Antenna Switch
2170023-4.0

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APN Content Level	BASIC		INTERMEDIATE	✓	ADVANCED		Confidentiality	Public	✓	Private	✓

Hardware Compatibility	Product Line	AirPrime	Series	All	

Software Compatibility	ALL	Document Type	Application Note	✓	Technical Note	

1 Version

Application Notes may be updated over their lifetime. To ensure you are designing with the correct version, please check the application notes page in www.sierrawireless.com for latest versions.

2 Introduction

This Application Note (APN) is provided to Sierra Wireless distributors and clients to aid more rapid development of embedded applications using the Sierra Wireless portfolio of cellular solutions. To request a new application note, please contact your regional Sierra Wireless Product Marketing Manager.

3 Overview

The antenna switch function described in this APN allows an application to select one of two antenna's. This switching function can be used together with an antenna detection circuit, as discussed in the Sierra Wireless "Antenna diagnosis" application note.

4 Glossary

Initials	Definition
2G	GSM
3G	UMTS/ W-CDMA
4G	LTE
ESD	ElectroStatic Discharge
PCB	Printed Circuit Board
PTS	Product Technical Specification
RF	Radio Frequency
SPDT	Single Pole Double Throw

5 Block Diagram

The figure below shows a typical antenna switch function block diagram.

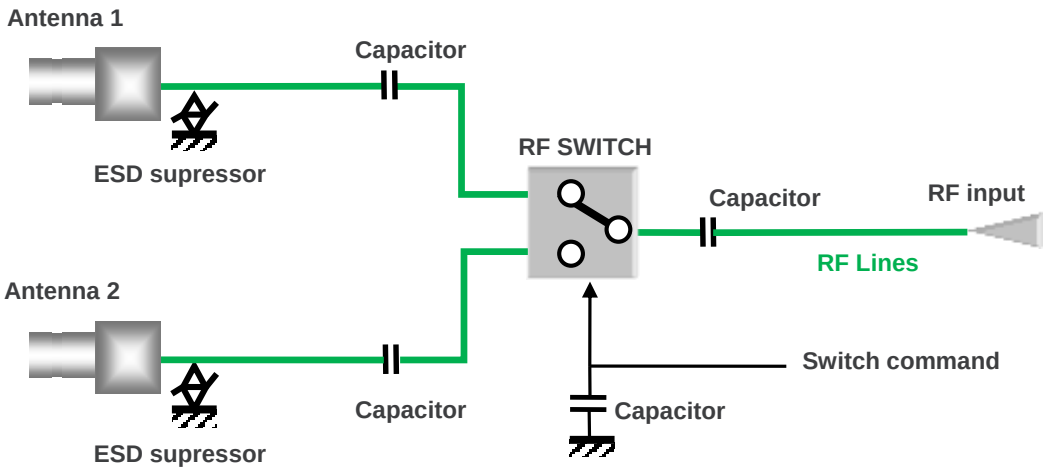

Figure 1. Typical Antenna Switch Function Block Diagram

The RF antenna port of an AirPrime module can be connected to either antenna 1 or antenna 2 according the “Switch command” signal state.

6 Components Selection

Requirements and specifications for the different components used are discussed in the following sections.

6.1 RF Switch

The RF switch is SPDT type whose main requirements are as follows:

- ✓ **Frequency range**

  Frequency bands to be covered can be from 700MHz to 3800MHz, detailed band descriptions for each Sierra Wireless module can be checked in their relevant PTS.

- ✓ **Power handling**

  The requirements between 2G and 3G/4G are different because 2G can use higher transmit power compared to 3G/4G. A good switch for 2G applications will also meet 3G/4G requirements, however, the reverse situation is not sure and it must be checked if a switch specified for 3G/4G switching can also be used for 2G switching.

  The maximum GSM transmit power is +33dBm for the GSM low bands (GSM900 and GSM850) and +30dBm for the high bands (DCS 1800 and PCS 1900). Having 3dB margin above these figures should be implemented as good practice.

  The maximum 3G/4G nominal transmit power is +24dBm. A +27dBm minimum power handling is required for the switch, allowing for 3dB margin.

- ✓ **Harmonics level**

  This is a critical point in the “Radiated Spurious Emission“ certification test. The required harmonic maximum level specification is -30dBm.

  Worst case conditions are with maximum GSM transmit power, i.e. +33dBm in low bands (GSM850 and GSM900) and +30dBm with the high bands (DCS1800 and PCS1900).

  Considering a 5dB margin, switch specifications should be harmonics lower than -35dBm (or -68dBc) @ +33dBm input with GSM850/GSM900 bands and lower than -35dBm (or -65dBc) @+30dBm input with DCS1800/PCS1900 bands.

- ✓ **Insertion loss**

  The lower the better, typical figures around 0.5dB are correct.

✓ **Isolation**

20dB typical isolation should be a minimum for most applications.

✓ **Suggested components selection**

The following table is a non-exhaustive list of RF switches with some specification extracts:

Table 1: RF Switches Information

Manufacturer	Product	Insertion loss (dB)		Harmonics	
		@1GHz	@2GHz	@1GHz	@2GHz
INFINEON	BGS12PL6 *	0.36 typ	0.46 typ	-80dBc typ @ +27.5dBm	NS
MACOM	MASWSS0181	0.4 typ	0.5typ	-75dBc typ @+34dBm	NS
NEC	UPG2155	0.35 typ	0.4 typ	-65dBc max @+34.5dBm	-64dBc max @+31.5dBm
	UPG 2156	0.45 typ	0.45 typ	-65dBc max @+35dBm	-65dBc max @+33dBm
RFMD	RF1200	0.3 typ	0.4 typ	-75dBc max @+34.5dBm	-70dBc max @+31.5dBm
SKYWORKS	AS193-73	0.35 typ	0.45 typ	-65dBc typ @ +34.5dBm	NS
*: This switch is only clearly specified for 3G/4G applications					

Manufacturers and/or distributors must be asked for complete specifications, application notes and products availability!

6.2 Additional Components

Passive components around the RF switch must be carrefully selected, this section reviews main requirements.

✓ **Capacitors**

Most of RF switches require external DC blocks on all RF ports, this point must be checked in their datasheet. These capacitors should have low impedance at working frequencies: values in the 22pF to 39pF range (0603 or 0402 size) are correct for this use. The capacitors maximum DC voltage specification must be in accordance with any expected DC voltage on antenna connectors.

It is recommended to add 22pF to 39pF decoupling capacitors on the switch command lines for interference prevention.

✓ **ESD protections**

RF switches are ESD sensitive devices, as a result additional ESD protection should be considered in case of externally accessible connectors or antennas.

This additional protection must have very low parasitic capacitance to minimize losses and must be free of harmonic generation (so, no diodes allowed!).The 0402ESDA-MLP1 from Cooper Bussmann has been sucessfully used.

Inductors of 82nH, 0603 or 0402 size have provided good protection as well.

✓ **Connectors**

Connectors need to be RF specified for the upper working frequency range and be 50Ω

7 PCB Design Guidelines

Usual RF design rules must be followed.

✓ RF connections must be 50Ωcharacteristic impedance lines and as short as possible to minimize losses.

Line structure can be microstrip, stripline or coplanar waveguide.

Free simulation software (Appcad from Agilent, TxLine from AWR…) can be used to tune the line width according the pcb stackup and to check losses as a function of frequency.

✓ RF traces with right angle bend must be avoided, round bend or 45° corners are prefered.

✓ No signal allowed near the RF lines to prevent coupling.

✓ It is recommended to embed the command lines on inner pcb layers to prevent interference from or towards these lines and to locate the decoupling capacitors (22pF to 39pF) on these control signals close to the switch with a short direct grounding.

- ✓ ESD protection: located as close as possible to the antenna connectors, with one pad on the RF line (no T connection!) and the second pad directly on a large ground (use at least 3 ground vias to inner ground layer).

8 Useful Links

- ✓ MACOM: http://www.macomtech.com
  - MASWSS0181 page: http://cdn.macom.com/datasheets/MASWSS0181.pdf
- ✓ RENESAS / NEC: http://www.cel.com/
  - UPG2155 page: http://www.cel.com/parts.do?command=load&idRootPart=712
  - UPG2156 page: http://www.cel.com/parts.do?command=load&idRootPart=1020#
  - Evaluation board link : http://www.cel.com/pdf/datasheets/uPG2155TB-EVAL-A.pdf
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  - ESD protection page: http://www.cooperindustries.com/content/dam/public/bussmann/Electronics/Resources/product-datasheets/Bus_Elx_DS_0402ESDA_MLP1_ESD_Suppressor.pdf
- ✓ AGILENT (Appcad download): http://www.hp.woodshot.com/
- ✓ AWR (TxLine download): http://www.awrcorp.com/products/optional-products/tx-line-transmission-line-calculator

9 Support

For direct clients: contact your Sierra Wireless FAE

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10 Document History

Level	Date	History
001	May 10, 2006	Creation (document reference: WM_DEV_AUTO_APN_002_001)
002	May 10, 2008	Updated
003	January 09, 2012	Updated with new template and new reference 2170023
4.0	November 2, 2016	Updated with new switch references and 2016 legal boilerplate.

11 Legal Notice