ASSEMBLY INSTRUCTIONS FOR SCHA600 SERIES

Technical Note

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1 Objective

This document provides general guidelines for Printed Circuit Board (PCB) design and assembly of Murata's SCHA600 series components. It should be emphasized that this document serves only as a design guideline to help develop the optimal assembly conditions. User need to evaluate performance and reliability carefully in system. If user did not follow the requirement and recommendation, it may lead to safety risk. It is essential that users also use their own manufacturing practices and experience to be able to fulfill the needs of varying end-use applications.

2 Murata's 32-lead Dual In-line Package (DIL-32)

The SCHA600 series products are SMD DIL-32 components, pick-and-place mountable, and reflow solderable. These components are completely lead-free and designed to meet the demanding lead free soldering processes. The package consists of a pre-molded plastic housing, with a copper based lead frame having gull-wing type of lead pins on the side of the package to provide electrical contact to the PCB. A metal lid is attached to the top of the package. The DIL-32 package is presented in Figure 1.

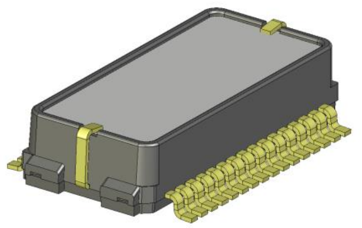


Figure 1. Three dimensional view of the DIL-32 package.

3 DIL-32 Package Outline and Dimensions

The outline and dimensions for the DIL-32 package are presented in Figure 2.

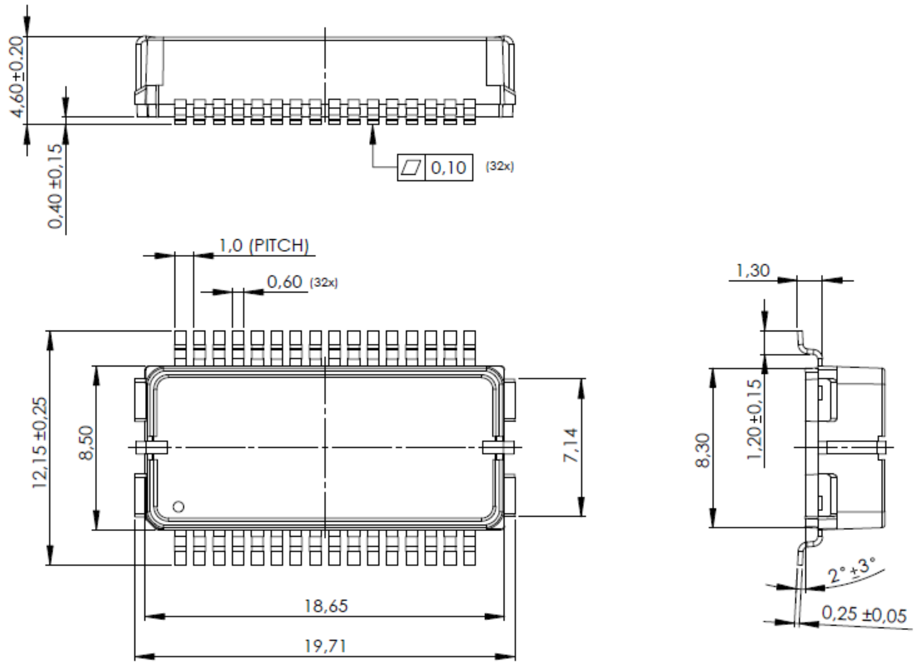


Figure 2. Outline and dimensions for DIL-32 package. Dimensions are in millimeters [mm].

All tolerances are according to ISO 2768-f unless otherwise specified.

4 Tape and reel specifications

Packing tape dimensions are presented in Figure 3. The unreeling direction and component polarity on tape are presented in Figure 4.

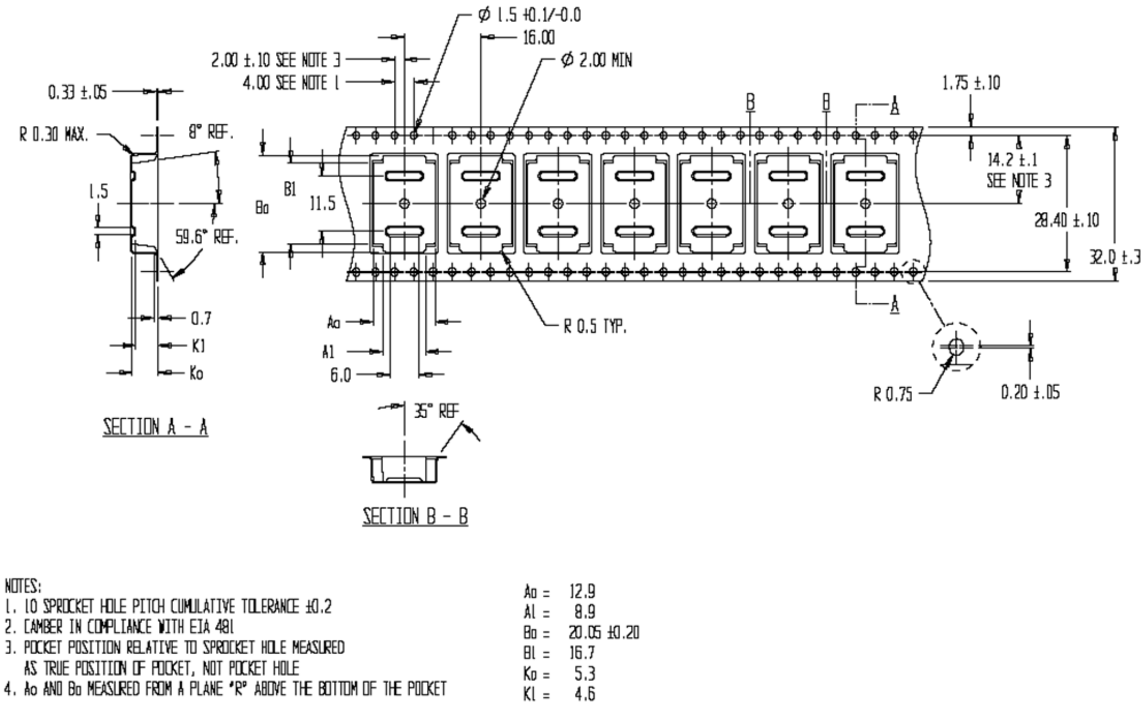


Figure 3. Packing tape dimensions for the DIL-32 Package. Dimensions are in millimeters [mm].

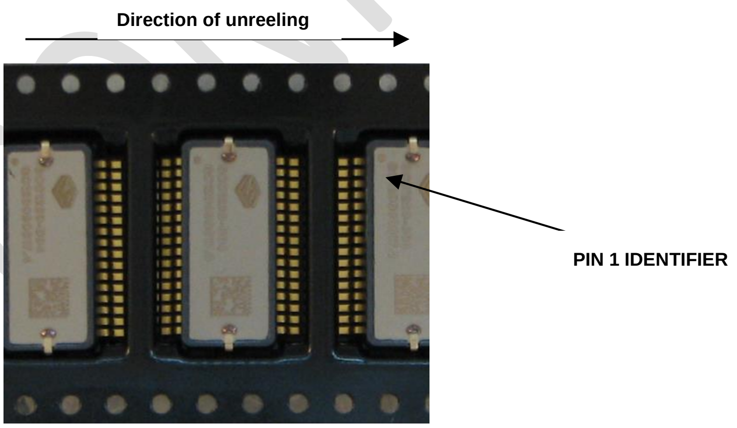


Figure 4. Package orientation on the tape and unreeling direction on tape.

The reel dimensions are presented in Figure 5 and Table 1. Packing reel dimensions [mm].below. Dimensions are in millimeters [mm].

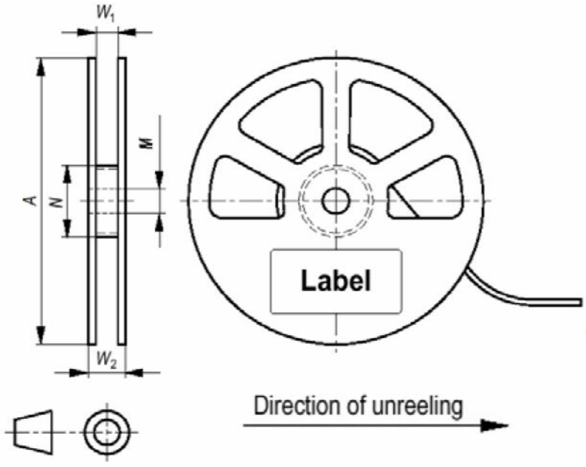


Figure 5. Reel dimensions. All dimensions are in millimeters [mm].

Table 1. Packing reel dimensions [mm].

A	N	W1	W_{2max}	M
330	100±1	32.4 (-0/+2.0)	38.4	∅ 13 (-0.2/+0.5)

5 Printed Circuit Board (PCB) Level Guidelines

5.1 PCB design recommendations

For optimal soldering and solder joint reliability results of Murata's DIL component, the PCB terminal pads should be designed larger than the package leads. Reference dimensions for the land pad design are presented in Figure 6. Note that this is only an example and e.g. much narrower pads can be used and also the length can be different.

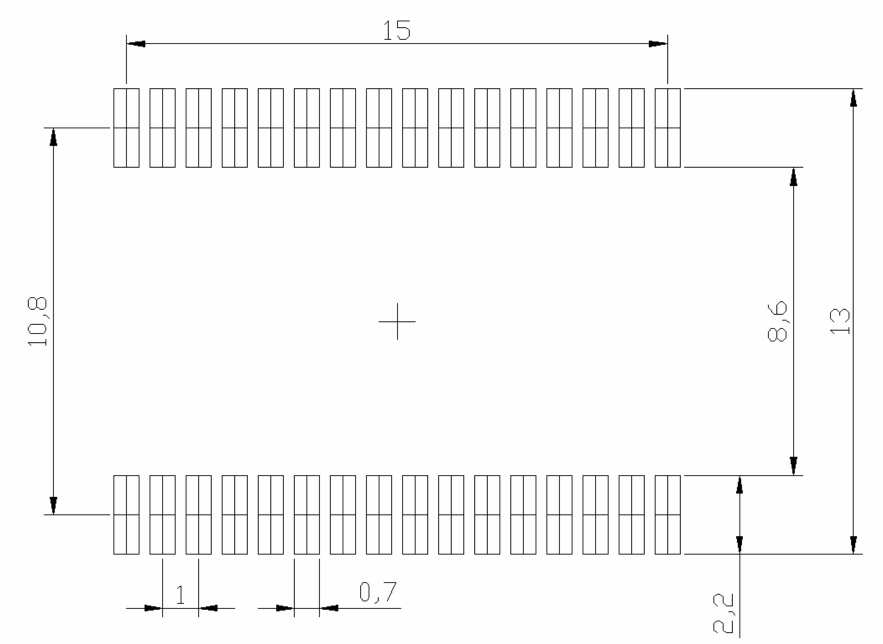


Figure 6. PCB pad lay-out for the DIL-32.

Murata's DIL packages can be soldered on commonly used substrates, e.g. FR-4, ceramic etc. The pad metallization should be solder wettable in order to assure good quality solder joints. For fine pitch assembly, the quality of plating is important. Generally used circuit board finishes for fine pitch SMD soldering are NiAu, OSP, Electroless-Ag and Electroless-Sn.

For the vibration sensitivity, it is recommended that PCB or Unit resonance modes are analyzed to verify that there are no critical modes close to sensor operating frequencies or excessive amplifications of hundreds of Gs.

5.2 Vibration reduction on PCB level

Performance might be inferior if the application PCB induces high resonance gain to the sensor component. Therefore, properly designed PCB attachment points together with PCB layout is of utmost important for applications that are intended to be used at vibrating environment.

5.2.1 Vibration mechanical range in application

It is recommended that user measures the resonance gain over frequency from the vicinity of the SCHA600 component at the application. In order to maintain proper operation of the sensor, the g-values at the application use environment must not exceed the specified mechanical range of the sensor component (refer to the component datasheet) (Requirement). E.g. PCB resonance modes can amplify external harmonic vibrations that can cause excessive vibration input to sensor component that exceeds the specified mechanical range. Murata cannot guarantee operation in conditions where the mechanical range of SCHA600 is exceeded and takes no responsibility if sensor operation failure occurs in such a case.

5.2.2 Application induced frequencies

Sensor component can have adverse performance if the use application induces vibration peaks at critical frequency bands of the sensor component. It is advised that application induced vibrational peak frequencies at the vicinity of the SCHA600 component should not overlap with Table 2 frequencies. Such vibration peaks can be caused by e.g. natural modal resonances of the use application's structures (PCB, lid, casing, mechanical fixtures) or other components at the use environment.

Table 2: Frequency bands to avoid.

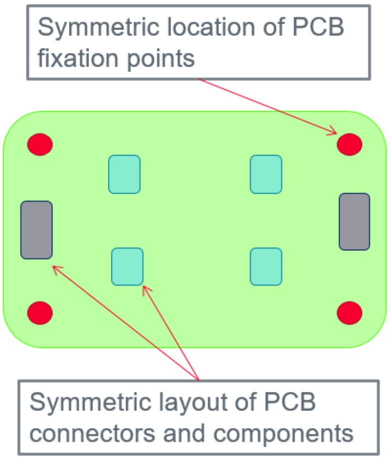
Product version	Recommendation to avoid excessive excitation vibration on these frequency bands.
SCHA600 series	15.8kHz - 17.8kHz (xyz), 28-35.6kHz (xyz) 18.3kHz - 20.3kHz (xyz)
	xy = in-plane vibration *z = out-of-plane vibration*

5.2.3 PCB Design

PCB design has a major impact on system level performance for applications that are intended to be used at vibrating environment.

PCB properties

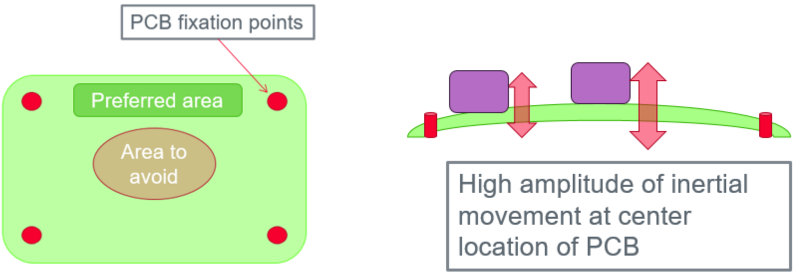
- Symmetricity
  - Murata recommends using symmetrically shaped PCB to minimize the potential amount of vibrational modes on system level.



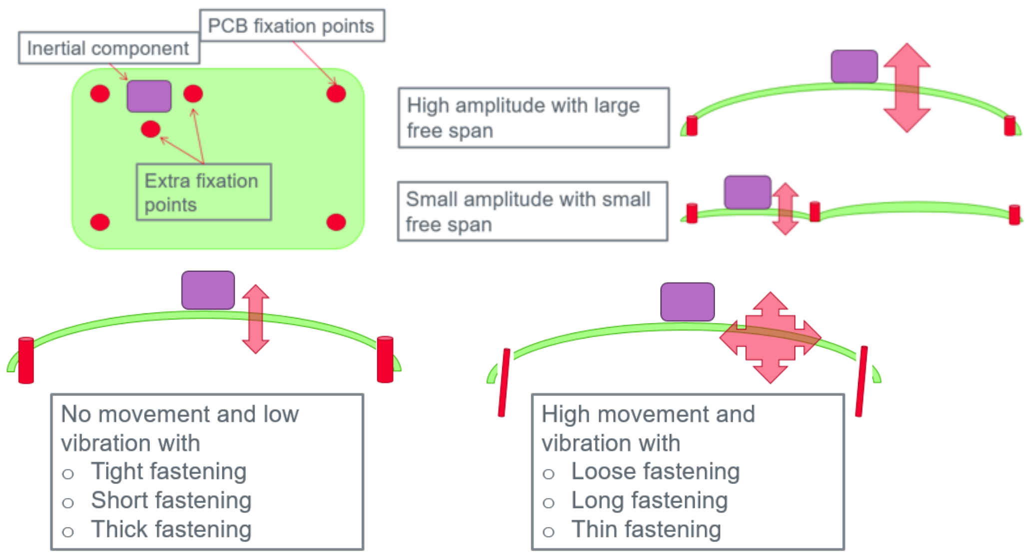
PCB attachment

- The distance from attachment points to the component (e.g. free span) affects stiffness, fundamental frequency and damping properties of the PCB that the component experiences.

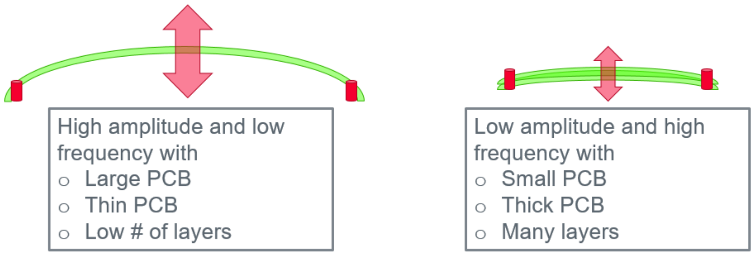
In general, the center part of the PCB is more exposed to Z-directional acceleration than PCB edges, therefore recommendation is to prefer PCB edge areas for inertial sensor location than center area.



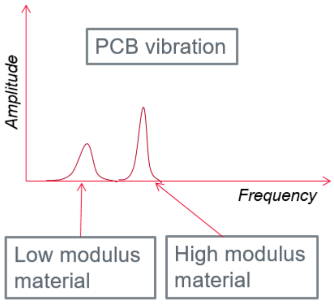
- Attachment method and the amount and location of attachment points have a major effect on the PCB behavior
  - Increased amount of attachment points in preferably symmetric locations stiffens the PCB and has potential for improving vibration behavior
  - It is recommended to minimize free span over inertial sensor component by adding extra fastening points around sensor component
  - Secure and tight fastening of PCB to system minimizes the movement of PCB and excitation of vibration modes
  - Always use high stiffness attachment method like thick screws or similar to attach PCB to next level system. Using of loose attachment method, e.g. press fit contacts, for mechanical mounting of PCB will increase risk of high amplitude PCB vibration modes that can cause sensor operation failure.



- Size and thickness (cross-sectional area)
  - Cross-sectional area affects stiffness, fundamental frequency and damping properties of the PCB. In general
    - Smaller PCB size will have lower Z-directional amplitude and higher vibrational frequencies.
    - Thicker PCB will increase vibrational frequencies.
    - Number of copper layers stiffens PCB and increases vibrational frequencies
  - PCB size and thickness should be chosen so that the PCB resonances will not overlap with Table 2 frequencies.



- PCB material
  - Elastic modulus affects stiffness, fundamental frequency and damping properties of the PCB. In general, high modulus material will
    - increase PCB stiffness
    - increase vibrational frequencies
    - decrease damping properties of PCB

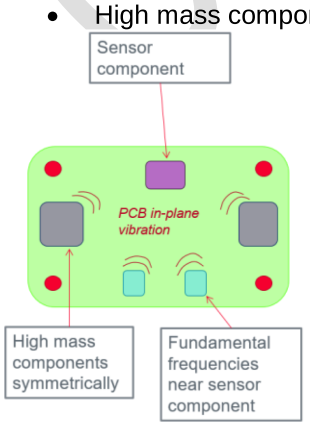


  - If the PCB is too flexible, it can be artificially stiffened using PCB stiffening ribs.

- Rubber dampers/vibration mounts at the attachments can reduce high frequency vibrations
  - It is possible to use rubber dampers at module level also
  - Good shock isolator is not always a good vibration isolator due to dynamic strain properties of elastomers
- If PCB is attached using screws, the screw material and screw length has an effect on the vibration behavior
- PCB edge guides have a slight effect on the vibration behavior

Effect of other components

- To avoid dynamic coupling, the resonances of other components near SCHA600 components should be at least one octave away from the resonances bands defined in Table 2
  - If it is not possible to avoid these components or resonances cannot be tuned, the components should be laid out as far away from each other as possible
- High mass components should be laid out on the PCB symmetrically



5.3 Solder paste

The DIL package can be soldered with lead-free SAC (tin-silver-copper) solder. The SAC solder paste composition should be near eutectic. The melting point of lead-free SAC solder can vary between 217–221ºC, depending on the composition of solder alloy. In order to guarantee full RoHS compatibility lead-free solder should be used for the soldering of Murata's DIL component. Also traditional eutectic SnPb solder can be used for soldering the DIL packages if a lead-free process is not required. With the eutectic SnPb solder, the melting point is 183°C.

A no-clean solder paste should be used, since the cleaning process is not recommended. The metal lid on the pre-molded package is not fully sealed and there is a risk that cleaning fluids might penetrate inside the package. If cleaning is used, user must validate that the process does not decrease the performance or reliability of the component. Ultrasonic agitation is strictly prohibited for Murata's MEMS components. Ultrasonic might destroy the MEMS structures.

The solder paste which is used must be suitable for printing it through the stencil aperture dimensions. Type 3 paste is recommended (grain size 25-45µm).

5.4 Stencil

The solder paste is applied onto the PCB using stencil printing. The stencil thickness and aperture determines the precise volume of solder paste deposited onto the land pattern. Stencil alignment accuracy and consistent solder volume transferring are important parameters for achieving uniform reflow soldering results. Too much solder paste can cause bridging and too little solder paste can cause insufficient wetting. Generally the stencil thickness needs to be matched to the needs of all components on the PCB taking account the co-planarity spec of Murata's DIL components.

The co-planarity of Murata's DIL components is specified max 0.1mm (100µm). For the DIL-24 package, the recommended stencil thickness is 0,15mm (150µm). The minimum thickness is 0,125mm (125µm).

Stencil apertures in general can be 1:1 to PWB pad sizes, or stencil apertures can be reduced by 5-10% from all sides in regard to the PCB land pad size. This reduction of aperture size can reduce bridging between solder joints.

5.5 Paste printing

The paste printing speed should be adjusted according to the solder paste specifications. It is recommended that proper care of printing speed is taken during the paste printing in order to ensure correct paste amount, shape, position, and other printing characteristics. Neglecting any of these can cause open solder joints, bridging, solder balling, or other unwanted soldering results.

5.6 Component picking and placement

The DIL package can be picked from the carrier tape using either vacuum assist or mechanical type pick heads. Typically a vacuum nozzle is used. Pick up nozzles are available in various sizes and shapes to suit a variety of different component geometries. Murata's DIL packages are relatively large and heavy and on the other hand accelerometers require as accurate positioning as possible. For this reason, it is recommended that different pick up nozzles are tested to find the best one. The polarity of the part must be assured in taping process. The orientation of the part on tape is presented in Figure 4.
DIL packages must be placed onto the PCB accurately according to their geometry. The reference planes are the bottom and the side walls of the component. Placement should be done with modern automatic component pick & place machinery using vision systems. Recognition of the packages

automatically by a vision system enables correct centering and orientation of packages. Pin #1 is indexed by a dot mark on the component lid as illustrated in Figure 4.

In the case of double sided SMT assembly, it should be noted that Murata's components are relatively heavy and they should be glued on the PCB if they are located on the bottom side of the PCB during the second solder reflow process. Murata's does not recommend any specific glue for this purpose. Some of Murata's customers have used standard epoxy based SMD adhesives.

Cover tape of reel is pressure forming type tape with glue. Caution has to be taken care when rolling off the cover tape to prevent the tape sticking and machine jamming. Extensive baking should be avoided, because it can increase the sticking of the cover tape.

5.7 Reflow soldering

A forced convection reflow oven is recommended to be used for soldering DIL components. IR-based reflow ovens are not generally suitable for lead-free soldering. Figure 7 presents a general forced convection reflow solder profile and it also shows the typical phases of a reflow process. The reflow profile used for soldering the DIL package should always follow the solder paste manufacturer's specifications and recommended profile. If washing process is done after the soldering process, it must be noted that ultrasonic agitation wash after reflow is not allowed for Murata's DIL packaged MEMS components. As mentioned before (section 5.2) a no-clean paste is recommended.

The typical ramp up rate is 3°C/second max. For lead-free soldering with SnAgCu solder the pre-heat temperature zone is ~ 150°-200° and should last for ~ 60-180 seconds. Time above the liquidus temperature (~217°C) should be ~ 60-150 seconds. The reflow peak max. temperature should not exceed 245°. Temperature within actual peak temperature is typically ~20-40 seconds. Ramp down rate should generally be 6°C/second max.

Maximum number of assembly reflow cycles for SCHA600 series components is three.

Reflow soldering with vacuum condition is prohibited as it may have effect for sensor performance.

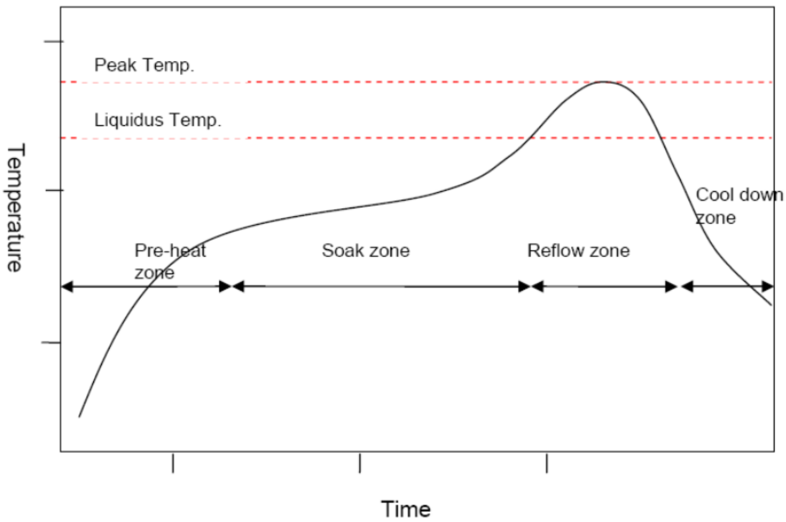


Figure 7. Typical convection reflow soldering phases and profile.

The process window for lead-free soldering is narrower than for traditional eutectic SnPb solders. Thus, caution has to be taken care when adjusting the reflow profiles. The reflow profile should be measured using a thermo-couple measurement system. It is recommended to use at least three thermo-couples, depending on the application. As a general guide, one thermo-couple should be placed under a component having the largest thermal mass, one next to the smallest component, one should be in contact with DIL component's solder joint, and others to the appropriate spots on a circuit board, e.g. corner, center, bottom of the board etc. The reflow profile should be adjusted according to the measured data so that each solder joint experiences an optimal reflow profile. The temperature gradient should be as small as possible across the circuit board. Extreme caution has to be taken if the circuit board contains components with highly different thermal masses.

5.8 Moisture sensitivity level (MSL) classification

The Moisture Sensitivity Level of the DIL component is Level 3 according to the IPC/JEDEC J-STD-020D. The part is delivered in a dry pack. The manufacturing floor time (out of bag) at the customer's end is 168 hours. Maximum soldering peak temperature for the DIL package is 245°C/40sec, measured from the package body.

Following instruction shall be followed:

1. Calculated shelf life in sealed bag: 12 months at < 40 °C and < 90% relative humidity (RH).

2. Maximum soldering peak temperature for the package is 245°C/40sec, measured from the package body.

3. After bag is opened, devices that will be subjected to reflow solder or other high temperature process must be

   a) Stored at <10%RH
   or
   b) Mounted within 168 hours of factor conditions ≤30 °C/60%RH.

   Note: Do not re-store devices that have exposed >10% RH conditions.

4. Devices require bake, before mounting, if:

   a) Humidity Indicator Card is > 10% when read at 23 ± 5 °C
   b) 3a or 3b not met.

5. If baking is required, devices may be baked for 24 hours at 85°C.

   Note: Also Tape&Reel materials are applicable for baking at 85°C.

Note: Packing materials and procedures according to IPC/JEDEC J-STD-033
Note: Level and body temperature defined by IPC/JEDEC J-STD-020

5.9 Inspection

Optical and visual inspection of solder joints can be done easily, since the solder joints are clearly seen. A visual inspection of the solder joints with conventional AOI (automatic optical inspection) system can be used. Also X-ray inspection can be used.

Cross-sectional analysis is also an approved method to inspect how well solder has wetted the pads of component. Cross-sectional analysis is not used for production inspection, but if required, it can be used to establish and optimize the component assembly process parameters Cross-sectioning is a destructive inspection method. An example of a DIL solder joint cross-section is presented in Figure 8.

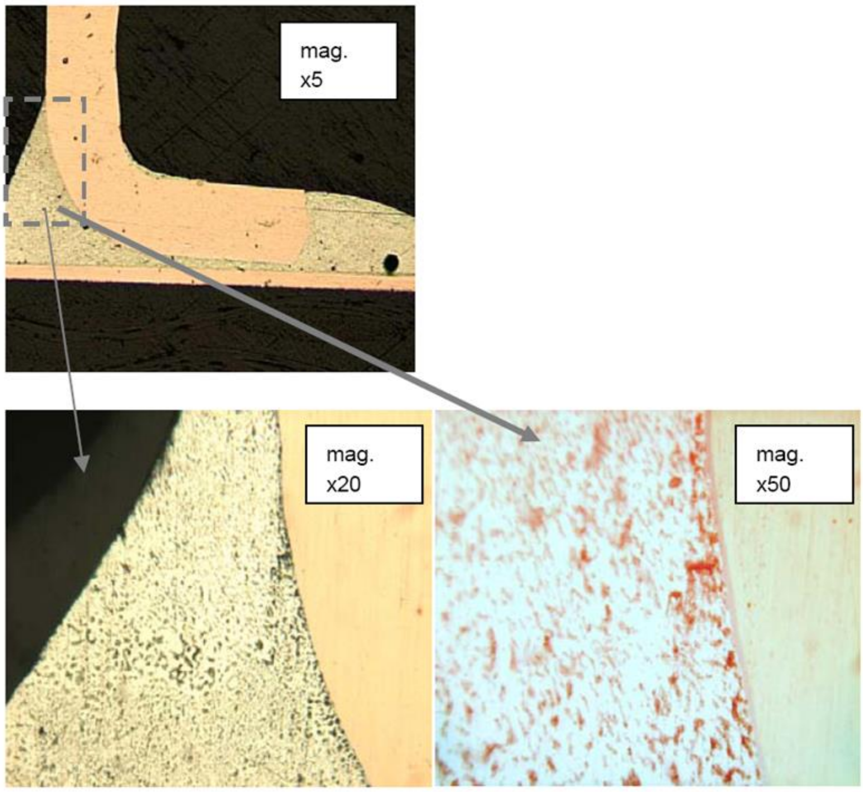


Figure 8. Cross-section of the DIL package lead's solder joint (with eutectic SnPb solder).

5.10 Precautions

MEMS sensors are mechanically and electrically sensitive components. Following sections describe typical processes or treatments, but are not limited to, which may be harmful for sensor component. Exceeding these limits or neglecting these guidelines may lead to malfunction of sensor component.

The reliability requirements for the devices are applied and validated according to AEC-Q100 Rev. G.

5.10.1 Mechanical shocks

Shocks may cause mechanical damage to the internal structures of MEMS sensor, causing malfunction of sensor, therefore mechanical shocks should be avoided. The level depends heavily on the pulse width and shape and should be evaluated case by case. As a general guideline, the lighter assembly or part, the higher shock levels will be generated on sensor component.

Any dropped component shall not be used and shall be scrapped (Requirement).

Sensor components are mechanical devices and especially sensitive to repetitive vibrations and shocks, therefore vibration of the device should be avoided both prior to or during assembly. Many assembly processes can induce vibration, typical ones being PCB singulation, dropping or knocking parts on hard surfaces, transportation, friction welding, ultra-sonic cleaning, and usage of pneumatic wrenches.

Maximum allowable linear acceleration g-levels during assembly for SCHA600 series is shown in Figure 7 (Requirement). If g-level is observed to be higher during component handling and assembly, each case has to be analyzed individually (Requirement).

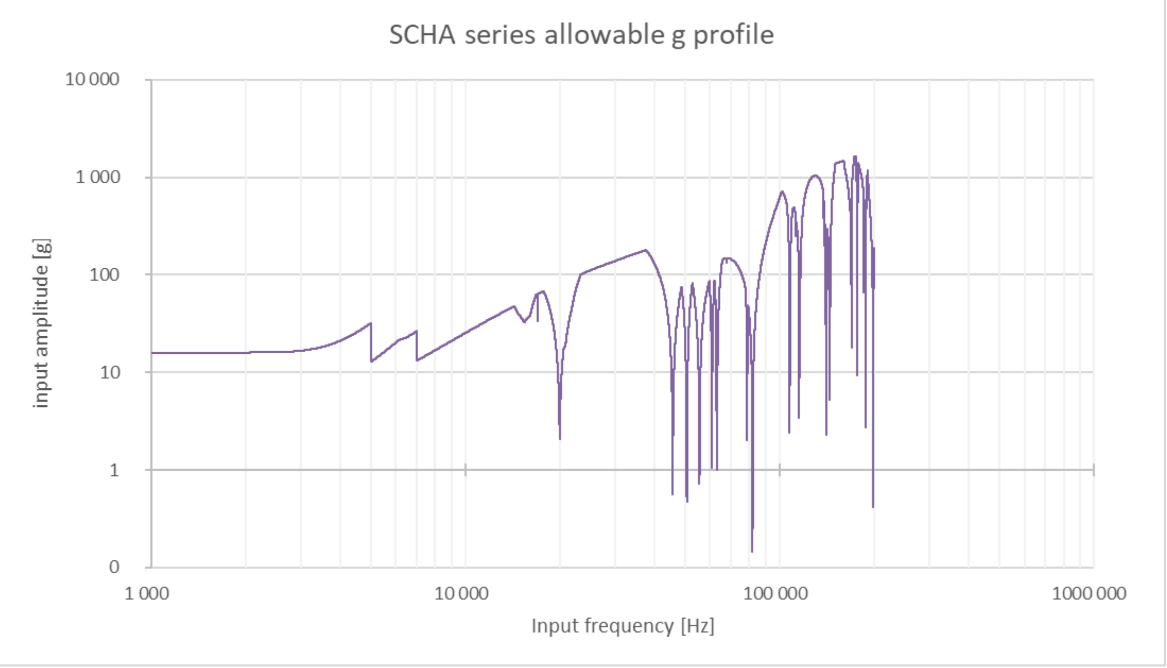


Figure 7 Maximum allowable g-level for SCHA600 series

5.10.2 Chemicals

Sensor components shall not be exposed to:

- Chemicals which are known to react with silicones, such as solvents. These are for example used in various cleaning processes
- Chemicals with high impurity levels, such as Cl-, Na+, NO3-, SO4-, NH4+
- Pressurized low molecular gas such as He or H2, used for example in leak test for hermetical sealing
- Materials with high amount of volatile content, like solvents

Materials containing halogens (F, Br, I or Cl), halides, their compounds or phosphorus containing materials (such as in flame retardants, thermal stabilizers in plastics, Bromine in PCB material or halogens/halides in soldering paste) shall be avoided in close vicinity of sensor component.

If heat stabilized polymers are used in application, user should check that iodine, or other halogen, containing additives are not used. Iodide compounds are known to cause issues with gold aluminum interconnects. User should also check that excessive amount of I, Br or other halogen containing additive are not used. Quantitative value is depending on number of factors, including the total volume of such halogen material, stability of halogen within material, hermeticity level of application and temperature, among others.

Life-time reliability tests should always be performed at application level to validate the end product against life-time requirements/mission profile, as corrosion effects heavily depend on the final construction of application, temperature, time and other application specific factors.

5.10.3 Coatings

Coatings on sensor component are not generally recommended. Coating penetration inside the component is high risk for performance change. If coating is required, the effect of coating on sensor component reliability and electrical performance has to be evaluated case by case. As a general guideline, lower the viscosity or higher the modulus of coating, higher the probability of adverse effects on sensor component.

Sealing of the component lid is prohibited.

5.10.4 Vacuum level

Vacuum levels lower than 0.4 bar shall not be applied on sensor component. Fast pressure changes of over 0.5 bar/min should be avoided. Example processes can be vacuum sealing or pressure testing of the device.

5.10.5 Air blowing

Heavy compressed air blowing directly onto sensor component shall be avoided. Air blowing could be used for example during cleaning of the PCB.

5.10.6 ESD

Sensor components are electrical devices. Sensor components should be handled under good ESD practices and ESD discharges should be avoided. The following numbers are absolute maximum ratings:

- ±500 V charged device model (test will be done in DV)
- ±2 kV human body model (test will be done in DV)

5.10.7 Moisture

Sensor components are moisture sensitive devices, classified as MSL3 level. Guidelines defined by IPC/JEDEC J-STD-020D shall be followed.

5.10.8 Mechanical stress

Mechanical stress due to PCB bending, molding and potting may affect the sensor performance. Excessive stress due to PCB bending shall be avoided. If molding or potting material is hard material, contact to sensor shall be avoided.

5.11 Cleaning

Items listed in section "5.9 Precautions" are applied to cleaning also. Examples of cleaning procedures which may have a negative effect on the sensor component performance or functionality are:

- Wet cleaning with solvent
- Ultrasonic
- Heavy air blowing
- Plasma cleaning with vacuum

6 Rework Guidelines

The components after reworked shall not be used for vehicles or any safety critical application because rework with excessive stress may cause component performance change. If it becomes necessary to rework a SCHA600 series component, the preferred way to remove the component is by hot air. Use of a hot air rework station with a vacuum chuck, is the preferred method. A key issue in using hot-air is preventing thermal damage to the component or adjacent components.

If hot air rework station is not available, rework with thermal tweezers is also an acceptable alternative

Removing of the component with hot iron only is difficult as it is easy to get the part too hot and destroy it. It is not recommend method if failure analysis.

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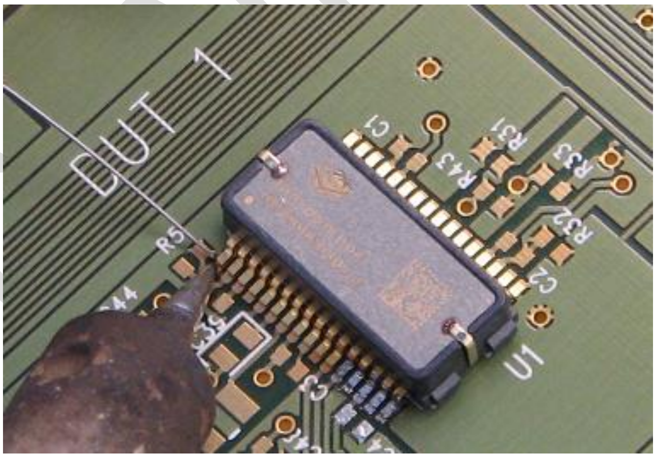


Figure 8. Using tin wire and soldering iron for hand soldering. Picture for reference only.

Soldering by applying solder paste and then using reflow heating or soldering iron

1. Apply the solder paste onto the PCB land pads. The paste can be applied by two different methods.
   - Manual solder paste printing through a stencil with normal openings designed for the DIL component.
   - Needle dispensing of solder paste manually onto the PCB pads. Murata recommends use of a microscope in manual solder paste dispensing. Dispensing needle tip size can be 0.12"-0.16".
2. Place the component gently on top of the solder paste. To avoid solder bridging, push only very gently on top of the component.
3. **i)** Melt the solder paste by putting the part through reflow oven *or* **ii)** by using soldering iron as mentioned in the previous part.

6.1 Instructions for desoldering and removing of component

Soldering Station (Pace SensaTemp ST25E-PS90) and thermal tweezers (Pace Thermotweez) with Pace 1121-0416-P1 tool head are used for de-soldering and removing of the component.

Figure 9. Pace SensaTemp ST25E-PS90

Figure 10. Thermal tweezers, Pace Thermotweez.

Figure 11. Tool head, Pace 1121-0416-P1.

The plastic molding compound on the component is LCP (liquid crystal polymer) which withstands very high temperatures and is good material for Pb-free assembly. LCP's melting point is 335ºC. However, the mechanical properties start to change already near 280ºC. If the pins are heated too long the plastic around pin will be softened and if there at the same time is some stress on the pin there is a risk that pin might move and cause increased reliability or wirebond break inside housing.

In order to melt all pins simultaneously, tweezers are recommended for de-soldering of the component. Also with tweezers, special care must be taken if failure analysis or re-use of the component is desired.

In the component removal process, the temperature setting in soldering station is normally +315ºC. The temperature on the tip of the tool is 270...275ºC. Tool is pressed against pins only for few seconds. Same temperature is used both for Pb-free and SnPb-solder joints, even though SnPb solders melt already below 200ºC. Some temperature adjustment might be needed. Especially if tool head is old and 'dirty' temperature needs to be increased.

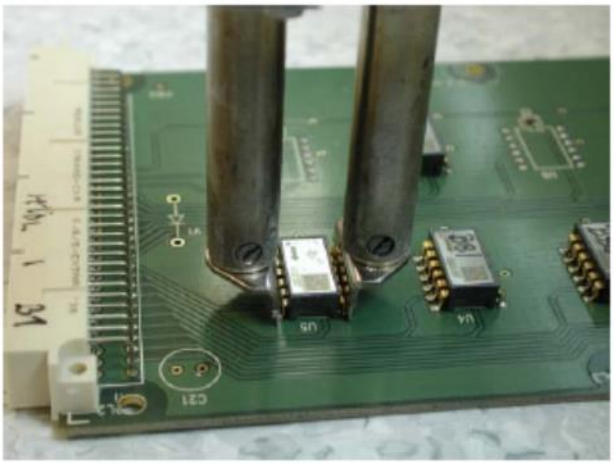


Figure 12. Tool head is carefully pressed around component and kept in this position for few seconds.

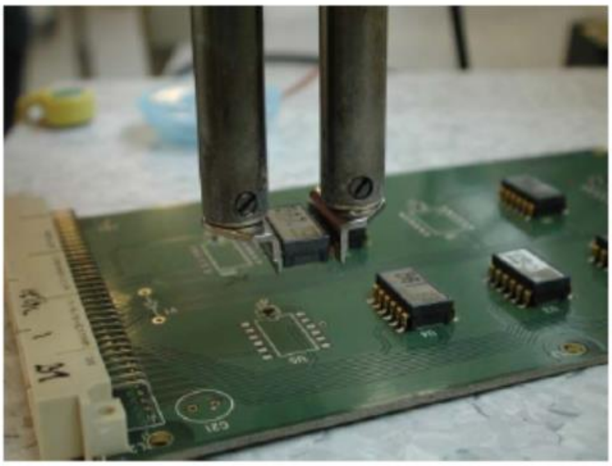
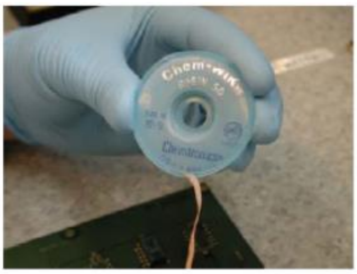
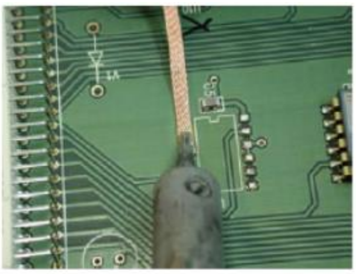


Figure 13. Immediately after solder melting, component is lifted.

Remove the solder from the PCB using either a solder vacuum or solder braid making sure to clean the area of solder thoroughly.





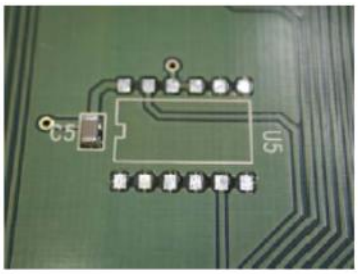


Figure 14. Soldering iron and solder braid used for solder removal.

Note that the performance and the reliability of the reworked component may have decreased due to the rework operation! Murata does not recommend rework.

7 Environmental Aspects

Murata Electronics Oy respects environmental values and thus, its DIL packages are lead-free and RoHS compatible. Murata Electronics' sensors should be soldered with lead-free solders in order to guarantee full RoHS compatibility. De-soldered, reworked components can not be re-used. It must be thrown away following user's own laws and regulations.

8 References

JEDEC / Electronic Industries Alliance, Inc. Moisture/Reflow Sensitivity Classification for Non-Hermetic Solid State Surface Mount Devices (J-STD-020D).

Handling, Packing, Shipping and Use of Moisture/Reflow Sensitive Surface Mount Devices (IPC/JEDEC J-STD-033).

Document Change Control

Author	Approved by
Tomoaki Omoda, Teppo Syrjänen	
Department/Role	
Packaging Development & Lead Engineering	

Version	Date	Change Description	Author	Reviewed by
1	30.5.2019	First release	TES	TOOM
2	7.11.2019	2nd revision	MAKI	TOOM
3	29.1.2021	3rd revision	MAKI	VNU