HOCHSCHULE RHEINMAIN

PHYSICS LAB 3

Experiment P3-2
Signal Propagation in Coaxial Cables

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Date of experiment:	Dezember 1st, 2020
Date of submission:	December 16, 2020

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1 Introduction

1.1 Terms and Definitions

Transmission Line

In there simplest form cables are made out of a conducting material to transport electrical energy or signals from point A to point B. The higher the frequency of the signal to transmit, the less the wave nature of can be neglected.

Characteristic Impedance, Velocity Factor and Propagation Speed

Characteristic impedance: The impedance, when connected to a transmission line, suppresses any reflections and standing waves [1]. Velocity factor: Relative signal propagation speed inside a transmission line expressed as percent of speed of light. Propagation speed: The absolute speed at which a signal propagates through a medium.

Time Domain Reflectometry

A method to inspect properties of a transmission line i.e. length, characteristic impedance and velocity factor as well as the presence, nature and location of defects.

Avalanche Pulse Generator

A circuit to generate ultra short pulses on a scale of picoseconds. Its main working principle abuses the avalanche breakdown of a transistor across the collector-emitter line. The breakdown voltage is usually much higher than the voltages during normal operation.

Boost Converter

A circuit capable of *boosting* a constant current input voltage to a much higher output voltage by repeatedly switching an inductor on and off. The fly back voltage induced by the break down of the magnetic field gets stored in a capacitance and forms the voltage at the output terminals.

Pulse Width Modulation

A constant current switched on and off at a fixed frequency. The time the signal is considered high relatively to the period time is called the duty cycle.

Amplitude, Rise Time, Fall Time, Pulse Width

Text

Bandwidth and Rise Time of an Oscilloscope

Text

1.2 Preparation

Reflection on a Transmission Line

!!! Insert Diagram Here !!!

SPICE-Simulation of a Boost Converter

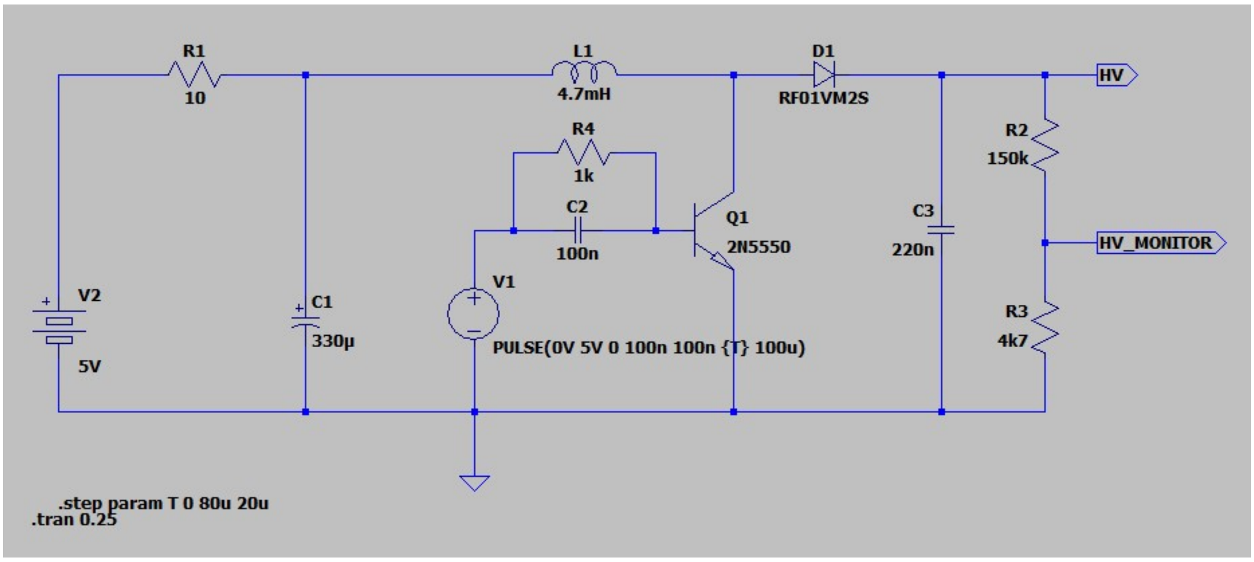

Figure 1.1: Simulated circuit of a boost converter using LTSPICE.

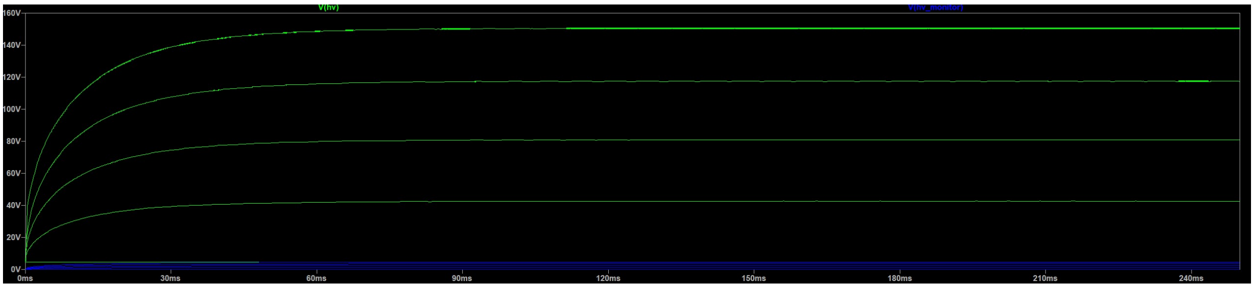

Figure 1.2: Plot of the output voltage at *HV*. The voltage is subsequently progressing towards a peak voltage of $\hat{U}_{HV} \approx 150\,\mathrm{V}$for various PWM duty cycles.

Charge/Discharge Time of a Capacitor

Charging:

$$U_{Br} = U_+ \left(1 - e^{-\frac{t_{charge}}{R_6 C_5}}\right)$$

$$\Leftrightarrow$$

$$t_{charge} = -\ln\left(1 - \frac{U_{Br}}{U_+}\right) \cdot R_6 C_5 \tag{1.1}$$

Discharging:

$$U_{C_5} = U_{Br}\left(e^{-\frac{t_{discharge}}{R_7 C_5}}\right)$$
$$\Leftrightarrow$$
$$t_{discharge} = -\ln\left(\frac{U_{C_5}}{U_{Br}}\right)\cdot R_7 C_5 \tag{1.2}$$

plugging in the values for $U_{Br} = 65\,\mathrm{V}, U_+ = 75\,\mathrm{V}, U_{C_5} = 5\,\mathrm{V}, C_5 = 2.2\,\mathrm{pF}, R_6 = 1\,\mathrm{M\Omega}$ and $R_7 = 51\,\Omega$ equates to the following charging/discharging times t_{charge} and $t_{discharge}$:

$$\begin{aligned} t_{charge} &= -\ln\left(1 - \frac{65\,\mathrm{V}}{75\,\mathrm{V}}\right)\cdot 10^6\,\Omega\cdot 2.2\cdot 10^{-12}\,\mathrm{F} \\ &\approx 4.43\cdot 10^{-6}\,\mathrm{s} \end{aligned} \tag{1.3}$$

$$\begin{aligned} t_{discharge} &= -\ln\left(\frac{5\,\mathrm{V}}{65\,\mathrm{V}}\right)\cdot 51\,\Omega\cdot 2.2\cdot 10^{-12}\,\mathrm{F} \\ &\approx 2.88\cdot 10^{-10}\,\mathrm{s} \end{aligned} \tag{1.4}$$

With these numbers, the minimum time per charge/discharge cycle would be the sum of both times. Thus, the maximum number of repetitions per second f_{Rep} is

$$f_{Rep} = (t_{charge} + t_{discharge})^{-1} \approx 225.7\,\mathrm{kHz} \tag{1.5}$$

Cable Characteristics of RG-58/U Coaxial Cable

Nominal characteristic impedance: $53\,\Omega$
Nominal velocity of propagation: 69.5%
Nominal delay (translates to the inverse of the absolute speed of propagation): $4.85588\,{}^{ns}/_{\mathrm{m}}$
The values above are taken from the technical datasheet [2].

Determining the Suitability of the Oscilloscope

Sampling Rate

2 Set-Up of Experiment

3 Execution

4 Evaluation

5 Conclusion

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A Distinct event

A Appendix

Figure A.1: During the course of the experiment captured oscillograms.

Table A.1: Handwritten notes corresponding each measurement.

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Bibliography

[1] ATIS. *ATIS Telecom Glossary. American National Standard T1.523-2001*. ATIS.

[2] Belden. *82240 Coax - RG-58/U Type technical Datasheet*. URL: https://catalog.belden.com/techdatam/82240.pdf (visited on 10/12/2020).