BGS22WL10

Performance of DPDT (Dual-Pole / Double-Throw) RF MOS switch

Broadband Differential LTE, WCDMA, CDMA, UMTS Mobile Diversity Applications

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Table of Content

List of Figures

List of Tables

1 Introduction

The BGS22WL10 RF MOS switch is specifically designed for differential diversity applications (e.g. Figure 1) in low bands up to 3 GHz like 3G WCDMA diversity, CDMA diversity, UMTS diversity or LTE diversity RF frontend system solutions. Therefore, the Insertion loss of the BGS22WL10 below 2 GHz is closed to 0.35 dB, upto 3 GHz the IL is in the range of 0.45 dB and the port to port Isolation is more than 26 dB. A typical application is to combine two Rx paths in a mobile cellular device after the Rx filters or duplexers into one input to the tranceiver IC. The IC can also be used for a wide variety of applications switching balanced signals in a frequency range of 0.1 - 3 GHz.

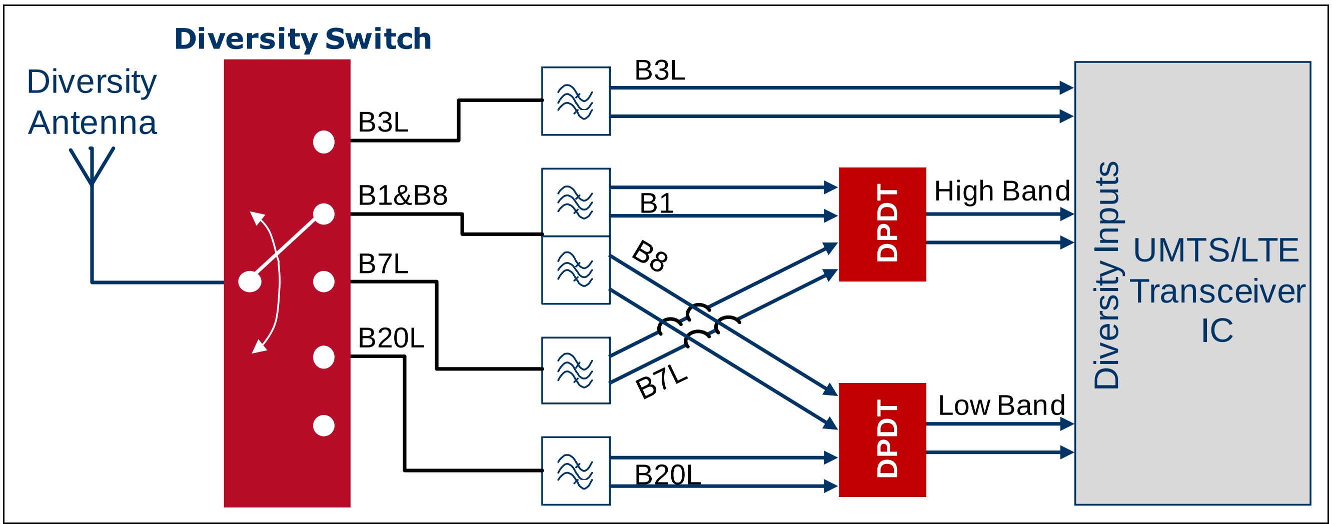


Figure 1 Differential Band select Switching application

Unlike GaAs technology, external DC blocking capacitors at the RF Ports are only required if DC voltage is applied externally. The BGS22WL10 RF Switch is manufactured in Infineon's patented MOS technology, offering the performance of GaAs with the economy and integration of conventional CMOS including the inherent higher ESD robustness. This DPDT (Dual-Pole / Double Throw) RF MOS switch which combines two differential signals into one differential output or splits one differential signal into two separate differential lines. The parallel paths of the

switch are controlled simultaneously through the same signals. The switch is designed to operate in battery powered applications with a supply voltage range of 2.4 - 3.6 V while the current consumption is below 300 µA. The highly symmetric design ensures best phase- and amplitude accuracy.

The RF switch is packaged in a standard RoHS compliant TSLP-10-1 package with a small outline of only 1.55 x 1.15 mm².

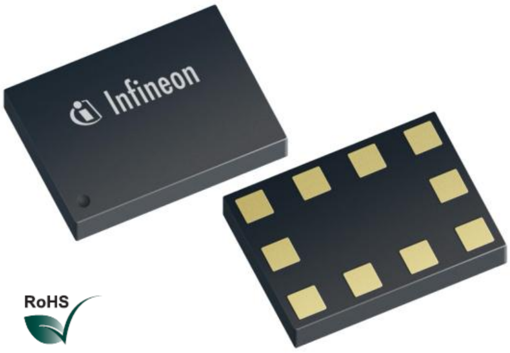
Table 1 Device desciption

Product Name	Product Type	Package	Marking
BGS22WL10	DPDT RF Switch	TSLP-10-1	W2

2 Features

2.1 Main Features

- DPDT (Dual-Pole / Double-Throw) differential RF switch
- All ports fully symmetrical
- High ESD robustness
- Frequency range: 0.1 - 3 GHz
- High signal power up to 30 dBm
- Extremely low insertin loss
- High port-to-port-isolation
- Supply voltage 2.4 - 3.6 V
- No decoupling capacitors required if no DC applied on RF lines
- Lead and halogen free package (RoHS and WEEE compliant)
- Small leadless package TSLP-10-1 with the size of 1.55 x 1.15 mm² and a maximum height of 0.77 mm.



2.2 Functional Diagram

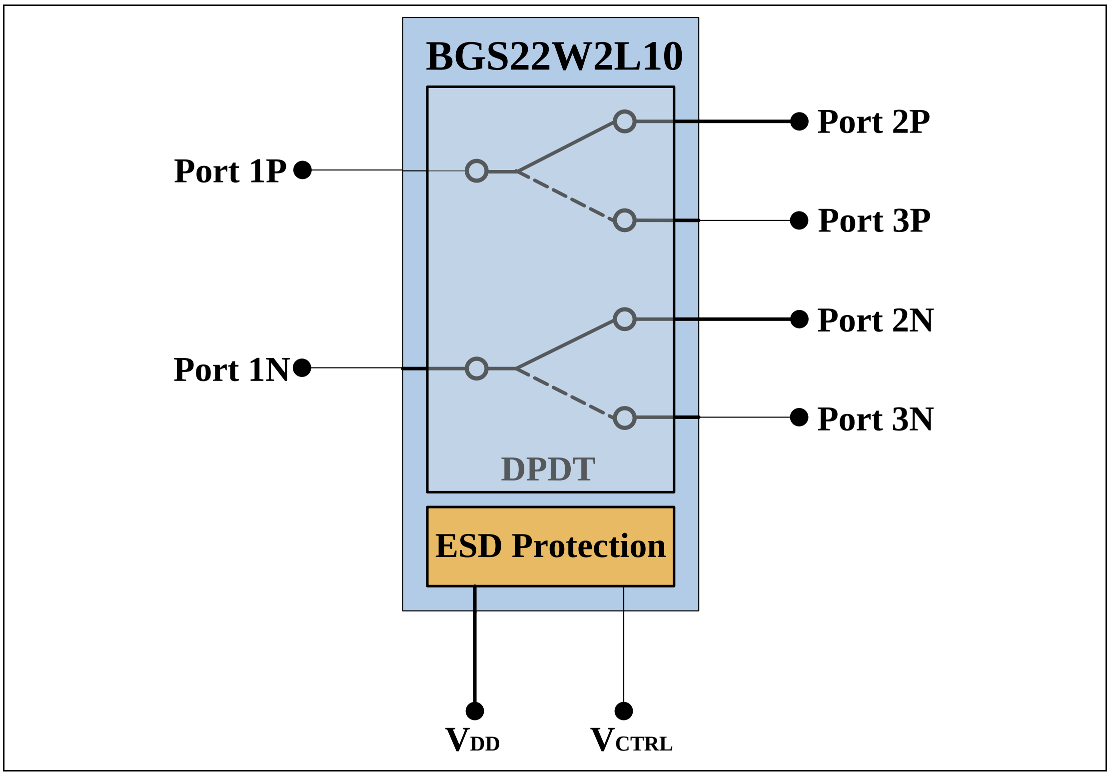


Figure 2 Functional Diagram

2.3 Signal Description

Table 2 Pin Description (top view)

Pin NO	Name	Pin Type	Function
1	Port 3P	I/O	RF port 3P
2	GND	GND	Ground
3	GND	GND	Ground
4	Port 2N	I/O	RF port 2N
5	Port 2P	I/O	RF port 2P
6	CTRL	I	Control Pin
7	Port 1P	I/O	RF port 1P
8	Port 1N	I/O	RF port 1N
9	VDD	Supply	Supply voltage
10	CTRL	I	Control Pin

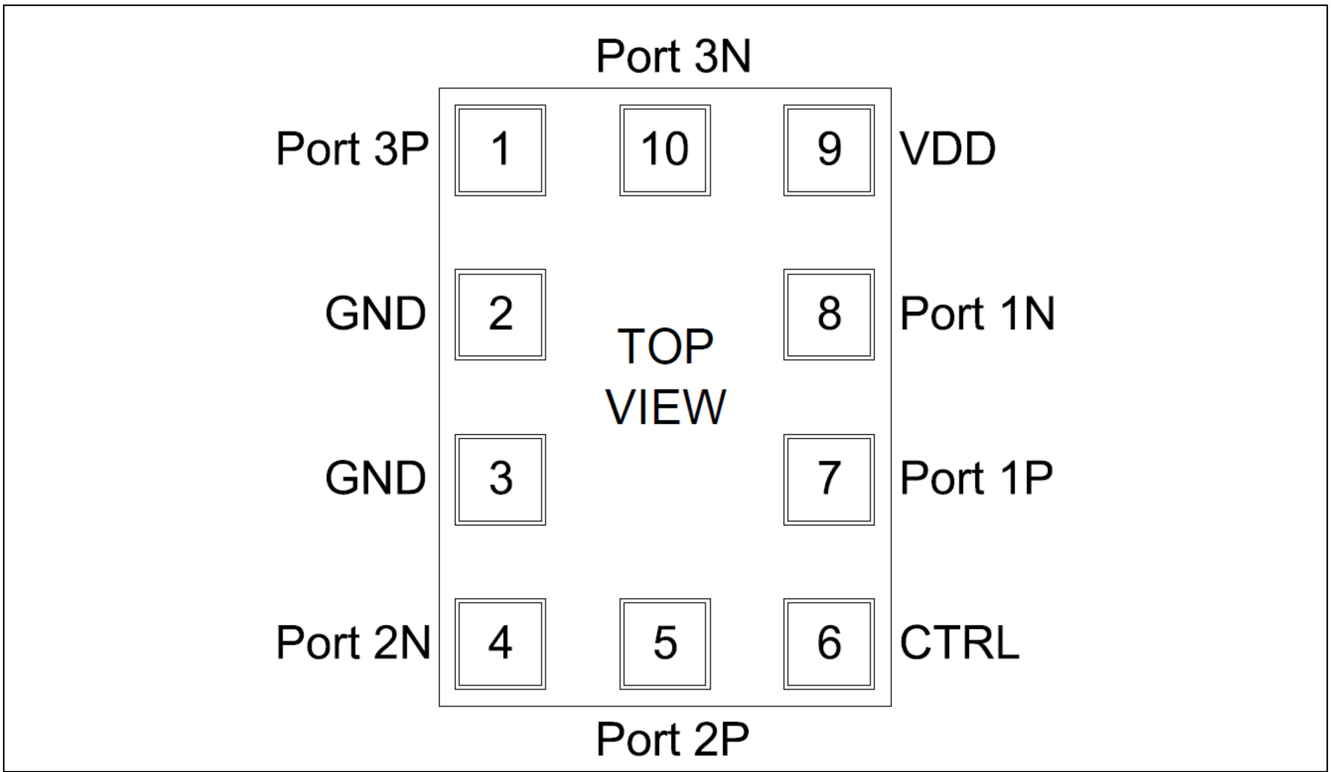


Figure 3 Pin configuration of BGS22WL10

Table 3 Truth table

Pin No.	Control
Port1 to Port2	0
Port1 to Port3	1

3 Small Signal Characteristics Measurement Results

All measurement results of this application note are measured with a typical device of the BGS22WL10 on an application board. The measurement procedure is shown in **chapter 8** including the needed deembedding.

The small signal characteristics are measured at 25 °C, 0 dBm Pin, 3 Volt Vdd, 3 V Vcrlt up to 10 GHz with a Network analyzer connected to an automatic multiport switch box in single ended mode. A differential simulation is possible ba using a ideal trabnsformator inbetween the Port 1P to 1N, 2P to 2N and 3P to 3N thanks to the full s-Parameter matrix of the BGS22WL10 which is provided @ Infinieon's internet page.

In the following tables and graphs the most important RF parameter of the BGS22WL10 are shown. The markers are set to the most important frequencies of the WCDMA system.

3.1 Insertion Loss

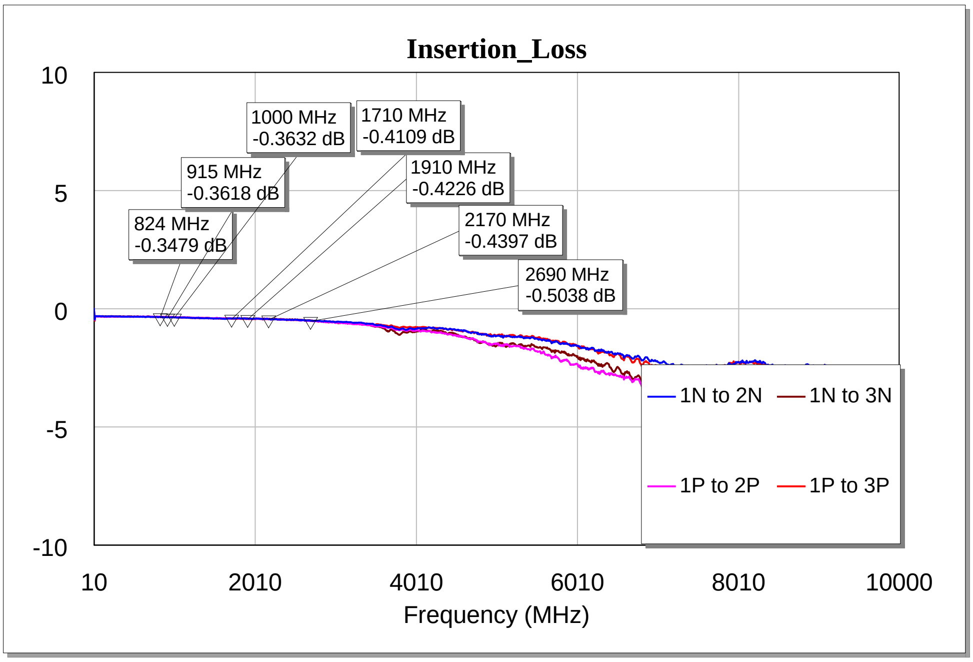


Figure 4 Forward Transmission curves for all RF paths

Table 4 Insertion Loss of throw between port1 (1P/1N) and port2 (2P/2N)

Frequency (MHz) / RF path	824	915	1000	1710	1910	2170	2690
1P → 2P	0.35	0.36	0.36	0.41	0.42	0.44	0.5
1N → 2N	0.34	0.35	0.35	0.41	0.42	0.44	0.52

Table 5 Insertion Loss of throw between port1 (1P/1N) and port3 (3P/3N)

Frequency (MHz) / RF path	824	915	1000	1710	1910	2170	2690
1P → 3P	0.34	0.35	0.36	0.41	0.41	0.43	0.5
1N → 3N	0.34	0.36	0.36	0.42	0.43	0.44	0.5

3.2 Return loss

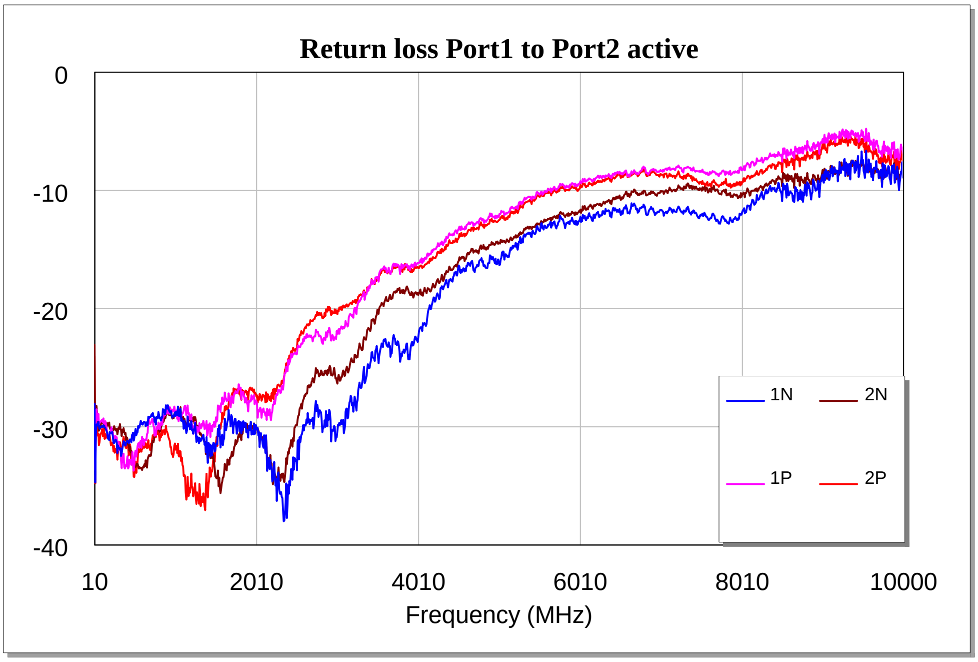


Figure 5 Return loss for active port 2 (2P/2N)

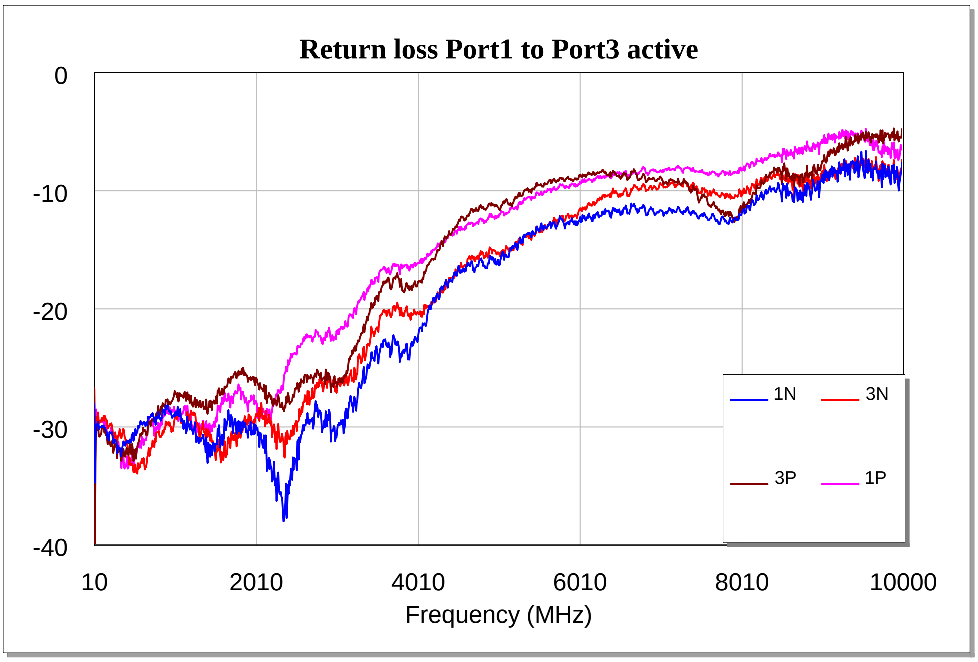


Figure 6 Return loss for active port 3 (3P/3N)

Table 6 Return loss of active ports

Frequency (MHz) / Active Path	port	824	915	1000	1710	1910	2170	2690
Throw **port 1** to **port 2**	1P	-29.4	-28.2	-28.8	-29.5	-30.5	-33.3	-29.4
	1N	-29.8	-28.6	-28.6	-27.6	-28.3	-28.6	-22.4
	2P	-30.2	-28.9	-29	-32.4	-30.2	-33.1	-26.2
	2N	-30.7	-30.7	-31.4	-27.1	-27.4	-27.7	-21
Throw **port 1** to **port 3**	1P	-29.2	-28.7	-23.2	-24.4	-22.5	-28.9	-25.8
	1N	-32.7	-37.6	-31.6	-32.4	-26.6	-23.9	-31.5
	3P	-28.9	-27.7	-27	-25.8	-26	-27.3	-25.8
	3N	-30.9	-29.8	-29.3	-31	-29.3	-29.5	-27.5

3.3 Isolation of inactive paths

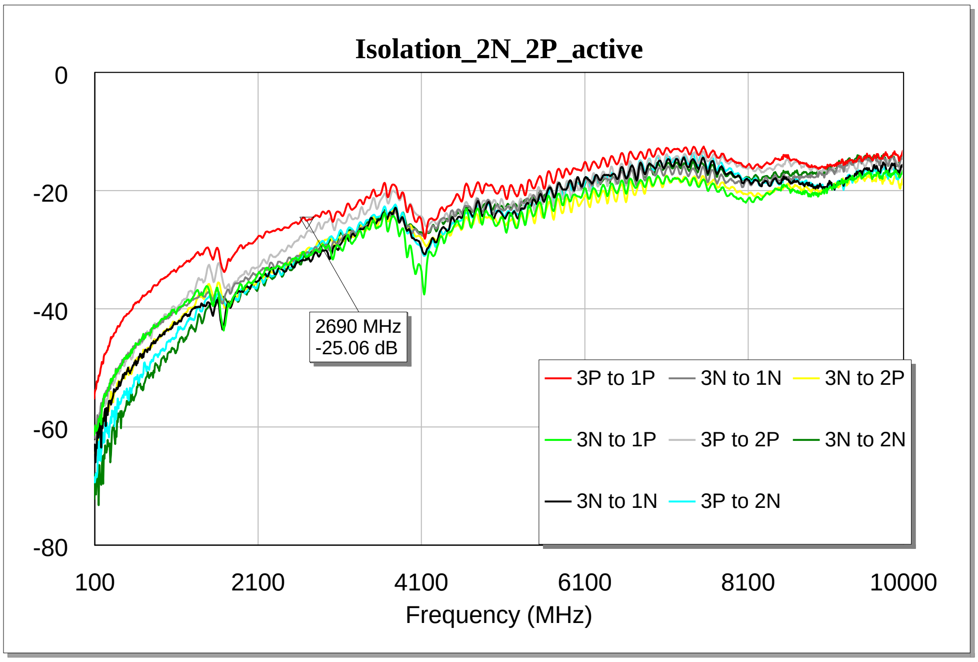


Figure 7 Isolation of Port 3 (3P/3N) by active Port 2 (2P/2N)

Table 7 Isolation of Port3 (3P/3N) bby active port 2 (2P/2N)

Port to port isolation	824	915	1000	1710	1910	2170	2690
3P → 1P	-36	-35	-34.3	-33.1	-29.6	-27.7	-25.1
3N → 1P	-42.8	-41.8	-41.2	-41.4	-36.6	-34.1	-31.2
3P → 1N	-45.6	-44.6	-43.6	-40.1	-37.1	-34.1	-31.7
3N → 1N	-43.3	-42.2	-41.6	-37.3	-35.3	-33.2	-30.6
3P → 2P	-42.8	-42.2	-41.4	-36.5	-34.3	-31.7	-27.2
3P → 2N	-48.1	-46.9	-45.6	-39.4	-36.8	-35.6	-31
3N → 2P	-45.3	-44.4	-43.8	-39.8	-37.1	-34.6	-30.1
3N → 2N	-50.6	-48.7	-47.5	-38.6	-36.6	-35.9	-31.5

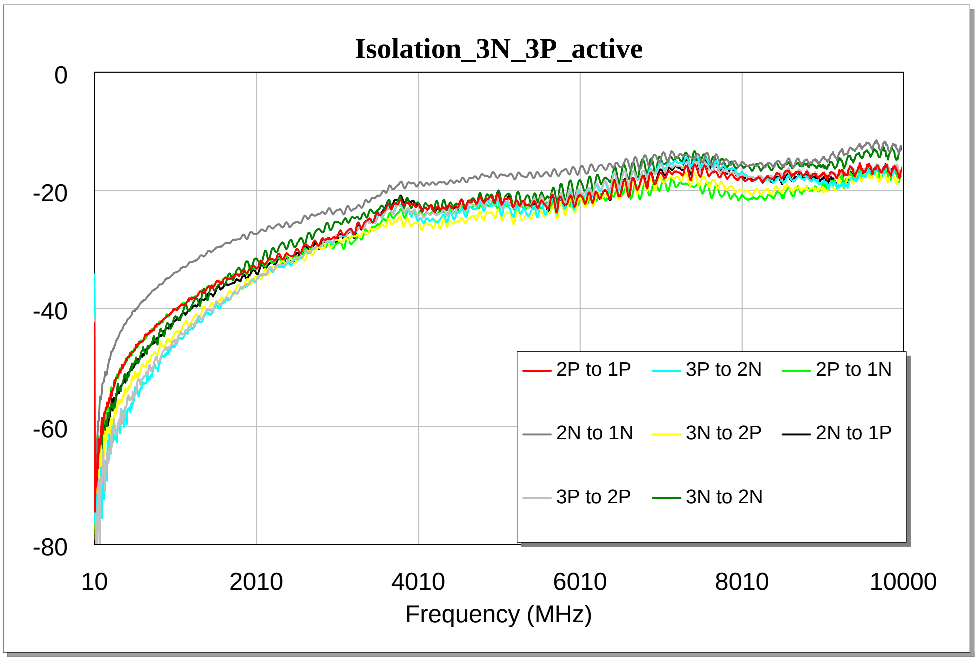


Figure 8 Isolation of Port 2 (2P/2N) by active Port 3 (3P/3N)

Table 8 Isolation of Port2 (2P/2N) bby active port 3 (3P/3N)

Port to port isolation	824	915	1000	1710	1910	2170	2690
2P → 1P	-36.3	-35.1	-34	-32.9	-29.1	-27.3	-24.2
2N → 1P	-42.5	-41.3	-41.1	-39.4	-35.6	-34.4	-31.5
2P → 1N	-45.1	-44.2	-43.6	-40.3	-34.5	-34.2	-31.2
2N → 1N	-42.5	-41.2	-40.1	-34.8	-33.7	-31.7	-29.5
2P → 3P	-36	-35	-34	-28.5	-27.9	-26.1	-24.1
2P → 3N	-48.5	-47	-45.3	-37.9	-35.9	-33.2	-30.2
2N → 3P	-49	-47.8	-46.5	-37.8	-36	-33.4	-30.3
2N → 3N	-46	-45.1	-44.3	-37.7	-35.1	-34.1	-30.9

4 Switching time

4.1 Measurement Specifications

Switching On Time: 50% Trigger signal to 90 % RF Signal

Switching Off Time: 50% Trigger signal to 10% RF Signal

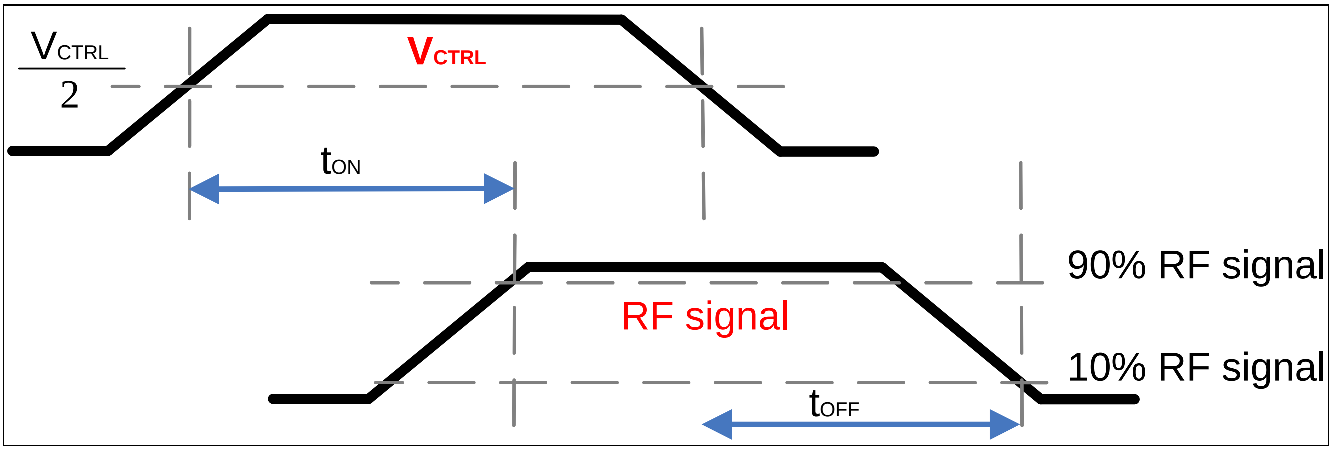


Figure 9 Switching Time

Rise time: 10% to 90% RF Signal

Fall time: 90% to 10% RF Signal

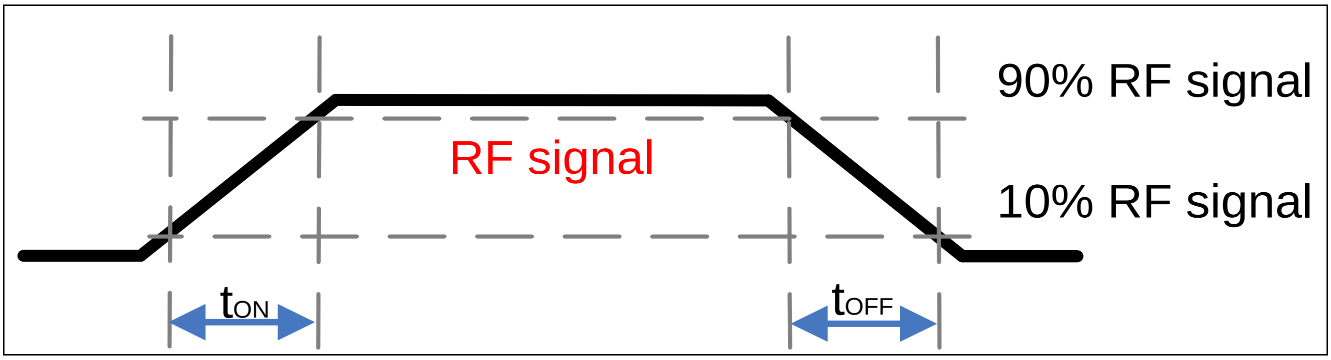


Figure 10 Rise/Fall Time

4.2 Measurement Setup

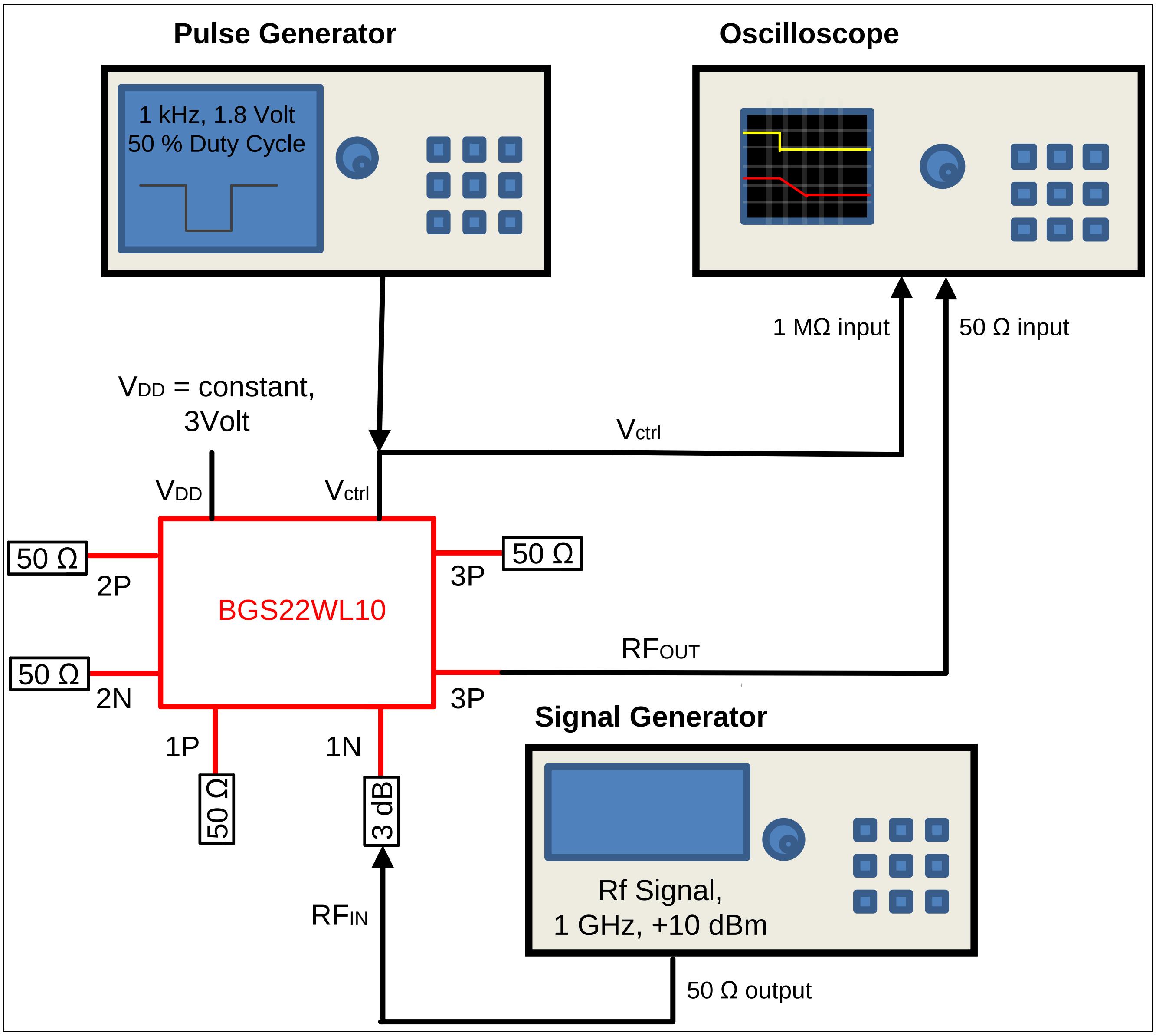


Figure 11 Switching Time Measurement Setup

The switching Time measurement setup consist of one pulse generator which generates a sqare wave with 50% duty cycle and an amplitude of 1.8 Volts, an oscilloscope which can detect the 1 GHz signal and the 1 kHz signal and one Signal generator which is set to an output signal of 1GHz with a power level 10 dBm.

If the oscilloscope can not detect the 1 GHz signal of the RF path, due to small bandwith, it is possible tu use a cristal oscillator in front of the oscilloscope (such a device detects any RF signal present at input and commutate that one) that the RF signal can be detected.

4.3 Measurement results

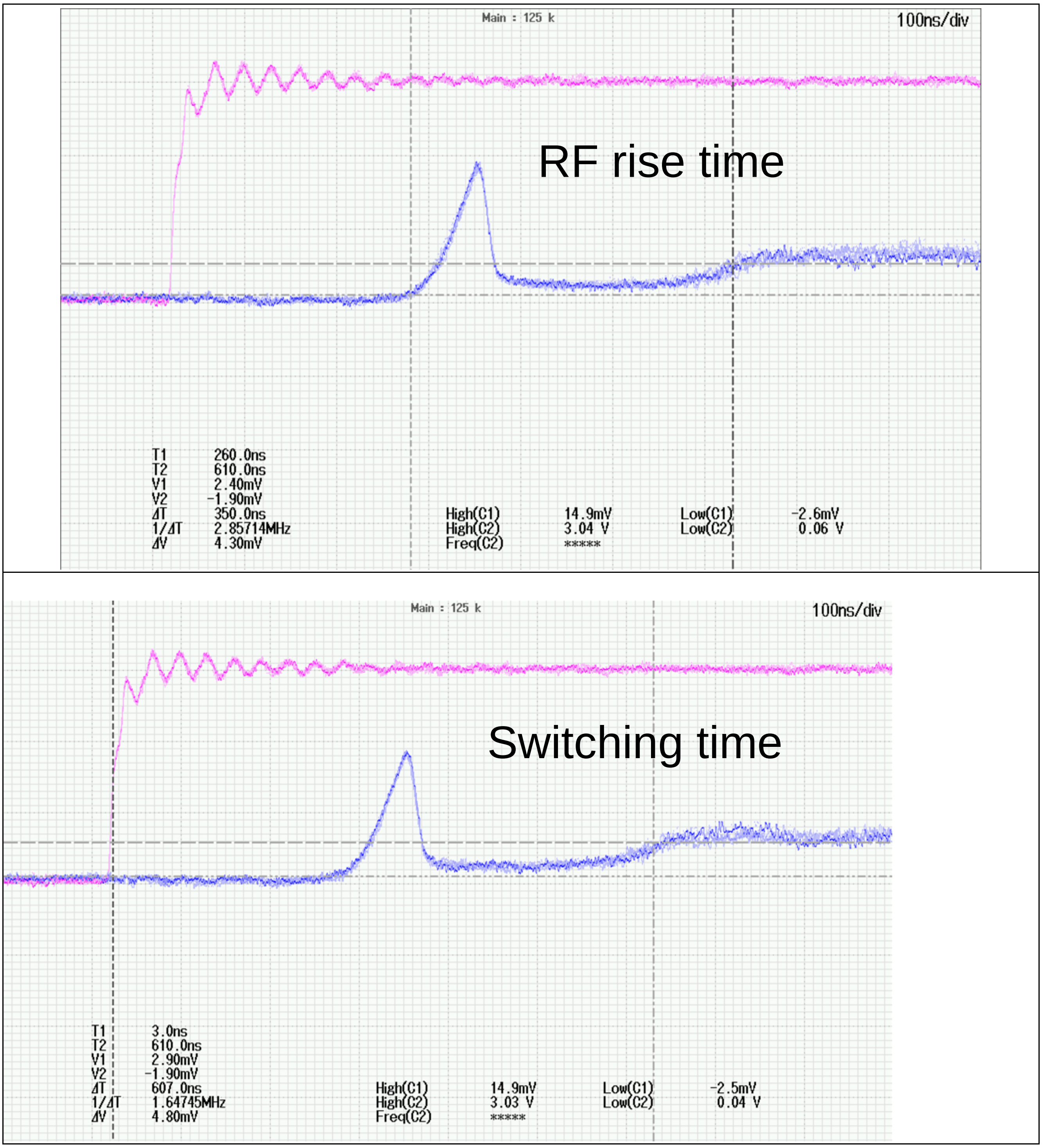


Figure 12 Switching Time of BGS22WL10

Table 9 Switching time measurement results of BGS22WL10

BGS22WL10	RF rise time (ns)	Switching time (ns)
	350	607

5 Intermodulation

5.1 Test conditions

Another very important parameter of a RF switch is the large signal capability. One of the possible intermodulation scenarios is shown in **Figure 13**.The transmission (Tx) signal from the main antenna is coupled into the diversity antenna with with high power.This signal (20 dBm) and a received Jammer signal (-15 dBm) are entering the switch. Thank to the spezified application for the BGS22WL10 inbetween the filters and the Transceiver, the Tx signal from the main antenna loose until arriving at the switch input moslty 5 to 10 or more dB, depending of the filter and pcb structure of the RF frontend. The IMD products are measured with a Tx of 20dBm, which is corresponding to the IMD spec of a main antenna diversity switch like Infineons BGSF110GN. Therefore, the measured IMD products will be extremly better in the spezified application circuit within the filters and transceiver as showed in the measurement results below.

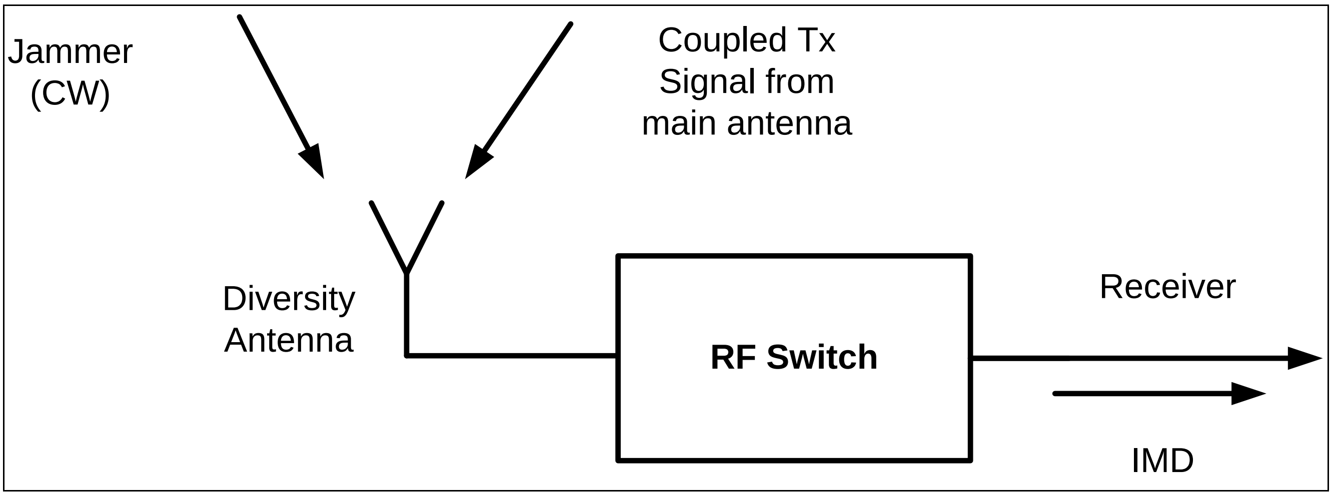


Figure 13 Block diagram of RF Switch intermodulation

Special combinations of TX and Jammer signal are producing intermodulation products 2nd and 3rd order, which fall in the RX band and disturb the wanted RX signal.

In **Table 10** frequencies for 3 bands and the linearity specifications for an undisturbed communication are given.

Table 10 Test conditions and specifications of IMD measurements

Test Conditions (Tx = +20dBm, Bl = -15dBm,freq.in MHz,@25°C)						Linearity Specification			
Band	Tx Freq.	Rx Freq.	IMD2 Low Jammer 1	IMD3 Jammer 2	IMD2 High Jammer 3	IM2 (dBm)	IIP2 (dBm)	IM3 (dBm)	IIP3 (dBm)
850	836.5	881.5	45	791.5	1718	**-105**	110	**-105**	65
1900	1880	1960	80	1800	3840	**-105**	110	**-105**	65
2100	1950	2140	190	1760	4090	**-105**	110	**-105**	65

5.2 Measurement Setup

The test setup for the IMD measurements has to provide a very high isolation between RX and TX signals. As an example the test set-up and the results for the high band are shown (**Figure 14** and **Table 11**).

For the RX / TX separation a professional duplexer with 80 dB isolation is used.

In **Table 12** the results for Low band are given.

For each distortion scenario there is a min and a max value given. This variation is caused by a phase shifter connected between switch and duplexer. In the test set-up the phase shifter represents a no ideal matching of the switch to 50 Ohm.

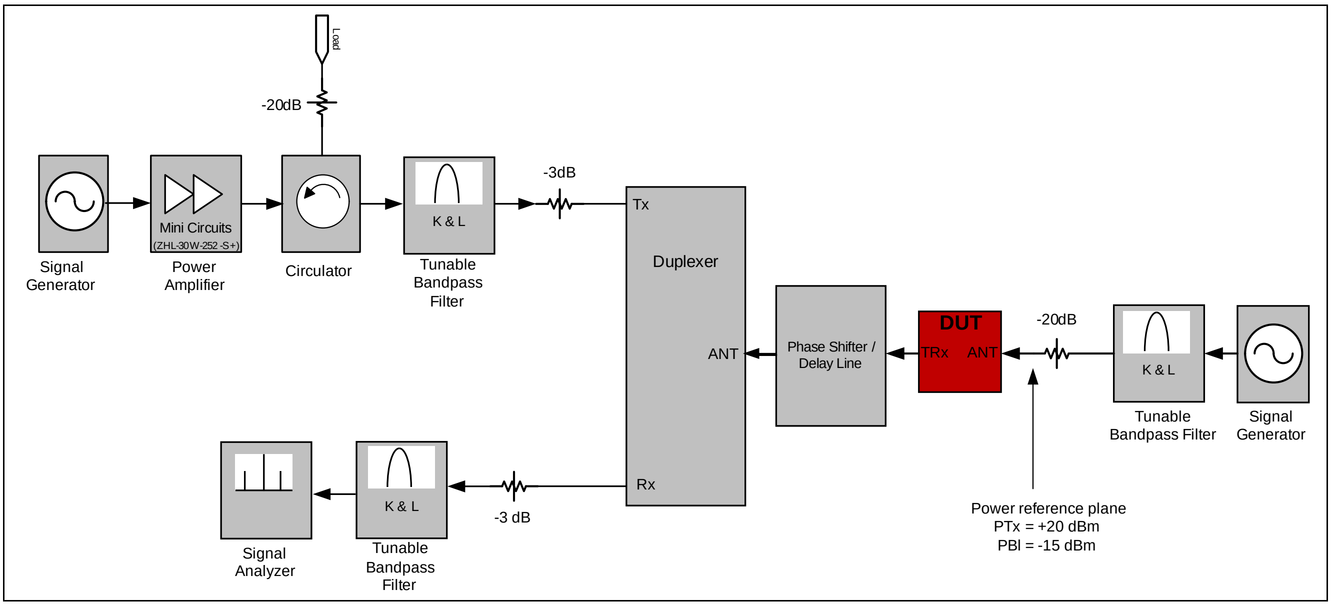


Figure 14 Test set-up for IMD Measurements

5.3 Measurement results

Table 11 IMD products of Band I

IMD Band 1	1P → 2P		1N → 2N		1P → 3P		1N → 3N	
	Min	Max	Min	Max	Min	Max	Min	Max
IMD2Low ($f_{blocker}$ = 190 MHz)	-116.72	-109.12	-117.71	-109.40	-118.60	-110.42	-118.89	-111.11
IMD2High ($f_{blocker}$ = 4090 MHz)	-118.37	-114.48	-115.80	-113.08	-118.23	-115.11	-119.19	-115.91
IMD3 ($f_{blocker}$ = 1760 MHz)	-123.37	-117.75	-123.00	-117.54	-122.55	-117.68	-123.19	-116.54

Table 12 IMD products of Band V

IMD Band 5	1P → 2P		1N → 2N		1P → 3P		1N → 3N	
	Min	Max	Min	Max	Min	Max	Min	Max
IMD2Low ($f_{blocker}$ = 45 MHz)	-107.69	-96.55	-108.80	-97.42	-108.59	-97.75	-107.62	-96.32
IMD2High ($f_{blocker}$ = 1718 MHz)	-113.11	-108.38	-112.34	-109.11	-112.65	-108.11	-113.55	-109.56
IMD3 ($f_{blocker}$ = 791.5 MHz)	-112.88	-108.46	-111.70	-107.97	112.86	-108.50	-113.62	-108.74

6 Harmonic Generation

6.1 Measurement setup

Harmonic generation is another important parameter for the characterization of a RF switch. RF switches have in such a Differential Band select Switching application to deal with high RF levels, up to 24 dBm. With this high RF power at the input of the switch harmonics are generated. This harmonics (2nd and 3rd) can disturb the other reception bands or cause distortion in other RF applications (GPS, WLan) within the mobile phone.

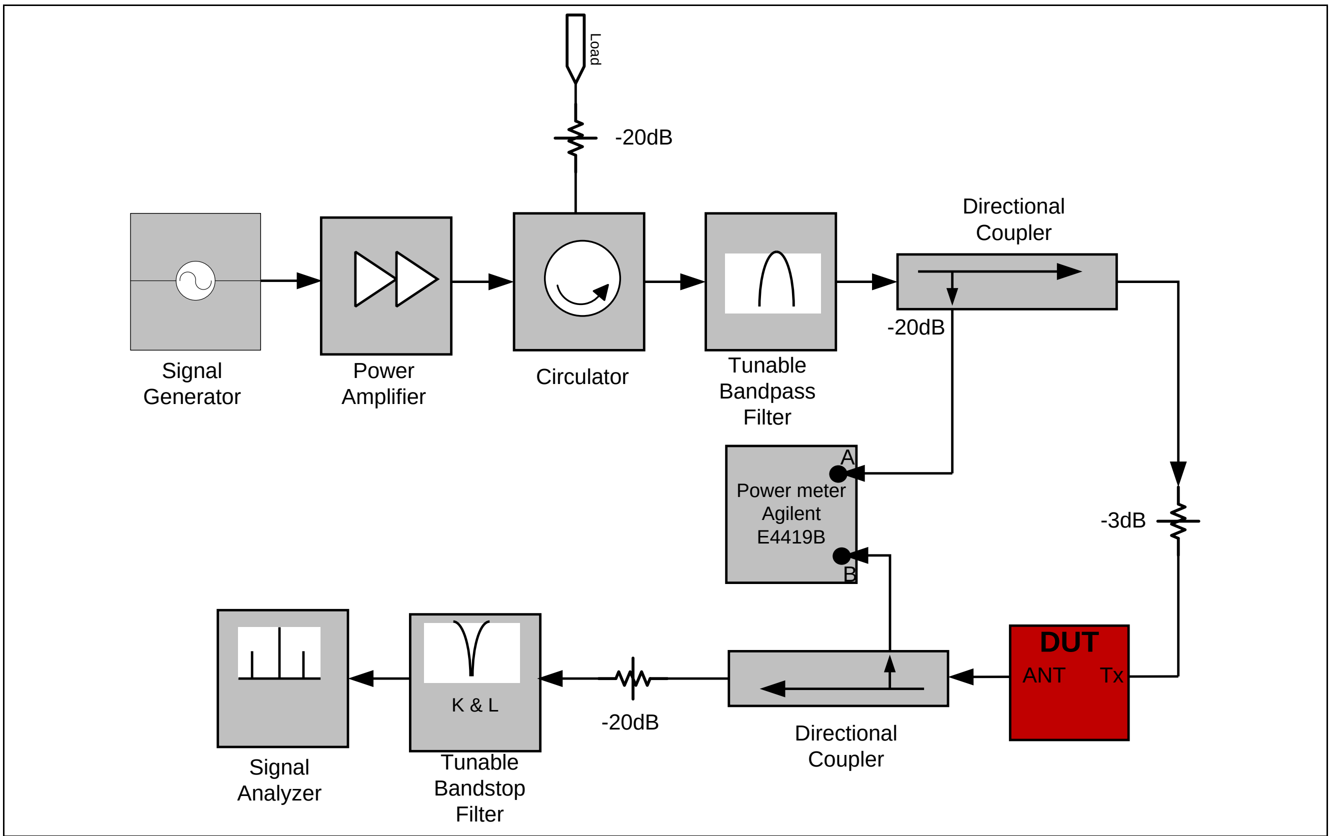


Figure 15 Set-up for harmonics measurement

The results for the harmonic generation at 830 MHZ are shown in Figure 16 (2nd harmonic) and Figure 17 (3rd harmonic) for all RF ports.

At the x-axis the input power is plotted and at the y- axis the generated harmonics in dBm.

6.2 Measurement results

6.2.1 Low Band (824 MHz)

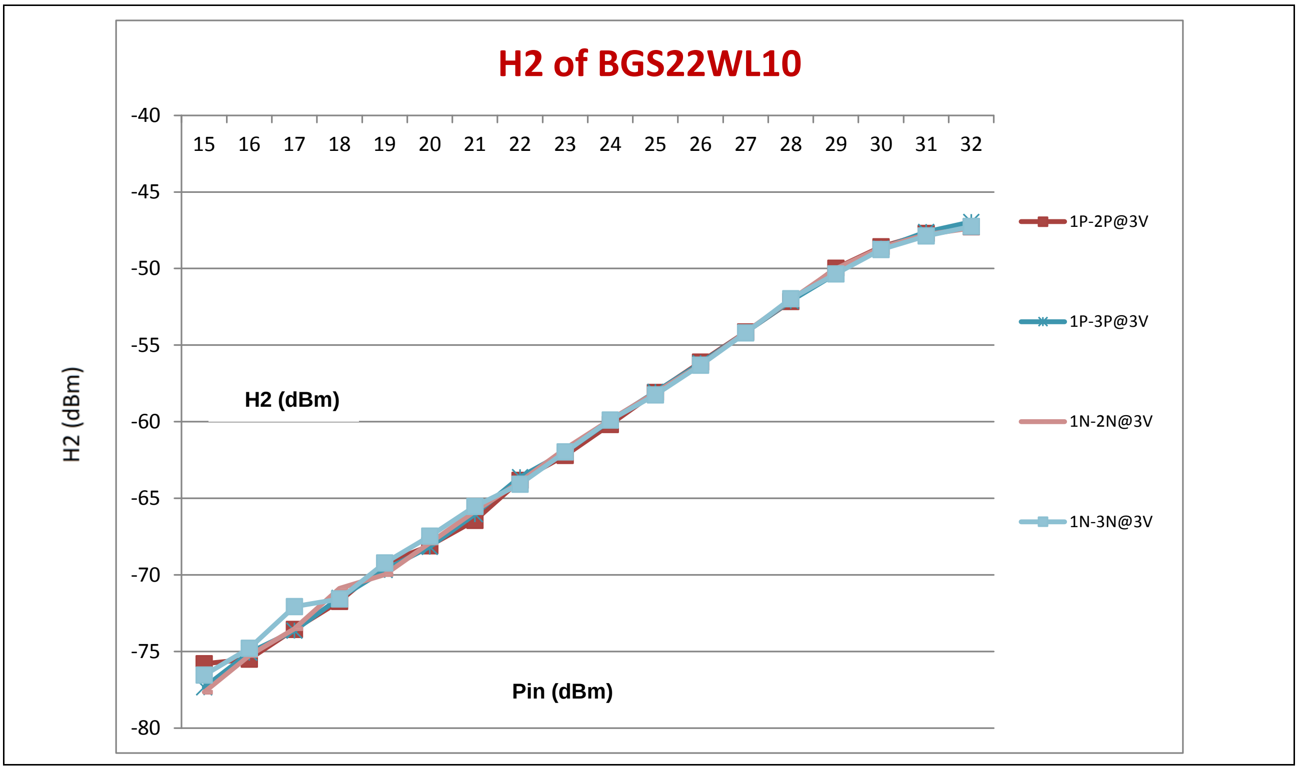


Figure 16 2nd harmonic at f_c=824 MHz

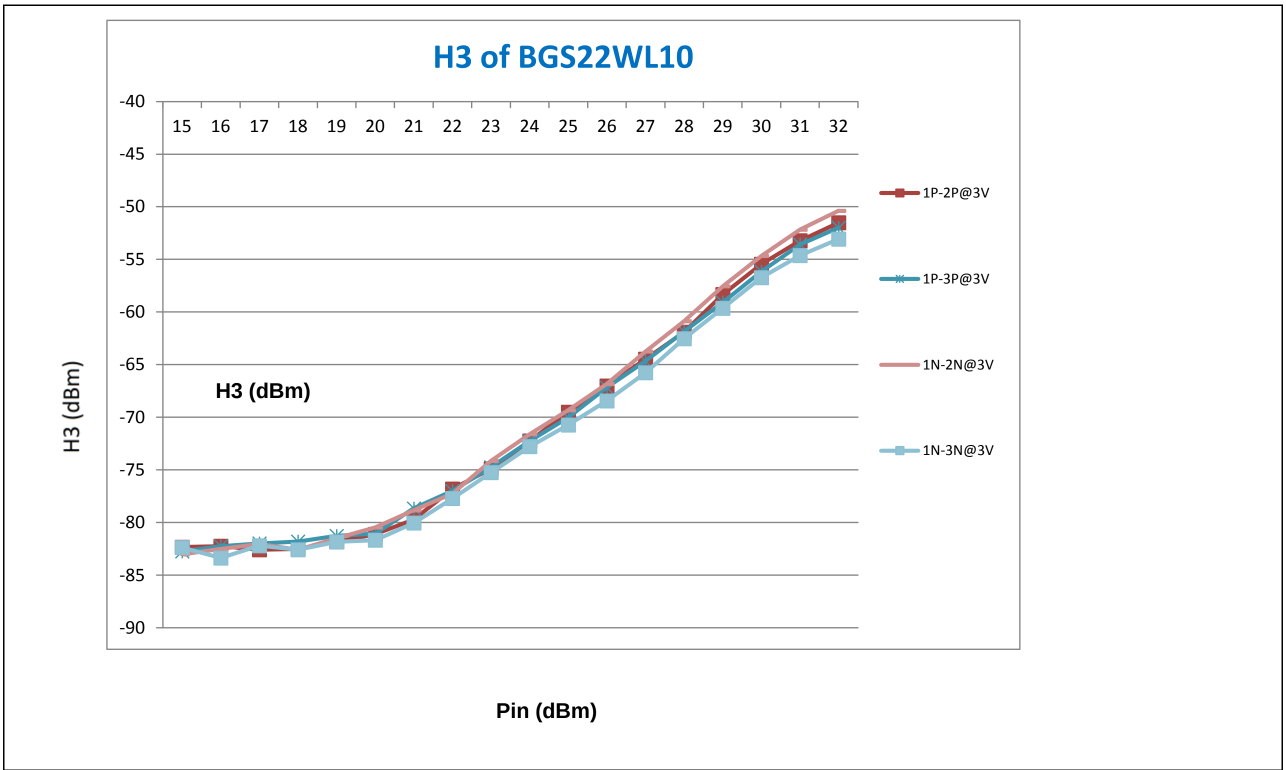


Figure 17 3rd harmonic at f_c=824 MHz

6.2.2 High Band (1800 MHz)

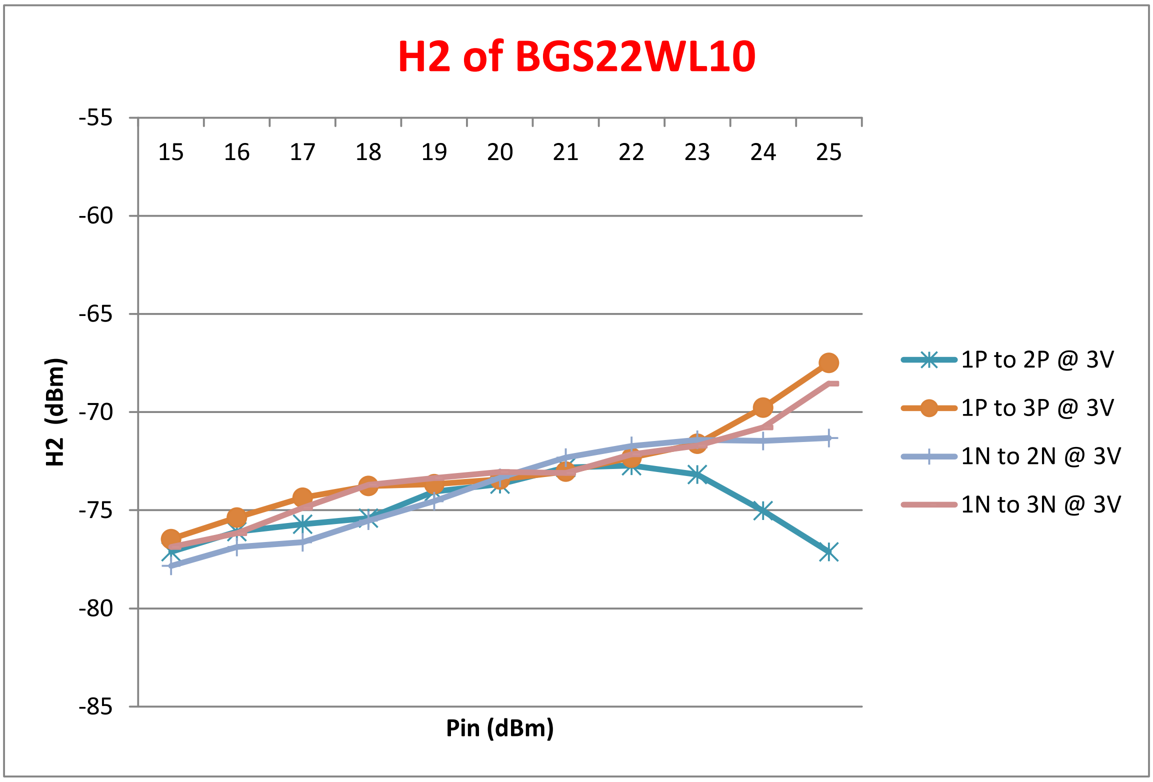


Figure 18 2nd harmonic at f_c=1800 MHz

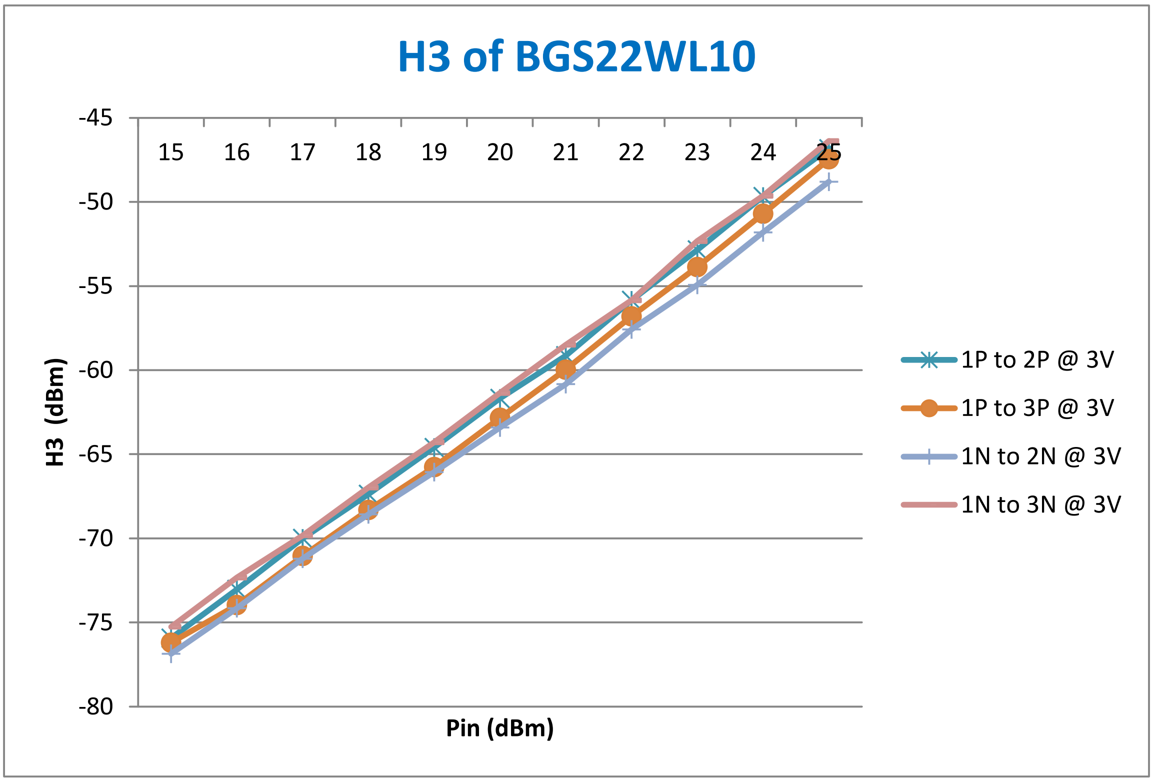


Figure 19 3rd harmonic at f_c=1800 MHz

7 Power Compression Measurements

To judge the large signal capability the power compression is a usual measurement tool. The input power is increase and at the output the power is measured. At a certain point the output power could not follow the input and the switch compresses the RF signal. In the diagram below (**Figure 20**) the IL is plotted versus the injected input power. The input power can be increased to 29 dBm and there is no compression visible of the RF port.

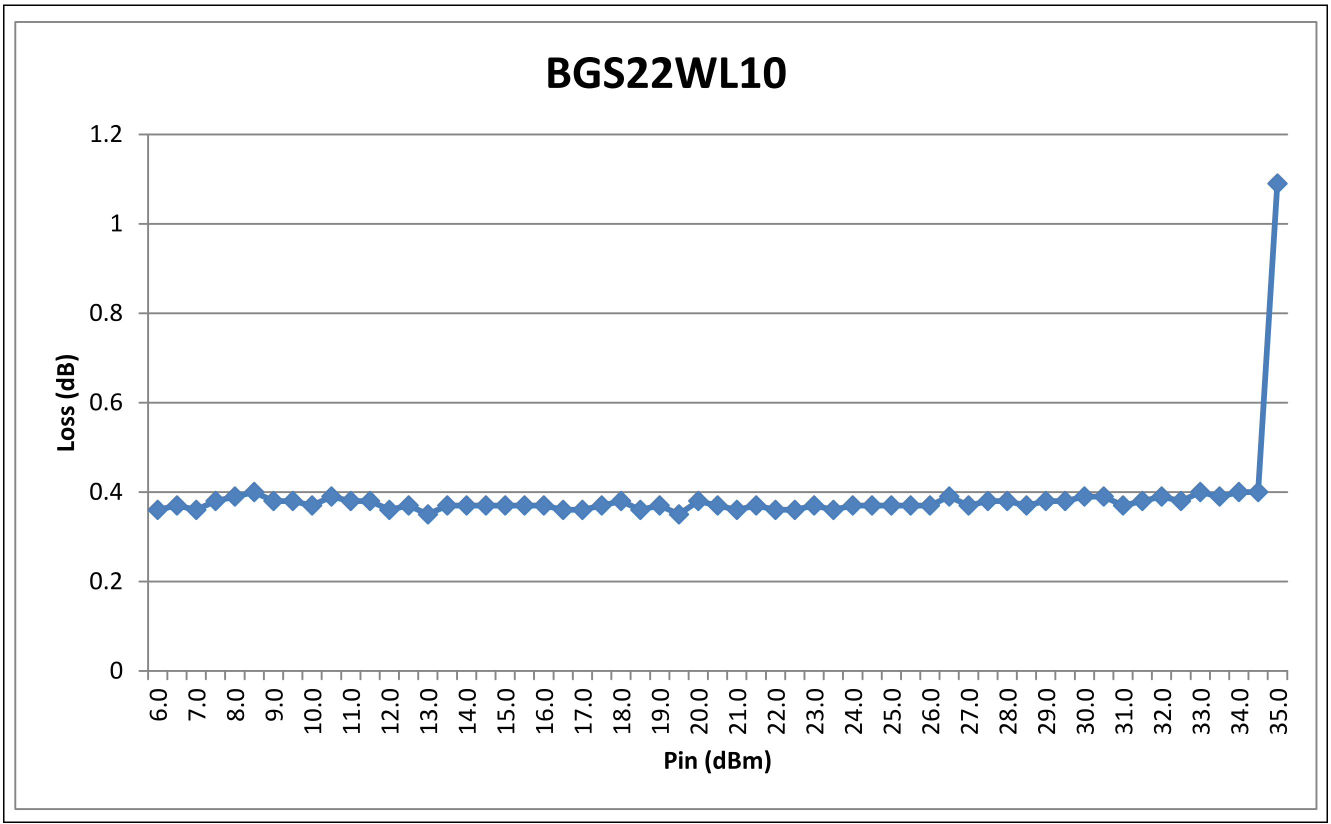


Figure 20 Power Compression Measurement Results at f_c=824 MHz

The measurements are done on Large Signal measurement setup which is not calibrated for Insertion Loss with high precision. So the values here may differ with the actual IL values earlier in this report.

8 Application Board and Measurement desciption

8.1 Application board

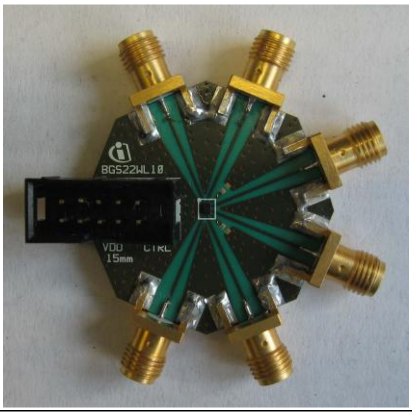


Figure 21 BGS22WL10 application board

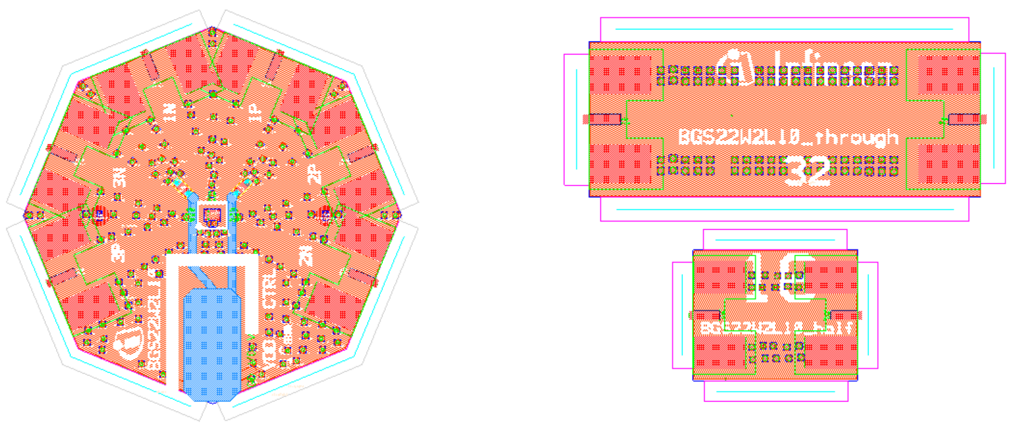


Figure 22 Layout of the application board and deembedding kit

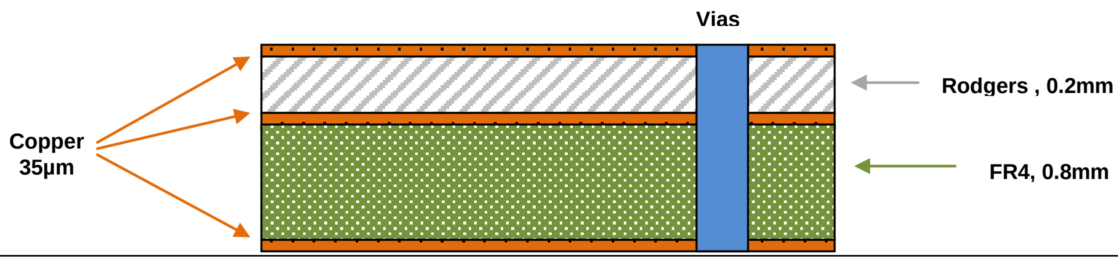


Figure 23 PCB layer information

8.2 Measurement description and deembedding

Below is a picture of the evaluation board used for the measurements (Figure 22). The board is designed in the way that all connecting 50 Ohm lines have the same length.

To get correct called “device level” measurement values for the insertion loss of the BGS22WL10 all influences and losses of the evaluation board, lines and connectors have to be eliminated. Therefore a separate de-embedding board, representing the line length is necessary.

After full port calibration of the network analyzer (NWA) a deembedding has to be done in severall steps:

- Attach empty SMA connector (with cutted RF line, **Figure 24**) at any port of the measurements setup and perform “open” port extension for that one. Turn port extensions on.
- Connect the “half” de-embedding board (**Figure 22**, smallest board) between the the port where one of the two RFin port (1P/1N) of the BGS22WL10 will be connected and the port with the maded port extension, store this as a S-parameter (s2p) file.
- Turn all port extention off.
- Load the stored s-parameter file as de-embedding on all used NWA ports
- Check insertion loss with the de-embedding through board (**Figure 22** right upper board)

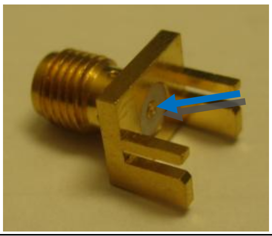


Figure 24 SMA connector for deembedding procedure

If the check of the deembedding shows an insertion loss of the through about +- 0.4 dB (depending on the measurement setup accuracy, e.g. NWA) then the Device itself can be measured.

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