MIPOT LoRa™ MODEM COMMAND REFERENCE

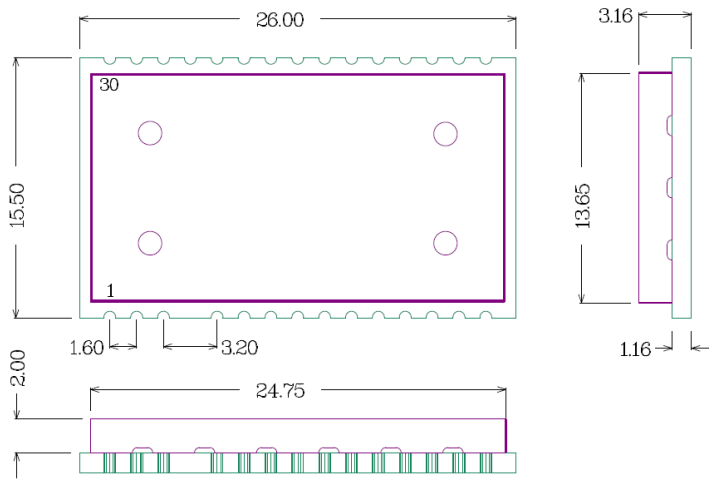
Product Code: **32001345M**

PRODUCT SUMMARY:

The 32001345M is a **LoRa™ technology**-based transceiver operating in the 868 MHz SRD band, optimized for **ultra-long range**, **ultra-low consumption** applications, suitable for **low power networks**.
In addition to its unparalleled range, spread spectrum modulation assures great immunity to interferers.

A proprietary stack makes this module an **RF modem**, allowing to implement from **point-to-point communication** to more complex **custom networks** (provided that the network protocol is managed from the outside).
Small LCC form factor (15.5 x 26 mm only) and ultra-low current consumption make this module ideal for the implementation of highly integrated low power (battery operated) solutions for Internet of Things (IoT) applications, security systems, alarms, sensor networks, metering, smart buildings, agriculture, supply chain.
All messages can be cyphered with **AES128 encryption** algorithm ensuring confidential authentication and integrity during the exchanging 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 (0 V)	
2	RF I/O	A IN/OUT	Tx: output RF Rx: input RF	Note 3
3	GND	Supply	Ground (0 V)	
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 (0 V)
16	GND	Supply	Ground (0 V)
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 (0 V)

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 LoRaTM 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).

4.3. Message Structure

Structure of the messages is the following:

HEADER	CMD	LENGTH	Payload (n Bytes)	Checksum

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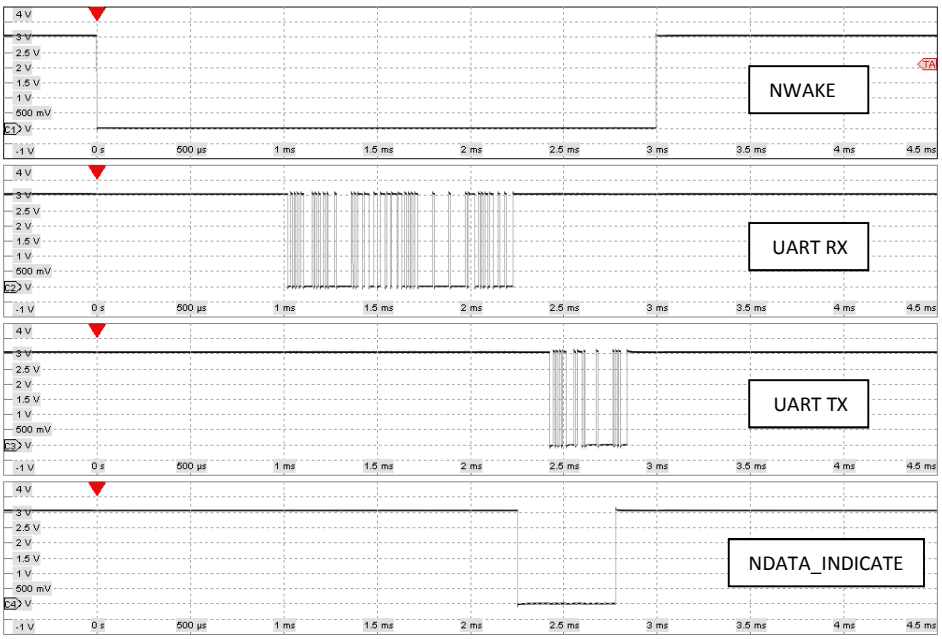
Where:
HEADER = 0xAA
CMD = Command code to module, see following table.
LENGTH = Payload length
Checksum = 2's complement of the sum of all preceding bytes

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 -> Module):



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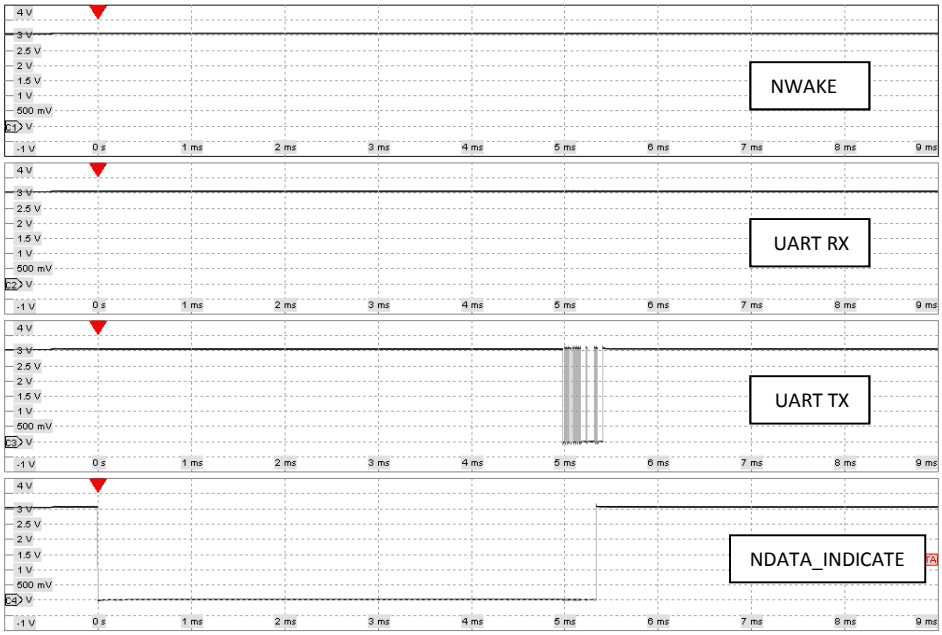
4.4.2.Example of UART RX Command session (DATA_INDICATE_TIMEOUT = 5ms) (Module -> Host):



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
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

5.3. EEPROM_WRITE_CMD(0x32)

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

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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. 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. Grey cells for 125 kHz bandwidth and black ones for 250 kHz bandwidth.

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Spreading Factor	Number of bytes	Time on Air (milliseconds)	
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

5.8. TX_MSG_IND(0x52)

This command indicates the end of a transmission session.

Module: 0xAA, 0x52, 0x05, Status, checksum

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

5.9. 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

5.10. 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.

5.11. 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.

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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 – 74	2	Check frequency index table
Bandwidth	TX Bandwidth	0x02	0-1	0	0 = 125 kHz 1= 250 kHz
Spreading Factor	Spreading Factor expressed in chips	0x03	7 - 12	10	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

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

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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	

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)**

6.5. Frequency Index Table

Index		Index		Index		Index	
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

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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		

7. EXAMPLES

This section describes some examples for network configuration and message exchange.
The examples will consider two 32001345M 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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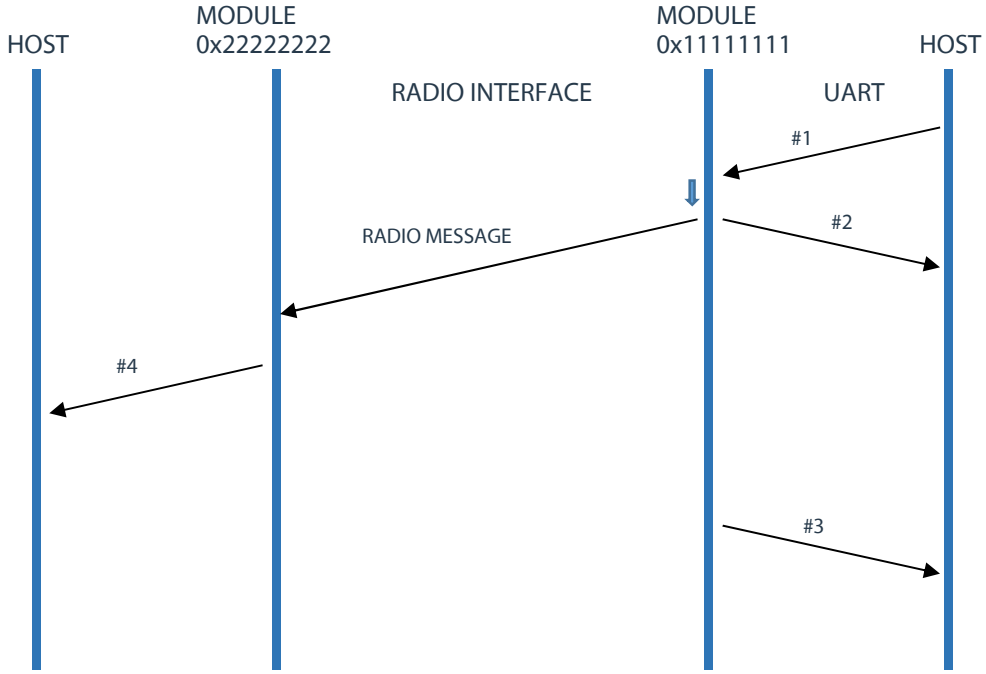

8. GLOSSARY

SN = Serial Number
Fw = Firmware
LSB = Least significant byte
MSB = Most significant byte

9. REFERENCES

[1] Sx1272 Datasheet

10. REVISION HISTORY

Revision	Date	Description
0.0	26-06-2018	Preliminary
0.1	12-09-2018	Font change and minor corrections
0.2	16-10-2018	UART default baudrate changed to 9600baud
1.0	27-08-2019	Final release

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