Abstract

Among the various sensing techniques to measure current, current transformers (CTs) are still widely used in most of the applications. The output current of a CT is inversely proportional to the turn-ratio of secondary and primary windings; and therefore higher number of secondary turns is preferred for better current sensing sensitivity. The maximum induced output voltage across the burden resistor in the secondary circuit is directly proportional to operating frequency, maximum flux density of the magnetic core, cross section area of the magnetic core and the number of turns in the secondary winding. Besides transforming primary current to secondary current, the CT itself consumes a portion of the primary current for magnetizing current, eddy current loss and hysteresis loss. These currents cause magnitude and phase errors in the measurement. Magnetic cores with larger cross sectional area are preferred to prevent saturation of the core and obtaining higher secondary induced voltage. Commercially available CTs are usually bulky, rigid and heavy. The motivation of this thesis is to explore the use of thin and highly flexible magnetic core for CT design.

The major contribution of this thesis describes a comprehensive design guide, from analysis to fabrication of an ultra-thin and highly flexible CT. The proposed CT is flexible enough to wrap around an electrical cable for current sensing without taking much space. The circuit model of the CT takes into consideration of the nonlinearity of the flexible magnetic core based on the *Jiles-Atherton* (*JA*) hysteresis model, which is validated experimentally. A combined errors compensation method for the current sensing measurement is also proposed so that the CT can also be used for high current measurement.

Also, wireless senor network (WSN) forms the backbone to realize Internet of Things (*IoT*). Autonomous devices with energy harvester are in demands. Among the available types of energy, magnetic field arounds a power cable can be tapped for such purposes. Flexible CT can also double up as an electromagnetic energy harvester to energize wireless transceivers or any other low power sensor actuator device. Since priority is given on harvesting maximum possible power, flexible magnetic material with higher saturation flux density is required to optimize design analysis. The harvested alternating current is rectified and voltage level is converted to drive a Bluetooth low energy (*BLE*) transceiver directly.

Excess energy is stored in a coin-cell Li-ion battery to use when primary energy source is unavailable. This thesis presents an overall development of autonomous online-condition monitoring systems to monitor current flow in power cables for energy management, safety and protection by integrating flexible CTs for sensing and energy harvesting.