

LIST OF SYMBOL

P_t	: Transmitted power of the radar
G_t	: Gain of the transmitting antenna
λ	: Wavelength of the radar signal
σ	: Radar cross section or electrical conductivity (context-dependent)
A	: Effective area of the target
R	: Distance between radar and target
L	: Attenuation factor or path loss
A_r	: Effective aperture area of the receiving antenna
α	: Attenuation constant
β	: Phase constant
ω	: Angular frequency
μ	: Permeability of the medium
ε	: Permittivity of the medium
ε_0	: Vacuum permittivity
μ_0	: Vacuum permeability
η	: Intrinsic impedance of a medium
Z	: Total impedance at a specific point in a medium

Γ	: Reflection coefficient between two media
γ	: Propagation constant ($\gamma = \alpha + j\beta$)
ε_r	: Relative permittivity
v	: Volume fraction of a component
ε_m	: Effective permittivity of the mixture
ε_a	: Permittivity of component A (e.g., air)
ε_b	: Permittivity of component B (e.g., vegetation)
v_b	: Volume fraction of component B (e.g., stems)
x	: $\sigma / (\omega\varepsilon)$, ratio of conductivity to permittivity-frequency product
t	: Time
f	: Frequency
S_{11}, S_{21}	: Reflection and transmission coefficients (S-parameters)
Δt	: Time delay due to propagation
$\varepsilon_1, \varepsilon_2, \varepsilon_3$	: Permittivity of air, vegetation, and soil layers
μ_1, μ_2, μ_3	: Permeability of air, vegetation, and soil
η_1, η_2, η_3	: Intrinsic impedance of air, vegetation, and soil
Z_1, Z_2, Z_3	: Total impedance of air, vegetation, and soil

$\Gamma_{1,2}, \Gamma_{2,3}, \Gamma_{3,4}$: Reflection coefficients at each interface

$\sigma_1, \sigma_2, \sigma_3$: Conductivity of air, vegetation, and soil

y' : Depth position into the layer

d : Thickness of vegetation layer

θ : Angle of incidence

N : Number of frequency steps in SFCW

Δf : Frequency step size

B : Total bandwidth

T : Total sweep duration