ZL70102

Medical Implantable RF Transceiver MICS RF Telemetry

Short Form Data Sheet

June 2010

Features

- 402-405 MHz (10 MICS channels) and 433-434 MHz (2 ISM channels)
- High data rate (800/400/200 kbps raw data rate)
- High performance MAC with automatic error handling and flow control, typ < $1.5x10^{-10}$ BER
- Very few external components (3 pcs + antenna matching)
- Extremely low power consumption (typical 5 mA, continuous average TX / RX, 1 mA idle power mode)
- Ultra low power wake-up circuit (typical 290 nA at 1s strobe period)
- Standards compatible (MICS, ETSI, FCC, IEC)

Applications

- Implant Medical Devices
  - Cardiac Rhythm Management
  - Neurostimulators
  - Drug delivery, sensors and diagnostics
- Body area network, short range device applications using the 433 MHz ISM band

Ordering Information

ZL70102LDG1	48 pad QFN
ZL70102UEJ2	49 pad CSP
ZL70102UBJ	bare-die

Please see “Ordering and Package Overview” on page 7 for details.

Description

The ZL70102 is a high performance half duplex RF communications link for medical implantable applications.

The system is very flexible and supports several low power wake-up options. Extremely low power is achievable using the 2.45 GHz ISM Band wake-up receiver option. The high level of integration includes a Media Access Controller, providing complete control of the device along with coding and decoding of RF messages. A standard SPI interface provides for easy access by the application.

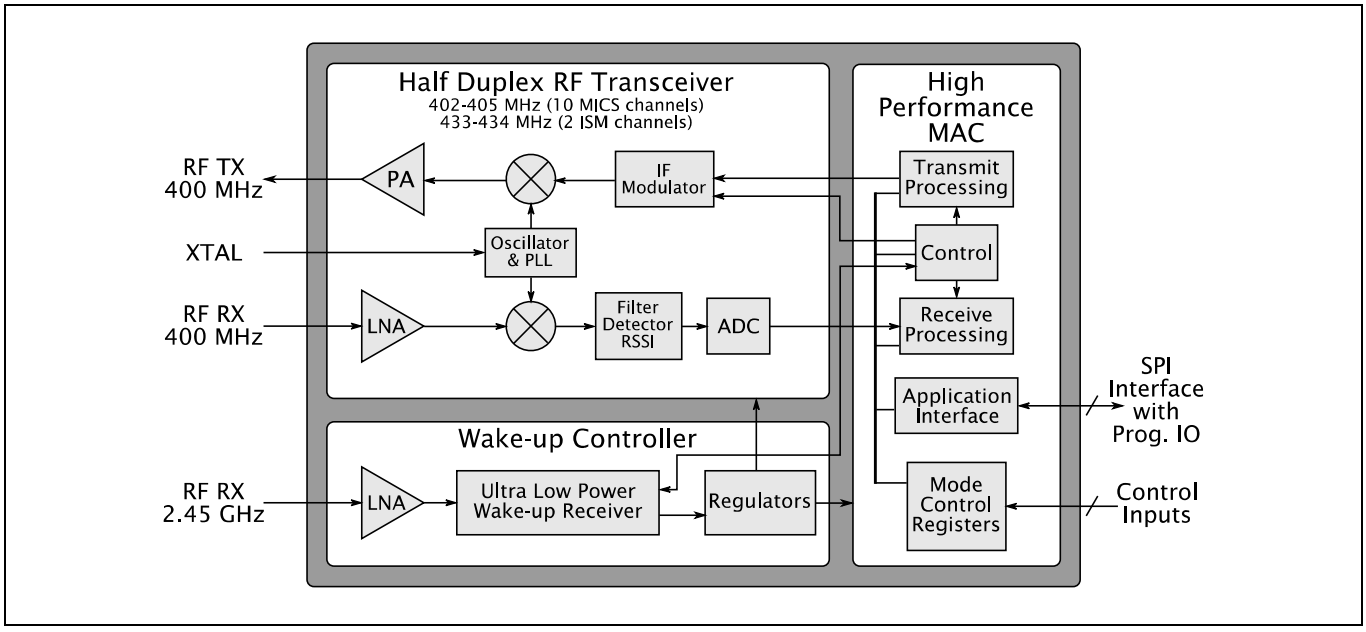

Figure 1 - ZL70102 Block Diagram

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Schematic Interconnect Diagram of the ZL70102

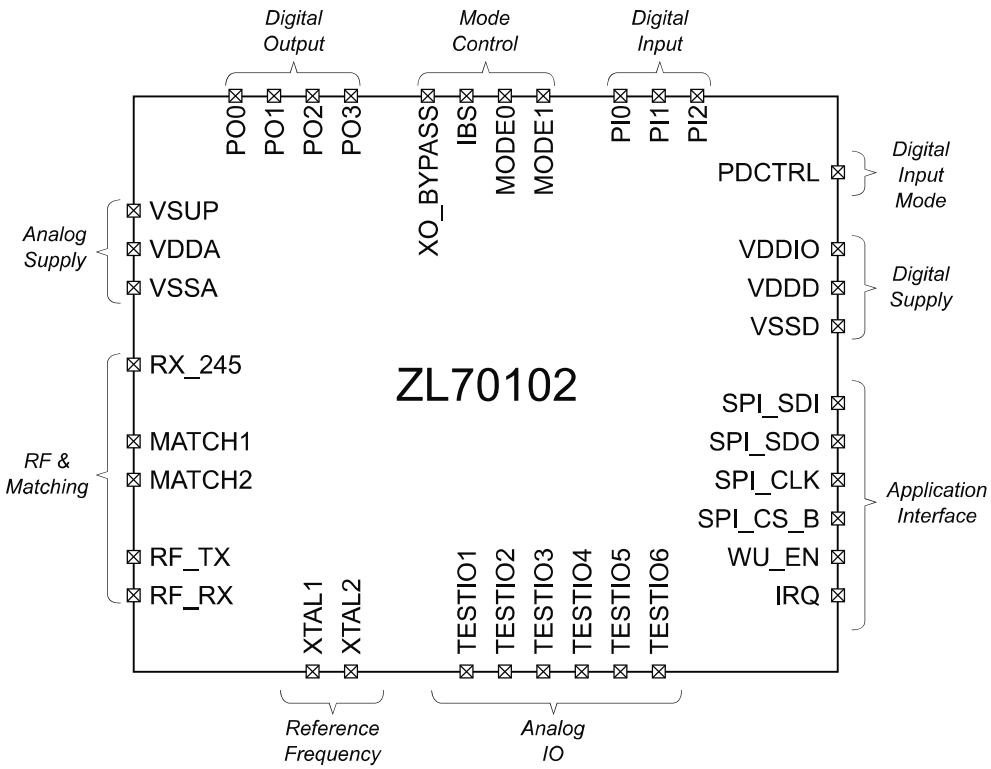


Figure 2 - ZL70102 Schematic Interconnect Diagram

The schematic interconnect diagram above shows all the important connections that are available in all package forms. The diagram does not show some additional connections like designated ground connections to the different blocks as well as some additional connections.

Symbol	Description
Analog Supply	
VSSA	Analog ground
VDDA	Analog on-chip regulated power (internal analog 2V domain)
VSUP	Unregulated supply for PA, wake up and voltage regulator input
RF & Matching	
RX_245	2.45 GHz RF wake-up receiver input
MATCH1 MATCH2	Antenna tuning capacitors for the RF matching network
RF_TX	400 MHz RF transmitter output to matching network
RF_RX	400 MHz RF receive input from matching network
Reference Frequency	
XTAL1 XTAL2	Connection to the reference frequency crystal. The chip can also use an external oscillator connected to XTAL1 (controlled by XO_BYPASS)
Analog IO	
TESTIO1-6	Analog input/output. Mainly used during electrical testing in chip production. 6 I/O's.
Application Interface	
IRQ	Interrupt request
WU_EN	Wake-Up enable signal used for strobing the wake-up LNA
SPI_CS_B	SPI Chip Select (active low)
SPI_CLK	SPI Serial Clock
SPI_SDO	SPI Serial Data Out
SPI_SDI	SPI Serial Data In
Digital Supply	
VDDIO	Digital I/O supply to level shifters
VDDD	Digital on-chip regulated power (internal digital 2V domain). (This regulator can be disabled with pin VREG_MODE on the bare-die and CSP package version)
VSSD	Digital Ground
Digital Input Mode	
PDCTRL	Digital input pull-down control for the following pins: MODE0, MODE1, IBS, XO_BYPASS, and PI0-2. If PDCTRL=VDDIO, then these inputs are pulled low with a 90K Ohm internal resistor and do not need to be grounded externally.
Digital Input	
PI0-2	Programmable digital inputs (3 inputs)
Mode Control	
MODE0	The MODE0 input selects normal operation mode or test mode (only for Zarlink usage). Should be tied low for normal operation.
MODE1	Controls if HK messages can write to registers. MODE1=0 disables HK writes.
IBS	Implant/Base mode selection
XO_BYPASS	Bypass the on-chip crystal oscillator circuit and use external oscillator connected to XTAL1.
Digital Output	
PO0-3	Programmable digital outputs (4 outputs). There is also a 5'th output on the chip that is only available for the bare-die delivery option.

Table 1 - Schematic Overview of the ZL70102 Interconnects

1.0 Product Description

1.1 Introduction

The ZL70102 is an ultra low power RF transceiver for implantable medical applications. It operates in the Medical Implantable Communication Service[1] (MICS) band at 402-405 MHz and provides a complete radio modem enabling communication to a medical device in the body. The wireless RF Telemetry link replaces the traditional inductively coupled wand and enables benefits including:

- Higher data rates
- Placement of the programmer further away from the body (outside the sterile area) during surgery
- Remote monitoring outside the medical clinic
- Body-worn applications allowing patient control and monitoring
- Link to other non-implanted medical devices and sensors for more advanced applications

The ZL70102 RF transceiver provides a complete radio system solution and can be used in both ends of the link, i.e., both in the Implantable Medical Device (IMD) and in the external device (base station, programmer, remote monitor, patient controller etc).

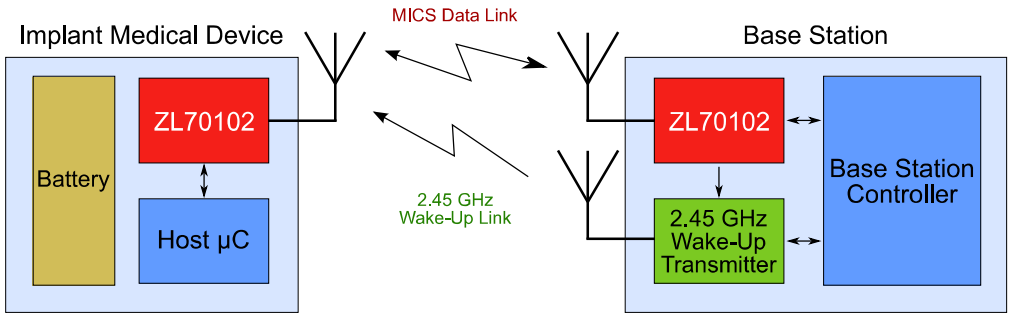


Figure 3 - Application Example

1.1.1 Dedicated for the Medical Implant Market

The ZL70102 has been developed specifically for the medical implant market and is optimized for the requirements driven by these types of products. Robustness, quality and security have been cornerstones in the ZL70102 system definition.

1.1.2 Extreme Ultra Low Power

The ZL70102 RF Transceiver is designed from the bottom-up to be a true ultra low power device. Implant medical devices normally have very limited battery resources and longevity is one of the core values of the application. The RF Telemetry link is expected to use a fraction of the battery resources from the target treatment of the IMD.

Low current consumption during transmission is essential but even more important is that the radio can be kept in sleep mode for as much time as possible while maintaining responsiveness. Every block of the ZL70102 has therefore been carefully designed with ultra low power consumption in mind and advanced power management is implemented on all levels.

1. MICS is a dedicated band for non-audio implantable applications. One side of the link has to be implanted.

1.1.3 Innovative Wake-Up System

To conserve battery power it is essential to provide an ultra low power wake-up system. The ZL70102 is very versatile and supports several wake-up methods:

- 2.45 GHz wake-up receiver — Fully autonomous, extreme ultra low power wake-up receiver, utilizing the higher transmitted power allowed for by the 2.45 GHz ISM band. Modulation and protocol are optimized for ultra low power and robustness.
- In-band (MICS) wake-up — Advanced support for MICS in-band wake-up enables a simple hardware implementation (some support from the host required)
- Wake-up by host — Wake-up by the host controller in combination with support for the Low Duty-Cycle Mode enables scheduled communication schemes or ad-hoc wake-up initiated by the implant.

1.1.4 High Performance MAC and Autonomous Operation

The ZL70102 has a simple to use packet level interface supported by a high performance MAC with automatic error correction and flow control. The host controller can concentrate on the treatment and delegate the communication to the ZL70102 transceiver. The radio can be controlled remotely through the link and could in principle operate with no host controller using the on-chip general purpose I/O's to control a simple application.

1.1.5 Self-contained

The ZL70102 Transceiver is highly integrated and self-contained. Very few external components are required to make a complete radio system:

- Antenna with suitable matching network
- SAW filter to suppress unwanted blockers
- Crystal for the reference frequency (on-chip oscillator)
- De-coupling capacitors for power supply (on-chip regulators)

1.2 Typical Applications

Three typical applications are presented below. The chapter "Typical Application Examples" on page 12 will provide schematics and more details. These three typical applications are intended as a starting point for the target application.

1.2.1 Extreme Ultra Low Power Devices

This application area has been dominated by Cardiac Rhythm Management products like pacemakers and Implantable Cardioverter Defibrillators (ICD) where low power and device longevity were very important characteristics of the device market long before RF Telemetry was introduced. This means that the industry is willing to take extra efforts to save power even if this results in a moderate increase in complexity. There are other new applications that also fall into this category.

To address this need the ZL70102 is equipped with an extreme ultra low power 2.45 GHz Wake-Up system that provides by far the lowest power consumption. The 2.45 GHz wake-up system is also autonomous and fully integrated when the ZL70102 is used in an implant.

1.2.2 Ultra Low Power Devices

Many neurostimulators, drug delivery systems, sensors and diagnostic applications are operated in a mode allowing higher power consumption since the core function itself consumes more power requiring use of larger or re-chargeable batteries. This allows alternative wake-up solutions to be used like the in-band MICS wake-up that simplifies the hardware design (the matching network and antenna only uses the 400 MHz MICS band).

1.2.3 External Devices

- Programming base stations
- Home/remote monitoring devices
- Handheld, mobile and belt-worn applications

This is the other side of the MICS link with a higher allowed power budget in comparison with the implanted device. The external device, acting as a base station, also has to fulfill other requirements in the MICS standard like Clear Channel Assessment (CCA) and it is required to transmit the 2.45 GHz wake-up packet if the 2.45 GHz wake-up option is used.

2.0 Ordering and Package Overview

The ZL70102 RF Transceiver is available in several package options. Some of these packages are intended for implant devices and some for external devices (base stations). Depending on the application there are some differences in the electrical specification.

Ordering Code	Temp Range [°C]	Package	Delivery Form	Pb Free	Implant Grade	Application Area	
						Implant Devices	External Devices
ZL70102LDG1	0 to +55	48 pad QFN	trays, bake and dry-pack	YES[1]	NO[2]		X
ZL70102UEJ2	0 to +55	49 pad CSP	trays	YES	YES	X	
ZL70102UBJ	0 to +55	bare-die	trays	N/A	YES	X	

Table 2 - Ordering and Package Overview

1. Pb Free (Matte Tin).
2. Not for implantable use.

Note: The Information in this data sheet regarding the ZL70102UEJ2 (CSP) version is preliminary.

3.0 Functional Description

3.1 General

The ZL70102 is an ultra low power, high bandwidth RF transceiver for medical implantable applications. It operates in the Medical Implantable Communication Service (MICS) band at 402-405 MHz. It uses a forward error correction scheme together with CRC error detection to achieve an extremely reliable link. For standard data-blocks a maximum Bit Error Rate (BER) of less than $1.5x10^{-10}$ is provided assuming a raw radio channel quality of 10^{-3} BER. An even higher quality of $2x10^{-14}$ BER is available for housekeeping messages.

3.1.1 Basic Modes

The ZL70102 transceiver is designed for operation in both an implant and base station application. These systems have different requirements especially with regard to power consumption. Therefore, the ZL70102 transceiver has defined two basic modes (configured by the IBS pin):

- IMD Mode — The device is asleep waiting for a wake-up event
- Base-Idle Mode — The device is powered up and idle

When configured in IMD Mode, the transceiver is usually asleep and in an ultra low current state. The IMD may be woken up to initiate communications by either receipt of a specially coded 2.45 GHz wake-up message or directly by the IMD processor via the WU_EN pin.

This flexibility leads to the following options for waking up an IMD transceiver for communication.

- IMD transceiver woken up by specially coded 2.45 GHz wakeup message using an ultra low power sniffing method.
- IMD transceiver woken up to sniff 400 MHz link. The ZL70102 supports such a mode of operation although the 2.45 GHz wakeup system has lower power consumption.
- IMD transceiver woken to send an emergency message in which case no clear channel assessment by the Basestation is required.
- IMD transceiver woken to send a low duty cycle mode message in which case no clear channel assessment by the Basestation is required[1].
- IMD transceiver woken up by the IMD host processor based on some alternative mechanism.

1. The allowed maximum radiated output power is reduced in this mode.

4.0 Electrical Reference

Voltages are with respect to ground (VSS) unless otherwise stated.

4.1 Absolute Maximum Ratings

ID	Parameter	Symbol	Condition	Limits		Unit	Note
				Min	Max		
1.0	Supply Voltage	V_{SUP}		0	3.6	V	
1.1	Input voltage (digital IO)	V_{DDIO}			V_{SUP}	V	Note 1
1.2	Storage temperature	T_{stg}	Unpowered	-40	+125	°C	

Table 3 - Absolute Maximum Ratings

Note 1: V_{DDIO} must never be higher than VSUP even during system start up

4.2 Recommended Operating Conditions

The recommended operating conditions define the nominal conditions for the device. This means that a specified parameter is valid for the recommended operating conditions stated in the table below unless the conditions are further specified as stated by additional conditions in the **Condition** column or stated in one of the notes.

ID	Parameter	Symbol	Condition	Limits		Unit	Note
				Min	Max		
2.0	Supply Voltage	V_{SUP}		2.05	3.50	V	
2.1	Input voltage (digital IO)	V_{DDIO}		1.50	V_{SUP}	V	
2.2	Operating temperature	T_{op}		0	+55	°C	

Table 4 - Recommended Operating Conditions

5.0 Mechanical Reference

5.1 48 pad QFN Package

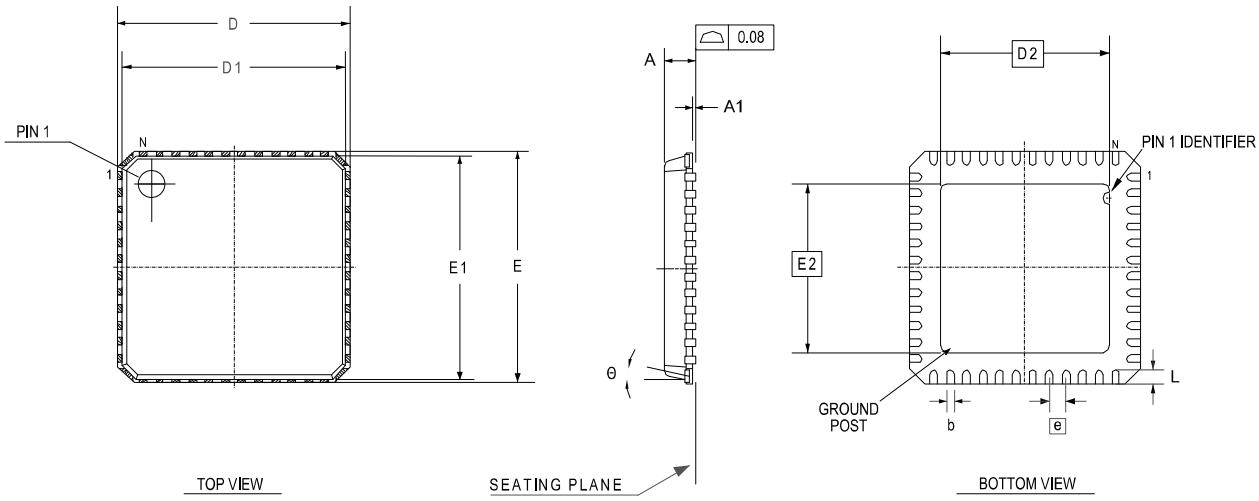


Figure 4 - 48 Pad QFN Package Drawing

Symbol	COMMON DIMENSIONS		
	Minimum	Nominal	Maximum
A	0.800	0.850	0.900
A1	0.005	0.025	0.045
b	0.180	0.230	0.300
D	6.900	7.000	7.100
D1	6.650	6.750	6.850
D2	5.10 BSC		
E	6.900	7.000	7.100
E1	6.650	6.750	6.850
E2	5.10 BSC		
N	48		
Nd	12		
Ne	12		
e	0.50 BSC		
L	0.300	0.400	0.500
q	10°	11°	12°

Table 5 - 48 Pad QFN Package Dimensions

Note 1: Conforms to JEDEC M0-220.

Note 2: Dimensioning and tolerances conform to ASME Y14.5M. - 1994.

Note 3: N is number of terminals.

Note 4: All dimensions are in millimeters.

Note 5: Lead count is 48.

Note 6: Package warpage max 0.08 mm.

Note 7: Not to scale.

5.2 49 Pad CSP Package

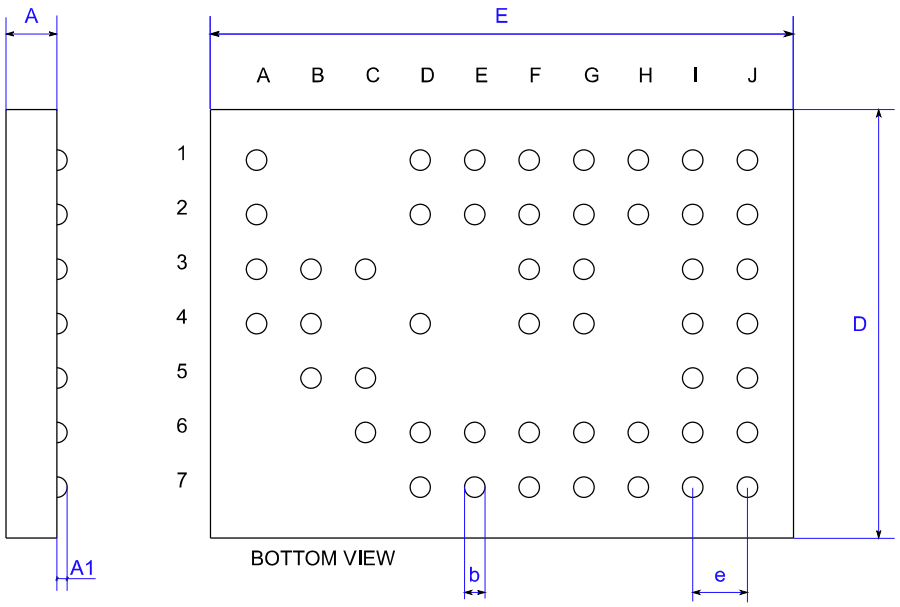
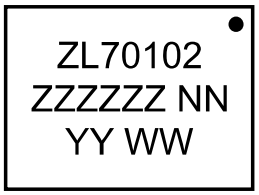


Figure 5 - 49 Pad CSP Package Drawing

Symbol	COMMON DIMENSIONS [mm]		
	Minimum	Nominal	Maximum
A	0.325	0.375	0.425
A1	0.115	0.130	0.145
b[1]		0.150	
D			3.145
E			4.275
N	49		
e	0.40 BSC		

Table 6 - 49 Pad CSP Package Dimensions

1. UBM diameter



Notes:

1. ZZZZZZ = Lot number
2. NN = Wafer ID
3. YY = Calendar year
4. WW = Calendar week
5. Orientation marker corresponds to pad A1

Figure 6 - 49 Pad CSP Marking

6.0 Typical Application Examples

Three typical application examples are presented with principle schematics in this chapter, two different implants and one external device (base station). Matching networks have to be adopted to the applicable antenna impedance. Please see the ZL70102 ADK for more information. All examples are assuming clean power supplies.

6.1 Extreme Ultra Low Power Implant Device

This implementation has full focus on reducing power consumption. This is achieved by using the extreme ultra low power 2.45 GHz Wake-Up system that provides by far the lowest power consumption. The 2.45 GHz wake-up system is also autonomous and fully integrated. Using the 2.45 wake-up system requires a more complex implementation both on the implant side as well as on the base station side.

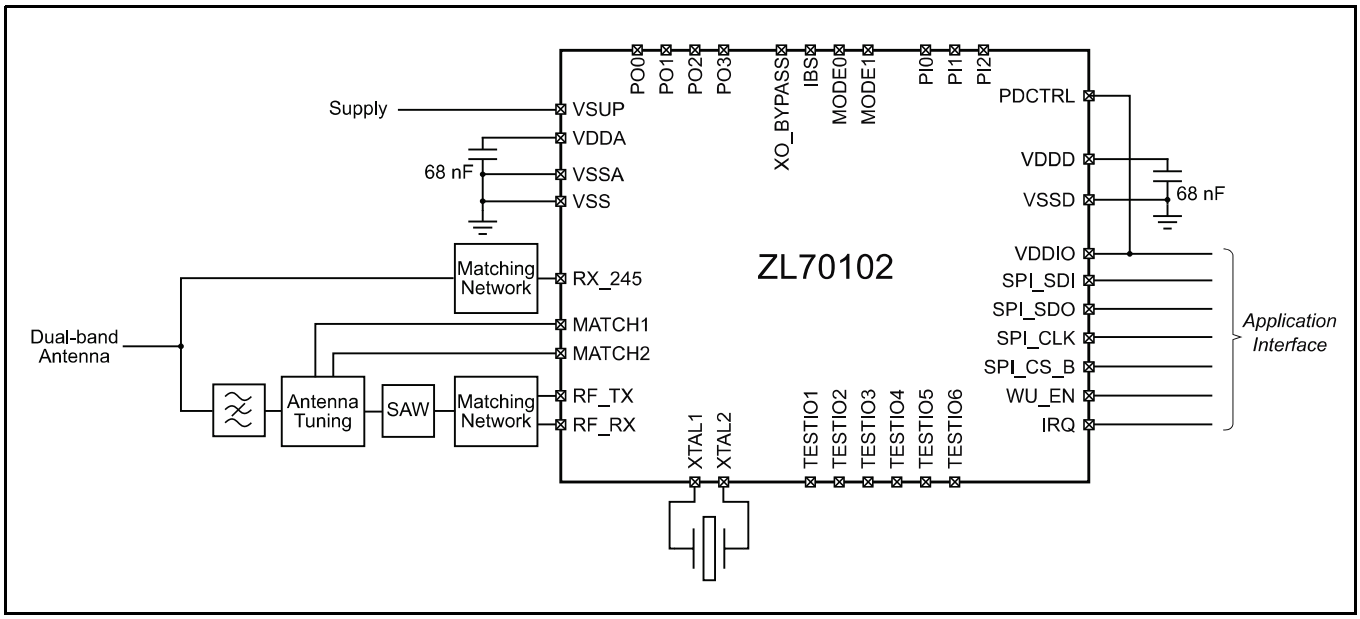


Figure 7 - Extreme Ultra Low Power Implant Device

6.2 Ultra Low Power Implant Device

This implementation utilizes the in-band 400 MHz wake-up system that allows for a simpler hardware implementation but with the drawback of a higher average power consumption and higher burden on the implant host processor since portions of the wake-up control have to be implemented in the host processor firmware.

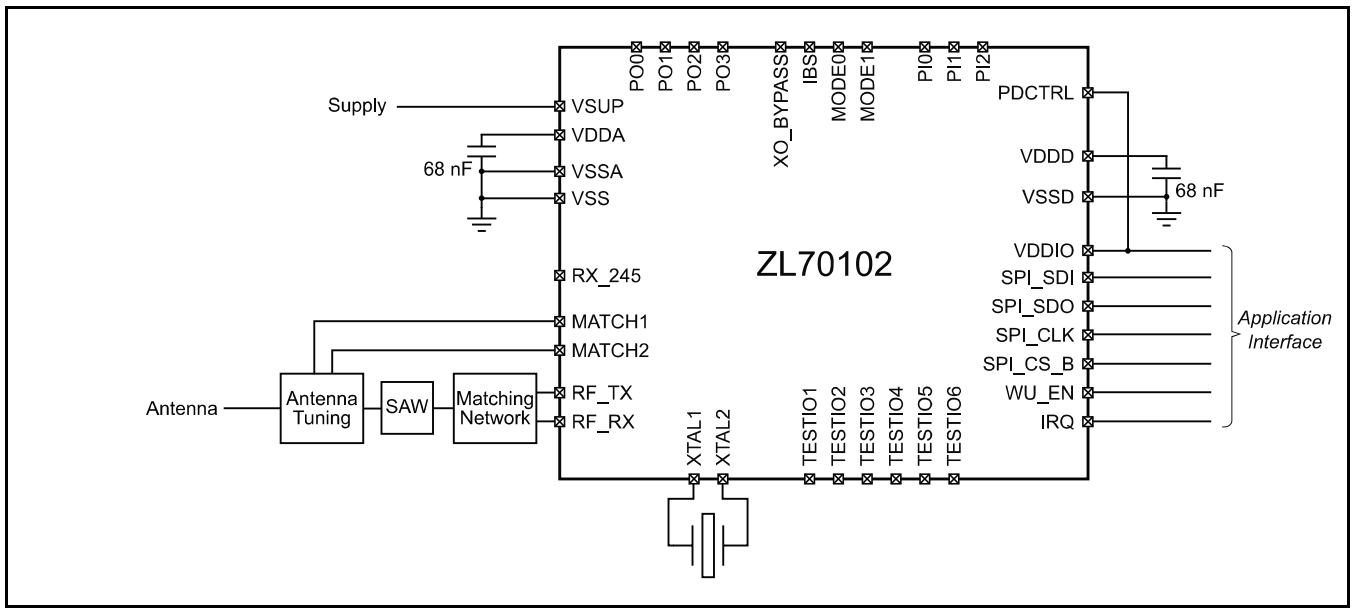


Figure 8 - Ultra Low Power Implant Device

6.3 External Device

The external device (base station) has less stringent power supply requirements compared to the implant devices but more effort is required on power control and unwanted emissions to ensure that the regulatory requirements are met. The schematic below shows support for the 2.45 GHz wake-up system. If the in-band 400 MHz wake-up system is used the 2.45 GHz transmitter and antenna can be skipped.

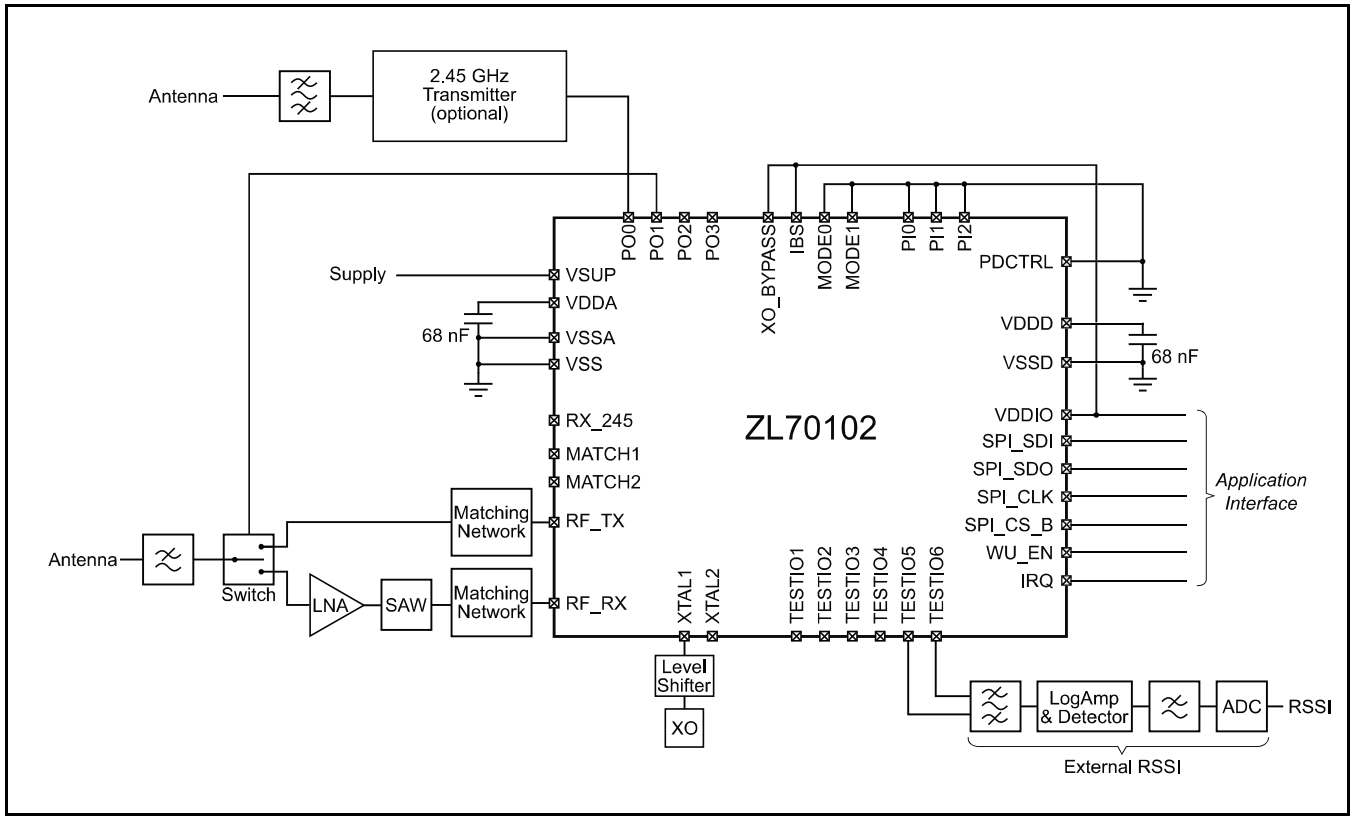


Figure 9 - External Device

Note: The performance of the SAW filter has to be verified for the target application environment.

7.0 Quality

The ZL70102 can be delivered as bare-die, CSP or QFN package, please see the section “Ordering and Package Overview” on page 7 for further details.

The bare-die and CSP are intended for implantable applications. The QFN package is intended for base station applications and for non-implantable applications. It is not approved for use in implantable products.

For all versions of the product, manufacturing processes are carried out in ISO9001 approved facilities and all products are fully tested and qualified to ensure conformance to this data sheet.

8.0 Revision History

ZL70102 Short Form Data Sheet (138041):

Version	Date	Changes
1	2010-08-06	First Release

Table 7 - Revision History

9.0 Additional Information

A full Data Sheet and Design Manual are available for the ZL70102. Please contact Zarlink for more Information.

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