introspect technology

USER GUIDE

SV2C In-Field Calibration Standard Operating Procedures

SV2C Personalized SerDes Tester

C SERIES

Published in Canada on March 25, 2021
EN-G055E-E-21083

INTROSPECT.CA

Table of Contents

Introduction

OVERVIEW

This document provides the full set of instructions for performing in-field calibrations of an SV2C Personalized SerDes Tester within a customer production environment. There are four types of calibrations and validations which may be performed, as listed below:

1. SV2C RX Threshold Voltage Calibration
2. SV2C RX Common Mode Voltage Calibration
3. SV2C RX Equalization (CTLE) Calibration
4. SV2C Internal Frequency Validation

There are currently three different SV2C firmware releases for use with the calibrations listed above. This document will specify the required combinations of firmware / software / test procedures for each type of in-field calibration.

There are specific use-cases for each of the above calibrations and validations. For example, a particular calibration may be required when the SV2C is being upgraded to a more recent firmware version or may be required when the SV2C is reverted to a previous firmware version. This document will provide the full use-case requirements for each type of calibration and validation.

The main body of this document will provide full, step-by-step instructions for executing each type of in-field calibration.

Note: to improve the ease of reading in this document, the following three abbreviations for will frequently be used to designate the three versions of firmware:

FWIESPSV2C03A009 will be abbreviated as “FW09”
FWIESPSV2C03A011 will be abbreviated to “FW11”
FWIESPSV2C03A016 will be abbreviated to “FW16”

HARDWARE REQUIREMENTS

- (QTY = 1) SV2C Personalized SerDes Tester
- (QTY = 1) 12 V power supply units (manufacturer part number CUI SDI65-12-UDC-P5)
- (QTY = 2) MXP to SMA cable assemblies (manufacturer part number: Huber and Suhner MF53/2x8A_21MXP/21SMA/152).
- (QTY = 16) SMA 50 ohm terminator (example part number Mini-Circuits ANNE-50+)
- (QTY = 16) SMA DC block (example part number Mini-Circuits BLK-18-S+)
- (QTY = 16) SMA adapters, male pin to male pin (example part number Amphenol RF 132168)
- (QTY = 1) USB2 cable for connection between SV2C and a PC
- (QTY = 1) Personal computer, with Windows 7, 8, or 10 installed.

There are two TX to RX loopback configurations used for the procedures in this document: (a) fully differential configuration and (b) single-ended configuration. Connection diagrams for each are shown below in Figure 1. Refer to example part numbers given above.

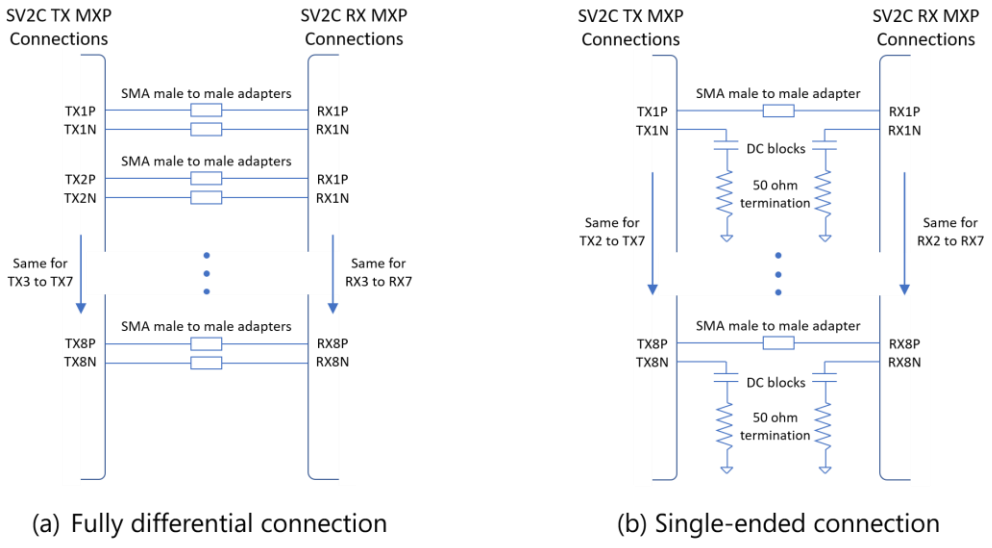


Figure 1: SV2C loopback connection diagrams for (a) fully differential and (b) single-ended configurations

FIRMWARE / SOFTWARE / TEST FOLDER REQUIREMENTS

There are currently four production calibration and/or validations which may be performed in the field. The required pairing of firmware, software, and test procedure folder combinations for each calibration type are provided below in Table 1 to Table 4.

TABLE 1: RX THREHSOLD VOLTAGE CALIBRATION

FIRMWARE RELEASE	SOFWARE RELEASE	TEST PROCEDURE FOLDER
FWIESPSV2C03A016	IESP 21.1.0	rxThresholdCal_FW16
FWIESPSV2C03A011	IESP 3.6.83	rxThresholdCal_FW09
FWIESPSV2C03A009	IESP 3.6.74	rxThresholdCal_FW09

TABLE 2: RX COMMON MODE VOLTAGE CALIBRATION

FIRMWARE RELEASE	SOFWARE RELEASE	TEST PROCEDURE FOLDER
FWIESPSV2C03A016	IESP 21.1.0	SV2RxCommonModeCalibration_HiSilicon_21p1p0
FWIESPSV2C03A011	IESP 3.6.83	SV2RxCommonModeCalibration_HiSilicon__3p6p74_3p6p83
FWIESPSV2C03A009	IESP 3.6.74	SV2RxCommonModeCalibration_HiSilicon__3p6p74_3p6p83

TABLE 3: RX EQUALIZATION (CTLE) CALIBRATION

FIRMWARE RELEASE	SOFWARE RELEASE	TEST PROCEDURE FOLDER
FWIESPSV2C03A016	IESP 21.1.0	HiSiliconCTLECalibration_21p1p0
FWIESPSV2C03A011	IESP 3.6.83	HiSiliconCTLECalibration_3p6p74_3p6p83
FWIESPSV2C03A009	IESP 3.6.74	HiSiliconCTLECalibration_3p6p74_3p6p83

TABLE 4: INTERNAL FREQUENCY VALIDATION

FIRMWARE RELEASE	SOFWARE RELEASE	CORRESPONDING TEST SCRIPT
FWIESPSV2C03A016	IESP 21.1.0	Test_20201217-Python-freqMeasurement.py
FWIESPSV2C03A011	IESP 3.6.83	Not supported
FWIESPSV2C03A009	IESP 3.6.74	Not supported

CALIBRATION / VALIDATION USE CASES

There are currently four in-field calibration and validations which may be performed. The use cases for each are described below.

1. RX THRESHOLD VOLTAGE CALIBRATION / VALIDATION

The RX threshold voltage calibration and validation procedures in this test folder need to be performed on an SV2C in the following cases:

- Each time the firmware is upgraded between FW09/FW11 and FW16
- Each time the firmware is reverted from FW16 to FW09/FW11

Note that this procedure does not need to be performed when switching between FW09 and FW11.

The RX threshold voltage calibration and validation procedures must be performed in either of "Differential" or "Single-ended" mode. For example, if the SV2C is being calibrated for the "Differential" test case, then the user must execute the following test procedures:

1. rxThresholdCal_SV2,
2. sv2ProgramFlash, and
3. rxThresholdVal_SV2

and if the SV2C is being calibrated for the "Single-ended" test case, then the user must execute the following test procedures:

1. rxThresholdCal_SV2_singleEnded,
2. sv2ProgramFlash, and
3. rxThresholdVal_SV2_singleEnded

The differential calibration is not valid for single-ended operation, nor is the single-ended calibration valid for differential operation. Therefore, the calibration and validation procedures in this test folder need to be performed on an SV2C in the following cases:

- Each time SV2C operation is switched from differential to single-ended usage
- Each time SV2C operation is switched from single-ended to differential usage

Step-by-step procedures for performing RX threshold calibrations are found starting on page 8 of this document.

2. RX COMMON MODE VOLTAGE CALIBRATION

First, note that the common mode voltage calibration is only required if the SV2C is used for single-ended operation. For differential operation, the default common mode voltage value of "15" should always be used.

The common mode voltage calibration procedure needs to be performed on an SV2C in the following cases:

- Each time the firmware is upgraded between FW09/FW11 and FW16
- Each time the firmware is reverted from FW16 to FW09/FW11

Note that the common mode voltage calibration needs to be performed at least once per product development cycle (ie, when the SV2C is configured to operate with a new type of DUT device). This will ensure the optimal setting of the SV2C common mode level for the new DUT.

Step-by-step procedures for performing RX common mode voltage calibrations are found starting on page 29 of this document.

3. RX EQUALIZATION (CTLE) CALIBRATION

The RX Equalization calibration procedure must be to be performed each time the SV2C module is powered up. This calibration may be performed for either the differential or single-ended test case.

Step-by-step procedures for performing RX common mode voltage calibrations are found starting on page 34 of this document.

4. INTERNAL FREQUENCY VALIDATION

The internal frequency validation check needs to be performed periodically. Introspect recommends that this validation be performed at the start of each new wafer under test. This internal frequency validation can only be performed when using FW16.

Step-by-step procedures for performing RX common mode voltage calibrations are found starting on page 43 of this document.

Step-By-Step Calibration Procedures

RX THRESHOLD VOLTAGE CALIBRATION / VALIDATION

This section of the document will provide the procedures the following four cases of RX threshold voltage calibration:

Case 1: Differential RX threshold calibration, firmware = FW16
Case 2: Single-ended RX threshold calibration, firmware = FW16
Case 3: Differential RX threshold calibration, firmware = FW09 or FW11
Case 4: Single-ended RX threshold calibration, firmware = FW09 or FW11

Please refer to Table 1 for the valid firmware / software / test procedure folder combinations for this calibration and refer to the step-by-step procedures below.

CASE 1: PROCEDURES FOR DIFFERENTIAL THRESHOLD CALIBRATION WITH FWIESPSV2C03A016

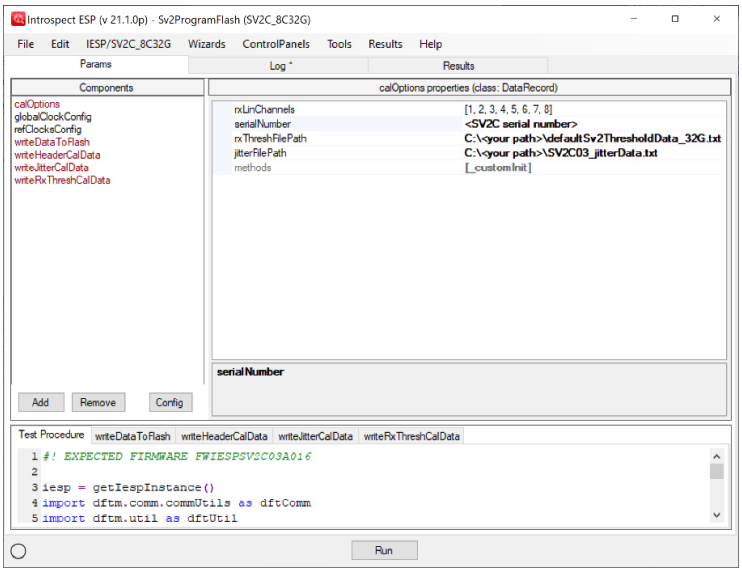
1. Ensure that you are using the firmware / software / test procedure folder combination:

   Firmware = FW16
   Software = IESP 21.1.0
   Test Folder = rxThresholdCal_FW16

2. **Load the default RX threshold calibration file**. To do this, from the GUI version listed above, open the test procedure "Sv2ProgramFlash". Under "calOptions" change the following settings to enter the module serial number (printed on the back of the module) and point the test procedure to the default calibration text files provided by Introspect Technology:

   calOption.serialNumber = <module serial number>
   calOption.rxThreshFilePath = C:\ **<your full path here>** \defaultSv2ThresholdData_32G.txt
   calOption.jitterFilePath = C:\ **<your full path here>** \SV2C03_jitterData.txt

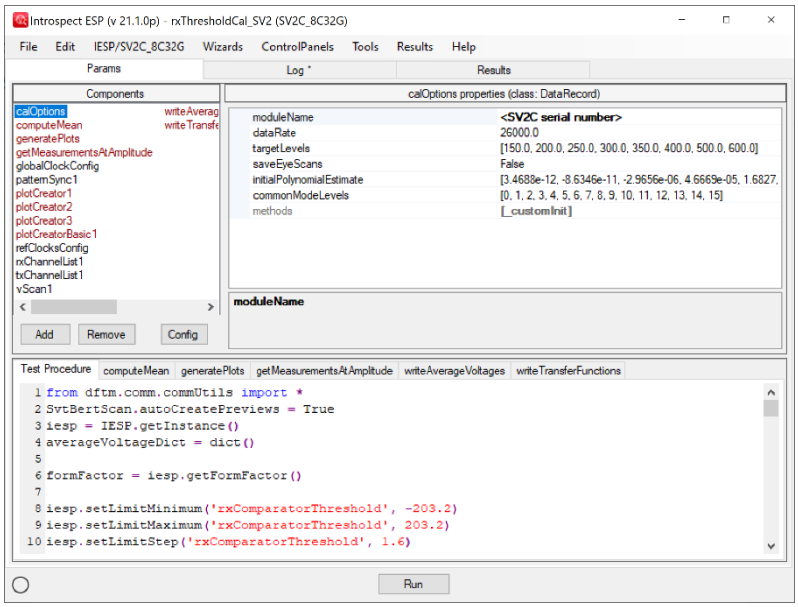
   This is as shown in the figure below.



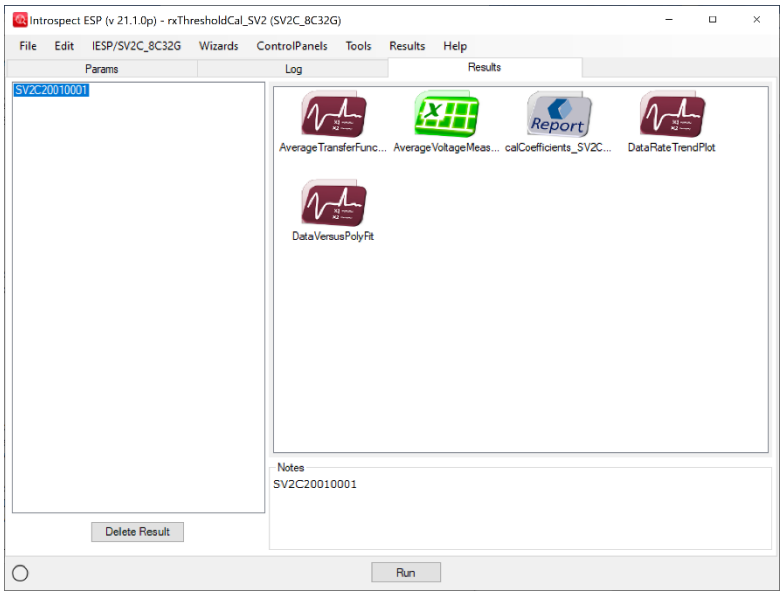
3. Press “Run” from the GUI and wait for the test procedure to finish.
4. Very important: when the test procedure has completed, power cycle the SV2C module.
5. **Start the RX threshold calibration.** To do this, configure the MXP cables so that all TX signals are looped back to RX signals using the differential configuration (see Figure 1(a) on page 4 for connection details).
6. Open the test procedure “rxThreshold**Cal**_SV2”. Under “calOptions” change the following settings to enter the module serial number (printed on the back of the module).

   calOption.serialNumber = <module serial number>

   This is as shown in the figure below.



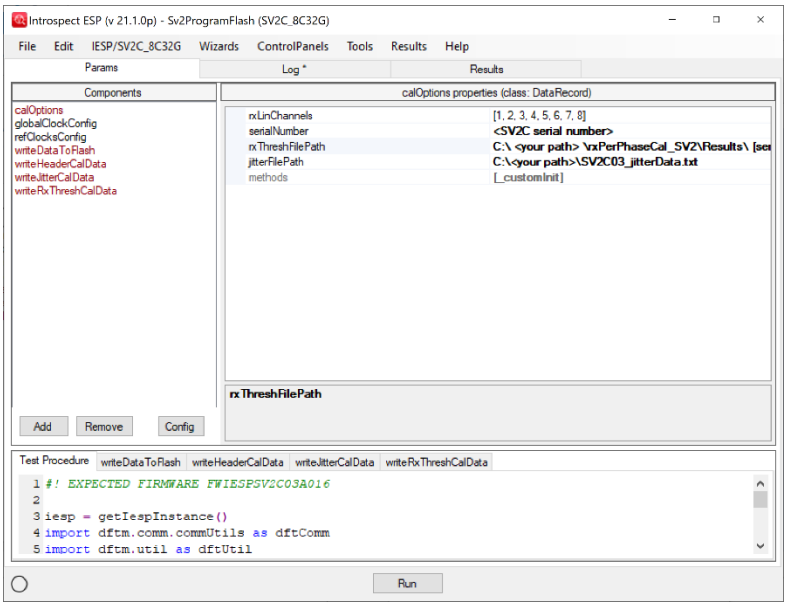
7. Press “Run” from the GUI. Ensure that the software connects and proceeds without error before leaving it to execute. Test completion takes approximately 20 minutes.
8. When the test procedure is complete it is important to rename results folder from the automatically generated name to the SV2C serial number. The completed test procedure will appear as shown in the figure below.



9. **Load the RX threshold calibration data onto the SV2C.** To do this, reopen the test procedure "Sv2ProgramFlash". Under "calOptions" change the following settings to enter the module serial number (printed on the back of the module) and point the test procedure to the default calibration text files provided by Introspect Technology:

   calOption.serialNumber = <module serial number>
   calOption.rxThreshFilePath = C:\ **<your full path here>** \rxPerPhaseCal_SV2\Results\ [serial number] calCoefficients_[serial number]\calCoefficients_[serial number].txt
   calOption.jitterFilePath = C:\ **<your full path here>** \SV2C03_jitterData.txt

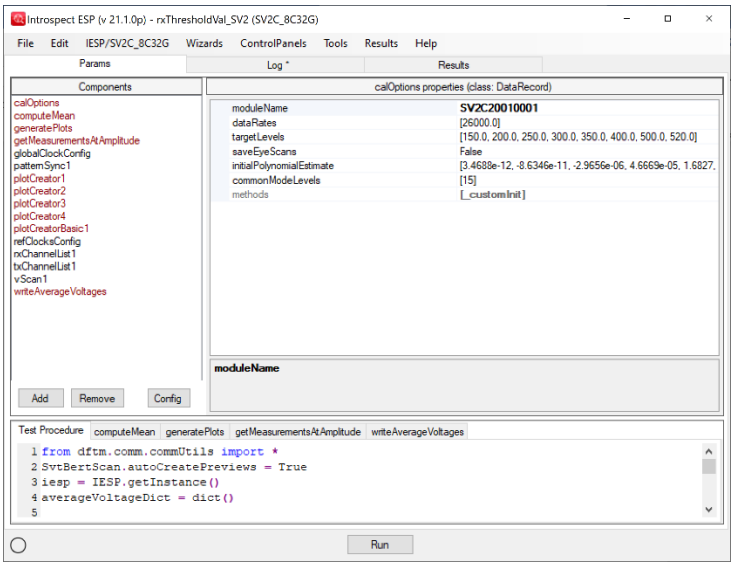
   This is as shown in the figure below.



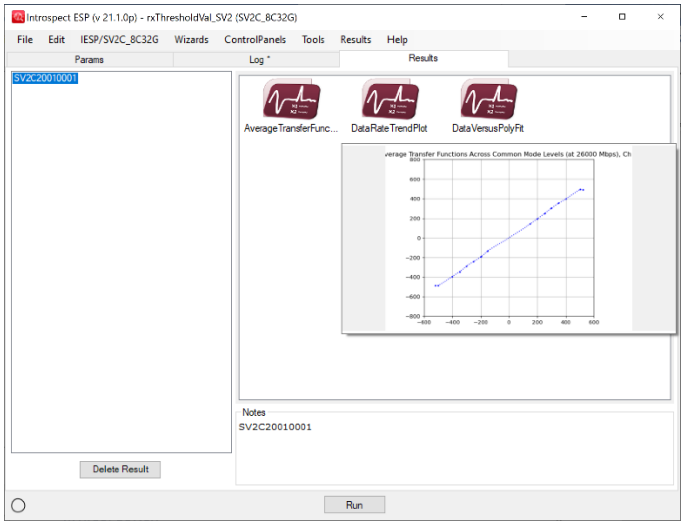
10. Press “Run” from the GUI and wait for the test procedure to finish.
11. Very important: when the test procedure has completed, power cycle the SV2C module, and close the GUI before proceeding.
12. **Start the RX threshold validation.** To do this, reopen the GUI and open the test procedure “rxThreshold**Val**_SV2”. Under “calOptions” change the following settings to enter the module serial number (printed on the back of the module)

    calOption.serialNumber = <module serial number>

    This is as shown in the figure on the following page.
13. Press “Run” from the GUI. The test completion takes approximately 2 minutes.



14. When the validation is complete it is important that you rename results folder from the automatically generated name to the SV2C serial number. The completed test procedure is as shown in the figure below.



15. Verify that the transfer functions are linear (check under the "DataRate Trend Plot" icon) similar to the case shown above. This completes the SV2C RX threshold calibration and validation.

CASE 2: PROCEDURES FOR SINGLE-ENDED THRESHOLD CALIBRATION WITH FWIESPSV2C03A016

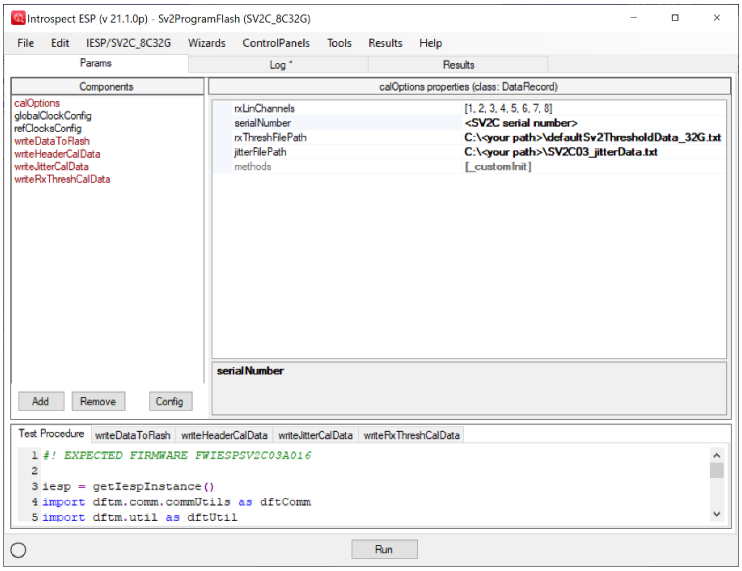
1. Ensure that you are using the firmware / software / test procedure folder combination:

   Firmware = FW16
   Software = IESP 21.1.0
   Test Folder = rxThresholdCal_FW16

2. **Load the default RX threshold calibration file**. To do this, from the GUI version listed above, open the test procedure "Sv2ProgramFlash". Under "calOptions" change the following settings to enter the module serial number (printed on the back of the module) and point the test procedure to the default calibration text files provided by Introspect Technology:

   calOption.serialNumber = <module serial number>
   calOption.rxThreshFilePath = C:\ **<your full path here>** \defaultSv2ThresholdData_32G.txt
   calOption.jitterFilePath = C:\ **<your full path here>** \SV2C03_jitterData.txt

   This is as shown in the figure below.

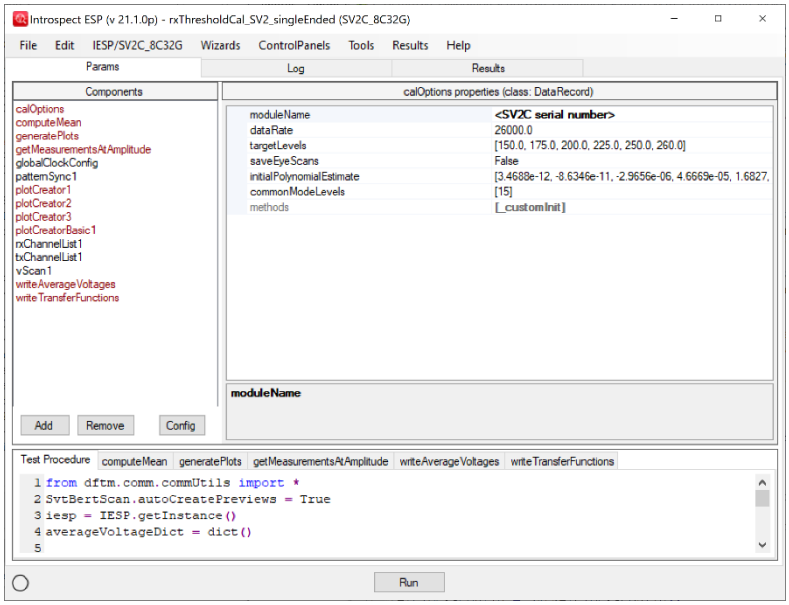


3. Press "Run" from the GUI and wait for the test procedure to finish.
4. Very important: when the test procedure has completed, power cycle the SV2C module.

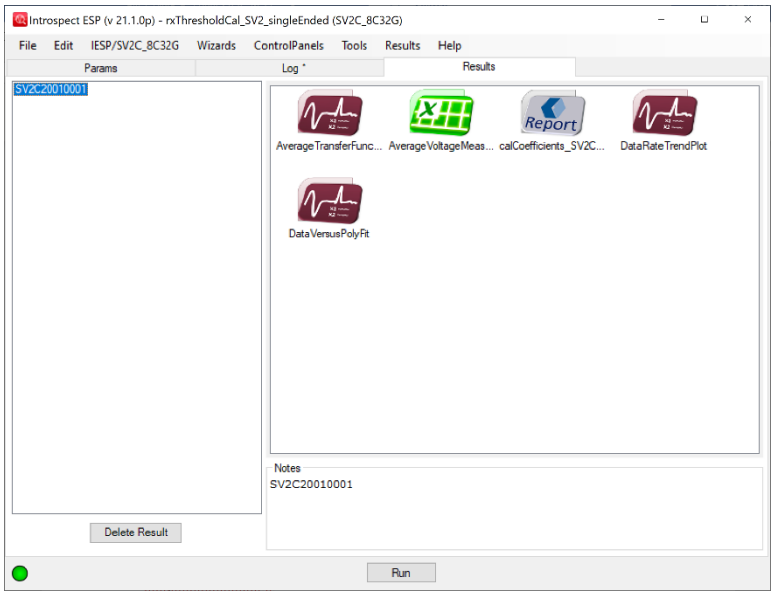
5. **Start the RX threshold calibration.** To do this, configure the MXP cables so that all TX signals are looped back to RX signals using the single-ended configuration (see Figure 1(b) on page 4 for connection details).
6. Open the test procedure "rxThreshold**Cal**_SV2_**singleEnded**". Under "calOptions" change the following settings to enter the module serial number (printed on the back of the module).

   calOption.serialNumber = <module serial number>

   This is as shown in the figure below.



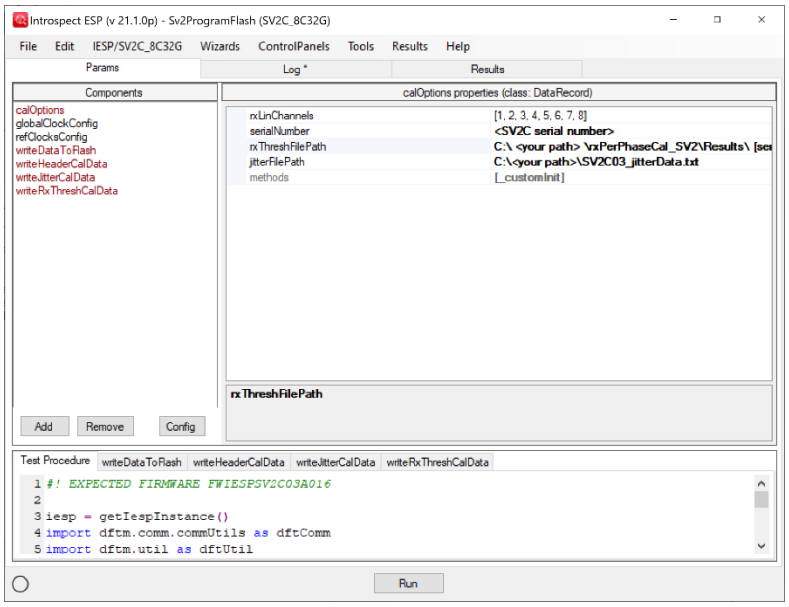
7. Press "Run" from the GUI. Ensure that the software connects and proceeds without error before leaving it to execute. Test completion takes approximately 10 minutes.
8. When the test procedure is complete it is important that you rename results folder from the automatically generated name to the SV2C serial number. The completed test procedure will appear as shown in the figure below.



9. **Load the RX threshold calibration data onto the SV2C.** To do this, reopen the test procedure "Sv2ProgramFlash". Under "calOptions" change the following settings to enter the module serial number (printed on the back of the module) and point the test procedure to the default calibration text files provided by Introspect Technology:

   calOption.serialNumber = <module serial number>
   calOption.rxThreshFilePath = C:\ **<your full path here>** \rxPerPhaseCal_SV2\Results\ [serial number] calCoefficients_[serial number]\calCoefficients_[serial number].txt
   calOption.jitterFilePath = C:\ **<your full path here>** \SV2C03_jitterData.txt

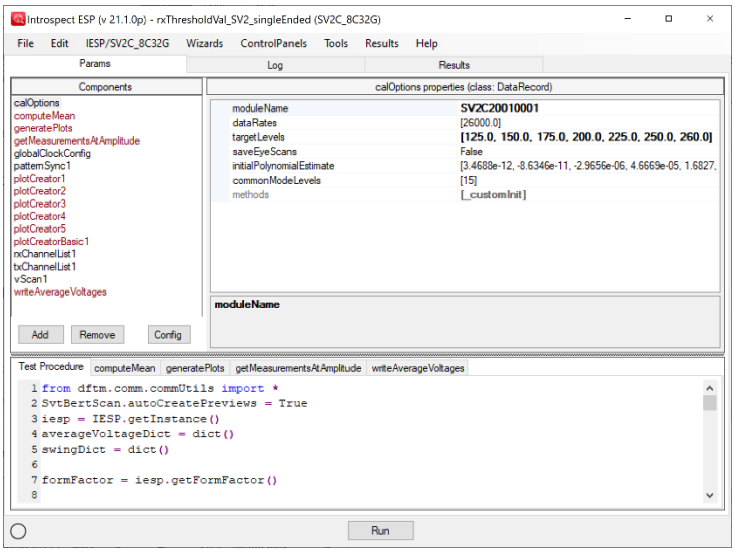
   This is as shown in the figure below.



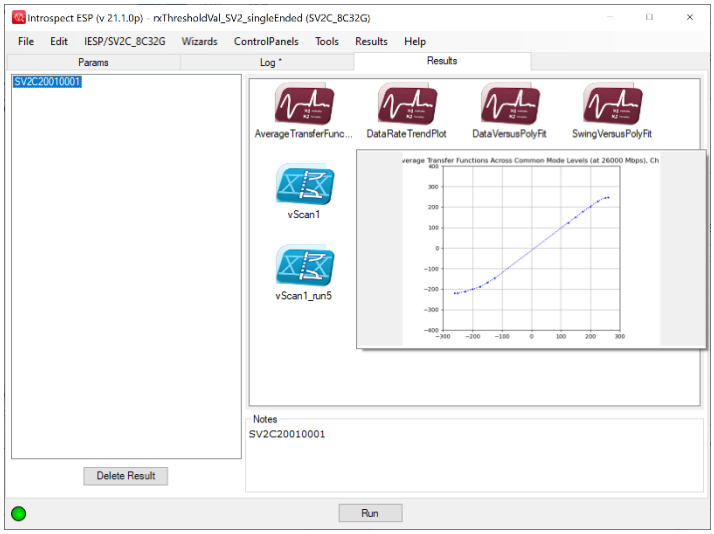
10. Press “Run” from the GUI and wait for the test procedure to finish.
11. Very important: when the test procedure has completed, power cycle the SV2C module, and close the GUI before proceeding.
12. **Start the RX threshold validation.** To do this, reopen the GUI and open the test procedure “rxThreshold**Val**_SV2_**singleEnded**”. Under “calOptions” change the following settings to enter the module serial number (printed on the back of the module)

    calOption.serialNumber = <module serial number>

    This is as shown in the figure on the following page.
13. Press “Run” from the GUI. Test completion takes approximately 2 minutes.



14. When the validation is complete it is important that you rename results folder from the automatically generated name to the SV2C serial number. The completed test procedure is as shown in the figure below.



16. Verify that the transfer functions are linear (check under the "DataRate Trend Plot" icon) similar to the case shown above. This completes the SV2C RX threshold calibration and validation.

CASE 3: PROCEDURES FOR DIFFERENTIAL THRESHOLD CALIBRATION WITH FWIESPSV2C03A009 AND FWIESPSV2C03A011

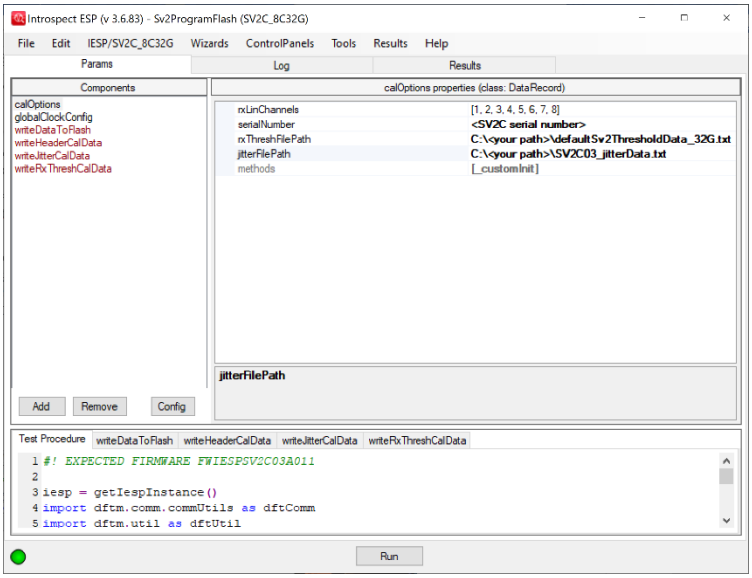
1. Ensure that you are using the firmware / software / test procedure folder combination:

   Firmware = FW09 or FW11
   Software = IESP 3.6.74 or IESP 3.6.83
   Test Folder = rxThresholdCal_FW09

2. **Load the default RX threshold calibration file**. To do this, from the GUI version listed above, open the test procedure "Sv2ProgramFlash". Under "calOptions" change the following settings to enter the module serial number (printed on the back of the module) and point the test procedure to the default calibration text files provided by Introspect Technology:

   calOption.serialNumber = <module serial number>
   calOption.rxThreshFilePath = C:\ **<your full path here>** \defaultSv2ThresholdData_32G.txt
   calOption.jitterFilePath = C:\ **<your full path here>** \SV2C03_jitterData.txt

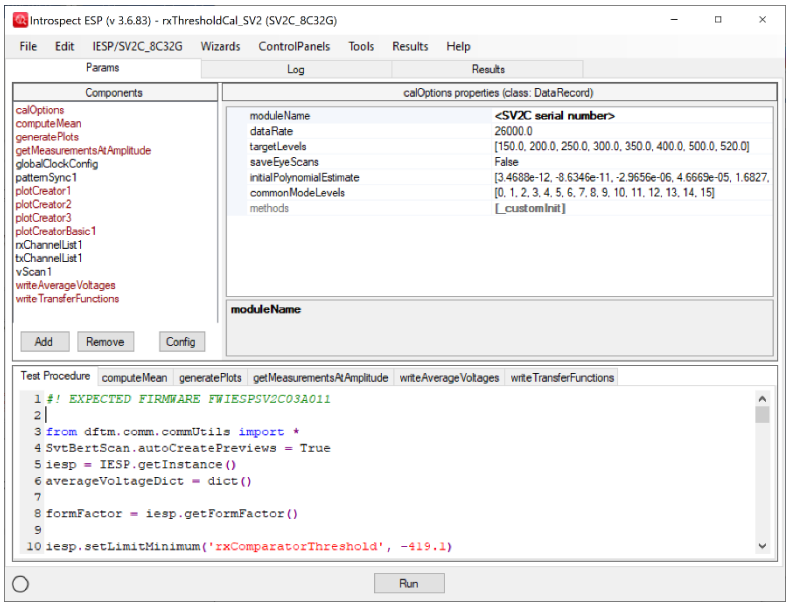
   It may also be necessary to change the first line of the test procedure to the correct expected firmware version, either FW09 or FW11 as required. This is all as shown in the figure below.



3. Press “Run” from the GUI and wait for the test procedure to finish.
4. Very important: when the test procedure has completed, power cycle the SV2C module.
5. **Start the RX threshold calibration.** To do this, configure the MXP cables so that all TX signals are looped back to RX signals using the differential configuration (see Figure 1(a) on page 4 for connection details).
6. Open the test procedure “rxThreshold**Cal**_SV2”. Under “calOptions” change the following settings to enter the module serial number (printed on the back of the module).

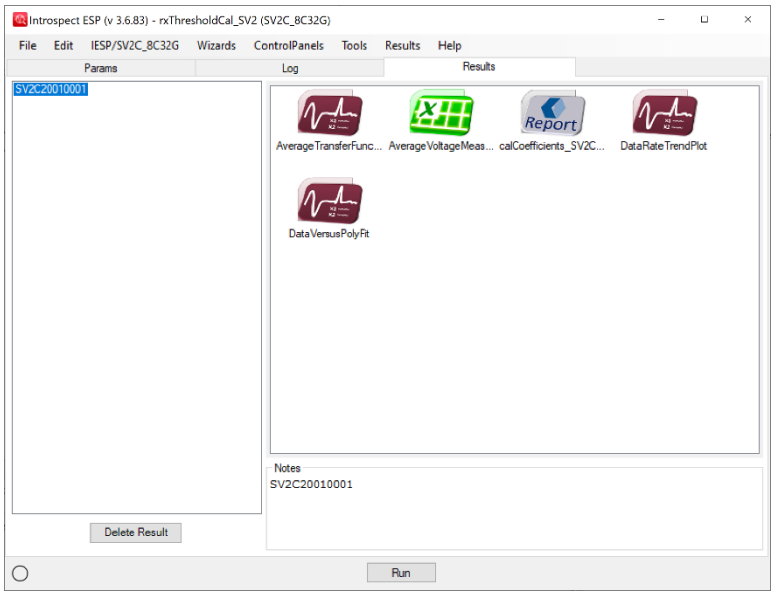
   calOption.serialNumber = <module serial number>

   It may also be necessary to change the first line of the test procedure to the correct expected firmware version, either FW09 or FW11 as required. This is all as shown in the figure below.



7. Press “Run” from the GUI. Ensure that the software connects and proceeds without error before leaving it to execute. Test completion takes approximately 10 minutes.

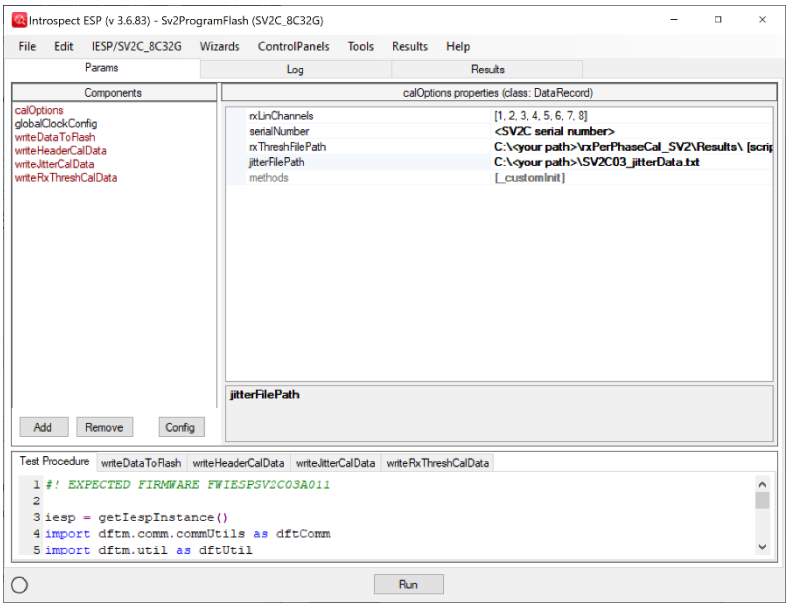
8. When the test procedure is complete it is important to rename results folder from the automatically generated name to the SV2C serial number. The completed test procedure will appear as shown in the figure below.



9. **Load the RX threshold calibration data onto the SV2C.** To do this, reopen the test procedure "Sv2ProgramFlash". Under "calOptions" change the following settings to enter the module serial number (printed on the back of the module) and point the test procedure to the default calibration text files provided by Introspect Technology:

   calOption.serialNumber = <module serial number>
   calOption.rxThreshFilePath = C:\ **<your full path here>** \rxPerPhaseCal_SV2\Results\ [serial number] calCoefficients_[serial number]\calCoefficients_[serial number].txt
   calOption.jitterFilePath = C:\ **<your full path here>** \SV2C03_jitterData.txt

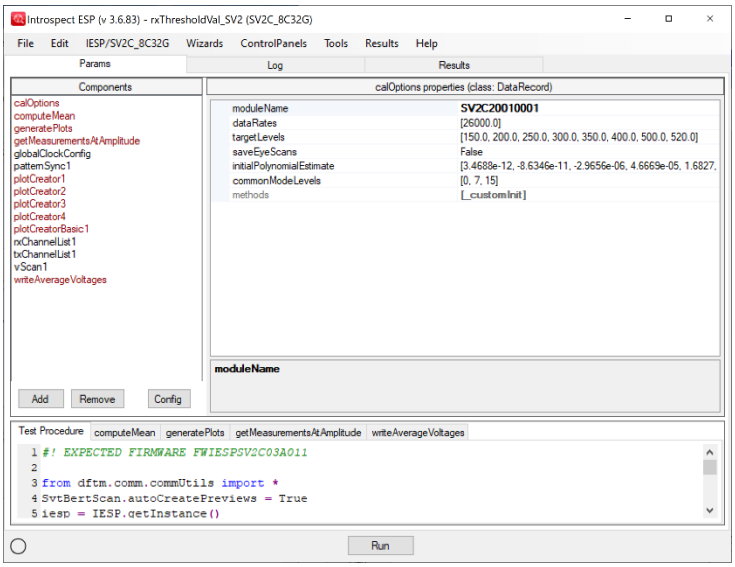
   It may also be necessary to change the first line of the test procedure to the correct expected firmware version, either FW09 or FW11 as required. This is all as shown in the figure below.



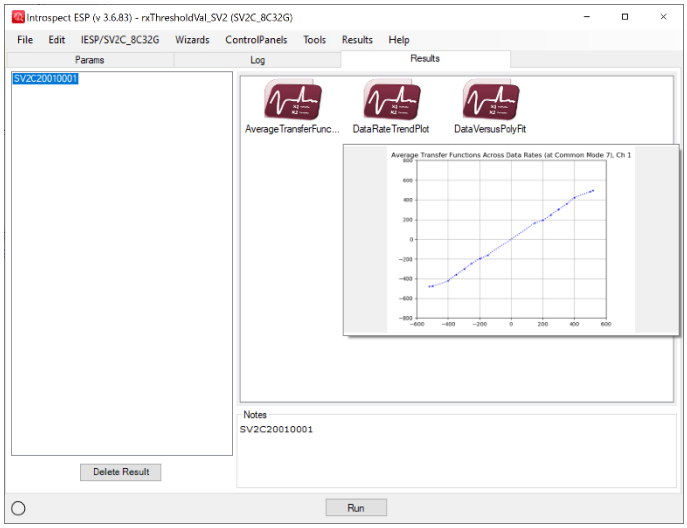
10. Press “Run” from the GUI and wait for the test procedure to finish.
11. Very important: when the test procedure has completed, power cycle the SV2C module, and close the GUI before proceeding.
12. **Start the RX threshold validation.** To do this, reopen the GUI and open the test procedure “rxThreshold**Val**_SV2”. Under “calOptions” change the following settings to enter the module serial number (printed on the back of the module)

    calOption.serialNumber = <module serial number>

    It may also be necessary to change the first line of the test procedure to the correct expected firmware version, either FW09 or FW11 as required. This is all as shown in the figure below.
13. Press “Run” from the GUI. The test completion takes approximately 2 minutes.



14. When the validation is complete it is important that you rename results folder from the automatically generated name to the SV2C serial number. The completed test procedure is as shown in the figure below.



15. Verify that the transfer functions are linear (check under the "DataRate Trend Plot" icon) similar to the example shown above. This completes the SV2C RX threshold calibration and validation.

CASE 4: PROCEDURES FOR SINGLE-ENDED THRESHOLD CALIBRATION WITH FWIESPSV2C03A009 AND FWIESPSV2C03A011

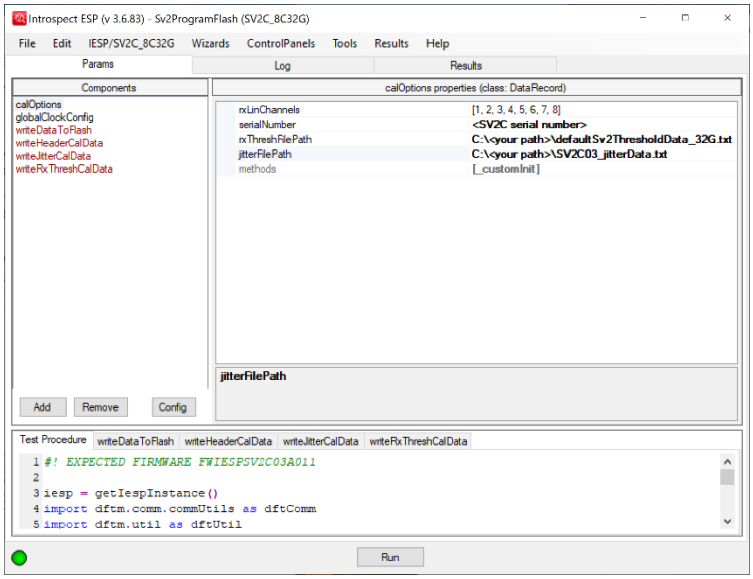
1. Ensure that you are using the firmware / software / test procedure folder combination:

   Firmware = FW09 or FW11
   Software = IESP 3.6.74 or 3.6.83
   Test Folder = rxThresholdCal_FW09

2. **Load the default RX threshold calibration file**. To do this, from the GUI version listed above, open the test procedure "Sv2ProgramFlash". Under "calOptions" change the following settings to enter the module serial number (printed on the back of the module) and point the test procedure to the default calibration text files provided by Introspect Technology:

   calOption.serialNumber = <module serial number>
   calOption.rxThreshFilePath = C:\ **<your full path here>** \defaultSv2ThresholdData_32G.txt
   calOption.jitterFilePath = C:\ **<your full path here>** \SV2C03_jitterData.txt

   This is as shown in the figure below.

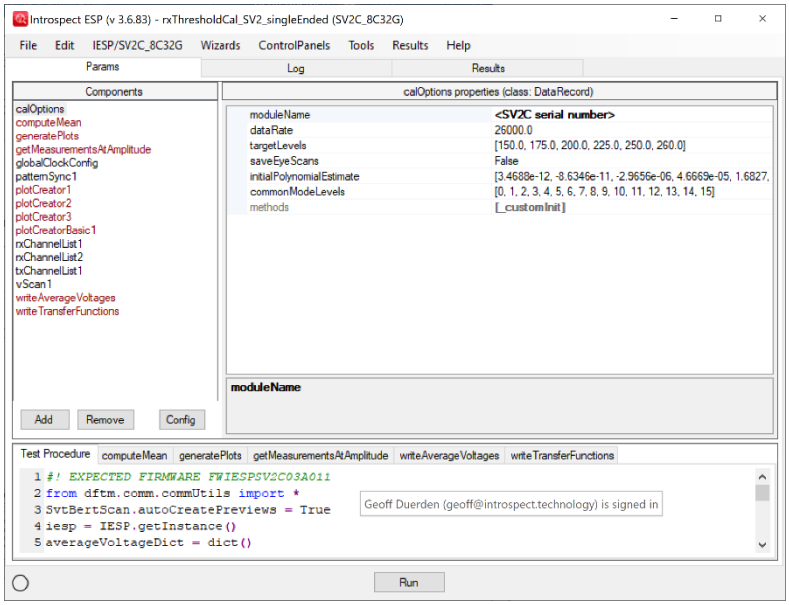


3. Press "Run" from the GUI and wait for the test procedure to finish.
4. Very important: when the test procedure has completed, power cycle the SV2C module.

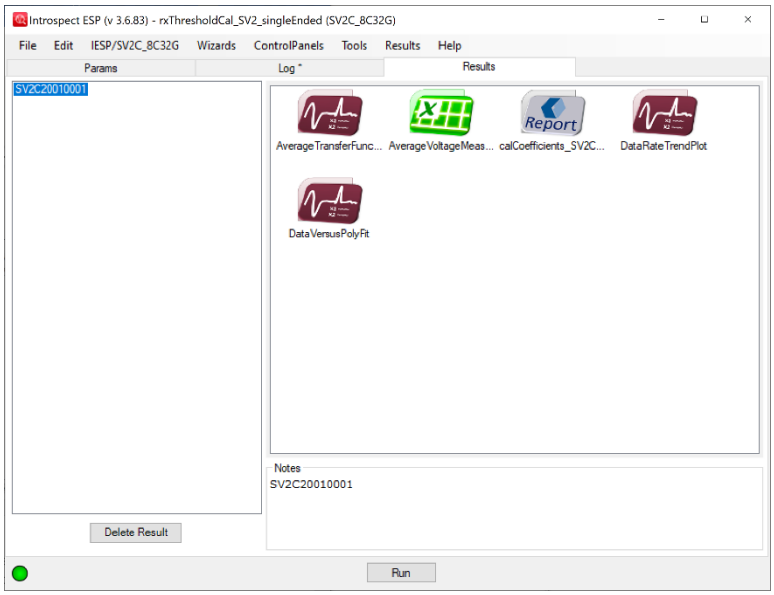
5. **Start the RX threshold calibration.** To do this, configure the MXP cables so that all TX signals are looped back to RX signals using the single-ended configuration (see Figure 1(b) on page 4 for connection details).
6. Open the test procedure "rxThreshold**Cal**_SV2_**singleEnded**". Under "calOptions" change the following settings to enter the module serial number (printed on the back of the module).

   calOption.serialNumber = <module serial number>

   This is as shown in the figure below.



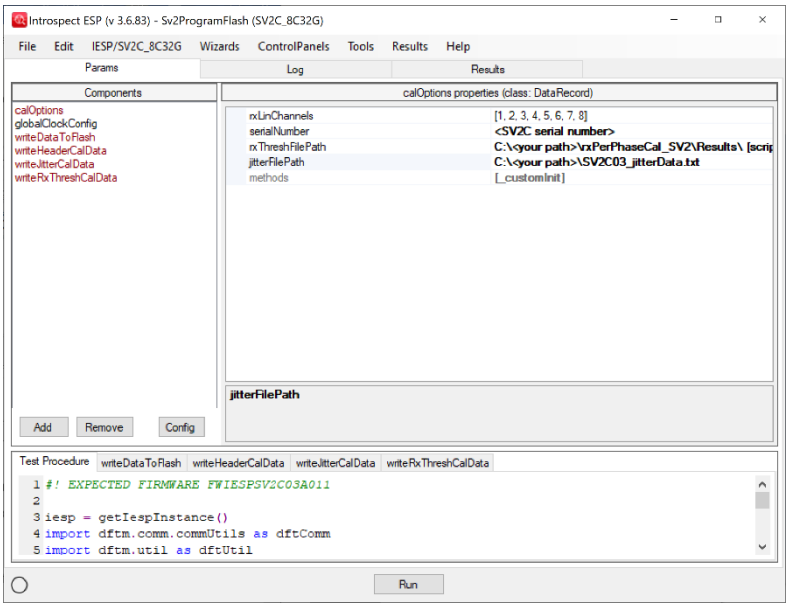
7. Press "Run" from the GUI. Ensure that the software connects and proceeds without error before leaving it to execute. Test completion takes approximately 2 minutes.
8. When the test procedure is complete it is important that you rename results folder from the automatically generated name to the SV2C serial number. The completed test procedure will appear as shown in the figure below.



9. **Load the RX threshold calibration data onto the SV2C.** To do this, reopen the test procedure "Sv2ProgramFlash". Under "calOptions" change the following settings to enter the module serial number (printed on the back of the module) and point the test procedure to the default calibration text files provided by Introspect Technology:

   calOption.serialNumber = <module serial number>
   calOption.rxThreshFilePath = C:\ **<your full path here>** \rxPerPhaseCal_SV2\Results\ [serial number] calCoefficients_[serial number]\calCoefficients_[serial number].txt
   calOption.jitterFilePath = C:\ **<your full path here>** \SV2C03_jitterData.txt

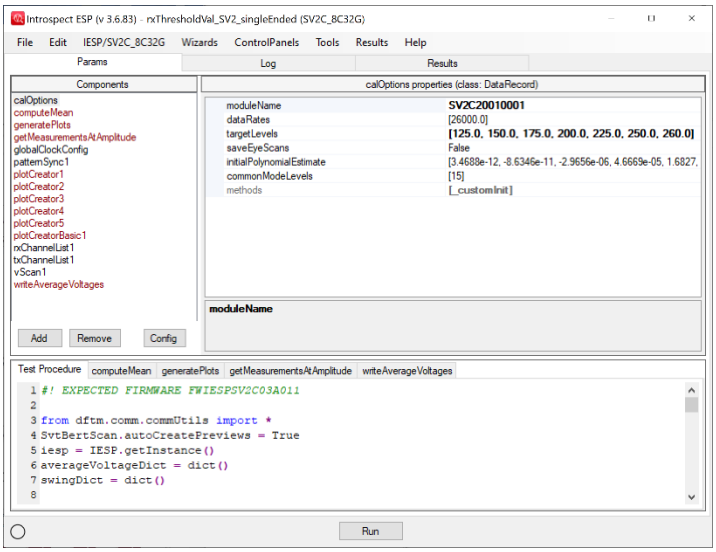
   This is as shown in the figure below.



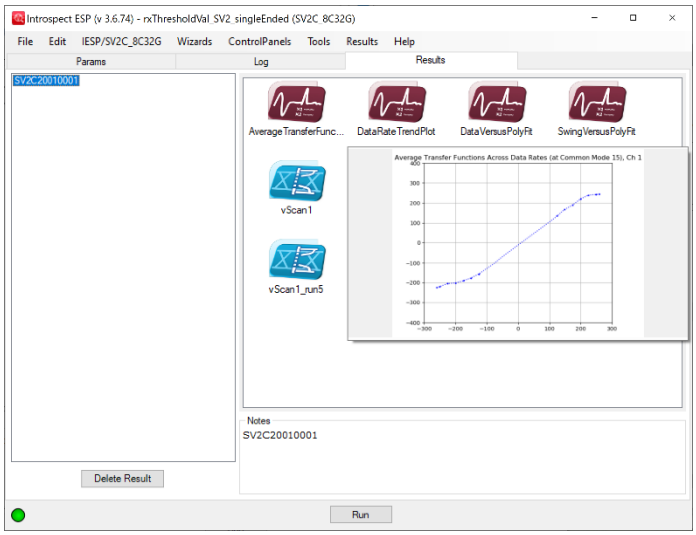
10. Press “Run” from the GUI and wait for the test procedure to finish.
11. Very important: when the test procedure has completed, power cycle the SV2C module, and close the GUI before proceeding.
12. **Start the RX threshold validation.** To do this, reopen the GUI and open the test procedure “rxThreshold**Val**_SV2_**singleEnded**”. Under “calOptions” change the following settings to enter the module serial number (printed on the back of the module)

    calOption.serialNumber = <module serial number>

    This is as shown in the figure on the following page.
13. Press “Run” from the GUI. Test completion takes approximately 2 minutes.



14. When the validation is complete it is important that you rename results folder from the automatically generated name to the SV2C serial number. The completed test procedure is as shown in the figure below.



17. Verify that the transfer functions are linear (check under the "DataRate Trend Plot" icon) similar to the example shown above. This completes the SV2C RX threshold calibration and validation.

RX COMMON MODE VOLTAGE CALIBRATION

This section of the document will provide the procedures for the following two cases for RX common mode voltage calibration:

Case 1: Single-ended RX common mode calibration, firmware = FW16
Case 2: Single-ended RX common mode calibration, firmware = FW09 or FW11

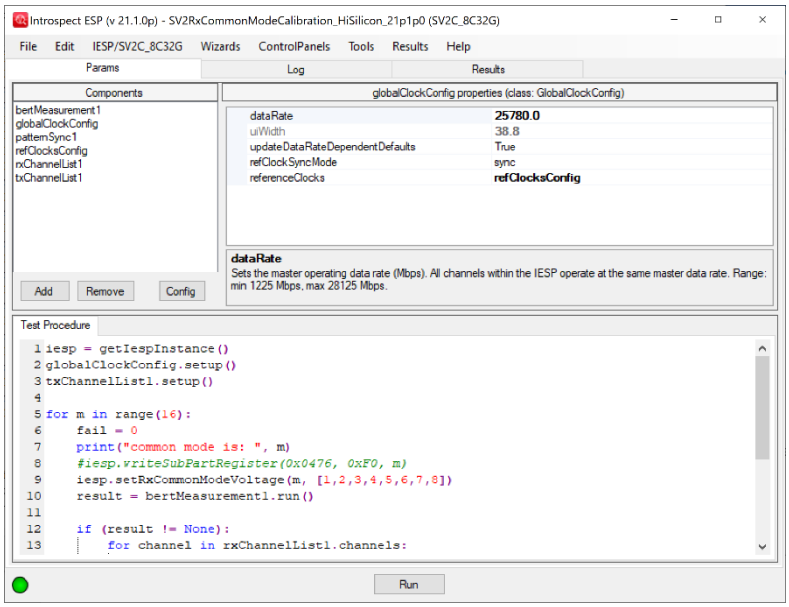
Please refer to Table 2 for the valid firmware / software / test procedure folder combinations for this calibration and refer to the step-by-step procedures below.

CASE 1: PROCEDURES FOR RX COMMON MODE CALIBRATION WITH FWIESPSV2C03A016

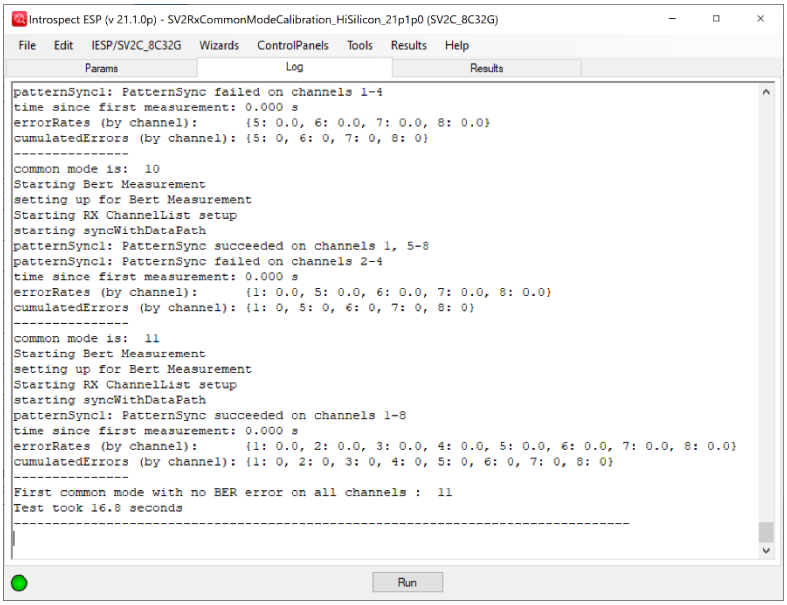
1. Ensure that you are using the firmware / software / test procedure folder combination:

   Firmware = FW16
   Software = IESP 21.1.0
   Test Folder = SV2RxCommonModeCalibration_HiSilicon_21p1p0

2. **Start the RX common mode calibration.** To do this, configure the MXP cables so that all TX signals are looped back to RX signals using the single-ended configuration (see Figure 1(b) on page 4 for connection details).
3. Open the test procedure "SV2RxCommonModeCalibration_HiSilicon_21p1p0". There are no "CalOptions" to modify. Simply press "Run" from the GUI as shown in the figure below.



4. The test will execute in approximately 20 seconds. The test will finish when it finds the lowest value of common mode voltage which results in error-free BER operation across all channels. The required information is printed in the log window of the test procedure, as shown in the figure below.



5. In this case, a common mode voltage setting of "11" was the lowest common mode voltage value which resulted in error-free BER operation. Once this common mode voltage setting is reported in the test procedure log, the SV2C RX common mode voltage calibration is complete.
6. To incorporate the common mode calibration result into a subsequent test, the following two lines of should be added to the subsequent Python file or test procedure. The example of setting the common mode voltage to "11" is shown below:

   ```
   iesp = getIespInstance() # if not defined elsewhere
   iesp.setRxCommonModeVoltage(11, [1,2,3,4,5,6,7,8])
   ```

7. Note: if differential operation is required in a procedure that previously defines this common mode voltage, the default common mode voltage setting of "15" should be used, as shown below:

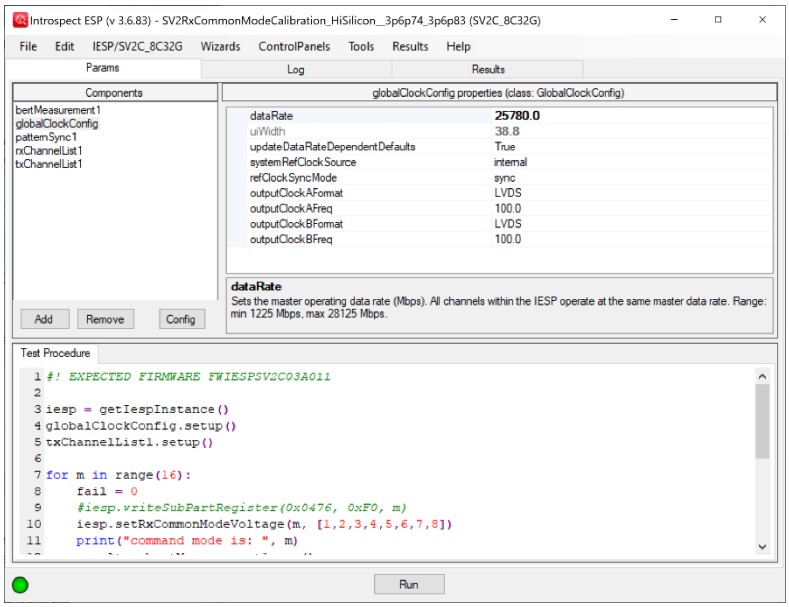
   ```
   iesp = getIespInstance() # if not defined elsewhere
   iesp.setRxCommonModeVoltage(15, [1,2,3,4,5,6,7,8])
   ```

CASE 2: PROCEDURES FOR RX COMMON MODE CALIBRATION WITH FWIESPSV2C03A009 AND FWIESPSV2C03A011

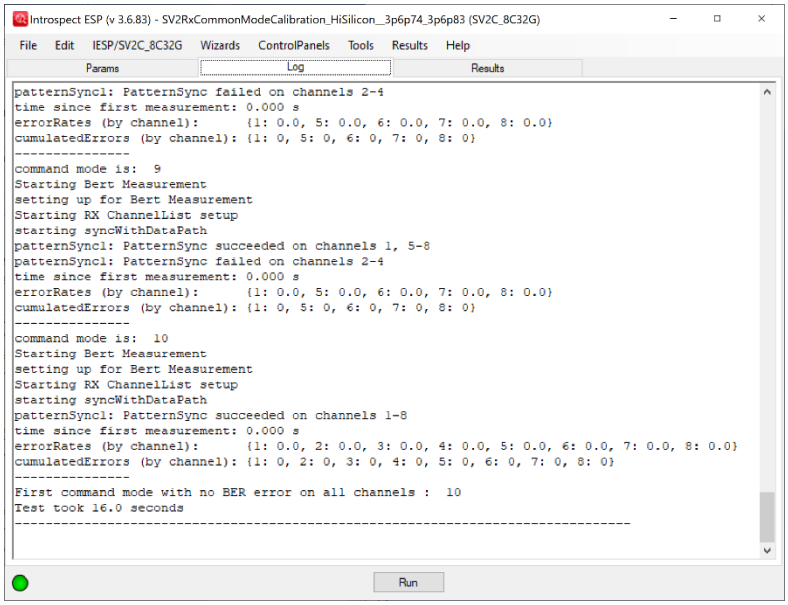
1. Ensure that you are using the firmware / software / test procedure folder combination:

   Firmware = FW09 or FW11
   Software = IESP 3.6.74 or IESP 3.6.83
   Test Folder = SV2RxCommonModeCalibration_HiSilicon__3p6p74_3p6p83

2. **Start the RX common mode calibration.** To do this, configure the MXP cables so that all TX signals are looped back to RX signals using the single-ended configuration (see Figure 1(b) on page 4 for connection details).
3. Open the test procedure "SV2RxCommonModeCalibration_HiSilicon__3p6p74_3p6p83". There are no "CalOptions" to modify. Simply press "Run" from the GUI as shown in the figure below.



4. The test will execute in approximately 20 seconds. The test will finish when it finds the lowest value of common mode voltage which results in error-free BER operation across all channels. The required information is printed in the log window of the test procedure, as shown in the figure below.



5. In this case, a common mode voltage setting of "10" was the lowest common mode voltage value which resulted in error-free BER operation. Once this common mode voltage setting is reported in the test procedure log, the SV2C RX common mode voltage calibration is complete.
6. To incorporate the common mode calibration result into a subsequent test, the following two lines of should be added to the subsequent Python file or test procedure. The example of setting the common mode voltage to "10" is shown below:

```
iesp = getIespInstance() # if not defined elsewhere
iesp.setRxCommonModeVoltage(10, [1,2,3,4,5,6,7,8])
```

7. Note: if differential operation is required in a procedure that previously defines this common mode voltage, the default common mode voltage setting of "15" should be used, as shown below:

```
iesp = getIespInstance() # if not defined elsewhere
iesp.setRxCommonModeVoltage(15, [1,2,3,4,5,6,7,8])
```

RX EQUALIZATION (CTLE) CALIBRATION

This section of the document will provide the procedures for the following four cases for RX equalization (CTLE) calibration:

Case 1: Differential RX CTLE calibration, firmware = FW16
Case 2: Single-ended RX CTLE calibration, firmware = FW16
Case 3: Differential RX CTLE calibration, firmware = FW09 or FW11
Case 4: Single-ended RX CTLE calibration, firmware = FW09 or FW11

Please refer to Table 3 for the valid firmware / software / test procedure folder combinations for this calibration and refer to the step-by-step procedures below.

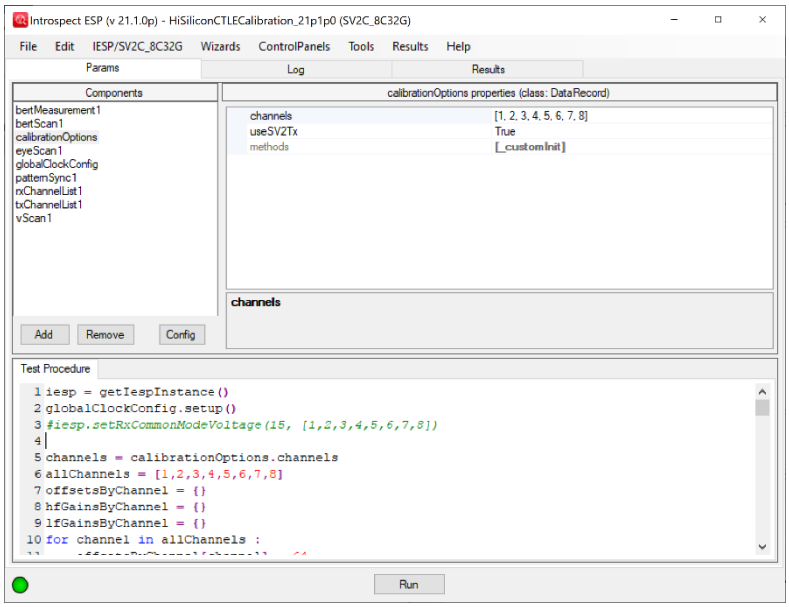
Important note: when performing **differential** RX CTLE calibration, as in Cases 1 or 3 above, ensure that **differential** RX threshold voltage calibration data has previously been loaded onto the module. Similarly, when performing **single-ended** CTLE calibration as in cases 2 and 4 above, ensure that the **single-ended** RX threshold voltage calibration data has been previously loaded onto the module. Performing the CTLE calibration with incorrect RX threshold calibration data, or without RX threshold calibration data, will result in an incorrect CTLE calibration.

CASE 1: PROCEDURES FOR DIFFERENTIAL RX CTLE CALIBRATION WITH FWIESPSV2C03A016

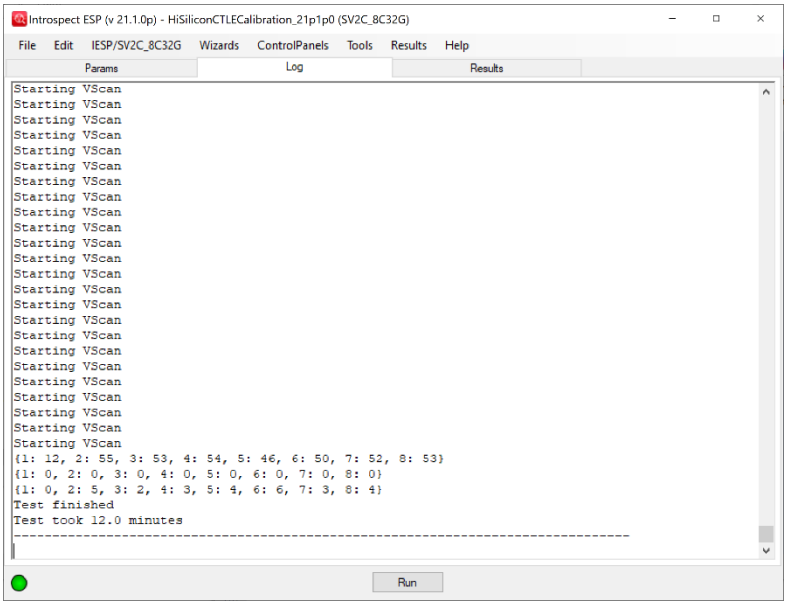
1. Ensure that you are using the firmware / software / test procedure folder combination:

   Firmware = FW16
   Software = IESP 21.1.0
   Test Folder = HiSiliconCTLECalibration_21p10

2. **Start the RX CTLE calibration.** To do this, configure the MXP cables so that all TX signals are looped back to RX signals using the differential configuration (see Figure 1(a) on page 4 for connection details).
3. Open the test procedure "HiSiliconCTLECalibration_21p10". There are no "CalOptions" to modify. Simply press "Run" from the GUI as shown in the figure below.



4. The test will execute in approximately 12 minutes. When the test finishes, the calibrated CTLE settings will be printed at the end of the test log. An example of the output log of a typical run is shown in the figure below.



5. As shown in the example output log file:

   The first row of coefficients contain the CTLE offsets, per channel,
   the second row of coefficients contain the CTLE high frequency gain settings, per channel, and
   the third row of coefficients contain the low frequency gain settings, per channel.

6. Once the calibration settings are reported in the test procedure log, the SV2C RX differential CTLE calibration is complete.
7. The optimal CTLE parameters are set at the end of this calibration procedure and remain in effect until the SV2C module power is cycled. There is no need to reprogram the CTLE settings even if subsequent test procedures are executed, as long as the subsequent test procedures do not attempt to overwrite the calibrated CTLE settings. In general, this SV2C RX differential CTLE calibration procedure should be run once after each SV2C power cycle.
8. To incorporate these CTLE values manually into another test procedure, please refer to the Introspect "Help files" available in the Introspect ESP GUI for both Python syntax and examples. The most common iesp functions for setting the CTLE values are listed below:

   setCtleOffsetCancellation()
   setCtleHighFreqGain()
   setCtleLowFreqGain()
   setCtleParams()

   and the calibration procedure itself, "HiSiliconCTLECalibration_21p10", contains several examples of setting CTLE parameters for reference.

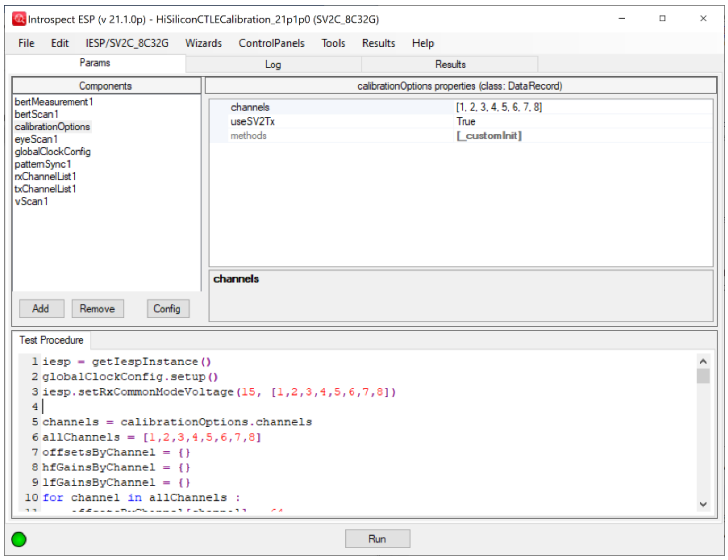
CASE 2: PROCEDURES FOR SINGLE-ENDED RX CTLE CALIBRATION WITH FWIESPSV2C03A016

1. Ensure that you are using the firmware / software / test procedure folder combination:

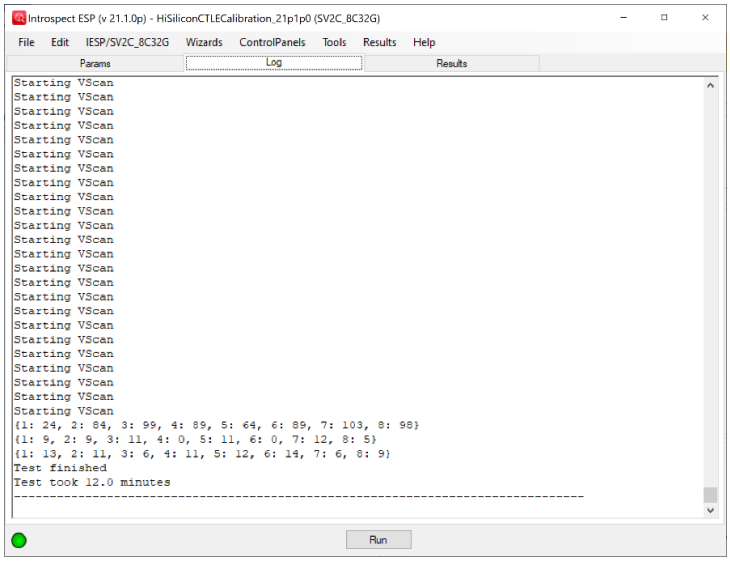
   Firmware = FW16
   Software = IESP 21.1.0
   Test Folder = HiSiliconCTLECalibration_21p10

2. **Start the RX CTLE Mode Calibration.** To do this, configure the MXP cables so that all TX signals are looped back to RX signals using the differential configuration (see Figure 1(b) on page 4 for connection details).

3. Open the test procedure "HiSiliconCTLECalibration_21p10". There are no "CalOptions" to modify, but note that a user may wish to explicitly set the RX common mode voltage in this procedure, as shown on line 3 of the test procedure below.



4. Press "Run" from the GUI as shown in the figure. The test will execute in approximately 12 minutes. When the test finishes, the calibrated CTLE settings will be printed at the end of the test log. An example of the output log of a typical run is shown in the figure below.



5. As shown in the example output log file in the previous figure:

   The first row of coefficients contain the CTLE offsets, per channel,
   the second row of coefficients contain the CTLE high frequency gain settings, per channel, and
   the third row of coefficients contain the low frequency gain settings, per channel.

6. Once the calibration settings are reported in the test procedure log, the SV2C RX single-ended CTLE calibration is complete.
7. The optimal CTLE parameters are set at the end of this calibration procedure and remain in effect until the SV2C module power is cycled. There is no need to reprogram the CTLE settings even if subsequent test procedures are executed, as long as the subsequent test procedures do not attempt to overwrite the calibrated CTLE settings. In general, this SV2C RX differential CTLE calibration procedure should be run once after each SV2C power cycle.
8. To incorporate these CTLE values into another test procedure, please refer to the Introspect "Help files" available in the Introspect ESP GUI for both Python syntax and examples. The most common iesp functions for setting the CTLE values are listed below:

   setCtleOffsetCancellation()
   setCtleHighFreqGain()
   setCtleLowFreqGain()
   setCtleParams()

   and the calibration procedure itself, "HiSiliconCTLECalibration_21p10", contains several examples of setting CTLE parameters.

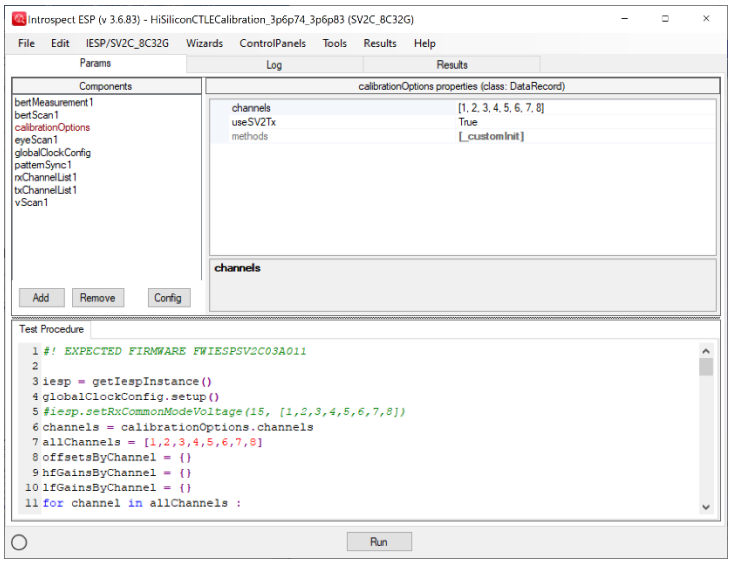
CASE 3: PROCEDURES FOR DIFFERENTIAL RX CTLE CALIBRATION WITH FWIESPSV2C03A009 OR FWIESPSV2C03A011

1. Ensure that you are using the firmware / software / test procedure folder combination:

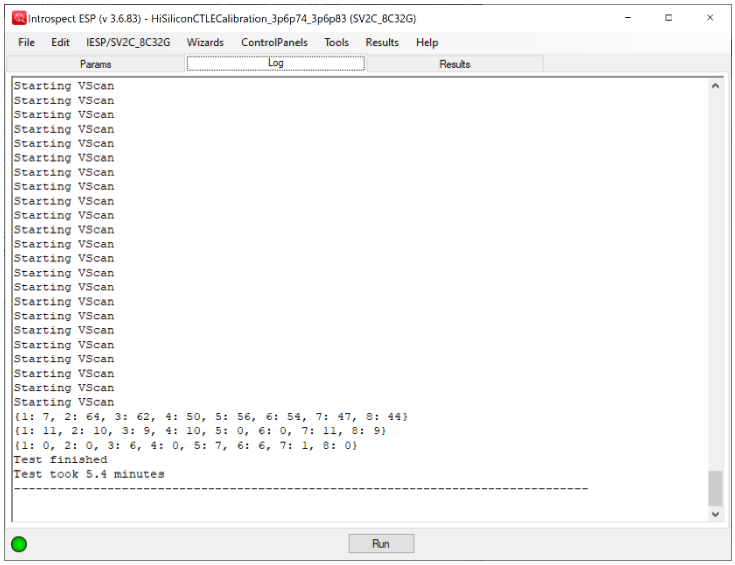
   Firmware = FW09 or FW11
   Software = IESP 3.6.74 or 3.6.83
   Test Folder = HiSiliconCTLECalibration_3p6p74_3p6p83

2. **Start the RX CTLE calibration.** To do this, configure the MXP cables so that all TX signals are looped back to RX signals using the differential configuration (see Figure 1(a) on page 4 for connection details).

3. Open the test procedure "HiSiliconCTLECalibration_3p6p74_3p6p83". There are no "CalOptions" to modify. Simply press "Run" from the GUI as shown in the figure below.



4. The test will execute in approximately 6 minutes. When the test finishes, the calibrated CTLE settings will be printed at the end of the test log. An example of the output log of a typical run is shown in the figure below.



5. As shown in the example output log file:

   The first row of coefficients contain the CTLE offsets, per channel,
   the second row of coefficients contain the CTLE high frequency gain settings, per channel, and
   the third row of coefficients contain the low frequency gain settings, per channel.

6. Once the calibration settings are reported in the test procedure log, the SV2C RX differential CTLE calibration is complete.
7. The optimal CTLE parameters are set at the end of this calibration procedure and remain in effect until the SV2C module power is cycled. There is no need to reprogram the CTLE settings even if subsequent test procedures are executed, as long as the subsequent test procedures do not attempt to overwrite the calibrated CTLE settings. In general, this SV2C RX differential CTLE calibration procedure should be run once after each SV2C power cycle.
8. To incorporate these CTLE values manually into another test procedure, please refer to the Introspect "Help files" available in the Introspect ESP GUI for both Python syntax and examples. The most common iesp functions for setting the CTLE values are listed below:

   setCtleOffsetCancellation()
   setCtleHighFreqGain()
   setCtleLowFreqGain()
   setCtleParams()

   and the calibration procedure itself, "HiSiliconCTLECalibration_3p6p74_3p6p83", contains several examples of setting CTLE parameters for reference.

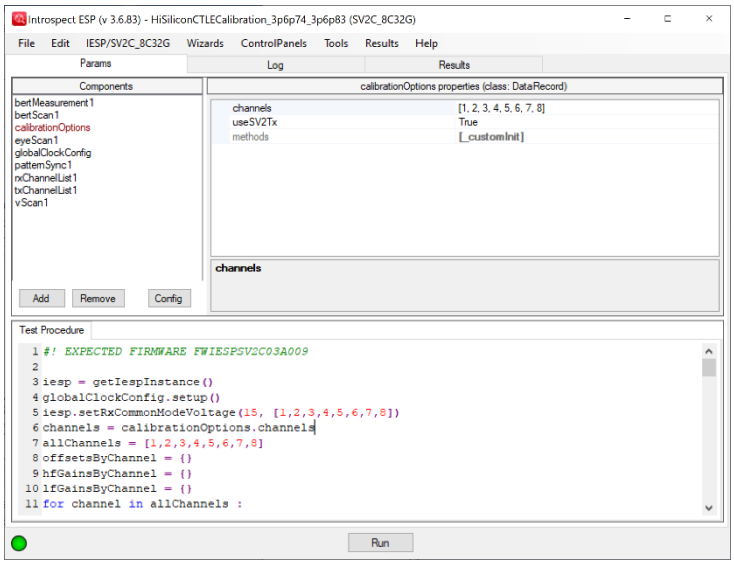
CASE 4: PROCEDURES FOR SINGLE-ENDED RX CTLE CALIBRATION WITH FWIESPSV2C03A009 AND FWIESPSV2C03A011

1. Ensure that you are using the firmware / software / test procedure folder combination:

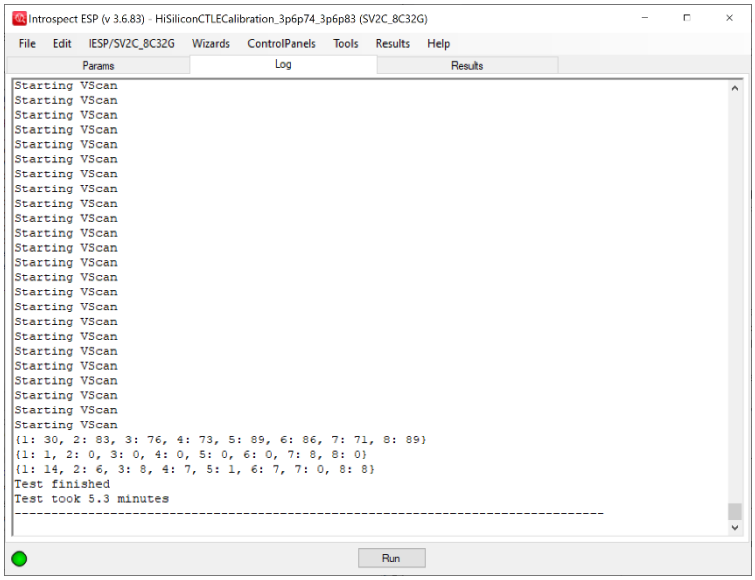
   Firmware = FW09 or FW11
   Software = IESP 3.6.74 or IESP 3.6.83
   Test Folder = HiSiliconCTLECalibration_3p6p74_3p6p83

2. **Start the RX CTLE Mode Calibration.** To do this, configure the MXP cables so that all TX signals are looped back to RX signals using the differential configuration (see Figure 1(b) on page 4 for connection details).

3. Open the test procedure "HiSiliconCTLECalibration_21p10". There are no "CalOptions" to modify, but note that a user may wish to explicitly set the RX common mode voltage in this procedure, as shown on line 5 of the test procedure below.



4. Press "Run" from the GUI as shown in the figure. The test will execute in approximately 6 minutes. When the test finishes, the calibrated CTLE settings will be printed at the end of the test log. An example of the output log of a typical run is shown in the figure below.



5. As shown in the example output log file in the previous figure:

   The first row of coefficients contain the CTLE offsets, per channel,
   the second row of coefficients contain the CTLE high frequency gain settings, per channel, and
   the third row of coefficients contain the low frequency gain settings, per channel.

6. Once the calibration settings are reported in the test procedure log, the SV2C RX single-ended CTLE calibration is complete.

7. The optimal CTLE parameters are set at the end of this calibration procedure and remain in effect until the SV2C module power is cycled. There is no need to reprogram the CTLE settings even if subsequent test procedures are executed, as long as the subsequent test procedures do not attempt to overwrite the calibrated CTLE settings. In general, this SV2C RX differential CTLE calibration procedure should be run once after each SV2C power cycle.

8. To incorporate these CTLE values into another test procedure, please refer to the Introspect "Help files" available in the Introspect ESP GUI for both Python syntax and examples. The most common iesp functions for setting the CTLE values are listed below:

   setCtleOffsetCancellation()
   setCtleHighFreqGain()
   setCtleLowFreqGain()
   setCtleParams()

   and the calibration procedure itself, "HiSiliconCTLECalibration_3p6p74_3p6p83", contains several examples of setting CTLE parameters.

INTERNAL FREQUENCY VALIDATION

This section will of the document will provide the procedures for the internal frequency validation. This validation is only available when using FW16. The IESP 21.1.0 software must be installed, but the Python file provided by Introspect may be executed from any Python environment. There are no external MXP cable connections required.

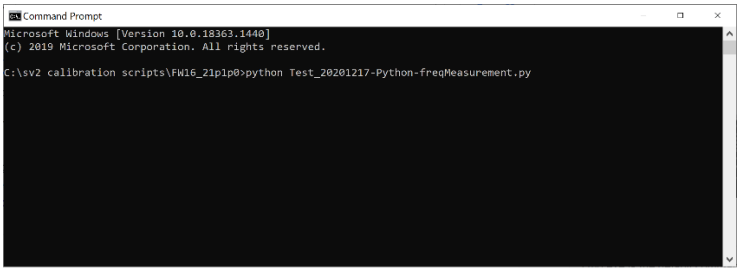
1. Ensure that you are using the following firmware / software / Python file combination:

   Firmware = FW16
   Software = IESP 21.1.0
   Python File = Test_20201217-Python-freqMeasurement.py

2. Modify the "Test_20201217-Python-freqMeasurement.py" file as required to work within the desired Python environment. The only expected modification to be made is on line 6 of this file, where the location of the SvtPython libraries from the IntrospectESP 21.1.0 installation are defined. The modification to the line will be of the form shown below:

   sys.path.append(r"C:**<your full path here>**\IntrospectESP_21.1.0\SvtPython")

3. **Start the Internal Frequency Validation.** An example of executing the test on a PC from a command prompt is show in the figure below. The current working directory in this case is "sv2 calibration scripts\FW16_21p1p0".



4. The resulting output file, "freq.csv" will be written to the same current working directory. This output file currently contains only two comma separated entries, as defined below:

   The first entry contains "1" if the high-frequency accuracy check has passed for 25781.25 Mbps, and contains "0" if a failure has occurred.
   The second entry contains "1" if the high-frequency accuracy check has passed at 27952.5 Mbps, and contains "0" if a failure has occurred.

5. Once these two results are reported, the SV2C internal frequency validation is complete.

RECAPITULATION OF CALIBRATION AND VALIDATION PROCEDURES

This document has provided the full set of step-by-step instructions for performing in-field calibrations for the SV2C. There are four types of calibrations and validations which may be performed in the field:

1. SV2C RX Threshold Voltage Calibration
2. SV2C RX Common Mode Voltage Calibration
3. SV2C RX Equalization (CTLE) Calibration
4. SV2C Internal Frequency Validation

and there are currently three different SV2C firmware releases for use with the calibrations listed above. A user only needs to execute the combination of procedures and firmware versions relevant to their testing application, according to the use cases described within this document.

Revision Number	History	Date
1.0	Document Release	March 25, 2021

The information in this document is subject to change without notice and should not be construed as a commitment by Introspect Technology. While reasonable precautions have been taken, Introspect Technology assumes no responsibility for any errors that may appear in this document.

Published in Canada on March 25, 2021
EN-G055E-E-21083

INTROSPECT.CA