DHX91 DHAN-S Module

DECT-ULE Platform

Datasheet

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1. Introduction

General Description

The DSPG DHAN-S module is based on the state-of-the-art DHX91 - a 4th generation DECT SOC. The DHAN-S module is shipped with SW that is immediately suited for a ULE Device (Node) where the application runs on an external MCU that communicates with the DHAN-S via the UART interface. In this configuration, the DHAN-S is simply a wireless transceiver. However, when loaded with the appropriate SW stack, the DHAN-S module can also play other roles in the DECT-ULE system: 1) application processor + wireless transceiver in a ULE device or GAP/CAT-IQ compliant cordless phone (CMHS), 3) communication transceiver in a ULE Hub or DECT Base Station (CMBS).

The DHAN-S features a compact mechanical footprint, a hibernation mode which facilitates long battery life in IoT applications and excellent RF Link and Selectivity characteristics.

Features

- Excellent radio performance, with over 123dB system gain
- Radio covers all regional DECT bands. A simple re-configuration of the EEPROM is required
- Radio is fully compliant with ETSI, FCC DECT and ULE standards
- Compact module footprint of 20.7x15.5x3.72 (including the RF shield height)
- Hibernation mode current of <2µA extends battery life to >5 years for many IoT applications
- Operating Temperature spanning -20ºC to 70ºC

Block Diagram

DXH91 DHAN-S Module Block Diagram

2. Pin and Signal Description

PIN NO.	NAME	DESCRIPTION/TYPE
1	GND	GND
2	DCINS	Leave as not connected (NC)
3	DCIN3	ADC input used to monitor battery level. Input level should be <3.2V. See Application Schematic section below
4	RSTN	For systems using an external application MCU, this pin can be connected to an MCU Output and used to reset the DHAN-S – See Application Schematic section below for more detail
5	SCL (GPIO0)	GPIO or I2C Clock. Open Drain, reset value is floating. Leave as not connected if not used. See Note 1
6	SDA (GPIO1)	GPIO or I2C Data. Open Drain, reset value is floating. Leave as not connected if not used. See Note 1
7	IIC_ACK (GPI03)	GPIO or I2C ACK. Leave as not connected if not used
8	GPIO7	GPIO or SPI Data In. Leave as not connected if not used. See Note 1
9	GPIO8	GPIO or SPI Data Out. Leave as not connected if not used. See Note 1
10	RxD (GPIO9)	GPIO or UART Rx (most typically) or SPICLK. See Note 1
11	TDI	JTAG Data In. Should be connected to TP (see Application Schematic Section below)
12	TMS	JTAG Mode Select. Should be connected to TP
13	TDO	JTAG Data Out. Should be connected to TP
14	TCK	JTAG Clock. Should be connected to TP
15	RTCK	JTAG Reset. Should be connected to TP
16-17	GND	GND
18	TxD (GPIO10)	GPIO or UART Tx or SPICS. See Note 1
19	GND	
20	GND	
21	VCC	Power Supply Input. Connect to Battery or regulated supply
22	DOUBCAP2P	Pull down with 1M if VCC ≥ 3.1V
23	DCIN2	Leave Unconnected

PIN NO.	NAME	DESCRIPTION/TYPE
24	VCC3V	3V (Doubler) **Output**. While DHAN-S is hibernating, this pin is either in tristate (default SW configuration) or pulled to GND. Can be used in conjunction with GPIO7&8 above to drive an LED or button during non-hibernation modes
25	LEDSINK/DCIN	ULE I/O. Should be left as NC when VCC ≥ 3.3V
26-27	GND	GND
28	AMP2_OUT	ULE I/O. If not used, can be left NC
29	AMP1_P	ULE non-inverting sensor conditioning input
30	AMP1_OUT	ULE I/O. If not used, can be left NC
31	MPWR/ANA2_IN	ULE I/O (or Microphone Power). During hibernate, Logic High should not be applied to this pin (it can result in leakage current). If not used, can be left NC
32	MIN	If not used, can be left as NC
33	MIP	If not used, can be left as NC
34	ANA_IN1	ULE I/O. If not used, can be left NC
35	SPOUTP	If not used, can be left as NC
36	SPOUTN	If not used, can be left as NC
37	PWM0	Analog Output
38	XIN_32K	
39	XOUT_32K	
40	VDD_ULE	1.8V test point. Active during hibernate. Leave NC
41	VccRF	Power Supply Input to RF. Add 10pF bypass capacitor adjacent to this pin!
42-43	GND	GND
44	Antenna	RF In/Out, 50 Ohm
45-46	GND	GND

Note 1: GPIOs 0, 1, 7, 3, 8 and 9 are not powered during hibernation. Furthermore, these pins are not back-drive protected. Therefore, care must be taken NOT to apply voltage to these pins during hibernation as this voltage will likely leak to the IO supply rails and result in undesirable leakage current. Additionally, when entering or exiting hibernation, these GPIOs will experience a 10mS positive going pulse.

16 GND2
15 RTCK
14 TCK
13 TDO
12 TMS
11 TDI
10 GPIO9/RxD_SPICLK
9 GPIO8/SPIDO
8 GPIO7/SPIDI
7 IIC_ACK
6 SDA
5 SCL
4 RSTN
3 DCIN3
2 DCINS
1 GND1
17 GND3
18 GPIO10/TxD_SPICS
19 GND4
20 GND5
21 VBAT
22 DOUBCAP2P
23 DCIN2
24 VCC3V
25 LEDSINK/DCIN1
26 GND6
46 GND11
45 GND10
44 ANT
43 GND9
U?
<Value>
27 GND7
28 AMP2_OUT
29 AMP1_P
30 AMP1_OUT
31 MPWR/ANA2_IN
32 MIN
33 MIP
34 ANA_IN1
35 SPOUTP
36 SPOUTN
37 PWM0
38 XIN_32K
39 XOUT_32K
40 VDD_ULE
41 VBATRF
42 GND8

3. Module Electrical Specifications

All parameters are for 25ºC.

Absolute Maximum Rating

Table 3-1: Absolute Maximum Rating

PIN NAME	PIN	MIN	MAX	UNIT
VCC	21	-0.3	4.6	V
VccRF	41	-0.3	4.6	V
I2C	5, 6, 7	-0.3	4.6	V
JTAG	11, 12, 13, 14, 15	-0.3	4.6	V
GPIO	8, 9, 10, 18	-0.3	4.6	V
DCINs,DCIN1,2,3	2, 3, 23, 25	-0.3	4.6	V
Storage Temperature	-	-45	+90	°C

Note: Functionality at or above these limits is not implied. Exposure to absolute maximum ratings for extended periods may affect device reliability.

Recommended Operating Conditions

Table 3-2: Recommended Operating Conditions

RATING	CONDITIONS	MIN	TYP	MAX	UNIT
Operating ambient temperature		-20*	+25	+70	°C
VccRF, VCC		1.95	3.0	3.6	V
JTAG, UART	VIL VIH VOL VOH (VCC is at nominal 3V)	 2.0 2.4		0.8 0.4	V
DCIN3		1.95	3.0	VCC	V

Note: Part # DHX91MDMCFBH6AMI can operate down to -40°C

Peak Currents and Hibernation Current

PARAMETER	TEST CONDITIONS	TYP	MAX	UNIT
Tx Current	VccRF=3 V VCC=3 V Band=EU @ 23dBm	400	480	mA
Tx Current	VccRF=3 V VCC=3 V Band=US @ 21 dBm	250	300	mA
Rx Current	VccRF=3 V VCC=3 V	125	135	mA
Hibernation	VccRF=3 V VCC=3 V	1.7	2.5	uA

Transmitter

Table 3-3: Tx Characteristics

CHARACTERISTICS	TEST CONDITIONS	MIN	TYP	MAX	UNIT
NTP	VccRF=3 V VCC=3 V Band=EU	21.5	23	24	dBm
NTP	VccRF=3 V VCC=3 V Band=US	19	20	21	dBm
Harmonics	VccRF=3 V VCC=3 V Band=EU & US		-40	-35	dBm
Transmission Mask	EN 301406 Paragraph 5.3.3		Comply		N/A
Frequency Offset	EN 301406 Paragraph 5.3.1	-50	8	+50	KHz
Frequency Drift	EN 301406 Paragraph 5.3.5	-15	0	+15	KHz/Slot
Emission Due Modulation	EN 301406 Paragraph 5.3.6.2 M±1 M±2 M±3 M>±3		 -20 -42 -47 -50	 -8 -30 -40 -44	dBm

Receiver

Table 3-4: Rx Characteristics

CHARACTERISTICS	TEST CONDITIONS	MIN	TYP	MAX	UNIT
Sensitivity, BER < 1000ppm	VccRF=3 V VCC=3 V		-96	-93	dBm
Maximum input power	VccRF=3 V VCC=3 V			15	dBm

4. DHAN-S SW Image and Customization

There are two different methods for loading a new SW image or modifying EEPROM parameters on the DHAN-S:

*Via JTAG (see following section for schematic implications) using a JTAG Adaptor Board (USB-UAJTI2C-CNV.BRD)

*Via UART I/F using CMND API features – Multiple modules can be flashed in parallel using this interface

During the development cycle, it is convenient to have access to the JTAG I/F. Therefore, customers are encouraged to include this connector on their application PCB layout – see the following section for schematic recommendation. For the production line, if customers need to burn a new image on their DHAN-S (eg DHAN-S runs the application, DHAN-S is the ULE Controller, standard SDK does not supply needed functionality), the UART I/F should be available as a connector or as Test Points to facilitate fixturing and programming in parallel multiple modules – See Reference "ULE Device Production Flow with DHAN-S".

The DHAN-S module is loaded with the standard HAN-FUN SDK image, configured for application control by an external MCU via the UART CMND API – see HAN FUN - CMND API SPEC. If the customer application runs on an external MCU and the DHAN-S is required for wireless connectivity only, in most cases the customer will not need to burn a new SW image. However, certain EEPROM Parameters WILL require updating. During the development cycle this can be accomplished by either JTAG or UART I/F. In production, the Host MCU can use the CMND API Production and Parameter Tools to initialize the relevant EEPROM settings at power up or reset.

5. Application Schematic

Power Supply Detail

JTAG Connection

Easy access to the JTAG interface is a MUST for customers requiring a SW image other than the ULE, Dual-mode SDK stack which is standard on the DHAN-S. The standard 20-pin connector shown in the reference schematic is convenient if the application board can accommodate it. Alternatively, test pins should be added which can be accessed during both prototyping and production.

RSTN Input

At power-up, the Application Host on the external MCU should hold this pin at logic Low until it is ready to establish communication (via UART) with the DHAN-S. When ready, the App Host should apply a rising edge (and leave at Logic High) and wait for the “Hello” indication from the DHAN-S. If at some point later on the MCU cannot communicate with the DHAN-S, it should apply a low going pulse of >100uS to reset the DHX91 on the DHAN-S.

Wake Up Input

Wake up the DHAN-S (from hibernation) by applying a positive going edge to AMP2_OUT (Pin27). The DHAN-S will reply at the (UART) CMND API with a “Hello_Ind”. At that point the wakeup signal can be lowered.

Wake Up Output

In applications where the Device can be paged by the Hub, the external MCU can enter hibernation. When paged, the DHAN-S will inform the external MCU via UART. If needed, the DHAN-S can wake up the external MCU by applying a rising edge from ANA_IN1 (Pin33)

32KHz XTAL

Many battery-powered applications can leverage the DHX91 (on-board) 32.768KHz RC oscillator to maintain a clock during hibernation and therefore the XIN/OUT_32K pins can be left unconnected. Similarly, AC powered devices which do not hibernate, also can omit this XTAL. However, customer applications that require the radio to wake up at short (<60s) intervals to check for an incoming page from the ULE Controller ("pageable") will require this XTAL.

MIC and Speaker

Dual-mode applications (or CMHS applications) can make use of the MIC and SPK, as shown below:

Other notes to the schematic:

a) For standalone DHAN-S applications, the external MCU can be removed

b) For alkaline batteries (AAA or AA) or CR2 battery, a bulk cap of 100µF should be applied close to VccRF (C4 shown in schematic). For CR123 battery, C4 of 10µF as shown is OK

c) 20-pin JTAG connector is optional. It is recommended for those developing applications on the DHAN-S (DHX91) where debug and reprogramming of the SW image is a must. For applications running on an external MCU, the image on the DHAN-S as shipped should suffice

d) Audio interface is required for dual-mode ULE applications only

e) Sensor interface (I^2C or otherwise) is relevant when the application host runs on the DHAN-S. With the application host runs on an external MCU, sensors or actuators should interface with it and DHAN-S should be used for wireless connectivity only

f) 32KHz XTAL is required for ULE Devices which need to respond to incoming paging from the Hub with low-latency (within seconds or 10's of seconds)

6. DHAN-S Standalone Applications

The DHX91 ULE block includes a Sensor Conditioning Module which can facilitate many types of ULE applications. This module is a highly configurable analog circuit that can be used to interface to a wide variety of sensor transducers.

The module is built around the following sub-circuits:

- Two analog operational amplifiers (op-Amps) with shared bias source
- Two analog comparators with digital output
- One configurable digital potentiometer
- Three configurable ratiometric voltage references with selectable source
- Several analog distribution MUXes
- Several sample-and-hold (S&H) mechanisms

For more information about the Sensor Conditioning Module, please contact DSP Group.

7. Application PCB Design Recommendations

It is recommended that unused pads on the Application PCB not be left as isolated islands of copper but rather be anchored with via to inner layers of the PCB. It is also recommend that GND vias be applied liberally in the vicinity of the antenna pin (44) and the associated GND pins (43, 45, 46).

The following layout recommendations need to be apply on Main Board:

1. Implement a solid ground under the DHAN-S module.
2. Do not route signal traces under the module. Use the bottom layer for signal routing.
3. Make sure no components are near the antenna.
4. Locate the antenna on the edge of the PCB.
5. Use coplanar wave-guide trace between the DHAN-S module and antenna, it should be designed to be as short as possible with 50Ω impedance.
6. Add GND vias alongside the RF trace.
7. Route the RF trace with gradual bends and no sharp corners.
8. Design the antenna position according to the common usage/position of the ULE product for optimal range.

Antenna Recommendations

A Pi-scheme should be added between the DHAN-S module antenna port and the antenna. This circuit will be used for antenna matching, if needed.

Pi-Scheme for Antenna Matching

Applications can use chip, wire or printed antennas – the latter being the most cost-effective and assembly-friendly. However it requires space on the application PCB.

Wire Antennas

The wire antenna should be bent according to the cabinet structure one should try to implement minimal of parallel structures. The total length of the wire antenna should be ¼ Lambda (~40.0 mm). It is important to ensure an adequate ground plane near the antenna port in order to obtain maximal antenna gain and efficiency.

Chip Antennas

P/N	Manufacturer
H2U74W1H1M0100	Unictron
ANT8868LL00R1880A	Yageo
CAN4311112001881K	Yageo
W3022	Pulse Elect

Printed Antennas

The most popular are INV-F-Antenna and monopole antenna, RF CAD tools are recommended to use when designing such, below one can find typical INV-F-Antenna dimensions for DECT band.

INV-F-Antenna Dimension

A practical, more compact version of this inverted-F is shown below. Contact DSPG to obtain the design file.

8. Assembly Information

Electronic version of the information in this Section can be downloaded from the link given in the Reference Section

Mechanical Drawing

PCB Metal Land Pattern Recommendation

PCB Solder Mask Recommendation

PCB Stencil Pattern Recommendation

Pick & Place, Reflow

The DHAN-S module uses a flat shield cover to facilitate a fully automatic assembly process. For backing and reflow recommendations, use MSL 3 in the JEDEC/IPC standard J-STD-20b. The temperature classification (TC) for the module is 245° C.

9. Supplementary Information

Photo

Labeling (appended to the module shield)

1) Year
2) Week
3) 6-digit serial#
4) HW Version
5) SW Version

FCC ID, Industry Canada, ETSI and JDECT

While the DHAN-S has been tested for compliance with these regulatory standards, it currently has not been certified by any Test House. See Reference 3 for detailed guidance on conducting FCC certification for a ULE Device

IPEI and EMC

Each DHAN-S Module is shipped to the customer with a unique IPEI. As shown in the diagram below, the IPEI is the ULE Device's unique identity. The IPEI is stored in the DECT portion of the EEPROM. The DHAN-S IPEI is hexadecimal 2E9Exxxxx, where xxxxx ranges from 0x00600 to 0xFFFFF. The IPEI is the modules unique identifier

DHAN-S will ship with an "EMC" of 0xFEB. This is the DSP Group "generic" EMC. The EMC setting identifies a Device as belonging to a specific group of ULE Devices/Hubs that utilize some proprietary signaling.

In either case, the customer is free to re-program these parameters.

Ordering Information

Part#	SW Image
DHX91MDMCFB**G**6AMI	T_HAN_DEVICE_1.1.K_32.28_19DEC2017
DHX91MDMCFBH6AMI	T_HAN_DEVICE_1.1.K_32.28.01_05JUL2019

Change Log

Table 9-1: List of Changes

REVISION	DATE	DESCRIPTION
0.1	September 2015	Baseline release
1.0	October 19 2015	*Add recommendation to include JTAG connector in support of prototype phase *Add LED Active Low Schematic *Correct Mechanical Drawing (Device Length is now 20.7mm) and PCB footprint *Adjust the minimum limit for NTP *Eliminate reference to direct UART connection. Connect via ULE Block only *Add reference to Unictron chip antenna
1.1	October 27, 2015	*Pg6: Corrected module dimensions – now matching mechanical drawing at end of document *DCIN3 and battery measurement. DHX91 DCIN3 pin is shorted internally to pin21 (VCC). So, pin3 should be left not connected. Corrected all relevant portions of the data sheet *Pg15: Added Unictron Part# for JTAG connector
1.2	December 13, 2015	*DCIN3 reverts back to original description, ie it is no longer shorted to VCC. See Pin Description and Application Schematic notes *SPI Level Shifter/Isolator Diagram corrected *RSTN Pin Description Clarified
1.3	January 05, 2016	*Correct Pinout Tabulation Antenna and GND numbering to match 46-pin mechanical drawing in Section 8. Add electrical symbol depicting this
1.4	February 08, 2016	*Correct the PCB footprint recommendation drawing, Section 8

REVISION	DATE	DESCRIPTION
1.5	Sept4	*Further clarification to RSTN pin, Tabulation in Section 2. Also clarification added to Application Schematic RSTN Section *GPIO (0,1,7,8,9,10) – Behavior of these IOs in hibernation mode called out in Tabulation 2 *Add warning about applying Logic High to ANA2_IN during hibernate *Corrected Pin Names 19, 20 (to GND) in DHAN-S schematic symbol shown in Section 2 *Corrected the pin spacing called out in the mechanical drawing in Section 8 (1.27mm. Now matches PCB footprint) *Add recommendations for Solder Mask and Stencil *Added schematic recommendation for applications running on external MCU *Corrected UART interconnect to external MCU schematic recommendation *Comment in which applications 32KHz XTAL needs to be added *Clarified options for burning new SDK image on the DHAN-S and for modifying EEPROM parameters *Clarified that the DHAN-S is NOT certified with any of the Regulatory bodies *Clarify IPEI and EMC settings assigned to the module
2.0	December 3, 2017	*Add recommendation for 10pf bypass cap at Pin41 (VccRF) *Reword RSTN Pin Description *Updated Schematic Recommendations
2.1	August 13, 2018	*Clarify Bulk Cap C4 on VCCRF *Correct SW Version for Part# DHX91MDMCFB**G**6AMI
2.2	May 27, 2019	*Modify Operational temperature range to -20 to +70°C
2.3	July 30, 2020	*Add Part # DHX91MDMCFB**H**6AMI and note that its temperature range is -40 to +70°C