VSWR Measurements using a Slotted Line

Objectives:
- To utilize a slotted line setup to demonstrate standing waves due to impedance mismatch.
- To utilize slotted line measurements to determine the impedance of loads.

Equipment:
- Slotted line (Type 874-LBA slotted line)
- RF signal generator (HP 8647A)
- Sampling oscilloscope (Tektronix CSA 8000)
- Cables and Adapters
- Slotted line terminations
  - Short circuit (874-WN3)
  - Open circuit
  - Matched impedance (874-W50B)
  - Coax cable (GR 874)
  - Given impedance (100 pf capacitor)
- Tape measure

Prelab:

1. Voltage minima on the slotted line are located 20 cm apart. What is the frequency of the signal being used for the slotted line test?

2. For a particular load, the maximum sinusoidal voltage along the slotted line is measured to be 20 mV and the minimum sinusoidal voltage is 100 µVolt.
   - What is the VSWR?
   - What is the magnitude of the reflection coefficient?
   - What is the SWR (in dB)?

3. The 50 Ω slotted line is terminated with a 50 Ω load. The sinusoidal voltage at 10 cm from the load is 100 mV.
   - What is the VSWR?
   - What is the magnitude of the reflection coefficient?
   - What is the SWR (in dB)?
   - What is the sinusoidal voltage 15 cm from the load? 20 cm from the load?

PROCEDURE

Be sure that you wear the antistatic wrist strap while working with the CSA
Setup:

- Configure the RF signal generator for a frequency of 400 MHz and a power level of 2.0 dBm. Ensure the RF is ON. Connect the RF out to the slotted line input (connector on the moving portion of the carriage).

- Ensure that the sampling scope is connected to the slotted line as follows: The slotted line input is connected to the “Trigger Direct Input”. The slotted line output (at the left side of the carriage) is connected to the 80E04 Sampling Module’s CH 1.

- Power on the sampling oscilloscope. Press CH > 1 under the Vertical heading. Select (click) the peak-to-peak (Pk-Pk) icon among those that appear above the trace. You should see this measurement being displayed on the right side of the trace. Set the averaging to 16 samples (Setup > Acquire > Acq > 16) and enable (above display > Acq Mode > Average).

1. Open Circuit Line.

- Connect the open circuit termination to the right end of the slotted line. This termination is the disk with no components places between the central terminal and outer disk.

**Observation:** Measure and record HERE the actual position of the open load relative to the end of the carriage (55 cm mark).

- Move the carriage along the slotted line using the drive drum and stop at point where the scope measurement is a maximum.

**Observation:** What is this maximum Pk-Pk voltage measurement and the carriage position at which it occurred?

- Once again, move the carriage along the slotted line but this time stop at point where the scope measurement is a minimum.

**Observation:** What is this minimum Pk-Pk voltage measurement and the carriage position at which it occurred?

- To determine the $\lambda/2$ length, locate the adjacent minimum and record that value HERE.

**Observation:** Why are voltage minima (vs. maxima) used to determine the $\lambda/2$ length?
Record the voltages at the positions noted in Table 1.

2. Short Circuited Line.
   - Connect the short circuit termination to the right end of the slotted line. This termination is marked with 874-WN3.

   **Observation:** Measure and record HERE the actual position of the load relative to the end of the carriage (55 cm).

   - Move the carriage along the slotted line using the drive drum and stop at point where the scope measurement is a maximum.

   **Observation:** What is this maximum Pk-Pk voltage measurement and the carriage position at which it occurred?

   - Once again, move the carriage along the slotted line and stop at point where the scope measurement is a minimum.

   **Observation:** What is this minimum Pk-Pk voltage measurement and the carriage position at which it occurred?

   - Record the voltages at the positions noted in Table 1.

   - Attach the 50 Ω termination (874-W50B) to the right end of the slotted line.

   - Record the voltages at the positions noted in Table 1.

   **Observation:** What do you notice in this test scenario that differs from Parts 1 and 2? WHY?

   **Observation:** What are the voltage maxima and minima measured?

- Attach the “unknown” load to the right end of the slotted line. This is the termination with the capacitor mounted between two twist terminals.
- Move the carriage along the slotted line using the drive drum and stop at point where the scope measurement is a maximum.

**Observation:** What is this maximum Pk-Pk voltage measurement and the carriage position at which it occurred?

- Once again, move the carriage along the slotted line and stop at point where the scope measurement is a minimum.

**Observation:** What is this minimum Pk-Pk voltage measurement and the carriage position at which it occurred?

- Accurately measure the distance from the load to the voltage minima closest to the load. Record that value HERE.

- Record the voltages at the positions noted in Table 1.

5. Coax Cable.

- Attach the coaxial cable (GR 874) to the right end of the slotted line. Ensure the far end of the coax is terminated with the open circuit load.

**Observation:** Measure and record HERE the actual position of the load relative to the end of the carriage (55 cm).

- Move the carriage along the slotted line using the drive drum and stop at point where the scope measurement is a maximum.

**Observation:** What is this maximum Pk-Pk voltage measurement and the carriage position at
Once again, move the carriage along the slotted line and stop at point where the scope measurement is a minimum.

Observation: What is this minimum Pk-Pk voltage measurement and the carriage position at which it occurred?

Accurately measure the distance from the near side of the cable to its closest minima. Record that value here.

Record the voltages at the positions noted in Table 1.

Laboratory Summary Questions:

1. Use your data from Part 1 to calculate the frequency this test is being performed. Discuss the constraints that limit the accuracy of this method.

2. Use your data to determine VSWR and SWR for each of the five (5) tests being performed.

3. Use Excel/Matlab and your Table 1 data to plot the standing wave pattern for each of the five (5) test scenarios.

4. Use your standing wave pattern for the open circuit case to determine the effective position of the open circuit termination. Compare this to the physical position of the open circuit.

5. Repeat problem 4, this time for the short circuit case. Use the pattern to determine the effective position of the open circuit. Compare with the actual position of the open circuit.

6. Use your data from Part 4 to determine the impedance of the capacitor at 400 MHz. Reference pages 6 & 7 of the handout as to methodology. Compare your results with what you expect the impedance of a 100 pf capacitor to be at 400 MHz (show all calculations).

7. Use your data from Part 5 to determine the impedance of the coax at 400 MHz. Discuss your results.

Please note any corrections to the procedure and give them to the instructor or TA. Thanks.
Table 1. Standing Wave Pattern Data

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