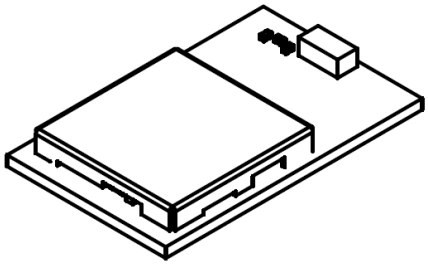

GEM3 Dual Band Bluetooth and ANT+ Module

Hardware Integration Guide
Version 0.1
January 9, 20

North Pole Engineering
221 N 1st St, Minneapolis, MN 55401
www.npe-inc.com
612.305.0440

Revision History

Version	Revision Date	Change History
0.1	07/27/2019	Initial Draft

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CONTENTS

1 OVERVIEW AND KEY FEATURES

The GEM3 module has been designed to allow OEMs to easily add Bluetooth and ANT+ wireless connectivity in their product offering. The GEM3 module incorporates North Pole Engineering software specifically designed to enable fitness machines such as treadmills, exercise bikes, ellipticals, rowers, stair climbers and step machines, etc. to wirelessly communicate exercise data with smart phones or tablets as well as leaderboard software systems. For applications other than fitness machines, developer's can use Nordic Semiconductor's SDK to create their own embedded application specific software.

The GEM3 module is based on Nordic Semicondutor's nRF52840 multiprotocol Bluetooth and ANT+ chipset with 1 MB of flash and 256kB of RAM. The GEM3 module offers a variety of peripheral interfaces including USB, NFC, UART, SPI, I2C, ADC, and GPIO, has a maximum transmit power of +8dBm, and a sensitivity of -103dBm. This manual is intended to assist hardware integration of the GEM3 module into a given design. Details on North Pole Engineering GEMSAFE and GEMHCI software can be found http://npe-inc.com For applications using Nordic Semiconductor SDK, please refer to Nordic Semiconductor's SDK available at developer.nordicsemi.com.

1.1 FEATURES

- -103 dBm sensitivity
- TX Power-20 to +8dBm in 4dB steps
- 600m line of sight range @ +8dBm ,125Kbps(coded) phy
- 4.8 mA peak TX @ 0dB
- 4.6 mA peak RX
- 1dB dB RSSI resolution
- ARM® Cortex™M4 32 bit processor running at 64MHz
- 1 MB embedded flash memory and 256 kB RAM
- Onboard NFC for Out of Band pairing
- Peripheral Interfaces: USB, QSPI, PPI, ADC, GPIO, SPI, I2C, UART, I2S, PWM, QDEC, Low power comparator, Temperature sensor.
- AES HW encryption
- FCC, CE, IC, China, South Korea, and Japan certified
- Integrated Antenna
- RoHS compliant
- Bluetooth End Product Listed
- Integrated Fitness Equipment Firmware and mobile application

2 SPECIFICATION

2.1 SPECIFICATION SUMMARY

Category	Feature	Implementation
RF	Bluetooth ANT+ Frequency Maximum Transmit Power Minimum Transmit Power Receive Sensitivity	4.2 Single Mode Peripheral Broadcast 2.402-2.480 GHz +8dBm -20dBm -103dBm
RF Range	0 dBm, 1M Phy, 1.82m ht. 0 dBm, Coded Phy, 1.82m ht. +8 dBm, 1M Phy, 1.82m ht. +8 dBm, Coded Phy, 1.82m ht.	Up to 240m line of sight Up to 320m line of sight Up to 360m line of sight Up to 600m line of sight
Peripherals	UART Host Interface GPIO	TX, RX 115.2kbps 8,N,1 Link Indicator Pairing Button
FW Upgrade	North Pole Engineering Firmware	Over the air Via JTAG interface
Control Protocol	GEMSAFE or GEMHCI	CSAFE Command Interface or GEM HCI binary command interface
Supply Voltage	Min Max Recommended	1.7V 5.5V 3.3V
Power Consumption		Radio transmitting @+8dBm 15mA @ 3.3v Radio transmitting @ 0dBm 6.2mA # 3.3v
Physical		13.0 mm x 21.0 mm
Environmental		-40 to +85C
Approvals		FCC, IC, CE, China, South Korea, Japan, and Bluetooth EPL

3.2 PIN DEFINITIONS

Pin Number	Pin Name	Function	Comment
1	GND	GND	Connect to GND Plane
2	P0.03/AIN1	Host configurable I/O	Low Speed GPIO
3	P0.28/AIN4	Host configurable I/O	Low Speed GPIO
4	P0.29/AIN5	Host configurable I/O	Low Speed GPIO
5	P0.02/AIN0	Host configurable I/O	Low Speed GPIO
6	P0.31/AIN7	Host configurable I/O	Low Speed GPIO
7	P0.30/AIN6	Host configurable I/O	Low Speed GPIO
8	P0.05/AIN3	Host configurable I/O	
9	P0.27	Host configurable I/O	
10	P0.07/TRC_CLK	Host configurable I/O	
11	P0.26	Host configurable I/O	
12	P0.04/AIN2	Host configurable I/O	
13	P0.06	Host configurable I/O	
14	GND	GND	Connect to GND Plane
15	P0.08	Host configurable I/O	
16	P0.11/TRC_D2	Host configurable I/O	
17	P0.12/TRC_D1	Host configurable I/O	
18	P0.00/XL1	32.768 kHz Crystal	
19	P0.01/XL2	32.768 kHz Crystal	
20	P0.16	UART Module TX	See Section 4.1.3 Host Interface
21	P0.14	UART Module RX	See Section 4.1.3 Host Interface
22	VDD_HV	Module Power High Voltage Mode / Low voltage detect	
23	D+	USB DATA POS	See Section 4.1.4 USB Interface
24	D-	USB DATA NEG	See Section 4.1.4 USB Interface
25	VBUS	USB VBUS	See Section 4.1.4 USB Interface
26	VDD_nRF	Module Power Normal Mode / Voltage output HV Mode	See Section 4.1.1 VDD_nRF
27	GND	GND	Connect to GND Plane
28	P0.18/RESET/QCSN	Host configurable I/O	
29	P0.19_QSCK	Host configurable I/O	
30	P0.20	Host configurable I/O	

31	P0.21/QSPI	Host configurable I/O	
32	P0.23/QSPI	Host configurable I/O	
33	P0.25	Host configurable I/O	
34	P0.24	Host configurable I/O	
35	P0.22/QSPI	Host configurable I/O	
36	SWDIO	SWD Programmer I/O	See Section 4.1.2 Updating Module Firmware
37	SWDCLK	SWD Programmer Clock	See Section 4.1.2 Updating Module Firmware
38	P0.09/NFC1	NFC antenna input 1	See Section 4.1.5 NFC
39	P0.10/NFC2	NFC antenna input 2	See Section 4.1.5 NFC
40	GND	GND	Connect to GND Plane
41	P1.06	Host configurable I/O	Low Speed GPIO
42	P1.04	Host configurable I/O	Low Speed GPIO
43	P1.07	Host configurable I/O	Low Speed GPIO
44	P1.05	Host configurable I/O	Low Speed GPIO
45	P1.00/TRC_D0	Host configurable I/O	
46	P1.02	Host configurable I/O	Low Speed GPIO
47	P1.01	Host configurable I/O	Low Speed GPIO
48	GND	GND	Connect to GND Plane
49	P0.13	Host configurable I/O	
50	P0.15	Host configurable I/O	
51	P0.17	Host configurable I/O	
52	P1.03	Host configurable I/O	Low Speed GPIO
53	P1.09/TRC_D3	Host configurable I/O	
54	P1.08	Host configurable I/O	
55	P1.15	Host configurable I/O	Low Speed GPIO
56	P1.14	Host configurable I/O	Low Speed GPIO
57	P1.13	Host configurable I/O	Low Speed GPIO
58	P1.12	Host configurable I/O	Low Speed GPIO
59	P1.10	Host configurable I/O	Low Speed GPIO
60	P1.11	Host configurable I/O	Low Speed GPIO

3.3 ELECTRICAL SPECIFICATIONS

3.3.1 Absolute Maximum ratings

Parameter	Min	Max
VDD_nRF	-0.3V	+3.9V
VDD_HV	-0.3V	+5.8V
VBUS	-0.3V	+5.8V
VIO, VDD_nRF <= 3.6V	-0.3V	VDD+0.3V
VIO, VDD_nRF > 3.6V	-0.3V	3.9V
Storage Temperature	-40C	+85C

3.3.2 Recommended Operating Parameters

Parameter	Min	Typical	Max
VDD_nRF	1.7V	3.0V	3.6V
VDD_nRF maximum ripple			10mV
VDD_nRF Rise time			60ms
Operating Temperature	-40C		+85C

4 DESIGN CONSIDERATIONS

The GEM3 module has been designed for easy integration into OEM applications requiring minimal additional componentry. The following section provides suggestions to ensure successful integration of the GEM3 module.

4.1 HARDWARE

4.1.1 VDD_nRF

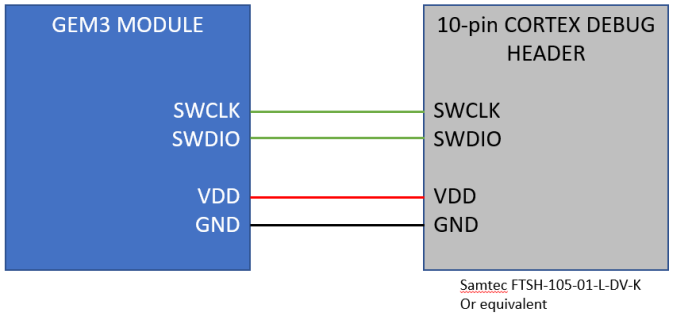
Ensure the power source operating range and noise is within the specified limits for the GEM3 module and filter capacitors are incorporated as needed. The GEM3 module includes decoupling capacitors for circuits within the module. External circuits sharing the same power source should also be decoupled locally at connections to VDD_nRF and GND.

4.1.2 Updating Module Firmware

The GEM3 module firmware can be updated over the air using the North Pole Engineering utility application. The North Pole Engineering utility application can be downloaded here: www.xxxx.yyy.com

The GEM3 module firmware can also be updated through the Serial Wire Debug interface. The following circuit example provides a reference for developers wanting an alternative to programming the GEM3 module over the air:

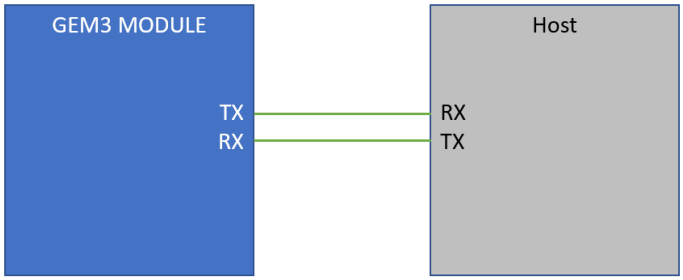
North Pole Engineering
221 N 1st St, Minneapolis, MN 55401
www.npe-inc.com
612.305.0440



Serial Wire Debug Interface

4.1.3 UART Host

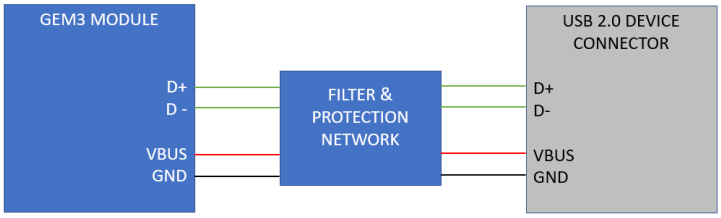
The UART is required for communicating between the GEM3 module and fitness machine console using the GEMSAFE or HCI command protocol. Pins 20 and 21 of the GEM3 module have been configured as the UART interface. Pin 20 is the GEM3 module TX line that connects to the Host RX line. Pin 21 is the GEM3 module RX line that connects to the Host TX line.



UART Host

4.1.4 USB

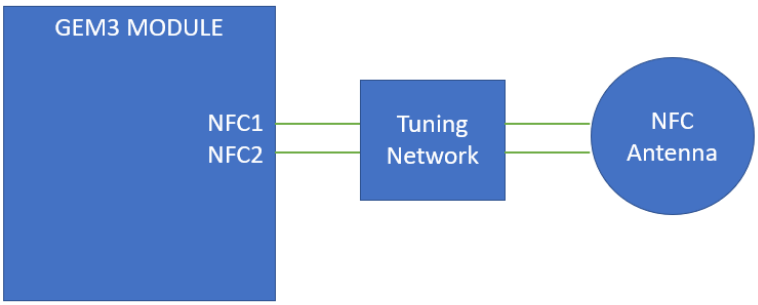
Integrated (on-module) USB transceiver (PHY). The USB device (USBD) controller implements a full speed USB device function that meets 2.0 revision of the USB specification.



USB

4.1.5 NFC

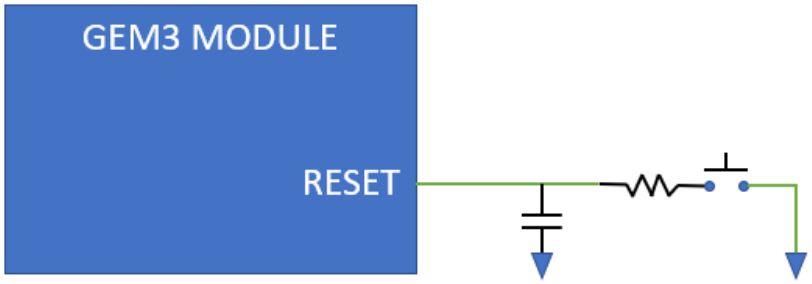
The GEM3 contains a 13.56 MHz AM receiver and a 13.56 MHz load modulator compatible with the NFC-A listen mode operation defined in the NFC Forum with 106 kbps data rate. The GEM3's NFC-A support allows for Out-of-Band (OOB) pairing simplifying pairing between two Bluetooth devices by exchanging authentication information over an NFC link.



NFC

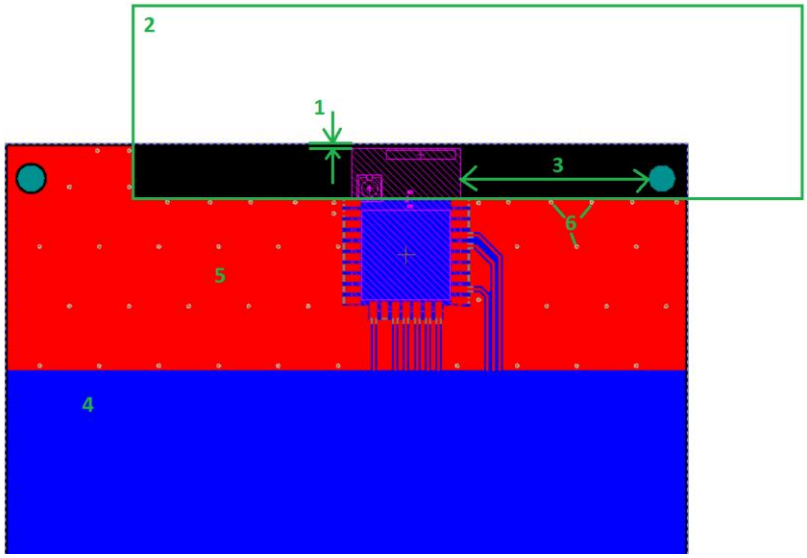
4.1.6 Reset

The GEM3 module can be reset by holding PIN 25 low for 0.5us. The following is an example reset circuit:



Example Reset Circuit

5 MODULE LAYOUT CONSIDERATIONS



1. Good: Place the module antenna side as close as possible to the board edge.
   Better: Allow the module antenna area to overhang the edge of the board by ~6.0mm.

2. Good: Define a copper keepout area approx. 53mm x 20mm, 6mm in from module edge. Better: Increase the keepout area, starting at 6mm in from module edge.

3. Mechanical items (especially metal) should be kept as far as possible from the module antenna in all directions, including above and below the board surface. If possible, move mechanical items out and away from the keepout area.

4. Bottom layer ground plane under the module strongly recommended. Connect all ground pins directly to ground plane.

5. Top layer ground plane is good to have wherever practical, but avoid having copper directly under the module.

6. Place Via stitching where both top and bottom layer ground planes are used, especially along the plane edges adjacent the module.

Top-side area directly under the module should be kept clear of copper, silkscreen and vias

6 MECHANICAL INFORMATION

7 SOLDERING GUIDELINES

See the Stencil pattern above for solder paste application. Recommended Stencil thickness is 120um.

8 REGULATORY & STANDARDS INFORMATION

8.1 FCC & INDUSTRY CANADA

The GEM3 module has modular approval for the United States and Canada. To ensure compliance when using the GEM3 module in a design, the OEM is required to adhere to the implementation considerations supplied in this hardware integration guide.

8.1.1 Federal Communication Commission (FCC) Radiation Exposure Statement:

This device is in compliance with SAR for general population/uncontrolled exposure limits in ANSI/IEEE C95.1-1999 and had been tested in accordance with the measurement methods and procedures specified in OET Bulletin 65 Supplement C.

This transceiver must not be co-located or operating in conjunction with any other antenna, transmitter, or external amplifiers. Further testing / evaluation of the end product will be required if the OEM's device violates any of these requirements.

The GEM3 Module is fully approved for mobile and portable applications.

8.1.2 FCC/IC Labeling Requirements

WARNING: The OEM must ensure that FCC labeling requirements are met. This includes a clearly visible label on the outside of the OEM enclosure specifying the appropriate FCC / IC identifier.

Contains FCC ID: XRH-NPE105
IC: 11922A- NPE105

If OEM device is larger than 8x10cm, the following FCC part 15.19 statement has to be visible on outside of device:

The enclosed 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.

Label and text information type should be large enough to be legible and consistent with the dimensions of the equipment and the label. The type size is not required to be larger than eight points.

Comments
The OEM should have their device tested by a qualified test house to verify compliance with FCC Part 15 Subpart B limits for unintentional radiators.

Any modifications to the GEM3 module could void the OEM's authority to operate the equipment.

This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does not cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to correct the interference by one or more of the following measures:

- Re-orient or relocate the receiving antenna
- Increase the separation between the equipment and the receiver
- Connect the equipment to an outlet on a circuit that is different from that to which the receiver is connected.
- Consult the dealer or an experienced radio/TV technician for help.

8.1.3 FCC Warning:

"THIS DEVICE COMPLIES WITH PART 15 OF THE FCC RULES AND INDUSTRY CANADA LICENSE-EXEMPT RSS STANDARD(S). 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.

8.1.4 Industry Canada (IC) Warning:

This device complies with Industry Canada license-exempt RSS standard(s). Operation is subject to the following two conditions: (1) this device may not cause interference, and (2) this device must accept any interference, including interference that may cause undesired operation of the device.

French equivalent:
Le présent appareil est conforme aux CNR d'Industrie Canada applicable aux appareils radio exempts de licence. L'exploitation est autorisée aux deux conditions suivantes : (1) l'appareil ne doit pas produire de brouillage, et (2) l'utilisateur de l'appareil doit accepter tout brouillage radioélectrique subi, même si le brouillage est susceptible d'en compromettre le fonctionnement.

IC Radiation Exposure Statement

This device is in compliance with SAR for general population/uncontrolled exposure limits in IC RSS-102 and had been tested in accordance with the measurement methods and procedures specified in IEEE 1528.

REMARQUE IMPORTANTE
Déclaration IC d'exposition aux radiations Ce EUT est conforme avec SAR pour la population générale / limites d'exposition non contrôlée à IC RSS-102 et a été testé en conformité avec les méthodes de mesure et procédures spécifiées dans la norme IEEE 1528.

Modular Approval
OEM is still responsible for testing their product for any additional compliance requirements required with this module installed (for example, digital device emissions, PC peripheral requirements, etc.).

Approbation modulaire
OEM intégrateur est toujours responsable de tester leur produit final pour les exigences de conformité supplémentaires nécessaires à ce module installé (par exemple, les émissions de périphériques numériques, les exigences de périphériques PC, etc.)

IMPORTANT NOTE:
In the event that these conditions cannot be met (for example certain laptop configurations or co-location with another transmitter), then the Canada authorization is no longer considered valid and the IC ID cannot be used on the final product. In these circumstances, the OEM integrator will be responsible for re-evaluating the end product (including the transmitter) and obtaining a separate Canadian authorization.

NOTE IMPORTANTE:
Dans le cas où ces conditions ne peuvent être satisfaites (par exemple pour certaines configurations d'ordinateur portable ou de certaines co-localisation avec un autre émetteur), l'autorisation du Canada n'est plus considéré comme valide et l'ID IC ne peut pas être utilisé sur le produit final. Dans ces circonstances, l'intégrateur OEM sera chargé de réévaluer le produit final (y compris l'émetteur) et l'obtention d'une autorisation distincte au Canada.

Le produit final doit être étiqueté dans un endroit visible avec l'inscription suivante: " GEM3 Module Contient des IC: 11922A- NPE105"

8.2 CE

*** Update EN numbers once testing is complete ***
The GEM3 Module has been tested against the appropriate regulatory standards for European market. OEMs should consult a qualified test house to ensure their product meets all regulatory requirements.

The GEM3 Module Declaration of Conformities is below. Test reports are available upon request.

Health and Safety – EN60950-1: 2006+A11:2009+A1:2010+A12:2011

Electromagnetic compatibility – EN301489-17 V3.1.1 in accordance with EN 301 489-1 V2.1.1

Radio Frequency Radiated Emissions: EN300 328 V2.1.1

Human exposure to electromagnetic fields: EN62479:2010

North Pole Engineering declares under our sole responsibility that the essential radio tests have been carried out and that the GEM3 Module to which this declaration relates is in conformity with all applicable essential requirements of Directives 2014/53/EU and 2015/863/EU when used for its intended purpose.

Place of Issue: North Pole Engineering
221 N 1st Street, Suite 310
Minneapolis, MN 55401
+1-612-305-0440

8.3 BLUETOOTH QUALIFICATION

The GEM3 module has been listed with the Bluetooth Special Interest Group (SIG) as a qualified an End Product.

The Bluetooth SIG requires every product implementing Bluetooth technology to have a Declaration ID even though the end product references a Bluetooth design with its own Declaration ID.

An over of the Bluetooth SIG Qualification Process is as follows:

1. Register as a member of the Bluetooth SIG – www.bluetooth.org
2. Go to product listing page https://www.bluetooth.org/en-us/test-qualification/qualification-overview
3. Go to Create a Listing: https://www.bluetooth.org/tpg/QLI_SDoc.cfm
4. In the area "Reference a Qualified Design, Enter End Product ID: 77930
5. Select your Declaration ID or Purchase a Declaration ID. Fees for Declaration IDs vary based on Bluetooth SIG membership level.
6. Once you have completed your listing and paid your declaration fee, your design will be listed on the Bluetooth SIG website.

You can find more details on the Bluetooth SIG listing process at the following webpage: https://www.bluetooth.org/en-us/test-qualification/qualification-overview

9 ORDERING DETAILS

Part Number	Reel Size	MOQ	Multiple
GEMSRB030X	500 pieces	500	500

10 FURTHER ASSISTANCE

Please contact North Pole Engineering at 1-612-305-0440 or via email at sales@npe-inc.com if additional help is needed.

FCC Statement

This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to part 15 of the FCC rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

-Reorient or relocate the receiving antenna.

-Increase the separation between the equipment and receiver.

-Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.

-Consult the dealer or an experienced radio/TV technician for help.

To assure continued compliance, any changes or modifications not expressly approved by the party.

Responsible for compliance could void the user’s authority to operate this equipment. (Example- use only shielded interface cables when connecting to computer or peripheral devices).

This equipment 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.

FCC Radiation Exposure Statement:

This equipment complies with FCC radiation exposure limits set forth for an uncontrolled environment. End users must follow the specific operating instructions for satisfying RF exposure compliance.

Note 1: This module certified that complies with RF exposure requirement under mobile or fixed condition, this module is to be installed only in mobile or fixed applications.

A mobile device is defined as a transmitting device designed to be used in other than fixed locations and to generally be used in such a way that a separation distance of at least 20 centimeters is normally maintained between the transmitter's radiating structure(s) and the body of the user or nearby persons. Transmitting devices designed to be used by consumers or workers that can be easily re-located, such as wireless devices associated with a personal computer, are considered to be mobile devices if they meet the 20 centimeter separation requirement.

A fixed device is defined as a device is physically secured at one location and is not able to be easily moved to another location.

Note 2: Any modifications made to the module will void the Grant of Certification, this module is limited to OEM installation only and must not be sold to end-users, end-user has no manual instructions to remove or install the device, only software or operating procedure shall be placed in the end-user operating manual of final products.

Note 3: Additional testing and certification may be necessary when multiple modules are used.

Note 4: The module may be operated only with the antenna with which it is authorized. Any antenna that is of the same type and of equal or less directional gain as an antenna that is authorized with the intentional radiator may be marketed with, and used with, that intentional radiator.

Note 5: To ensure compliance with all non-transmitter functions the host manufacturer is responsible for ensuring compliance with the module(s) installed and fully operational. For example, if a host was previously authorized as an unintentional radiator under the Supplier’s Declaration of Conformity procedure without a transmitter certified module and a module is added, the host manufacturer is responsible for ensuring that the after the module is installed and operational the host continues to be compliant with the Part 15B unintentional radiator requirements. Since this may depend on the details of how the module is integrated with the host, North Pole Engineering. shall provide guidance to the host manufacturer for compliance with the Part 15B requirements.

Note 6: FCC ID label on the final system must be labeled with “Contains FCC ID: XRH-NPE105” or “Contains transmitter module FCC ID: XRH-NPE105”

IC Radiation Exposure Statement:

This device and its antenna(s) must not be co-located with any other transmitters except in accordance with IC multi-transmitter product procedures. Referring to the multi-transmitter policy, multiple-transmitter(s) and module(s) can be operated simultaneously without reassessment permissive change.

Cet appareil et son antenne (s) ne doit pas être co-localisés ou fonctionnement en association avec une autre antenne ou transmetteur.

This equipment complies with IC RSS-102 radiation exposure limits set forth for an uncontrolled environment. This equipment should be installed and operated with minimum distance 20cm between the radiator & your body.

Cet équipement est conforme aux limites d'exposition aux rayonnements IC établies pour un environnement non contrôlé. Cet équipement doit être installé et utilisé avec un minimum de 20cm de distance entre la source de rayonnement et votre corps.

This module is limited to OEM installation only and must not be sold to end-users, end-user has no manual instructions to remove or install the device, only software or operating procedure shall be placed in the end-user operating manual of final products. Additional testing and certification may be necessary when multiple modules are used.

Any changes or modifications not expressly approved by the manufacturer could void the user's authority to operate this equipment.

The final end product must be labeled in a visible area with the following " Contains IC: 11922A-NPE105".

Any Changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment