Magnetic nanopartide (MNP)-assisted microwave hyperthermia using an active integrated heat applicator is presented in this paper. The effect of MNPs on microwave hyperthermia has been analyzed by coupled electromagnetic-thermal analysis considering the frequency- and temperature-dependent properties of biological tissues. For enhanced heating efficiency and material sensitivity, the optimum microwave frequency for hyperthermia has been identified using the presented analysis and confirmed with experiments. In order to demonstrate MNP-assisted hyperthermia, an active integrated applicator is developed. A microwave signal generation module, which has a voltage-controlled oscillator and a power amplifier, has been fabricated in monolithic microwave integrated circuits and integrated on the microwave heat applicator based on a spiral radiator. A dual-channel logarithmic power detector and a directional coupler have been also employed to monitor power levels during hyperthermia, which allows understanding of the heating mechanism. In vitro heating experiments on phantoms, pork muscles, and tumors with and without MNPs show a large difference in temperature rises, which demonstrates the effectiveness of MNPs for low-power and material-specific hyperthermia. Combined with MNP targeting on the cancer cells, MNP-assisted microwave hyperthermia can be a promising method for a low-power and cancer-specific treatment with minimal collateral damage.