Modules

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Getting Started Guide

HL781x NTN

July 2025

41114876 Rev. 4

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Revision History

Revision number	Release date	Changes
1	September 2024	Document creation, preliminary release
2	February 2025	Added 2.2 Position Configuration Added 2.5.2 Detach, 2.6 RAT switech, and 2.7 Power Saving Added 3.1 AT+KNTNCMD and AT+KNTNCFG Added 2.5 Sending Small Data Updated 1. Introduction Updated AT+KNTNCFG under 2.3.1 AT Commands Setup Updated 2.4 Manual Position Connection Setup Updated 2.4.1 AT Commands Setup Updated NTNCMD and NTNCFG
3	May 2025	Updated 2.2 Position Configuration Updated 2.3 IGNSS Connection Setup Updated 2.3.1 AT Commands Setup Updated 2.4 Manual Position Connection Setup Updated 2.4.1 AT Commands Setup Updated 2.5.3 Detach for Manual/Dynamic Mode
4	July 2025	Updated Table 4-1: HL781x Supported RF NB-IoT NTN Bands/Connectivity

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1: Introduction

NB-IoT Non-Terrestrial Networks (NB-IoT NTN) is a cellular technology introduced in 3GPP Release 17, enabling satellites to provide telecommunication services to NB-IoT modems.

This technology extends coverage globally wherever a suitable satellite is overhead. It is particularly useful for maintaining connectivity in areas where terrestrial networks are impractical, such as remote or maritime regions. Additionally, it ensures coverage in scenarios where terrestrial infrastructure is unavailable due to cost constraints or damaged by natural disasters like earthquakes and floods.

Unlike traditional NB-IoT, NB-IoT NTN connects directly from the module to the satellite instead of an eNodeB. This results in significantly greater propagation delays and an increased timing advance (TA).

TA calculation depends on the positions of both the module and the satellite. The module can determine its position using the HL781x IGNSS (internal GNSS) feature or by manual configuration, while the satellite's position is obtained from SIB31.

This document outlines the necessary steps to configure and operate the HL781x for communication via NB-IoT NTN.

2: Setup and Operation

The following sections describe the set up and operation of the HL781x to setup the unit to attach to the network and send data.

2.1 Hardware, Antenna, and Location

Testing has been carried out using a standard (blue and red) HL78 development kit along with a standard LTE antenna as indicated in Figure 2-1.

Figure 2-1: NTN Test Antenna

Initial testing must be performed outside to ensure the visibility of GEO satellites, especially to the north in the southern hemisphere and south in the northern hemisphere. Only GEO satellites are currently supported. Indoor operation is possible but might impact the link budget and subsequent results.

Other antennas that have been tested and shown to work (with different levels of performance):

- Taoglas PA.26A surface mount ceramic antenna
- Taoglas FXBU flex antenna

2.2 Position Configuration

All NB-IoT NTN setups are identical to NB-IoT, except that the UE (User Equipment) position is required for NTN TA (Timing Advance) calculation and connection. The HL781x provides two modes to retrieve its position: IGNSS or manual.

- **IGNSS:** The HL781x uses its internal GNSS to acquire the position automatically.
- **Manual:** The user must manually enter the UE position using the +KNTNCMD AT command.

To specify the UE's mobility type as either static or dynamic, the system considers the distance between the current position and the original fix. If the UE's position remains within 600 meters of the initial fix, static mode can still be used. However, if the positional variation exceeds 600 meters, dynamic mode is recommended.

That said, most of the mobility in our use cases, such as street lighting and water meter, primarily rely on static mode, where the position remains largely unchanged over time.

- **Static Mode:** In this mode, the UE is assumed to remain in a fixed position. The position acquired during the initial fix is retained and used until the device is rebooted.
- **Dynamic Mode:** In this mode, the UE is assumed to be in motion. The acquired UE position is used only for a single network operation. In IGNSS mode, the UE acquires a new position from ALT1250 internal GNSS for each network operation request. In manual mode, the position must be updated before any outgoing network operation. Additionally, the position must be sent after receiving an unsolicited +KNTNEV: "POSREQ" indication.

Note:

- *If the UE's position remains within 600 meters of the original fix, it can still be configured in static mode. However, if the variation exceeds 600 meters, dynamic mode should be used instead.*
- *High UE positional accuracy is not critical, a position inaccuracy of up to 600m is tolerable for communication to be maintained.*
- *IGNSS/Dynamic UL/DL NIDD continuously transmitting needs optimization (TBD). Just a reminder, this is not a real use case.*

2.3 IGNSS Connection Setup

Follow the guidelines for NTN connection setup in this section if you are using the IGNSS/Static mode.

2.3.1 AT Commands Setup

Before attempting to establish a connection with the NTN network, the following initial settings must be configured on HL781x.

```
/*** Clear the preferred RAT, since automatic RAT selection currently is not supported for
NTN ***/
AT+KSELACQ=0,0

/*** Set RAT to NB-IoT NTN ***/
AT+KSRAT=3

/*** The default setting supports bands 23, 255, and 256 ***/
AT+KBNDCFG=3,C00000000000000000000000000000000000000000000000000000000400000

/*** Configure the APN (XXX), which depends on the SIM card used, and the PDN type for the
Non-IP service ***/
AT+CGDCONT=1,"Non-IP","XXX"

/*** Configure the positioning mode to IGNSS/Static. See Chapter 3.2 for details ***/
AT+KNTNCFG="POS","IGNSS","0"

/*** [Optional] Network Registration URC ***/
AT+CEREG=1

/*** The module needs to be reset to apply the configuration. ***/
AT+CFUN=1,1
```

2.3.2 Unsolicited Responses

Below is a sample flow of unsolicited responses after the AT Commands Setup.

```
/*** The module is searching NTN network.***/
+CEREG: 2

/*** The module switches off the cellular RF to prioritize the GNSS RF. The module is
searching for the GNSS network, which may take a while, potentially several minutes. ***/
+CEREG: 0

+CEREG: 2

/*** The module is connected to the NTN network when the first parameter is 1 ***/
+CEREG: 1,"0BB9","00019259",9
```

2.4 Manual Position Connection Setup

To retrieve a position manually in Manual/Static mode, refer to the following guidelines.

2.4.1 AT Commands Setup

```
/*** Clear prefer RAT ***/
AT+KSELACQ=0,0

/*** Set RAT to NB-IoT NTN ***/
AT+KSRAT=3

/*** The default setting supports bands 23, 255, and 256. ***/
AT+KBNDCFG=3,C000000000000000000000000000000000000000000000000000000000400000

/*** Configure the APN (XXX), which depends on the SIM card used, and the PDN type for the
Non-IP service ***/
AT+CGDCONT=1,"Non-IP","XXX"

/*** Configure the Manual/Static mode ***/
AT+KNTNCFG="POS","MANUAL","0"

/*** The module needs to be reset to apply the configuration. ***/
AT+CFUN=1,1
```

```
/*** Once SIB31 is retrieved, the UE position will be requested:***/
+KNTNEV: "POSREQ"

/*** Once the +KNTNEV: "POSREQ" is received, enter the UE position using WGS84 (see
chapter 3.1 for details). The following is just an example. It is recommended to enter
this command within 10 seconds after receiving +KNTNEV: "POSREQ".***/
AT+KNTNCMD="POS","48.825972","2.267738","85.6"

/*** Registered URC ***/
+CEREG: 1,"0BB9","00019259",9
```

2.5 Sending Small Data (<150 bytes)

Once the unit is attached to the network, data can be sent via Non-IP Data Delivery (NIDD) and IP. For details, refer to the following examples which uses NIDD.

Note: NIDD was the primary service available as part of the deployed NB-NTN services. Additionally, NIDD is well-suited for IoT devices, particularly for low-power, low-data-volume applications (such as water, gas, and electricity meters, environmental monitoring, and trackers). The availability of IP/UDP services depends on the operator's deployment strategy. Due to the high cost and inherent latency of NTN data, IP/TCP is generally not recommended and may not be available in many deployments.

2.5.1 UL NIDD

To send NIDD from the device to the network:

```
/*** On the device, send data using AT+CSODCP command ***/
AT+CSODCP=1,5,"0123456789",0,0
```

Parameter	Value in Example	Description
#0 (<cid>)	1	CID of PDP context to be used
#1 (<cpdata_length>)	5	Length in bytes of data to be sent
#2 (<cpdata>)	"0123456789"	Hexadecimal data in string format
#3 (<RAI>)	0	Release Assistance Indication, 0 meaning no information available Other values not tested
#4 (<type_of_user_data>)	0	0 means Regular data Other values not tested

2.5.2 DL NIDD

To send NIDD from the network to the device:

```
/*** Enable reporting of terminating data via the Control Plane ***/:
AT+CRTDCP=1
   /*** Check data has been received on the device through URC ***/
+CRTDCP: 1,5, "0102030405"
```

Parameter	Value in Example	Description
#0 (<cid>)	1	CID of PDP context to be used
#1 (<cpdata_length>)	5	Length in bytes of data to be received
#2 (<cpdata>)	"0102030405”	Hexadecimal data in string format

2.5.3 Detach for Manual/Dynamic Mode

Under manual/dynamic mode, it is highly recommended to enter the position before executing the detach command, such as AT+CFUN=0 or AT+CFUN=1,1.

When RRC is inactive, the position needs to be re-entered as explained in Position Configuration.

For example:

```
/*** Enter this AT command to configure position ***/
AT+KNTNCMD="POS","48.825972","2.267738","85.6"
/*** Detach ***/
AT+CFUN=0
```

2.6 RAT Switch

Automatic RAT switching between NTN and TN is not supported.

2.7 Power Saving

2.7.1 eDRX

The settings are the same as NB-IoT, including AT commands. For example:

```
/*** Set the eDRX cycle for 81.92 seconds.***/
AT+CEDRXS=1,5,5
```

2.7.2 PSM

The settings are the same as those for NB-IoT,including AT commands. For example:

```
/*** Set T3412 to 1 hour and T3324 to 20 seconds. ***/
AT+CPSMS=1,,,"00000110","00001010"
```

Note that if under manual and dynamic mode during TAU, the position request URC +KNTNEV: "POSREQ" will be shown. At this point the position must be updated manually using +KNTNCMD.

2.8 Troubleshooting

If the UE cannot find or attach to the network after setup, troubleshoot using the following steps:

1. Double-check your AT commands setup.
2. Ensure there is a good view of the sky.
3. Use at%meas="8" command to measure the signal quality. This should be at the range of around RSRP = -132, %MEAS: Signal Quality: RSRP = -132, RSRQ = -13, SINR = -2, RSSI = -118.

3: NTN AT Commands

Note: For the details and latest information on the following AT Commands, refer to the HL78xx AT Command Reference guide on the Source.

Important: ***%NTNCMD*** *and* ***%NTNCFG*** *commands have been deprecated and are no longer recommended for use.*

3.1 AT+KNTNCMD

This AT command is used to control the NTN feature, including setting the position under manual mode.

Write Command:

```
AT+KNTNCMD=<obj>,<param1>, <param2>,<param3>
```

Parameters:

<obj>

POS — Used to read/write position retrieval method. The configuration is read out if params1 and 2 are not specified.

<param1>

Latitude coordinate in degrees in WGS84 ("-90.0" - "90.0")

<param2>

Longitude coordinate in degrees in WGS84 ("-180.0" - "180.0")

<param3>

Altitude in meters from earth surface ("-5000.0" - "40000000.0")

3.2 AT+KNTNCFG

This AT command is used to configure the NTN feature parameters, including the position retrieval method.

Write Command:

```
AT+KNTNCFG=<obj>[,<param1>, <param2>]
```

Parameters:

<obj>

POS — Used to read/write position retrieval method. The configuration is read out if param1 and 2 are not specified.

<param1>

IGNSS — Internal GNSS to get UE position

MANUAL — Set UE position using +KNTNCMD

<param2>

0 — Static mode, position that has either been set or acquired will be used for the current power session.

1 — Dynamic mode, position is acquired for each Timing Advance computation.

3.3 AT Command Timeout

The NB-IoT NTN attach process will potentially take longer than a terrestrial procedure due to the TA calculations, RTT, and general latency in the system. Some AT commands may require additional time versus operating against terrestrial CAT-M and NB-IoT such as:

- AT+CFUN=1,1
- AT+CFUN=0

It is suggested that a timeout of up to 2 minutes be used to take into account the additional background operations.

If performing a firmware update, it is recommended to detach from the network using at+cfun=0 to ensure that NB-IoT NTN operation and its extended latencies do not interfere with the procedure.

4: RF Performance

4.1 Supported RF Bands/Connectivity

Table 4-1 details the bands that are currently assigned to the NB-IoT NTN operation globally. As with terrestrial networks, a suitable antenna should be chosen for the correct operation.

Table 4-1: HL781x Supported RF NB-IoT NTN Bands/Connectivity

Module	RF Band	Transmit (TX) Frequency (MHz)	Receive (Rx) Frequency (MHz)
HL7810 HL7812	NB-IoT NTN B23	2000-2020 MHz	2180-2200 MHz
	NB-IoT NTN B255[a]	1626.5-1660.5 MHz	1525-1559 MHz
	NB-IoT NTN B256	1980-2010 MHz	2170-2200 MHz

a. To ensure CE compliance near NB-IoT NTN band edges, the supported TX channel ranges do not include outer channels. Supported channel ranges are:
- B255: 1626.7 ~ 1659.9 MHz

4.2 Maximum Output Power

The HL781x module's NB-IoT NTN maximum transmitter output power for all bands in normal operation conditions (25°C) is specified in Table 4-2.

Since the RF power is the same between TN and NTN networks, the unit will not consume any more current when using NTN. Although the link budget is strained, it will probably be operating at higher transmit powers more often versus a TN.

Table 4-2: HL7810/HL7812 Conducted Tx Max Output Power Tolerances – NB-IoT NTN[a]

RF Band	Min	Typ	Max	Max Units	Notes
NB-IoT NTN B23/255/256	21.5	23	24.5	dBm	Power class 3

a. Under normal operating conditions (25°C)

4.3 Rx Sensitivity

The module's NB-IoT NTN receiver sensitivity is specified in the following tables.

Table 4-3: HL781x Typical Conducted NB-NTN RX Sensitivity[a]

RF Band	Typical Reference Sensitivity Level @ 95% of Maximum Throughput	
	@ +25°C (dBm)	3GPP Limit (dBm)
NB-IoT NTN B23	-113	-107.5[b]
NB-IoT NTN B255	-113	-108.2[c]
NB-IoT NTN B256	-113	-108.2[c]

a. For B23: Test conditions per 3GPP TS 36.521-1 v18.4: on DL Reference Measurement Channel defined
For B255/B256: Test conditions per 3GPP TS 36.102 v18.5: on DL Reference Measurement Channel defined
b. Displayed limits derived from 3GPP TS 36.521-1 v18.4, Table 7.3F.1.5-1, adjusted by +0.7 dB for measurement uncertainty.
c. 3GPP TS 36.102 v18.5 Table 7.3B-1

A: Appendix Title

A.1 References

- HL78xx AT Command Reference Guide
  Reference number: 41111821

A.2 Abbreviations

Table A-1: Acronyms and Definitions

Acronym or Term	Definition
API	Application Programming Interface
GEO	Geo stationary Earth Orbit
IGNSS	Internal GNSS
IP	Internet Protocol
LEO	Low Earth Orbit
MEO	Medium Earth Orbit
NIDD	Non IP Data delivery
NTN	Non Terrestrial Networks
PLMN	Public Land Mobile Network
PoC	Proof of Concept
RRC	Radio Resource Control
RTT	Round Trip Time
SIB	System Information Broadcast
TA	Timing Advance
TAU	Tracking Area Update
TCP	Transmission Control Protocol
TN	Terrestrial Networks
UDP	User Datagram Protocol
URC	Unsolicited Result Code