This is my original strip calculation where I ignore the transverse H field and I end up getting a result which is only half the Kuester result. This led to my email with him and to my learning my error.

C.5 The DC internal inductance of a thin strip conductor

The strip geometry is as follows, where we assume J_z is uniform and total current is I :

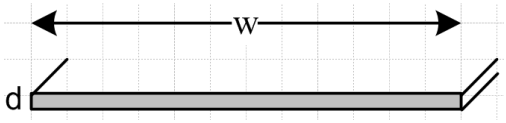

Fig C.5

We also assume w >> d so we can ignore end effects. The figure below is an end view of the flat conductor rotated to a vertical position, but only a central segment of the conductor is shown.

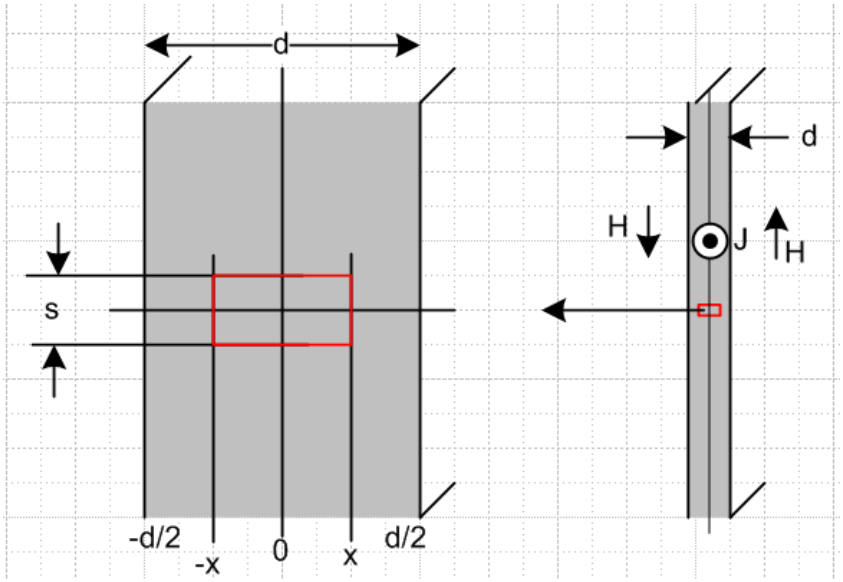

Fig C.6

The uniform current density J_z is out of the plane of paper as shown on the right. Based on Fig C.2 we expect the H field to have the directions shown on the right, both inside and not far away outside the surface of the conductor.

The current density is given by I/area,

$$J_z = I/(wd) \; . \qquad \text{(C.5.1)}$$

Applying Ampere's Law to the red loop one finds

$$\int_S \mathbf{J} \bullet d\mathbf{S} = \oint_C \mathbf{H} \bullet d\mathbf{s} \qquad \textit{(1.1.37)}$$

so

$J_z\ 2x\ s\ =\ 2H(x)s \quad => \quad H(x) = J_z x\ = Ix/(wd) \qquad H/I = x/(wd) \qquad (C.5.2)$

$$dL_i = \mu_i \int_{in} dS\ (H/I)^2\ = \mu_i\ (wd)^{-2}\ s\ \int_{-d/2}^{d/2} dx\ x^2\ = \mu_i\ (wd)^{-2}\ 2s\ (1/3)(d/2)^3$$

$$= (1/12)\ \mu_i\ (sd/w^2) \qquad // \ dS = sdx$$

Ignoring end effects, we then set s = w to get the DC internal inductance of the full strip,

$$L_i = (1/12)\ \mu_i\ (d/w)\ = (\mu_i/8\pi)\ [\ 2\pi/3\ (d/w)\ ] \qquad // \text{ strip } w>>d \qquad (C.5.3)$$

[the correct solution has 1/6 instead of 1/12]