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Current driven NiFe/Cu composite wire magnetic permeability interference sensor with a pick-up coil LC circuit

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A current driven magnetic permeability interference sensor for weak magnetic field is presented. It is formed by a micro composite wire sensing element of NiFe/Cu with a high frequency ac current and wounded by a micro pick-up coil that connects to a capacitor in parallel for detecting the magnetic flux variation caused by the change of magnetic permeability of the NiFe on the wire. The ac current through the wire produces an ac circumferential magnetic field that drives the permeability of the NiFe layer to a dynamic state. It is showed that the optimum frequency f_{DR} of such a driving current is the maximum MI effect frequency of the wire, f_{MI}. The pick-up coil measures the variation of magnetic flux in the composite wire, which performs better at a larger number of turns. It is showed that the larger the number of the turns the higher the resolution of the sensor. The capacitor together with the pick-up coil forms an oscillation circuit for the output, which gives the maximum output/input ratio at a resonance frequency, f_r. It is shown that f_r relates to f_{DR}, and the highest output/signal ratio can be achieved when $f_r = 2 f_{DR}$. It is also showed that the sensitivity and resolution of the sensor depend on the magnetic properties of the composite wire sensing element, including the magnetic anisotropy of the NiFe layer, in which a longitudinal anisotropy make higher sensitivity and resolution of the sensor compared to that with circumferential anisotropy. It is showed that using a sensing element of 20 um copper core electroplated with a layer of $Ni_{80}Fe_{20}$ of 2 um thickness and of longitudinal anisotropy, a sensitivity of 2.27 V/Oe and a resolution of 7.0 nT were obtained.