

WLAN Operational Description

Model: SM-A305FN/DS

FCC ID: A3LSMA305FN

Please find below the capabilities that are operational for this device:

- 2.4GHz 802.11b/g/n (20 MHz)
- 5GHz 802.11a (20 MHz)/ n (20/40 MHz) / ac (20/40/80 MHz)
- Mobile Hotspot 2.4GHz(Ch.1 ~ Ch.13), Mobile Hotspot 5GHz(Ch.149)
- Wi-Fi Direct 2.4GHz(Ch.1 ~ Ch.13), 5GHz(Ch. 36,40,44,48,149, 153, 157, 161, 165), Wi-Fi Display

Although the chipset documentation may indicate possible functions, the following have been permanently disabled in this device and cannot be enabled by the end user or service provider:

- FM Transmitter

See the KDB 905462 D06. The device supports the following frequency ranges and is only a client device in DFS Bands. The following table lists the actual channel/frequency plan for the 2.4GHz and 5GHz operation in USA. This device only supports Active scanning on non-DFS frequencies.

WLAN: 2412 – 2462MHz

UNII: 5180 – 5240MHz, 5260 – 5320MHz, 5500 – 5720MHz, 5745 – 5825MHz

- 2.4 GHz 20MHz BW (BPSK, QPSK, 16QAM, 64QAM)

Channel	Freq.(MHz)	Scanning	Channel	Freq.(MHz)	Scanning
1	2412	Active	8	2447	Active
2	2417	Active	9	2452	Active
3	2422	Active	10	2457	Active
4	2427	Active	11	2462	Active
5	2432	Active	12	2467	Passive
6	2437	Active	13	2472	Passive
7	2442	Active			

- By default (U.S MCC), only Channels 1-11 are enabled.
- The device uses MCC information obtained from the public cellular carrier to determine that it is operating outside the U.S. and then enable channels 12 and 13 only if a non-US MCC that supports 12, 13 is confirmed
- The MCC code is always monitored by the software in real-time
- Whenever the MCC code is not received (e.g., out of service, airplane mode, MCC not broadcasted by network, etc.) or whenever cellular connection is switched from one carrier to another, the power and channel settings immediately falls back to default (passive) before new MCC and MNC codes are confirmed
- Passive scan is used for Channels 12 and 13 as they considered to be secondary channels due to power lower then Ch. 1-11.

- 5 GHz 20MHz BW (BPSK, QPSK, 16QAM, 64QAM)

Channel	Freq.(MHz)	Scanning	Channel	Freq.(MHz)	Scanning
36	5180	Active	120	5600	Passive
40	5200	Active	124	5620	Passive
44	5220	Active	128	5640	Passive
48	5240	Active	132	5660	Passive
52	5260	Passive	136	5680	Passive
56	5280	Passive	140	5700	Passive
60	5300	Passive	144	5720	Passive
64	5320	Passive	149	5745	Active
100	5500	Passive	153	5765	Active
104	5520	Passive	157	5785	Active
108	5540	Passive	161	5805	Active
112	5560	Passive	165	5825	Active
116	5580	Passive			

- 5 GHz 40MHz BW (BPSK, QPSK, 16QAM, 64QAM)

Channel	Freq.(MHz)	Scanning	Channel	Freq.(MHz)	Scanning
38	5190	Active	118	5590	Passive
46	5230	Active	126	5630	Passive
54	5270	Passive	134	5670	Passive
62	5310	Passive	142	5710	Passive
102	5510	Passive	151	5755	Active
110	5550	Passive	159	5795	Active

- 5 GHz 80MHz BW (BPSK, QPSK, 16QAM, 64QAM, 256QAM)

Channel	Freq.(MHz)	Scanning
42	5210	Active
58	5290	Passive
106	5530	Passive
122	5610	Passive
138	5690	Passive
155	5775	Active

- The device operates strictly as a client in DFS channels (with passive scan). It does not support ad-hoc, Wi-Fi direct Group Owner, Hotspot or any other peer-to-peer modes that may initiate a network in DFS channels.
- Wi-Fi Direct operates only in associated mode under the control of a master device.
- Channels 118-128 are used only if permitted by a master device.
- The device's processor constantly monitors each data session and automatically discontinues transmission in the absence of information to transmit within 4ms or when operational failure is detected by the CPU watchdog timers.
- The device employs a transmit power control scheme that meets 15.407(h)(1) requirement.
- Frequency stability – Fundamental emission maintained within the band of operation under all conditions, (Temperature variation of -30° to + 50°C at normal supply voltage, Voltage variation of battery endpoint to high voltage at a temperature of 20°C)

The software design described above has been verified and validated internally. Users do not have access to change the country code, channel plan or power setting

Ad-hoc or peer-to-peer modes are not supported operating in the UNII DFS bands (Band 2A and 2C). This NII transmitter is a client-only device without radar detection capability in the DFS bands. The client software and associated drivers can not initiate any transmission on DFS frequencies, which includes transmissions for beacon, ad-hoc, and peer-to-peer modes. Operation as an access point on non-DFS legacy frequencies is also not supported. The software is locked by the module manufacturer such that there is no access and the settings cannot be changed by the integrator of the module or the end user of the device. When Hotspot Mode is activated by the end-user, only 2.4/5.8 GHz bands are enabled.

In 5GHz band, WLAN chipset works only for necessary data transmission. When data transmission is not needed, this device actually shutdown Tx path. So, this device automatically discontinues its transmission in case of either absence of information to transmit or operational failure.

Basic Operation of the WLAN Radio

Software queues data packets to the WLAN radio MAC/PHY. The radio detects a packet is available to transmit and listens to the medium per the IEEE 802.11 media access protocol. When the medium is free as described in the IEEE 802.11 media access protocol, the radio controller turns on the transmitter and data and control signals are sent. After completion of transmission of the data packet(s) the controller turns off the transmitter. The radio circuitry is implemented so that the default state of the radio is off, and only the correct enabling signals and data from the higher layers, will allow the radio to begin data transmission.

Transmit Logic and Safeguards of the WLAN Radio

In normal operation, the transmission of data packets is expected to stop within 4ms. A watchdog circuit is implemented in the hardware which monitors transmission by the radio. This watchdog circuit will detect all other types of failure states and will reset the radio to a non active state if the radio is erroneously transmitting beyond the longest allowable packet size.

In addition, software logic is implemented to monitor the packet/data queue. If the queue does not progress within a time limit, due to an upper layer failure state, software will initiate recovery by resetting the radio.

WI-FI Direct Description

If Mobile Hotspot sessions were active, it is necessary forced to close due to the need for the dedicated WI-FI connection in WI-FI Direct mode.

WI-FI Direct Channel

- ✓ All Channels in the 2.4 GHz band spectrum.
 - ✓ Limited to Channels 149-165 in the 5 GHz band spectrum.
 - ✓ Limited to Channels 36~48 in the 5 GHz band spectrum.
- (But, these channels are used for Wi-Fi Direct channel only if the AP is already connected to these channels)

The main transmitter of the antenna on the device is not restricted from simultaneously transmitting with WI-FI while WI-FI Direct is enabled.

Wi-Fi Direct is not expected to be used simultaneously with another licensed transmitter held-to-ear, body-worn or in the user's pocket. We expect Wi-Fi Direct to be used while in the person's hand (typical) or connected to the wall outlet (for more prolonged usage)

Wi-Fi Direct Certified devices can support either an infrastructure connection or a peer to peer connection. The devices connect by forming Groups that function like Infrastructure BSS (Basic Service Set).

Keep in mind that Wi-Fi Direct devices don't have full Wi-Fi functionality like you would find in Access Points. Consider a Peer to Peer Group that is made up of a legacy Wi-Fi device and a couple of Wi-Fi Direct devices.

One of the Wi-Fi Direct devices has to serve as the Group owner.

As part of the specification, there are multiple mandatory mechanisms that must be filled by devices in the group.

1. Group Formation is the mechanism to determine which Wi-Fi Direct device is the leader of the group.
2. Device Discovery is the mechanism to locate Wi-Fi Direct devices and exchange pertinent information about each device in the group.
3. Client Discovery is the mechanism that enables a Wi-Fi Direct device to determine all the devices in the group.

S5N5C12A01

WiFi/BT/FM

**Revision 0.1
October 2017**

Data Sheet

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Revision History

Revision No.	Date	Description	Author(s)
X01 0.0	Dec 24, 2016	• The preliminary draft	Sanghoon Kang
X01 0.1	May 26, 2017	• Package name is changed to WLCSP (WLP) • Package drawing is updated from draft version to final version.	Sanghoon Kang
X01 0.2	June 29, 2017	• Pin name errors in Table 1 are fixed.	Jounghyun Yim
A01 0.0	Sep. 6, 2017	• Current consumption, NF is added.	Jounghyun Yim
A01 0.1	Oct. 11, 2017	• Max limit of NF is added.	Jounghyun Yim

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1 Introduction

This document is the data sheet of S5N5C12 (S612), an RF IC for WLAN/BT/FM used in conjunction with SOC incorporating the Maxwell140 (MXL140) subsystem. S5N5C12 comprises a WLAN RF transceiver, a Bluetooth RF transceiver with modulator/de-modulator and an FM RF receiver with demodulator.

1.1 IC Features

- S.LSI 28 nm CMOS
- Package: Wafer level chip scale package (WL-CSP) (2.533 mm × 2.920 mm, 7.40 mm²)
 - 42 balls
- Overall
 - Connectivity RF chip with WLAN RF transceiver, BT radio and FM receiver
 - 26MHz TCXO sharing with Cellular & GNSS system or 40MHz TCXO sharing with GNSS
 - Power supply from companion PMIC chip
- WLAN
 - Supports dual-band single stream 802.11ac mode (20, 40, 80MHz bandwidth)
 - Highly integrated front-end eliminates external PA and LNA matching
 - Optional external 5GHz PA for higher output power and efficiency
 - Concurrent WLAN + BT reception
 - Built-in calibrations for PVT variation
 - No manufacturing calibration needed
 - 8-wire analog baseband interface (optional 4-wire mode with Rx/Tx multiplexing)
 - 2-wire WLAN dedicated digital control interface (1 x Master SPEEDY and 1 x Slave SPEEDY)
- Bluetooth
 - Include RF transceiver, mixed (ADC/DAC) and baseband modem for BT 4.2 + BR/EDR + BLE + ANT
 - Support for BT-WLAN coexistence operation, including concurrent receive via shared LNA with WLAN
 - Support for class 1 and class 2 power-level transmissions without requiring an external PA
 - No factory calibration required
 - 2-wire digital baseband interface for both BT data and control (1 x Master SPEEDY and 1 x Slave SPEEDY)

- FM
 - Worldwide FM band support (65 to 108 MHz) with 50 kHz channel spacing
 - Digital stereo demodulator
 - Full RDS/RBDS decoding supported
 - Automatic antenna tuning, auto search and tuning, volume control
 - Mono/Stereo blending
 - Support both internal and earphone antenna
 - Adaptive filter to suppress narrow band interference in the FM channel
 - Single-wire digital baseband interface for both FM data and control (1 x Slave SPEEDY)

1.2 Block Diagram

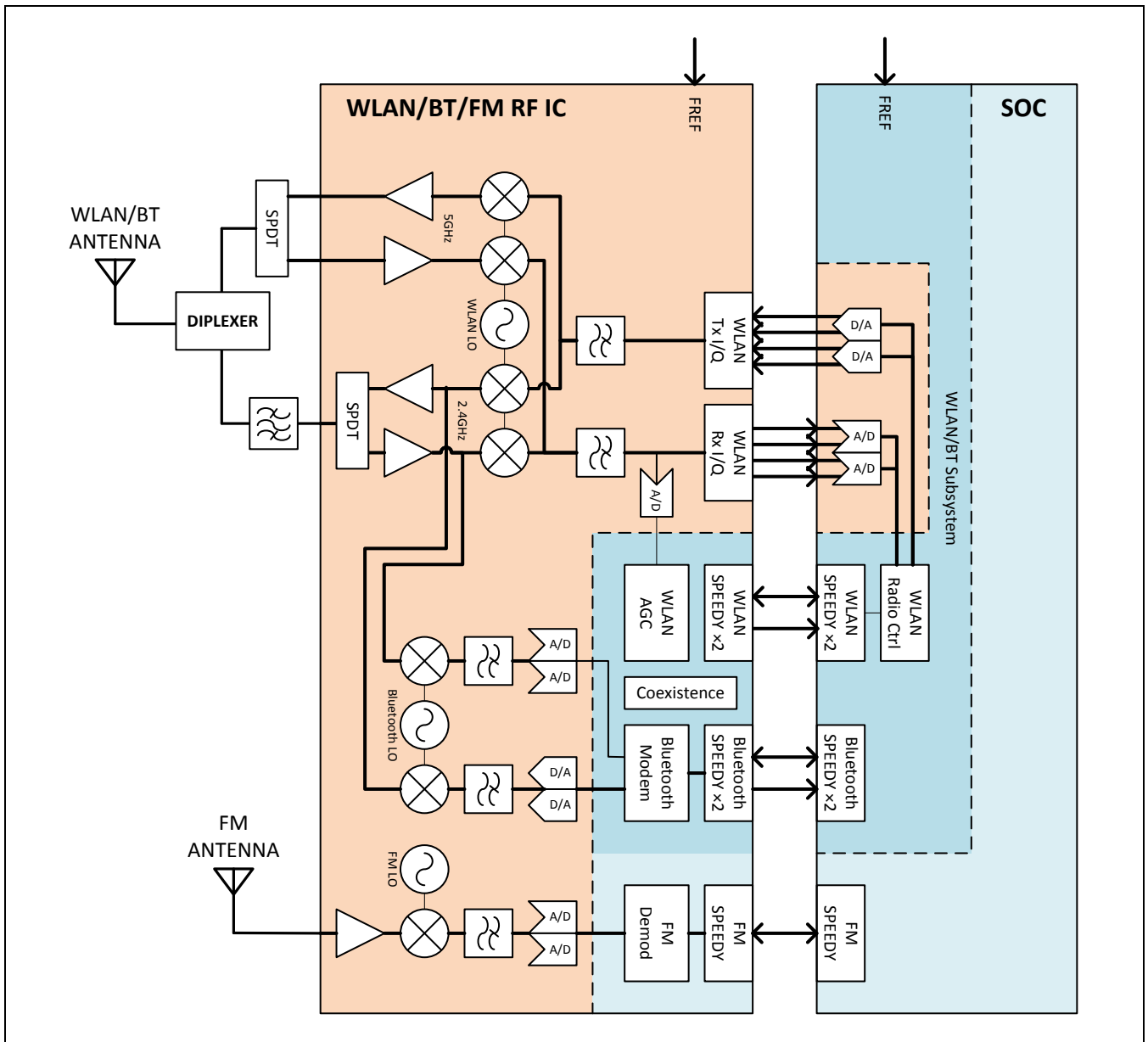


Figure 1 S5N5C12 Block Diagram

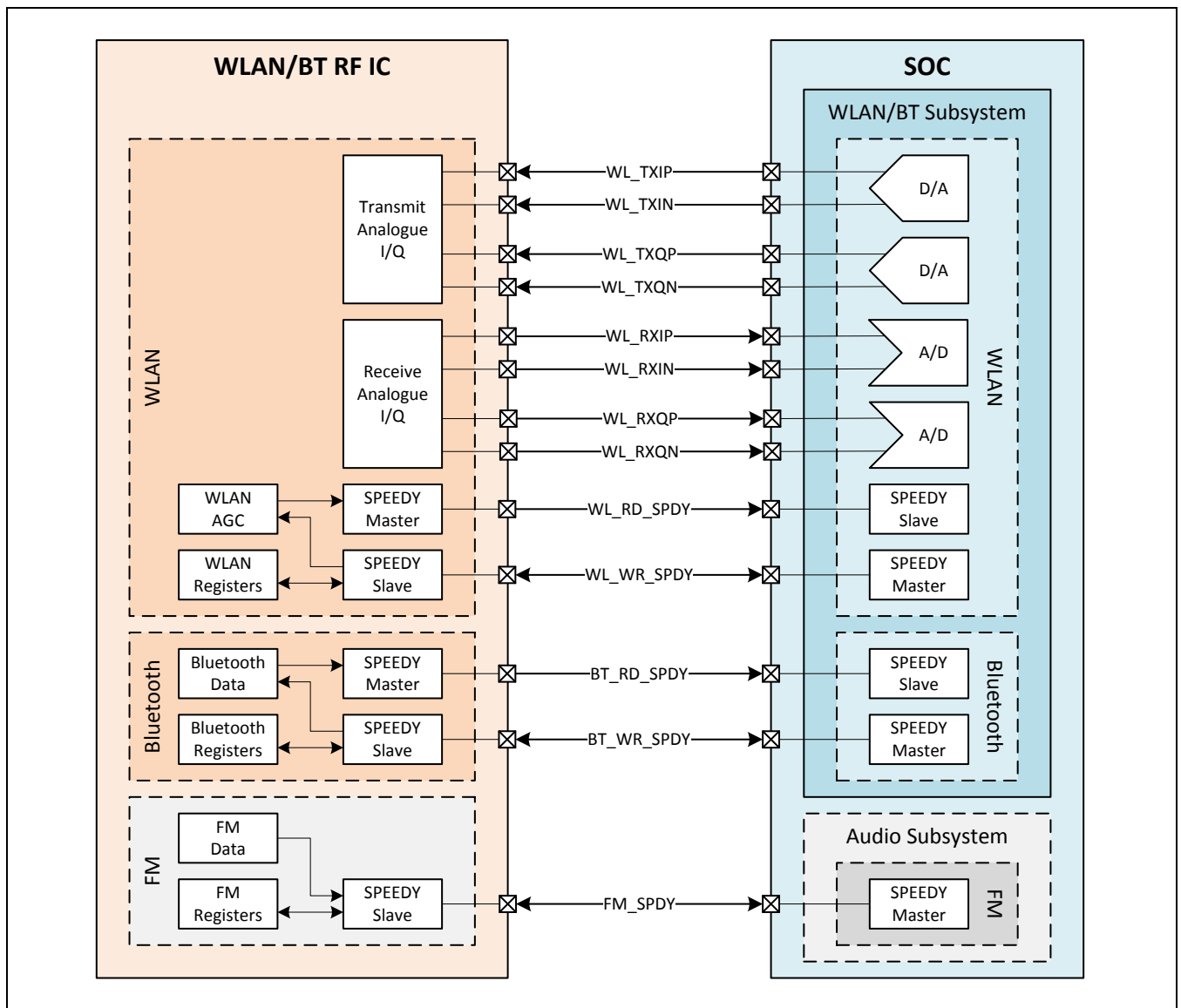


Figure 2 S5N5C12-SOC Interface Diagram

2

Pin Definition

2.1 Pin Map

The package type of S5N5C12 is a WLCSP (WLP) of which ball pitch is 400um.

	1	2	3	4	5	6
A	FM_RF	WB_RF_5GX	WL_TX_5G	WL_RX_5G	WL_RXQP	WL_RXIP
B	WL_TX_5G_EXT	AVDD33_WL_5G	GND_WL	AVDD11_RF	WL_RXQN	WL_RXIN
C	FEM_CTRL0	GND_FM	GND_WL	AVDD11_LO	WL_TXQP	WL_TXIP
D	FEM_CTRL1	AVDD18	GND_WL	GND_WL	WL_TXQN	WL_TXIN
E	FM_SPDY_S	VDD_CORE	AVDD18_PA	GND_WL	GND_WL	WB_RF_2G
F	BT_SPDY_M	VDD18_IO	GND_IO	GND_BT	AVDD33_WL_2G	WB_RF_2GX
G	BT_SPDY_S	WL_SPDY_S	WL_SPDY_M	REFCLK	WL_PDET	AVDD11_BT

Top View

	6	5	4	3	2	1
A	WL_RXIP	WL_RXQP	WL_RX_5G	WL_TX_5G	WB_RF_5GX	FM_RF
B	WL_RXIN	WL_RXQN	AVDD11_RF	GND_WL	AVDD33_WL_5G	WL_TX_5G_EXT
C	WL_TXIP	WL_TXQP	AVDD11_LO	GND_WL	GND_FM	FEM_CTRL0
D	WL_TXIN	WL_TXQN	GND_WL	GND_WL	AVDD18	FEM_CTRL1
E	WB_RF_2G	GND_WL	GND_WL	AVDD18_PA	VDD_CORE	FM_SPDY_S
F	WB_RF_2GX	AVDD33_WL_2G	GND_BT	GND_IO	VDD18_IO	BT_SPDY_M
G	AVDD11_BT	WL_PDET	REFCLK	WL_SPDY_M	WL_SPDY_S	BT_SPDY_S

Bottom View (Ball Side View)

Figure 3 Ball Map of S5N5C12 WLCSP

2.2 Pin Descriptions

Pins of S5N5C12 are listed and described in [Table 1](#).

Table 1 Pin Descriptions of S5N5C12

Category	Pin Name		Description	Comments
RF	WB_RF_2G	E6	2.4GHz WLAN + BT Tx/Rx	
	FM_RF	A1	FM RF input	
	WL_TX_5G	A3	5GHz WLAN Tx	
	WL_RX_5G	A4	5GHz WLAN Rx	
	WL_TX_5G_EXT	B1	5GHz WLAN Tx PA driver out	
	FEM CTRL0	C1	External 5GHz WLAN FEM control	Uses AVDD33_WL
	FEM CTRL1	D1		
	WL_PDET	G5	Input from external 5G PA power detector	Also general purpose AIO for analogue test
Signal Interface to BB	WL_RXIP	A6	WLAN Rx baseband I/Q interface	Differential current
	WL_RXIN	B6		
	WL_RXQP	A5		
	WL_RXQN	B5		
	WL_TXIP	C6	WLAN Tx baseband I/Q interface	Differential voltage
	WL_TXIN	D6		
	WL_TXQP	C5		
	WL_TXQN	D5		
Clock	REFCLK	G4	Reference clock input	26MHz TCXO
Control Interface	WL_SPDY_M	G3	WLAN SPEEDY Control	
	WL_SPDY_S	G2		Also digital reset source
	BT_SPDY_M	F1	BT SPEEDY Control	
	BT_SPDY_S	G1		
	FM_SPDY_S	E1	FM SPEEDY Control	Also digital reset source
VDD	AVDD33_WL2G	F5	3.3V supply for 2.4GHz WLAN PA	
	AVDD33_WL5G	B2	3.3V supply for 5GHz WLAN PA and external FEM control signals	
	AVDD11_RF	B4	1.1V supply for WLAN and FM	
	AVDD11_BT	G6	1.1V supply for BT and FM	
	AVDD11_LO	C4	1.1V supply for LO	
	AVDD18	D2	1.8V supply for reference bias	
	AVDD18_PA	E3	1.8V supply for BT PA	
	VDD18_IO	F2	1.8V digital I/O supply	
	VDD_CORE	E2	1.0V internal LDO output	Requires external capacitor

Category	Pin Name		Description	Comments
GND	WB_RF_5GX	A2	5GHz PA ground	
GND	WB_RF_2GX	F6	2.4GHz PA ground	
GND	GND_WL	B3 C3 D3 D4 E4 E5	WLAN analog ground	
	GND_BT	F4	BT analog ground	
	GND_FM	C2	FM analog ground	
	GND_IO	F3	Digital core and I/O ground	

3

Electrical Specifications

3.1 Absolute Maximum Ratings

Stress exceeding the ranges listed in [Table 2](#) may cause permanent damage to the device. Exposure to absolute maximum rating conditions for extended periods may affect device reliability. Maximum ratings are absolute ratings; exceeding even one of these values may cause irreversible damage to the integrated circuit. Please note that the device is not guaranteed to be functional within these absolute maximum ranges.

Table 2 Absolute Maximum Ratings

Parameter	Symbol	Value	Unit
Storage temperature	T_{stor}	–40 to +125	°C
DC supply voltage (Analog/Digital)	V_{CC1}	–0.5 to 1.21	V
DC supply voltage (Analog/Digital)	$V_{\text{CC2}}, V_{\text{DD}}$	–0.5 to 1.98	V
DC supply voltage (Analog)	V_{CC3}	–0.5 to 3.6	V
Input voltage	V_{IN}	–0.3 to ($V_{\text{CC}} + 0.3$)	V

3.2 Recommended Operating Conditions

Operating conditions include parameters that are under the control of the user: power supply voltage and ambient temperature ([Table 3](#)). The S5N5C12 RFIC meets all performance specifications listed in Sections 3.4 through 3.6 when used within the recommended operating conditions unless otherwise noted in those sections (provided the absolute maximum ratings have never been exceeded).

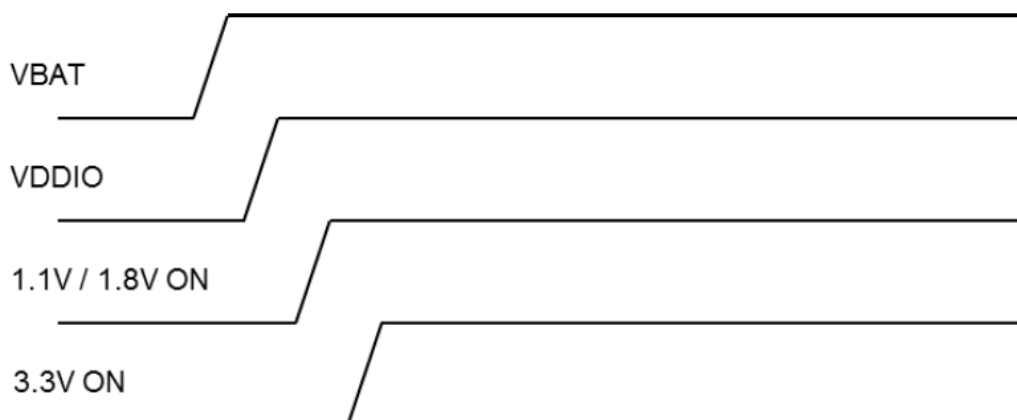
Table 3 Recommended Operating Conditions

Parameter	Symbol	Conditions	Min.	Typ.	Max.	Unit
Ambient operating temperature	T_{oper}		-20		+85	°C
Analog supply voltage (AVDD11_RF, AVDD11_BT, AVDD11_LO)	V_{CC1}	Operation	1.045	1.1	1.155	V
Analog supply voltage (AVDD18, AVDD18_PA)	V_{CC2}	Operation	1.71	1.8	1.89	V
Analog supply voltage (AVDD33_WL2G, AVDD33_WL5G)	V_{CC3}	Operation	3.14	3.3	3.47	V
Digital supply voltage (VDD18_IO)	V_{DD2}	SPEEDY I/O	1.71	1.8	1.89	V
Low level input voltage	V_{IL}	SPEEDY control pins	0.0	0.0	+0.1	V
High level input voltage	V_{IH}		1.71	1.8	1.89	V
Reference clock frequency	f_{REF_CLK}			26		MHz
Reference clock amplitude	V_{REF_CLK}		0.7		2.0	V _{pp}

3.3 Power sequencing

1.1V (AVDD11_RF, AVDD11_BT, AVDD11_LO) and 1.8V (AVDD18, AVDD18_PA) turn on at the same time and 3.3V (AVDD33_WL2G, AVDD33_WL5G) turns on later.

VDDIO (VDD18_IO) turns on earlier than 1.1/1.8V or at the same time.



3.4 WLAN Characteristics

3.4.1 WLAN 2.4 GHz Transmitter

Table 4 WLAN 2.4 GHz transmitter specifications

Parameter	Conditions	Min.	Typ.	Max.	Unit
RF output frequency range		2.4		2.5	GHz
11b (1 Mbps) output power	Mask and EVM compliant		19		dBm
11b (11 Mbps) output power	Mask and EVM compliant		19		dBm
11g (6 Mbps) output power	Mask and EVM compliant		18		dBm
11g (54 Mbps) output power	Mask and EVM compliant		16		dBm
11n, HT20 (MCS0) output power	Mask and EVM compliant		17		dBm
11n, HT20 (MCS7) output power	Mask and EVM compliant		15		dBm
Power Consumption	Continuous Tx ^a		300		mA

a. 11n HT20 (MCS0), 100% duty cycle @ 17 dBm, 4V Vbat

3.4.2 WLAN 2.4 GHz Receiver

Table 5 WLAN 2.4 GHz receiver specifications

Parameter	Conditions	Min.	Typ.	Max.	Unit
RF input frequency range		2.4		2.5	GHz
11b (1 Mbps) input sensitivity			-97		dBm
11b (11 Mbps) input sensitivity			-89		dBm
11g (6 Mbps) input sensitivity			-94		dBm
11g (54 Mbps) input sensitivity			-76		dBm
11n, HT20 (MCS0) input sensitivity			-93		dBm
11n, HT20 (MCS7) input sensitivity			-74		dBm
11b (11 Mbps) maximum input level				-5	dBm
11g (6 Mbps) maximum input level				-10	dBm
11g (54 Mbps) maximum input level				-10	dBm
11n, HT20 (MCS0) maximum input level				-10	dBm
11n, HT20 (MCS7) maximum input level				-10	dBm
Full Chain Noise Figure	Maximum Gain		4.2	6.2	dB
Power Consumption	Continuous Rx ^a		36		mA

a. 11n HT20 (MCS0), 100% duty cycle @ 4V Vbat

3.4.3 WLAN 5 GHz Transmitter

Table 6 WLAN 5 GHz transmitter specifications

Parameter	Conditions	Min.	Typ.	Max.	Unit
RF output frequency range		4.9		5.9	GHz

11a (6 Mbps) output power	Mask and EVM compliant		17		dBm
11a (54 Mbps) output power	Mask and EVM compliant		15		dBm
11n, HT20 (MCS0) output power	Mask and EVM compliant		16		dBm
11n, HT20 (MCS7) output power	Mask and EVM compliant		14		dBm
11n, HT40 (MCS0) output power	Mask and EVM compliant		15		dBm
11n, HT40 (MCS7) output power	Mask and EVM compliant		13		dBm
11ac, HT20 (MCS0) output power	Mask and EVM compliant		15		dBm
11ac, HT20 (MCS7) output power	Mask and EVM compliant		13		dBm
11ac, HT20 (MCS8) output power	Mask and EVM compliant		13		dBm
11ac, HT40 (MCS0) output power	Mask and EVM compliant		14		dBm
11ac, HT40 (MCS7) output power	Mask and EVM compliant		13		dBm
11ac, HT40 (MCS9) output power	Mask and EVM compliant		13		dBm
11ac, HT80 (MCS0) output power	Mask and EVM compliant		13		dBm
11ac, HT80 (MCS7) output power	Mask and EVM compliant		12		dBm
11ac, HT80 (MCS9) output power	Mask and EVM compliant		12		dBm
Power Consumption	Continuous Tx ^a		390		mA

a. 11n HT20 (MCS0), 100% duty cycle @ 17 dBm, 4V Vbat

3.4.4 WLAN 5 GHz Receiver

Table 7 WLAN 5 GHz receiver specifications

Parameter	Conditions	Min.	Typ.	Max.	Unit
RF input frequency range		4.9		5.9	GHz
11a (6 Mbps) input sensitivity			-94		dBm
11a (54 Mbps) input sensitivity			-76		dBm
11n, HT20 (MCS0) input sensitivity			-93		dBm
11n, HT20 (MCS7) input sensitivity			-74		dBm
11n, HT40 (MCS0) input sensitivity			-90		dBm
11n, HT40 (MCS7) input sensitivity			-71		dBm
11ac, HT20 (MCS0) input sensitivity			-92		dBm
11ac, HT20 (MCS7) input sensitivity			-68		dBm
11ac, HT20 (MCS8) input sensitivity			-68		dBm
11ac, HT40 (MCS0) input sensitivity			-90		dBm
11ac, HT40 (MCS7) input sensitivity			-65		dBm
11ac, HT40 (MCS9) input sensitivity			-65		dBm
11ac, HT80 (MCS0) input sensitivity			-88		dBm
11ac, HT80 (MCS7) input sensitivity			-62		dBm
11ac, HT80 (MCS9) input sensitivity			-62		dBm
Full Chain Noise Figure	Maximum Gain		3.7	5.7	dB

Parameter	Conditions	Min.	Typ.	Max.	Unit
Power Consumption	Continuous Rx ^a		40		mA

a. 11n HT20 (MCS0), 100% duty cycle @ 4V Vbat

3.5 Bluetooth Characteristics

3.5.1 Bluetooth Transmitter

Table 8 Bluetooth basic rate transmitter specifications

Parameter	Conditions	Min.	Typ.	Max.	Unit
RF output frequency range		2.402		2.480	GHz
RF output power (GFSK)	Max power output level		11		dBm
Power control step size		2	4	8	dB
Initial carrier frequency drift		-75		75	kHz
Carrier frequency drift	One slot packet (DH1)			25	kHz
	Three slot packet (DH3)			40	kHz
	Five slot packet (DH5)			40	kHz
	Max. drift rate			20	kHz/50us
Modulation characteristics	Δf_{1avg}	140		175	kHz
	Δf_{2max} (for at least 99% of all Δf_{2max})	115			kHz
	$\Delta f_{2avg} / \Delta f_{1avg}$	0.8			
20dB bandwidth				1	MHz
In-band spurious emission	± 2 MHz offset			-20	dBm
	± 3 MHz offset			-40	dBm
	> 3 MHz offset			-40	dBm
Out-of-band spurious emission	30MHz to 1GHz			-36	dBm
	1GHz to 12.75GHz			-30	dBm
	1.8GHz to 1.9GHz			-47	dBm
	5.15GHz to 5.3GHz			-47	dBm

Table 9 Bluetooth enhanced data rate transmitter specifications

Parameter	Conditions	Min.	Typ.	Max.	Unit
RF output frequency range		2.402		2.480	GHz
RF output power (GFSK)	$\pi/4$ DQPSK		9		dBm
	8PSK		9		dBm
Relative transmit power	$\pi/4$ DQPSK	-4		1	dB
	8PSK	-1		1	dB
Frequency errors	Packet error (ω_i)	-75		75	kHz
	Block error (ω_o)	-10		10	kHz
	Total error ($\omega_i + \omega_o$)	-75		75	kHz
Modulation accuracy ($\pi/4$ DQPSK)	RMS DEVM			20	%
	99% DEVM			30	%
	Peak DEVM			35	%
Modulation accuracy (8PSK)	RMS DEVM			13	%
	99% DEVM			20	%
	Peak DEVM			25	%
In-band spurious emission ($\pi/4$ DQPSK and 8PSK)	± 1 MHz offset			-26	dB
	± 2 MHz offset			-20	dBm
	≥ 3 MHz offset			-40	dBm

Table 10 Bluetooth low energy transmitter specifications

Parameter	Conditions	Min.	Typ.	Max.	Unit
RF output frequency range		2.402		2.480	GHz
RF output power	Max power output level		8		dBm
Carrier frequency offset and drift	Frequency offset	-150		150	kHz
	Frequency drift	-50		50	kHz
	Max drift rate	-20		20	Hz/us
Modulation characteristics	Δf_{1avg}	225		275	kHz
	Δf_{2max} (for at least 99% of all Δf_{2max})	185			kHz
	$\Delta f_{2avg} / \Delta f_{1avg}$	0.8			
In-band spurious emission	± 2 MHz offset			-20	dBm
	≥ 3 MHz offset			-30	dBm

3.5.2 Bluetooth Receiver

Table 11 Bluetooth basic rate receiver specifications

Parameter	Conditions	Min.	Typ.	Max.	Unit
RF input frequency range		2.402		2.480	GHz
Receiver sensitivity	BER < 0.1%		-93		dBm
Maximum usable input	BER < 0.1%		0		dBm
C/I co-channel	Co-channel selectivity (BER < 0.1%)			11	dB
C/I 1MHz	Adjacent channel selectivity (BER < 0.1%)			0	dB
C/I 2MHz	2nd adjacent channel selectivity (BER < 0.1%)			-30	dB
C/I ≥ 3MHz	3rd adjacent channel selectivity (BER < 0.1%)			-40	dB
C/I image channel	Image channel selectivity (BER < 0.1%)			-9	dB
C/I image 1MHz	1MHz adjacent to Image channel selectivity (BER < 0.1%)			-20	dB
Out-of-band blocking	30 MHz to 2000 MHz	-10			dBm
	2001 MHz to 2339 MHz	-27			dBm
	2501 MHz to 3000 MHz	-27			dBm
	3001 MHz to 12.75 GHz	-10			dBm
Intermodulation	Max interference level to maintain 0.1% BER	-39			dBm

Table 12 Bluetooth enhanced data rate receiver specifications

Parameter	Conditions	Min.	Typ.	Max.	Unit
RF input frequency range		2.402		2.480	GHz
Receiver sensitivity	$\pi/4$ DQPSK (BER < 0.01%)		-93		dBm
	8PSK (BER < 0.01%)		-86		dBm
Maximum usable input	$\pi/4$ DQPSK (BER < 0.1%)	-20			dBm
	8PSK (BER < 0.1%)	-20			dBm
C/I co-channel	$\pi/4$ DQPSK (BER < 0.1%)			13	dB
	8PSK (BER < 0.1%)			21	dB
C/I 1MHz	$\pi/4$ DQPSK (BER < 0.1%)			0	dB
	8PSK (BER < 0.1%)			5	dB
C/I 2MHz	$\pi/4$ DQPSK (BER < 0.1%)			-30	dB
	8PSK (BER < 0.1%)			-25	dB

Parameter	Conditions	Min.	Typ.	Max.	Unit
C/I $\geq$ 3MHz	$\pi/4$ DQPSK (BER < 0.1%)			-40	dB
	8PSK (BER < 0.1%)			-33	dB
C/I image channel	$\pi/4$ DQPSK (BER < 0.1%)			-7	dB
	8PSK (BER < 0.1%)			0	dB
C/I image 1MHz	$\pi/4$ DQPSK (BER < 0.1%)			-20	dB
	8PSK (BER < 0.1%)			-13	dB

Table 13 Bluetooth low energy receiver specifications

Parameter	Conditions	Min.	Typ.	Max.	Unit
RF input frequency range		2.402		2.480	GHz
Receiver sensitivity	PER < 30.8%		-93		dBm
Maximum usable input	PER < 30.8%	-10			dBm
C/I co-channel	Co-channel selectivity (PER < 30.8%)			21	dB
C/I 1MHz	Adjacent channel selectivity (PER < 30.8%)			15	dB
C/I 2MHz	2nd adjacent channel selectivity (PER < 30.8%)			-17	dB
C/I $\geq$ 3MHz	3rd adjacent channel selectivity (PER < 30.8%)			-27	dB
C/I image channel	Image channel selectivity (PER < 30.8%)			-9	dB
C/I image 1MHz	1MHz adjacent to Image channel selectivity (PER < 30.8%)			-15	dB
Out-of-band blocking	30 MHz to 2000 MHz	-30			dBm
	2001 MHz to 2339 MHz	-35			dBm
	2501 MHz to 3000 MHz	-35			dBm
	3001 MHz to 12.75 GHz	-30			dBm

3.6 FM Characteristics

3.6.1 FM Receiver

Table 14 FM receiver specifications

Parameter	Conditions	Min.	Typ.	Max.	Unit
Input frequency range		65		108	MHz
Receiver sensitivity (note1, 3)	SINAD = 26dB		2		dBuVemf
RDS sensitivity	$\Delta f=2\text{kHz}$, BLER<5%		15		dBuVemf
AM suppression	$m=0.3$		57		dB
Maximum input level		118			dBuVemf
Audio mono SINAD (note1, 3)		56			dB
Audio stereo SINAD (note2, 3)		51			dB
Audio stereo separation	$\Delta f=75\text{kHz}$, VRF=1mV		45		dB

NOTE:

1. $\Delta f=22.5\text{kHz}$, $f_m=1\text{kHz}$, mono, L=R
2. $\Delta f=22.5\text{kHz}$, $f_m=1\text{kHz}$, 50us de-emphasis, stereo
3. A-weighting, BW = 300Hz to 15kHz