ElecEng 2FL3

ASSIGNMENT 4

Quasi-TEM Transmission Lines – Voltage & Current Waves

Jinyi Tan, Zekun Xia, and Natalia K. Nikolova

1. *Instructions*

- Answer all questions.
- Submit your answers through A2L by the deadline.
- Submission format for each question is provided right after the question itself.

This assignment does not require an analytical solution. It contains four parts:

A. Writing a MATLAB program to calculate: (i) the complex propagation constant, (ii) the phase velocity, (iii) the wavelength, and (iv) the characteristic impedance, of a transmission line (TL) defined by its per-unit-length (*PUL*) parameters. In this part, a **low-loss TL** is analyzed.

Although an analytical solution is not required, it is strongly recommended that the students verify their MATLAB code by performing an analytical calculation at one frequency and comparing their result with the MATLAB output at this frequency. This analytical calculation is fast as the approximate formulas from Lecture 5 sl. 27 can be used.

B. Modifying the input parameters for the MATLAB program written in Part A to calculate: (i) the complex propagation constant, (ii) the phase velocity, (iii) the wavelength, and (iv) the characteristic impedance, of a **lossy** TL defined by its per-unit-length (*PUL*) parameters.

It is strongly recommended that the students verify their MATLAB code by performing an analytical calculation at one frequency and comparing their result with the MATLAB output.

2. *Problem Statement*

It is assumed that at this stage the students have gained sufficient knowledge of the MATLAB programming environment in order to be able to complete the MATLAB portion of this Assignment without having the benefit of an example ***.m file.

A. MATLAB Problem: Low-loss Transmission Line [50 points]

A TL has the *PUL* parameters R' (Ω/m), L' (nH/m), G' (mS/m), and C' (pF/m). Pick a set of *PUL* parameters based on the **last two digits of your student number** from **Table I**. Write a MATLAB code to calculate: (i) the complex propagation constant γ, (ii) the phase velocity v_p, (iii) the wavelength λ, and (iv) the characteristic impedance Z_0 in the frequency range from 100 MHz to 10 GHz. The code must also generate the following plots:

(a) $\alpha = \mathrm{Re}\,\gamma$ versus frequency,
(b) $\beta = \mathrm{Im}\,\gamma$ versus frequency,
(c) phase velocity v_p versus frequency,
(d) wavelength λ versus frequency,
(e) ReZ_0 (real part of Z_0) versus frequency,
(f) ImZ_0 (imaginary part of Z_0) versus frequency.

Label the axes on your plots properly using SI units.

Submission format: MATLAB code upload to A2L. Please name properly, e.g., A4A_LastName_FirstName.m

B. MATLAB Problem: Lossy Transmission Line [50 points]

Pick a set of *PUL* parameters based on the **last two digits of your student number** from **Table II**, repeat the task in Part A with the respective plots (a), (b), (c), (d), (e), and (f).

Submission format: MATLAB code upload to A2L. Please name properly, e.g., A4B_LastName_FirstName.m

Summary of Required Files to be Submitted for Assignment 4

Part A: MATLAB file, `A4A_LastName_FirstName.m`
Part B: MATLAB file, `A4B_LastName_FirstName.m`

Table I and Table II follow on next pages.

TABLE I
VARIATIONS OF *PUL* PARAMETERS FOR PARTS A, C, AND D

Last 2 Digits	*R'* (Ω/m)	*L'* (nH/m)	*G'* (mS/m)	*C'* (pF/m)
00	1.05	167	0.38	67
01	1.08	172	0.39	69
02	1.11	177	0.4	71
03	1.14	181	0.41	73
04	1.17	186	0.43	74
05	1.2	191	0.44	76
06	1.23	196	0.45	78
07	1.26	201	0.46	80
08	1.29	205	0.47	82
09	1.32	210	0.48	84
10	1.35	215	0.49	86
11	1.38	220	0.5	88
12	1.41	224	0.51	90
13	1.44	229	0.52	92
14	1.47	234	0.53	94
15	1.5	239	0.55	95
16	1.53	244	0.56	97
17	1.56	248	0.57	99
18	1.59	253	0.58	101
19	1.62	258	0.59	103
20	1.65	263	0.6	105
21	1.68	267	0.61	107
22	1.71	272	0.62	109
23	1.74	277	0.63	111
24	1.77	282	0.64	113
25	1.8	286	0.65	115
26	1.83	291	0.67	117
27	1.86	296	0.68	118
28	1.89	301	0.69	120
29	1.92	306	0.7	122
30	1.95	310	0.71	124
31	1.98	315	0.72	126
32	2.01	320	0.73	128
33	2.04	325	0.74	130
34	2.07	329	0.75	132

35	2.1	334	0.76	134
36	2.13	339	0.77	136
37	2.16	344	0.79	138
38	2.19	349	0.8	139
39	2.22	353	0.81	141
40	2.25	358	0.82	143
41	0.75	179	0.43	72
42	0.81	193	0.46	77
43	0.87	208	0.5	83
44	0.93	222	0.53	89
45	1.05	251	0.6	100
46	1.11	265	0.63	106
47	1.17	279	0.67	112
48	1.23	294	0.7	117
49	1.29	308	0.74	123
50	1.35	322	0.77	129
51	1.41	337	0.81	135
52	1.47	351	0.84	140
53	1.59	253	0.26	45
54	1.62	258	0.26	46
55	1.65	263	0.27	47
56	1.68	267	0.27	48
57	1.74	277	0.28	49
58	1.77	282	0.29	50
59	1.8	286	0.29	51
60	1.83	291	0.3	52
61	1.86	296	0.3	53
62	1.92	306	0.31	54
63	1.95	310	0.32	55
64	1.98	315	0.32	56
65	2.01	320	0.32	57
66	2.04	325	0.33	58
67	2.07	329	0.33	59
68	2.13	339	0.34	60
69	2.16	344	0.35	61
70	2.19	349	0.35	62
71	2.22	353	0.36	63
72	2.25	358	0.36	64

73	1.26	301	0.32	53
74	2.13	339	0.19	34
75	2.19	349	0.2	35
76	2.25	358	0.2	36
77	1.98	472	1.03	189
78	1.74	442	1.06	177
79	1.75	417	0.91	167
80	1.55	394	0.94	157
81	1.56	373	0.82	149
82	1.39	355	0.85	142
83	1.19	284	0.62	114
84	1	254	0.61	102
85	1.03	245	0.54	98
86	0.85	203	0.44	81
87	0.78	198	0.47	79
88	0.74	187	0.45	75
89	0.67	169	0.41	68
90	1.9	484	0.51	86
91	1.78	426	0.41	76
92	1.61	410	0.44	73
93	1.65	395	0.38	70
94	1.54	368	0.36	65
95	1.86	444	0.24	44
96	1.69	431	0.26	43
97	1.75	418	0.23	42
98	1.6	407	0.24	41
99	1.66	395	0.22	40

TABLE II
VARIATIONS OF *PUL* PARAMETERS FOR PART B

Last 2 Digits	R' (Ω/m)	L' (nH/m)	G' (mS/m)	C' (pF/m)
00	262.5	167	57	67
01	108	172	97.5	69
02	277.5	177	60	71
03	114	181	102.5	73
04	292.5	186	64.5	74
05	120	191	110	76
06	307.5	196	67.5	78
07	126	201	115	80
08	322.5	205	70.5	82
09	132	210	120	84
10	337.5	215	73.5	86
11	138	220	125	88
12	352.5	224	76.5	90
13	144	229	130	92
14	367.5	234	79.5	94
15	150	239	137.5	95
16	382.5	244	84	97
17	156	248	142.5	99
18	397.5	253	87	101
19	162	258	147.5	103
20	412.5	263	90	105
21	168	267	152.5	107
22	427.5	272	93	109
23	174	277	157.5	111
24	442.5	282	96	113
25	180	286	162.5	115
26	457.5	291	100.5	117
27	186	296	170	118
28	472.5	301	103.5	120
29	192	306	175	122
30	487.5	310	106.5	124
31	198	315	180	126
32	502.5	320	109.5	128
33	204	325	185	130
34	517.5	329	112.5	132

35	210	334	190	134
36	532.5	339	115.5	136
37	216	344	197.5	138
38	547.5	349	120	139
39	222	353	202.5	141
40	562.5	358	123	143
41	187.5	179	64.5	72
42	202.5	193	69	77
43	217.5	208	75	83
44	232.5	222	79.5	89
45	262.5	251	90	100
46	277.5	265	94.5	106
47	292.5	279	100.5	112
48	307.5	294	105	117
49	322.5	308	111	123
50	337.5	322	115.5	129
51	352.5	337	121.5	135
52	367.5	351	126	140
53	397.5	253	39	45
54	162	258	65	46
55	412.5	263	40.5	47
56	168	267	67.5	48
57	174	277	70	49
58	442.5	282	43.5	50
59	180	286	72.5	51
60	457.5	291	45	52
61	186	296	75	53
62	192	306	77.5	54
63	487.5	310	48	55
64	198	315	80	56
65	502.5	320	48	57
66	204	325	82.5	58
67	517.5	329	49.5	59
68	532.5	339	51	60
69	216	344	87.5	61
70	547.5	349	52.5	62
71	222	353	90	63
72	562.5	358	54	64

73	315	301	48	53
74	213	339	47.5	34
75	219	349	50	35
76	225	358	50	36
77	495	472	154.5	189
78	261	442	265	177
79	437.5	417	136.5	167
80	232.5	394	235	157
81	390	373	123	149
82	208.5	355	212.5	142
83	297.5	284	93	114
84	150	254	152.5	102
85	257.5	245	81	98
86	212.5	203	66	81
87	117	198	117.5	79
88	111	187	112.5	75
89	100.5	169	102.5	68
90	285	484	127.5	86
91	445	426	61.5	76
92	241.5	410	110	73
93	412.5	395	57	70
94	385	368	54	65
95	465	444	36	44
96	253.5	431	65	43
97	437.5	418	34.5	42
98	240	407	60	41
99	415	395	33	40