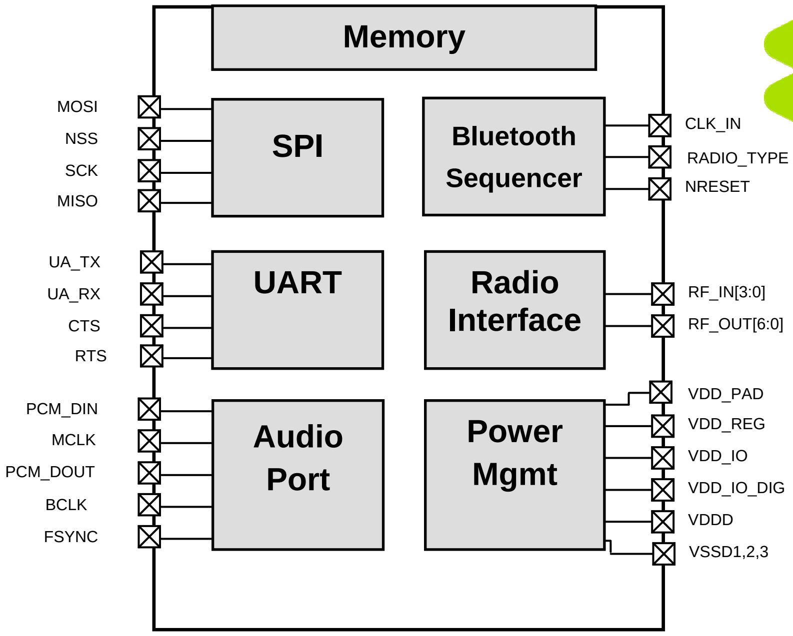
SEMTECH INTERNATIONAL AG
WIRELESS AND SENSING PRODUCTS



EasyBlue™

XE1401

Ultra low power Bluetooth® Baseband Controller up to HCI for portable data and voice applications

GENERAL DESCRIPTION

The XE1401 is a ROM based, stand alone Bluetooth baseband protocol-on-chip solution bridging radio and Host Controller Interface (HCI). The device is interfaced through a standard UART with programmable baud rate. The XE1401 supports transmission of all types of ACL and SCO links using the Bluetooth rev. 1.1 protocols and is already prepared to support Bluetooth rev. 1.2.

For Bluetooth voice applications, the device is optimized to directly interface to Semtech ultra low power CODEC XE3005/6.

The on-chip Power Management Unit provides a regulated typ. output voltage of 1.8V to supply any additional external components e.g. CODEC, 2.4 GHz radio modules or sensors.

Any 8, 16 or 32 bit Microcontroller can be used to handle the upper layer Bluetooth protocol as well as application specific tasks.

APPLICATIONS

- Wireless Headset Applications
- Human Interface Devices
- PDA's and other battery powered applications
- Wireless games, peripherals and accessories

KEY PRODUCT FEATURES

- ROM based Bluetooth protocol rev. 1.1 baseband controller up to HCI.
- Fully compliant with Bluetooth rev. 1.2
- Supports SCO (HV packages) and ACL (DM, DH packages) data formats.
- Supports Bluetooth radio chips from Skyworks Inc. and Silicon Wave.
- Supports Class1, Class2 and Class3 radios
- High speed UART for HCI transport layer.
- Full transparent SPI port to interface to any peripherals like e.g. Semtech XE3005 CODEC device or sensors.
- On-chip 1.8V Power Management Unit.
- Ultra low power consumption, typ. 4 mA during full operation.

REFERENCES

Extended Part Number	Description
XE1401I041TRLF	LQFP48, Leadfree, T&R
XE1401I064TRLF	UltraCSP, Leadfree, T&R

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1 SYSTEM LEVEL BLOCK DIAGRAM

A typical application example of the XE1401 is shown in Figure 1. The Semtech Bluetooth baseband controller XE1401 bridges the Host Controller Interface (HCI) to the Radio Interface, not requiring any external components.

In a headset application for example, the on-chip Serial Peripheral Interface (SPI) directly interfaces to the Semtech ultra low power CODEC XE3005. The on chip CVSD allows compression using a linear CODEC device. The XE1401 and all externals can be configured using vendor specific HCI commands. Radio interface and SPI is fully transparent and therefore not a single additional Host Controller I/O port is required.

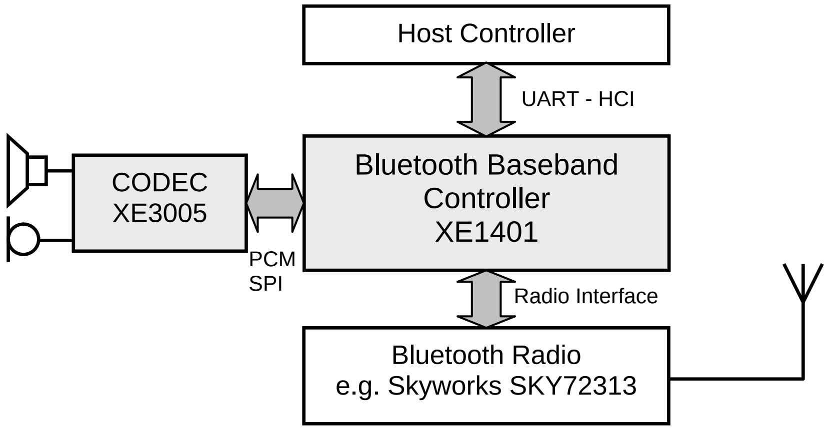


Figure 1: Bluetooth Headset Application

The Semtech Bluetooth Baseband controller operates completely independently from tasks running above HCI. Software Development, test and qualification of the higher protocol layers, profiles and application layer can be made completely independent from the lower protocol stack.

Depending on the complexity of the application any host processor can be chosen. On the host processor the user has to run their own application software as well as the upper layer Bluetooth protocol stack software. Qualified upper Bluetooth protocol software running on various controllers – 8, 16 and 32 Bit architectures - can be supplied in combination with the Semtech baseband chip.

This system architecture definitely eases the software development process and the Bluetooth qualification as well as guarantying the highest possible flexibility. When compared to alternative solutions, the usage of different semiconductor processes enables the manufacturer to benefit from greater volume production yields, superior RF and baseband performance and a reduced number of external components.

If the UltraCSP® package of the XE1401 is used, the required PCB surface is identical or even smaller than when using known embedded solutions.

As only few Bits of code must be programmed to initialize the total Bluetooth system, volume production and system maintenance through software updates becomes easy.

The Bluetooth qualification process for the final application is simplified by the fact that the XE1401 is purely ROM based and fully Bluetooth qualified.

2 XE1401 PINOUT DIAGRAM

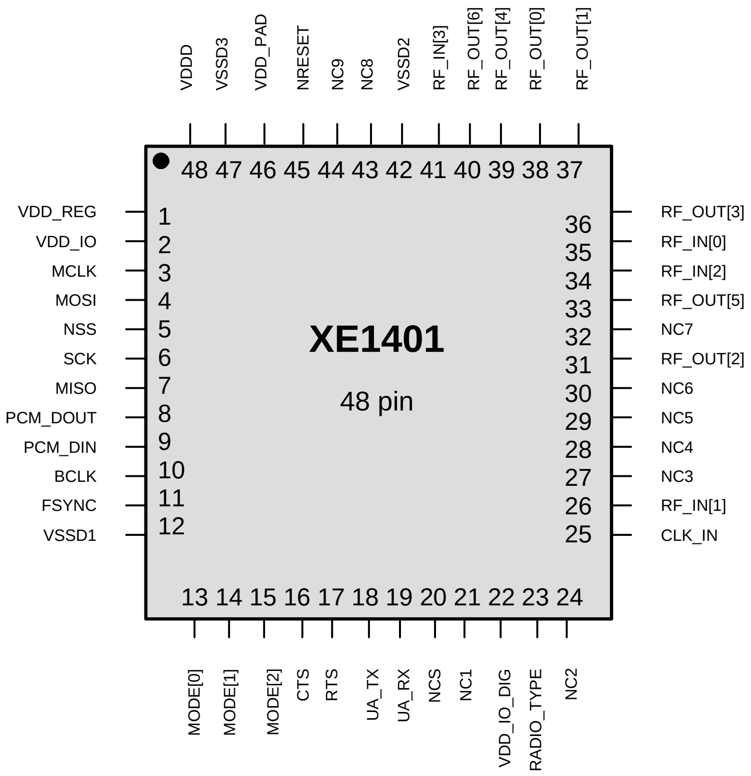


Figure 2: Pin Diagram

2.1 PACKAGE

The XE1401 is available in several different packages as well. Each package will have the same pin functionality but a different form factor.

The physical dimensions of these packages are described in the Mechanical Information section at the end of this document, in Section 6.

2.2 TERMINAL DESCRIPTIONS

Pin	Symbol	Type	Description	Comments
1	VDD_REG	AO	Regulator Voltage (1.8V)	-
2	VDD_IO	AI	I/O Voltage	-
3	MCLK	DO	CODEC Master Clock	(1)
4	MOSI	DO	SPI Master Out Slave In	(1)
5	NSS	DO	First SPI Slave Select	(1)
6	SCK	DO	SPI Serial Clock	(1)
7	MISO	DI	SPI Master In Slave Out	(1)
8	PCM_DOUT	DO	Serial Data Output	(1)
9	PCM_DIN	DI	Serial Data Input	(1)
10	BCLK	DO	CODEC Bit Clock	(1)
11	FSYNC	DO	CODEC Frame Clock	(1)
12	VSSD1	AI	Ground	-
13	MODE[0]	DI PD	Used by Manufacturer	(2)
14	MODE[1]	DI PD	Used by Manufacturer	(2)
15	MODE[2]	DI PD	Used by Manufacturer	(2)
16	CTS	DI PD	UART flow control	(2)
17	RTS	DO	UART flow control	(2)
18	UA_TX	DO	UART Transmit Signal	(2)
19	UA_RX	DI PD	UART Receive Signal	(2)
20	NCS	DO	Second SPI Slave Select	(1)
21	NC1	-	Not Connected (leave open)	-
22	VDD_IO_DIG	AI	Digital I/O Voltage	-
23	RADIO_TYPE	DI PD	Radio Selection	(2)
24	NC2	-	Not Connected (leave open)	-
25	CLK_IN	DI PD	Master Clock	(3)
26	RF_IN[1]	DI	Generic Radio Input	(3)
27	NC3	-	Not Connected (leave open)	-
28	NC4	-	Not Connected (leave open)	-
29	NC5	-	Not Connected (leave open)	-
30	NC6	-	Not Connected (leave open)	-
31	RF_OUT[2]	DO	Generic Radio Output	(3)
32	NC7	-	Not Connected (leave open)	-
33	RF_OUT[5]	DO	Generic Radio Output	(3)
34	RF_IN[2]	DI	Generic Radio Input	(3)
35	RF_IN[0]	DI	Generic Radio Input	(3)
36	RF_OUT[3]	DO	Generic Radio Output	(3)
37	RF_OUT[1]	DO	Generic Radio Output	(3)
38	RF_OUT[0]	DO	Generic Radio Output	(3)
39	RF_OUT[4]	DO	Generic Radio Output	(3)
40	RF_OUT[6]	DO	Generic Radio Output	(3)
41	RF_IN[3]	DI	Generic Radio Input	(3)
42	VSSD2	AI	Ground	-
43	NC8	-	Not Connected (leave open)	-
44	NC9	-	Not Connected (leave open)	-
45	NRESET	DI PU	Master Reset (can be left open – see chapter Reset Sequence)	(2)
46	VDD_PAD	AI	Main Supply Voltage	-
47	VSSD3	AI	Ground	-
48	VDDD	AI	Core Supply Voltage	-

AI : Analog Input
AO: Analog Output
PU : Internal Pull Up
PD : Internal Pull Down

DI : Digital Input
DO: Digital Output
DI/O : Digital Input/Output

(1) : Digital Level 1.8V
(2) : VDD_IO_DIG voltage
(3) : VDD_IO voltage

Table 1 – Pin description

3 FUNCTIONAL DESCRIPTION

3.1 BLOCK DIAGRAM

A high-level block diagram of the XE1401 is shown in Figure 3. The core of the XE1401 is a Semtech ultra low power 8 Bit, RISC Controller using BOOST™ rev.1.1. The Controller takes care of all Bluetooth tasks below HCI and automatically handles all interactions between the baseband, the CODEC and radio device. Synchronization, frequency hopping, link negotiation, encryption, RSSI handling and audio processing are autonomously done on the XE1401.

As a Host interface, the XE1401 provides a standard 4 wires 16450/16550 compatible high speed UART.

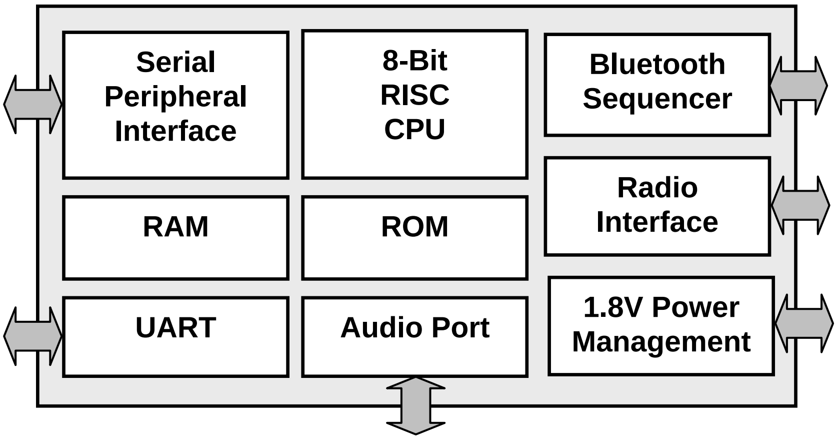


Figure 3: XE1401 Block Diagram

The XE1401 does not need any external memory and represents a ROM version of the Lower Bluetooth Protocol Stack up to HCI. During start-up an initialization routine is required to properly configure several parameters of the XE1401, the radio device and any peripherals connected through the XE1401.

The XE1401 is a true 1.8V design however the on chip power management allows supply voltages up to 3.6V. For the different interfaces, different supply voltages levels can be selected to optimize the system power consumption.

The fully embedded HCI software running on the XE1401 provides the following Bluetooth functionality:

- Supports all operation modes (Active, Hold, Sniff, Park, Standby).
- All Bluetooth data packages are supported.
- Simultaneous operation with up to 7 ACL and one SCO link.
- Point-to-point, Piconet and Scatternet operation.
- Standard high speed UART for HCI transport layers.
- Supports full Bluetooth data rate.

The following extra functionality is provided on the XE1401:

- On-chip CVSD compression.
- Embedded 1.8V supply regulator for external devices.
- Fully transparent and user programmable SPI.
- Supports Skyworks Inc. and Silicon Wave radio devices.

3.2 POWER MANAGEMENT UNIT

The on chip power management allows the use of any supply voltage ranging from nominal 1.8V up to 3.6V. On chip level shifter can be used to select the optimal interfaces voltage for each building block.

The VDD_PAD [Pin 46] is the main supply input pin for the integrated power management unit. The supply can be unstable but a blocking capacitor is recommended. VDD_REG [Pin 1] is the regulator output pin providing a stabilized 1.8V supply for any external components. In this configuration a 4.7 uF capacitor should be connected between VDD_REG [Pin1] and ground.

The levels for the PCM (Pulse Code Modulated) audio port and SPI (Serial Peripheral Interface) are fixed to 1.8V. The interface level for the UART as well as the radio port can be selected by applying the appropriate interface voltage at VDD_IO [Pin 2] for the radio interface and at VDD_IO_DIG [Pin 22] for the UART.

Depending on the radio operating voltage, VDD_IO [Pin 2] should be connected to a 3V supply (e.g. VDD_PAD) or to any 1.8V supply (e.g. VDD_REG). VDD_IO_DIG [Pin 22] sets the UART interface levels. This allows the use of any host controller supply voltage ranging from 1.8V to 3.6V. For details see the various configuration examples.

The supply for the XE1401 core must be applied to VDDD [Pin48]. The nominal core supply voltage is 1.8V. An external connection between VDD_REG [Pin1] and VDDD [Pin48] is required to power the core when using supply voltages above 1.8V.

If several supply voltages are available within the system e.g. 1.8V and 3V, the level shifter can be directly connected to the appropriate power source. For further details see the configuration examples on the following pages. See also the "Comment" column in the Terminal Description section.

Whenever possible, the lowest possible interface voltage should be used to reduce the systems power consumption.

3.2.1 Single 1.8V supply - configuration example

The following configuration can be used if a regulated 1.8V supply is available. The radio, UART, generic Serial Peripheral Interface (SPI) as well as the Audio Port interface is set to interface to digital signals of typ. 1.8V.

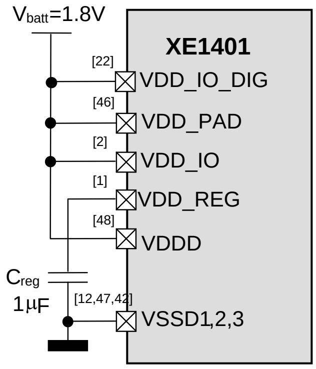


Figure 4: Configuration example using a stabilized 1.8V supply.

The on-chip power management unit provides a stabilized typ. 1.8V output voltage. When using the internal regulator, an unstable supply of nominal above 2.2V can be used. For details see the following configuration examples.

3.2.2 Single 3V supply - configuration example: 1.8V radio, UART and CODEC

The following configuration is used to operate all interfaces at 1.8V. The UART, radio, generic Serial Peripheral Interface (SPI) as well as the Audio Port interface are set to interface to digital signals at 1.8V. The on chip regulator is able to provide up to 50 mA peak current for the peripherals.

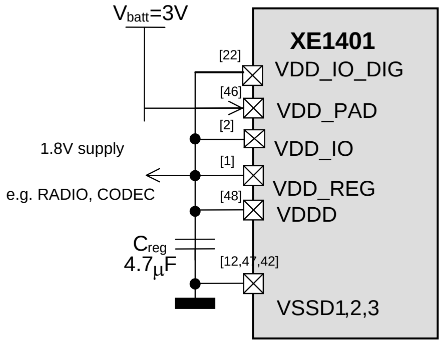


Figure 5: Configuration example using a 3V supply, 1.8V for radio, UART and CODEC

3.2.3 Single 3V supply - configuration example: 3V radio and UART, 1.8V CODEC

The following configuration is used to operate the radio (e.g. Silicon Wave) and UART lines at 3V. The generic Serial Peripheral Interface (SPI) as well as the Audio Port interface are still set to interface to digital signals at 1.8V. The on chip regulator is able to provide up to 50 mA peak current for the peripherals.

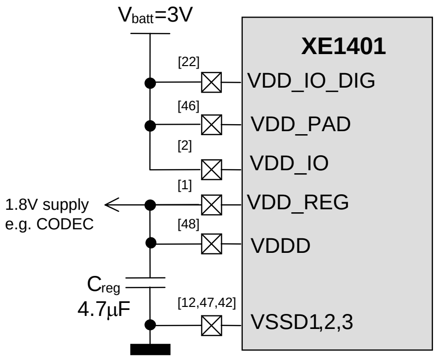


Figure 6: Configuration example using a 3V supply, 3V for radio and UART, 1.8V CODEC

3.2.4 Single 3V supply - configuration example: 1.8V radio and CODEC, 3V UART

The following configuration is used to operate the UART lines at 3V and the radio at 1.8V. The generic Serial Peripheral Interface (SPI) as well as the Audio Port interface are still set to interface to digital signals at 1.8V. If a single supply is used the on chip regulator is able to provide up to 50 mA peak current at 1.8V for the peripherals.

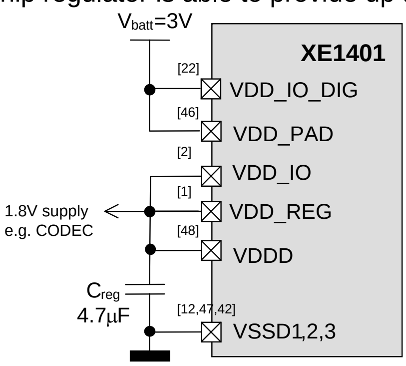


Figure 7: Configuration example using a 3V supply, 1.8V for radio and CODEC, 3V UART

3.3 CLOCKING SOURCES

The radio circuit provides the high and low frequency system clock for the XE1401. Besides a low frequency clock of 32 kHz, two baseband clocks are supported, 13 MHz and 16 MHz.

The Skyworks radio typically provides a 13 MHz clock, the SiW1502 a 16 MHz clock. Programmable dividers on the radio chip can be used to derivate the low frequency clock from the high frequency clock.

CLK_IN [Pin 25] input is used to provide the baseband with the main clock. The required clocks for the CODEC or any other peripherals are internally derived from the CLK_IN signal – details see chapter CODEC Interface.

3.4 RADIO INTERFACE

The radio type can be set with the RADIO_TYPE [Pin 23] pin. The XE1401 automatically adjusts the internal divider ratios to generate a common time base. The XE1401 does not require any additional crystal or external clock sources.

The XE1401 is able to interface without any additional logic to the Skyworks CX72303 / SKY72313 radio and the Silicon Wave SiW1502 radio.

The voltage levels at the RADIO_TYPE pin should be:

RADIO_TYPE [Pin23] : Skyworks Radios = 0V / VSSDx
: Silicon Wave Radio = 1.8V or 3V depends on VDD_IO_DIG

The table below shows how to connect the XE1401 to the different the radio interfaces.

Pin Name	Pin Number	CX72303 / SKY72313 RADIO_TYPE='0V'	SiW1502 RADIO_TYPE='VDD_IO_DIG'
CLK_IN	25	SYS_CLK_OUT	BB_CLK
RF_IN[0]	35	RX_DATA	MODEM_RX/TX_DATA
RF_IN[1]	26		MODEM_RX_CLK
RF_IN[2]	34	SPI_DATA_OUT	SPI_TXD
RF_IN[3]	41	SLW_CLK_OUT	32KHZ_OUT
RF_OUT[0]	38	TX_DATA	MODEM_TX_DATA
RF_OUT[1]	37	RX_EN	HOP_STRB
RF_OUT[2]	31	SYNC_DETECT	ENABLE_RM
RF_OUT[3]	36	TX_EN	MODEM_CD/TXEN
RF_OUT[4]	39	SPI_DATA_IN	SPI_RXD
RF_OUT[5]	33	SPI_CLK_IN	SPI_CLK
RF_OUT[6]	40	SPI_EN	SPI_SS

Table 2 – Radio interface

3.5 SERIAL AUDIO PORT INTERFACE

The Audio Port can be used to interface to the Semtech ultra low power CODEC device XE3005. This device is a general-purpose audio CODEC and can be operated in different software configurable modes. The Audio Port is fixed to operate at 1.8V.

The CODEC is supposed to operate in SLAVE mode, the XE1401 PCM interface will be in MASTER mode. All clock signals (MCLK, BCLK, FSYNC) are provided by the XE1401, no external clock is required. For more detailed information about operation modes and device initialization please refer to the latest XE3005 datasheet.

The Serial Audio Interface of the XE1401 consists of 6 lines with the following functionality.

MCLK	[Pin 3]	: CODEC master clock of 2.048MHz.
BCLK	[Pin 10]	: Bit serial clock, one cycle corresponds to one data bit transmitted or received.
FSYNC	[Pin11]	: Frame synchronization signal indicating the start of a data word.
PCM_DOUT	[Pin 9]	: Serial Data In (SDI) sent to DAC.
PCM_DIN	[Pin 8]	: Serial Data Out (SDO) received from ADC.

To adjust the speaker or the microphone volume, registers are defined inside the XE1401 to control the gain of the PCM data stream. Vendor specific HCI commands are used to set the volume on the XE1401 via the HCI interface.

3.6 GENERIC SERIAL PERIPHERAL INTERFACE - SPI

The general purpose SPI of the XE1401 can be used to interface and initialize any external peripherals, for example a CODEC or configuration memory. The SPI is fixed to operate at 1.8V interface levels.

The SPI is fully transparent at the Host Controller Interface (HCI), SPI read/write command can be directly issued from the host controller, not interfering with ongoing lower layer real time Bluetooth tasks. Vendor specific HCI commands are defined to access external peripherals through the HCI.

The Serial Peripheral Interface consists of 4 lines with the following functionality when used to interface to the SEMTECH CODEC XE3005.

SCK	[Pin 6]	: The serial clock synchronizes the data bits of MOSI and MISO
MOSI	[Pin 4]	: Master out, Slave in data, synchronous with the SPI clock SCK
MISO	[Pin 7]	: Master in, Slave out data, synchronous with the SPI clock SCK
NSS	[Pin 5]	: Not Slave Select (NSS) sets the CODEC into slave configuration

3.7 INTERFACE EXAMPLE - CODEC

To build up a Bluetooth voice application in combination with SEMTECH' ultra low power CODEC XE3005, nine lines are used to connect the SPI and Audio Port.

Audio Port

MCLK	[Pin 3]	: CODEC master clock of 2.048MHz.
BCLK	[Pin 10]	: Bit serial clock, one cycle corresponds to one data bit transmitted or received.
FSYNC	[Pin11]	: Frame synchronization signal indicating the start of a data word.
PCM_DOUT	[Pin 9]	: Serial Data In (SDI) sent to DAC.
PCM_DIN	[Pin 8]	: Serial Data Out (SDO) received from ADC.

Serial Peripheral Interface

SCK	[Pin 6]	: The serial clock synchronizes the data bits of MOSI and MISO
MOSI	[Pin 4]	: Master out, Slave in data, synchronous with the SPI clock SCK
MISO	[Pin 7]	: Master in, Slave out data, synchronous with the SPI clock SCK
NSS	[Pin 5]	: Not Slave Select (NSS) sets the CODEC into slave configuration

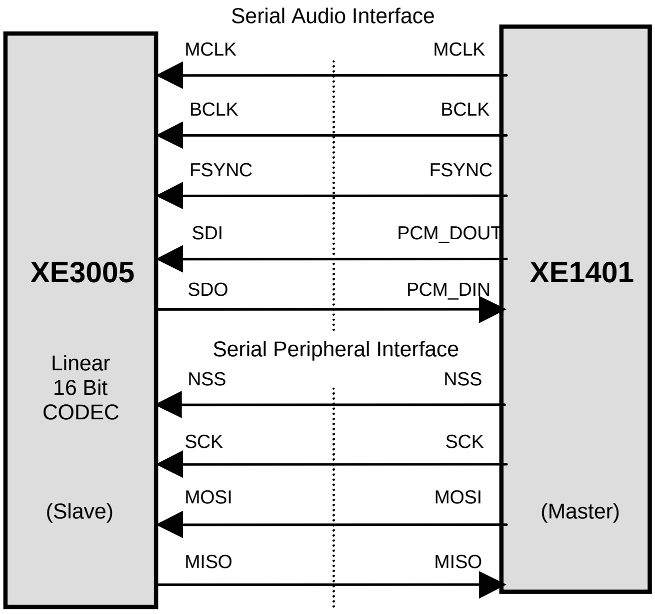


Figure 8: Interface configuration using the Semtech CODEC XE3005

3.8 UART INTERFACE

The high speed UART is a standard, 16450/16550 compatible, asynchronous serial interface providing the following interface lines:

CTS	[Pin 16]	: Terminal Control Signal
RTS	[Pin 17]	: Terminal Control Signal
UA_TX	[Pin 18]	: UART Transmit Signal
UA_RX	[Pin 19]	: UART Receive Signal

Its main characteristics are:

- All standard bit rates up to 921 kbit/s are supported (115.2 kbit/s by default after start up).
- Single interrupts source for host processor.
- 5, 6, 7 and 8bit character format.
- 1 or 2 stop bits (1.5 in case of a 5bit character format).
- Parity bit: none, even, odd, mark or space.
- 16 byte RX and TX FIFOs reducing the maximum interrupt rate down to about 1.4ms for 115.2 kbit/s per direction.
- Standard logic interface signals to commercial line driver components.

The following UART settings used after start up are:

Baudrate .... 115.2 kbit/s
Character format .... 8 bit
Stop bits 1
Parity bit .... none

The UART baudrate is configurable through internal registers using vendor specific commands. The following formulas can be used to calculate possible UART baudrates:

BD_DIV $\geq$ 1 : baudrate = 460800 / BD_DIV in bits/s
BD_DIV = 0 : baudrate = 921600 bit/s

The following table shows some baudrates examples:

Standard baudrates (bits/s)	BD_DIV
38400	0x000C
…	…
115200	0x0004
230400	0x0002
460800	0x0001
921600	0x0000

Table 3 – UART Baudrate examples

For more details, see the reference document PC16550D Universal Asynchronous Receiver/Transmitter with FIFOs, National Semiconductor, June 1995.

3.9 RESET SEQUENCE

During start-up, an internal Power-On-Reset (POR) block fixes the reset conditions. The POR also has the responsibility for resetting the digital part of the circuit when the power supply decreases below a critical value. The user can force an asynchronous external reset through the NRESET [Pin 45] (active low).

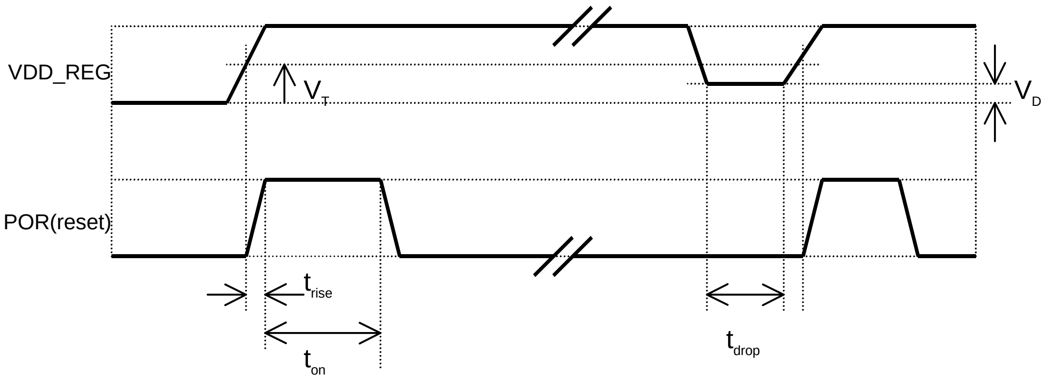


Figure 9: Reset Conditions

Symbol	Description	Min	Max	Unit
V_T	Start Voltage	0.7	1.1	V
V_D	Drop Voltage	0.7	-	V
t_{on}	Reset Time	-	300	µs
t_{rise}	Rise Time	-	1.5	µs
t_{drop}	Drop Time	10	-	µs

Table 4 – Reset parameters

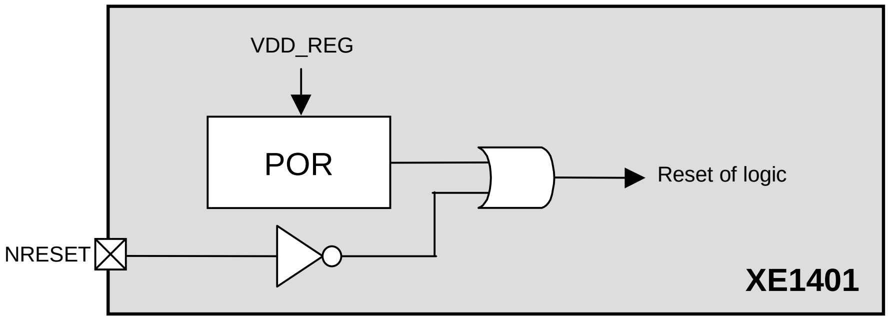


Figure 10: Reset Circuitry

3.10 BLUETOOTH SEQUENCER

The Bluetooth Sequencer includes all hardware blocks required to comply with the Bluetooth rev. 1.1 communication standard. The XE1401 is already prepared for the next generation and fully compliant with the Bluetooth rev. 1.2 standard.

This building block manages all tasks of the lower layer Bluetooth protocol up to the HCI. It ensures a “transparent” usage of the Bluetooth wireless communication via the HCI. It receives the data directly from the higher layers and then autonomously performs the various transmits, receives and protocol timing tasks without any interaction from the host controller. The host processor communicates through a standard UART with the XE1401.

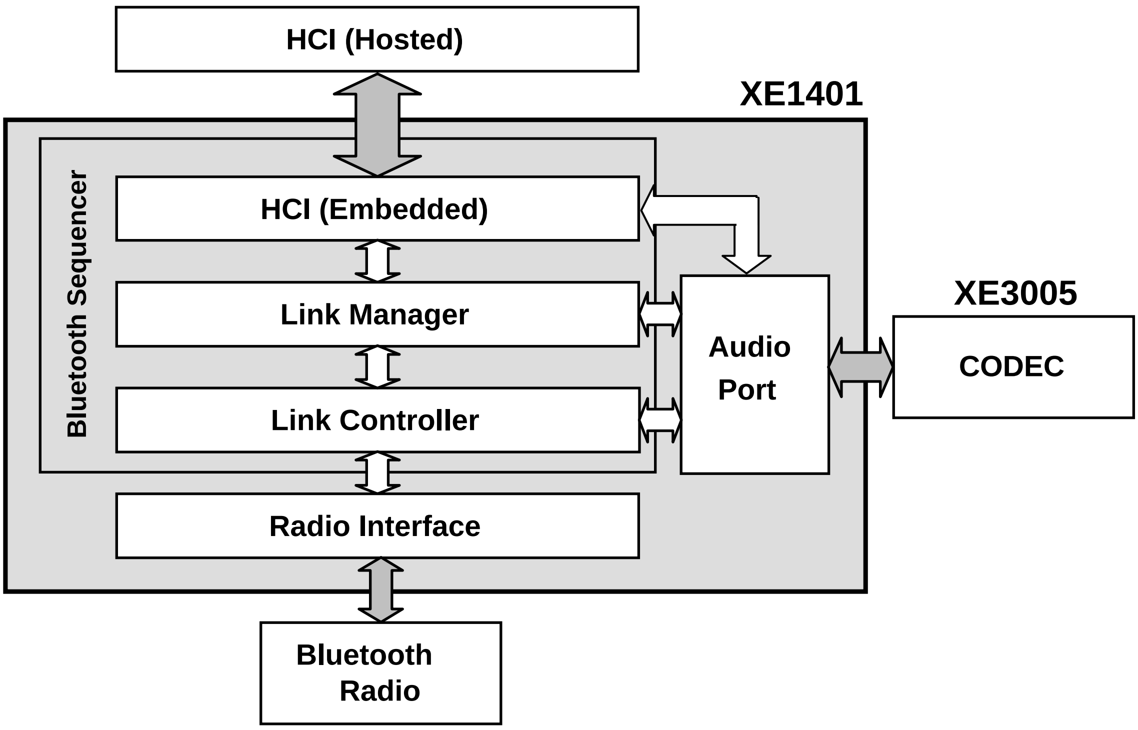


Figure 11: EasyBlue Stack Model

3.11 VENDOR SPECIFIC HCI COMMANDS – "EASYBLUE™ COMMANDS"

The user is able to communicate with the XE1401 through the EasyBlue™ commands, which have an identical format to the HCI commands [1]. Only three commands (EasyBlue_WriteReg**,** EasyBlue_ReadReg and EasyBlue_SetBdAddr) are sufficient to support all additional features of the XE1401. The commands are briefly described below.

For a more detailed description of the "EasyBlue Commands" please refer to the "XE1401SK - Demo software Users Guide" for the Semtech XE1401 Starter Kit.

3.11.1 Registers - Writing

Command	OGF	OCF	Parameters	Return parameters
EasyBlue_WriteReg	0x3F	0x02	Address, Type, Length, Data	Status

This command is used to write a value in XE1401 registers. The format of the data should be 8 bits, 16 bits or 32 bits. The *type* and *length* parameters must be set in accordance with this format. The standard HCI command "CommandCompleteEvt" returns the parameter.

3.11.2 Registers - Reading

Command	OGF	OCF	Parameters	Return parameters
EasyBlue_ReadReg	0x3F	0x01	Address, Type, Length	Status, length, data

This command is used to read a value from the XE1401 registers. The format of the data should be 8 bits, 16 bits or 32 bits. The *type* and *length* parameters must be in accordance with this format. The standard HCI command "CommandCompleteEvt" returns the parameter.

3.11.3 Setting of the Bluetooth Address

Command	OGF	OCF	Parameters	Return parameters
EasyBlue_SetBdAddr	0x3F	0x03	Reserved1, BD_ADDR, Reserved2	Status

3.12 LINK CONTROLLER FEATURES

The Link Controller supports the following features described in the table below.

Link Controller Features	Supported
SCO links	**Yes**
ACL links	**Yes**
Packet formatting	**Yes**
Control packets (ID, NULL, POLL, FHS)	**Yes**
Voice packets (HV1, HV2, HV3)	**Yes**
Mixed voice-data packets (DV)	**Yes**
Single-slot data packets (DM1, DH1, AUX1)	**Yes**
Multi-slots data packets (DM3, DH3, DM5, DH5)	**Yes**
Page and page scan (mandatory page mode)	**Yes**
Inquiry and inquiry scan	**Yes**
Broadcasting of messages	**Yes**
Sniff mode	**Yes**
Hold mode	**Yes**
Park mode	**Yes**

Link Controller Features	Supported
Single piconet point-to-point operation (master or slave)	**Yes**
Single piconet operation (master with multiple slaves)	**Yes**
Master-Slave switch	**Yes**
Scatternet operation (master of a piconet and slave of another)	**Yes**
CVSD compression (*1)	**Yes**
PCM support (linear) from CODEC (internal or external)	**Yes**
PCM support (A - or u-law) from CODEC (internal or external)	**No**
Voice channel (1 channel)	**Yes**
Bluetooth test mode (standard)	**Yes**

Table 5 – Link Controller features

(*1) CVSD is not implemented inside the Link Controller; this functionality is implemented on a separate building block directly on the XE1401.

3.13 LINK MANAGER FEATURES

The table shows the supported Link Manager (LM) features.

Link Manager Features	Supported
Encryption	**Yes**
Encryption key size	**Yes**
Clock offset request	**Yes**
Slot offset information	**Yes**
Master-slave switch	**Yes**
Hold mode	**Yes**
Sniff mode	**Yes**
Park mode	**Yes**
Power control	**Yes**

Table 6 – Link Manager features

3.14 STANDARD HOST CONTROLLER INTERFACE (HCI) COMMANDS

The table contains all messages which can sent to or received from the Link Manager of the XE1401. A detailed description of the command and of its parameters can be found in the HCI specification of the Bluetooth Specification [1].

The following Host Controller Interface Commands (HCI) are supported by the XE1401.

Command	Description
ChangeConnectionLinkKey	Command
ChangeConnectionLinkKeyCompleteEvt	Complete Event
ChangeConnectionLinkKeyStatusEvt	Status Event
ChangeLocalName	Command
ChangeLocalNameCompleteEvt	Complete Event
CreateNewUnitKey	Command
CreateNewUnitKeyCompleteEvt	Complete Event
DataBufferOverflowEvt	Event
DeleteStoredLinkKey	Command
DeleteStoredLinkKeyCompleteEvt	Complete Event
EnableDeviceUnderTestMode	Command
EnableDeviceUnderTestModeCompleteEvt	Complete Event
ExitPeriodicInquiryMode	Command
ExitPeriodicInquiryModeCompleteEvt	Complete Event
HostBufferSize	Command
HostBufferSizeCompleteEvt	Complete Event
Inquiry	Command
InquiryCancel	Command
InquiryCancelCompleteEvt	Complete Event
InquiryCompleteEvt	Complete Event
InquiryStatusEvt	Status Event

Command	Description
LinkKeyNotificationEvt	Event
LinkKeyRequestEvt	Event
LinkKeyRequestNegativeReply	Command
LinkKeyRequestNegativeReplyCompleteEvt	Complete Event
LinkKeyRequestReply	Command
LinkKeyRequestReplyCompleteEvt	Complete Event
MaxSlotsChangeEvt	Event
PeriodicInquiryMode	Command
PeriodicInquiryModeCompleteEvt	Complete Event
PINCodeRequestEvt	Event
PINCodeRequestNegativeReply	Command
PINCodeRequestNegativeReplyCompleteEvt	Complete Event
PINCodeRequestReply	Command
PINCodeRequestReplyCompleteEvt	Complete Event
ReadClassOfDevice	Command
ReadClassOfDeviceCompleteEvt	Complete Event
ReadConnectionAcceptTimeout	Command
ReadConnectionAcceptTimeoutCompleteEvt	Complete Event
ReadCountryCode	Command
ReadCountryCodeCompleteEvt	Complete Event
ReadCurrentIACLAP	Command
ReadCurrentIACLAPCompleteEvt	Complete Event
ReadHoldModeActivity	Command
ReadHoldModeActivityCompleteEvt	Complete Event
ReadInquiryScanActivity	Command
ReadInquiryScanActivityCompleteEvt	Complete Event
ReadLocalName	Command
ReadLocalNameCompleteEvt	Complete Event
ReadLocalVersionInformation	Command
ReadLocalVersionInformationCompleteEvt	Complete Event
ReadLoopbackMode	Command
ReadLoopbackModeCompleteEvt	Complete Event
ReadNumberOfSupportedIAC	Command
ReadNumberOfSupportedIACCompleteEvt	Complete Event
ReadNumBroadcastRetransmissions	Command
ReadNumBroadcastRetransmissionsCompleteEvt	Complete Event
ReadPageScanActivity	Command
ReadPageScanActivityCompleteEvt	Complete Event
ReadPageScanMode	Command
ReadPageScanModeCompleteEvt	Complete Event
ReadPageScanPeriodMode	Command
ReadPageScanPeriodModeCompleteEvt	Complete Event
ReadPageTimeout	Command
ReadPageTimeoutCompleteEvt	Complete Event
ReadPINType	Command
ReadPINTypeCompleteEvt	Complete Event
ReadRemoteVersionInformation	Command
ReadRemoteVersionInformationCompleteEvt	Complete Event
ReadRemoteVersionInformationStatusEvt	Status Event
ReadStoredLinkKey	Command
ReadStoredLinkKeyCompleteEvt	Complete Event
ReadTransmitPowerLevel	Command
ReadTransmitPowerLevelCompleteEvt	Complete Event
ReadVoiceSetting	Command
ReadVoiceSettingCompleteEvt	Complete Event
RemoteNameRequest	Command
RemoteNameRequestCompleteEvt	Complete Event
RemoteNameRequestStatusEvt	Status Event
ReturnLinkKeyEvt	Event
SetEventFilter	Command
SetEventFilterCompleteEvt	Complete Event
SetEventMask	Command
SetEventMaskCompleteEvt	Complete Event
WriteClassOfDevice	Command
WriteClassOfDeviceCompleteEvt	Complete Event
WriteConnectionAcceptTimeout	Command
WriteConnectionAcceptTimeoutCompleteEvt	Complete Event
WriteCurrentIACLAP	Command
WriteCurrentIACLAPCompleteEvt	Complete Event

Command	Description
WriteHoldModeActivity	Command
WriteHoldModeActivityCompleteEvt	Complete Event
WriteInquiryScanActivity	Command
WriteInquiryScanActivityCompleteEvt	Complete Event
WriteLoopbackMode	Command
WriteLoopbackModeCompleteEvt	Complete Event
WriteNumBroadcastRetransmissions	Command
WriteNumBroadcastRetransmissionsCompleteEvt	Complete Event
WritePageScanActivity	Command
WritePageScanActivityCompleteEvt	Complete Event
WritePageScanMode	Command
WritePageScanModeCompleteEvt	Complete Event
WritePageScanPeriodMode	Command
WritePageScanPeriodModeCompleteEvt	Complete Event
WritePageTimeout	Command
WritePageTimeoutCompleteEvt	Complete Event
WritePINType	Command
WritePINTypeCompleteEvt	Complete Event
WriteStoredLinkKey	Command
WriteStoredLinkKeyCompleteEvt	Complete Event
WriteVoiceSetting	Command
WriteVoiceSettingCompleteEvt	Complete Event

Table 7 - Host Controller Interface commands

4 ELECTRICAL SPECIFICATIONS

4.1 ABSOLUTE MAXIMUM RATINGS

Stresses above the limits listed in the following table may cause permanent failure. Exposure to absolute ratings for extended time periods may affect device reliability.

The limiting values are in accordance with the Absolute Maximum Rating System (IEC 134).
All voltages referenced to ground (VSSD1, VSSD2, VSSD3).

Symbol	Parameter	Conditions	Min	Max	Unit
VDD	Supply voltage		-0.3	3.65	V
Tstor	Storage temperature		-65	150	°C
Tamb	Operating ambient temperature		-40	85	°C
Tfunc	Operating temperature at which circuit is functional, but analogue specs are degraded		-40	125	°C
Ves	Electrostatic handling	1)		2000	V
Ilus	Static latch-up current	2)		98	mA

1) Tested according JESD22-A114-B (Standardized Human Body Model: 100 pF, 1500Ω, 3 pulses, protection related to substrate).
2) Static latch-up values are valid at room temperature (for CTS pin: Ilus = 50 mA)

Table 8 – Absolute Maximum Ratings

4.2 RECOMMENDED OPERATING RANGES

All voltages are referenced to ground (VSSD1,2,3). Typical operating conditions are at 25°C, 3V supply, 1.8V interface configuration – see also chapter Power Management Unit.

Symbol	Description	Min	Typ.	Max	Unit	Comments
VDD_PAD	Supply for regulator and level shifter	2.2		3.6	V	Supply voltage > 1.8V, Interface config.: 1.8V
		2.7		3.6	V	Supply voltage > 1.8V Interface config.: 3V / 1.8V
VDDD	Core supply voltage	1.6	1.8	2.0	V	Digital core
IVDD_PAD	Current consumption		4		mA	13MHz CLK, Supply 3V, interface config. 1.8V, no load on VDD_REG
VDD_REG	Regulator voltage output	1.7	1.8	1.9	V	
IREG	Regulator output current			50	mA	load on VDD_REG
VDD_IO	Radio interface level	1.6		3.6	V	
VDD_IO_DIG	UART interface level	1.6		3.6	V	

Table 9 – Recommended supply range

Operating ranges define the limits for functional operation and parametric characteristics of the device as described in this section. Functionality outside these limits is not implied.

4.3 TYPICAL AVERAGE POWER CONSUMPTION

The measurements are done using several configuration examples. All typical averaged values are measured at room temperature (25°C) using the CX72303 Bluetooth radio from Skyworks in a Class 2 (typ. +3.5 dBm) mode operating at 1.8V. A high frequency system clock of 13 MHz provided by the radio chip was used. The default UART speed is 115 kbit/s.

4.4 SYSTEM POWER CONSUMPTION - 13 MHZ AND 32 KHZ CRYSTAL

To conserve energy the XE1401 automatically disables the 13 MHz oscillator of the Skyworks radio whenever the various operation modes allow running on the low frequency 32 kHz clock. Both clock signals are provided by the radio and generated on two different oscillators.

4.4.1 1.8V Supply – Configuration Example

The on chip power management unit is not used; a stabilized 1.8V supply is used for the complete system.

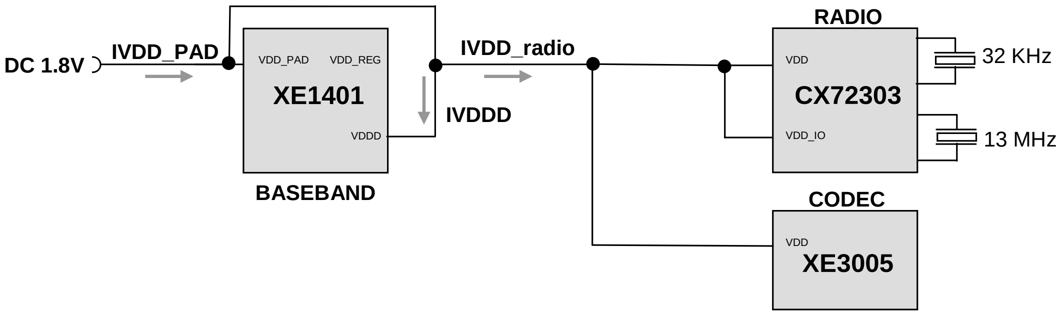


Figure 12: Block Diagram used for current measurements

Modes	Total system current [mA]	Current consumption per building block [mA]		Comments
	IVDD_PAD	IVDDD (XE1401)	IVDD_radio (XE3005+CX72303)	
Stand-by Mode, 32kHz crystal running (*1)	0.06	0.03	0.03	Wake-up by RESET
No scan and connected to UART	0.26	0.15	0.11	-
Page scan and connected to UART	0.4	0.16	0.24	1.28s interval
Inquiry & Page scan and connected to UART	0.51	0.21	0.3	1.28s interval
ACL link maintained (Master)	7.0	4.6	2.4	POLL interval 25ms
ACL link maintained (Slave)	11.6	4.6	7.0	POLL interval 25ms
ACL link maintained (Master/Slave), sniff mode enabled, no data transfer	6.1	3	3.1	20 ms wake-up time, 40 ms interval
ACL link maintained (Master/Slave), sniff mode enabled, no data transfer	1.4	0.6	0.8	20 ms wake-up time, 200 ms interval
ACL link maintained (Master/Slave), sniff mode enabled, no data transfer	0.6	0.25	0.35	20 ms wake-up time, 1.28s interval
ACL link, DM1 (Master/Slave) (*2)	14.9	4.6	10.3	115 kbit/s UART
ACL link, DH5 (Master/Slave) (*3)	21	4.6	16.4	115 kbit/s UART
ACL link, DH5 (Master/Slave) (*3)	TBD	TBD	TBD	921 kbit/s UART
SCO link, HV3 (Master/Slave), sniff mode enabled	12.5	4.6	7.9	1.28s interval
SCO link, HV3 (Slave)	15.1	4.6	10.5	-
SCO link, HV1 (Master/Slave)	22.9	4.6	18.3	-

(*1) no radio activity, 13 MHz crystal is disabled
(*2) Each slot is used for TX/RX protocol (1 TX for 1 RX)
(*3) Each slot is used for TX/RX protocol (5 TX for 5 RX)

Table 10 – Typical current consumption 1.8V supply

4.4.2 3V Supply – Configuration example: 1.8V radio, UART and CODEC

The on chip power management unit is used to generate a stabilized 1.8V supply for the radio and CODEC device out of a 3V supply.

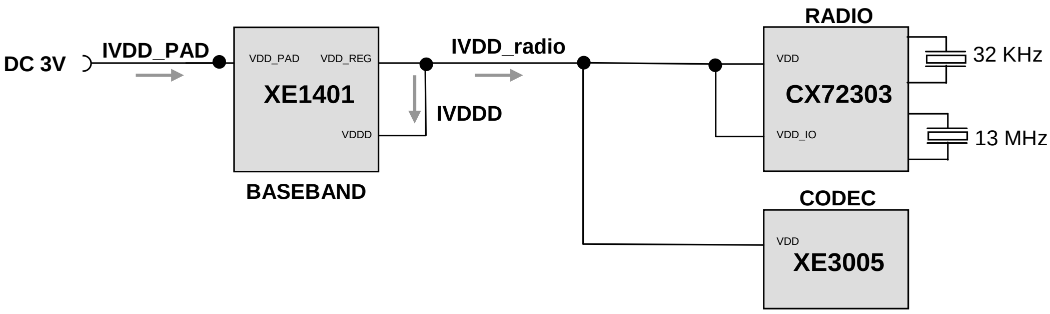


Figure 13: Block Diagram used for current measurements

Modes	Total system current [mA]	Current consumption per building block [mA]		Comments
	IVDD_PAD	IVDDD (XE1401)	IVDD_radio (XE3005+CX72303)	
Stand-by Mode, 32kHz crystal running (*1)	0.06	0.03	0.03	Wake-up by RESET
No scan and connected to UART	0.26	0.15	0.11	-
Page scan and connected to UART	0.4	0.16	0.24	1.28s interval
Inquiry & Page scan and connected to UART	0.51	0.21	0.3	1.28s interval
ACL link maintained (Master)	7.0	4.6	2.4	POLL interval 25 ms
ACL link maintained (Slave)	11.6	4.6	7.0	POLL interval 25 ms
ACL link maintained (Master/Slave), sniff mode enabled, no data transfer	6.1	3	3.1	20 ms wake-up time, 40 ms interval
ACL link maintained (Master/Slave), sniff mode enabled, no data transfer	1.4	0.6	0.8	20 ms wake-up time, 200 ms interval
ACL link maintained (Master/Slave), sniff mode enabled, no data transfer	0.6	0.25	0.35	20 ms wake-up time, 1.28s interval
ACL link, DM1 (Master/Slave) (*2)	14.9	4.6	10.3	115 kbit/s UART
ACL link, DH5 (Master/Slave) (*3)	21	4.6	16.4	115 kbit/s UART
ACL link, DH5 (Master/Slave) (*3)	TBD	TBD	TBD	921 kbit/s UART
SCO link, HV3 (Master/Slave), sniff mode enabled	12.5	4.6	7.9	1.28s interval
SCO link, HV3 (Slave)	15.1	4.6	10.5	-
SCO link, HV1 (Master/Slave)	22.9	4.6	18.3	-

(*1) no radio activity, 13 MHz crystal is disabled
(*2) Each slot is used for TX/RX protocol (1 TX for 1 RX)
(*3) Each slot is used for TX/RX protocol (5 TX for 5 RX)

Table 11 - Typical current consumption 3V supply, with 1.8V radio, UART, and CODEC

4.5 SYSTEM POWER CONSUMPTION - 13 MHZ CRYSTAL ONLY

To conserve energy the XE1401 automatically disables the 13 MHz oscillator of the Skyworks radio whenever the various operation modes allow running on the low frequency 32 kHz clock. In this configuration the Skyworks radio is deriving the 32 kHz clock from the 13 MHz oscillator by using its internal dividers. Both clock signals are provided by the radio using the 13MHz oscillator of the CX72303.

4.5.1 1.8V Supply – Configuration Example

The on chip power management unit is not used; a stabilized 1.8V supply is used for the complete system.

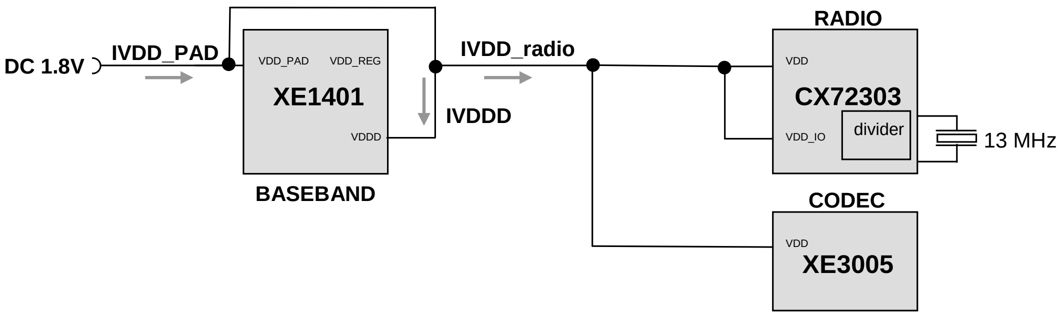


Figure 14: Block Diagram used for current measurements

Modes	Total system current [mA]	Current consumption per building block [mA]		Comments
	IVDD_PAD	IVDDD (XE1401)	IVDD_radio (XE3005+CX72303)	
Stand-by Mode, 32kHz delivered to XE1401 through 13MHz oscillator on radio.	0.28	0.03	0.25	Wake-up by RESET
No scan and connected to UART, 32kHz delivered to XE1401 through 13MHz oscillator on radio	0.53	0.15	0.38	-
Page scan and connected to UART, 32kHz delivered to XE1401 through 13MHz oscillator on radio	0.60	0.16	0.44	1.28s interval
Inquiry & Page scan and connected to UART, 32kHz delivered to XE1401 through 13MHz oscillator on radio	0.86	0.21	0.65	1.28s interval
ACL link maintained (Master)	7.0	4.6	2.4	POLL interval 25ms
ACL link maintained (Slave)	11.6	4.6	7.0	POLL interval 25ms
ACL link maintained (Master/Slave), sniff mode enabled, no data transfer	6.4	3	3.4	20 ms wake-up time, 40 ms interval
ACL link maintained (Master/Slave), sniff mode enabled, no data transfer	1.7	0.6	1.1	20 ms wake-up time, 200 ms interval
ACL link maintained (Master/Slave), sniff mode enabled, no data transfer	0.9	0.25	0.65	20 ms wake-up time, 1.28s interval
ACL link, DM1 (Master/Slave) (*1)	14.9	4.6	10.3	115 kbit/s UART
ACL link, DH5 (Master/Slave) (*2)	21	4.6	16.4	115 kbit/s UART
ACL link, DH5 (Master/Slave) (*2)	TBD	TBD	TBD	921 kbit/s UART
SCO link, HV3 (Master/Slave), sniff mode enabled	12.5	4.6	7.9	1.28s interval
SCO link, HV3 (Slave)	15.1	4.6	10.5	-
SCO link, HV1 (Master/Slave)	22.9	4.6	18.3	-

(*1) Each slot is used for TX/RX protocol (1 TX for 1 RX)
(*2) Each slot is used for TX/RX protocol (5 TX for 5 RX)

Table 12 - Typical current consumption, 13 MHz crystal configuration, 1.8V supply

4.5.2 3V Supply – Configuration Example: 1.8V radio UART and CODEC

The on chip power management unit is used to generate a stabilized 1.8V supply for the radio and CODEC device out of a 3V supply.

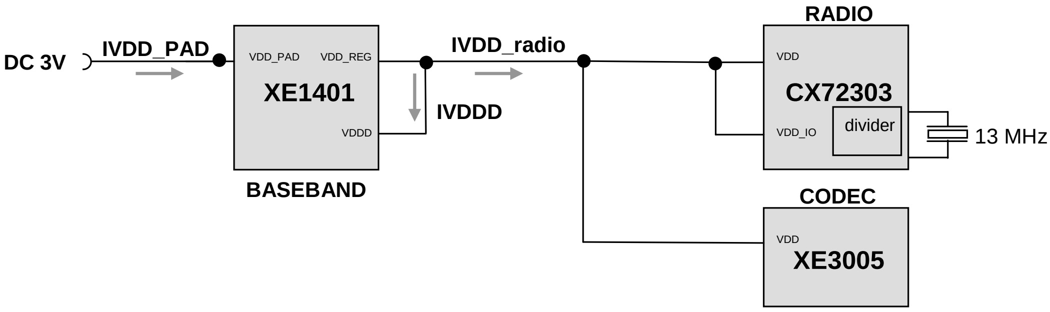


Figure 15: Block Diagram used for current measurements

Modes	Total system current [mA]	Current consumption per building block [mA]		Comments
	IVDD_PAD	IVDDD (XE1401)	IVDD_radio (XE3005+CX72303)	
Stand-by Mode, 32kHz delivered to XE1401 through 13MHz oscillator on radio.	0.28	0.03	0.25	Wake-up by RESET
No scan and connected to UART, 32kHz delivered to XE1401 through 13MHz oscillator on radio	0.53	0.15	0.38	-
Page scan and connected to UART, 32kHz delivered to XE1401 through 13MHz oscillator on radio	0.60	0.16	0.44	1.28s interval
Inquiry & Page scan and connected to UART, 32kHz delivered to XE1401 through 13MHz oscillator on radio	0.86	0.21	0.65	1.28s interval
ACL link maintained (Master)	7.0	4.6	2.4	POLL interval 25ms
ACL link maintained (Slave)	11.6	4.6	7.0	POLL interval 25ms
ACL link maintained (Master/Slave), sniff mode enabled, no data transfer	6.4	3	3.4	20 ms wake-up time, 40 ms interval
ACL link maintained (Master/Slave), sniff mode enabled, no data transfer	1.7	0.6	1.1	20 ms wake-up time, 200 ms interval
ACL link maintained (Master/Slave), sniff mode enabled, no data transfer	0.9	0.25	0.65	20 ms wake-up time, 1.28s interval
ACL link, DM1 (Master/Slave) (*1)	14.9	4.6	10.3	115 kbit/s UART
ACL link, DH5 (Master/Slave) (*2)	21	4.6	16.4	115 kbit/s UART
ACL link, DH5 (Master/Slave) (*2)	TBD	TBD	TBD	921 kbit/s UART
SCO link, HV3 (Master/Slave), sniff mode enabled	12.5	4.6	7.9	1.28s interval
SCO link, HV3 (Slave)	15.1	4.6	10.5	-
SCO link, HV1 (Master/Slave)	22.9	4.6	18.3	-

(*1) Each slot is used for TX/RX protocol (1 TX for 1 RX)
(*2) Each slot is used for TX/RX protocol (5 TX for 5 RX)

Table 13 - Typical current consumption, 13 MHz crystal only, 3V supply, with 1.8V radio, UART, and CODEC

5 APPLICATION SCHEMATICS – BLUETOOTH HEADSET

Configuration example using a single 2.2V … 3.6V supply for XE1401 and UART interface levels and 1.8V for the radio and CODEC

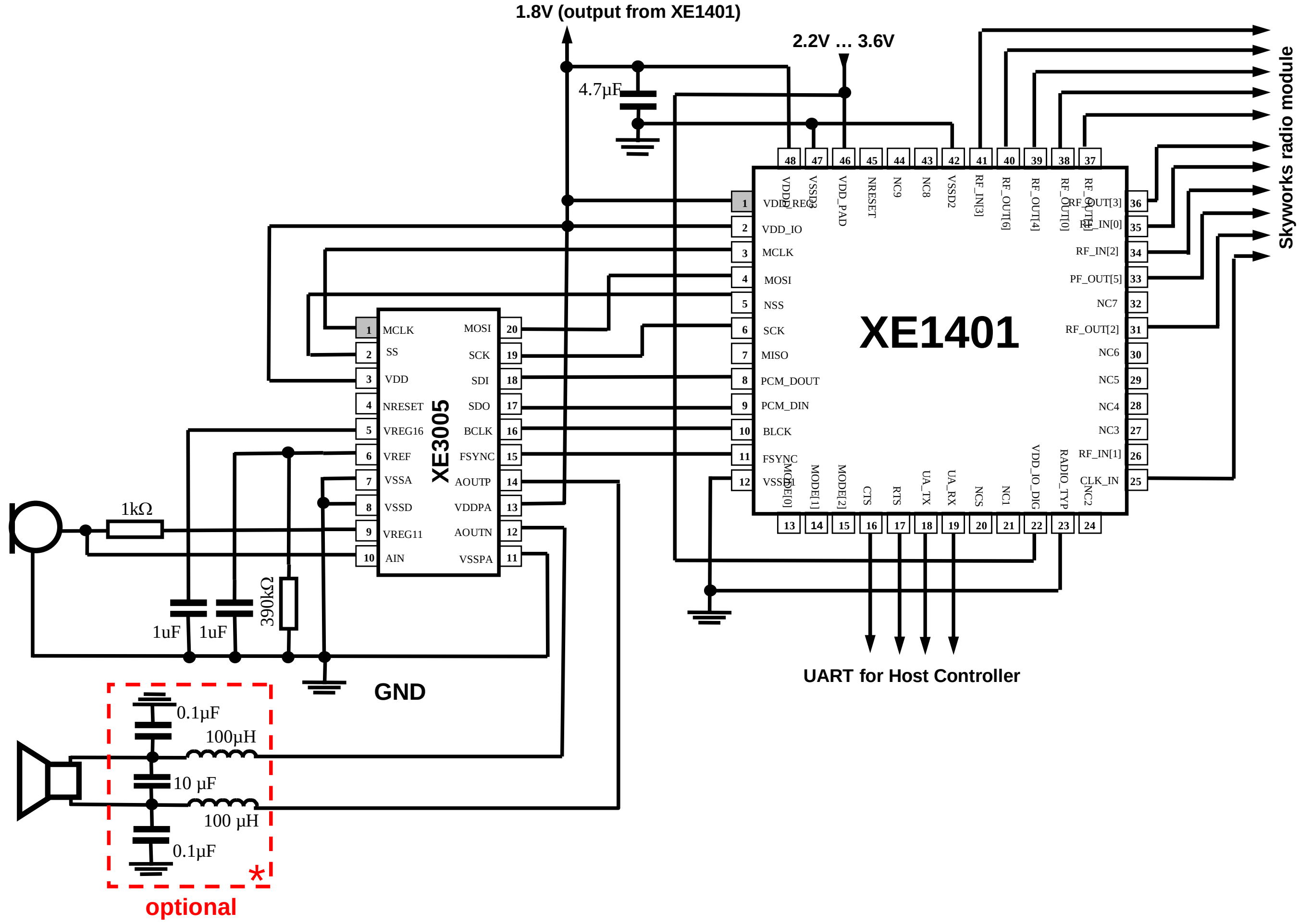


Figure 16: 3V Bluetooth Headset Application Schematic with Skyworks radio

Configuration example using a single 1.8V supply for XE1401, UART interface radio and CODEC

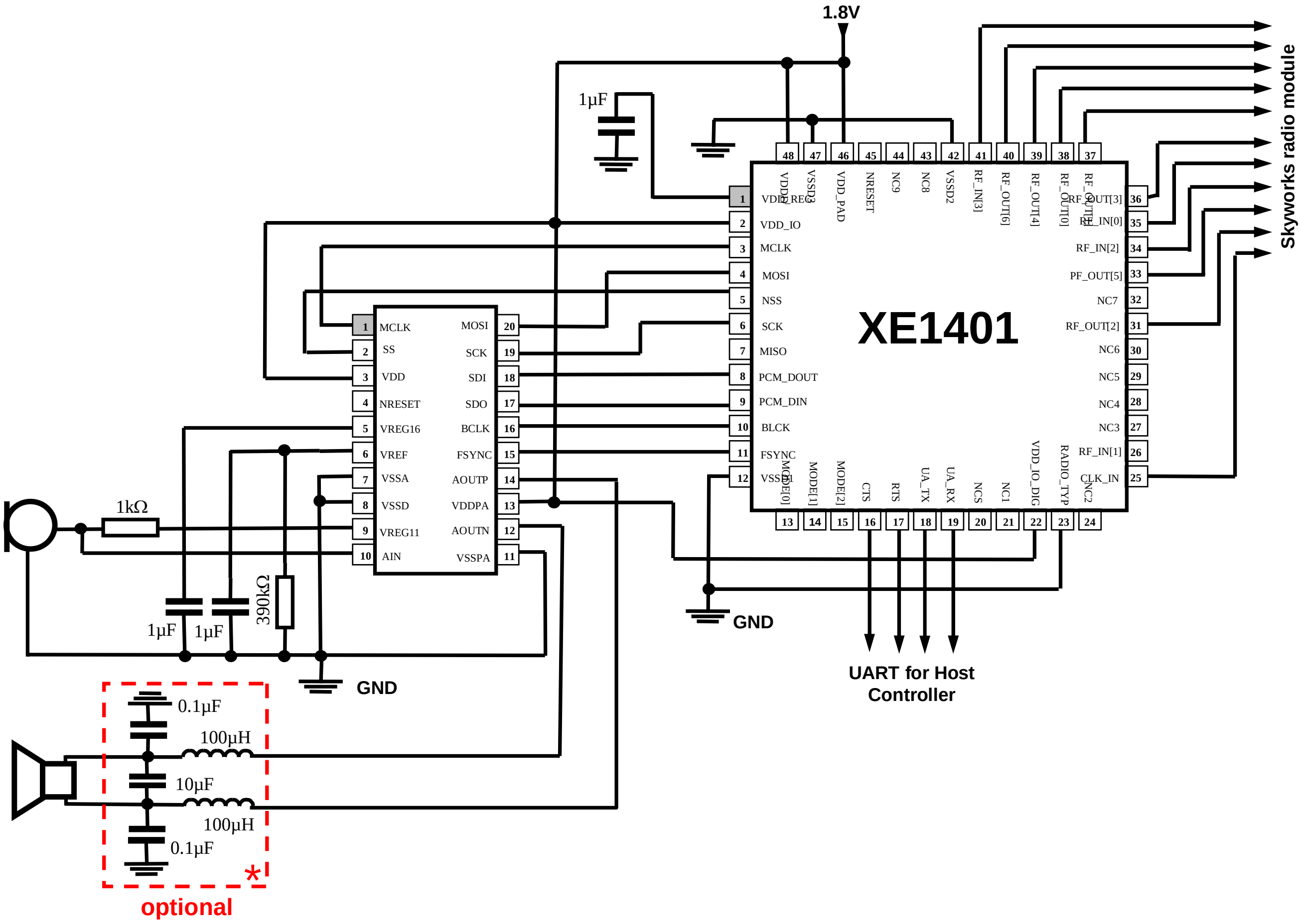
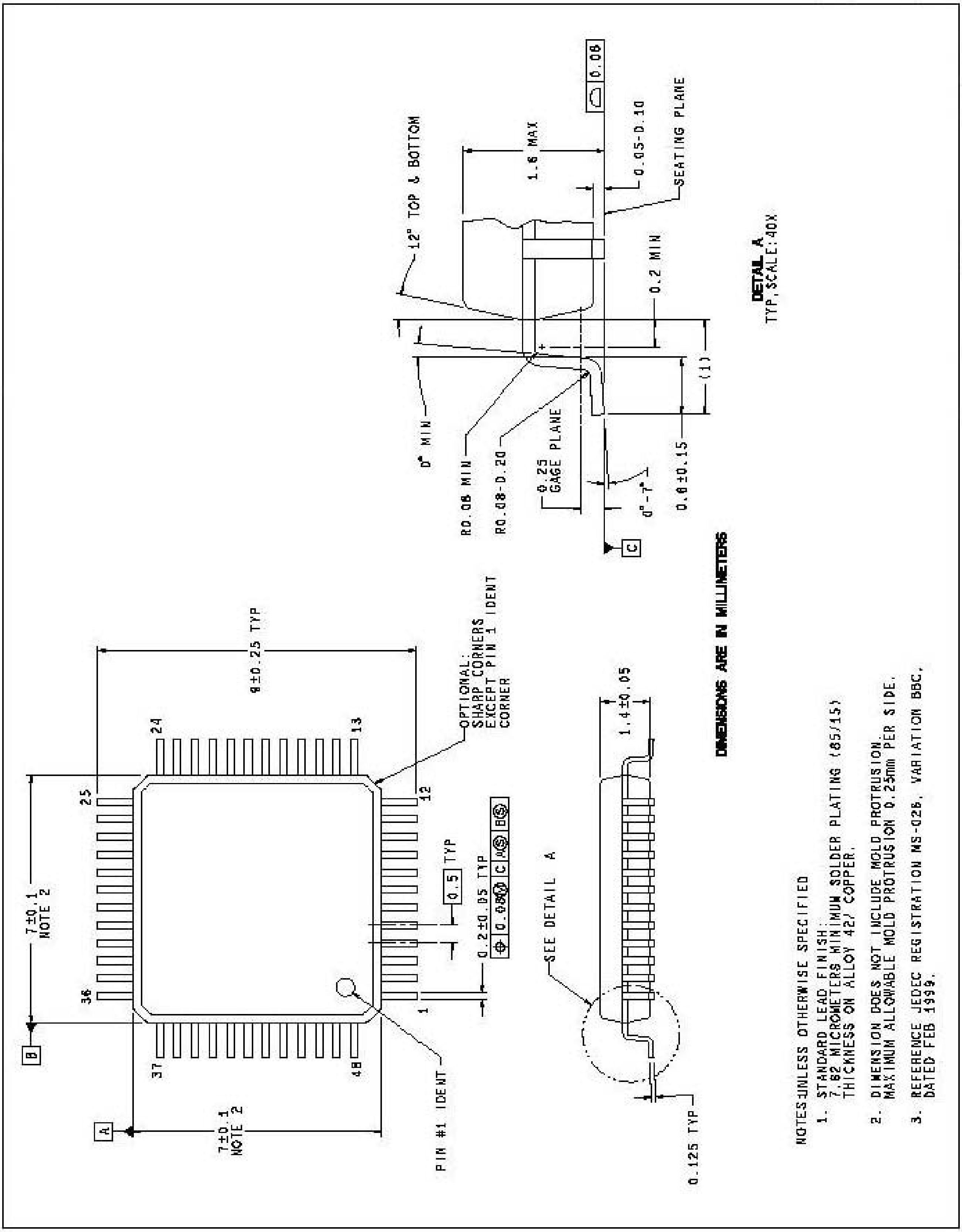


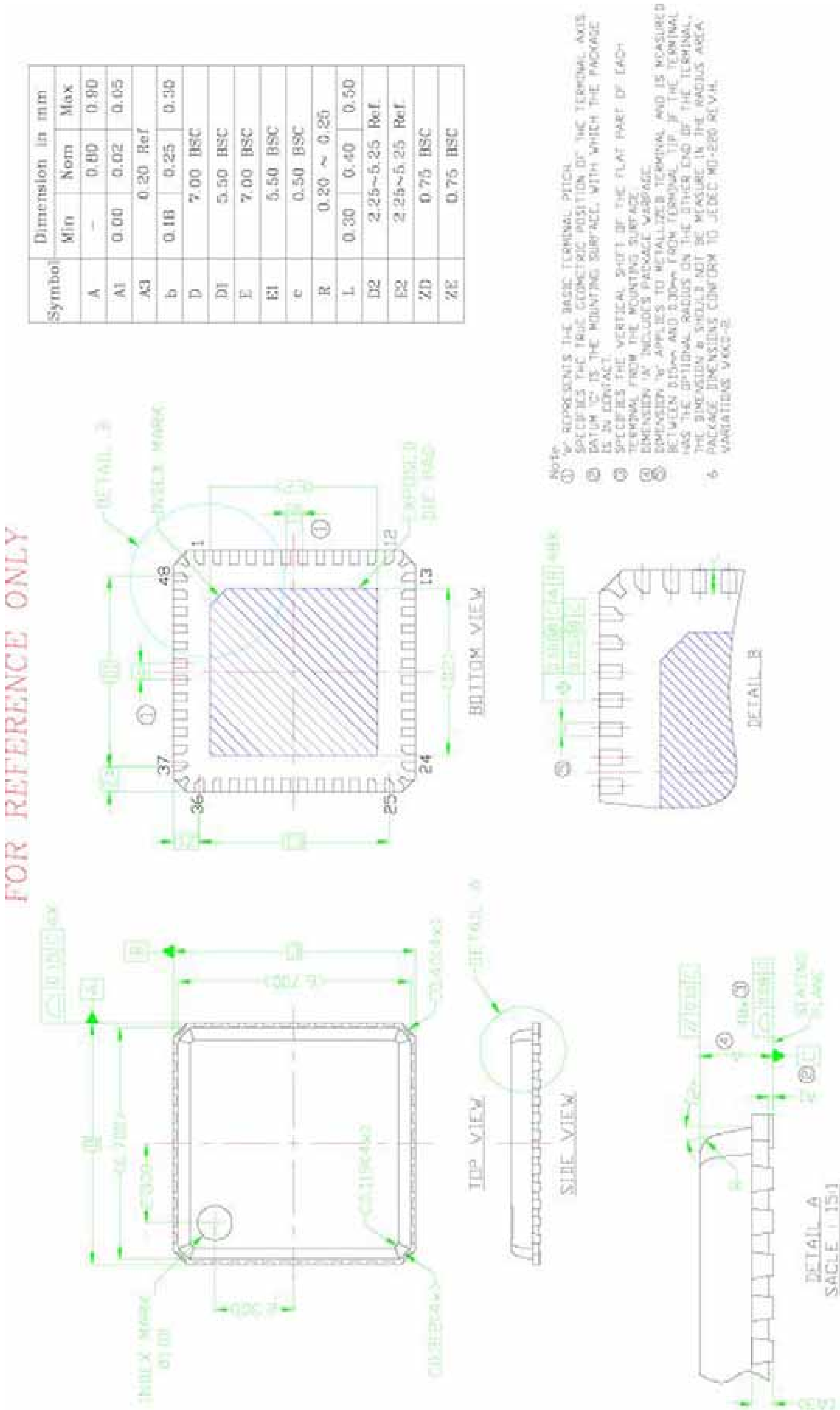
Figure 17: 1.8V Bluetooth Headset Application Schematic with Skyworks radio

6 MECHANICAL INFORMATION

6.1 48PIN LQFP PACKAGE



6.2 48PIN VQFN PACKAGE



Symbol	Dimension in mm		
	Min	Nom	Max
A	-	0.80	0.90
A1	0.00	0.02	0.05
A3	0.20 Ref		
b	0.18	0.25	0.30
D	7.00 BSC		
D1	5.50 BSC		
E	7.00 BSC		
E1	5.50 BSC		
e	0.50 BSC		
R	0.20 ~ 0.25		
L	0.30	0.40	0.50
D2	2.25~5.25 Ref.		
E2	2.25~5.25 Ref.		
ZD	0.75 BSC		
ZE	0.75 BSC		

6.3 36-PIN ULTRACSP PACKAGE

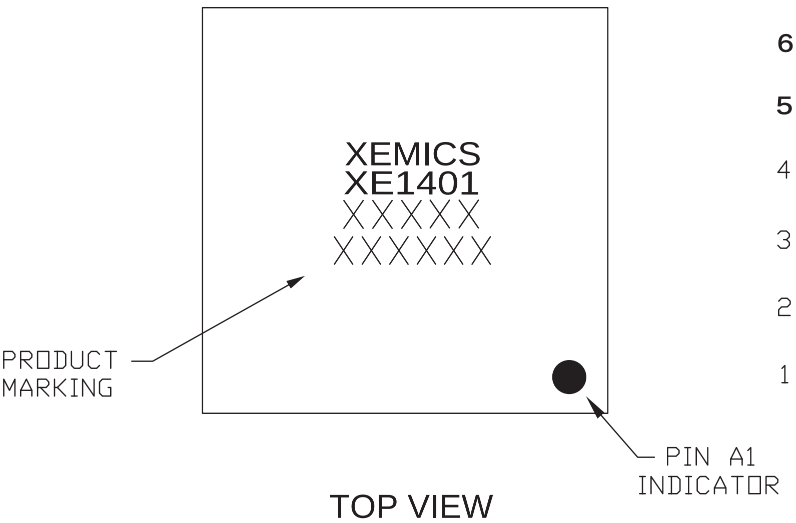
6.3.1 Pinout

Pin	Symbol	Type	Description	Comments
A1	RF_OUT[1]	DO	Generic Radio Output	(3)
A2	RF_OUT[3]	DO	Generic Radio Output	(3)
A3	RF_IN[0]	DI	Generic Radio Input	(3)
A4	RF_OUT[2]	DO	Generic Radio Output	(3)
A5	RF_IN[1]	DI	Generic Radio Input	(3)
A6	RADIO_TYPE	DO	SPI Serial Clock	(1)
B1	RF_OUT[6]	DO	Generic Radio Output	(3)
B2	RF_OUT[4]	DO	Generic Radio Output	(3)
B3	RF_OUT[0]	DO	Generic Radio Output	(3)
B4	RF_OUT[5]	DO	Generic Radio Output	(3)
B5	CLK_IN	DI PD	Radio Selection	(2)
B6	VDD_IO_DIG	AI	Digital I/O Voltage	-
C1	VSSD2	AI	Ground	-
C2	NRESET	DI PU	Master Reset (can be left open – see chapter Reset Sequence)	(2)
C3	RF_IN[3]	DI	Generic Radio Input	(3)
C4	RF_IN[2]	DI	Generic Radio Input	(3)
C5	NCS	DO	Second SPI Slave Select	(1)
C6	UA_RX	DI PD	UART Receive Signal	(2)
D1	VDD_PAD	AI	Main Supply Voltage	-
D2	VDD_REG	AO	Regulator Voltage (1.8V)	-
D3	MOSI	DO	SPI Master Out Slave In	(1)
D4	UA_TX	DO	UART Transmit Signal	(2)
D5	FSYNC	DO	CODEC Frame Clock	(1)
D6	RTS	DO	UART flow control	(2)
E1	VSSD3	AI	Ground	-
E2	VDD_IO	AI	I/O Voltage	-
E3	SCK	DO	SPI Serial Clock	(1)
E4	MISO	DI	SPI Master In Slave Out	(1)
E5	BCLK	DO	CODEC Bit Clock	(1)
E6	CTS	DI PD	UART flow control	(2)
F1	VDDD	AI	Core Supply Voltage	-
F2	MCLK	DO	CODEC Master Clock	(1)
F3	NSS	DO	First SPI Slave Select	(1)
F4	PCM_DOUT	DO	Serial Data Output	(1)
F5	PCM_DIN	DI	Serial Data Input	(1)
F6	VSSD1	AI	Ground	-

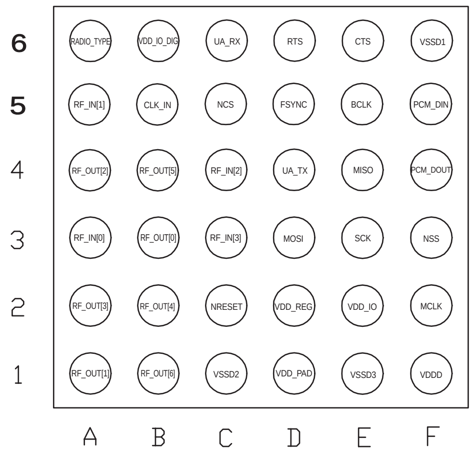
AI : Analog Input
AO: Analog Output
PU : Internal Pull Up
PD : Internal Pull Down

DI : Digital Input
DO: Digital Output
DI/O : Digital Input/Output

(1) : Digital Level 1.8V
(2) : VDD_IO_DIG voltage
(3) : VDD_IO voltage

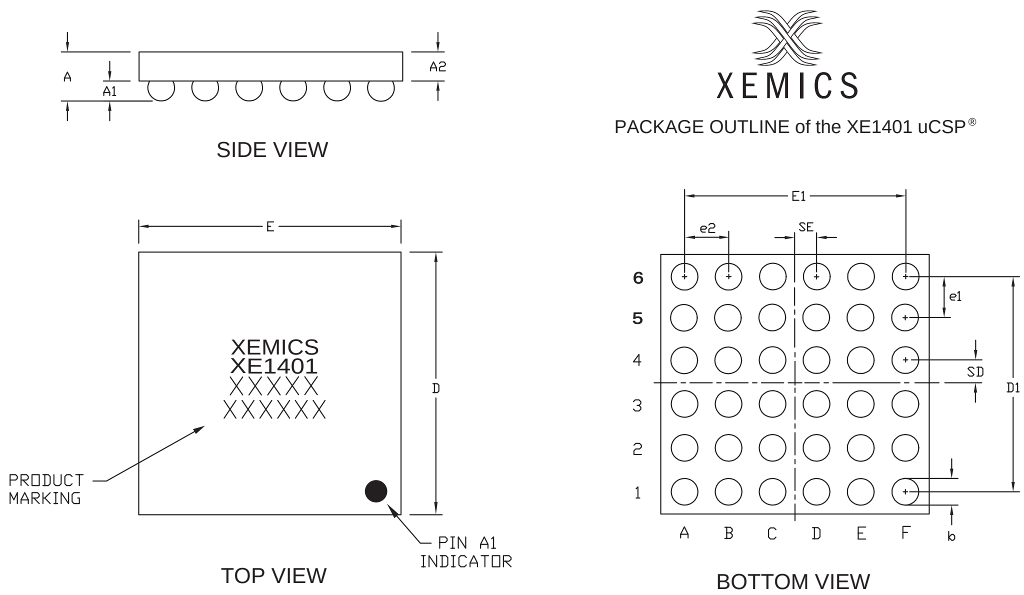


TOP VIEW



BOTTOM VIEW

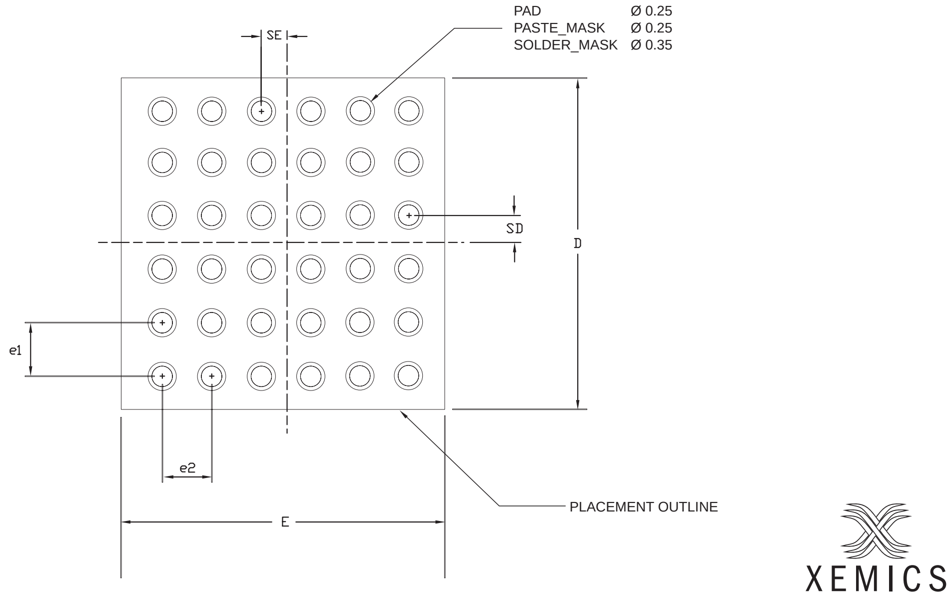
6.3.2 Package outline



Nominal dimensions in mm

	A	A1	A2	b	D	D1	E	E1	e1	e2	SD	SE
	< 0.8	0.31	0.46 max	0.30	3.62 ± 0.10	2.50	3.71 ± 0.10	2.50	0.50	0.50	0.25 ± 0.10	0.25 ± 0.10

6.3.3 Land pattern recommendation



LAND PATTERN RECOMMENDATION
for the XE1401 uCSP®

Nominal dimensions in mm

	D	E	e1	e2	SD	SE						
	3.72	3.81	0.50	0.50	0.25	0.25						

7 REFERENCE DOCUMENTS, TRADEMARKS

[1] Bluetooth System, Core, Version 1.1, Part H:1

[2] XE3005/6 Datasheet, Ultra Low Power Sandman™ CODEC, June 2003

[3] SKYWORKS, CX72303 Data Sheet, July 2002

[4] SILICONWAVE, SiW1502 Data Sheet, November 2000

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EasyBlue and Sandman are trademarks of Semtech.

Contact Information

Taiwan	Tel: 886-2-2748-3380 Fax: 886-2-2748-3390	Switzerland	Tel: 41-32-729-4000 Fax: 41-32-729-4001
Korea	Tel: 82-2-527-4377 Fax: 82-2-527-4376	United Kingdom	Tel: 44-1794-527-600 Fax: 44-1794-527-601
Shanghai	Tel: 86-21-6391-0830 Fax: 86-21-6391-0831	France	Tel: 33-(0)169-28-22-00 Fax: 33-(0)169-28-12-98
Japan	Tel: 81-3-6408-0950 Fax: 81-3-6408-0951	Germany	Tel: 49-(0)8161-140-123 Fax: 49-(0)8161-140-124

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