Evidence of Detection of High-Energy Microwave Radiation in Electronic Equipments

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***Abstract*—For commercial products and their possible failure, especially during the warranty period, it is very important to demonstrate that the product has been damaged in the correct application or has been tampered with.**
For electronic products, the quasi-exclusive intervention of unauthorized interference can be verified by post-identification of the enclosure breakdown, by the presence of a seam of a screw connection, or by a thin layer of thin film bonded to the main body of the housing.
In the electronics tool manufacturers market, the totally incorrect customer behavior is becoming more and more problematic, which can cause permanent damage to the devices purchased without external grievance.
In this article we present practical, experiential and theoretical solutions.[2]

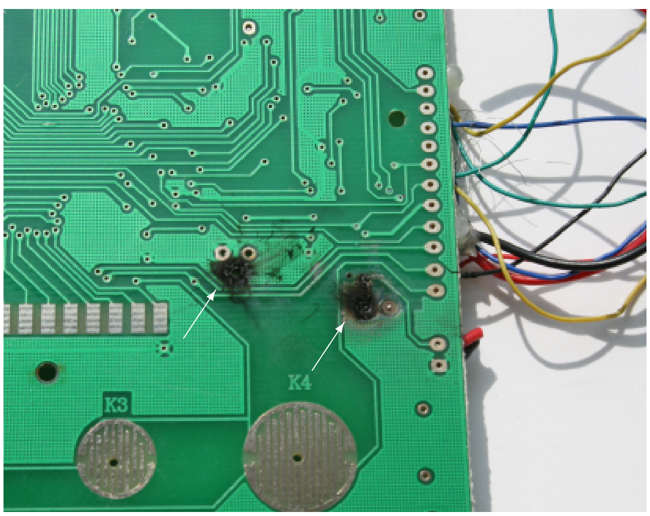

Fig. 1. Burns of phenomenal of microwave energy on surface of FR4 type two sided printed circuit board.

I. Introduction

One of the most commonly occurring occurrences is that a broken or tapping device is placed in a microwave oven for a few seconds with microwave energy. Consequently, it is often not detectable, or only in a verifiable way, to damage certain internal components, wires, isolations of printed circuits (Fig.1-3), integrated circuits (Fig.4), components (Fig.5), internal structural elements. On figures there are damage points are indicated by white arrows. [11] [9] [6]

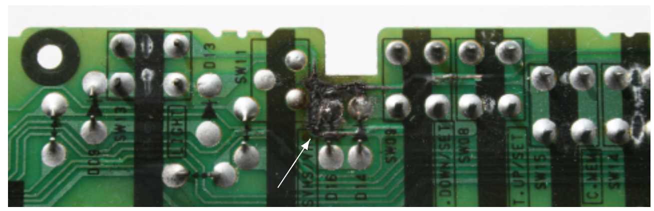

Fig. 2. urns of phenomenal of microwave energy on surface of paper phenol type one sided printed circuit board.

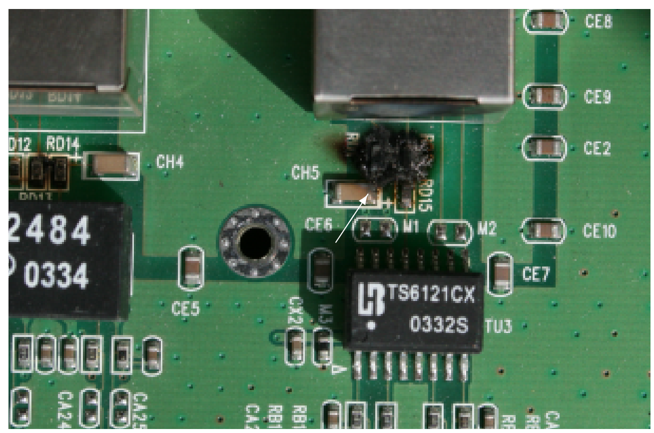

Fig. 3. Cracking an package of an LSI circuit at irradiation of 800W for 4s.

High-energy microwave radiation generates electrical voltages on all efficient antenna-like surfaces, wires. Nearly one kilowatt power enough big to can generate hundreds of volts in one of the radiated antenna loads. Of course, a printed circuit board, its wiring and components are most likely to form an effective antenna. The component or insulation at the output of antennas will damaged [12].
Damage can be basically two types; electrical breaks or electric shorts. Electrical break is generated by the high current, which flowing through the conductor (copper foil of PCB, pin to pin gold wire, strip of silicon); the conductor (metal, coal, graphite) sublimates [1].

II. Damage by microwave energy

The magnetron of household microwave ovens oscillates at about 2.4GHz frequency ($f_{\mu W} = 2,4GHz$). The power of these

Fig. 4. An LSI circuit's package cracking at 800W for 8s time irradiation.

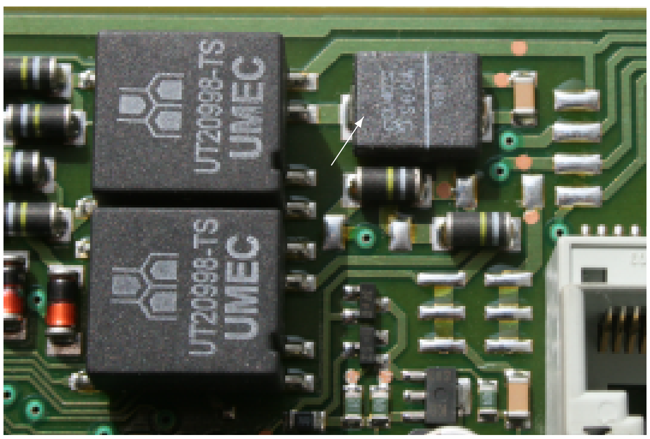

Fig. 5. CU4032 type voltage-dependent resistance package cracking at 800W for 5s time irradiation.

devices are between 400W and 1,2kW or can be adjustable [8]. according equation (1);

$$\lambda_{\mu W} = \frac{v_l}{f_{\mu W}} n \tag{1}$$

where; $\lambda_{\mu W}$ is wavelength of radiation of microwave-oven, v_l is the about speed of light. In the next, we'll work with a half-wave dipole as the most effective antenna. This value in actual frequency, from equation (1) is $\sim$12cm.
For the experimental presentation of the effect, various quasi-calculated antennas were prepared (Fig.6). In Fig.7 is seen folia-structure of Fig.6 after 800W, 4 seconds microwave irradiation.

III. Possible Electronic-Circuit Solutions

In the following, we will present the possible pragmatic solutions. Our main facets are the simple implementation of commercial parts, the cheapest solution, the irreversible change that is clearly and easily detectable. It takes as few spaces as possible.

Fig. 6. Quasi-adjustable microwave Al-folia antenna on paper, for spark gap experiments, before the microwave irradiation.

Fig. 7. Burning damage at 800W microwave power 2s long irradiation.

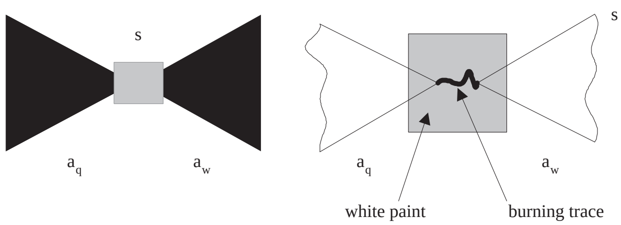

Fig. 8. The microwave antenna (left) and the spark gap (right) with burning trace.

A. Spark-Gap

The half-wave dipole, space-saving or surface-saving practical reasons can be approached with a trap antenna (Fig.8). The antenna consist of two element; a_q, a_w, which are formed from the 17,5μm thick copper foil of the printed circuit board. There are about 1mm between the two elements of antenna, this is the spark gap. The spark that may be generated, leaving a clear burning mark (s) on the paint. [7]

B. Resistor

On Fig. 9 is seen such solution when we use a resistor (R_s) between two pole (a_q, a_w) of trap antennas. Value of resistance (R_s) is equal of wave impedance; ($R_s = Z_0$), where Z_0 is output impedance of trap antennas.
There are two kinds of damage to the resistor in this case; electrical breaks (R_{s0}) or short circuit conductivity (R_{sc}). Both cases can be easily checked using an Ohm-meter.[17] [15]

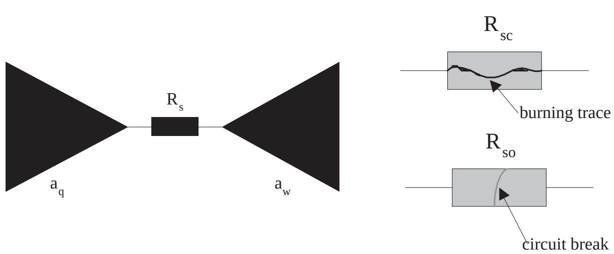

Fig. 9. Low power resistance, such as a microwave-damaged component.

C. Diode

Fig. 10 shows that solution when we use a diode for sensing an extra great microwave irradiation. In this case we have opportunity for create a big sensitivity arrangement. For this need application of Schottky-diode [2]. Damage of semiconductor two, earlier described, kind able. The detectable failure of the semiconductor may be two, earlier described types (D_{sc}, D_{s0}).

D. Low Power Bulb Lamp

Similarly to the foregoing, we select an element where high energy microwave irradiation can be clearly demonstrated. For this purpose, a low-powered bulb lamp (L_s) is excellent Fig. 11. Its operation is understandable. If it is operated with too

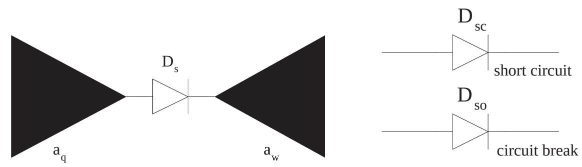

Fig. 10. Semi-conductor diode, such as an microwave-damaged component.

high electrical power, the lamp will burn out (L_s0). Detection of this can be done here. It is a more elegant solution when the bulb is functionally controlled. With generator drive, with normal operating parameters, visually inspected.

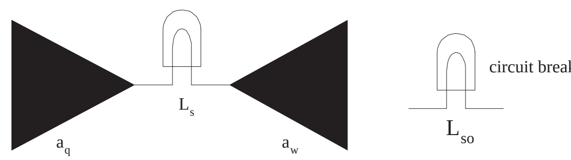

Fig. 11. Light bulb as a as a microwave-damaged component.

E. Fuse

On Fig. 12 can follow the arrangement of this solution. The function of the fuse in this application is physically equivalent at the bulb described; ($F_s \rightarrow F_{s0}$), electronic conductor function changed to electronic break.[5] [4]

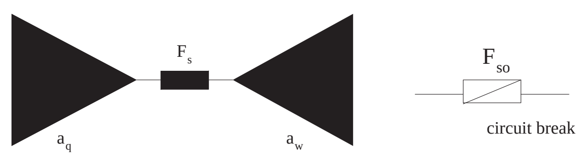

Fig. 12. Fuse as an microwave-damaged component.

IV. Technology Aspects

The solutions described have common symmetrical dipole (trap) antenna, preferably with output impedance fitting. The antenna itself can be made from the copper foil of the printed circuit board at the cheapest, though not small, surface. The recommended electronic components are SMD type.
Space saving is the solution when making a self-adhesive foil-like device that can be attached to the inside surface of the equipment. [14] [16]
Until now we have proposed symmetrical antennas. It may also be useful to use an asymmetric antenna (a_s of Fig. 13) for a large, long wire, for example ground-potential (a_g).

V. Conclusions, Future Work

The engineer is full of skepticism when he writes an existing incorrect phenomenon and thus formulates the antitheism of his own intent. However, I am convinced that somehow it has to be protected against the phenomenon [3]. In the near future, manufacturers will have a strong expectation. [17] [1]

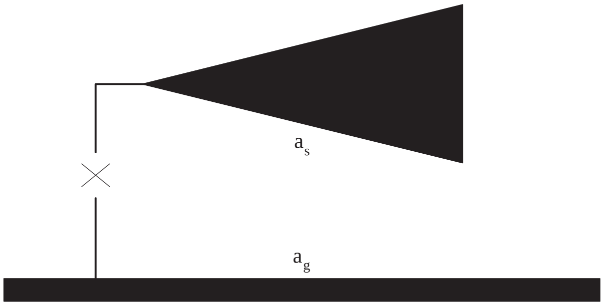

Fig. 13. Antenna (a_s) constructed in relation to the large equipotential (a_g) surface.

An interesting developmental requirement is the development of circuitry solutions that can electronically ask about the parameter of an irreversible change. [13]
The choice of specific, large series solutions is the next development phase. With many measurements, simulations and ready-made designs. [10]

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