MIPOT 2.4 GHz MODEM COMMAND REFERENCE

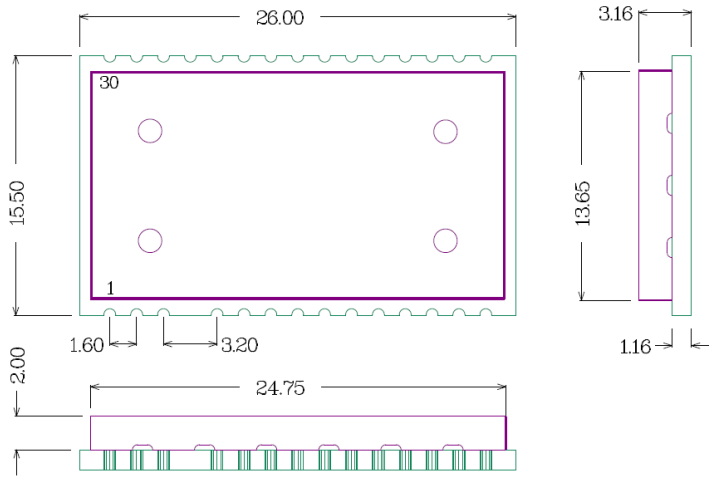
Product Code: **32001445** **-PRELIMINARY-**

PRODUCT SUMMARY:

The 32001445 is a **2.4 GHz transceiver** that implements a physical layer of the IEEE 802.15.4 standard, optimized for **ultra-low consumption** applications, suitable for **low power networks**.
Its spread spectrum modulation assures great immunity to interferers.

This module works as a **RF modem**, allowing the implementation of **point-to-point communication** or more complex **custom networks** (provided that the network protocol is managed from an external host).
Small LCC form factor (15.5 x 26 mm only) and ultra-low current consumption makes this module ideal for highly integrated low power (battery operated) solutions for Internet of Things (IoT) applications, security systems, alarms, sensor networks, metering, smart buildings, supply chain.
All messages can be cyphered with **AES128 encryption** algorithm ensuring confidential authentication and integrity during the exchange of data payload.
The module meets all the requirements in the **industrial temperature range -40/+85°C** and is compliant with **REACH**, **RoHS** and **2014/53/EU Radio Equipment (RED)** directives.

1. MECHANICAL CHARACTERISTICS



ALL DIMENSIONS ARE IN MILLIMETERS
GENERAL TOLERANCE +/-0.1MM

2. PIN DESCRIPTION

Pin	*Name*	*Pin type*	*Description*	*Notes*
1	GND	Supply	Ground (0V)	
2	RF I/O	A IN/OUT	TX: output RF RX: input RF	Note 3
3	GND	Supply	Ground (0V)	
5	NU	NC	Not Used Pin – do not connect	
6	NDATA_INDICATE	D OUT	Data Indicate Pin	
7	NWAKE	D IN	Wake-up Pin	
8	NU	NC	Not Used Pin – do not connect	
9	NU	NC	Not Used Pin – do not connect	

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10	NU	NC	Not Used Pin – do not connect
11	UART TX	D OUT	UART TX Pin
12	UART RX	D IN	UART RX Pin
13	NU	NC	Not Used Pin – do not connect
14	NU	NC	Not Used Pin – do not connect
15	GND	Supply	Ground (0V)
16	GND	Supply	Ground (0V)
17	Vcc	Supply	Power supply
18	SWDAT	NC	Reserved for programming – do not connect
19	SWCLK	NC	Reserved for programming – do not connect
20	SWV	NC	Reserved for programming – do not connect
21	NRST	D IN	Reset. Input Pull-Up
22	NU	NC	Not Used Pin – do not connect
23	NU	NC	Not Used Pin – do not connect
24	NU	NC	Not Used Pin – do not connect
25	NU	NC	Not Used Pin – do not connect
26	NU	NC	Not Used Pin – do not connect
27	NU	NC	Not Used Pin – do not connect
28	NU	NC	Not Used Pin – do not connect
29	NU	NC	Not Used Pin – do not connect
30	GND	Supply	Ground (0V)

3. MODEM DESCRIPTION

All messages can be cyphered with **AES128 encryption** algorithm ensuring confidential authentication and integrity during the exchanging of data payload.

4. UART INTERFACE DATA FRAME FORMAT

UART interface allows the Host both to configure the module and to exchange radio data frames.

4.1. Physical Parameters

Default UART configuration is 9600 baud, 8n1. Baud rate can be changed by configuring an EEPROM parameter.

Communication interface:

Pin	Description	Notes
UART TX	UART TX pin. Output push-pull.	
UART RX	UART RX pin. Input pull-up.	Equivalent Internal Pull-up 40 kΩ (typical value)
NDATA_INDICATE	Module digital output. Indicates radio frame reception.	
NWAKE	Module digital input. This pin wakes up the module from sleep state.	Equivalent Internal Pull-up 40 kΩ (typical value)

4.2. Byte Order

Multiple byte values are transmitted in Little Endian order, with least significant byte first (LSB).

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4.3. Message Structure

Structure of the messages is the following:

HEADER	CMD	LENGTH	Payload (n Bytes)	Checksum

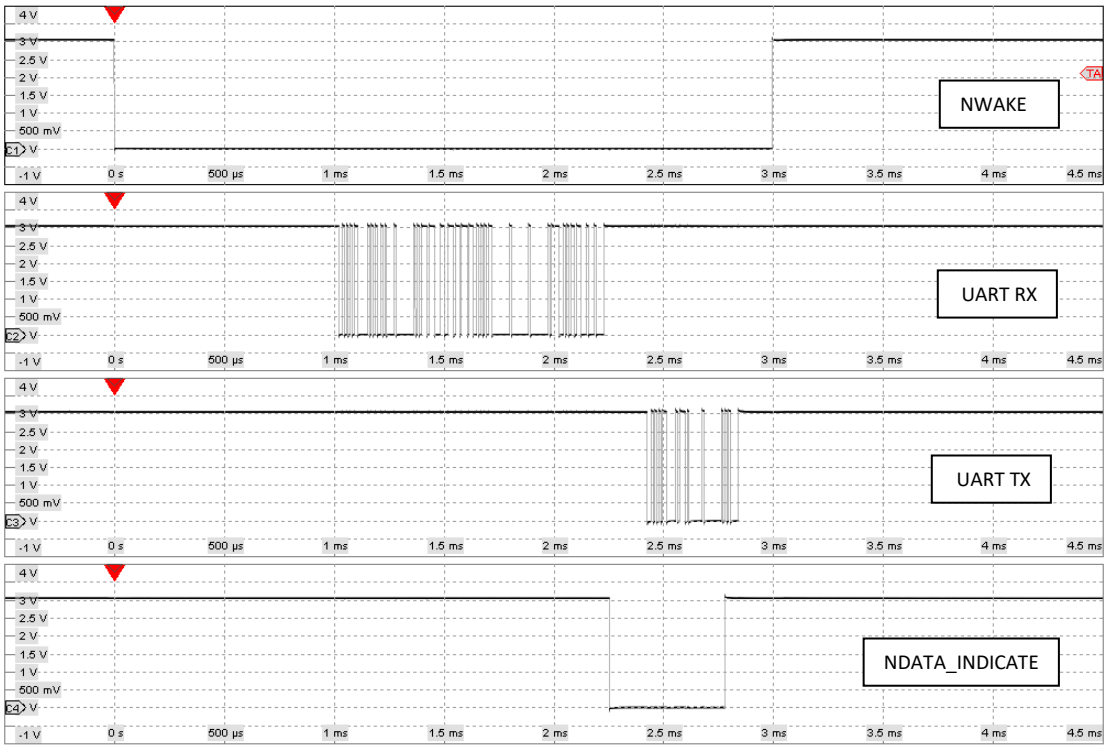
Where:
HEADER = 0xAA
CMD = Command code to module, see following table.
LENGTH = Payload length
Checksum = 2's complement of the sum of all preceding bytes

Each command issued by the Host invokes an answer by the Module in the same format. The answer to the Host has the CMD field equal to (Host Request Command) OR (0x80).

4.4. Detailed Signal Flow

When the module receives a valid command and the checksum is correct, the module sets NDATA_INDICATE LOW, transmits the answer through UART TX pin and then sets NDATA_INDICATE HIGH.
In order to transfer a received radio frame to the Host microcontroller, the module has to set NDATA_INDICATE LOW, wait for DATA_INDICATE_TIMEOUT expiration, then send the message on UART TX pin. DATA_INDICATE_TIMEOUT represents the time (in milliseconds) between the instant in which NDATA_INDICATE pin goes LOW and the start of transmission on UART TX pin.
The module enters sleep mode as soon as possible after power up. Before starting a UART session or to set the module in RX state, the Host shall wake it up by setting the NWAKE pin LOW (pin 7). Setting the pin HIGH sets the module into sleep mode.

4.4.1.Example of UART TX command session (Host to Module):



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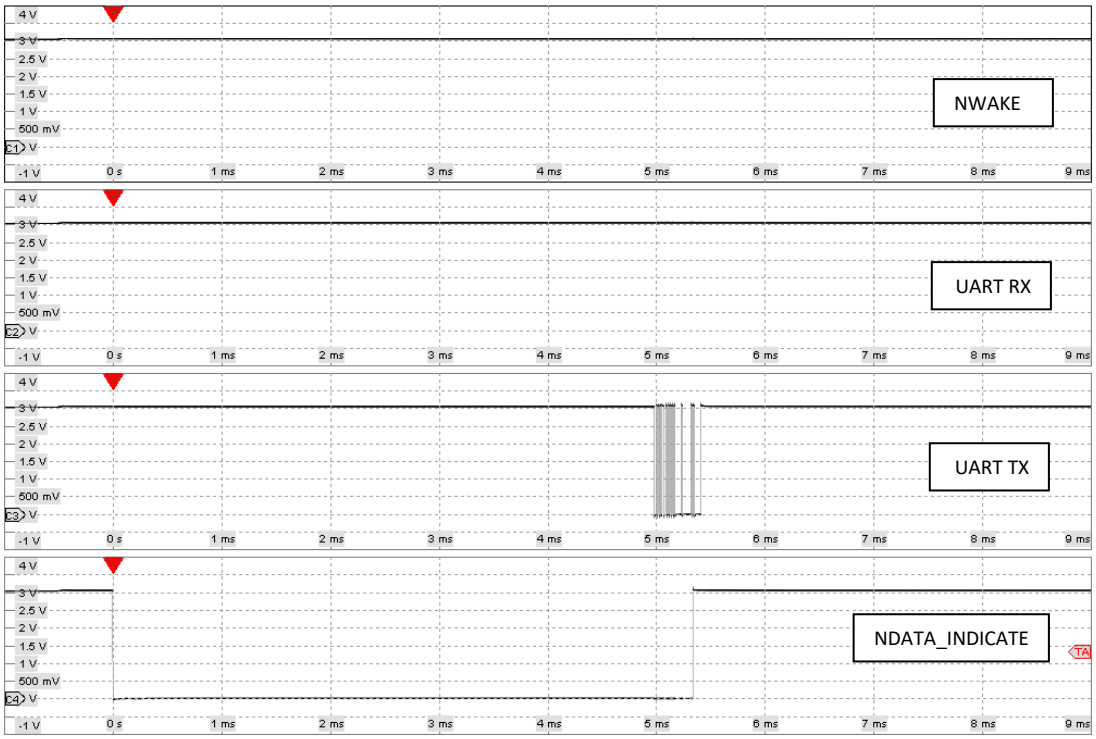
Example of UART RX Command session (DATA_INDICATE_TIMEOUT = 5ms) (Module to Host):



5. COMMAND DESCRIPTION

Command (CMD)	Value	Description
RESET_CMD	0x30	Module Software Reset
FACTORY_RESET_CMD	0x31	Restore EEPROM to factory default values
EEPROM_WRITE_CMD	0x32	Write EEPROM parameter
EEPROM_READ_CMD	0x33	Read EEPROM parameter
GET_FW_VERSION_CMD	0x34	Get Firmware Version
GET_SERIALNO_CMD	0x35	Get Serial Number stored in Module
GET_UID_CMD	0x36	Get Unique Identification number stored in Module
TX_MSG_CMD	0x50	Transmission of Radio Message
TX_MSG_IND	0x52	Indication of Radio Message Transmission
RX_MSG_IND	0x53	Indicate Radio Message Reception
SET_AES_KEY_CMD	0x58	Write EEPROM parameter AES encryption key
SET_INIT_VECT_CMD	0x59	Write EEPROM parameter IV for encryption

5.1. RESET_CMD (0x30)

This command performs a Module Reset. The reset will be performed after about 1s.
When a valid reset request is received, the Module starts a timer and replies immediately to the Host microcontroller. When the timeout expires the module resets. UART interface will be disabled during the reset procedure.

Host: 0xAA, 0x30, 0x00, 0x26
Reply: 0xAA, 0xB0, 0x00, 0xA6

5.2. FACTORY_RESET_CMD (0x31)

This command restores EEPROM factory default values.

Host: 0xAA, 0x31, 0x00, 0x25
Reply: 0xAA, 0xB1, 0x01, Status, checksum
Status: 0x00: Success
A value different from 0: error

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5.3. EEPROM_WRITE_CMD(0x32)

This command performs an EEPROM data write. For Addresses and Data values see “Module Configuration” section.

Host: 0xAA, 0x32, Length, Start Address, <Data>, checksum
Reply: 0xAA, 0xB2, 0x01, EEWriteStatus, checksum

Note: Data outside allowed range will not be stored in EEPROM and the current value will not be modified. If the variable to be updated has the same value of the new one then the EEPROM will not be updated in order to minimize memory write cycles.

EEWriteStatus: 0x00: Success
0x01: Invalid address

5.4. EEPROM_READ_CMD(0x33)

This command reads EEPROM data. For Addresses and Data values see “Module Configuration” section.

Host: 0xAA, 0x33, 0x02, Start Address, Number of bytes, checksum
Reply: 0xAA, 0xB3, Length, Status, Data, checksum
Status: 0x00: Success, Data contains EEPROM values
0xFF: failure, Data is empty and Length is equal to 1

5.5. GET_FW_VERSION_CMD(0x34)

Get 32-bit firmware version.

Host: 0xAA, 0x34, 0x00, 0x22
Reply: 0xAA, 0xB4, 0x04, FWV0, FWV1, FWV2, FWV3, checksum
FWV0, FWV1, FWV2, FWV3: Firmware version

5.6. GET_SERIALNO_CMD(0x35)

Get unique 32-bit Serial Number.

Host: 0xAA, 0x35, 0x00, 0x21
Reply: 0xAA, 0xB5, 0x04, SN0, SN1, SN2, SN3, checksum
SN0, SN1, SN2, SN3: 32-bit Mipot Serial Number

5.7. GET_UID_CMD (0x36)

Get unique 64-bit Unique Identification number.

Host: 0xAA, 0x36, 0x00, 0x20
Reply: 0xAA, 0xB6, 0x08, ID0, ID1, ID2, ID3, ID4, ID5, ID6, ID7 checksum
SN0, SN1, SN2, SN3, ID4, ID5, ID6, ID7: 64-bit Unique Identification Number

5.8. TX_MSG_CMD(0x50)

This command performs the transmission of a radio frame.

Host: 0xAA, 0x50, Length, <MsgPayload>, checksum
Reply: 0xAA, 0xD0, 0x01, Status, checksum

MsgPayload: Data to be transmitted. **Maximum allowed payload size is 240 bytes.**
With AES encryption enabled the number of byes to be transmitted shall be a multiple of 16.

Status: 0x00: Success
0x01: Device busy
0x03: Payload error

NOTE:
The module does not manage automatically duty cycle restrictions. Host application must handle the duty cycle requirements in order to assure compliance with the harmonized standard limits.

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5.9. TX_MSG_IND(0x52)

This command indicates the end of a transmission session.

Module: 0xAA, 0x52, 0x01, Status, checksum

Status: 0x00 = success
A value different from zero means that an error has occurred

5.10. RX_MSG_IND(0x53)

This command indicates the reception of radio frames.

Module: 0xAA, 0x53, Length, Status, RssiLSB, RssiMSB, LQI, <Payload>, checksum

Status: 0x00 = success
Values different from zero are reserved.
RssiLSB/MSB: 16-bit Rssi Value expressed in dBm
LQI: Link quality indicator

Payload: Data Message

5.11. SET_AES_KEY_CMD(0x58)

This command performs an EEPROM data write.

Host: 0xAA, 0x58, 0x10, <AESKey>, checksum

Reply: 0xAA, 0xD8, 0x01, Status, checksum

AESKey: 16 bytes in Little Endian Order. Needed for Application encryption customization.
This key is used only when AppEnAES parameter is set to 1.

Status: 0x00 = success
Values different from zero are reserved.

5.12. SET_INIT_VECT_CMD(0x59)

This command performs an EEPROM data write.

Host: 0xAA, 0x59, 0x10, <InitVector>, checksum

Reply: 0xAA, 0xD9, 0x01, Status, checksum

InitVector: 16 bytes in Little Endian Order. Needed for Application encryption customization. This key is used only when AppEnAES parameter is set to 1.

Status: 0x00 = success
Values different from zero are reserved.

6. MODULE CONFIGURATION

Multiple byte values are expressed in Little Endian order with Least Significant Byte first (LSB).

6.1. Radio Physical Parameters

Parameter	Description	Address	Range	Default	Notes
Power	Power expressed in dBm	0x00	2-14	14	Power expressed in dBm
Frequency	Channel Frequency selection	0x01	0 – 15	2	Check frequency index table

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6.2. Module Parameters

Parameter	Description	Address	Range	Default	Notes
DATA_INDICATE_TIMEOUT	Timeout in ms	0x05	1-255	5	Expressed in ms
UART Baud rate	UART baud rate selection	0x06	0 – 4	0	0 = 9600 1 = 19200 2 = 38400 3 = 57600 4 = 115200
AppEnAES	Application AES Key Enable/Disable	0x07	0 – 1	0	0 = Disabled 1 = Enabled

6.3. Internal DATA (Read Only)

Parameter	Description	Notes
SerialNumber0	Byte 0 SN	Serialization at 32 bits
SerialNumber1	Byte 1 SN	
SerialNumber2	Byte 2 SN	
SerialNumber3	Byte 3 SN	
FwVersion0	Byte 0 FW Version	Firmware Version
FwVersion1	Byte 1 FW Version	
FwVersion2	Byte 2 FW Version	
FwVersion3	Byte 3 FW Version	
UID0	Byte 0 UID	Unique ID number
UID1	Byte 1 UID	
UID2	Byte 2 UID	
UID3	Byte 3 UID	
UID4	Byte 4 UID	
UID5	Byte 5 UID	
UID6	Byte 6 UID	
UID7	Byte 7 UID	

6.4. Internal DATA (Read Only)

The module implements on-board network AES encryption with an internal key (not accessible to the Host microcontroller). If the Host microcontroller needs to customize the encryption at application level, it has to enable this feature by setting AppEnAes parameter to 1 and write AESKey through SET_APP_KEY_CMD.

Parameter	Description	Values Range	Default	Notes
AESKey	16 bytes AES Key	0-255 for all 16 bytes	0 for all 16 bytes	**Used at application level (Write Only Variable)**
InitVect	16 bytes Initialization Vector	0-255 for all 16 bytes	0 for all 16 bytes	**Used at application level (Write Only Variable)**

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6.5. Frequency Index Table

Index		Index	
0	2405	8	2445
1	2410	9	2450
2	2415	10	2455
3	2420	11	2460
4	2425	12	2465
5	2430	13	2470
6	2435	14	2475
7	2440	15	2480

7. EXAMPLES

This section describes some examples for network configuration and message exchange.
The examples will consider two 32001445 modules with the following serial number:

- 0x11111111
- 0x22222222

7.1. MESSAGE TRANSMISSION SESSION

This example shows how to send a message from a module to another to send a PAYLOAD equal to {0x11, 0x22, 0x33, 0x44}:

Host command: 0xAA, 0x50, 0x04, 0x11, 0x22, 0x33, 0x44, 0x53 (#1)
Module Answer: 0xAA, 0xD0, 0x01, 0x00, 0x85 (#2)

When the session ends, the module sends back to the host an indication message containing the session time-on-air:

Module Indicate: 0xAA, 0x52, 0x05, 0x00, 0xC9, 0x00, 0x00, 0x00, 0x36 (#3)

When the other module receives a radio message, it indicates this to Host through UART interface:

Module Indicate: 0xAA, 0x53, 0x08, 0x00, 0xC7, 0xFF, 0x06, **0x11, 0x22, 0x33, 0x44**, 0x81 (#4)

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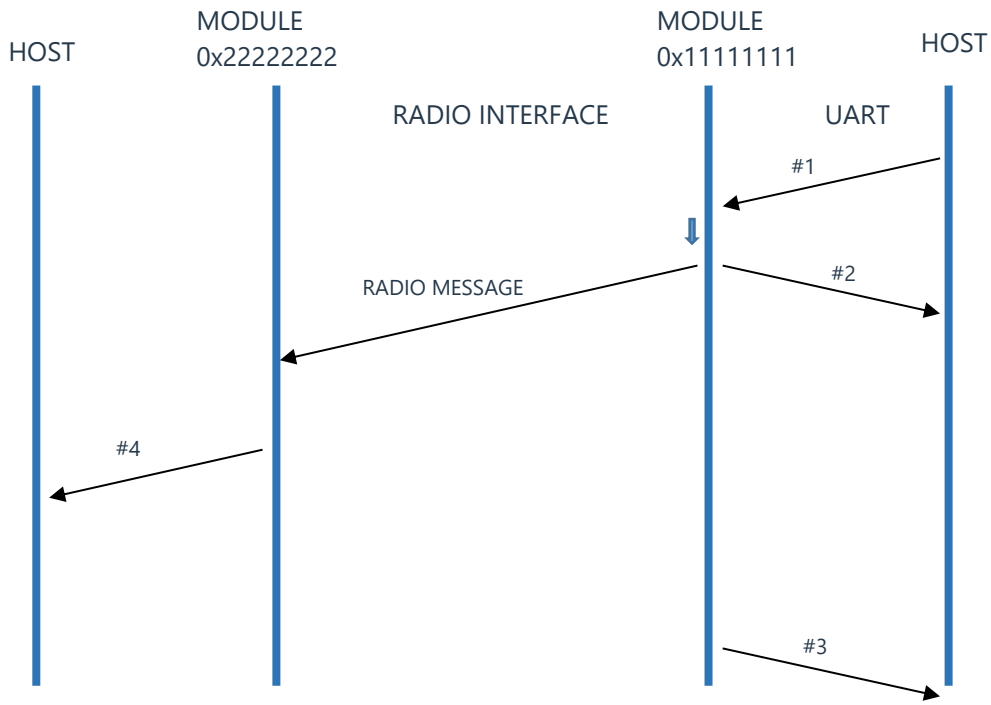

8. GLOSSARY

SN = Serial Number
Fw = Firmware
UID = Unique Identification number
LSB = Least significant byte
MSB = Most significant byte

9. REFERENCES

10. REVISION HISTORY

Revision	Date	Description
0.0	21-05-2019	Preliminary

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