



Application Note

AN000373

CCS811

End of Line Functionality Testing

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1 Introduction

This application note offers guidance on how to implement a factory test procedure for end of line testing. This will ensure the CCS811 sensor is fully functional on a high volume production line.

The CCS811 sensor is assembled into a 10 lead 2.7mm x 4mm 0.6mm pitch, LGA package. The package consists of a substrate and a molded lid which contains apertures to allow the unobstructed flow of ambient air through the package to ensure the MOX sensing element is exposed to the analyte gas.

ams undergoes 100% test coverage during manufacture to ensure the finished product meets the specification defined in the datasheet.

The CCS811 Sensor passes industry standard reliability and quality standards, but it is still possible for damage to occur in handling or for errors in assembly, which would affect the performance of the CCS811 sensor in the finished product.

The end of line factory test described in this application note is designed to run in under 1 second and provide the best possible test coverage without waiting for the gas sensor to warm up.

The following restrictions should be considered within the product test environment:

- Ambient temperature: 15°C to 35°C
- Ambient Humidity: 20% to 80%, non-condensing



Attention

ESD precautions should be taken when handling the CCS811 sensor.

2 Test Procedures

2.1 Generic Notes

The overall work flow of this test process is to power the device and check for error messages. Run the sensor and check for error messages. Read the raw data and check the sensor is behaving as expected.

Throughout the testing, the I²C communications is checked for errors. Where required each test step should check the **STATUS** register error bit. If the error bit shows an error then check to see if what type of error is reported by reading the **ERROR** register which will report the cause.

Once the application mode has started each read of the **STATUS** register should show 0x90. This indicates the CCS811 sensor is in the application mode and there are no errors. When performing a sensor resistance read, a **STATUS** register showing 0x98 indicates that new data is available.

2.2 Resistance Calculations

The sensor resistance should be calculated from the raw data (Register 0x03) using the following example calculation; ADC = **496**, Current = **4**

$$\text{Resistance} = \frac{1.65 \times (\text{raw ADC})}{\text{Current (A)} \times 1023} = \frac{1.65 \times \mathbf{496}}{0.000004 \times 1023} = 200,000$$

The sensor resistance raw data readings should be calculated and compared. After comparing the 3 readings a test is declared as passed if the following criteria is met.

- The resistance has changed in a positive direction.
- Each successive reading being greater than the previous.

If the resistance has not changed or is the minimum value of 0 ohm or the maximum value of 1.65M ohm, the resistance test be a fail.

2.3 Error Codes

At any stage the **STATUS** register bit 0 being set to a 1 indicates an error condition has occurred and an error ID code can be read from the **ERROR** register. The error code should be read over I²C from the **ERROR** register at address 0xE0. Each error is referenced by a different bit so multiple error codes can be read in a single read operation. The errors indicated by these bits in the **ERROR** register are reported by the 'Built In Self Test' (BIST). The **ERROR** register and error bit in the **STATUS** register are then cleared to show persistent or new errors.

2.4 Test Case Matrix

Figure 1 shows the relationship between test case and CCS811 sensor pin implementation.

If a pin is not implemented then the test marked with an 'X' can be left out of the "end of line" testing. Obviously there are some pins such as VCC/GND/SCA/SDA which are mandatory to the operation of the CCS811 sensor and the successful completion of these test cases.

Figure 1 :
CCS811 Sensor Pin to Test Case Matrix

CCS811 Sensor Pin	Test Case 1	Test Case 2	Test Case 3	Test Case 4	Test Case 5	Test Case 6	Test Case 7	Test Case 8	Test Case 9	Test Case 10
NWAKE	X									
ADDR		X								
SDA/SCL			X	X	X	X	X	X	X	X
NINT						X	X	X		
NRESET										X
VDD/GND	X	X	X	X	X	X	X	X	X	X

3 Test Cases

3.1 Test 1 “NWAKE Pin Connection”

The purpose of this test is to confirm that the CCS811 sensor does not respond to commands when the NWAKE pin is held high. A low on this pin is used to wake the CCS811 sensor and put it in a state ready for I²C commands.

1. Apply Power to the CCS811 sensor device
2. Hold the NWAKE pin high, ADDR pin low.
3. Send I²C write to **STATUS** register and check the I²C acknowledge bit.

The outcome of this test will be a number of repeated attempts by the I²C master to access the CCS811 sensor. The CCS811 sensor will ignore the I²C write commands sent to its address and eventually the I²C master will timeout. The test is considered a pass if a NACK signaling bit is detected by the I²C master.

3.2 Test 2 “ADDR Pin Connection”

The purpose of this test is to confirm that the CCS811 sensor does not respond to commands when incorrect combinations of the CCS811 sensors address and ADDR pin are used. The CCS811 sensor will be activated and then an I²C transaction to an incorrect ADDR/I²C address combination will be issued.

1. Pull NWAKE pin low, ADDR pin high.
2. I²C setup write to **STATUS** register using secondary CCS811 sensor address.

The outcome of this test will be a number of repeated attempts by the I²C master to access the device at this primary address. The CCS811 sensor will expect I²C commands on the secondary address and so will ignore the I²C write commands sent to the primary address and eventually the I²C master will timeout. The test is considered a pass if a NACK signaling bit is detected by the I²C master.

3.3 Test 3 “I²C Address ACK”

The purpose of this test is to confirm that the CCS811 sensor responds to I²C commands from an I²C master. The CCS811 sensor is still activated from the previous test and then an I²C read transaction, on the correct ADDR/I²C address combination, from the **STATUS** register will be issued.

1. Pull NWAKE pin low, pull ADDR pin low.
2. Read **STATUS** register using the correct primary CCS811 sensor address.

The outcome of this test will be an I²C read transaction to the **STATUS** register. The test is considered a pass if an ACK signaling bit is detected by the I²C master, the value of the **STATUS** register returned is 0x10. This value indicates we are in firmware mode, there is a valid application loaded and no errors have been detected. If the least significant bit (error bit) is set then this indicates an error and the **ERROR** register is read to retrieve the outcome of the ‘Built In Self Test’ (BIST).

3.4 Test 4 “Enter Application Mode”

The purpose of this test is to switch the CCS811 sensor from boot mode into application mode.

1. Pull NWAKE pin low, pull ADDR pin low.
2. Write any value to the **APP_START** register.
3. Read the **STATUS** register and check the error bit.

The outcome of this test is that the NINT pin will be high, the returned value from the **STATUS** register will be 0x90. The value of 0x90 shows fw_mode bit indicates application mode, app_valid bit indicates a valid application is loaded and the error bit shows no errors. If the error bit is ‘1’ then the **ERROR** register can be read to get the error reported by the BIST.

3.5 Test 5 “Resistance Check”

The purpose of this test is to switch the CCS811 sensor from mode 0 (idle) to mode 4 (constant power mode 250ms). This will configure the CCS811 sensor to provide measurement readings every 250ms. If the NINT pin is used to indicate a reading is ready then the int_datardy bit must also be set to 1.

1. Pull NWAKE pin low, pull ADDR pin low.
2. Read the **MEAS_MODE** register.
3. Update the int_datardy bit to reflect the use of the NINT pin.
4. Update the drive_mode bits to mode_4 '100'.
5. Write the value back to the **MEAS_MODE** register.

The outcome of this test is that the NINT pin will toggle low when data is ready to be read from the **RAW_DATA** register and return high when a read from the **ALG_RESULT_DATA** register is performed. If the NINT pin is not used then the **STATUS** register must be polled for the data_ready bit to be high. The data_ready bit will also transition low after a read from the **ALG_RESULT_DATA** register.

3.6 Test 6/7/8 “Heater”

The purpose of this test is to read resistance values from the **RAW_DATA** register, convert the reading to a resistance and then observe a positive trend in 3 consecutive readings. The readings should also not be the minimum value of ‘0’ Ohms or maximum value of 1.65M Ohms. If the NINT pin is not used then step 2 will not be performed and step 4 will be used to detect a reading.

1. Pull NWAKE pin low, pull ADDR pin low.
2. If using NINT pin wait for the pin to go low.
3. Read the **STATUS** register and check the error bit.
4. If not using the NINT pin, wait for the data_ready bit in the **STATUS** register to transition to ‘1’.
5. Read the **RAW_DATA** register (ADC and current) and calculate resistance.
6. Read the **ALG_RESULT_DATA** register to reset NINT pin and data_ready bit.
7. Repeat steps 2 to 6 another 2 times to give 3 resistance readings.

The outcome of this test is that at no time should the error bit be set in the **STATUS** register. The NINT pin should transition to ‘0’ after approximately 250ms. The NINT pin should reset back to high and the data_ready bit should be set to ‘0’ after the **ALG_RESULT_DATA** register is read. The resistance readings should increase as each reading is taken and the reading should not be the minimum value of ‘0’ Ohms or the maximum value of 1.65M Ohms.

So, $0 < R1 < R2 < R3 < 1.65M$. Where R1, R2 and R3 are the consecutive resistance readings.

3.7 Test 9 “Stop”

The purpose of this test is to put the CCS811 sensor into idle mode and stop it taking measurements.

1. Pull NWAKE pin low, pull ADDR pin low.
2. Read the **MEAS_MODE** register.
3. Update the int_datardy bit to disable the use of the NINT pin.
4. Update the drive_mode bits to mode_0 ‘000’.
5. Write the value back to the **MEAS_MODE** register.

The outcome of this test is that if the NINT pin is being used it will stop toggling low every 250ms and the data_ready bit in the **STATUS** register will also remain at ‘0’.

3.8 Test 10 “Reset”

The purpose of this test is to confirm the NRESET pin is connected and will reset the CCS811 sensor into boot loader mode. If this pin is not used then the soft reset can be used to reset the CCS811 sensor back in to boot loader mode. If the NRESET pin is not used then ignore step 3.

1. Pull NWAKE pin low, pull ADDR pin low.
2. Read **STATUS** register and confirm the fw_mode bit it '1'.
3. If NRESET pin is used, pull NRESET low, wait more than 20us, pull NRESET high.
4. If NRESET is not used, issue reset sequence [0x11, 0xE5, 0x72, 0x8A] to the **SW_RESET** register.
5. Wait 2ms and then read **STATUS** register and confirm the fw_mode bit it '0'

The outcome of this test is that the fw_mode bit has been reset back to '0' indicating the CS811 sensor is in boot mode.

4 Summary

The outcome of the tests detailed in section 3 will provide, confidence that the CCS811 sensor has been integrated into a product at the manufacturing stage, and that no defects have been introduced by the manufacturing process itself.

5 Revision Information

Changes from previous version to current revision v2-00	Page
Rework of whole document for ams template	All
Rework of test procedures to meet new 1sec constraint	6 to 9

- Page and figure numbers for the previous version may differ from page and figure numbers in the current revision.
- Correction of typographical errors is not explicitly mentioned.

6 Legal Information

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