CMR3000 Assembly Instructions

CMR3000 Series
3-axis gyro

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1 Objective

This document describes guidelines for Printed Wiring Board (PWB) design and assembly of the CMR3000 3-axis gyro. It also aims to help customers achieve the optimum soldering process.

2 VTI's 3D Stacked Wafer Level Chip-on-MEMS Package (CoM)

CMR3000 features a novel packaging concept called Chip-on-MEMS (CoM). Its approach has been to maintain the benefits of manufacturing the MEMS devices and ASICs on separate wafers. For this Chip-on-MEMS concept, ASIC chips are flip-chipped onto the MEMS wafer in known good locations. Redistribution and isolation layers are applied to the MEMS wafer, solder spheres are provided for external connection before the ASICs are added and the MEMS and ASIC chips are then isolated using a passivation layer. The concept is illustrated in Figure 1.

Figure 1. The concept of the CMR3000 component.

CoM-technology offers a variety of benefits including reduced lead inductance, an extremely small sized chip scale package, thin profile (< 1mm), low weight, excellent solderability and reworkability due to solder spheres. Because the CoM-technology represents the latest in the surface mount packaging technology, it is important that the design of the printed wiring board, as well as the assembly process, follow the suggested guidelines outlined in this document.

It should be emphasized that these guidelines are general in nature and should only be considered as a starting point. The user must employ their actual experiences and development efforts to optimize designs and processes for their manufacturing practices and the needs of varying end-use applications.

3 CMR3000 CoM Package Outline and Dimensions

The outline and dimensions for the CMR3000 CoM package are presented in Figure 2.

Note: Solder sphere surfaces may contain marks originated from the calibration process. These are not damages and they do not have an effect on solderability.

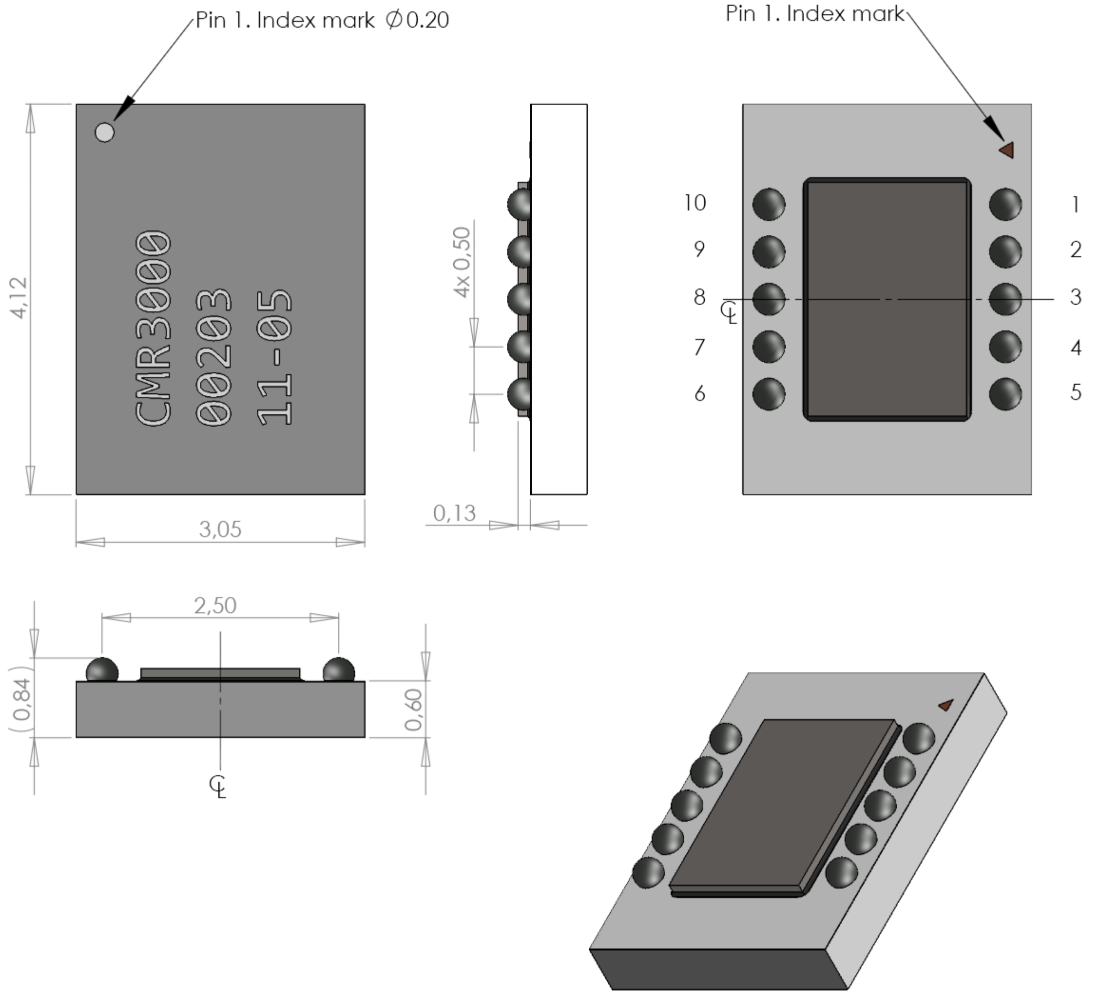


Figure 2. Outline and dimensions for the CMR3000 component mm with ±50 µm tolerance for reference only. Please check the corresponding data sheet for details.

Pin 1 index mark can be seen in Figure 3.

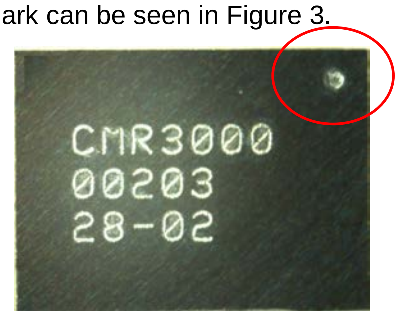


Figure 3. Pin 1 index mark on top of CMR3000.

4 Packing

CMR3000 is available on three different reel sizes listed in Table 1 below.

Table 1. CMR3000 available reel sizes.

Components on reel	Reel diameter	Carrier tape width
100 pcs	7 inches	12 mm
1000 pcs	7 inches	12 mm
5000 pcs	13 inches	12 mm

4.1 Order codes

Table 2. Order codes for prodcut type CMR3000-D01.

Order code	Description	Packing	Quantity
CMR3000-D01-1	3-Axis gyro with SPI&I²C interface, +/-2000dps, 100 pcs	T&R	100 pcs
CMR3000-D01-10	3-Axis gyro with SPI&I²C interface, +/-2000dps, 1000 pcs	T&R	1000 pcs
CMR3000-D01-50	3-Axis gyro with SPI&I²C interface, +/-2000dps, 5000 pcs	T&R	5000 pcs
CMR3000-D01 PWB	PWB assy for 3-Axis gyro with SPI&I²C interface, +/-2000dps	Bulk	1 pc
CMR3000-D01 DEMO	CMR3100-D01 Demo Kit with USB interface to PC	Bulk	1 pc

4.2 Reel Specifications

4.2.1 7 inch reel

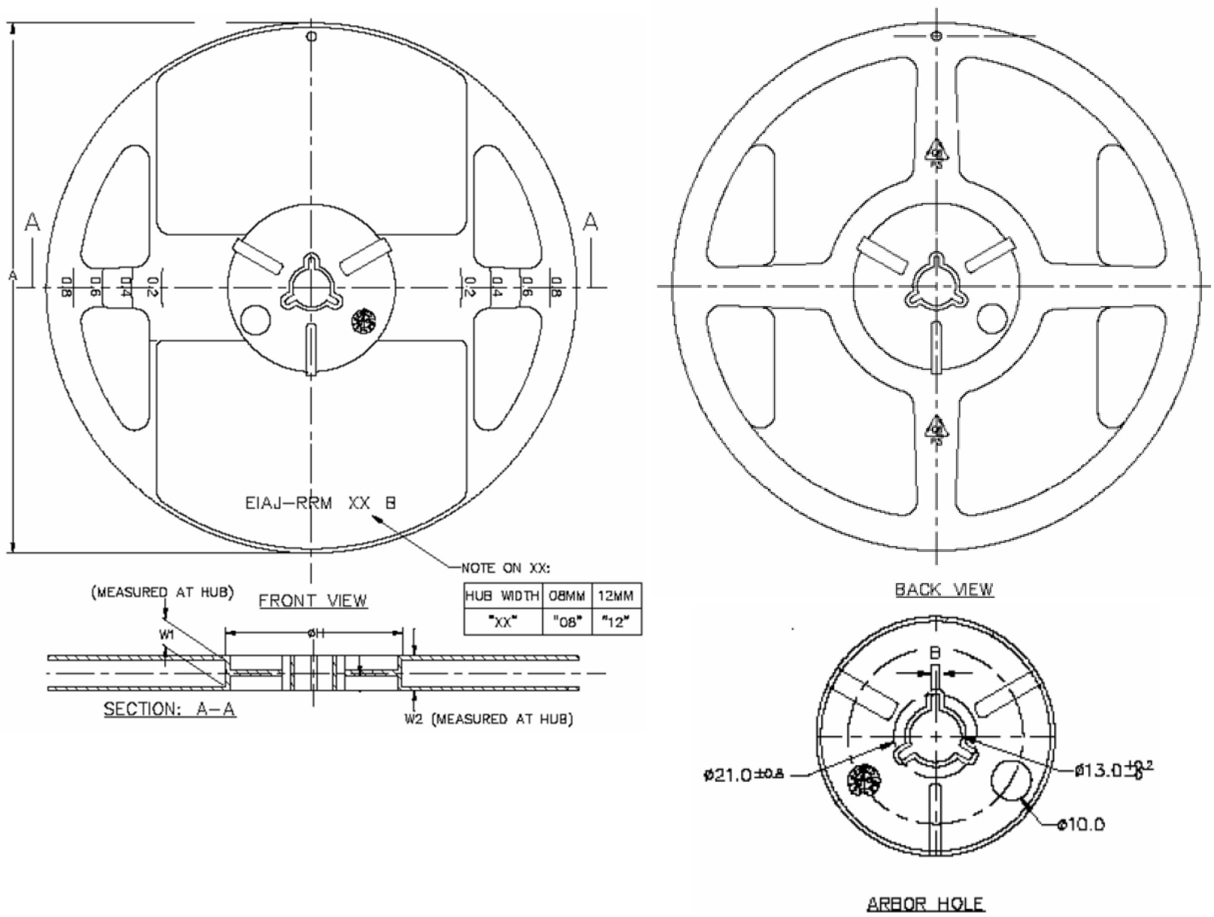


Figure 4. Reel dimensions for 7 inch reel.

Table 3. Reel specifications for 7 inch reel, dimensions in [mm] (refer to Figure 4).

Tape width	ØA	B	W1	W2	ØH
12 mm	180.0 (+0.0 / -3.0)	2.0 (+0.2 / -0.0)	13.0 (+0.3 / -0.3)	15.4 (+1.0 / -1.0)	60.0 (+1.0 / -0.0)

4.2.2 13 inch reel

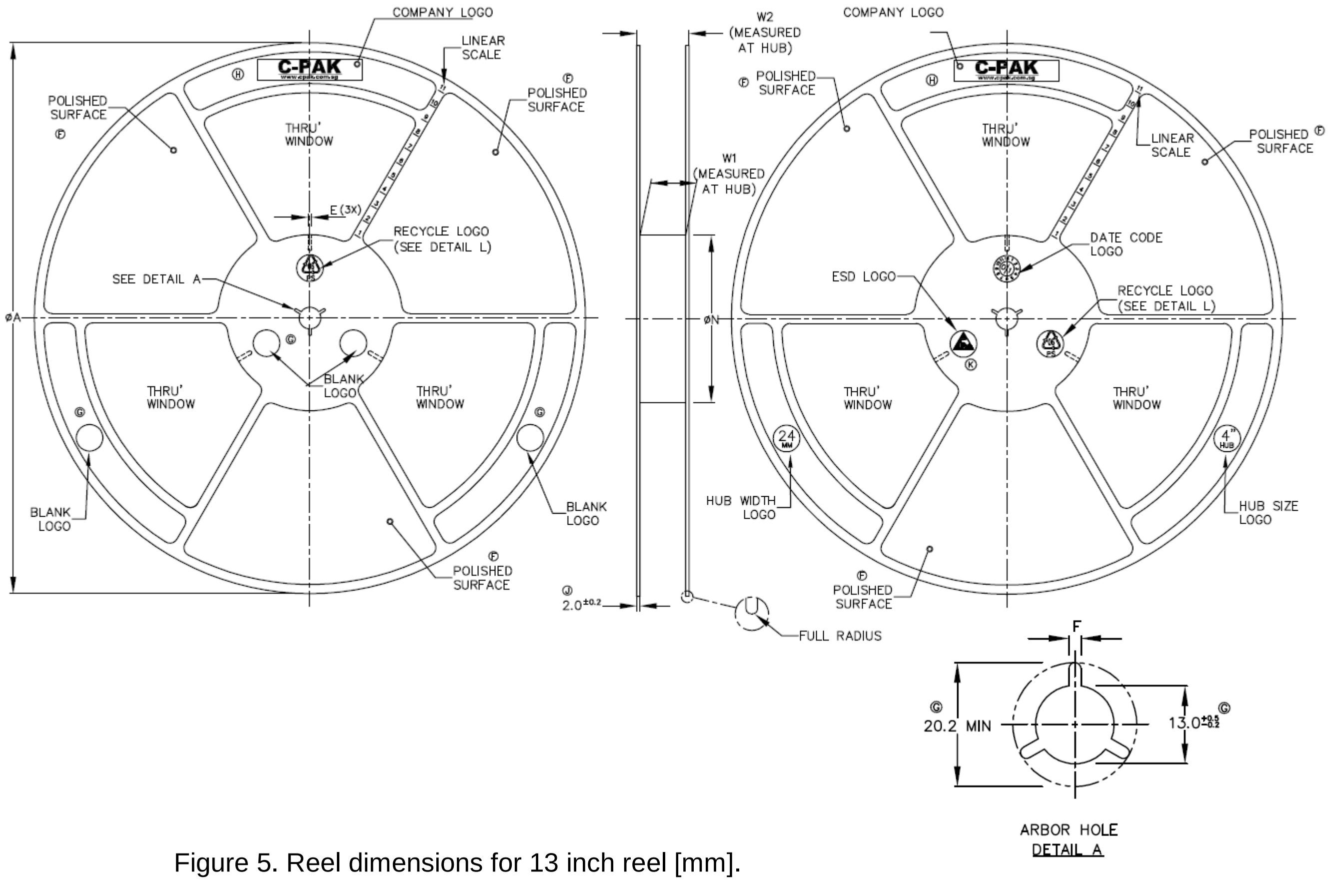
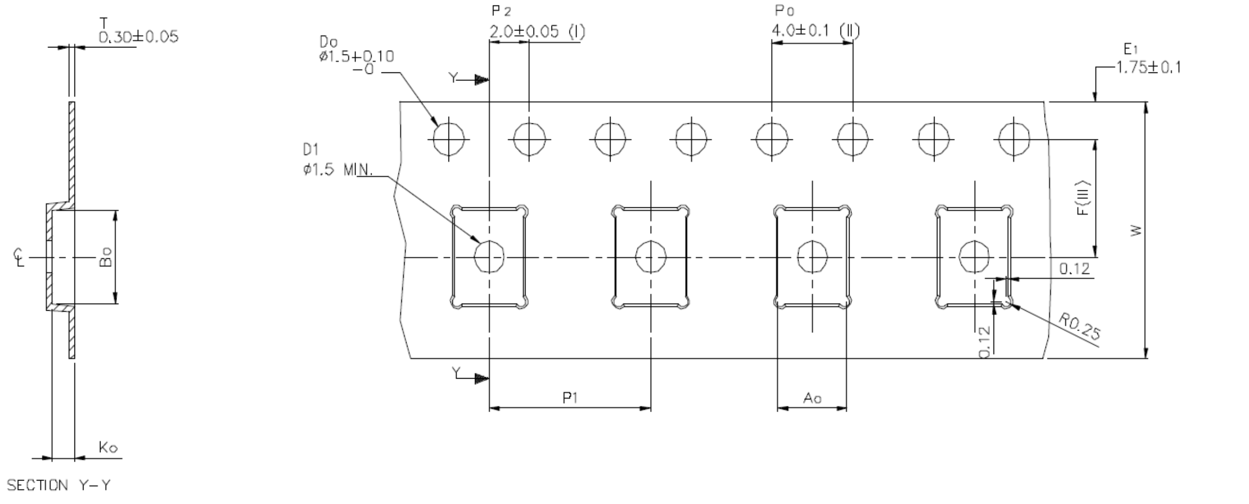


Figure 5. Reel dimensions for 13 inch reel [mm].

Table 4. Reel specifications for 13 inch reel, dimensions in [mm] (refer to Figure 5).

Tape width	ØA	ØN	W1	W2	E	F
12 mm	max 330.0	100 (+2.0 / -2.0)	12.4 (+2 / -0)	max 18.4	min 2.5	min 1.5

4.3 Tape Specifications



Ao	3.40 +/− 0.1
Bo	4.40 +/− 0.1
Ko	1.10 +/− 0.1
F	5.50 +/− 0.05
P1	8.00 +/− 0.1
W	12.00 +/− 0.3

(I) Measured from centreline of sprocket hole to centreline of pocket.
(II) Cumulative tolerance of 10 sprocket holes is ± 0.20 .
(III) Measured from centreline of sprocket hole to centreline of pocket.
(IV) Other material available.
(V) Typical SR of form tape Max 10^9 OHM/SQ
ALL DIMENSIONS IN MILLIMETRES UNLESS OTHERWISE STATED.

Figure 6. Tape dimensions [mm].

Tape feeding is typically 750±250 mm. The polarity of the part on tape looks as follows:

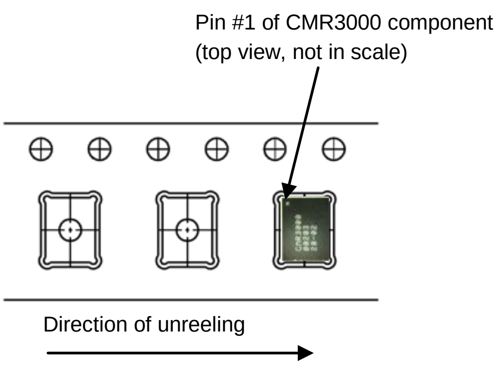


Figure 7. CMR3000's orientation on a tape.

4.4 Shipping label and reel packing

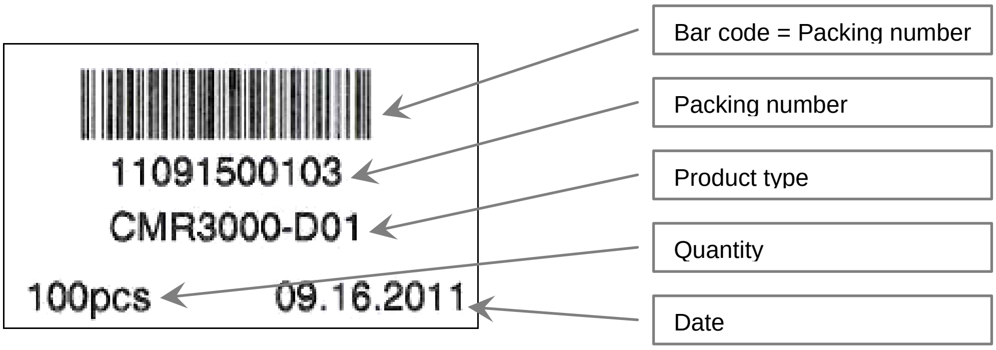


Figure 8. Shipping label with packing number.

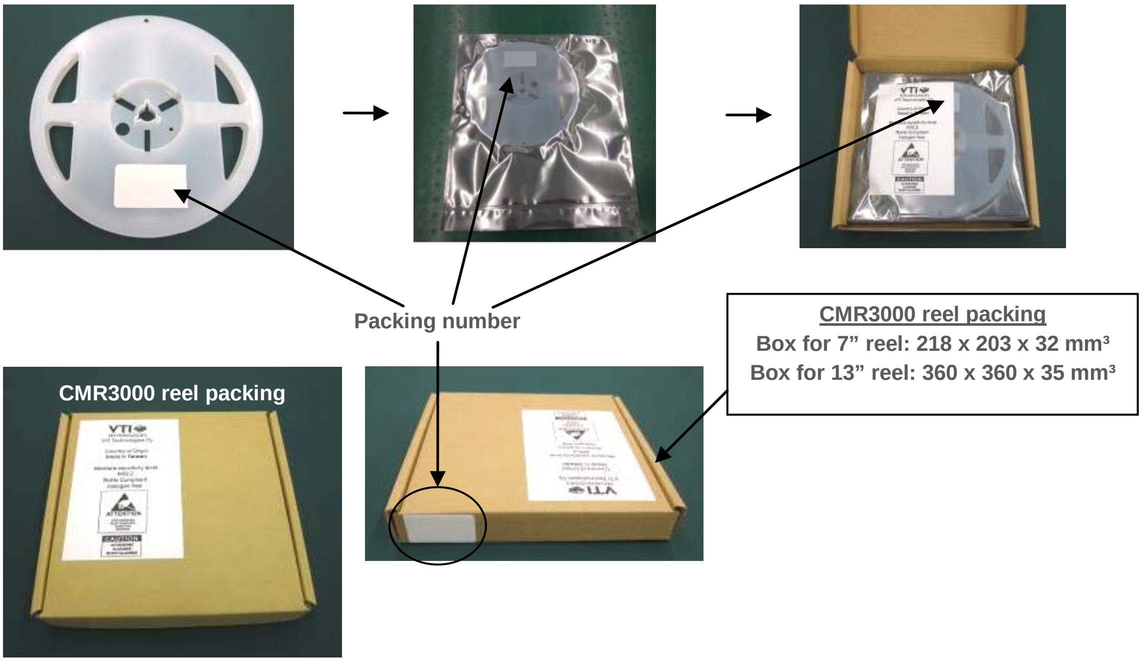


Figure 9. Reel packing.

5 Recommended Storage Conditions

- Temperature between 5 degC to 30 degC
- Humidity between 10 to 70% RH
- Clean air
- Stored on a plane area
- Avoid
  - Harmful gas or dust
  - Outdoor exposure or storage in areas subject to rain or water spraying
  - Exposure to direct sunlight
  - Rapid changes of temperature
  - Condensation
  - Mechanical stress such as vibration and impact
  - Storage up side down or placed against the wall
- Products shall not be placed directly on the floor

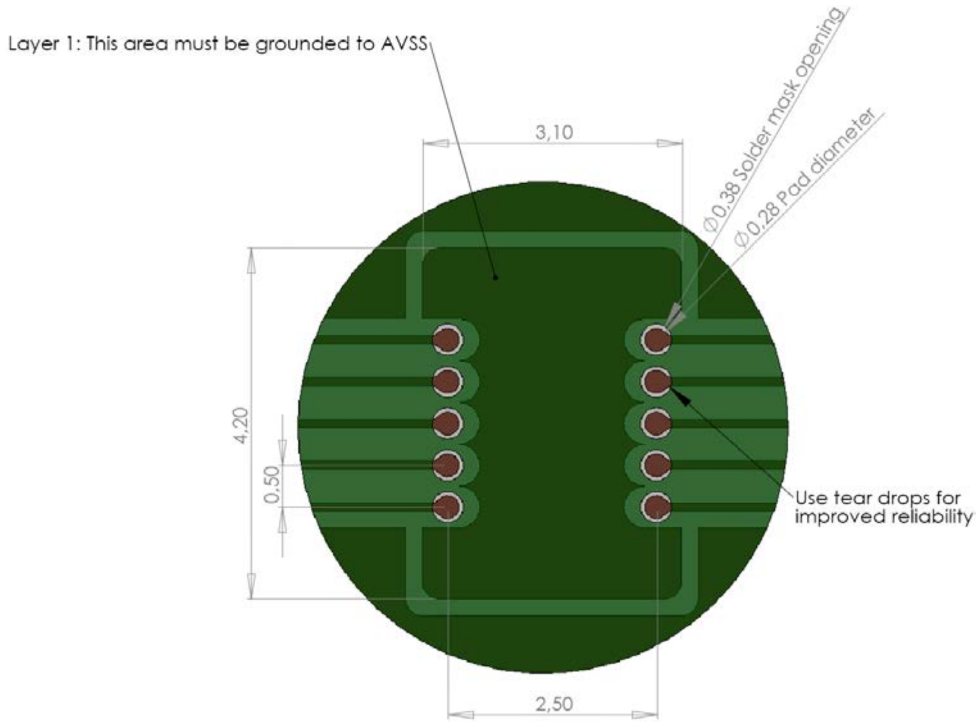
6 Printed Wiring Board (PWB) Level Guidelines

6.1 PWB layout

Two types of land patterns are generally used for surface mount packages:
1) Non-Solder Mask Defined Pads (NSMD)
2) Solder Mask Defined Pads (SMD).

NSMD pads have an opening which is larger than the pad itself, and SMD pads have a solder mask opening that is smaller than the metal pad on PWB. NSMD is preferred since the copper etching process has tighter process control compared to the solder mask process and less solder mask originated defects. Recommended solder mask thickness is max 20 µm.

Symmetrical pad and trace designs on the CMR3000 component PWB area are highly recommended as those would guarantee an optimal component performance. Moreover, traces should not be routed beneath the CMR3000 component, but to use ground plane instead in order to optimize immunity to noise coupled from signal lines. Recommended PWB land pattern and dimensions for the CMR3000 component are presented in Figure 10. Reference layouts are presented in corresponding product family specifications:
CMR3000-D0X_Product_Family_Specification_82112900.



Solder Pad	Copper Pad	Solder Mask Opening	Trace Width
Non-Solder-Mask Defined (NMSD)	280 µm (+0, -25 µm)	380 µm (+0, -25 µm)	100 µm (±25 µm)

Figure 10. Recommended PWB pad layout and dimensions for CMR3000 component.

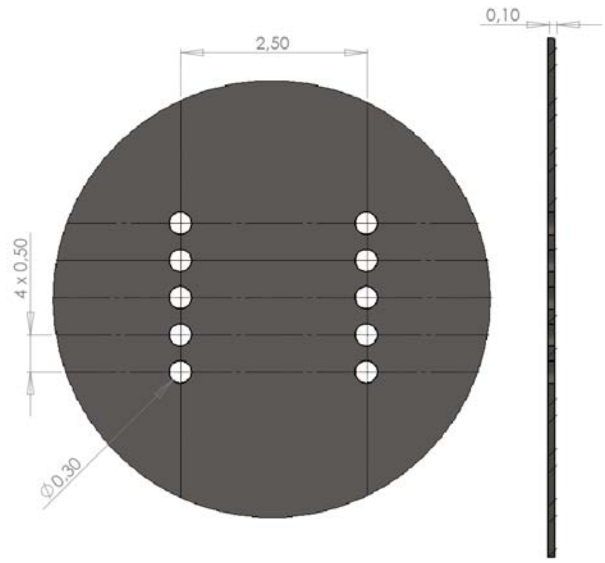
VTI Technologies' sensors can be soldered on commonly used substrates, e.g. FR-4, ceramic, flex-print etc. The pad metallization should be solder wettable in order to assure good quality solder joints. Generally used circuit board finishes for fine pitch SMD soldering are NiAu, OSP, I-Sn, and I-Ag.

6.2 Solder Paste

For the optimum metallurgical compatibility, it is recommended to solder the CMR3000 component with lead-free SAC-based (tin-silver-copper) solder paste as the solder spheres on the CMR3000 component are based on this alloy. A near eutectic solder paste composition is recommended. The melting point of lead-free SAC solder can vary between 217–221°C, depending on the composition of the solder alloy. A no-clean solder paste is recommended as **ultrasonic agitation wash of the CMR3000 component is prohibited**. The solder paste must be suitable for printing it through the stencil aperture dimensions. Type 3 paste is recommended (grain size 25-45µm).

6.3 Stencil

The solder paste is applied onto the PWB by 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 transfer 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 PWB. The recommended stencil openings and dimensions for the CMR3000 component are presented in Figure 11.



Stencil opening	Stencil thickness
Round 300 µm (+0, -25 µm)	100 µm (±25 µm)
Square 275 µm x 275 µm (±0 µm)	100 µm (±25 µm)

Figure 11. Recommended stencil openings and dimensions for CMR3000 component. Round openings are preferred.

Note that the stencil openings should always be matched to the selected PWD pad design and solder paste type for the optimal solder paste release. Furthermore, the stencil material and method of forming those have an effect on solder paste release.

6.4 Paste Printing

The paste printing speed should be adjusted according to the solder paste specifications. Care should be taken during 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.

6.5 Component Picking

The CMR3000 component can be picked from the carrier tape using vacuum nozzles. Pick up nozzles are available in various sizes and shapes to suit a variety of different component geometries. It is recommended to that different pick up nozzles are tested to find the best one suited for the purpose. The polarity of the part on tape is presented in section 4.2.

In case manual handling of the CMR3000 component is required, special attention should be paid on the handling procedures. Delicate handling is a necessity as exposed silicon surfaces on the CMR3000 component are very sensitive to mechanical handling. Handling with metallic tweezers is forbidden. Note that any sort of manual handling is not recommended.

Proper ESD procedures should always be followed when handling the CMR3000 component. Equipment, tools, and setups used for component picking must be verified to be ESD-safe in advance.

6.6 Component Placement

The CMR3000 components must be placed onto PWB accurately according to their geometry. Reflowable solder spheres provide self-alignment for the component, which will help with accurate positioning. Positioning the packages manually is not recommended.

Placement can be done with typical automatic component pick & place machinery capable of placing similar sized components. Recognition of the packages automatically by a vision system enables correct centering of the packages. The Z placement should be carefully controlled as too high force or overdriving during the component placement may damage the component and cause misalignment. Maximum assembly force is 4 N. Locally the mounting pressure should not exceed 1 MPa.

6.7 Reflow Soldering

A forced convection reflow oven is recommended to be used for soldering CMR3000 components. The reflow profile used for soldering the CMR3000 should always follow the solder paste manufacturer's specifications and recommended profile. The ramp-up rate should typically be less than 3°C/second. The reflow maximum peak temperature (measured from the component body) should not exceed 260°C and the minimum temperature (measured from the solder joints) should be higher than 230°C. The ramp down rate should be 6°C/second max. Figure 12 presents a general forced convection reflow solder profile with the typical phases of a reflow process. Please refer to IPC/JEDEC J-STD-020C table 5-2 and figure 5-1 for details. Recommended max number of reflow cycles is 3.

Profile Feature	Sn-Pb Eutectic Assembly	Pb-Free Assembly
Average 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	150 °C 200 °C 60-180 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 of 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 minutes max.	8 minutes max.

Note 1: All temperatures refer to topside of the package, measured on the package body surface.

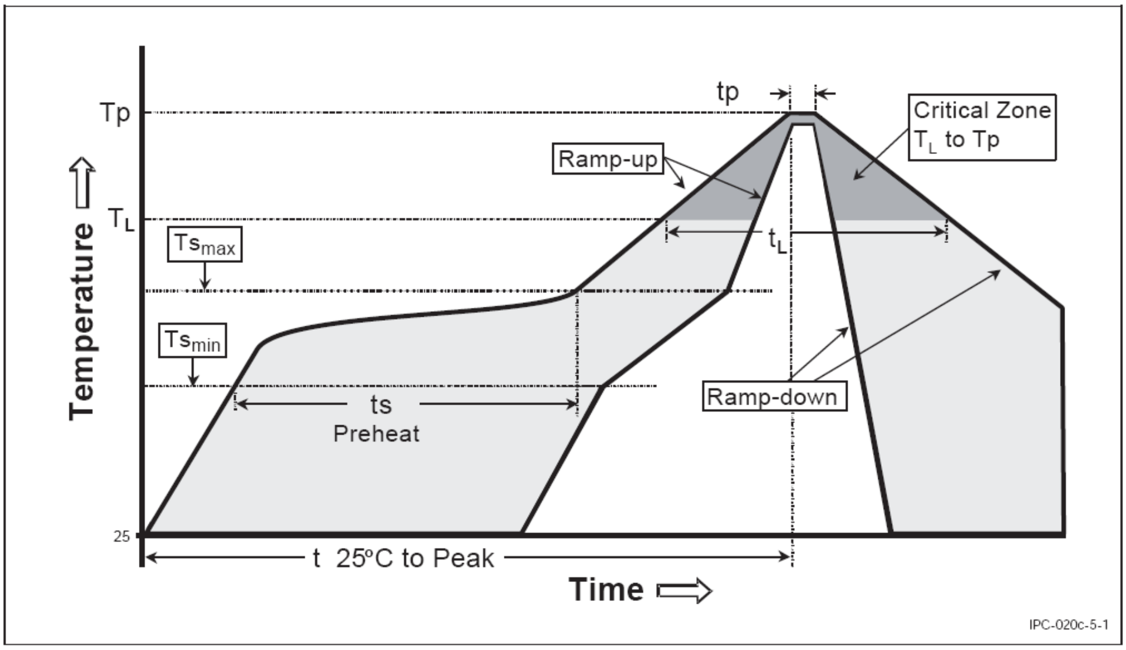


Figure 12. Typical convection reflow soldering phases and profile (IPC/JEDEC J-STD-020C table 5-2 and figure 5-1).

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 that at least three thermo-couples are used, 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 CMR3000 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 and the components. Extreme caution has to be taken if the circuit board contains components with vastly different thermal masses.**

Underfilling or coating of the CMR3000 is not recommended. This can affect on the component performance.

6.8 Moisture sensitivity level (MSL) classification

The Moisture Sensitivity Level of the CMR3000 component is Level 2 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 1 year. Maximum soldering peak temperature for the CMR3000 component is 260°C and maximum time above 255°C is 30sec, measured from the package body, as specified in IPC/JEDEC J-STD-020D.

6.9 Inspection

The CMR3000 component's solder joint quality can be inspected with similar methods as any other solder sphered SMD component. Optical and visual inspection can be done only partly, since the solder spheres are located beneath the component. However, the visual inspection is recommended for checking the proper alignment and level of the component. X-ray inspection is recommended for checking voids, solder bridges, and short-circuits between the solder joints. Cross-sectional analysis is also an approved method for inspection of metallurgical integrity and wettability of the solder joints. An example of properly soldered CMR3000 component is illustrated in Figure 13.

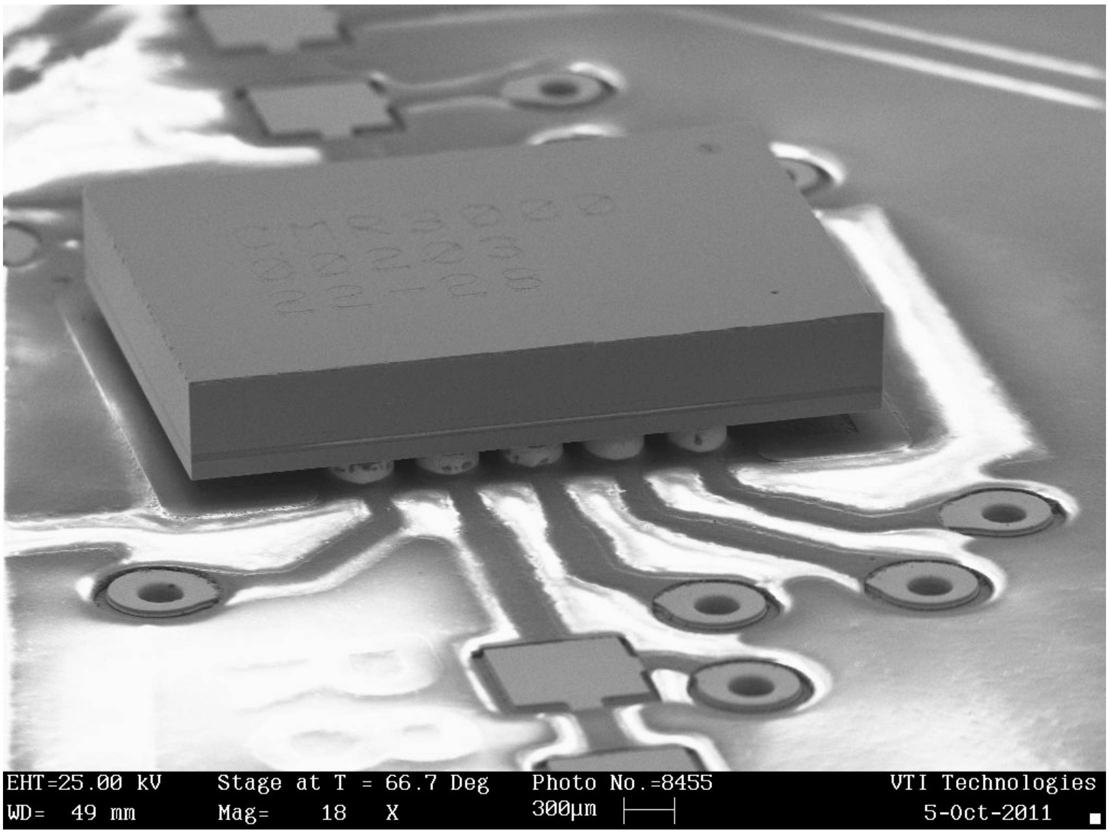


Figure 13. SEM-image of a properly soldered CMR3000 component.

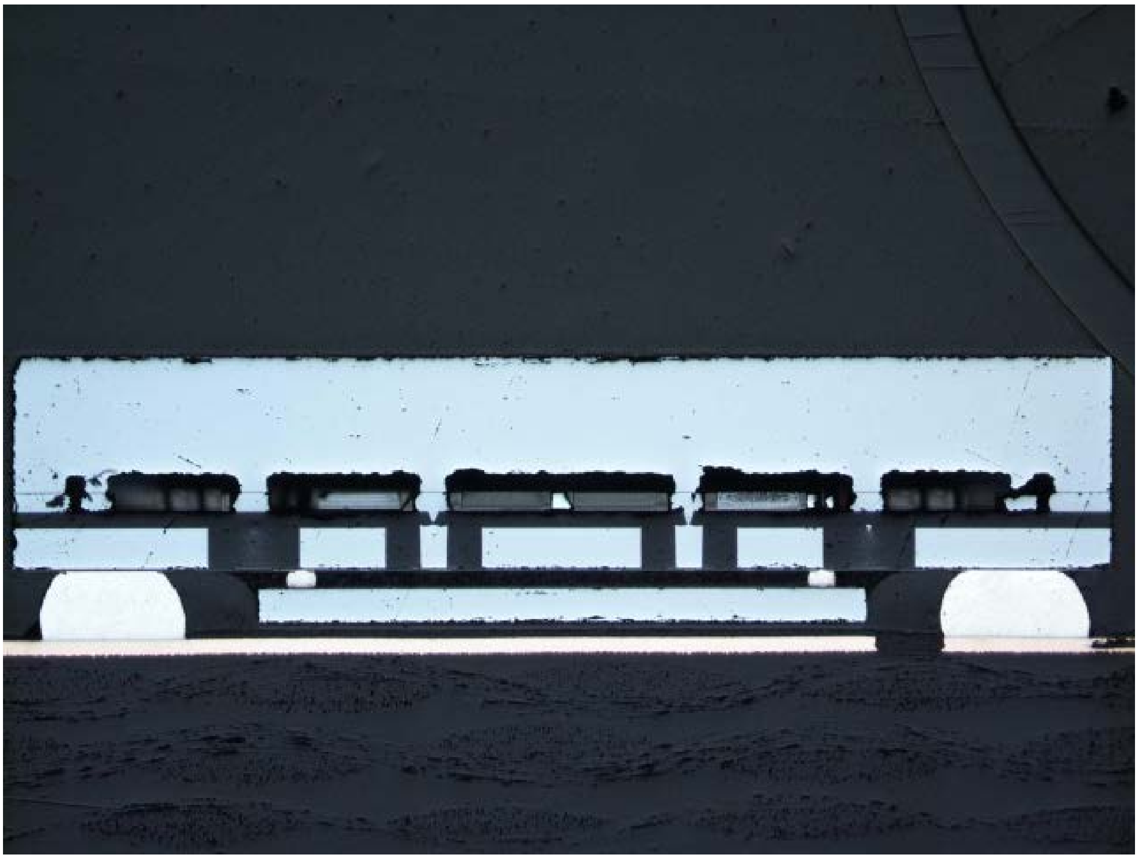


Figure 14. Cross section image of a properly soldered CMR3000 component.

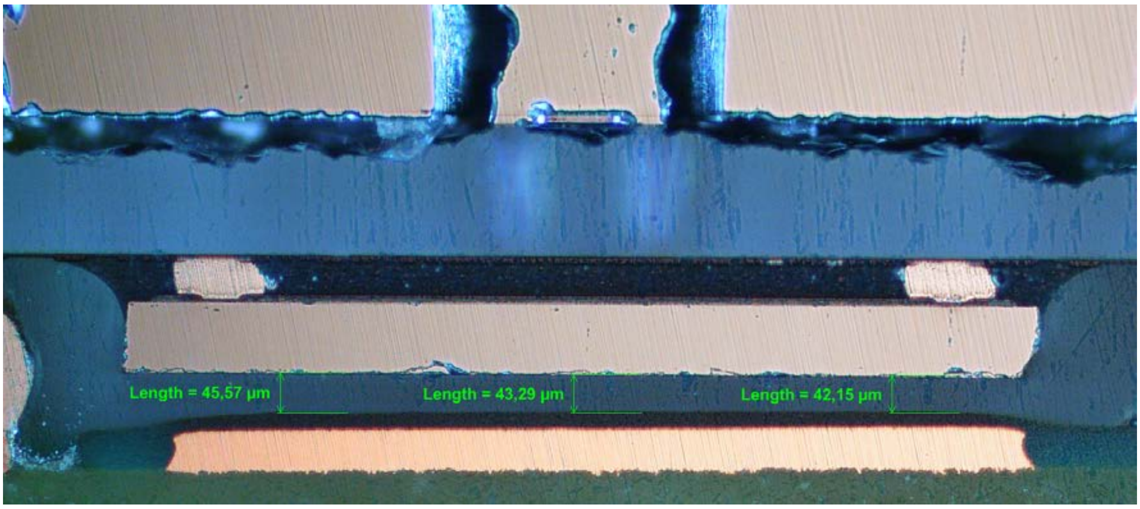


Figure 15. Gap between the component and the PWB.

7 Rework Guidelines

There are several rework systems on the market. Some will heat solder joints directly from the sides of component package, while others will direct heat on the top of component. Occasionally, very rough rework methods are used such as hand placement and heating with a soldering iron. However, these rough methods are not recommended for CMR3000 component. It is recommended that the heat flow of hot-air convection directed at the edge and under the component body directly to the solder joints and component pad areas would be used. Secondary methods include a horizontal flow method, a conduction method, and a conduction heating from the top of the package.

7.1 Preparations

Prior to the rework process, PWBs and components should be free from moisture. If necessary, baking and drying processes should be performed.

The reflow profile for the component removal should be similar to the normal reflow process. A carefully adjusted reflow profile is essential for the successful rework operation. A proper reflow profile should be measured with thermo-couples. During the reflow profiling, at least the solder joints, the top of the component, and the bottom of the PWB should be monitored. If there are other components near the component to be reworked, the temperatures of those should also be monitored. The bottom side heating of the PWB is recommended in order to reduce the PWB warpage during the rework operation.

CMR3000 component is sensitive to ESD, just like all semiconductor devices. Rework method and equipment should therefore be verified to be ESD-safe by suitable measurements. CMR3000 can easily survive rework but may sustain damage if proper ESD-procedures are not rigorously followed. VTI recommends user to follow the procedures laid out in JEDEC Standard JESD625-A.

7.2 Component removal

Once the solder joints have been fully melted, the component can be carefully removed from the PWB. The common rework methods for the component removal can be used, i.e. a vacuum nozzle etc. It is absolutely necessary to ensure the complete melting of the solder joints before the component lifting. If the solder joints are not fully melted before the lifting operation, pad damage may occur on the PWB and the component.

7.3 PWB cleaning

After the component is removed, the pad areas of the PWB should be cleaned using common rework methods. These include the applying of a rework flux, an excess solder and flux removal using a vacuum solder removal tool or a solder wick and a soldering iron with a wide chisel tip, and the cleaning of solder pads with alcohol and brush. The PWB cleaning process should be performed gently as too high force or a scrubbing motion can cause pad lifting and trace damage.

7.4 Component reuse

It is not recommended to reuse the component.

7.5 Applying flux or solder paste

Prior to the placement of a replacement component onto the reworked PWB, solder paste or flux should be applied onto the cleaned PWB pads. Recommended methods for applying solder paste or flux are the usage of a micro-stencil or dispensing. If the micro-stencil is used, it should be cleaned after each paste application to prevent clogging. For the solder paste and the stencil, the same guidelines as for the normal reflow process should be used. The usage of solder paste over mere flux is recommended due to an increased stand-off.

7.6 Component placement

An accurate alignment of the component is an important process step although the surface tension of the solder during the reflow step will help with the self-alignment. The use of a split-vision alignment system is recommended to ensure the precise alignment of the component to the PWB. The Z placement force should be carefully controlled in order to prevent the solder bridging, component damage and misalignment.

7.7 Reflow soldering

The same reflow profile, as for the component removal, can be used for the re-attachment of the replacement component as long as all solder joints will fully melt and properly wet the contact areas. Otherwise, a new and proper reflow profile must be developed and measured from the solder joints. Note that the reflow profile is always solder paste and flux dependent. The reworked PWBs should be allowed to cool to the room temperature. The PWBs and the components should be inspected after the rework process for possible defects. The use of X-ray inspection techniques can be used to verify the success of the rework process.

8 Hand Soldering Guidelines

Hand soldering of the CMR3000 component with soldering iron is not recommended. For proto-uses of the CMR3000 component, VTI can provide pre-assembled component on a PWB. For more information on this, please find the document CMR3000-D0X PWB specification 8287500A and CMR3000-D0X PWB specification 8287600A. These can be found from the Internet at www.vti.fi.

9 Environmental Aspects

VTI Technologies respects environmental values and thus its CoM packaged gyro sensors are lead-free and RoHS compatible. VTI Technologies' sensors should be soldered with lead-free solders in order to guarantee full RoHS compatibility.

10 References

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

11 Document Revision History

Version	Date	Change Description
0.1	16-Jun-10	Initial preliminary release
0.2	05-Nov-10	Figures 1, 2, 3, 4, 5, 6, 7,12,14 updated, sections 3, 9 updated
0.3	20-Dec-10	Added section 5 Recommended Storage Conditions
0.4	25-Mar-11	Figure 7 and section 6.1 updated, section effect of the reflow soldering removed.
0.5	21-Oct-11	Dimensions for tape, reel packing and figure 13 updated.
0.6	21-Dec-11	Order codes updated.