BGSF18D

Optimizing the Performance of SP8T Antenna Switch Module

GSM/UMTS Mobile Applications

Application Note AN247

Revision: Rev. 1.0
2010-10-13

RF and Protection Devices

Edition 2013-08-05

Published by
Infineon Technologies AG
81726 Munich, Germany

Application Note AN247	
Revision History: 2010-10-13	
Previous Revision: prev. Rev. x.x	
Page	**Subjects (major changes since last revision)**

Table of Content

List of Figures

List of Tables

1 Introduction

The BGSF18D is a Single Pole Eight Throw (SP8T) switch module optimized for wireless applications up to 2.7GHz. The switch module is designed to meet the evolving challenges due to the continuous advancement in mobile phone technologies. The convergence of GSM, EDGE and UMTS standards, leads to the design handsets capable of multiband multimode operation which poses a great challenge on the system designer.

To meet the requirements of today's multiband multimode handsets, the ASM (**A**ntenna **S**witch **M**odule) has two exclusive GSM/EDGE transmit paths including harmonic filters and six identical RF ports which can be flexibly used as GSM/EDGE receive or UMTS transmit receive paths.

This document is a guide to help the system designer to get the optimum performance out of the ASM.

Scope of this document:

1. Configuration of ports: Insertion Loss and Port to Port Isolation considerations
2. Optimizing Harmonics and Insertion Loss of GSM Low Band
3. PCB design guidelines

2 BGSF18D Schematic

Below is the application schematic of BGSF18D. There is only one optional external component (L_{ext}), which gives the designer flexibility to further optimize the performance of the ASM.

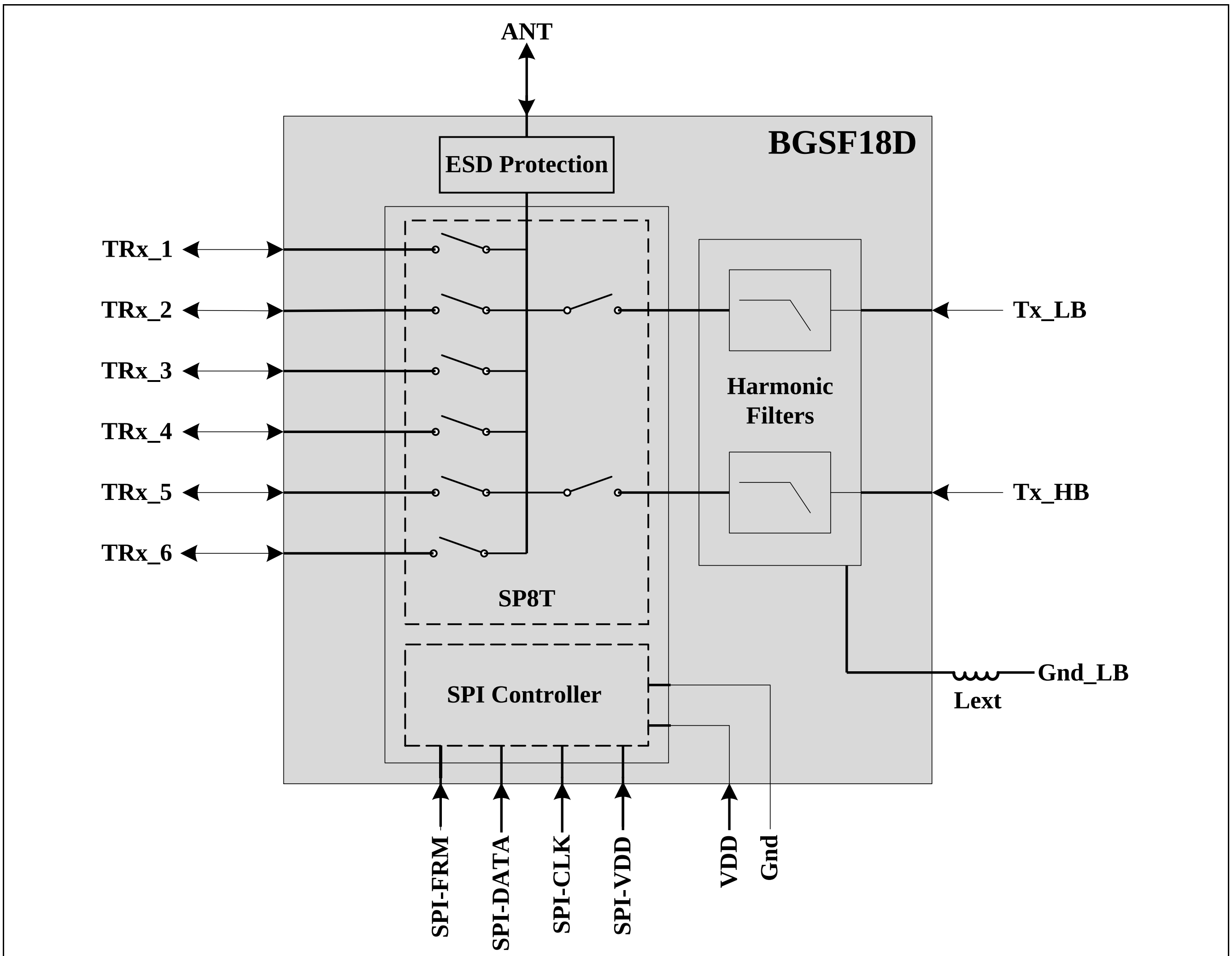

Figure 1 BGSF18D Application Schematic

3 Configuration of ports

Before we start with the port configuration of BGSF18D, it is valuable to have an insight into the list of frequencies recognized by 3GPP for GSM/EDGE and UMTS as shown in Table 1 and Table 2.

Table 1 GSM/EDGE Frequencies

Band	Tx (MHz)	Rx(MHz)
GSM850	824 to 849	869 to 894
GSM900	890 to 915	935 to 960
DCS	1710 to 1785	1805 to 1880
PCS	1850 to 1910	1930 to 1990

Table 2 UMTS Frequencies

Band	Tx(MHz)	Rx(MHz)
I	1920 to 1980	2110 to 2170
II	1850 to 1910	1930 to 1990
III	1710 to 1785	1805 to 1880
IV	1710 to 1755	2110 to 2155
V	824 to 849	869 to 894
VI	830 to 840	875 to 885
VII	2500 to 2570	2620 to 2690
VIII	880 to 915	925 to 960
IX	1749.9 to 1784.9	1844.9 to 1879.9
X	1710 to 1770	2110 to 2170
XI	1427.9 to 1447.9	1475.9 to 1495.9
XII	698 to 716	728 to 746
XIII	777 to 787	746 to 756
XIV	788 to 798	758 to 768
XIX	830 to 845	875 to 890
XX	832 to 862	791 to 821
XXI	1447.9 to 1462.9	1495.9 to 1510.9

Based on the system design, different band combinations from the above listed frequency bands can be used. From the table above, we can see that some of the transmit frequencies of one band overlap with the receive frequencies of the other. Therefore, care should be taken to have good port to port isolation between these bands.

Below are the most critical combinations

1. Band I Tx and Band II/PCS Rx
2. Band II/PCS Tx and Band III/DCS Rx

Therefore, it should be taken into account that they are not routed through adjacent ports. Table 3 shows two such recommended combinations, to get the best possible isolation between the different paths. All TRx ports on the BGSF18D are identical, which gives designer the flexibility to configure other ports to different bands.

Table 3 Port Configuration Proposals

UMTS / GSM Band	Option 1	Option 2
Band I	TRx2	TRx3
Band II / PCS	TRx4	TRx1
Band III / DCS	TRx6	TRx5

The port to port isolation values are tabulated in a table below. It is to be observed that the isolation between adjacent ports is lower than other combinations.

Table 4 BGSF18D Port to Port Isolation (in dB)

	Freq (GHz)	TRx1	TRx2	TRx3	TRx4	TRx5	TRx6	LB	HB
TRx1	0.85		37.1	45.1	56.4	51.4	50.1	35.4	49.3
	1.71		30.8	38.2	43.3	39.8	39.7	36.4	38.5
	1.91		29.7	36.9	41.7	37.7	38.8	37	37.7
	1.98		29.3	36.5	41.2	37.1	38.2	38.9	37.4
TRx2	0.85	36		35.4	47.6	49.2	52.7	35.4	48.4
	1.71	29.3		29.3	39.4	38.4	40.2	36.4	39.2
	1.91	28.1		28.3	38	36.5	38.8	36.7	38.8
	1.98	27.7		27.9	37.5	36	38.2	38.4	38.6
TRx3	0.85	39.1	33.9		39.8	44.3	51.8	35.4	47.8
	1.71	31.9	27.7		33.5	35.9	39.7	36.2	41.6
	1.91	30.6	27		32.4	34.2	37.9	36.4	42.5
	1.98	30.2	26.4		32	33.8	37.4	38.1	42.9
TRx4	0.85	51.8	46.2	38.9		36.3	43.7	35.4	44.6
	1.71	39.1	39	33		30	36.3	35.9	38.9
	1.91	37.4	37.6	32		28.8	34.5	36.1	39.5
	1.98	36.8	37.2	31.6		28.5	34.3	37.7	39.9
TRx5	0.85	51.4	53.9	46	36.1		36.8	35.5	43.3
	1.71	38.8	41.6	38.9	30		30.6	36	37.8
	1.91	37.1	40	37.5	28.9		29	36.1	38.2
	1.98	36.5	39.4	37.2	28.6		28.9	37.7	38.5
TRx6	0.85	49.4	54.2	56.3	43.6	39.7		35.8	41.9
	1.71	39	42.4	44.6	37.1	32.3		36	36.4
	1.91	37.5	41	42.8	35.7	30.8		36.2	36.7
	1.98	37	40.3	42.2	35.4	30.4		37.7	36.9
LB	0.85	47	47.2	47.6	48.4	43	43.5		39.6
	1.71	50.1	51.2	52.3	55	42.6	46		38.9
	1.91	49.9	51.5	53.1	52.5	44.5	48		38.6
	1.98	45.8	47.2	48.3	47.8	43.6	45.5		38.1
HB	0.85	49.1	52.7	53.1	49	48.8	47.5	35.1	
	1.71	34.7	37.8	39.6	39	37.7	37.7	35.6	
	1.91	32.3	35.4	37.2	37	35.5	36.3	36	
	1.98	31.5	34.5	36.3	36.3	34.7	35.5	37.4	

4 Optimizing Harmonics of GSM Low Band

As shown in the application schematic earlier, an external inductor L_{ext} can be used to optimize the Harmonic behavior of the ASM.

The external inductor gives system designer the flexibility to improve the Harmonic performance of the ASM by adapting to the peripheral components. The inductor plays two roles

1. It helps to shape the filter curve as required
2. It influences the harmonic generation of the switch

Let us now see the two effects in detail.

4.1 Optimizing Harmonic Filter characteristic

In Figure 2, we see the effect of varying the inductor (L_{ext}) value on the filter response. The measurements are done on application board using Murata LQP03xx inductors. The inductor value is varied between short and 2nH. It is observed that there is a significant effect on the 3rd harmonic suppression and also an impact on the 2nd harmonic suppression. The filter curve can thus be tuned as to fit to the system performance. The short is achieved using a jumper which normally has a certain inductance too. A perfect short can be achieved using vias directly at the GND pad.

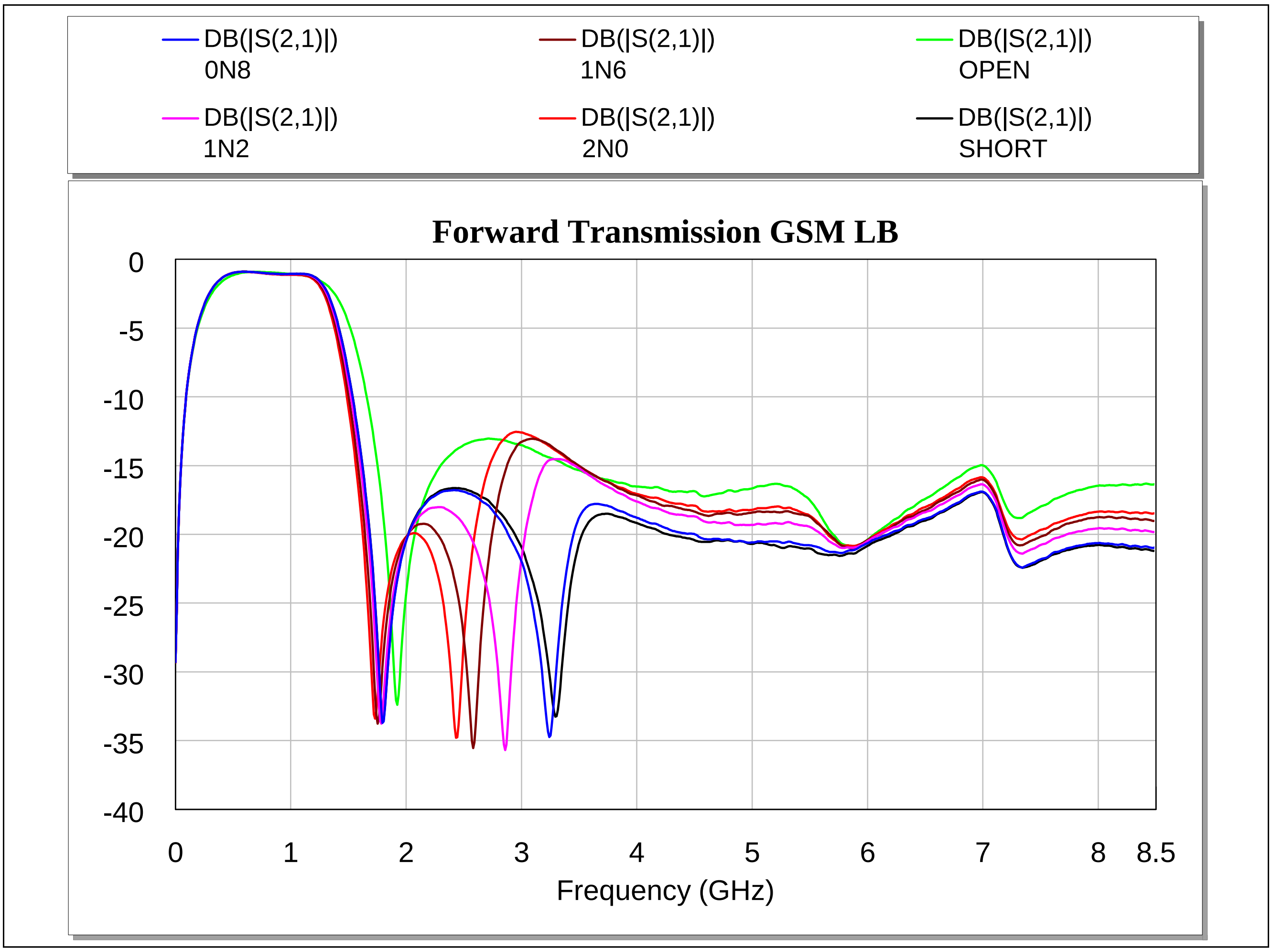

Figure 2 Effect of L_{ext} on Filter Curve

From the graph above, it can be seen that filter notches can be fine tuned to achieve a good trade off between 2nd and 3rd harmonic suppression for low and high side of the GSM850/900 bands.

System measurements at Infineon have shown that 1.6nH inductor provides an optimum solution. The forward transmission curve with a 1.6nH inductor is shown in the figure below.

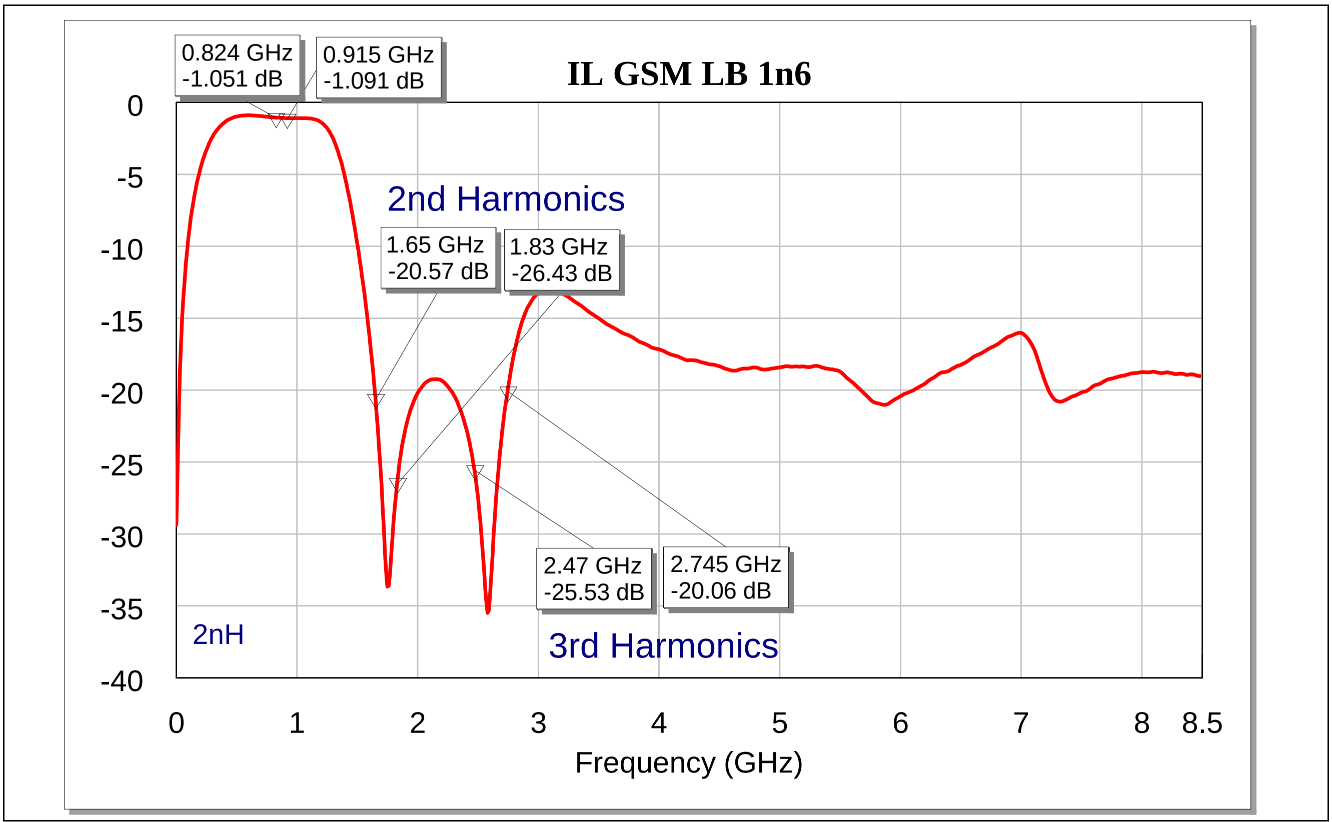

Figure 3 Switch and Filter Response with L_{ext}=1.6nH

It is to be noted that using the inductor slightly deteriorates the Insertion Loss of the Switch. The variation in Insertion Loss can bee seen in Table 5. It can be seen that going from short to 2nH, the Insertion Loss of the RF path increases by 0.05dB.

Table 5 Variation in Insertion Loss by changing L_{ext}

L_{ext} (nH)	IL (dB) 824 MHz	IL (dB) 850 MHz	IL (dB) 915 MHz
Short	1.03	1.04	1.07
1.2	1.05	1.06	1.08
1.6	1.05	1.06	1.09
2.0	1.08	1.09	1.12

4.2 Optimizing 3rd Harmonic generation of the Switch

As we know, the harmonic generation of an active device depends on the source and load terminations. The inductor L_{ext} changes the impedance of the filter as seen by the Switch input and thus has an effect on the harmonic generation of the Switch. Little impact is seen in 2nd harmonic generation (Figure 4) but significant impact can be seen in the 3rd harmonics. From the graph below, we can see that by using a 2nH inductor we can gain up to 10dB margin in the 3rd harmonic generation with a Switch input power of 35dBm.

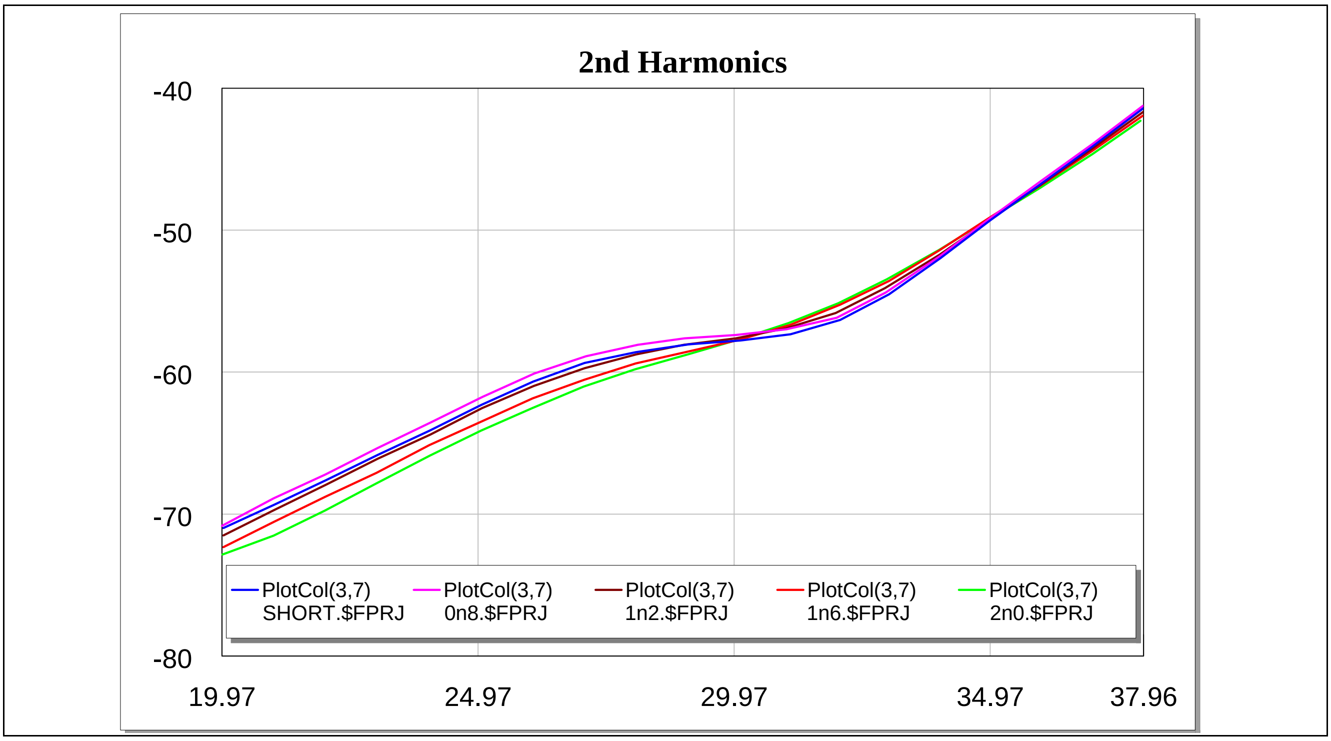

Figure 4 2nd Harmonic Generation

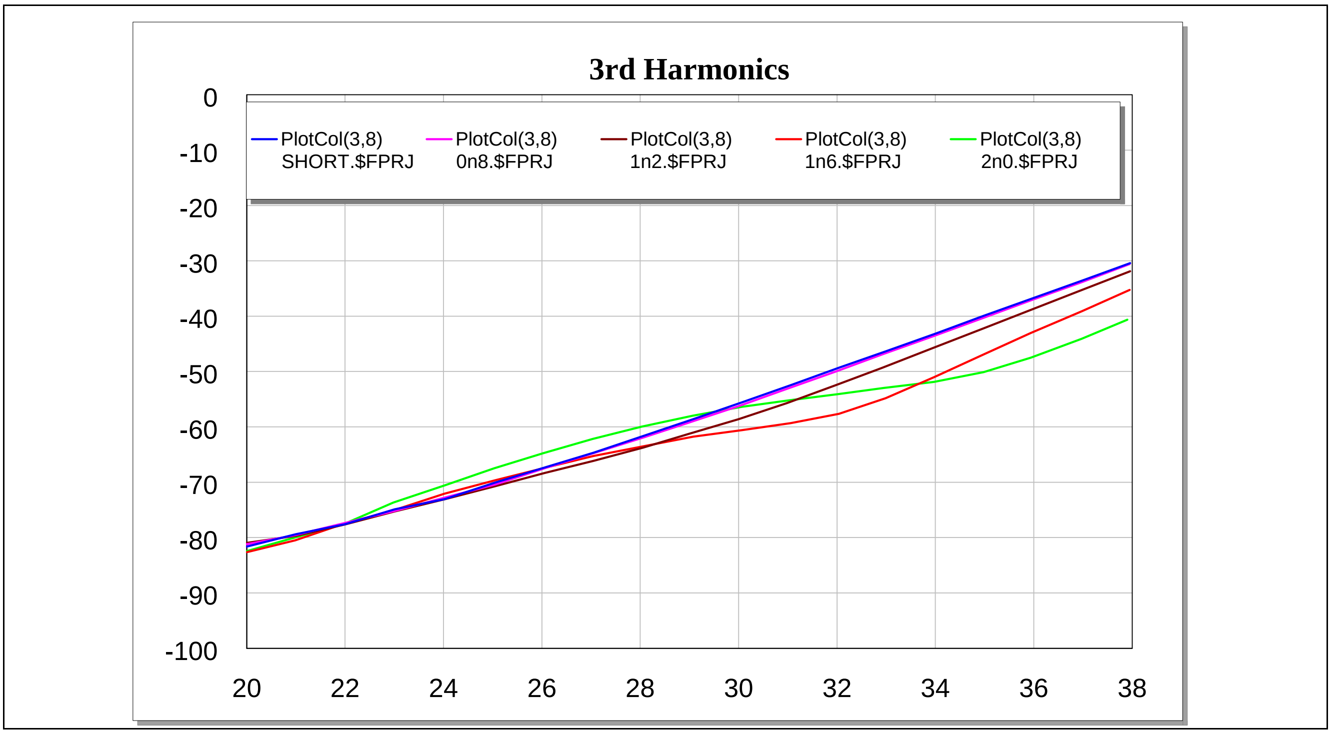

Figure 5 3rd Harmonic Generation

5 PCB Design Guide Lines

Figure 6 shows the package outline. The ASM has 16 pads with 1 big center pad, which is a Ground pad and also acts as a heat sink.

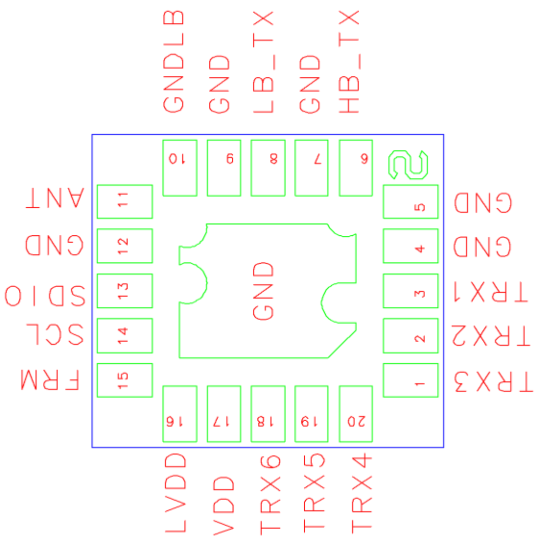

Figure 6 ASM Package: Top View

As we know, the performance of RF devices is strongly influenced by the PCB design. Here are a few points to realize a good PCB layout for the BGSF18D:

1. The center pad should be grounded using several vias directly under the pad to provide a good RF grounding. Improper grounding of this pad can have negative effects on the filter curve and isolation.
2. All other ground pads should be connected to the center ground as shown in the PCB proposal below.
3. General guidelines for a good RF board to be applied, namely, right characteristic line impedance, optimum spacing between lines, short line lengths etc.

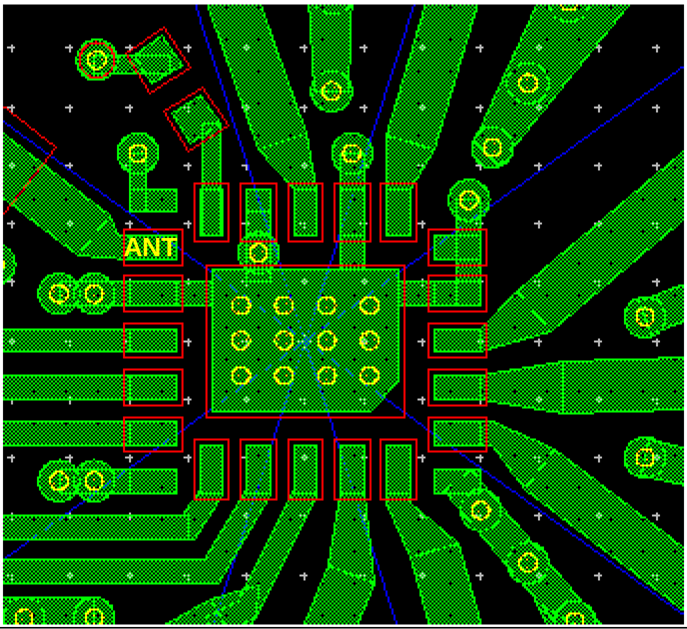

Figure 7 PCB Layout Proposal

Appendix: Switch Controller Unit

The BGSF18D is controlled via SPI interface and Infineon offers a SPI controller unit to ease the evaluation of its BGSF18D 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 8. The controller unit requires a DC supply of 5.5V with a current capability of 50mA.

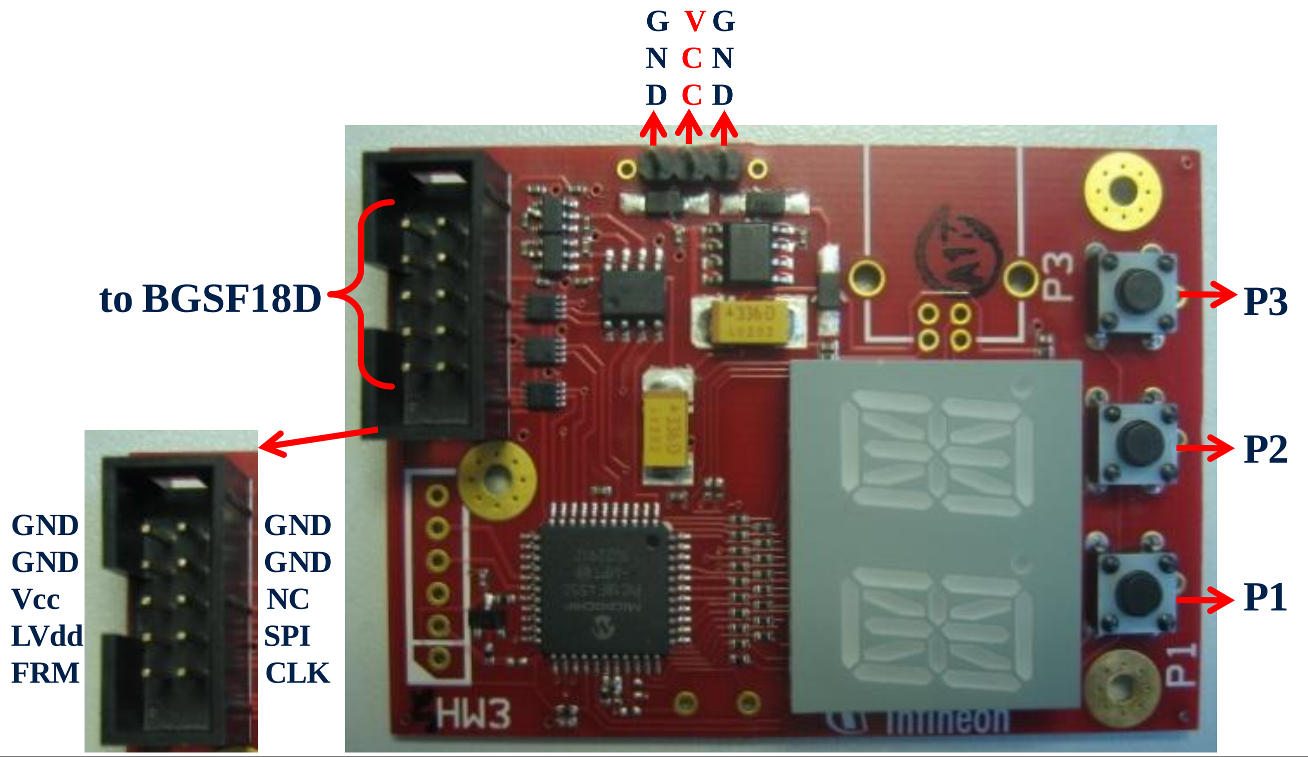

Figure 8 Switch Controller Unit Board

Please observe the following steps to use the controller unit:

1. **Step1:** Attach the power supply and “OK” appears on the display.
2. **Step2:** Set the control mode:
    a. Press and hold “P1” and “P3” simultaneously until “8A” appears on the display
    b. “P2” can be used to set the Vdd to the switch between 1.8V, 3.5V (default) and 4.0V
    c. To use 4V, please connect to 6V power supply instead of 5.5V
    d. “8A” addresses BGSF18D device
3. **Step3:** Connect the control unit to the switch with an appropriate cable according to the connector pinout shown in Figure 8.
4. **Step4:** Set the switch state to measure using “P1” and “P3”. The active paths corresponding to the state displayed are tabulated in Table 6.

Table 6 Active RF Path

Display	Active RF Path
LB	ANT – GSM LB Tx
HB	ANT – GSM HB Tx
P1	ANT – TRx1
P2	ANT – TRx2
P3	ANT – TRx3
P4	ANT – TRx4
P5	ANT – TRx5
P6	ANT – TRx6
AO	All OFF, Device is ON but all ports in isolation mode
GW	Global Stand-by (Power Down)
DS	Switch Stand-by (Power Down)

Author

Deepak Bachu, Senior Application Engineer of the Business Unit “RF and Protection Devices”

w w w . i n f i n e o n . c o m

Published by Infineon Technologies AG

AN247