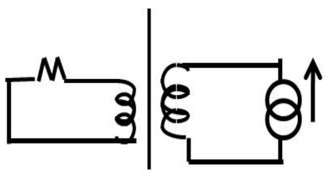


Fig. 4: Scenario 2.

Thank you for raising such questions; these clarify my ideas too!

Points to remember:

1. In magnetic circuits with coils having AC voltage source, the flux has to be AC with constant amplitude. The coil current is decided by reluctance and by any "reflected" current.

2. In magnetic circuits with coils having DC excitation, the current is decided by V/R. The accompanying flux is decided by reluctance.

3. In magnetic circuits with two coils, one of which has AC excitation and the other dc excitation, we have to decide the flux based only on the AC excitation and on the fact that V = N $\frac{d\phi}{dt}$. That is the fascinating part about magnetic circuits with both ac & dc excitation.

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