Avago PCB Soldering/Assembly Best Practices

Application Note 5578

Introduction

In the printed circuit board (PCB) assembly industry, flux is commonly used – from cleaning component leads to reflow/wave soldering. Using halide and non-halide flux have their own individual challenges. Halide flux always faces the issue of corrosion on the components during post-assembly processes.

This application note highlights the effect of halide content in PCBs, and Avago recommended guidelines for PCB assembly operations, including surface mount assembly.

Definition of Halide-Free and Classification

By definition, halide-free means a product does not contain any halogenated compounds. Halogenated compounds are mostly found in PCBs, solder masks, mold compounds, connectors, cable insulation and wiring conduit. In broad terms, halides are associated with soldering operations while halogens are associated with Printed Wiring Board (PWB) or components. Hydrolizable Chlorine, also known as brominated chlorine retardants, are common halogen (different from halide) found in mold compounds for their flame retarding properties.

IPC J-STD-004B (Designed around soldering fluxes) defines halide-free as:

- < 500 ppm of a flux's solids content, as chloride (fluoride and bromide are adjusted for molecular weight difference and calculated as chloride).

The International Electrochemical Commission, IEC 61249-2-21 (Designed around PCBs) defines halogen-free as:

- < 900 ppm Cl, chlorine
- < 900 ppm Br, bromine
- <1500 ppm total halogens.

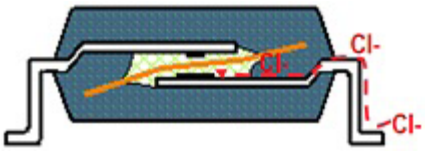

Figure 1. Mechanism for chlorine to corrode the bondpad

Halides can be detected using simple spot tests, as described in IPC J-STD-004B. Halide containing halogens are highly reactive. They are used in the board assembly process to aid in soldering performance by providing oxide-removal capabilities to enhance wetting, but they can be harmful or lethal in sufficient quantities. A flux that is classified as halide-free by IPC J-STD-004B is actually only free of ionic halides. IPC has classified electronic soldering fluxes to determine their potential corrosives if left unclean on an electronic assembly. The classification method categorizes fluxes as L, M or H (Low, Medium or High) based on their level of corrosiveness. In addition, the fluxes are rated for halide content as 0 or 1 (0 as absence of halide content and 1 as presence of halide content). This is shown in Table 1 (reference to IPC J-STD-004B).

Effects of Halides to PCB Assembly

Halides are ionic and have a charge; for example, Cl-, Br- and F-. Chlorine is the most electronegative ion, and the species migrates into the package through electrical field drifts due to V_{cc} (power supply) potential. V_{cc} (power supply) pad is typically the first pad to be 'attacked' by chlorine-related issues. Generally, the GND (ground) pad is normally not corroded, because this pad is generally at ground potential or lowest potential. This indicates that it is unnecessary to de-laminate the lead mold interface for the ionic contaminants to ingress. The mere presence of ionic species, in the presence of acceleration factors such as moisture and potential differences, is sufficient to initiate the ionic contamination process. The mechanism of how the chlorine ions from the environment can be brought into the package and corrode the bondpad is shown in Figure 1. Figure 2 shows that chlorine is found at the interface between the leadframe to mold compound (non-delaminated), and Figure 3 shows bondpad corrosion resulting from using halide flux.

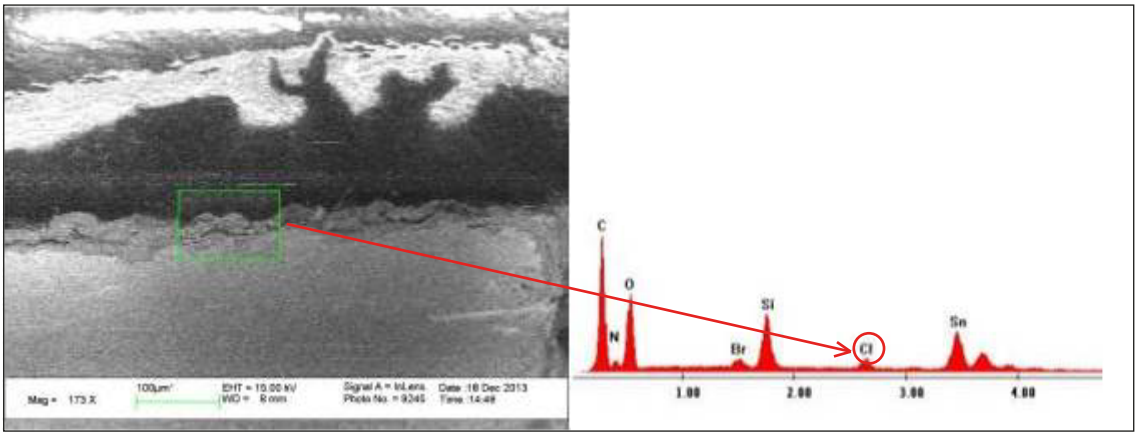

Figure 2. Leadframe to mold compound interface at power supply pin. Chlorine detected in the green box as indicated from the EDX shown

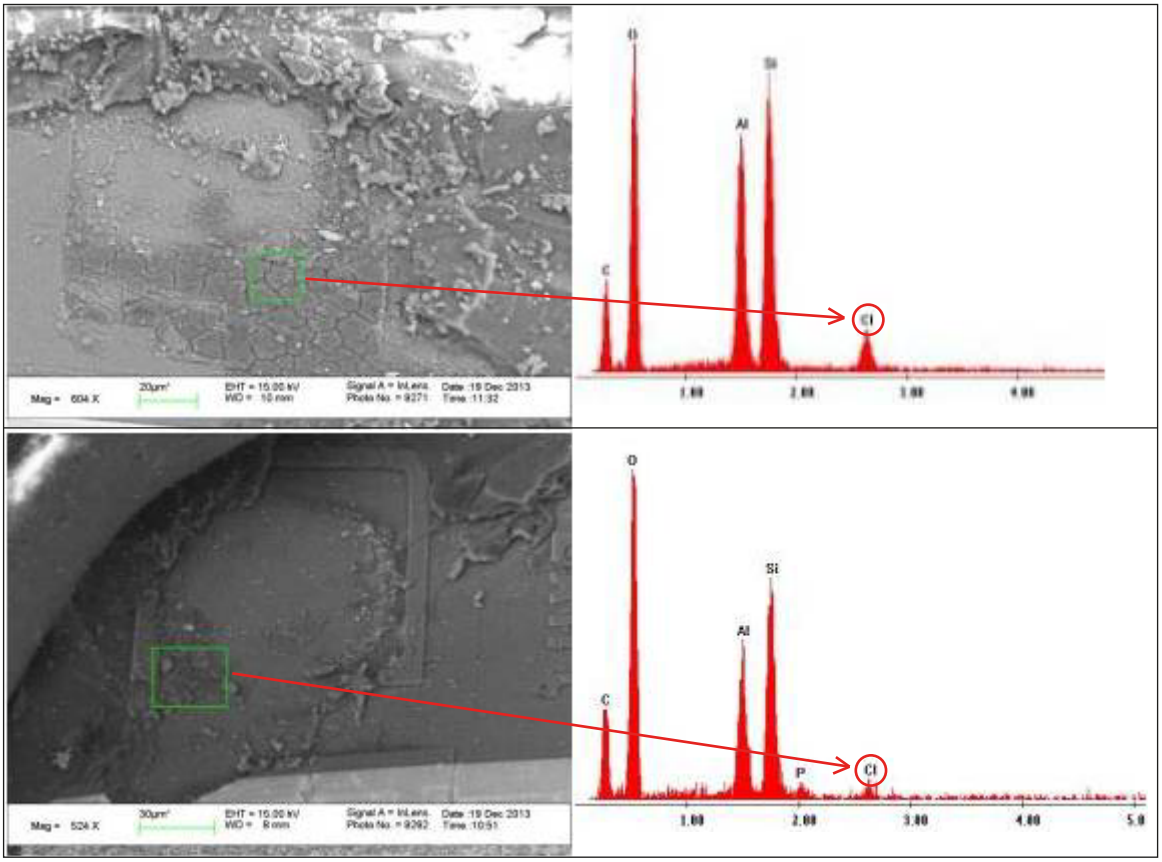

Figure 3. Corroded bondpads. Chlorine detected in the green boxes as indicated from the EDX shown

Avago plastic optocouplers certified to MSL1

Moisture sensitivity level (MSL) relates to the packaging and handling precautions for some semiconductors devices. It indicates the maximum time period in which a moisture-sensitive device can be exposed to ambient room conditions (approximately 30 °C/60% RH). If not adhered to, expansion of the trapped moisture within the devices and exposure to solder reflow temperatures may result in wire bond damage, die damage and internal cracks, affecting the yield and reliability degradation.

For moisture-sensitive devices, these are packaged in a moisture barrier antistatic bag with a desiccant and a sealed moisture indicator card. The moisture sensitivity levels are classified accordingly to IPC J-STD-020D guidelines. For MSL 1, the floor life is unlimited under condition ≤ 30 °C/85% RH environment. For subsequent MSL levels, there is a maximum allowable period of time in which the devices need to be mounted and undergo reflow once removed from the Moisture Barrier Bag (MBB). Usage of moisture-sensitive devices can also be referenced from IPC J-STD-033.

Unless otherwise stated, all Avago plastic optocouplers are classified as MSL1. This is stated in Avago Reliability datasheets.

Avago soldering/assembly best practices

In PCB assembly, Avago recommends that the solder paste/flux and cleaning solvents must not contain any halide (this includes chlorine, bromine, Iodine) in them. Halide flux is known to cause contamination and corrosion; and therefore, reliability issue concerns.

Thermal shock can cause the expansion and contraction of the molding compound and silicone, causing possible ingress of moisture, chemicals, and cleaning agents into the package.

To reduce the chance of moisture ingress, avoid a direct high pressure wash on the parts.

The de-ionized water wash is acceptable, but perform it with these guidelines in mind:

a. Any soldering flux or cleaning solvents associated with an optocoupler *must* be "halide-free". Halide (Chlorine, Bromine, or Iodine, if present in the fluxes) can ingress the package under water wash and initiate the ionic corrosion process, corroding bondpads and wires, and ultimately lead to "catastrophic" failures. This provision of using non-halide flux is indicated in every data sheet for Avago plastic optocoupler, under the "Soldering profile" section.

b. A good practice is that after soldering is performed on the PCBs, which are generally at an elevated temperature, the boards undergo some time to cool off before they are immersed in the de-ionized water wash. This is to prevent any thermal shock-related issues.

c. The pressure of the de-ionized wash is kept at reasonably low levels, such as 50 psi or lower. This is to prevent pressure induced moisture ingress into the package. Also, Avago highly recommends that the duration of any de-ionized wash be kept to a minimum: no more than three minutes.

d. After the de-ionized water wash, the boards undergo dry-heat so that any remaining moisture is evaporated. This can probably be done by a couple of hours of drying at 125 °C ambient storage.

Avago recommendations for automatic PCB assembly operations including surface mount assembly guidelines to ensure proper operation and long-term reliability of our optocouplers are as follows:

a. Solder Reflow Process
   - Only one soldering operation is recommended within the thermal profile. (see Figure 4 for the thermal profile, guidelines for the time and temperature are indicated in tables 2, 3 and 4, with reference to IPC J-STD-020D)
   - With infrared lamp heating, use precautions to avoid localized temperature rise in the resin.
   - Also, the resin should not be immersed in the solder.

b. Wave Soldering
   - Maximum solder temperature allowed is 260 °C for 10 seconds, with the solder 1.6 mm below the seating plane.

c. Solvent Cleaning
   - The solvent temperature and immersion time should not exceed 45 °C and three minutes, respectively.
   - For ultrasonic cleaning, environmentally safe solvents such as ethyl and methyl alcohol are recommended.

d. Staging Time
   - Maximum time allowable for PCBAs between soldering and cleaning.
   - The longer the staging time, the higher the chance of organic contaminants creeping into the package, so washing will not be effective.
   - For the recommended staging time, you will need to consult with the respective vendor for the flux.

e. ESD Precautions
   - To prevent damage or degradation of the device, standard electrostatic discharge precautions should be taken in handling and assembly of the optocouplers.

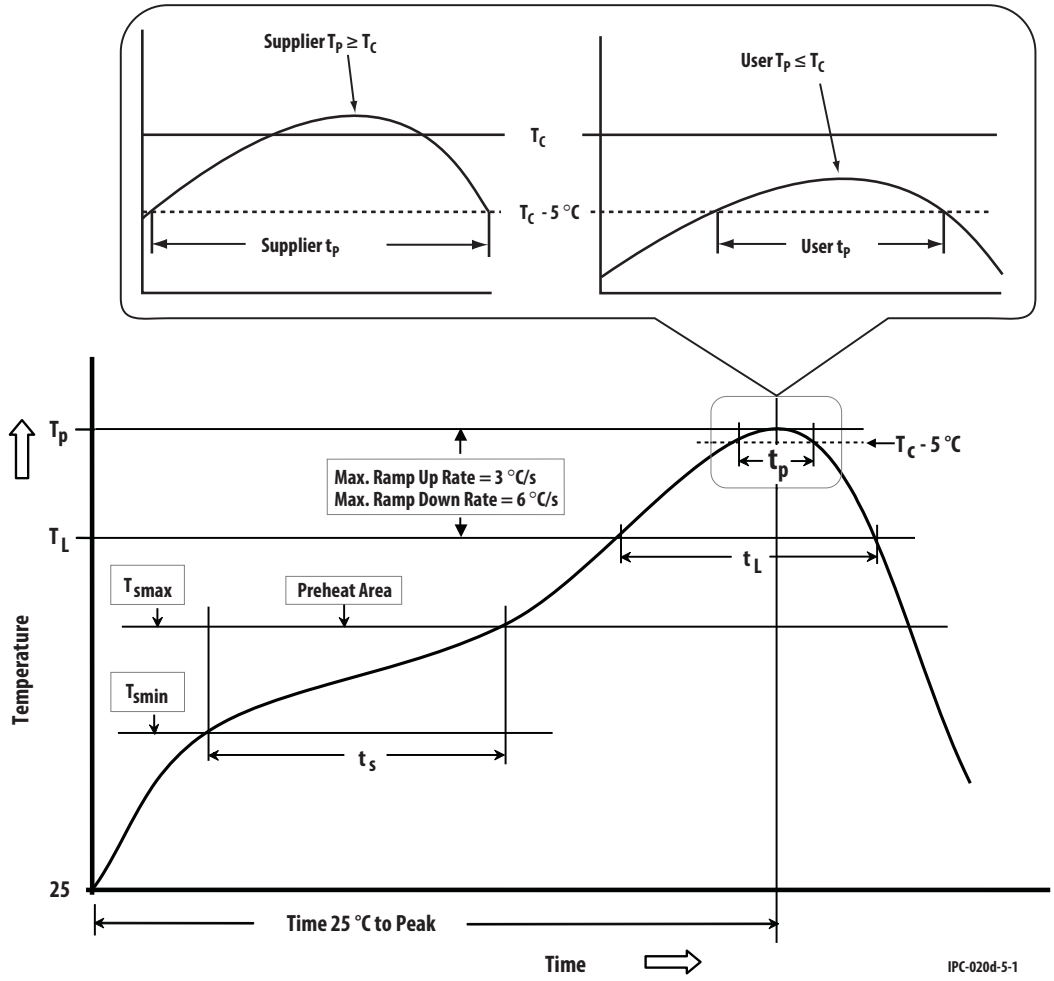

Figure 4. Solder IR Profile (reference to JEDEC J-STD-020D)

Table 1. Flux Identification System (Reference to Table 1-1 of IPC J-STD-004B)

FluxComposition	Flux/FluxResidue ActivityLevels	%Halide (byweight)	FluxType	FluxDesignator
Rosin (RO)	Low	<0.05%	L0	ROL0
		<0.5%	L1	ROL1
	Moderate	<0.05%	M0	ROM0
		0.5-2.0%	M1	ROM1
	High	<0.05%	H0	ROH0
		>2.0%	H1	ROH1
Resin (RE)	Low	<0.05%	L0	REL0
		<0.5%	L1	REL1
	Moderate	<0.05%	M0	REM0
		0.5-2.0%	M1	REM1
	High	<0.05%	H0	REH0
		>2.0%	H1	REH1
Organic (OR)	Low	<0.05%	L0	ORL0
		<0.5%	L1	ORL1
	Moderate	<0.05%	M0	ORM0
		0.5-2.0%	M1	ORM1
	High	<0.05%	H0	ORH0
		>2.0%	H1	ORH1
Inorganic (IN)	Low	<0.05%	L0	INL0
		<0.5%	L1	INL1
	Moderate	<0.05%	M0	INM0
		0.5-2.0%	M1	INM1
	High	<0.05%	H0	INH0
		>2.0%	H1	INH1

Table 2. Classification Reflow Profiles (Reference to Table 5-2 of IPC J-STD-020D)

Profile Feature	Sn-Pb Eutectic Assembly	Pb-Free Assembly
Preheat/Soak		
Temperature Min (T_{smin})	100 °C	150 °C
Temperature Max (T_{smax})	150 °C	200 °C
Time (t_s) from (T_{smin} to T_{smin})	60 - 120 seconds	60 - 120 seconds
Ramp-uprate(T_L to T_P)	3 °C/second max.	3 °C/second max.
Liquidous temperature (T_L)	183 °C	217 °C
Time (t_L) maintained above T_L	60 - 150 seconds	60 - 150 seconds
Peak package body temperature (T_P)	For users T_P must not exceed the Classification temp in Table 4-1. For suppliers T_P must equal or exceed the Classification temp in Table 4-1.	For users T_P must not exceed the Classification temp in Table 4-2. For suppliers T_P must equal or exceed the Classification temp in Table 4-2.
Time (t_P)* within 5 °C of the specified classification temperature (T_C), see Figure 5-1.	20* seconds	30* seconds
Ramp-down rate (T_P to T_L)	6 °C/second max.	6 °C/second max.
Time 25 °C to peak temperature	6 minutes max.	8 minutes max.

*Tolerance for peak profile temperature (T_P) is defined as a supplier minimum and a user maximum.

Table 3. SnPb Eutectic Process – Classification Temperatures (Tc) (Reference to Table 4-1 from IPC J-STD-020D)

PackageThickness	Volume mm^3 < 350	Volume mm^3 ≥ 350
< 2.5 mm	235 °C	220 °C
≥ 2.5 mm	220 °C	220 °C

Table 4. Pb-Free Process - Classification Temperatures (Tc) (Reference to Table 4-2 from IPC J-STD-020D)

Package Thickness	Volume mm^3 < 350	Volume mm^3 350 - 2000	Volume mm^3 > 2000
< 1.6 mm	260 °C	260 °C	260 °C
1.6 mm - 2.5 mm	260 °C	250 °C	245 °C
> 2.5 mm	250 °C	245 °C	245 °C

Summary

Avago does not use any halide content in its optocoupler manufacturing processes. The effects of halides to PCB Assembly will result in corrosion and impact the reliability of the optocouplers. Based on our experience, the majority of the failures encountered by customers out in the field are corrosion-related issues, a result of exposure to halide-based fluxes.

It is recommended that customers adhere to the Avago soldering/assembly practices as detailed in this application note.

References

[1] Requirement for Solder Fluxes, IPC J-STD-004B - January, 2004.

[2] Moisture/Reflow Sensitivity Classification for Nonhermetic Solid State Surface Mount Devices, IPC J-STD-020D - March, 2008.

[3] Halogens and Halides, Chrys Shea, Circuit Assembly The Journal for Surface Mount and Electronics Assembly - Dec 31, 2007.

[4] Designer Guide, Datasheets 5989-0802EN, Avago Technologies - Jun 01, 2006.

[5] Plastic Optocoupler Products ESD and Moisture Sensitivity, Reliability Datasheet AV02-0310EN, Avago Technologies – Sep 18, 2013.

AV02-4463EN - March 10, 2014