Lab 6 : Time-Domain Reflectometer

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**Part II.**

We connected a 73 inch RG-58 coaxial cable to the O-scope with a square wave (20% duty cycle, 100mVPP) being sent down the transmission line. Table 1, 2, and 3 show our measurements for each voltage step and the time they occurred for an open circuit, short circuit, 50 ohm load, and a variety of capacitors and inductors. In addition to the step voltages, we measured the time constant of the circuit. The graphs of our circuits can be found on the last page of our lab report.

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | Peak | | Drop | | Stepdown | | End | |
| Open Circuit | 100 mV | 0 ns | 199 mV | 98 ns | 100 mV | 1.85 us | 0 V | 1.95 us |
| Short Circuit | 98 mV | 0 ns | 0 V | 94 ns | -103 mV | 1.85 us | 0 V | 1.95 us |
| 50-Ohm Load | 101 mV | 0 ns |  |  |  |  | 0 V | 1.86 us |

Table 1: Voltage Values for Open, Short, and 50-Ohm load circuits

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Event | 1 nF | | 100 nF | | 10uF | | 33 uF | |
| Start Voltage | 0 V |  | 12.5 mV |  | 32.5 mV |  | 32.5mV |  |
| Step up | 98 mV | 0ns | 114.4 mV | 0ns | 136.25mV | 0ns | 135mV |  |
| Drop | 30 mV | 90ns | 21.25 mV | 84ns | 44.375 | 104 ns | 49.375mV | 106ns |
| Rise to peak | 200 mV | 344ns | 69.3 mV | 1.85us |  |  |  |  |
| Drop | 1007 mV | 1.85us | -32.5 mV | 1.85us | -58.75 mV | 1.854us | 53.125mV | 1.856us |
| Spike | 168 mV | 1.95us | 63.75 mV | 1.94us | 1.968us |  |  | 1.964us |
| Decay to 0 V | 0 v | 2.22us | 12.5 mV | 10 us | 32.5 mV | 2.07us | 30.625mV | 2.032 us |
| Time constant | 29ns | | 6.67 us | | ? Never charges | | ? Never charges | |

Table 2: Capacitor Voltage Values

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | 36.5 nH | | 475 nH | |
| Rise | 103.125 mV | 0 ns | 101.875mV | 0 ns |
| Fall | 6.875mV | 104 ns | 6.250mV | 104 ns |
| Fall | -98.125mV | 1.856 us | -100mV | 1.856 us |
| Rise |  | 1.964 us |  | 1.966 us |
| Decay | 0mV | 2.08 us | 0 mV | 2.092 us |
| Peak | 123.75mV |  | 148.5mV |  |
| Time Constant | 1 ns | | 16 ns | |

Table 3: Inductor Voltage Values

**Part II B.**

To measure the characteristic impedance of the RG-58 coaxial cable, we chose to use the first method describe in the lab spec. We chose this method because the second method is virtually impossible. To find the characteristic impedance we used equation 1 to solve for ZO where V1+ is 101 mV, VG is 200 mV (measured at the O-scope), and RG is 50 ohms. By solving the equation, we find ZO to be 49.99 Ohms.

Equation 1: Voltage Divider

**Part III.**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | ZL | ΓL | V1+ | V1- | 1st Step | 2nd Step | Time Constant |
| Open | ∞ | 1 | .1 | .1 | .1 | .2 |  |
| Short | 0 | -1 | .1 | -.1 | .1 | 0 |  |
| 50-Ohm load | 50 | 0 | .1 | 0 | .1 | .1 |  |
| 33 uF Capacitor | .048 | -.99 | .1 | -.099 | .1 | .001 | 1.65 ms |
| 100 nF Capacitor | 15.91 | -.517 | .1 | -.052 | .1 | .048 | 5 us |
| 475 nH Inductor | .298 | -.98 | .1 | -.098 | .1 | .002 | 9.5ns |

Table 4: Calculated Voltage Values and Time Constants

The first step which shows V1+, is the voltage going down the transmission line which is at 0s. The second step, V1-, is the reflection wave which takes time 2T from the first step. The timing between major events is very similar between different termination types. The main difference between different termination types is what the voltage does at each timing event.

**Part IV.**

To calculate the propagation speeds for the two different length lines, we used equation 2 with measured values. Our results can be found in Table 5.

Equation 2: Propagation Speed

|  |  |  |
| --- | --- | --- |
| Length (meter) | 1 | 6.654 |
| Time to travel line 2 times (ns) | 9 | 56.2 |
| Propagation Speed (m/s) | 2.222 \* 10^8 | 2.37 \* 10^8 |

Table 5: Propagation Speed

The shorter line was harder to measure because the time to travel to the end of the line and back is a lot shorter. This made the distance between voltage steps a lot smaller on the O-Scope and harder to measure. In the end, we attached the long line to the end of the short line and subtracted the time for the long line to find the time for the short line.

**Part V.**

Since we have the characteristic impedance of the transmission line, we decided to terminate the line with an unknown resistor and find the value of the resistor. In order to find the unknown resistor we used the equation for V1-. Our waveform stepped down from .1 V (V1+) to .075 V ((1+ ΓL)\* V1+) which means our ΓL is -.25 which means our RL is about 30 Ohms. Our actual value of RL is 33 Ohms.