Chipsmall Limited consists of a professional team with an average of over 10 year of expertise in the distribution of electronic components. Based in Hongkong, we have already established firm and mutual-benefit business relationships with customers from,Europe,America and south Asia,supplying obsolete and hard-to-find components to meet their specific needs.

With the principle of “Quality Parts,Customers Priority,Honest Operation,and Considerate Service”,our business mainly focus on the distribution of electronic components. Line cards we deal with include Microchip,ALPS,ROHM,Xilinx,Pulse,ON,Everlight and Freescale. Main products comprise IC,Modules,Potentiometer,IC Socket,Relay,Connector.Our parts cover such applications as commercial,industrial, and automotives areas.

We are looking forward to setting up business relationship with you and hope to provide you with the best service and solution. Let us make a better world for our industry!

Contact us

Tel: +86-755-8981 8866 Fax: +86-755-8427 6832
Email & Skype: info@chipsmall.com Web: www.chipsmall.com
Address: A1208, Overseas Decoration Building, #122 Zhenhua RD., Futian, Shenzhen, China

nRF24AP2

nRF24AP2-1CH, nRF24AP2-8CH

Single-chip ANT™ ultra-low power wireless network solution

Product Specification v1.2

Key Features

- Second generation single chip ANT solution
- nRF24AP2-1CH supports 1 ANT (logic) channel – ideal for sensors
- nRF24AP2-8CH supports up to eight ANT (logic) channels – ideal for hubs
- World wide 2.4 GHz ISM band operation
- Fully embedded, enhanced ANT protocol stack
- True ultra-low power operation
- Typically years of battery lifetime on a coin cell
- Built-in device search and pairing
- Built-in timing and power management
- Built-in interference handling
- Configurable channel period 5.2 ms - 2 s
- Broadcast, Acknowledged and Burst communication modes
- Burst data rate up to 20 kbps
- Simple to complex network topologies: Peer-to-peer, star, tree and practical mesh
- Supports public, private and managed networks
- Support for ANT+ device profile implementations enabling multivendor interoperability
- Fully interoperable with nRF24AP1 and Dynastream ANT chipset / module based products and other nRF24AP2 variants
- Simple asynchronous/ synchronous host interface
- Single 1.9 - 3.6V power supply
- RoHS compliant 5×5 mm 32-pin QFN package
- Low cost external 16 MHz crystal
- Optional on-chip 32.768 kHz crystal oscillator

Applications

- Sports
- Wellness
- Home health monitoring
- Home/industrial automation
- Environmental sensor networks
- Active RFID
- Logistics/goods tracking
- Audience-response systems

June 2010

Liability disclaimer

Nordic Semiconductor ASA reserves the right to make changes without further notice to the product to improve reliability, function or design. Nordic Semiconductor ASA does not assume any liability arising out of the application or use of any product or circuits described herein.

All application information is advisory and does not form part of the specification.

Limiting values

Stress above one or more of the limiting values may cause permanent damage to the device. These are stress ratings only and operation of the device at these or at any other conditions above those given in the specifications are not implied. Exposure to limiting values for extended periods may affect device reliability.

Life support applications

Nordic Semiconductor's products are not designed for use in life support appliances, devices, or systems where malfunction of these products can reasonably be expected to result in personal injury. Nordic Semiconductor ASA customers using or selling these products for use in such applications do so at their own risk and agree to fully indemnify Nordic Semiconductor ASA for any damages resulting from such improper use or sale.

Datasheet status	
Objective product specification	This product specification contains target specifications for Nordic Semiconductor's product development.
Preliminary product specification	This product specification contains preliminary data; supplementary data may be published from Nordic Semiconductor ASA later.
Product specification	This product specification contains final product specifications. Nordic Semiconductor ASA reserves the right to make changes at any time without notice in order to improve design and supply the best possible product.

Contact details

For your nearest dealer, please see www.nordicsemi.com.

Main office:

Otto Nielsens veg 12
7004 Trondheim
Phone: +47 72 89 89 00
Fax: +47 72 89 89 89
www.nordicsemi.com

RoHS statement

Nordic Semiconductor's products meets the requirements of Directive 2002/95/EC of the European Parliament and of the Council on the Restriction of Hazardous Substances (RoHS). Complete hazardous substance reports as well as material composition reports for all active Nordic Semiconductor products can be found on our web site www.nordicsemi.com.

Revision History

Date	Version	Description
April 2010	1.1	Updated schematics. Added section 2.4.1 on page 12, updated sections 8.1 on page 43 and 8.2 on page 46.
June 2010	1.2	Updated sections 2.1 on page 8 and 2.4 on page 11, Table 4. on page 22, section 4.2.2 on page 16, section 8.1 on page 43, and chapter 11 on page 49.

Contents

1 Introduction

nRF24AP2 is a member of Nordic Semiconductor's low-cost, high-performance family of 2.4 GHz ISM single-chip connectivity devices with the ANT protocol stack embedded. nRF24AP2 offers the market's most efficient, single chip, transceiver solution for Ultra Low Power (ULP) networks, through the integration of the extremely power efficient ANT protocol stack, the world leading Nordic Semiconductor 2.4 GHz RF technology as well as critical low-power oscillator and timing features.

This document covers the two products:

- nRF24AP2-1CH
- nRF24AP2-8CH

1.1 Prerequisites

In order to fully understand the product specification, a good knowledge of electronics and software engineering is necessary. Please also refer to the document *ANT Message Protocol and Usage* when reading this product specification. You can download the document from Nordic's web site www.nordicsemi.com or from www.thisisant.com.

1.2 Writing conventions

This product specification follows a set of typographic rules to ensure that the document is consistent and easy to read. The following writing conventions are used:

- Commands, bit state conditions, and register names are written in `Courier New`.
- Pin names and pin signal conditions are written in **`Courier New bold`**.
- Cross references are underlined and highlighted in blue.

2 Product overview

ANT is a demonstrably superior Wireless Sensor Network (WSN) RF protocol for almost all practical ultra-low power networking applications – from simple point-to-point links to complex networks. Embedded in nRF24AP2 devices, it is paired up with Nordic Semiconductor's market leading 2.4 GHz radio technology. The combination gives you high performance, ultra-low-power network connectivity to applications, and requires minimal resources in the application's microcontroller. Less than 1 kB of code space, and an Asynchronous or Synchronous serial interface are all it takes to enable ANT connectivity in your application.

The nRF24AP2 variants meet the specific requirements of end nodes and central nodes in a network. nRF24AP2-1CH offers one logic communication channel (ANT channel) for end nodes like sensors to connect to data collectors. nRF24AP2-8CH can manage up to eight ANT channels to collect data from multiple sensors.

Figure 1. shows a network in which a network node with nRF24AP2-8CH embedded, communicates with ANT nodes with nRF24AP2-1CH devices embedded. An example might be a sports watch collecting data from several sensors (like heart rate-, speed- and distance sensors). Of course, the 8-channel node can also set up ANT channels with other central nodes (gym equipment, for instance). These central nodes are in turn connected to additional sensors.

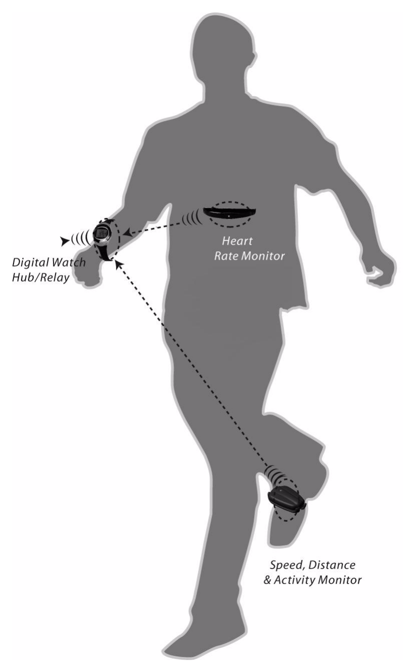

Figure 1. Simple setup with nRF24AP2

See Figure 10. on page 21 for more complex ANT-network topologies.

2.1 Features

Features of the 1-channel nRF24AP2-1CH and 8-channel nRF24AP2-8CH include:

- Ultra low power 2.4 GHz transceiver
  - World wide 2.4 GHz ISM band operation
  - Based on nRF24L01+ transceiver
  - GFSK modulation
  - 1 Mbps on-air data rate
  - 1 MHz frequency resolution
  - 78 RF channels
  - -85 dBm sensitivity
  - Up to 0 dBm output power
- ANT protocol stack
  - Full implementation of the physical, data link, network- and transport OSI layers
  - Packet-based communication – 8 byte payload per packet
  - Optimized for ultra-low power operation
- ANT channels
  - Logic communication channel between ANT nodes
  - nRF24AP2-1CH supports 1 channel – ideal for sensors
  - nRF24AP2-8CH support up to 8 channels – ideal for hubs
  - Built-in timing and power management
  - Built-in interference handling
  - Configurable channel period 5.2 ms - 2 s
  - Broadcast, acknowledged and burst communication modes
  - Burst data rate up to 20 kbps
- Device search and pairing
  - Wild-card searches
  - Proximity searches
  - Specific searches
  - Automatic link establishment if correct device is found
  - Automatic re-link attempt if link is lost
  - Configurable search timeout
- Network topologies
  - Point-to- point and star networks using independent ANT channels
  - Shared networks: Polled data collection (N:1) by using ANT shared channel option
  - Broadcast networks: Mass distribution of data (1:N)
- Network management / ANT+
  - Supports public and private (managed) networks
  - Support for ANT+ system implementations enabling multi-vendor interoperability
- ANT core stack enhancements
  - Background scanning channel
  - Continuous scanning mode
  - High density node support
  - Improved channel search
  - Channel ID management
  - Improved transmission power control on a per channel basis
  - Frequency agility
  - Proximity search
- Power Management
  - Fully controlled by ANT protocol stack
  - On-chip voltage regulator
  - Single DC supply operation
  - 1.9 to 3.6V supply range
- Ultra low power operation
  - Up to 50% lower average compared to nRF24AP1
  - Up to 40% lower peak current compared to nRF24AP1
  - 20 µA average current consumption at 1 Hz broadcast
  - 71 µA average current consumption at 4 Hz broadcast
- On-chip oscillators and clock inputs
  - 16 MHz crystal oscillator supporting low-cost crystals
  - 16 MHz clock input
  - Ultra low power 32.768 kHz crystal oscillator
  - 32.768 kHz clock input
- Host interface
  - Supports asynchronous and synchronous modes
  - 5-pins for asynchronous
  - 6-pins for synchronous

2.2 Block diagram

nRF24AP2 is composed of five main blocks as shown in Figure 2. The blocks indicate the interface, power management, the ANT protocol engine, on-chip oscillators and the RF transceiver.

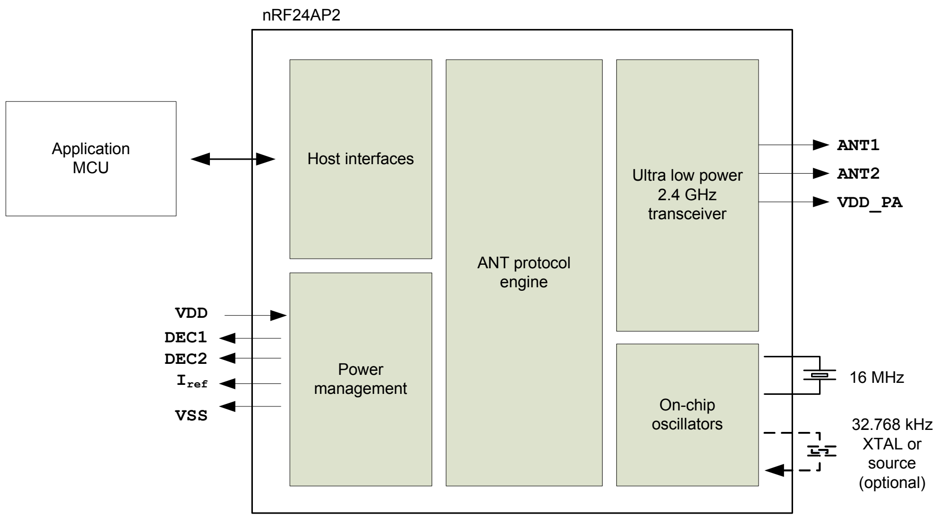

Figure 2. Block diagram of nRF24AP2 solution

To find more information about each block in the diagram, see Table 1.

Name	Reference
RF Transceiver	Chapter 3 on page 13
ANT protocol engine	Chapter 4 on page 15
Host interfaces	Chapter 5 on page 23
On-chip oscillators	Chapter 6 on page 34
Power management	Chapter 8 on page 40

Table 1. Block diagram cross references

2.3 Pin Assignments

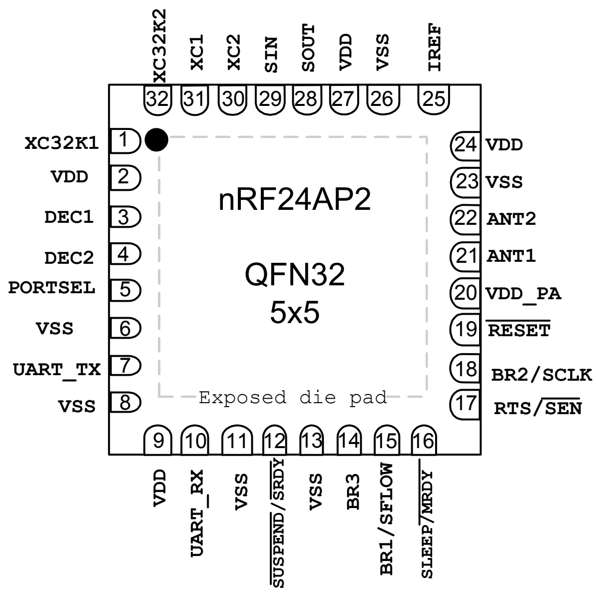

Figure 3. nRF24AP2 pin assignment (top view) for a QFN32 5×5 mm package

2.4 Pin Functions

Pin	Pin name	Pin functions	Description
1	**XC32K1**	Analog input	Crystal connection for 32.768 kHz crystal oscillator, optionally a synthesized or external 32.768 kHz clock can be used as described in chapter 6 on page 34
2	**VDD**	Power	Power Supply (1.9-3.6V DC)
3	**DEC1**	Power	Power supply outputs for de-coupling purposes (100nF)
4	**DEC2**	Power	Power supply outputs for de-coupling purposes (33nF)
5	**PORTSEL**	Digital input	Port Select Asynchronous serial interface: Tie to VSS Synchronous serial interface: Tie to VDD
6	**VSS**	Power	Ground (0V)
7	**UART_TX**	Digital IO	Asynchronous mode: Transmit data signal Synchronous mode: Tie to VSS or VDD.
8	**VSS**	Power	Ground (0V)
9	**VDD**	Power	Power Supply (1.9-3.6V DC)
10	**UART_RX**	Digital input	Asynchronous mode: Receive data signal Synchronous mode: Tie to VDD
11	**VSS**	Power	Ground (0V)
12	$\overline{\mathrm{SUSPEND}}/\overline{\mathrm{SRDY}}$	Digital input	Asynchronous mode: Suspend control Synchronous mode: Serial port ready
13	**VSS**	Power	Ground (0V)
14	**BR3**	Digital input	Asynchronous mode: Baud rate selection Synchronous mode: Tie to VSS
15	**BR1/SFLOW**	Digital input	Asynchronous mode: Suspend Control Synchronous mode: Bit or Byte flow control select (Bit: Tie to VDD, Byte: Tie to VSS)
16	$\mathrm{SLEEP}/\overline{\mathrm{MRDY}}$	Digital input	Asynchronous mode: Sleep mode enable Synchronous mode: Message ready indication
17	$\mathrm{RTS}/\overline{\mathrm{SEN}}$	Digital output	Asynchronous mode: Request to send Synchronous mode: Serial enable signal
18	**BR2 / SCLK**	Digital IO	Asynchronous mode: Baud rate selection Synchronous mode: Clock output signal
19	$\overline{\mathrm{RESET}}$	Digital input	Reset, active low. Internal pull up. Leave unconnected if not used.
20	**VDD_PA**	Power output	Power supply output (+1.8V) for on-chip RF Power amplifier
21	**ANT1**	RF	Differential antenna connection (TX and RX)
22	**ANT2**	RF	Differential antenna connection (TX and RX)
23	**VSS**	Power	Ground (0V)
24	**VDD**	Power	Power Supply (1.9-3.6V DC)
25	**IREF**	Analog output	Device reference current output. To be connected to reference resistor on PCB.
26	**VSS**	Power	Ground (0V)
27	**VDD**	Power	Power Supply (1.9-3.6V DC)
28	**SOUT**	Digital IO	Asynchronous mode: Tie to VSS or VDD. Synchronous mode: Data output
29	**SIN**	Digital input	Asynchronous mode: Tie to VDD Synchronous mode: Data input
30	**XC2**	Analog output	Crystal connection for 16 MHz crystal oscillator

Pin	Pin name	Pin functions	Description
31	**XC1**	Analog Input	Crystal connection for 16 MHz crystal oscillator
32	**XC32K2**	Analog output	Crystal connection for 32.768 kHz crystal oscillator, optionally a synthesized or external 32.768 kHz clock can be used as described in chapter 6 on page 34
Exposed die pad	**VSS**	Power	Connects the die pad to **VSS**

Table 2. nRF24AP2 pin functions

2.4.1 Reset pin

The **RESET** pin provides an optional reset when the nRF24AP2 is placed in a system that has a master reset source. This pin is not needed for normal application. Pull **RESET** pin low for minimum 0.2 µs and return to high, this will reset the nRF24AP2 to the default state. Leave unconnected if not used in the application.

3 RF Transceiver

All transceiver operations are controlled solely by the ANT protocol stack. Configuration of the ANT protocol stack occurs through a serial interface by issuing ANT commands to nRF24AP2.

3.1 Features

Features of the RF transceiver include:

- General
  - Worldwide 2.4 GHz ISM band operation
  - Common antenna interface in transmit and receive
  - GFSK modulation
  - 1 Mbps on air data rate
- Transmitter
  - Programmable output power: 0, -6, -12 or -18 dBm
- Receiver
  - Integrated channel filters
  - -85 dBm sensitivity
- RF Synthesizer
  - Fully integrated synthesizer
  - 1 MHz frequency programming resolution
  - 78 RF channels in the 2.4 GHz ISM band
  - Accepts low cost ± 50 ppm 16 MHz crystal
  - 1 MHz non-overlapping channel spacing

3.2 Block diagram

Figure 4. shows a block diagram of the RF transceiver in nRF24AP2.

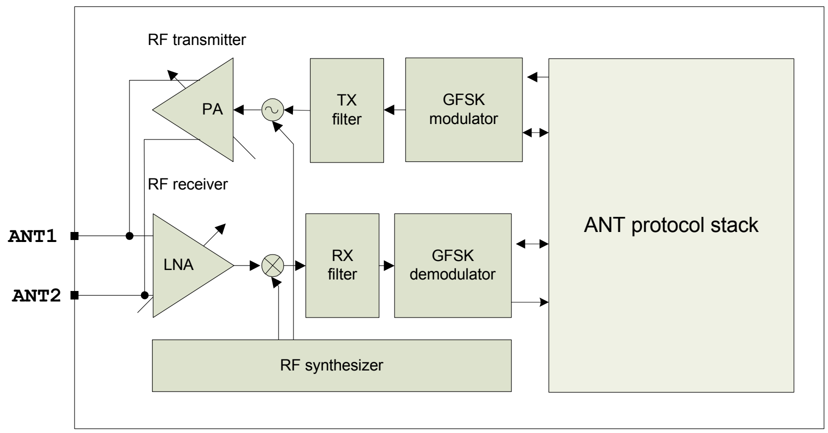

Figure 4. Internal circuitry of RF transceiver relative to ANT

4 ANT overview

The ANT protocol has been engineered for simplicity and efficiency. In operation, this results in ultra-low power consumption, maximized battery life, a minimal burden on system resources, simpler network designs and lower implementation costs.

4.1 Block diagram

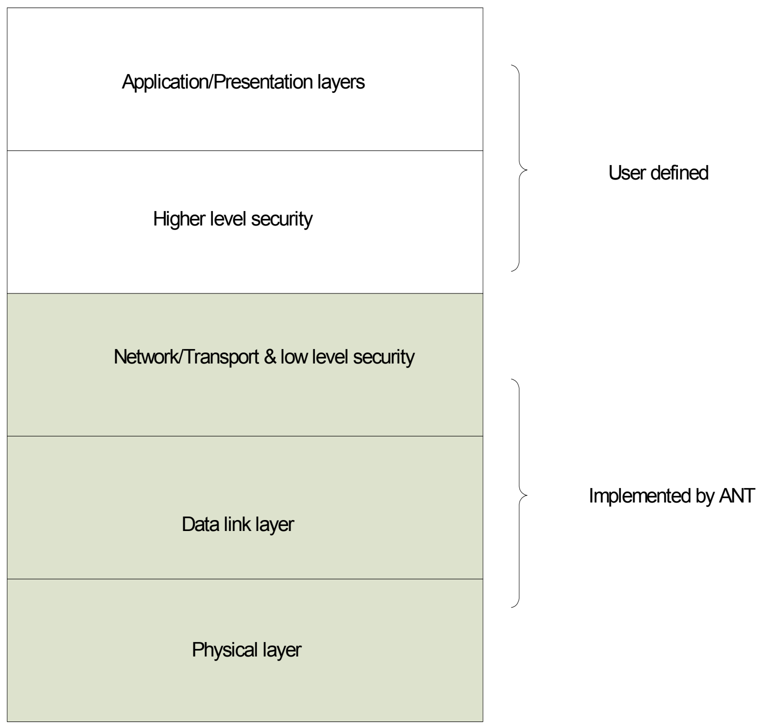

Figure 5. OSI layer model of ANT protocol stack

ANT provides carefree handling of the Physical, Data Link, Network, and Transport OSI layers. See Figure 5. In addition, it incorporates key, low-level security features that form the foundation for user-defined, sophisticated, network-security implementations. ANT ensures adequate user control while considerably easing the computational burden, by providing a simple yet effective wireless networking solution.

4.2 Functional description

A brief overview of the ANT concept is presented here for convenience. A complete description of the ANT protocol is found in the *ANT Message Protocol and Usage* document available at www.nordicsemi.com or www.thisisant.com.

4.2.1 ANT nodes

All ANT networks are built up of nodes. See the ANT node represented in Figure 6. on page 16. A node can be anything from a simple sensor to a complex, collection unit like a watch or computer. Common to all nodes is that they contain an ANT engine (nRF24AP2) handling all connectivity to other nodes and a host processor handling the application features. nRF24AP2 interfaces to the host processor through a serial interface, and all configuration and control are performed using a simple command library.

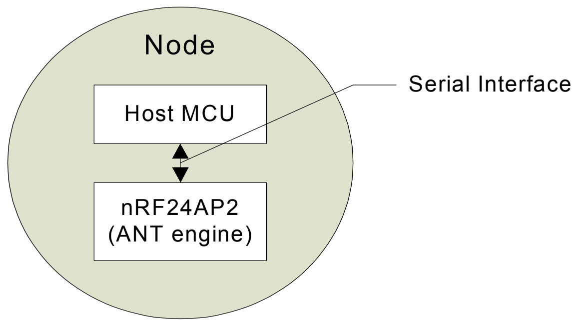

Figure 6. The ANT node

4.2.2 ANT channels

nRF24AP2 can establish one or up to eight logic channels, called ANT channels, to other ANT nodes. The number of ANT channels available depends on the nRF24AP2 variant being used.

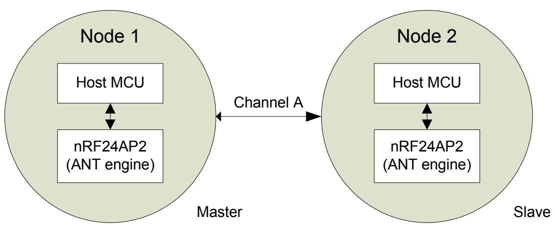

Figure 7. ANT nodes and the channel between them

The simplest ANT channel is called an independent channel and consists of two nodes, one acting as master, the other as slave for this channel. For each ANT channel opened, nRF24AP2 will set up and manage a synchronous wireless link, exchanging data packets with other ANT nodes at preset time intervals called channel periods. See Figure 8. on page 17. The master controls the timing of a channel, that is to say, it will always initiate communication between the nodes. The slave locks on to the timing set by the master, receives the transmissions from the master and can then (if configured so) send acknowledge and/or data (if any) back to the master.

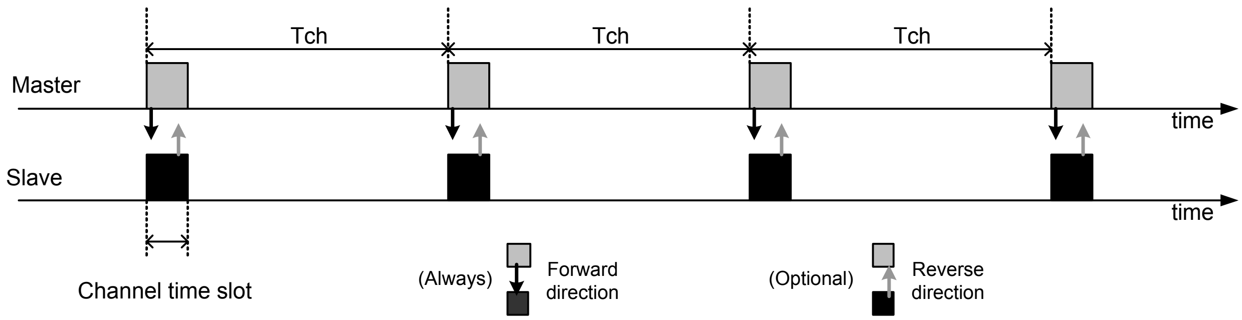

Figure 8. Channel communication showing forward and reverse directions. Not to scale

At each time slot an ANT channel can transfer user data (8 bytes) both ways as simple broadcasts, broadcast with acknowledgement from the receiver, or transfer data as bursts (this will extend the time slot used) to accommodate transfer of larger blocks of user data. The total available payload bandwidth in an ANT node is shared between active ANT channels through a Time Division Multiple Access (TDMA) scheme. If a channel time slot comes up, but there is no new data from the master. The master will still send the last packet to keep the timing of the channel and enable the slave to send data back if needed.

Each ANT channel available in the nRF24AP2 can for example be configured as a simple, uni-directional (broadcast) or bi-directional independent channel; or as a more complex, shared channel where a master interfaces to multiple slaves (1:N topologies). Please see the *ANT Message Protocol and Usage* document for further details on shared ANT channels.

4.2.3 ANT channel configuration

Unique to ANT is that the setup of each ANT channel is independent from all the other ANT channels in the network, including other channels in the same node. This means that one ANT node can act as master on one ANT channel while being a slave to another. Since there is no overall 'network master' present in ANT networks, ANT allows you to configure and run each ANT channel solely based on the needs of the nodes on that channel. Search- and pairing algorithms in ANT let you easily set up and shut down ANT channels in an ad-hoc fashion. This gives you ultimate flexibility in adjusting ANT channel parameters like data rate and latency versus power consumption. Moreover, you only make the network as complex as it needs to be at any given time. In order for two ANT nodes to set up an ANT channel, they must share a common channel configuration and channel ID. The necessary configuration parameters are summarized in Table 3. on page 18.

Parameter	Comment
Channel configuration	
Channel period	Time interval between data exchanges on this channel (5.2 ms - 2 s)
RF frequencies	Which of the 78 available RF frequencies is used by this channel
Channel type	Bi-directional slave, bi-directional master, shared bi-directional slave, Slave Receive only
Network type	Decides if this ANT channel is going to be generally accessible (public) to all ANT nodes, or if it shall limit its connectivity to devices belonging to a managed or private network
Channel ID	
Transmission type	1 byte – Identifying characteristics of the transmission, can for instance contain codes on how payload is to be interpreted
Device type	1 byte - ID to identify the device type of the channel master (Ex: heart rate belt, temperature sensor etc.)
Device number	2 byte - Unique ID for this channel

Table 3. ANT channel ID

The channel configuration parameters are static, system parameters that must match in the master and slave, and the channel ID is included in all transmissions identifying the two nodes for each other. For in-depth details on each parameter please refer to *ANT Message Protocol and Usage*.

Network

In addition to setting the content of the channel ID, which is the primary ID of an ANT node, ANT nodes can limit their connectivity to a selection of other ANT nodes by defining a network for each ANT channel. The limited access to certain networks is managed through unique network keys

The defined ANT networks are:

1. **Public networks:** These are open ANT networks with no limitation on connectivity. All ANT nodes sharing the same channel configuration (by design or by accident) will be able to connect. This is the default setting in nRF24AP2.
2. **Managed networks:** These are ANT networks managed by special interest groups or alliances. An example is the ANT+ alliance for sport and wellness products. To join the ANT+ alliance, visit www.thisisant.com. By joining the ANT+ alliance and complying with the ANT+ device profiles set by the alliance, you achieve two goals:
   - Limited connectivity: Only other ANT+ compliant devices can connect to this channel.
   - Interoperability: Your node can connect to ANT+ compliant products from other vendors.
3. **Private networks:** Your own protected networks, and no other devices, will be able to connect to your ANT nodes unless you share the network key with someone outside the network. Please note that this requires purchase of a unique network key from ANT, see www.thisisant.com.

Since the network parameter can be chosen independently for each ANT channel, one ANT node (1 nRF24AP2-8CH) can have up to eight ANT channels, operating on different networks at the same time.

> **Note:** The network parameter has no impact on the network topologies you can build. It is merely a tool to protect your ANT network and prevent accidental or deliberate access from other ANT nodes.

Channel ID, search and pairing

The primary parameters which two ANT nodes use to identify each other make up the **channel ID**. Once an ANT channel is established, the **channel ID parameters** must of course match; but they don't have to be known by both nodes (pre-configured) to be able to establish an ANT channel.

When an nRF24AP2 configured as a master (set in channel type) opens an ANT channel, it will broadcast its entire **channel ID**. Hence you must configure all three **channel ID parameters** before opening an ANT channel as a master.

On the other hand, in a slave you can configure nRF24AP2 to search for and connect with both known and unknown masters. To connect with a known master you must configure the **Transmission type**, **Device type** and **Device number** in nRF24AP2 before opening the ANT channel.

You can also configure the nRF24AP2 to conduct wild-card searches on one or more of the three parameters in the **channel ID** to enable it to pair up with unknown masters. You can for instance set only the **Device type** of the masters you want to link up with, and set wild cards on the **Transmission type** and **Device number**. If a new master with a matching **Device type** is found, the slave device will connect and store the unknown parts of the **channel ID**. The new parts of the **channel ID** can then be stored in the host MCU to enable specific searches for this master later.

4.2.4 Proximity search

When using the basic search and pairing algorithm a slave will automatically identify and connect to the first master it finds matching the search criteria. In areas where you either have a high density of similar master nodes or high density of independent ANT networks, there is always the chance that multiple masters are found within the coverage area. This presents the risk that it is not the master you wanted to connect to that is found first. The proximity search feature in ANT designates 'bins' of proximity from 1 (closest) to 10 (furthest) as shown in Figure 9.

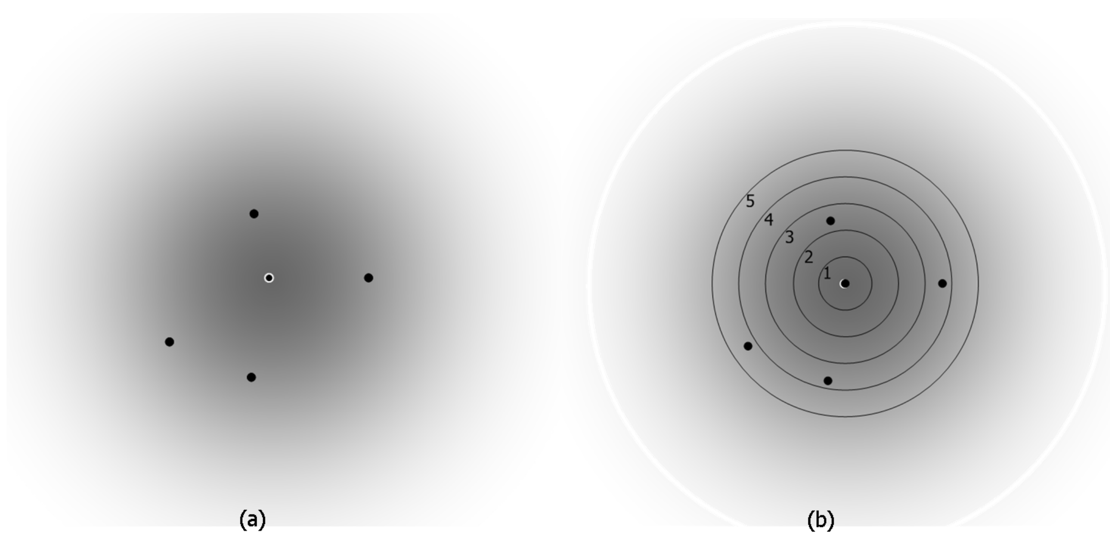

Figure 9. Standard search (a), Proximity search (b), showing bins 1-5 (of maximum 10)

This 'binning' enables you to further control your search by for instance only accepting the master that is closest (only accept masters that fall in bin 1-2). This makes it easy for a user to pair up network nodes and prevent accidental connection to nodes possibly belonging to another network close by.

4.2.5 Continuous scanning mode

Continuous scanning mode allows for fully asynchronous communication between an ANT node using continuous scanning mode, and any other ANT node using a standard master channel. This has two main advantages over only using standard ANT channels. The first is that the latency to initiate communication with the scanning node is reduced to zero and every message sent by a master channel in proximity will be received by the scanning device. Secondly, the requirement to maintain communication for the purpose of synchronization while in proximity is removed. This means that it is possible for nodes to come and go very quickly or to turn off for long periods of time in between communication events. This saves power on the transmitting node.

The disadvantage of continuous scanning mode is that it consumes much more power than standard ANT channels and will therefore only typically be used on devices that are plugged in and not mobile such as a computer (USB dongle). Another disadvantage is that a node in scanning mode can no longer be configured to have discoverable master channels because scanning mode disables standard ANT channel functionality. It is worth noting that two ANT nodes in scanning mode cannot communicate with one another because neither will be able to spontaneously generate communication.

Standard ANT channels are recommended over scanning channels, even in dynamic systems where devices are coming and going. This is because scanning channels are not recommended for mobile networks which is the primary area of application for ANT. Scanning channels will typically be used in statically located networks where the scanning channel node is plugged in and not mobile.

4.2.6 ANT network topologies

By combining ANT channels with different features depending on local needs, you can build anything from very simple peer-to-peer links and star networks to complex networks as shown in Figure 10. on page 21.

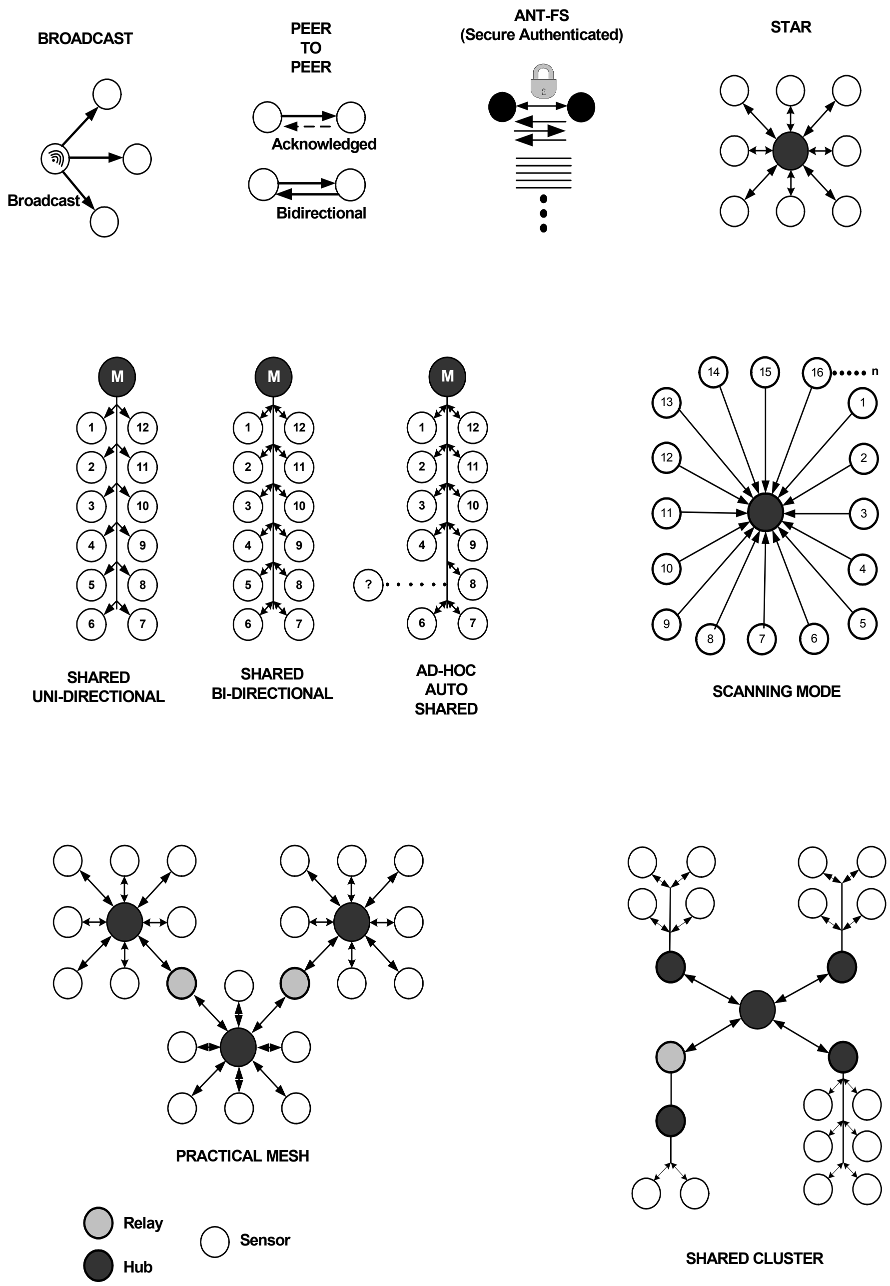

Figure 10. Network topology examples supported by ANT

4.2.7 ANT message protocol

All the configuration and control of the various ANT node and channel parameters in nRF24AP2 are handled by the host microcontroller over a simple serial interface by using the command library. See the document *ANT Message Protocol and Usage* for further details on the command library.

Class	Type	Commands in ANT command library	Reply	From
Config. messages	Unassign Channel	ANT_UnassignChannel()	Yes	Host
	Assign Channel	ANT_AssignChannel()	Yes	Host
	Channel ID	ANT_SetChannelId()	Yes	Host
	Channel Period	ANT_SetChannelPeriod()	Yes	Host
	Search Timeout	ANT_SetChannelSearchTimeout()	Yes	Host
	Channel RF Frequency	ANT_SetChannelRFFreq()	Yes	Host
	Set Network	ANT_SetNetworkKey()	Yes	Host
	Transmit Power	ANT_SetTransmitPower()	Yes	Host
	ID List Add	ANT_AddChannelID()[a]	Yes	Host
	ID List Config	ANT_ConfigList()[a]	Yes	Host
	Channel Transmit Power	ANT_SetChannelTxPower()	Yes	Host
	Low Priority Search Timeout	ANT_SetLowPriorityChannelSearchTimeout()	Yes	Host
	Enable Ext RX Mesgs	ANT_RxExtMesgsEnable()	Yes	Host
	Crystal Enable	ANT_CrystalEnable()	Yes	Host
	Frequency Agility	ANT_ConfigFrequencyAgility()	Yes	Host
	Proximity Search	ANT_SetProximitySearch()	Yes	Host
Notifications	Startup Message	→ ResponseFunc(-, 0x6F)	-	ANT
Control Messages	SystemReset	ANT_ResetSystem()	No	Host
	Open Channel	ANT_OpenChannel()	Yes	Host
	Close Channel	ANT_CloseChannel()	Yes	Host
	Open Rx Scan Mode	ANT_OpenRxScanMode()[a]	Yes	Host
	Request Message	ANT_RequestMessage()	Yes	Host
	Sleep Message	ANT_SleepMessage()	No	Host
Data Messages	Broadcast Data	ANT_SendBroadcastData() → ChannelEventFunc(Chan,EV)	No	Host/ANT
	Acknowledge Data	ANT_SendAcknowledgedData() → ChannelEventFunc(Chan, EV)	No	Host/ANT
	Burst Transfer Data	ANT_SendBurstTransferPacket() → ChannelEventFunc(Chan, EV)	No	Host/ANT
Channel Event Messages	Channel Response/ Event	→ ChannelEventFunc(Chan, MessageCode) or → ResponseFunc(Chan, MsgID)	-	ANT
Requested Response Messages	Channel Status	→ ResponseFunc(Chan, 0x52)	-	ANT
	Channel ID	→ ResponseFunc(Chan, 0x51)	-	ANT
	ANT Version	→ ResponseFunc(Chan, 0x51)	-	ANT
	Capabilities	→ ResponseFunc(-, 0x3E)	-	ANT
Test Mode	CW Init	ANT InitCWTestMode()	Yes	Host
	CW Test	ANT SetCWTestMode()	Yes	Host
Ext Data messages	Extended Broadcast Data	ANT SendExtBroadcastData()[b] → ChannelEventFunc(Chan, EV)	No	Host
	Extended Ack. Data	ANT SendExtAcknowledgedData()[b] → ChannelEventFunc(Chan, EV)	No	Host
	Extended Burst Data	ANT SendExtBurstTransferPacket()[b] → ChannelEventFunc(Chan, EV)	No	Host

a. This is only supported by the nRF24AP2-8CH.
b. nRF24AP2 does not send these ChannelEventFunctions() to the host. nRF24AP2 will send extended messages by appending the additional bytes to standard broadcast, acknowledged and burst data.

Table 4. ANT message summary supported by nRF24AP2

5 Host interface

The host microcontroller can configure and control all of the nRF24AP2 features through a simple serial interface. Three interface options are available, enabling both high and low end microcontrollers to be used.

5.1 Features

Serial interfaces supported by nRF24AP2:

- Asynchronous (UART)
  - Interface requires 5 pins to host microcontroller
  - Configurable baud rate from 4800 to 57600 baud
- Synchronous
  - Bit or byte flow
  - Interface requires 6 pins to host microcontroller

5.2 Asynchronous serial interface

The host MCU and nRF24AP2 may communicate using the asynchronous mode of the serial interface. Asynchronous mode is selected by the PORTSEL input being tied low.

5.2.1 Block diagram

The asynchronous serial interface between nRF24AP2 and the host MCU is shown in Figure 11.

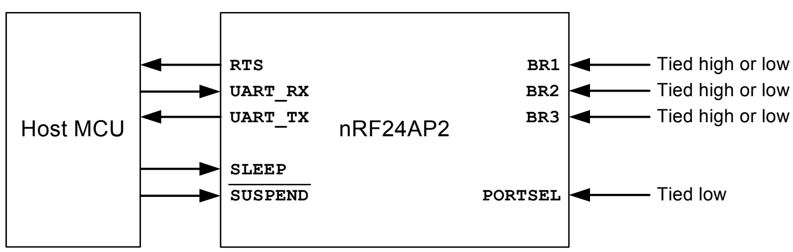

Figure 11. Asynchronous mode connections

The **UART** communication is for one start bit, one stop bit, 8 bits of data and no parity. Data is sent and received LSBit first.

5.2.2 Baud rate

The baud rate of the asynchronous communication between the host and ANT is controlled by the speed select signals **BR1**, **BR2** and **BR3**. Table 5. shows the relationship between the states of the speed select signals and the corresponding baud rates.

BR3	BR2	BR1	Baud rate
0	0	0	4800
0	1	0	19200
0	0	1	38400
0	1	1	50000
1	0	0	1200
1	1	0	2400
1	0	1	9600
1	1	1	57600

Table 5. Relationship between states of speed-select signals and corresponding baud rates

Note: The baud rate may have a significant impact on system current consumption. Refer to section 8.2 on page 46 for application-specific current consumption figures.

5.2.3 Asynchronous Port Control (RTS)

When nRF24AP2 is configured in asynchronous mode, a full duplex asynchronous serial port is provided with flow control for data transmission from the host to ANT. The flow control is performed by the **RTS** signal, which conforms to standard hardware flow control CMOS signal levels. The signal may therefore be attached to a computer serial port (with use of an RS-232 level shifter), or to any other RS-232 device. The RTS signal is de-asserted for approximately 50 µs after each correctly formatted message has been received. This **RTS** signal duration is independent of the baud rate. Incorrect messages or partial messages are not acknowledged.

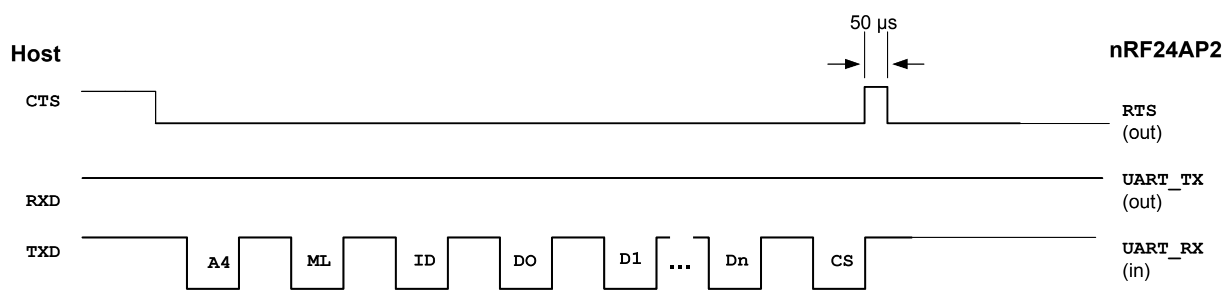

Figure 12. RTS signal following a serial host -> nRF24AP2 transfer

When nRF24AP2 raises the **RTS** signal high, the host MCU may not send any more data until the **RTS** signal is lowered again. There is no flow control for data being transmitted from nRF24AP2 to the host controller, and therefore the host controller must be able to receive data at any time. **RTS** is toggled following a reset.

The **RTS** signal is raised by nRF24AP2 after the last byte of a message has been received, and nRF24AP2 will therefore lose any bytes that were sent, or in the process of being sent, before the **RTS** signal is acted upon by the host MCU, and the transmission is halted. To avoid this problem, either the messages need to be spaced apart by the host MCU or 0-pad bytes need to be added to the end of each message being transmitted to handle whatever byte pipeline is in place. For example, when considering computer communication, two 0-bytes must be appended to every message, since computers interpret CTS at the driver- rather than the hardware level.

nRF24AP2 will discard 0-pad bytes received. This issue usually occurs only when using burst transfers from the host to nRF24AP2 and high data rates are expected.

5.2.4 Sleep enable (`SLEEP`)

The **`SLEEP`** input signal allows nRF24AP2 to sleep when the serial port is not required. The signal is essential for conserving power when using the asynchrnous serial interface. This control mechanism is illustrated in Figure 13.

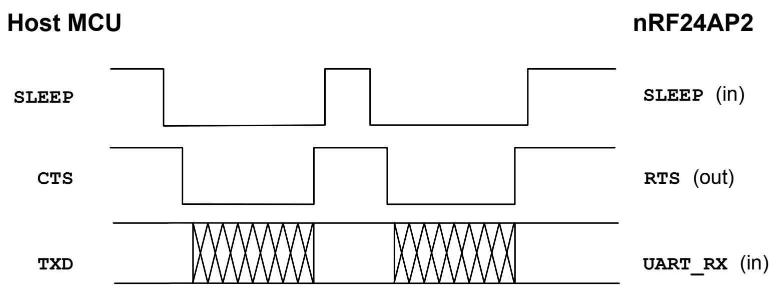

Figure 13. nRF24AP2 sleep control

If the **`SLEEP`** signal is not used, then it must be tied low. In this configuration, the nRF24AP2 will never sleep and will always be ready to receive data. The **`SUSPEND`** functionality cannot be used if the **`SLEEP`** signal is not used.

The **`SLEEP`** and **`RTS`** signals only affect the data being transferred from the host MCU to nRF24AP2. nRF24AP2 will send data to the host, when available, regardless of the state of these two signals.

5.2.5 Suspend mode control ($\overline{\mathtt{SUSPEND}}$)

When using the asynchronous serial interface, you also have a $\overline{\mathtt{SUSPEND}}$ signal available.The assertion of the $\overline{\mathtt{SUSPEND}}$ signal will cause nRF24AP2 to terminate all RF and serial port activity and power down. This will happen immediately, regardless of the state of the nRF24AP2 system. This signal provides support for use in USB applications, where USB devices are required to quickly enter a low-power state through hardware control.

Entering and exiting from the suspend mode require the use of the **`SLEEP`** signal, in addition to the $\overline{\mathtt{SUSPEND}}$ signal. The assertion of $\overline{\mathtt{SUSPEND}}$ is only recognized if **`SLEEP`** is also asserted at the time. De-assertion of the **`SLEEP`** signal is the only method for exiting from suspend mode, as shown in Figure 14. on