Azure Sphere Guardian 100 Hardware User Guide

v1.4 – April 27, 2020

1 Document Control

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2 Version History

Version	Date	Comment
1.0	10/25/2019	Initial draft release
1.1	10/28/2019	Added internal images and corrected URLs Added Wi-Fi --targeted-scan detail
1.2	10/28/2019	Added Japan and Asia contact info
1.3	11/17/2019	Added procedure for equipment interface test application
1.4	04/27/2020	Wi-Fi Manager application instructions added. Equipment Interface Test application details updated.

Contents

Figures

3 Hardware Checklist

Hardware items recommended for application development for Guardian 100 are the following

#	Item Description
1	Development Computer with Windows-10 Operating System
2	Avnet Azure Sphere Guardian 100 Secure Edge Module (plus provided cables) http://avnet.me/mt3620-guardian

4 Software Checklist

Listed below are the software items mentioned in this document

#	Item Description
1	**Visual Studio 2019** (Enterprise, Professional or Community edition) downloadable from: https://visualstudio.microsoft.com/
2	**Microsoft Azure Sphere SDK for Visual Studio** (Windows commandline application) downloadable from: http://aka.ms/AzureSphereSDK Azure_Sphere_SDK_Preview_for_Visual_Studio.exe
3	**G100 WiFi Manager** (Windows application) G100 Wifi Manager-v1.0.3.zip
4	**iPerf3** server application (Windows console application) downloadable from https://iperf.fr/iperf-download.php iperf-3.1.3-win64.zip
5	Module: iPerf3 performance test application (production-signed) iperf3_ps.imagepackage
6	Module: guardian_test application (production-signed) guardian_test_ps.imagepackage

- Production-signed Azure Sphere executable images are available for download from the product folder (on Element14 website), under the Downloads tab at http://avnet.me/mt3620-guardian

5 Introduction

The **Azure Sphere Guardian 100** is a **Secure Edge Module** that connects existing equipment (via Ethernet or USB UART) through a Microsoft Azure Sphere secured wireless connection to the cloud.

Guardian 100 is designed around Avnet's globally certified Azure Sphere MT3620 Module, which is based on the MT3620 multi-core dual band Wi-Fi SoC. The MT3620 is the first Azure Sphere certified "microcontroller", a completely new class of connected SoC IoT device that features "end-to-end security". User applications can target it's 500 MHz ARM Cortex-A7 core as well as two general purpose 200 MHz ARM Cortex-M4F I/O subsystem cores designed to support real-time requirements. The on-chip peripherals (GPIO, UART, I2C, SPI, I2S, PWM and ADC) can be mapped to any of these three user-accessible cores.

Additional differentiators of the MT3620 device are the built-in Pluton security subsystem (with dedicated Arm Cortex-M4F core) for secure boot and secure system operation, its dual-band 802.11 b/g/n Wi-Fi connectivity, as well as integration of on-chip PMU, RTC plus FLASH and SRAM memory. Wi-Fi based OTA firmware and user application updates (using strict certificate-based authentication) are hosted by Microsoft for the lifetime of the MT3620 device

The Arm Cortex-A7 application processor runs Microsoft's Azure Sphere OS (Linux-based). Custom user applications are developed in C using Microsoft Visual Studio IDE, which includes debugging features like single-step execution, breakpoints and watch-points (supported via dedicated Azure Sphere service UART)

Online authentication and firmware updates are supported for the MT3620 device lifetime.

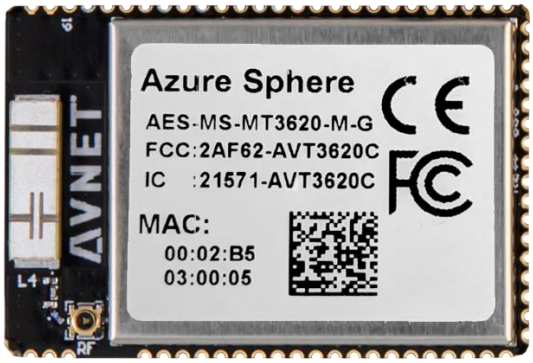


Figure 1 – Avnet Azure Sphere MT3620 Module (Chip Antenna version)

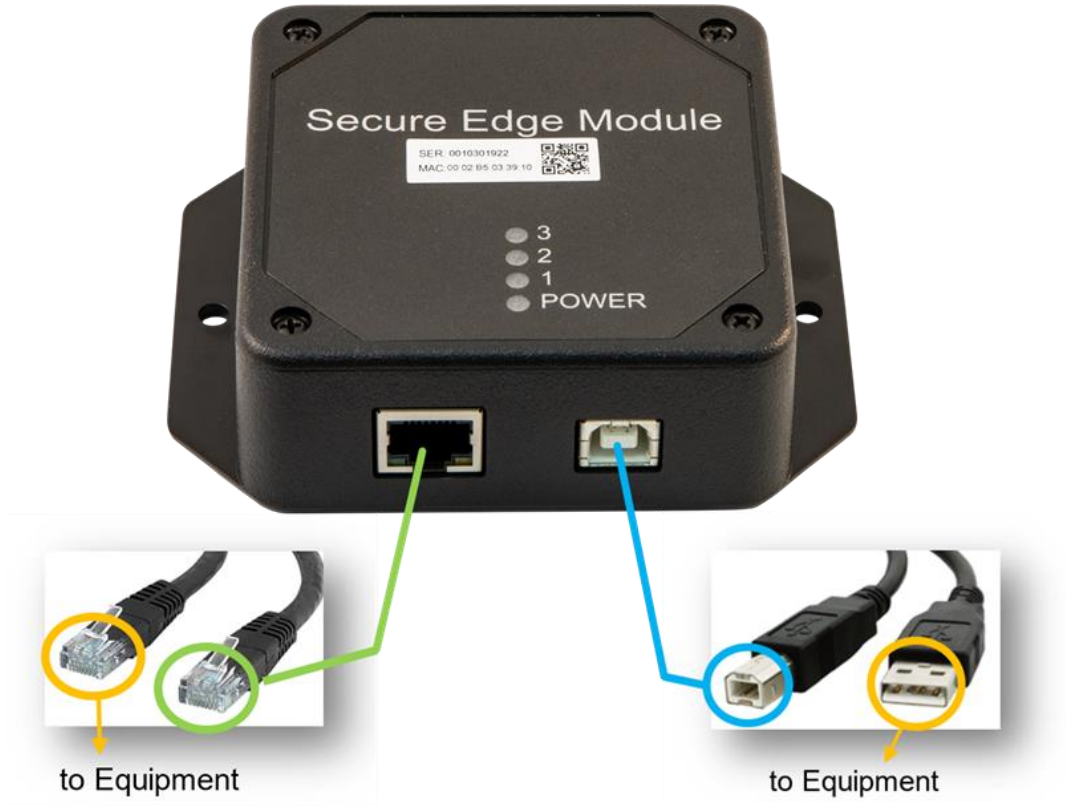


Figure 2 – Avnet Azure Sphere Guardian 100

5.1 Azure Sphere Guardian 100 Info

- Part Number: AES-MS-MT3620-GUARD-100
- Product Page URL: http://avnet.me/mt3620-guardian

5.2 Items Included with Guardian 100

- Azure Sphere Guardian 100 Secure Edge Module
- Azure Sphere Guardian 100 QuickStart Card
- USB 2.0 type-A to type-B cable
- Ethernet Cat-5 cable (RJ45 connectors)
- Access to downloadable reference designs and documentation

5.3 Important Reference Documents

Key Avnet documents are located under the **Technical Documents** tab at http://avnet.me/mt3620-guardian

- Azure Sphere Guardian 100 QuickStart Card
- Azure Sphere Guardian 100 Product Brief
- Azure Sphere Guardian 100 Hardware User Guide
- Azure Sphere Guardian 100 Schematic
- Azure Sphere Guardian 100 3D PCB Mechanical Assembly

Key Avnet documents are located under the **Technical Documents** tab at http://avnet.me/mt3620-modules

- Azure Sphere MT3620 Module Product Brief
- Azure Sphere MT3620 Module Datasheet & Integration Guide

Key Mediatek and Microsoft documentation is located at:

- MediatTek MT3620 Product Brief and Datasheet
- Microsoft Azure Sphere Installation Instructions
- Microsoft Azure Sphere Detailed Documentation

5.4 Technical Support Resources

- Microsoft Azure Sphere MSDN forum (technical questions, answers and support) https://aka.ms/AzureSphereSupport
- Microsoft Azure Sphere Documentation https://docs.microsoft.com/en-us/azure-sphere/
- Avnet Azure Sphere Starter Kit Community Discussion Forums http://avnet.me/mt3620-kit
- Avnet Azure Sphere Technical Training Course http://avnet.me/azsphere-ttc

5.5 Guardian Use-Case Example

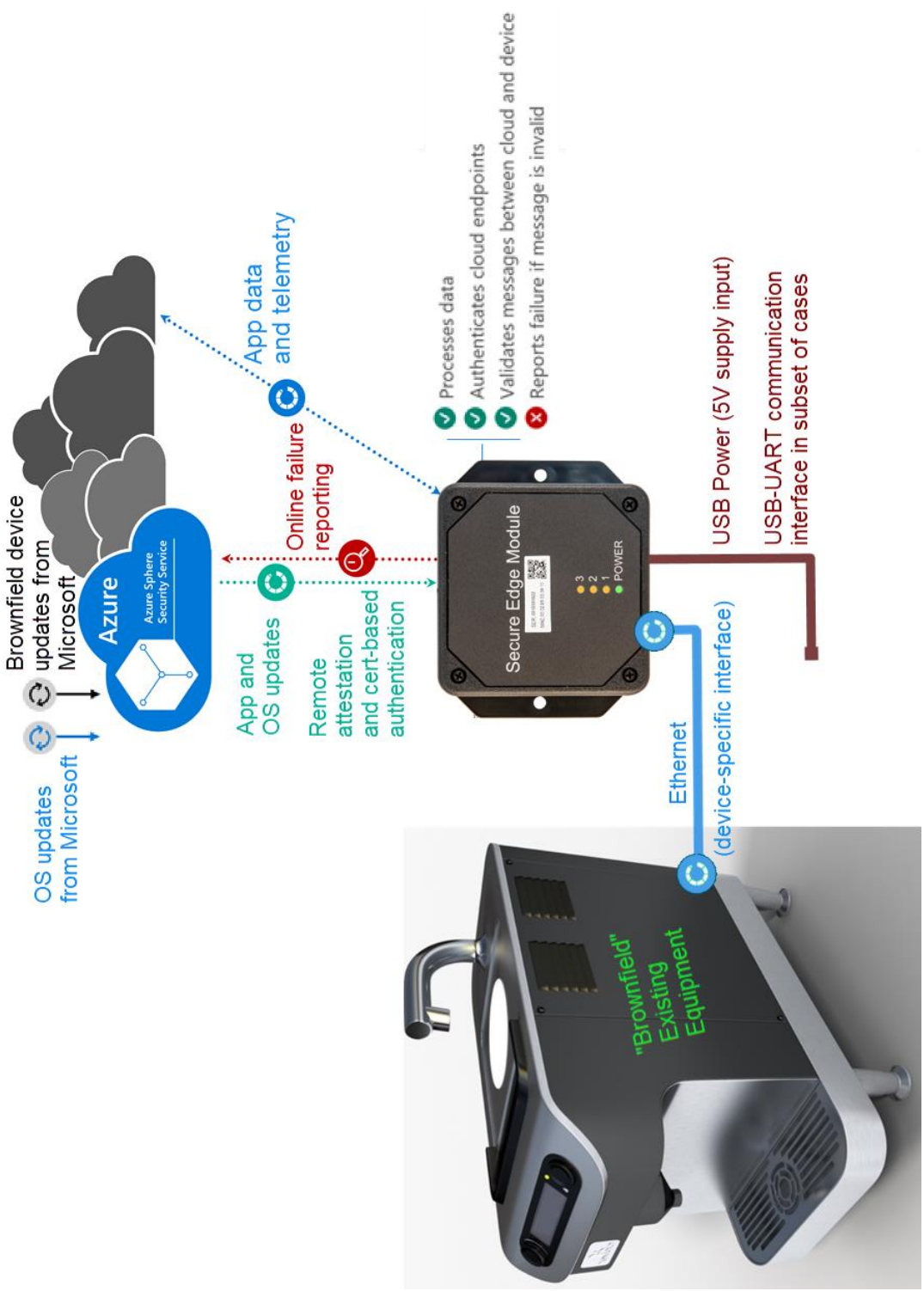


Figure 3 – Guardian Use Case Example

6 Guardian 100 Architecture and Features

6.1 List of Features

Azure Sphere Guardian 100

- Uses Avnet Azure Sphere Module based on Mediatek MT3620AN SoC that features:
  - 1x 500MHz ARM Cortex A7, 4MB SRAM
  - 2x 200MHz ARM Cortex M4F cores, 64KB SRAM
  - On-chip 16 MB QSPI Flash Memory (2x 8MB dual-channel QSPI Flash memory)
  - Dual-band 2.4/5GHz 802.11 b/g/n Wi-Fi
  - Dual-band 2.4/5GHz Chip Antenna (Pulse W3006)

- USB to serial FTDI 4-port Program/Debug interface (internal microUSB connector)
  - MicroUSB interface connector (requires lid removal)
  - Supports development computer Debug, Service, Recovery UARTs and M4 SWD interfaces
  - FT4232HQ 4-port FTDI device, buffers and USB activity LED

- Ethernet 10BaseT Interface, RJ45 connector and Magnetics (uses ISU0)

- USB 2.0 Device Interface and USB power. USB Type-B connector (uses ISU1)

- 6x External LEDs
  - Power, User 1, User-2, User-3
  - Ethernet Connection, Ethernet Activity

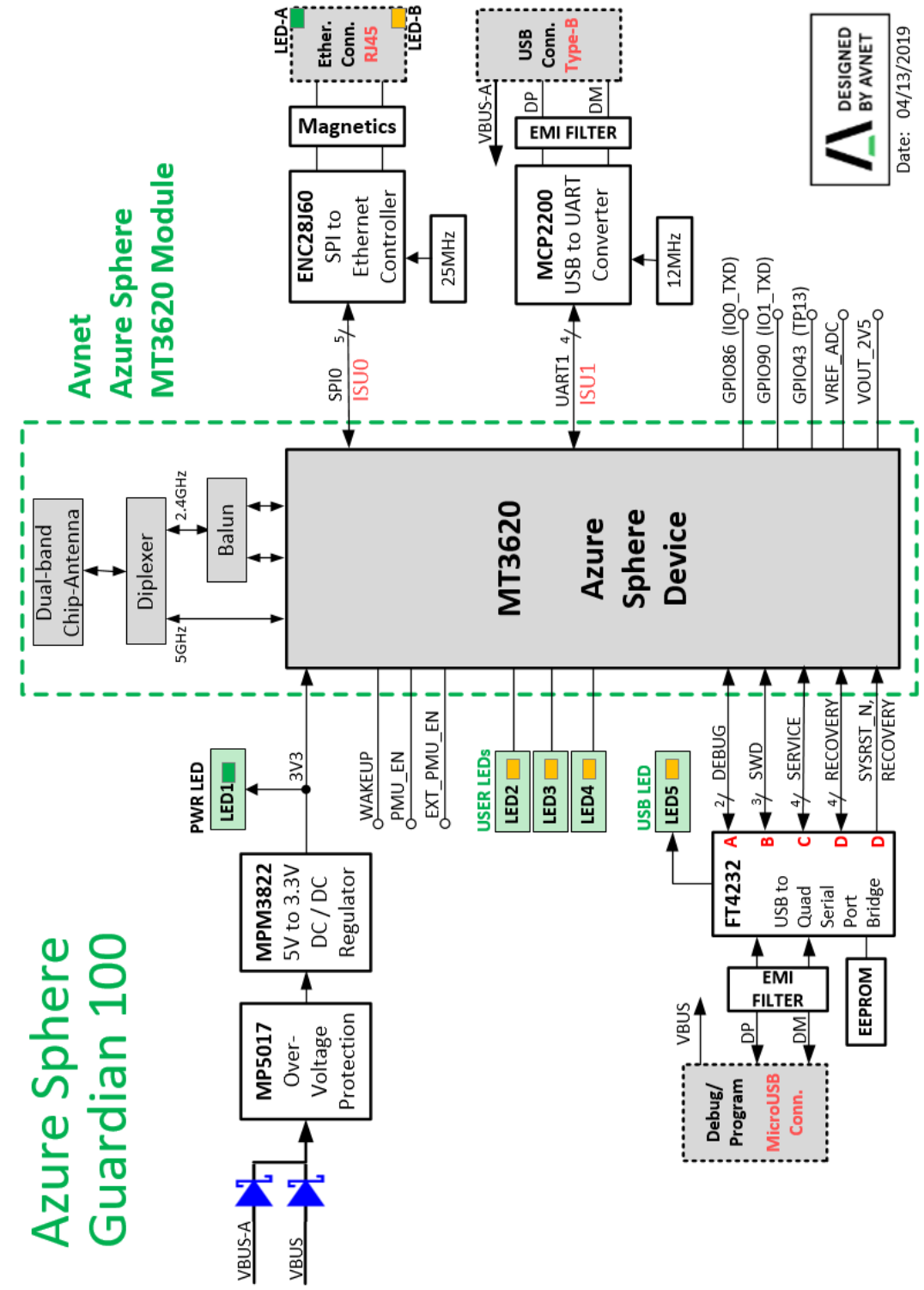
- 5V to 3.3V DC/DC Power Regulation (2A max, with over voltage protection)

- Operating Temperature: -30 ~ 85°C

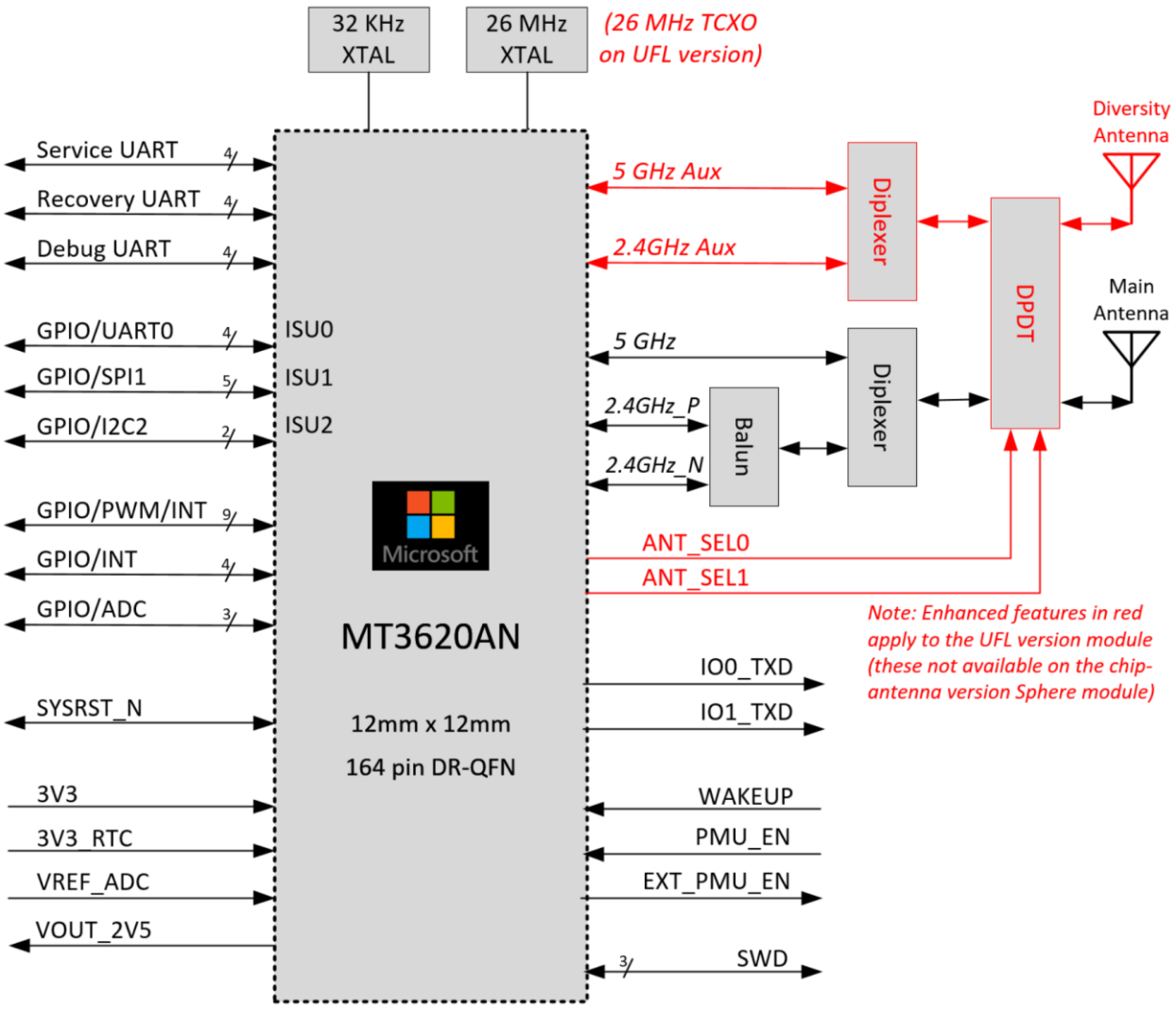
- Dimensions: 108mm x 85mm x 32mm (including mounting flanges)

- Module wireless certifications include FCC, IC, CE, (MIC, Anatel and RCM are pending)

6.2 Block Diagram - Avnet Azure Sphere Guardian 100



6.3 Block Diagram - Azure Sphere MT3620 Module



Note: Avnet's Sphere Guardian 100 is fitted with the "chip antenna" version Azure Sphere MT3620 module (ie. sections of diagram colored red are not applicable)

7 Installation Instructions

7.1 Provided Hardware Items

Ethernet Cable

Guardian Module

USB A-B Cable

7.2 Claiming the Guardian Device to an Azure Sphere Tenant

New Guardian devices need to be "claimed" to an Azure Sphere tenant (that has previously been setup for your organization). This one-time process of claiming a device to a tenant, must be done from a computer:

a) on which **Azure Sphere SDK** has been installed (see detail in next section), and

b) from which the user has logged-into the Azure Sphere tenant to which the device will be claimed (the Microsoft Azure Sphere documentation provides details of this process here)

The Guardian device is then claimed using one of the following two methods:

a) Using cut + paste record of this Guardian's Device ID (128 characters) into the following command:
`azsphere device claim --deviceid <device ID>`

b) Alternatively the Guardian can be claimed via connection of a **type-A to microUSB cable** that is attached to the **Debug USB** connector (located inside the enclosure) to the computer.
This method requires removal of the Guardian enclosure lid (4 screws) to access the Debug USB connector. The command then used does ***not*** require entry of the Device ID
`azsphere device claim`

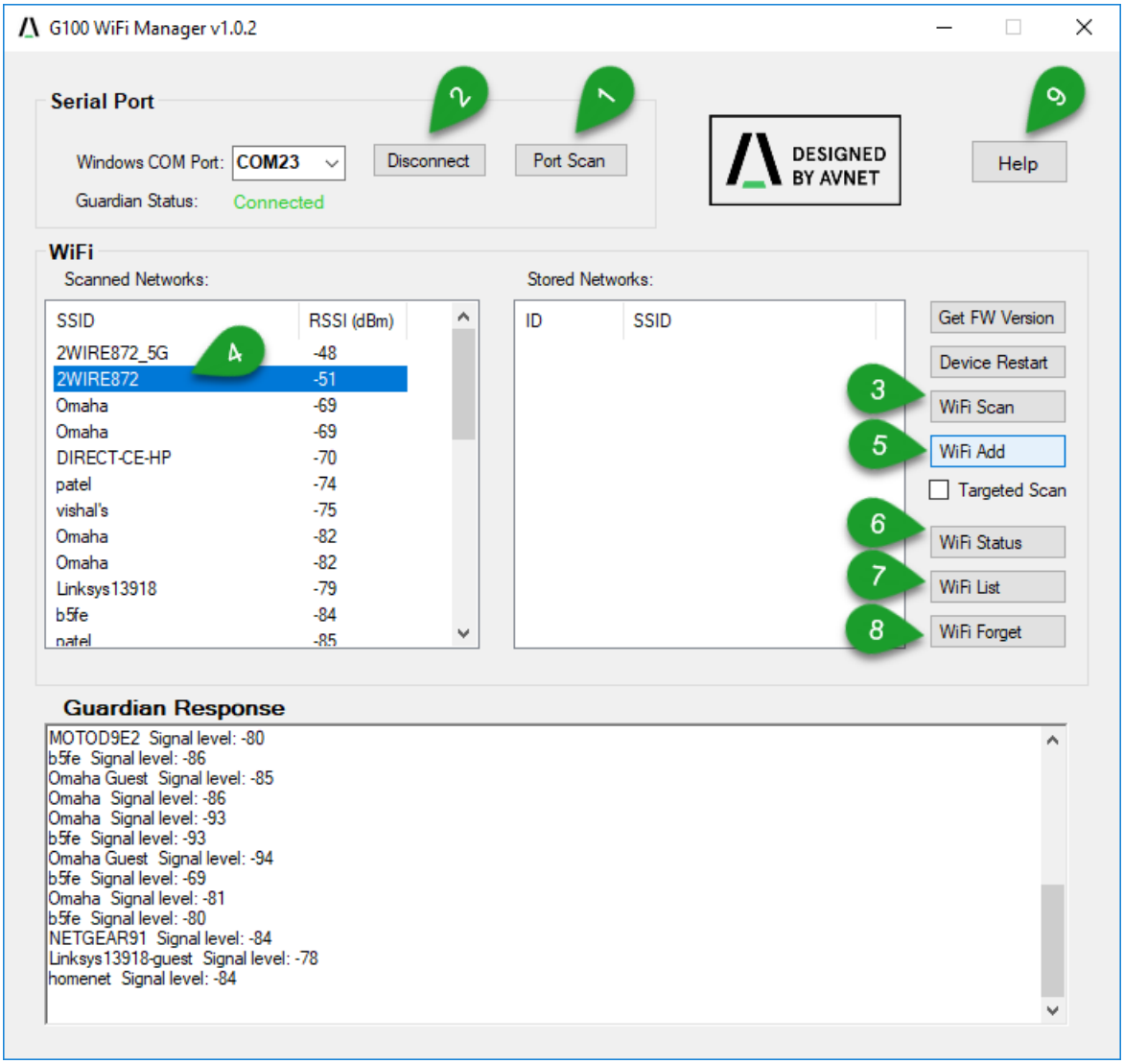
Note! Both these tenant-claiming methods require resources or actions not typically expected of a field installation person. It is recommended that all Guardian units be "claimed" at a central facility, prior to distribution to their end-destinations.

7.3 Wi-Fi Setup (using WiFi Manager Windows Application)

From April 2020, Guardian 100 ships with **WiFi Manager** embedded utility application programmed into flash memory. This facilitates a simplified field-setup of Guardian's non-volatile Wi-Fi settings, using just the supplied **USB-A to USB-B cable**, connected from Guardian's external USB-B connector, to a laptop computer where the only requirement is that it runs the provided **WiFi Manager Windows application**. (Note: Azure Sphere SDK installation is ***not*** required on this computer)

Check the Serial Number (SER) on Guardian's barcode label (located on the enclosure lid).
The last 4-digits represent a date code in YYWW format. Date codes of 2014 or later, confirm that the Guardian has been factory-programmed to auto-run the WiFi Manager application on power-up.

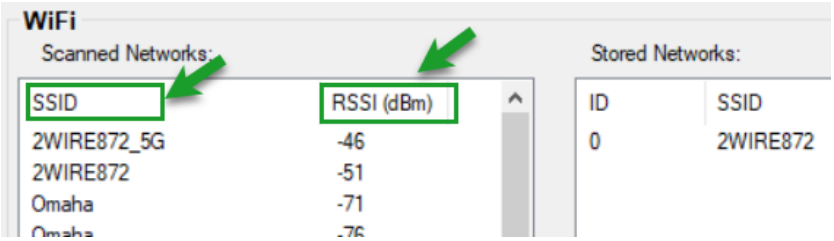
Names of Wi-Fi access points are selected and their passwords entered within the user-friendly Windows WiFi Manager application, ***without*** need for Azure Sphere SDK or access to Guardian's Debug USB port.



1) Connect the provided USB-A to USB-B cable from Guardian to the computer, then click on the "**Port Scan**" button to auto-populate the relevant Windows COM port in the drop-down list (The Ethernet cable does not need to be attached at this time)

2) Click the "**Connect**" button. The reported Guardian Status should change to **Connected**.

3) Click the "**WiFi Scan**" button. After a couple of seconds, a listing of Access Points will be reported in the Scanned Networks panel. Click on the RSSI column label to sort the reported results by signal strength (or click on the SSID column label, to sort this alphabetically)



4) Highlight the name of the Wi-Fi network for which password credentials will be entered

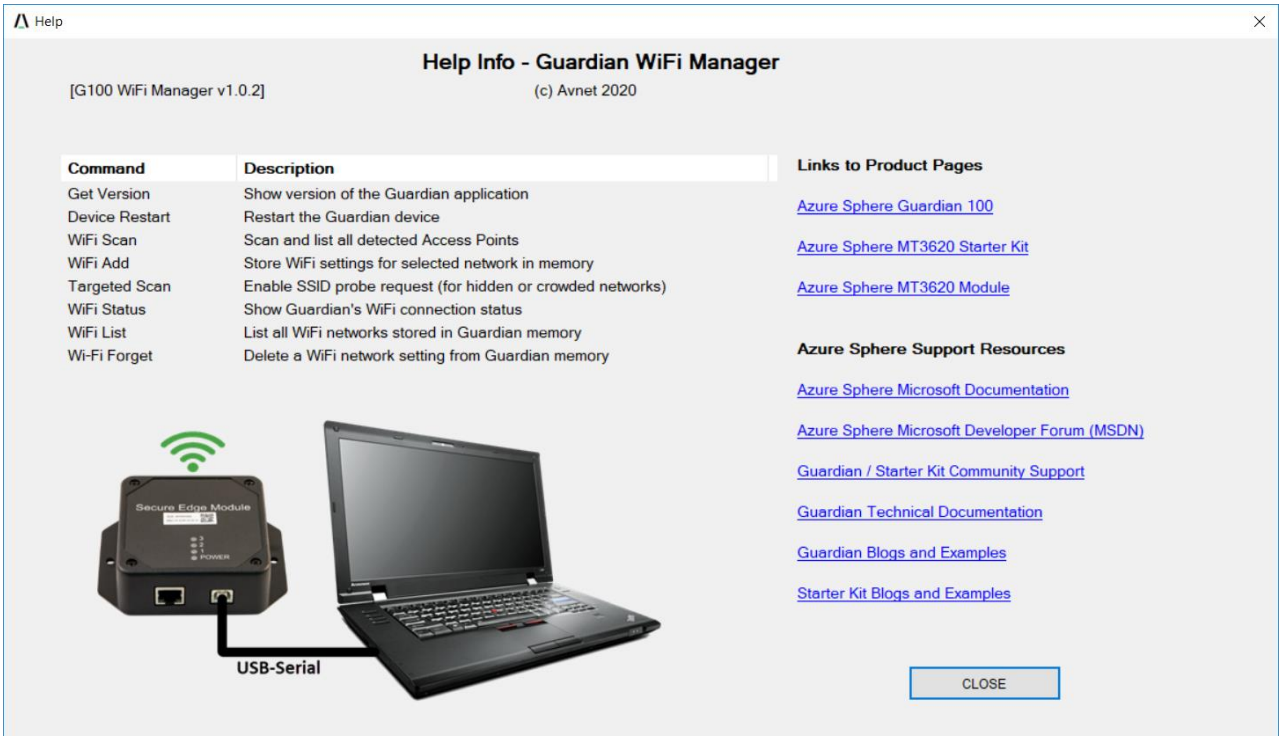
5) Click the "**WiFi Add**" button. A dialog window will open, prompting you to enter a password for this Wi-Fi network. The "**Targeted Scan**" checkbox is provided to provide a way to connect to networks whose name is not reported (due to hidden SSID, or where there is a lot of competing Wi-Fi activity). If this box is checked, you will be prompted to enter the SSID name in addition to the password)

6) Click the "**WiFi Status**" button (Pause 5 seconds before clicking, after Wi-Fi Add or WiFi Forget). This reports the name of the connected network as well as it's RSSI signal strength (in dB). Installation Tip: You can repeatedly press this **WiFi Status** button while positioning the Guardian for best signal strength (Note: Numerically lower -dB values indicate higher signal strengths)

7) Click the "**WiFi List**" button (Pause 5 seconds before clicking, after Wi-Fi Add or WiFi Forget) to get a listing of all currently stored networks

8) If a stored Wi-Fi network needs to be deleted or have it's Wi-Fi password credentials re-entered, highlight this network name in the Stored Networks panel, then click "**WiFi Forget**"

9) Click on the "Help" button to view additional setup and command information. Links to Avnet Azure Sphere product pages, documentation and technical support resources are also provided.



Notes:

- Click “**Get FW Version**” button to view version of WiFi Manager firmware installed on Guardian. An "*ERROR:timeout*” response implies that the utility has been deleted or overwritten. (This occurs when new applications are programmed into Guardian, via Debug USB connector, or via OTA from the Microsoft server. The stored Wi-Fi settings however remain persistent)

- A log file (G100_WiFi_Error_Log.txt) records locally any issues encountered during the session

7.4 Re-installing the WiFi Manager Embedded Application

The factory installed WiFi Manager application makes the Wi-Fi setup task for field installation personnel very much simpler. In a small percentage of cases the embedded application may need to be reinstalled (eg. if relocating equipment to a different location, or if needing to deploy Guardian units that were manufactured prior to April 2020)

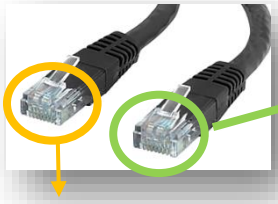
Instructions on how to reinstall the WiFi manager application requires use of a computer on which Azure Sphere SDK has been installed. The procedure for re-programming this application into Guardian’s flash memory, is currently available on request via a separate Application Note document.

7.5 Guardian 100 Connections

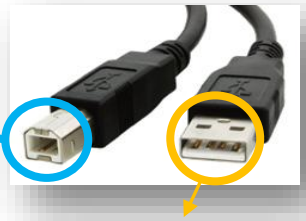
Ethernet Cable

Guardian Module

USB A-B Cable



to Equipment



to Equipment

1. For equipment with an Ethernet interface, connect the provided Ethernet cable from Guardian to the equipment.
2. Connect the USB cable from Guardian (type-B panel connector) to the equipment (this provides power to Guardian, and is also the data interface in cases where the monitored equipment does not have an Ethernet interface).
3. Once connected, the LEDs on the Guardian Module should be as follows:

Status LEDs	Color	Description
Power	Green	Confirmation that 3.3V supply rail voltage is OK
1, 2, 3	Amber	Controlled by the Azure Sphere user application (Factory test application will sequence these LEDs)
RJ45 LEDA	Green	Green when connected
RJ45 LEDB	Yellow	Flashes intermittently with Ethernet activity

Note
The factory test application is detailed in the previous section (facilitates Wi-Fi Setup using a companion WiFi Manager Windows Application) and provides LED confirmation that the Guardian is operational.

It is essential that a suitable application be programmed into the Azure Sphere device in order for Guardian to perform the relevant cloud-connected equipment management functions

In order to reprogram Guardian, the latest Azure Sphere SDK and Microsoft Visual Studio IDE need to be installed on a development computer. The next section details these requirements.

8 Software Development Environment Preparation

8.1 Microsoft Installation Instructions

Detailed guidance is provided at: http://avnet.me/azure_sphere_sdk_installation_directions

8.2 Verify Windows 10 Version

1) Before commencing software installation, verify the version of Windows 10 Operating System meets requirements. In the Windows search box (**Windows key + R**), enter **winver** to check…

2) The version reported must be **1607** or later…
https://en.wikipedia.org/wiki/Windows_10_version_history

8.3 Install Azure Sphere SDK

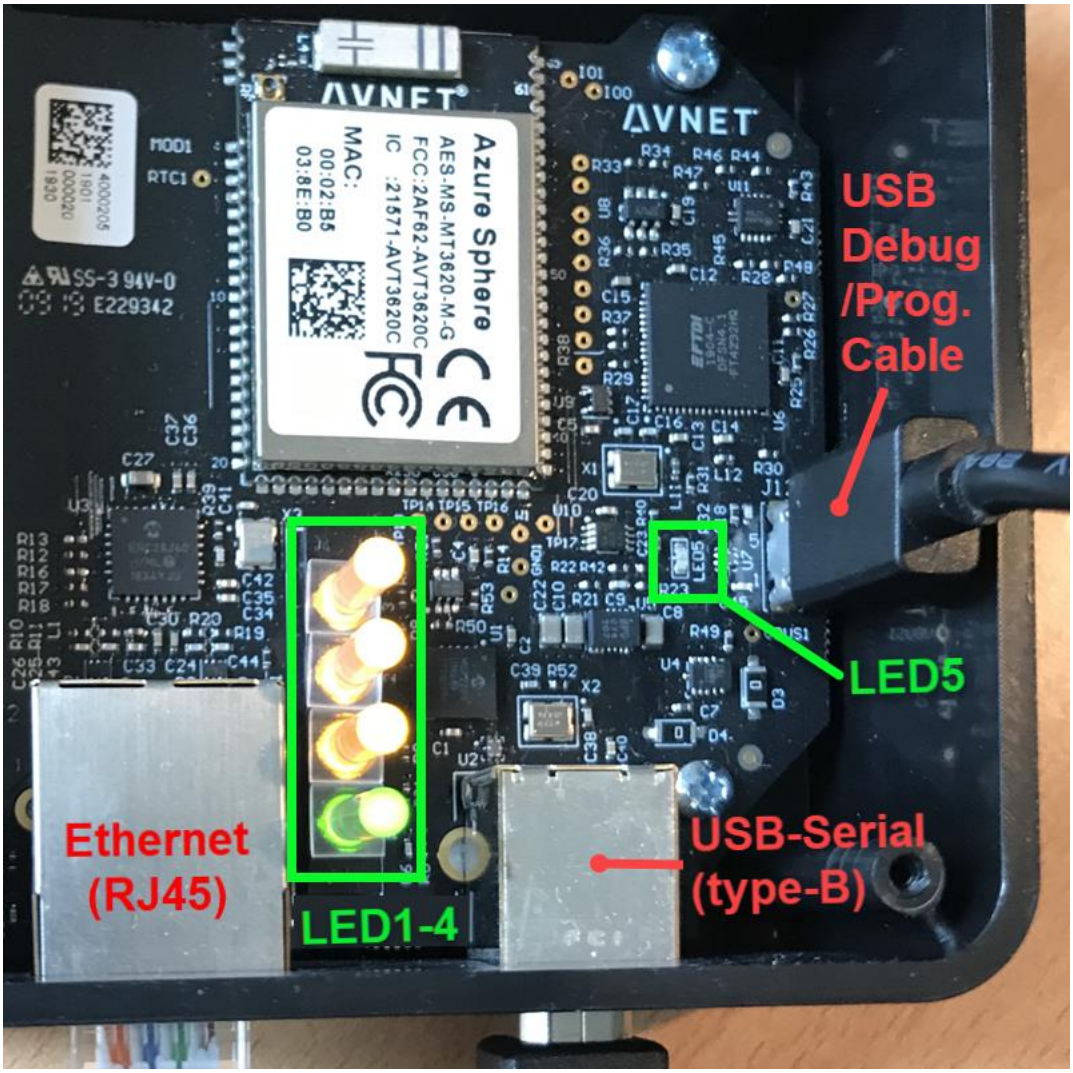
1) Download and unzip the latest Microsoft Azure Sphere SDK from:
http://aka.ms/AzureSphereSDK

2) Install this SDK on a Windows 10 computer, using the instructions located at:
http://avnet.me/ms_sphere_docs

3) Once installed, launch the application and at the Azsphere command prompt, enter this command to confirm the Sphere SDK version:

```
azsphere show-version
```

The version reported should be **20.01** or later
(Note: Connection to Sphere Guardian 100 hardware is *not* required for this command)



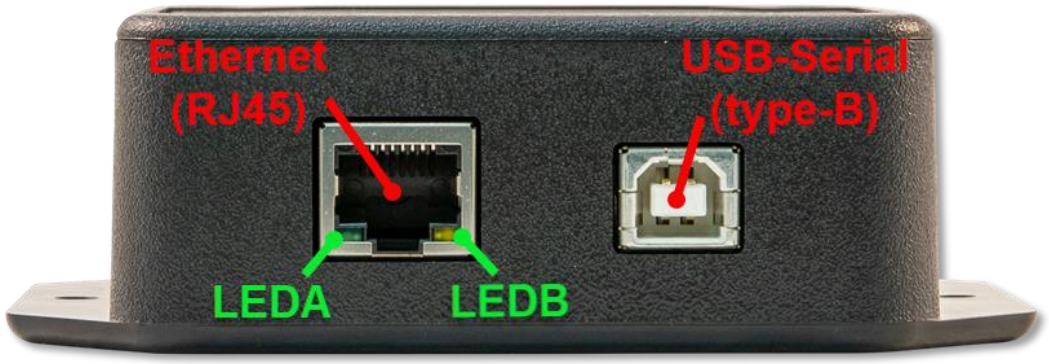


Figure 4 – Guardian 100 Interfaces and LED Detail

8.4 Debug/Programmer FTDI USB Interface Access

1) Disconnect all cables from Guardian, unscrew the four screws and remove the enclosure lid

2) Plug-in a USB Debug/Programmer cable (type-A to MicroUSB) from the vertically oriented MicroUSB connector on the Guardian PCB, to a USB port on the development computer

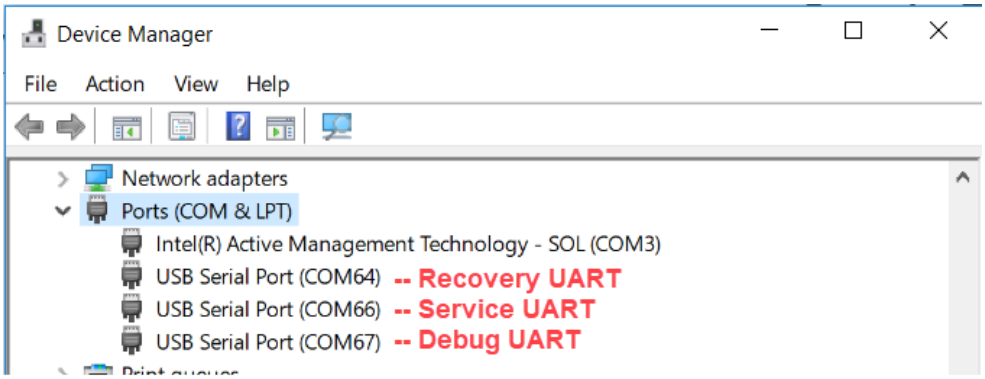
8.4.1 Windows FTDI USB Driver Installation

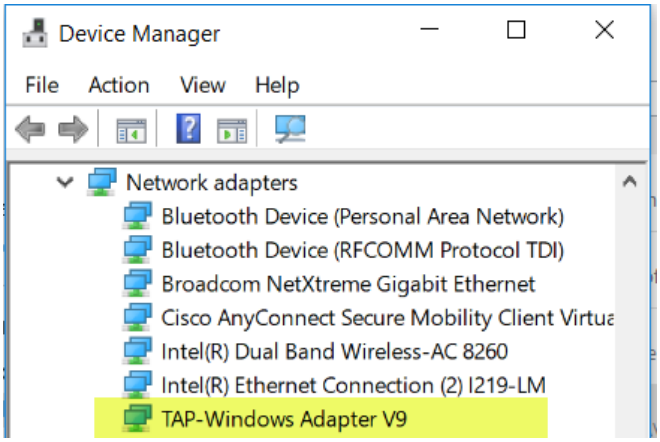
1) On first-time connection of Guardian to the development computer, the USB drivers should automatically download and install (this can be slow). If drivers do not install automatically, right-click on the device name in Windows Device Manager and select **Update driver**. Alternatively, download the drivers from Future Technology Devices International (FTDI), - choose the driver that matches your Windows 10 installation (32- or 64-bit).

2) Additional assistance on this aspect is available at:
https://docs.microsoft.com/en-us/azure-sphere/install/troubleshoot-installation

8.4.2 Windows FTDI Interface Verification

3) Open Windows Device Manager and confirm the following are listed:
- three new **COM ports** (under Ports COM & LPT)
- a **TAP-Windows Adaptor V9** (under Network Adaptors)

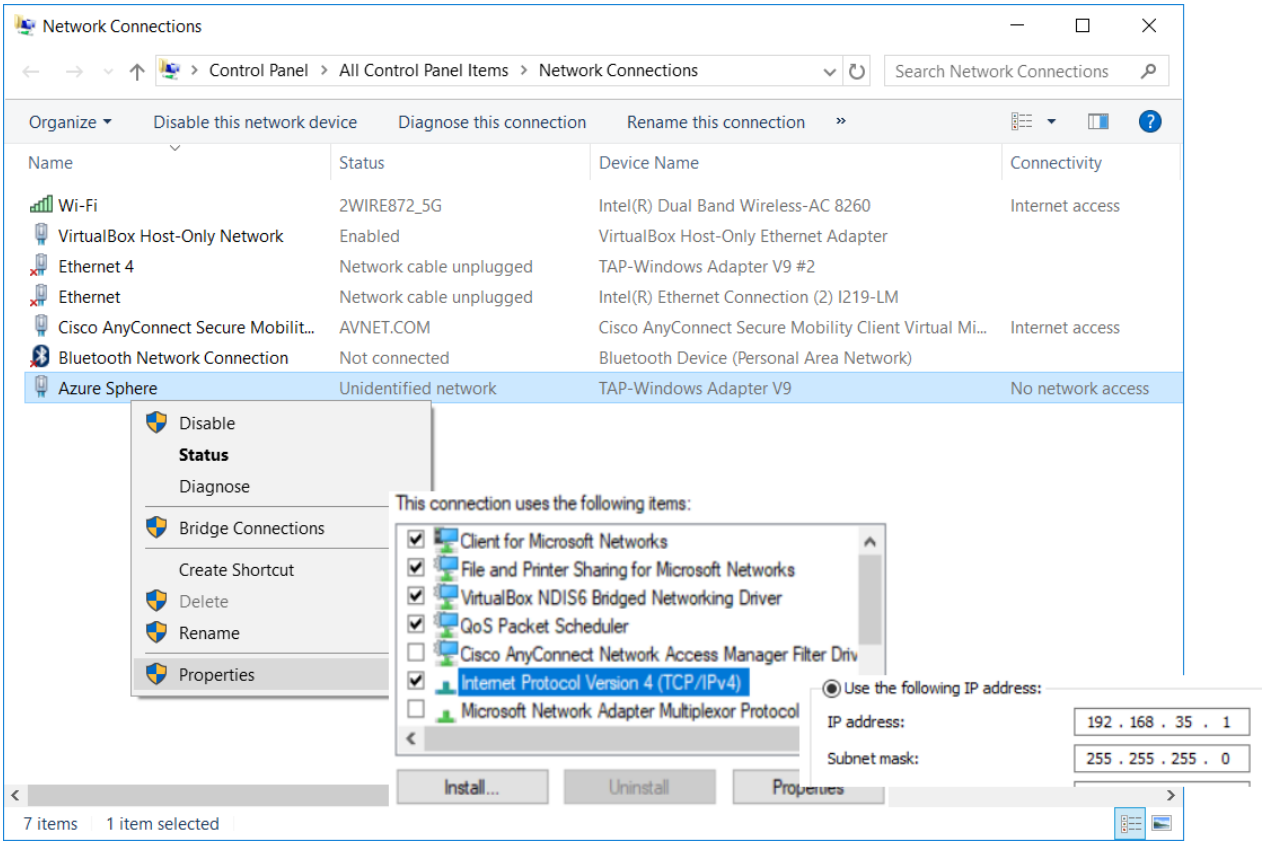




4) The steps below are **only required** if the FTDI **SERVICE interface fails** during first-time connection to the Azure Sphere Guardian 100

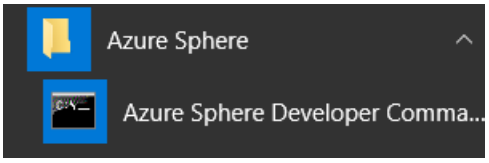
5) Open Windows network adapter settings
ie. Windows search box (**Windows key + R**) then enter **ncpa.cpl**

6) Right-click on **Azure Sphere** TAP-Windows Adapter V9.
Check it's properties are as shown below:



8.5 SERVICE interface

1) Open the Azure Sphere Developer Command-Line tool… (Sphere CLI)



2) Plug-in the USB cable from Guardian 100 to the PC, then enter the following *Sphere CLI* command:

```
azsphere device show-attached
```

3) The Secure Edge Module will report it's unique Azure Sphere Device ID…

```
C:\TEST>azsphere device show-attached
Device ID: DCED354379F883891026A30CC2C38F09928021FED3EC3428
9215331CF886F9FE642
Command completed successfully in 00:00:01.3812178.
```

8.6 DEBUG Interface

1) The DEBUG UART is typically the highest numbered COM port (of the three new COM ports) reported by Windows Device Manager, for the Guardian 100's FTDI USB interface

2) To view the output of this serial port, open Tera Term (or other serial console application) and configure it for the noted COM number, with UART set for 115200 8N1 communication rate

3) Connect the Tera Term terminal then enter the following *Sphere CLI* command:

```
azsphere device restart
```

4) Startup debug text similar to the following should appear on the terminal screen

5) Note! Terminal connection to the Debug Interface must be closed before attempting to use the RECOVERY interface!

8.7 RECOVERY Interface

This interface is for reloading/updating the Azure Sphere OS via a wired UART interface (typically for factory reprogramming of the MT3620 device) and will not be required by most developers.

Once an Azure Sphere Guardian 100 is connected to the internet, Sphere OS updates are initiated automatically (or on demand) via the Over-The-Air (OTA) Wi-Fi interface

The Azure Sphere OS programmed into Guardian 100 by the manufacturer is out of date with the later reference designs provided. It is necessary to update the OS to version **19.09** (or later)

Check the current OS version by entering the following command at the SDK prompt:

```
azsphere device show-deployment-status
```

```
C:\TEST>azsphere device show-deployment-status
Your device is running Azure Sphere OS version 20.04.
The Azure Sphere Security Service is targeting this device with Azure Sphere OS version 20.04.
Your device has the expected version of the Azure Sphere OS: 20.04
```

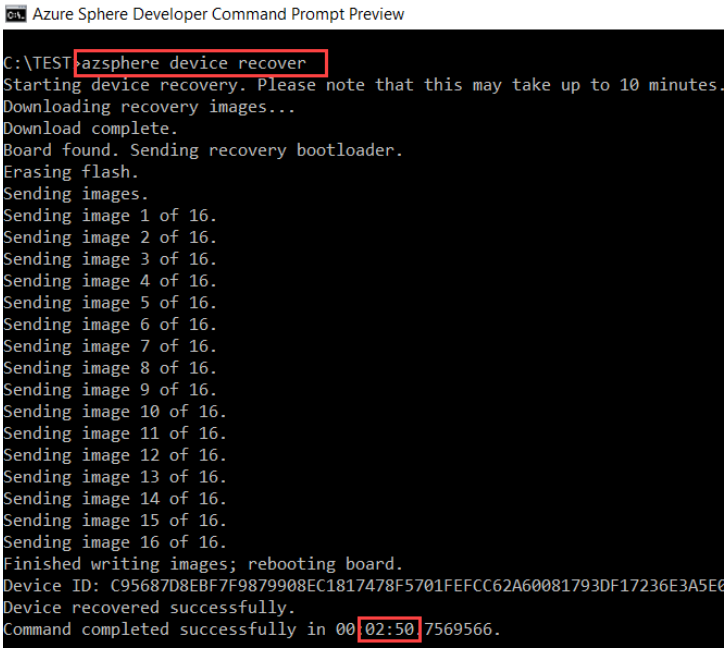
Two methods are available to update the OS on Guardian 100:
- via the development computer (must have internet connection and Azure Sphere SDK installed)
- via direct OTA update of the MT3620 device (requires configured device Wi-Fi settings)

The first method is typically only used during factory test, using the following command to download and program the device with the latest available Azure Sphere OS version:

```
azsphere device recover
```

Note that all contents of flash memory get erased during RECOVERY (ie. Sphere OS, application software, Wi-Fi credentials and other configuration data)

This takes around ~3 minutes to complete



9 Configure Device Wi-Fi Network Settings

Two options are available to configure Guardian's Wi-Fi settings:

a) Use **WiFi Manager** Windows application, to communicate via the external USB-B interface with the factory-programmed WiFi Manager embedded application (which auto-starts on power-up).
- *Section 7 Installation Instructions* in this document details this method

b) Use **Azure Sphere CLI**, to communicate via the internal debug USB interface, directly with the Azure Sphere OS on Guardian. The section below details this method

9.1 Scan for Wi-Fi Access Points

A quick-check of Wi-Fi reception can be done by entering the following *Sphere CLI* command:

```
azsphere device wifi scan
```

After 10 seconds or so, a scan report will display a listing of the detected Wi-Fi networks, with their SSIDs, signal-levels, etc in the format shown below:

```
Scan results:
SSID                : 2WIRE872_5G
Security state      : psk
BSSID               : 2c:56:dc:d6:fc:84
Signal level        : -46
Frequency           : 5180
```

9.2 Configuring the Wi-Fi Network Settings

To ensure connection in congested Wi-Fi environments, use of the **--targeted-scan** parameter (abbreviated as **-t**) is recommended when configuring the Wi-Fi network settings
In the commands below, replace **??????** with the applicable network credentials:

```
azsphere device wifi add --ssid ?????? --psk ??????? –targeted-scan
```
or simply abbreviated to:
```
azsphere device wifi add -s ?????? -p ??????? -t
```

Verify the present Wi-Fi connectivity status by entering:
```
azsphere device wifi show-status
```

Other useful Wi-Fi commands are:
```
azsphere device wifi list
azsphere device wifi enable
azsphere device wifi disable
azsphere device wifi forget –i 0
```

Note: Appendix-B in this document includes instructions for running a pre-compiled copy of the **iPerf3** test application, to check Wi-Fi bit-rate performance with the currently selected Wi-Fi Access Point

10 Hardware Functional Description

10.1 Avnet Azure Sphere MT3620 module

The module pins-out a subset of the MT3620 SoC device functionality, via 66 castellated “stamp-hole” pads along three edges of its compact 33mm x 22mm form-factor.

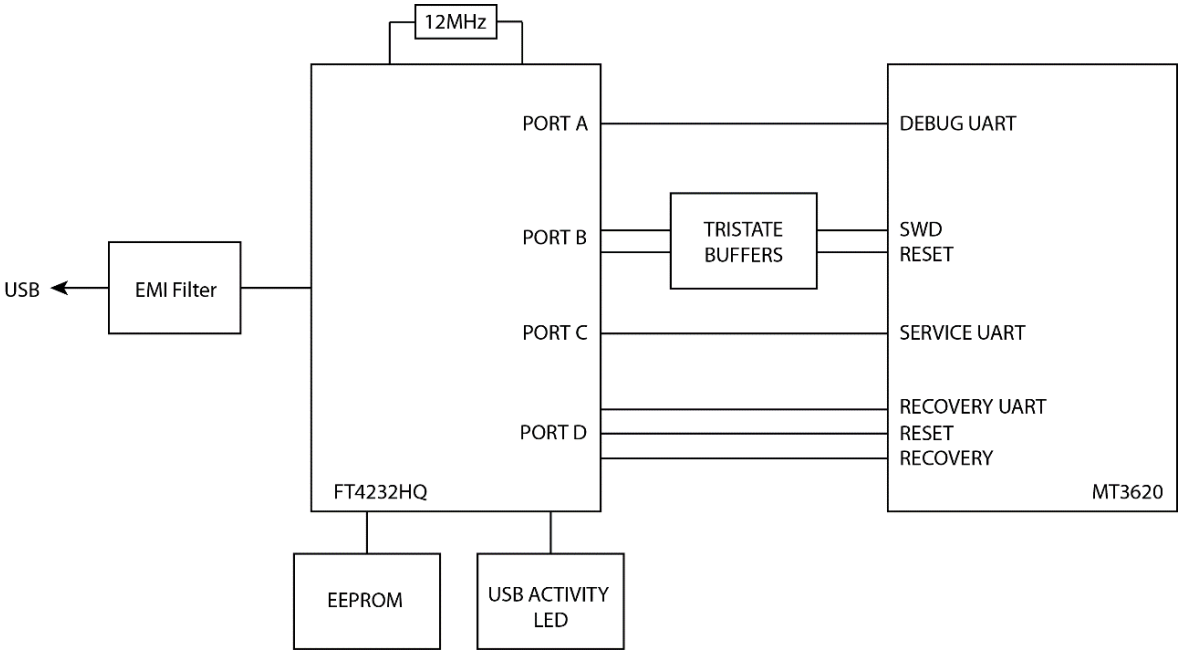
Refer to the following documents for detailed information on Avnet’s certified Azure Sphere MT3620 module as well as the MT3620 Azure Sphere SoC device that this is based on

- Azure Sphere MT3620 Module Product Brief
- Azure Sphere MT3620 Module Datasheet & Integration Guide
- MediatTek MT3620 Product Brief and Datasheet documents

10.2 USB-Debug/Prog. Interface (FT4232HQ)

Guardian 100 includes on-board, the Microsoft-specified FTDI 4-port USB to Serial bridge implementation of the RECOVERY, SERVICE, DEBUG and SWD interfaces. These interfaces are primarily used for software application development and/or programming of Guardian 100. This requires a USB cable to be connected from the internal microUSB connector, to a Windows-10 (or Linux) computer on which Azure Sphere SDK and the relevant USB drivers have been installed

A simplified block diagram of this 4-port USB to Serial bridge circuit is shown below:



See section of this document on Windows FTDI USB Driver Installation and Verification, for in-depth detail on driver installation and the use of these four interfaces

10.3 USB-UART Application Interface (MCP2200)

The onboard MicroChip MCP2200 USB-UART device provides a USB to Serial CDC type interface. (This device includes 64 byte transmit and 64 byte receive buffers, as well as 256 byte User EEPROM).

ISU1 is used for **UART1** interface signals to the MCP2200 device

Signal Name UART1 (ISU1)	MT3620 GPIO #	Comments
APP_TXD	GPIO31	ISU1
APP_RTS	GPIO32	ISU1
APP_RXD	GPIO33	ISU1
APP_CTS	GPIO34	ISU1
RST	3V3	

10.4 Ethernet Interface (ENC28J60)

The onboard MicroChip ENC28J60 ethernet controller device provides a 10 Mbps interface (compatible with 10/100/1000 Base-T networks) using TCP or UDP network protocols:

a) Private network, with network services (not connected to the internet), or
b) Public network, communicating with Azure IoT or other internet-based services.

Use of Ethernet requires a "*board configuration image*" in addition to the user application image. This contains info required by the Azure Sphere Security Monitor to add Ethernet support to Azure Sphere OS. **ISU0** is used for **SPI0** interface signals to the ENC286J60 device, with interrupts on **GPIO5**.

Signal Name SPI0 (ISU0)	MT3620 GPIO #	Comments
SCK_ENC	GPIO26	ISU0
MOSI_ENC	GPIO27	ISU0
MISO_ENC	GPIO28	ISU0
CS_ENC	GPIO29	ISU0
INT_ENC	GPIO5	
RST_N_ENC	GPIO6	Not connected
SYSRST_N	SYSRST_N	

More detail on this topic is available here:
https://docs.microsoft.com/en-us/azure-sphere/network/connect-ethernet

Microsoft provides sample application code for the Ethernet interface for a number of use cases, eg.

- The Private Network Services sample demonstrates how to connect Azure Sphere to a private network and use several network services.
- The AzureIoT sample demonstrates how to use the Azure IoT SDK C APIs in an Azure Sphere application to communicate with Azure IoT Central or Azure IoT Hub.
- The HTTPS samples demonstrate how to use the cURL APIs with Azure Sphere over a secure HTTPS connection.

Ethernet and Wi-Fi network interfaces can run simultaneously, connected to public (internet-connected) or private networks. At least one interface however, must be connected to a public network.

In Private Network applications, the high-level application configures Azure Sphere OS managed DHCP and SNTP servers, implementing a basic TCP server

10.5 Dual Band Wi-Fi Interface (MT3620)

The MT3620 device on the Azure Sphere module integrates a Wi-Fi 802.11 bgn radio with on-board dual-band chip antenna. This is used to connect Guardian to a wireless access point for Internet access. This separate Azure Sphere module PCB assembly has global regulatory certifications and is intended as a building block component for OEM boards.

10.6 Status / Indicator LEDs

Four LEDs are visible through the top-side enclosure lid of Guardian 100

The LED2, LED3 and LED4 functions are user defined in the application software and their intensity can be varied via MT3620 PWM settings

Status LEDs	Color	Ref. Des.	MT3620 GPIO	MT3620 Function
POWER	Green	LED1	-	-
1 (R)	Amber	LED2	GPIO8	GPIO / PWM
2 (G)	Amber	LED3	GPIO9	GPIO / PWM
3 (B)	Amber	LED4	GPIO10	GPIO / PWM

Two LEDs in the lower corners of the RJ45 connector, provide Ethernet status information
One LED is internal (only seen when enclosure lid is removed and programming USB cable is fitted)

Status LEDs	Color	Ref. Des.	LED is controlled by
FTDI USB Activity	Amber	LED5	FT4232 device
RJ45 LEDA	Green	n/a	ENC28J60 device
RJ45 LEDB	Yellow	n/a	ENC28J60 device

Figure 5 – Location of the Status LEDs

10.7 Hardware Expansion

Hardware expansion options are limited to devices that can be attached via the Wi-Fi, Ethernet and USB-Serial interfaces.

Internally Guardian 100 provides a limited set of GPIO on PCB test-points that can facilitate further functionality, but the enclosure does not provide connector access to these signals:

Test-Point PCB Label	MT3620 GPIO #	MT3620 Alternative Function
TP13	GPIO43	ADC2 input
IO0	GPIO86	IO0_TXD output
IO1	GPIO90	IO1_TXD output

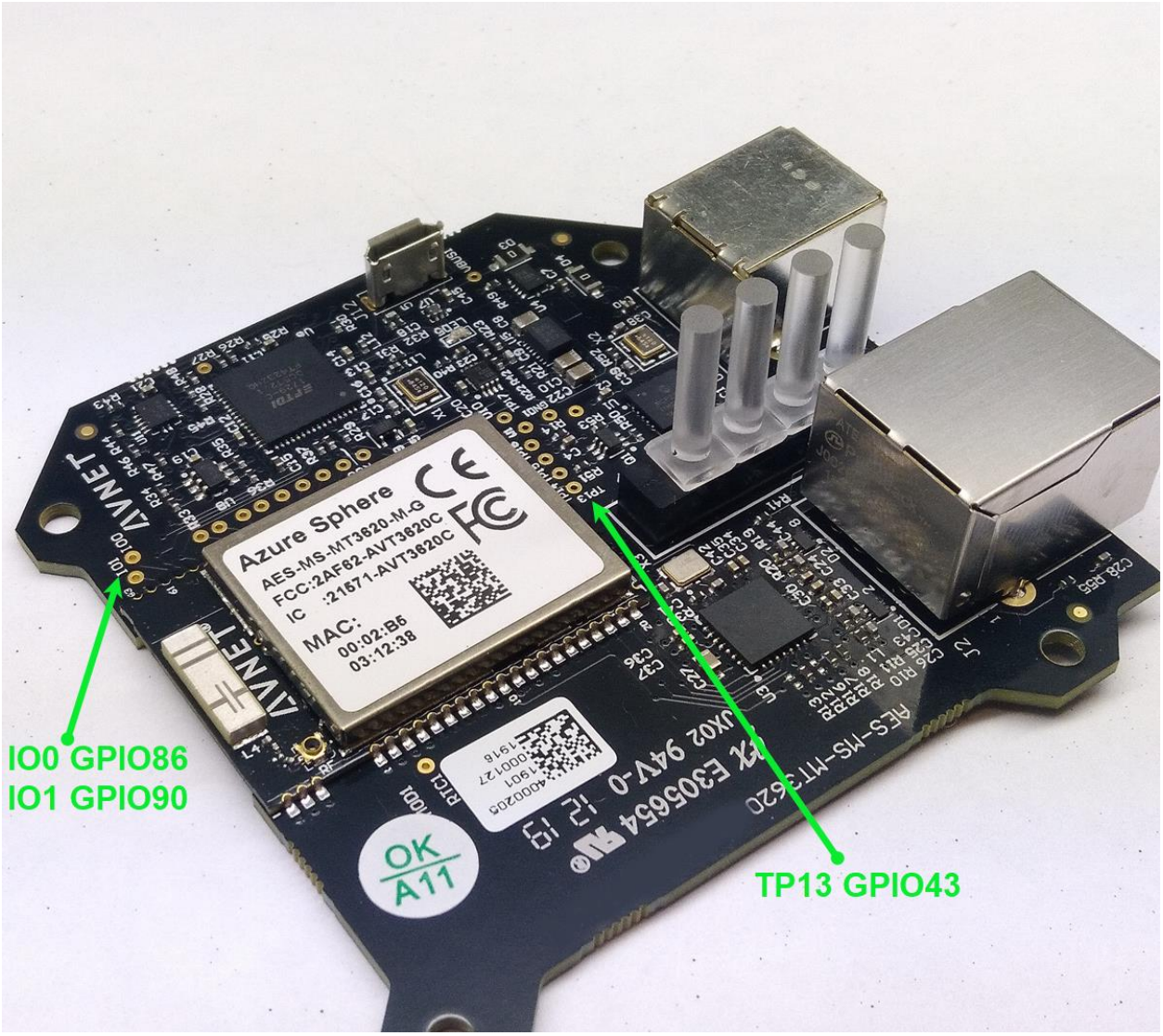


Figure 6 – Guardian 100 PCB Assembly

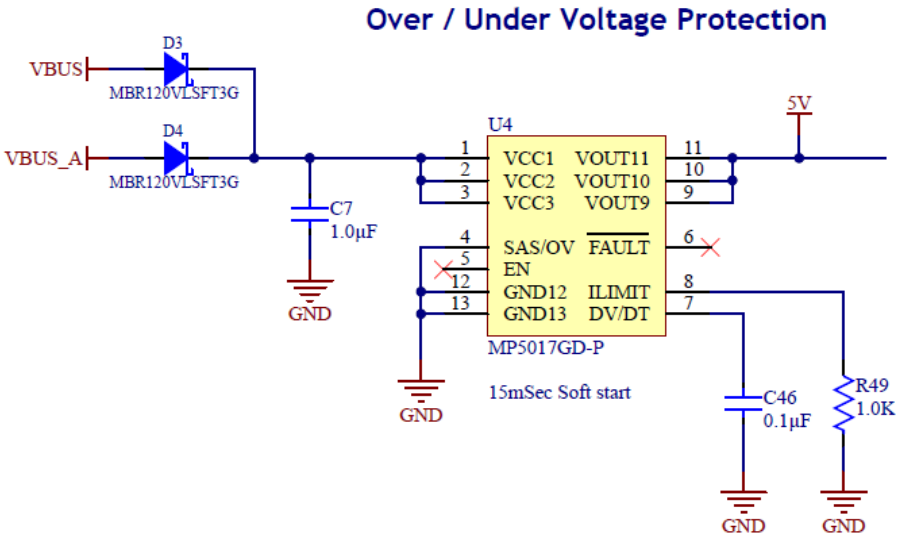
10.8 Power Inputs, Over-Voltage Protection and Voltage Regulation

The supply voltage to Guardian is +5V VBUS from one of the two USB cable inputs, ie.

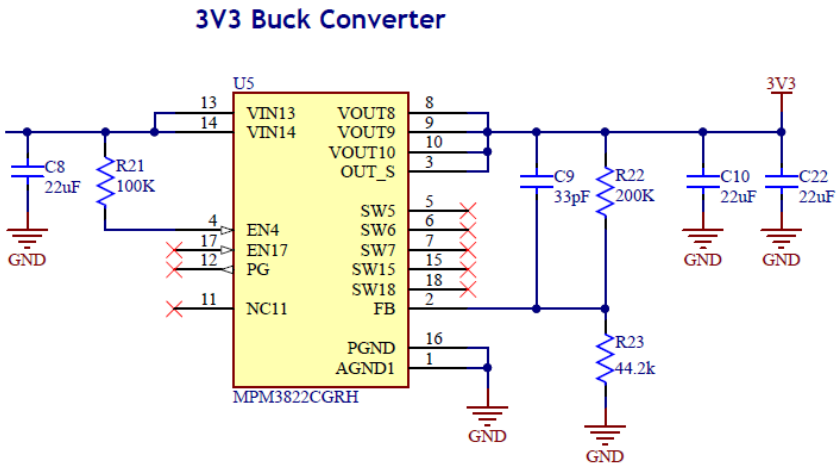
a) **USB FTDI Programmer Interface**
(used for RECOVERY, SERVICE, DEBUG and SWD interfaces)

b) **USB-UART Application Interface**
(used for UART-based communication between Guardian and the equipment)

An active “Over/Under Voltage Protection” circuit provides input voltage protection to the DC/DC regulator (MP5017GD input voltage max = 6.0V)



A 5V to 3.3V buck convertor (rated for 2A max) regulates the 3.3V VCC rail voltage



11 Contact Info and Technical Support

Documentation, reference designs and community discussion forums are accessible from the product page http://avnet.me/mt3620-guardian

Extensive Microsoft Azure Sphere Documentation is available at:
https://docs.microsoft.com/en-us/azure-sphere/

Microsoft Azure Sphere MSDN forum (technical questions, answers and support) is at
https://aka.ms/AzureSphereSupport

Relevant instructional blogs are also available under the Azure Sphere Starter Kit community page
http://avnet.me/mt3620-kit

For further info on Azure Sphere boards and certified modules, contact your local Avnet representative at:

Region	Organization	Email	Address & Phone
North America	Avnet Americas	Microsoft@avnet.com	AVNET - Americas 2211 South 47th Street Phoenix, AZ 85034, USA Phone: +1-800-585-1602
Europe	Avnet Silica	Microsoft@silica.com	Avnet Silica Gruber Str. 60c 85586 Poing, Germany Phone: +49-8121-77702
Japan	Avnet Japan	eval-kits-jp@avnet.com	Yebisu Garden Place Tower, 23F 4-20-3 Ebisu, Shibuya-ku Tokyo 150-6023, Japan Phone: +81-(0)3-5792-8210
Asia	Avnet Asia	iot-asia@avnet.com	151 Lorong Chuan #06-03 New Tech Park Singapore 556741 Phone: +65-6580-6000

12 Disclaimer

The Azure Sphere Guardian 100 Secure Edge Module is intended as a secure communication accessory to an end-product, without additional steps being performed to ensure regional certification compliance.

Avnet assumes no liability for modifications that a user chooses to make to this Guardian 100.

13 Safety Warnings

Safety Warnings

1) This product can be powered from one of two power sources:

   a) +5V via the provided microUSB cable, connected to the development computer
   b) +5V via the provided type-B USB cable, connected to end equipment that is rated to deliver at least 1.0 A. The end-equipment power source shall comply with relevant regulations and standards applicable in the country of intended use.

2) Only compatible equipment shall be connected to Guardian 100. Connection of incompatible equipment may affect compliance or result in damage to the unit and void the warranty.

3) This product must be operated in a well-ventilated environment.
   If an additional enclosure is used, this must provide adequate ventilation.

4) Ambient operating temperature when using Guardian 100 Starter Kit shall not exceed the range of: -30C to +85C

Appendix-A: Azure Sphere Module Pinout Detail

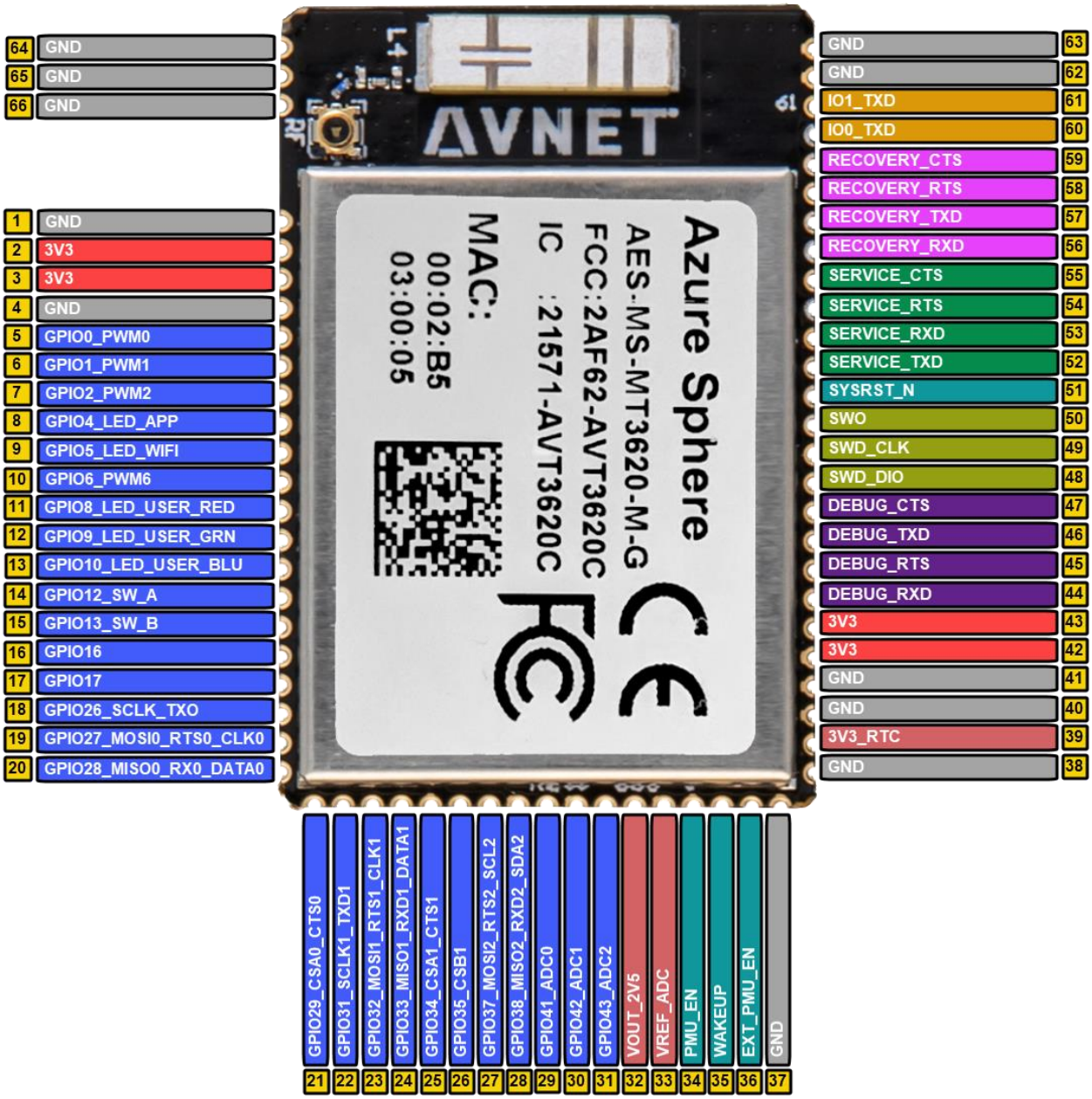


Figure 7 – Azure Sphere Module Pinout

Azure Sphere Module Pinout Detail

Module Pad	MT3620 Pad	MT3620 Net Name	I/O	Pin Function	Pre-Assigned Guardian 100 Function=blue
1		GND	GND		
2	2,3	3V3	Power		
3	2,3	3V3	Power		
4			GND		
5	13	GPIO0_PWM0	I/O	GPIO / INT in / PWM out	
6	14	GPIO1_PWM1	I/O	GPIO / INT in / PWM out	
7	15	GPIO2_PWM2	I/O	GPIO / INT in / PWM out	
8	17	GPIO4_PWM4	I/O	GPIO / INT in / PWM out	
9	18	GPIO5_PWM5	I/O	GPIO / INT in / PWM out	**INT_ENC**
10	19	GPIO6_PWM6	I/O	GPIO / INT in / PWM out	**RST_N_ENC**
11	21	GPIO8_PWM8	I/O	GPIO / INT in / PWM out	**GPIO8_LED_USER_R** (1)
12	22	GPIO9_PWM9	I/O	GPIO / INT in / PWM out	**GPIO9_LED_USER_G** (2)
13	25	GPIO10_PWM10	I/O	GPIO / INT in / PWM out	**GPIO10_LED_USER_B** (3)
14	27	GPIO12	I/O	GPIO / INT in	
15	28	GPIO13	I/O	GPIO / INT in	
16	31	GPIO16	I/O	GPIO / INT in	
17	32	GPIO17	I/O	GPIO / INT in	
18	39	GPIO26_SCLK0_TXD0	I/O	GPIO / ISU0	**SCK_ENC** (SPI0)
19	40	GPIO27_MOSI0_RTS0_SCL0	I/O	GPIO / ISU0	**MOSI_ENC** (SPI0)
20	42	GPIO28_MISO0_RXD0_SDA0	I/O	GPIO / ISU0	**MISO_ENC** (SPI0)
21	43	GPIO29_CSA0_CTS0	I/O	GPIO / ISU0	**CS_ENC** (SPI0)
22	46	GPIO31_SCLK1_TXD1	I/O	GPIO / ISU1	**APP_TXD** (UART1)
23	47	GPIO32_MOSI1_RTS1_SCL1	I/O	GPIO / ISU1	**APP_RTS** (UART1)
24	48	GPIO33_MISO1_RXD1_SDA1	I/O	GPIO / ISU1	**APP_RXD** (UART1)
25	49	GPIO34_CSA1_CTS1	I/O	GPIO / ISU1	**APP_CTS** (UART1)
26	50	GPIO35_CSB1	I/O	GPIO / ISU1	
27	52	GPIO37_MOSI2_RTS2_SCL2	I/O	GPIO / ISU2	
28	53	GPIO38_MISO2_RXD2_SDA2	I/O	GPIO / ISU2	
29	58	GPIO41_ADC0	I/O	GPIO / ADC in	
30	59	GPIO42_ADC1	I/O	GPIO / ADC in	
31	60	GPIO43_ADC2	I/O	GPIO / ADC in	**TP13**
32	66	VOUT_2V5	AO		
33	67	VREF_ADC	AI		min 1.8V, max 2.5V
34	81	PMU_EN	I		pull-up on module
35	70	WAKEUP	I	Ext. Wakeup Input	pull-up on module
36	69	EXT_PMU_EN	O	Ext. 3V3 regulator enable	
37		GND	GND		

Module Pinout Detail (continued)

Module Pad	MT3620 Pad	MT3620 Net Name	I/O	Pin Function	Pre-Assigned Guardian 100 Function=BLUE
38		GND	GND		
39	71	3V3_RTC	Power		min 2.50 V, max 3.63V
40		GND	GND		
41		GND	GND		
42	88,89	3V3	Power		
43	88,89	3V3	Power		
44	94	DEBUG_RXD	I	Debug UART	**DEBUG_RXD**
45	96	DEBUG_RTS	O	Debug UART (pulled-down / FTDI controlled strapping state on Guardian 100)	**DEBUG_RTS**
46	95	DEBUG_TXD	O	Debug UART (pulled-down on module)	**DEBUG_TXD**
47	97	DEBUG_CTS	I	Debug UART	**DEBUG_CTS**
48	98	SWD_DIO	I/O	CM4F SWD	**SWD_DIO**
49	99	SWD_CLK	I	CM4F SWD	**SWD_CLK**
50	100	SWO	O	CM4F SWD	**SWO**
51	125	SYSRST_N	I		**SYSRST_N**
52	127	SERVICE_TXD	O	Service UART	**SERVICE_TXD**
53	129	SERVICE_RXD	I	Service UART	**SERVICE_RXD**
54	128	SERVICE_RTS	O	Service UART	**SERVICE_RTS**
55	130	SERVICE_CTS	I	Service UART	**SERVICE_CTS**
56	134	RECOVERY_RXD	I	Recovery UART	**RECOVERY_RXD**
57	135	RECOVERY_TXD	O	Recovery UART (PU on module)	**RECOVERY_TXD**
58	136	RECOVERY_RTS	O	Recovery UART (pulled-down on module)	**RECOVERY_RTS**
59	137	RECOVERY_CTS	I	Recovery UART	**RECOVERY_CTS**
60	139	IO0_GPIO86/IO0_TXD	O	IO0_GPIO / IO0_TXD (pulled-down on module)	**IO0_TXD**
61	143	IO1_GPIO90/IO1_TXD	O	IO1_GPIO / IO1_TXD (pulled-down on module)	**IO1_TXD**
62 - 66		GND	GND	GND pour	
67		PADGND	GND	Thermal pad for MT3620	

14 iPerf3 Wi-Fi Data Rate Test

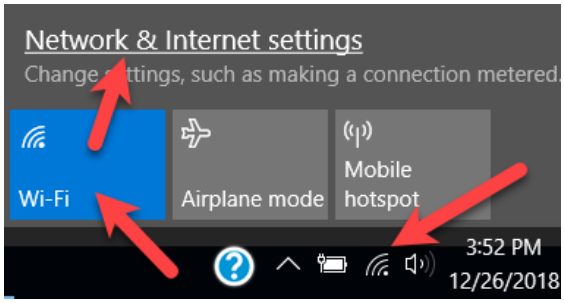
This uses a pre-compiled, production-signed application that is side-loaded into the MT3620 device from the azsphere command window. The iPerf3 test measures TCP data throughput of the network connection between Guardian (running iPerf3 in Client mode) connected via Wi-Fi, with a test computer (running iPerf3 in Server mode) at a static IP address of 192.168.1.35 on same subnet as Guardian.

Important to note is that this test does ***not*** require:

- The Guardian device to be claimed to an Azure Sphere tenant
- Use of Microsoft Visual Studio to build an iPerf3 executable

14.1 Computer: iPerf3 Server

1) On the development computer, download and unzip the iPerf 3.1.3 Windows application from https://iperf.fr/iperf-download.php

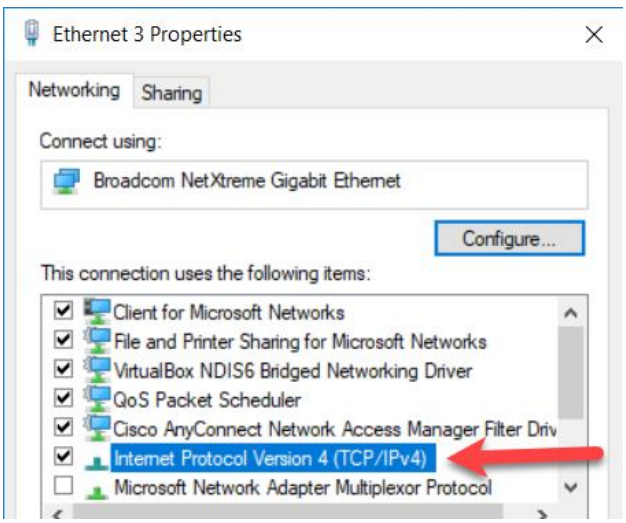


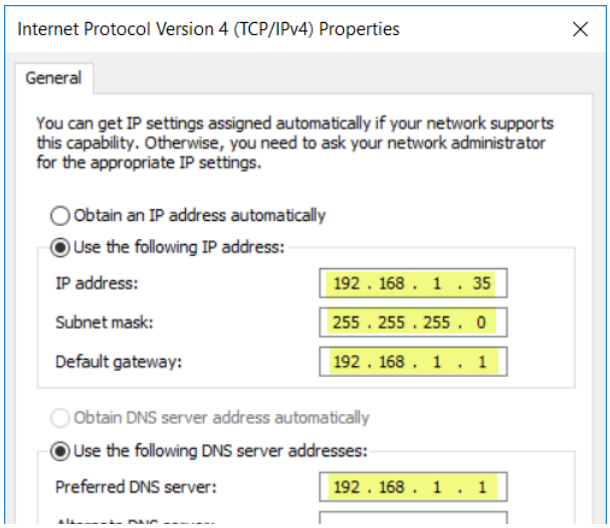
2) For a better assessment of just the Guardian Wi-Fi connection, it is recommended to turn-off the computer's Wi-Fi adaptor and instead use a wired LAN connection from computer to network router

3) Connect the Ethernet port of the test computer via CAT-5 cable connection to the Network Router
Note! The same Network Router (ie. same subnet) must be used for the iPerf3 server (connected via Ethernet) and the Guardian iPerf3 client (connected via Wi-Fi)

4) The Guardian iPerf3 application is preconfigured to connect to an iPerf3 server at a specific static address. It is therefore necessary to set the computer's **ethernet adaptor** to have a static IP address of **192.168.1.35** (plus the other highlighted settings shown below…)

5) Launch the **iperf3 server** using the command: **`iperf3 -s`**





14.2 Guardian: iPerf3 Client

1) From the Guardian product page http://avnet.me/mt3620-guardian download the pre-compiled "production-signed" iperf3 application **`iperf3_ps.imagepackage`** (located under **Downloads**)

2) With the enclosure lid removed, connect a USB cable from the computer to the Debug/Program microUSB connector that is accessed on the PCB inside the enclosure

3) From the azsphere commandline window, now side-load the downloaded image file into Guardian flash memory using the following command:
`azsphere device sideload deploy -p iperf3_ps.imagepackage`

14.3 Guardian: Configure Wi-Fi

1) Use the following command to configure the Wi-Fi (replace **`??????`** with applicable credentials)
`azsphere device wifi add -ssid ?????? -psk ??????? -t`

2) After Wi-Fi connects, reported iPerf bitrates should start appearing in the console window…

```
***********************************************************
*      Starting iPerf3 Server on the Test Computer      *
***********************************************************
-----------------------------------------------------------
Server listening on 5201
-----------------------------------------------------------
Accepted connection from 192.168.1.200, port 47070
[  5] local 192.168.1.35 port 5201 connected to 192.168.1.200 port 47072
[ ID] Interval           Transfer     Bandwidth
[  5]   0.00-1.00   sec  4.85 MBytes  40.7 Mbits/sec
[  5]   1.00-2.00   sec  5.25 MBytes  44.0 Mbits/sec
[  5]   2.00-3.00   sec  5.36 MBytes  45.0 Mbits/sec
[  5]   3.00-4.00   sec  5.33 MBytes  44.6 Mbits/sec
[  5]   4.00-5.00   sec  5.31 MBytes  44.6 Mbits/sec
[  5]   5.00-6.00   sec  5.31 MBytes  44.6 Mbits/sec
[  5]   6.00-7.00   sec  5.16 MBytes  43.3 Mbits/sec
[  5]   7.00-8.00   sec  5.18 MBytes  43.5 Mbits/sec
[  5]   8.00-9.00   sec  5.15 MBytes  43.2 Mbits/sec
[  5]   9.00-10.00  sec  5.22 MBytes  43.8 Mbits/sec
[  5]  10.00-10.02  sec  78.8 KBytes  39.0 Mbits/sec
- - - - - - - - - - - - - - - - - - - - - - - - -
[ ID] Interval           Transfer     Bandwidth
[  5]   0.00-10.02  sec  0.00 Bytes  0.00 bits/sec                  sender
[  5]   0.00-10.02  sec  52.2 MBytes  43.7 Mbits/sec                receiver
.
Restart iPerf3 Test or Quit ? [ r / q ]
Type input:
```

Notes:
If the reported bandwith (bitrate) is zero, use:
CTL+C to stop the iPerf3 Server application, then
`iperf3 -s` to restart the iPerf3 Server application (on the development computer)

15 Guardian Equipment Interface Test

A pre-compiled, production-signed application is side-loaded into the MT3620 from the azsphere command window (ie. does not require Microsoft Visual Studio build of an executable)

This test exercises and configures Guardian's Wi-Fi, as well as the Ethernet and USB-Serial equipment interfaces and the status LEDs:

- USB-serial equipment interface
  Implements a console user interface. Lists a menu of test options and provides test feedback

- Ethernet equipment interface
  A browser-based webserver interface is accessed via ethernet to scan and configure Guardian's Wi-Fi settings

- Wi-Fi interface
  Scanning of Wi-Fi SSIDs and their reported RSSI measurements is easily exercised.
  The webserver-based Wi-Fi scan results can be accessed via Ethernet or Wi-Fi (once configured)

- Status LEDs
  All seven Guardian LEDs are exercised. The User LEDs confirm which test is being executed.

Figure 8 – Hardware Test Setup

15.1 Guardian: Test Application Installation

1) From the Guardian product page http://avnet.me/mt3620-guardian download the pre-compiled "production-signed" test application **guardian_test_ps.imagepackage** (under **Downloads**)

2) Plug-in a USB cable from the computer to the Debug/Program microUSB connector. Wait 5 seconds, then enter the following command to delete any previously side-loaded images:
```
azsphere device sideload delete
```

3) Package and deploy the board configuration image for the Microchip ENC286J60 Ethernet combo MAC and PHY device that is on Guardian 100, using the following two commands:

```
azsphere image-package pack-board-config --preset lan-enc28j60-isu0-int5 --output enc28j60-isu0-int5.imagepackage
```

```
azsphere device sideload deploy --imagepackage enc28j60-isu0-int5.imagepackage
```

4) Now side-load the downloaded production-signed guardian test application image file into flash memory using the following command:
```
azsphere device sideload deploy -p guardian_test_ps.imagepackage
```

5) Unplug the Debug/Program USB cable

15.2 Computer: Equipment Interfaces and LED Tests (Terminal-based)

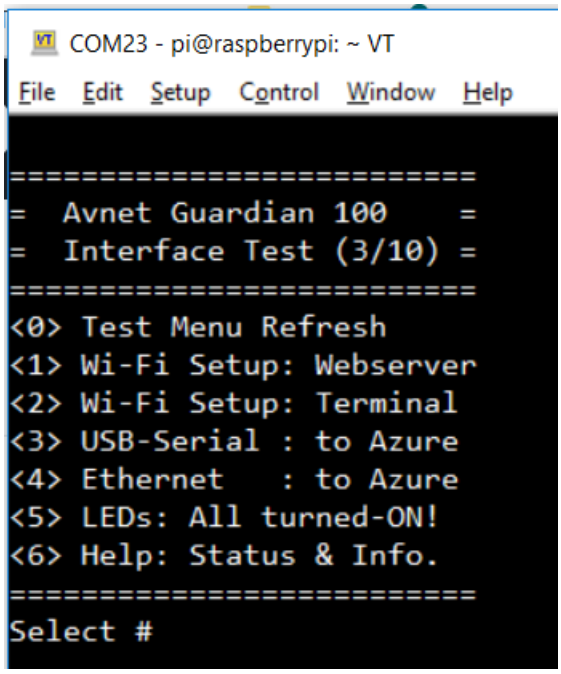
1) Connect the USB type-B equipment interface cable from Guardian to the development computer, a new serial port driver should enumerate

2) Launch a Tera Term (or Putty) serial console and select the COM port allocated to this Guardian USB-serial interface. Set serial port settings to **115200 8-N-1** and the terminal type to **VT100**

3) At start-up the test application on Guardian is waiting for a keyboard entry via the USB-serial interface. **Left mouse-click** on the terminal window (to ensure this is the active window for the keyboard). Now press **0** or **spacebar** to display Guardian's test menu in this terminal window

4) If a specific test is not selected, the LEDs display a continuous "scanning sequence"
(– Pressing a non-menu key, exits currently selected test and returns to this mode

5) Press the **1,2,3,4** numeric keys to enter the different tests. The 1, 2, 3 Status LEDs then confirm which test has been entered (the test mode is also confirmed on the terminal screen)



Exercise the Guardian test menu options by pressing the corresponding number key:

0: Test Menu Refresh
Pressing **0** or **spacebar** will refresh the test menu

1: Wi-Fi Setup: Webserver
Pressing **1** illuminates **LED1** and descriptive detail of this test is displayed on console
(Menu stub for future option. Scan and report of Wi-Fi SSIDs is currently done from browser interface)

2: Wi-Fi Setup: Terminal
Pressing **2** illuminates **LED2** and descriptive detail of this test is displayed on console
(Menu stub for future option. Scan and report of Wi-Fi SSIDs is currently done from browser interface)

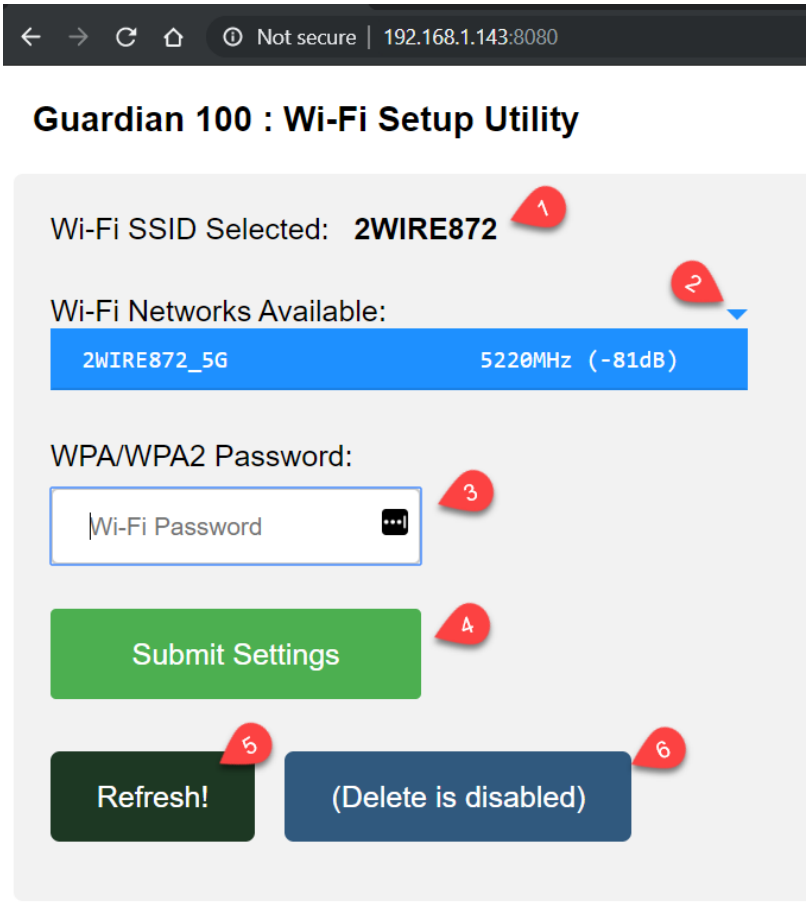
3: USB-Serial: to Azure
Pressing **3** illuminates **LED3** and descriptive detail of this test is displayed on console
(Menu stub for future option: Sending of simulation data to Azure is **not** currently implemented)

4: Ethernet: to Azure
Pressing **4** turns-off all LEDs. Descriptive detail of this test is displayed on console
(Menu stub for future option: Sending of simulation data to Azure is **not** currently implemented)

5: LEDs: All turned-ON!
Pressing **4** turns-on all LEDs (**LED1**, **LED2**, **LED3)**
(Later version will also turn-on the **RJ45 LEDs**)

6: Help: Status & Info
Pressing **5** turns-off the User LEDs and displays informational help text
(Menu stub for future option: Later version will provide Network Status reporting)

15.3 Computer or SmartPhone: Wi-Fi Scan and Setup (Browser-based)



The fields of the internet browser-based Guardian webserver screen are as follows:

1) **Wi-Fi SSID Selected:**
Confirmation of Guardian's currently selected Wi-Fi network

2) **Wi-Fi Networks Available:**
Drop-down list of available Wi-Fi networks (with channel frequencies and RSSI signal strengths)
Click on the relevant SSID name to select that network

3) **WPA/WPA2 Password:**
Password entry for the selected new Wi-Fi network

4) **Submit Settings**:
Write new Wi-Fi setting to flash memory (Note: This deletes previously entered Wi-Fi settings)

5) **Refresh:**
Refresh the drop-down scan list (of SSIDs, channels and RSSI measurements)

6) **Delete All:**
(Manual option to erase Wi-Fi settings - Disabled in this version)

Functionality of the **Wi-Fi Networks Available** drop-down list includes:

a) The ability to select an SSID name and enter password credentials for this Wi-Fi network

b) Reporting of **SSID**, **Channel Frequency** and **RSSI signal strength** for each network listed

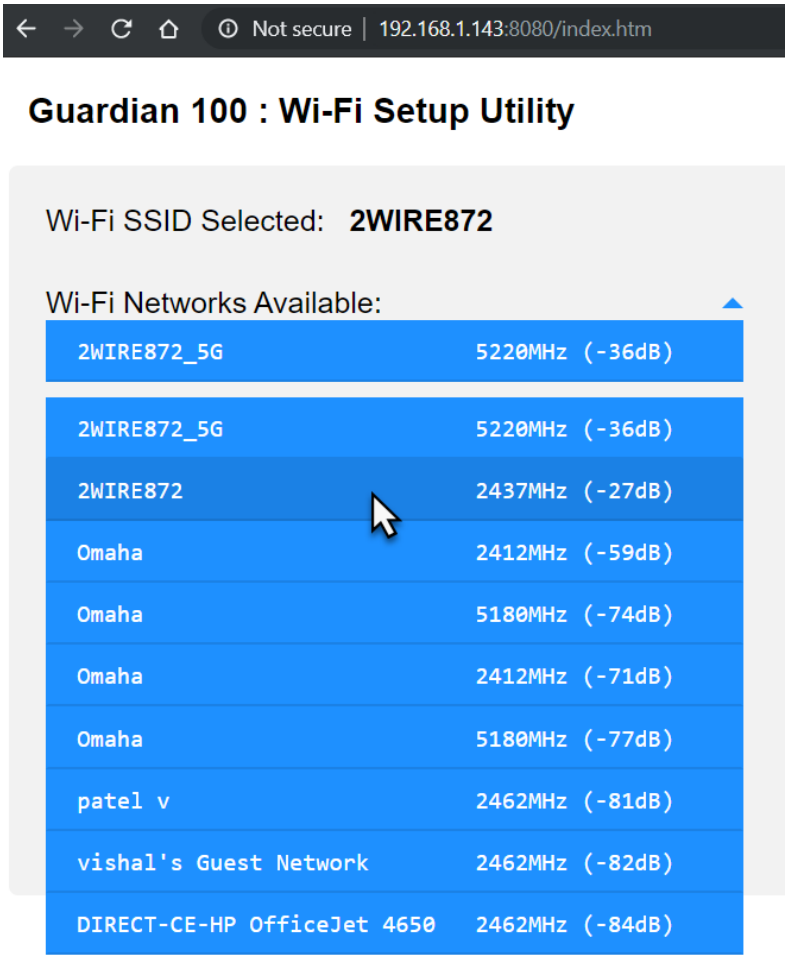


Figure 9 – Drop-down list of scanned Wi-Fi SSIDs

Notes:

1) When setting-up Wi-Fi, use wired Ethernet connection to access Guardian's webserver

2) Select desired Wi-Fi network from Wi-Fi Networks Available drop-down list,

3) Enter **Password** then click on **Submit Settings**

5) During first-time Wi-Fi setup, “Wired” Ethernet **eth0** connection (not Wi-Fi!) and a computer must be used to connect to Guardian’s webserver

6) Once Guardian has valid Wi-Fi settings, a Smartphone can be used to modify the Wi-Fi settings

7) From network router’s admin screens, use the “Client View” to determine the Guardian IP addresses (this aspect will be simplified in future version)

8) In screenshot below, Guardian IP addresses (+ Port) accessible from a browser are as follows:

   eth0 (Wired interface)
   192.168.1.143:8080

   wlan0 (Wi-Fi interface, Avnet Wi-Fi MAC addresses always start with **00:02**)
   192.168.1.205:8080

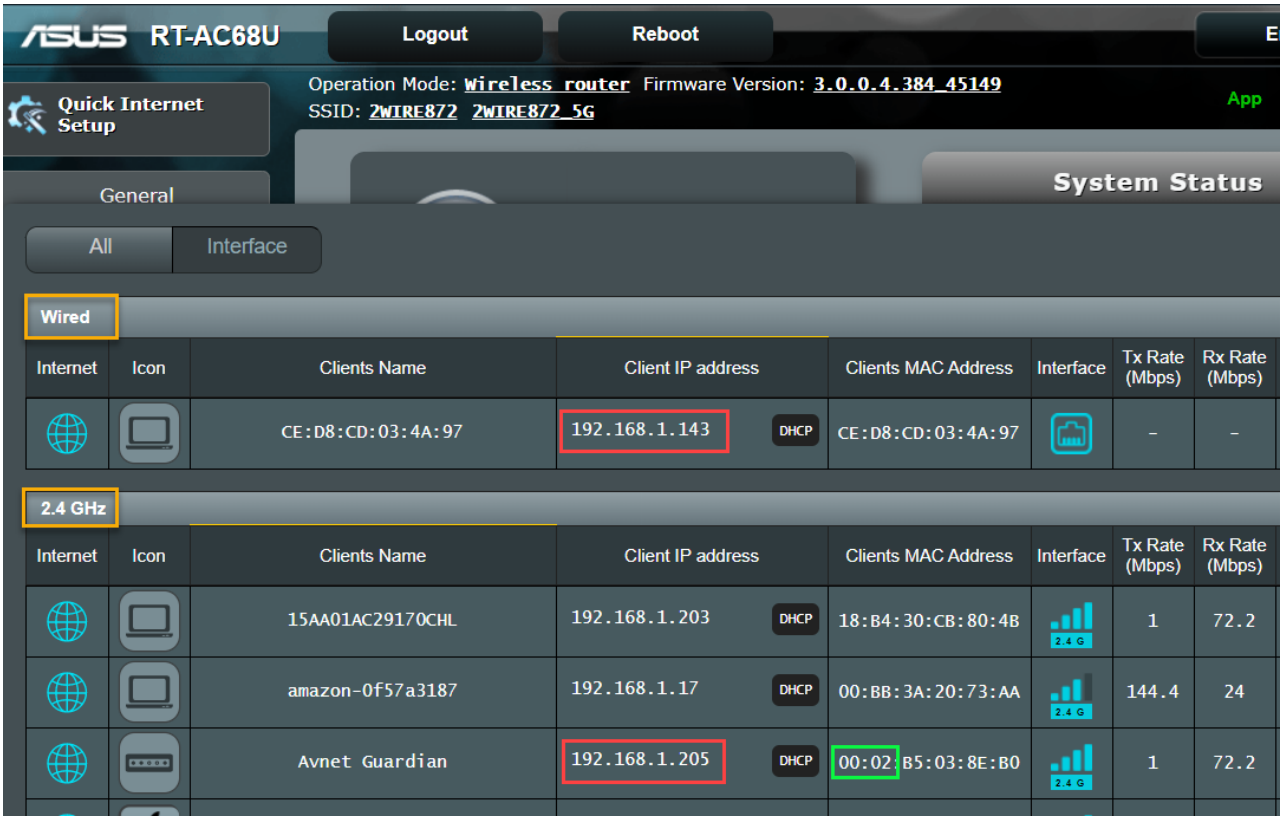


Figure 10 – Network router’s “Client View” admin screen