# ETE Transistor

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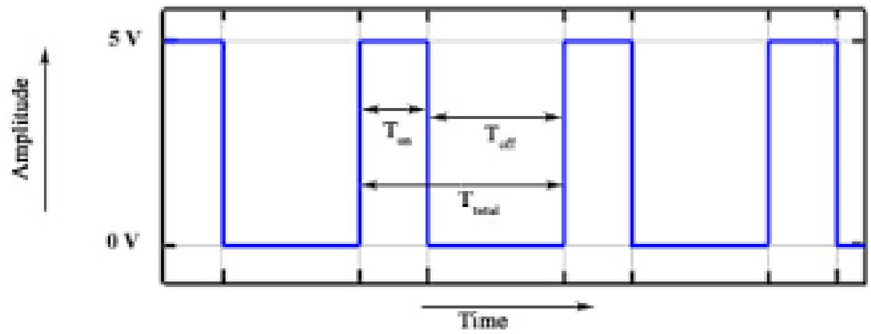
## 1 Introduction

The known variables are

$$U_0 = 96V, \quad R_L = 13.2\Omega, \quad L = 60mH, \quad f_T = 1.5, 6, 24, 96KHz, \quad t_{TURN} = 12\mu s, \quad \frac{T_{OFF}}{T_{ON}} = 1.5 \tag{1}$$

## 2 PWM Signal

The bare PWM Signal has a Voltage over time graph depending on the frequency $f_T$ and the relation between active and inactive current flow.




The total time $T_{total}$ is calculated as follows

$$T_{total} = T_{ON} + T_{OFF} = \frac{1}{f_T} = \underline{666\mu s, 166\mu s, 41.6\mu s, 10.4\mu s} \tag{2}$$

$$T_{ON} = \frac{T_{total}}{2.5} \quad T_{OFF} = T_{total} - T_{ON} \tag{3}$$

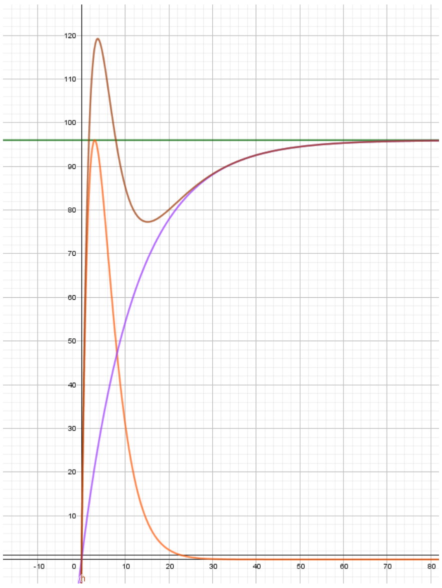
So the the variables for the four different frequencies result in

| $f_T$ | $T_{total}$ | $T_{ON}$ | $T_{OFF}$ |
|---|---|---|---|
| 1.5 | 666 $\mu s$ | 266 | 400 |
| 6 | 166 $\mu s$ | 66.6 | 100 |
| 24 | 41.6 $\mu s$ | 16.7 | 25 |
| 96 | 10.4 $\mu s$ | 4.17 | 6.25 |

# 3 Turn-Off sequence approximations

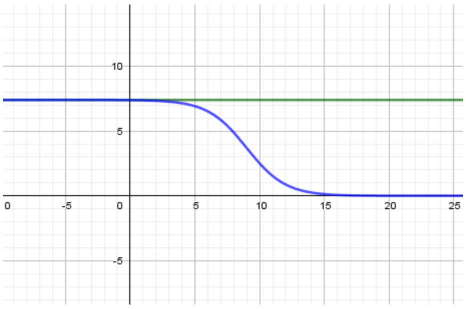
As the circuit has a given magnetism, the curves of voltage $u(t)$ and $i(t)$ are not vertical

$$u_{OFF}(t) = \frac{U_0}{2 \cdot t_P} \cdot t \cdot e^{-\frac{t}{2 \cdot t_P}} + U_0 \cdot (1 - e^{\frac{-t}{T_{OFF}}}); \quad t_P = \frac{T_{OFF}}{2} \tag{4}$$



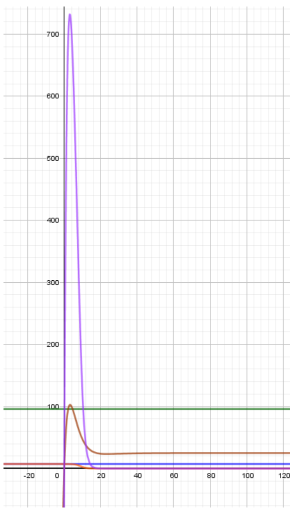

For the approximation of the current, the sigmoid function is used

$$i_{OFF}(t) = \frac{I_0}{1 + e^{\frac{x \ln(I_0)}{t_P/2}}} \quad t_P = \frac{T_{OFF}}{2} \tag{5}$$




So the power is calculated using

$$p_{OFF}(t) = i_{OFF}(t) \cdot u_{OFF}(t) \tag{6}$$



# 4 Calculation

The actual calculation of the average power-usage is calculated as follows

$$I_0 = \frac{U_0}{R_L} = \underline{7.27A} \quad P_0 = I_0 \cdot 1V = \underline{7.27W} \tag{7}$$

$$\overline{P_{CE}} = \frac{P_0 \cdot \Delta T_{OFF} + \overline{P_{OFF}} \cdot T_{TURN}}{\Delta t_{ON} + \Delta t_{OFF}}; \quad \overline{P_{OFF}} = \frac{1}{T_{TURN}} \cdot \int_0^{T_{TURN}} p_{OFF}(t)dt \tag{8}$$

So the average power consumption for the four given frequencies

| $f_T$ | $\overline{P_{OFF}}$ | $\overline{P_{CE}}$ |
|---|---|---|
| 1.5 | 400W | 11.6W |
| 6 | 400W | 33.1W |
| 24 | 400W | 199.27W |
| 96 | 400W | 465.9W |

The last result does barley make sense, because the total period approaches the turn time

# 5 Magnetism without diode

Without a diode, the energy of magnetism only passes out slowly. The energy of magnetism is calculated using

$$E_M = \frac{L \cdot I^2}{2} \tag{9}$$

So an approximation would be

$$i(t) = I_0 \cdot e^{\frac{-xR}{L}} \tag{10}$$