Measurement of Harmonics with a Capacitive Voltage Transformer

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Abstract: A simple equation representing the frequency response of a capacitive voltage transformer is graphed for various burdens (VA). The transformer's bandwidth decreases with increasing burden.

Instrument Voltage Transformers (VTs)

There are two main types of voltage (potential) transformers: Inductive Voltage Transformer (IVT); and Capacitive Voltage Transformer (CVT). IVTs work like regular transformers utilising the principle of electromagnetic induction and where energy is coupled from the primary coil to the secondary coil. A CVT is essentially step-down transformer with a capacitive voltage divider stack at the front-end together with a compensating reactor and is the preferred configuration at high voltages. Many CVTs also include a damping circuit. Refer to Figure 1.

CVTs are utilised to step down HV and MV to LV, to operate instruments such as meters and protection devices. Today, the power system is contaminated with many frequencies and include harmonics of the Power Frequency. Electrical utilities also connect Power Quality Analysers (PQAs) at the LV side of VTs to measure not only the voltage at the Power Frequency but also Mains Signalling and harmonics.

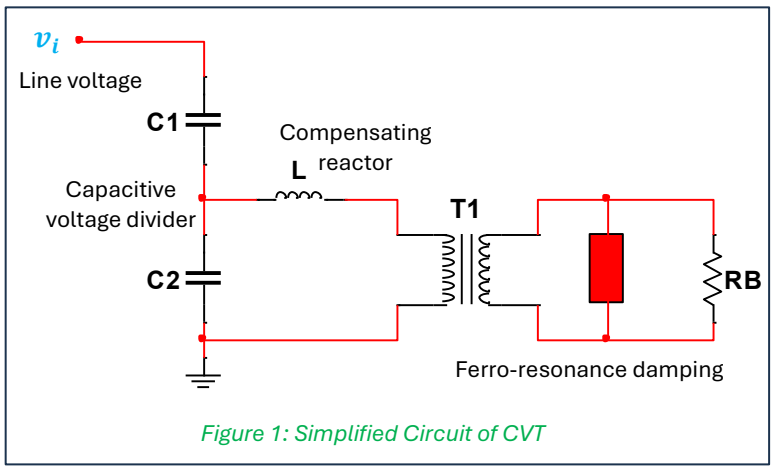

Figure 1: Simplified Circuit of CVT

Frequency Response of CVTs

Figure 1 shows a simplified circuit of a CVT. Assuming no losses and no parasitic components, a simplified voltage transfer function was derived and graphed for various burdens, refer to Figure 2. The transfer function parameters together with the burdens were chosen to demonstrate the impact on the frequency response. The compensating reactor is chosen to ensure the capacitive reactance is cancelled at the Power Frequency and therefore the magnitude is unity at 50Hz and regardless of the load. Note, the phase is zero at 50Hz. In practice, increasing the burden will reduce the measured voltage at the Power Frequency due to the resistive and parasitic effects.

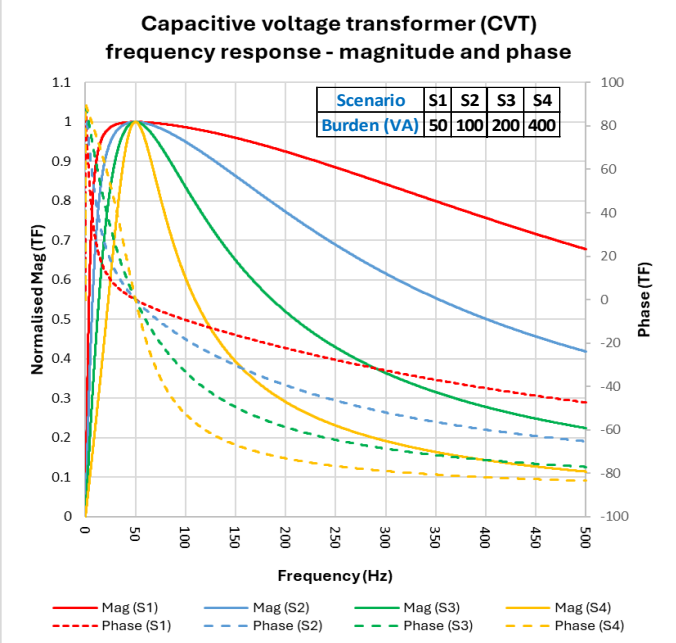

Figure 2: Lossless CVT, frequency response versus Burden

Key Takeaways

Figure 2 shows that decreasing the burden flattens the frequency response and extends the bandwidth of the VT; enabling the VT to measure harmonics and interharmonics.