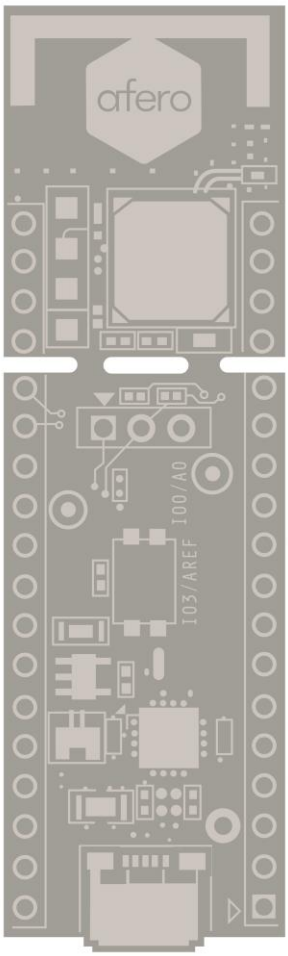
Modulo User Guide

Part Number: AFERO-BL24-01

Rev: 1.0



Contents

1 Overview

1.1 About Afero

Afero builds integrated hardware, software, and cloud services for IoT connectivity and data analytics. The Afero turnkey platform incorporates a secure Bluetooth® Smart module, scalable cloud services, and a range of development tools that enable companies and developers to quickly prototype and build connected devices.

The Afero platform is vertically integrated, giving developers a solution that combines security and connectivity at the three key touch points for all connected devices:

- Product (embedded secure radio module)
- Mobile application (app-level monitoring and control)
- Cloud services (web APIs)

This vertical integration accelerates the creation of connected devices by minimizing the investment normally required for software development and testing – while ensuring a secure and scalable solution.

The Afero Secure Radio module (ASR-1, Murata P/N AFERO-BL24-01) comes programmed with authentication, encryption, and connection management software, ensuring a reliable connection to the Afero Cloud. The Afero mobile application, available for both Android and iOS phones, allows users to manage their smart devices and services from their phone.

Developers wanting to build or prototype connected products Powered by Afero can choose from the following options:

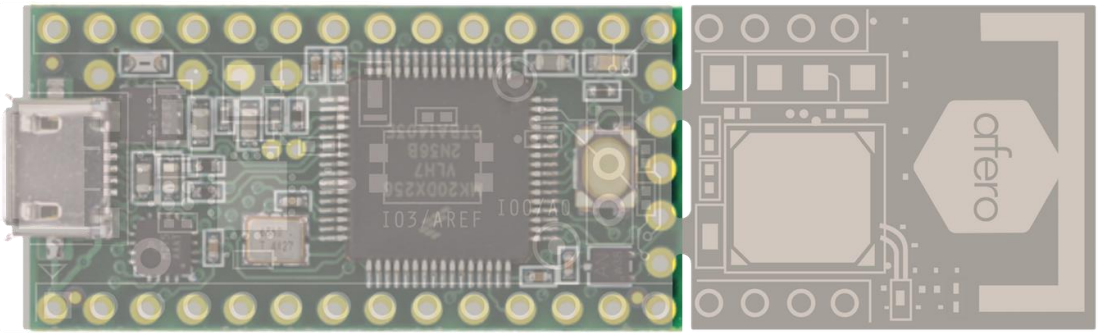
- An Afero Modulo development board (P/N: AFERO-DB-01), to be used standalone or in conjunction with an external board equipped with its own microcontroller.
- An Afero Plinto development board (P/N: AFERO-DB-02), to be used in conjunction with an Arduino board.
- A standalone ASR-1 (P/N: AFERO-BL24-01), to be directly integrated into a product and used either standalone (multiple I/O ports provided) or used in conjunction with a host microcontroller.

Afero development boards and tools are available at developer.afero.io.

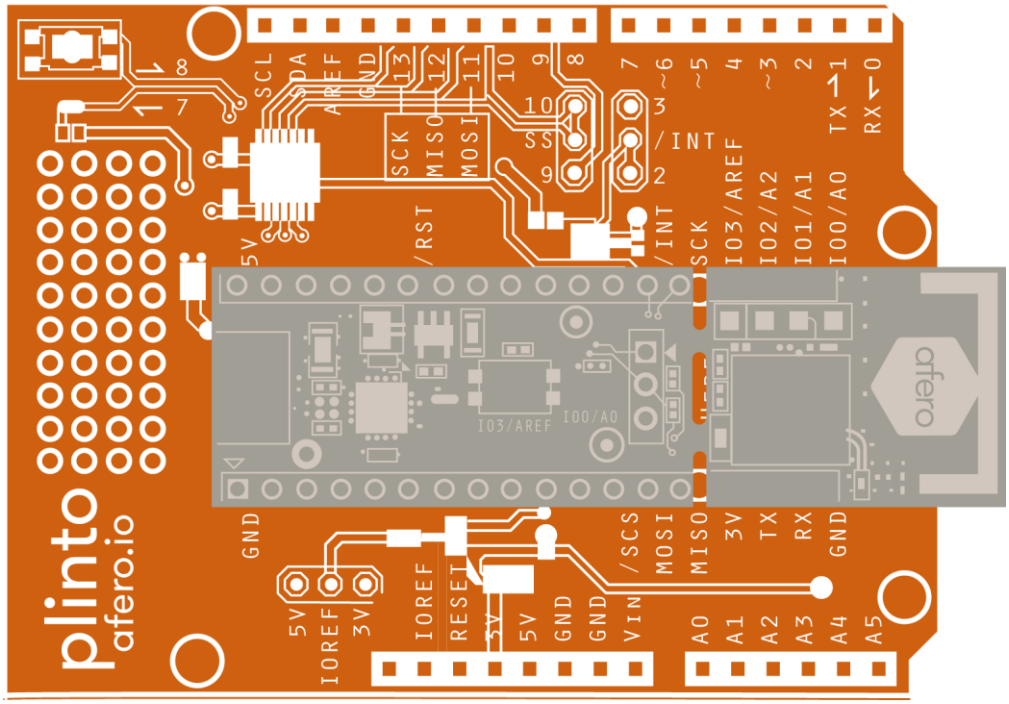
1.2 Intro to Modulo

Modulo is the demonstration platform board for the Afero ASR-1 module. ASR-1 is a Bluetooth® Smart wireless technology module. It enables ultra-low power connectivity for data communication. The ASR-1 integrates Bluetooth® Smart wireless technology IC, security IC, RF front end, and crystal into a very small package.

The Modulo is designed to attach directly to a Teensy (3.1 or better) board, or to a standard Arduino Shield board, through the use of an Afero Plinto Shield board (sold separately).



Modulo-Teensy connections

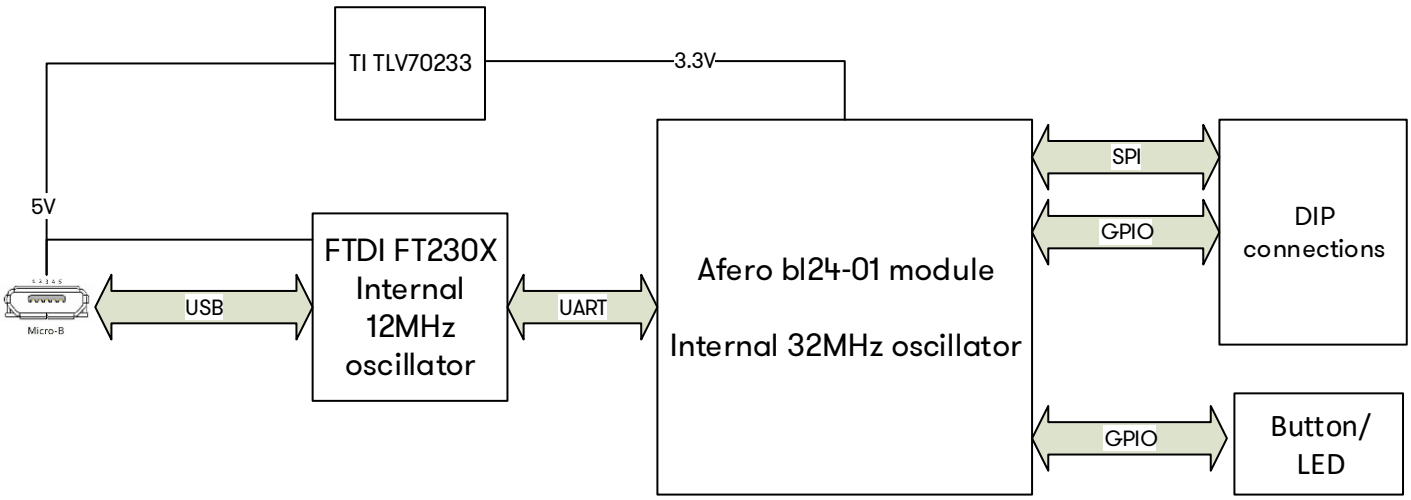


Modulo-Plinto connections

1.3 Specification

Model name	Modulo
Model number	AFERO-DB-01
Description	Afero secure radio module development kit
Bluetooth	Bluetooth® Smart wireless technology (4.1)
Buetooth radio frequency	2.4 GHz
Ports	Backup battery connection
Buttons	1 GPIO input (configurable)
LED indicators	1 GPIO output (configurable)
Security type	256-bit ECC (Afero security)
Dimensions	2.35"W x .7"H x 0.175"D
Unit weight	5g
Power	5V, 100mA max
Certifications	FCC, IC
Operating temperature	0 to 40° C
Storage temperature	-20 to 60° C
Operating humidity	10 to 80% non-condensing
Storage humidity	5 to 90% non-condensing

1.4 Block Diagram



1.5 Acronyms

AIO	Analog Input / Output
GAP	Generic Access Profile
GATT	Generic ATTribute protocol
HID	Human Interface Device
L2CAP	Logical Link Control and Adaptation Protocol
PIO	Programmable Input / Output
PWM	Pulse Width Modulation
SPI	Serial Peripheral Interface
UART	Universal Asynchronous Receiver Transmitter

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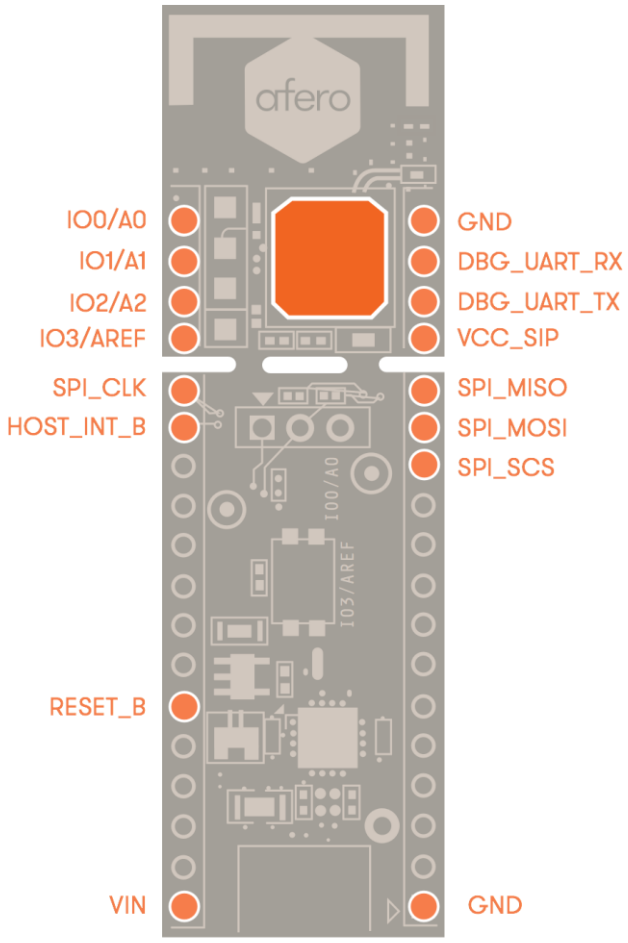
2.1 Pin Configuration

2.1.1 Pinout Diagram Top View



2.1.2 Pin descriptions

Pin Name	I/O	Description
GND	I/O	Ground
VCC	I/O	Module power (3.3V)
VIN	I	Power input from Teensy/Plinto (5V)
RESET_B	I	System reset (active low)
HOST_INT_B	O, open-drain	GPIO; host interrupt
IO0/A0	I/O	GPIO; ADC input 4 (Used for Modulo LED)
IO1/A1	I/O	GPIO; ADC input 2
IO2/A2	I/O	GPIO; ADC input 3
IO3/AREF	I/O	GPIO; ADC reference voltage (Used for Modulo button)
SPI_MISO	O	GPIO; SPI master input/slave output
SPI_SCS	I	GPIO; SPI slave select
SPI_SCLK	I	GPIO; SPI clock
SPI_MOSI	I	GPIO; SPI master output/slave input
DBG_UART_RX	I	Debugging/Factory UART RX
DBG_UART_TX	O	Debugging/Factory UART TX

3 DC Electrical Specification

3.1 Typical Power Consumption

	Current	Unit
TX Active (peak current)	15.5	mA
RX Active (peak current)	14.5	mA

3.2 GPIO Specification

A total of four lines of programmable bidirectional I/O are provided. Three of the GPIO lines can be configured to analog ADC or comparator inputs, and one (IO3/AREF) can be configured as an external analog reference.

3.2.1 Digital I/O Characteristics

Input Voltage Levels	Min.	Typ.	Max.	Unit
V_{IH} input logic level high	0.7 x VCC**	-	VCC**	V
V_{IL} input logic level low	Vss	-	0.3 x VCC**	V
V_{OH} output logic level high (std. drive, 0.5 mA)	VCC**-0.3	-	VCC**	V
V_{OH} output logic level high (high drive, 5 mA)*	VCC**-0.3	-	VCC**	V
V_{OL} output logic level low (std. drive, 0.5 mA)	Vss**	-	0.3	V
V_{OL} output logic level low (high drive, 5 mA)	Vss**	-	0.3	V
R_{PU} Pull-up resistance	11	13	16	
R_{PD} Pull-down resistance	11	13	16	

* Maximum number of pins with 5mA high driver is 3.
* VCC is 3.3V; Vss is 0V

3.3 SPI Interface

The SPI interface operates in slave mode, at up to 1MHz.

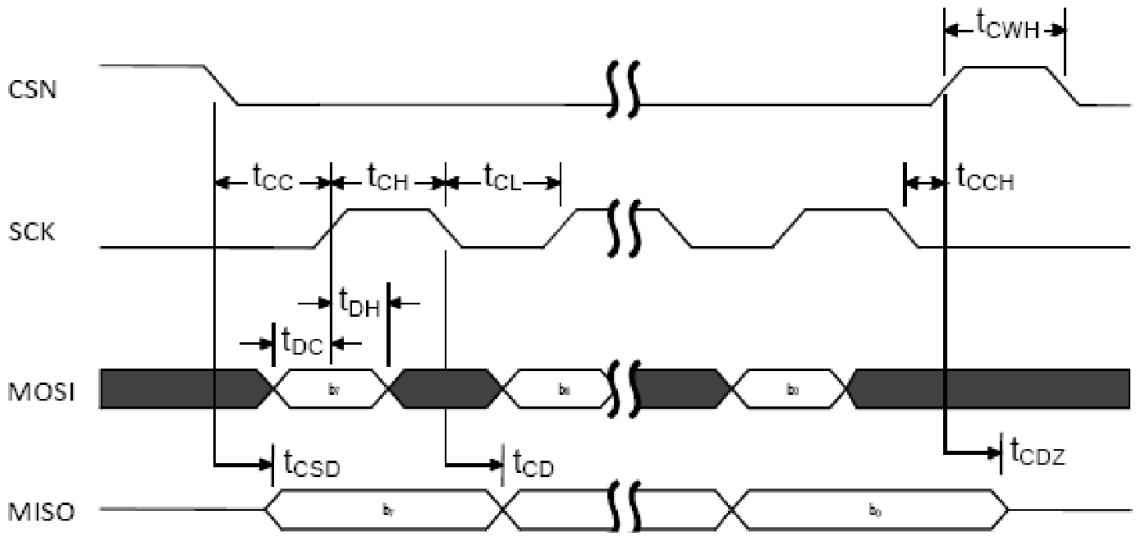
3.3.1 SPI Slave Specification

3.3.1.1 Slave Characteristics

Parameters	Description	Min.	Typ.	Max.	Unit
$I_{SPIS125K}$	Run current for SPI slave at 125 kbps*		180		µA
I_{SPIS2M}	Run current for SPI slave at 2Mbps*		183		µA
f_{SPIS}	Bit rates for SPIS	0.125		1	Mbps

* CSN asserted.

3.3.1.2 SPI Slave Timing Diagram, One Byte Transmission, SPI Mode 0



3.3.1.3 SPI Slave Timing Parameters

Parameters	Description	Note	Min.	Typ.	Max.	Unit
t_{DC}	Data to SCK setup		10			ns
t_{DH}	SCK to Data hold		10			ns
t_{CSD}	CSN to Data valid	Low power mode			7100	ns
		Constant latency mode			2100	ns
t_{CD}	SCK to Data valid	C_{LOAD} = 10pF			97**	ns
t_{CL}	SCK Low time		40			ns
t_{CH}	SCK High time		40			ns
t_{CC}	CSN to SCK setup	Low power mode	7000			ns
		Constant latency mode	2000			ns
t_{CCH}	Last SCK edge to CSN Hold		2000			ns
t_{CWH}	CSN Inactive time		300			ns
t_{CDZ}	CSN to Output High Z				40	ns
f_{SCK}	SCK frequency		0.125		1	MHz
t_R,t_F	SCK Rise and Fall time				100	ns

** Increases/decreases with 1.2 ns/pF load.

3.4 UART Interface

The UART interface offers fast, full-duplex, asynchronous serial communication support in hardware up to 115.2Kbps. Parity checking is supported. It is connected to an FTDI FT230X UART-to-USB conversion IC.

3.4.1 UART Interface Parameters

Parameters	Description	Min.	Typ.	Max.	Unit
$I_{UART115k}$	Run current at 115200 bps	-	220-	-	µA
$I_{UART1k2}$	Run current at 1200 bps	-	210	-	µA
f_{UART}	Baud rate for UART	1.2	-	1000	kbps

3.5 ADC/Comparator Interface

The module supports one comparator input on pins IO0-2 and/or up to 3 A/D inputs on IO0-2. There is an optional external reference voltage on IO3/AVREF, or an internal voltage reference of 1-8 8ths of VCC can be used.

3.5.1 Auxiliary ADC Characteristics

Parameters	Description	Min.	Typ.	Max.	Unit
DNL_{10b}	Differential non-linearity (10bit mode)		< 1		LSB
INL_{10b}	Integral non-linearity (10 bit mode)		2		LSB
V_{os}	Offset error.	-2		+2	%
e_{G*}	Gain error.	-2		+2	%
V_{REF_VBG}	Internal Band Gap reference voltage (VBG).				
$V_{REF\_VBG\_ERR}$	Internal Band Gap reference voltage error.				
$V_{REF\_VBG\_DRIFT}$	Internal Band Gap reference voltage drift.	-200		+200	ppm/°C
V_{REF_EXT}	External reference voltage (AREF0/1).	0.83	1.2	1.3	V
$V_{REF\_VDD\_LIM}$	Limited supply voltage range for ADC using VCC with prescaler as the reference. CONFIG.REFSEL = SupplyOneHalfPrescaling	1.7		2.6	V
	CONFIG.REFSEL = SupplyOneThirdPrescaling	2.5		3.6	V
t_{ADC10b}	Time required to convert a single sample in 10 bit mode.		68		µs
t_{ADC9b}	Time required to convert a single sample in 9 bit mode.		36		µs
t_{ADC8b}	Time required to convert a single sample in 8 bit mode.		20		µs
I_{ADC}	Current drawn by ADC during conversion.		260		µA
ADC_ERR_1V8	Absolute error when used for battery measurement at 1.8 V, 2.2 V, 2.6 V, 3.0 V, and 3.4 V		3		LSB
ADC_ERR_2V2			2		LSB
ADC_ERR_2V6			1		LSB
ADC_ERR_3V0			1		LSB
ADC_ERR_3V4			1		LSB

* Source impedance less than 5 kΩ.

** Internal reference, input from VCC/3, 10 bit mode. VCC is 3.3V

4 Environmental Specification

4.1 Absolute Maximum Rating

Description	Min	Max	Unit
Storage temperature	-40	85	°C
Operating temperature	-20	75	°C
VCC	-0.3	+3.9	V
VIO	-0.3	VCC+0.3	V

4.2 Recommended Operating Condition

Parameter	Min	Max	Unit
Operating Temperature Range	-20	75	°C
VCC	2.1	3.6	V

5 Regulatory information

Warning: Changes or modifications to this device not expressly approved by Afero could void the user's authority to operate the equipment.

5.1 FCC

NOTE: This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to part 15 of the FCC rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his own expense.

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

5.2 Industry Canada

This device complies with Industry Canada licence-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.

Le présent appareil est conforme aux CNR d'Industrie 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, et (2) l'utilisateur de l'appareil doit accepter tout brouillage radioélectrique subi, même si le brouillage est susceptible d'en compromettre le fonctionnement.