EFFECT OF CONFORMAL COATING ON CIRCUIT BOARD VIBRATION RESPONSE

By Tom Irvine

Email: tomirvine@aol.com

July 15, 2009

Introduction

Conformal coating is a material applied to circuit boards to protect the electronics from moisture, solvents, contamination, dust, fungus, metallic debris particles, etc. These molecules or particles could otherwise degrade the electrical performance or cause outright failure.

In addition, the conformal coat provides:

1. Protection against corrosion, short circuiting, and abrasion
2. Electrical insulation for high-voltages components, particularly at high altitudes
3. Insulation against temperature extremes
4. Shock and vibration attenuation

Materials

The conformal coating is typically transparent. Common coating materials are:

Table 1. Conformal Coat Materials

Type	Material	Characteristics
AR	Acrylic	Easy to apply and remove
ER	Epoxy	Tough, durable, and very chemically-resistant
SR	Silicone	Soft, useful over a wide temperature
UR	Polyurethane or urethane	Good moisture and chemical resistance, good electrical insulation
XY	Paraxylylene	Very thin coating

The material conforms to the shape of the circuit board and its piece parts.

Another concern is the likelihood of repair or rework. Some materials are difficult to remove.

Application

The coating is more effective if all surface contamination is removed first, using a highly repeatable industrial process such as vapor degreasing. Cleanliness is necessary for surface adhesion.

The material is applied by brushing, spraying or dipping. It is then dried, or cured. Ultraviolet (UV) curing is used in some cases.

Thickness

The coating thickness is typically a few mils, or a fraction of a millimeter.

Thicker coats may be used in some cases. For example, a 14-mil thickness may be used if the circuit board will be exposed to corrosive gases and salt-spray atmospheres. Hydrogen sulfide is an example of a corrosive gas.

Vibration Attenuation

The following factors affect the vibration attenuation of the conformal coat:

1. Material Type and Properties
2. Thickness
3. Surface Adhesion
4. Quality of cleaning and curing

Conformal coating adds both mass and stiffness to a circuit board. Mass is the dominant parameter such that the coating causes the circuit board's natural frequency to decrease.

The conformal coat also provides damping. The amount of damping varies significantly depending on the four factors given above.

Test Results

The author participated in some testing of circuit boards with conformal coating in 1993 to 1995.

Note that the circuit boards did not have any wiring or electrical piece parts, which would have altered the response.

The same circuit board part number was used in each test.

Each circuit board was excited via a shaker table to a common base input level, which was 5.7 GRMS overall.

A summary of the response results is given in the following tables. Note that power transmissibility is the ratio of the response to the input at a given frequency, with units of (G^2/G^2).

Table 2. Test Series I

Board Configuration	Overall Response (GRMS)	Power Transmissibility at First Mode	Power Transmissibility at Second Mode
2B74	6.5	102 at 110 Hz	8 at 665 Hz
UV986	9.7	234 at 125 Hz	15 at 840 Hz
Solithane 113	13.8	2186 at 95 Hz	74 at 545 Hz
No Coat	32.7	4399 at 150 Hz	1837 at 790 Hz

Table 3. Test Series II

Board Configuration	Overall Response (GRMS)	Power Transmissibility at First Mode	Power Transmissibility at Second Mode
GE615	23.6	3792 at 100 Hz	1472 at 595 Hz
BIWAX 82.878	23.3	4777 at 100 Hz	829 at 565 Hz
GE RTV655	18.8	996 at 95 Hz	997 at 570 Hz
Solithane 113	8.8	502 at 95 Hz	32 at 590 Hz
No Coat	30.0	2589 at 140 Hz	998 at 790 Hz

Table 4. Test Series III

Board Configuration	Board Number	Overall Response (GRMS)	Power Transmissibility at First Mode	Power Transmissibility at Second Mode
2B74	1	9.0	310 at 100 Hz	11 at 620 Hz
BIWAX 628	2	7.0	120 at 95 Hz	10 at 600 Hz
	3	7.0	180 at 100 Hz	7 at 650 Hz
	9	7.4	90 at 110 Hz	15 at 720 Hz
SOLITHANE 113	4	18.9	3100 at 95 Hz	400 at 580 Hz
	5	9.3	750 at 85 Hz	90 at 540 Hz
BIWAX 82.878	6	25.9	6000 at 100 Hz	1800 at 550 Hz
GE RTV 615	7	15.2	2000 at 100 Hz	70 at 600 Hz
GE RTV 655	8	21.3	6000 at 95 Hz	30 at 560 Hz

Recommendation

Alas, the 2B74 and the UV986 materials appear to be no longer commercially available.

Solithane 113 appears to be the best, remaining material. On average, it provided an overall response that was about 8 dB lower than the board with no coating.

Solithane 113 is a urethane material. It is a resin which requires a curing agent. The type and amount of curing agent affects the resulting hardness.[1]

Further information is given at:

http://www.spolymers.com/pdf/Solithane_113.pdf

Reference Documents

1. MIL-I-46058
2. ASTM-D-1005
3. IPC-HDBK-830
4. NASA-STD-8739.1

[1] The curing agent was not documented in the previously described testing, however.