BGS16MN14

SP6T Antenna Switch

Diversity RF Frontend Applications

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1 Introduction

The BGS16MN14 is a Single Pole Six Throw (SP6T) Diversity Switch optimized for wireless applications up to 2.7 GHz. It is a perfect solution for multi-mode handsets based on quadband GSM, WCDMA and LTE. The switch configuration is shown in Fig. 1. The BGS16MN14 comes in a miniature TSNP package and comprises of a high power CMOS SP6T switch with integrated MIPI RFFE interface.

No external DC blocking capacitors are required in typical applications as long as no DC is applied to any RF port.

2 BGS16MN14 Features

2.1 Main Features

- Suitable for multi-mode EDGE / C2K / WCDMA / LTE applications
- Ultra-low insertion loss and harmonics generation
- 6 high-linearity, interchangeable WCDMA RX ports
- 0.1 to 2.7 GHz coverage
- High port-to-port-isolation
- Direct to battery supply enabled by large supply voltage range from 2.5 V to 5.5 V
- Integrated MIPI RFFE interface supporting 1.2 and 1.8 V bus voltage
- Software programmable MIPI RFFE USID
- No decoupling capacitors required if no DC applied on RF lines
- Small form factor 2.0 mm x 2.0 mm
- 1 kV HBM ESD protection
- RoHS and WEEE compliant package

2.2 Functional Diagram

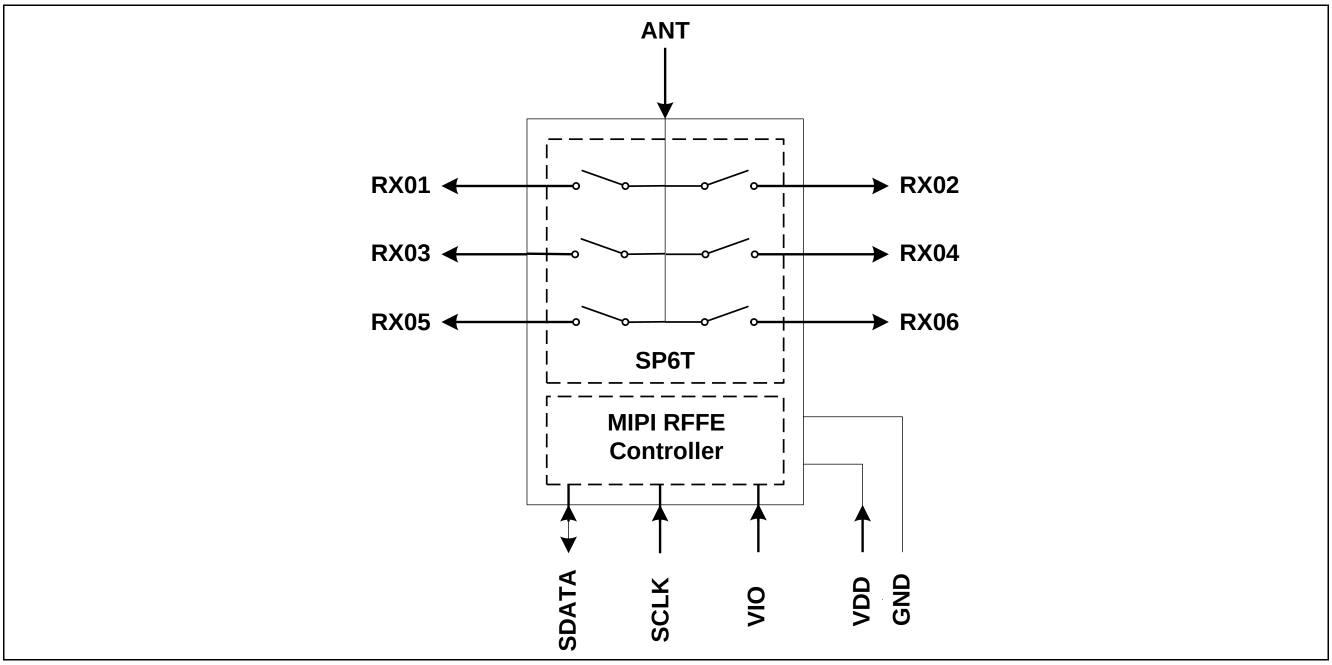

Figure 1 BGS16MN14 Functional Diagram

2.3 Pin Configuration

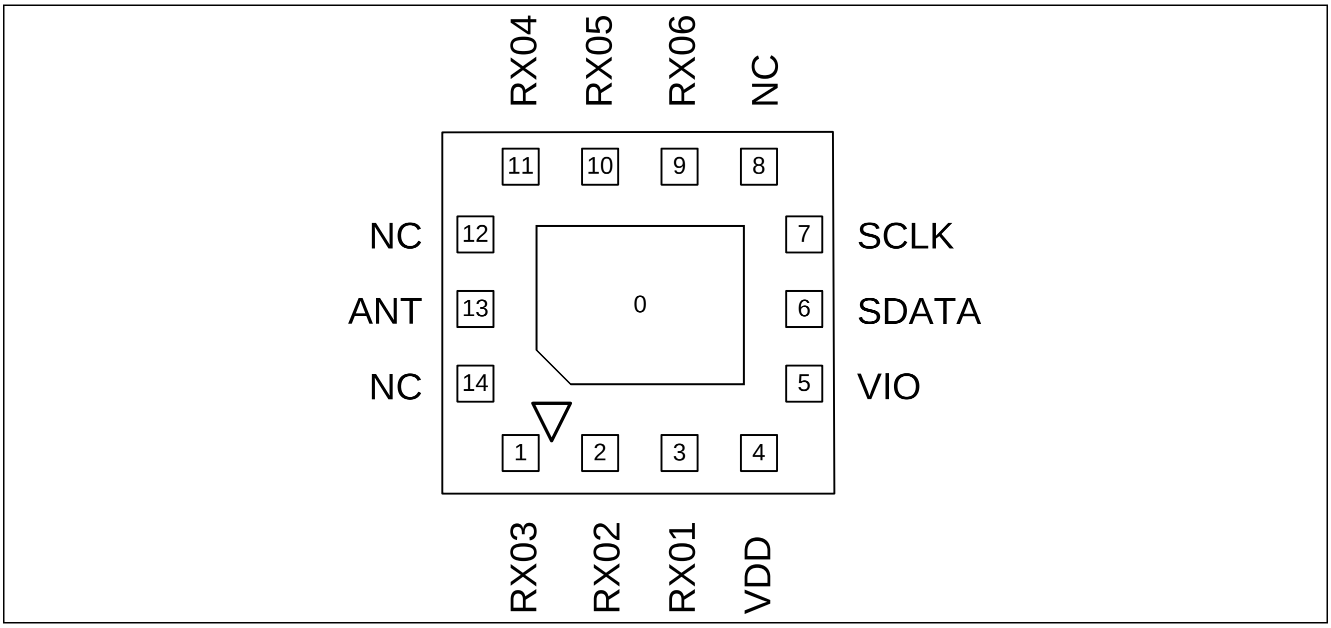

Figure 2 BGS16MN14 Pin Configuration

2.4 Pin Description

Table 1 Pin Description (top view)

Pin NO	Name	Pin Type	Function
0	GND	GND	RF ground; die pad
1	RX03	I/O	RX port 3
2	RX02	I/O	RX port 2
3	RX01	I/O	RX port 1
4	VDD	PWR	V_{DD}Supply Voltage
5	VIO	PWR	MIPI RFFE Supply
6	SDATA	I/O	MIPI RFFE data
7	SCLK	I	MIPI RFFE clock
8	NC		Not connected
9	RX06	I/O	RX port 6
10	RX05	I/O	RX port 5
11	RX04	I/O	RX port 4
12	NC		Not connected
13	ANT	I/O	Antenna port
14	NC		Not connected

3 Application

A typical application of the BGS16MN14 RF switch in a mobile phone application is shown in Figure 3. In the diversity path of the RF frontend the BGS16MN14 switches the different receive bands to the inputs of the transceiver. Infineon offers also a broad portfolio of **L**ow **N**oise **A**mplifiers and **A**ntenna **S**witch **M**odules.

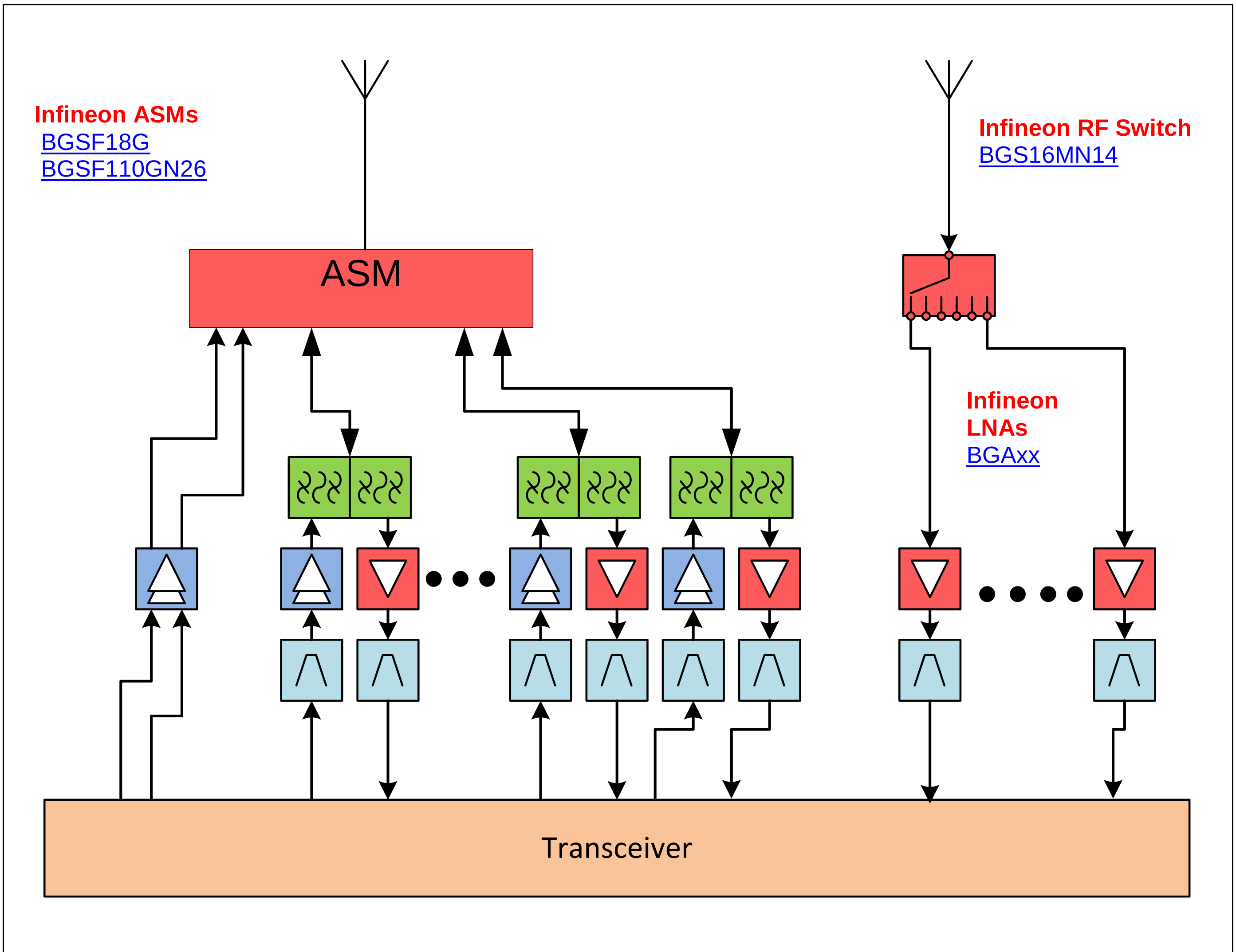

Figure 3 RF switch in mobile phone cellular frontend

3.1 Application Board

Below is a picture of the evaluation board used for the measurements (Figure 4). The board is designed so that all connecting 50 Ohm lines have the same length.

In order to get accurate values for the insertion loss of the BGS16MN14 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 (Figure 5).

The calibration of the network analyser (NWA) is done in severall steps:

- Perform full calibration on all NWA ports.

- Attach empty SMA connector at port 2 and perform “open” port extension. Turn port extensions on.

- Connect the “half” de-embedding board (Figure 5 left board) between port1 and port2, store this as a s-parameter (.s2p) file.
- Turn all port extentions off.
- Load the stored s-parameter file as de-embedding file for all used NWA ports
- Switch all port extentions on
- Check insertion loss with the de-embedding through board (Figure 5 right board)

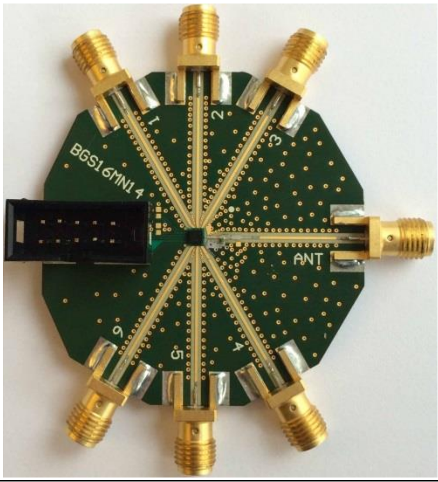

Figure 4 Layout of the application board

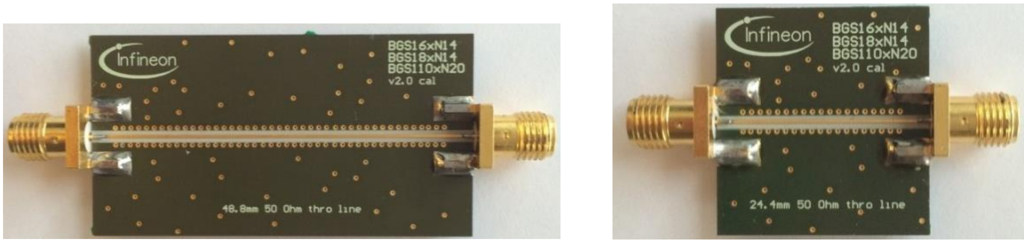

Figure 5 Layout of de-embedding boards

The construction of the PCB is shown in Figure 6.

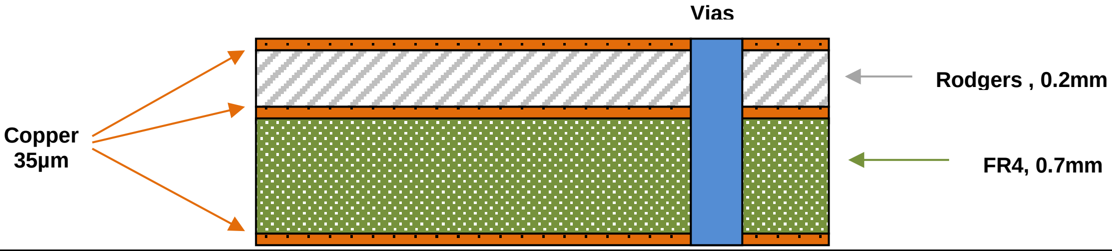

Figure 6 PCB layer information

4 Small Signal Characteristics

The small signal characteristics are measured at 25 °C with a Network analyzer in an application circuit shown in figure 7.

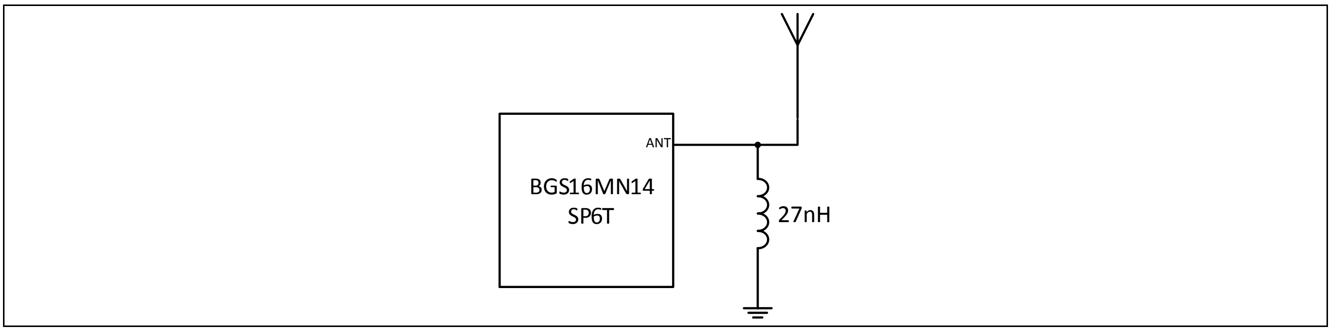

Figure 7 Application circuit

4.1 Insertion Loss from Antenna to the respective RF port

Table 2 Insertion Loss from Antenna to the respective RF port with all other ports terminated with 50Ω

Frequency (MHz)	740	751	881	942	1842	1960	2017	2140	2350	2593	3500
RX1	0.43	0.42	0.36	0.34	0.31	0.32	0.33	0.34	0.36	0.38	0.52
RX2	0.41	0.41	0.36	0.34	0.33	0.34	0.35	0.36	0.38	0.41	0.56
RX3	0.4	0.4	0.34	0.32	0.29	0.3	0.31	0.33	0.36	0.4	0.61
RX4	0.42	0.41	0.36	0.34	0.32	0.33	0.34	0.35	0.39	0.43	0.65
RX5	0.41	0.4	0.34	0.32	0.3	0.31	0.32	0.33	0.36	0.38	0.48
RX6	0.44	0.44	0.38	0.36	0.32	0.33	0.34	0.35	0.37	0.4	0.54

4.2 Return Loss from Antenna to the respective RF port

Table 3 Antenna Return Loss with all other ports terminated with 50Ω

Frequency (MHz)	740	751	881	942	1842	1960	2017	2140	2350	2593	3500
RX1	15	15.1	16.9	17.7	33.7	32.6	31.7	30.4	28.6	27	20.2
RX2	15.5	15.6	17.5	18.4	29.6	29.3	29	28.7	27.6	25.3	18.2
RX3	15.3	15.5	17.4	18.2	33.6	29.6	28	25.6	22.9	20.5	15.2
RX4	15.5	15.6	17.7	18.6	31.6	29	27.7	25.9	23.4	20.9	15.1
RX5	15	15.2	17.7	18.8	24.4	22.7	22.1	21.1	19.7	19.2	19.5
RX6	14.7	14.9	16.6	17.5	37.7	32.8	30.9	28.8	27.1	26.2	20.9

4.3 Forward Transmission

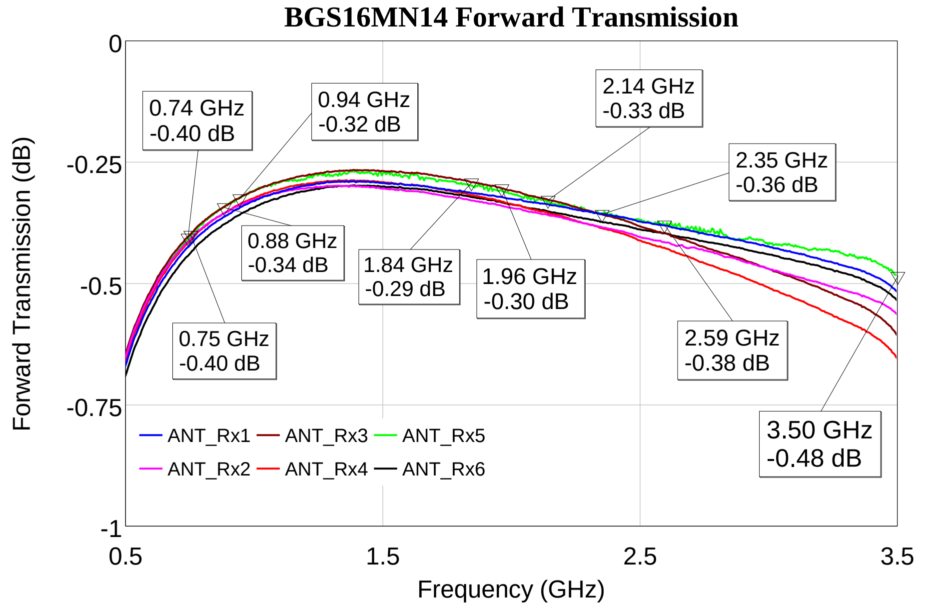

Figure 8 Forward Transmission Curves for RF Ports

4.4 Reflection Antenna Port

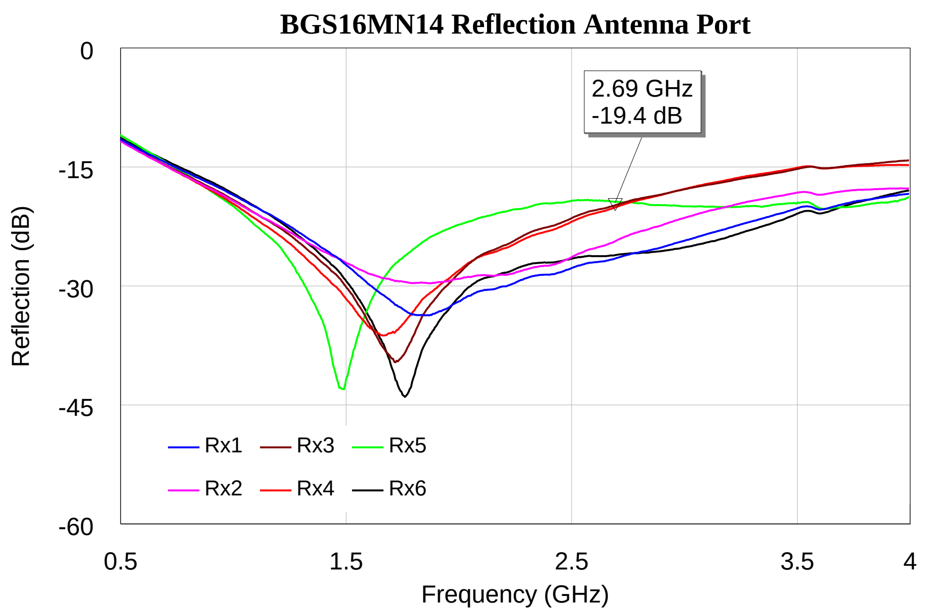

Figure 9 Reflection Antenna Port

4.5 Port Reflection

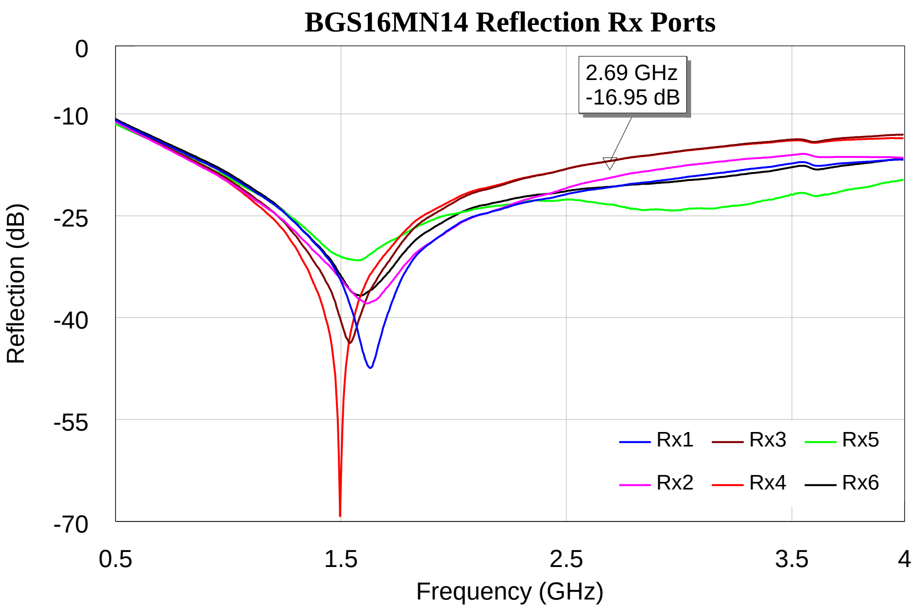

Figure 10 Port Reflection

4.6 Antenna Isolation Neighbour Ports

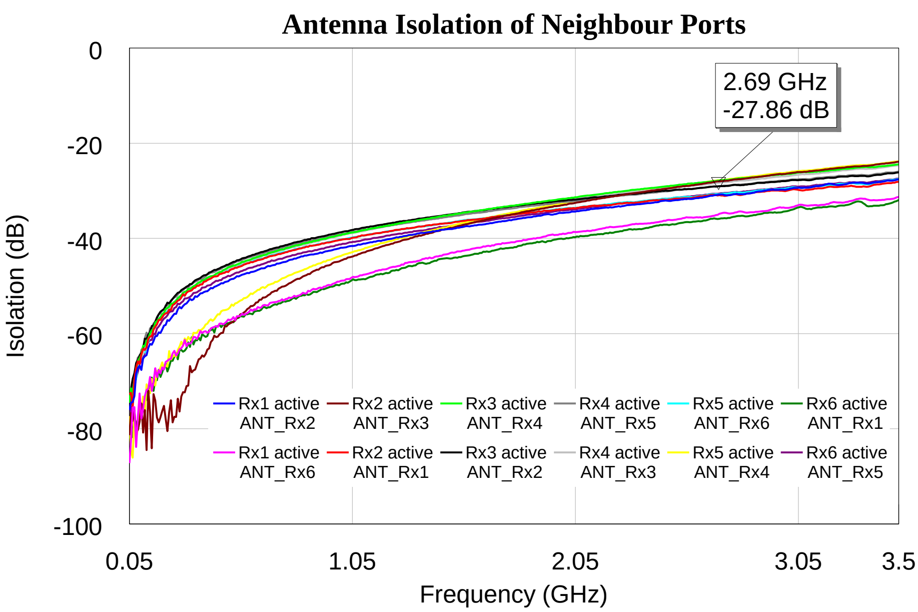

Figure 11 Antenna Isolation Neighbour Ports

4.7 Port Isolation Neighbour Ports

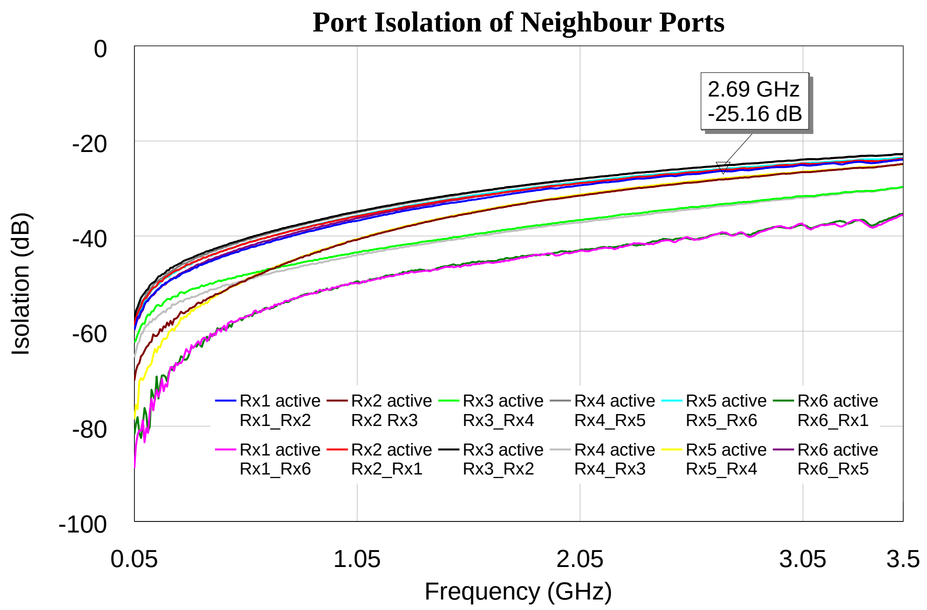

Figure 12 Port Isolation of Neighbour Ports

5 Intermodulation

5.1 Introduction

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.

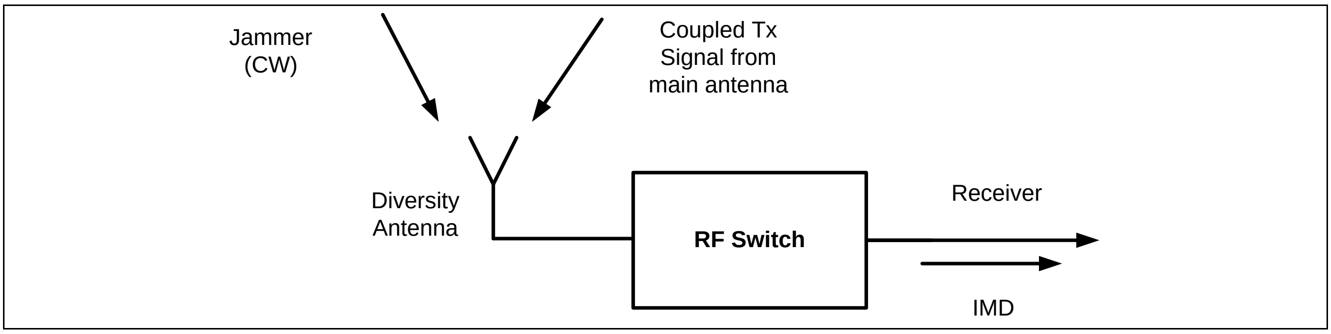

Figure 13 Block diagram of RF Switch intermodulation

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

5.2 IMD Test Set-up

The test setup for the IMD measurements has to provide a very high isolation between RX and TX signals. (**Figure 14**).For the RX / TX separation a professional duplexer with 80 dB isolation is used.

Please find the results for high and low band in **table 5** below. 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.

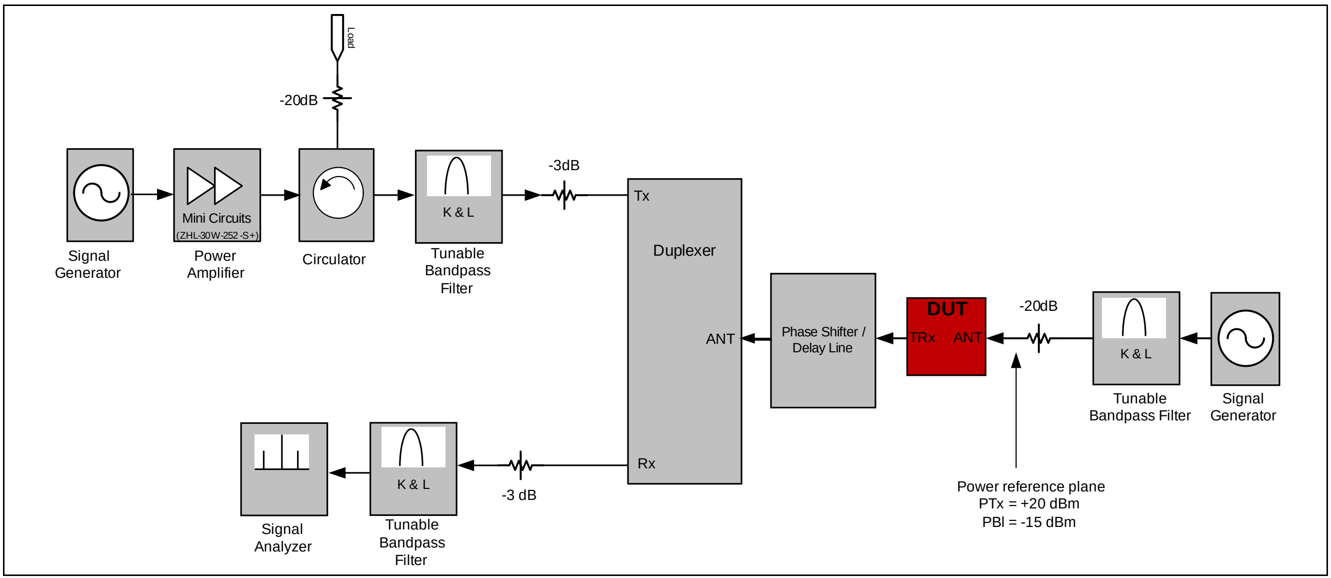

Figure 14 Test set-up for IMD Measurements

5.3 IMD Test Results for Band 1 and 5

Table 4 IMD Measurements

Band 1	TX		Interferer			Intermodulation Products UMTS Band 1		
Testcase	F_{IN} (MHz)	P_{IN} (dBm)	F_{IN} (MHz)	P_{IN} (dBm)		F_{IMD} (MHz)	P_{IMD} (dBm)	IIPx (dBm)
IMD3	1950	20	1760	-15		2140	-113	68
IMD2 low	1950	20	190	-15		2140	-94	99
IMD2 high	1950	20	4090	-15		2140	-111	116

Band 5	TX		Interferer			Intermodulation Products UMTS Band 5		
Testcase	F_{IN} (MHz)	P_{IN} (dBm)	F_{IN} (MHz)	P_{IN} (dBm)		F_{IMD} (MHz)	P_{IMD} (dBm)	IIPx (dBm)
IMD3	835	20	790	-15		880	-111	68
IMD2 low	835	20	45	-15		880	-99	105
IMD2 high	835	20	1715	-15		880	-110	115

6 Harmonic Generation

Harmonic generation is another important parameter for the characterization of a RF switch. RF switches have to deal with high RF levels, up to 27 dBm. With this high RF power at the input of the switch harmonics are generated. This harmonics (2^{nd} and 3^{rd}) can disturb the other reception bands or cause distortion in other RF applications (GPS, WLan) within the mobile phone.

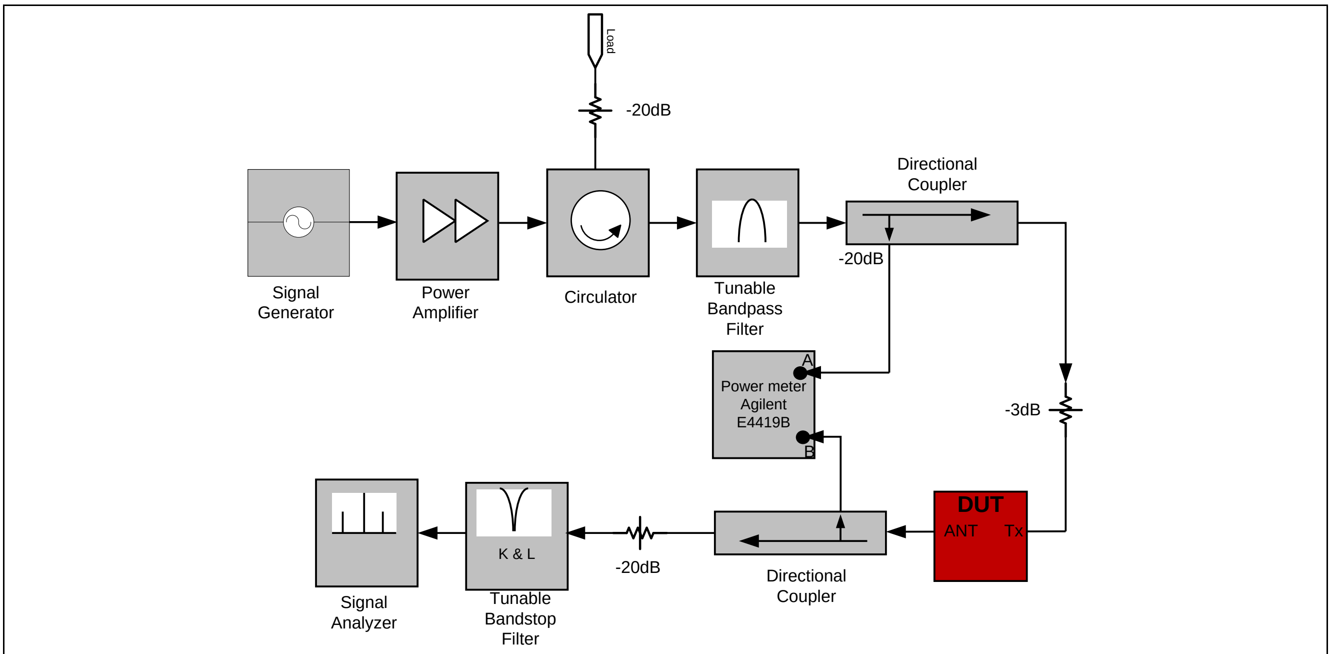

Figure 15 Set-up for harmonics measurement

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.

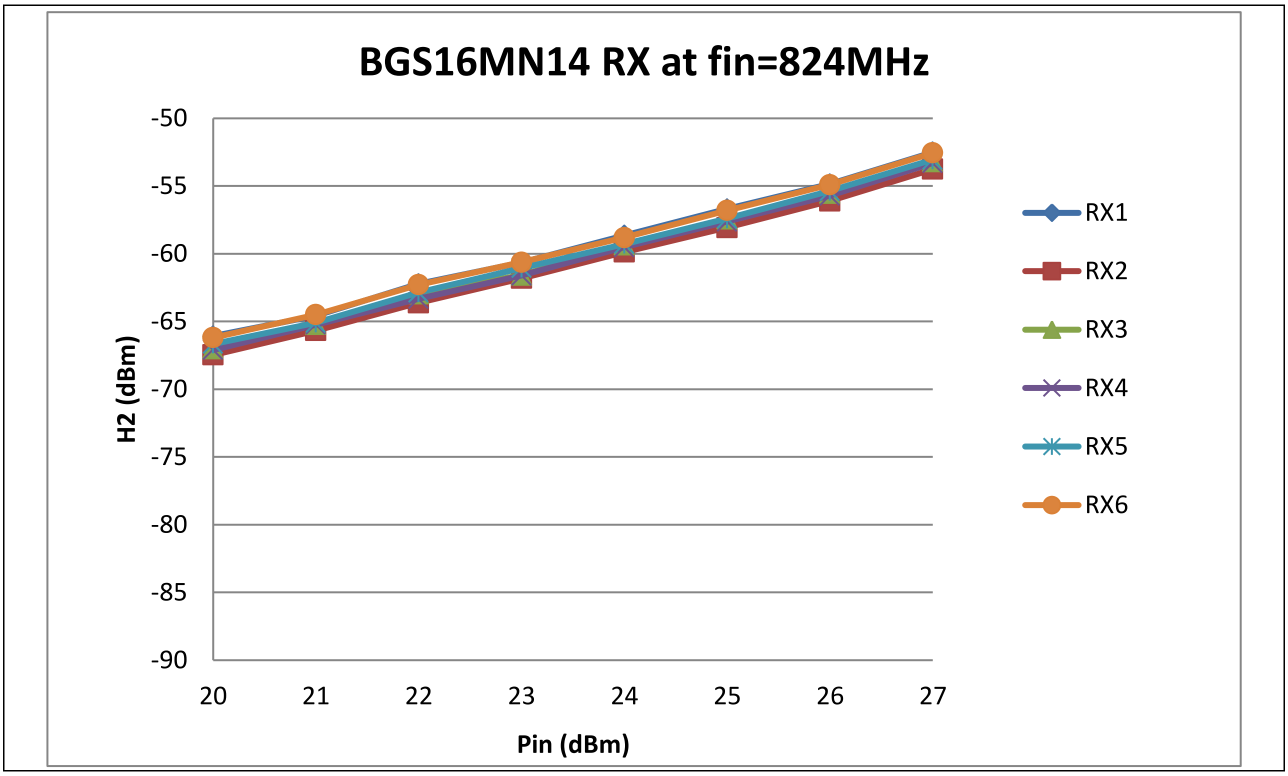

Figure 16 2nd Harmonic at f_c=824 MHz

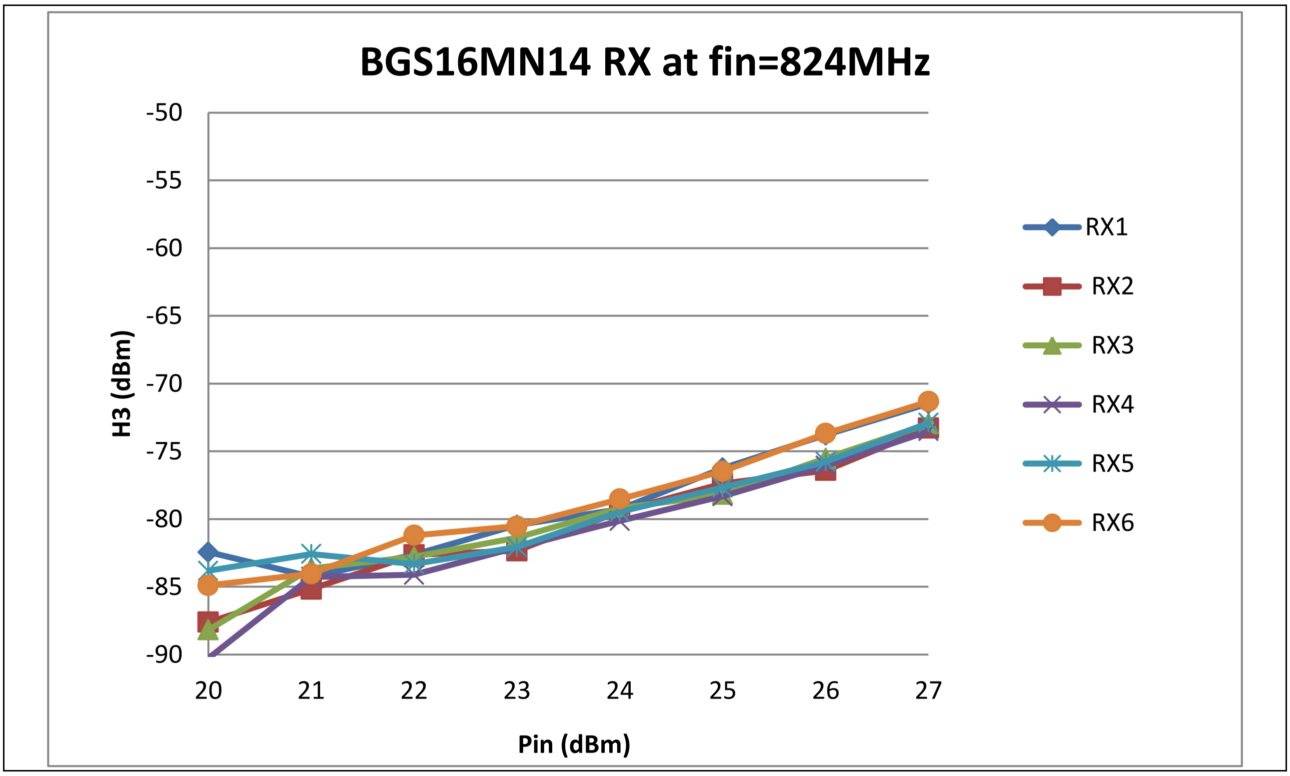

Figure 17 3rd harmonic at f_c=824 MHz

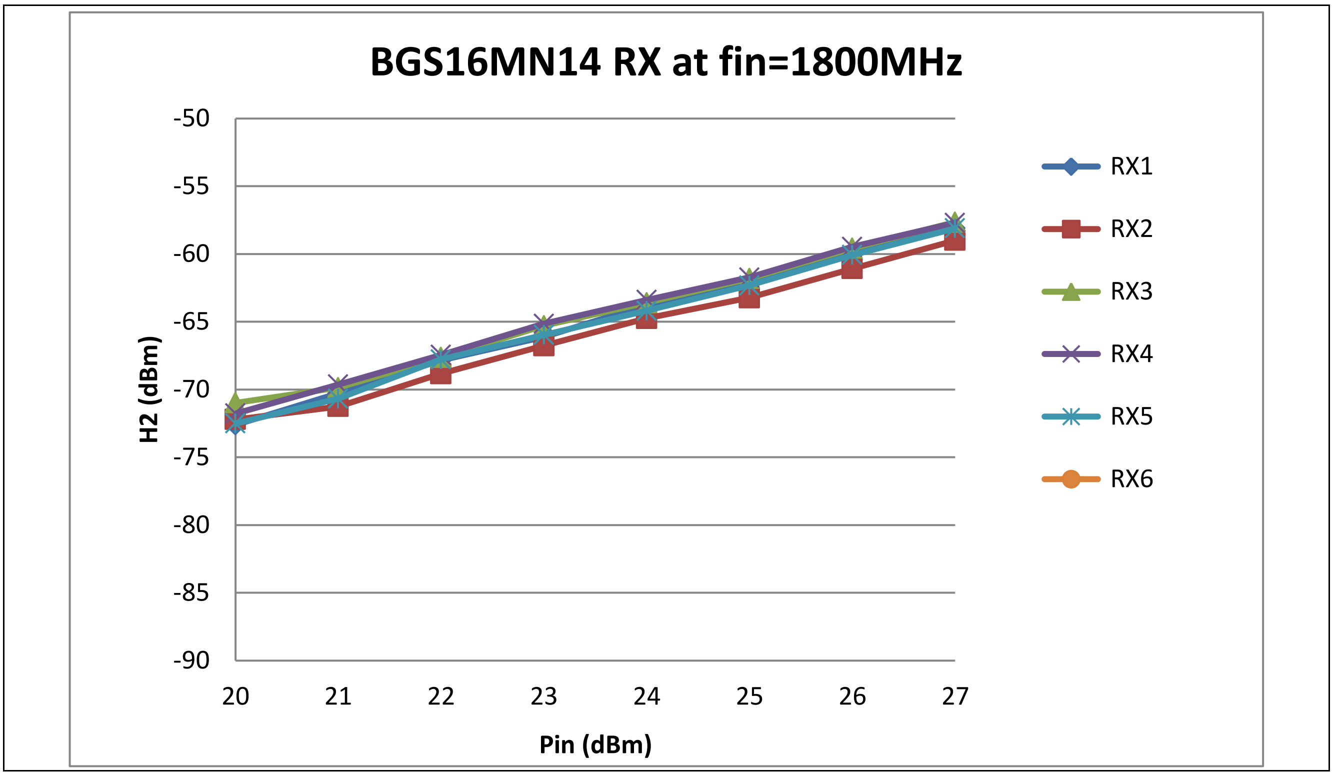

Figure 18 2nd Harmonic at f_c=1800 MHz

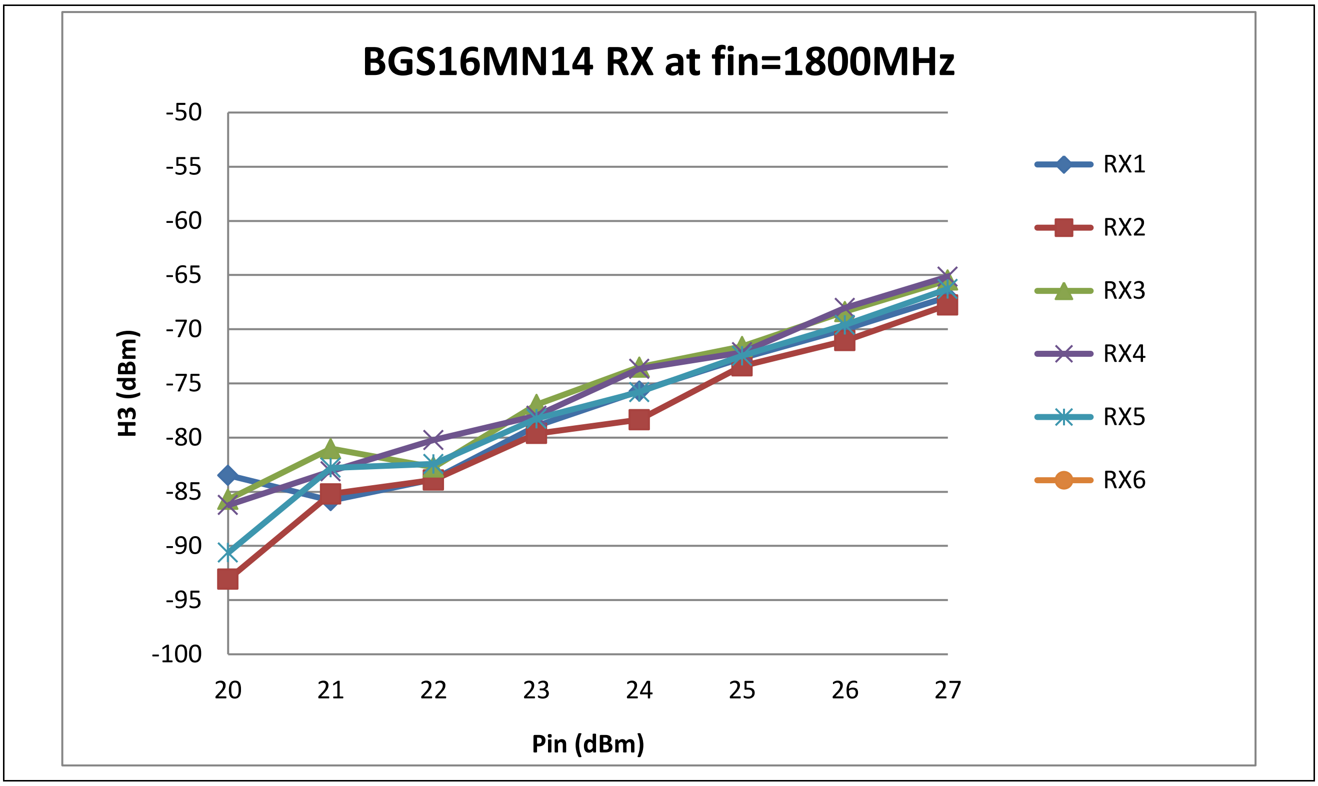

Figure 19 3rd Harmonic at f_c=1800 MHz

7 Appendix: Switch Controller Unit

The BGS18MN14 is controlled via MIPI interface and Infineon offers a MIPIcontroller unit to ease the evaluation of its BGS18MN14 on application board. The unit is very simple to use with a few buttons to select the right device and different states.

This section helps as a short user guide for the controller unit shown in Figure 20. The controller unit requires a DC supply of 5.5V with a current capability of 50mA.

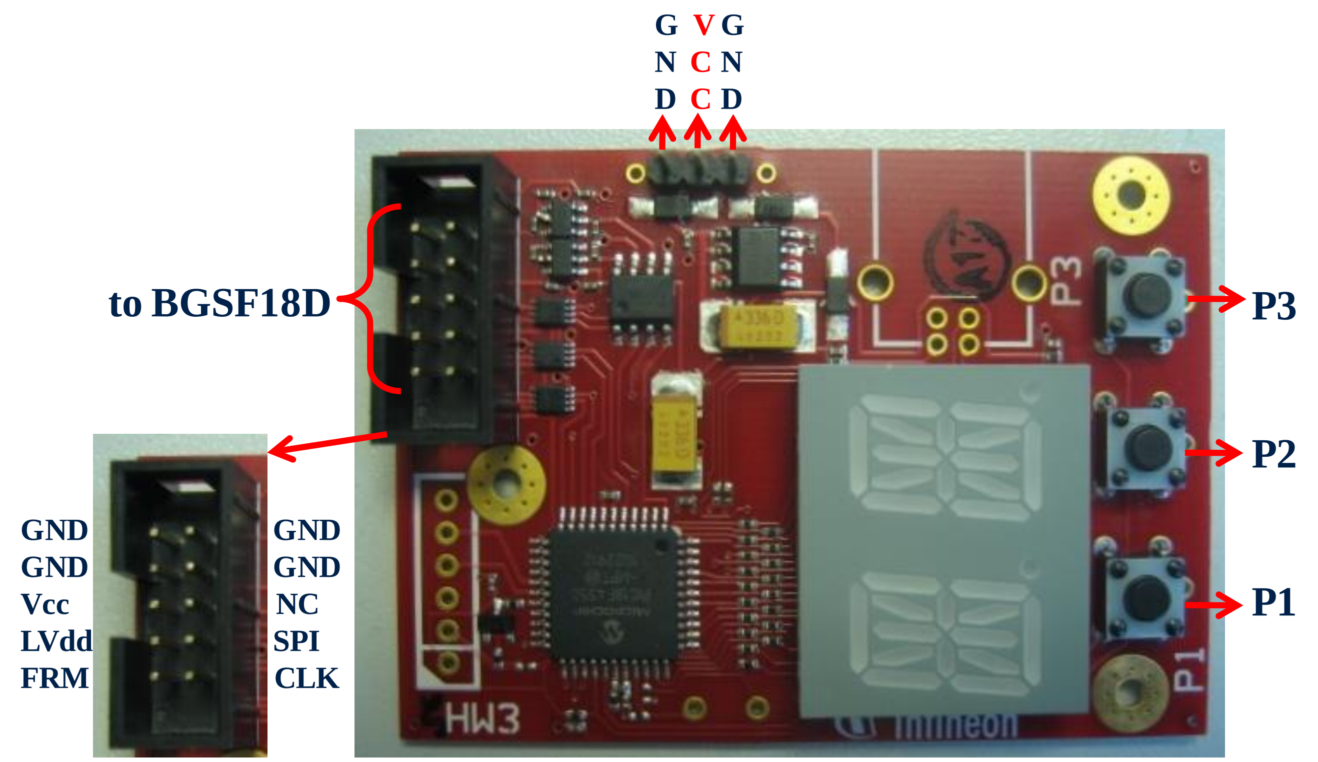

Figure 20 Switch Controller Unit Board

Please observe the following steps to use the controller unit:

7.1 Operating Guide

1. Connect evalboard and control unit via controller cable
2. Connect control unit to power supply
3. Version number “S.0” is displayed
4. Press P1 and P3 simultaneously until desired switch type is displayed
    - “0D” for BGS110MN20
    - “8D” for BGS18MN14
    - “6D” for BGS16MN14
5. Press P1 or P3 to enable active mode “PU” is displayed*
6. Press P1 or P3 to alter switch state
    - IS … Isolation Mode (all channels off)
    - PD … Power Down Mode (low current consumption)
    - PU ... Power Up Mode (active mode)
    - R1 – R0 ... RX1 – RX10 enabled

8 Authors

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