Some thoughts on asymmetrical transformers

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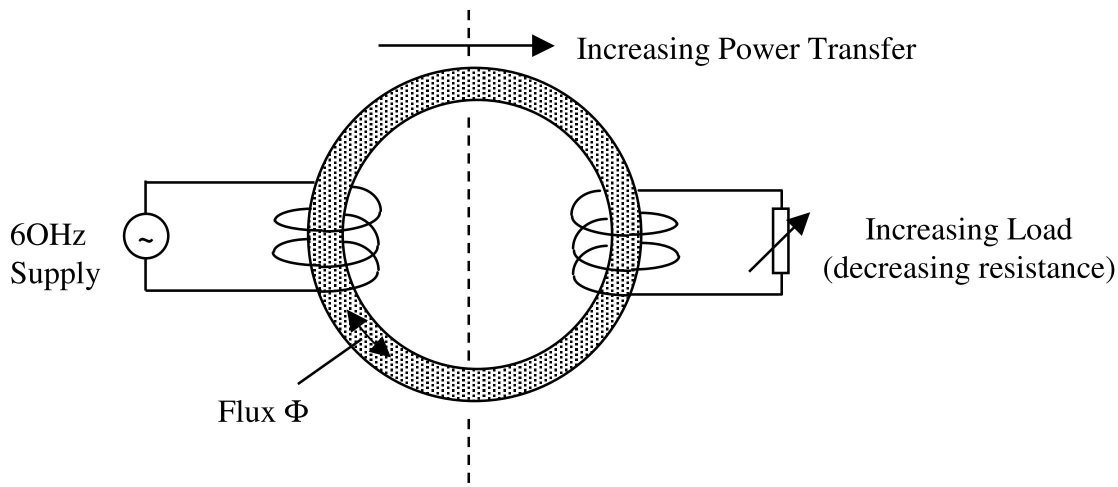
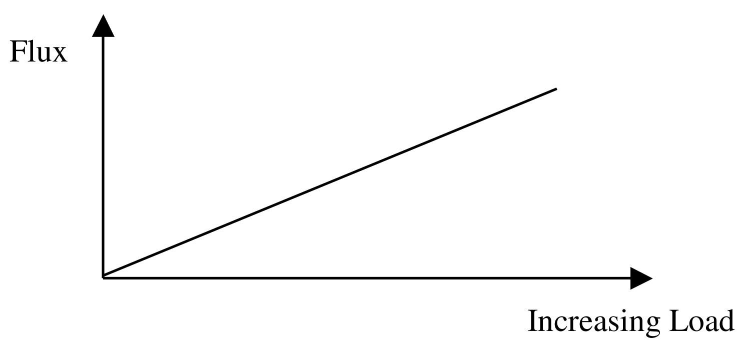
This paper look at classical transformer operation to challenge the common myth that secondary load-current creates so-called "Lenz flux", and that OU researchers should look at ways of reducing said Lenz flux. It would be more correct to call it "Lenz magnetomotive force", and if we are to make progress here we should look at means of reducing that mmf.

First we pose a simple question about the relationship between the flux in the transformer core and the load current in the secondary coil. The primary is connected to a mains voltage supply. The secondary has an increasing load applied to it. The mains voltage does not change. Ignore resistive losses in primary and secondary.

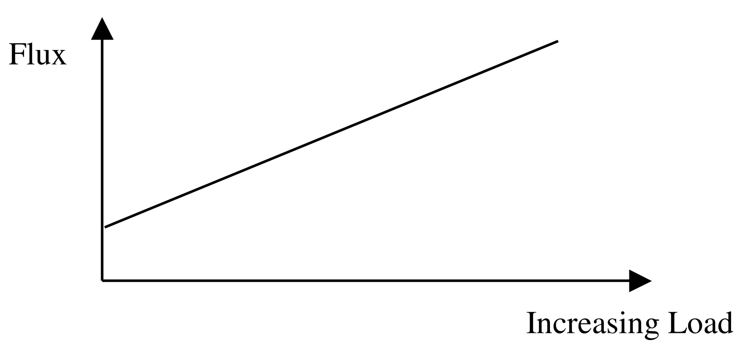


Question. Does the alternating flux Φ :-

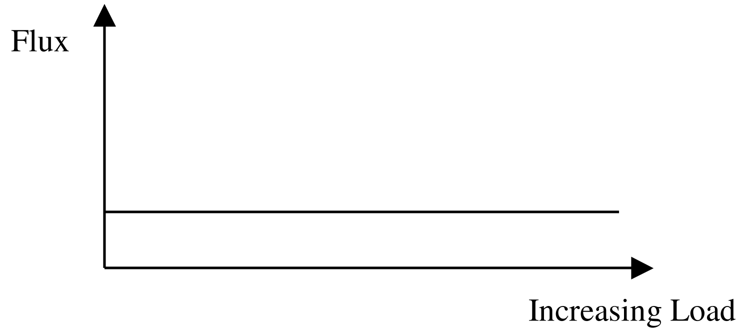
(A). Start at zero with zero (open circuit) load, then increase in value as the load increases?



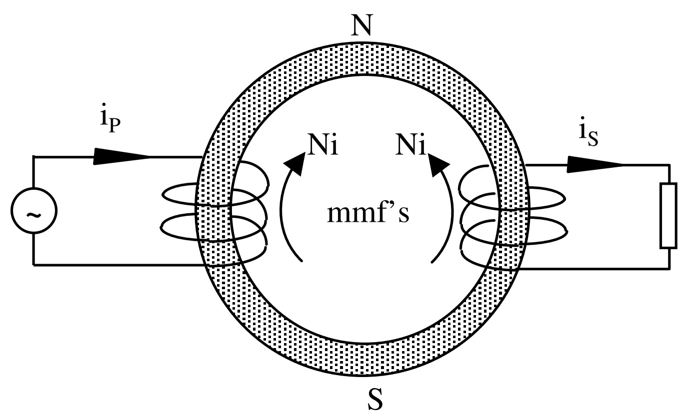
(B). Start at a small value for zero load, then increase in value with increasing load?



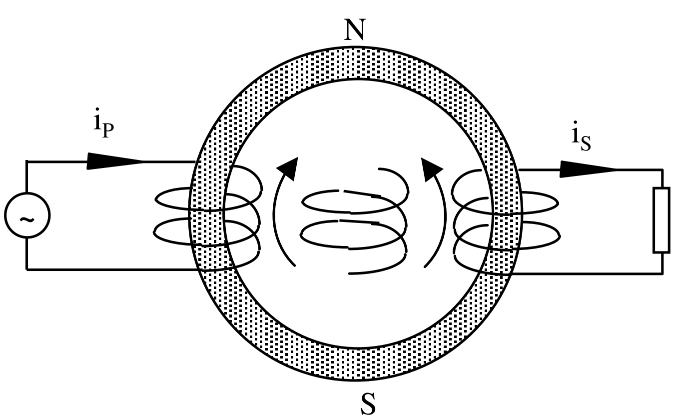
(C). Remain at a constant value independant of the load?

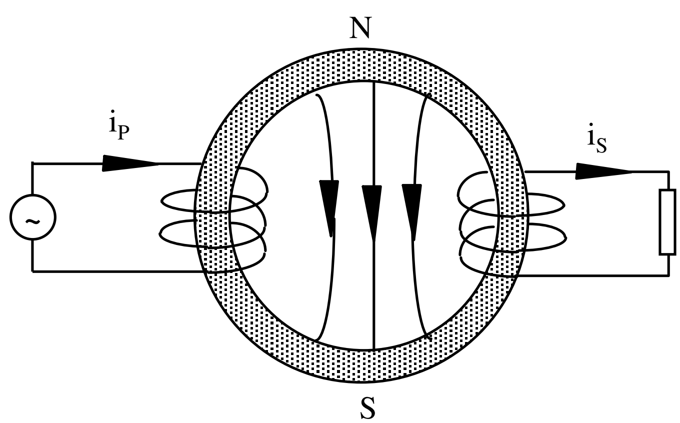


The answer is C, the AC flux remains constant irrespective of the load. How then can a constant flux carry different amounts of power? If one asked the question electrically, how can a constant current transport different power, the answer would be obvious to most people, by different voltage levels. So it is with magnetics, *it is the mmf which changes value*. When you look at the forward mmf from the primary and the equal value back mmf from the secondary you find that the ring core is AC polarised, as shown in the next diagram at one peak of the AC cycle.



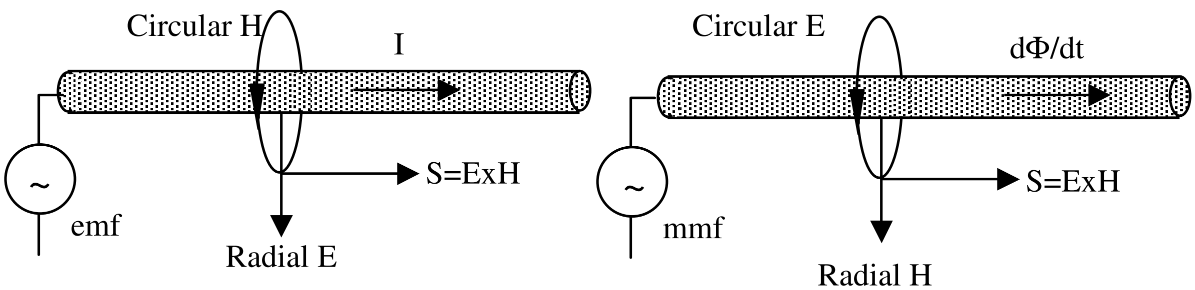
There is a scalar magnetic potential difference between the top and bottom of the ring core, depicted by the N and S poles. If you don't believe this you can perform a simple experiment. place a test coil within the ring as shown below.





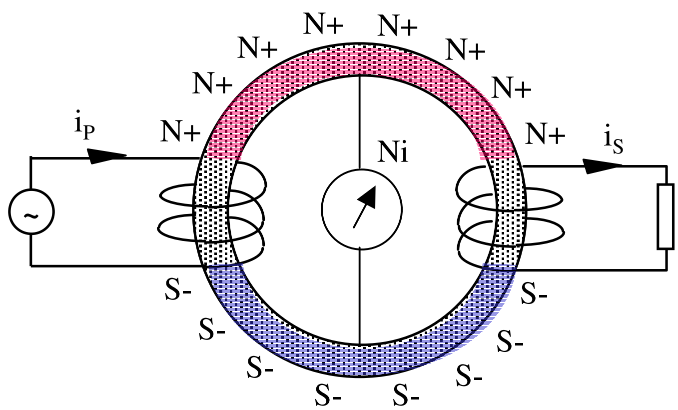
If you connect this test coil to an oscilloscope you will find a magnetic field going across the core from top to bottom, but only when there is secondary current flowing. ***This field is not the classical leakage field, it is an essential part of the power flow.*** The core transport of power is accompanied by a Poynting vector in the space outside the core. This vector is created by the vector multiplication (like Fleming's RH Law) of E and H fields.

The diagram below shows the Poynting S vector in the well known case for a conductor compared to this lesser known case for a magnetic core.

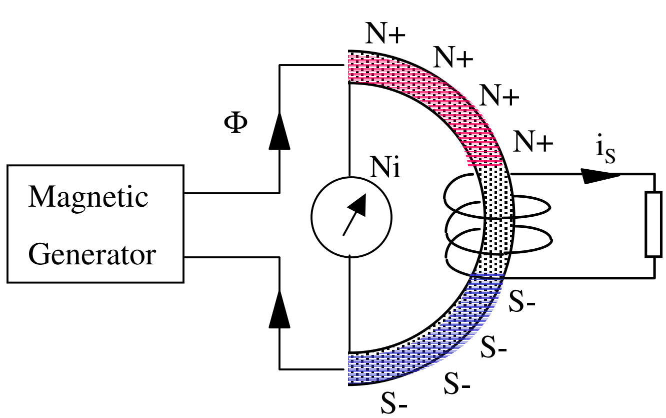


The lesson to be learned from this is that the magnetic field is NOT confined to the core. There HAS to be a magnetic field outside the core when it is transferring power. That external field is at 90º phase from the flux Φ flowing around the core as driven by the magnetizing current in the primary. Note that both the primary load-current and the secondary current drive that external flux in opposite directions, and although one might rightly call that secondary flux "Lenz flux" ***it never reaches the primary coil***.

Because the reluctance of the core is very low and any mmf drop across due to flux along it is negligible, the top of the core is virtually all at the same positive (N pole) potential while the bottom is at the same negative (S pole) potential. If we could connect a mmf meter across the core we would measure the magnetic "voltage" that is Ni ampere-turns, that Ni being that of both the secondary and also the primary load current.

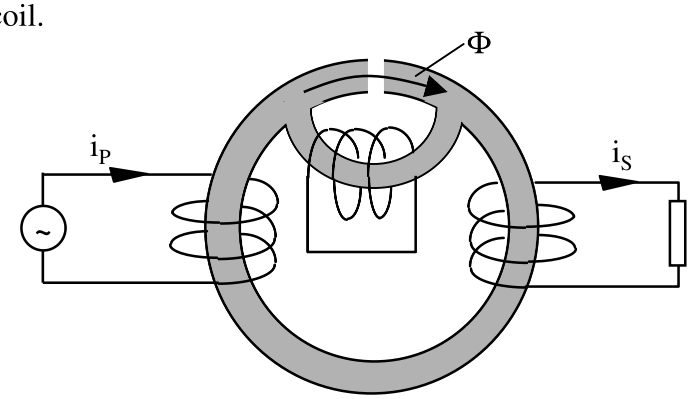


If we do a cut across the system and look towards the secondary we can establish what form a magnetic generator must take to drive power towards the load.

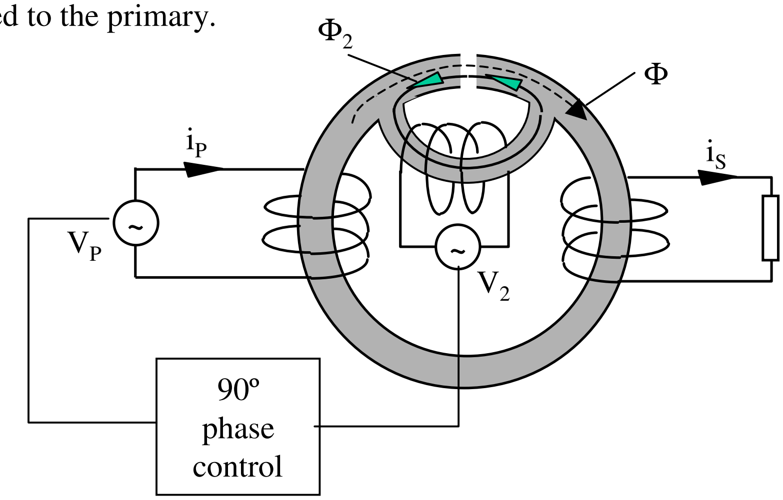


That magnetic generator has to drive alternating flux Φ at an alternating potential Ni that is 90º shifted in phase from that flux. Of course in the normal transformer that happens automatically, the primary coil current has two components 90º apart, the magnetizing current that creates the circulating flux Φ and the Ni load current that doesn't create circulating flux. The question now is can that symmetry within the transformer be modified so as to make it OU? Clearly we cannot negate the flux Φ besause that would mean there could be no secondary voltage. So we are left with trying to negate the alternating potential Ni. We can't just wind an extra coil and drive Ni ampere-turns in opposition to that from the secondary as that is just what the primary does, and the 90º flux Φ induces voltage that must be supplied by the current source, hence demanding power from that source. We need a means for creating the negating Ni from a coil that doesn't involve the flux Φ passing through it. The next diagram suggests a possible scheme.

The core is given a region of higher reluctance that is conveniently achieved by inserting an air gap. This air gap is bridged by another section of core, which may seem silly but all will be revealed. The bridging section has a coil wound on it that is shorted, thus acting to block any flux from flowing through it. Thus the flux Φ continues to flow through the air gap and the transformer still works as before, the only down side being the small added resistive losses due to the increased magnetizing current in the primary and the induced current through the shorted coil.

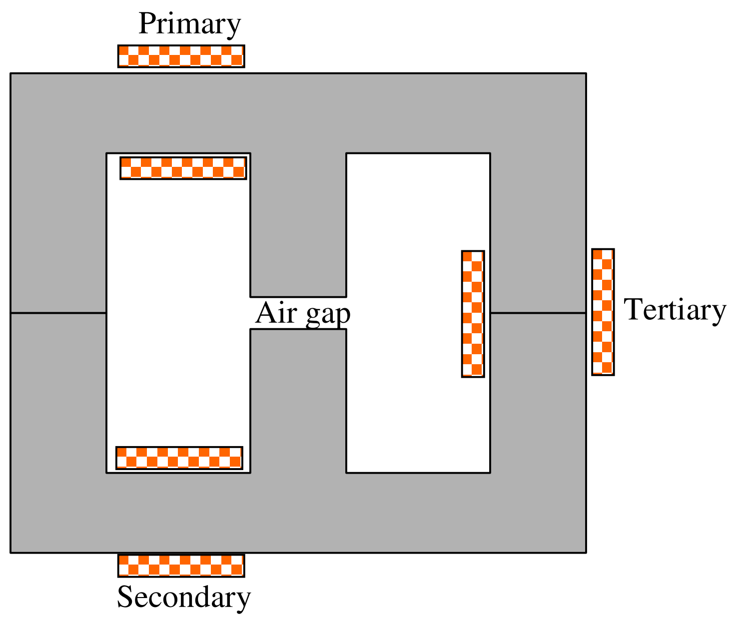


Next we connect the extra coil to a very low impedance voltage source, and irrespective of the applied voltage it still acts like the shorted coil to any other flux, the flux Φ still flows through the gap. The alternating voltage applied there will drive its own flux Φ_2 such that $d\Phi_2/dt = V/N$, and that flux will flow around the loop through the air gap. It will be prevented from flowing around the ring core because the primary is connected to a low impedance voltage source, thus acting like a shorted coil to any imposed flux. The aim is to have Φ_2 phased so that its mmf drop across the air gap exactly negates the back-mmf from the secondary. This requires the applied voltage V_2 there to be 90º phased from that of the voltage supplied to the primary.



This scheme offers the possibility that the primary supply voltage V_P supplies only magnetizing current to magnetize the ring core, and doesn't have to supply the load current needed to match the "Lenz mmf" from the secondary. That magnetized flux Φ flows through the loaded secondary coil where the load current creates the Ni "Lenz mmf". The other voltage V_2 supplied to the tertiary coil drives flux Φ_2 (90º shifted from the magnetized flux Φ) around the subsidiary loop where it creates a mmf drop across the gap that opposes the Ni Lenz mmf so that the primary no longer sees that back-mmf. At first sight it appears that both the primary and the terntiary inputs will appear reactive, but that is deceptive. The tertiary input has to supply reactive current to drive flux Φ_2 around it but it has to do that against the mmf drop from the 90º Φ across the air gap which acts just like a back-mmf. So it will have to supply real power, and the liklihood of this system being OU is low. However it would be an interesting experiment to perform.

Such an experiment could easily be set up using an E core as shown in the next diagram.



Adding capacitors to the coils to create resonance or merely to create phase shifts could also be explored.