**Proposed flow of Quality Assurance and Module Assembly –**

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| **Step 1: Inspection of Components** | | | | |
| **No.** | **Activity** | **Category** | **Items needed** | **Progress/ Delegated To** |
| 1.1 | Inspection of component: Sensor   * Visual inspection for damage   Do this step just before Step 3.1 protomodule assembly to keep the sensor protected. | Quality Assurance | Sensor inspection SOP:   * Visual inspection at the time of assembly (not planned to do with microscope) * Record any scratches or chips in the GUI   + (further determine how to grade damage)   [See SOP](https://cernbox.cern.ch/files/spaces/eos/user/a/abutlern/CMS HGCal MACs/QC and Individual Component Data/QC/Step 1%3A Inspection of Components/1.1 Component inspection - sensor.docx) in QC folder | * Done. Needs group review. |
| 1.2 | Inspection of component: Baseplate  OGP measurements and comparison to nominal:   * Average thickness   + calipers * Widths between edges * Center location * Flatness OGP * Size and depth of center hole and slot * Mousebite and notches OGP   Manufacturer to perform QC steps. MACs just measure flatness and thickness. Baseplate gauge will be a quick double check for widths, holes, mousebites, and notches in the long term. | Quality Assurance | * OGP survey program * script for evaluating survey data * Grade of baseplate quality: Green, Yellow, Red * (further determine how to grade) * Record in GUI   [See SOP](https://cernbox.cern.ch/files/spaces/eos/user/a/abutlern/CMS HGCal MACs/QC and Individual Component Data/QC/Step 1%3A Inspection of Components/1.2 Component inspection - baseplate.docx) in QC folder. | Production expectation is no QC at the MACS  Need OGP survey program and how-to for pre-series – (draft of how-to is done). |
| 1.3 | Inspection of component: Hexaboard  OGP measurements comparison to nominal:   * Average thickness calipers * Widths between edges OGP * Center location OGP * Flatness OGP   [QC discussion](https://cernbox.cern.ch/files/spaces/eos/user/a/abutlern/CMS HGCal MACs/QC and Individual Component Data/QC/Step 1%3A Inspection of Components/Shared QC programs for hexaboard survey/Discussion/QC focus group - hexaboard review summary.pdf)  Electronics Test of Hexa-board  Test stand measurements:   * ?? | Quality Assurance | * OGP survey program * script for evaluating survey data (if OGP can’t do) * Grade of hexaboard quality: Green, Yellow, Red * (further determine how to grade) * Record in GUI   [See SOP](https://cernbox.cern.ch/files/spaces/eos/user/a/abutlern/CMS HGCal MACs/QC and Individual Component Data/QC/Step 1%3A Inspection of Components/1.3 Component inspection - hexaboard.docx) in QC folder | * Need any OGP programs for pre-series survey * Need any electronic testing write up – consider NTU as they wrote up module testing |
| **Step 2: Preparation of Components** | | | | |
| 2.1 | Cleaning of Sensor, baseplate and Hexa-board visual or OGP – Sindhu and Pritam working on photo analysis | Quality Assurance | cleaning SOPs for sensor, baseplate and hexaboard  [See SOPs](https://cernbox.cern.ch/files/spaces/eos/user/a/abutlern/CMS HGCal MACs/QC and Individual Component Data/QC/Step 2%3A Preparation of Components) in QC folder | * Sensor handling doc (UCSB) is done. * SOP for baseplate and hexaboard cleaning (UCSB) done. |
| **Step 3: Protomodule Assembly and Survey** | | | | |
| **No.** | **Activity** | **Category** | **Items needed** | **Delegated To** |
| 3.1 | Gluing of Silicon Sensor on base plate  [Inspect sensor before assembly (step 1.1)](https://cernbox.cern.ch/files/spaces/eos/user/a/abutlern/CMS HGCal MACs/QC and Individual Component Data/QC/Step 3%3A Protomodule Assembly and Survey/3.1 Assembly Step LabView - Sensor to Baseplate.pptx)  [LV steps listed here](https://cernbox.cern.ch/files/spaces/eos/user/a/abutlern/CMS HGCal MACs/QC and Individual Component Data/QC/Step 3%3A Protomodule Assembly and Survey/3.1 Assembly Step LabView - Sensor to Baseplate.pptx)  Use Pos1 on the gantry  Wait 20 minutes to proceed with step 3.2. | Module Assembly | * Sensor gluing SOP * Gantry program for sensor gluing * Record in GUI | * Glue step how to draft by CMU is done. Needs group review. |
| 3.2 | Inspection of glued Base plate + Sensor (protomodule)  Prior to running the OGP survey, switch baseplate vacuum to external vacuum pump. Use Vacuum Switch Panel.vi to turn off the O-ring vacuum only. Remove PUT only. Keep the baseplate vacuum on. Disconnect all other assembly tray tubing from gantry and move the tray onto the OGP.  Jupyter Notebooks = JN  OGP measurements:   * X, Y placement offset OGP and JN * rotation offset OGP and JN * average thickness OGP * ~~minimum, maximum thickness~~ * visual inspection for glue spillage * flatness OGP   Keep vacuum on for OGP. When done with survey  [QC discussion](https://cernbox.cern.ch/pdf-viewer/eos/user/a/abutlern/CMS HGCal MACs/QC and Individual Component Data/QC/Step 3: Protomodule Assembly and Survey/QC focus group - protomodule assembly and survey summary.pdf?contextRouteName=files-spaces-generic&contextRouteParams.driveAliasAndItem=eos/user/a/abutlern/CMS HGCal MACs/QC and Individual Component Data/QC/Step 3%3A Protomodule Assembly and Survey)  [Follow these instructions to calculate offsets](https://cernbox.cern.ch/files/spaces/eos/user/a/abutlern/CMS HGCal MACs/QC and Individual Component Data/QC/Step 3%3A Protomodule Assembly and Survey/UCSB Python code for use with OGP surveys/OGP Assembly Survey Python how-to.pdf)  JN files located on OGP computer C:\Users\Admin\Desktop\module\_assembly\_surveys\offsets | Quality Control | * OGP survey program * script for evaluating survey data * SOP for visual inspection for glue spillage * Grade of Protomodule quality: Green, Yellow, Red * (further determine how to grade) * Record in GUI | * UCSB has OGP survey program and Jupyter grading program with instructions uploaded. Works for prototype modules (pre-series might have different fiducials) * Still need SOP for glue spillage |
| **Step 4: Module Assembly and Survey** | | | | |
| **No.** | **Activity** | **Category** | **Items needed** | **Delegated To** |
| 4.1 | Cover the hexaboard center hole with tape to prevent leaking vacuum.  Gluing of Hexa-board on Protomodule  [LV steps listed here](https://cernbox.cern.ch/files/spaces/eos/user/a/abutlern/CMS HGCal MACs/QC and Individual Component Data/QC/Step 4%3A Module Assembly and Survey/4.1 Assembly Step LabView - Hexaboard to Sensor.pptx)  Wait 20 minutes before proceeding with step 4.2. | Module Assembly | * Hexaboard gluing SOP * Gantry program for Hexaboard gluing * Record in GUI | * Glue step how to – consider CMU as they wrote up protomodule step |
| 4.2      4.2 | Inspection of Module before Bonding  OGP measurements:   * X, Y placement offset OGP * rotation offset OGP * average thickness OGP * ~~max, min thickness~~ * visual inspection for glue spillage   Keep vacuum on for OGP  [Follow these instructions to calculate offsets](https://cernbox.cern.ch/files/spaces/eos/user/a/abutlern/CMS HGCal MACs/QC and Individual Component Data/QC/Step 3%3A Protomodule Assembly and Survey/UCSB Python code for use with OGP surveys/OGP Assembly Survey Python how-to.pdf)  Place in carrier tray for second OGP program for glue spillage and unconstrained flatness and thickness | Quality Control | * OGP survey program * script for evaluating survey data * SOP for visual inspection * Grade of Module quality: Green, Yellow, Red * (further determine how to grade) * Record in GUI | * Need OGP program for surveying * If using, need Jupyter script to evaluate the results (UCSB)and produce XML file for database * SOP for glue spillage |
| **Step 5: Backside Wirebonding and Encapsulation** | | | | |
| **No.** | **Activity** | **Category** | **Items needed** | **Delegated To** |
| 5.1 | Backside Wire Bonding of the module  OGP  Place in backside carrier tray for OGP  Use program LDV3HI00.bpx for V7 PCB wire bonding – [more info](https://cernbox.cern.ch/pdf-viewer/public/XWc1a9k0a56AmHb/Backside wirebond program options for LDV3 - new mousebite.pdf?contextRouteName=files-public-link&contextRouteParams.driveAliasAndItem=public/XWc1a9k0a56AmHb) | Module Assembly | * SOP for Backside wirebonding * bond program for backside * Record in GUI   [See notes](https://cernbox.cern.ch/files/spaces/eos/user/a/abutlern/CMS HGCal MACs/QC and Individual Component Data/QC/Step 5%3A Backside Wirebonding and Encapsulation/Backside wirebond program options and instructions/Backside wirebond program options for LDV3.pdf) | * SOP (UCSB) * wirebond program (UCSB)   \* have not successfully done with a permanent backside wirebond fixture so have not written up |
| 5.2 | Visual Inspection of backside wirebonds  OGP | Quality Control | * SOP for visual inspection * Record in GUI   [See SOP](https://cernbox.cern.ch/files/spaces/eos/user/a/abutlern/CMS HGCal MACs/QC and Individual Component Data/QC/Step 5%3A Backside Wirebonding and Encapsulation/5.2 Inspect backside wirebond.docx) | * Done. Needs group review. |
| 5.3 | Encapsulation of backside and curing | Module Assembly | * SOP for backside encapsulation * mini gantry program for backside encapsulation * Record in GUI   [See notes](https://cernbox.cern.ch/files/spaces/eos/user/a/abutlern/CMS HGCal MACs/QC and Individual Component Data/QC/Step 5%3A Backside Wirebonding and Encapsulation/Backside encap program and notes/Backside mini gantry program for LDV3.pdf) | * Old SOP for by hand (UCSB) has been uploaded * mini gantry backside program LD V3 (UCSB) * SOP for mini gantry LDV3   \* which carrying tray? |
| 5.4 | Visual Inspection of backside encapsulation  OGP | Quality Control | * SOP for visual inspection * Record in GUI   [See SOP](https://cernbox.cern.ch/files/spaces/eos/user/a/abutlern/CMS HGCal MACs/QC and Individual Component Data/QC/Step 5%3A Backside Wirebonding and Encapsulation/5.4 Inspect backside encapsulant.docx) | * Done. Needs group review. |
| **Step 6: Frontside Wirebonding and Encapsulation** | | | | |
| **No.** | **Activity** | **Category** | **Items needed** | **Progress/ Delegated To** |
| 6.1 | Pull Testing for frontside bonding  Pull test measurements:   * average pull strength * standard deviation of pull test data | Quality Control | * SOP for pull testing * Record in GUI   [See notes](https://cernbox.cern.ch/files/spaces/eos/user/a/abutlern/CMS HGCal MACs/QC and Individual Component Data/QC/Step 6%3A Frontside Wirebonding and Encapsulation/6.2 Front Side Wirebond LDV3.docx) – use “bond test” instead of “device” to place test bonds  [See notes](https://cernbox.cern.ch/files/spaces/eos/user/a/abutlern/CMS HGCal MACs/QC and Individual Component Data/QC/Step 6%3A Frontside Wirebonding and Encapsulation/Older files/Pull Testing How To.pdf) – how to pull test | * ~~SOP (old)~~ * Update SOP |
| 6.2 | Wire Bonding frontside of the module  Use LDV3HI01.bpx for LD V3 live boards (squarish mousebites) – [more info](https://cernbox.cern.ch/pdf-viewer/public/z5ccQQ5UvjFTI1G/LDV3 front side wire bond new mousebite.pdf?contextRouteName=files-public-link&contextRouteParams.driveAliasAndItem=public/z5ccQQ5UvjFTI1G)  Use LDV3UP00.BPX for unpopulated V3 boards (semicircle mousebites) – [more info](https://cernbox.cern.ch/remote.php/dav/public-files/z5ccQQ5UvjFTI1G/old mousebite/LDV3 wirebond program notes.pdf) | Module Assembly | * SOP for frontside bonding * bond program for frontside * Record in GUI   [See notes](https://cernbox.cern.ch/files/spaces/eos/user/a/abutlern/CMS HGCal MACs/QC and Individual Component Data/QC/Step 6%3A Frontside Wirebonding and Encapsulation/6.2 Front Side Wirebond LDV3.docx) to run program  [See notes](https://cernbox.cern.ch/files/spaces/eos/user/a/abutlern/CMS HGCal MACs/QC and Individual Component Data/QC/Step 6%3A Frontside Wirebonding and Encapsulation/LDV3 wirebond program notes.pdf) to set up program  [See notes](https://cernbox.cern.ch/files/spaces/eos/user/a/abutlern/CMS HGCal MACs/QC and Individual Component Data/QC/Step 6%3A Frontside Wirebonding and Encapsulation/6.2 Wire Repair SOP - draft.docx) for wire repair | * Wirebond program for LD V3 uploaded * Wirebond troubleshooting SOP uploaded * SOP for running wirebond proram uploaded * Needs group review |
| 6.3 | Visual Inspection of Bonded module before encapsulation  OGP | Quality Control | * visual inspection SOP? * visual inspection OGP program * script for evaluation survey data (maybe with machine learning program) * Record in GUI | * OGP program LDV3 captures image of each hole uploaded * SOP for running OGP program uploaded * If Machine learning step this needs to be added |
| 6.4 | Encapsulation of the module and curing | Module Assembly | * SOP for frontside encapsulation * mini gantry program for frontside encapsulation * Record in GUI | * LD V3 front side mini gantry program uploaded * SOP for running mini gantry LDV3 uploaded |
| 6.5 | Visual Inspection of encapsulated module  OGP | Quality Control | * SOP for inspection of frontside encapsulation * Record in GUI | * Need SOP |
| **Step 7: Module Testing** | | | | |
| **No.** | **Activity** | **Category** | **Items needed** | **Progress/ Delegated To** |
| 7.1 | Electrical Test of the final module | Quality Control | * SOP for electronics testing * testing programs * test evaluation scripts * Grade of Module quality: Green, Yellow, Red * Record in GUI | * NTU uploaded SOP for electronics testing * Single module test stand summary of results |
| 7.2 | IV Curves | Quality Control | * Bias module up to at least 800 V * Confirm that the leakage current at 600 V is less than 100 microA * Confirm that the leakage current at 800 V is less than 2.5 times the previous current value * We need to determine some range of allowed currents to grade the module. Right now the sensor group just grades as GREEN and RED. We should centralize how each MAC plans to record these values | * Develop methods to analyze IV curve * Export results to XML file to attach to module in the DB |
| 7.3 | Single Module Test Stand   * Mainly pedestal and noise scan * Consider adding more tests as things progress | Quality Control | * Module will need to be biased to at least 250 V depending on thresholds. Run pedestal scan test with hexacontroller. There is separate analysis code that will run through the results and qualify channels. * We need to decide the allowable noisy/bad/unreadable channels for each grade of the module | * Script to summarize results from each test/channel of the module * Export results as an ASCII file to store in the DB |