

BGS12PL6

SPDT RF CMOS Switch

For High Power Applications

Application Note AN319

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RF and Protection Devices

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BGS12PL6 High Power Applications up to 35 dBm

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Table 1

Table 2

Pin Description (top view)7 Forward Transmission from RFIN Port to the Respective RF Port with All Other Ports Terminated



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1 Introduction

The BGS12PL6 general purpose RF MOS power switch is designed to cover a broad range of high power applications from 30 MHz to 4 GHz, mainly in the transmit path of WCDMA and LTE mobile phones. The symmetric design of its single pole double throw (SPDT) configuration, as shown in Figure 1 offers high design flexibility.

This single supply chip integrates on-chip CMOS logic driven by a simple, single-pin CMOS or TTL compatible control input signal. The 0.1 dB compression point exceeds the switch's maximum input power level of 35 dBm, resulting in linear performance at all signal levels. The RF switch has a very low insertion loss of 0.33 dB in the 1 GHz, 0.42 dB in the 2 GHz and 0.6 dB in the 3 GHz range.

Unlike GaAs technology, external DC blocking capacitors at the RF ports are only required if DC voltage is applied externally.

The BGS12PL6 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.

The device has a very small size of only 0.7x 1.1 mm² and a maximum height of 0.4 mm.

2 BGS12PL6 Features

2.1 Main Features

- 2 high-linearity TRx paths with power handling capability of up to 35 dBm
- · All ports fully symmetrical
- No external decoupling components required
- Very low insertion loss
- Very low harmonic generation
- High port-to-port-isolation
- 0.1 to 4 GHz coverage
- High ESD robustness
- On-chip control logic
- Small lead and halogen free package TSLP-6-4 (0.7 x 1.1 mm²)
- RoHS compliant package





2.2 Functional Diagram

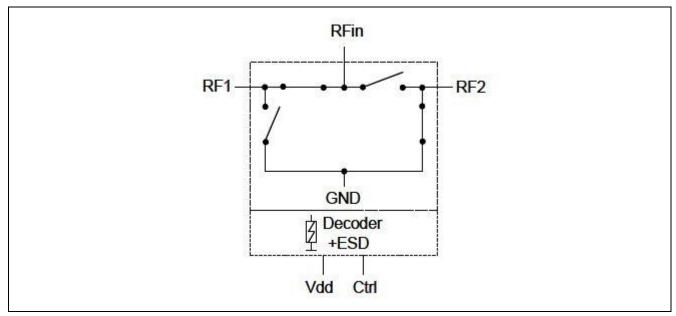


Figure 1 BGS12PL6 Functional Diagram

2.3 Pin Configuration

In Figure 2 the pin configuration in top view is given.

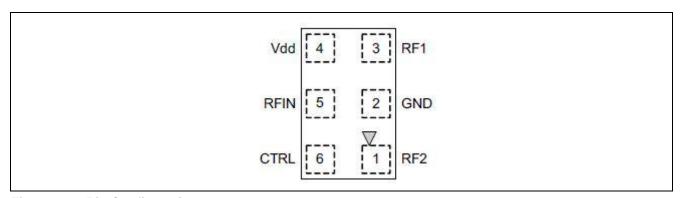


Figure 2 Pin Configuration

2.4 Pin Description

Table 1 Pin Description (top view)

Pin No.	Name	Pin Type	Function
1	RF2	I/O	RF port 2
2	GND	GND	Ground
3	RF1	I/O	RF port 1
4	Vdd	PWR	Supply Voltage
5	RFIN	I/O	RF port In
6	CTRL	-	Control Pin



3 Application

3.1 LTE Band Switch

The next generation smart phones are required to support upto 15 different frequency bands and even more number of band combinations. Often the number of pins on the transceiver is limited. An RF switch can be used to expand the number of reception bands. One of the possible applications of this high power SPDT is an LTE band switch which can be used after the Power Amplfier (PA) as shown in the figure below.

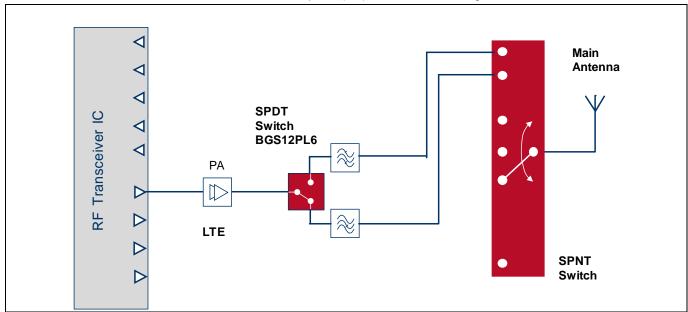


Figure 3 Application LTE Switch

3.2 Antenna switch

Another application is the antenna switch for certain bands in LTE and CDMA.

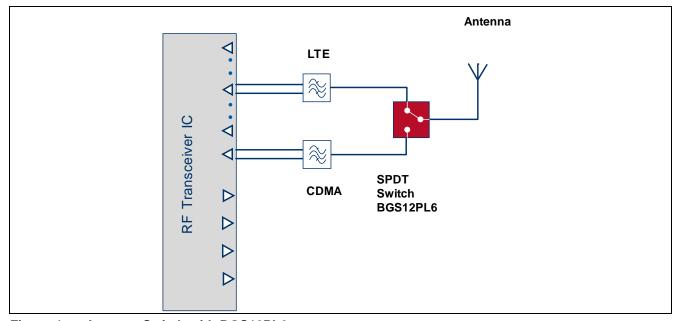


Figure 4 Antenna Switch with BGS12PL6



3.3 Application Board

Below is a picture of the evaluation board used for the measurements (Figure 5). 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 BGS12PL6 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 6).

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 6 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 6 right board)

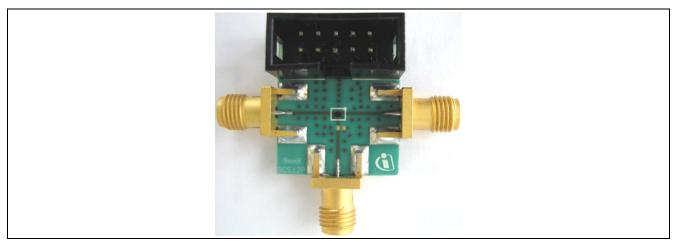


Figure 5 Photo of the Application Board



Figure 6 Photos of De-embedding Boards

The construction of the PCB is shown in Figure 7.

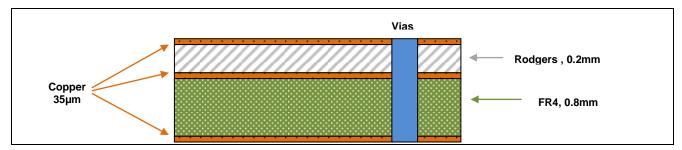


Figure 7 PCB layer information



Small Signal Characteristics

Small Signal Characteristics

The small signal characteristics are measured at 25 °C with a 4-port Network Analyzer.

4.1 **Measurement Results**

In the following tables and graphs the most important RF parameters of the BGS12SL6 are shown. The markers are set to the most important frequencies of the WDCDMA system.

Table 2 Forward Transmission from RFIN Port to the Respective RF Port with All Other Ports Terminated with 50Ω

Frequency (MHz)	824	915	1000	1710	1910	2170	2690
RF Path	024	915	1000	1710	1910	2170	2090
RF1	-0.38	-0.39	-0.39	-0.46	-0.47	-0.51	-0.58
RF2	-0.37	-0.38	-0.38	-0.44	-0.46	-0.49	-0.57

Table 3 Reflection RFin Port to the Respective RF Port with All Other Ports Terminated with 50Ω

Frequency (MHz) RF Path	824	915	1000	1710	1910	2170	2690
RF1	-29.1	-27.8	-27.7	-25.3	-24	-22.2	-20
RF2	-29.2	-28.1	-27.9	-25.4	-23.9	-22	-19.6

Table 4 Reflection RF Port to the Respective RF Port with All Other Ports Terminated with 50Ω

Frequency (MHz) RF Path	824	915	1000	1710	1910	2170	2690
RF1	-29.8	-29.4	-29.3	-26.2	-25.3	-23.7	-20.2
RF2	-30.8	-30.2	-30.3	-26.6	-25.4	-23.2	-19.3



4.2 Forward Transmission

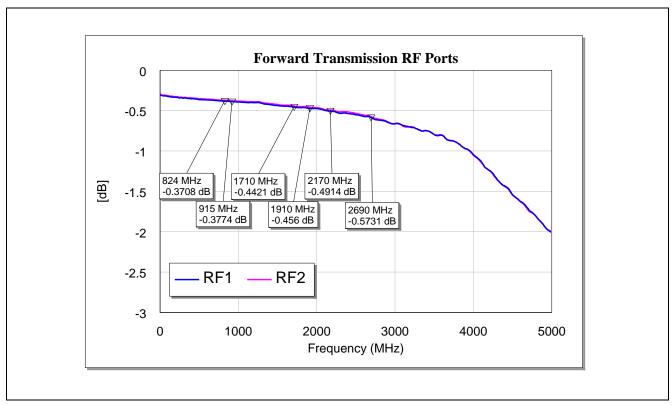


Figure 8 Forward Transmission Curves for RF Ports

4.3 Reflection RFin Port

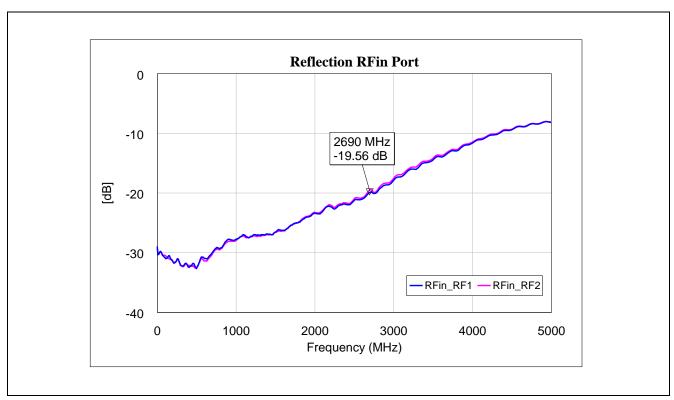
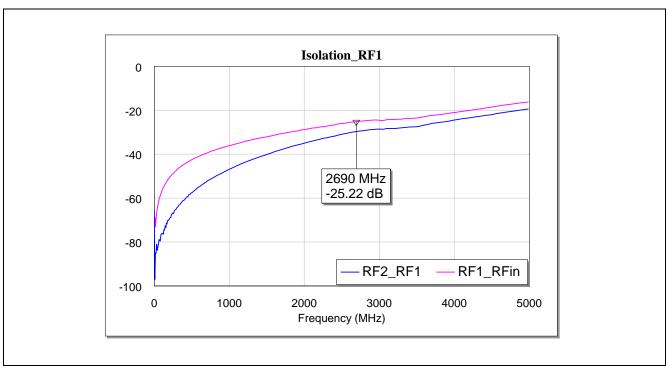


Figure 9 Reflection RFin Port

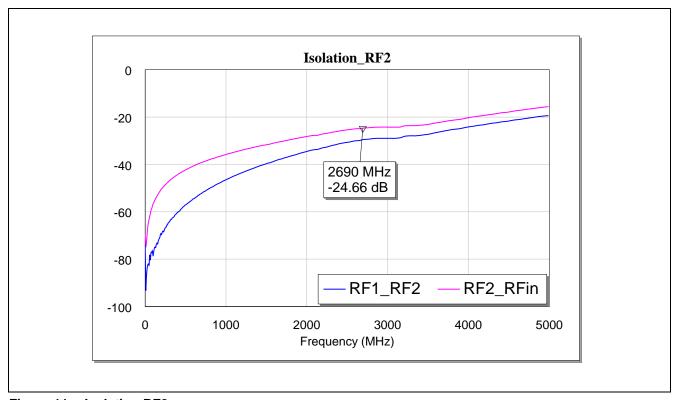


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Isolation RF1 Figure 10

4.5 **Isolation RF2**



Isolation RF2 Figure 11



Intermodulation

5 Intermodulation

Another very important parameter of a RF switch is the large signal capability. One of the possible intermodulation scenarios is shown in Figure 12. The transmission (Tx) signal from the main antenna is coupled into the diversity antenna with high power. This signal (20 dBm) and a received Jammer signal (-15 dBm) are entering the switch.

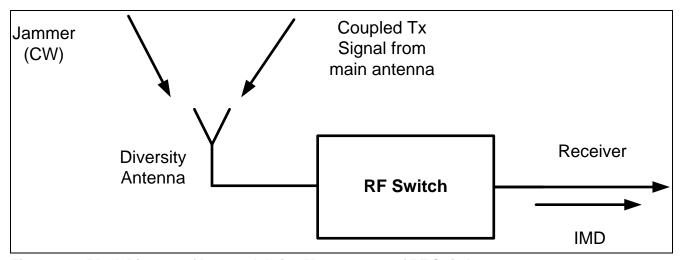


Figure 12 Block Diagram of Intermodulation Measurement of RF Switch

Special combinations of TX and Jammer signals produce 2nd and 3rd order intermodulation products, which fall in the RX band and interfere with the wanted RX signal.

In Table 5 frequencies for 3 bands and the intermodulation specifications for an undisturbed communication are given.

Table 5 Test Conditions and Specifications of IMD Measurements

Test Co	onditions					Intermod	lulation S	pecificat	ion
(Tx = +)	20dBm, B	l = -15dBı	m,freq.in MI	Hz,@25°C)					
Band	Tx Freq.	Rx Freq.	IMD2 Low	IMD3	IMD2 High		IIP2	IMD3	IIP3
(MHz)	(MHz)	(MHz)	Jammer 1	Jammer 2		(dBm)	(dBm)	(dBm)	(dBm)
			(MHz)	(MHz)	(MHz)				
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

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 13 and Figure 14).

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

Intermodulation

Figure 14 and Figure 15 show the results for Band I and Band V. For each distortion scenario there is a min. and a max. value given. This variation is caused by a phase shifter connected between the switch and the duplexer. In the test set-up the phase shifter represents a non-ideal matching of the switch to 50 Ohm.

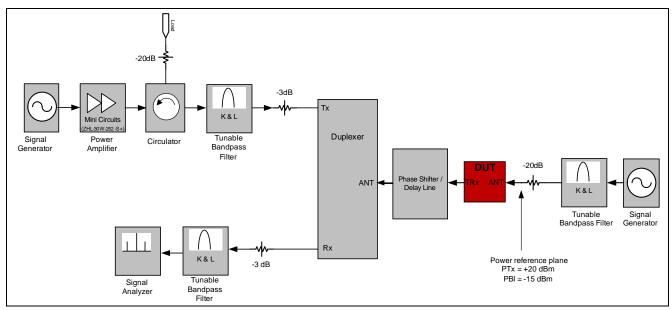


Figure 13 Test Set-Up for IMD Measurements

			IMD Band - I							
		IMPO		IMPO	111-1	18.6	20			
		INID2	IMD2 low		High	IMI	D3			
		f _b = 190 MHz		fь = 4090 MHz		fь = 1760 MHz				
Power	RF-port	Min	Max	Min	Max	Min	Max			
P _{Tx} = + 10dBm	RF1	-113,46	-102,93	-118,42	-113,63	-133,97	-125,14			
P _{int} = - 15dBm	RF2	-112,95	-102,45	-117,31	-113,76	-134,87	-126,04			
$P_{Tx} = +20dBm$	RF1	-105,52	-96,24	-111,64	-107,45	-118,05	-106,35			
$P_{int} = -15dBm$	RF2	-105,22	-95,58	-109,22	-106,19	-121,13	-108,86			

Figure 14 IMD Results for Band I

			IMD Band - V						
		IMD2	low	IMD2	High	IM	D3		
		fь = 45 MHz		f _b = 1718 MHz		fь = 791.5 MHz			
Power	RF-port	Min	Max	Min	Max	Min	Max		
P _{Tx} = + 10dBm	RF1	-116,31	-106,04	-119,20	-110,94	-124,54	-116,64		
P int = - 15dBm	RF2	-115,84	-106,67	-116,66	-111,30	-126,02	-121,25		
P _{Tx} = + 20dBm	RF1	-106,54	-97,06	-111,53	-105,13	-105,18	-98,54		
P _{int} = - 15dBm	RF2	-107,77	-98,87	-108,43	-103,60	-108,59	-102,33		

Figure 15 IMD Results for Band V



Harmonic Generation

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 35 dBm. Harmonics are generated with such high RF power levels at the input of the switch. These harmonics (2nd and 3rd) can disturb the reception of other bands or cause distortion in other RF applications (GPS, WLAN...) within the mobile phone.

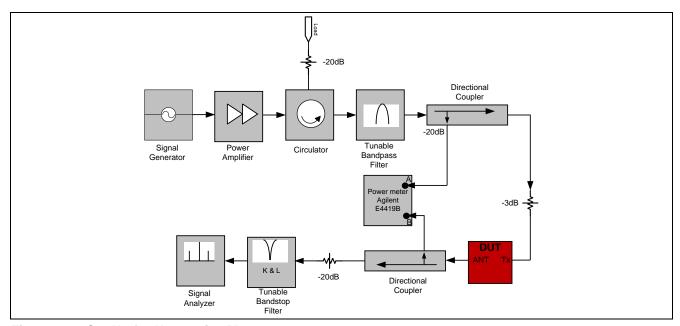


Figure 16 Set-Up for Harmonics Measurement

The results for the harmonic generation at 830 MHz are shown in Figure 17 (2nd harmonic) and Figure 18 (3rd harmonic) for all RF ports. In Figure 19 and Figure 20 the results for 1800 MHz are given.

On the x-axis the input power is plotted and on the y- axis the generated harmonics in dBm.

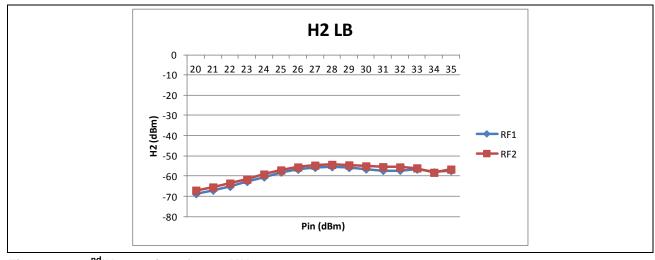


Figure 17 2nd Harmonic at f_c=830 MHz



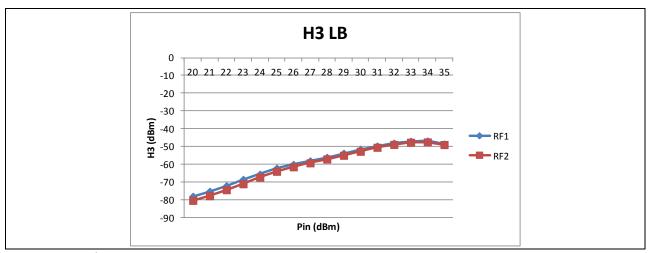


Figure 18 3rd Harmonic at f_c=830 MHz

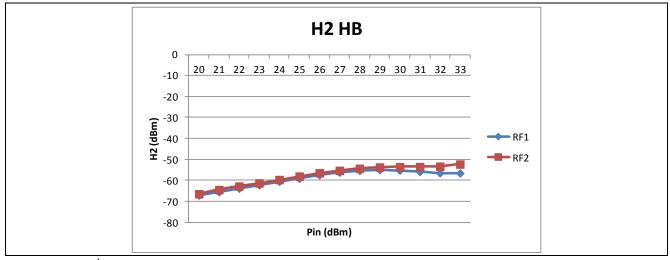


Figure 19 2nd Harmonic at f_c=1800 MHz

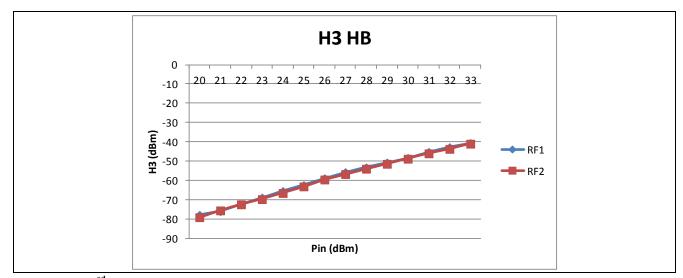


Figure 20 3rd Harmonic at f_c=1800 MHz



Power Compression Measurements on all RF Paths

To judge the large signal capability of a switch, 'power compression' is a widely used measurement. The output power is measured while the input power increasing gradually. At a certain point the output power does not follow the input power and the switch compresses the RF signal. In the diagram below (Figure 21) the IL is plotted versus the injected input power. The input power can be increased up to 38 dBm and there is no compression visible on any of the RF ports.

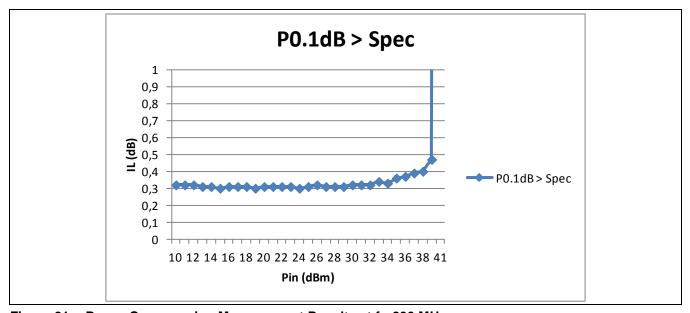


Figure 21 Power Compression Measurement Results at f_c=830 MHz

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 Authors

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