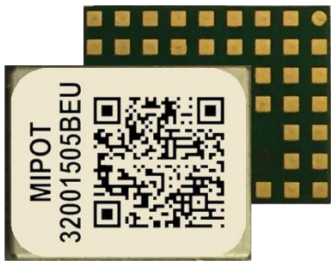
Wireless Protocol Modules MiP Series 32001505DEU

LoRa™ Modem

Command Reference



Description

This document provides list of commands that the 32001505DEU implement and the description of their use.

Contents

1. Network description

A simple stack makes this module a RF modem, allowing the user to implement a simple point-to-point communication or a more complex custom network (provided that the network protocol is managed on the host device).

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

2. Communication interface

The **32001505DEU** is a host based module needing an external microcontroller to configure and operate it. The communication interface between the module and the external microcontroller can be one among available SPI, I^2C or UART, depending on user application needs.

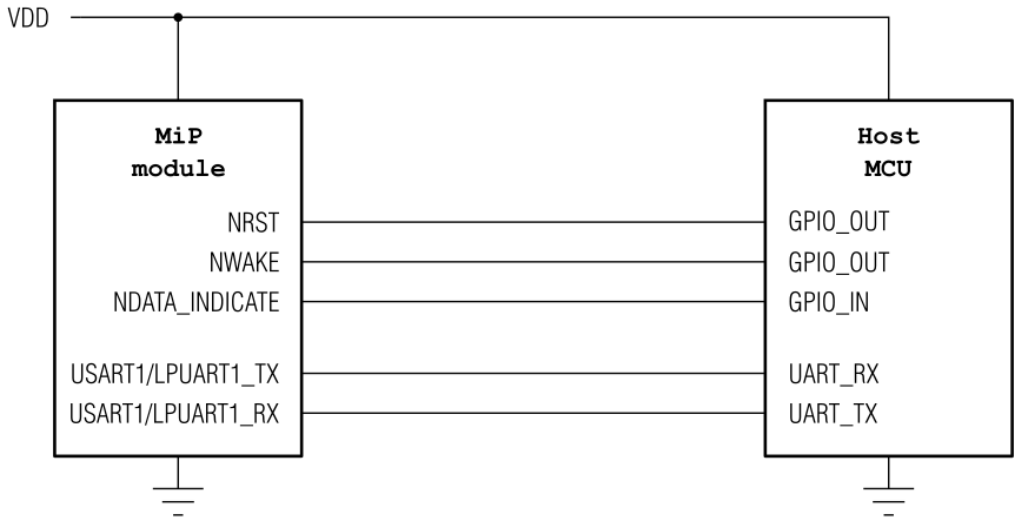
2.1. SPI/I^2C/UART interface

SPI/I^2C/UART interface allows Host both to configure the module and to exchange LoRa radio frame data messages.

One among available SPI, I^2C or UART interfaces can be chosen. There is no need to preliminary configure the interface to use. After reset the module listens for messages on each of the available ports and automatically elects as communication interface the channel where the first valid message is received.

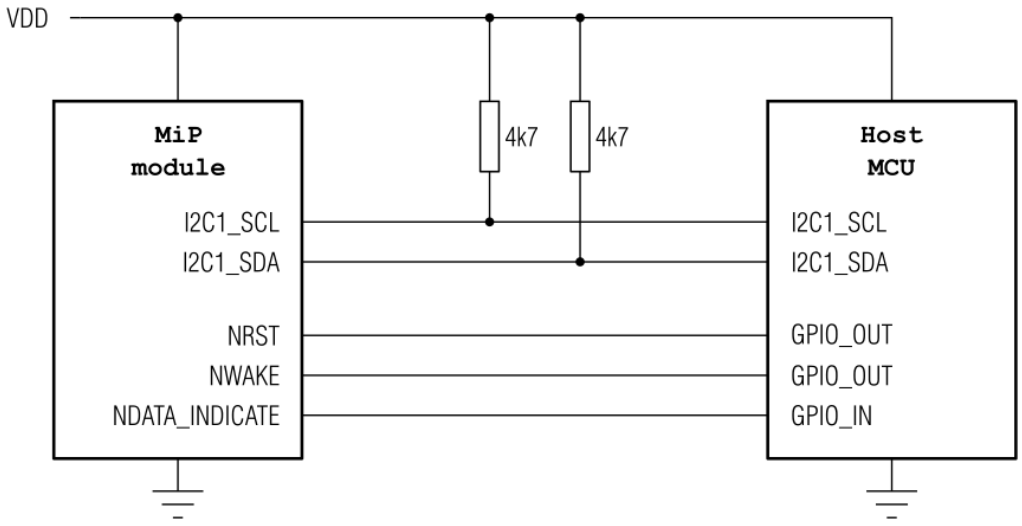
2.2. Connection with USART1 or LPUART1

The serial port uses the DTE terminology and direction



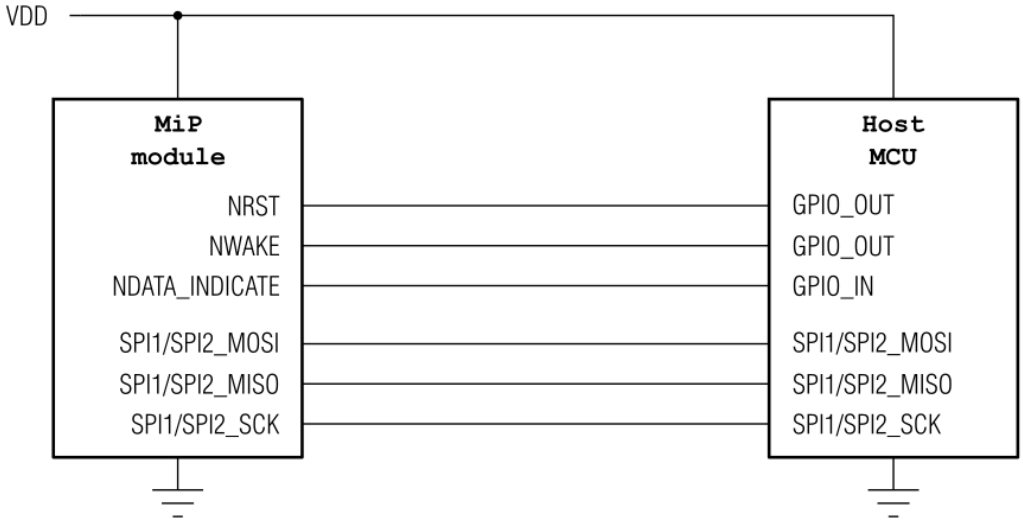
2.3. Connection with I2C1

The I2C interface requires an external pullup on the communication lines.



2.4. Connection with SPI1 or SPI2

The NWAKE pin can be used as the SPI's NSS signal.



3. Communication interface: SPI/UART

SPI/UART interface allows Host both to configure the module and to exchange LoRa radio frame data messages.

3.1. Byte Order

Multiple byte values are transmitted in little endian order with least significant byte first (LSB).

3.2. Message Structure

The structure of the messages is the following:

HEADER	CMD	LENGTH	PAYLOAD (n Bytes)	CHECKSUM

Where:

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

Each command from the host invokes an answer from the module in the same format.

The answer to the host has the CMD field equal to host request OR 0x80.

3.3. Message Types

There are three types of messages:

Commands: sent from the host to the module to request an information or an action.

Replies: sent from the module to the host as direct reply to a command, their command code is equal to the host request OR 0x80.

Indications: messages sent from the module to the host that are sent without prior action from the host, triggered by events on the radio interface. (e.g.: a received transmission).

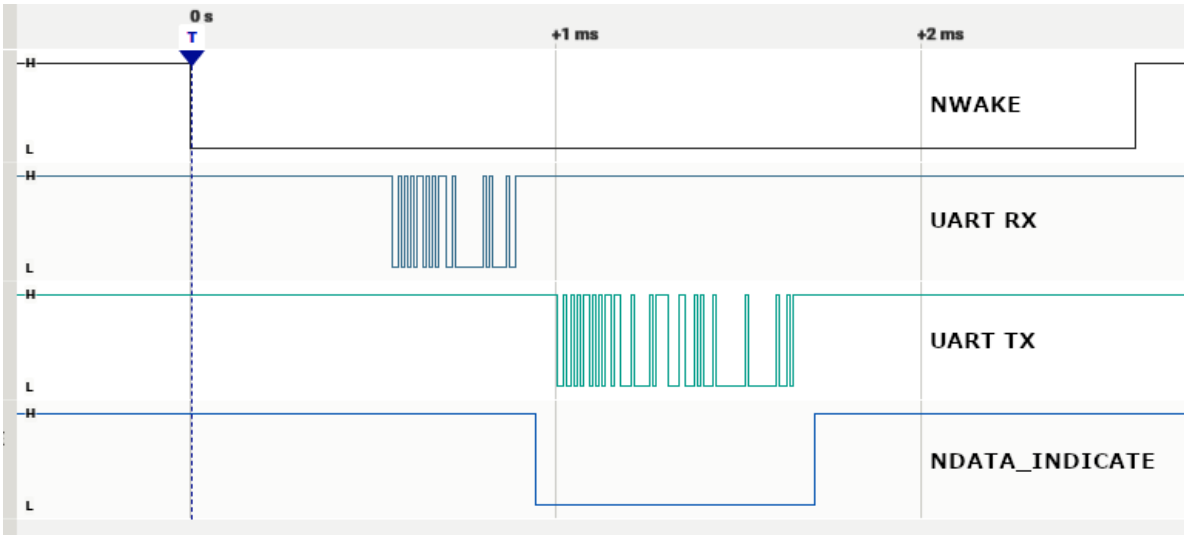
3.4. Detailed Signal Flow

The module enters sleep mode as soon as possible therefore, before initiating a UART session, the host shall wake it up by setting the NWAKE pin LOW and then setting it back HIGH at the end of the session.

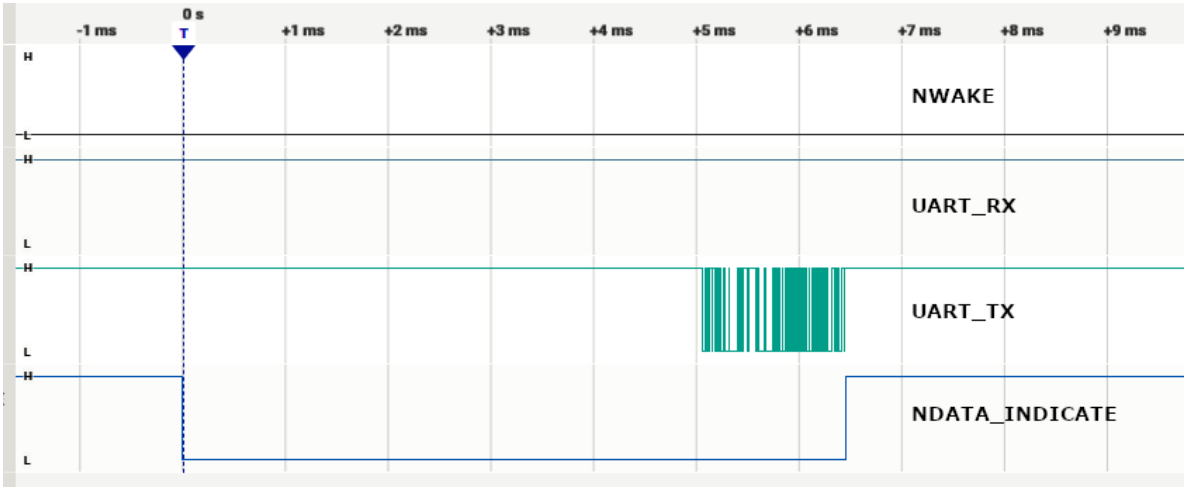
When the module receives a valid command and the checksum is correct, the module sets NDATA_INDICATE LOW, transmits the answer through UART TX pin and then sets NDATA_INDICATE HIGH.

When transferring a received radio frame to the host microcontroller, the module set NDATA_INDICATE LOW, wait for DATA_INDICATE_TIMEOUT expiration, and then send the message on UART TX pin. DATA_INDICATE_TIMEOUT represents the time (in ms) between the instant when NDATA_INDICATE pin goes LOW and the start of transmission on UART TX pin.

3.5. Example of UART command session (Host -> Module):



3.6. Example of UART RX indicate message session (DATA_INDICATE_TIMEOUT = 5ms) (Module -> Host):



4. Command Set Description

List of the implemented command:

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
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_IV_CMD	0x59	Write EEPROM parameter IV for encryption

4.1. RESET_CMD (0x30)

This command performs a module Reset.

When a valid reset request is received, the module replies immediately to the host microcontroller.

All communication interfaces will be disabled during the reset procedure.

Host: 0xAA, 0x30, 0x00, 0x26

Reply: 0xAA, 0xB0, 0x00, 0xA6

4.2. 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

4.3. 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

EEWriteStatus:

0x00 = Success

0x01 = Invalid address

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.

4.4. 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

4.5. 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

4.6. 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.

4.7. 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.

The following table shows time-on-air for a single frame as a function of the number of transmitted bytes at 4/5 coding rate.

Spreading Factor	Number of bytes	Time on Air (ms)	
		BW = 125 kHz	BW = 250 kHz
7	10	46	23
	120	271	135
	240	517	258
8	10	82	41
	120	461	230
	240	870	435
9	10	164	82
	120	799	399
	240	1496	748
10	10	288	144
	120	1435	717
	240	2664	1332
11	10	577	288
	120	2543	1271
	240	4755	2377
12	10	991	495
	120	4595	2297
	240	8527	4263

4.8. **TX_MSG_IND (0x52)**

This command indicates the end of a transmission session.

Module: 0xAA, 0x52, 0x05, Status, Time1, Time2, Time3, Time4, checksum

Status: 0x00 = success

A value different from zero means that an error has occurred.

Time1, Time2, Time3, Time4:

Time on Air, total time needed for the transmission, in ms.

4.9. **RX_MSG_IND (0x53)**

This command indicates the reception of radio frames.

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

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

RssiLSB/MSB: 16-bit Rssi Value expressed in dBm

SNR: 8-bit Signal-to-Noise Ratio

Payload: Data Message

4.10. **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.

4.11. **SET_IV_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.

5. Module Configuration

Multiple byte values are expressed in little endian order with least significant byte first (LSB).

5.1. 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_AES_KEY_CMD (0x58).

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)**

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	

5.2. LoRa stack 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 - 74	2	Check frequency index table
Bandwidth	TX bandwidth	0x02	0 - 2	0	0 = 125 kHz 1 = 250 kHz 2 = 500 kHz
Spreading Factor	Spreading factor expressed in chips	0x03	6 - 12	10	6 = 64 chips 7 = 128 chips 8 = 256 chips 9 = 512 chips 10 = 1024 chips 11 = 2048 chips 12 = 4096 chips
Code Rate	Code rate	0x04	1 - 4	1	1 = 4/5 2 = 4/6 3 = 4/7 4 = 4/8

5.3. Frequency index table

Index	Freq [MHz]	Index	Freq [MHz]	Index	Freq [MHz]	Index	Freq [MHz]
0	868.075	20	868.575	40	869.075	60	869.575
1	868.100	21	868.600	41	869.100	61	869.600
2	868.125	22	868.625	42	869.125	62	869.625
3	868.150	23	868.650	43	869.150	63	869.650
4	868.175	24	868.675	44	869.175	64	869.675
5	868.200	25	868.700	45	869.200	65	869.700
6	868.225	26	868.725	46	869.225	66	869.725
7	868.250	27	868.750	47	869.250	67	869.750
8	868.275	28	868.775	48	869.275	68	869.775
9	868.300	29	868.800	49	869.300	69	869.800
10	868.325	30	868.825	50	869.325	70	869.825
11	868.350	31	868.850	51	869.350	71	869.850
12	868.375	32	868.875	52	869.375	72	869.875
13	868.400	33	868.900	53	869.400	73	869.900
14	868.425	34	868.925	54	869.425	74	869.925
15	868.450	35	868.950	55	869.450		
16	868.475	36	868.975	56	869.475		
17	868.500	37	869.000	57	869.500		
18	868.525	38	869.025	58	869.525		
19	868.550	39	869.050	59	869.550		

5.4. **Module parameters**

Parameter	Description	Address	Range	Default	Notes
DataIndicate Timeout	Interval between data indicate low and data transmission	0x05	1-255	5	Expressed in ms
Uart Baudrate	Serial communication baud rate	0x06	0 - 4	4	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. Revision History

Revision	Date	Description
0.1	13.05.2021	Preliminary
1.0	24.10.2022	-Add connection examples -Add timing diagrams
1.1	11.11.2022	Corrected parameters of TX_MSG_IND (0x52)