TECHNICAL BULLETIN

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Wire Tacking – The Options

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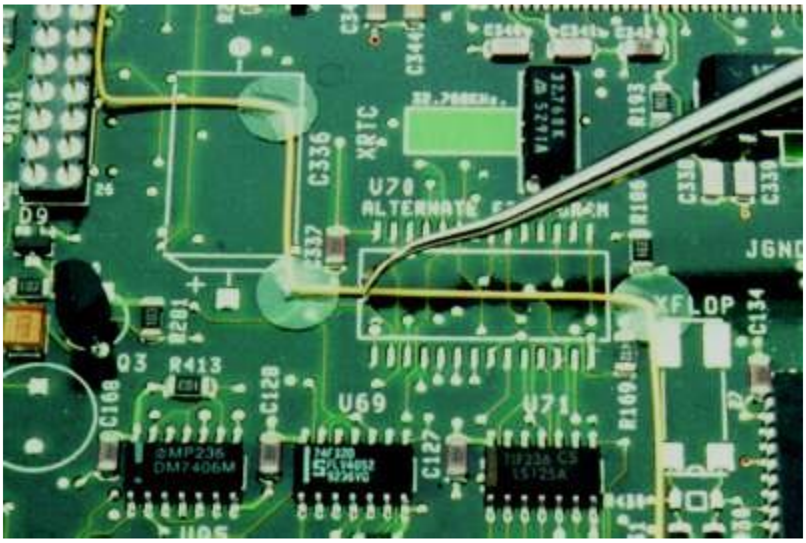
Introduction

The addition of wires to printed circuit boards appears to be a necessary evil in a fast changing design environment. The wires are used to increment or replace the printed wiring on the pcb. These wires are often called jumper wires, wire tacks, patch wires, etc. Actually, IPC-50-T[1] defines a "Jumper Wire" as a "discrete electrical connection that is part of the original design and is used to bridge portions of the conductor pattern formed on a printed board". A "Haywire", on the other hand, is defined as a "discrete electrical connection that is added to a printed board in order to modify the basic conductor pattern formed on the board."



There are three main reasons for adding these wires:

- A design flaw will appear once the boards are in production and test
- An upgrade or modification is needed, but it is not feasible to scrap the boards in stock
- Board damage or improper manufacture necessitates a repair

Typically, an insulated wire is stripped and soldered at each end to pads or component leads, and then bonded or staked to the board substrate. The bonding is required to preclude the wire from flapping around, or in more extreme environments (i.e. where vibration is anticipated), to act as strong structural adhesive. The wire may be routed through the components so that it looks neat, and sometimes to minimise additional 'noise'.

Good practice suggests that bonds should be made near the soldered ends, at every change of direction, or at a minimum of 25mm intervals along the wire path. More definitive instructions and a workmanship standard may be found in IPC-A-610C Acceptability for Electronic Assemblies[2], section 11.2. Another source for procedural advice is the Rework & Repair Guide found in our **Technical Resources** section.

The wire tacks can be very expensive to implement. Unfortunately, like all rework, they are difficult to avoid completely, though they ought to be minimised.

The following is a review of some of the procedures used for wire tacking, with a view to enabling the engineer to choose the best method based on efficacy, cosmetics, cost and process considerations.

Selection Factors

There are a number of different factors, and as usual, it is always necessary to make compromises in some areas in order to achieve minimum requirements in others. Many of the factors are inter-related, and trade-offs are likely.

1) Ease & rate of application

   How easy is it to apply the adhesive system, in conjunction with forming and placing the wire onto the pcb? Can the amounts of material be easily and consistently controlled?

2) Speed of cure

   Almost without exception, the faster, the better.

3) Cost

   Material charges (including wire, adhesive system, etc.) tend to be a minor part of the cost equation. Operator time is the most expensive part, which is why ease and rate of application, and speed of cure are very important factors when assessing cost.

4) Cosmetic appearance

   Operator skill may be the dominant element, but some systems are easier to use in a neat and efficient manner. Sometimes, this is not relevant (if the whole assembly is to be potted up into a brick of resin, some sloppy wire tacking will not matter much).

5) Bond strength

   This is one of the less well specified factors. In many, many instances, the adhesive strength does not have to be very high; a light tack to the pcb prevents the wire from flapping about, being caught up and torn off. In other instances, the adhesive must withstand high vibration or other physical rigours, and a higher bond strength ought to be specified. In general, a high bond strength requirement limits advantages in other areas, so do not over-specify. In many instances, bond strength to the insulated wire itself is negligible, as the plastic insulations are difficult to bond to. Usually this is satisfactory, as long as the bond bridges over the wire and retains it to the board.

6) Health & Safety

   The use and handling of any adhesive system is of growing concern. All options must be assessed under current legislation, and internal codes of practice. Some of these adhesives are toxic, irritant or bond skin. Solvents may be flammable.

7) Environment

   Almost hand in hand with health & safety comes environmental considerations. Are there VOC chemicals involved? Are there other environmental costs in either the manufacture or the use of the system? Are there aggravating odours?

8) Solvent resistance

   Often, after wire tacking, the assembly is required to be cleaned, in order to remove flux residues and other contaminants. The wire tacking system needs to be able to withstand this treatment

9) Environmental resistance

   The bonds need to withstand the environment in which the assembly is to live, for the life of the product. One may need to assess resistance to humidity, temperature, chemicals, shock, vibration, etc.

10) Conformal coating

   If the assembly is to be conformally coated, then the wire and adhesive system must be compatible with the coating.

11) Rework

What happens if you need to rework the rework? How easy is it to remove the bond, neatly and without damaging the board surface?

12) Electrical

Usually, the adhesive need to be an insulating material, so as to preclude it from interfering with the circuit. High tech applications may require very high insulation resistance, and a material which is electrolytically non-corrosive.

13) Special equipment

Is special equipment required (for mixing, application or curing), and if so, at what cost? In most cases, a material dispenser will make the job more efficient and more effective.

The Material Options

1) Epoxies

Two part epoxies have been used for this process for quite some time, especially in military applications where high bond strength and endurance is very important. They do not score well in the other areas, being slow and inconvenient. Whilst room temperature cure grades are available, many grades (including the better physical performers) will require some form of thermal cure, such has heating in an oven. Two part fast cure toughened acrylics are another viable option.

2) Cyanoacrylates

Special, thick and viscous grades of cyanoacrylate adhesive (CA) are available for this application. Currently, this may be the most popular methodology. Cyanoacrylates usually cure interfacially, so these grades need an accelerator or activator to speed the cure, which is 20-30 seconds. In general, cyanoacrylates are thought difficult to handle and dispense, and their resistance to moisture and solvents is not good. However, they cure pretty quickly with no special equipment.

The CA activators used to be formulated with 1,1,1 trichloroethane as a carrier for the active ingredient, but other solvents are now used, like acetone/ketone. However, the health & safety issues of the use of these chemicals (often applied in an aerosol form) are still a concern. Cyanoacrylates bond to skin very easily.

In comparison with some other methods, CAs are difficult to rework, although special de-bonding chemicals are available which allows the adhesive to be physically removed from the pcb.

3) UV Curable Adhesives

For this application, the adhesives are normally acrylic based. Using a safe, long wave UV spot curing lamp, adhesives are available which cure in a few seconds. The adhesives are 100% solids, single part materials which contain no volatiles or solvents. By combining pressure dispensing and spot curing in one, hand-held unit, an operator can apply and cure wire tacking bonds very quickly indeed (less than five seconds). This methodology scores very highly in nearly all the factors, and is rapidly gaining in popularity.

New formulations of these chemistries cure with a synergistic combination of UV and visible light, which gives speed advantages, and allows the possibility of less intense, less expensive curing lamps.

Light curing adhesive formulations are available in a range of hardness, from soft and flexible to quite hard.

4) Hot Melt

Polyamide adhesives are applied in a hot, liquid form from special hot melt guns. The adhesive solidifies quite quickly, giving medium bond strengths. Temperature resistance is obviously poor, as is solvent resistance. Hot melt guns are difficult to use for small bond areas, and the adhesive might be quite stringy.

5) Preleg

The application problems of hot melts are addressed by this product. A suitable wire is supplied complete with a hot melt adhesive concentrically applied. The adhesive coated Preleg wire is presented to the pcb, and a hot tip with a groove in the end is placed over the wire. This melts the adhesive. When the tip is removed, the adhesive rapidly solidifies. The method is very easy to use, fast and very neat cosmetically, as the wire can be routed as it is being bonded. Preleg wire is readily re-worked. The Preleg iron tip does not affect wire, insulation or pcb surface.

6) Adhesive Tapes

Small die-cut circles or rectangles of adhesive tape may be used to retain wires. The adhesive should be a non-silicone variety, especially if there are subsequent coating operations. Thermosetting adhesives would get stronger with heat in time. This solution is neat and fast, but needs a lot of board real estate, and may suffer in the strength and stamina departments.

7) RTV Silicones

RTV silicone rubber adhesives provide good, resilient bonds, but in the past, cure time has been long in comparison to other methods. New RTV chemistries now combine fast curing with a non-corrosive, neutral cure.

Selection Table

In the following table, the author has rated each material, subjectively, under the major selection factors. 5 is best, 1 is worst. The totals are for guidance only; engineers undertaking such an evaluation would make their own ratings, and probably weight each factor according to their own circumstances.

Factor	Epoxy	CA	UV Light	Hot Melt	Preleg	Tape	Silicone
Speed of cure	1	4	5	4	4	5	2
Ease/rate of application	1	3	5	3	5	4	3
Cosmetic appearance	3	3	4	3	5	3	3
Bond strength	5	3	4	2	2	2	3
Health & safety/environment	2	2	4	4	4	4	4
Solvent resistance	5	3	4	2	2	3	3
Environmental resistance	5	3	4	3	3	3	4
Rework	1	2	3	4	4	5	3
TOTAL	**23**	**23**	**33**	**25**	**29**	**29**	**25**

Notes

1) **IPC-T-50** Terms and Definitions for Interconnecting and Packaging Electronic Circuits

2) **IPC-A-610C** Acceptability for Electronic Assemblies

3) An early version of this article appeared in Electronic Production magazine, March 1992.

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