

## **ECE 6130 Lecture 6 -- Lossy Transmission Lines**

Text Section 2.7, Handout from Iskander text

### **Lossy Transmission Lines**

Recall: Loss comes from conductor losses (R) and substrate losses (G).

Conductor losses come from:

- (a) main conductor
- (b) ground plane

- (1) non-infinite conductivity of metal (limited mobility of “free” electrons)
- (2) skin effect slowing and attenuating wave on surface of metal
- (3) surface roughness increasing effective path length and additional losses

Our text includes (a-1) in a simplified form.

Another text (see handout) gives a more complete summary for many kinds of transmission lines. Microstrip lines, for example ....

### **Effects of loss**

- (1) Attenuation (reducing the magnitude of the wave)
- (2) Slowing of wave (reduced velocity of propagation, results in phase change)

### **Skin Depth**

Wave traveling in the z-direction attenuates as  $e^{-\alpha z}$ .

Skin depth: distance at which the wave with magnitude 1.0 has reached a value of  $1/e$ .

Skin depth =  $1/\alpha$  (meters)

Increase frequency ... skin depth decreases. Higher frequency waves penetrate less. For purposes of calculation of loss, field values are considered significant down to the skin depth of the material (usually metal). Also, thickness of metallization needs to be only 2-3 skin depths to be “completely” metal.

### **Smith Chart Solution of Lossy Lines**

See transparency example.

SEE TLINE EXAMPLE.