

Modeling and Representation of Power Electronic Converter Parameters

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BASIC GOALS OF THE PRESENTED PAPER

- Modeling of significant parameters of an electric power converter
- An original approach based on index matrices, which is used for generation of voltage and amperage sequences
- Software implementation
- Three - dimensional presentation of output characteristics according to the parameters

INDEX MATRICES

$$A = \left[K, L, \left\{ a_{k,l} \right\}_{k \in K, l \in L} \right] = \begin{array}{c|cccc} & \underline{l_1} & \underline{l_2} & \underline{\dots} & \underline{l_n} \\ k_1 & a_{k_1, l_1} & a_{k_1, l_2} & \dots & a_{k_1, l_n} \\ k_2 & a_{k_2, l_1} & a_{k_2, l_2} & \dots & a_{k_2, l_n} \\ \vdots & \vdots & \vdots & \ddots & \vdots \\ k_m & a_{k_m, l_1} & a_{k_m, l_2} & \dots & a_{k_m, l_n} \end{array} .$$

INDEX MATRICES ON ELECTRONIC COMPONENTS

Common time set : $\Theta = \{0, \Delta t, 2\Delta t, 3\Delta t, \dots\} \subset \mathbb{R}$

A two-terminal element of a circuit, denoted by c_m ,
is modelled by R-IM $F_m(t)$.

$$F_m(t) \stackrel{\text{pro}}{\square} I_2(F_m), \{x\} (X_m(t) \oplus X_o) = O$$

INDEX MATRICES ON ELECTRONIC COMPONENTS

$u_m(t), u_m(t - \Delta t)$ – voltage values

$i_m(t), i_m(t - \Delta t)$ – amperage values

associated to this element at the respective time moments

$$X_m(t) = \begin{array}{c|c} \hline & x \\ \hline u_m^{cu} & u_m(t) \\ i_m^{cu} & i_m(t) \\ u_m^{pr} & u_m(t - \Delta t) \\ i_m^{pr} & i_m(t - \Delta t) \\ \hline \end{array} ; \quad X_o = \begin{array}{c|c} \hline & x \\ \hline o & 1 \\ \hline \end{array} .$$

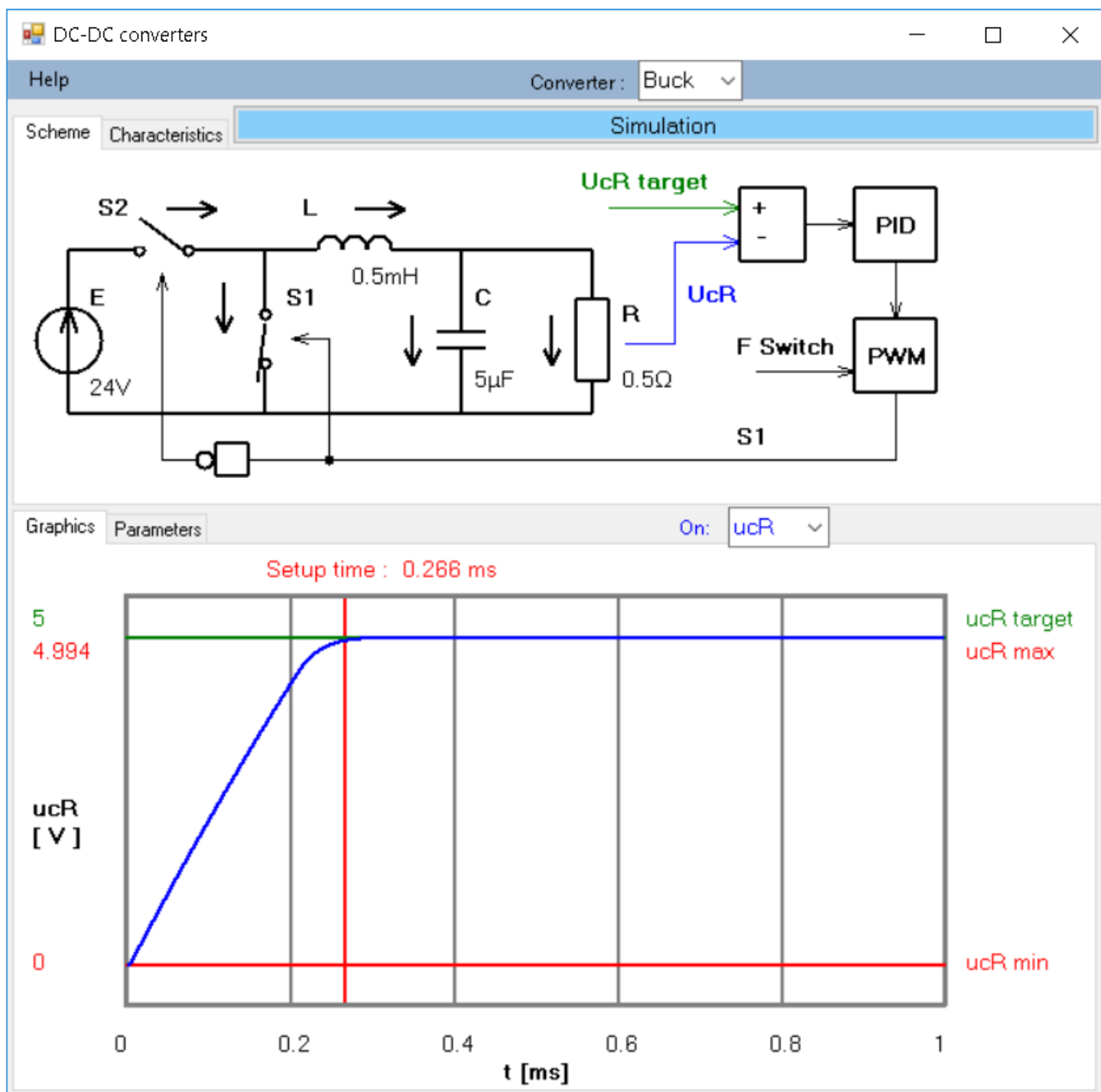
INDEX MATRICES ON ELECTRONIC CIRCUITS

A common mathematical model of components:

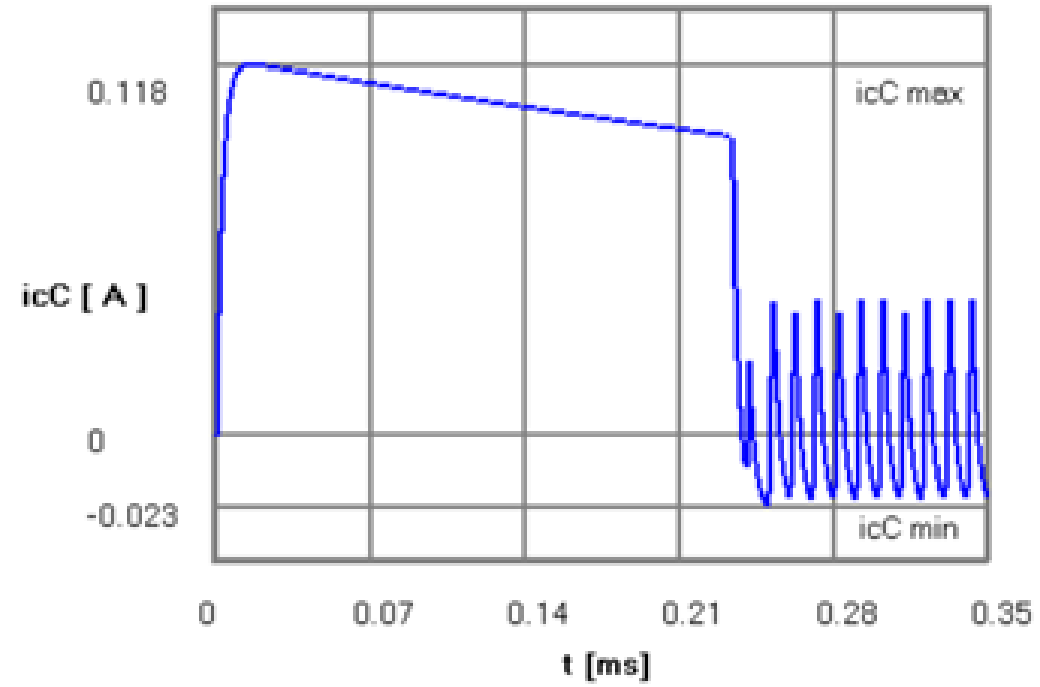
$$F_M(t) = \bigoplus_{m \in M} F_m(t);$$

$$X(t) = \left(\bigoplus_{m \in M} X_m(t) \right) \oplus X_0;$$

$$F_M(t) \sqcap \text{pro}_{I_2(F_M(t)), \{x\}} X(t) = O.$$



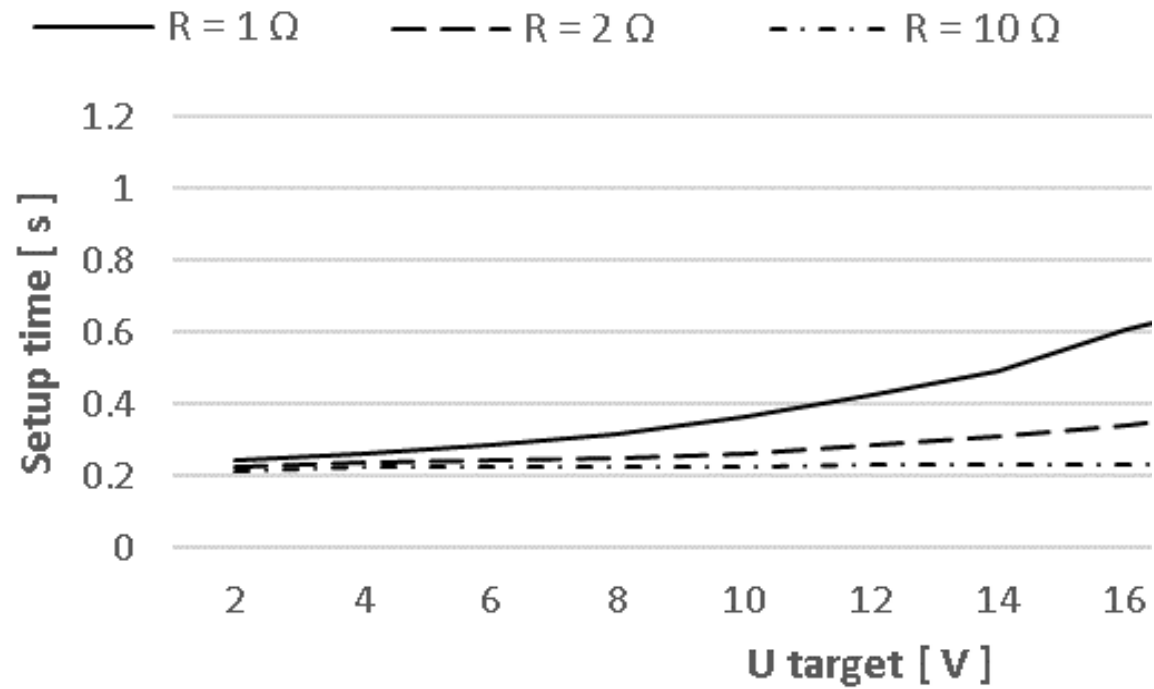
**SCHEME AND
GRAPHICS ON
OUTPUT VOLTAGE IN
SOFTWARE
IMPLEMENTATION**



**CAPACITOR VOLTAGE IN
SOFTWARE IMPLEMENTATION**

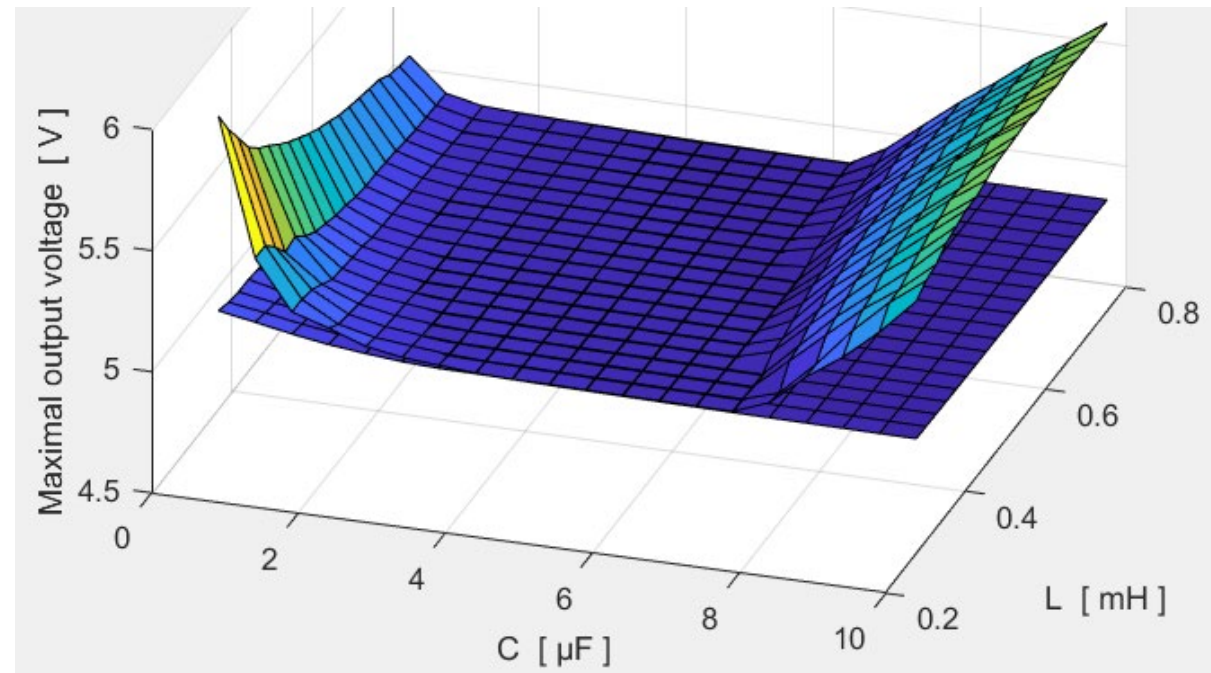
INPUT PARAMETERS AND OUTPUT CHARACTERISTICS

| Scheme | Characteristics | Simulation |
|---|-----------------|---|
| Input voltage: - $U_{cE} = 24$ V | | Characteristics of components: L = 0.5 mH C = 5 μ F R = 0.5 Ω Switching frequency : 500 kHz |
| Output voltage (target): $U_{cR} = 5$ V | | |
| Time: Duration: 1 ms Discretization frequency : 5 MHz | | Koeficients of PID regulator : K P : 5 K D : 0.0001 K I : 0.0005 |
| Graphics | | Parameters On: ucR |
| All functioning | | Established mode |
| Duration : 1 ms | | Setup time : 0.266 ms |
| Minimum : 0 V | | Average : 4.993 V |
| Maximum : 4.994 V | | Minimum : 4.991 V |
| | | Maximum : 4.994 V |
| | | Ripple factor : 0.00365 % |



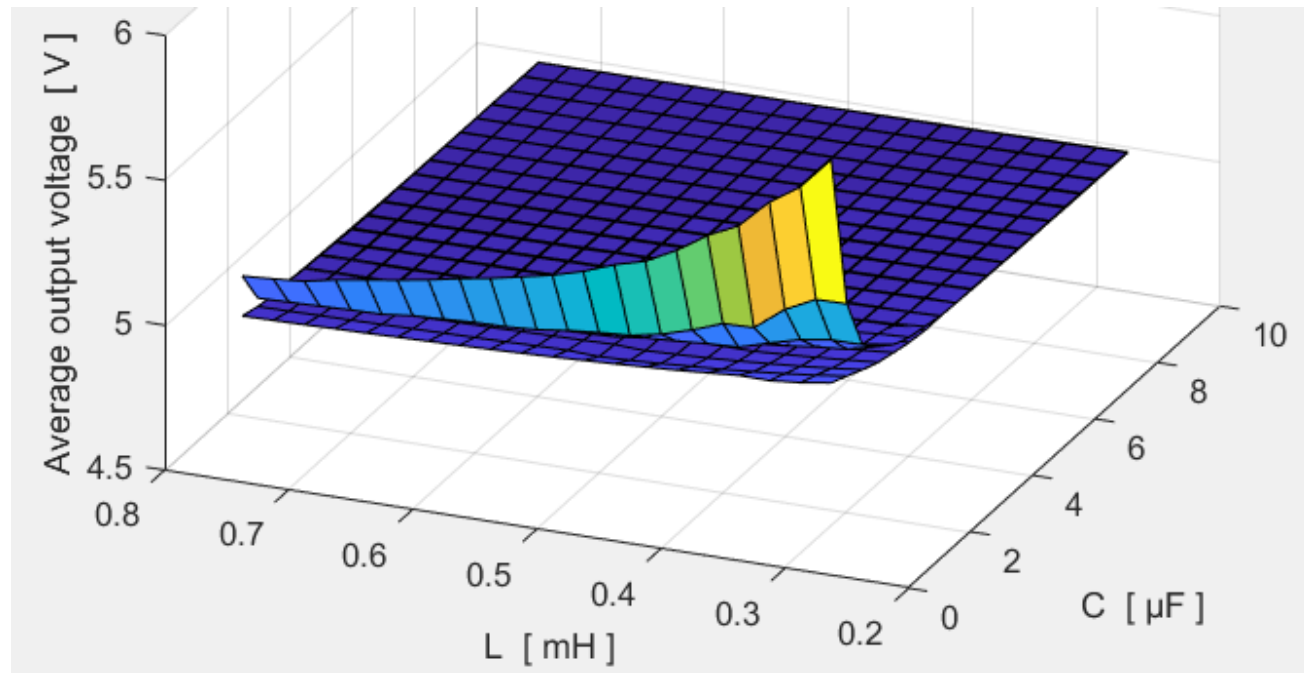
TWO-DIMENSIONAL REPRESENTATION
OF SETUP TIME

THREE-DIMENSIONAL REPRESENTATIONS



MAXIMAL OUTPUT VOLTAGE (1)

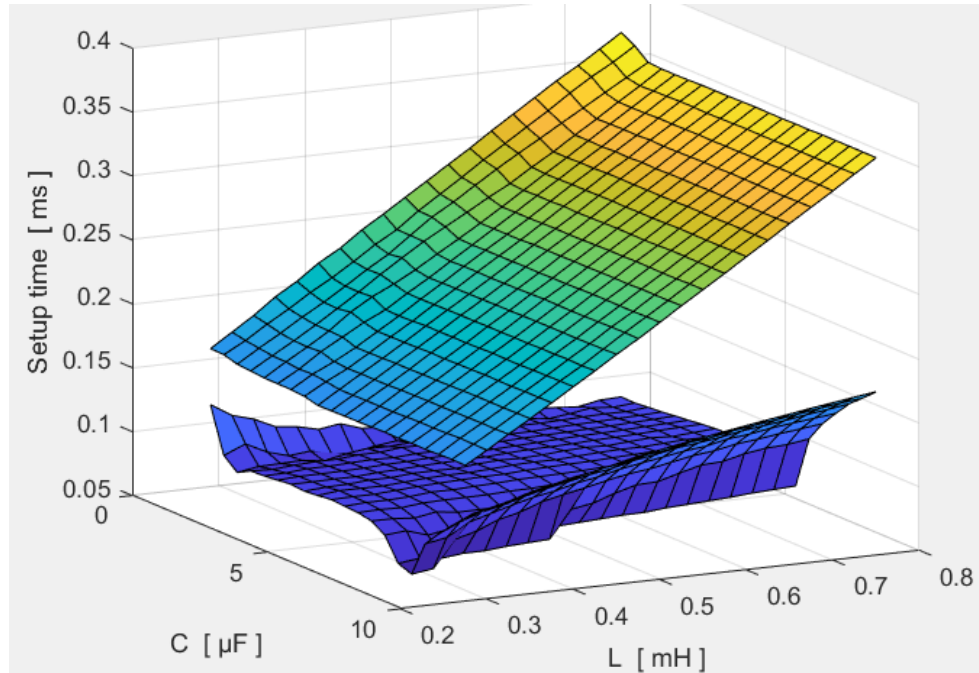
Output amperage: 1 – 10 A;



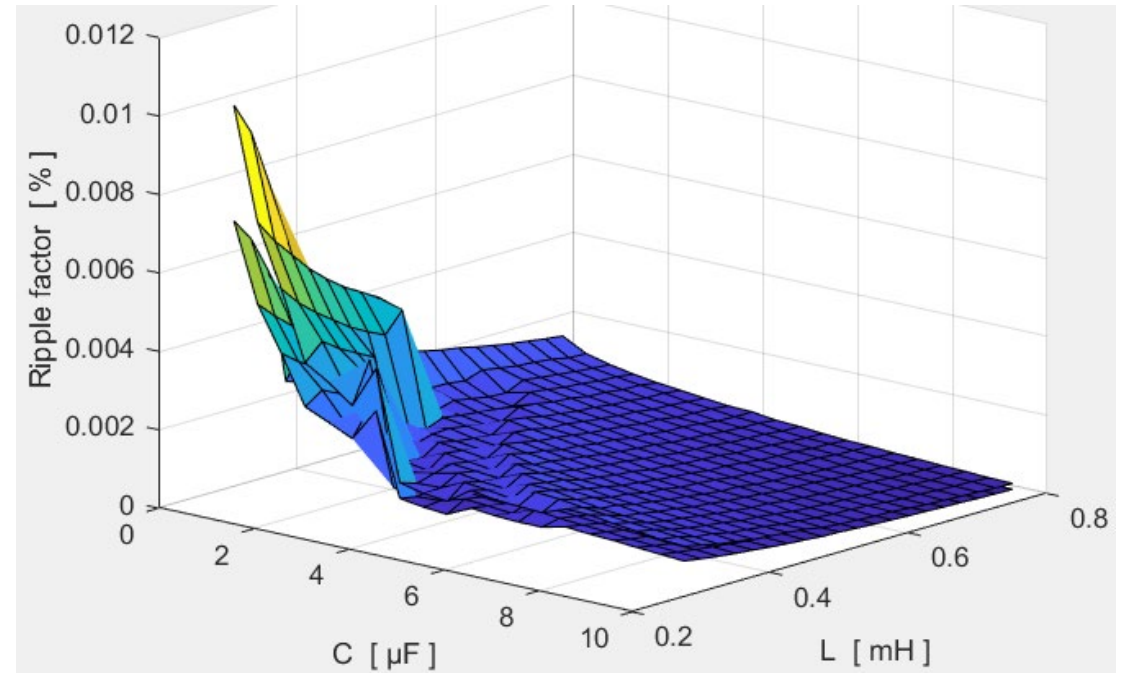
AVERAGE OUTPUT VOLTAGE (1)

$K_P = 5$; $K_D = 1 \cdot 10^{-4}$

THREE-DIMENSIONAL REPRESENTATIONS



SETUP TIME (1)

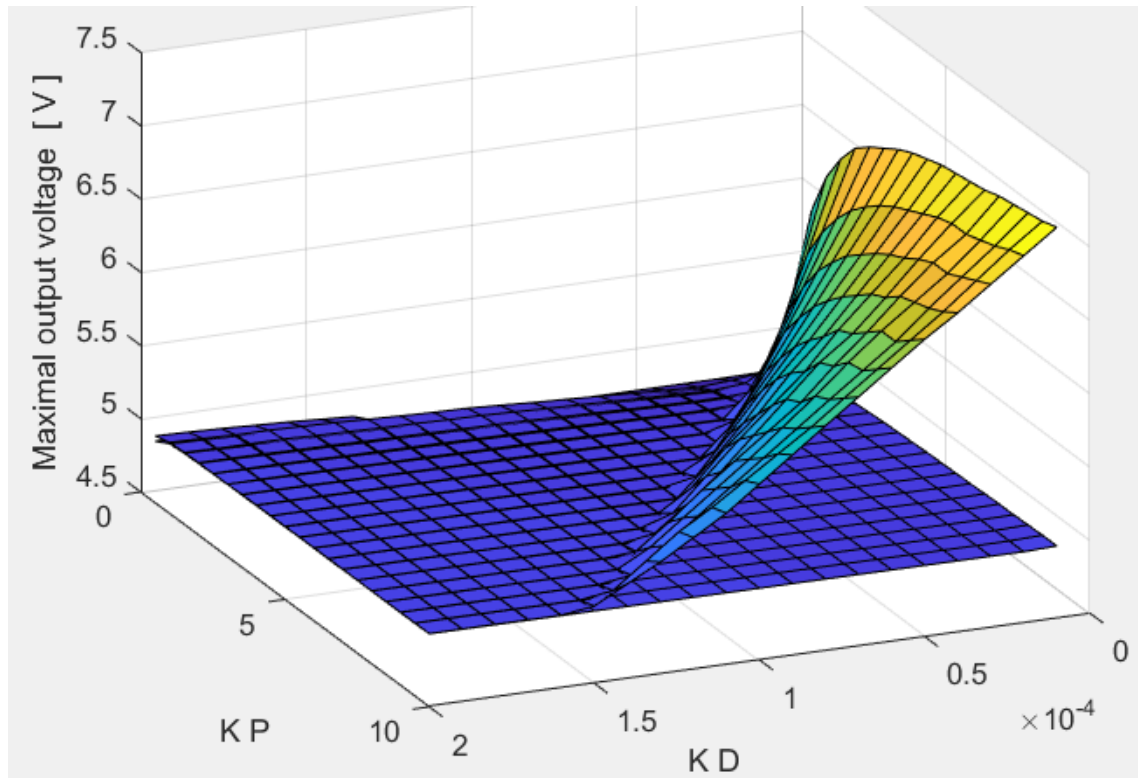


RIPPLE FACTOR (1)

Output amperage: 1 – 10 A;

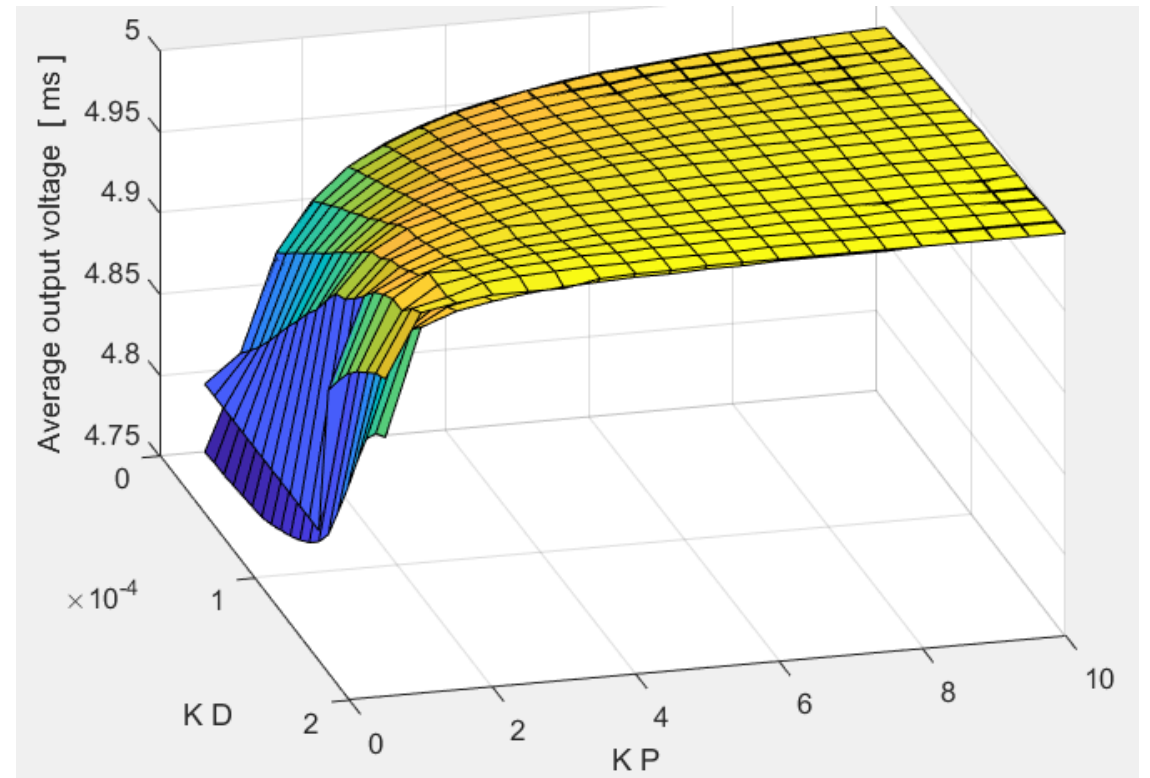
$K_P = 5$; $K_D = 1 \cdot 10^{-4}$

THREE-DIMENSIONAL REPRESENTATIONS



MAXIMAL OUTPUT VOLTAGE (1)

Output amperage: 1 – 10 A;

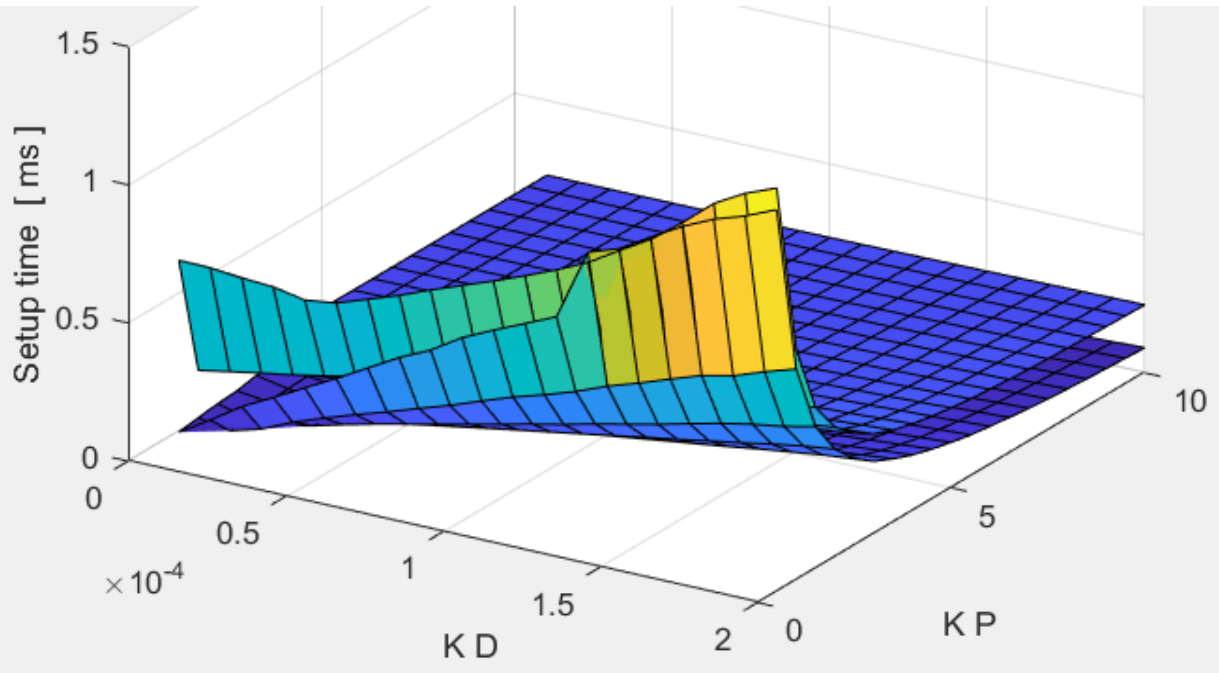


AVERAGE OUTPUT VOLTAGE (1)

$L = 0.5$ mH;

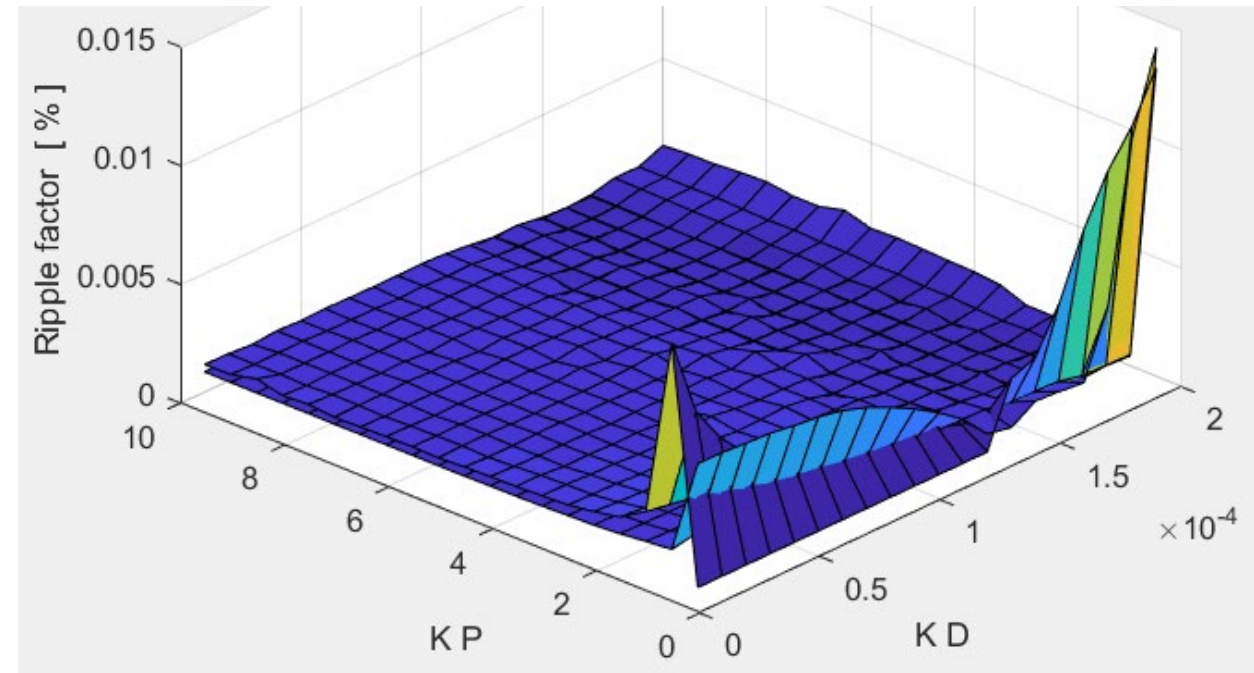
$C = 5$ μ F

THREE-DIMENSIONAL REPRESENTATIONS



SETUP TIME (1)

Output amperage: 1 – 10 A;



RIPPLE FACTOR (1)

$L = 0.5 \text{ mH};$

$C = 5 \text{ }\mu\text{F}$