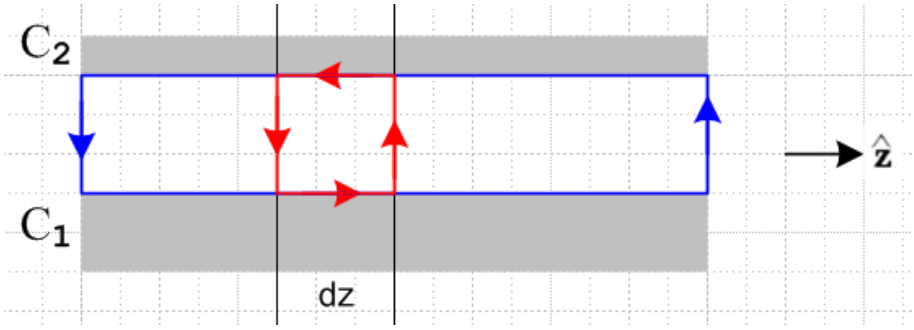
**Ch 4 Transmission line as inductor** PhL 10.16.13

Something like this will get into Chapter 4.

The Stokes theorem applied to **B** = curl **A** says

$$\text{curl } \mathbf{A} = \mathbf{B} \quad \Leftrightarrow \quad \oint \mathbf{A} \bullet d\mathbf{s} = \int_S \mathbf{B} \bullet d\mathbf{A} \qquad (**)$$

Consider the red loop shown in this top view of the two transmission line conductors. The loop is intended to have a tiny width dz, and the top view obscures the fact that each conductor has an arbitrary cross section.




Since we neglect any transverse components of **A**, the Stokes theorem says

$$[A_{z1}(\text{bottom}) - A_{z2}(\text{top})]\, dz = [\text{ flux through red loop}]$$

We can imagine the entire transmission line as forming a long thin horizontal loop of wire as shown in blue. The long loop has some total external inductance which has this definition: (flux through blue loop) = $L_{tot,ext}$ I where I is the loop current. This is an external inductance only because it does not account for the stored field energy inside the conductors, as we saw in the case of a round wire in Appendix C.3. The blue loop is a superposition of many red loops, and for the red loop shown we write

$$[\text{ flux through red loop}] = (L_e dz)\, i(z)$$

where recall i(z) is the loop current. Now $L_e$ is the external inductance per unit length of the transmission line. Combining the above and cancelling the dz's we find from (4.4.1) that

$$W(z) = L_e\, i(z)$$

Therefore, from (4.4.3) we have