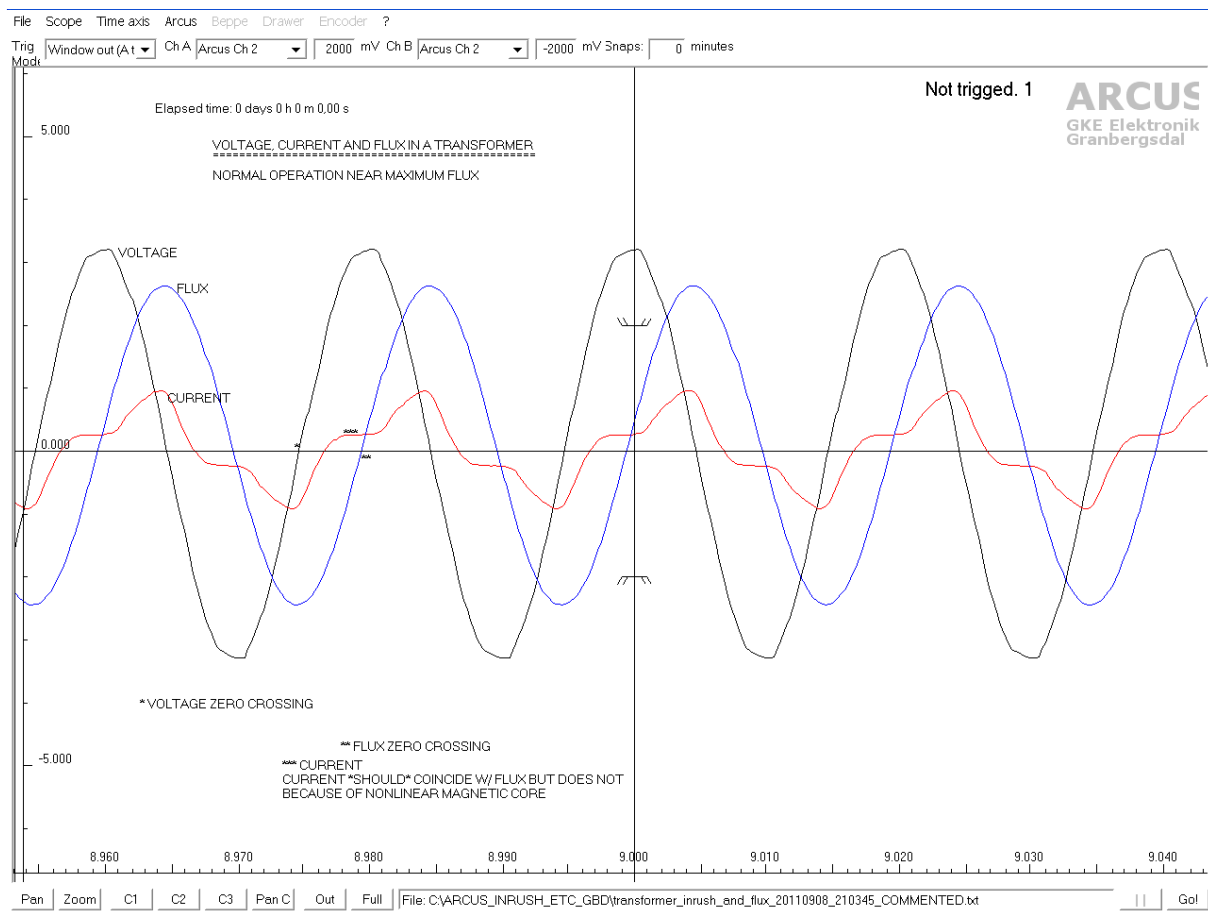


Transformer inrush

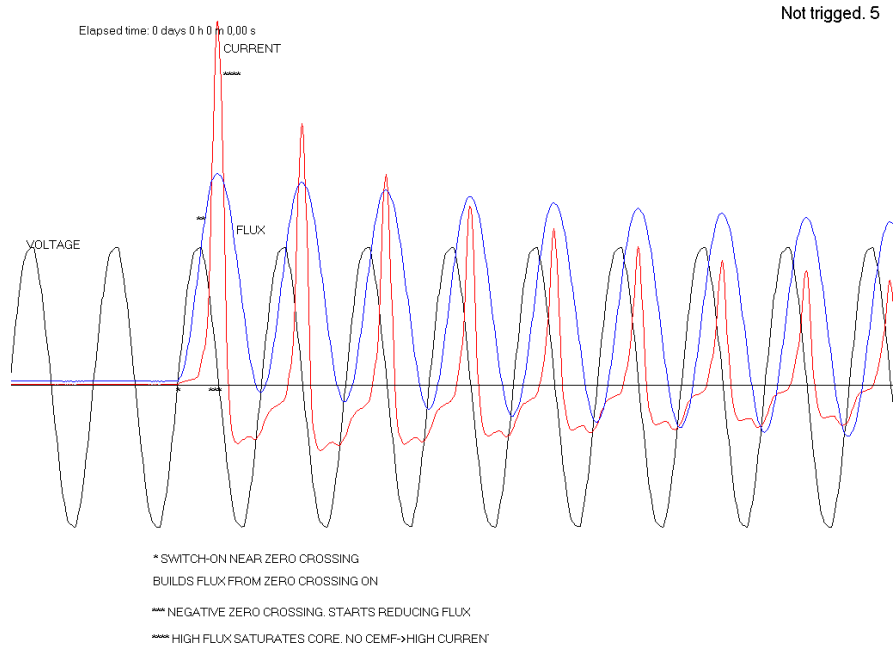
What switch-on angle is best?

The primary current in any transformer is limited by the counter-EMF produced by the core flux. The core is made from iron, iron alloys or other magnetic material which all have a maximum flux density limit known as saturation flux. When the flux gets near this limit, more and more current is needed to produce enough flux to counteract the impressed primary voltage. As long as flux stays within limits, the current is low. In a well designed transformer, the core gets quite close to – but not into – saturation. The resulting current reflects this by being more or less distorted with odd harmonics.

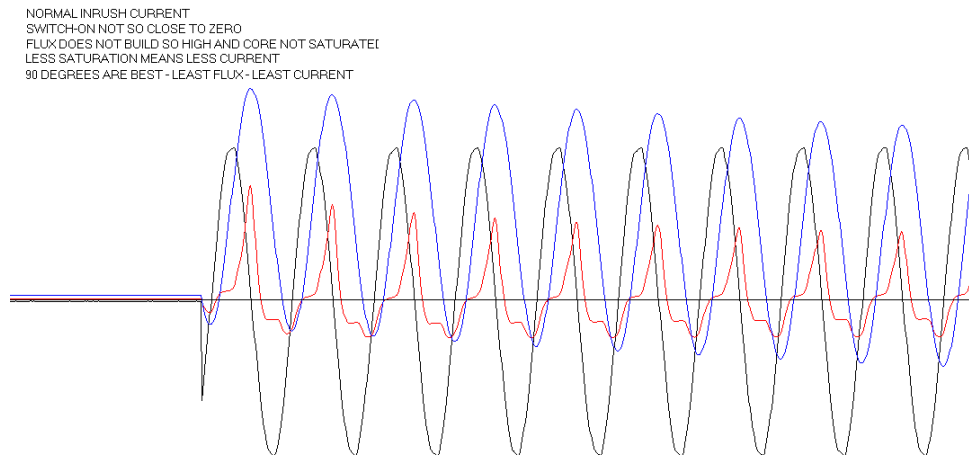


Normal operation. Note distorted current (red) while flux (blue) is sine shaped.

The flux builds in positive direction when voltage is positive. That can be easily seen in picture above. The * point shows where voltage starts in positive direction. Please observe that flux (blue) then is at its maximum negative value and starts from there in positive direction. It builds in positive direction all the time the voltage is above zero – the flux corresponds to the surface between voltage curve and the time axis and is therefore expressed in volt-seconds [Vs]. When voltage goes negative, the flux starts moving in negative direction.



In this picture, voltage switch-on is near the zero crossing. That means that flux starts from zero instead of maximum negative flux, which means that it reaches saturation earlier and therefore causes an increased inrush current.



Some distance from zero reduces inrush current. Best is 90 degrees, but that needs special relays (SSR) with the corresponding synchronization and delay. They are available but not commodities like zero-crossing relays.

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