Let's derive the reflection coefficient $r = E_r^- / E_i^+$ where the an electric field uniform plane wave UPW is incident from material 1 and hits an interface with material 2.

Using phasor notation $E(x, t) = Real\{e^{j\omega t}\bar{E}(x)\}$ where $\bar{E}(x)$ is a complex function of x.

We have travelling wave field incident from material 1 and reflected from or transmitted through to material 2. The interface between the two materials is at $x = 0$.

Phasor notation allows us to solve for the boundary conditions in the spatial variable x only:
(1) for the field in material 1: $\bar{E}_1(x) = E_i^+ e^{-\gamma_1 x} + E_r^- e^{+\gamma_1 x}$
(2) for the field in material 2: $\bar{E}_2(x) = E_t^+ e^{-\gamma_2 x}$

and applying the boundary condition at $x = 0$, the interface between the two materials:
$E_1(0) = E_2(0)$ results in a relationship between field amplitudes

$E_i^+ e^{-\gamma_1 0} + E_r^- e^{+\gamma_1 0} = E_t^+ e^{-\gamma_2 0}$
$E_i^+ + E_r^- = E_t^+$

A similar result is obtainable for the magnetic field amplitudes H

$$H_i^+ + H_r^- = H_t^+$$

Note however that for uniform plane electromagnetic fields, there is an Ohm's Law like relationship between the electric and magnetic field amplitudes
$H_i^+ = E_i^+ / \eta_1$ while
$H_i^- = -E_i^- / \eta_1$ so that

$$H_i^+ + H_r^- = H_t^+ \rightarrow E_i^+ / \eta_1 - E_r^- / \eta_1 = E_t^+ / \eta_2$$

this results in $(E_i^+ - E_r^-)\eta_2 = E_t^+ \eta_1 \rightarrow E_i^+ \eta_2 - E_r^- \eta_2 = E_t^+ \eta_1$

The two results for the electric and magnetic field amplitudes are
(3) $E_i^+ + E_r^- = E_t^+$
(4) $E_i^+ \eta_2 - E_r^- \eta_2 = E_t^+ \eta_1$

Solving for the REFLECTION COEFFICIENT r

First let's calculate for the electric field reflection coefficient $r = E_r^- / E_i^+$. We multiply Equation (3) by η_1 then combine with Equation (4) to cancel out $E_t^+ \eta_1$ to get

$$E_i^+ \eta_1 + E_r^- \eta_1 = E_i^+ \eta_2 - E_r^- \eta_2$$

transposing and combining field terms
$E_i^+ \eta_1 + E_r^- \eta_1 + E_r^- \eta_2 = E_i^+ \eta_2$

$E_r^-(\eta_1 + \eta_2) = E_i^+\eta_2 - E_i^+\eta_1$

we finally obtain

$$E_r^-(\eta_1 + \eta_2) = E_i^+(\eta_2 - \eta_1)$$

taking the ratio of the reflected to the incident field amplitudes we get

$$r = E_r^-/E_i^+ = (\eta_2 - \eta_1)/(\eta_2 + \eta_1)$$

Solving for the TRANSMISSION COEFFICIENT t

Now we calculate for the transmission coefficient, $t = E_t^+/E_i^+$, the ratio of the transmitted field amplitude to the incident field amplitude at the interface $x = 0$.

As before, the starting points are the two equations derived from the requirement of continuity at the $x = 0$ interface between both materials
(3) $E_i^+ + E_r^- = E_t^+$
(4) $E_i^+\eta_2 - E_r^-\eta_2 = E_t^+\eta_1$

However, since we have already derived r, we can use the previous result.
We divide Equation (3) by E_i^+ to get

$$1 + E_r^-/E_i^+ = E_t^+/E_i^+ = t$$

and we easily obtain

$$t = 1 + r$$

INDEX OF REFRACTION, R and T for Power/Intensity

Usually for dielectrics, the indices of refraction are given, not the material impedances.

Since $\eta_0 = \sqrt{\frac{\mu_0}{\epsilon_0}} = 377\ \Omega$ where the two parameters μ_0 and ϵ_0 are the magnetic permeability and the electric permitivitty, respectively, in a vacuum.

For a dielectric material one writes $\epsilon = \epsilon_r\epsilon_0$, where ϵ_r is called the relative permitivitty or the dielectric constant.

The index of refraction n is related to the dielectric constant $n = \sqrt{\epsilon_r}$.

Hence the intrinsic impedance in a dielectric material of relative permitivitty ϵ_r is given by

$$\eta = \sqrt{\mu_0/\epsilon_r\epsilon_0} = (1/\sqrt{\epsilon_r})(\sqrt{\frac{\mu_0}{\epsilon_0}})$$

$$\eta = (1/n)\eta_0$$

Therefore we can write the reflection coefficient $r = (\eta_2 - \eta_1)/(\eta_2 + \eta_1)$ as

$$r = (\frac{\eta_0}{n_2} - \frac{\eta_0}{n_1})/(\frac{\eta_0}{n_2} + \frac{\eta_0}{n_1}) = (\frac{1}{n_2} - \frac{1}{n_1})/(\frac{1}{n_2} + \frac{1}{n_1})$$

So the field reflection coefficient in terms of indices of refraction is

$$r = (n_1 - n_2)/(n_1 + n_2)$$

The field transmission coefficient is:

$$t = 1 + r = (n_1 + n_2)/(n_1 + n_2) + (n_1 - n_2)/(n_1 + n_2)$$

$$t = 2n_1/(n_1 + n_2)$$

The Power reflectivity R is calculated from r^2 (note: $R = rr^*$ for complex dielectric constants).

$$R = (n_1 - n_2)^2/(n_1 + n_2)^2$$

$$T = 1 - R$$