Department of Electrical and Computer Engineering
FIELDS AND WAVES LABORATORY
Courses ECE 320F and ECE 357S
<u>III Year</u>
Periodic Transmission Line (Photonic Crystals)

Experiment;

In this experiment you will measure the transmission magnitude, phase, and group delay of a periodic transmission line (PTL) in the frequency domain. You will then study the time-domain propagation of a Gaussian pulse through the PTL in both the pass and stop bands. Consequently, you will observe the subluminal and superluminal group velocities and group delays.

References:

1) A. Haché and L. Poirier, in *Long-range superluminal pulse propagation in a coaxial photonic crystal,* Applied Physics Letters, Vol 80, No. 3 (2002)
2) Your class notes

Lab Equipment Required:

1. HP 8712ET Vector Network Analyzer (VNA).
2. Agilent 33250A Arbitrary Waveform Generator (ARB).
3. Agilent DSO3202A Oscilloscope.
4. One coil of periodic coaxial cable consisting of 12 unit cells as described below. This is our PTL mentioned above.
5. One coil of RG58 regular coaxial cable, 24.6 meters long. This is our regular transmission line (TL.)
6. Mini-circuits Power Divider ZFRSC-2050.
7. One 30 cm long 50 Ω RG58 coaxial cable.
8. One 60 cm long 50 Ω RG58 coaxial cable.
9. Two 50Ω feed through terminations connected to scope inputs.
10. 128 MB USB memory stick (provided, if necessary, TO BE RETURNED).

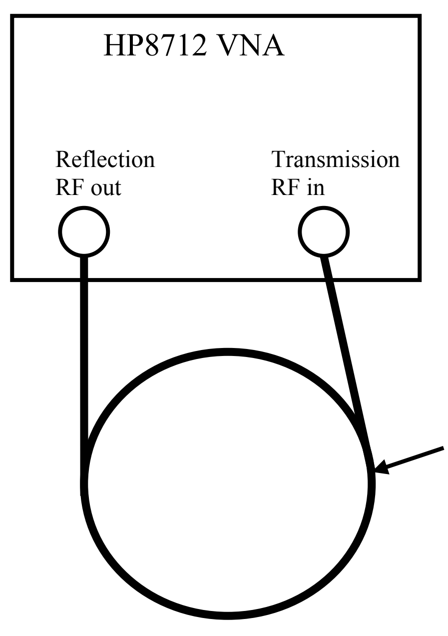

Figure 1: Network Analyzer Setup

Part 1: Frequency Domain Measurement

Figure 1 shows the initial setup for Part 1 of the Lab-4. The PTL has 12 unit cells of coaxial cable connected in series. One unit cell consists of one segment of one meter long 50 Ω RG58, a female-female BNC barrel connector, and one segment of one meter long 75 Ω RG59 coaxial cable (red markings on connectors and slightly larger outside diameter), as shown in Fig. 2.

Figure 2: One unit cell of the PTL

Setup the VNA for a frequency sweep of 20 MHz to 80 MHz by doing the following;

1. Press Freq
2. Press Start
3. Enter 20 using the front panel keyboard.
4. Press MHz.
5. Press Stop
6. Enter 80 using the front panel keyboard.
7. Press MHz.
8. Press Menu
9. Press Number of Points
10. Set the number of points to 801

Using the supplied BNC calibration standards (50 Ω load, open, short) calibrate the VNA by doing the following;

1. Press Cal.
2. Press Enhanced Response.
3. Follow the instructions on the screen. For the through, use the 30 cm cable connected between the Reflection RF out and Transmission RF in ports.
4. Press Meas 1
5. Press Transmission

Measuring the transmission magnitude, phase, and group delay of the regular 24.6 meter coaxial transmission line:

Connect the regular 50 Ω RG58 coaxial cable to the VNA. The length of this cable is equal to the total length of the 12 unit cell PTL described above. Attach one end of the regular TL to the reflection port of the VNA and the other to the transmission port. Measure and record the transmission magnitude, phase, and group delay of the regular TL by doing the followings:

1. To measure the transmission magnitude in linear format (not dB) press format and then choose Lin Mag. Measure and record the transmission coefficient magnitude on the analyzer CRT.
2. To measure the transmission phase press format and then choose Phase. Measure and record the transmission coefficient phase on the analyzer CRT.
3. To measure the group delay press format and then choose Delay. Measure and record the group delay on the analyzer CRT.

Disconnect the cable when finished.

Measuring the transmission magnitude, phase, and group delay of the PTL:

Connect the 12 unit cell PTL to the VNA. The 12 unit cells are already connected in series, in a coil held together with cable ties. There is a cable tie located at the end of unit cells 6, 9, and 12 with a mark indicating the number of unit cells. Attach the 50 Ω end of the PTL to the reflection port of the VNA and the 75 Ω end to the transmission port. Measure and record the transmission magnitude, phase, and group delay of the PTL by doing the following:

1. To measure the transmission magnitude in linear format (not dB) press format and then choose Lin Mag. Measure and record the transmission coefficient magnitude on the analyzer CRT.
2. To measure the transmission phase press format and then choose Phase. Measure and record the transmission coefficient phase on the analyzer CRT.
3. To measure the group delay press format and then choose Delay. Measure and record the group delay on the analyzer CRT.
4. Press Meas 1.
5. Press Reflection.
6. To mesure the reflection magnitude in linea format (not dB) press format and then choose Lin Mag. Measure and record the reflection coefficient magnitude on the analyzer CRT.
7. Press Meas 1.
8. Press Transmission.

Leave the 50 Ω cable end connected to the Reflection port (RF out). Disconnect the 75 Ω cable from the Transmission port. Disconnect the barrel connector at the 75 Ω end (red markings) at the unit cell marked 9. Leave the barrel connector connected to the 50 Ω end. Connect the 75 Ω end to the Transmission port (RF in). Measure and record the transmission magnitude, phase, and group delay of the nine unit cell PTL by repeating the steps 1-8 above. Re-connect the 75 Ω cable to the same barrel connector that it was removed from.

Leave the 50 Ω cable end connected to the Reflection port (RF out). Disconnect the barrel connector at the 75 Ω end (red markings) at the unit cell marked 6. Leave the barrel connector connected to the 50 Ω end. Connect the 75 Ω end to the Transmission port (RF in). Measure and record the transmission magnitude, phase, and group delay of the six unit cell PTL by repeating the steps 1-8 above. Re-connect the 75 Ω cable to the same barrel connector that it was removed from.

Part 2: Time Domain Measurements

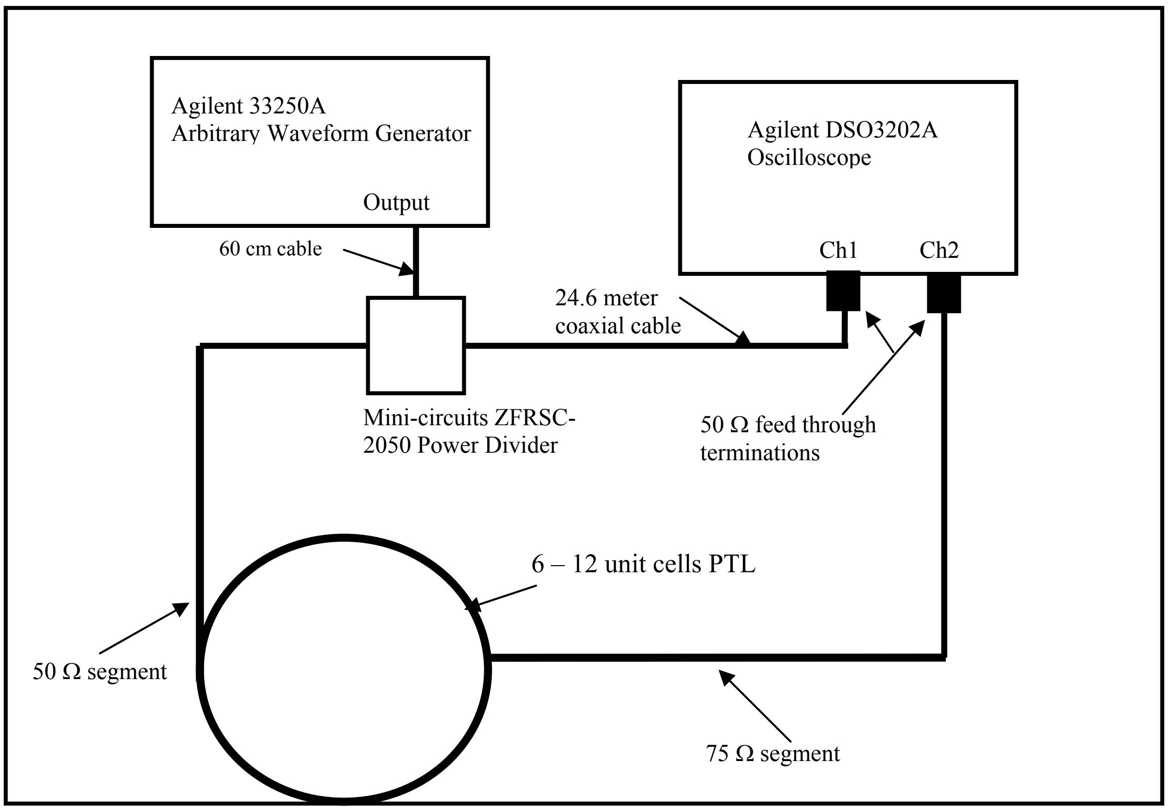

Figure 3: Arbitrary Waveform Generator (ARB) and Oscilloscope Setup

Figure 3 shows the setup for part 2 of the experiment. Connect the 50 Ω segment of the PTL to the Min-circuit power divider and the 75 Ω segment of the PTL to the 50 Ω feed through as shown in Fig. 3. Turn on the ARB and oscilloscope. The Mini-circuits power divider splits the output waveform of the ARB into two equal signals. One signal is sent to the coaxial PTL and the second directly to Channel-1 of the oscilloscope through the 24.6 meter RG58 regular TL. The input impedance of the oscilloscope is normally 1 Meg Ω, the 50 Ω feed through makes this input impedance equal to 50 Ω. Trigger the oscilloscope on Channel 1.

To access the stored waveforms on the ARB do the following;

1. Press Arb on the front panel.
2. Press Select Wform.
3. Press Stored Wforms. The ARB has three waveforms saved in its memory. The saved waveforms represent frequencies below, above, and in the stop band of the PTL as determined in Part 1 of this experiment. The three frequencies are modulated by a Gaussian shaped pulse. They are designated BDPASSLO (Mem 1), BDPASSHI (Mem 2) and BDSTOP (Mem 3).
4. Press Arb Mem1 to access the BDPASSLO waveform.
5. Press Select Arb.
6. Freq is highlighted. Set the frequency for 1 MHz by pressing 1 then press MHz.
7. Press Ampl and set the output level to 7.0 Volt p-p.
8. On the front panel turn on the output.

Measure and record the time traces on the CH1 and CH2 of the oscilloscope. Record the time difference between the peaks of the pulses on CH1 and CH2. Repeat the above measurements using the waveform BDPASSHI located in Mem 2. Repeat the above measurements using the waveform BDSTOP located in Mem 3.