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Multicriteria optimization of a meander line with broad-side coupling by genetic algorithms

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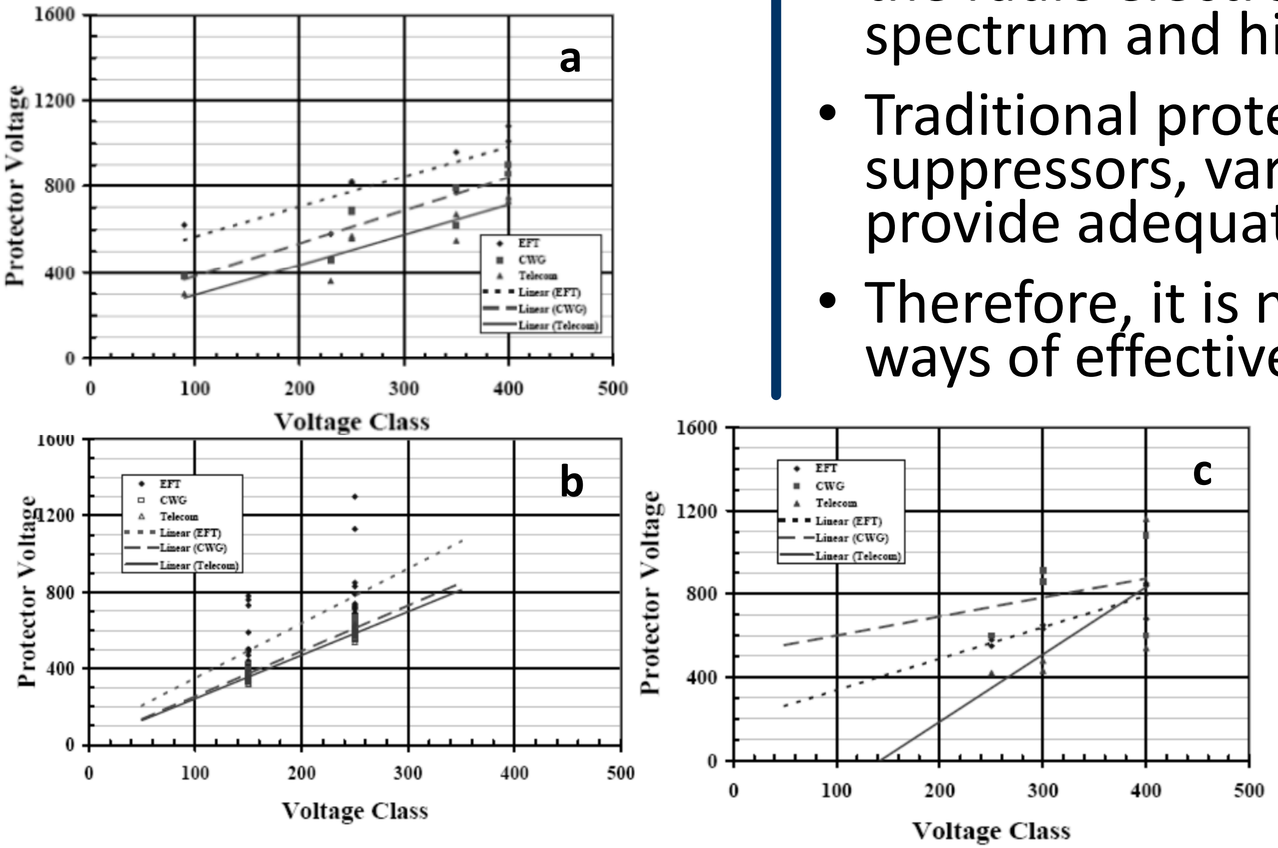
Problem statement

- A powerful ultrashort pulse (USP), which can penetrate into the radio electronic equipment and disable it due to its wide spectrum and high power, is particularly dangerous
- Traditional protection means (for example, voltage suppressors, varistors, passive RC and LC filters) often cannot provide adequate protection due to their disadvantages
- Therefore, it is necessary to search for and explore the new ways of effective protection



Dependencies of the real operating voltage relative to the declared:
a – 3-Electrode Gas Discharge Tube; **b** – for metal oxide varistors;
c – TVS diodes (With actuating signals with a front / width ratio:
5 ns/50 ns for EFT, **1,2 μs/50 μs** for CWG, **10 μs /1000 μs** for Telecom**)

<u>The aim of this paper</u> is to perform multicriteria GA optimization of a meander line with broad-side coupling by the criteria of complete USP decomposition and minimization of its amplitude

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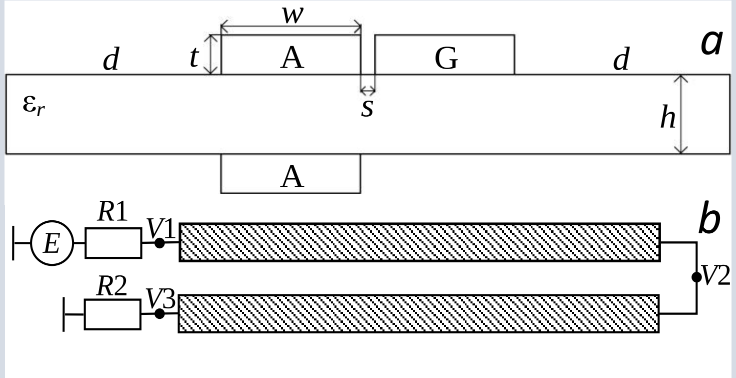
Results of the work



Cross-section (*a*) and circuit diagram (*b*) of the meander line turn with broad-side coupling

Formulated criteria for the <u>first objective function</u>:

$f_1=t_\Sigma-2l\tau_e$ $f_2=t_\Sigma-l(\tau_o-\tau_e)$ $f_3=\max|U(t)|$

Formulated multicriteria quality function 1:

$$F_1=M_1\frac{f_1}{K_1}+M_2\frac{f_2}{K_2}+M_3\frac{f_3}{K_3}$$

where $M_1=M_2=M_3$ in the optimization of the line with the first set of parameters, and $M_1=M_2=0.2$, $M_3=0.6$ - with the second.

Formulated criteria for the <u>second objective function</u>: $f_1=3\tau_{min}-\tau_{max}$

f_2 and K_2 for F_2 are the same as f_3 and K_3 for F_1 respectively

Formulated multicriteria quality function 2:

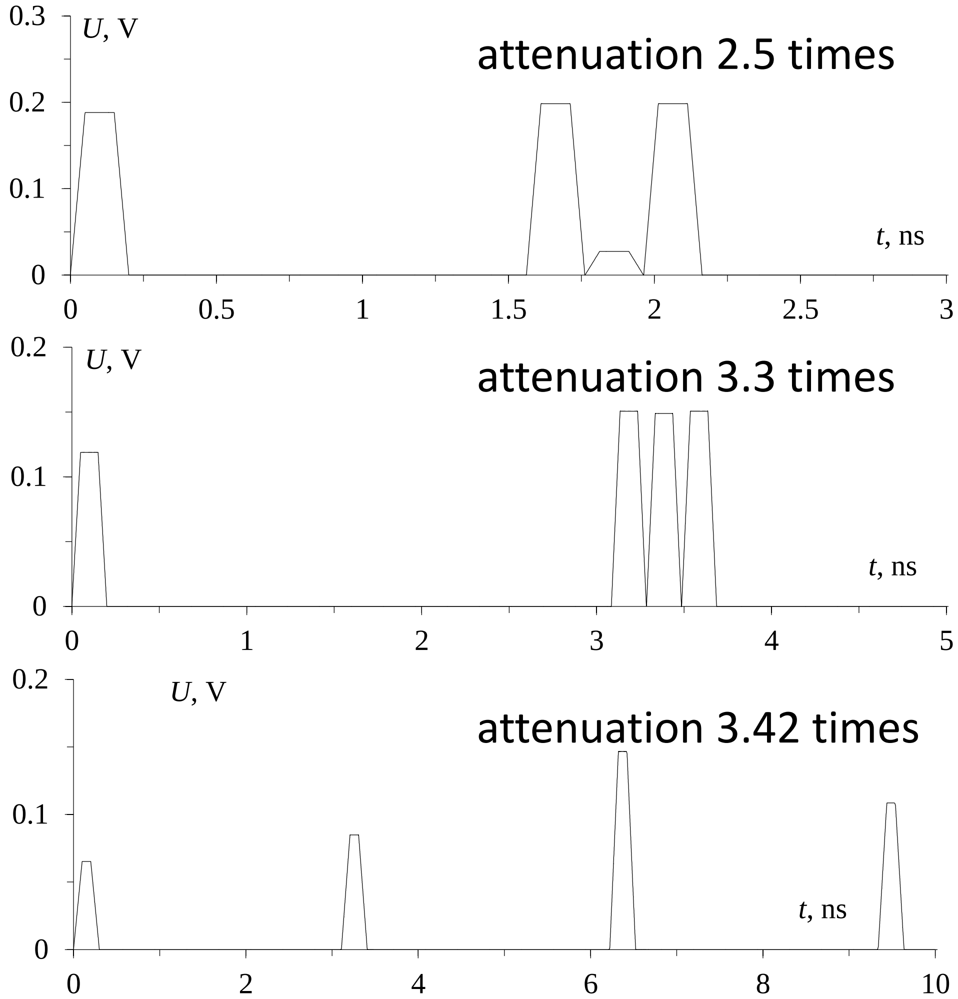
$$F_2=M_1\frac{f_1}{K_1}+M_2\frac{f_2}{K_2}$$, where $M_1=M_2$

№	ε_r	*h*, μm	*l*, mm	
1	5	540	150	- for F_1
2	20	940	150	- for F_1
3	500	1200	80	- for F_2

For the first set – 900 μm≤ *w*≤1100 μm, 10 μm≤*t*≤26 μm, 150≤*s*≤250 μm; for the second – 250 μm≤ *w*≤450 μm, 10 μm≤*t*≤26 μm, 150≤*s*≤250 μm; for the third – 900 μm≤ *w*≤1100 μm, 106 μm≤*t*≤166 μm, 2≤*s*≤15 μm

Table 2 - Optimization results for the line under investigation using F_1 and F_2

№	*w*, μm	*t*, μm	*s*, μm	τ_{max}, ns/m	τ_{min}, ns/m	*U*, V
1	903.507	25.908	155.196	6.54487	5.2058	0.198
2	283.527	10.8679	167.636	11.6206	10.2814	0.151
3	1070.79	161.423	2.00476	58.3685	19.4275	0.146



Voltage waveforms at the end of the line under investigation with optimal sets: 1 (*a*), 2 (*b*), 3 (*c*)

Conclusion

- Multicriteria quality functions for the USP decomposition into a sequence of pulses and the minimization of its amplitude were formulated.
- The optimization was performed by simple GA using these functions.
- As a result, 3 sets of optimal parameters providing the given criteria were obtained.
- Comparison of the results of the heuristic search and GA showed their similarity.
- The fulfillment of these conditions makes it possible to attenuate a USP at the end of the meander MSL of 3 turns by 8.1 times, of 4 turns – 19.9 times and of 5 turns – 33.16 times.
- As a result of the GA optimization in accordance with the formulated criteria, the USP attenuation achieved 2.5 times for the set of parameters 1, 3.3 times – for set 2, and 3.42 times – for set 3.
- The formulated criteria will be used in the further practical implementation of the device, at the stage of optimizing its real geometric parameters (in accordance with the technological capabilities of PCB manufacturers)

Quasi-static simulation was performed in the TALGAT software

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