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Signal Conditioning Electronics for UHF Partial Discharge Detection and Location System

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Partial Discharge (PD) occurs in damaged high-voltage insulation. PD results in UHF electromagnetic radiation which can be used to detect and locate insulation faults in HV power systems equipment such as transmission lines and transformers thereby providing early indication of equipment failure [1 - 5]. The majority of the power in the PD radiation is contained in the band 50 MHz to 800 MHz. A wireless sensor network (WSN) is being designed and implemented to receive this PD radiation to provide a non-invasive method of locating and monitoring PD. Each WSN node is required to operate for as long as possible (≥1 year) without the need to change the energy source and to be sufficiently cheap to make a dense sensor network viable. Low cost, low power, circuitry for each node has therefore been developed. It is impractical to consider sampling radiated PD signals directly due to their large bandwidth leading to large data storage and/or data transmission requirements. The system being developed reduces signal bandwidth, and therefore the sampling rate and volume of data to be processed, using signal conditioning electronics (SCE) based on a transistor-reset integrator (TRI).

Figure 1 shows the PD WSN node. It comprises an ultra-wideband antenna, a low-noise amplifier (LNA), a four-way power splitter, three signal measurement channels and one pulse counting and sampling control channel. All four channels incorporate an envelope detector to convert the received radio frequency (RF) PD signal pulses to baseband pulses. The pulse counting and sampling control channel counts the received pulses. The three measurement channels incorporate filters to separate the received RF PD pulse energy into 50 - 290 MHz, 290 - 470 MHz and 470 – 800 MHz bands allowing a crude frequency spectrum of the received signal to be estimated. This spectrum has the potential to distinguish between damaging internal PD and less damaging corona, for example. The envelope detector in each measurement channel is followed by a TRI which produces an output voltage proportional to the intensity (i.e. area) of the filtered, detected, PD pulse. The outputs of the three integrators are sampled when a pulse has been detected on the pulse counting and sampling control channel. The feedback capacitor of the TRI is discharged once the output voltage has reached a pre-set threshold to avoid permanent saturation and thus enable continuous PD detection. The period between discharges is a measure of aggregate PD intensity within the measurement bandwidth.

The TRI effectively collapses the bandwidth of the received signal thus reducing sampling requirements per channel. This reduces the memory requirement for the sampled PD pulses and the power requirements to transmit the data over from the sensor node to the data collection node of the WSN. The integrators are sampled by the internal ADC of a microcontroller, stored in on-board memory and transmitted for processing to a data collection station by a WirelessHart transmission module.

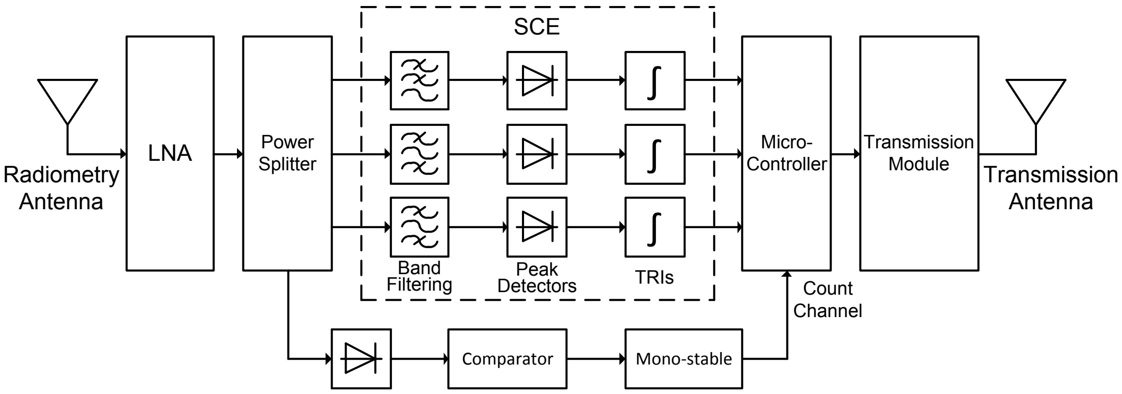

Fig. 1 Partial discharge wireless sensor node

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