Qualifying Exam Fall 2011: Transmission Lines, Fields and Waves

Note that $\epsilon_0 = 8.8542 \cdot 10^{-12}$ F/m, and $\mu_0 = 4\pi \cdot 10^{-7}$ H/m.

1. (a) The reflection coefficient at the input gate of a microwave FET in the grounded source configuration, is measured as 0.3$\angle$ -25 $^\circ$ in a 50Ω transmission line system at 6 GHz, with the transmission line velocity 1×10^8 m/sec.

   i. At what distance in wavelengths and cms, nearest to the gate is the voltage minimum along this line? (Use a Smith Chart) (0.5 points)

   ii. What is the input impedance in ohms at this voltage minimum? (0.5 points)

   iii. Design a quarter-wave transformer matching circuit for the input gate of this device to 50 Ω from this voltage minimum. (1 point)

   (b) With crude oil prices of over $80 per barrel, extraction of oil from shale is an economic proposition. In one such procedure, a coaxial line with slots is placed in a borehole, and radiates at 915 MHz into the shale, to separate the oil and water from the soil. Assume that the ϵ_r of wet oil loaded shale is 25.5 and σ is 0.5 S/m, and also assume **plane wave propagation**.

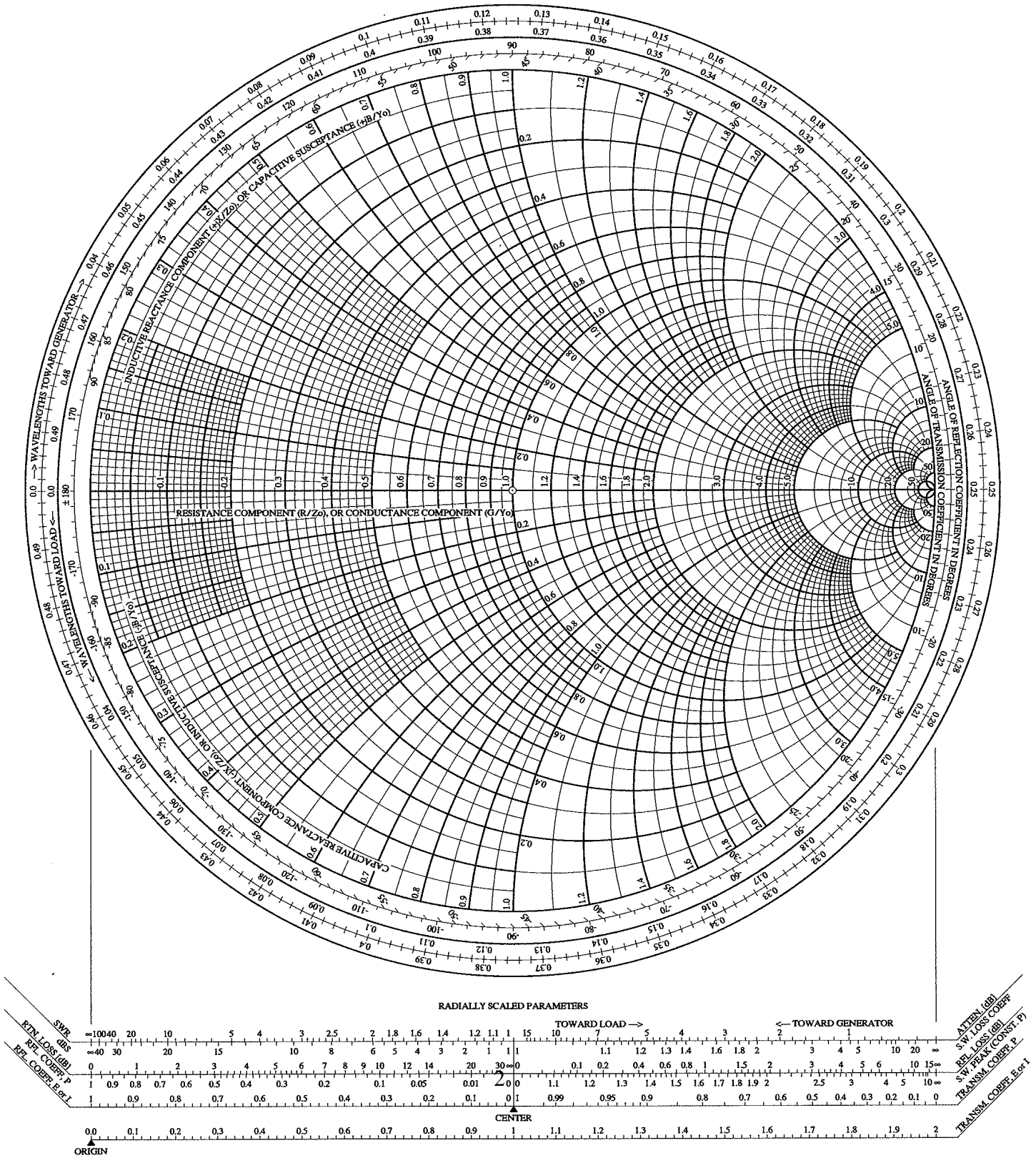
   i. What is the complex permittivity ϵ_c of the shale? (0.5 points)

   ii. What is the skin depth of the medium? 0.5 points)

   iii. What is the attenuation in dB/m in the direction away from the borehole? (0.5 points)

   iv. Determine the the distance at which the radiated power decays to an electric field value of 10 μV/cm if the initial power density in the soil at the edge of the borehole is 2.75KW/m^2. (0.5 points)

Smith Chart


RESISTANCE COMPONENT (R/Zo), OR CONDUCTANCE COMPONENT (G/Yo)
INDUCTIVE REACTANCE COMPONENT (+jX/Zo), OR CAPACITIVE SUSCEPTANCE (+jB/Yo)
CAPACITIVE REACTANCE COMPONENT (-jX/Zo), OR INDUCTIVE SUSCEPTANCE (-jB/Yo)
ANGLE OF REFLECTION COEFFICIENT IN DEGREES
ANGLE OF TRANSMISSION COEFFICIENT IN DEGREES
--> WAVELENGTHS TOWARD GENERATOR -->
<-- WAVELENGTHS TOWARD LOAD <--
--> ANGLE OF TRANSMISSION COEFFICIENT -->
RADIALLY SCALED PARAMETERS
TOWARD LOAD -->
<-- TOWARD GENERATOR
SWR
RTN. LOSS (dB)
RFL. COEFF. P
RFL. COEFF. E or I
ATTEN. (dB)
S.W. LOSS COEFF
RFL. LOSS (dB)
S.W. PEAK (CONST. P)
TRANSM. COEFF. E or I
CENTER
ORIGIN