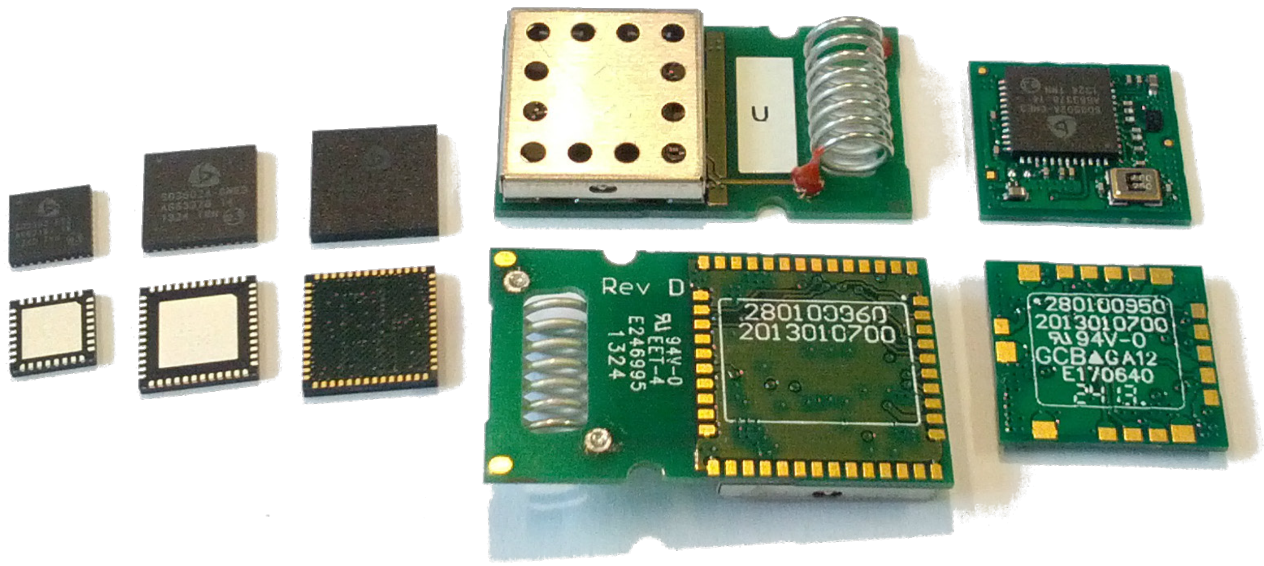
INTEGRATION GUIDE FOR Z-WAVE® DEVICES



The purpose of this document is to provide an implementation guide for integrating Z-Wave devices into product designs. It is intended for product design engineers who aim for a fast integration of 500 series Z-Wave devices.

1 OVERVIEW

The 500 series Z-Wave device portfolio is shown in Table 1.1. The SD3503 serial interface SoC is designed for easy integration and provides OEM customers short time-to-market. It exposes the Z-Wave serial API via the USB or UART. The SD3502 is a general-purpose SoC with a built-in microcontroller and Z-Wave radio transceiver, making it ideal for single chip products. The ZM5101 SiP module combines the general-purpose SoC, crystal, supply decoupling components, and RF matching components into a single small-footprint module requiring only an external SAW filter for use. The ZM5304 serial interface module is a fully self-contained module that includes a Z-Wave modem, on-board NVM, and built-in antenna. The module is approved as a FCC modular transmitter. The ZM5202 general-purpose Z-Wave module combines the general-purpose SoC, crystal, supply decoupling components, RF matching components, and SAW filter into an I/O limited module.

Table 1.1: Z-Wave device portfolio

Type	QFN32 SoC 5mm x 5mm	QFN48 SoC 7mm x 7mm	LGA56 SiP 8mm x 8mm	PCB48 SoM 15mm x 27mm	PCB18 SoM 13mm x 14mm
Chip	SD3503	SD3502			
Module			ZM5101	ZM5304	ZM5202

The applicable modules are clearly stated at the beginning of each of the following sections.

2 CONTENT

1 OVERVIEW 1

3 PROGRAMMING AND DEBUGGING INTERFACE 3

3.1 PROGRAMMING INTERFACE OVERVIEW 4
3.2 NON-VOLATILE REGISTERS 4

4 CALIBRATION 4

4.1 TRANSMITTER 4
4.2 CRYSTAL 4

5 RF VERIFICATION TOOL 4

6 COMPONENT SPECIFICATIONS 5

6.1 EXTERNAL NVM 5
6.1.1 Recommended Components 7
6.2 SAW FILTER 8
6.2.1 Mandatory Components 9
6.2.2 OPTIONAL Components 10
6.3 CRYSTAL 10
6.3.1 Mandatory Components 10

7 SUPPLY FILTER 10

7.1 WITH ANALOG POWER DOMAIN 11
7.2 WITHOUT ANALOG POWER DOMAIN 11

8 MATCHING CIRCUIT 11

8.1 MATCHING PROCEDURE 12
8.2 MEASUREMENT SETUP 12

9 PCB IMPLEMENTATION 13

9.1 PLACEMENT 13
9.2 STACK-UP 13
9.3 POWER ROUTING 14
9.4 DECOUPLING 14
9.5 RF TRACE 14
9.6 IC GROUNDING 16

10 ANTENNA DESIGN 16

11 ESD 17

12 SDK SPECIFIC REQUIREMENTS 17

12.1 SDK 6.7X 17

13 ABBREVIATIONS 18

14 REVISION HISTORY 20

15 REFERENCES 21

3 PROGRAMMING AND DEBUGGING INTERFACE

SD3503	SD3502	ZM5101	ZM5304	ZM5202
Applicable	Applicable	Applicable	Applicable	Applicable

A programming interface is **mandatory** if In-System Programming of a Z-Wave device is required, i.e., programming whilst soldered onto the product PCB. Depending on the available space, either a connector or test pads as shown in Figure 3.1 and Figure 3.2 can be chosen. A connector is useful for debugging during the development phase of the product, while test pads are suitable for a production environment.

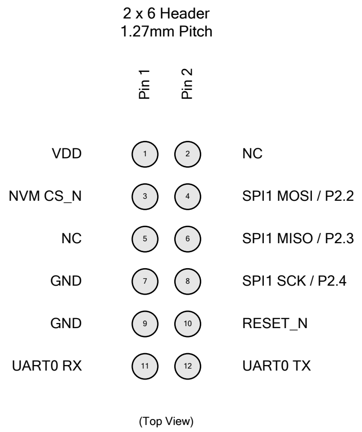


Figure 3.1: Z-Wave SPI ISP interface (*SD3502, ZM5101, ZM5202*)

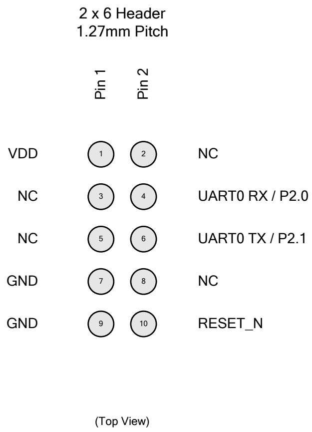


Figure 3.2: Z-Wave UART ISP interface (*SD3503, ZM5304*)

If a connector is used, the Harwin M50-3800542 male IDC connector, and Harwin M50-3000645 or M50-3000545 female board connector is recommended. The functionality of the pins from the programmer's perspective is shown in Table 3.1. Refer to [1] for programming instructions.

Table 3.1: Z-Wave ISP pin functionality

Pin Name	Pin Location (SPI)	Pin Location (UART)	Type	Function
GND	7, 8	7, 8	S	Common ground between the programmer and Z-Wave device
VDD	1	1	S	+3.3V supply used to power the programmer
NC	2, 5	2, 3, 5, 8	-	Not connected
RESET_N	10	10	O	Driven low by the programmer to place the Z-Wave device in a reset state
UART0 TX / P2.1	12	6	I	Receive UART serial data from Z-Wave device
UART0 RX / P2.0	11	4	O	Transmit UART serial data to Z-Wave device
SPI1 MISO / P2.3	6	-	I	Receive SPI serial data from Z-Wave device
SPI1 MOSI / P2.2	4	-	O	Transmit SPI serial data to Z-Wave device
SPI1 SCK / P2.4	8	-	O	SPI clock provided by the programmer to Z-Wave device
NVM CS_N	3	-	O	Chip select of external NVM sharing SPI bus

3.1 PROGRAMMING INTERFACE OVERVIEW

Below is a table showing which interfaces can be used to program the flash memory of the various Z-Wave products:

Table 3.2: Available programming interfaces

	SD3502	SD3503	ZM5101	ZM5202	ZM5304
SPI programming	X		X	X	
UART programming	X	X	X		X
USB programming	X	X	X		X

3.2 NON-VOLATILE REGISTERS

All Z-Wave devices contain a NVR flash page that is used to store critical calibration and configuration information, please refer to [5] for details. It is **mandatory** to preserve the NVR contents when programming.

4 CALIBRATION

It is **mandatory** to calibrate Z-Wave devices during production. Refer to [2] for calibration instructions.

4.1 TRANSMITTER

SD3503	SD3502	ZM5101	ZM5304	ZM5202
Applicable	Applicable	Applicable	NA	NA

The radio transmitter must be calibrated to ensure optimum frequency separation during modulation.

4.2 CRYSTAL

SD3503	SD3502	ZM5101	ZM5304	ZM5202
Applicable	Applicable	NA	NA	NA

The crystal frequency must be calibrated to ensure minimum error of the radio carrier frequency.

5 RF VERIFICATION TOOL

SD3503	SD3502	ZM5101	ZM5304	ZM5202
Applicable	Applicable	Applicable	Applicable	Applicable

The Micro RF Link tool can be used to verify the RF performance of a device without the overhead of the Z-Wave protocol. The same RF PHY present in the Z-Wave protocol is used. The tool is suitable when investigating RF performance and performing RF regulatory tests. It requires that the chip can be programmed over ISP or APM and that UART0 is connected to a terminal over RS-232 if a user interface is required. For a comprehensive users-manual to the Micro RF Link tool, please refer to [3].

6 COMPONENT SPECIFICATIONS

6.1 EXTERNAL NVM

SD3503	SD3502	ZM5101	ZM5304	ZM5202
Applicable	Applicable	Applicable	NA	Applicable

Some Z-Wave firmware APIs require external memory implemented on the product PCB for information storage (like routing table, HomeID, etc.). It is **important** that the correct memory size be chosen. Refer to [4] for details about the external NVM selection criteria.

As shown in Figure 6.1 the SPI interface is used to access an external serial EEPROM or flash, and a GPIO is used as the chip select. The GPIO chosen as the chip select can be specified in the NVR flash page. Refer to [5] for the NVR flash page contents.

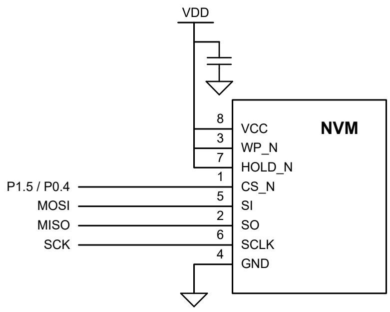


Figure 6.1: Example external NVM

Minimum specifications of an external EEPROM defined by the Z-Wave protocol are described below.

Table 6.1: EEPROM specification

Parameter	Value
Size	32kByte
SPI Modes	(CPOL=0,CPHA=0) & (CPOL=1,CPHA=1)
Supply Voltage Range	2.3V to 3.6V
Clock Speed	4MHz
Page Write Size	Max 256B
Software Protection	Yes
Self-timed Write Cycle	5ms
Endurance	1 Million Cycles
Data Retention	100 Years
Temperature	-40°C to +85°C

Table 6.2: EEPROM instruction set

Command	Opcode	Description
WREN	0x06	Enable Write Operations
WRDI	0x04	Disable Write Operations
RDSR	0x05	Read Status Register
WRSR	0x01	Write Status Register
READ	0x03	Read Data from Memory
WRITE	0x02	Write Data to Memory

Table 6.3: EEPROM status registers

Bit	Name	Description
7	WPEN	Write Protect Enable
6, 5, 4	X	Undefined
3	BP1	Block Protection Bit 1
2	BP0	Block Protection Bit 0
1	WEN	Write Enable Latch
0	N_RDY	Ready

Minimum specifications of an external flash defined by the Z-Wave protocol are described below. It is important to select a flash memory with a small page erase size in order to fulfill the endurance required within the lifetime of Z-Wave products.

Table 6.4: Flash specification

Parameter	Value
Size	128kByte (1Mbit), for 6.71+ controllers and newer 256kByte (2Mbit)
SPI Modes	(CPOL=0,CPHA=0) & (CPOL=1,CPHA=1)
Supply Voltage Range	2.3V to 3.6V
Clock Speed	4MHz
Page Write Size	256B
Page Erase Size	256B
Software Protection	Yes
Page Read	85µs
Page Write Cycle	25ms
Endurance	100k Cycles
Data Retention	>20 Years
Temperature	-40°C to +85°C

Table 6.5: Flash instruction set

Command	Opcode Adesto	Opcode Micron	Description
WREN	0x06	0x06	Write Enable
WRDI	0x04	0x04	Write Disable
RDID	0x9F	0x9F	Read Identification
RDSR	0xD7	0x05	Read Status Register
WRSR	0x01	0x01	Write Status Register
READ	0x03	0x03	Read Data Bytes
FAST_READ	0x0B	0x0B	Read Data Bytes at Higher Speed
PW	0x58	0x0A	Page Write (256B)
PP	0x02	0x02	Page Program
PE	0xDB	0xDB	Page Erase (256B)
DP	0xB9	0xB9	Deep Power-down
UDP	0x79H	-	Ultra-deep Power-down
RDP	0xAB	0xAB	Release from Deep Power-down

Table 6.6: Flash status register

Bit	Name	Description
7	SRWD	Status Register Write Disable
6, 5, 4	X	Undefined
3	BP1	Block Protect 1
2	BP0	Block Protect 0
1	WEL	Write Enable Latch
0	WIP	Write In Progress

6.1.1 RECOMMENDED COMPONENTS

Table 6.7: External NVM components

Type	Manufacturer	Component Number	Size	Supported by SDKs	EOL Issued
EEPROM	ON Semiconductor	CAT25256	32kB	All	-
EEPROM	Atmel Corporation	AT25256B	32kB	All	-
EEPROM	ST Microelectronics	M95256-DRE	256kB	All	-
EEPROM	Fudan Microelectronics	FM25256	256kB	All	-
EEPROM	Giantec Semiconductor	GT25C256	256kB	All	-
Flash (note 3)	Adesto Technologies	AT25PE20	256kB	6.51.07+, 6.61+, 6.71+ & 6.81+	-
Flash (note 3)	Adesto Technologies	AT25PE40	512kB	6.51.07+, 6.61+, 6.71+ & 6.81+	-
Flash (note 3)	Adesto Technologies	AT25PE80	1MB	6.51.07+, 6.61+, 6.71+ & 6.81+	-
Flash (note 3)	Adesto Technologies	AT25PE16	2MB	6.51.07+, 6.61+, 6.71+ & 6.81+	-
Flash (note 1)	Micron Technology	M25PE10	128kB	All	Yes
Flash (note 1)	Micron Technology	M25PE20	256kB	All	Yes
Flash (note 1)	Micron Technology	M25PE40	512kB	All	Yes
Flash (note 1)	Micron Technology	M25PE80	1MB	6.51.07+, 6.61+, 6.71+ & 6.81+	Yes
Flash (note 2 & 3)	Adesto Technologies	AT45DB021E	256kB	6.51.07+, 6.61+, 6.71+ & 6.81+	-
Flash (note 2 & 3)	Adesto Technologies	AT45DB041E	512kB	6.51.07+, 6.61+, 6.71+ & 6.81+	-
Flash (note 2 & 3)	Adesto Technologies	AT45DB081E	1MB	6.51.07+, 6.61+, 6.71+ & 6.81+	-
Flash (note 2 & 3)	Adesto Technologies	AT45DB161E	2MB	6.51.07+, 6.61+, 6.71+ & 6.81+	-
Flash (note 2 & 3)	Adesto Technologies	AT45DB321E	4MB	6.51.07+, 6.61+, 6.71+ & 6.81+	-
Flash (note 2 & 3)	Adesto Technologies	AT45DB641E	8MB	6.51.07+, 6.61+, 6.71+ & 6.81+	-

Note 1: Not recommended in new designs.

Note 2: Not pin compatible (with EEPROM and Micron) requiring a new printed circuit board layout compared to ZDB5101.

Note 3: Flash software driver initialize to 256 bytes page size.

The NVR flash page must be initialize with configuration information about the external NVM component used, please refer to [5] for details.

6.2 SAW FILTER

SD3503	SD3502	ZM5101	ZM5304	ZM5202
Applicable	Applicable	Applicable	NA	NA

It is **mandatory** that a SAW filter be used in Z-Wave device designs. A SAW filter attenuates unwanted radio emissions and improves the receiver blocking performance. Three regions are defined to cover the global Z-Wave frequency range. The SAW filter specifications described in

Table 6.8,

Table 6.9, and

Table 6.10 is recommended for new designs, while legacy designs could still use the 400 series SAW filter specifications.

Table 6.8: Region E

	Frequency Range	Unit	Minimum	Typical	Maximum
Operating temperature	-	°C	-30	-	+85
Insertion loss	865.0 to 870.1MHz	dB	-	-	3.5
Amplitude ripple	865.0 to 870.1MHz	dB	-	-	2.0
Relative attenuation	0.1 to 800.0MHz	dB	40	-	-
	805 to 830MHz	dB	35	-	-
	835 to 855MHz	dB	-	-	-
	860 to 862MHz	dB	-	-	-
	890 to 1000MHz	dB	40	-	-
	1005 to 2000MHz	dB	30	-	-
	2005 to 3000MHz	dB	30	-	-
	3005 to 4000MHz	dB	30	-	-
	4005 to 6000MHz	dB	-	-	-
In / out impedance	-	Ω	-	50	-

Table 6.9: Region U

	Frequency Range	Unit	Minimum	Typical	Maximum
Operating temperature	-	°C	-30	-	+85
Insertion loss	908.2 to 916.3MHz	dB	-	-	2.5
Amplitude ripple	908.2 to 916.3MHz	dB	-	-	1.5
Relative attenuation	720 to 800MHz	dB	45	-	-
	805 to 840MHz	dB	-	-	-
	845 to 870MHz	dB	40	-	-
	870 to 895MHz	dB	-	-	-
	940 to 1000MHz	dB	9	-	-
	1005 to 2000MHz	dB	9	-	-
	2005 to 3000MHz	dB	17	-	-
	3005 to 4000MHz	dB	-	-	-
	4005 to 6000MHz	dB	-	-	-
In / out impedance	-	Ω	-	50	-

Table 6.10: Region H

	Frequency Range	Unit	Minimum	Typical	Maximum
Operating temperature	-	°C	-30	-	+85
Insertion loss	919.5 to 926.5MHz	dB	-	-	3.2
Amplitude ripple	919.5 to 926.5MHz	dB	-	-	1.0
Relative attenuation	40 to 870MHz	dB	40	-	-
	875 to 885MHz	dB	35	-	-
	890 to 905MHz	dB	20	-	-
	945 to 955MHz	dB	20	-	-
	960 to 1000MHz	dB	20	-	-
	1005 to 1500MHz	dB	40	-	-
	1505 to 3000MHz	dB	20	-	-
	3005 to 4000MHz	dB	-	-	-
	4005 to 6000MHz	dB	-	-	-
In / out impedance	-	Ω	-	50	-

6.2.1 MANDATORY COMPONENTS

Table 6.11: SAW filters

Region	Distributor	Component Number	Note
E	ACTE A/S, www.acte.dk, salessupport@acte.dk	SF4000-868-07-SX	Preferred
	ACTE A/S, www.acte.dk, salessupport@acte.dk	SF1141-868-02-SX	Alternative
U	ACTE A/S, www.acte.dk, salessupport@acte.dk	SF4000-914-06-SX	Preferred
	ACTE A/S, www.acte.dk, salessupport@acte.dk	SF1141-911-01-SX	Alternative
H	ACTE A/S, www.acte.dk, salessupport@acte.dk	SF1256-923-02	

6.2.2 OPTIONAL COMPONENTS

Table 6.12: SAW filters

Region	Distributor	Component Number	Note
E	ACTE A/S, www.acte.dk, salessupport@acte.dk	SF4000-869-14-SX	Improved LTE rejection

6.3 CRYSTAL

SD3503	SD3502	ZM5101	ZM5304	ZM5202
Applicable	Applicable	NA	NA	NA

The crystal is part of the oscillator that generates the reference frequency for the digital system clock and RF carrier. It is a critical component of a Z-Wave device. Further, it is **mandatory** to calibrate the crystal, refer to section 4.

External load capacitors must be mounted to ensure proper oscillation of the parallel resonant crystal as shown in Figure 6.2.

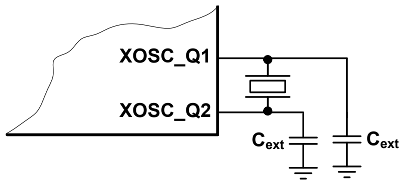


Figure 6.2: External load capacitors for crystal

The value of each external load capacitor can be calculated using the following formula:

$$C_{ext} = 2(C_{load} - C_{stray})$$

Where C_{ext} is a single external load capacitor, C_{load} is the crystal load capacitance specified in the datasheet, and C_{stray} is the stray capacitance in the oscillator circuit, which is typically around 2pF.

6.3.1 MANDATORY COMPONENTS

Table 6.13: Crystals

Distributor	Component Number	EOL issued
ACTE A/S, www.acte.dk, salessupport@acte.dk	QD1251-01-SX	Yes
ACTE A/S, www.acte.dk, salessupport@acte.dk	QD2750-07-SX	

The value of C_{ext} should be approximately 20 pF, but varies according to the stray capacitance of the PCB.

7 SUPPLY FILTER

A good power supply filter is strongly recommended as part of the schematic. A symmetric π filter with a ferrite can be used. The ferrite suppresses high frequency noise, while the capacitors decouple the power supply by acting as a source for fast transients currents.

7.1 WITH ANALOG POWER DOMAIN

SD3503	SD3502	ZM5101	ZM5304	ZM5202
Applicable	Applicable	Applicable	NA	NA

For Z-Wave devices that have an analog supply, the filter shown in Figure 7.1 is **strongly recommended**.

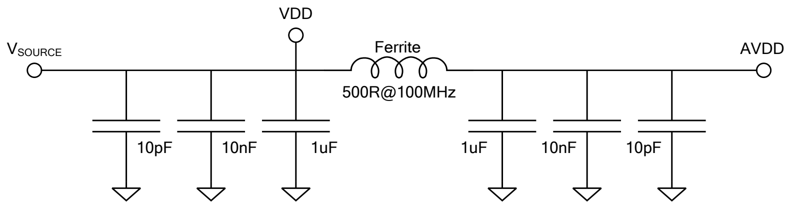


Figure 7.1: Filter with analog supply

7.2 WITHOUT ANALOG POWER DOMAIN

SD3503	SD3502	ZM5101	ZM5304	ZM5202
NA	NA	NA	Applicable	Applicable

For Z-Wave devices with only the digital supply, the filter shown in Figure 7.2 is **strongly recommended**.

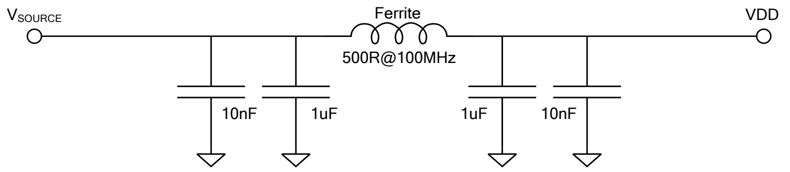


Figure 7.2: Filter without analog supply

8 MATCHING CIRCUIT

SD3503	SD3502	ZM5101	ZM5304	ZM5202
Applicable	Applicable	NA	NA	NA

The PA of the transmitter should be matched for maximum power transfer and the LNA of the receiver must be matched for lowest noise. The components C1, L1, and L2 form the matching circuit of the PA, while the components L2 and L3 form the matching circuit of the LNA. The matching circuit is show in Figure 8.1.

The components that are selected should conform to the minimum specification described in Table 8.1.

Table 8.1: Matching components

Parameter	Value
Temperature	-30 to +85°C
Tolerance	±3% for inductors ±0.1pF for capacitors
Self-resonance	>> 1GHz

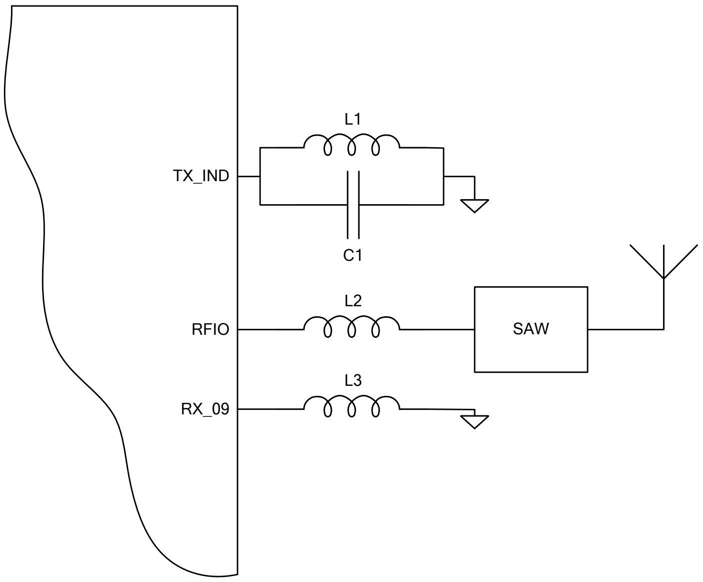


Figure 8.1: Matching circuit

8.1 MATCHING PROCEDURE

Finding appropriate values for the components should be considered an iterative task.

Table 8.2: Recommended initial values

Designator	Value
C1	5.6 pF
L1	5.6 nH
L2	12 nH
L3	27 nH

1. Select initial values for L1, and C1 to resonate at the Z-Wave carrier frequency, $f_{carrier}$.

$$f_{carrier} = \frac{1}{2\pi\sqrt{L1 \cdot C1}}$$

2. Select an initial value for L2. In general, reducing the value of L2 increases the transmit power and harmonics, while increasing it reduces the transmit power and harmonics.
3. Fine tune C1 and L1 to obtain maximum transmit power. Several iterations of step 2 and 3 would be required to arrive at an optimum solution. The *txsweep* command of the Micro RF Link tool can be used to verify the desired frequency range.
4. Select an initial value of L3 and fine-tune it to obtain the best sensitivity and lowest LO leakage. In some cases, L2 may require a retuning. If the value of L2 is changed, then the transmit power should be rechecked. The *rx r <framecount>* command of the Micro RF Link tool can be used to measure the FER.
5. Finally verify that the output power and harmonics of the transmitter, and sensitivity and LO leakage of the receiver, is as specified in the datasheet of the Z-Wave device.

8.2 MEASUREMENT SETUP

The output power should be measured with a spectrum analyzer as shown in Figure 8.2 and sensitivity as shown in Figure 8.3. In both cases, place the fixed attenuator as close as possible to the transmitter.

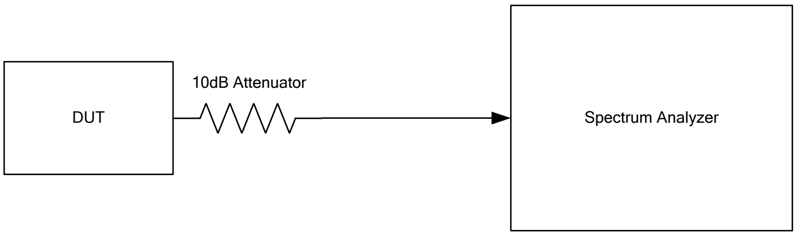


Figure 8.2: Measuring transmitter output power

When measuring the sensitivity, first measure and record the output power of the Z-Wave frame generator using the spectrum analyzer. A Z-Wave module programmed with the Micro RF Link tool can be used as the Z-Wave frame generator. Then a fixed attenuator can be used along with a variable attenuator to adjust the input power of the DUT. For example, by setting the output power of the Z-Wave generator to -20dBm, a fixed 50dB attenuator and a variable 50dB attenuator can be used to measure the sensitivity with a 1dB resolution. Place the fixed attenuator close to the Z-Wave generator and conduct the measurements is radio silent environment.

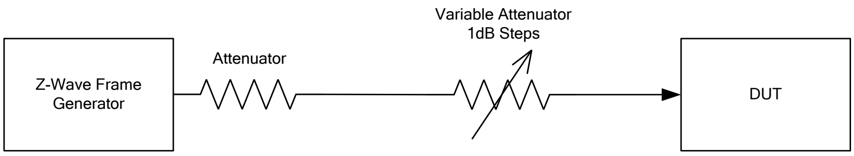


Figure 8.3: Measuring receiver sensitivity

9 PCB IMPLEMENTATION

SD3503	SD3502	ZM5101	ZM5304	ZM5202
Applicable	Applicable	Applicable except section 9.6	Applicable except section 9.5 and 9.6	Applicable except section 9.6

A good PCB implementation is required to obtain the best performance from a Z-Wave device. The following subsections describe items that should be considered when designing the PCB layout.

9.1 PLACEMENT

In general, it is **mandatory** that all decoupling and matching components should be placed as close as possible to the Z-Wave device, and on the same layer to reduce trace parasitics. It is also recommended that the SAW filter placed as close as possible to inductor L2 on the same layer.

It is **strongly recommended** that the Z-Wave device be placed at close to a corner of the PCB, away from any high frequency switching circuits.

9.2 STACK-UP

If designing a product with the SD3502 or SD3503, it is recommended to use a 4-layer stack-up PCB as shown in Figure 9.1. The thickness of the PCB stack-up can be chosen to optimize cost. It is **strongly recommended** that a solid copper plane be used as the ground plane layer L2.

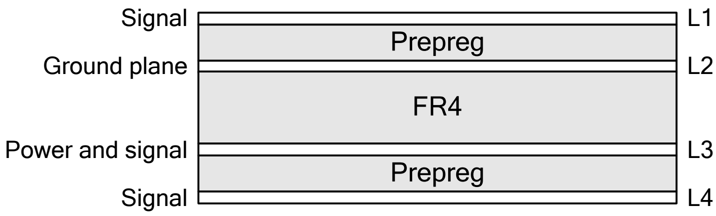


Figure 9.1: 4-layer stack-up

9.3 POWER ROUTING

It is **strongly recommended** that a star topology be adopted when routing power traces as shown in Figure 9.2. The supply filter is mounted at the root of the star, and smaller decoupling capacitors at the end of each branch.

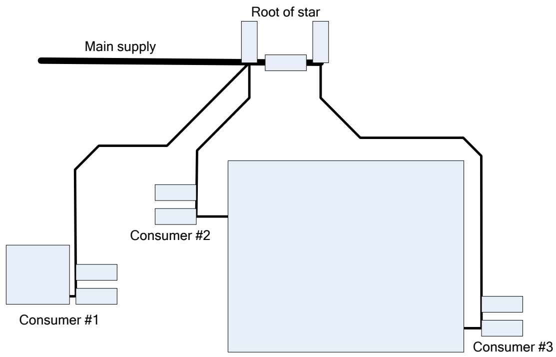


Figure 9.2: Star topology power routing

9.4 DECOUPLING

Power should be driven through decoupling capacitors to prevent parasitic inductances as shown in Figure 9.4. At least two grounding vias is recommended for each component as shown in Figure 9.3.

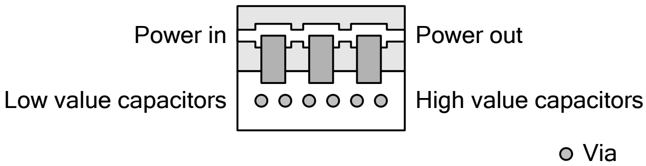


Figure 9.3: Grounded components

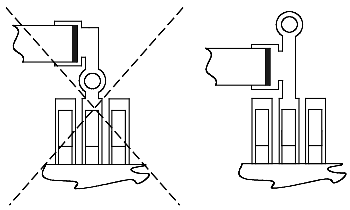


Figure 9.4: Pin decoupling

9.5 RF TRACE

It is **mandatory** that all high frequency RF traces, such as the trace to the antenna, be designed as transmission lines with a 50Ω characteristic impedance. A coplanar waveguide similar to Figure 9.5 is recommended for a transmission line on signal layer L1.

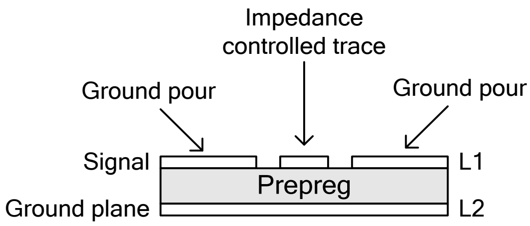


Figure 9.5: Coplanar waveguide

A via fence is recommended on both sides of a coplanar waveguide, as shown Figure 9.6, to short any return currents induced on the top layer to ground.

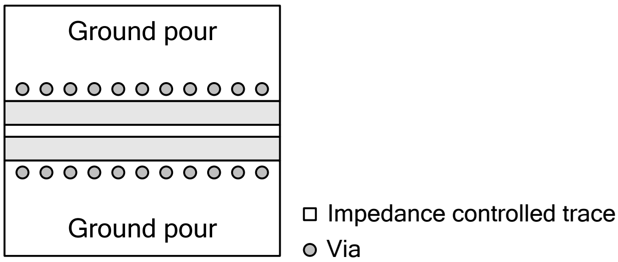


Figure 9.6: Via fence

A free tool, such as Saturn PCB Design Toolkit (http://www.saturnpcb.com/pcb_toolkit.htm), can be used to calculate the dimensions of the traces conveniently.

9.6 IC GROUNDING

QFN chips should be provided with a ground paddle with stitched-vias to minimize parasitic inductance and to provide a good thermal heat sink as shown in Figure 9.7.

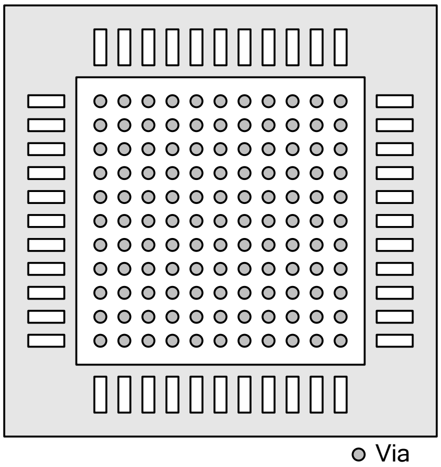


Figure 9.7: IC ground paddle

10 ANTENNA DESIGN

SD3503	SD3502	ZM5101	ZM5304	ZM5202
Applicable	Applicable	Applicable	NA	Applicable

Since antenna design is very product dependent, it is **mandatory** to perform the antenna matching. Each product requires an individual design for best power transfer to the antenna and radiation characteristics. Refer to [6] for more information.

11 ESD

SD3503	SD3502	ZM5101	ZM5304	ZM5202
Applicable	Applicable	Applicable	Applicable	Applicable

Since ESD can destroy the Z-Wave product, great care must be taken during manufacturing and assembly of final goods to avoid ESD.

By design, all pins of SD3502, SD3503 and ZM5101 are ESD protected up to a level of **2kV HBM**.

For the ZM5202 and ZM5304 modules, this level of ESD protection cannot be guaranteed, since the SAW filter of the modules has a much lower ESD level. This means, that the ESD level for the RFIO pin of ZM5202 and the antenna of ZM5304 is set by the ESD level of the SAW filters, whereas all other connections on the two modules are set by the ESD levels of the SD3502/SD3503 chips.

The ESD level of a SAW filter is typically **<< 2kV HBM**.

12 SDK SPECIFIC REQUIREMENTS

Some SDK versions impose additional requirements that must be addressed during production. This section describes those requirements. Only the SDKs mentioned here have additional requirements.

12.1 SDK 6.7X

It is **mandatory** to set the Readback protection lock bit of the flash [1] in the SoC on SDK 6.71+ devices to protect IP and security of the Z-Wave network.

NVR layout v0.2 or newer is **mandatory** for SDK 6.71+ devices. Two new fields, PUK and PRK are added and are a requirement for the S2 solution. It is **mandatory** to populate these fields according to the algorithm given in reference [5].

13 ABBREVIATIONS

Abbreviation	Description
2FSK	2-key Frequency Shift Keying
2GFSK	2-key Gaussian Frequency Shift Keying
ACM	Abstract Control Model
ACMA	Australian Communications and Media Authority
ADC	Analog-to-Digital Converter
AES	Advanced Encryption Standard
API	Application Programming Interface
APM	Auto Programming Mode
AV	Audio Video
BOD	Brown-Out Detector
CBC	Cipher-Block Chaining
CDC	Communications Device Class
CE	Conformité Européenne
COM	Communication
CPU	Central Processing Unit
CRC	Cyclic Redundancy Check
D	Differential
D-	Differential Minus
D+	Differential Plus
DAC	Digital-to-Analog Converter
DC	Direct Current
DMA	Direct Memory Access
DUT	Device Under Test
ECB	Electronic CodeBook
EMS	Electronic Manufacturing Services
EOL	End Of Life
ESD	Electro Static Discharge
ESR	Equivalent Series Resistance
FCC	Federal Communications Commission
FET	Field Effect Transistor
FER	Frame Error Rate
FLiRS	Frequently Listening Routing Slave
FR4	Flame Retardant 4
FSK	Frequency Shift Keying
GFSK	Gaussian Frequency Shift Keying
GP	General Purpose
GPIO	General Purpose Input Output
HBM	Human Body Model
I	Input
I/O	Input / Output
IC	Integrated Circuit
IDC	Insulation-Displacement Connector
IF	Intermediate Frequency
IGBT	Insulated-Gate Bipolar Transistor
INT	Interrupt
IPC	Interconnecting and Packaging Circuits
IR	Infrared
IRAM	Indirectly addressable Random Access Memory
ISM	Industrial, Scientific, and Medical
ISP	In-System Programming
ITU	International Telecommunications Union
JEDEC	Joint Electron Device Engineering Council
LED	Light-Emitting Diode

Abbreviation	Description
LNA	Low-Noise Amplifier
LO	Local Oscillator
lsb	Least Significant Bit
LSB	Least Significant Byte
MCU	Micro-Controller Unit
MIC	Ministry of Internal affairs and Communications, Japan
MISO	Master In, Slave Out
MOSI	Master Out, Slave In
msb	Most Significant Bit
MSB	Most Significant Byte
NA	Not Applicable
NMI	Non-Maskable Interrupt
NRZ	Non-Return-to-Zero
NVM	Non-Volatile Memory
NVR	Non-Volatile Registers
O	Output
OEM	Original Equipment Manufacturer
OFB	Output FeedBack
OTP	One-Time Programmable
PA	Power Amplifier
Pb	Lead
PCB	Printed Circuit Board
PHY	L1 Physical Layer
POR	Power-On Reset
PWM	Pulse Width Modulator
QFN	Quad-Flat No-leads
RAM	Random Access Memory
RF	Radio Frequency
RoHS	Restriction of Hazardous Substances
ROM	Read Only Memory
RS-232	Recommended Standard 232
RX	Receive
S	Supply
SAW	Surface Acoustic Wave
SCK	Serial Clock
SFR	Special Function Register
SiP	System-in-Package
SPI	Serial Peripheral Interface
SRAM	Static Random Access Memory
T0	Timer 0
T1	Timer 1
TX	Transmit
UART	Universal Asynchronous Receiver Transmitter
USB	Universal Serial Bus
WUT	Wake-Up Timer
XRAM	External Random Access Memory
XTAL	Crystal
ZEROX	Zero Crossing

14 REVISION HISTORY

Date	Version	Affected	Revision
2022/04/05	16	Table 6.7	Added EEPROMs M95256-DRE,FM25256,GT25C256
2018/02/21	15	Table 6.7	Added Adesto Tech. AT25PE20/40/16 DataFlash.
2017/03/28	14	§ 6.1	Added Adesto Tech. 2-megabit AT25PE20-SSHN-T DataFlash. Added Adesto Tech. opcodes.
		§ 12.1	SDK 6.7x specific instructions added. Readback protection and keypair in NVR. Algorithm for keypair generation.
		§ 4.1	Changed ZM5202 and ZM5304 TX CAL to NA, as they are calibrated from factory.
2017/03/15	13	Table 6.7	Micron issued EOL for M25PE40 and M25PE80
2016/11/23	12	§6.1	Removed EEPROM STMicroelectronics M95256 (32KB). Reference to NVR configuration of the external NVM used.
2016/05/10	11	§6.2	SAW filter alternatives added, Region E and U specifications changed accordingly. Added SAW with LTE improved rejection
2016/04/13	10	Tabel 6.12	Crystals: QD1251-01-SX EOL, added QD2750-07-SX Added EOL in section 12 Abbreviations
2016/02/24	9	Table 6.7	Updated external NVM components list
2015/10/09	8	Table 6.7	Changed EEPROM spec. to 32kB
		§6.2	SAW filters recommendation changed
		§6.3	Recommendations for crystals removed
2014/06/18	7	§6	EEPROM Page Write Size = Max 256B
2014/05/14	6A	§5	Reference to users-manual, removed table 5.1 and figure 5.1
		§3.1	Added section 3.1, overview of programming interfaces
		§9.2	SD3502 and SD3503 added to the sentence of 4-layer PCB
		§11	Added section about ESD
		§15	Changed document reference number to Micro RF Link
		All	Added detailed contact information to Acte A/S
2013/11/04	5A	Figure 3.1, Figure 3.2,	Updated the Z-Wave programming connector layout
		Table 3.1,	Updated the pin numbers
		§3,	Updated the recommended connector type
		Table 6.13	Updated the frequency tolerance of crystal
2013/10/17	4A	Figure 9.2,	Updated the routing diagram
		Figure 9.4,	Added pin decoupling diagram
		§13,	Repeating table heading on subsequent pages
		§15	Fixed the reference document name
2013/10/14	3C	§6.1	Added reference to SRN for external NVM selection
2013/10/14	3B	§All	Removed preliminary watermark
2013/10/14	3A	Table 6.7	Increase recommended external NVM sizes
2013/10/01	2D	§3,	Removed the GPIO from the UART
		§6.1	Clarified the NVM specification
2013/10/01	2C	§3,	Added the UART ISP connector layout
		§4,	Changed calibration to mandatory
		§6.2	Changed SAW filter to strongly recommended
2013/09/30	2B	§9.1,	Clarified the placement layer, and clarified the device placement
		§9.6,	Clarified the statement about stitched-vias
		§10	Clarified the requirement of antenna matching
2013/09/20	2A	§All	Initial draft

15 REFERENCES

[1] Sigma Designs, “500 Series Z-Wave Chip Programming Mode”, INS11681.

[2] Sigma Designs, “500 Series Calibration User Guide”, INS12524.

[3] Sigma Designs, “Micro RF Link”, INS12880.

[4] Sigma Designs, “Z-Wave 500 Series SDK v6.51.00”, SRN12428.

[5] Sigma Designs, “500 Series Z-Wave Chip NVR Flash Page Contents”, SDS12467.

[6] Sigma Designs, “Antennas for Short Range Devices”, APL10045.

IoT Portfolio
www.silabs.com/products

Quality
www.silabs.com/quality

Support & Community
www.silabs.com/community

SILICON LABS

Silicon Laboratories Inc.
400 West Cesar Chavez
Austin, TX 78701
USA

www.silabs.com