BB 6.6 (Good conductors)

A material is considered a good conductor when the conduction current $\bar{J}_c = \sigma \bar{E}$ exceeds the displacement current $\bar{J}_D = \epsilon \frac{\partial E}{\partial t}$. If an electromagnetic wave of the form $\bar{E} = E_0 e^{i(kz-\omega t)}$ strikes a material, then the displacement current is $\bar{J}_D = -i\omega\epsilon\bar{E}$. The i here just means that the electric field and displacement current may be out of phase with each other. More importantly, the amplitude of the displacement current to the amplitude of the conduction current can be expressed as

$$\frac{J_c}{J_D} = \frac{\sigma \bar{E}}{K_e \epsilon_0 \omega \bar{E}} = \frac{\sigma}{K_e \epsilon_0 \omega}$$

It is a good conductor if $\boxed{\frac{\sigma}{K_e \epsilon_0 \omega} > 1}$. So consider

material	$\sigma\ (\Omega\text{-m})^{-1}$	K_e	max ω	max f (Hz)	wavelength
Copper	5.8e7	1	6.55e18	1.04e18	0.3 nm (x-rays)
Sea Water	3	81	4.18e9	6.66e8	45cm (micro) (microwave)
fresh water	2e-4	81	2.79e5	44.4 kHz	6.7 km (long...)
earth/rock	1e-5	6	1.88e5	30 kHz	10 km (long...)