Operating Manual

nL400

400–480 MHz Narrowband Modem

Revision 0.20, November 18, 2009

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nL400 Regulatory Requirements

PLEASE READ THIS SECTION CAREFULLY

⚠️ WARNING:

To satisfy FCC RF exposure requirements for mobile transmitting devices, a separation distance is based on the above them ranging from 39 cm to 305 cm between the antenna of this device and persons during device operation. To ensure compliance, operations at closer than this distance is not recommended. The antenna used for this transmitter must not be co-located in conjunction with any other antenna or transmitter.

Antenna	Impedance (ohms)	Antenna Gain (dBi)	Minimum Separation Distance (cm)
Minimum Gain	50	0	24
Maximum Gain	50	18	192

⚠️ WARNING:

EQUIPMENT LABELING
The FCC and IC numbers depend on the model of the radio module. Do NOT use the Marketing Name of the product but the Model to distinguish the Certifications Numbers. This device has been modularly approved. The manufacturer, product name, and FCC and Industry Canada identifiers of this product must appear on the outside label of the end-user equipment.

SAMPLE LABEL REQUIREMENT for Model: nL400:

> **Contains:**
>
> **FCCID: NS909P30   IC : 3143A-09P30**

> **This device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) this device may not cause harmful interference, and (2) this device must accept any interference received including interference that may cause undesired operation.**

Contents

2. General

2.0   Product Overview

The nL400 is a high-performance embedded wireless data transceiver. Operating in the 400 - 480 MHz band, this narrowband module is capable of providing reliable wireless data transfer between almost any type of equipment which uses an asynchronous serial interface. The small-size and superior RF performance of this module make it ideal for many applications.

While a pair of nL400 modules can link two terminal devices ("point-to-point" operation); multiple modules can be used together to create a network of various topologies, including "point-to-multipoint" and "repeater" operation. Multiple independent networks can operate concurrently, so it is possible for unrelated communications to take place in the same or a nearby area without sacrificing privacy or reliability.

1.1 Features

Key features of the nL400 include:

- a serial I/O data port with handshaking and hardware flow control, allowing the nL400 to interface directly to any equipment with an asynchronous serial interface.
- ease of installation and use – the nL400 module uses a subset of standard AT style commands, very similar to those used by traditional telephone line modems.
- all units in a system are physically identical, and can be configured as a master, repeater or slave using the AT command set. No hardware modifications are required
- 32-bit of CRC error detection and auto re-transmit to provide accuracy and reliability of data.

- TDMA (time division multiple access) support, allowing multi-slave access in point-to-point mode.
- roaming ability, allowing repeaters and slaves to re-synchronize with a new master if the synchronization pulse from the original master is lost.

While the typical application for the nL400 is to provide a short- to mid-range wireless communications link between DTEs, it can be adapted to almost any situation where an asynchronous serial interface is used and data intercommunication is required.

2.1 Output Power Level

The Output Power Level determines at what power the nL400 transmits. The nL400's sensitive receiver can operate with very low power levels, so it is recommended that the lowest power necessary is used; using excessive power contributes to unnecessary "RF pollution".

Ideally, you should test the communications performance between units starting from a low power level and working upward until the RSSI is sufficiently high and a reliable link is established. The conditions will vary widely between applications, the output power settings can be calculated based on following information.

- Transmitter antenna gain

- Cable loss

- Effective radiated power (ERP) requirement by FCC Regulations

Power Setting = 36 – Antenna Gain – Cable Loss

The power setting must be no more than the above calculation value. Any higher is a violation of FCC rules. See IMPORTANT warning below.

Table 1 Output Power

Power Setting (dBm)	Approx. Output Power (mW)
0	1
20	100
21	125
22	160
23	200
24	250
25	320
26	400
27	500
28	630
29	800
30	1000
33	2000
35	3162
37	5000

3. Installation

3.0 Overview

Qualified and experienced personnel must carry out the installation, removal or maintenance of all antenna components.

The nL400 complies with FCC part 15 at the modular level for operation in the license-free 400 to 480MHz depending on the country of operation there maybe some band restrictions. This chapter provides guidelines for installing and deploying equipment which incorporates the nL400 module.

3.1 Estimating the Gain Margin

Successful communication between nL400 modules is dependent on three main factors:

- System Gain
- Path Loss
- Interference

System gain is a calculation in dB describing the performance to be expected between a transmitter-receiver pair. The number can be calculated based on knowledge of the equipment being deployed. The following four factors make up a system gain calculation:

1. Transmitter power (user selectable)

2. Transmitter gain (transmitting antenna gain minus cabling loss between the transmitting antenna and the nL400 module)

3. Receiver gain (Receiving antenna gain minus cabling loss between the receiving antenna and the module)

4. Receiver sensitivity (Specified as -108dBm on the nL400 module)

In the following illustration, the transmitting antenna has a gain of 6 dB, and the receiving antenna has a gain of 3 dB. The cable loss between the module and the antenna is 2 dB on both the transmitting and receiving side.
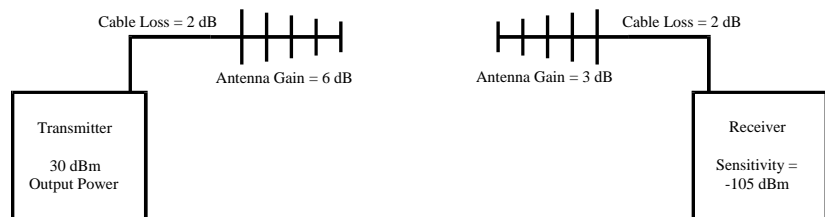
Cable Loss = 2 dB

Antenna Gain = 6 dB

Antenna Gain = 3 dB

Cable Loss = 2 dB

Transmitter

30 dBm
Output Power

Receiver

Sensitivity =
-105 dBm

Figure 1 Gain Calculation

The power level has been set to 30dBm (1W) on the transmitter, and the receiver sensitivity for the nL400 is -108dBm.

System gain would be calculated to be:

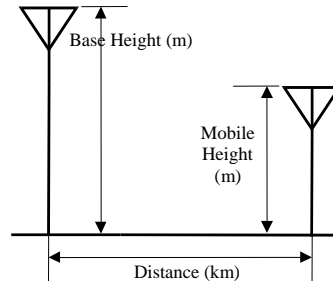30 - 2 + 6 + 3 - 2 + 108 = 143 dB.

Figure 2 System Deploying

When deploying your system, care must be taken to ensure the **path loss** (reduction of signal strength from transmitter to receiver in dB) between equipment does not exceed the system gain (140 dB in the above example). It is recommended to design for a **gain margin** of at least 20 dB to ensure reliable communication. Gain margin is the difference between system gain and path loss. Referring to the same example, suppose the path loss is 100 dB, the gain margin would be 40 dB, which is more than adequate for reliable communication.

Path loss is a very complicated calculation which mainly depends on the terrain profile, and the height of the antennas off the ground.

The following table provides path loss numbers for varying antenna heights and antenna separation: These numbers are real averages taken from rural environments. They do not apply to urban, non-line-of-sight environments.

Table 2 Path Loss

Distance (km)	Base Height (m)	Mobile Height (m)	Path Loss (dB)
5	15	2.5	116.5
5	30	2.5	110.9
8	15	2.5	124.1
8	15	5	117.7
8	15	10	105
16	15	2.5	135.3
16	15	5	128.9
16	15	10	116.2
16	30	10	109.6
16	30	5	122.4
16	30	2.5	128.8

Once the equipment is deployed, you can verify the signal strength by entering into Command Mode and reading Register S123. This register provides the average signal strength in dBm. The minimum strength for communication is roughly -108dBm. For consistent reliable communication, you should try to deploy the equipment such that signal strength exceeds -95dBm.

3.2 Antennas and Cabling

This section describes the recommended procedure for installing cabling and antennas for use with the nL400 module.

3.2.1 Internal Cabling

The most common method for installing the module is to run a cable from the module's MCX connector to a reverse TNC, N-female, or SMA bulkhead connector on the chassis of the equipment as shown in Figure 3. This cable can be purchased from Microhard Systems.
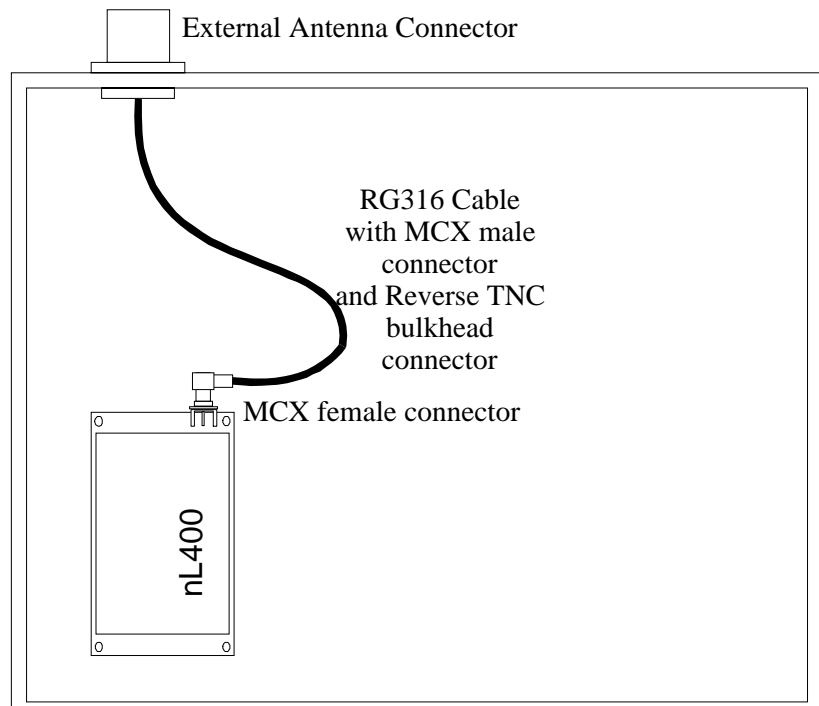
<div style="float: left; width: 30%;">

⚠ WARNING:

Qualified and experienced personnel must carry out the installation, removal or maintenance of all antenna components.

</div>

External Antenna Connector

RG316 Cable
with MCX male
connector
and Reverse TNC
bulkhead
connector

MCX female connector

nL400

Figure 3 Suggested Internal Cabling

Cable losses are negligible for the short piece used within the chassis. Additional losses up to 0.5 dB may be present in the MCX and Reverse TNC connections.

3.2.2   Installing External Cables, Antennas and Lightning Arrestors

Qualified and experienced personnel must carry out the installation, removal or maintenance of all antenna components. Never work on an antenna system when there is lightning in the area.

Direct human contact with the antenna is potentially unhealthy when the nL400 is generating RF energy. Always ensure that the nL400 equipment is powered down during installation. At all times a distance of shown below should be maintained between the antenna and any person when the device is in operation.

Antenna	Impedance (ohms)	Antenna Gain (dBi)	Minimum Separation Distance (cm)
Min Gain	50	0	39
Max Gain	50	18	305

Surge Arrestors

The most effective protection against lightning is to install two lightning (surge) arrestors, one at the antenna, the other one at the interface with the equipment. The surge arrestor grounding system should be fully interconnected with the transmission tower and power grounding systems to form a single, fully integrated ground circuit. Typically, both ports on surge arrestors are N-female.

External Filter

Although the nL400 is capable of filtering out RF noise in most environments, there are circumstances that require external filtering. Paging towers and cellular base stations in close proximity to the nL400 antenna can desensitize the receiver. Microhard Systems' external cavity filter eliminates this problem. The filter has two N-female ports and should be connected in line at the interface to the RF equipment.

Cabling

The following coax cables are recommended:

Table 3 Cable Loss

Cable	Loss (dB/100ft)
LMR 195	10.7
LMR 400	3.9
LMR 600	2.5

⚠ WARNING:

The nL400 can only be used with any antennas listed in Appendix A and this the antenna separations shown in Appendix A.

⚠ WARNING:

Be careful with dBi vs dBd gains on antenna specifications.

Antenna manufactures may not clearly indicate the gain on the antenna if it is dBd or dBi. Note 1dBd = 2.15dBi.

Factors to take into consideration when choosing a cable are:

- price;
- bend radius limitations (the lower performance cables generally can bend more sharply)
- performance requirements; and,
- distance between the equipment and the antenna.

When installing the cable, always begin fastening at the top near the antenna connector/surge arrestor. The cable must be supported at the top with a hose clamp or wrap lock, and at 5 ft intervals down the length of the tower. Over-tightening the fasteners will dent the cable and reduce performance. If properly grounded surge arrestors are not installed at both the top and the bottom of the cable, then the cable should be grounded to the tower at these locations using a cable grounding kit. If the tower is non-conductive, then a separate conductor, physically separate from the cable, should be run down the tower.

Antenna

Before choosing an antenna, you should have some knowledge of the path loss and the topology of the equipment. If the equipment is in a fixed location and is to communicate with only one other unit also in a fixed location, then a Yagi antenna is suitable. Choose a Yagi with enough gain to ensure adequate gain margin. When deploying the Yagi, point the antenna towards the intended target, ensuring the antenna elements are perpendicular to the ground for vertical polarization.

In applications where there are multiple units that you must communicate with or units, which are in motion, you may select an Omni-directional antenna with appropriate gain.

See appendix A for a list of approved antennas types that can be used with the nL400 radio modem. If you require another type of antenna please contact Microhard Systems Inc.

Microhard Systems Inc. can provide you with approved antennas to ensure FCC and Industry Canada compliance.

ERP is calculated as follows:

ERP = Tx Power(dBm) - Cable/Connector Loss(dB) + Ant Gain(dBi)

Antenna Gains must be in dBi when calculating the 36dBm ERP limit.

1dBd = 2.15dBi

Use the guidelines in the previous section for calculating cable and connector losses. If cabling and connector losses are 2 dB, then the maximum allowable gain of the antenna will be 8 dB.

A. Antenna / Separations

Antenna	Impedance (ohms)	Antenna Gain (dBi)	Minimum Separation Distance (cm)
Minimum Gain	50	0	24
Maximum Gain	50	18	192

RF EXPOSURE DISTANCE LIMITS

$$r = \sqrt{\frac{P \cdot G}{4 \cdot \pi \cdot S}} = \sqrt{\frac{EIRP}{4 \cdot \pi \cdot S}}$$

Sample calculation:

S = 406.1/1500 mW/cm^2

EIRP = 51 dBm $= 10^{55/10}$ mW = 125893 mW (Worst Case)

$$(\text{Minimum Safe Distance, r}) = \sqrt{\frac{EIRP}{4 \cdot \pi \cdot S}} = \sqrt{\frac{125893}{4 \cdot \pi \cdot (406.1/1500)}} \approx 192cm$$

⚠ WARNING:
Changes or modifications not expressly approved by Microhard Systems Inc. could void the user's authority to operate the equipment. Please Contact Microhard Systems Inc. if you need more information.

⚠ WARNING:
To satisfy FCC RF exposure requirements for mobile transmitting devices, a separation distance is based on the above them ranging from 24 cm to 192 cm between the antenna of this device and persons during device operation. To ensure compliance, operations at closer than this distance is not recommended. The antenna used for this transmitter must not be co-located in conjunction with any other antenna or transmitter.