Application Guide

TWIG V UNO Module 13732

Nelson Irrigation Corporation

Document Revision: A

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1. Introduction

1.1. Purpose and Scope

The purpose of this document is to provide details regarding the use of the TWIG V UNO 13732 module. It covers all certified off module antenna options, which consist of an on-board PCB antenna, Yagi, and omni antennas. and is intended to be used by an OEM for incorporating the TWIG V UNO module into an end product. It will inform the designer as to the details required to retain the modular certification for the TWIG V UNO 13732 module.

1.2. Applicable Documents

a. U.FL to RPSMA Cable Jack Bulkhead, Pigtail 20 cm (L-Com #CA-UFLRSBQC20 datasheet)

b. RPSMA Plug to N-Male, Pigtail 10 ft CA-195 coax (L-Com #CA-RSPNMA010 datasheet)

c. Yagi Antenna (L-Com # HG912YE-NF datasheet)

d. Yagi Antenna (L-Com # HG909Y-NF datasheet)

e. Omni Antenna (L-Com #HG906UP-NF datasheet)

1.3. List of Rules

The FCC rules governing this module are found in 47 CFR § 15.247.

2. Operational Use Conditions

The modular transmitter is only FCC authorized for specific rule parts (i.e. FCC transmitter rules) listed on the grant. The host product manufacturer is responsible for compliance to any other FCC rules that apply to the host not covered by the modular transmitter grant of certification.

The TWIG V UNO module is designed to be used for outdoor agricultural and industrial applications. The module should be installed in an enclosure that protects the module from moisture.

The TWIG V UNO module radio network is generally intended to be used with antennas that are vertically polarized. The TWIG V module may be mounted as shown in figure 1 below when using the internal antenna:
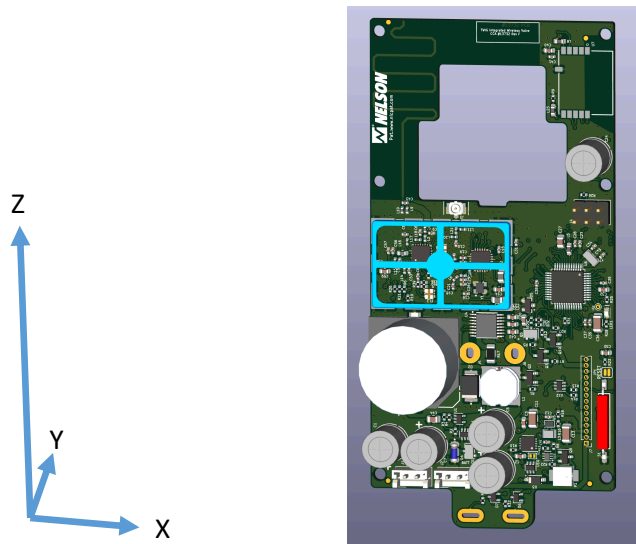
Figure 1. Using Internal Antenna in a Vertical Orientation.

All external antennas used with the TWIG V UNO module should be connected in a manner outlined in chapter 6 of this manual.

The firmware in the TWIG V module enables the wireless transceiver to operate using LoRa$^{®}$ modulation using a spreading factor of eight using a 500 KHz bandwidth. The transmit power is set to 24 dBm. The wireless transceiver is configured to operate on any of 49 channels, with channel 2 centered at 903.0 MHz and channel 50 centered at 927.0 MHz.

3. RF Exposure Considerations

The maximum transmit duty cycle for the TWIG V module is 25%. For safe operation, persons should maintain a distance greater than 20 cm from any antenna that is connected to the TWIG V UNO module.

4. Module and Accessories

Part Number	Description
Nelson Irrigation Corporation #13732	Module with factory firmware. At the factory, the module is assigned a permanent and unique ID after it is integrated into its enclosure. This unique ID also specifies its type. The factory firmware utilizes the unique ID to determine how the module functions within the radio network. At the factory, the module is assigned a permanent antenna assignment (either internal or external).
L-Com #CA-UFLRSBQC20	U.FL to RPSMA Jack Bulkhead, Pigtail 20 cm
L-Com #CA-RSPNMA010	RPSMA Plug to N-Male, Pictail 10 ft CA-195 coax
L-Com #HG912YE-NF	Yagi Antenna, 12 dBi. Must be installed in a VERTICAL orientation
L-Com #HG909Y-NF	Yagi Antenna, 9 dBi. Must be installed in a VERTICAL orientation
L-Com #HG906UP-NF	Omin Antenna, 6 dBi. Must be installed in a VERTICAL orientation

5. Specifications

Network Frequency Range	902 – 928 MHz
Channels	49 (Channel 2 = 903.0 MHz …. Channel 50 = 927.0 MHz)
Output Power	24 dBm
Modulation Type	LoRa® i.e. a proprietary spread spectrum modulation scheme that is derivative of Chirp Spread Spectrum modulation
External Antenna Connector	U.Fl. 50 ohms
Internal Antenna Type	PCB meandered monopole
Nominal Bandwidth	500 KHz
Spreading Factor	8

DC Voltage Input Range	1.8 to 5.5 volts for module; on-board buck/boost power supply maintains 2.0 volts to the RF portion (VCC)
Setup Interface and Protocol	BLE 4.1
Debug/Programming Port Interface	Debug: Async Serial 230,400 baud, 8/n/1 … 3.3V tolerant Programming: Atmel-ICE
Console Port Interface	Async Serial 115,200 baud, 8/n/1 … 3.3V tolerant
Motor Port	DC pulse, peak 14.5 volts for 120 msec. Energy limit to 0.4 joules.
Verify Connector Interface	2.0V TTL inputs with diode protection and current limiting

6. Approved Antennas

6.1. PCB Antenna specification

The internal antenna configuration for the module utilizes a PCB meandered monopole. The monopole has the dimensions shown below and has a trace width of 0.5mm:
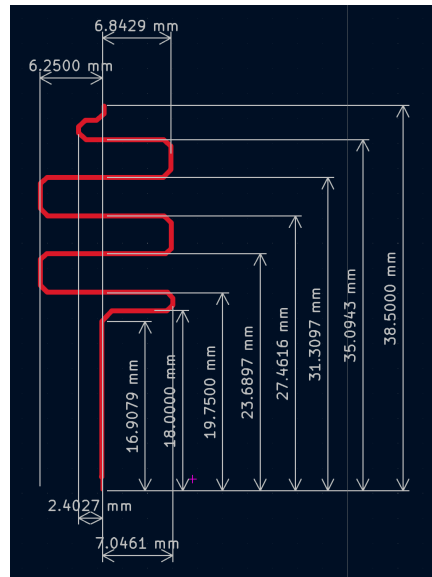
The printed circuit board has the following stack up:

LAYER	TYPE	MATERIAL	THICKNESS
F.SILKSCREEN	TOP SILK SCREEN	NOT SPECIFIED	
F.PASTE	TOP SOLDER PASTE		
F.MASK	TOP SOLDER MASK	NOT SPECIFIED	0.01mm
TOP	COPPER		1 oz
DIELECTRIC 1	CORE	FR4	.48mm
ROUTE2	COPPER		1 oz
DIELECTRIC 2	PREPEG	FR4	.48mm
ROUTE15	COPPER		1 oz
DIELECTRIC 3	CORE	FR4	.48mm
BOTTOM	COPPER		1 oz
B.MASK	BOTTOM SOLDER MASK	NOT SPECIFIED	.01mm
B.PASTE	BOTTOM SOLDER PASTE		
B.SILKSCREEN	BOTTOM SILK SCREEN	NOT SPECIFIED	

PCB PHYSICAL STACK UP

The antenna trace is on the top layer only. The overall board thickness is 0.062" with a tolerance of +/-10%. The remaining layers should be copper-free starting from the base of the antenna and out to a distance of 2 cm off the side of the antenna.

6.2. External Antenna Connector

The external antenna configuration utilizes an on-board a U.FL connector (J3). The outside enclosure must have an RPSMA bulkhead connector. This requirement is satisfied by using a U.FL to RPSMA bulkhead patch cable.

6.3. Yagi Antenna Specifications

Model	HG912YE-NF
Frequency	824 – 960 MHz
Gain	12 dBi
Polarization	VERTICAL
Horizontal Beam Width	43 degrees
Vertical Beam Width	36 degrees
Front to Back Ratio	18 dB
Impedance	50 ohms
Connector	N-Female

Model	HG909YE-NF
Frequency	824 – 960 MHz
Gain	9 dBi
Polarization	VERTICAL
Horizontal Beam Width	53 degrees
Vertical Beam Width	42 degrees
Front to Back Ratio	15 dB
Impedance	50 ohms
Connector	N-Female

6.4. Omni Antenna Specification

Model	HG906UP-NF
Frequency	902-928 MHz
Gain	6 dBi
Polarization	VERTICAL
Horizontal Beam Width	360 degrees
Vertical Beam Width	15 degrees
Impedance	50 ohms
Connector	N-Female

7. Regulatory Compliance

This chapter describes the current approval status of certification in each country and the regulatory requirements that must be met when using the TWIG V UNO in an end-product.

7.1. Country approvals

The TWIG V UNO module will be certified for various countries including the USA and Canada. Each market has its own regulatory requirements that must be fulfilled. The module integrator must ensure that the requirements are met in the end-product.

7.2. FCC/ISED compliance

The TWIG V UNO module may [has] receive[d] Federal Communications Commission (FCC) CFR47 Telecommunications, Part 15 Subpart C "Intentional Radiators" modular approval in accordance with Part 15.247 Modular Transmitter approval.

Any changes or modifications may cause the module to not comply with the FCC rules part 15 thus void the user's authority to operate the equipment. The FCC-ID is ZH6-TWIGVUNO and the IC ID is 9686A-TWIGVUNO.

7.2.1. FCC compliance statements

Federal Communication Commission Interference 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 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.

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.

Note: This statement must be in the user manual if it is not included on the FCC ID label.

FCC CAUTION: Any changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate this equipment.

To satisfy RF exposure requirements, this device and its antenna must operate with a separation distance of at least 20 cm from all persons.

7.3. End-product user manual instructions

7.3.1. FCC Compliance

For an end product that uses the TWIG V UNO module, there must be a label containing the FCC-ID number. The label must be affixed on an exterior surface of the end product such that it will be visible upon inspection in compliance with the modular approval guidelines developed by the FCC. This label should include the following text: 'contains FCC ID ZH6-TWIGVUNO'.

In accordance with 47 CFR § 15.19, the end product shall bear the following statement in a conspicuous location on the device:

"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."

The label must be affixed on an exterior surface of the end product such that it will be visible upon inspection in compliance with the modular approval guidelines developed by the FCC.

When the device is so small or for such use that it is not practicable to place the statement above on it, the information shall be placed in a prominent location in the instruction manual or pamphlet supplied to the user or, alternatively, shall be placed on the container in which the device is marketed.

In case, where the final product will be installed in locations where the end-user is not able to see the FCC ID and/or this statement, the FCC ID and the statement shall also be included in the end-product manual.

7.3.2. ISED compliance

The TWIG V UNO module is certified for use in Canada under Innovation, Science and Economic Development Canada (ISED) Radio Standards Specification (RSS) RSS-247 Issue 3 and RSSGen. The host product shall be properly labelled to identify the modules within the host product.

The final host device, into which this RF Module is integrated must be labeled with an auxiliary label stating the IC of the RF Module, such as" Contains transmitter module IC: 9686A-TWIGVUNO".

This device contains license-exempt transmitter(s)/receiver(s) that comply with Innovation, Science and Economic Development Canada's license-exempt RSS(s). Operation is subject to the following two conditions:

(1) This device may not cause interference.

(2) This device must accept any interference, including interference that may cause undesired operation of the device.

Le périphériquehôte final, danslequelce module RF estintégré "doitêtreétiqueté avec uneétiquetteauxiliaireindiquant le CI du module RF, tel que" Contient le module émetteur IC: 9686A-TWIGVUNO".

L'émetteur/récepteur exempt de licencecontenudans le présentappareilestconforme aux CNR d'Innovation, Sciences et Développementéconomique Canada applicables aux appareils radio exempts de licence. L'exploitationestautorisée aux deux conditions suivantes:

(1) L' appareil ne doit pas produire de brouillage.

(2) L' appareildoit accepter tout brouillageradioélectriquesubi, mêmesi le brouillageest susceptible d' encompromettre le fonctionnement.

The Innovation, Science and Economic Development Canada certification label of a module shall be clearly visible at all times when installed in the host product; otherwise, the host product must be labelled to display the Innovation, Science and Economic Development Canada certification number for the module, preceded by the word "contains" or similar wording expressing the same meaning.

Le produit hôte devra être correctement étiqueté, de façon à permettre l'identification des modules qui s'y trouvent.

L'étiquette d'homologation d'un module d'Innovation, Sciences et Développement économique Canada devra être posée sur le produit hôte à un endroit bien en vue, en tout temps. En l'absence d'étiquette, le produit hôte doit porter une 25ecessair sur laquelle figure le numéro d'homologation du module d'Innovation, Sciences et Développement économique Canada, précédé du mot « contient », ou d'une formulation similaire allant dans le même sens et qui va comme.

For end-products that include a detachable antenna, the user manual shall also contain the following notice and list of antennas in a conspicuous location:

> *This radio transmitter 9686A-TWIGVUNO has been approved by Innovation, Science and Economic Development Canada to operate with the antenna types listed below, with the maximum permissible gain indicated. Antenna types not included in this list that have a gain greater than the maximum gain indicated for any type listed are strictly prohibited for use with this device.*

List of antenna types that can be used with the transmitter:

External Antenna Type	Maximum Gain	Impedance
Omni	6 dBi	50 ohms
Yagi	12 dBi	50 ohms

7.4. End-product compliance

The module has been tested and approved as a Modular Radio in accordance with the appropriate FCC and IC standards. The supporting test data may be found in the modular test report.

Since this module and its associated set of approved antennas have been certified as a Modular Radio, this allows the end user to integrate this module into an end-product without the requirement of re-certifying the radio module. The module-integrator is responsible for the unintentional conducted and radiated emissions and must *verify* that the integrated product is compliant with the rules associated with unintentional radiators. The module integrator is also required to maintain an engineering record of the verification testing and declare on the product through proper labeling and marking that the device is compliant with these particular rules.

7.4.1. End-product with external antenna

The module, when configured for use with the external antenna connector, must use a u.fl to RPSMA bulkhead followed by an RPSMA to N-Connector coax cable with a minimum length of 10 feet using CA-195 coax or equivalent.

Antennas for use with the module:
a. Yagi type antennas with maximum forward gain of 12 dBi and mounted for vertical polarization.
b. Omni type with maximum gain of 6 dBi and mounted for vertical polarization.

The incorporation of the largest practical free-space clearance around the antenna is important for maximizing overall performance. Further, the antenna must be placed such that at least a 8 inch separation distance is maintained from the antenna to all other radio transmitters.

7.4.2. End-product with internal antenna

For the internal antenna configuration, it is recommended that all wiring be routed so that it does not approach the PCB antenna structure.

8. Product Testing

8.1. Module production test

All modules are fully tested using a functional test fixture. The fixture includes the following tests:

1) Transmitter power supply voltage (VCC)
2) RF characteristics including modulation, frequency, radiated transmit power relative to test reference and receiver sensitivity. This test includes a go/no go test where a device under test is compared against a known compliant reference device.
3) Module power consumption

8.2. End-product production test

As all TWIG V UNO modules undergo testing so end-product manufacturers do not need to repeat any functional tests that might otherwise be necessary to confirm RF performance.

8.3. EMC Test Mode

An EMC Test mode is available using firmware number 0xb3e4f3f. This mode is accessed using the connector J7 as shown in Figure 2.
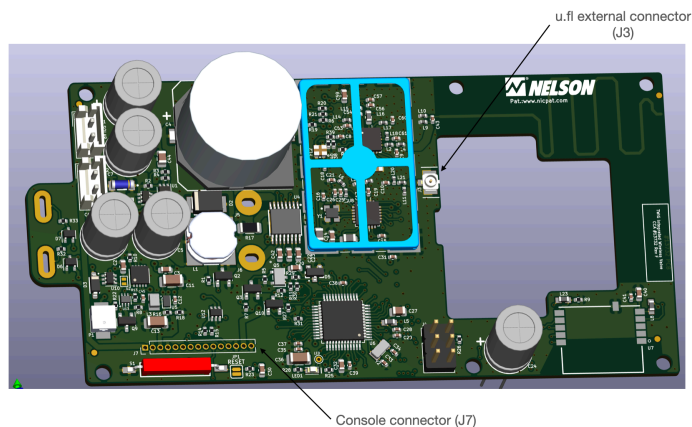

Figure 2. TWIG V UNO Module showing testing access points.

The console connector (J7) has the following pinout that is relevant for testing:

Pin 1: Supply voltage (1.8 to 5.5 volts DC)
Pin 2: Ground
Pin 11: MCU TX
Pin 12: MCU RX

The serial port that is configured as 115,200 baud, 8 bits, no parity, and one stop bit (115200/8/N/1).

The available commands for this test are:

abc - test command that returns "abc=0"

bleSilent - silence the BLE advertising

setAntenna - select the antenna.
example to set INTERNAL (on-board) Antenna: setAntenna=0<CR><LF>
example to set EXTERNAL antenna: setAntenna=1<CR><LF>

setTxPower - specify the transmit power.
example to set power to 24dBm (900 MHz ISM): setTxPower=10<CR><LF>

setModulatedTx – operate the transmitter in pseudo-random transmit for n cycles.
example to set for 1000 cycles: setModulatedTx=1000<CR><LF>

getFrequency - return current testing frequency in Hz.
example: getFrequency<CR><LF>

setFrequency - set the testing frequency in Hz.
setFrequency=915000000<CR><LF>

To configure the TWIG V UNO module for use as an RTU for as an unintentional radiator, the following command sequence is recommended:

setFrequency=915000000<CR>
`Testfrequency=915000000`

bleSilent<CR>
`BLE in quiet mode`