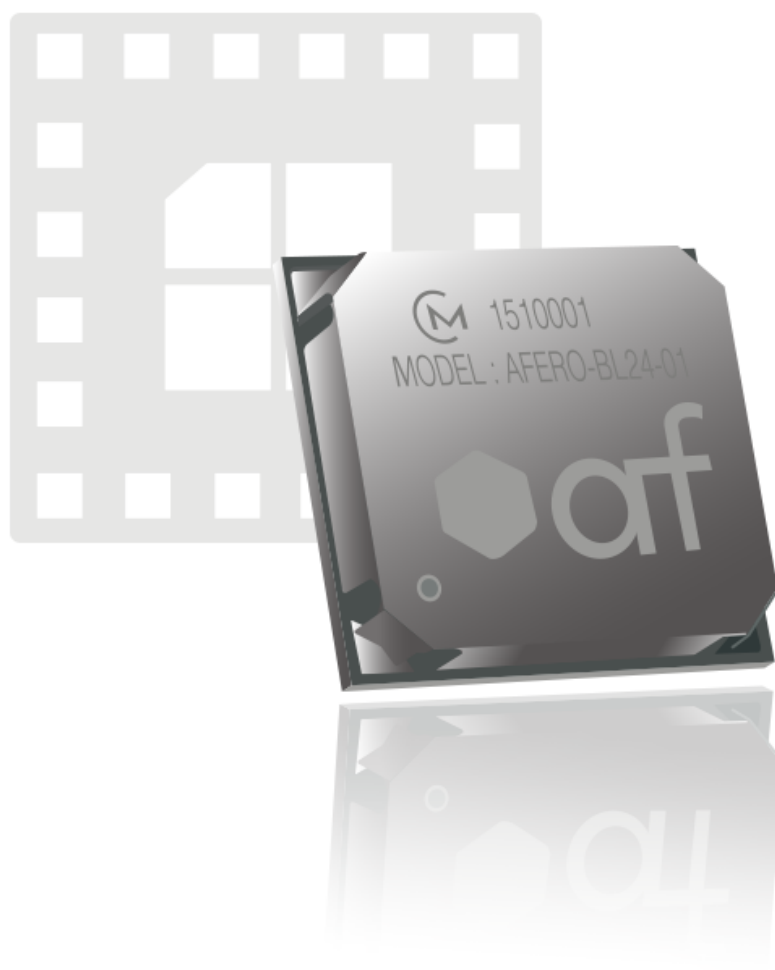




AFERO-BL24-01 Data Sheet

BLE Module



Revision History

Revision	Date	Author	Change Description
1.0	12/15/2015	RF PD	Formal release.
1.1	12/22/2015	CM	Part number reference to Murata removed, restyling.
1.2	1/18/2016	CM	Added reflow process reference.
1.3	2/11/2016	CDV	Unit abbreviation corrections.
1.4	3/8/2016	DI	Corrected pinout diagram; modified PCB landing pattern diagram; added recommended stencil dimensions diagram.
1.5	10/5/2016	CDV	Clarification of comparator input.

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1 Introduction

AFERO-BL24-01 is a Bluetooth® Smart module. It enables ultra-low power connectivity for data communication. The product integrates a Bluetooth Low Energy IC, security IC, RF front end, and crystal into a very small package. This is an ideal solution for Internet of Things (IoT) application.

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 (app-level monitoring and control)
- Cloud (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, 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. Afero Dynamic Hub Technology further extends users' control over their devices by providing a secure network that connects wirelessly to the Afero Cloud using LTE.

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 shield (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. Your ASR-1 must be activated before it will function. For more information about ASR-1 activation, go to afero.io/activate.

1.2 Features

- Bluetooth 4.1
- Dimensions: 7.5 x 8.0 x 1.8 mm
- Package: LGA
- Antenna Configuration: RF pin
- Maximum transmit power: +3.5dBm (at antenna port)
- Receive sensitivity: -92dBm
- Power consumption: TX/RX peak current 15.5mA/14.5mA
- Host interface: SPI
- Other interfaces: 4xGPIO, 1xComparator with optional external voltage reference, Debug UART
- Operating temperature range: -20° C to 75° C
- Bluetooth, RoHS compliant
- MSL Level 3, in accordance with JEDEC J-STD-020

1.3 Applications

- Home Automation

1.4 Block Diagram

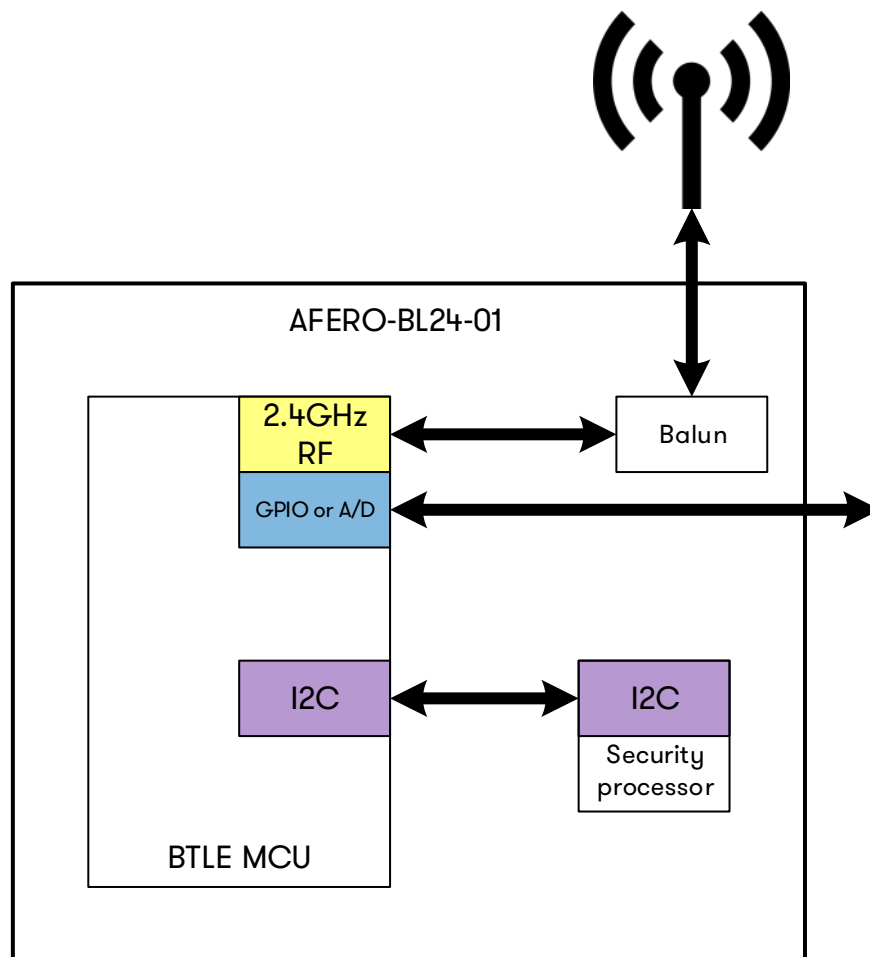


Figure 1.1 Block Diagram

1.5 Acronyms

AIO	Analog Input / Output
BTLE	Bluetooth Low Energy or Bluetooth Smart technology
GAP	Generic Access Profile
GATT	Generic ATtribute protocol
HID	Human Interface Device
I2C	Inter-Integrated Circuit communications protocol
L2CAP	Logical Link Control and Adaptation Protocol
MCU	MicroController Unit
PIO	Programmable Input / Output
PWM	Pulse Width Modulation
SPI	Serial Peripheral Interface
UART	Universal Asynchronous Receiver Transmitter

2 Mechanical Specification

2.1 Module Dimensions

Table 2.1: Module Dimensions

Parameter	Typical	Unit
Dimension (L x W x H)	7.5 x 8.0 x 1.8	mm
Dimension tolerances	±0.2	mm

2.2 Top and Side View

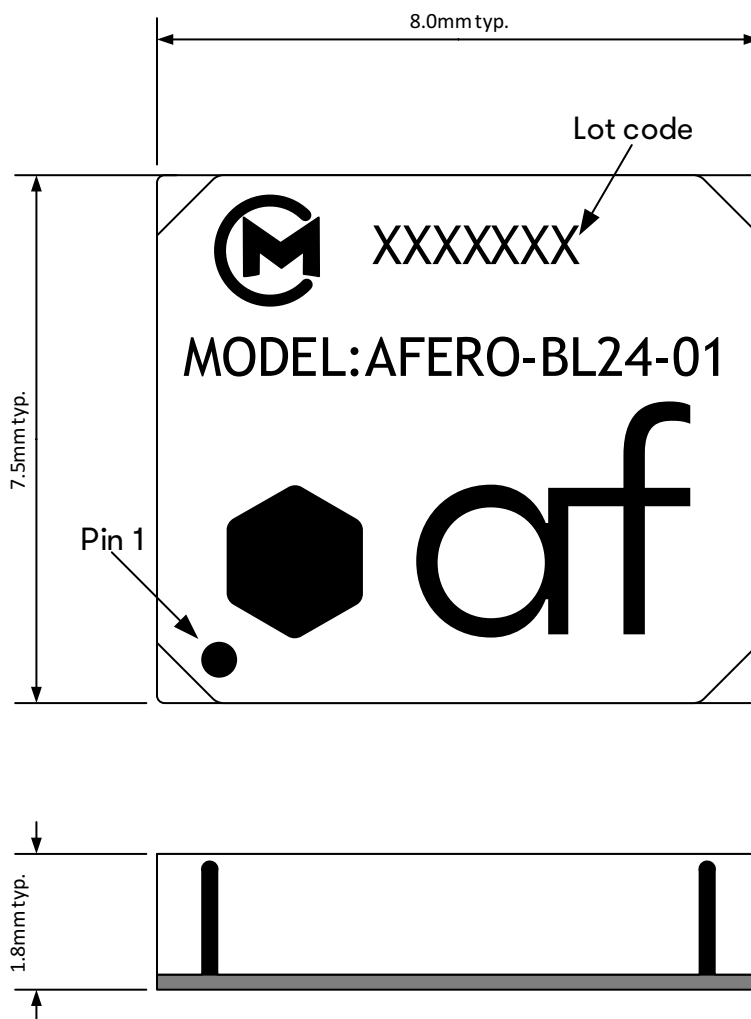


Figure 2.1 Module Top and Side View (Unit: mm)

2.3 PCB Footprint Top View

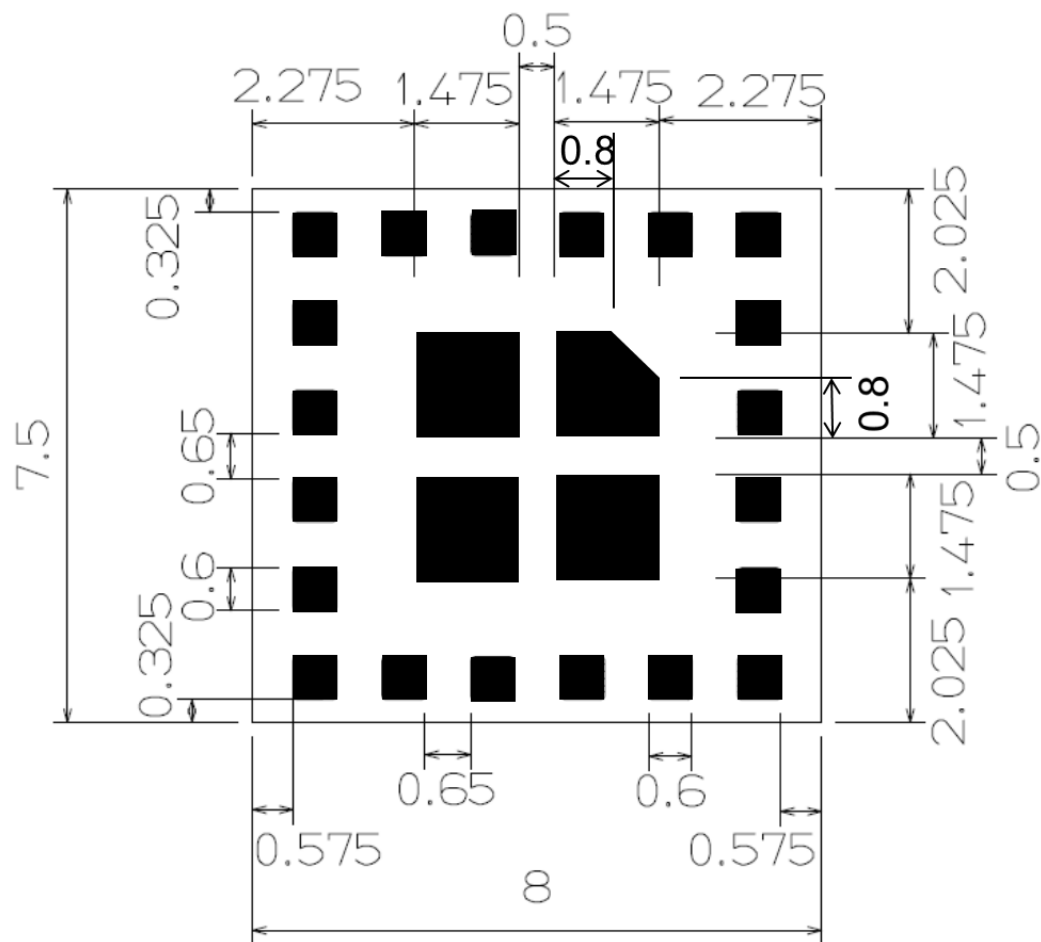


Figure 2.2 Module Footprint Top View (Unit: mm)

2.4 Pin Configuration

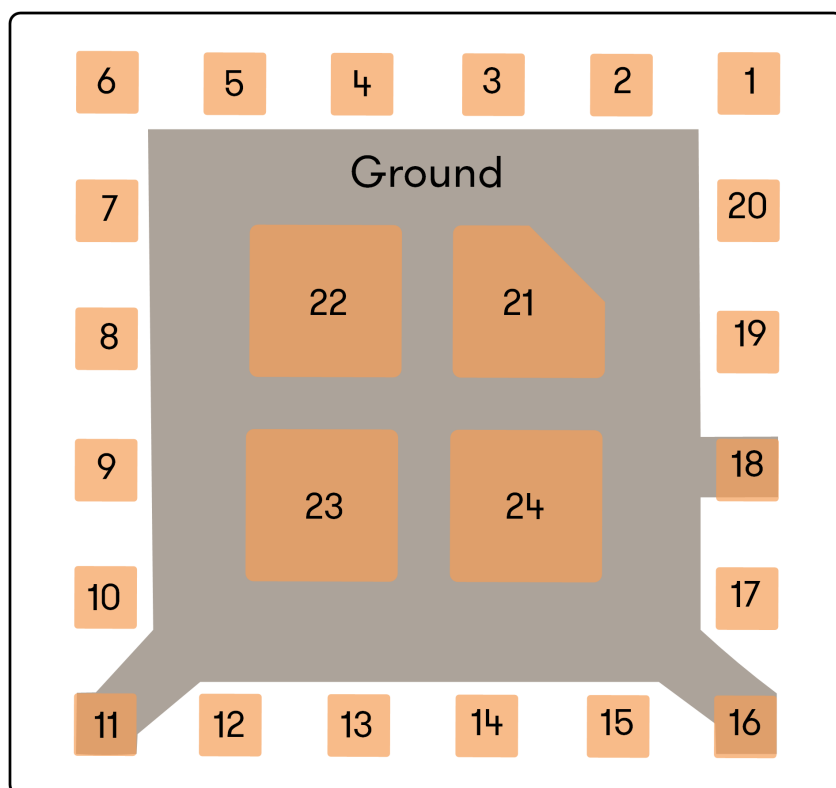


Figure 2.3 Pinout Diagram Top View

Table 2.2 Pinouts

Pin #	Pin Name	I/O	Description
1	HOST_INT_B	O, open-drain	GPIO; host interrupt
2	IO0/A0	I/O	GPIO; ADC input 0
3	IO1/A1	I/O	GPIO; ADC input 1
4	IO2/A2	I/O	GPIO; ADC input 2
5	IO3/AREF	I/O	GPIO; ADC reference voltage
6	V _{CC}	I	Module power input
7	SPI_MISO	O	GPIO; SPI master input/slave output
8	SPI_SCS	I	GPIO; SPI slave select
9	SPI_SCLK	I	GPIO; SPI clock
10	SPI_MOSI	I	GPIO; SPI master output/slave input
11	GND		Ground
12	RES1	I/O	Reserved for factory use
13	RES2	I/O	Reserved for factory use
14	DBG_UART_RX	I	Debugging/factory UART RX
15	DBG_UART_TX	O	Debugging/factory UART TX
16	GND		Ground
17	RF_ANT_OUT	I/O	RF Signal Out
18	GND		Ground
19	RSTB	I	System reset (active low)
20	RES3	I	Reserved for future use
21	GND		Ground
22	GND		Ground
23	GND		Ground
24	GND		Ground

2.5 Recommended PCB Landing Pattern

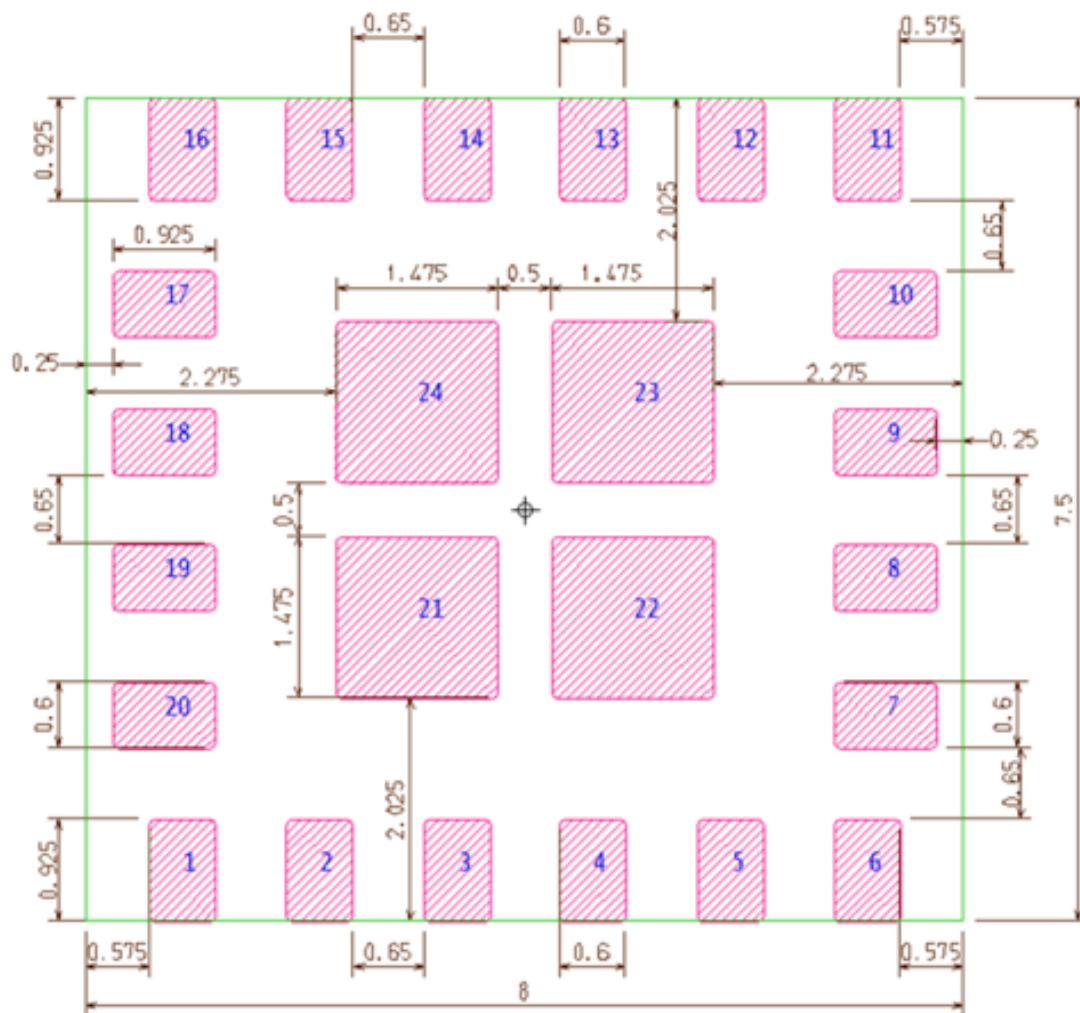


Figure 2.4 Recommended PCB Landing Pattern

2.6 Recommended Stencil Dimension

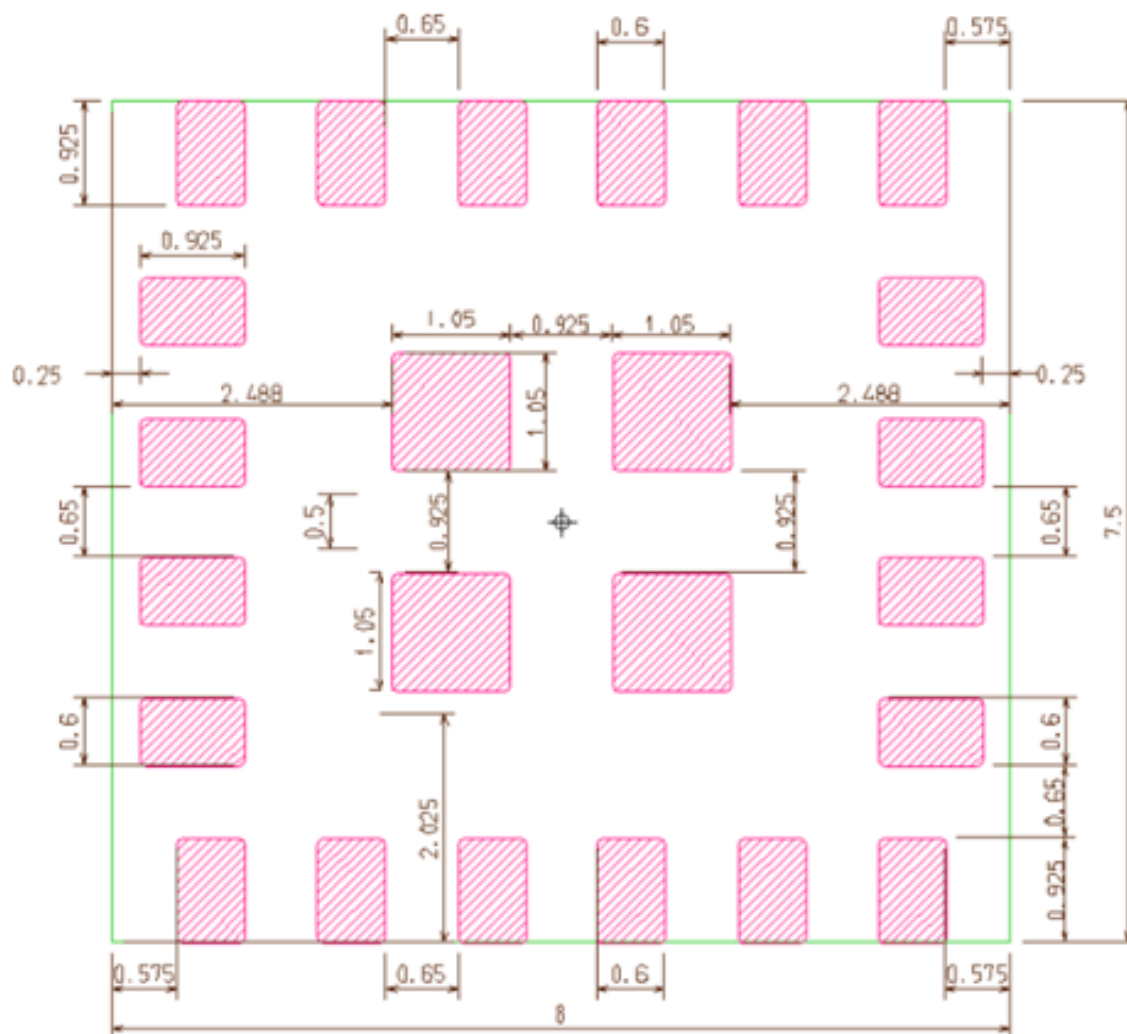


Figure 2.5 Recommended Stencil Dimension

3 DC Electrical Specification

3.1 Typical Power Consumption

Table 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 4 lines of programmable bidirectional I/O are provided. 3 of the GPIO lines can be configured to analog ADC/comparator inputs and one (IO3/AREF) can be configured as an external analog reference.

Table 3.2 Digital I/O Characteristics

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

* Maximum number of pins with 5mA high driver is 3.

** V_{CC} is 3.3V; V_{SS} is 0V

3.3 SPI Interface

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

3.3.1 SPI Slave Specification

Table 3.3 SPI Slave Characteristics

Parameters	Description	Min.	Typ.	Max.	Unit
I _{SPI} 125K	Run current for SPI slave at 125 kbps*		180		μA
I _{SPI} 2M	Run current for SPI slave at 2Mbps*		183		μA
f _{SPI}	Bit rates for SPI	0.125		1	Mbps

* CSN asserted.

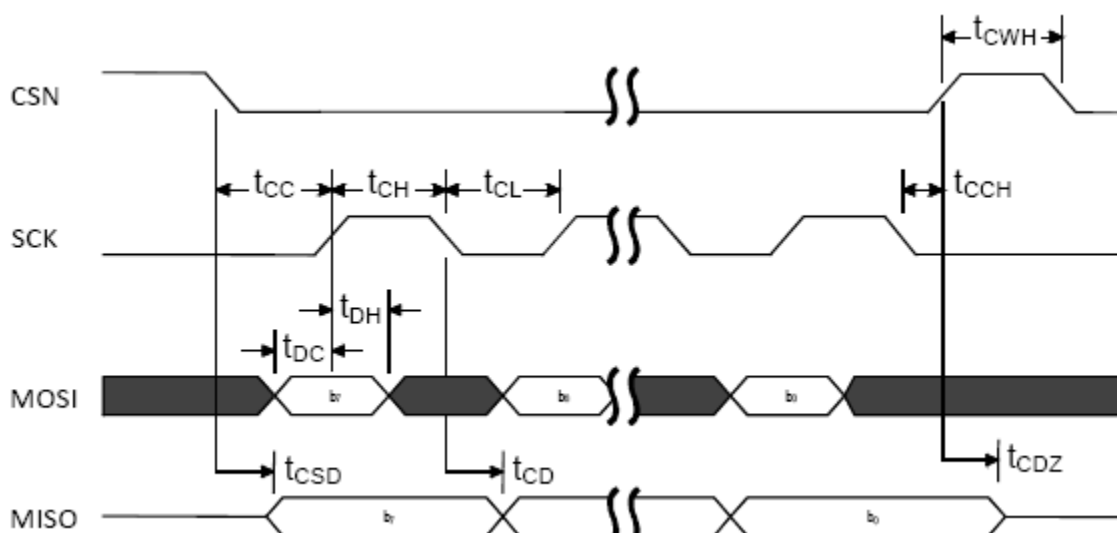


Figure 3.1 SPI Slave timing diagram, one byte transmission, SPI Mode 0

Table 3.4 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 115.2 kbps. Parity checking is supported.

Table 3.5 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 IO 0-2. The comparator has an optional external reference voltage on IO3/AVREF or it can use an internal voltage reference of 1-8 8ths of V_{CC} .

Table 3.6 Auxiliary ADC Characteristics

Parameters	Description	Min.	Typ.	Max.	Unit
DNL_{10b}	Differential non-linearity (10-bit 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).		1.2		V
$V_{REF_VBG_ERR}$	Internal Band Gap reference voltage error.	-1.5		+1.5	%
$V_{REF_VBG_DRIFT}$	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 V_{CC} 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 $V_{CC}/3$, 10-bit mode. V_{CC} is 3.3V.

4 RF Specification

Conditions: 25°C, $V_{CC}=3.3V$, Parameters measured at RF connector.

Table 4.1 RF Characteristics

RF Characteristics	Specification			Unit
	Min.	Typ.	Max.	
Center frequency	2402	-	2480	MHz
Channel Spacing	-	2	-	MHz
Number of RF Channels	-	40	-	-
Output power	-	3.5	-	dBm
Modulation Characteristics				
1) $\Delta f_{1_{avg}}$	225	-	275	kHz
2) $\Delta f_{2_{max}}$ (at 99.9%)	185	-	-	kHz
3) $\Delta f_{2_{avg}} / \Delta f_{1_{avg}}$	0.8	-	-	-
Carrier frequency offset and drift				
1) Frequency offset: $ f_n - f_{TX} $	-	-	150	kHz
2) Frequency drift: $ f_0 - f_n $	-	-	50	kHz
3) Drift rate #0: $ f_1 - f_0 $	-	-	20	kHz
4) Drift rate #n: $ f_n - f_{n-5} $	-	-	20	kHz
Receiver sensitivity (PER < 30.8%)	-	-92	-70	dBm
Maximum input signal level (PER < 30.8%)	-10	-	-	dBm

5 Environmental Specification

5.1 Absolute Maximum Rating

Table 5.1 Absolute Maximum Rating

Description	Min	Max	Unit
Storage temperature	-40	85	°C
Operating temperature	-20	75	°C
V _{CC}	-0.3	+3.9	V
V _{IO}	-0.3	V _{CC} +0.3	V

5.2 Recommended Operating Condition

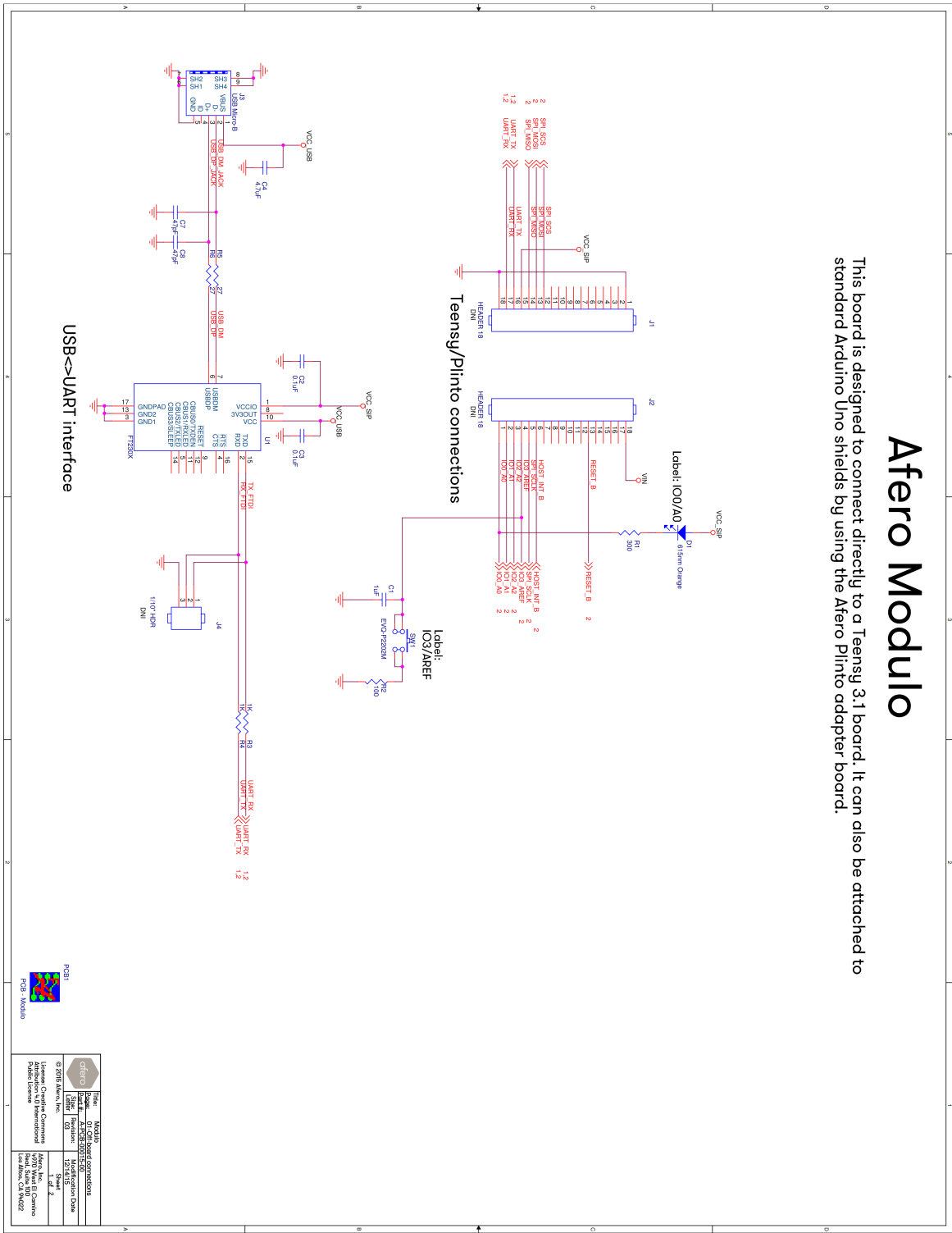
Table 5.2 Recommended Operating Condition

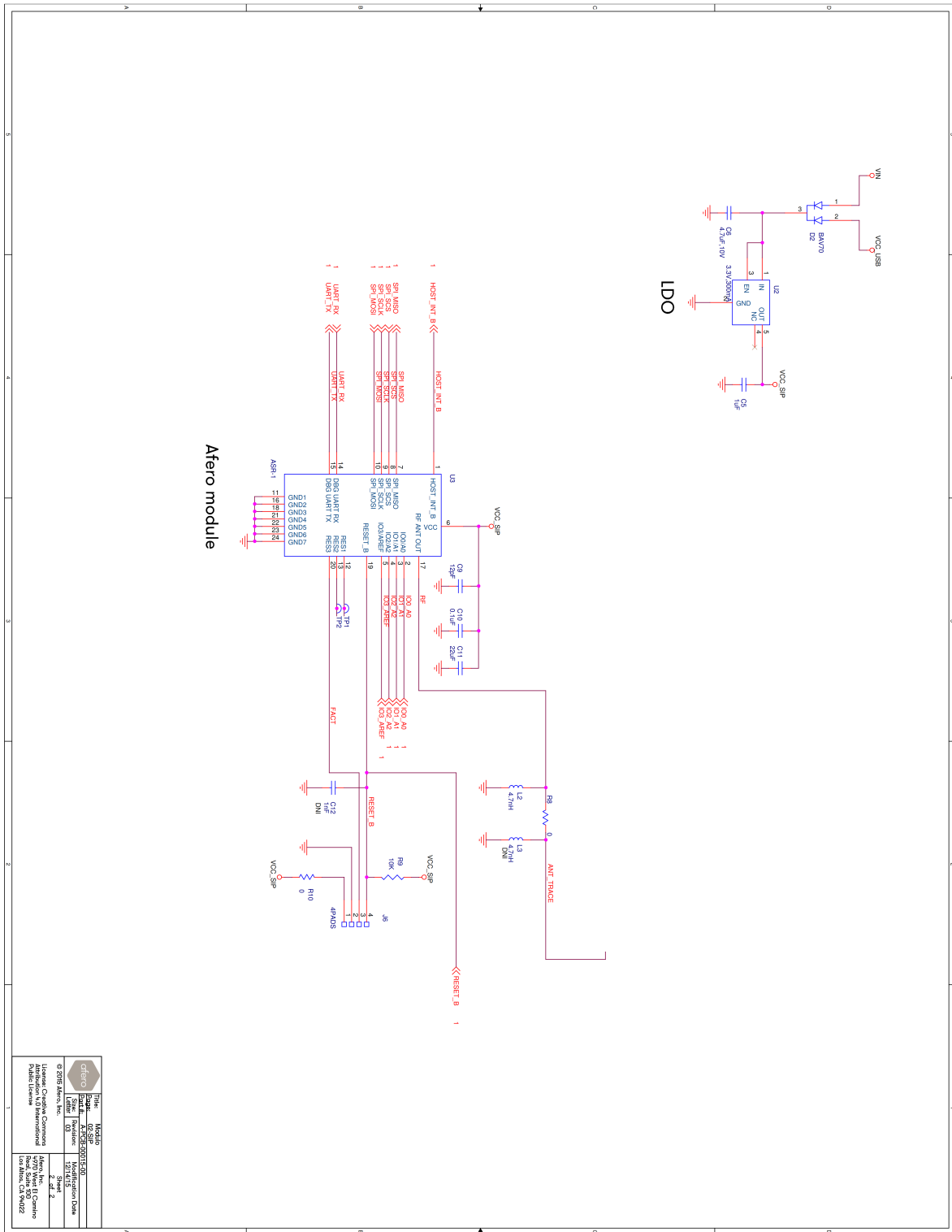
Parameter	Min	Max	Unit
Operating Temperature Range	-20	75	°C
V _{CC}	2.1	3.6	V

6 Application Reference

Afero Modulo

This board is designed to connect directly to a Teensy 3.1 board. It can also be attached to standard Arduino Uno shields by using the Afero Plinto adapter board.





7 Assembly Information

When attaching the ASR-1 module to its host PCB, use the recommended lead-free soldering reflow profile shown in the graph below.

The metal shield is nickel silver plated and the reflow condition may change color to brown. Use of N2 reflow is recommended to prevent any color change.

When products are immersed in solvent after mounting, pay special attention to maintain the temperature difference within 100°C. Set up the highest temperature of reflow within 260°C.

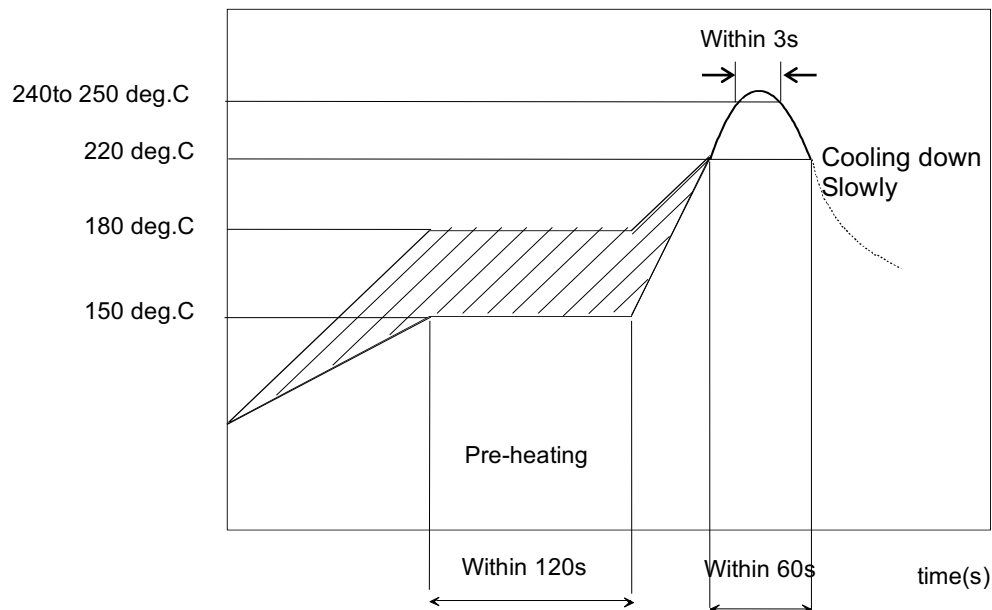


Figure 7.1 Reflow soldering standard conditions (Example)

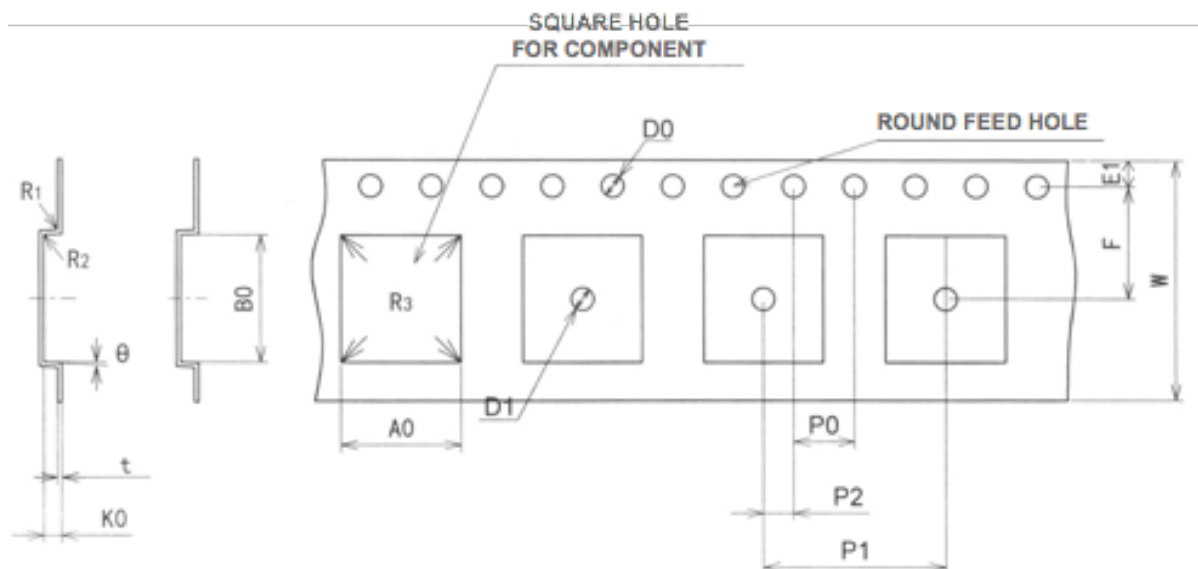
The module is designed to withstand two reflows.

Use rosin type flux or weakly active flux with a chlorine content of 0.2 wt % or less.

Since this Product is Moisture Sensitive, no cleaning is permitted.

8 Packaging and Marking Information

8.1 Carrier Dimensions



Symbol	A0	B0	W	F	E1	P1
Value (mm)	7.9±0.1	8.4±0.1	16.0±0.2	7.5±0.1	1.75±0.1	12.0±0.1
Symbol	P2	P0	D0	K0	D1	T
Value (mm)	2.0±0.1	4.0±0.1	1.5 +0.1/-0	2.02±0.1	1.5±0.1	0.3±0.05
Symbol	R1	R2	R3	θ		
Value (mm)	0.3 MAX	0.3 MAX	0.3 MAX	3° MAX		

Figure 8.1 Carrier Tape Dimensions (Unit: mm)

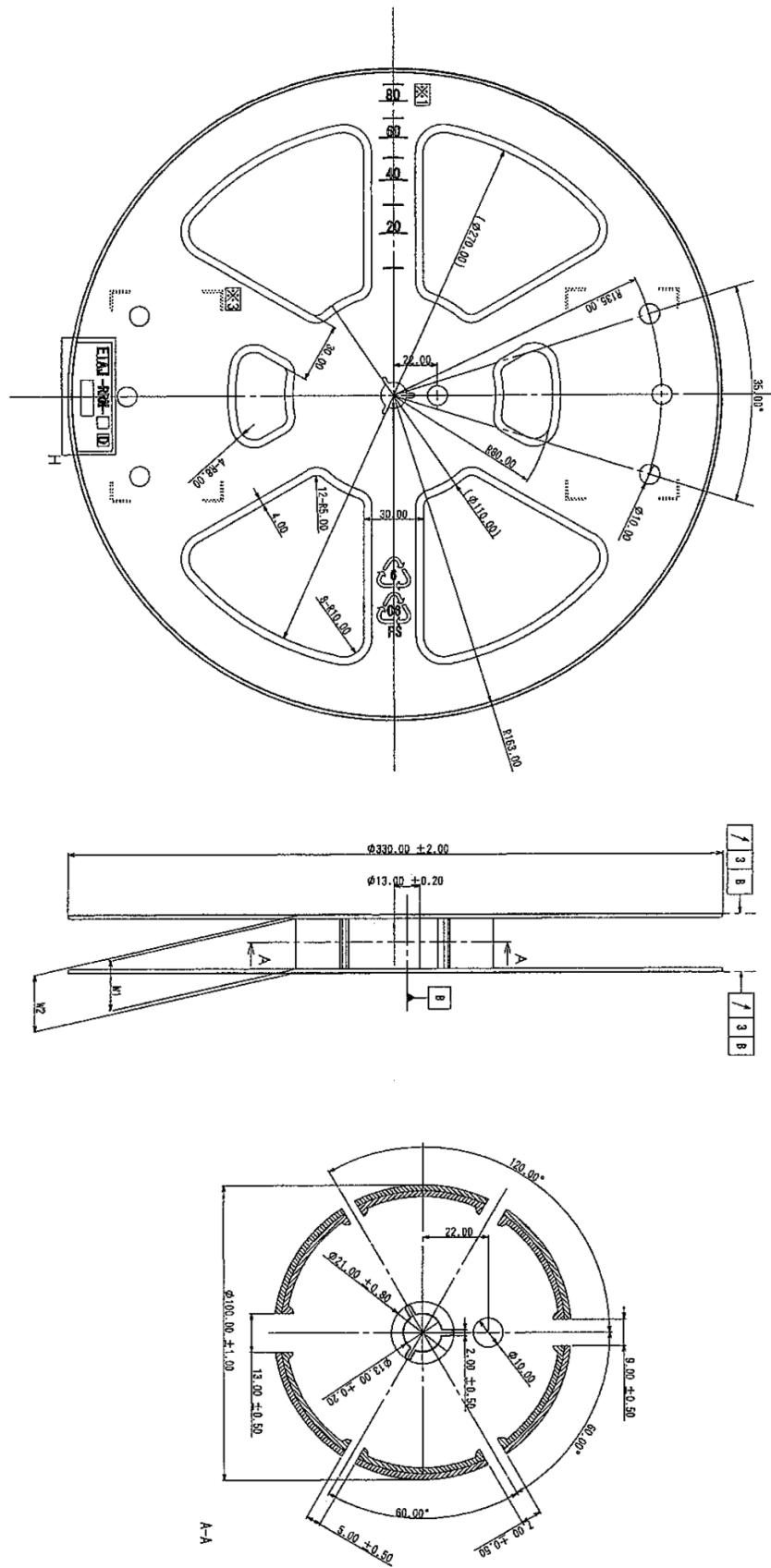


Figure 8.2 Packaging Reel Dimensions (Unit: mm)

8.2 Moisture Sensitivity Level

The AFERO-BL24-01 is qualified to moisture sensitivity level 3 in accordance with JEDEC J-STD-020.

9 RoHS Information

The AFERO-BL24-01 module conforms to RoHS requirement.

10 Ordering Information

Product	Part Number	Standard Order Increment
ASR-1 BLE Module	AFERO-BL24-01	1000 pc

11 Technical Support Contact

Afero, Inc.
4970 El Camino Real Suite 100
Los Altos, CA 94022
USA