Chapter 14: Passive Contact Probes

14.1C In many student laboratories, the scope "probe" consists of two alligator clips connected to a three foot, 50 Ω coaxial cable. This cable is sometimes connected directly to the 1 MΩ, 25 pF input of the scope. The mismatch at the scope and the loading of the circuit under test by the probe are often ignored. For what frequencies and circuit impedances is this justified?

14.2 In reference to the improved model of the low-impedance passive probe discussion in this chapter, sketch the Bode magnitude and phase plot of the input impedance of the probe:

$$Z_{probe} = \frac{R\dfrac{1}{j\omega C_p}}{R + \dfrac{1}{j\omega C_p}} + 50$$

14.3 Repeat the entire analysis given in the improved model of the low-impedance probe discussion in this chapter but assume that the parasitic capacitance of the probe is negligible while the series parasitic inductance of the probe is not negligible.

14.4 It is stated that the upper operating frequency of a resistive probe can be extended by replacing the single probe resistor of value R with two series resistors each of value $R/2$. Determine the validity of this claim. Assume the parasitic capacitance of R is equal to C_p, and the parasitic capacitance of each $R/2$ is also equal to C_p.

14.5C Repeat the entire analysis given in the improved model of the cable and scope discussion in this chapter for the low-impedance probe using the appropriate transmission line equation(s) to model the 50 Ω transmission line instead of the lumped circuit model. Discuss the results.

14.6C Repeat the entire analysis given in the improved model of the cable and scope discussion in this chapter for the low-impedance probe but assume that the transmission line is lossy with a resistance of R Ω/ft. The transmission line can be assumed electrically short. Discuss the results. Use a reasonable value for R for the <u>numerical</u> analysis.

14.7C In reference to the high-impedance passive probe discussion in this chapter, instead of plotting the magnitude of the input impedance and gain, plot the angle of the input impedance and gain over the same range of frequencies. If the phase angle is not constant over the range of constant input impedance and gain, determine the consequences of the varying angle.

14.8E Repeat the analysis given in the high-impedance probe compensator discussion in this chapter but do not neglect the inductance of the cable.

14.9C Repeat the entire analysis given in the testing with a square wave discussion in this chapter but use a triangular wave instead of a square wave.

14.10C Repeat the entire analysis in the testing with a square wave discussion in this chapter but use a half-wave rectified sine wave instead of a square wave.

14.11C Plot, using the first 100 harmonics, a signal in the time domain that has the same amplitude coefficients as a square wave but zero phase for all frequency components. Does the signal look like a square wave?

14.12C Repeat the entire analysis given in the inductance effects of the probe discussion in this chapter but assume that the transmission line is lossy with a resistance of 10 Ω/ft, 40 Ω/ft, and 80 Ω/ft. Discuss the results. Does the frequency range of the probe increase with line loss?

14.13 Often for impedance matching, 50 Ω input oscilloscopes and spectrum analyzers are used with 50 Ω lines. Why is a 50 Ω input more susceptibility to damage than a 1 MΩ input?

14.14 Provide two different reasons why the connection of a scope to a circuit may actually increase the noise to a circuit.

14.15 Provide two different reasons why the connection of a scope to a circuit may actually decrease the noise to a circuit.

14.16 Differential measurements reduce the effect of ground loops and reject common-mode noise sources. Why? If one coaxial line is used as the transmission line between the probe and the scope, why is the measurement not differential? Two coaxial lines can be used to produce a differential probe. Explain how this can be accomplished. How would this probe be calibrated? How would a null experiment be performed? What should be done with the shields (ground leads) at the probe end?

14.17 Null experiments are used to validate a measurement. Null experiments have an obvious outcome, usually zero. For example, when using a pickup loop, is the loop measuring the current in the circuit or some other time-varying noise? How can a null experiment be performed for a "sniffer" pickup loop discussed in the *Inductance, Magnetic Coupling, and Transformer* chapter? Assume the measurement device is either a scope or spectrum analyzer.