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Mimosa-22e, Phase-1 and Ultimate Sensor Testing for the Pixel Detector

We are in the latter stages of sensor development for the STAR Pixel vertex detector. At the current time, we envision three sensors that will need to be tested. The Mimosa-22e will be tested as an individual sensor only. The Phase-1 sensor and Ultimate sensor will need extensive testing at LBNL including individual testing, batch testing in a probe station(s) and testing in assembled ladder form. This document is intended to discuss the sensor testing that will be needed as well as to indicate a direction for the actual tests that will be performed. It is intended that this will lead to a testing plan for all sensors.

Mimosa-22e Sensor Testing

The Mimosa-22e sensor is a sensor that is being developed by IPHC for the EUDET telescope effort. It has 18.4 micron square pixels, on chip CDS, and column level discriminators. In many ways, the Mimosa-22e architecture is quite similar to the Phase-1 sensor that is being developed for the STAR detector patch that will be deployed in 2010. The Mimosa-22e sensor will undergo only individual testing at LBNL mounted to test boards developed at IPHC and read out by the STAR Pixel Phase-1 RDO system via interface boards yet to be designed. The user manual for the Mimosa-22e can be found at http://rnc.lbl.gov/hft/hardware/docs/Phase1/Mimosa22_v1_Doc.pdf. This sensor also has analog readout pixels. An example of a simplified test procedure for this sensor is shown below.

Power on tests –

1. Current draw for digital and analog voltage supplies at power up and during clocked operation.
2. JTAG testing – test communication with the sensor JTAG system, program and read back registers.

Digital function tests -

1. Proper operation for clock, SPEAK, START.
2. Proper operation markers.
3. Proper operation of test modes including programmed output pattern mode.

Sensor functional tests –

1. Test discriminator threshold response on noise. Raise threshold from below noise to above. Check response.
2. Digitize the analog pixel outputs simultaneously with the digital acquisition and examine the noise. Do the transitions / efficiency curves look reasonable?
3. Examine pixel (analog and digital) response to pulsed LED.
4. Check 55Fe source response on analog pixels. How is S/N?
5. Beam test with electrons, Landau energy deposition function peak and S/N.

Phase-1 Sensor Testing

The Phase-1 sensor is being designed at IPHC to be a prototype for use at STAR to deploy a vertex detector patch in 2010. The Phase-1 characteristics include 30 micron square pixels, on chip CDS, and column level discriminators. The sensor runs on a 160 MHz clock which gives a 640 us integration time. There are four digital outputs / sensor that provide hit information in a rolling shutter format at a 160 MHz readout clock. There is an analog output mode but it can not (we believe) be run in parallel with the normal data taking mode. These are full reticule size sensors. In addition to individual sensor testing, we anticipate probe testing these sensor individually post thinning with probe stations and also testing full ladders of sensors with 10 sensors mounted on each ladder.

Individual testing –

Power on tests –

1. Current draw for digital and analog voltage supplies at power up and during clocked operation.
2. JTAG testing – test communication with the sensor JTAG system, program and read back registers.

Digital function tests -

1. Proper operation for clock, SPEAK, START.
2. Proper operation markers.
3. Proper operation of test modes including programmed output pattern mode.

Sensor functional tests –

1. Test discriminator threshold response on noise. Raise threshold from below noise to above. Check response.
2. Digitize the analog pixel outputs and examine the noise. Compare with the digital discriminator response. Do the transitions / efficiency curves look reasonable?
3. Examine pixel (analog and digital) response to pulsed LED.
4. Check 55Fe source response on analog pixels. How is S/N?
5. Beam test with electrons, Landau energy deposition function peak and S/N?

Probe testing

We will probably be able to perform only a subset of the tests that we will employ for the individual testing of this sensor. The tests will need to be scripted and the sensors binned.

Power on tests –

1. Current draw for digital and analog voltage supplies at power up and during clocked operation.
2. JTAG testing – test communication with the sensor JTAG system, program and read back registers.

Digital function tests -

1. Proper operation for clock, SPEAK, START.
2. Proper operation markers.
3. Proper operation of test modes including programmed output pattern mode.

Power / clock range test –

1. Test sensor function with power supply voltage 5% below nominal
2. Test sensor function with RDO frequency 5% above nominal.

Sensor functional tests –

1. Test discriminator threshold response on noise. Raise threshold from below noise to above in 3 steps. Check response on digital outputs.
2. Set threshold at 5x noise level. Test pixel response to flashed LED.

Ladder testing

Ladder testing is done after assembly of 10 sensors onto a ladder. The testing is for basic functionality.

Power on tests –

1. Current draw for digital and analog voltage supplies at power up and during clocked operation for entire ladder.
2. JTAG testing – test communication with the ladder JTAG system chain, program and read back registers.

Digital function tests -

1. Proper operation for clock, SPEAK, START.
2. Proper operation marker.
3. Proper operation of test modes including programmed output pattern mode for all sensors. Check for crosstalk, etc.

Sensor functional tests –

1. Test discriminator threshold response on noise. Raise threshold from below noise to above in 3 steps. Check response on digital outputs.
3. Set threshold at 5x noise level. Test pixel response to flashed LED.

Ultimate Sensor Testing

The Ultimate sensor is being designed at IPHC to be the primary sensor for use at STAR in the Pixel vertex detector. The Ultimate sensor characteristics include the following; 18.4 micron square pixels, on chip CDS, column level discriminators, and a on-chip zero suppression system called SUZE. The SUZE system can process 9 clusters (up to three adjacent hits per row) before it reaches overflow. The sensor has a 200 us integration time and two outputs for digital address data. There is an analog output mode but it can not (we believe) be run in parallel with the normal data taking mode. These are full reticule size sensors. The SUZE system complicates the testing that is required since only a small percentage of pixels can be sampled before the overflow point of SUZE is reached. We will request from IPHC that they build in the functional ability to mask off columns so that we can test Ultimate pixels in sets of 8-9 columns at a time. In addition to individual sensor testing, we anticipate probe testing these sensor individually post thinning with probe stations and also testing full ladders of sensors with 10 sensors mounted on each ladder.

Individual testing –

Power on tests –

1. Current draw for digital and analog voltage supplies at power up and during clocked operation.
2. JTAG testing – test communication with the sensor JTAG system, program and read back registers.

Digital function tests -

1. Proper operation for clock, SPEAK, START.
2. Proper operation markers.
3. Proper operation of test modes including programmed output pattern mode.
4. Proper operation of column mask.

Sensor functional tests –

1. Test discriminator threshold response on noise in groups of eight columns. Raise threshold from below noise to above. Check response.
2. Digitize the analog pixel outputs and examine the noise. Compare with the digital discriminator response. Do the transitions / efficiency curves look reasonable?
3. Examine pixel (analog and digital) response to pulsed LED.
4. Check 55Fe source response on analog pixels. How is S/N?
5. Beam test with electrons, Landau energy deposition function peak and S/N?

Probe testing

We will probably be able to perform only a subset of the tests that we will employ for the individual testing of this sensor. The tests will need to be scripted and the sensors binned.

Power on tests –

1. Current draw for digital and analog voltage supplies at power up and during clocked operation.
2. JTAG testing – test communication with the sensor JTAG system, program and read back registers.

Digital function tests -

1. Proper operation for clock, SPEAK, START.
2. Proper operation markers.
3. Proper operation of test modes including programmed output pattern mode.
4. Proper operation of column mask.

Power / clock range test –

1. Test sensor function with power supply voltage 5% below nominal
2. Test sensor function with RDO frequency 5% above nominal.

Sensor functional tests –

1. Test discriminator threshold response on noise in groups of eight columns. Raise threshold from below noise to above in 3 steps. Check response on digital outputs.
2. Set threshold at 5x noise level. Test pixel response to flashed LED.

Ladder testing

Ladder testing is done after assembly of 10 sensors onto a ladder. The testing is for basic functionality.

Power on tests –

1. Current draw for digital and analog voltage supplies at power up and during clocked operation for entire ladder.
2. JTAG testing – test communication with the ladder JTAG system chain, program and read back registers.

Digital function tests -

1. Proper operation for clock, SPEAK, START.
2. Proper operation marker.
3. Proper operation of test modes including programmed output pattern mode for all sensors. Check for crosstalk, etc.
4. Proper operation of column mask.

Sensor functional tests –

1. Test discriminator threshold response on noise in groups of eight columns. Raise threshold from below noise to above in 3 steps. Check response on digital outputs.
2. Set threshold at 5x noise level. Test pixel response to flashed LED.