

Milli™5 - Product Specification

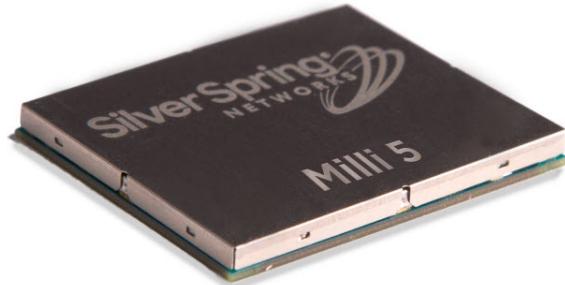
Overview

The Silver Spring Networks' Milli 5 is a cost-effective, energy-efficient sub-GHz wireless communications device.

The Milli 5 is optimized for a wide range of 802.15.4g network applications in domains such as smart grid, industrial control systems, smart city, wearables, consumer electronics, health monitoring, and more.

The Milli 5 is the first in the family of such devices and may be integrated with both battery-powered devices such as water meters and constantly powered devices such as voltage monitoring relays and photocells. It comes equipped with on-board firmware that supports wireless communications in an IPv6 wireless mesh network. It uses a well-defined API for standards-based communications with the integrated device over a serial port, supporting various protocols.

Figure 1. Silver Spring Networks Milli 5



Key Benefits

- Open standard communications with support for IPv6 and 802.15.4g radio
- Highly scalable and reliable operations including peer-to-peer functionality with mesh networking technology
- Battery Life of up to 20 years can be achieved with battery power optimization
- Security assurance with standard cryptographic algorithms and PKI-based implementation
- Simple integration into any device with small footprint and easy-to-use development kit
- Cost-effective with short development cycle, low infrastructure costs, and fast network deployment

Features

This section describes the features of Milli 5.

Radio and Networking Capabilities

- Operates from 870-875.6 and 902-928 MHz
- RF output power: 200 mW (+23 dBm)
- Standard signal and power interface
- ARM Cortex-M3 32bit-processing for low power
- 50 kbps data rate

Security Assurance

- Certificate-based device authentication
- Certificate-based mutual authentication and authorization between device and applications
- Data Confidentiality
- Firmware validation
- FIPS 140-2 level 3 compliant security capability
- On board flash storage for firmware and data

HW Interfaces available

- F/W currently supports CoAP over UART

Please contact Silver Spring Networks about the roadmap for supporting other interfaces and or if your application requires a different interface.

Specifications

This section describes the physical and electrical specifications for Milli 5.

Physical Specifications

Parameter	Value
Size	30x25x2.5mm
Weight	5g (approximately)
Package type	LGA – 72 pins
Material	PCB board

Electrical Specifications

This section contains electrical specifications for Milli 5.

Note: All specifications are preliminary and are subject to change without notice. Product specifications contain Silver Spring Networks confidential information and can be used only under the terms of the Non-disclosure agreement (NDA).

Absolute Maximum Ratings

Under no circumstances must the absolute maximum ratings be violated. Stress exceeding one or more of the limiting values may cause permanent damage to the device.

Parameter	Conditions	Value	Unit
Supply voltage	All supply pins must have the same voltage	-0.3 to 3.6	V
Voltage on any digital pin		-0.3 to VDD+0.3, max 3.6	V
Input RF level		+10	dBm
VSWR limit	At antenna port	10:1	
Storage temperature range		-40 to +120	°C
Reflow soldering temperature	According to IPC/JEDEC J-STD-020	260	°C
ESD	<ul style="list-style-type: none"> Human Body Model Charged Device Model (RF pins) Charged Device Model (non-RF pins) 	250 250 250	V

Recommended Operating Conditions

Parameter	Conditions	Min	Max	Unit
Ambient temperature range	0-95% RH	-40	85	°C

Parameter	Conditions	Min	Max	Unit
Supply voltage		3.1	3.6	V
Input voltage	Do not exceed the absolute maximum voltage	-0.3	VDD +0.3	V
Ripple			10	mV
Transient			20	mV

Power Consumption

Parameter	TYPE	Max	Unit	Conditions
Sleep/Power-down	~ 10 μ A target goal (RTC and SRAM retention)		μ A	32 kHz clock running, MCU register retention, full RAM retention
RF channel sense	~2		mA	
Power Consumption Radio RX	8		mA	RX sniff mode, searching for packet
Power Consumption Radio TX	170	200	mA	

Receive Parameters

Parameter	Min	TYP	Max	Units	Conditions (870 - 875.6 and 902 - 928 Mhz)
Sensitivity		-104		dBm	10% PER and 50 kbps
Blocking	40	50		dB	200 & 400kHz channels (802.15.4g)
Spurious Emissions		-55		dBm	< 1 GHz
Image Rejection		50		dB	FW controlled image rejection optimized

Transmit Parameters

Parameter	Min	TYP	Max	Conditions
Output power highest setting	20	22	23	dBm
Output power lowest setting	-3	0	5	dBm

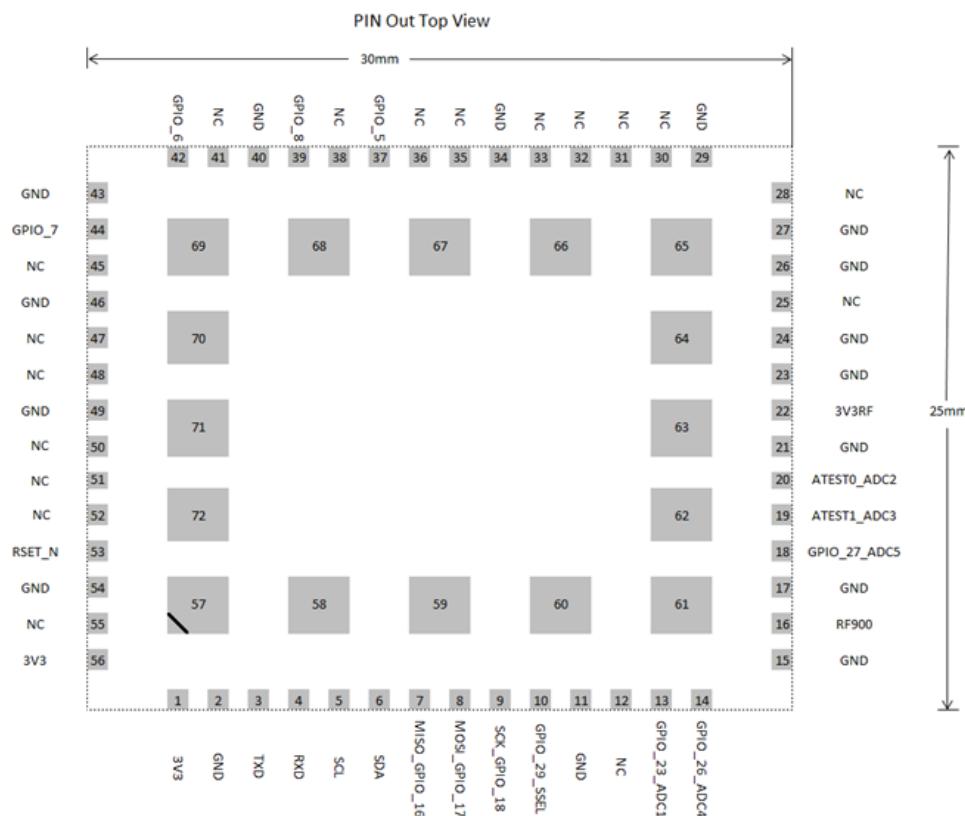
Signal Interface

The Silver Spring Networks Milli 5 is an SMT reflow Land Grid Array (LGA) module with I/O and power connections at the bottom.

Pin Assignments and Signal Description

The Milli 5 module provides connecting pads to integrate the module into external applications. Figure 2 shows the pin assignments and Table 1 lists the pins and signal descriptions. Note that pin assignments are preliminary and might change at a later date.

Figure 2 Pin assignments



Note: Pins marked “NC” (no connect) can be soldered but must be left open, and not be connected to an external application. It is highly recommended that all pads be soldered.

Table 1. Pins and signal descriptions.

Pin Number	Signal Name	Input/Output	Description
1	3V3	Power	3.1V - 3.6V main module supply
2	GND	Power	Ground

Pin Number	Signal Name	Input/Output	Description
3	TXD	Output	UART interface, RXD/TXD (Serial Interface) communications (up to 115,200 bps, 8-N-1)
4	RXD	Input	UART interface, RXD/TXD (Serial Interface communications (up to 115,200 bps, 8-N-1)
5	SCL	Output	NC
6	SDA	I/O	NC
7	MISO_GPIO_16	I/O	NC
8	MOSI_GPIO_17	I/O	NC
9	SCK_GPIO_18	I/O	NC
10	GPIO_29_SSEL	I/O	NC
11	NC (Test RSV)	I/O	NC
12	NC (Test RSV)	I/O	NC
13	GPIO_23_ADC1	I/O	NC
14	GPIO_26_ADC4	I/O	NC
15	GND	Power	Ground
16	RF900	I/O	RF I/O port, 50 ohm nominal
17	GND	Power	Ground
18	GPIO_27_ADC5	I/O	NC
19	ATEST1_ADC3	I/O	NC
20	ATEST0_ADC2	I/O	NC
21	GND	Power	Ground
22	3V3RF	Input	NC
23	GND	Power	Ground
24	GND	Power	Ground
25	NC	N/A	NC
26	GND	Power	Ground
27	GND	Power	Ground

Pin Number	Signal Name	Input/Output	Description
28	NC	N/A	NC
29	GND	Power	Ground
30	NC	N/A	NC
31	NC	N/A	NC
32	NC	N/A	NC
33	NC	N/A	NC
34	GND	Power	Ground
35	NC	N/A	NC
36	NC	N/A	NC
37	GPIO_5	I/O	Interrupt pin – Pin to wake up host processor from Milli 5
38	NC	N/A	NC
39	GPIO_8	Output	is an open collector pin that Milli 5 would pull low to affect the host device to reset.
40	GND	Power	Ground
41	NC	N/A	NC
42	GPIO_6	I/O	NC
43	GND	Power	Ground
44	GPIO_7	Input	Interrupt pin - wakes up Milli 5 so host processor can send data
45	NC	N/A	NC
46	GND	Power	Ground
47	NC	N/A	NC
48	NC	N/A	NC
49	GND	Power	Ground
50	NC	N/A	NC
51	NC	N/A	NC

Pin Number	Signal Name	Input/Output	Description
52	NC	N/A	NC
53	RSET_N	Input	Milli 5 module master reset Active low input. When asserted, all outputs will be made high impedance
54	GND	Power	Ground
55	NC	N/A	NC
56	3V3	Power	3.1V – 3.6V main module supply
57-72	GND	Power	Ground

* Pins 3-16 are bi-directional, inputs are pull up/pull down, and outputs are configurable as push-pull or open drain. Drive capacity varies with pin.

50 ohm PCB Design Guidelines

Antenna design and RF layout are critical in a wireless system that transmits and receives electromagnetic radiation in free space. The Milli 5 module does not include an antenna connector. The antenna (or unique antenna connector) must be connected to Milli 5 via a transmission line implemented on the host PCB.

SSN recommends the use of a co-planer Waveguide to minimize space and board real estate. The PCB trace should be kept as short as possible to minimize path loss.

IPC 6011 and IPC 6012 Class 2 or better PCB manufacturing practices must be followed to ensure repeatable results.

The transmission line trace will be bounded on both sides by a ground reference plane. For EMI considerations this ground plane should be extended and connected to other ground layers, one of which is on the opposite side of the PCB. The opposite side ground plane shall be contiguous under the trace and shall extend beyond the trace. These ground planes should be stitched together using vias spaced 40-50 mils (2 mm) apart. Avoid breaking up these ground planes by routing traces through them.

Avoid routing any other signal traces, especially high speed digital signals, near the transmission line. Locate the transmission line trace away from power supply lines and power supply regulatory circuitry.

Key design parameters

The antenna trace must have a characteristic impedance of $50 \Omega \pm 5\%$. The recommended dimensions and the Gerber layout for the antenna trace are provided on the following pages. To calculate the key parameters requires calculating transmission line parameters. Although there are many transmission line and trace impedance calculators found on-line, they are not as thorough as specialized tools, and in simplifying the calculations, may omit critical variables.

SSN recommends the use of AppCAD Design Assistant. This software is available as a free download from Avago Technologies: <http://www.avagotech.com/appcad>

Additional support information on AppCAD can be found here: <http://www.hp.woodshot.com/>

This reference design uses 1 oz copper. The base PCB material is ITEQ IT-180A. Data sheet available here: <http://www.prototron.com/documents/materials/IT-180A.pdf> which has an ϵ_r specified as 4.4.

PCB Design Guidelines; SSN Milli™5 Development board layout

Fig 1. Antenna trace design parameters

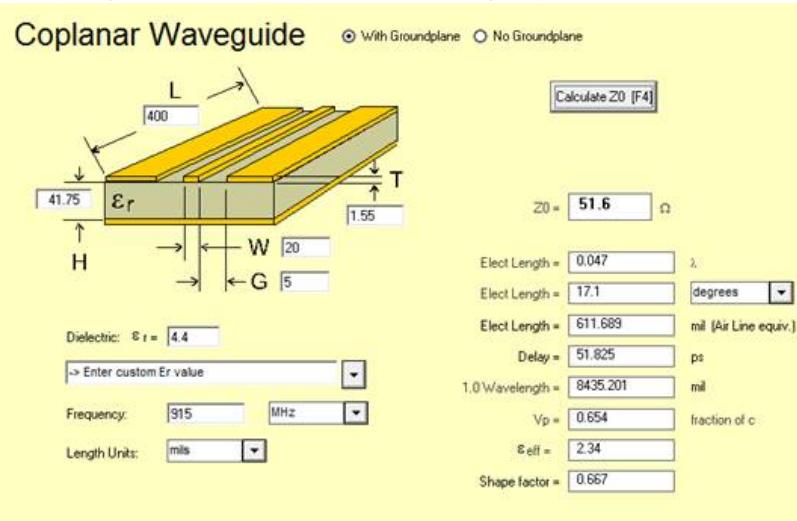
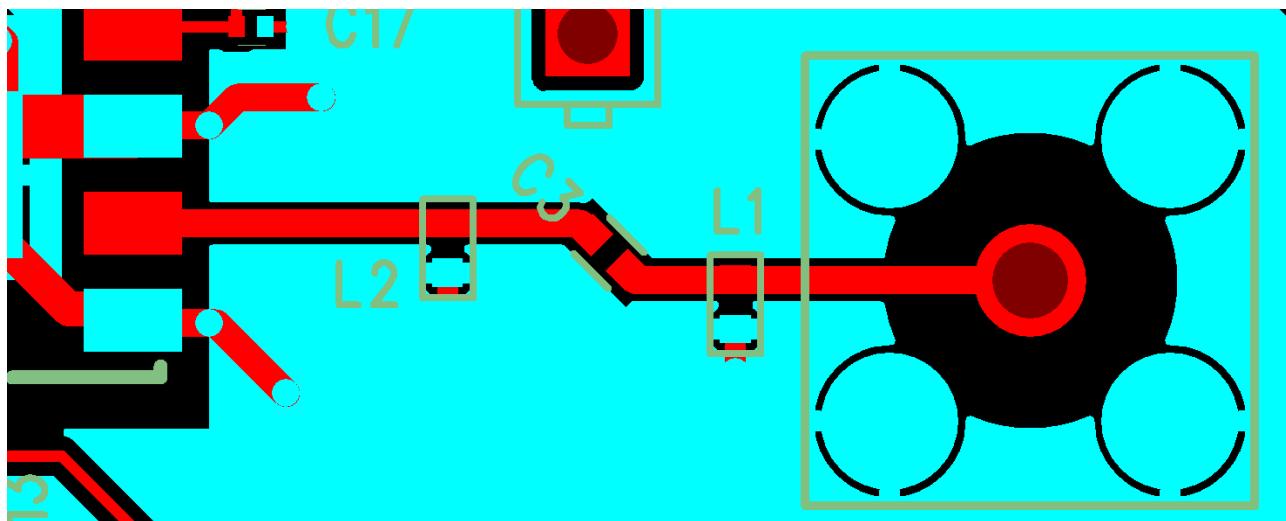
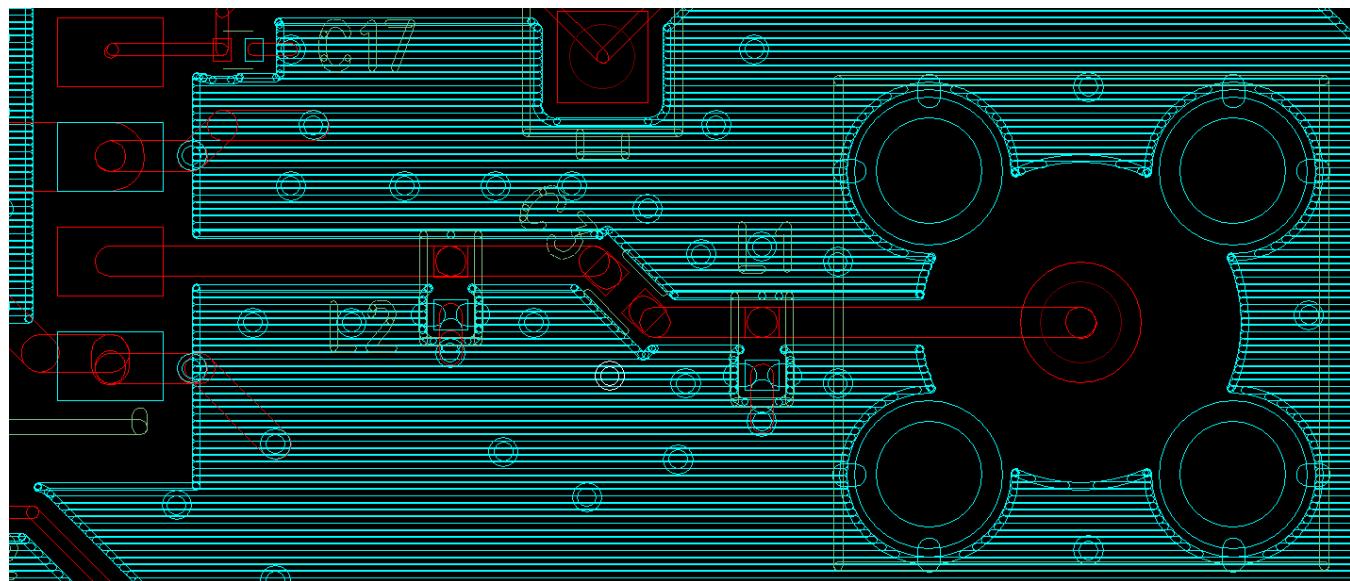


Fig 2. PCB Stackup

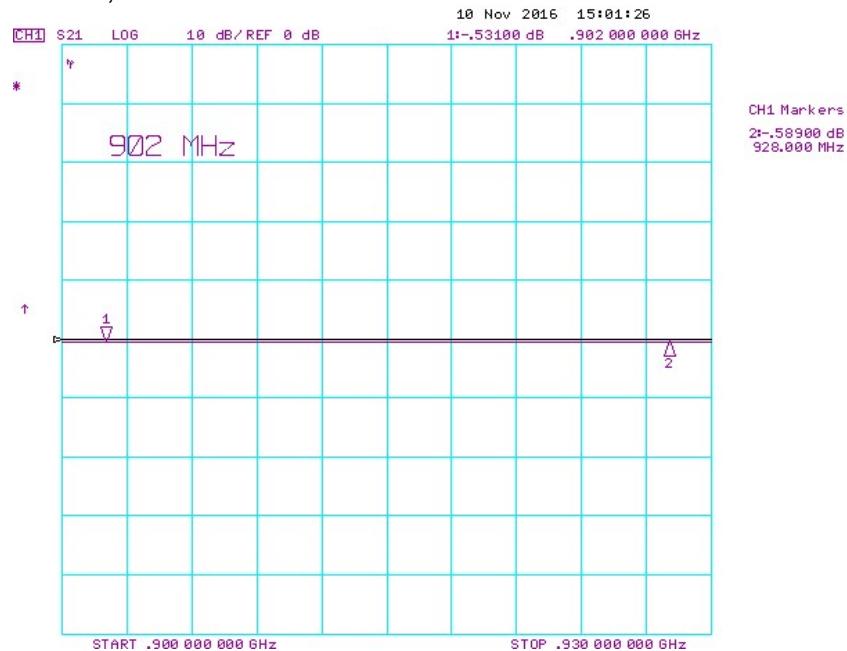
IT180A STACK-UP (ITEQ MATERIAL)					
Layer	Name	Type	Pressed THK.	Material	
1 (1-2)	Top Prepreg		0.8 1.55 41.75	Soldermask Foil + Plating (1 oz. Finished)	
	Bottom		1.55 0.8	Foil + Plating (1 oz. Finished) Soldermask	
Overall Thickness (Copper-to-copper): 47.244mil					

Fig 3. Coplanar Waveguide with Full Ground Pour**Fig 4. Coplanar Waveguide with ground outline showing vias 50 mils spaced**

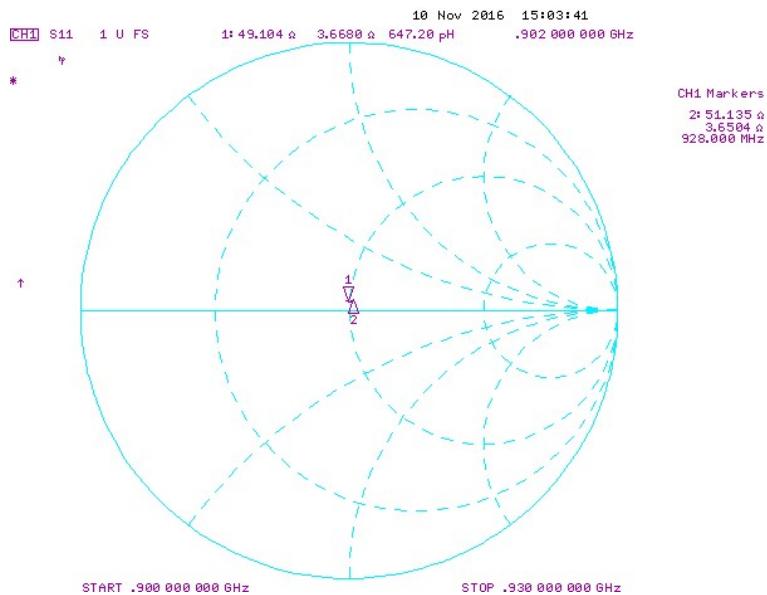
Transmission Line Measurements

For design verification, use of an S-Parameter Network Analyzer, such as Agilent 8719S may be used to characterize the losses of the transmission line. Solder a calibrated coaxial cable to pin 16 (RF900, RF I/O port) pin on the PCB to make the following measurements.

Path loss measurements, S12.



Line input impedance (Smith chart format) once the line has been terminated with a 50 ohm load is shown below.



Regulatory Compliance

FCC and Industry Canada Government Guidelines

Silver Spring Networks Milli 5

FCC ID: OWS-MIL51

IC: 5975A-MIL51

Modifications

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

Part 15 Certification Notice

This device complies with Part 15 of the FCC Rules and Industry Canada licence-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.

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

The device should be installed so that people will not come within 20 cm (8 in.) of the antenna.

Information to User for Class B digital device

This equipment has been tested and found to comply with Part 15 of the FCC Rules. 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.

Exigences d'Industrie Canada

La carte d'interface réseau (NIC) Silver Spring Network Relay Point (NRP) DOIT être installée par un technicien ayant reçu une formation adéquate. Une installation incorrecte peut annuler l'autorisation de l'utilisateur à se servir de l'équipement.

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.

L'antenne de cet émetteur ne doit pas se trouver à proximité de ou fonctionner en association avec une autre antenne ou un autre émetteur.

L'appareil doit être installé de telle sorte que les gens ne viendront pas au sein de 29 cm (11.4 in.) de l'antenne.

Les changements ou modifications apportés sans l'approbation expresse de l'autorité responsable de la conformité pourront entraîner l'annulation de l'autorisation d'utilisation de cet équipement.

Labeling Requirements for Host Device

The following is an extract from FCC PART 15 UNLICENSED MODULAR TRANSMITTER APPROVAL, DA 00-1407, Released: June 26, 2000, Section 6 describing labeling requirements for devices containing a modular transmitter.

Section 6. The modular transmitter must be labeled with its own FCC ID number, and, if the FCC ID is not visible when the module is installed inside another device, then the outside of the device into which the module is installed must also display a label referring to the enclosed module. This exterior label can use wording such as the following: "Contains Transmitter Module FCC ID: XYZMODEL1" or "Contains FCC ID: XYZMODEL1." Any similar wording that expresses the same meaning may be used. The Grantee may either provide such a label, an example of which must be included in the application for equipment authorization, or, must provide adequate instructions along with the module which explain this requirement.

In the latter case, a copy of these instructions must be included in the application for equipment authorization.

The following is an extract from RSS-GEN, General Requirements and Information for the Certification of Radio Apparatus, Section 3.2.1, describing labeling requirements for a host device integrating a radio module.

The host device shall be properly labelled to identify the modules within the host device.

The Industry Canada certification label of a module shall be clearly visible at all times when installed in the host device, otherwise the host device must be labelled to display the Industry Canada certification number of the module, preceded by the words "Contains transmitter module", or the word "Contains", or similar wording expressing the same meaning, as follows:

Contains transmitter module IC: XXXXXX-YYYYYYYYYYYY where XXXXXX-YYYYYYYYYYYY is the module's certification number.

L'extrait suivant provient du Cahier des charges sur les normes radioélectriques (CNR); exigences générales et information relatives à la certification des appareils radio, section 3.2.1, et décrit les exigences en matière d'étiquetage pour un dispositif hôte intégrant un module radio. Le dispositif hôte doit être correctement étiqueté afin d'identifier les modules qu'il comprend.

L'étiquette de certification Industrie Canada d'un module doit toujours être bien visible lors de l'installation sur un dispositif hôte. Dans le cas contraire, le dispositif hôte doit être étiqueté de façon à afficher le numéro de certification Industrie Canada du module, précédé de l'expression « Contains transmitter module » ou du mot « Contains », ou d'une formulation similaire ayant la même signification. Par exemple :

Contains transmitter module IC : XXXXXX-YYYYYYYYYYYY où XXXXXX-YYYYYYYYYYYY représente le numéro de certification du module.

The applicant for equipment certification of the module shall provide with each unit of the module either a label such as described above, or an explanation and instructions to the user as to the host device labelling requirements.

External Antenna Integration (RSS-GEN)

This radio transmitter 5975A-MIL51 has been approved by Industry Canada to operate with the antenna types listed in Table 2 with the maximum permissible gain and required antenna impedance for each antenna type indicated. Antenna types not included in this list, having a gain greater than the maximum gain indicated for that type, are strictly prohibited for use with this device.

Cet émetteur radio 5975A-MIL51 a été approuvé par Industrie Canada pour fonctionner avec les types d'antenne énumérés dans le tableau 2 ci-dessous avec le gain maximal admissible et l'impédance d'antenne requise pour chaque type d'antenne indiqué. Les types d'antennes ne figurant pas dans cette liste, ayant un gain supérieur au gain maximum

Table 2. External Antenna

Antenna	Antenna Type	900 MHz Gain (dBi)	Antenna Impedance
J-Pole, SSN 201-000006	Omni Directional	3	50
Pulse W1900	Stub	1	50

Under Industry Canada regulations, this radio transmitter may only operate using an antenna of a type and maximum (or lesser) gain approved for the transmitter by Industry Canada. To reduce potential radio interference to other users, the antenna type and its gain should be so chosen that the equivalent isotropically radiated power (e.i.r.p.) is not more than that necessary for successful communication.

Conformément à la réglementation d'Industrie Canada, le présent émetteur radio peut fonctionner avec une antenne d'un type et d'un gain maximal (ou inférieur) approuvé pour l'émetteur par Industrie Canada. Dans le but de réduire les risques de brouillage radioélectrique à l'intention des autres utilisateurs, il faut choisir le type d'antenne et son gain de sorte que la puissance isotrope rayonnée équivalente (p.i.r.e.) ne dépasse pas l'intensité nécessaire à l'établissement d'une communication satisfaisante.

Milli 5 Radio Certifications

Silver Spring Networks Milli 5 is integrated into application specific hosts which provide power regulation, buffered data inputs, and 50 ohm transmission line to antenna or external antenna connector. The following table describes the hosts which support Milli 5 FCC/IC Certification.

SSN P/N	Description	Antenna
174-0768-00	Hardware Development Kit (HDK)	External SMA
170-0818-00	Logistics NIC (L-NIC)	On-board – SSNI 420-0319-00
170-0845-00	Milli Arduino Shield Board	External SMA

OEM Certifications

Silver Spring Networks Milli 5 is FCC/IC Certified as Limited Modular Approval (LMA). LMA may be granted to a device which cannot meet all the requirements of a Single Modular Transmitter and if compliance can be demonstrated under the operating conditions in which the device will be used. OEMs have the following options for FCC/IC Certification using a LMA:

Option 1: Use current FCC/IC Grant, without need of an additional Certification by following these rules:

- Design to the strict guidelines for layout as described in *50 ohm PCB Design Guidelines*,
- Use an external antenna of same type as tested (J-Pole Omni-Directional) with equal or less gain,
- Deliver power regulation to Milli 5 as described in *Recommended Operating Conditions*,
- Deliver buffered modulation/data inputs to Milli 5
- Label the host device with, “Contains FCC ID: OWS-MIL51” and “Contains IC: 5975A-MIL51.”
- The user’s manual for the integrated end product must contain the following information in a prominent location: To comply with FCC & IC RF exposure requirement, the antenna used for this transmitter must be installed to provide a separation distance of at least 20 cm (8 in.) from all persons and must not be co-located or operating in conjunction with any other antenna or transmitter.

Contact Silver Spring Networks for authorization to apply for a Class II Permissive Change.

Option 2: If all rules from Option 1 are used, but a different type of antenna is required for the application, request a Change in ID application to reuse data from the current FCC/IC Grant, then apply for a Class 2 Permissive Change to add the antenna. The integration would require some additional conformity against CFR 47 Parts 15.203, 15.209, and RF exposure to add antenna to the Certification.

Option 3: Integration will need to pursue own full FCC Certification if design does not follow strict guidelines for layout. OEM may choose to obtain own FCC Certification even if guidelines are followed.

Collocation: If other wireless technologies are operational at the same time, then certification testing may be required for each technology, including evaluations of simultaneous transmissions from independent transmitters.

Australia

The Milli 5 is labeled with RCM mark with approval from ACMA.



Installation of all antenna-radiating elements shall have a minimum separation distance of 20cm from all persons and must not be co-located or operating in conjunction with any other transmitter.

New Zealand

The Milli 5 has been assessed to be compliant with New Zealand Radiocommunications (Radio Standard) Notice 2015 to a Level of Conformity A1.

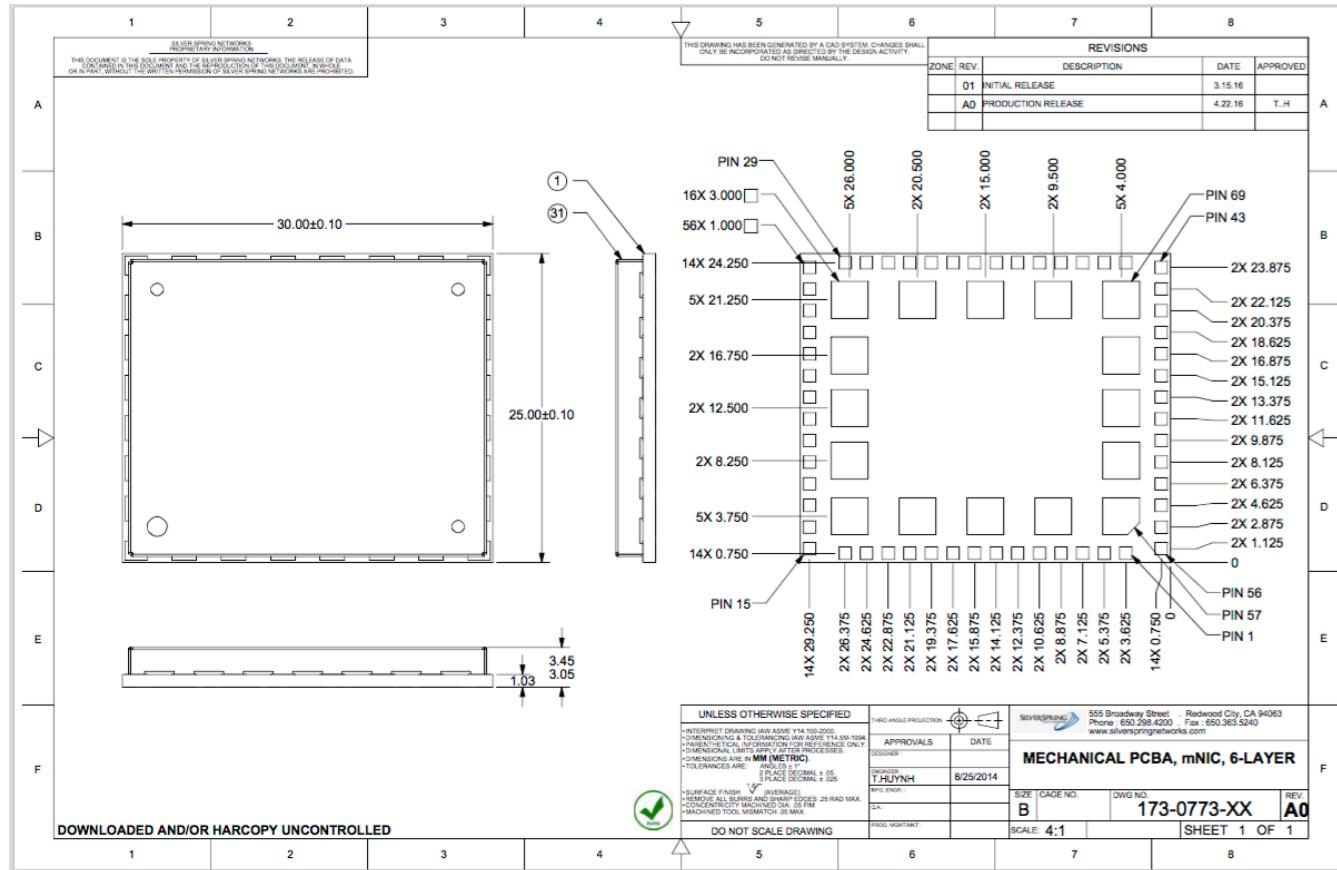
The Milli 5 is labeled with EMC Technologies New Zealand Ltd Supplier Code Number, Z1103.

Mechanical Specifications

Figure 3 shows the mechanical specifications and land patterns.

Note: The ground pads on the module's bottom side must be connected to electrical and thermal performance.

Figure 3. Mechanical dimensions and land pattern



Pin 1 Identification

On the top side, Milli 5 has a 2D barcode to identify MAC address, part number, and other key product data that is needed. The pin hole also represents the Pin 1 corner on Milli 5 module.

Manufacturing Specifications

Please refer to the Milli 5 layout footprint included in the Hardware Development Kit Gerber set.

Packaging Information

Tape and reel can be provided upon order. Box or tubes are also available for low count shipments.

Ordering Information

Please contact Silver Spring Networks for product availability and ordering information.

Revisions Table

Rev	Date	Changes
3	September 2016	Updated pin assignments, mechanical and moved all manufacturing specifics to separate document.
3v4	November 2016	Added regulatory information Other edits related to power
3v5	December 2016	Removed Electrical Specs from Physical Specs table Updated frequency ranges Updated DNC to NC
3v6	December 2016	Moved Revisions table to last page
3v7	December 2016	Added sections for Milli 5 Radio Certifications and OEM Certifications
3v8	January 2017	Added regulatory compliance sections for Australia and New Zealand.
3v9	April 2017	Updated with Milli Arduino Shield Board and stub antenna.