$$\delta v'' = 0.5\sin[2(\omega t - h_{ex}\sin\omega t + h_{ey}\cos\omega t)]. \quad (10)$$

where $\delta v'' \approx \delta v$ (Fig. 2 (c)). The external field in Fig. 2 consists of two strong components $|H_{ex}|=|H_{ey}|=|H_k|$ to emphasize the difference existing between exact solutions and the approximate curves. Fig. 3 shows relative errors of approximation in the MR sensor output obtained by (9) and (10) when $-0.5|H_k| \le H_e \le 0.5|H_k|$.

Fig. 2 (b), (c) and Fig. 3 demonstrate that the results of (9) are more exact than those given by (10). The error in both cases does not exceed 1% when $H_e = 5\%$ of H_k. The amplitude of H_{bx} should be at least twice that of H_k, and the amplitude of H_{by} should be at least three times that of H_k to provide this level of accuracy.

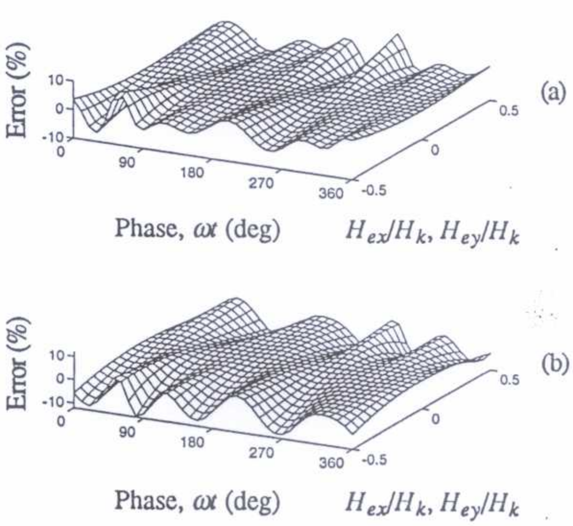

Fig. 3. Relative errors of the approximations obtained for the magnetoresistive sensor output.

(a) Relative errors of approximation obtained by (9).
(b) Relative errors of approximation obtained by (10).

4. Conclusions

Explicit and still simple expressions are obtained for closely describing the magnetization processes in thin ferromagnetic films saturated by an in-plane magnetic field. These expressions are successfully used to evaluate the output signals of barber-pole MR sensors in the case where the MR material is excited by an appropriate elliptically rotating bias. These relationships are advantageous for simplifying the analysis and design of thin ferromagnetic film devices, such as MR sensors, contactless angle detectors, thin-film magnetic heads, *etc.* It also enables a more straightforward insight into their operation.

References

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