A method for assessing the obsolescence of electrical appliances considering PCB maintenance

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Introduction

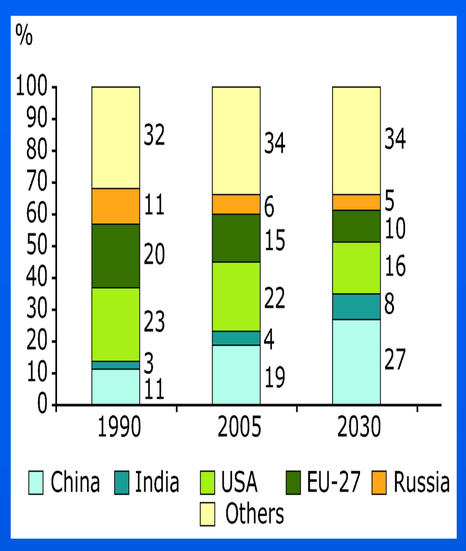

Figure 1: Global CO_2 emissions

The rise in population and improvement in living standards, particularly in industrialized nations, has resulted in increased use of residential electric appliances and average worldwide energy consumption, as well as increased CO_2 emissions per capita. Washing machines, dishwashers, dryers, mixers, blenders, fridges, power tools, and other domestic electric appliances all include a tiny electric motor within that is electronically controlled.

Figure 2: Electrical appliances service

Longer-lasting items are a cornerstone method of the circular economy for reducing the usage of non-reusable materials and the amount of trash to be handled at the end of the product's life cycle. Printed circuit boards (PCBs) are used in the production of contemporary electrical appliances. As PCBs get increasingly complex, the risk of failure rises. In this work, we concentrate on PCB maintenance taking into account the cost of repair and replacement.

Results & Discussion

The proposed methodology is implemented in a washing machine's printed circuit board. Figure 3 depicts this PCB and its corresponding components. Methodology provided in this paper aims at finding out which of the components presented in Figure III should be changed if a client has a limited budget to work with.

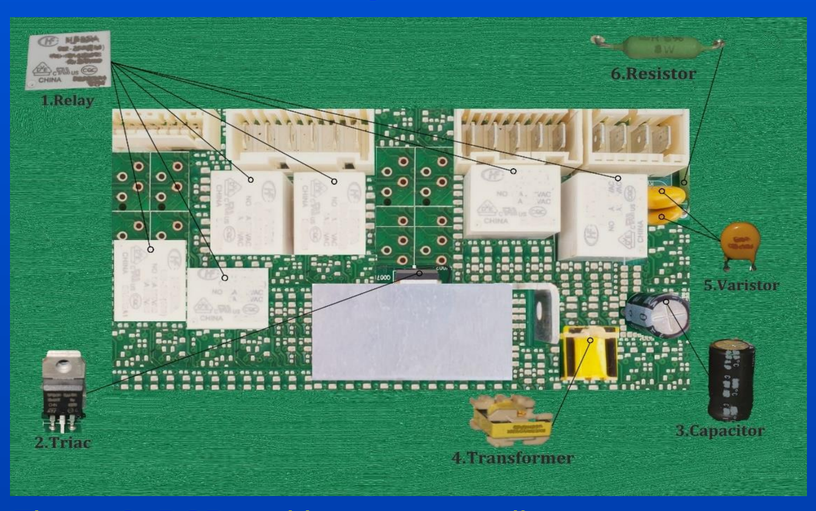

Figure 3: PCB and its corresponding components

Table 1 shows the maximum number of components connected on the PCB, the cost per component in Euros, and the "obsolescence index" of each one of the components.

Table 1: PCB components and corresponding cost and obsolescence indices

PCB Components	Cost (€/Component)	Obsolescence Index O_i
1	2.33	0.85
2	5.64	0.75
3	4.22	0.65
4	4.95	0.80
5	2.36	0.55
6	1.27	0.50

Let a PCB that has n different types of components that can be replaced and assume that $x=(x_1,\ldots,x_n)^T$ is the decision variable vector. Given a specific budget by the customer, the problem is formulated as Sequential Quadratic Problem:

$$\text{maximize} \sum O_i \cdot x_i$$

$$\text{s.t.} \prod\left(1-\frac{C_i}{B}\cdot x_i\right)=0$$

where B is the maximum customer's spending capacity, while C_i is the cost in euros (€) for each component. Note that the weight, O_i, expresses the obsolescence index taking values that selected through experimental tests and considering the lifespan of each component.

Table 2: Simulated case scenarios

Scenarios	Customer's spending capacity (€)
A	40.00
B	60.00
C	80.00

Three distinct scenarios are simulated based on a particular customer's spending capacity.

Results for simulated cases are shown in Figures 4–6.

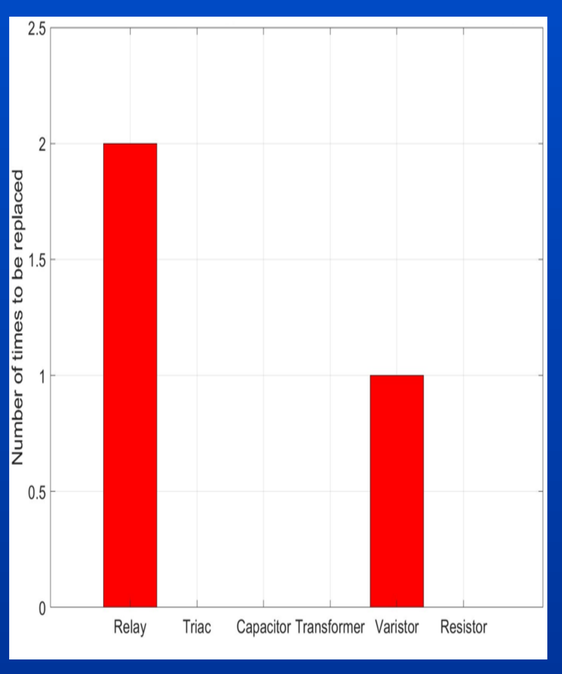

Figure 4: Simulation results for case “A”

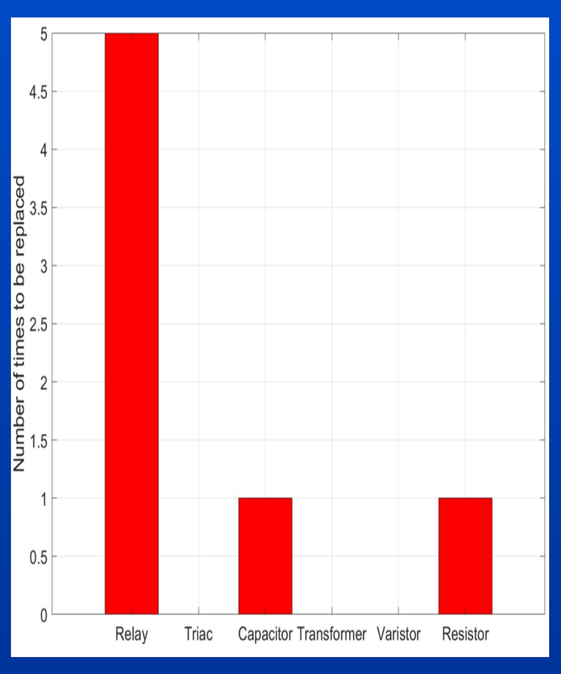

Figure 5: Simulation results for case “B”

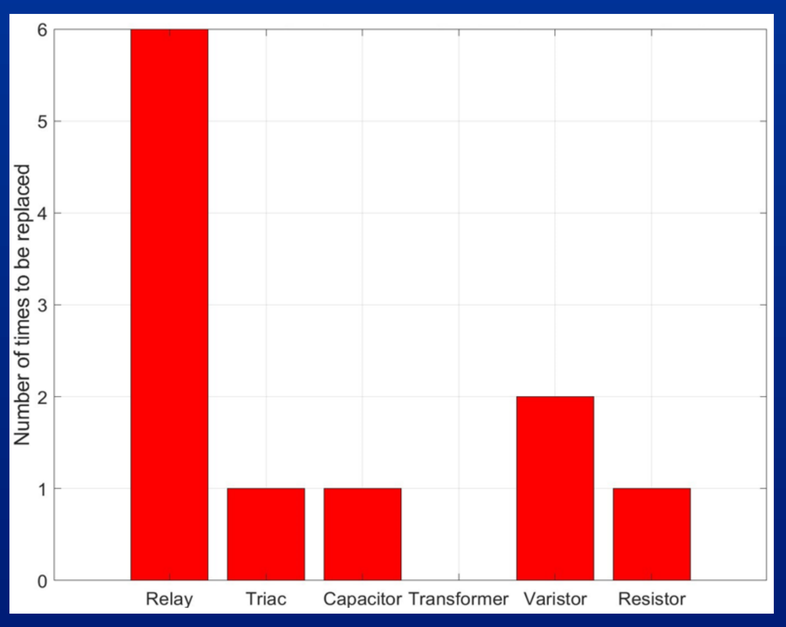

Figure 6: Simulation results for case “C”

It is clear that as the customer's spending capacity grows, the number of components that may be changed grows as well. Moreover, the most frequently PCB component to be replaced in both three cases is the “relay”.

Conclusions

This article investigates a simple, flexible, and straightforward SQP-based strategy for optimizing an objective function associated with the components on a printed circuit board, subject to an equality constraint, while guaranteeing that the overall cost of repair does not exceed a preset amount.
The proposed methodology was successfully tested on a PCB associated with a washing machine and the results confirmed the extension of the appliance's lifespan.