Pulse White Paper
Regarding
RoHS Compliance

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Executive Summary:

Pulse, a long-term environmental advocate, has been producing lead free products since 1999. With the passing of legislation by the European Union (EU) in 2015, Pulse has applied the requirements of the legislation to all products developed and manufactured by Pulse. At present, the majority of Pulse products are RoHS compliant in all aspects except for lead-containing solder chemistries. New solder processes and materials have now been defined, tested, and implemented to allow Pulse products to meet the RoHS requirements.

Pulse has identified four areas of customer concern regarding the status of Pulse RoHS compliance. This document provides information in response to these questions.

1. What is Pulse's capability to provide RoHS compliant products?
2. What material is being used to coat the terminals, i.e. can Pulse meet requirements for both lead containing
and lead-free solder system compatible products?
3. What is Pulse's status on tin whisker testing?
4. How will the moisture sensitivity level requirements be affected?

At present, Pulse has a number of RoHS compliant product lines and families available to supply to customers. Most standard Pulse products are ROHS-5 compliant. RoHS-5 and RoHS-6 products are available to meet customer needs. See Appendix 1 for Pulse definitions.

Pulse has selected tin (Sn) for component terminal coating for most ROHS-6 products. This material selection allows Pulse products to work with either lead-containing or lead-free solder chemistries in customer processes. We encourage customers to accept these forward and backward compatible products.

Pulse testing shows no change in the moisture sensitivity level requirements/specifications and performance on current products that are RoHS compliant. Customers will not need to change current moisture control handling practices for Pulse RoHS compliant products.

Customers are encouraged to contact the Pulse account manager to address the schedule and details to meet product availability.

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Background/History/Legislation:

The European directive **(EU) 2015/863** RoHS became European law on 2015. Member states were required to implement the law by June 4, 2015. Member states must ensure that by July 22,

2019, new electrical and electronic equipment placed on the market do not exceed certain levels of lead (Pb), mercury (Hg), cadmium (Cd), hexavalent chromium (Cr VI), polybrominated biphenyls (PBB), and polybrominated diphenyl ethers (PBDE) (See Appendix 2).
Materials Selection:
In compliance with customer requirements and the RoHS European directives to eliminate lead in the electronics industry, Pulse has adopted the use of RoHS compliant solder alloys using tin with greater than 95% content including 100% tin (Sn 100), tin-Silver (SnAg), tin-Copper (Sn-Cu) for external terminal plating. Tin-silver-copper (Sn-Ag-Cu) solder chemistries are used for internal solder connections. Some Pulse product materials have been upgraded so that the product is fully RoHS compliant and withstand the higher soldering temperatures of lead-free solder alloys. Product qualification has validated that the products withstand peak solder temperature rating per IPC/JEDEC JSTD-020D Table 5-2 and Figure 5 (See Appendix 3). Surface Mount Device (SMD) peak solder temperature rating is dependent on package volume for SnPb Eutectic Pb-free and process per IPC/JEDEC J-STD-020D Table 4-1 and 4-2 (See Appendix 4).
Pulse offers Sn100 or Sn alloy coatings on the component to PCB solderable termination (leadframes or pins). Pulse has thoroughly evaluated numerous materials and chemistries in selecting terminal coating materials. The decision to use Sn on the solderable termination is based on the material's excellent properties of solderability and resistance to corrosion. Pulse has chosen materials to specifically allow backward and forward compatibility with leaded and non-leaded solder chemistries and processes. Pulse RoHS compliant products meet industry solderability standard IPC/EIA/JEDEC J-STD-002B.
Certain types of Pulse products traditionally use high melting temperature solder (containing more than 85% lead) for internal solder connections. These solders are exempted per the WEEE/RoHS regulation due to the lack of viable compliant solder alloys. This high temperature solder is used only for internal product solder connections. External pin plating for these component types use one of the abovementioned Sn alloys.
Pulse is aware of and will continue to monitor ongoing studies to determine the propensity of these solder alloys to develop tin whiskers. As a preventive measure to reduce the possibility of tin whisker growth, Pulse has adopted the following mitigation factors.

Use of matte tin finish with a plating thickness of 100 to 500 micro-inches
Use of a Nickel under-plate with a plating thickness of 50 to 100 micro-inches
Use of Sn 100 hot tin dip process for final lead plating

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Testing/Validation:

Pulse has qualified RoHS compliant products on a family basis. This qualification approach provides the necessary process, reliability, environmental and solderability information to validate the change in all Pulse product configurations. To test resistance to solder heat of surface mount components, Pulse uses the peak solder temperature rating per J-STD-020D Table 5-2 and Figure 5 (see Appendix 3). Details of the test plan and specific data are available upon request from the Pulse sales account managers and sales representatives.

The Hong Kong Productivity Council has completed preliminary testing for Tin Whisker growth on Sn surfaces in early 2005. Preliminary test results show evidence of tin whisker growth with whisker length less than the current industry maximum specifications levels (< 40 micro meters in length). Subsequent testing is planned to further validate Pulse processes, materials and surface finishes containing Sn and Sn alloys.

Pulse has developed a tin whisker test scheme using the JEDEC standard JESD22A121 as a guide. The specific test conditions used for the test include:

1 – Ambient Storage Test – 1000 hours at 25° Celsius ± 2° and 30% to 80% RH

2 – Temperature Cycle Test – 1500 cycles from -55° Celsius +0°/-10° to +85° Celsius +10°/-0° with a 10 minutes soak at temperature

3 – Constant Temperature and Humidity Test – 1000 hours at 60° Celsius ± 2° and 90% to 95% RH

4 – High Temperature Storage Test – 1000 hours at 50° Celsius ± 2° and less than or equal to 50% RH

The testing started in January 2006.

Testing for moisture sensitivity level (MSL) has been completed to recertify that Pulse products meet the levels defined in the IPC/JEDEC J-STD-020D standard.

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Implementation/Conclusion:

Most Pulse products can now be manufactured in a RoHS-6 compliant configuration. Factory conversion was completed in July 2006. To make products forward and backward compatible, Pulse is ready to supply products with Sn coated terminals. Please contact the sales account manager or the sales representative to schedule deliveries.

Pulse has developed and maintains a detailed database on supplier material chemical and physical composition for use in assuring that material characteristics are thoroughly defined and understood. This database is used to respond to customer queries regarding RoHS compliant materials and chemistries and to assure that supplier materials are controlled.

A high level of control is in place to assure customers receive the lead-free RoHS compliant products ordered. Unique areas of the factory have been allocated and controls are in place to assure product is not mixed in the production environment. Pulse lead-containing and lead-free production lines are segregated from each other to minimize the possibility of cross contamination.

Pulse continuously maintains close contact with new industry and government developments on RoHS compliance and has a team of people assigned to the conversion process and development effort. This includes the investigation and development of cost effective materials necessary to mitigate the higher temperature requirements and material cost associated with the conversion to RoHS compliant product. Your sales account manager; distributor or customer service representative can also serve as a point of contact.

Pulse is ready to meet your RoHS component needs and requirements.

Reference:

- *Summary report on initial tin whisker test results – RoHS Report #1*
- *http://www.dti.gov.uk/sustainability/weee/index.htm*
- *http://www.inemi.org/cms/*
- http://leadfree.ipc.org/
- http://www.jedec.org/

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Appendix 1
RoHS-5 and RoHS-6 Definitions:
RoHS-6

Product does not contain Lead (Pb), Cadmium (Cd), Mercury (Hg), Hexavalent Chromium (Hex-Cr), Polybrominated Biphenyls (PBB), Polybrominated Diphenyl Ethers (PBDE1).

None of the exemptions listed in annex of the directive 2002/95/EC applies to RoHS-6 products.

Plating finish on component terminations is Lead-free only.

Products are typically identified with the suffix “NL”.

Maximum reflow temperature is per IPC/JEDEC J-STD-020 (Pb-Free Assembly) revision that was enforced at time of product release.

RoHS-5

Product does not contain Cadmium (Cd), Mercury (Hg), Hexavalent Chromium (Hex-Cr), Polybrominated Biphenyls (PBB), Polybrominated Diphenyl Ethers (PBDE).

Internal connections may contain lead (Pb) used in high melting temperature solder (i.e. tin-lead solder alloys containing more than 85 % lead).

Products are typically identified with the suffix “NL”.

Maximum reflow temperature is per IPC/JEDEC J-STD-020 (Pb-Free Assembly) revision that was enforced at time of product release.

Exempt

Product does not contain Cadmium (Cd), Mercury (Hg), Hexavalent Chromium (Hex-Cr), Polybrominated Biphenyls (PBB), Polybrominated Diphenyl Ethers (PBDE).

Product contains Lead in applications considered as solders including plating finish for component terminations, solder paste, solder balls, solder bumps, PCB finish, and solder columns.

Product part numbers do not contain the suffix “NL”.

Product is used for servers, storage and storage array systems (exemption granted until 2010) or for network infrastructure equipment for switching, signaling, transmission as well as network management for telecommunication.

Maximum reflow temperature is per IPC/JEDEC J-STD-020 (Sn-Pb Eutectic Assembly) revision that was enforced at time of product release.

1 Included Decabromodiphenyl ether as per latest EU's Restriction of Hazardous Substances Directive

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Appendix 2

Maximum Concentration Value (MCV) in homogeneous materials* of the RoHS restricted substances

Maximum concentration values were approved by EU Council on December 2015.
MCV in homogeneous materials* of the RoHS restricted substances are:

RoHS Restricted Substance	**Allowable Limit**
Cadmium and its compounds*	100 ppm (0.01 weight %)
Mercury and its compounds	1000 ppm (0.1 weight %)
Hexavalent chromium and its compounds	1000 ppm (0.1 weight %)
Lead and its compounds **	1000 ppm (0.1 weight %)
Polybrominated biphenyls (PBB)	1000 ppm (0.1 weight %)
Polybrominated diphenyl ethers (PBDE)	1000 ppm (0.1 weight %)
Phthalate (2 - ethyl hexyl ester (DEHP)	1000 ppm (0.1 weight %)
Butyl Benzyl Phthalate (BBP)	1000 ppm (0.1 weight %)
dibutyl phthalate (DBP)	1000 ppm (0.1 weight %)
Di Iso Butyl Ortho Phthalate (DIBP)	1000 ppm (0.1 weight %)

* Homogeneous material means a material that cannot be mechanically disjointed into different
materials
* Homogeneous material is any material that has a uniform composition throughout.

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Appendix 3

JEDEC Profiles:

JEDEC J-STD-020D Table 5-2 "Classification Reflow Profiles"

Profile Feature	SN-Pb Eutectic Assembly	Pb-Free Assembly
Arrange Ramp-Up Rate (Ts_{max} to Tp)	3°C/second max	3°C/second max
Preheat - Temperature Min (Ts_{min}) - Temperature Max (Ts_{max}) - Time (Ts_{min} to Ts_{max})	100°C 150°C 60-120 seconds	158°C 200°C 60-120 seconds
Time maintained above - Temperature (T_L) - Time (t_L)	183°C 60-150 seconds	217°C 60-150 seconds
Peak classification temperature (Tp)	See Table 4.1	See Table 4.2
Time within 5°C Actual Peak Temperature (tp)	10-30 seconds	20-40 seconds
Ramp-Down Rate	6°C/second max	6°C/second max
Time 25°C to Peak Temperature	6 minute max	6 minute max

JEDEC J-STD-020D Figure 5 . "Classification Reflow Profile"

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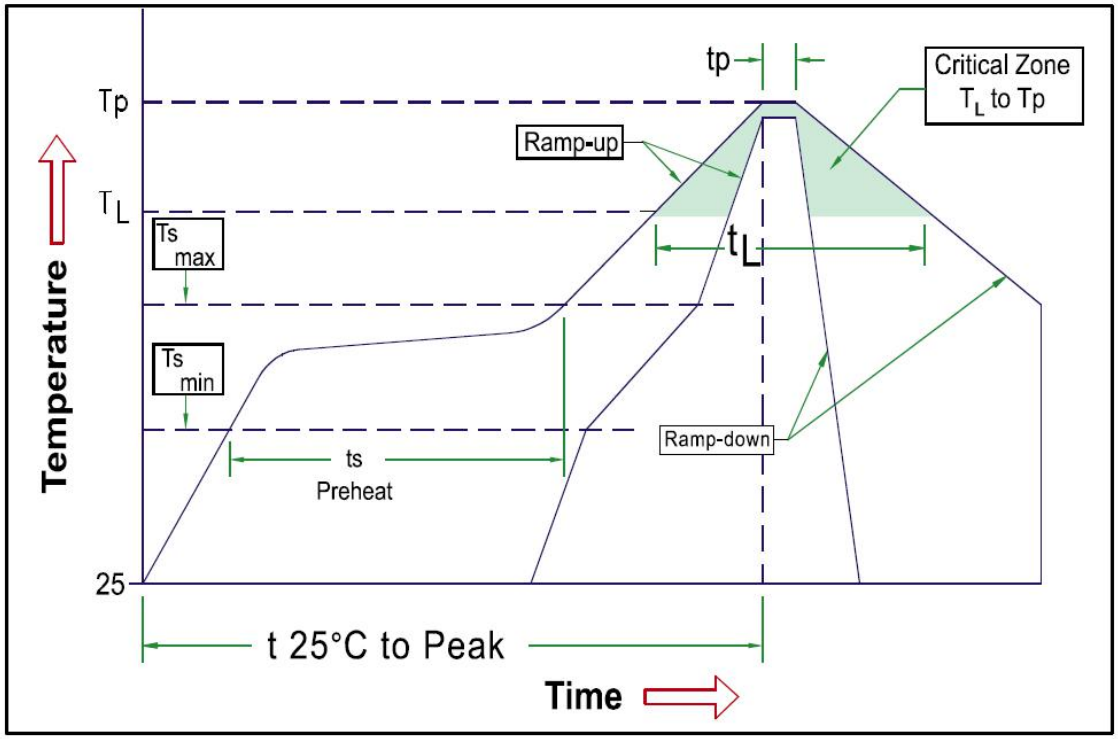

Appendix 4

JEDEC Profiles (*continued*):

JEDEC J-STD-020D Table 4-1 . SnPb Eutectic – "Package Peak Reflow Temperatures"
Package Thickness Volume mm3
< 350
Volume mm3
≥ 350
< 2.5 mm 240 +0/-5 ºC 225 +0/-5 ºC
≥ 2.5 mm 225 +0/-5 ºC 225 +0/-5 ºC
JEDEC J-STD-020D Table 4-2 . Pb-free Process – "Package Classification Reflow Temperatures"
Package Thickness Volume mm3
< 350
Volume mm3
350 - 2000
Volume mm3
< 2000
< 1.6 mm 260 +0 ºC * 260 +0 ºC * 260 +0 ºC *
1.6 mm – 2.5 mm 260 +0 ºC * 250 +0 ºC * 245 +0 ºC *

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≥ 2.5 mm 250 +0 ºC * 245 +0 ºC * 245 +0 ºC *
*Tolerance: The device manufacturer/supplier shall assure process compatibility up to and including the stated classification
temperature (this means Peak reflow temperature 0 ºC. For example 260ºC +0 ºC) at the rated MSL level.
Note 1: The profiling tolerance is +0 ºC, -X ºC (based on machine variation capability) whatever is required to control the
profile process but at no time will it exceed -5 ºC. The producer assures process compatibility at the peak reflow profile temperatures defined in Table 4-2.
Note 2: Package volume excludes external terminals (balls, bumps, lands, leads) and /or non-integral heat sinks.
Note 3: The maximum component temperature reached during reflow depends on package thickness and volume. The use
of convection reflow processes reduces the thermal gradients between packages. However, thermal gradients due to differences in thermal mass of SMD packages may still exist.
Note 4: Components intended for use in a “lead-free” assembly process **shall** be evaluated using the “lead-free” classification temperatures and profiles defined in Tables 4-1, 4-2 and 5-2 whether or not lead free.

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