BL653µ Series

Bluetooth® + 802.15.4 + NFC Modules

ROBUST RELIABLE BLUETOOTH CONNECTIVITY FOR IOT – JUST SMALLER

Laird Connectivity's latest range of Nordic nRF52833 based modules specifically targets OEMs where space is constrained in their designs. Yet still the **miniaturized BL653µ series** enables Industrial OEMs to robustly implement **longer range** BLE applications in the **harshest operating environments**. This series of secure, low power microcontroller modules with multi wireless capabilities is the future of wireless Internet of Things (IoT) connectivity.

Powered by **Nordic's nRF52833 WLCSP** silicon, the small form factor BL653µ modules provide for a secure, robust Bluetooth Low Energy and **Cortex -M4F** CPU for any OEM's product design. The BL653µ provides you with maximum development flexibility with programming options for the **Nordic SDK** or **Zephyr RTOS**, a simple, intuitive **AT command set**, as well as Laird Connectivity's own ***smart*BASIC** environment.

The BL653µ series brings out key nRF52833 hardware features and capabilities including **USB access,** up to **+8 dBm** transmit power, up to **5.5V** supply considerations, and **NFC tag (type 2 / 4)** implementation. Complete regulatory certifications enable faster time to market and reduced development risk completes Laird Connectivity's simplification of your next small form factor Bluetooth design!

- **Ultra-small footprint**
  - Integrated Antenna (6.3 mm x 8.6 mm x 1.6 mm)
  - Trace Pad Option (6.3 mm x 5.6 mm x 1.6mm)
- **Bluetooth v5.2** Bluetooth Low Energy (BLE) plus **NFC**
- **802.15.4** radio (non-certified) –ZigBee / Thread via nRF Connect SDK or Thread via Zephyr)
- **Widest range of configurable interfaces**: UART, I2C, I2S, SPI, ADC, GPIO, PWM, FREQ, USB, PDM, and NFC
- **Extended** Industrial **Temperature Rating** (-40° to +105 °C)
- Bluetooth Low Energy - Peripheral/Central roles supported
- 2 Mbps and **LE Long Range:** Support for 2 Mbps, 1 Mbps, & 125 Kbps coded PHY
- Bluetooth 5.1 - Direction finding – **AoA and AoD**
- **Hostless operation** – Internal MCU reduces BOM
- **Powerful Core** Cortex-M4F (512kB Flash, 128 k RAM)
- Built on years of experience with Nordic (BL600, BL652 & BL654 Series)
- **Application design choice:** Leverage Laird Connectivity's *smart*BASIC, simple AT command set, Zephyr RTOS or utilize Nordic SDK directly
- **Nordic nRF52833** – 3.175 x 3.175mm WLCSP with 32 GPIOs utilized.

FEATURES AT A GLANCE

TINY FOOTPRINT YET STILL HIGH PERFORMANCE

Nearly 24% reduction in overall module footprint compared to standard BL653 series.

SOFTWARE FLEXIBILITY AND SPEED TO MARKET

Simple AT Command set or easily write event-driven, automated applications, no toolchain required with *smart*BASIC. Alternatively utilize either Zephyr RTOS or the Nordic SDK directly – develop application SW your way

TRUE INDUSTRIAL OPERATING RANGE

Designed and certified to the highest industrial temperature range of -40 ºC to +105 ºC for every component utilised.

GLOBAL APPROVALS – MAKE YOURSELF AT HOME

Carries several modular FCC, IC, CE, RCM, MIC and Bluetooth SIG approvals.

PERSONAL SUPPORT FROM DESIGN TO MANUFACTURE

Our industry-renowned support is passionate about helping you speed your design to market.

APPLICATION AREAS

- Professional Lighting
- Direction Finding / AoA / AoD
- Secure Medical Peripherals
- Industrial IoT Sensors

Contact Sales - Americas: +1 262 375 4400 Europe: +44 1628 940 ext. 958 Korea: +82 10 2622 3935 Hong Kong: +852 2923 0610

For documentation, software, sample apps and more visit:
http://www.lairdconnect.com/BL653-ble-thread-nfc-modules

KEY SPECIFICATIONS

CATEGORY	FEATURE	SPECIFICATION
Wireless Specification	Bluetooth®	v5.2
	802.15.4	Thread and Zigbee support via Nordic nRF Connect SDK, Thread via Zephyr
	Frequency	2.402 - 2.480 GHz
	Transmit Power	+ 8 dBm (maximum). Configurable down to -40 dBm
	Receive Sensitivity	-96 dBm (typical @ BLE 1 Mpbs) -103 dBm (typical @ BLE 125 Kbps)
	Link Budget	103 dB (@ BLE I Mbps), 111 dB (@ BLE 125 Kbps)
	Antenna Options	Integrated chip antenna or RF trace pin for external antennas
	Raw Data Rates (Air)	1 Mbps, 2 Mbps, 125 Kbps
Host Interface and Peripherals	UART Interface	TX, RX, CTS, RTS. DTR, DSR, DCD, RI (GPIO) Default: 115200, N, 8, 1. Configurable from 1200 bps to 1 Mbps
	USB Interface	USB 2.0 full speed device
	Other	32 multifunction GPIO's that can provide: ▪ 2 UART (4 GPIO pins each) ▪ 8 ADC channels (1 pin each) ▪ 2 I2C (2 GPIO pins each) ▪ Upto 4 SPI Master / 3 SPI slave with easyDMA (4 GPIO pins including CS each) ▪ 2 PDM (2 GPIO pins each) ▪ 1 I2S (5 GPIO pins) ▪ 2 GPIO pins for 32.768 kHz crystal ▪ 2 GPIO pins for NFC ▪ PWM output on 16 pins ▪ FREQ output on 16 pins
Key BLE Features	Bluetooth Low Energy	▪ GATT client & GATT server – Any adopted/custom services ▪ Central/Peripheral roles ▪ Up to 8 BLE connections (*smart*BASIC) ▪ BLE Mesh – nRFConnect SDK / Zephyr ▪ CODED PHY ▪ 2M PHY ▪ LE advertising extensions ▪ LE secure connections ▪ Data packet length extensions ▪ LE privacy v1.2 ▪ LE ping ▪ vSP – Virtual Serial Port ▪ DTM Firmware (Test Modes) – Built In
Programmability Options	*smart*BASIC	On-board BASIC event driven programming language
	AT Command Set	Simple AT Hayes-style command protocol
	Nordic nRFConnect SDK	Software/Support available from Nordic directly https://devzone.nordicsemi.com/
	Zephyr RTOS	Software/Support available from https://www.zephyrproject.org/
FW upgrade		Via UART or JTAG (SWD)
Supply Voltage		1.7V – 5.5V
Power Consumption	Current	Max Peak Radio Current (@ +8 dBm TX) – 14.1 mA (DCDC at 3V) Max Peak Radio Current (@ 0 dBm TX) – 4.9 mA (DCDC at 3V)
		Standby Doze – 2.6 µA
		Deep Sleep –0.6 µA (external signal wake-up)
Physical	Dimensions	6.3 mm x 8.6 mm x 1.6mm (Integrated Antenna) 6.3 mm x 5.6 mm x 1.6mm (Trace Pad variant)
Environmental	Temp Range	-40°C to +105°C
Miscellaneous	Lead Free	Lead-free and RoHS-compliant
	Development Kit	None available – utilise larger BL653 DVK – part # 453-00039-K1 or 453-00041-K1
Development Tools	Utilities	UwTerminalX (Multi-platform) UWFlashX (Multi-platform) Nordic nRFConnect - Android and iOS applications
Qualifications	Bluetooth®	Complete Declaration ID
Regulatory	Approvals	FCC/IC/CE/MIC/RCM - All BL653µ Series

For full specifications on BL653 modules, please see the appropriate datasheet.

PART #	DESCRIPTION
453-00059R	BL653µ - Micro Bluetooth Low Energy module (Nordic nRF52833) – Integrated antenna (Tape/Reel)
453-00060R	BL653µ - Micro Bluetooth Low Energy module (Nordic nRF52833) – Trace pin (Tape/Reel)
453-00059C	BL653µ - Micro Bluetooth Low Energy module (Nordic nRF52833) – Integrated antenna (Cut Tape)
453-00060C	BL653µ - Micro Bluetooth Low Energy module (Nordic nRF52833) – Trace pin (Cut Tape)

Contact Sales - Americas: +1 262 375 4400 Europe: +44 1628 940 ext. 958 Korea: +82 10 2622 3935 Hong Kong: +852 2923 0610

For documentation, software, sample apps and more visit:
http://www.lairdconnect.com/BL653-ble-thread-nfc-modules

HARDWARE SPECIFICATIONS

Block Diagram and Pin-out

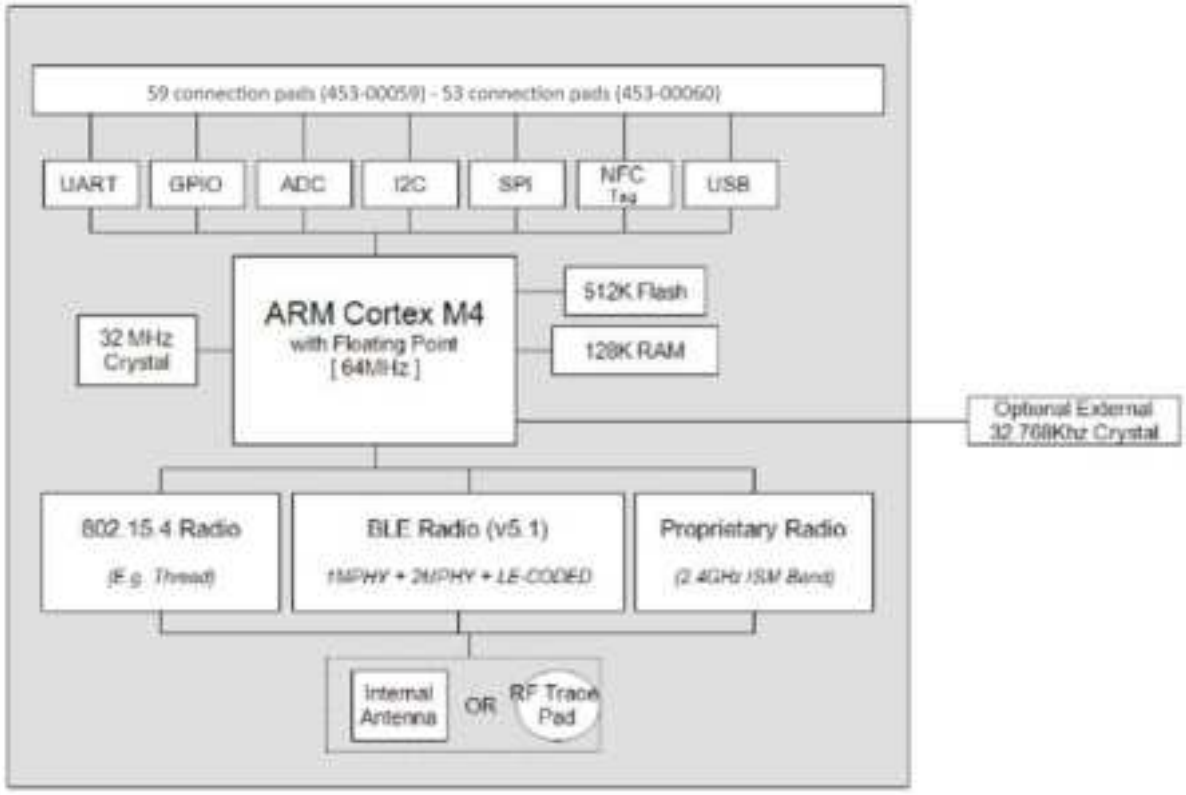


Figure 1: BL653µ block diagram

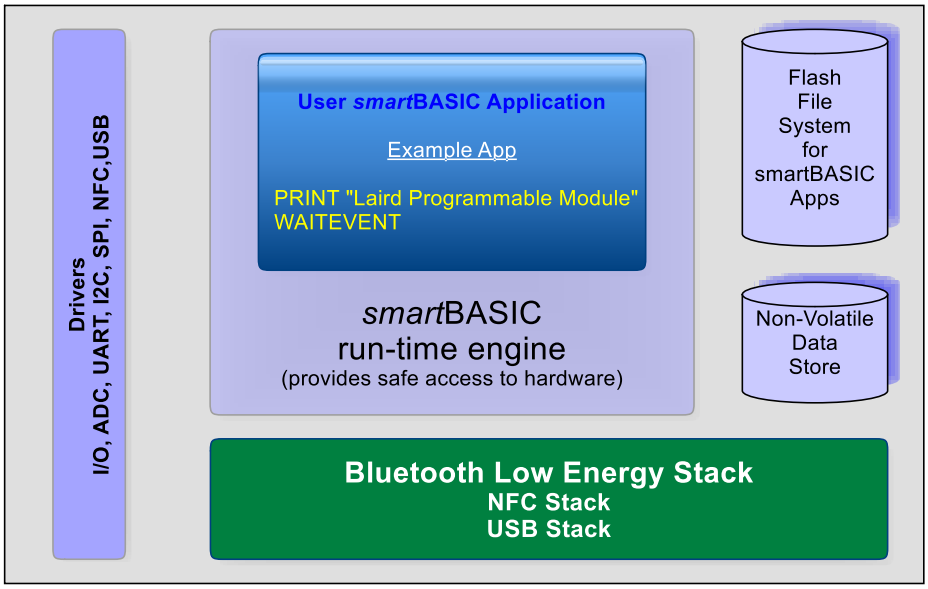


Figure 2: Functional HW and SW block diagram for BL653µ series BLE module

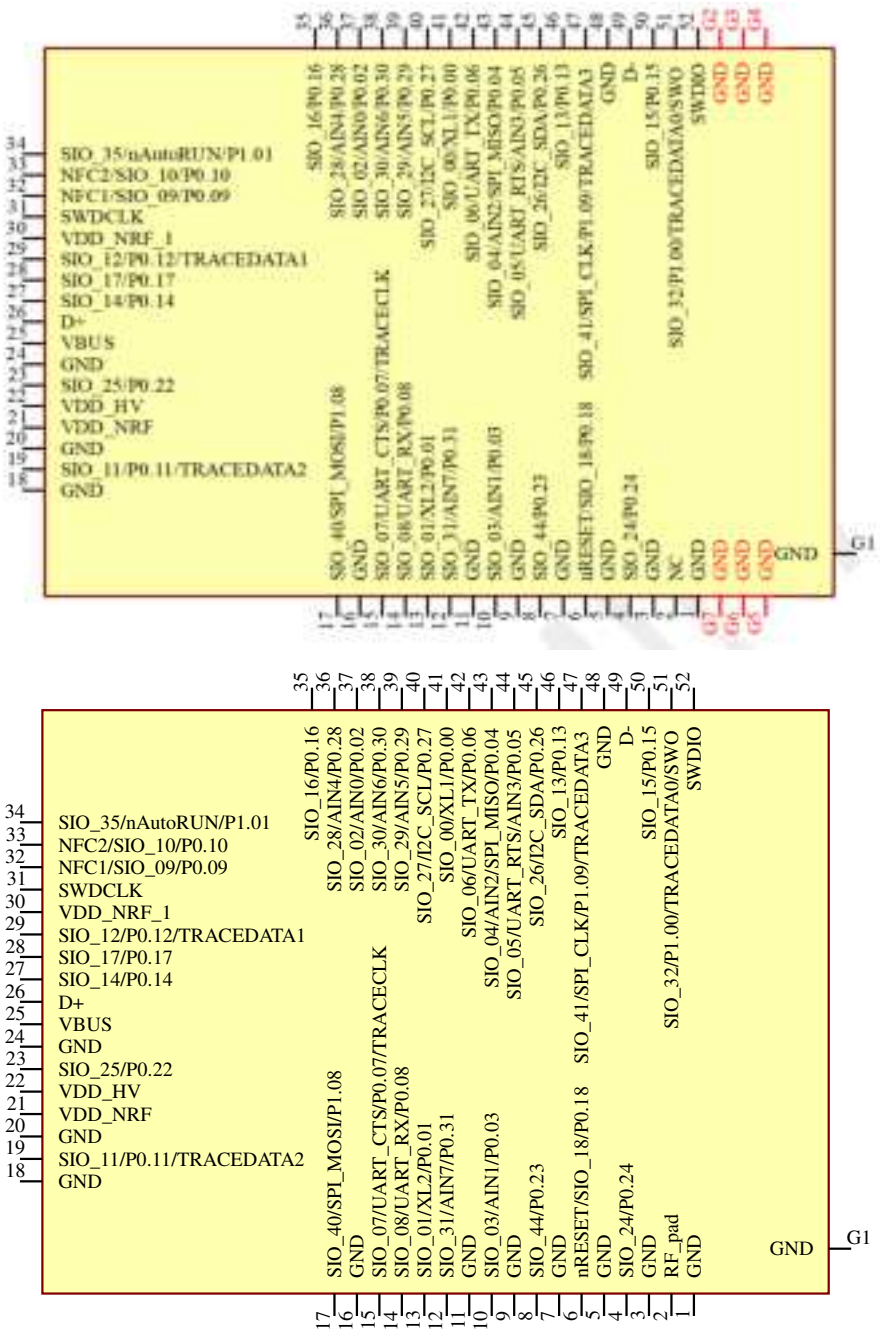


Figure 3: BL653µ module pin-out (top view).
453-00059 BL653u Micro BLE module (Nordic nRF52833) – Integrated antenna
453-00060 BL653u Micro BLE module (Nordic nRF52833) – Trace pin

FCC AND IC REGULATORY STATEMENTS

MODEL	US/FCC	CANADA/IC
453-00059	SQGBL653U	3147A-BL653U
453-00060	SQGBL653U	3147A-BL653U

The 453-00059 and the 453-00060 hold full modular approvals. The OEM must follow the regulatory guidelines and warnings listed below to inherit the modular approval.

PART #	FORM FACTOR	TX OUTPUTS	ANTENNA
453-00059	Surface Mount	8 dBm	Chip antenna
453-00060	Surface Mount	8 dBm	IPEX MHF4

Antenna Information

The BL653µ family has been designed to operate with the antennas listed below with a maximum gain of 2 dBi. The required antenna impedance is 50 ohms.

MANUFACTURER	MODEL	LAIRD CONNECTIVITY PART NUMBER	TYPE	CONNECTOR	PEAK GAIN	
					2400-2500 MHZ	2400-2480 MHZ
Laird Connectivity	NanoBlue	EBL2400A1-10MH4L	PCB Dipole	IPEX MHF4	2 dBi	-
Laird Connectivity	FlexPIFA	001-0022	PIFA	IPEX MHF4	-	2 dBi
Mag.Layers	EDA-8709-2G4C1-B27-CY	0600-00057	Dipole	IPEX MHF4	2 dBi	-
Laird Connectivity	mFlexPIFA	EFA2400A3S-10MH4L	PIFA	IPEX MHF4	-	2 dBI
Laird Connectivity	Laird Connectivity NFC	0600-00061	NFC	N/A	-	-
Yageo	ANT1608LL14R2400A	NA	Chip Antenna	N/A	2dBi	

Note: The OEM is free to choose another vendor's antenna of like type and equal or lesser gain as an antenna appearing in the table and still maintain compliance. Reference FCC Part 15.204(c)(4) for further information on this topic.

To reduce potential radio interference to other users, the antenna type and gain should be chosen so that the equivalent isotropic radiated power (EIRP) is not more than that permitted for successful communication.

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.

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.

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.

Important Note:

Radiation Exposure Statement

This equipment complies with FCC 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.

This transmitter must not be co-located or operating in conjunction with any other antenna or transmitter.

Integration Instructions for Host Product Manufacturers

Applicable FCC rules to module:

FCC Part 15.247

Summarize the specific operational use conditions:

This device is intended only for OEM integrators under the following condition:

- The transmitter module may not be co-located with any other transmitter or antenna

As long as 1 condition above are met, further transmitter test will not be required. However, the OEM integrator is still responsible for testing their end-product for any additional compliance requirements required with this module installed.

IMPORTANT NOTE: In the event that these conditions cannot be met (for example certain laptop configurations or co-location with another transmitter), then the FCC authorization is no longer considered valid and the FCC 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 FCC authorization. The OEM integrator has to be aware not to provide information to the end user regarding how to install or remove this RF module in the user's manual of the end product which integrates this module.

The end user manual shall include all required regulatory information/warning as show in this manual.

Limited module procedures

Not applicable

Trace antenna designs

Not applicable

RF exposure considerations

Co-located issue shall be met as mentioned in *Summarize the specific operational use conditions*.

Product manufacturer shall provide the following text in the end-product manual:

> ***FCC Radiation Exposure Statement***
>
> *The product complies with the US portable RF exposure limit set forth for an uncontrolled environment and are safe for intended operation as described in this manual. The further RF exposure reduction can be achieved if the product can be kept as far as possible from the user body or set the device to lower output power if such function is available.*

A 20-centimeter separation distance and co-located issue shall be met as mentioned in *Summarize the specific operational use conditions.*

Product manufacturer shall provide the following text in the end-product manual:

> *This equipment complies with FCC radiation exposure limits set forth for an uncontrolled environment. This equipment should be installed and operated with a minimum distance of 20 centimeters between the radiator and your body.*

Label and Compliance Information

Product manufacturers must provide, with the finished product, a physical or e-label that states the following:

> *Contains FCC ID: SQGBL653U*

Information on Test Modes and Additional Testing Requirements

Test tool: BleDtmRfTool shall be used to set the module to transmit continuously.

Additional Testing, Part 15 Subpart B Disclaimer

The module is only FCC authorized for the specific rule parts listed on the grant, and that 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 final host product still requires Part 15 Subpart B compliance testing with the modular transmitter installed

Industry Canada Statement

This device contains licence-exempt transmitter(s)/receiver(s) that comply with Innovation, Science and Economic Development Canada's licence-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

L'émetteur/récepteur exempt de licence contenu dans le présent appareil est conforme aux CNR d'Innovation, Sciences et Développement économique Canada applicables aux appareils radio exempts de licence. L'exploitation est autorisée aux deux conditions suivantes :

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

(2) L'appareil doit accepter tout brouillage radioélectrique subi, même si le brouillage est susceptible d'en compromettre le fonctionnement.

This radio transmitter (IC: 3147A-BL653U) 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.

Le présent émetteur radio (IC: 3147A-BL653U) a été approuvé par Innovation, Sciences et Développement économique Canada pour fonctionner avec les types d'antenne énumérés ci dessous et ayant un gain admissible maximal. Les types d'antenne non inclus dans cette liste, et dont le gain est supérieur au gain maximal indiqué pour tout type figurant sur la liste, sont strictement interdits pour l'exploitation de l'émetteur.

MANUFACTURER	MODEL	LAIRD CONNECTIVITY PART NUMBER	TYPE	CONNECTOR	PEAK GAIN	
					2400-2500 MHZ	2400-2480 MHZ
Laird Connectivity	NanoBlue	EBL2400A1-10MH4L	PCB Dipole	IPEX MHF4	2 dBi	-
Laird Connectivity	FlexPIFA	001-0022	PIFA	IPEX MHF4	-	2 dBi
Mag.Layers	EDA-8709-2G4C1-B27-CY	0600-00057	Dipole	IPEX MHF4	2 dBi	-
Laird Connectivity	mFlexPIFA	EFA2400A3S-10MH4L	PIFA	IPEX MHF4	-	2 dBI
Laird Connectivity	Laird Connectivity NFC	0600-00061	NFC	N/A	-	-
Yageo	ANT1608LL14R2400A	NA	Chip Antenna	N/A	2dBi	

Radiation Exposure Statement:

This equipment complies with Canada 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.

Déclaration d'exposition aux radiations:

Cet équipement est conforme Canada limites d'exposition aux radiations dans un environnement non contrôlé. Cet équipement doit être installé et utilisé à distance minimum de 20cm entre le radiateur et votre corps.

This device is intended only for OEM integrators under the following conditions:

1) The transmitter module may not be co-located with any other transmitter or antenna.

As long as the condition above is met, further transmitter testing is not required. However, the OEM integrator is still responsible for testing their end-product for any additional compliance requirements required with this module installed.

Cet appareil est conçu uniquement pour les intégrateurs OEM dans les conditions suivantes:

1) Le module émetteur peut ne pas être coïmplanté avec un autre émetteur ou antenne.

Tant que les 1 condition ci-dessus sont remplies, des essais supplémentaires sur l'émetteur ne seront pas nécessaires. Toutefois, l'intégrateur OEM est toujours responsable des essais sur son produit final pour toutes exigences de conformité supplémentaires requis pour ce module installé.

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 Canada 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.

End Product Labeling

The final end product must be labeled in a visible area with the following: “Contains IC: 3147A-BL653U.

Plaque signalétique du produit final

Le produit final doit être étiqueté dans un endroit visible avec l'inscription suivante: "Contient des IC: 3147A-BL653U.

Manual Information to the End User

The OEM integrator has to be aware not to provide information to the end user regarding how to install or remove this RF module in the user’s manual of the end product which integrates this module.

The end user manual shall include all required regulatory information/warning as show in this manual.

Manuel d'information à l'utilisateur final

L'intégrateur OEM doit être conscient de ne pas fournir des informations à l'utilisateur final quant à la façon d'installer ou de supprimer ce module RF dans le manuel de l'utilisateur du produit final qui intègre ce module.

Le manuel de l'utilisateur final doit inclure toutes les informations réglementaires requises et avertissements comme indiqué dans ce manuel

JAPAN (MIC) REGULATORY

The BL653µ is approved for use in the Japanese market. The part numbers listed below hold WW type certification. Refer to **ARIB-STD-T66** for further guidance on OEM’s responsibilities.

MODEL	CERTIFICATE NUMBER	ANTENNA
453-00059	201-200419	Chip Antenna
453-00060	201-200419	Trace pin

Antenna Information

The BL653µ was tested with antennas listed below. The OEM can choose a different manufacturers antenna but must make sure it is of same type and that the gain is lesser than or equal to the antenna that is approved for use.

MANUFACTURER	MODEL	LAIRD CONNECTIVITY PART NUMBER	TYPE	CONNECTOR	PEAK GAIN	
					2400-2500 MHZ	2400-2480 MHZ
Laird Connectivity	NanoBlue	EBL2400A1-10MH4L	PCB Dipole	IPEX MHF4	2 dBi	-
Laird Connectivity	FlexPIFA	001-0022	PIFA	IPEX MHF4	-	2 dBi

MANUFACTURER	MODEL	LAIRD CONNECTIVITY PART NUMBER	TYPE	CONNECTOR	PEAK GAIN	
					2400-2500 MHZ	2400-2480 MHZ
Mag.Layers	EDA-8709-2G4C1-B27-CY	0600-00057	Dipole	IPEX MHF4	2 dBi	-
Laird Connectivity	mFlexPIFA	EFA2400A3S-10MH4L	PIFA	IPEX MHF4	-	2 dBI
Laird Connectivity	Laird Connectivity NFC	0600-00061	NFC	N/A	-	-
Yageo	ANT1608LL14R2400A	NA	Chip	N/A	2.0 dBi	

CE Regulatory

The 453-00059/453-00060 have been tested for compliance with relevant standards for the EU market. The 453-00060 module was tested with a 2 dBi antenna. The OEM can operate the 453-00041 module with any other type of antenna but must ensure that the gain does not exceed 2 dBi to maintain the Laird approval.

The OEM should consult with a qualified test house before entering their device into an EU member country to make sure all regulatory requirements have been met for their complete device.

Reference the Declaration of Conformities listed below for a full list of the standards that the modules were tested to. Test reports are available upon request.

EU Declarations of Conformity

Manufacturer	Laird Connectivity
Products	453-00059, 453-00060
Product Description	Bluetooth v5.1 + 802.15.4 + NFC
EU Directives	2014/53/EU – Radio Equipment Directive (RED)

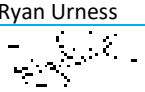
Reference standards used for presumption of conformity:

ARTICLE NUMBER	REQUIREMENT	REFERENCE STANDARD(S)	
3.1a	Low voltage equipment safety	EN 62368-1: 2014	
	RF Exposure	EN 62311:2008 EN 62479: 2010	
3.1b	Protection requirements – Electromagnetic compatibility	EN 301 489-1 v2.2.3 (2019-11) (Draft) EN 301 489-3 v2.1.1 (2019-03) EN 301 489-17 v3.1.1 (2017-02)	
3.2	Means of the efficient use of the radio frequency spectrum (ERM)	EN 300 328 v2.2.2 (2019-07)	Wide-band transmission systems
		EN 300 330 v2.1.1 (2017-02)	Short Range Devices (SRD)

Declaration:

We, Laird Connectivity, declare under our sole responsibility that the essential radio test suites have been carried out and that the above product to which this declaration relates is in conformity with all the applicable essential requirements of Article 3 of the EU Radio Equipment Directive 2014/53/EU, when used for its intended purpose.

The minimum distance between the user and/or any bystander and the radiating structure of the transmitter is 20 cm.

Place of Issue:	Laird Connectivity W66N220 Commerce Court, Cedarburg, WI 53012 USA tel: +1-262-375-4400 fax: +1-262-364-2649
Date of Issue:	2020, June 3
Name of Authorized Person:	Ryan Urness
Signature of Authorized Person:	

Antenna Information

The antennas listed below were tested for use with the BL653µ. For CE mark countries, the OEM is free to use any manufacturer's antenna and type of antenna if the gain is less than or equal to the highest gain approved for use (2dBi) Contact a Laird Connectivity representative for more information regarding adding antennas.

MANUFACTURER	MODEL	LAIRD CONNECTIVITY PART NUMBER	TYPE	CONNECTOR	PEAK GAIN	
					2400-2500 MHZ	2400-2480 MHZ
Laird Connectivity	NanoBlue	EBL2400A1-10MH4L	PCB Dipole	IPEX MHF4	2 dBi	-
Laird Connectivity	FlexPIFA	001-0022	PIFA	IPEX MHF4	-	2 dBi
Mag.Layers	EDA-8709-2G4C1-B27-CY	0600-00057	Dipole	IPEX MHF4	2 dBi	-
Laird Connectivity	mFlexPIFA	EFA2400A3S-10MH4L	PIFA	IPEX MHF4	-	2 dBI
Laird Connectivity	Laird Connectivity NFC	0600-00061	NFC	N/A	-	-
Yageo	ANT1608LL14R2400A	NA	Chip	N/A	2.0 dBi	

Note: The BL653µ module internal BLE chipset IC pins are rated 4 kV (ESD HBM). ESD can find its way through the external header connectors like JTAG connector (if used on the customer's design), if discharge is applied directly. Customer should ensure adequate protection against ESD on their end product design (using the BL653µ module) to meet relevant ESD standard (for CE, this is EN301-489).