

Advance your system level modeling and simulation skills

Murthy Upmaka, Ph.D

2020.07.09

Sr. Applications Engineer

murthy_upmaka@keysight.com 978 681 2083



Agenda



- Introduction
- The hidden or less known basics
 - Sample Rate
 - Signal Representation
- Useful trouble shooting techniques
 - RF system analysis
- Do more with scripting
 - VB scripts
 - Control from MATLAB (BaseBand Link)
- Useful reference material

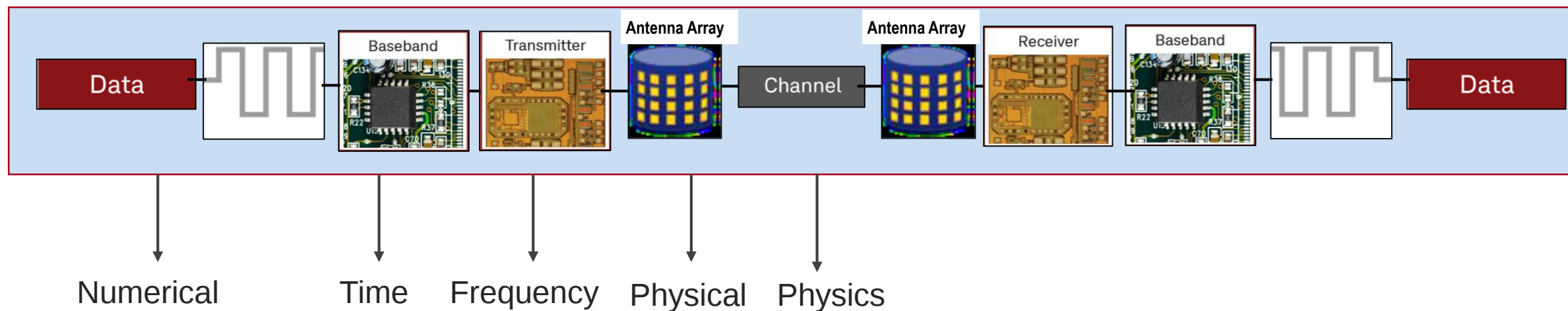
The System in today's discussion

Terrestrial Communications

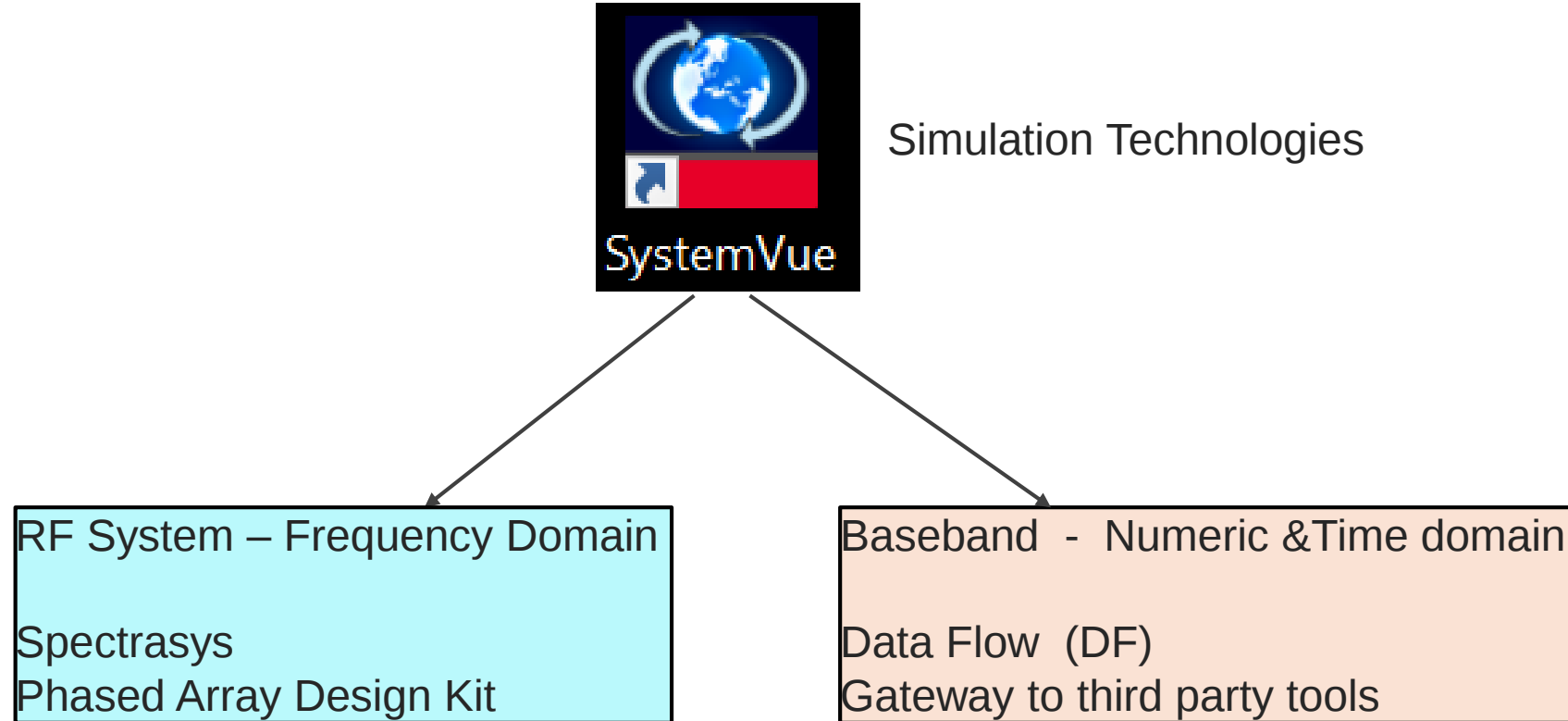
Radar

EW

Space comms



SystemVue has it all



Sample Rate - Data Flow

This is the heart (clock) of the system.

Every part (model) consumes (input) or produces (output) samples

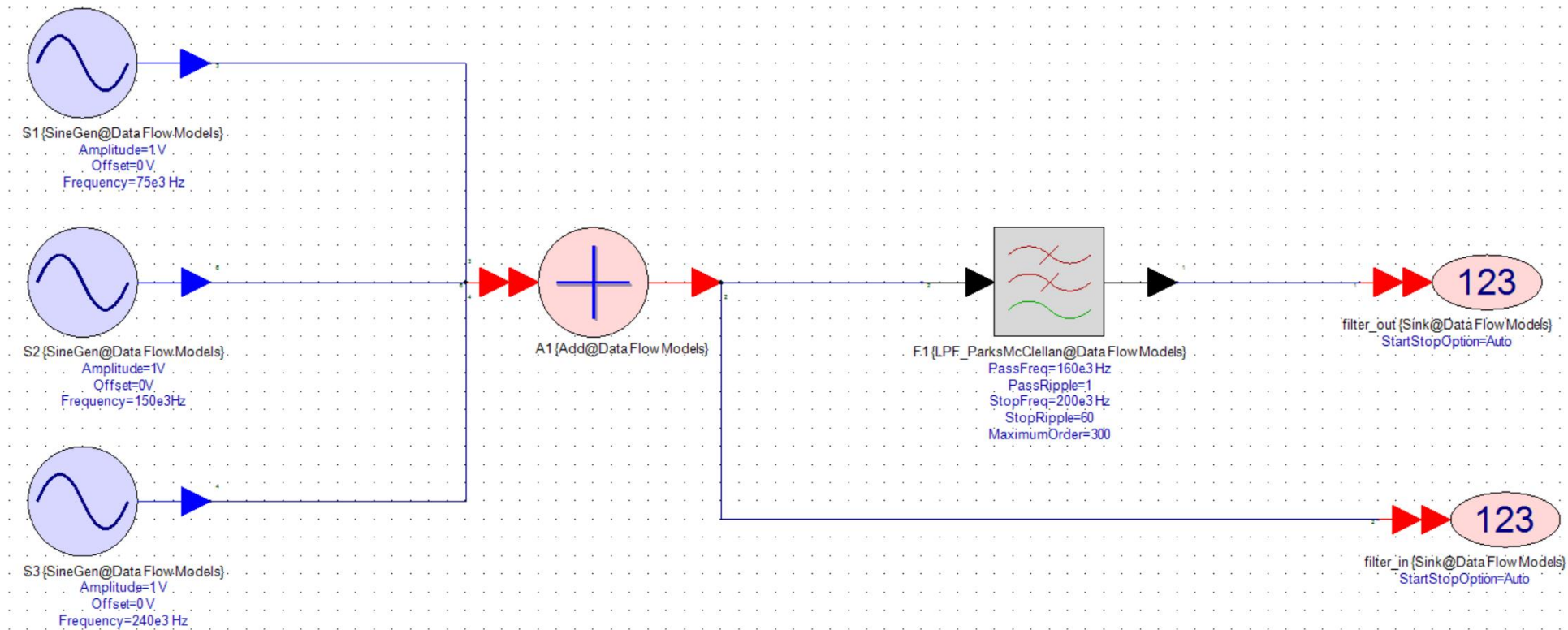
The meaning of sample varies. E.g., an integer, a complex number, an array or a matrix etc.

A system engineer should know the Sample Rate at every point in the system!

Let us learn how the tool decides the Sample_Rate.

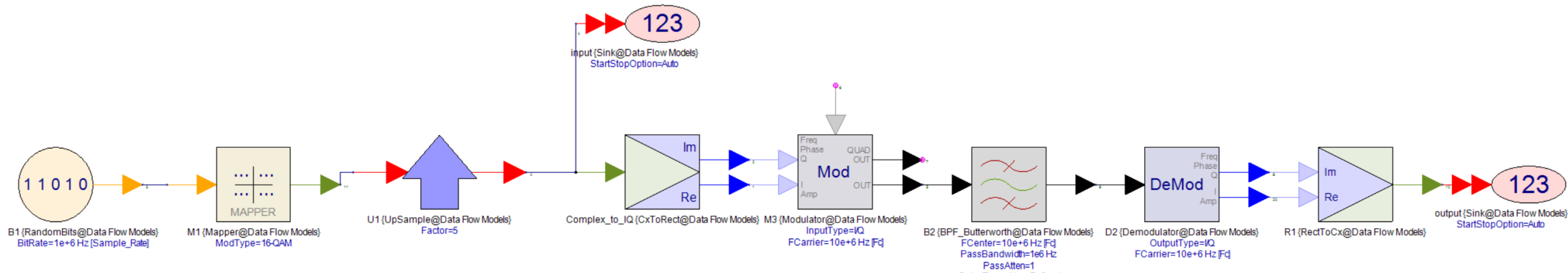
Sample Rate - Data Flow

Uni-rate system



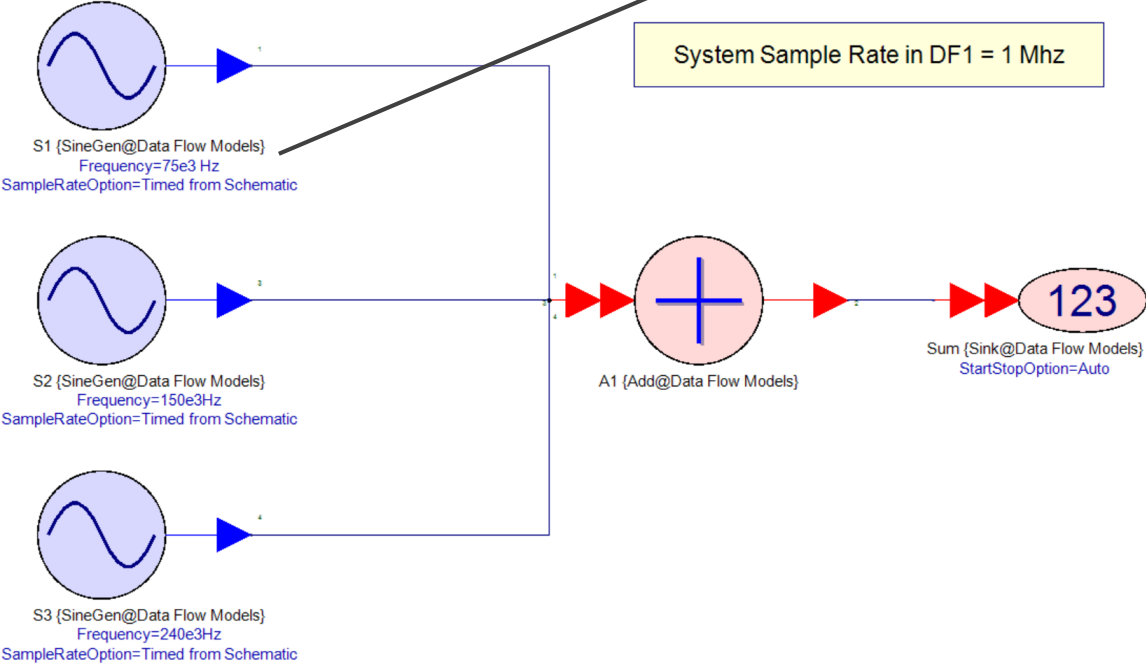
Sample Rate - Data Flow

Multi-rate system



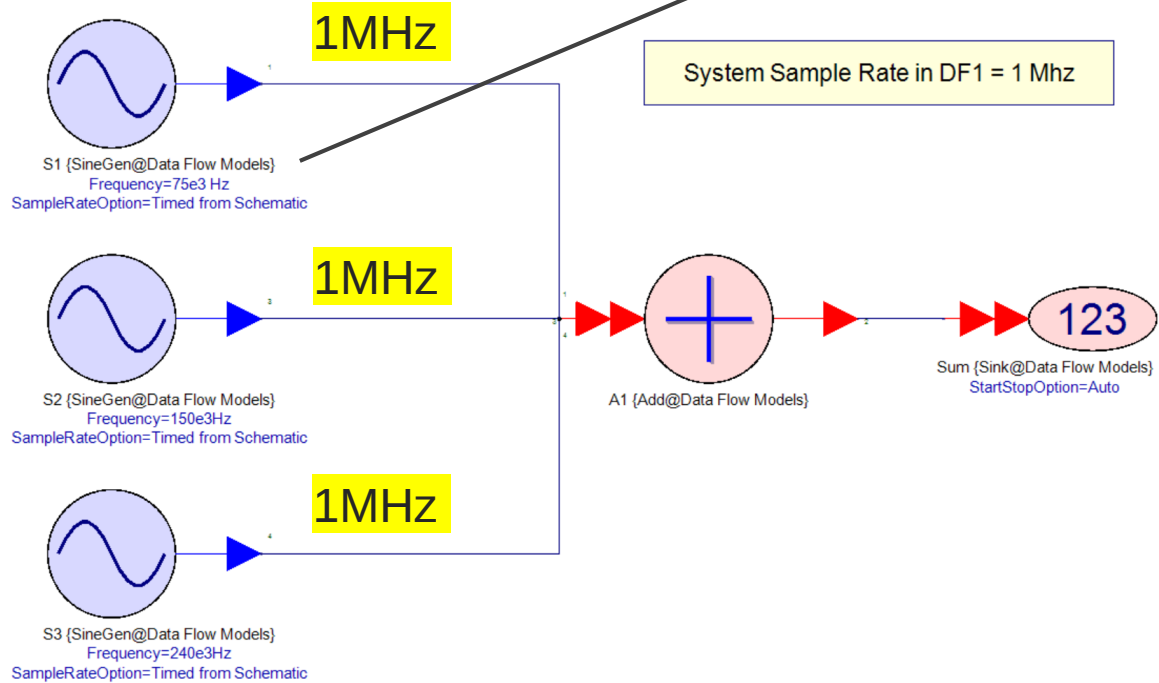
Sample Rate - Data Flow

Name	Value	Units	Default	Use Default	Tune	Show
Amplitude	1	V	1 V	☐	☐	☐
Offset	0	V	0 V	☐	☐	☐
Frequency	75e3	Hz	5e3 Hz	☐	☐	☒
Phase	0	deg	0 °	☒	☐	☐
ShowAdvancedParams	1:YES		0:NO	☐	☐	☐
SampleRateOption	2:Timed from Schematic		2:Timed from...	☐	☐	☒
InitialDelay	0:UnTimed	s	0 s	☒	☐	☐
BurstMode	1:Timed from SampleRate		0:OFF	☒	☐	☐
	2:Timed from Schematic					

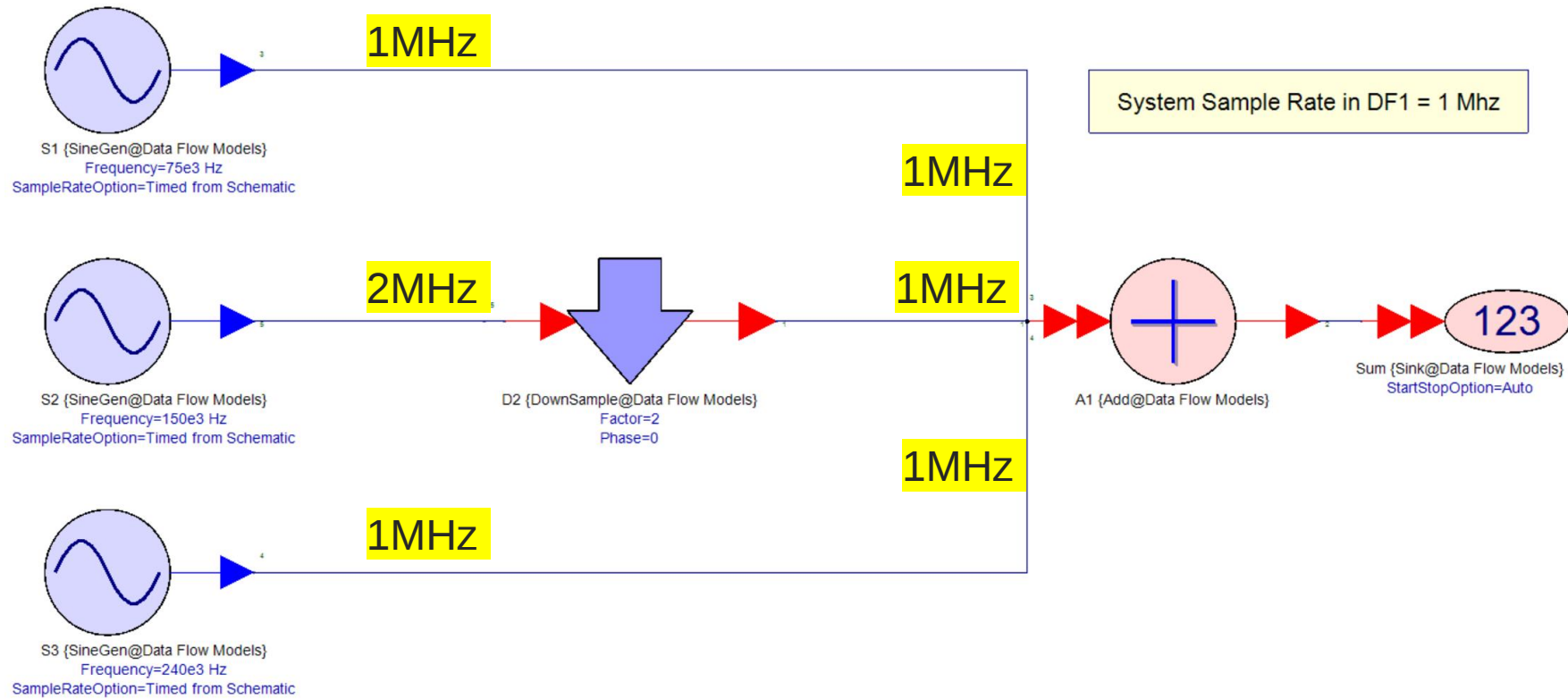


Sample Rate - Data Flow

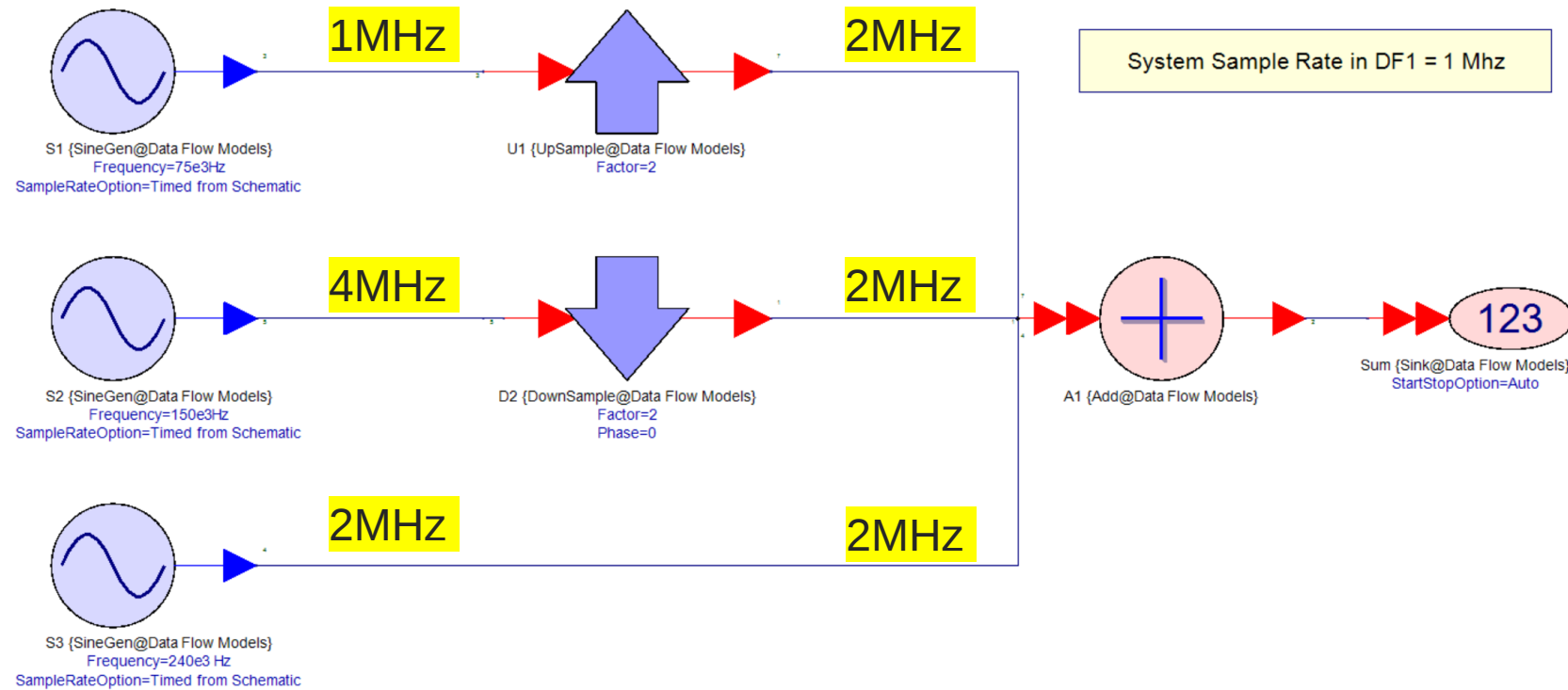
Name	Value	Units	Default	Use Default	Tune	Show
Amplitude	1	V	1 V	☐	☐	☐
Offset	0	V	0 V	☐	☐	☐
Frequency	75e3	Hz	5e3 Hz	☐	☐	☒
Phase	0	deg	0 °	☒	☐	☐
ShowAdvancedParams	1:YES		0:NO	☐	☐	☐
SampleRateOption	2:Timed from Schematic		2:Timed from...	☐	☐	☒
InitialDelay	0:UnTimed 1:Timed from SampleRate	s	0 s	☒	☐	☐
BurstMode	2:Timed from Schematic		0:OFF	☒	☐	☐



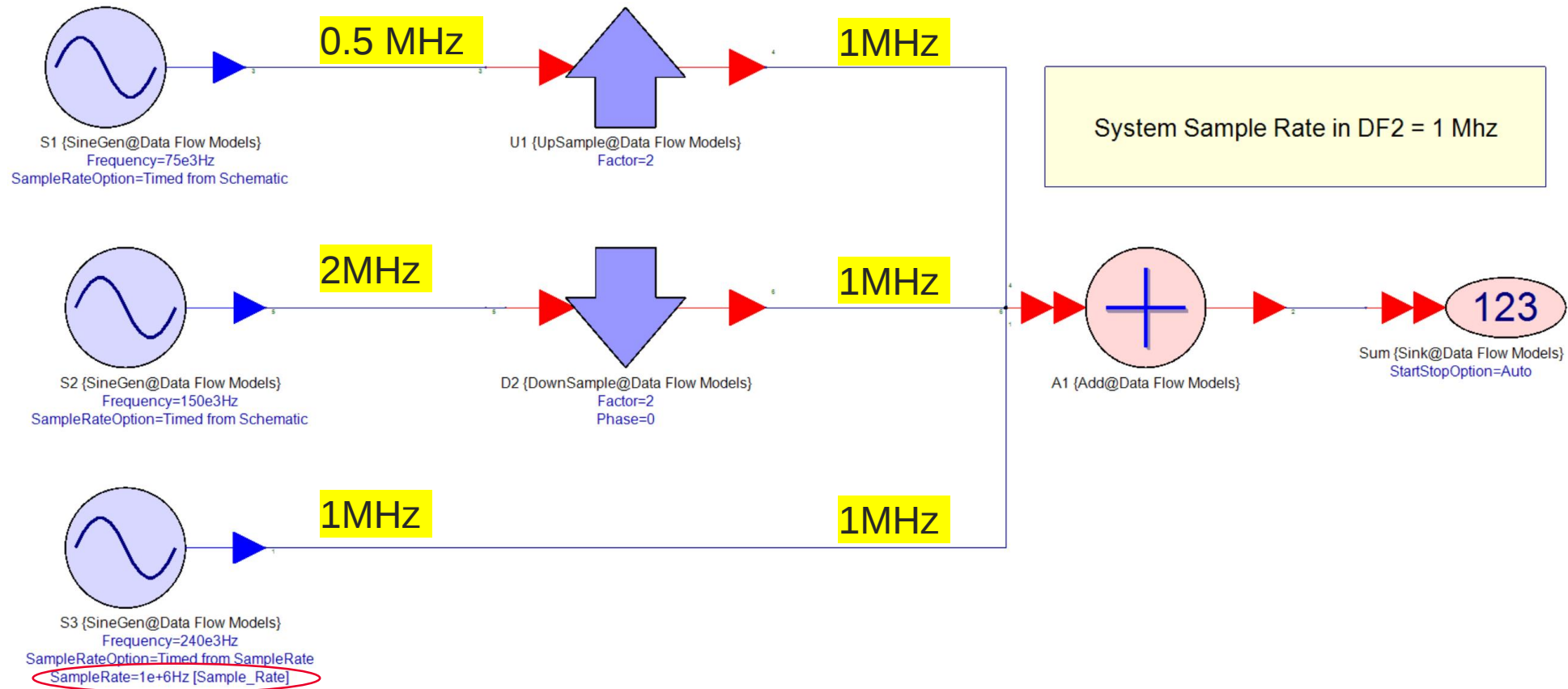
Sample Rate - Data Flow



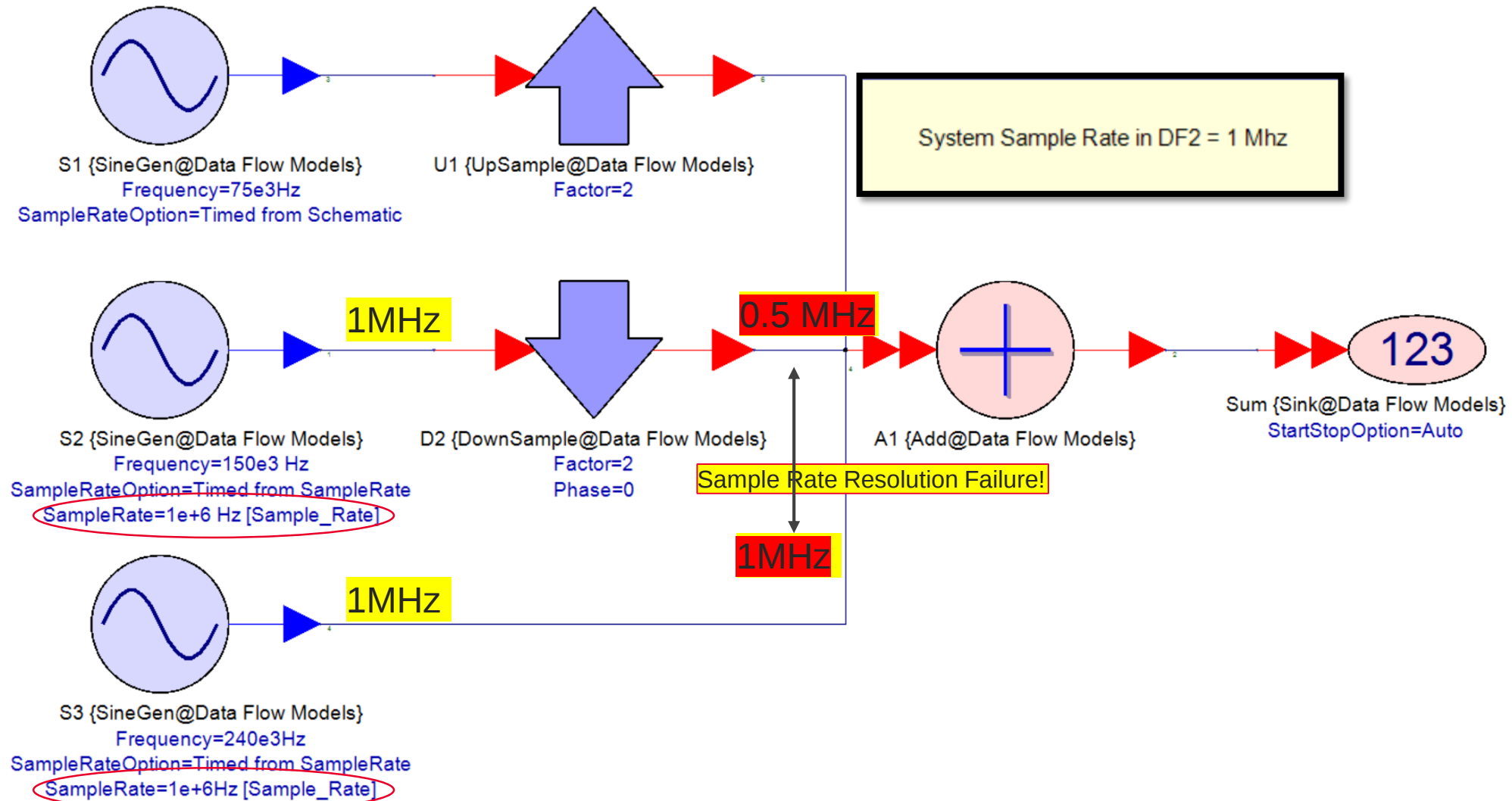
Sample Rate - Data Flow



Sample Rate - Data Flow



Sample Rate - Data Flow



Sample Rate - Data Flow

Take Aways

1. Sample_Rate is a global variable set in the DF.
2. The schematic parts may or may not use this variable.
3. The DF by and large tries to set up the Sample Rate at every node.
4. If it can not resolve the user has to intervene.
5. Sample Rate information can be viewed on the schematic.

Signal representation- Data Flow

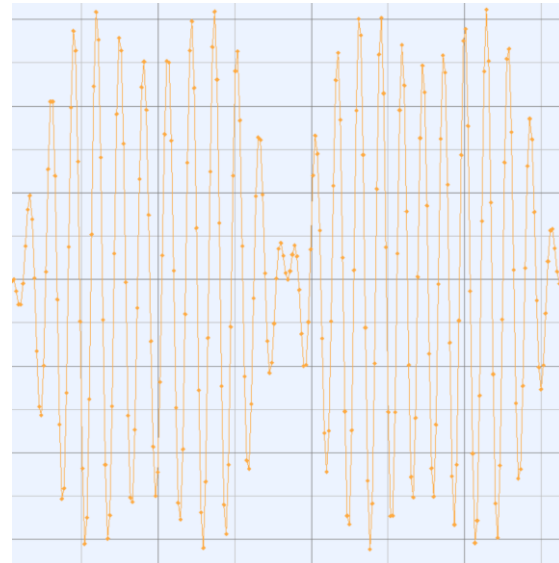
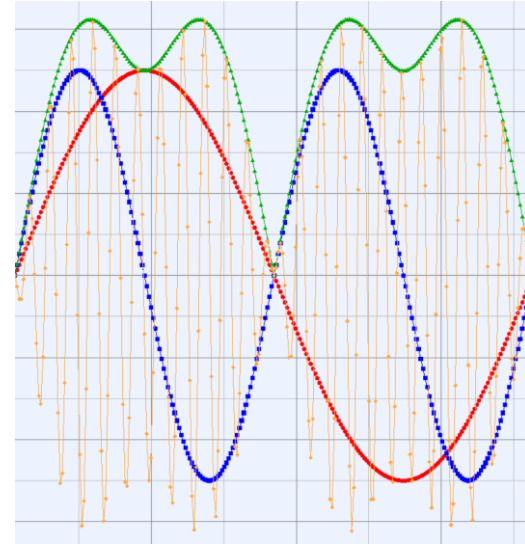
All the signals we encounter in general in real world are voltage vs. time.

For e.g., $S(t) = A \cos(2 \pi f t)$,
Signal in this form is called real signal.

A more general representation of a signal is
 $S(t) = [I(t) + jQ(t)] \exp(j 2 \pi f t)$. This is called analytic signal.

$\text{RE}(S(t)) = I(t) \cos(2 \pi f t) - Q(t) \sin(2 \pi f t)$.
This is the general form of a real signal.

SystemVue supports both representations.

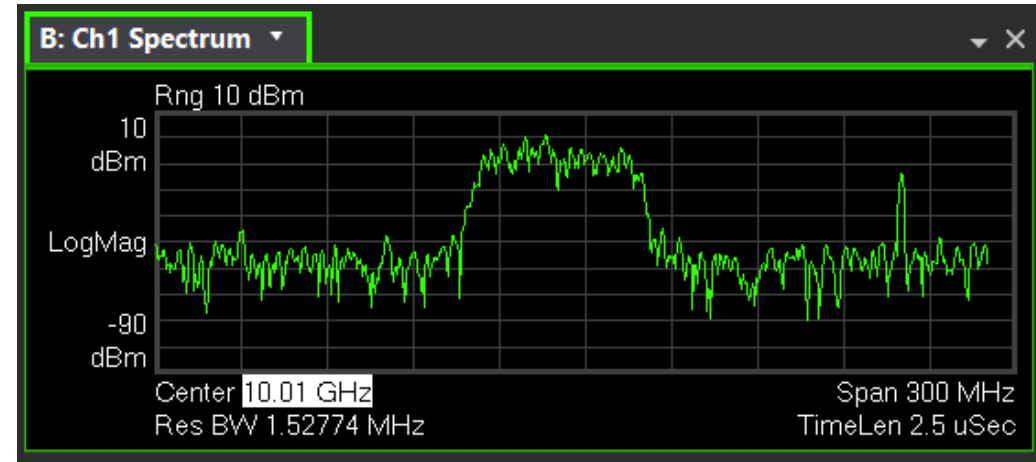
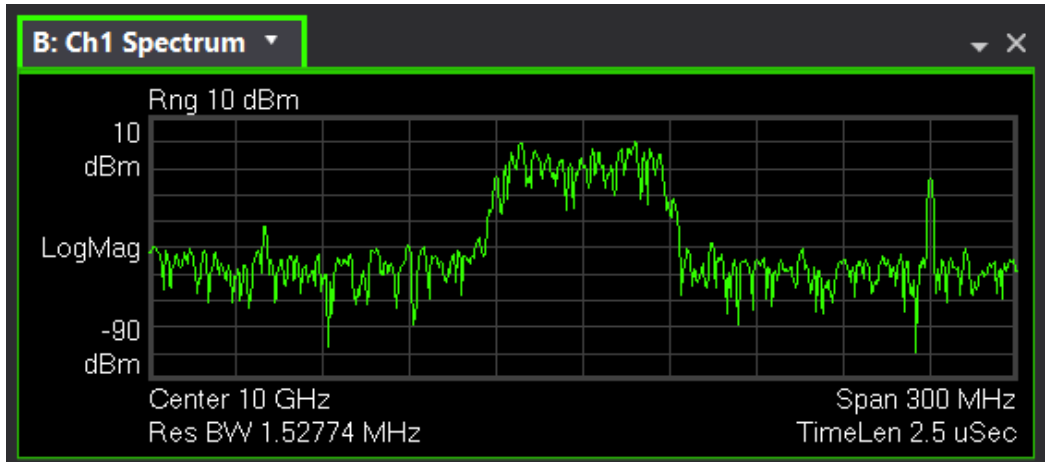


Signal representation- Data Flow

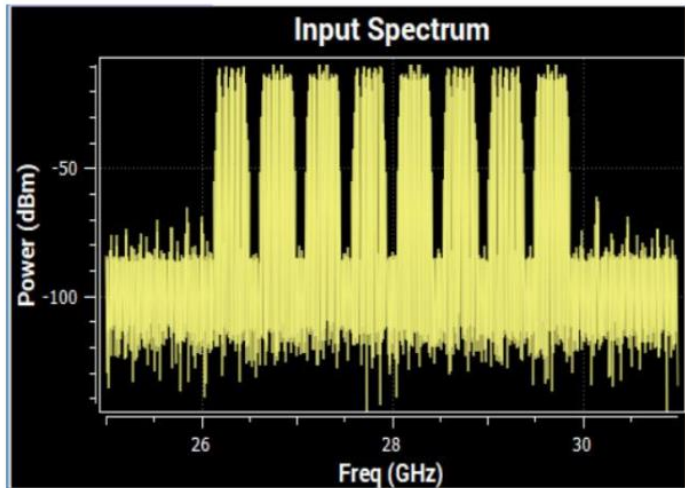
In the analytic form $S(t) = [I(t) + jQ(t)] \exp(j 2 \pi f_c t)$, $I(t) + jQ(t)$ is called complex envelope and f_c is called characterization frequency.

The key concept is that a signal can equivalently be represented with different complex envelopes and corresponding characterization frequencies

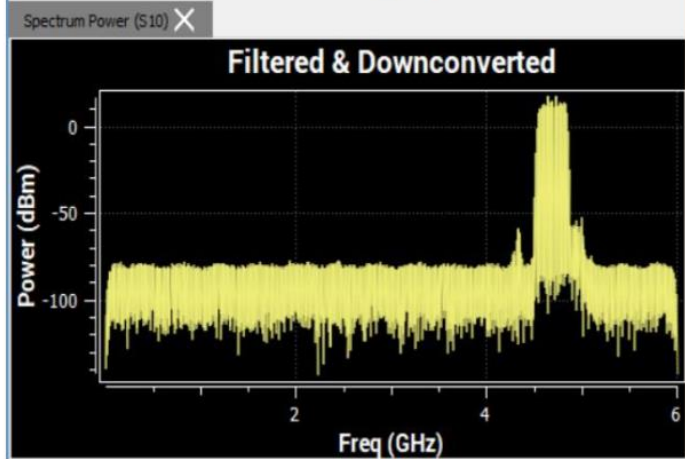
$$x_a(t) = (x_{i1}(t) + j x_{q1}(t)) \exp(j 2 \pi f_{c1} t) = (x_{i2}(t) + j x_{q2}(t)) \exp(j 2 \pi f_{c2} t)$$
$$x(t) = x_{i1}(t) \cos(2 \pi f_{c1} t) - x_{q1}(t) \sin(2 \pi f_{c1} t) = x_{i2}(t) \cos(2 \pi f_{c2} t) - x_{q2}(t) \sin(2 \pi f_{c2} t)$$



Signal representation- Data Flow



8 Radar signals



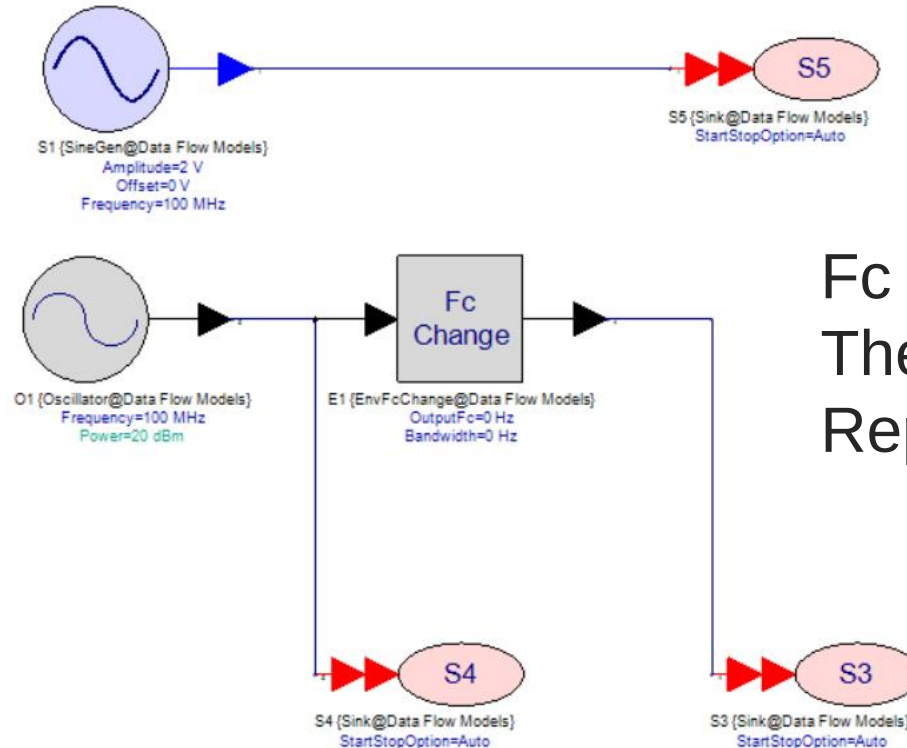
Down converted and filtered by RF subsystem

$F_c = 3\text{GHz}$, $F_{\text{carrier}} = 4.68\text{ GHz}$.

Signal representation- Data Flow

Real baseband signal
 $1.\cos(2\pi f t) - 0.\sin(2\pi f t)$

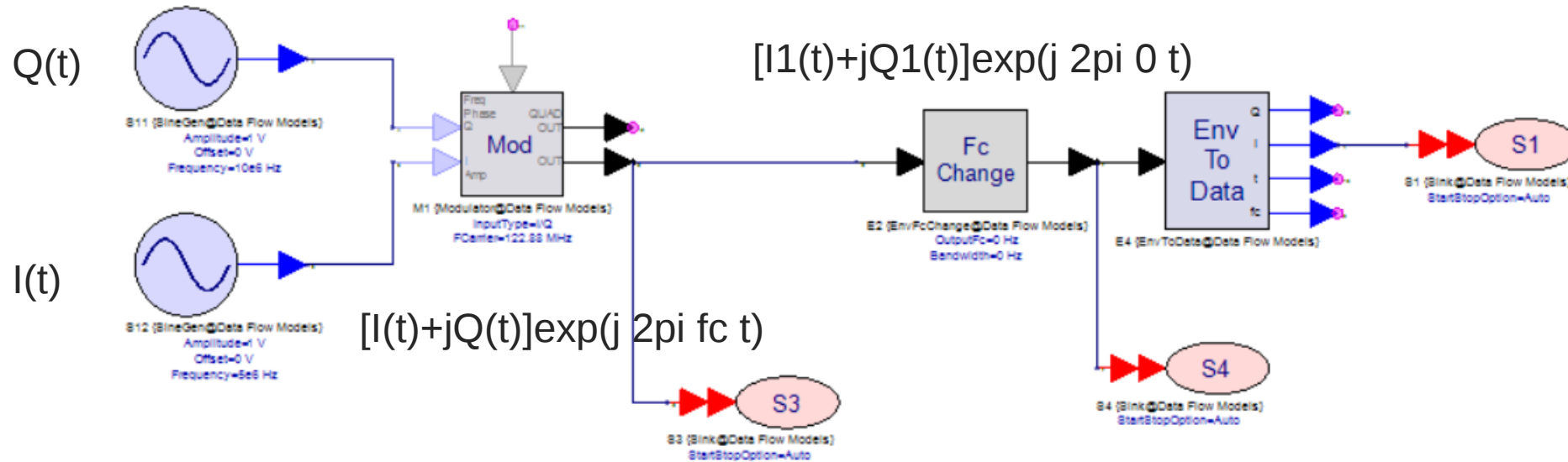
Envelope signal
 $(1+j0)\exp(j2\pi f t)$



Fc Change does not alter
The signal. It changes the
Representation of the signal.

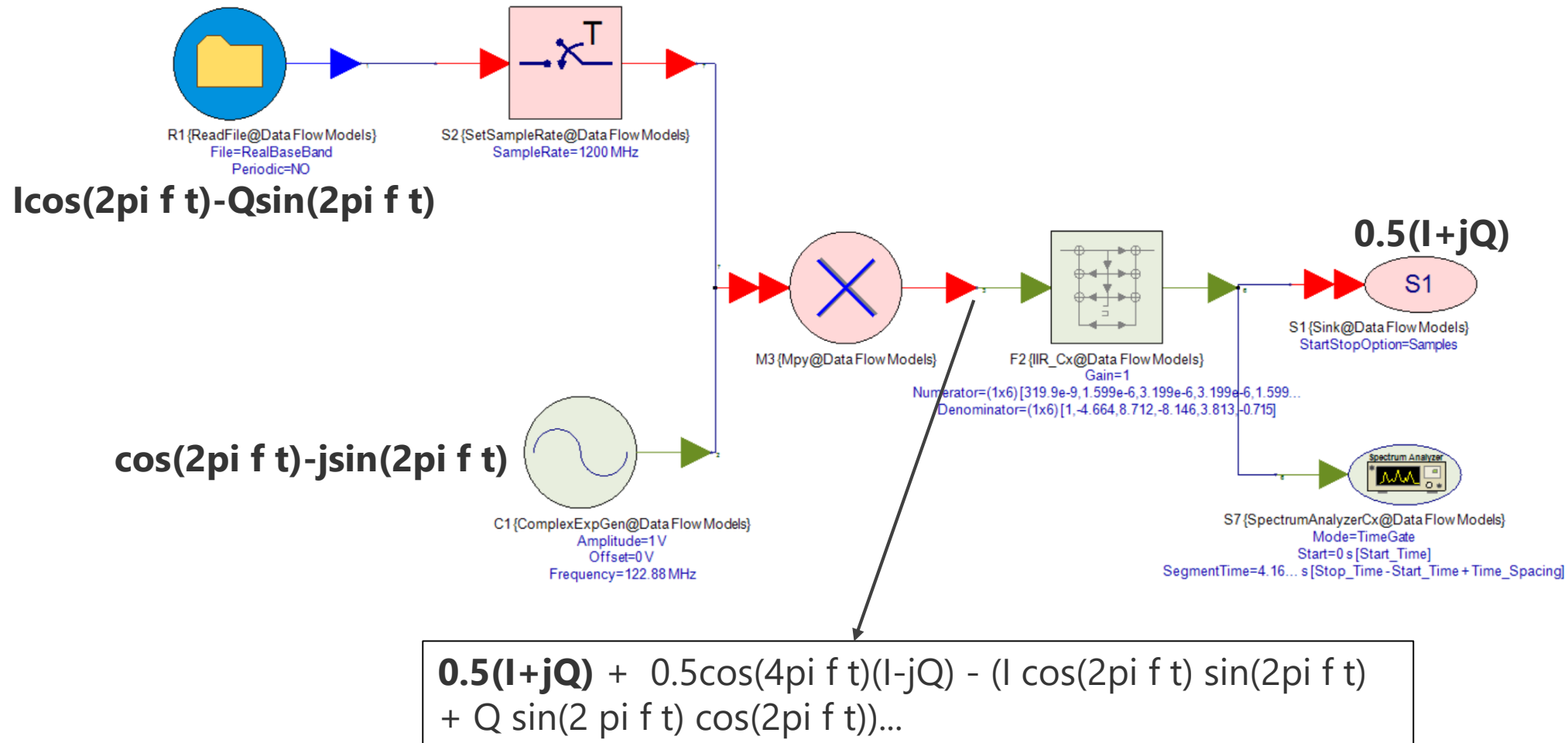
Signal representation- Data Flow

Creating and converting Envelope to real



Signal representation- Data Flow

Converting real baseband to Envelope



Signal representation- Data Flow

Why do I care about this and do I need to remember all this math?

We do have to care about envelope representation.

In SystemVue the signals propagate from one part to another with the following attributes

$I(t)$, $Q(t)$, F_c , and timestep. We have to sample only $I(t)$ and $Q(t)$ which are at lower frequency than F_c .

The required Sample rate is very small. Hence the simulation is very fast.

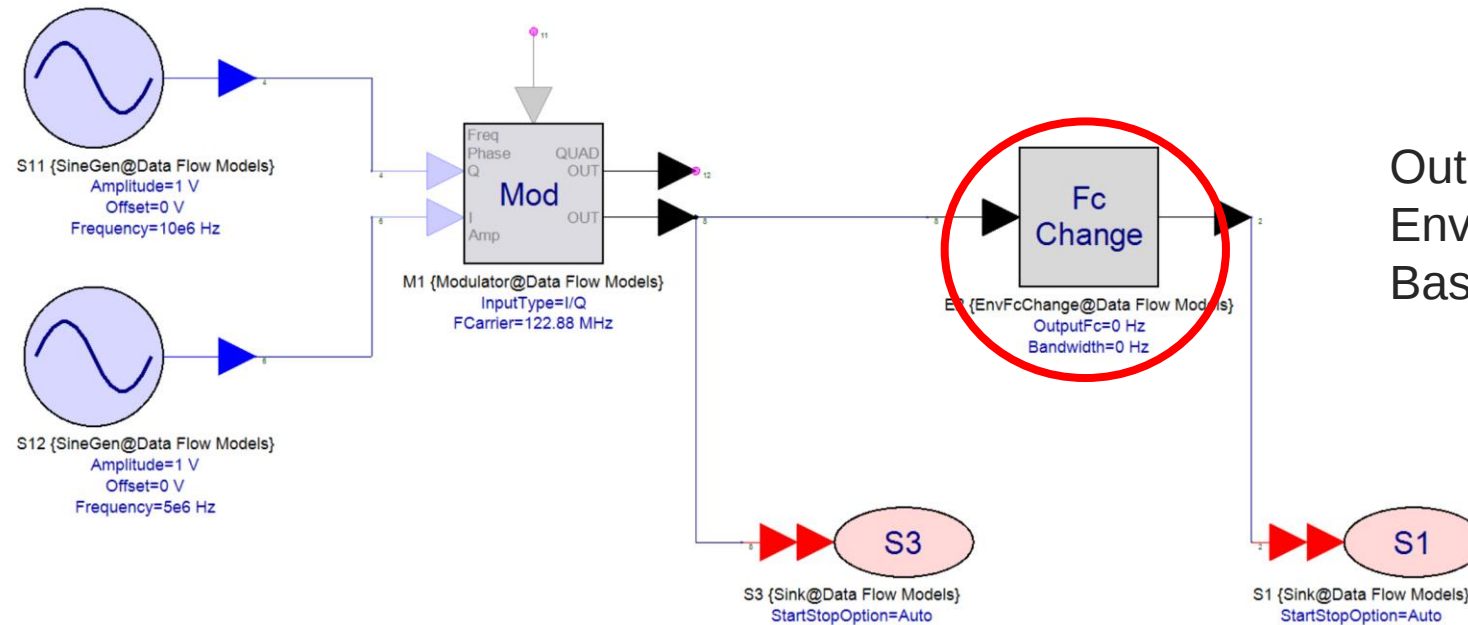
We do not have to remember the math. SystemVue does it for us!

Let us examine an example.

$$(I\cos(2\pi f t) - Q\sin(2\pi f t))(\cos(2\pi f t) - j\sin(2\pi f t)) = 0.5(I + jQ) + 0.5\cos(4\pi f t)(I - jQ) - (I\cos(2\pi f t)\sin(2\pi f t) + Q\sin(2\pi f t)\cos(2\pi f t))...$$

Signal representation- Data Flow

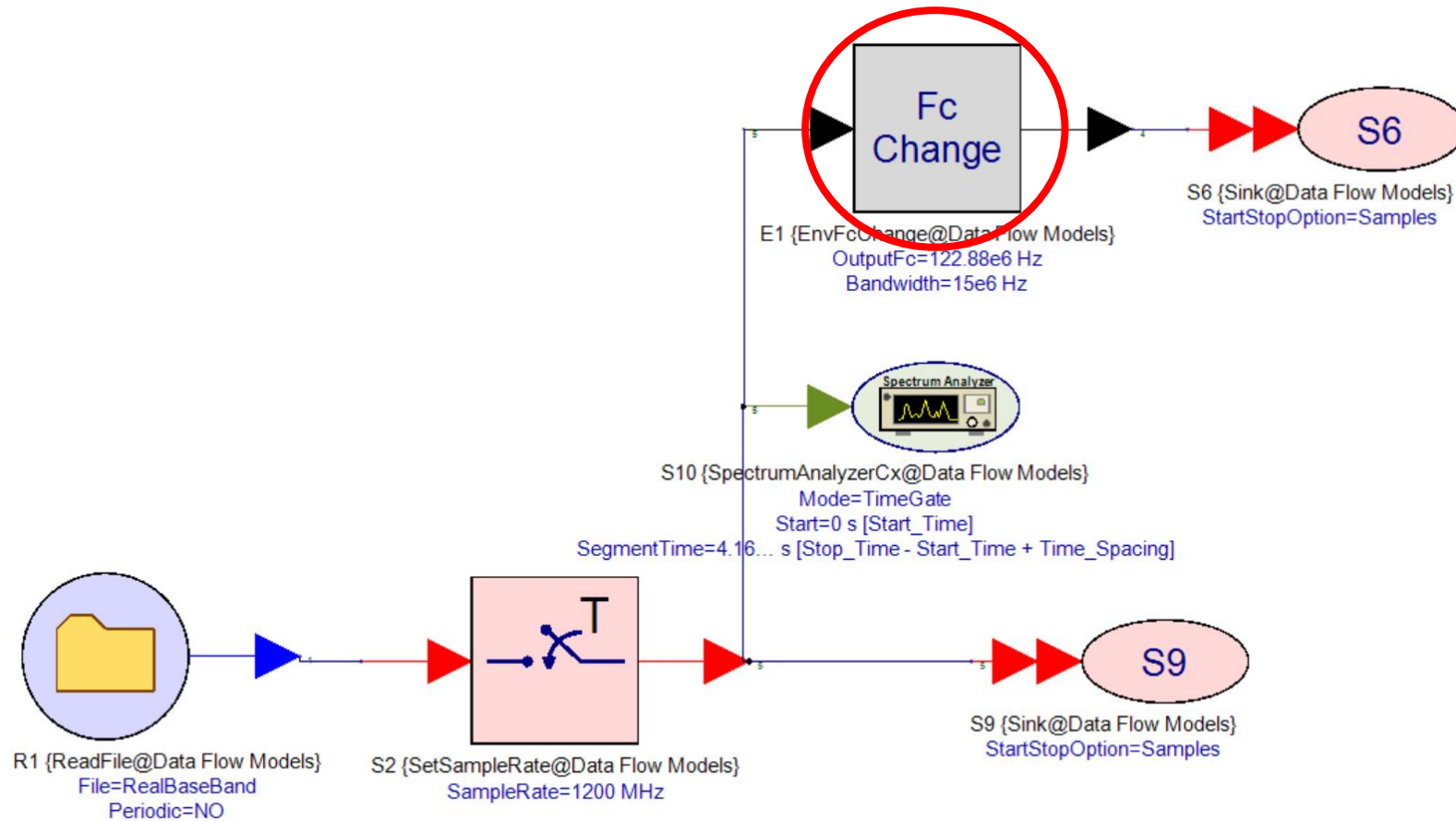
Converting Envelop signal to real base band.



OutputFc = 0 turns the Envelope signal to real Baseband.

Signal representation- Data Flow

Converting Envelop signal to real base band.



Signal representation- Data Flow

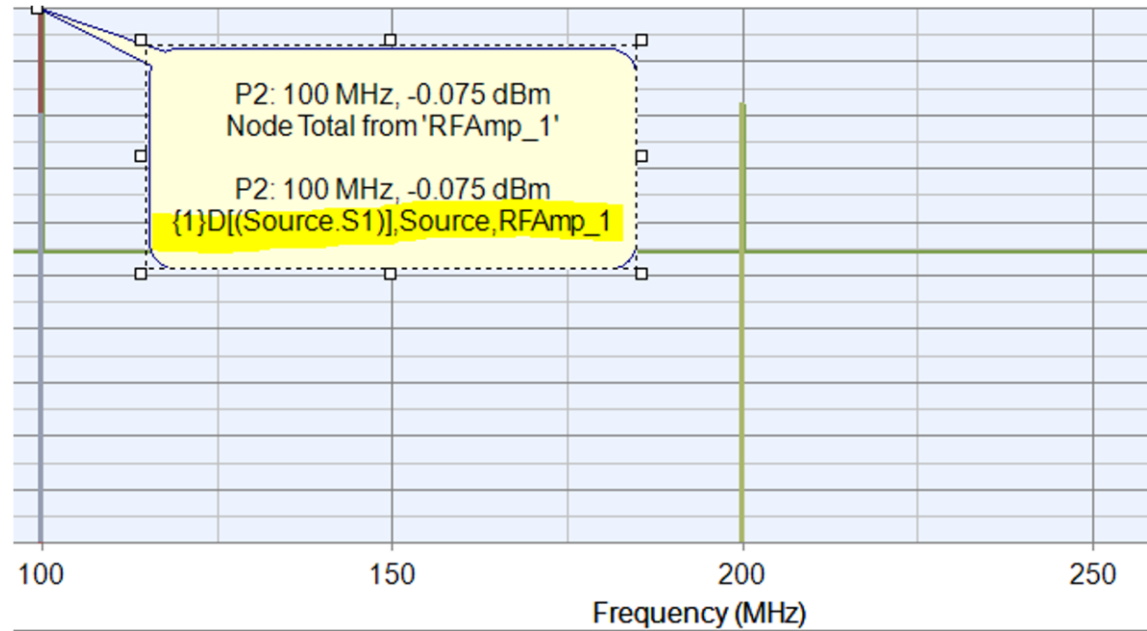
Take Aways

1. SystemVue supports both real baseband and envelope representations
2. It exploits envelope representation to make the simulation speed independent of carrier
3. Most parts in Systemvue are designed to handle envelope signals
4. Characterization frequency is not the carrier frequency but it can be.
5. Envelope is not just amplitude envelope, it is frequency and phase as well.

RF System - Trouble shooting

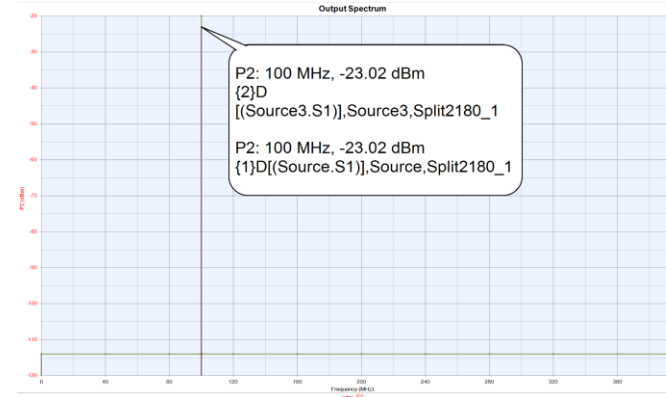
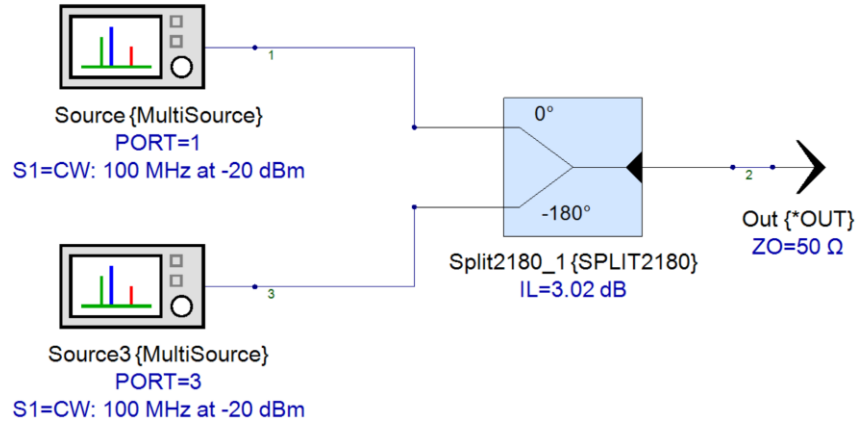
Just some basics first

{coherency #} D [freq eqn],Path

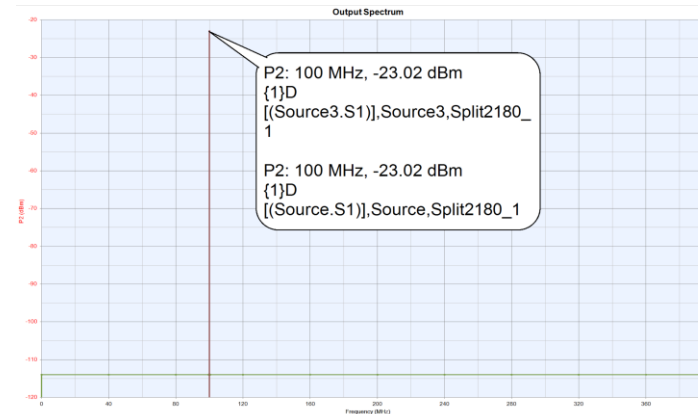
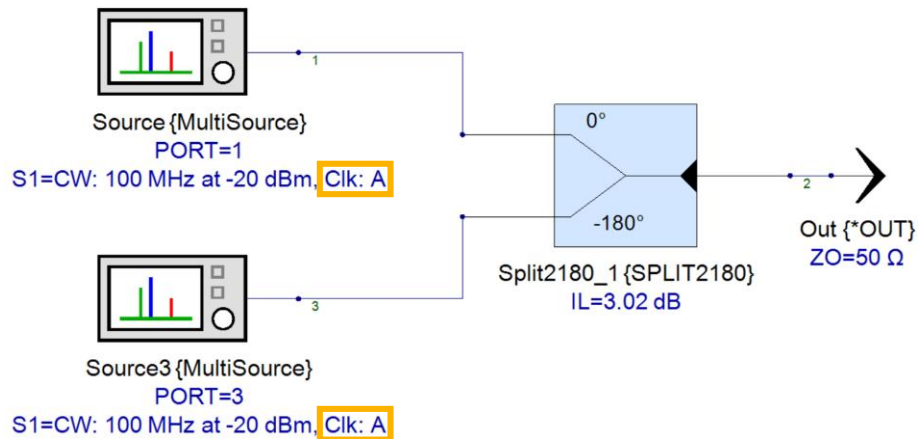


RF System - Trouble shooting

You are expecting the signals to cancel at a point but that does not seem the case.



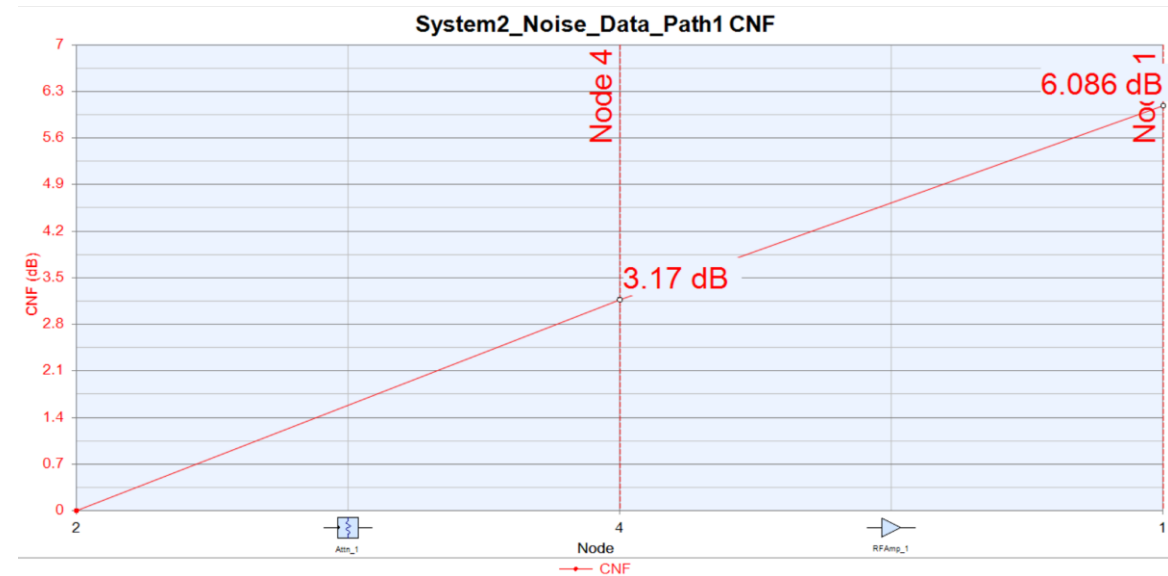
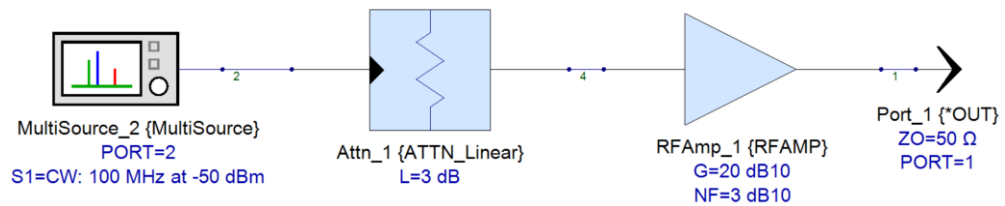
Why are the signals not canceled?



They are coherent
Why are the signals not still canceled?

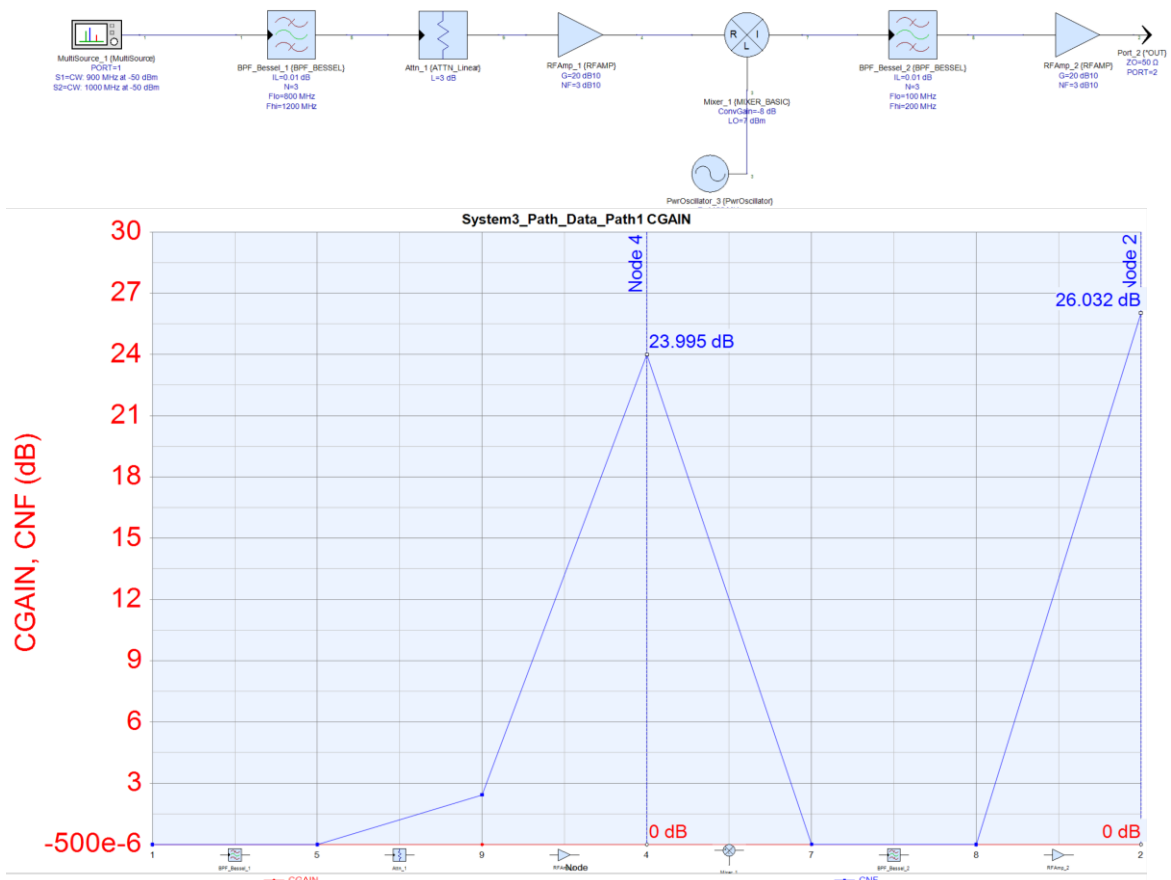
RF System - Trouble shooting

Why am I getting slightly more NF?



RF System - Trouble shooting

What is wrong with the path?



NodeNames	Parts	CF (MHz)	DCP (dBm)	CNP (dBm)	GAIN (dB10)	CGAIN (dB10)	CNDR (dB10)	CNF (dB10)	SDR (dB10)
1	MultiSource_1	100	-300	-152.076	0	0	-147.924	0	170
5	BPF_Bessel_1	100	-300	-157.873	0	0	-142.127	-495.6e-6	170
9	Attn_1	100	-300	-115.231	0	0	-184.769	2.427	170
4	RFamp_1	100	-300	-89.998	0	0	-210.002	23.995	90.221
7	Mixer_1	1000	-300	-141.871	0	0	-160.804	6.373e-3	33.223
8	BPF_Bessel_2	1000	-300	-148.148	0	0	-154.41	988.7e-6	170
2	RFamp_2	1000	-300	-87.954	0	0	-212.046	26.032	81.254

Simulation control through scripting

- A system design is done with a variety of tools.
- SystemVue organically has a lot of efficient and accurate modeling and simulation capability.
- It is highly flexible to easily integrate with other popular simulation and modeling environments
- You will be able to advance your system design by integrating with your own IP in other tools.
- One can control, preprocess and postprocess data by writing equations and scripts within SystemVue.
- One can also control SystemVue simulations from external environments like MATLAB, Visual Basic, C# etc.
- Let us examine MATLAB and Visual Basic.

Simulation control through scripting

Visual Basic

- VB scripts can be used to sequence and automate the simulation of several designs , preprocessing and post processing of equations.
- VB scripting can also be written to develop your own UI for a specific application you may have developed
- There is no need to remember any of the VB functions or syntax.
- VB Browser helps in building the script for automation.

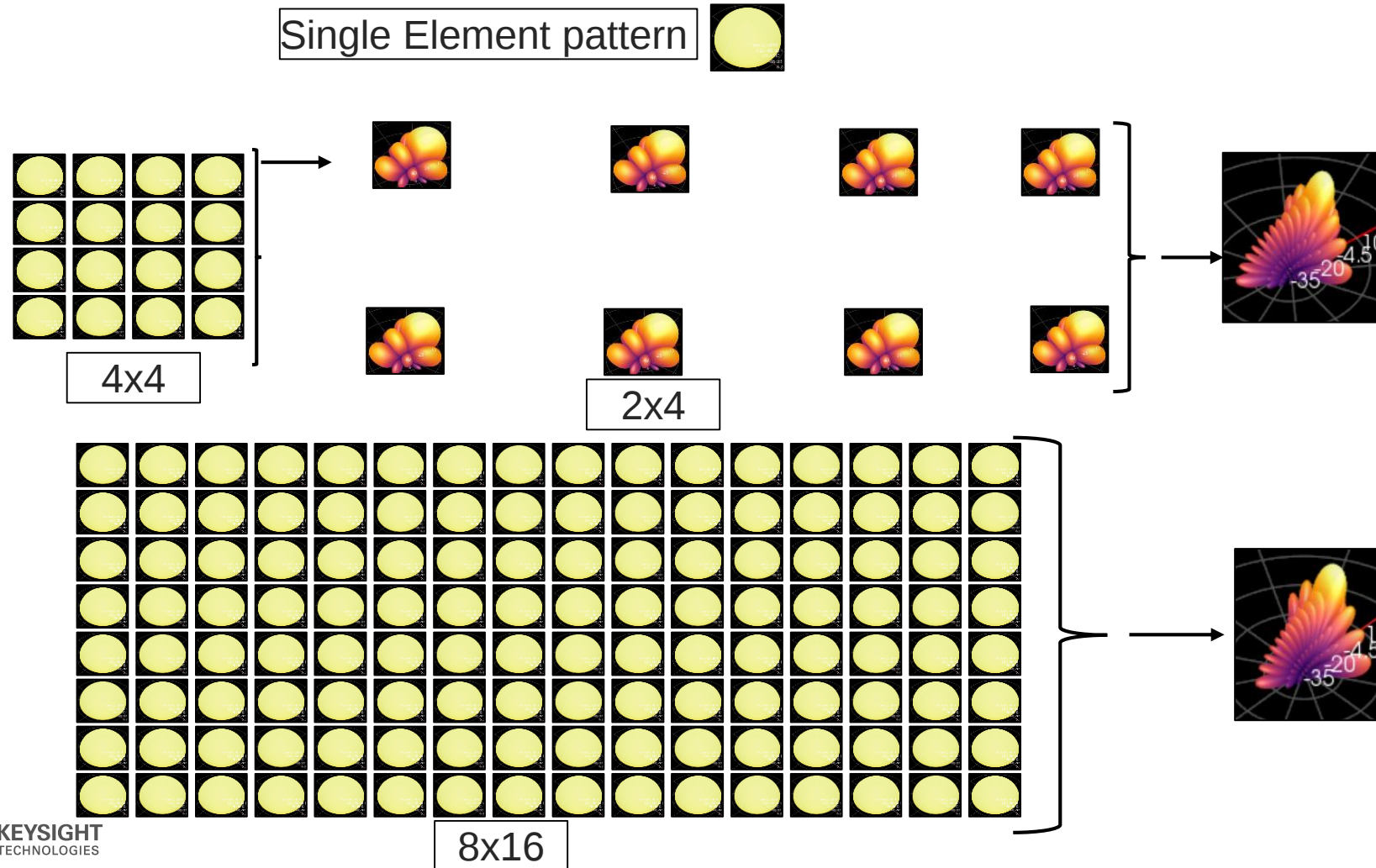
C:\ProgramFiles\Keysight\SystemVue2021\Examples\Tutorials\Simulation_Control_and_Scripting\Scripting\Visual Basic\Browser

 VBBrowser.exe

Simulation control through scripting

Visual Basic

 VBBrowser.exe



To check this concept for various conditions

We have to run three Analyses and two MTALBscripts.

How to automate this?

Simulation control through scripting

Visual Basic

 VBBrowser.exe

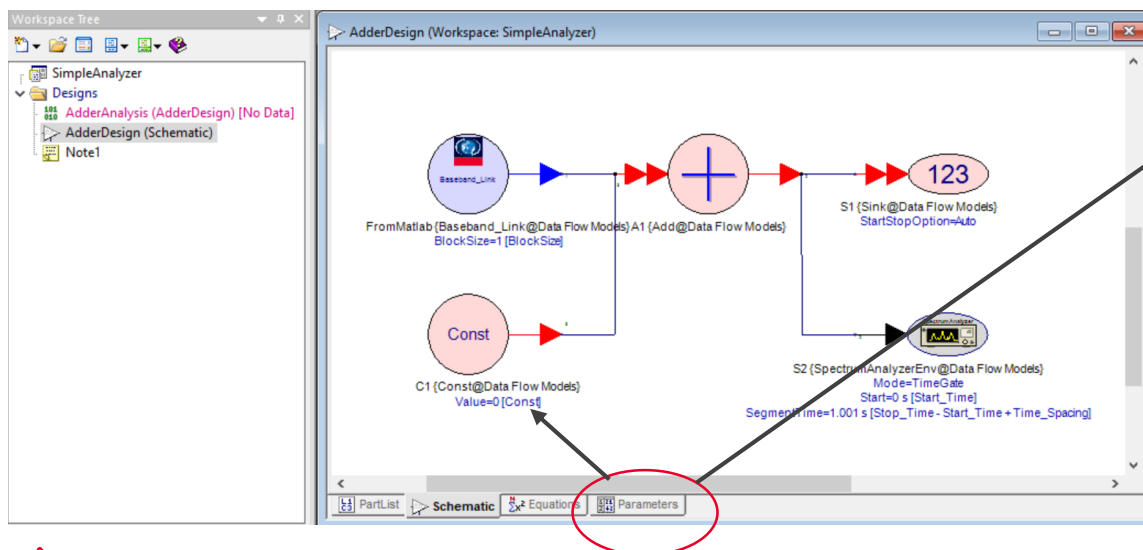
The following script will do the automation. How will I remember all the syntax?

```
Application.Manager.TilingConcept_PhasedArray.[TX Beamforming].PhasedArray1.RunAnalysis()  
Application.Manager.TilingConcept_PhasedArray.[TX Beamforming].Export4x4Patternfor2x4Tiling.Calculate()  
Application.Manager.TilingConcept_PhasedArray.[TX Beamforming].PhasedArray2.RunAnalysis()  
Application.Manager.TilingConcept_PhasedArray.[TX Beamforming].PhasedArray3.RunAnalysis()  
Application.Manager.TilingConcept_PhasedArray.[TX Beamforming].postprocessing.Calculate()
```

Simulation control through scripting

MATLAB

- When SystemVue is interacted from MATLAB we call the link as Baseband Link.
- In general when an external program interacts with SystemVue, it does it through SystemVue Engine (SVE)
- SVE is a faceless (NO GUI) program that can be invoked from other programs.
- Other programs transfer variables, to and from, through the design Parameters of a design.



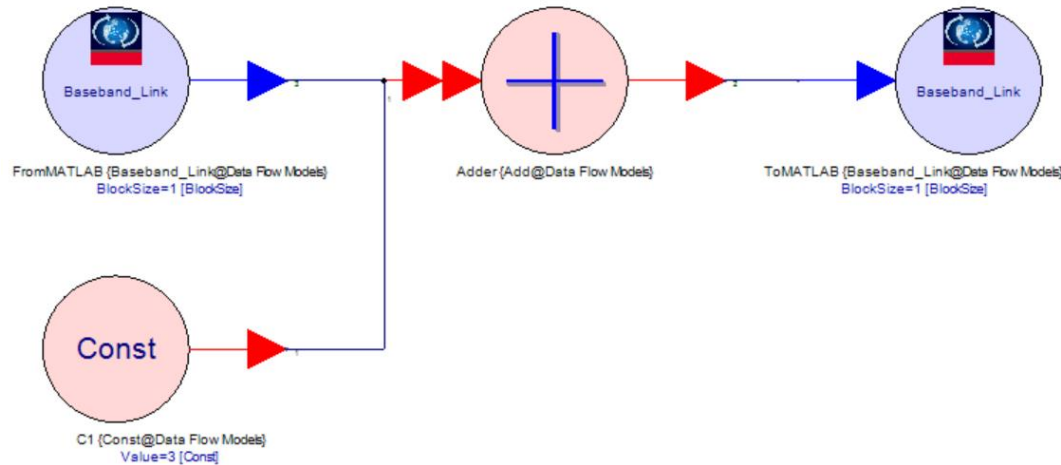
Name	Description	Default Value	Units	Tune	Show	Initially Use Default	Validation	Hide Condition
BlockSize		1	()	☐	☒	☐	Floating point num	
Const		0	()	☐	☒	☐	Floating point num	

```
% Open a workspace from the example area
myWorkspace = SystemVue.openExampleWorkspace('SimpleAdder.wsv')
% Get the analysis
myAnalysis = myWorkspace.analysis('AdderAnalysis')
% Set the design parameter
myAnalysis.param('Const').value = 5
% Execute two iterations of the analysis:
myAnalysis.calculate(7)
myAnalysis.calculate(9)
myAnalysis.stop();
```

Simulation control through scripting

MATLAB

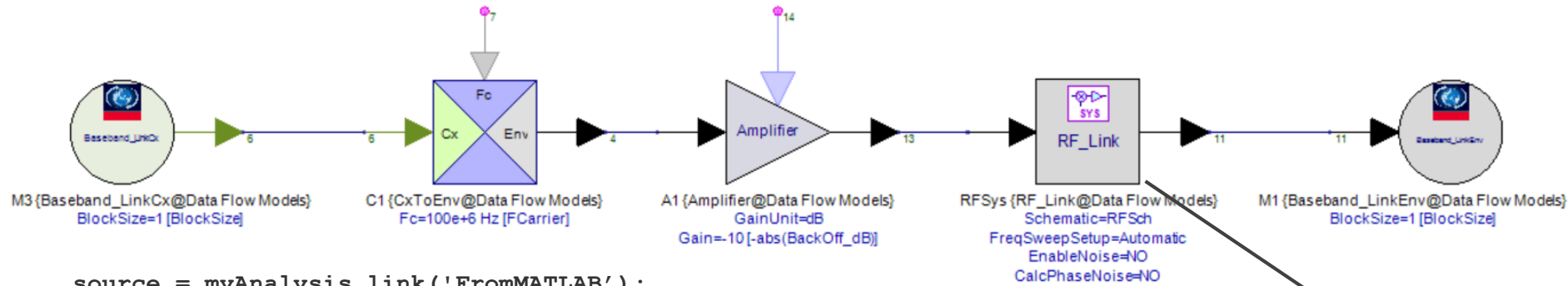
- When SystemVue is interacted from MATLAB we call the link as Baseband Link.
- In general when an external program interacts with SystemVue, it does it through SystemVue Engine (SVE)
- SVE is a faceless (NO GUI) program that can be invoked from other programs.
- Other programs transfer variables, to and from, through the design Parameters of a design.



Simulation control through scripting

MATLAB

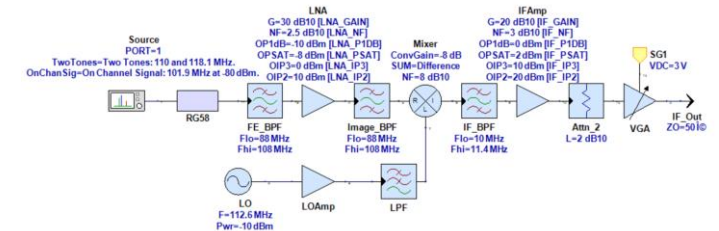
- RF system simulation in SystemVue is very accurate and fast.



```
source = myAnalysis.link('FromMATLAB');  
sink = myAnalysis.link('ToMATLAB');  
data = 1:5;  
result = zeros(1,5);  
myAnalysis.start(); % Execute five iterations of the analysis using setData/getData methods:
```

```
for n = 1:5  
    source.setData(data(n));  
    result(n) = sink.getData();  
    more code in MATLAB ...
```

```
end myAnalysis.stop();
```



Reference Material

SystemVue help

Sample Rate

Contents	Index	Bookmarks	Search
Contents			
Programmer's Guide			
Getting Started			
Users Guide			
Tutorials			
Algorithm Design			
Getting Started with Data Flow			
Understanding Data Flow Simulation			
Single Rate System Tutorial			
Single Rate Scheduling Tutorial			
Multi-Rate System Tutorial			
Multi-Rate Scheduling Tutorial			
CD to DAT Sampling Rate Conversion Tutorial			
Baseband and RF			
Envelope Bandpass Filter			
Baseband IF and RF			
Timed from Schematic			
Timed from SampleRate			
Frequency Response vs Sample Rate			
Filtering vs Sample Rate			
Deadlock			
Sample Rate Inconsistency			

Signal representation

Contents	Index	Bookmarks	Search
Contents			
Programmer's Guide			
Getting Started			
Users Guide			
Tutorials			
Simulation			
Cosimulation			
SystemC			
Distributed Simulation			
Verification Test Bench (VTB)			
SystemVue Engine			
Phased Array			
Data Flow			
About the Data Flow Simulator			
Introduction to Data Flow Simulation			
Setting up the Data Flow Analysis			
Envelope Signal			
Fixed Point Simulation			
Introduction to Dynamic Data Flow Simulation			
Timing Method			
Using Data Types			
RF Design Kit - Spectrasys and WhatIF			
Part Catalog			
Examples			
Search Tips			

Scripting - Visual Basic

Contents	Index	Bookmarks	Search
Contents			
Programmer's Guide			
Getting Started			
Users Guide			
Tutorials			
Algorithm Design			
Hardware Design			
Libraries and Applications			
Measurement Automation			
RF Design			
Simulation Control and Scripting			
Controlling SystemVue from External Programs			
Controlling SystemVue from TAP			
Exploring the Workspace Using Visual Basic			
Running a BER Analysis Controlled From MATLAB or C Sharp			
Running Scripts Using Visual Basic			
Optimizing a Simulation			
Using MATLAB Script For Sequence Control			
Performing a Monte Carlo Analysis on a Design			
Running a Yield Analysis on a Design			
Sweeping a Simulation			
Verification Test Bench Tutorial			
Simulation			
Part Catalog			
Examples			
Search Tips			

Scripting - MATLAB

Contents	Index	Bookmarks	Search
Contents			
Programmer's Guide			
Getting Started			
Users Guide			
Tutorials			
Algorithm Design			
Getting Started with Data Flow			
Understanding Data Flow Simulation			
Single Rate System Tutorial			
Single Rate Scheduling Tutorial			
Multi-Rate System Tutorial			
Multi-Rate Scheduling Tutorial			
CD to DAT Sampling Rate Conversion Tutorial			
Baseband and RF			
Envelope Bandpass Filter			
Baseband IF and RF			
Timed from Schematic			
Timed from SampleRate			
Frequency Response vs Sample Rate			
Filtering vs Sample Rate			
Deadlock			
Sample Rate Inconsistency			
Working with MATLAB and Simulink			
C Plus Plus Model Development			
C Plus Plus Code Generation Tutorial			
Subnetwork Recursion			
Cosimulation with SystemC			

Trouble shooting -RF

Contents	Index	Bookmarks	Search
Contents			
Programmer's Guide			
Getting Started			
Users Guide			
Tutorials			
Simulation			
Cosimulation			
SystemC			
Distributed Simulation			
Verification Test Bench (VTB)			
SystemVue Engine			
Phased Array			
Data Flow			
RF Design Kit - Spectrasys and WhatIF			
Spectrasys			
Design Kit Spectrasys			
Spectral Propagation and Root Cause Analysis			
Spectrasys Fundamentals			
Intermods			
Advanced Spectrasys			
Spectrasys Measurement Index			
Using Spectrasys Designs in Data Flow Schematics			
Troubleshooting			
Dialog Box Reference			
WhatIF Frequency Planner			
Linear Analysis			
Part Catalog			
Examples			
Search Tips			

Keysight EesofEDA Field AE Tips

<https://www.youtube.com/channel/UCjei4Ohw-ePx0SqtwkRc02g/>

Bhargava's Arena

<https://www.youtube.com/channel/UCuo4ZHW4J5k0EmuyKG8kYEA>

Al's Tech briefs Corner
[Click here](#)

AI's Tech Briefs Corner

[Writing Scripts in SystemVue and Genesys](#)

[Best Practices Working With Large Data](#)

[When Desired Signals Become Undesired](#)

[RF System Level optimization tutorial](#)

[Sweeping S-Data Files](#)

[Sweeping Filter Coefficients](#)

[Using MATLAB Functions](#)

[Making your own templates in SystemVue and Genesys](#)

[Waveform Sequence Composer](#)

[The Quickest Way to Reflection Measurements](#)

[Dataset content from Phased Array Simulation in SystemVue](#)

[Reading in Complex data into SystemVue](#)

[Linear simulation engine available in SystemVue 2020](#)

[Reading various file formats into SystemVue](#)

[Sweep plot to facilitate readability of Spectrums under swept input](#)

[Using X-parameter data in SystemVue and Genesys](#)

[Displaying Variables on the Schematic](#)

[Tracking desired signals that change frequency](#)

[How to Write CSV with SystemVue and Genesys](#)

[Intermod Measurements](#)

[Interpolating data with interp function in SystemVue and Genesys](#)

[Creating custom warnings errors info messages in SystemVue and Genesys](#)

[Matrix Signals](#)

[Measuring the Peak Power of a Pulse in SystemVue](#)

[Moving Around file system](#)

[SystemVue and Genesys Options Dialog](#)

[Way Better than a Spreadsheet](#)

[Reading Data from a Virtual Vector Signal Analyzer](#)

[Creating a custom model in SystemVue or Genesys](#)

[Creating an X-parameter model in SystemVue or Genesys](#)

[How to use Dynamic Graphs in SystemVue](#)

[Digital to Analog Converter in SystemVue](#)

[Dynamic symbols in SystemVue and Genesys](#)

[Putting Matlab functions into a library for re-use](#)

[Exporting data to Excel](#)

[FcChange](#)

[Implementing the Friis Equation](#)

[Histograms in SystemVue](#)

[Datasets in SystemVue and Genesys](#)

[Introduction to Looping in scripts written in SystemVue and Genesys](#)

[Script based autoloading of S-parameter files in SystemVue and Genesys](#)

[File based models in SystemVue and Genesys](#)

[Use of Matlab with SystemVue and Genesys](#)

[Measuring Band Power with Dynamic Graphs in SystemVue](#)

[Mixer Noise Figure](#)

[Mismatch Loss In RF System with SystemVue and Genesys](#)

[Phase Noise best practices for SystemVue and Genesys](#)

[Interpolating Data in Two Dimensions](#)

[How to import a P2D file into SystemVue Genesys](#)

[Creating Buses in SystemVue or Genesys](#)

[Another Way to Plot Gain Compression](#)

[Creating buttons in SystemVue or Genesys](#)

[How SystemVue Genesys Libraries Work](#)

[Making A Realistic Source Model](#)

[nonlinear behavioral model](#)

[Introduction to SystemVue simulators](#)

[Modeling with S2D files imported into SystemVue or Genesys](#)

[Calculating IP3 with only one input tone](#)

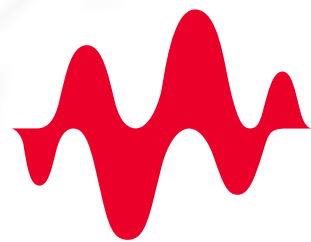
[Modeling a digitally tuned capacitor](#)

[Using Direct Digital Synthesis to create a signal in SystemVue and Genesys](#)

[Survey on different methods to read/write files in SystemVue or Genesys](#)

[Building a behavioral Mixer Model](#)

PS: You will need access to Keysight's Knowledge Center.



KEYSIGHT
TECHNOLOGIES