Interposer Partner-site Test Requirements

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Scope of Document

This document outlines the tests that need to be performed at the garment factories of partners who are integrating Jacquard interposers into the end product. The tests are intended to test that during the garment integration process there were no damages made to the interposer and that the sensor performance does not deviate unexpectedly from the IQC sensor module performance. The main audience of this document is intended for Jacquard engineers and the test fixture vendors who are responsible for building the interposer in-garment test fixture.

Glossary

TBD

Interposer Background Information and CapSense Theory

External Document Link.

Test Matrix

The tests are designed to mainly cover two functional blocks: process quality, and sensor performance.

The integration process of embedding the interposer sensor modules into the garment at the garment factory may damage the sensor elements, cause delamination of the carrier TPU layer, or improperly adhere the sensor module onto the inside of the garment which will affect the end performance. The tests included are designed to tease out significant process deviations during integration via capacitance measurements.

Additionally, the performance of the haptics motor and LED are also validated in final form factor to guarantee that those two user interface peripherals were not damaged in the assembly process.

The sensor performance is quantified by its SNR, uniformity, sensitivity, and shielding effectiveness. The tests for all the above parameters have been defined in this document.

The following matrix lists the proposed test items and the associated functional blocks.

Item	Process Quality	Sensor Performance
LinearSlider Sensor Baseline and Noise (CS-1)	✓	✓
LinearSlider Signal to Noise Ratio (CS-2)	✓	✓

LinearSlider Sensitivity (CS-3)	✓	✓
ProximitySensor Sensitivity (CS-4)	✓	✓
LinearSlider Sensor Response Uniformity (CS-5)	✓	✓
LinearSlider Non-Touch Side Attenuation Verification (CS-6)	✓	✓
Haptics Parametric Verification (HP-1)	✓	
Haptics Functional Verification (HF-1)	✓	
LED Parametrics Verification (LP-1)	✓	
LED FunctionalVerification (LF-1)	✓	

Test Coverage

The following table shows the test coverage at each garment assembly factory, in each step.

Item	**KML**			**KMY**			**KMS**		
	Interposer IQC	IPQC (cuff)	OQC (garment)	Interposer IQC	IPQC (strap)	OQC (backpack)	Interposer IQC	IPQC (strap)	OQC (backpack)
LinearSlider Sensor Baseline and Noise (CS-1)		✓			✓			✓	
LinearSlider Signal to Noise									

Ratio (CS-2)									
LinearSlider Sensitivity (CS-3)									
ProximitySensor Sensitivity (CS-4)									
LinearSlider Sensor Response Uniformity (CS-5)		✓			✓			✓	
LinearSlider Non-Touch Side Attenuation Verification (CS-6)									
LinearSlider Functional Verification (CS-7)	✓		✓	✓		✓	✓		✓
Haptics Parametric Verification (HP-1)		✓			✓			✓	
Haptics Functional Verification (HF-1)	✓		✓	✓		✓	✓		✓

Test HW and SW Ownership

TBD

Sensor Test Fixture Physical Requirements

- External Document Here

Test Description

LinearSlider Sensor Baseline and Noise (CS-1)

Description:
Establishing sensor baselines and catching module level lamination abnormalities caused by any garment integration processes.
Test Setup:
1. While no touch is engaged, for each sensor in the LinearSlider sensor array, read 50 samples of raw count.
2. For each sensor in the LinearSlider sensor array, calculate the difference between the minimum and maximum of the 50 raw count samples and record this as the ***Noise Raw Count*** for the sensor element, and also convert it into capacitance as ***Noise Capacitance.***
3. For each sensor in the LinearSlider sensor array, calculate the mean of the 50 raw count samples and record this as the ***Baseline Raw Count*** of the sensor element.
4. For each sensor in the LinearSlider sensor array, subtract the Baseline Raw Count from the max raw count: ($2^{\text{Scan Resolutioon}}$-1) and record this as the ***Effective Dynamic Range*.**
   Also calculate **Baseline %** by taking $\frac{Baseline\ Raw\ Count}{Max\ Raw\ Count}$
5. Convert the Baseline Raw Count into capacitance and record this as the ***Baseline Capacitance***
6. Convert Effective Dynamic Range into capacitance as **Effective Dynamic Range Capacitance**

LinearSlider Signal to Noise Ratio (CS-2)

Description:
Validates that the sensor stack up is sensitive to touch after integration in garment and free from significant lamination process errors.
Test Setup:
1. Engage touch mechanism to the top surface of the sensor in *Perpendicular Coverage.*
2. For each sensor in the LinearSlider sensor array, read 50 samples of raw count.
3. For each sensor in the LinearSlider sensor array, take the mean of the 50 raw count samples and subtract it by the Baseline Raw Count. Record this as the ***Signal Difference Count*.**

4. For each sensor in the LinearSlider sensor array, convert Signal Difference Count into capacitance. Record this as ***Signal Capacitance.***
5. Calculate ***SNR*** = $\frac{Signal\ Difference\ Count}{Noise\ Raw\ Count}$

LinearSlider Sensitivity (CS-3)

Description:
Validates that the LinearSlider is not overly sensitive to hands hovering above the sensor
Test Setup:

1. Lower the touch mechanism to **x** mm away from the sensor top surface in *Perpendicular Coverage.*
2. For each sensor in the LinearSlider sensor array, read the Difference Count (*raw count - baseline raw count*).

ProximitySensor Sensitivity (CS-4)

Description:
Validates the sensitivity of the ProximitySensor, which is periodically polled in low-power mode to trigger active scanning of the LinearSlider once a hand is detected in proximity.
Test Setup:

1. With no touch engaged, read 50 samples of ProximitySensor raw count.
2. Find the difference between the maximum and minimum of the 50 samples and record it as the ***PS Noise Raw Count***
3. Take the mean of the 50 samples and record it as the ***PS Baseline Raw Count***
4. Engage touch mechanism to the top surface of the sensor in *Perpendicular Coverage*, read 50 samples of ProximitySensor raw count.
5. Take the mean of the 50 samples and subtract it by PS Baseline Raw Count record it as ***PS Signal Difference Count***
6. Calculate ***PS SNR =*** $\frac{PS\ Signal\ Difference\ Count}{PS\ Noise\ Raw\ Count}$
7. Raise the touch mechanism to **x** mm vertically away from the surface and read the Difference Count (*raw count - baseline raw count*).

LinearSlider Sensor Response Uniformity (CS-5)

Description:
Verify that the sensors are laminated well to the garment inner surface such that each sensor element is tightly adhered to the garment inner surface and free of air gaps. If significant air gaps exist then a **localized touch** will bleed significantly into adjacent sensor elements as the air gaps will compress and increase capacitive readings for surrounding sensors.

Test Setup:

1. Lower the touch mechanism onto the top surface of the garment at the designated landing area.
2. Compress the touch mechanism by **x** mm / **x** N into the top surface of the DUT and begin sampling and recording Signal Difference Count of the entire LinearSlider and also begin recording the position of the touch mechanism actuator.
3. Move the touch mechanism across the entire length of the sensor area in *Co-linear Coverage*, maintaining the compression, until the designated take off area and stop sampling.
4. For each sample, calculate the sensor ***Centroid*** as $\frac{\sum_{i=0}^{N-1} i*diff_i}{\sum_{i=0}^{N-1} diff_i}$ (returns a decimal value between 0 and N-1)
5. For each sensor element's Signal Difference Count, convert them into capacitance. And find the maximum of the capacitance as ***Max Touch Capacitance*** for each sensor element.

LinearSlider Non-Touch Side Attenuation Verification (CS-6)

Description:
Once embedded in the garment, the interposer touch sensors will have an intended touch surface and a non-touch surface, from a user's perspective (e.g. the outside of a cuff vs. the inside of a cuff). This test verifies that the signal produced from a touch on the non-touch side is sufficiently attenuated compared to the touch side.
Test Setup:

1. Lower the touch mechanism to the top surface of the garment in *Perpendicular Coverage* and immediately begin recording **Signal Difference Count** as soon as the touch mechanism makes contact with the garment surface.
2. Collect 100 samples of the entire LinearSlider and disengage the touch mechanism.
3. For each sample, sum up the Signal Difference Count of all the sensor elements to obtain **Signal Difference Count Sum.**
4. Record the **Touch Side Max Signal Difference Count Sum** as the maximum of 100 sums in step 3.
5. Engage the touch mechanism to the bottom surface of the garment in *Perpendicular Coverage* and repeat steps 1-3 for the non-touch side.
6. Record the **Non-touch Side Max Signal Difference Count Sum.**

Haptics Parametric Verification (HP-1)

Verify that the haptics motor in the Interposer is vibrating with the specified acceleration profile.
Test Setup:

Probe the designated haptics area with an accelerometer and record the acceleration profile while the haptics motor is turned on.

Haptics Functional Verification (HF-1)

Basic functionality check of the haptics motor: does it turn on?
Test Setup:
Pulse the haptics motor in 500ms intervals and ask the operator to verify if it is pulsing.

LED Parametric Verification (LP-1)

Verify that the LED on the Interposer is illuminated with the specified colour profile.
Test Setup:
Optically inspect the LED illumination with input of 0xFFFFFF and record the transmitted spectrum from outside the garment.

LED Functional Verification (LF-1)

Basic functionality check of the LED: do all 3 (RGB) pixels turn on?
Test Setup:
Turn on the LED with input 0xFFFFFF and ask the operator to verify that it is “white”

Test Parameter Calculation Methods

Basics:

1. Convert Difference Count to Capacitance (pF)
    a. $G_c = (2^{13}-1)*2.0211V*(6000kHz)/(17*2.4uA/bit)$
    b. $G_c = 2.434*10^{15}\ F^{-1}$
    c. $Diff = 450$
    d. $Capacitance = 450 / 2.434*10^{15}\ F^{-1} = 1.84*10^{-13}\ F = 0.184\ pF$

Test Pass/Fail Criteria

External Document Here

Reference Documents

Document	Link
Interposer Background Information and CapSense Theory	GDrive Link
Interposer In-Garment Test Pass/Fail Criteria	GDrive Link

Interposer In-Garment Test Fixture ERD	GDrive Link

Version Control

Version	Date	Author	Remarks
0.6.0	Mar.04.2019	wtony@	Update test items and matrix for simplification of IQC/IPQC/OQC test suite.
0.5.2	Dec.12.2018	wtony@	Update Test coverage, CAD matrix, and some test definitions.
0.5.1	Dec. 11. 2018	wtony@	Update some test definitions.
0.5	Oct. 2. 2018	wtony@	Draft pending review