PSRF Application Skill Development Project Report

Project Sponsor – Terence Lim

Project Coordinator – TP Lim

Mentor – Ho-Kok Gho

Participant – Stephen Fu

December 15, 2010

Outlines

- Background
  - Project Introduction
  - Project Schedule
  - Pre-Requisites
- Test Program Development & Debugging
  - Test Flow and Bin Summary
  - Modulator (Baseband to RF) Test
  - Datalog and Waveform Analysis for Modulator
  - Demodulator (RF to Baseband) Test
  - Datalog and Waveform Analysis for Demodulator
- Summary

Background

Project Introduction

The purpose of this project is to further enhance AE's PSRF debugging and programming skill after attended the one week standard PSRF training. Treat this as customer project, AE will gain true learning RF project experience.

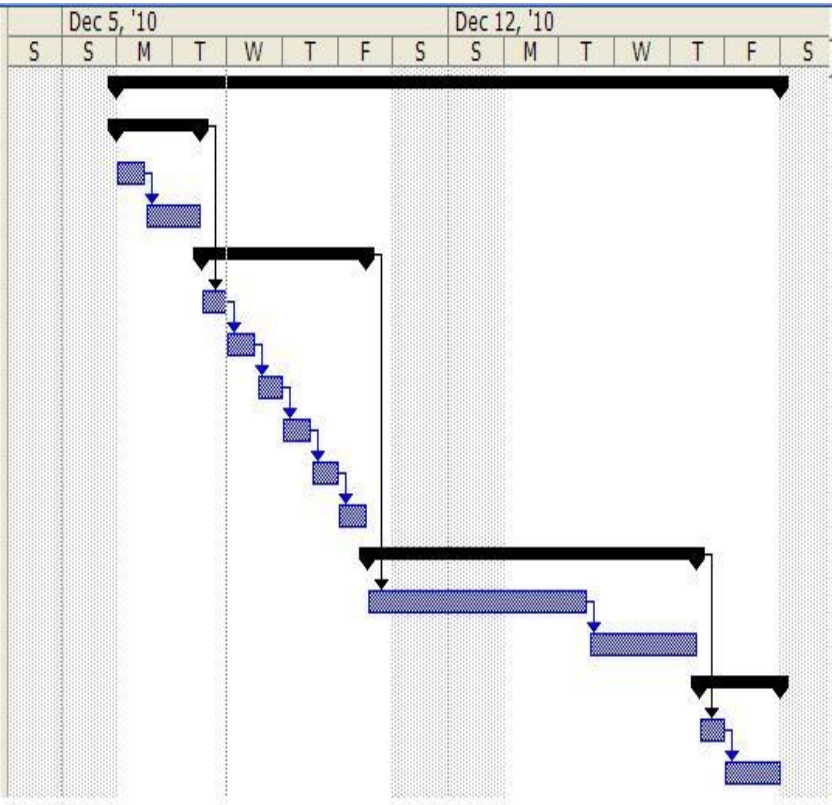
AE will also gain RF device knowledge after completing the project.

Background

Project Schedule

This project is planed to be finished within 2 weeks, schedule is created for project tracing.

	Task Name	Duration	Start	Finish	Predec
1	**PSRF ASD Project Schedule**	**10 days**	**Mon 12/6/10**	**Fri 12/17/10**	
2	**Preparation**	**1.5 days**	**Mon 12/6/10**	**Tue 12/7/10**	
3	Collection of Project information(test plan,datasheet	0.5 days	Mon 12/6/10	Mon 12/6/10	
4	Tester Booking & Study the test plan and device	1 day	Mon 12/6/10	Tue 12/7/10	3
5	**Offline Test Program Development**	**3 days**	**Tue 12/7/10**	**Fri 12/10/10**	
6	Transmitter(BB-RF) PowerOut Test	0.5 days	Tue 12/7/10	Tue 12/7/10	2
7	Transmitter(BB-RF) Sideband Suppression	0.5 days	Wed 12/8/10	Wed 12/8/10	6
8	Transmitter(BB-RF) Harmonics Test	0.5 days	Wed 12/8/10	Wed 12/8/10	7
9	Receiver(RF-BB) Gain Test	0.5 days	Thu 12/9/10	Thu 12/9/10	8
10	Receiver(RF-BB) P1dB Test	0.5 days	Thu 12/9/10	Thu 12/9/10	9
11	Receiver(RF-BB) I/Q Imbalance Test	0.5 days	Fri 12/10/10	Fri 12/10/10	10
12	**Debugging On Line**	**4 days**	**Fri 12/10/10**	**Thu 12/16/10**	
13	Transmitter(BB-RF) Debugging and Analysis	2 days	Fri 12/10/10	Tue 12/14/10	5
14	Receiver(RF-BB) Debugging and Analysis	2 days	Tue 12/14/10	Thu 12/16/10	13
15	**Datalog&Waveform Collection and Documentation**	**1.5 days**	**Thu 12/16/10**	**Fri 12/17/10**	
16	Test Program Optimize and Datalog&Waveform Colle	0.5 days	Thu 12/16/10	Thu 12/16/10	12
17	Project Documentation & Presentation	1 day	Fri 12/17/10	Fri 12/17/10	16



Background

Pre-Requisites

Software

SmarTest version 6.5.2

RedHat Linux System

Hardware

Pin Scale V93000 tester platform, Port Scale RF with 12 ports and 2 Source cards and Analog module S/M in position 231.

RedHat workstation

Universal RF Loadboard Rev4

Modulator (MiniCircuits ZAMIQ-895M) & Demodulator (MiniCircuits ZAMIQ-895D)

4 pcs of pin->SMA and 4 pcs of SMA->SMA

Personnel/Manpower

Man-hours required:

8 * 10 = 80 (hours)

Prerequisite knowledge/skill:

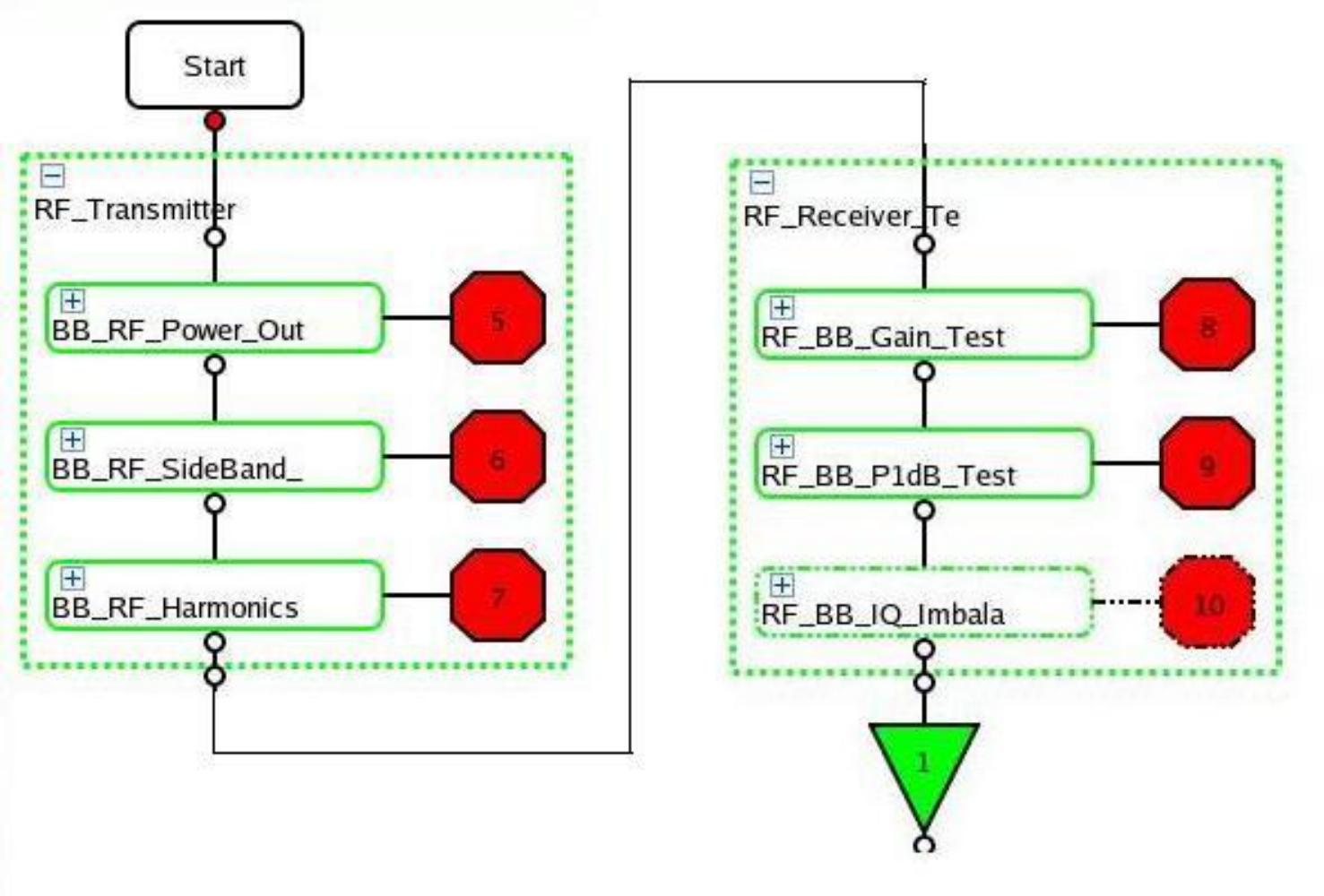
V93000 SOC Basic, Mix-Signal & PSRF Training

RF Fundamental Training or equivalent training

Knowledge of RF device testing concepts.

Test Program Development & Debugging

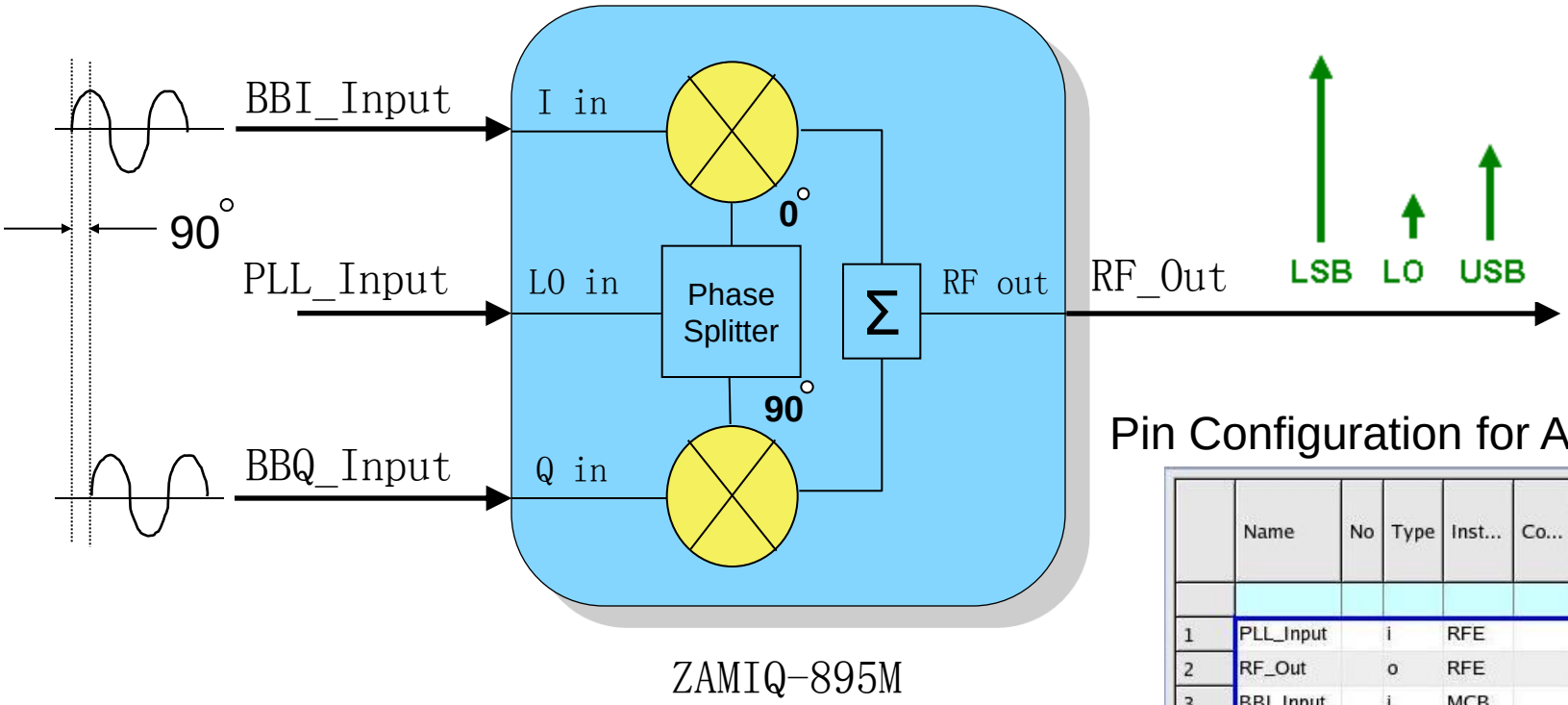
Test Flow and Bin Summary



Test Program Development & Debugging

Modulator (Baseband to RF) Test

Device Connections & Pin Names



ZAMIQ-895M

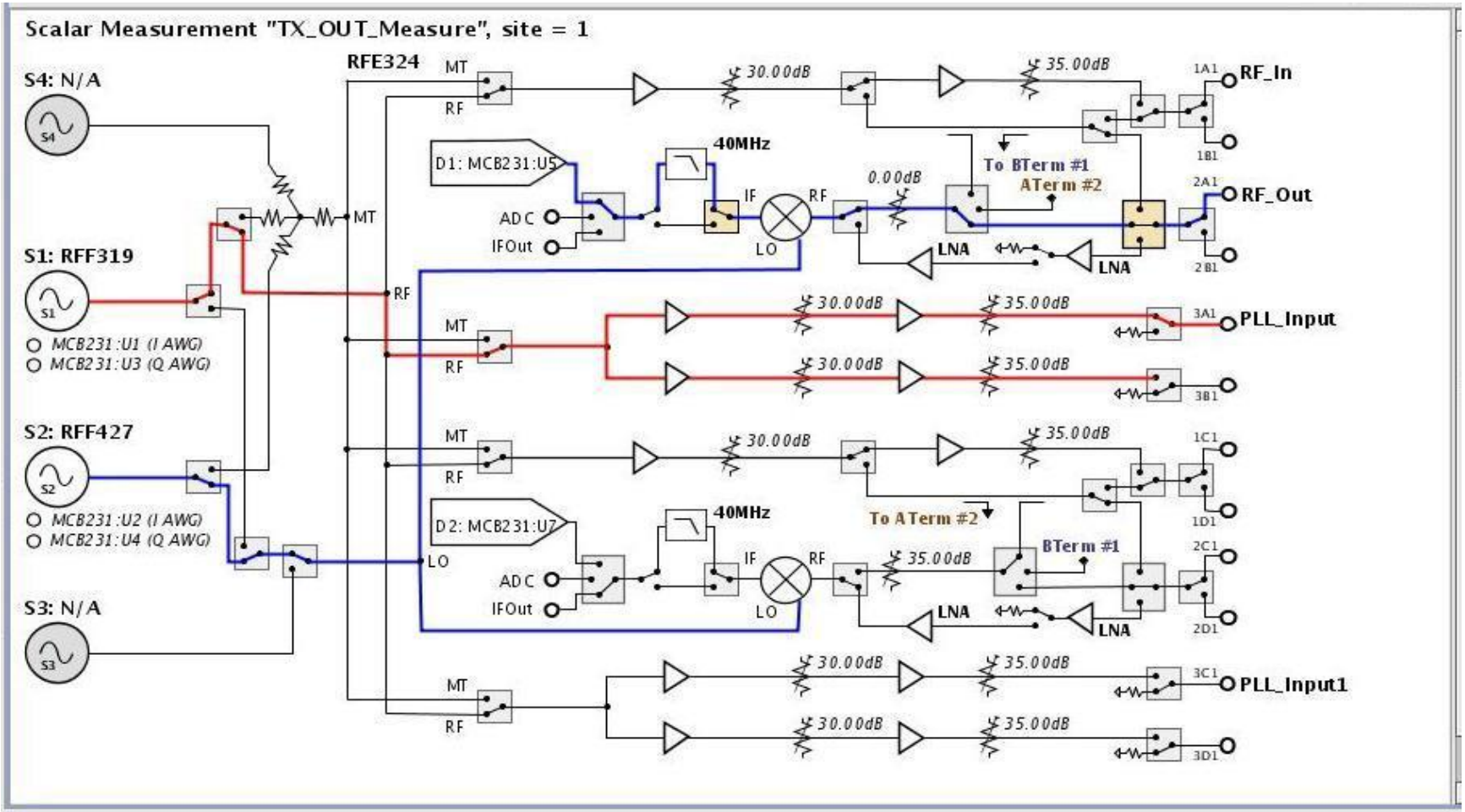
Pin Configuration for AWG access

	Name	No	Type	Inst...	Co...	Tester Channel Site 1 Pogo	Tester Channel Site 1 Pad
1	PLL_Input		i	RFE		324	3A1
2	RF_Out		o	RFE		324	2A1
3	BBI_Input		i	MCB		23116	S2
4	BBQ_Input		i	MCB		23112	S2
5	RF_In		i	RFE		324	1A1
6	BBI_Out		o	MCB		23116	S1
7	BBQ_Out		o	MCB		23112	S1
8	PLL_Input1		i	RFE		324	3C1

Test Program Development & Debugging

Modulator (Baseband to RF) Test

RF Port Block Diagram



Test Program Development & Debugging

Modulator (Baseband to RF) Test

Create the Frequency List for Power Out/Unwanted Sideband Suppression/ Harmonics Tests.

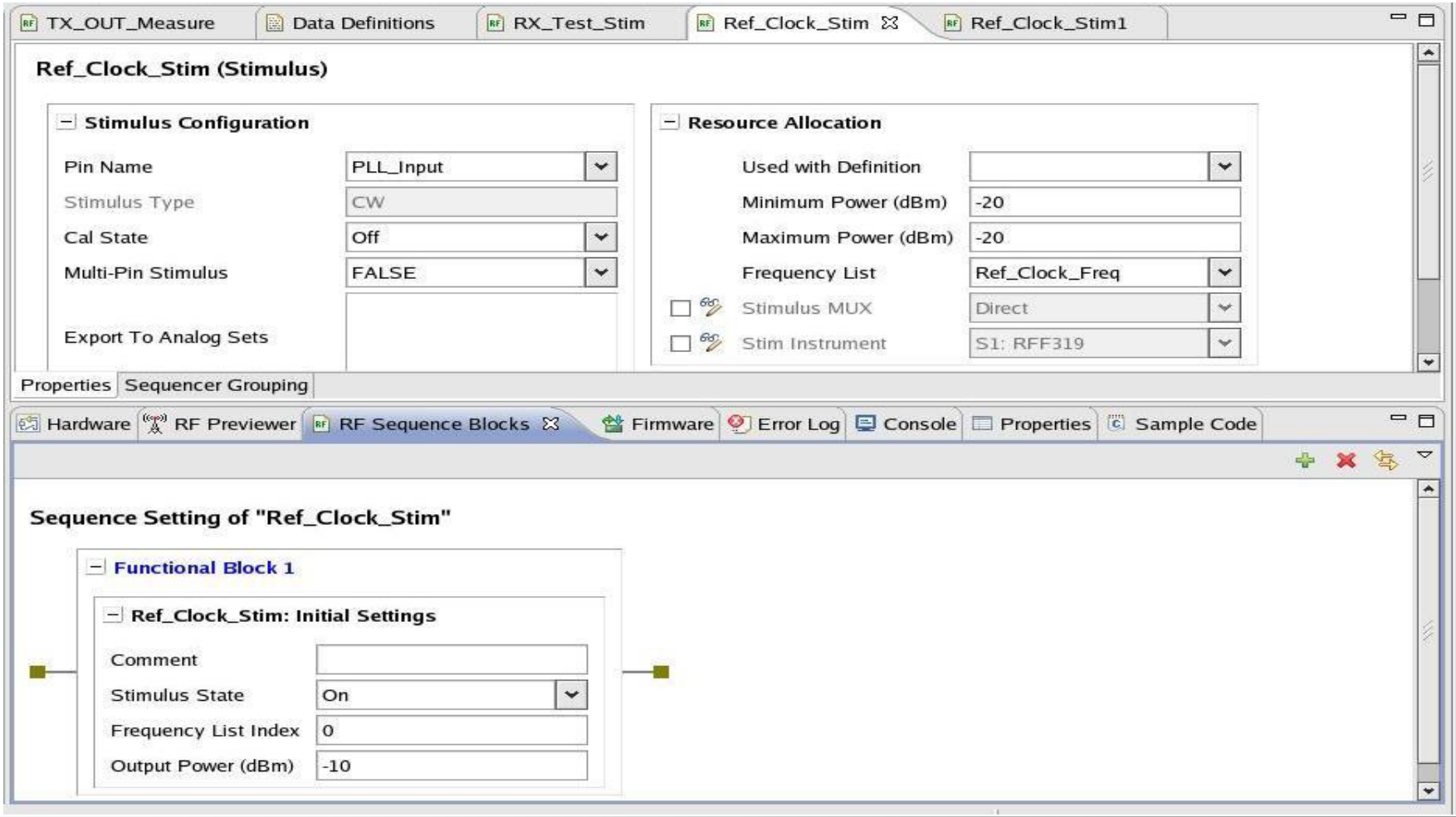
TX_OUT_Measure | Data Definitions

Name	Type	Description	Equation Definition	Evaluation Result
Carrier_Freq	Double Constant		880e6	880e6
Lower_Sideband	Double Constant		Carrier_Freq-Offset_Freq	877.8125e6
Lower_Sideband1	Double Constant		Carrier_Freq-Offset_Freq1	879.9e6
Lower_Sideband2	Double Constant		Carrier_Freq-Offset_Freq2	878e6
Offset_Freq	Double Constant		2.1875e6	2.1875e6
Offset_Freq1	Double Constant		0.1e6	100e3
Offset_Freq2	Double Constant		2e6	2e6
Offset_Freq3	Double Constant		3e6	3e6
RX_Test_Freq	Double Constant		Carrier_Freq+Offset_Freq3	883e6
Second_Harmonic	Double Constant		2*Lower_Sideband2	1.756e9
Upper_Sideband	Double Constant		Carrier_Freq+Offset_Freq	882.1875e6
Upper_Sideband1	Double Constant		Carrier_Freq+Offset_Freq1	880.1e6
Power_Sweep	Power List		step(-20,10,2)	-20 -18 -16 -14 -12 -10 -8 -6 -4 -2 0 2 4 6 8 10
RX_Stim_Freq	Frequency List		RX_Test_Freq	883e6
Ref_Clock_Freq	Frequency List		Carrier_Freq	880e6
TX_CS_SS	Frequency List		Lower_Sideband Carrier_Freq Upper_Sideband	877.8125e6 880e6 882.1875e6
TX_CS_SS1	Frequency List		Lower_Sideband1 Carrier_Freq Upper_Sideband1	879.9e6 880e6 880.1e6
TX_CS_SS2	Frequency List		Lower_Sideband2 Second_Harmonic	878e6 1.756e9
PowerValue	Double Variable		-20	-20

Test Program Development & Debugging

Modulator (Baseband to RF) Test

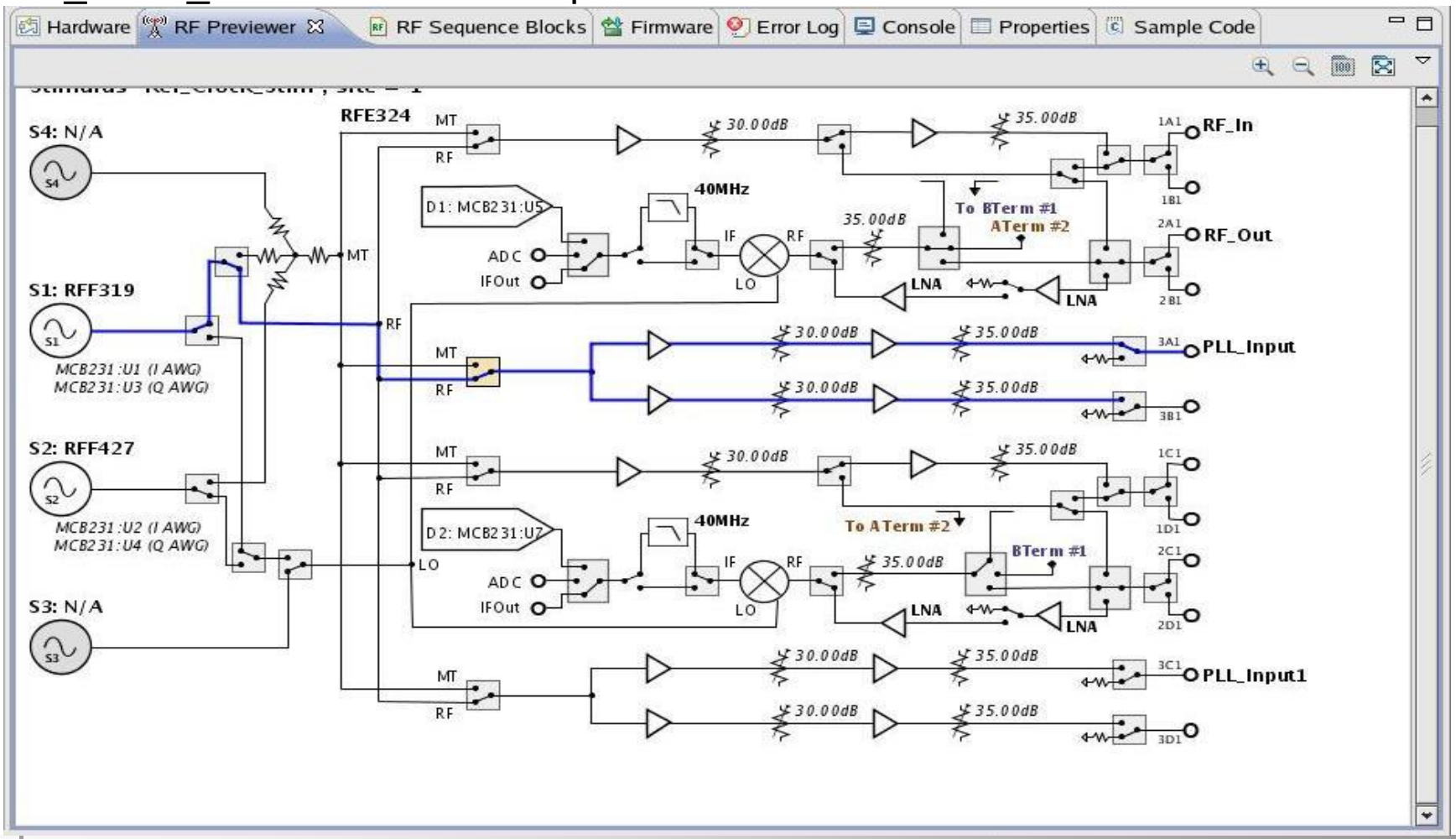
Create Ref_Clock_Stim.



Test Program Development & Debugging

Modulator (Baseband to RF) Test

Ref_Clock_Stim Hardware Setup



Test Program Development & Debugging

Modulator (Baseband to RF) Test

Calculate Fs for AWG Waveform

Power Out Test: Baseband Signal Ft = 2.1875MHz
Number of Points N = 512
Frequency Bin M = 7
Sampling Frequency Fs = 160 MHz
Master Clock on the RF Measurement can be set to Fs*3 = 480MHz

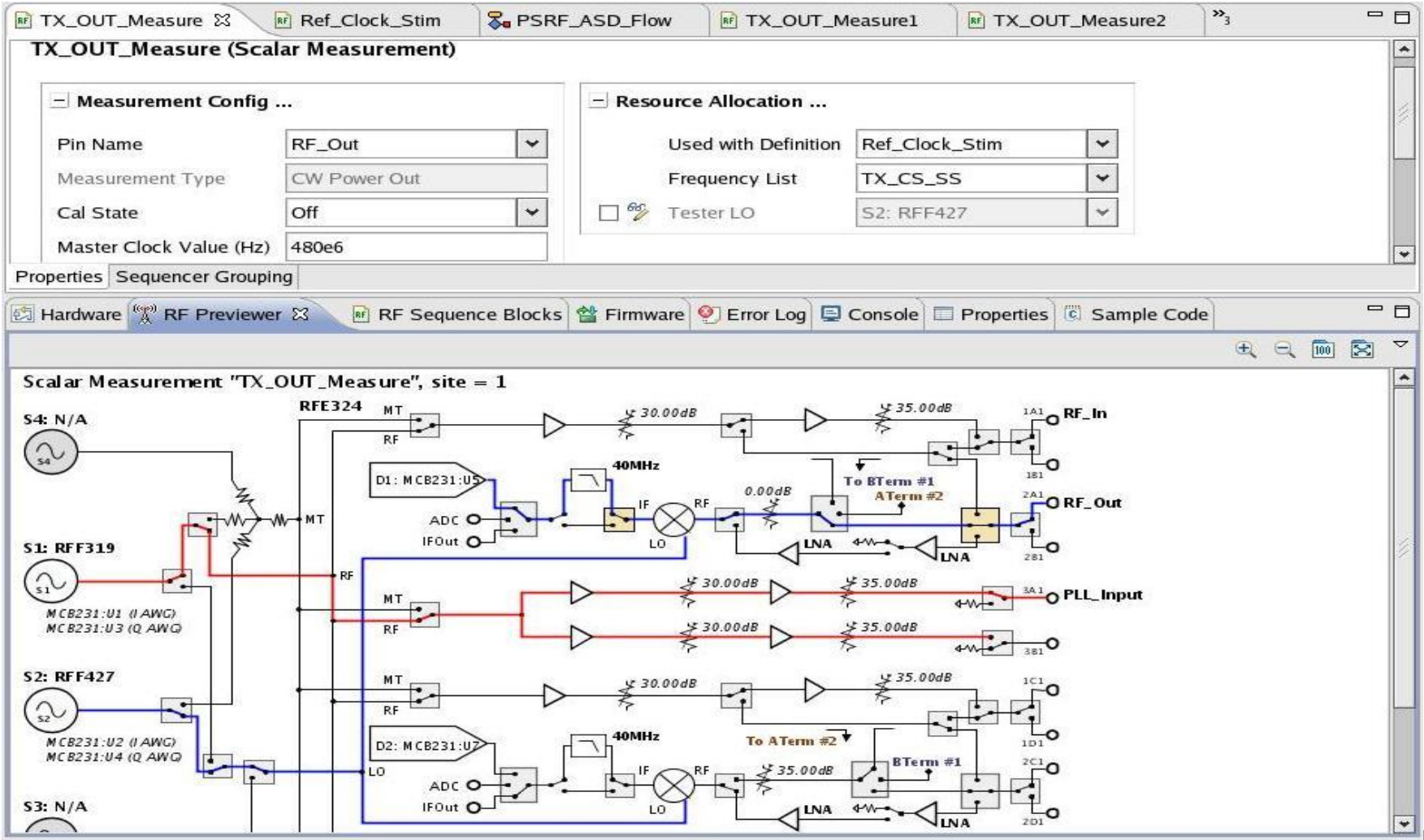
Sideband Suppression Test: Baseband Signal Ft = 100KHz
Number of Points N = 2048
Frequency Bin M = 5
Sampling Frequency Fs = 40.96 MHz
Master Clock on the RF Measurement can be set to Fs*10 = 409.6MHz

Harmonics Test: Baseband Signal Ft = 2MHz
Number of Points N = 256
Frequency Bin M = 5
Sampling Frequency Fs = 102.4 MHz
Master Clock on the RF Measurement can be set to Fs*4 = 409.6MHz

Test Program Development & Debugging

Modulator (Baseband to RF) Test

Create the TX_OUT_Measure Meas Definition

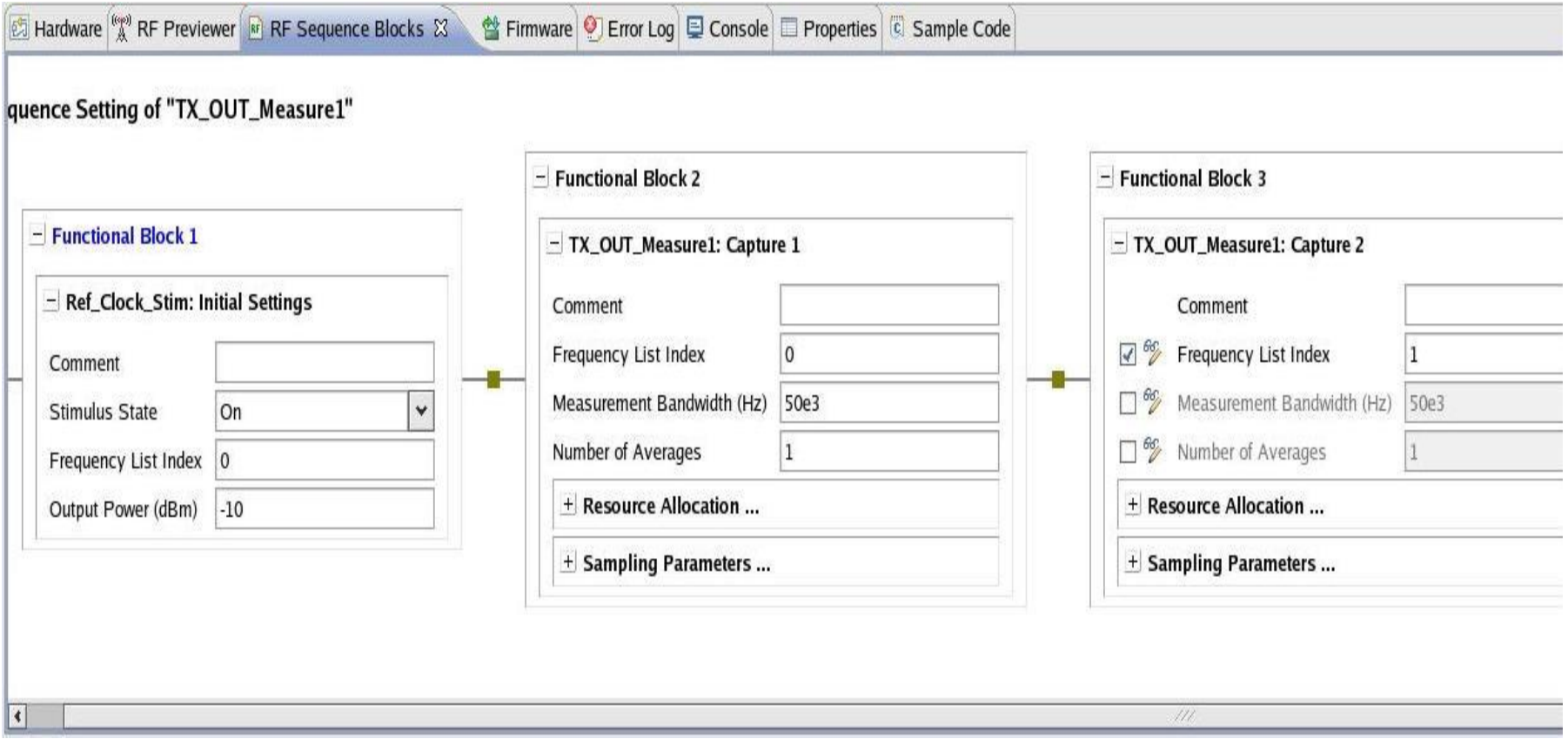


Test Program Development & Debugging

Modulator (Baseband to RF) Test

Final RF Sequence Block View

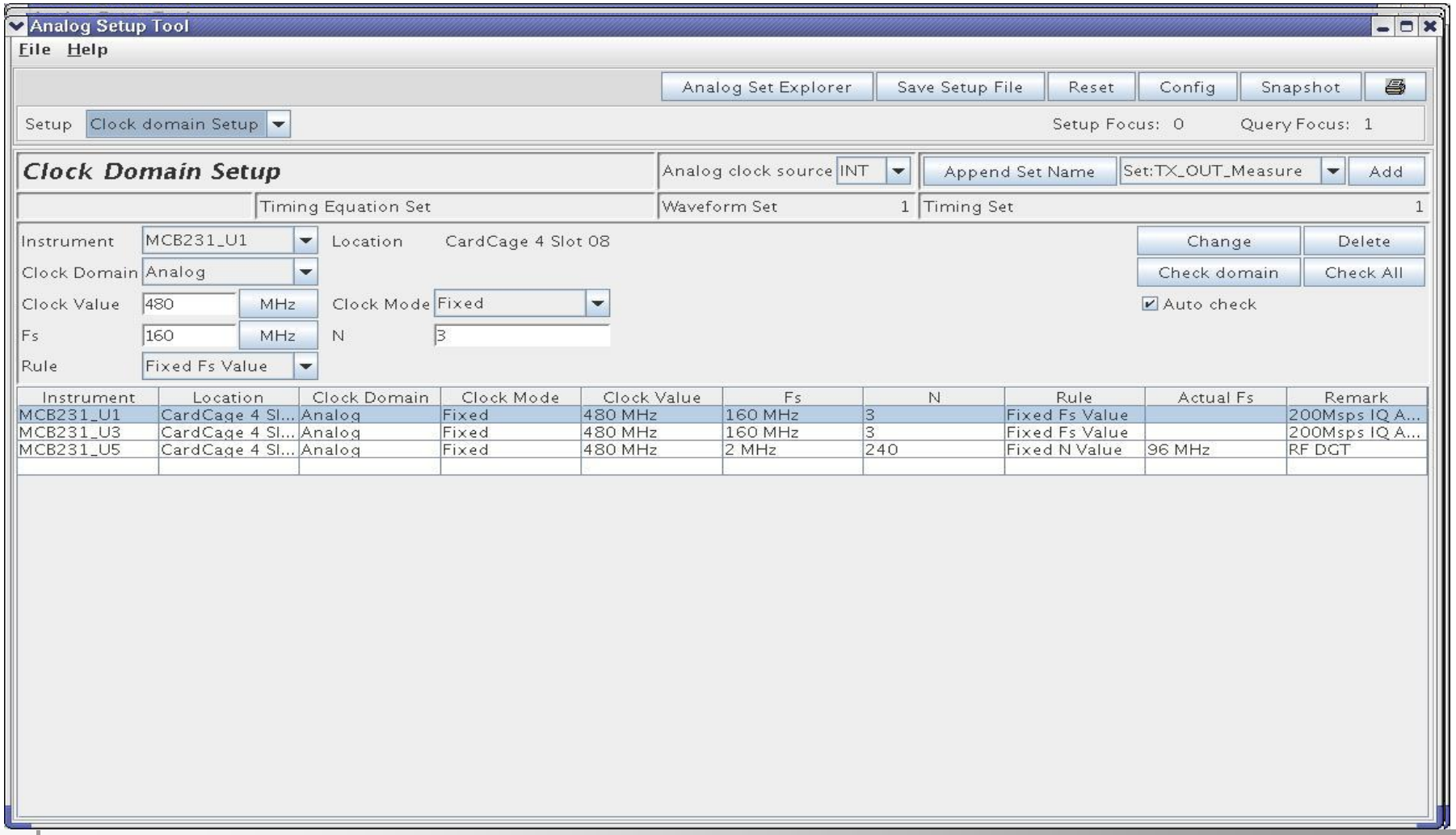
Add RF measurement for different output frequency depending test Requirement, Change measurement Bandwidth accordingly and Change the Output power for Ref_Clock_Stim depending on the device specification.



Test Program Development & Debugging

Modulator (Baseband to RF) Test

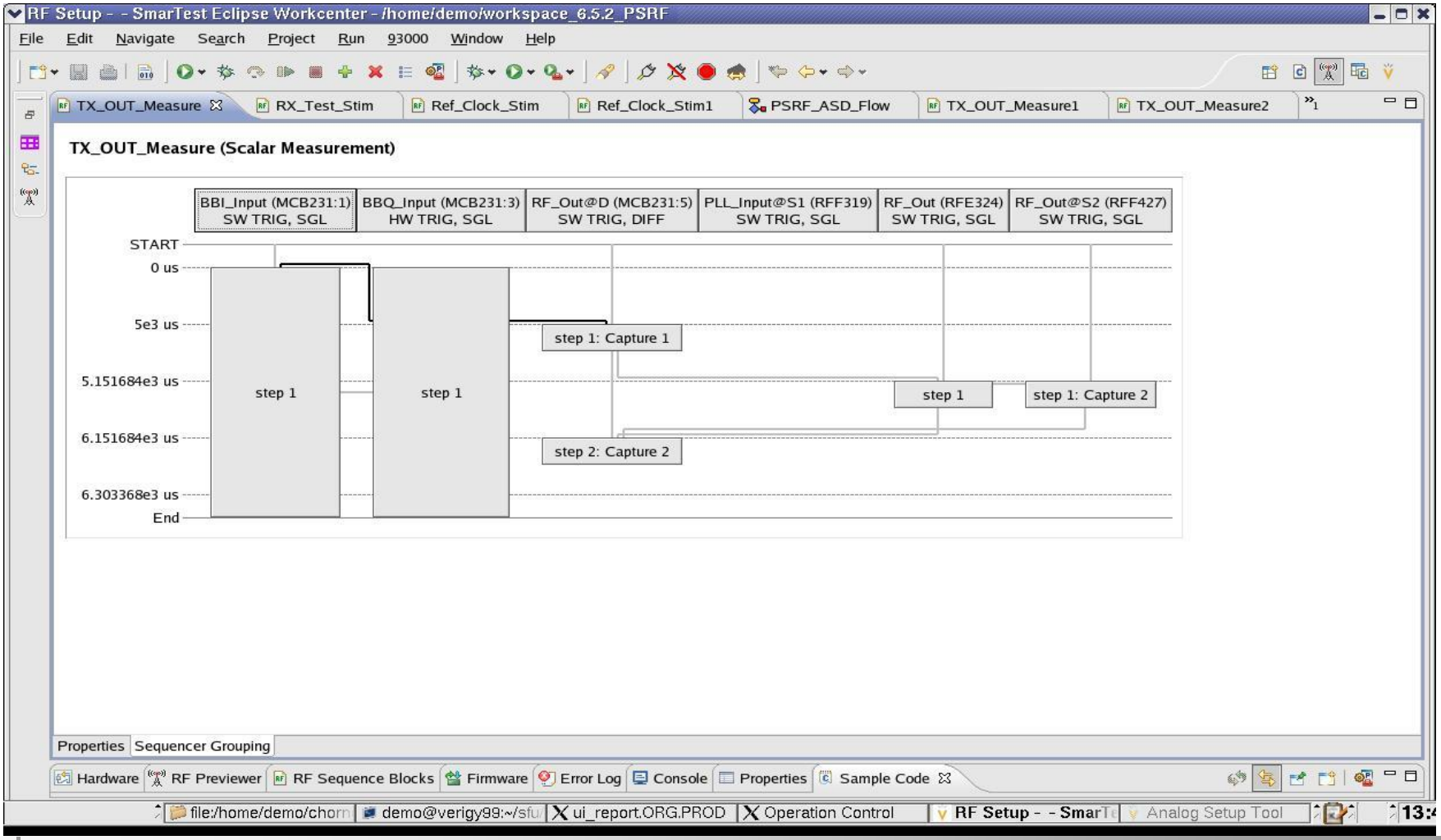
AWG Setups to TX_Out_Measure Analog Control Set



Test Program Development & Debugging

Modulator (Baseband to RF) Test

Final Sequencer Grouping & Code for Test Method



Test Program Development & Debugging

Modulator (Baseband to RF) Test

Final Sequencer Grouping & Code for Test Method

```
DOUBLE Carrier_Suppression,Image_Rejection;
const STRING measName = "TX_OUT_Measure1";
ON_FIRST_INVOCATION_BEGIN();
     Analog.primary(measName);                          //set the primary
     MEAS_DEF(measName).disableAll().connectAll();      // SW trigger the instruments in the Group and connect the pins
     EXECUTE_GROUP(measName);                           //Then Execute the definition's "sequence group" in the 1st invocation
ON_FIRST_INVOCATION_END();
//  Fetch the DSP parameters (and cal data) from the MEAS_DEF object.
ARRAY_D measParams = MEAS_DEF(measName).getParameters(1,0);
INT sizeOfOne = measParams.size();
INT numCaptures = 1;
MEAS_DEF(measName).get("NumCaptures", numCaptures);
ARRAY_D packedMeasParams(sizeOfOne*numCaptures);
DSP_EXTRACT(measParams, packedMeasParams, 0, 0, sizeOfOne);
for(INT capNum=1; capNum < numCaptures; capNum++)
{
     measParams = MEAS_DEF(measName).getParameters(capNum+1, 0);
     DSP_EXTRACT(measParams, packedMeasParams, 0, capNum*sizeOfOne, sizeOfOne);
}
//  Run the DSP on the captured data by execting the static DSP function
//    - the DSP_ROUTINES_BEGIN block cleanly handles multisite for you.
ARRAY_D measuredPowers(numCaptures);
DSP_ROUTINES_BEGIN();
     TX_OUT_Measure1Dsp(measName, packedMeasParams, measParams, measuredPowers);
DSP_ROUTINES_END();
//  Print results to ui.Report window
cout << "*********Testsuite: BB_RF_SideBand_Suppression*********"<<endl;
for(INT capNum=0; capNum < numCaptures; capNum++)
cout << "\t Capture Num = "  << capNum + 1<< ", Measured Power = " << measuredPowers[capNum]<<" dBm "<< endl;
Carrier_Suppression = measuredPowers[0] -  measuredPowers[1];
Image_Rejection = measuredPowers[0] -  measuredPowers[2];
cout <<"\t Carrier_Suppression = " << Carrier_Suppression <<" dB "<< endl;
cout <<"\t Image_Rejection = " << Image_Rejection <<" dB "<< endl;
TEST( "RF_Out", "Carrier_Suppression",Carrier_Suppression );
TEST( "RF_Out", "Image_Rejection",Image_Rejection );
//  To prevent warnings and errors you should disconnect DGTs and AWGs that will no longer be in use.
ON_FIRST_INVOCATION_BEGIN();
     MEAS_DEF(measName).disconnectAll();
ON_FIRST_INVOCATION_END();
```

Test Program Development & Debugging

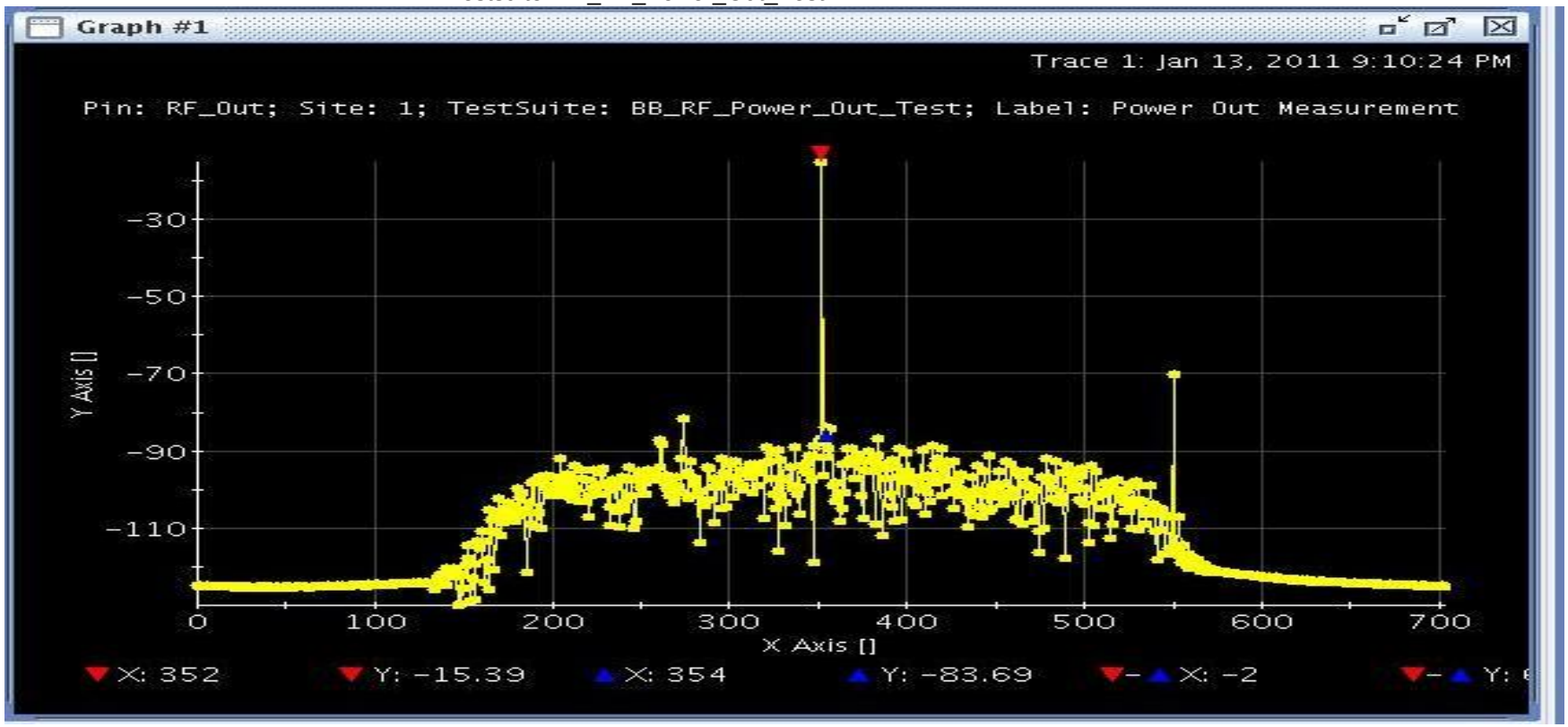
Datalog and Waveform Analysis for Modulator

Datalog for Modulator

Datalog_for_BBtoRF

Power Capture for Modulator

Testsuite: BB_RF_Power_Out_Test



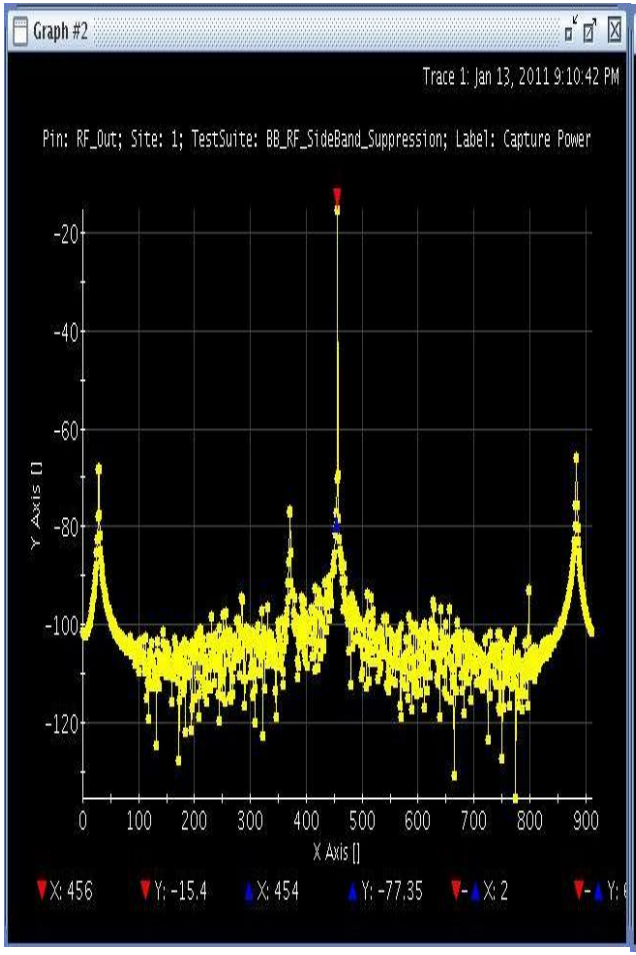
Measured Power : -30dBm < -15.386 dBm < 0dBm

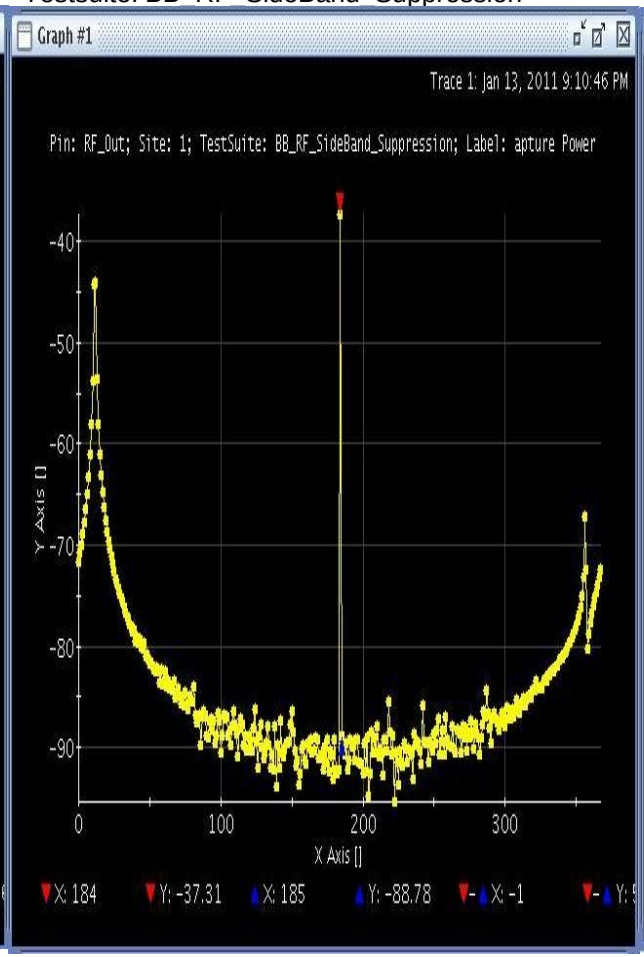
Test Program Development & Debugging

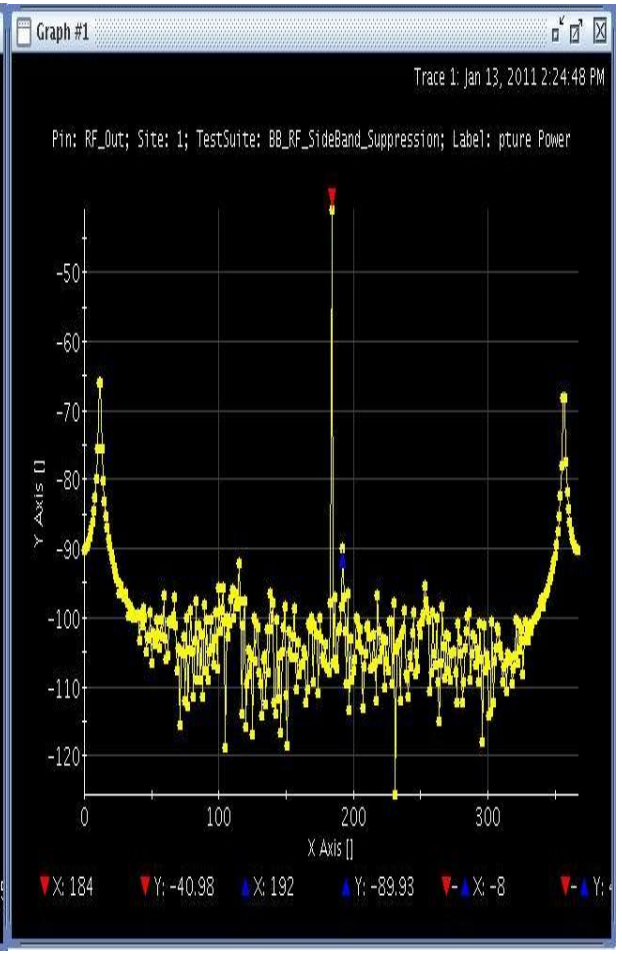
Datalog and Waveform Analysis for Modulator

Power Capture for Modulator

Testsuite: BB_RF_SideBand_Suppression







LSB = -15.396 dBm

LO = -37.295 dBm

USB = -40.975 dBm

Carrier_Suppression : 20dB < 21.8979 dB < 60dB

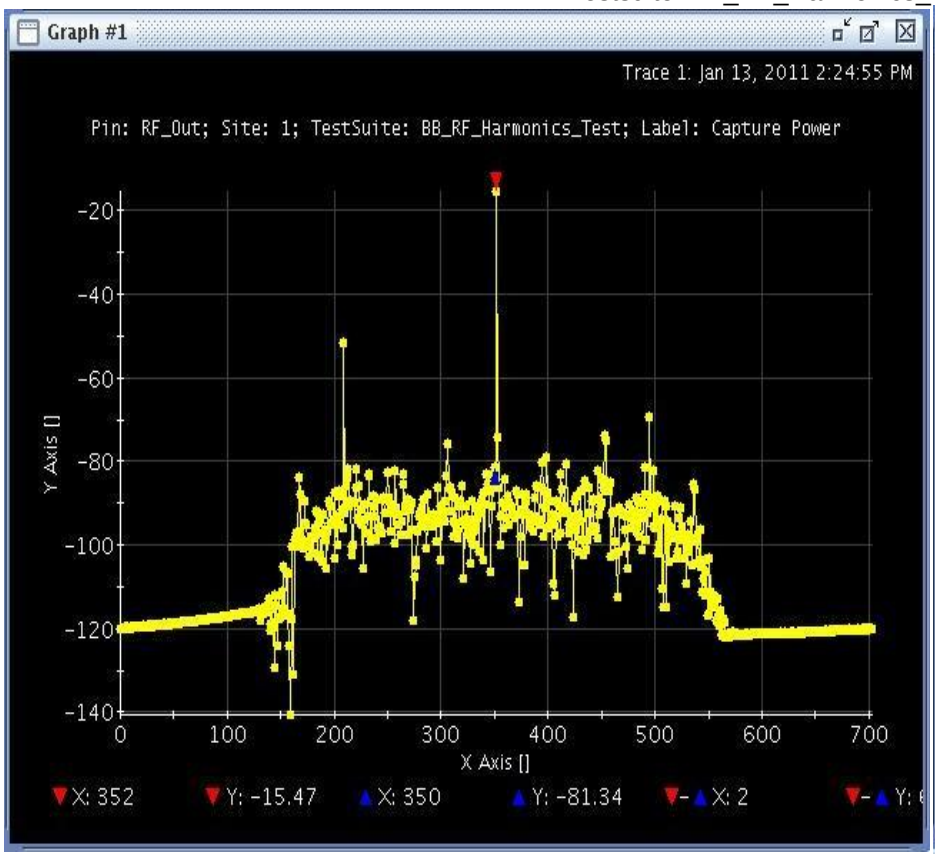
Image_Rejection : 20dB < 25.5781 dB < 60dB

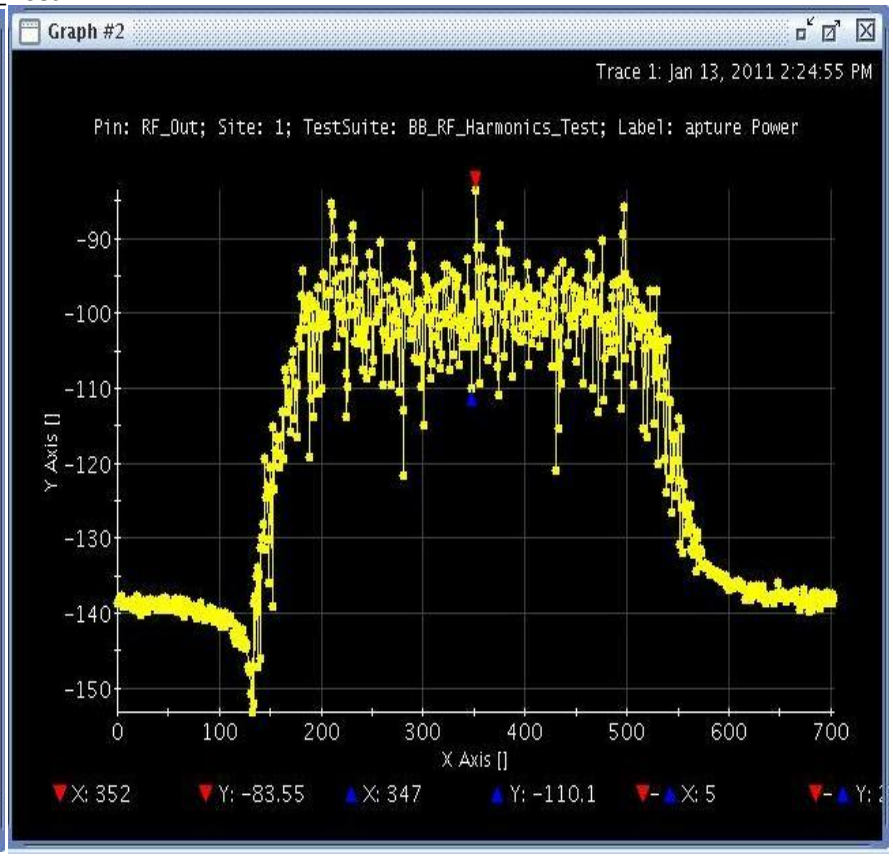
Test Program Development & Debugging

Datalog and Waveform Analysis for Modulator

Power Capture for Modulator

Testsuite: BB_RF_Harmonics_Test





Fundamental Signal Power = -15.4653 dBm

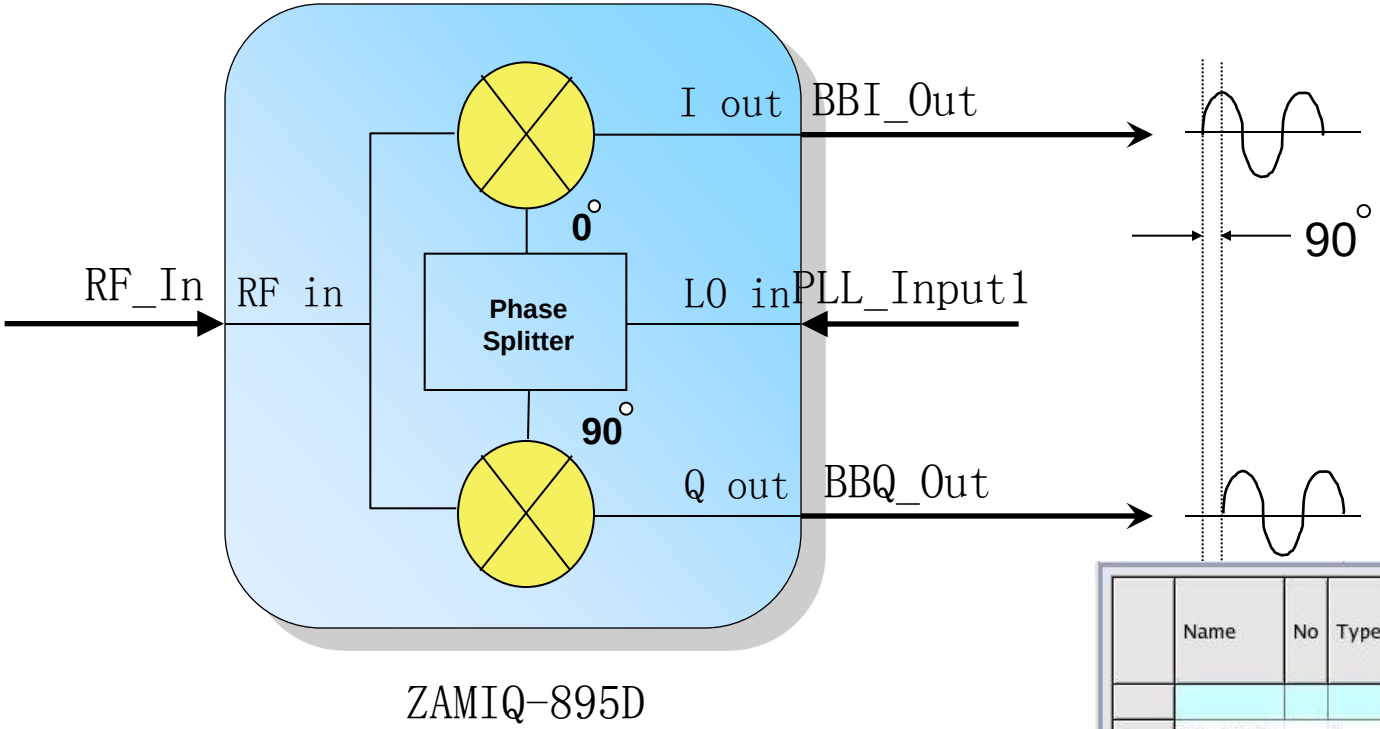
2nd Harmonics Power = -75.7937 dBm

2nd harmonics: 30 dB < 60.3283 dB

Test Program Development & Debugging

Demodulator (RF to Baseband) Test

Device Connections & Pin Names



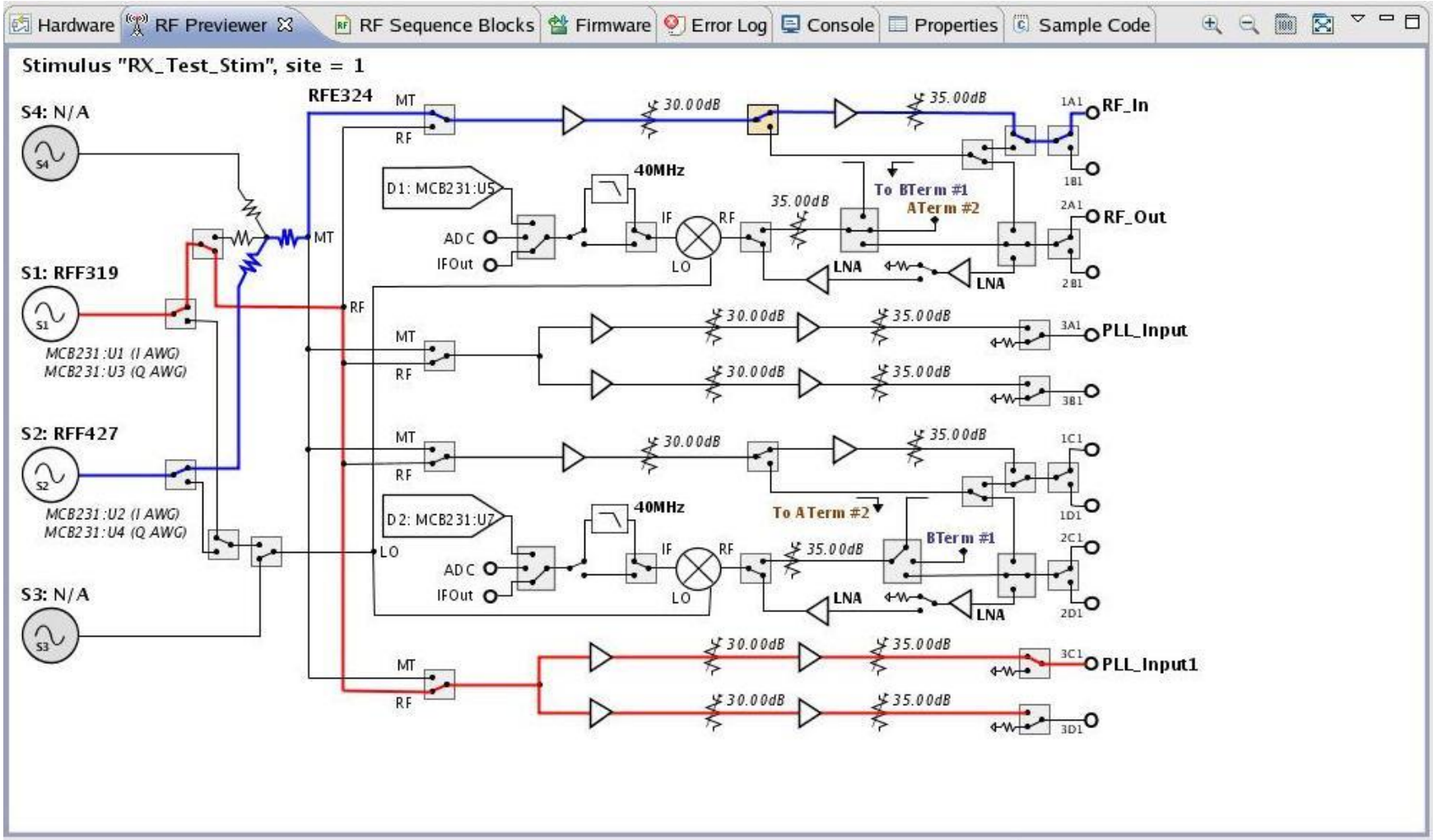
	Name	No	Type	Inst...	Co...	Tester Channel Site 1 Pogo	Tester Channel Site 1 Pad
1	PLL_Input		i	RFE		324	3A1
2	RF_Out		o	RFE		324	2A1
3	BBI_Input		i	MCB		23116	S2
4	BBQ_Input		i	MCB		23112	S2
5	RF_In		i	RFE		324	1A1
6	BBI_Out		o	MCB		23116	S1
7	BBQ_Out		o	MCB		23112	S1
8	PLL_Input1		i	RFE		324	3C1

Pin Configuration for Digitizer access

Test Program Development & Debugging

Demodulator (RF to Baseband) Test

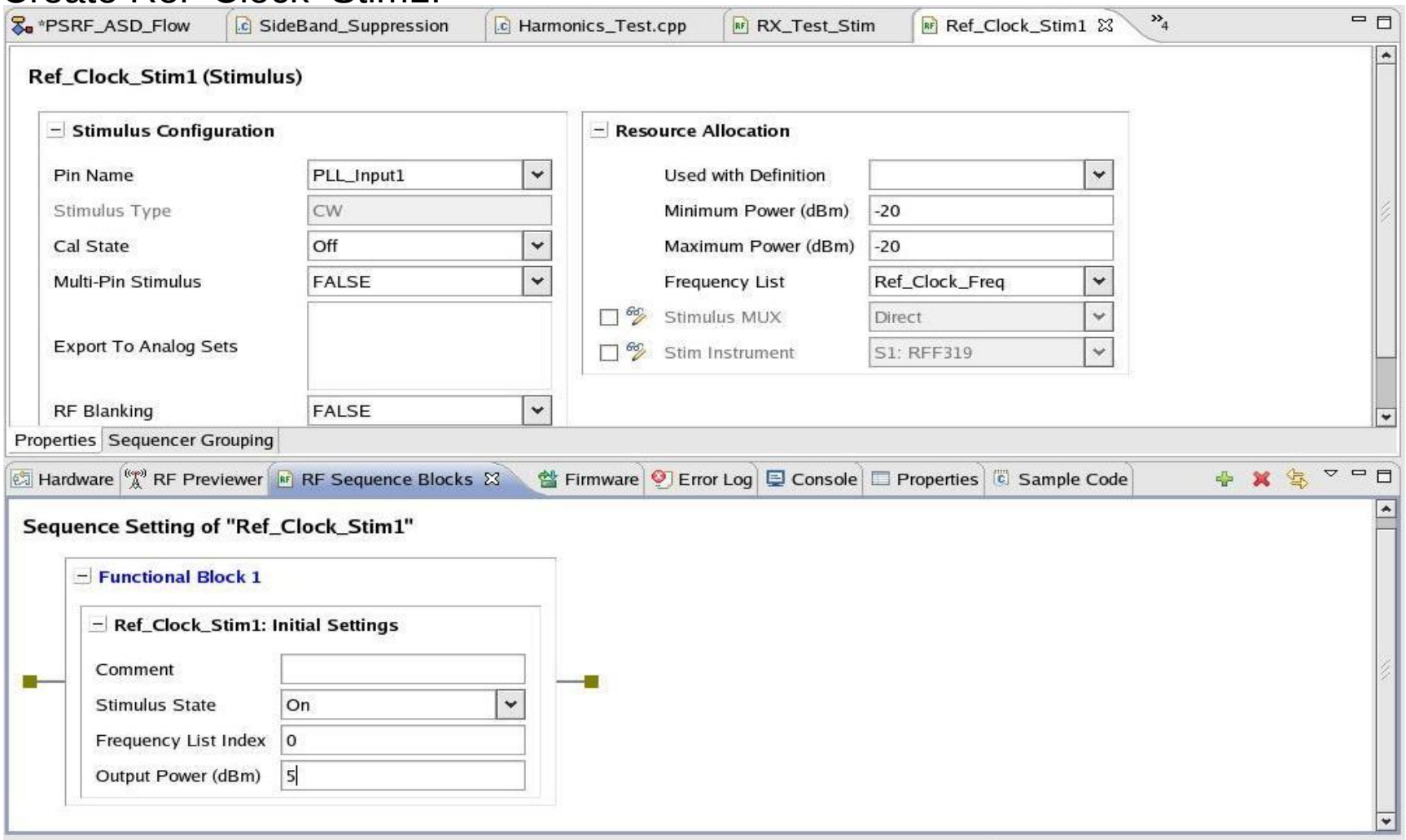
RF Port Block Diagram



Test Program Development & Debugging

Demodulator (RF to Baseband) Test

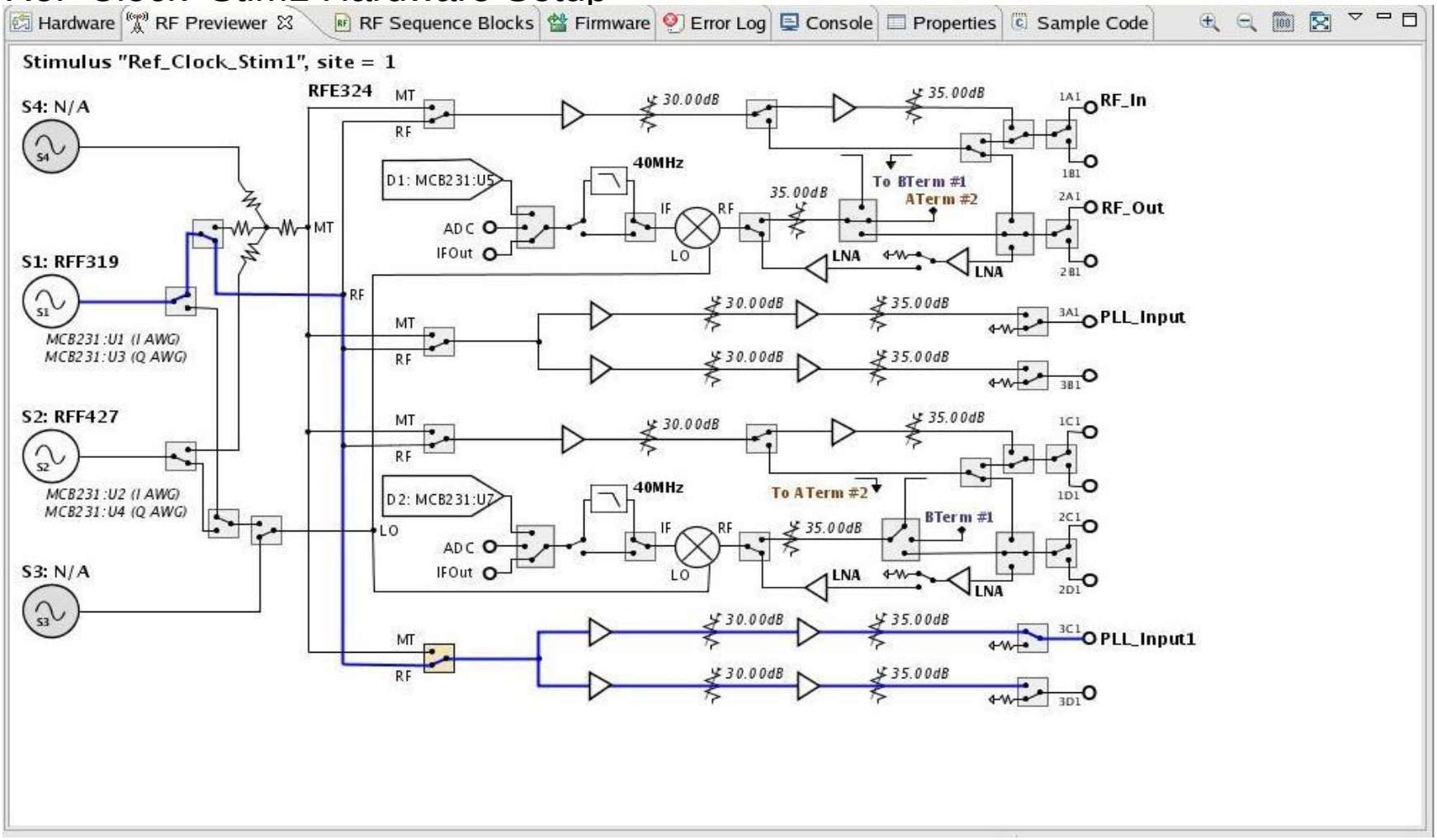
Create Ref_Clock_Stim1.



Test Program Development & Debugging

Demodulator (RF to Baseband) Test

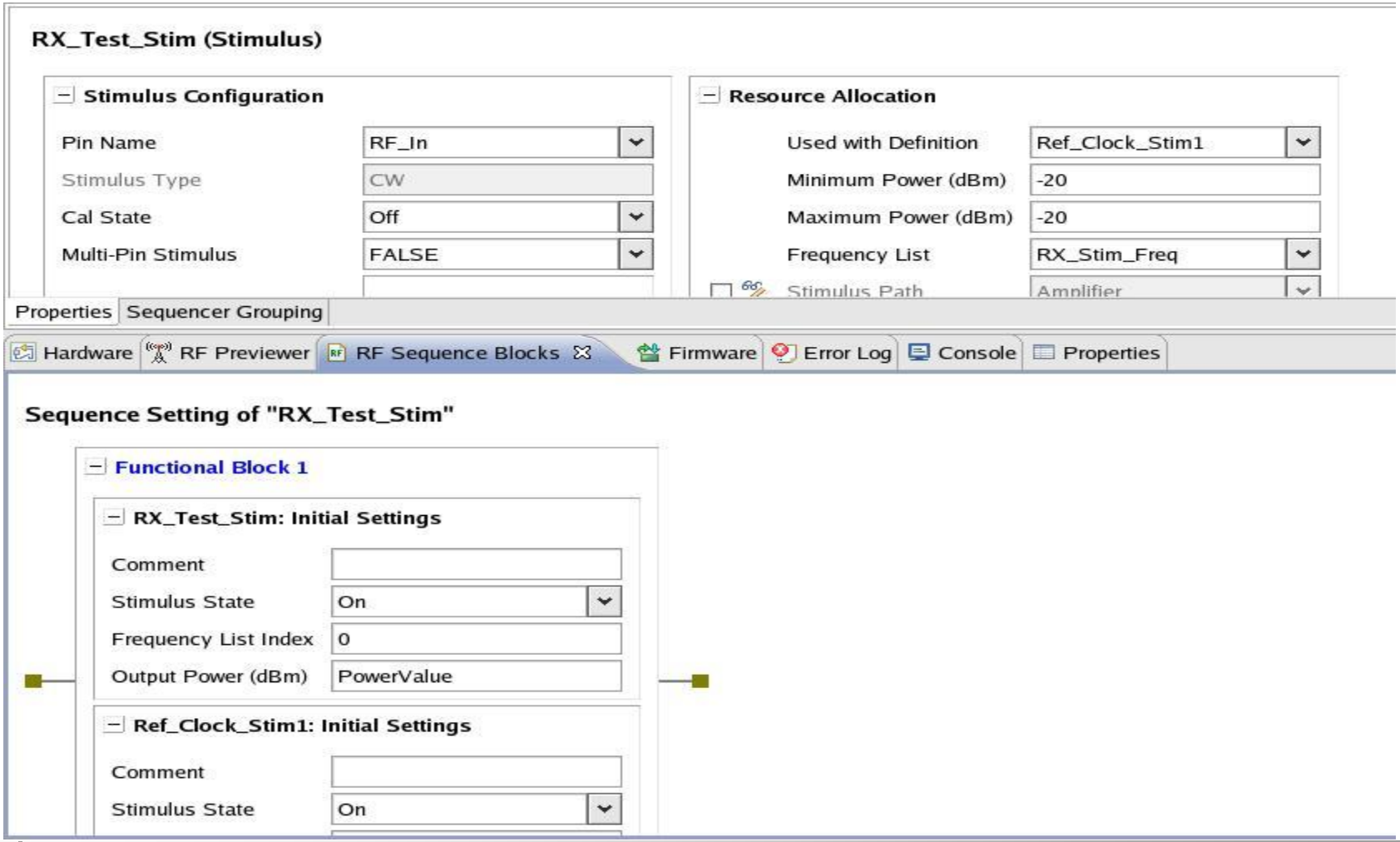
Ref Clock Stim1 Hardware Setup



Test Program Development & Debugging

Demodulator (RF to Baseband) Test

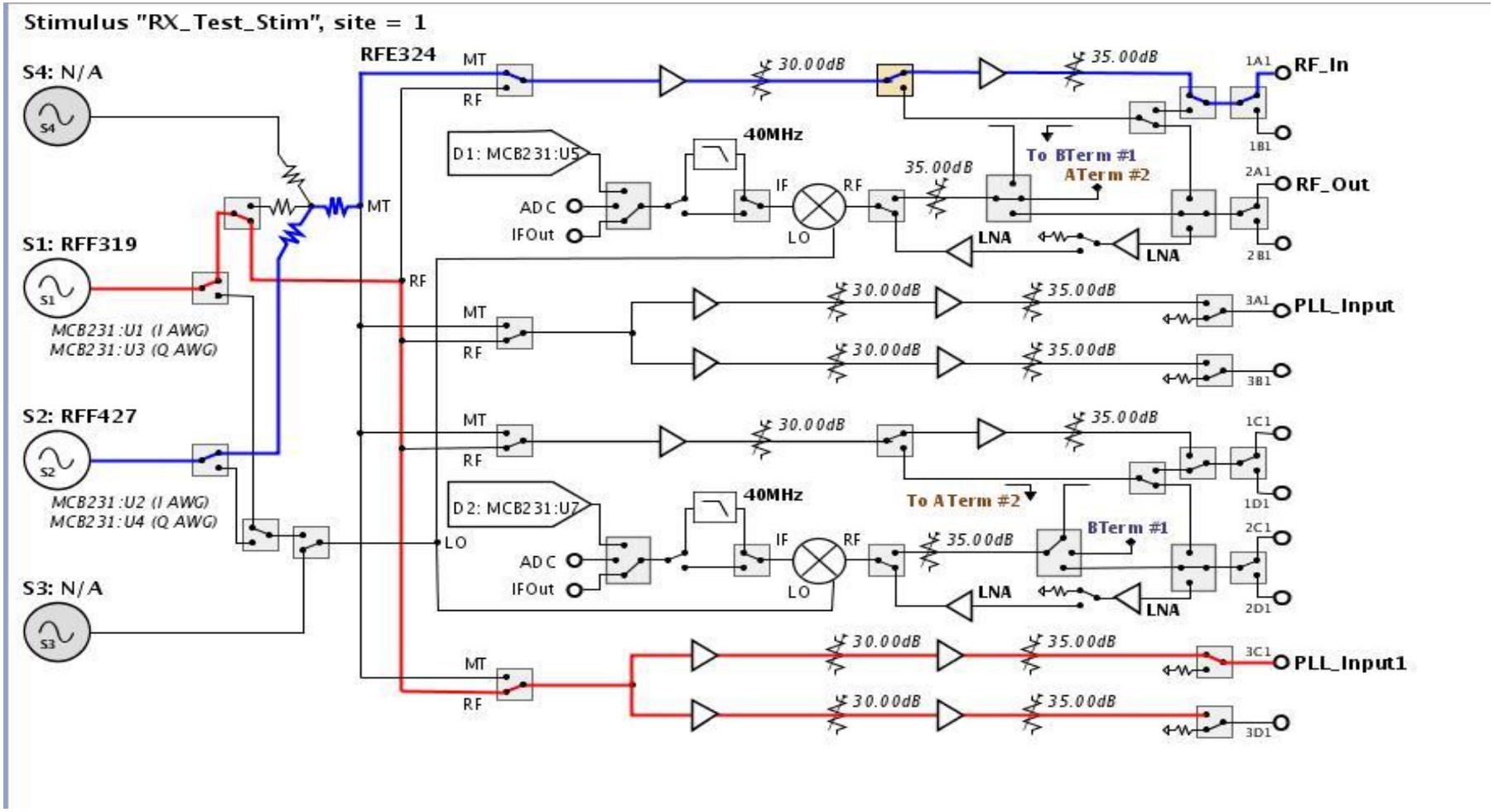
Create RX_Test_Stim



Test Program Development & Debugging

Demodulator (RF to Baseband) Test

RX_Test_Stim Hardware Setup



Test Program Development & Debugging

Demodulator (RF to Baseband) Test

Calculate Fs for Digitizer

RF to Banseband Test: Baseband Signal Ft = 3MHz

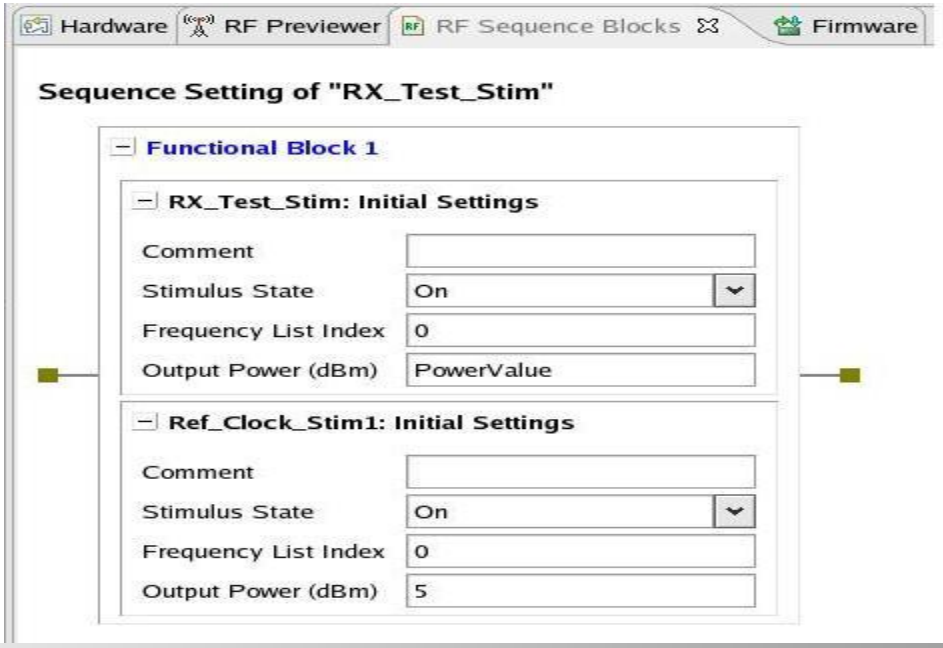
Number of Points N = 512

Frequency Bin M = 25

Sampling Frequency Fs = 61.44 MHz

Master Clock on the RF Measurement can be set to Fs*8 = 491.52MHz

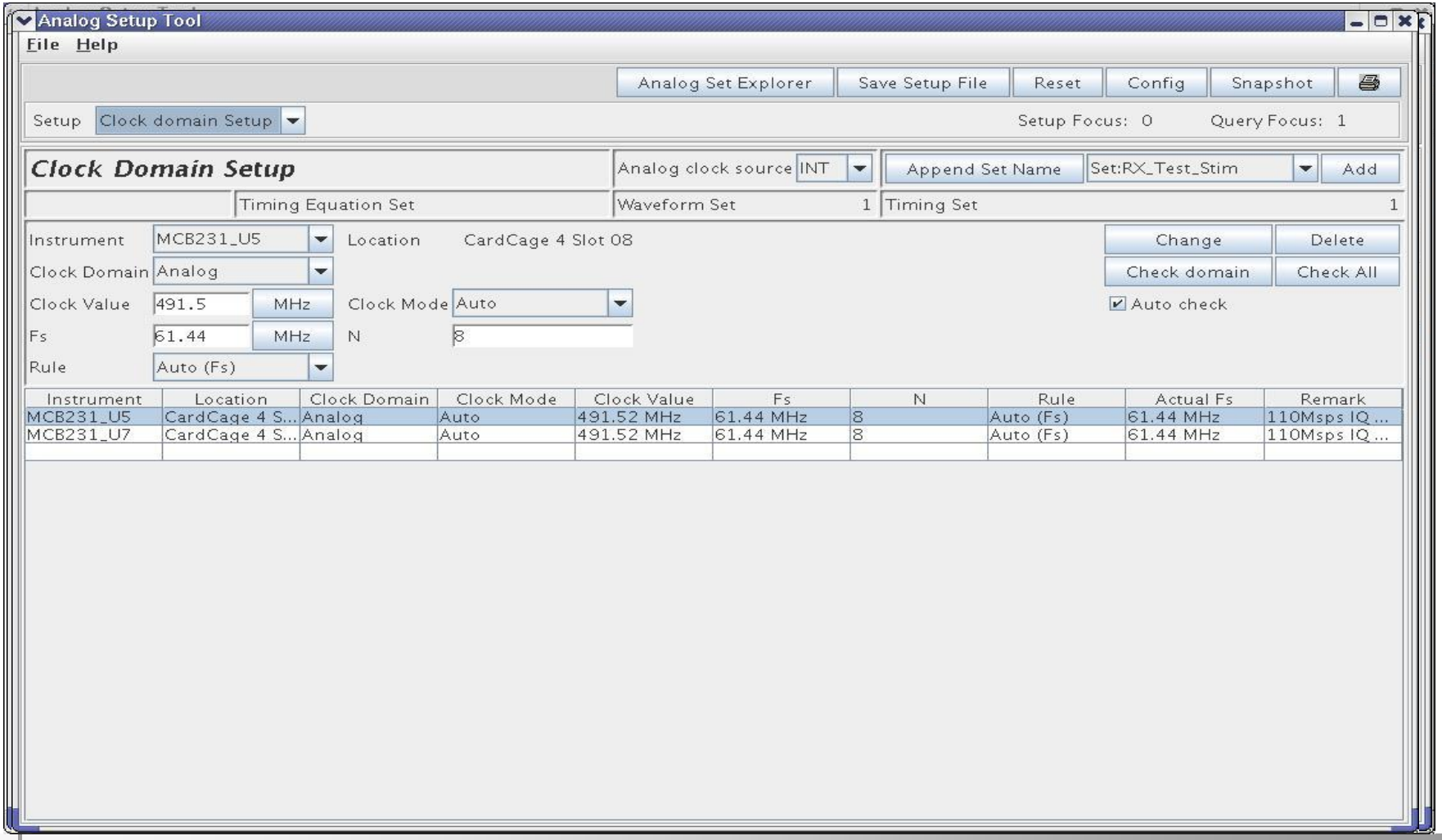
RF Sequencer Block View



Test Program Development & Debugging

Demodulator (RF to Baseband) Test

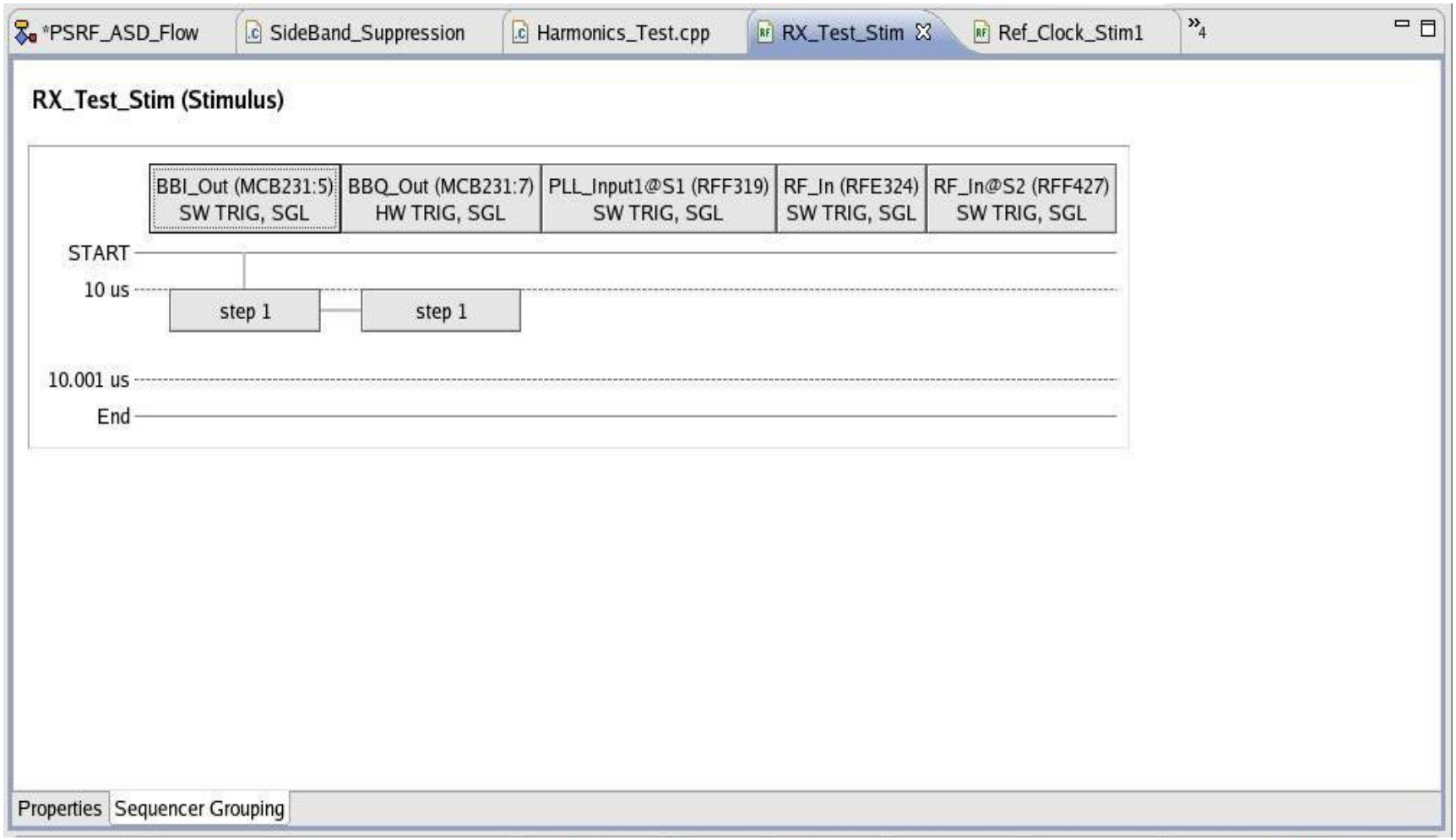
Digitizer Setups to RX_Test_Stim Analog Control Set



Test Program Development & Debugging

Demodulator (RF to Baseband) Test

Final Sequencer Grouping & Code for Test Method



Test Program Development & Debugging

Demodulator (RF to Baseband) Test

Final Sequencer Grouping & Code for Test Method

```
ARRAY_D freqArrayI,freqArrayQ,timeArrayI,timeArrayQ;
ARRAY_COMPLEX iqArray,ifreq,qfreq;
DOUBLE i_real,q_real,i_image,q_image,i_phase,q_phase,i_mag,q_mag;
DOUBLE RX_Amp_Imbalance, RX_Phase_Imbalance,pwr;
Analog.primary("RX_Test_Stim");
pwr = DATA_DEF("Power_Sweep").getValue(0);
DATA_DEF("PowerValue").set(pwr);
ON_FIRST_INVOCATION_BEGIN();
  STIM_DEF().disableAll().connectAll();
  EXECUTE_GROUP();                // SW Triggers the sequence
ON_FIRST_INVOCATION_END();
iqArray = DGT("BBI_Out").getComplexWaveform();
timeArrayI = iqArray.getReal(); timeArrayQ = iqArray.getImag();
DSP_FFT(timeArrayI,ifreq,RECT); DSP_FFT(timeArrayQ,qfreq,RECT);
i_real = ifreq[25].real();    i_image = ifreq[25].imag();
i_mag = sqrt(i_real*i_real+i_image*i_image);
q_real = qfreq[25].real();  q_image = qfreq[25].imag();
q_mag = sqrt(q_real*q_real+q_image*q_image);
i_mag = 20*log10(i_mag*sqrt(500.0/50.0)); //convert to dBm
q_mag = 20*log10(q_mag*sqrt(500.0/50.0)); //convert to dBm
i_phase = 180*(atan2(i_image, i_real))/M_PI; q_phase = 180*(atan2(q_image, q_real))/M_PI;
cout << "*********Testsuite: RF_BB_IQ_Imbalance_Test*********"<<endl;
cout <<"\t I mag = "<<i_mag<<" dBm "<<endl; cout <<"\t Q mag = "<<q_mag<<" dBm "<<endl;
cout <<"\t I phase = "<<i_phase<<" Degree "<<endl; cout <<"\t Q phase = "<<q_phase<<" Degree "<<endl;
RX_Amp_Imbalance = q_mag -  i_mag;
RX_Phase_Imbalance = 90 - abs(q_phase - i_phase);
if(RX_Phase_Imbalance > 180 )
{
        RX_Phase_Imbalance = RX_Phase_Imbalance -180;
}
 else if (RX_Phase_Imbalance < -180 )
{
        RX_Phase_Imbalance = RX_Phase_Imbalance +180;
}
cout <<"\t IQ Amplitude Imbalance = "<<RX_Amp_Imbalance<<" dB "<<endl;
cout <<"\t IQ Phase Imbalance = "<<RX_Phase_Imbalance<<" Degree "<<endl;
TEST( "BBI_Out,BBQ_Out", "RX_Amp_Imbalance",RX_Amp_Imbalance );
TEST( "BBI_Out,BBQ_Out", "RX_Phase_Imbalance",RX_Phase_Imbalance );
```

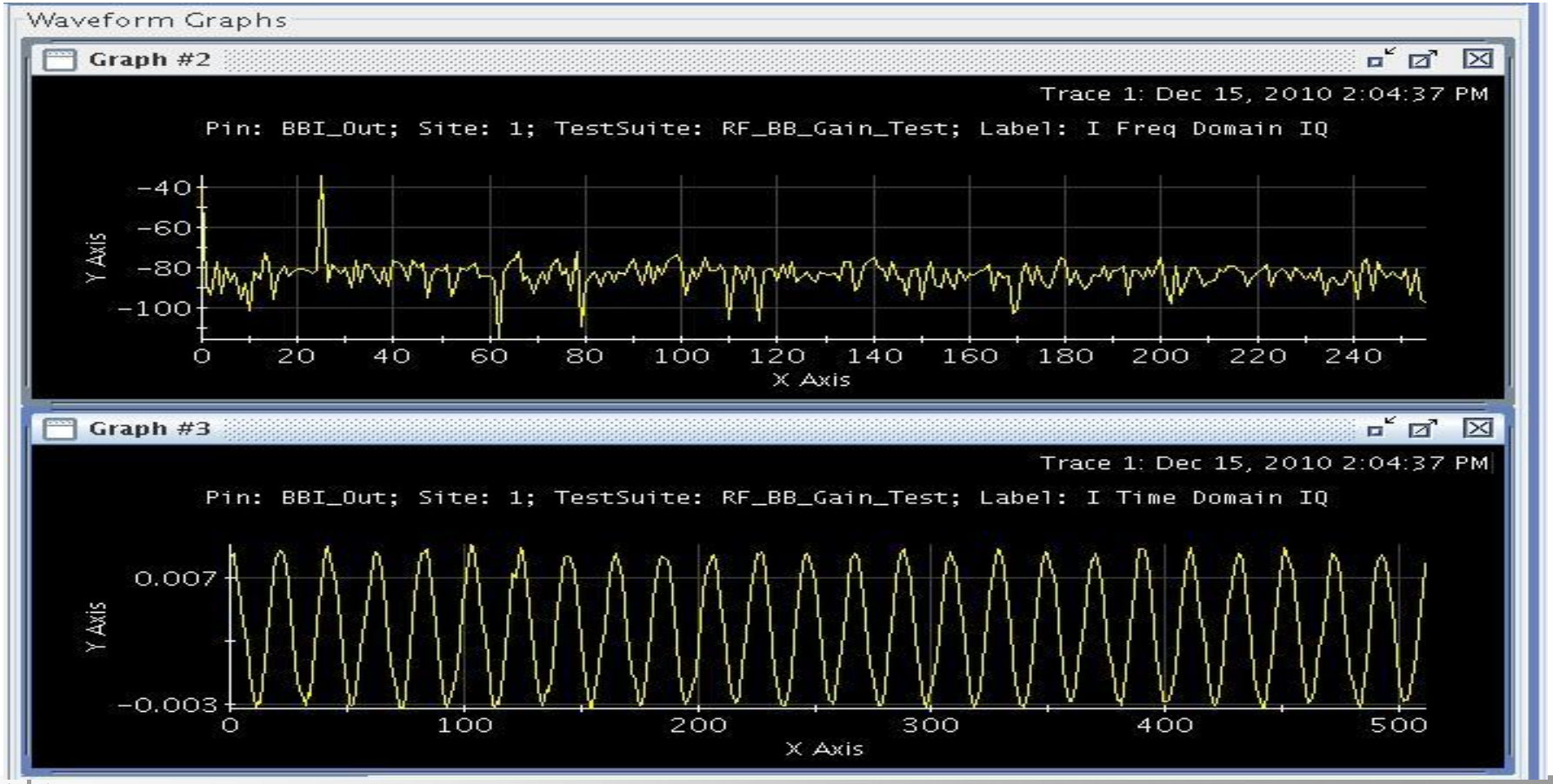
Test Program Development & Debugging

Datalog and Waveform Analysis for Demodulator

Datalog for Demodulator

Datalog for RFTOBB

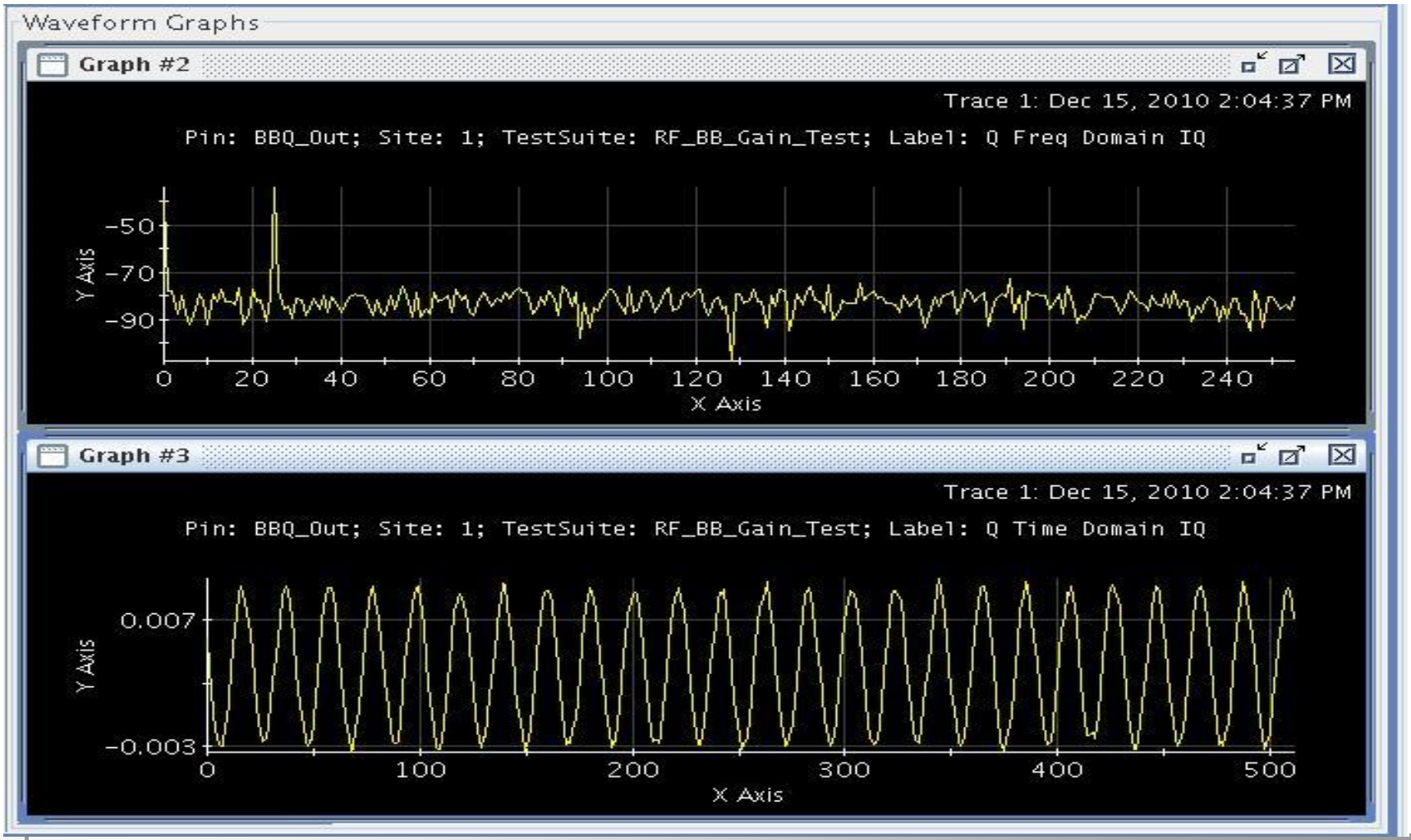
I Waveform Capture in Time & Frequency Domain



Test Program Development & Debugging

Datalog and Waveform Analysis for Demodulator

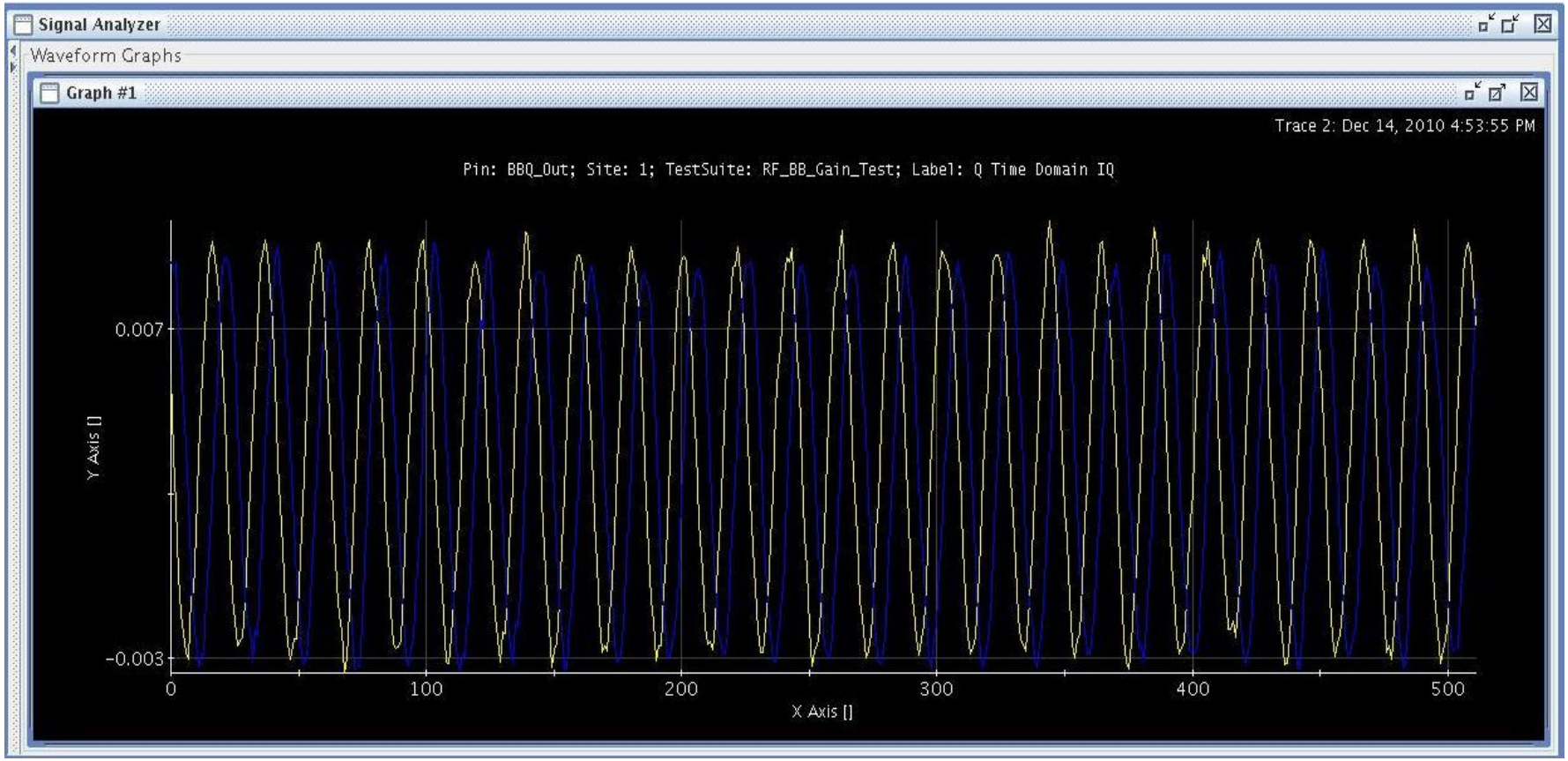
Q Waveform Capture in Time & Frequency Domain



Test Program Development & Debugging

Datalog and Waveform Analysis for Demodulator

I/Q Waveform Capture Overlap in Time Domain



IQ Amplitude Imbalance: -0.5 dB < 0.262095 dB < 0.5 dB

IQ Phase Imbalance: -5 Degree < 0.875716 Degree < 5 Degree

Summary

Achievement of Skill & Knowledge:

1. Basic Knowledge of RF testing and RF device.
2. Good Skill about basic RF test like IP3,S-parameter,Carrier Suppression.
3. Basic test development skill for RF chip, Create Frequency List, Stimulus and Power measurement .
4. How to use of Spectrum Analyzer to measure RF signal power.
5. How to debug RF testing with Sequencer Grouping.
6. Understanding of V93K Hardware for RF testing , RF source Card, RF Front End Card, MB Av8 Card.
7. Understanding and application of flowing API function: DATA_DEF, STIM_DEF, EXECUTE_GROUP, DSP_FFT, DSP_RF_CW_POWER, MEAS_DEF
8. Basic Calculation of power for sine signal.

Q/A

Thanks !