AbstractID: 7399 Title: Signal Dependence on Frequency in Magnetic Particle Imaging

Purpose: To evaluate the frequency dependence of signal detection in magnetic particle imaging (MPI) using heterodyne mixing of the odd harmonics down to DC for detection.

Method and Materials: Magnetic particle imaging detects the odd numbered harmonics generated when a sinusoidal driving field saturates the nanoparticles. A solenoidal coil was used to generate the driving field of approximately 10 mT in a 3.2 cm inner diameter tube. Smaller diameter loops were connected to a phase-lock amplifier to detect the harmonics. The difference in the third harmonic with and without a 1 ml sample of 300 microgram/ml, 40 nanometer, nanoparticles was measured over a one minute acquisition. The contrast to noise ratio (CNR) was calculated for frequencies between 500 Hz and 20 kHz.

Results: The CNR increased linearly with frequency; the linear correlation coefficient was 0.993 (p-value 10^{-7}). Further, the CNR per cycle was essentially constant (p-value 10^{-6}) over the entire range of frequencies. The sensitivity allowed detection of nanoparticles down to 20 microgram/ml concentrations.

The original work found that the best SNR was obtained using a swept low frequency excitation. However, filters were used to isolate the driving field from the harmonics. In contrast, the phase-lock amplifier heterodyne mixes the harmonic frequencies to DC before filtering so the filtering is much more effective. The difference in detection is probably responsible for the different results. The harmonic signal is generated from the edges in the magnetization occurring when the nanoparticles saturate so the harmonics should increase linearly with the number of edges which would result in a linear increase with frequency.

Conclusions: The CNR increases linearly with frequency. The constant CNR per cycle over all frequencies implies that distortion of the hysteresis curve that can reduce the harmonics for higher driving frequencies is not significant below 20 kHz for these nanoparticles.