

## Analysis & Probability/Algebra: Disk Drive Engineer

### Hewlett-Packard Company

**Job Description:** Design digital magnetic recording systems for use in hard disk drives.

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### Problem:

A magnetic recording engineer wants to determine the minimum write current ( $I_w$ ) he can use to drive a head to write magnetic transitions (bits of information) onto a disk in a disk drive.

The head cannot get any closer than 25 nanometers (1 nanometer =  $1 \times 10^{-9}$  meters) to the surface of the disk. The magnetic field at the head gap ( $H_g$ ) is roughly equal to product of the number of windings on the head ( $N$ ) times the write current (expressed in amps), divided by the distance of the gap ( $G$ ).

$$H_g = (N \times I_w) \div G$$

The magnetic field is expressed in a couple of terms, Oersteds (Oe) and Amp•Turns/Meters. One Oersted is equal to  $80 \cdot \pi$  Amp•Turns/Meter.

The head has 48 turns (or windings,  $N$ ) and the gap distance,  $G$ , is 1 micrometer ( $1 \times 10^{-6}$  meters or  $1 \mu\text{m}$ ). From previous modeling, he knows that the magnetic field decreases with distance away from the gap, such that it is roughly one half of  $H_g$  when the head is 25 nanometers away from the disk. He knows there is a demagnetizing field ( $H_d$ ) that occurs inside the disk during the write process.

This field opposes the field from the head. Previous calculations showed that  $H_d$  is 500 Oersteds. The net field for writing ( $H_x$ ) must be greater than the coercivity ( $H_c$ ) of the media plus the demagnetizing field. The coercivity of the media has been measured at 2000 Oersteds.

What is the minimum write current?

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**See problem for details.**

### Solution:

$$H_x > H_c + H_d$$

$H_x$  = net field for writing

$H_c$  = coercivity of media

$H_d$  = Demagnetizing field

$$H_c + H_d = 2000 \text{ Oe} + 500 \text{ Oe}$$

$$= 2500 \text{ Oe}$$

$$H_x = 0.5 H_g$$

$$\text{Therefore, } H_g = 2 \cdot H_x > 5000 \text{ Oe}$$

$$1 \text{ Oe} = 80 \cdot \pi \text{ Amp} \cdot \text{Turns} / \text{Meter, abbreviated } (A \cdot T) / m$$

$$\text{Therefore, } H_g > 5000 \text{ Oe } (80 \cdot \pi) (A \cdot T)/m$$

$$H_g > 1.26 \cdot 10^6 \text{ A} \cdot \text{T}/m$$

$$H_g = (I_w \cdot N)/G$$

$$I_w = H_g \cdot G/N = (1.26 \cdot 10^6 \text{ A} \cdot \text{T}/m)(1 \cdot 10^{-6} \text{ m}) / 48 \text{ T}$$

$$I_w > 0.026 \text{ Amps or } 26 \cdot 10^{-3} \text{ Amps (26 milliamps)}$$