Ferroresonance Phenomena and Strategy

When a circuit consisting of a capacitor and a magnetic (non-linear) device is subjected to a voltage change, a point of discontinuity develops producing an abrupt change in either current or voltage depending on series or parallel circuit connection.

A CVT without a proper ferroresonance damping circuit will exhibit sustained oscillatory behavior at fundamental or subharmonic frequencies. The phenomena can be triggered by the following system conditions:

1. High speed primary reclosing
2. Variation in secondary loads (overloads and short circuit)
3. Operation of potential ground switch

Before any of these switching operations, there would be a certain remnant flux in the core of the intermediate transformer. When a switching operation occurs, the voltage across the primary of the transformer will act to change the transformer core flux. The worst case is when the voltage polarity is such as to further increase the core flux and the voltage has just passed through zero. In this case, the peak flux in the core reaches 2.5 to 2.7 times the rated peak flux in the core. Transformers are not normally designed to operate at that level of flux without saturation. Thus the transformer core will go into deep saturation, reducing its magnetizing inductance by more than 100 times (to basically the air-core value). When the transformer inductance undergoes this change, at a certain point its value comes into resonance with the circuit capacitance, either at the frequency of the system voltage or at a subharmonic of it. When this happens there will be a sharply changing current waveform around that instance of resonance and corresponding resonant voltage amplification across both the capacitor and the transformer primary. Sustained oscillations may result unless some means of suppression is provided. The high impulse current then leads to excessive heating of the transformer primary winding and the overvoltages stress the transformer insulation and can lead to breakdown. A typical waveform of the transformer primary voltage is given in Fig. 1. This simplified description of a CVT without ferroresonance protection illustrates that ferroresonance cannot be avoided and it will always happen when the transformer core goes into saturation. Whether this happens is dependent on the previous remnant flux in the core and on the phase angle of the system voltage at the switching operation and is therefore statistical in nature. Some kind of device must be provided to suppress ferroresonance oscillations once they are initiated.

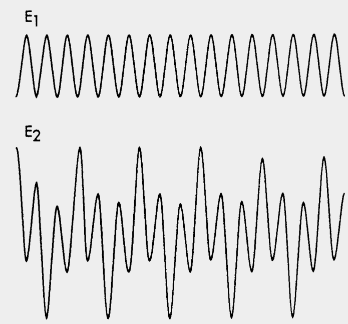

Fig.1 Typical Subharmonic Oscillation

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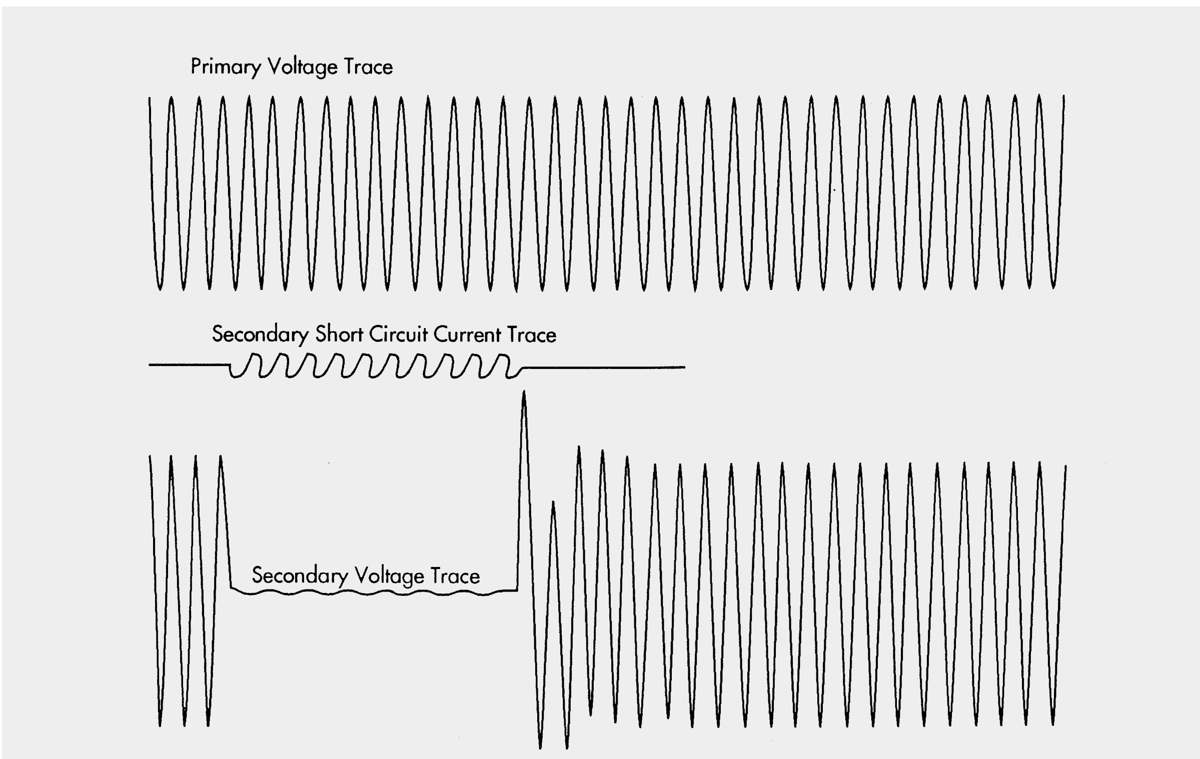
Trench has been successful in developing a ferroresonance strategy which is based upon the combination of low flux density in the electromagnetic unit and the use of a saturable reactor.

A CVT with an electromagnetic unit operating at low flux density usually performs well under ferroresonance conditions in terms of both recovery speed and overvoltage magnitude.

A saturable reactor is used by Trench as a voltage-sensing magnetic switch. Under normal voltage, it behaves as an open switch drawing virtually no current. When the voltage rises beyond its knee-point, the saturable reactor will turn on a damping resistor effectively nullifying parasitic voltage.



Typical Ferroresonance performance characteristic of a Trench CVT

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