

ANSOFT CORPORATION PRESENTS:



PARTNERS IN DESIGN



WORLDWIDE TECHNICAL WORKSHOPS

Ultrawideband Radio Design CMOS Antenna Switch

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CMOS UWB Antenna Switch

Designing UWB Switches using Ansoft Designer RFIC Design Kit

- Initial Design using UMC Design Kit
- Tuning on Designer
- Performance Optimization in Designer
- Physical Design procedure
- Results
 - Linear Analysis
 - Time Domain Analysis
 - Harmonic Balance Analysis
 - Corner Analysis
 - etc...
- Conclusion

Tx/Rx Switch

The ***Tx/Rx switch*** provides a time-division duplexing function to select between the transmit and receive modes. The switch shall meet or exceed the specifications as stated in Table. ***The in-band insertion loss must be minimized to maintain receiver noise figure. The Tx/Rx isolation must be maximized to prevent desensitizing and/or damaging the receiver.***

Parameter	Specification
Frequency Range	3.1 – 4.8 GHz
Insertion Loss	<0.5 dB
Isolation	>20 dB
Switching/Settling Time	<=2 ns
Maximum Input Power	20dBm
ESD Survivability	1000V

CMOS Antenna Switch Top View

Global Nodes For Bias/Switch/Pad

Switch Module

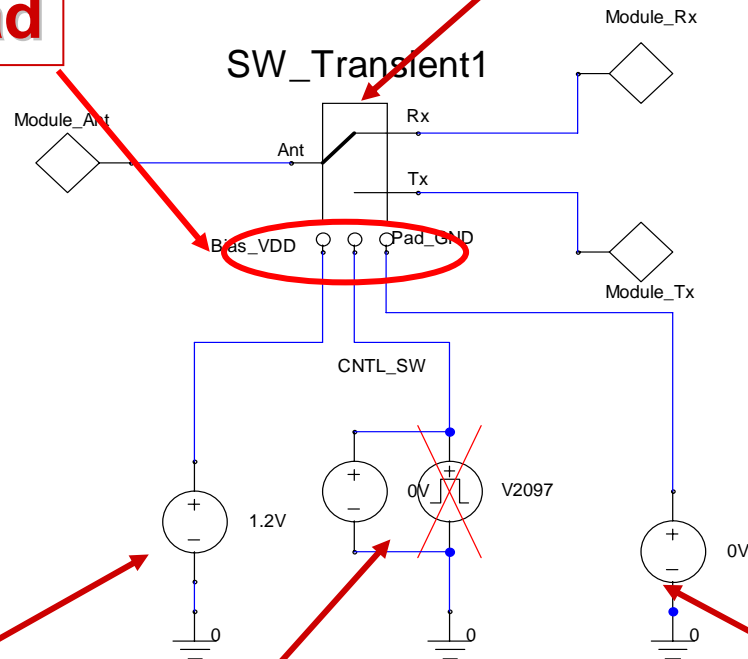
4.8GHz TX/RX Antenna Switch

Technology File



```

coremos_corner=ff
iomos_corner=tt
cirspl_case=typ
sqskspl_case=typ
mimcap_case=typ
varmis12_case=typ
varmis33_case=typ
vardio_case=typ
nnp_vn_case=typ
nnp_vs_case=typ
pnp_vn_case=typ
rnhr_case=typ
rnpo_case=typ
rnppo_case=typ
diopn_esd_case=typ
diop_esd_case=typ
pad_rf_case=typ
    
```



Bias for Inverter

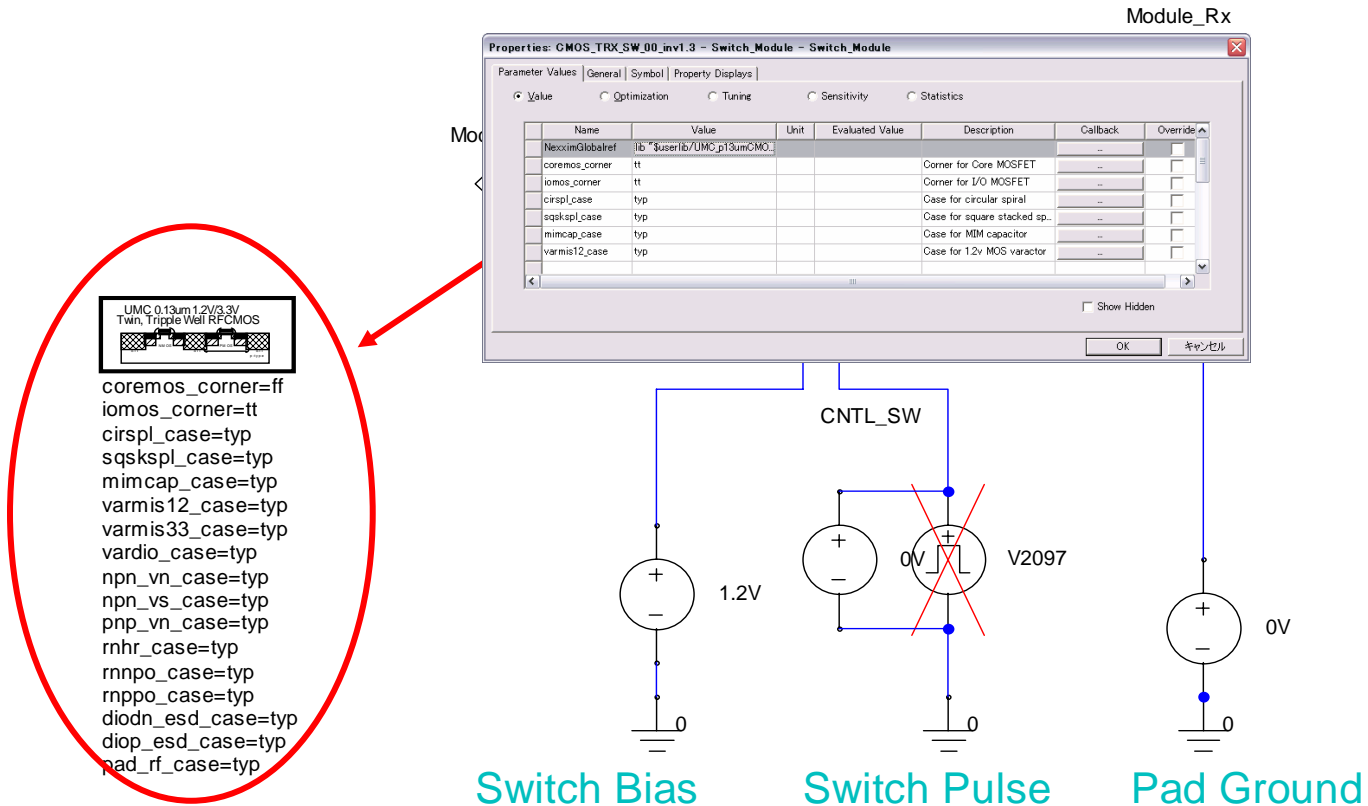
Pulse Control for Switch

Pad Ground

Reference: Integrated CMOS Transmit-Receive Switch Using LC-Tuned Substrate Bias for 2.4-GHz and 5.2 GHz Applications

Interfacing to Technology File

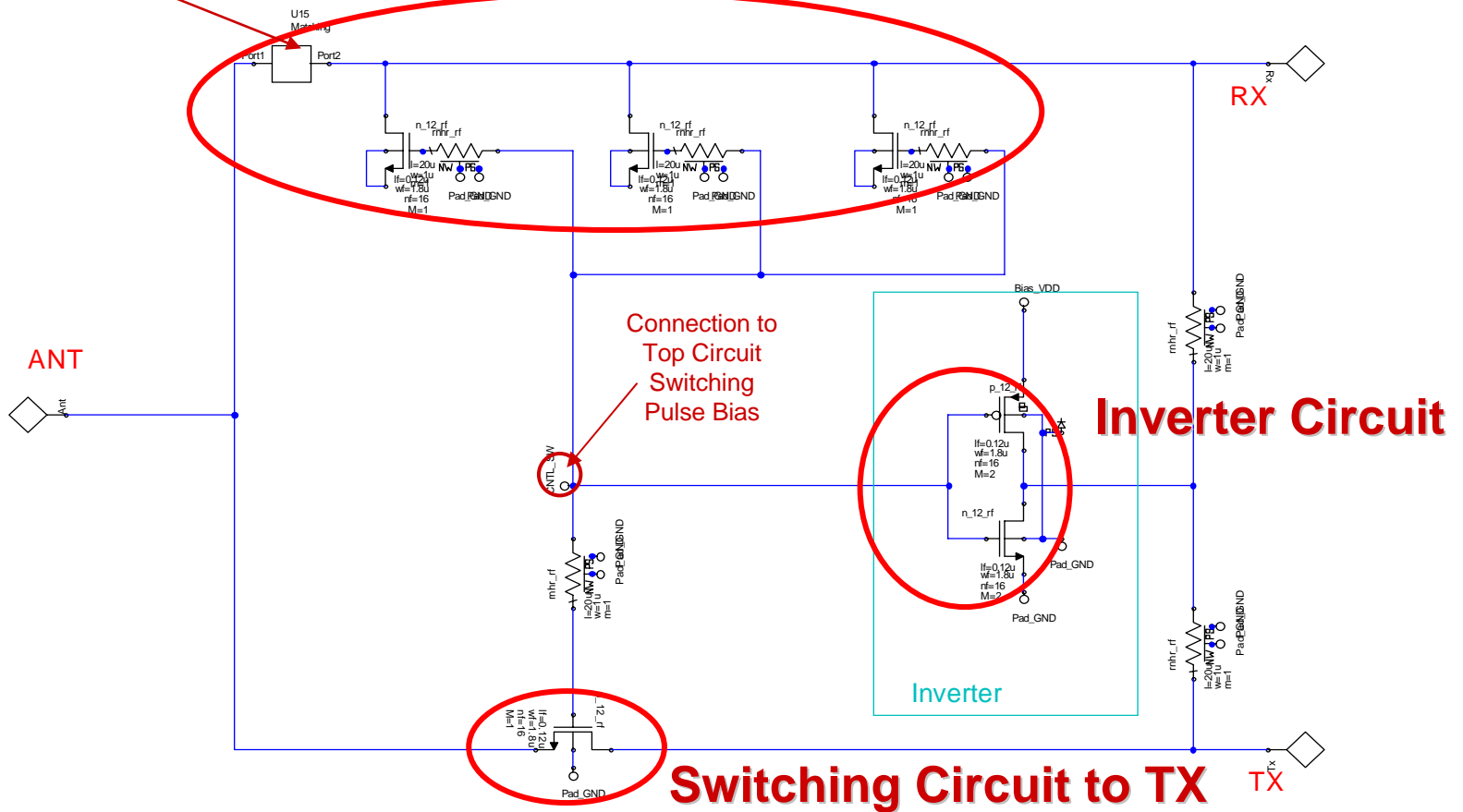
3.1GHz -4.8GHz TX/RX Antenna Switch



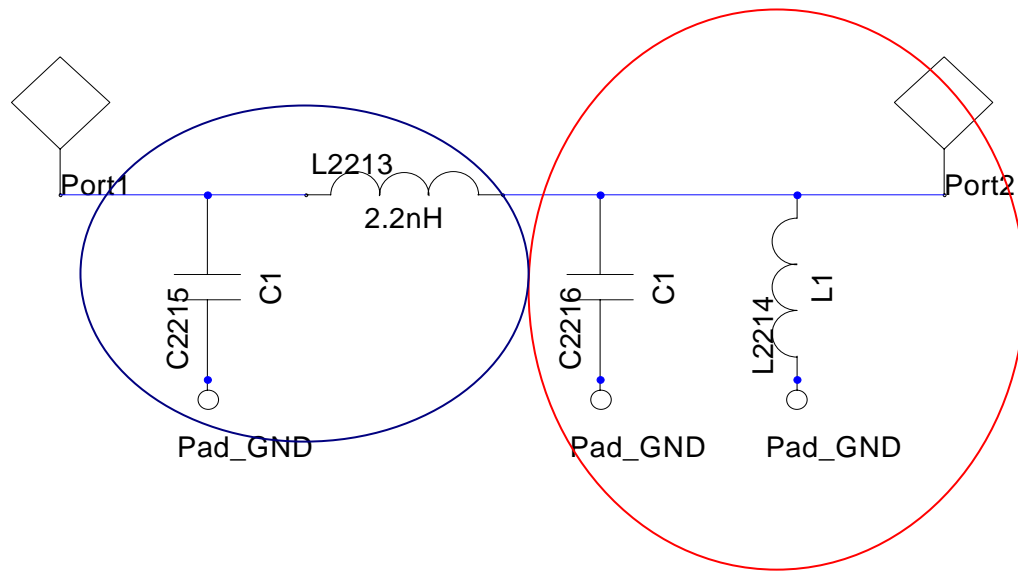
CMOS Switch Module

Matching Circuit to RX/TX (Control Insertion Loss)

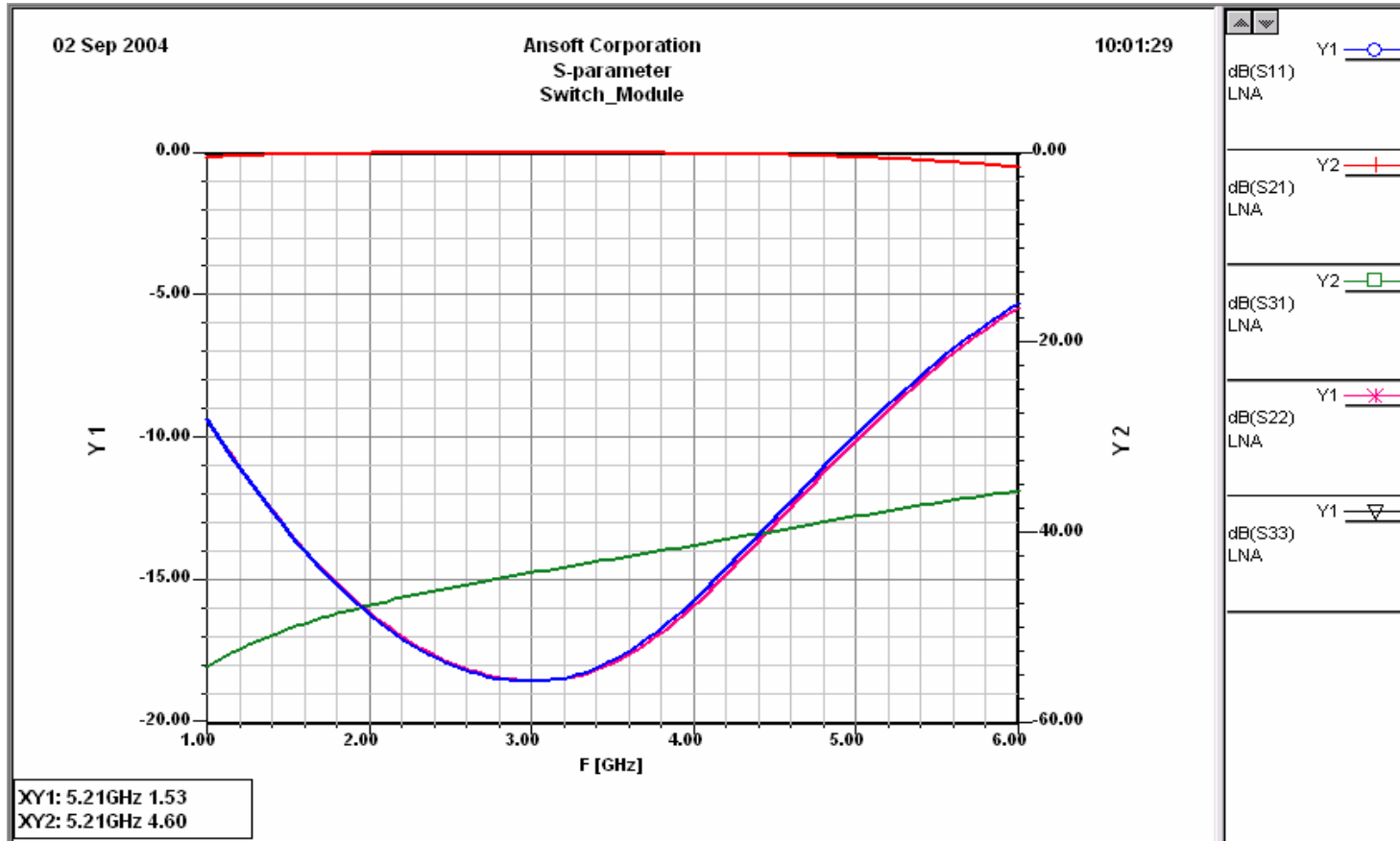
Passive Matching Circuit



Passive Matching Circuit (Ideal Circuit)



Linear Performance of the Antenna Switch



Setting up for Tuning

The screenshot displays the Ansoft Designer/Nexxim ALPHA software interface. The main workspace is divided into several panes:

- Top Left:** Project tree showing a hierarchy of components including Excitations, Ports, Analysis (LNA, Transient, Optimetrics, Results), and Definitions.
- Top Middle:** Schematic diagram of a 3.1GHz-4.8GHz TX/RX Antenna Switch, showing components like SWL_Transient1, Switch Bias, Switch Pulse, and Fall Ground.
- Top Right:** Another schematic view of the same circuit.
- Bottom Left:** A table of parameter values for the S-parameter analysis, circled in red. The table lists parameters L1, C1, Pin, L2, C2, and Status.
- Bottom Middle:** An S-parameter plot showing the magnitude of S11 and S22 versus frequency (F [GHz]).
- Bottom Right:** A detailed schematic of the antenna switch circuit, showing components like L2213, L2, C2215, C2, C1, L1, and L211.

The status bar at the bottom indicates "Number of selected items: 1".

Name	Value	Units
L1	L1	
C1	C1	
Pin	0	dBm
L2	L2	
C2	C2	
Status	Active	

Real Time Tuning on Filters

The screenshot displays the Ansoft Designer/Nexxim ALPHA software interface. The main window shows a circuit schematic for a filter. A 'Tune - Switch_Module' dialog box is open, allowing for real-time tuning of component values. The dialog includes a 'Real Time' checkbox, a 'Sim. Setups' list with 'Transient' selected, and four variable sweep controls: L1 (nH), C1 (pF), L2 (nH), and C2 (pF). The current values are 15, 0.75, 3.3, and 0.75 respectively. A 'Tune' button is visible. Below the dialog, a graph shows the filter's response, and a schematic diagram of the filter is displayed. The bottom status bar indicates 'Start tuning analysis on the design.'

Name	Value	Unit
L1	L1	
C1	C1	
Pin	0	dBm
L2	L2	
C2	C2	
Status	Active	

Optimizing for Performance

Setup Optimization

Goals Variables General

Optimizer:

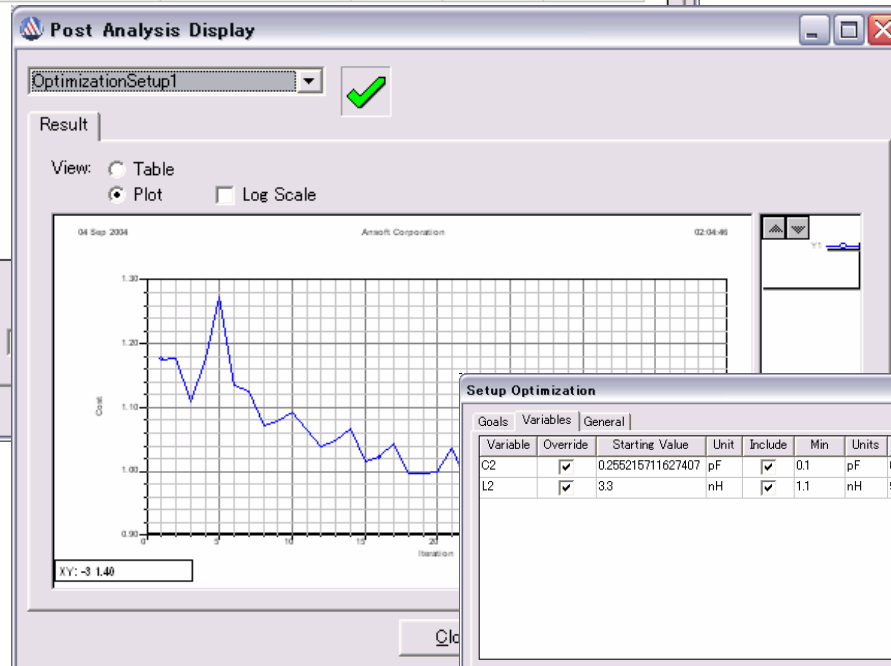
Max. No. of

Cost Function

Solution	Calculation	Calc. Range	Condition	Goal	Weight
LNA	dB(S31)	F(From 2GHz to 7GHz)	>=	[-0.5]	[1]

Add Delete

Acceptable Cost: Noise:



Setup Optimization

Goals Variables General

Variable	Override	Starting Value	Unit	Include	Min	Units	Max	Units	Min Step	Units	Max Step	Units
C2	<input checked="" type="checkbox"/>	0.255215711627407	pF	<input checked="" type="checkbox"/>	0.1	pF	0.75	pF	0.005	pF	0.05	pF
L2	<input checked="" type="checkbox"/>	33	nH	<input checked="" type="checkbox"/>	1.1	nH	9	nH	0.022	nH	0.22	nH

Linear Constraint... << Advanced

OK キャンセル

Optimizing for Dual states (RX/TX)

The screenshot displays the Ansoft Designer/Nexxim ALPHA - TX interface. The main workspace shows two circuit diagrams: TX (top) and RX (bottom). The TX diagram includes components like Switch Bias, Switch Pulse, and Pair Ground. The RX diagram shows a similar structure with an input port. A 'Setup Optimization' dialog box is open, showing the optimizer set to 'Quasi Newton' with a maximum of 1000 iterations. The cost function table is as follows:

Solution	Calculation	Calc. Range	Condition	Goal	Weight
LNA	dB(S21)	F(From 3GHz to 6GHz)	>=	[-0.5]	[1]
LNA	dB(S46)	F(From 3GHz to 6GHz)	>=	[-0.5]	[1]

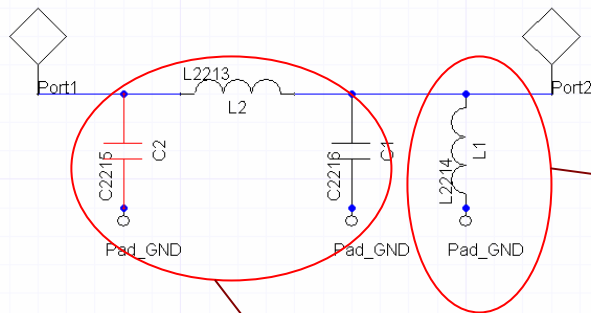
The 'Properties: CMOS_TRX_SW_00_inv1.4 - Switch_Module' dialog box is also open, showing the 'Value' tab. The table below lists the optimized values for the passive filter components, which are circled in red:

Name	Value	Unit	Evaluated value	Description	Read-only	Hidden
FF	3.5	GHz	3.5GHz		<input type="checkbox"/>	<input type="checkbox"/>
L1	7.99952	nH	7.99952nH		<input type="checkbox"/>	<input type="checkbox"/>
C1	0.42701098989859	pF	0.42701098989859pF		<input type="checkbox"/>	<input type="checkbox"/>
L2	2.31785897491806	nH	2.31785897491806nH		<input type="checkbox"/>	<input type="checkbox"/>
C2	0.48302047093626	pF	0.48302047093626pF		<input type="checkbox"/>	<input type="checkbox"/>

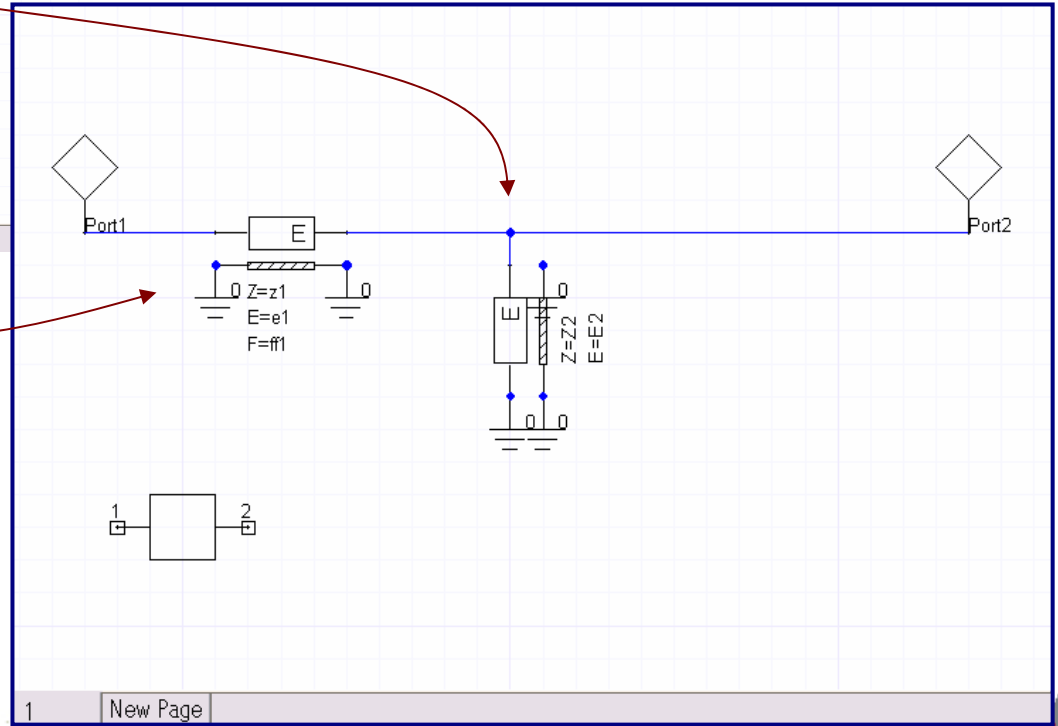
*Optimized Values for the
Passive filter*

How to realize Series/Shunt inductors

Original Lumped Circuit

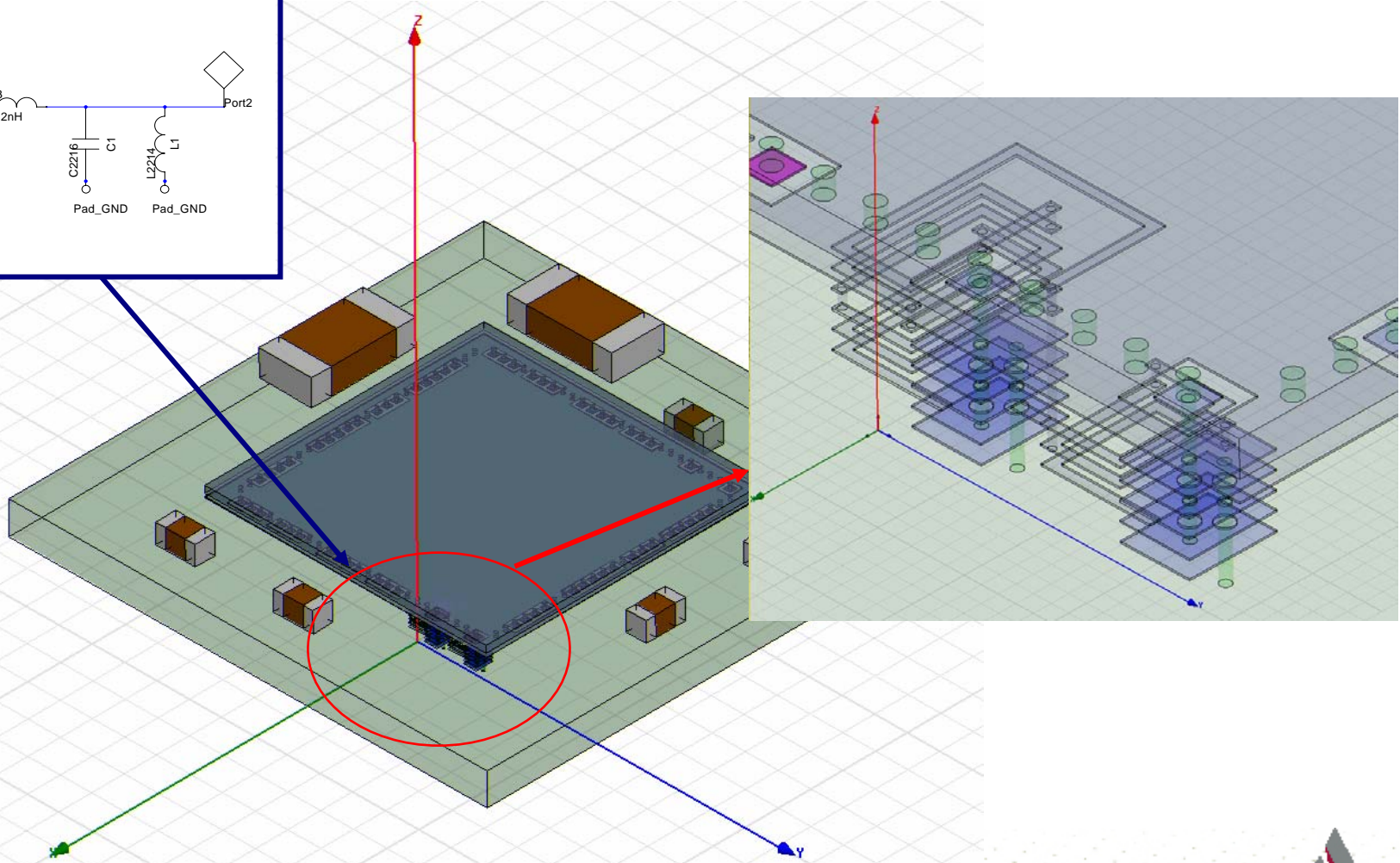
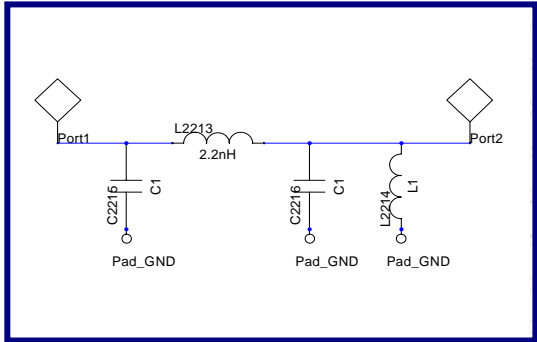


Modified TRL Circuit



**Performance Changes
But gives fairly good
results**

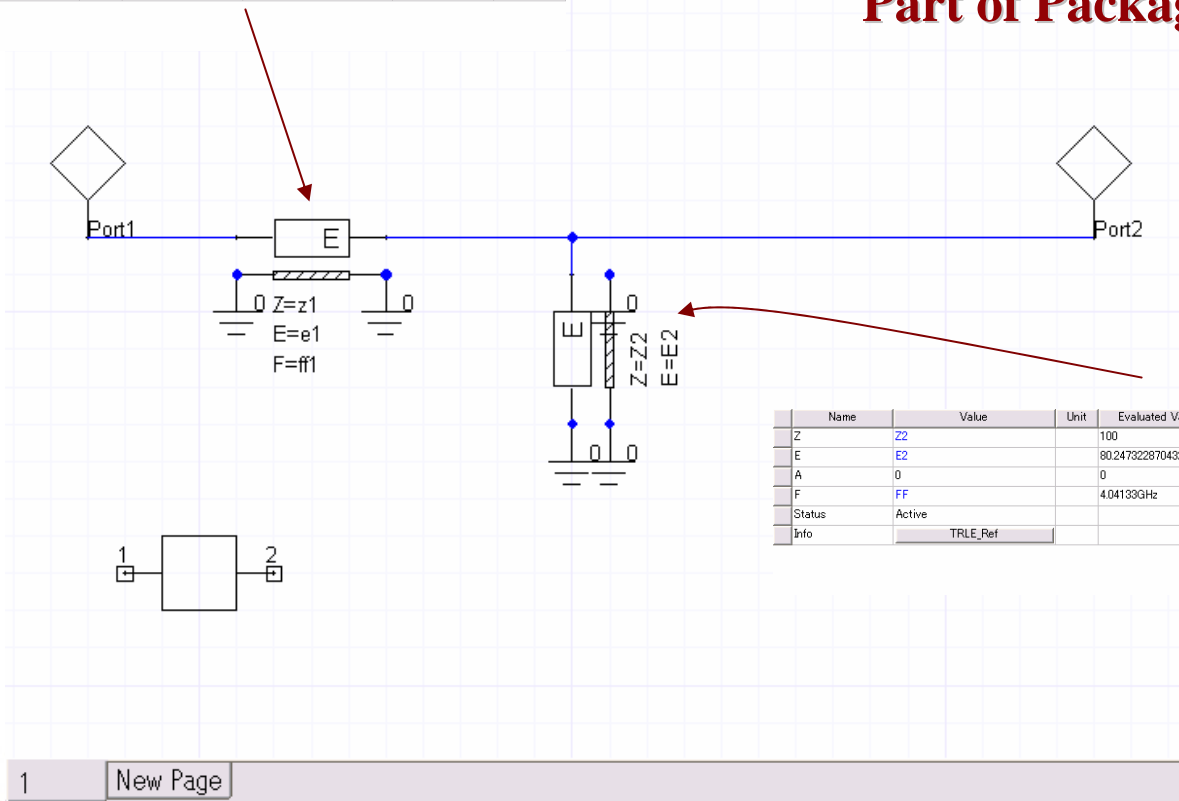
Physical Realization by using Package LTCC



Parameters Needed

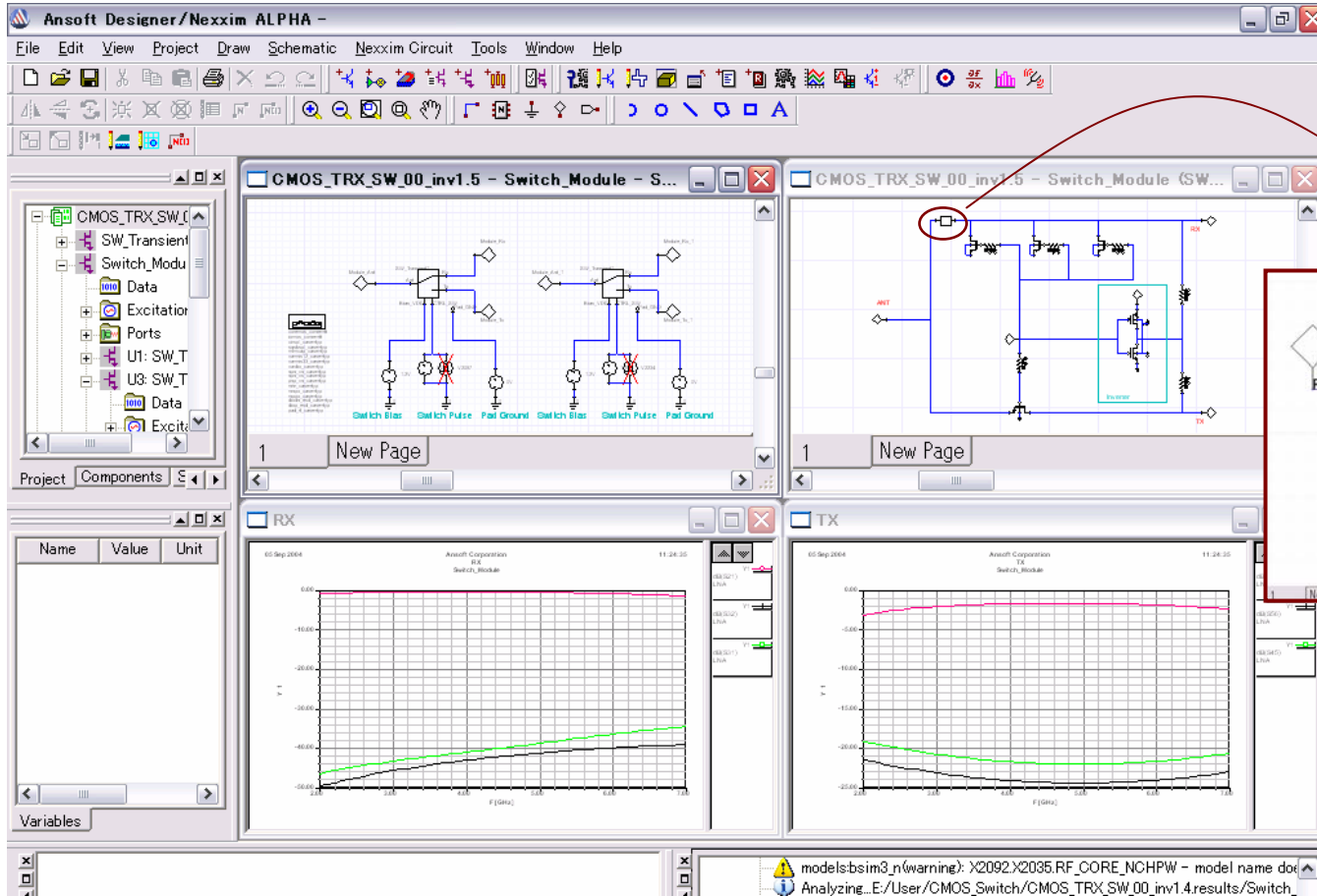
Name	Value	Unit	Evaluated Value	Description	Callback	Override
Z	z1		64.0127	Characteristic impedance	-	<input checked="" type="checkbox"/>
E	e1		83.326971019261deg	Electrical length	-	<input checked="" type="checkbox"/>
A	0		0	Attenuation at F	-	<input type="checkbox"/>
F	ff1		4.51304GHz	Reference frequency for E ...	-	<input checked="" type="checkbox"/>
Status	Active				-	<input type="checkbox"/>
Info	TRLE_Ref				-	<input type="checkbox"/>

Those parameters can be changed to physical parameters such as using Part of Package Lines



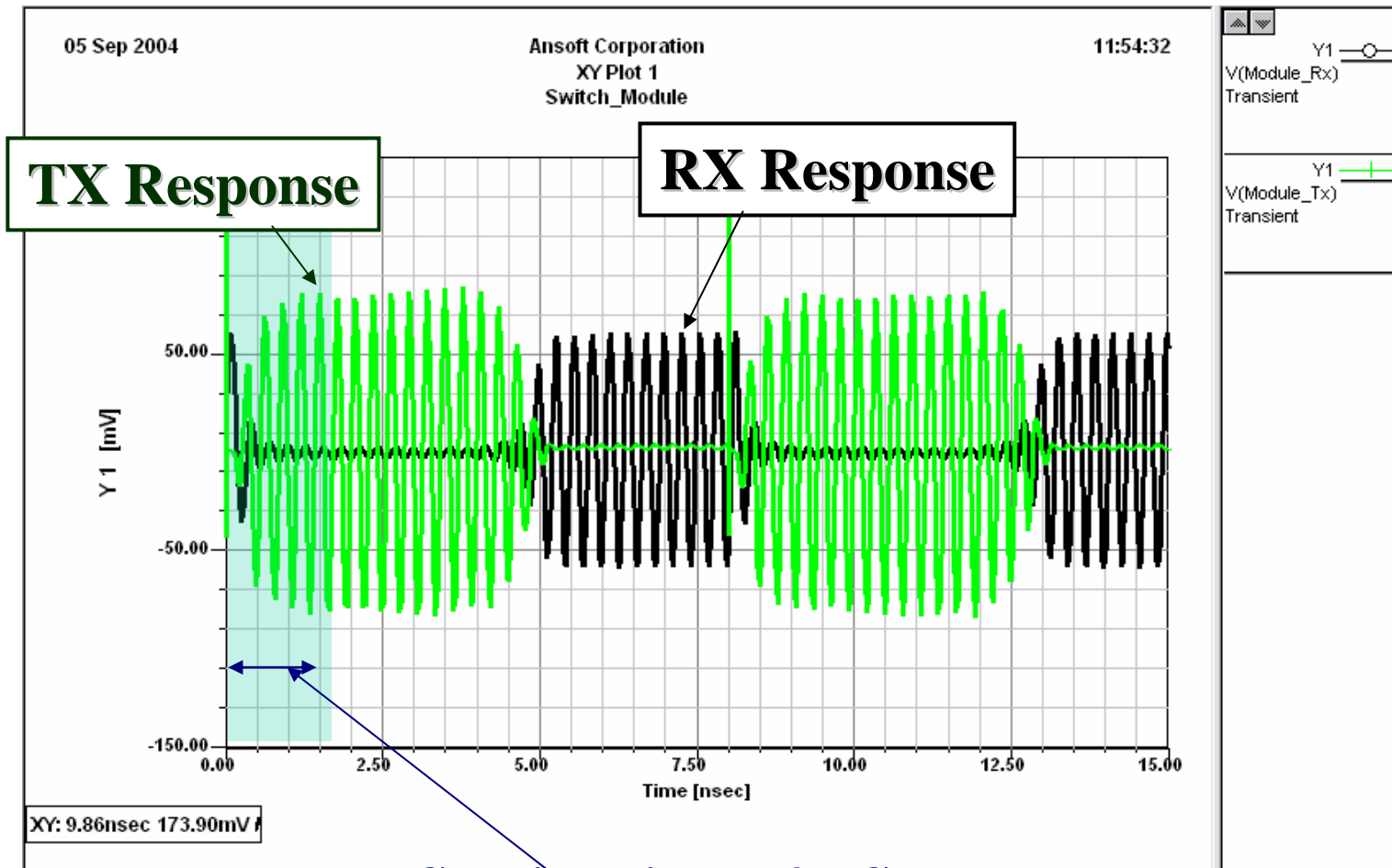
Name	Value	Unit	Evaluated Value	Description	Callback	Override
Z	Z2		100	Characteristic impedance	-	<input checked="" type="checkbox"/>
E	E2		80.24732228704328deg	Electrical length	-	<input checked="" type="checkbox"/>
A	0		0	Attenuation at F	-	<input type="checkbox"/>
F	FF		4.04133GHz	Reference frequency for E ...	-	<input checked="" type="checkbox"/>
Status	Active				-	<input type="checkbox"/>
Info	TRLE_Ref				-	<input type="checkbox"/>

New Performance of the Antenna Switch



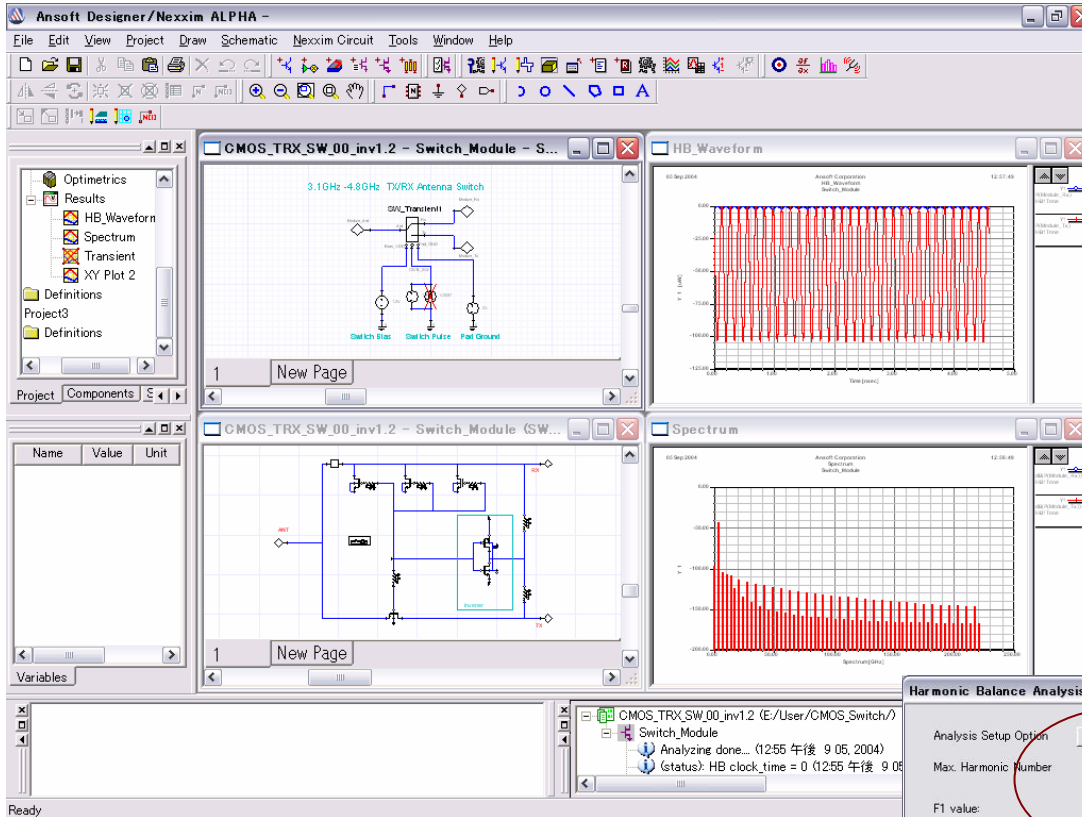
Receiver . Antenna IL is achieved <-0.5dB
Transmitter . Antenna IL is slightly worse than Specification
Isolations are achieved

Transient Response with Pulse Switch

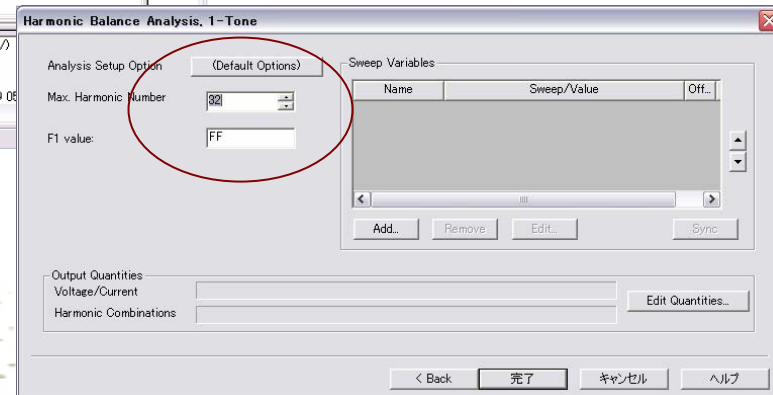


Settling time $< 2\text{n Sec}$
Meeting Specification

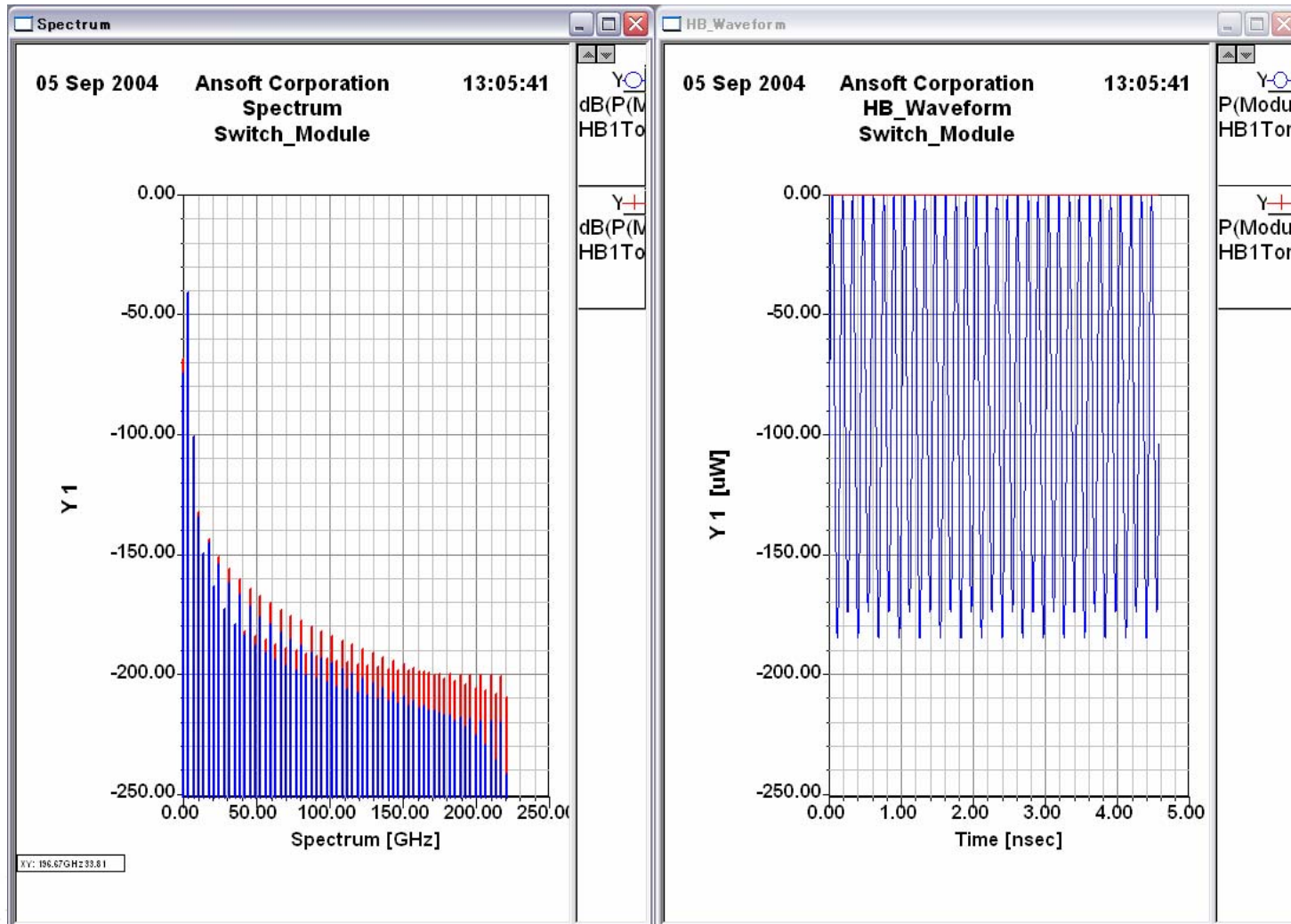
Analyzing in Harmonic Balance for Steady State Conditions



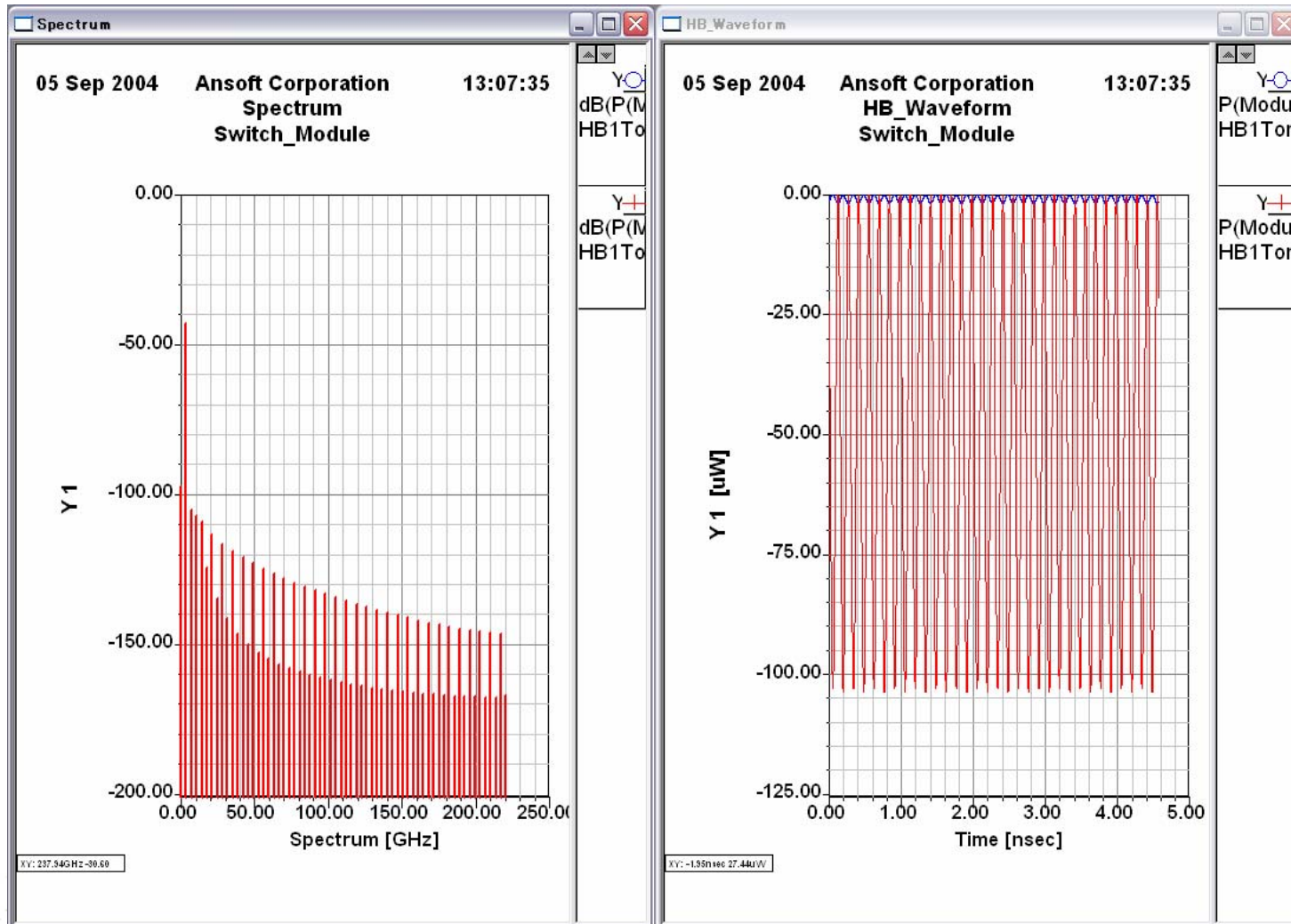
No Limitation to the Number of Harmonics!!



Results of Harmonic Balance Analysis (RX:ON TX:OFF)

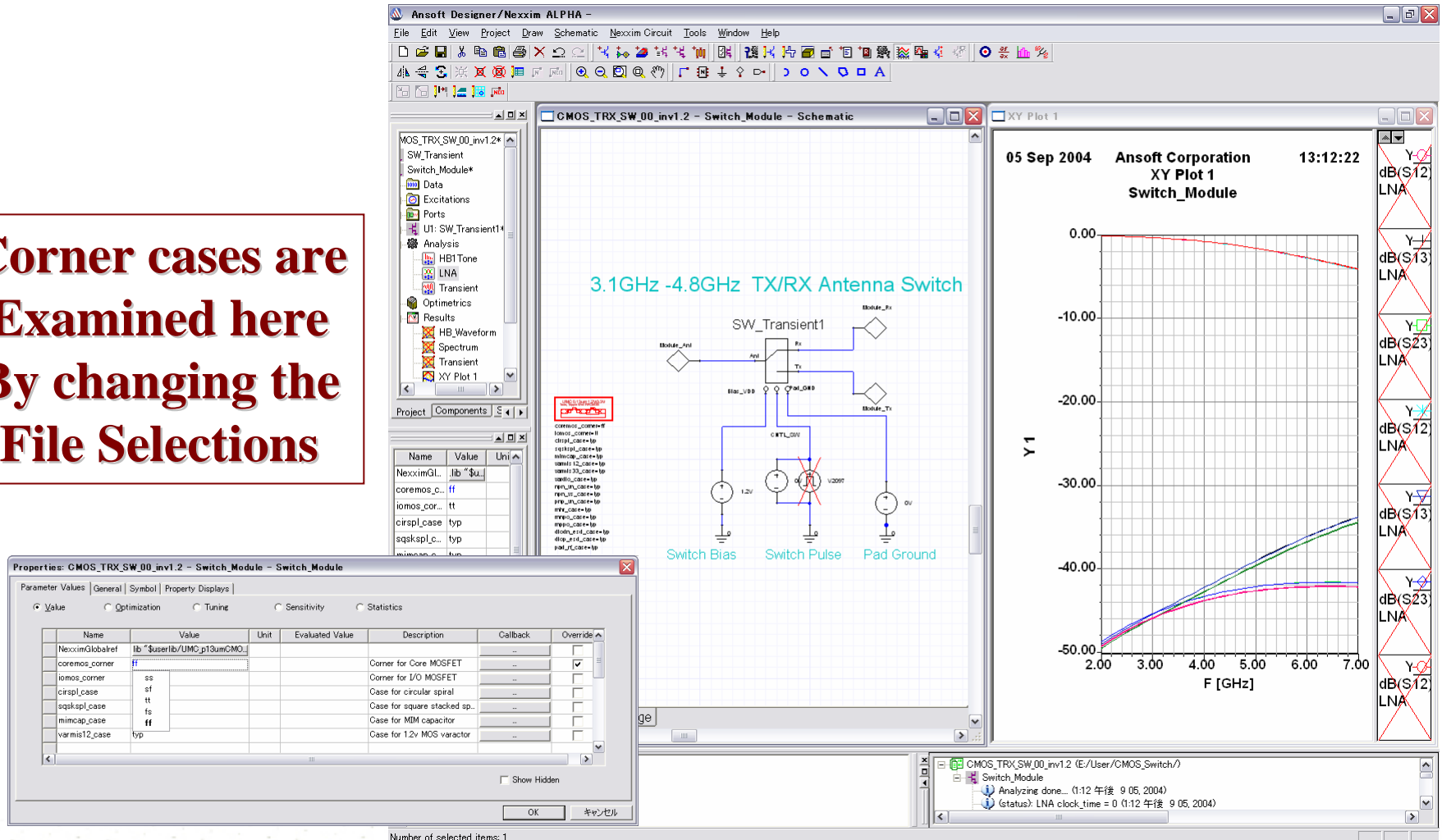


Results of Harmonic Balance Analysis (RX:OFF TX:ON)



Corner Analysis

Corner cases are Examined here By changing the File Selections



Conclusion

- ◆ **UWB Antenna Switch** has been examined using UMC Design Kit (*Ansoft Designer/Nexxim Version 2.1*)

Reference : Integrated CMOS Transmit-Receive Switch Using LC-Tuned Substrate Bias
for 2.4-GHz and 5.2 GHz Applications

- ◆ *Tuning* on *Designer Version 2.1*
- ◆ *Performance Optimization* on *Designer Version 2.1*
- ◆ Physical Design procedure
- ◆ Results
 - ◆ Linear Analysis
 - ◆ Time Domain Analysis
 - ◆ Harmonic Balance Analysis
 - ◆ Corner Analysis
 - ◆ etc...
- ◆ *Integrated Design Flow* in *Designer Version 2.1*, the superior performance of the simulation technology, gives
 - ◆ Freedom to change the analysis types in single environment.
 - ◆ Superior Analysis Speed for accurate Analysis
 - ◆ Backed up by the superior Electromagnetic Analysis