INTEGRATION GUIDE FOR SILICON LABS ZENGECKO Z-WAVE® DEVICES

The purpose of this document is to provide an implementation guide for integrating Z-Wave 700 devices into product designs. It is intended for product design engineers who aim for a fast integration of Z-Wave 700 devices.

1 OVERVIEW

The Z-Wave 700 device portfolio is shown in Table 1.1. The EFR32ZG14 SoC exposes the Z-Wave serial API via UART and is dedicated to gateway applications. The ZGM130S SiP module combines a general-purpose SoC, crystal, supply decoupling components, and RF matching components into a single small-footprint module requiring only two decoupling capacitors. The ZGM130S is mainly targeted at end-device applications, and, with its built-in ARM M4 core and ultra-low-power consumption, it is perfect for making single chip sensors and other end devices that require advanced processing and low-power consumption. Alternatively, the ZGM130S SiP module can be used in gateway applications as well.

Please refer to [1] for an overview of supported Z-Wave regions and frequency bands supported by the Z-Wave protocol.

Table 1.1: Z-Wave 700 Device Portfolio

Type	QFN32 SoC 5 x 5 mm	LGA64 SiP 9 x 9 mm
Chip	EFR32ZG14	
Module		ZGM130S

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

2 CONTENT

3 PROGRAMMING AND DEBUGGING INTERFACE

EFR32ZG14	ZGM130S
Applicable	Applicable

A programming interface is **mandatory** if in-system programming of a Z-Wave 700 device is required, i.e., programming a new/erased chip while soldered onto the product PCB. To design in a footprint for the Mini Simplicity header, Silicon Labs recommends using a small 10-pin 1.27 mm SMD header for both programming and debugging of chips from the Silicon Labs Gecko family.

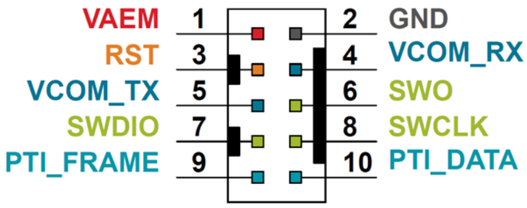

Figure 3.1: Silicon Labs Mini Simplicity Header

If a connector is used, the Samtec FTSH-105-01-F-DH surface mounted or Harwin M50-3500542 through-hole male connector is recommended and can be directly used with the BRD8010A STK/WSTK Debug Adapter. The functionality of the pins from the programmer's perspective is shown in Table 3.1. Refer to [2] and [6] for programming instructions and more about the Mini Simplicity Header.

Table 3.1: Z-Wave 700 Mini Simplicity Header Pin Functionality

Pin Name	Pin Location	Type	Function
GND	2	S	Common ground between the programmer and Z-Wave 700 device
VAEM	1	S	Target voltage on the debugged application. Supplied and monitored by the AEM when power selection switch is in the "AEM" position.
RST	3	O	Driven low by the programmer to place the Z-Wave 700 device in a reset state
VCOM_TX	5	I	Receive UART serial data from Z-Wave 700 device
VCOM_RX	4	O	Transmit UART serial data to Z-Wave 700 device
SWO	6	I	Serial Wire Output
SWDIO	7	I/O	Serial Wire Data
SWCLK	8	O	Serial Wire Clock
PTI_FRAME	9	I	Packet Trace Frame Signal
PTI_DATA	10	I	Packet Trace Data Signal

3.1 PROGRAMMING INTERFACE OVERVIEW

The table below shows which interfaces can be used to program the flash memory of the various Z-Wave 700 products:

Table 3.2: Available Programming Interfaces

	EFR32ZG14	ZGM130S
SWD programming	X	X
Bootloader UART programming	X	X

Notes:

- Bootloader is not programmed into the chip at delivery.
- SWD interface will be needed for new chips and after full chip / flash erase.

4 CALIBRATION

It is **mandatory** to calibrate the crystal in EFR32ZG14 Z-Wave 700 devices during product development to make sure that the mean value of the crystal frequency is correct. Refer to [5] for calibration instructions. Furthermore, for best possible performance, it is recommended that calibration be performed during production to minimize the spread in crystal frequency. All ZGM130S Z-Wave 700 devices are calibrated during production and therefore do not need any further crystal calibration.

4.1 CRYSTAL

EFR32ZG14	ZGM130S
Applicable	N/A

It is mandatory to calibrate the crystal frequency for the EFR32ZG14 devices to ensure minimum error of the radio carrier frequency.

5 RF VERIFICATION TOOL

EFR32ZG14	ZGM130S
Applicable	Applicable

The RailTest tool can be used to verify the RF performance of a device without the overhead of the Z-Wave protocol. The RailTest tool supports both ZGM130S and EFR32ZG14 devices. 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. To use the tool, it is required that the chip is programmable and the UART0 interface is connected to a terminal over RS-232 or through the WSTK. For a comprehensive user's manual for the RailTest tool, refer to [3] and [4].

As the RF PHY can be updated for new software releases, it is important to compile a RailTest version based on the same software release that will be used in the final product.

6 COMPONENT SPECIFICATIONS

6.1 SAW FILTER

EFR32ZG14	ZGM130S
Applicable	Applicable

It is **recommended** that a SAW filter is used in Z-Wave 700 gateway designs also containing GSM or LTE transceivers operating in the sub-GHz band. 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 6.1, Table 6.2, and Table 6.3 are recommended for new designs. An overview of supported Z-Wave regions and frequencies can be found in [1].

Find a guideline on when to use a SAW filter in [15].

Table 6.1: Region E

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

Table 6.2: Region U

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

Table 6.3: Region H

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

6.1.1 RECOMMENDED COMPONENTS FOR GSM/LTE GATEWAYS

Table 6.4: SAW filters

Region	Distributor	Component Number	Note
E	ACTE A/S, acte.biz, contact@acte.biz	SF4000-868-07-SX	Preferred
U	ACTE A/S, acte.biz, contact@acte.biz	SF4000-914-06-SX	Preferred
H	ACTE A/S, acte.biz, contact@acte.biz	SF1256-923-02	Preferred

6.1.2 OPTIONAL COMPONENTS FOR GSM/LTE GATEWAYS

Table 6.5: LTE improved SAW filters

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

6.1.3 Z-WAVE PROTOCOL SUPPORT FOR OPTIONAL SAW FILTER BANK

The Z-Wave Protocol offers support for usage of a SAW filter bank. Refer to the BRD4200A and BRD4201A reference designs for an example of such a SAW filter bank implementation.

Two GPIO pins on the Z-Wave 700 devices, GPIO PB14 and GPIO PB15, are assigned to control the selection of which SAW filter to use in the SAW filter bank:

Table 6.6: SAW Filter Control Pins

Region	State of PB14	State of PB15
E	High	Low
U	Low	High
H	Low	Low

6.2 CRYSTAL

EFR32ZG14	ZGM130S
Applicable	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 700 device. Further, it is **mandatory** to calibrate the crystal for EFR32ZG14-based designs. Refer to section 4 for more information.

The EFR32ZG14 has internal crystal capacitors and does not need any external circuitry apart from the crystal itself.

The ZGM130S has an integrated crystal and is calibrated at the time of production.

For more information about the crystal oscillator, crystals, and the EFR32ZG14 device, refer to [7].

Table 6.7: Crystal Specification for Z-Wave 700 Devices

Parameter	Symbol	Min	Typ	Max	Unit
Crystal frequency	fHFXO	—	39	—	MHz
Supported crystal equivalent series resistance (ESR)	ESRHFXO_39M	—	—	60	Ω
Supported range of crystal load capacitance 1	CHFXO_CL	6	—	12	pF
Initial frequency tolerance for the crystal	FTHFXO	-10		10	ppm
Temperature tolerance for the crystal	FTempHFXO -40°C - 85°C	-12		12	ppm
Aging	FAge	-3		3	ppm/5yr
Combined tolerance for the crystal	FTtotalHFXO	-25	—	25	ppm/5yr

6.2.1 RECOMMENDED COMPONENTS

Refer to UG522: Mandatory Crystal Adjustment for EFR32ZG14/EFR32ZG23 Based Products User's Guide for the crystal recommendations and other important aspects of the crystal selection.

7 SUPPLY FILTER

EFR32ZG14	ZGM130S
Applicable	Applicable

A good power supply filter is strongly recommended as part of the schematic. A filter with a ferrite and a capacitor can be used as seen in Figure 8.1. The ferrite suppresses high-frequency noise, while the capacitors decouple the power supply by acting as a source for fast transient currents.

For Z-Wave 700 devices, the filter shown in Figure 7.1 is **strongly recommended**. For normal scenarios, this will provide adequate filtering with a low BOM cost. In case of excessive supply noise, the 0 Ω resistor can be swapped for a ferrite bead to improve filtering.

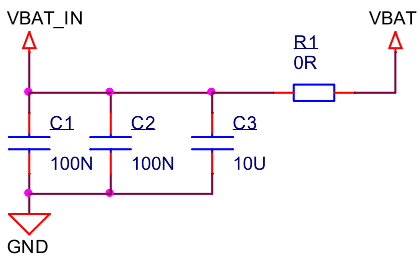

Figure 7.1: Recommended Supply Filter for Z-Wave 700 Devices

For more about supply decoupling, refer to section 9.4. More in-depth information about decoupling strategies and the power supply system of the Z-Wave devices can be found in [8] and [9].

8 MATCHING CIRCUIT

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 matching is divided into the following operations:

1. Matching the SoC transceiver to a 50 Ω RF line on the PCB.
2. Additional filtering for Z-Wave Long Range.
3. Matching the 50 Ω RF line of the PCB to the antenna.

The first part is already done in the ZGM130S SiP and is therefore only applicable to the EFR32ZG14. The second part applies to ZGM130S only when targeting Z-Wave Long Range. The third part must be done for all implementations unless a naturally matched antenna like the ones on the BRD4206A or BRD4207A radio boards are used.

8.1 SUMMARY OF MATCHING + FILTERING NETWORKS

The recommended matching + filtering networks for General Z-Wave and Z-Wave Long Range can be found below:

Table 8.1: Z-Wave Recommended Matches

	General Z-Wave		Z-Wave Long Range		
	EFR32ZG14	ZGM130S	EFR32ZG14		ZGM130S
Matching w/o SAW	IPD + DC-blocking cap	DC blocking cap (BRD4202A)	Discrete match with ceramic balun + 5-element Pi filter (BRD4206A)	Discrete match with ceramic balun + 5-element Pi filter (BRD4208A)	DC blocking cap + 3-element Pi filter (BRD4207A)
Matching w/SAW	IPD + DC-blocking cap + SAW in TX/RX path (BRD4201A)	DC blocking cap + SAW in TX/RX path (BRD4200A)	Discrete match with ceramic balun + 5-element Pi filter + SAW in TX/RX path	Discrete match with ceramic balun + 5-element Pi filter + SAW in TX/RX path	DC blocking cap + SAW in TX/RX path
Max. power for US	-1 dBm	-1 dBm	14 dBm	20 dBm	14 dBm
Max. power for EU	14 dBm	14 dBm	N/A	N/A	N/A

The IPD and Discrete match with ceramic balun solutions are detailed in section 8.2.

Alternatively, the following matching + filtering networks can be used for EFR32ZG14:

Table 8.2: Z-Wave Alternative Matches

	General Z-wave	Z-wave Long Range
	EFR32ZG14	EFR32ZG14
Matching w/o SAW	Discrete match with ceramic balun + 5-element Pi filter (Validated)	IPD + DC blocking cap + 3-element Pi filter (Tested)
	Full discrete match + 5-element Pi filter (Tested)	Full discrete match + 5-element Pi filter (Tested)
Matching w/ SAW	Discrete match with ceramic balun + 5-element Pi filter + SAW in TX/RX path (Validated)	IPD + DC-blocking cap + SAW in TX/RX path (Tested)
	Split TX/RX match + ceramic balun and 5-element Pi filter in TX path + RF switch + SAW in RX path (Simulated)	Split TX/RX match + ceramic balun and 5-element Pi filter in TX path + RF switch + SAW in RX path (Simulated)
Max. power for US	-1 dBm	14 dBm
Max. power for EU	14 dBm	N/A

The ”Discrete match with ceramic balun + 5-element Pi filter” is the same design that is present on BRD4206A. This solution is fully characterized and validated.

The details about the “Full discrete match + 5-element Pi filter” can be found in [16] section 3. This matching network has not been validated yet but has been optimized on prototype PCBs.

The Murata LFD21868MMF5E233 IPD is recommended for General Z-Wave for EFR32ZG14. It can be used for Z-Wave Long Range as well if an additional 3-element Pi filter is connected after the IPD for improved harmonic suppression. The proper component values for the 3-element Pi filter can be found in Figure 8.3.

If a SAW filter is required in the system for improved blocking performance against LTE and GSM signals, the SAW filter can be inserted in the common TX/RX path of all the above-mentioned matching networks. As an alternative, the TX and RX matches can be separated, and the SAW filter can be added in the RX path only so that the TX power is not affected by the insertion loss of the SAW filter. Details of such a configuration can be found in [17]. Note that the component values presented in this KBA are based on simulation results; therefore, fine tuning might be necessary on the actual PCB.

8.2 SOC TO RF LINE MATCHING

EFR32ZG14	ZGM130S
Applicable	NA

The EFR32ZG14 has separate differential LNA input and PA outputs and will therefore require both balun and matching externally. The recommended matching network for General Z-Wave with EFR32ZG14 is the Murata LFD21868MMF5E233 IPD, which matches the EFR32ZG14 PA to the 50 Ω RF line as shown in Figure 8.1. This match creates an easy and clean RF design with a very compact footprint with only the IPD, two decoupling capacitors, and a ferrite for suppressing high-frequency noise on the supply for the PA.

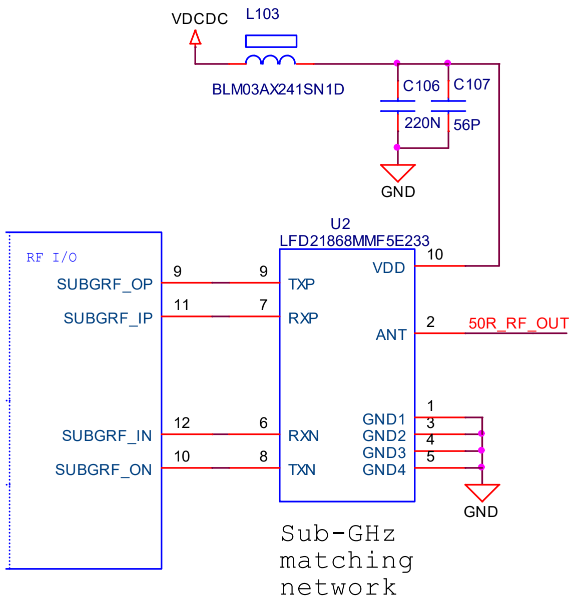

Figure 8.1: Recommended RF Matching Component for the EFR32ZG14 SoC for General Z-Wave: Murata LFD21868MMF5E233 IPD (BRD4201A)

The Murata part LFD21868MMF5E233 used for EFR32ZG14 circuits covers all supported Z-Wave regions and frequencies. The IPD contains a matching network, a balun, and harmonic filtering as well, which provides sufficient harmonic suppression for General Z-Wave applications.
For more in-depth knowledge about the IPD component and IPD's in general, refer to [13] and [14].

It is mandatory to connect the VDD pin of the IPD (U2) as shown in Figure 8.1. Connecting the VDD pin of the IPD to e.g., 3.3V, is not supported.

Z-Wave Long Range requires stronger harmonic suppression in the RF front-end, which the LFD21868MMF5E233 itself cannot provide. For Z-Wave Long Range up to +14 dBm, the recommended matching network is a discrete match combined with a ceramic balun and a 5-element low-pass filter:

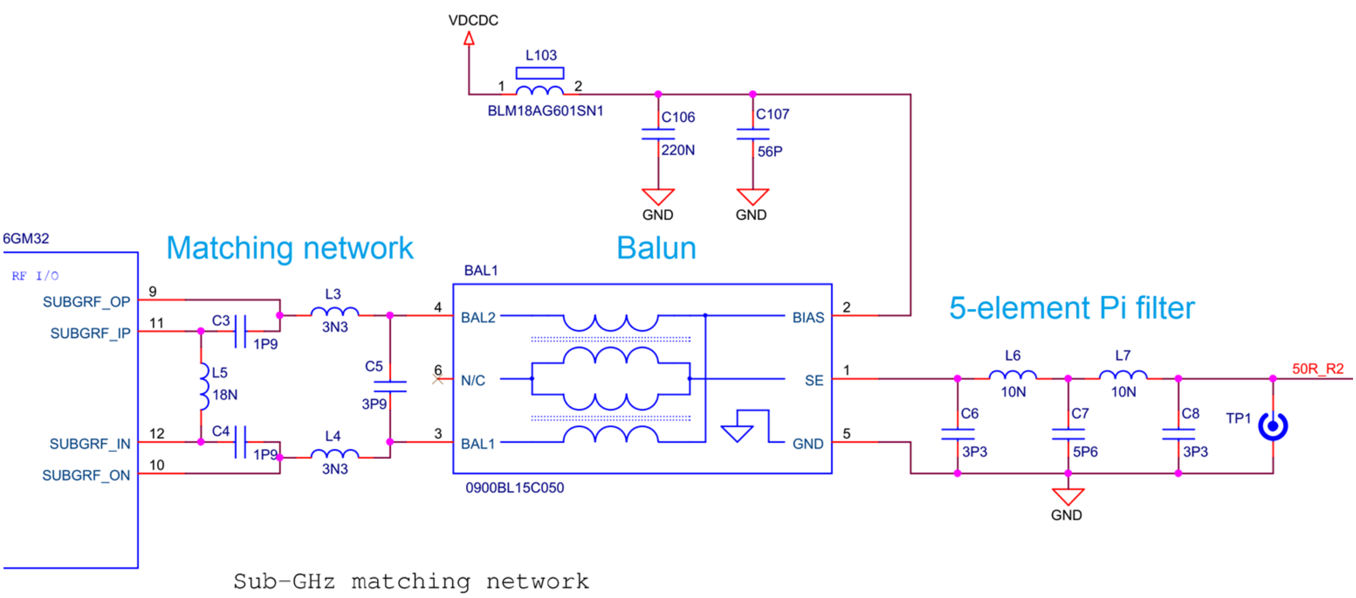

Figure 8.2: Recommended Matching Network for the EFR32ZG14 SoC for Z-Wave Long Range +14 dBm (BRD4206A)

The matching network shown in Figure 8.2 and used for EFR32ZG14 circuits is mainly recommended for Z-Wave Long Range but can be used for General Z-Wave applications and other Z-Wave regions as well. The circuit contains a match to 50 Ω, a differential to a single-ended balun, and a 5-element harmonic filtering network.

It is strongly recommended that one connect the VDD pin of the balun (BAL1) as shown in Figure 8.2 for optimal power efficiency at +14 dBm.

For Z-Wave Long Range up to +20dBm, the recommended matching network is very similar to the Z-Wave Long Range +14dBm recommendation with 2 minor differences:

- Minor adjustment in component values
- VDD pin of the balun is connected to the main 3.3V power supply

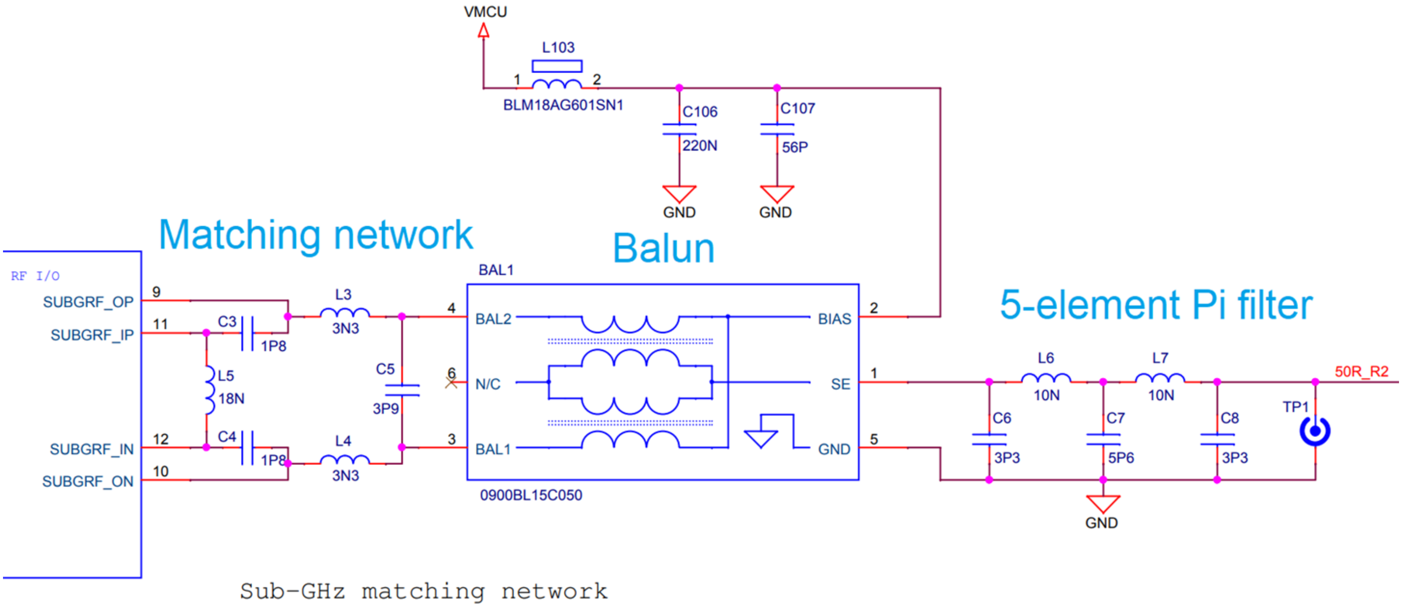

Figure 8.3: Recommended Matching Network for the EFR32ZG14 SoC for Z-Wave Long Range +20dBm (BRD4208A)

The VDD pin of the balun (BAL1) must be connected to the main 3.3V power supply to achieve +20dBm output power.

For more in-depth knowledge about matching circuits, refer to [10].

8.2.1 MANDATORY COMPONENTS FOR GENERAL Z-WAVE

Table 8.3: IPD

Manufacturer	Component Number	EOL Issued
Murata	LFD21868MMF5E233	

8.2.2 MANDATORY COMPONENTS FOR Z-WAVE LONG RANGE

Table 8.4: Balun

Manufacturer	Component Number	EOL Issued
Johanson Technology	0900BL15C050	

8.3 ADDITIONAL FILTERING FOR Z-WAVE LONG RANGE

EFR32ZG14	ZGM130S
NA	Applicable

ZGM130S has the matching and filtering network built-in, which provides acceptable harmonic performance for all Z-Wave regions when targeting General Z-Wave. However, Z-Wave Long Range allows higher transmit power, therefore, additional harmonic filtering is necessary. The following 3-element Pi filter should be connected to ZGM130S RF_ANT pin besides the DC blocking capacitor (C11) when targeting Z-Wave Long Range.

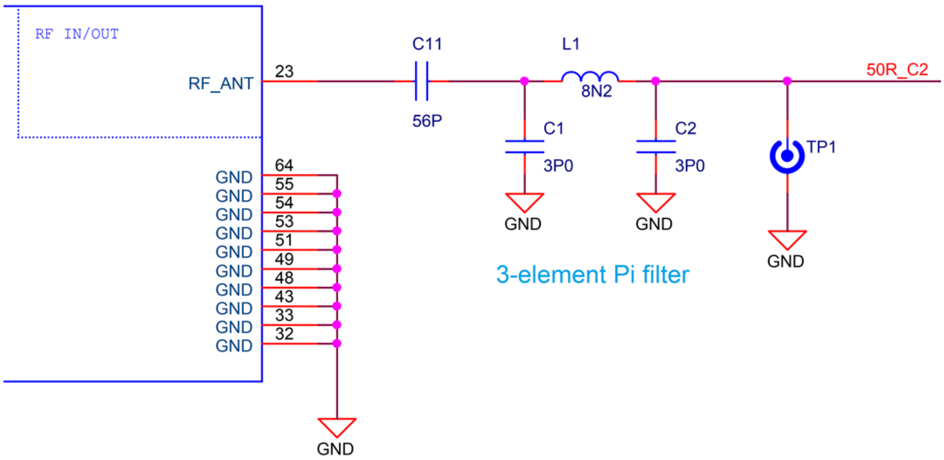

Figure 8.4: Recommended Three-Element Pi Filter

8.4 RF LINE TO ANTENNA MATCHING

EFR32ZG14	ZGM130S
Applicable	Applicable

Finding appropriate values for the components should be considered an iterative task. It is recommended to add a pi network for matching as shown in Figure 8.5. The following matching strategy is proposed:

1. Calibrate your Vector Network Analyzer (VNA) for a frequency range larger than the intended bandwidth of the antenna.
2. Connect an RF coaxial cable to the RF line (for instance by soldering a pigtail to the line). Connect the RF coaxial cable to a VNA to measure the reflection coefficient, S11, looking into the antenna through the matching network.
    a. Be sure to have a good connection to the ground plane to get the best electrical performance and the highest mechanical robustness during the measurement.
    b. Make sure to route the pigtail towards the center of the PCB and then perpendicularly away from the PCB at the center point. This will limit the effect of the cable on the measured data as much as possible.
3. Start out with no components on the antenna network shown in Figure 8.5:
    a. The shunt components are not mounted.
    b. The series component is not mounted.
4. Use line extension on the VNA to move the reference point to the footprint of R1 and R2.
    a. This is achieved when the locus of the S-parameters in the Smith chart on the VNA have assembled in a point at the right edge of the Smith chart.
5. Mount a 0 Ω resistor at R2 in Figure 8.5
6. Measure reflection coefficient for the frequency of interest (the frequency halfway between the lowest frequency and the highest frequency of the region of interest).
7. Use an online matching tool to calculate series and shunt component values to achieve 50 Ω match on the coaxial line.
    a. This will give a good starting point and should result in a reasonably good match at first attempt.
8. Iteratively change component values until match is acceptable.
    a. The standard matching criterion is either -6 dB or -10 dB reflection across all frequencies of interest.
    b. When this goal is achieved, it is recommended to use the same values on a small sample of boards to make sure that the matching is acceptable across production tolerances.

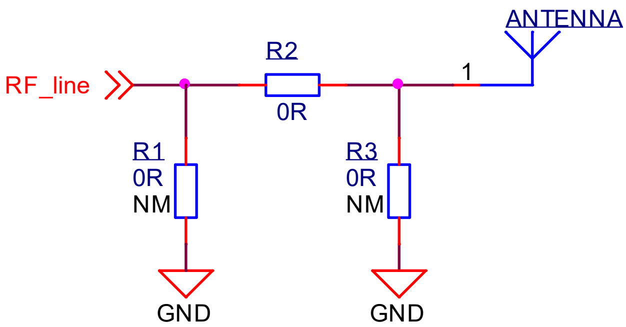

Figure 8.5: Recommended Antenna Matching Pi Network

A description of various antenna topologies can be found in [11]. Also refer to the reference designs BRD4206A, BRD4207A, and UZB7 for various methods of antenna implementations.

8.5 MEASUREMENT SETUP

The output power should be measured with a spectrum analyzer as shown in Figure 8.6 and sensitivity as shown in Figure 8.7. In both cases, place the fixed attenuator as close as possible to the transmitter. The fixed attenuator prevents RF reflections in the measurement setup.

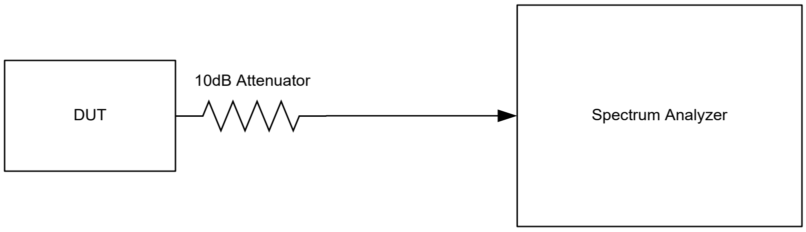

Figure 8.6: Measuring Transmitter Output Power

When measuring the sensitivity, first measure and record the output power of the Z-Wave frame generator using the spectrum analyzer. A Z-Wave 700 module programmed with the RailTest 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 -20 dBm, a fixed 50 dB attenuator and a variable 50 dB attenuator can be used to measure the sensitivity with a 1 dB resolution. Place the fixed attenuator close to the Z-Wave generator and conduct the measurements in a radio silent environment, e.g., by placing the DUT in a RF shielded box.

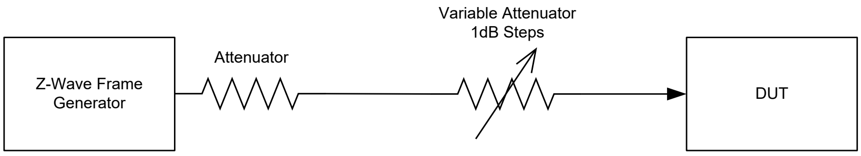

Figure 8.7: Measuring Receiver Sensitivity

9 PCB IMPLEMENTATION

EFR32ZG14	ZGM130S
Applicable	Applicable except section 9.6

A good PCB implementation is required to obtain the best performance from a Z-Wave 700 device. The following subsections describe items that should be considered when designing the PCB layout.

Besides the descriptions below, use the reference designs for the ZGM130S and the EFR32ZG14 devices as guidelines. The reference designs for the ZGM130S are: BRD4200A, BRD4202A, and BRD4207A. The reference designs for the EFR32ZG14 are: BRD4201A, BRD4206A, and UZB-7.

Further layout guidelines can be found in [12].

9.1 PLACEMENT

In general, it is **mandatory** that all decoupling and matching components are placed as close as possible to the Z-Wave 700 device, and on the same layer to reduce trace parasitics. For gateway devices with GSM or LTE transceivers, it is also **strongly recommended** to place the SAW filter as close as possible to the RF pin of the Z-Wave 700 device.

When implementing a Z-Wave system into a product, it is **strongly recommended** that the Z-Wave 700 device is placed close to a corner of the product’s PCB, away from any high frequency switching circuits used elsewhere in the product, e.g., host CPU systems, switching DC supplies, motor-controllers, etc.

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9.2 STACK-UP

If designing a product with the EFR32ZG14, 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.

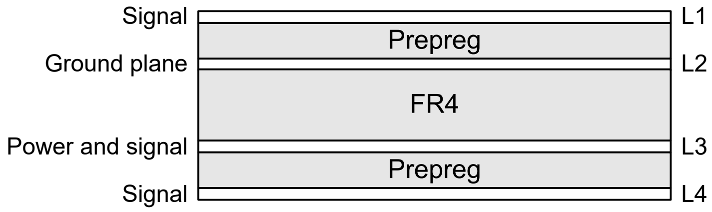

Figure 9.1: 4-layer Stack-Up

With the ZGM130S, the complex circuitry is contained inside the SiP. Therefore, there are good possibilities for making a cheap two-layer PCB design with ZGM130S. This does require extra care in designing the RF routing, power supply, and ground layout as no full-layer power and ground planes can be included.

Refer to the BRD4206A and BRD4207A designs for more information.

9.3 POWER ROUTING

Use as short VDD traces as possible. The VDD trace can be a hidden, unwanted radiator, so it is important to simplify the VDD routing as much as possible and use large, continuous GND pours with many stitching vias. To achieve the simplified VDD routing, try to avoid star topology of VDD traces (i.e., avoid connecting all VDD traces in one common point).

Consider using the reference designs BRD4206A and BRD4207A as the reference designs when creating the power routing.

9.4 DECOUPLING

Power should be driven through decoupling capacitors to prevent parasitic inductances as shown in Figure 9.3. At least two grounding vias is recommended for each component as shown in Figure 9.2.

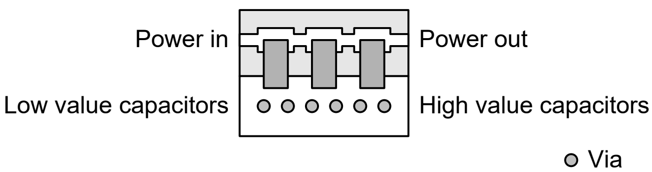

Figure 9.2: Grounded Components

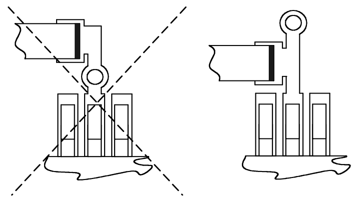

Figure 9.3: Pin Decoupling

9.4.1 FOR ZGM130S SIP MODULE

For the ZGM130S, most of the decoupling is built in. This includes all supply decoupling except for two 10 µF capacitors, one on AVDD and one on VDD and VDDIO combined.

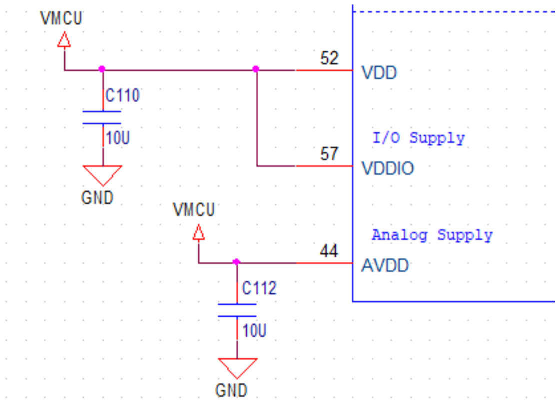

Figure 9.4: Recommended External Supply Decoupling for the ZGM130S

9.4.2 FOR EFR32ZG14 SOC

For an EFR32ZG14 device, the decoupling topology shown in Figure 9.5 is **strongly recommended**.

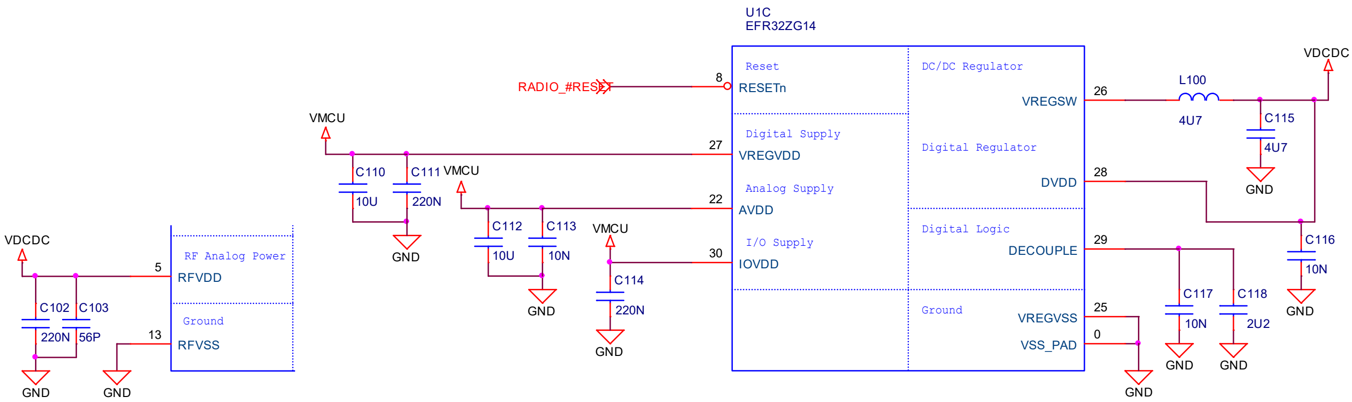

Figure 9.5: Minimum Supply Decoupling Required for the EFR32ZG14 SoC

9.5 RF TRACE

For RF traces longer than λ/16 at the fundamental frequency, it is **mandatory** to design the trace as a transmission line with a 50 Ω characteristic impedance. A coplanar waveguide similar to Figure 9.6 is recommended for a transmission line on signal layer L1.

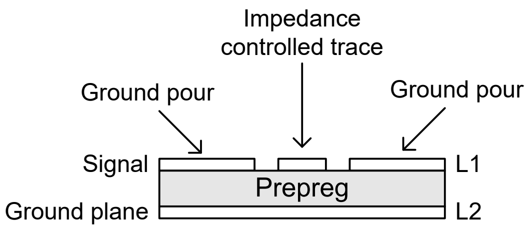

Figure 9.6: Coplanar Waveguide

A via fence is recommended on both sides of a coplanar waveguide, as shown Figure 9.7, to short any return currents induced on the top layer to ground.

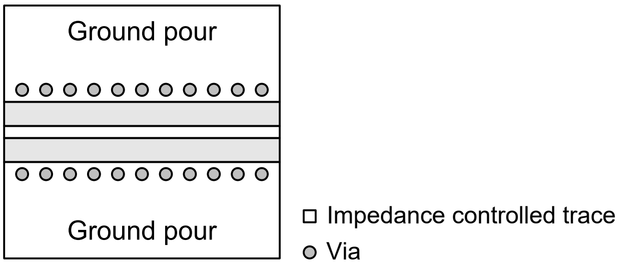

Figure 9.7: Via Fence

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 9.8.

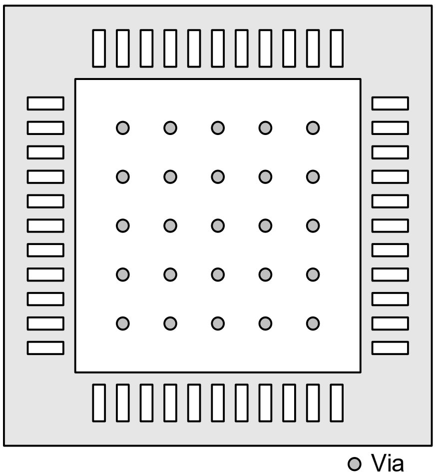

Figure 9.8: IC Ground Paddle

Refer to the BRD4206A layout to see a practical implementation of a QFN footprint with exposed pad.

10 ANTENNA DESIGN

EFR32ZG14	ZGM130S
Applicable	Applicable

Since antenna design is very product dependent, it is **mandatory** to perform the antenna matching as described in Section 8.4. Each product requires an individual antenna design for best power transfer and radiation characteristics.

The BRD4206A and BRD4207A radio boards example antenna designs are shown with naturally matched antennas not requiring any lumped components.

11 ESD

EFR32ZG14	ZGM130S
Applicable	Applicable

Since ESD can destroy the Z-Wave 700 product, great care must be taken during manufacturing and assembly of final goods to avoid ESD.

By design, all EFR32ZG14 and ZGM130S pins are ESD protected up to a level of **2.5 kV HBM**.

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

12 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
BALUN	Balanced to Unbalanced converter
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	Electrostatic 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
IPD	Integrated Passive Device
IR	Infrared

Abbreviation	Description
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
LNA	Low-Noise Amplifier
LO	Local Oscillator
lsb	Least Significant Bit
LSB	Least Significant Byte
MCU	Microcontroller 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
VNA	Vector Network Analyzer
WUT	Wake-Up Timer

Abbreviation	Description
XRAM	External Random Access Memory
XTAL	Crystal
ZEROX	Zero Crossing

13 REVISION HISTORY

Date	Version	Affected	Revision
2018/11/26	1A	§All	Initial draft based on INS12213-15: "500 Series Integration Guide"
2018/12/3	1B	P. 1, 3-5, 7, 9, 14, 18	Updated based on comments from JFR and OPP
2018/12/4	1C	P. 4, 6, 14	Updated based on comments from NTJ and MHANSEN
2018/12/4	1D	§All	Table 6.6 added and all references to devices corrected to "Z-Wave 700"
2018/12/5	1E	P. 18	Legal disclaimer updated based on Silicon Labs disclaimer from AN961
2018/12/5	1F	Front page	Corrected title to "Z-Wave 700 Integration Guide"
2018/12/6	1G	Table 6.6	Corrected temp range (-40 °C – 85 °C) and removed size specification
2019/02/26	1H	§All	Added references, corrected language, and clarified content.
2019/03/14	1I	Section 1, 6.1,6.1.3,8.1	Minor corrections and additions of references
2020/12/1	1J	All	Added support for Z-Wave Long Range
2021/03/10	1K	Section 6.1, Table 8.1, Table 8.2	Changing ZGM130S to applicable for SAW filters, minor corrections in Table 8.1 and Table 8.2, minor changes in content to reflect ZGM130S usability as a gateway, removed Split TX / RX + RF Switch option from Table 8.2
2021/06/28	1L	Section 3, 3.1	Additional information for programming interfaces
2022/07/12	1M	Section 6.1.1, Table 6.4: SAW filters	Correct URL and email.
2022/09/02	1N	Section 6.2.1	Redirect to UG522 for recommended crystals
2023/01/23	1O	Section 8	Added support for Z-Wave Long Range +20dBm and extended Table 8.2 with Split TX/RX with RF switch matching option
2023/01/31	1P	Front page	Improved image resolution

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