

IP•Link 1223

Embedded Wireless Module



User Manual
Version 1.1.02



Helicomm, Inc.

www.helicomm.com

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Revision and Iteration History

Version	Publication Date	Authors	Summary of Changes and Updates
1.0.00	12/17/2008	Yr.Qie	Initial Draft
1.1.00	07/20/2009	Wt.Wu	Modify AT registers,the comment parameters about IO ports . And modify the formula for get IP-Link 1223 temperature.
1.1.01	07/09/2101	Frank Tung	Revised dimension
1.1.02	08/03/2010	Frank Tung	Added FCC information

FOR FCC AND INDUSTRY CANADA REQUIREMENT:

"This device has been designed to operate with the antennas listed below, and having a maximum gain of [3] dB. Antennas not included in this list or having a gain greater than [3] dB are strictly prohibited for use with this device. The required antenna impedance is [50] ohms."

"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 permitted for successful communication."

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.

The equipment has been tested and found to comply with the limits for a Class B Digital Device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates uses and can radiate radio frequency energy and, if not installed and used in accordance with the instruction, may cause harmful interference to radio communication. However, there is no grantee that interference will not occur in a particular installation. If this equipment dose causes 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.

This device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) this device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

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

To comply with the RF exposure compliance requirements, this device and its antenna must not be co-located or operating to conjunction with any other antenna or transmitter. This equipment should be installed and operated with minimum distance 20cm between the radiator & your body.

To OEM installer:

1. ID label on the final system must be labeled with "**Contains FCC ID: RF2IPLINK12235142 / IC: 8576A-IPLINK5142**" or "**Contain transmitter module FCC ID: RF2IPLINK12235142 / IC: 8576A-IPLINK5142**".
2. In the user manual, final system integrator must be ensured that there is no instruction provided in the user manual to install or remove the transmitter module.
3. Transmitter module must be installed and used in strict accordance with the manufacturer is instructions as described in the user documentation that comes with the product. This device complies with the following radio frequency and safety standards.

The user manual of the final host system must contain the following statements:

This equipment has been tested and found to comply with the limits for a Class B Digital Device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instruction, may cause harmful interference to radio communication. However, there is no grantee that interference will not occur in a particular installation. If this equipment dose causes 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:

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1 Overview

IP-Link 1223 is Helicomm's embeddable, Surface Mount Technology (SMT) IEEE 802.15.4/ZigBee-compliant wireless module. IP-Link 1223 contains a powerful 8-bit 8051 microprocessor and a 2.4GHz IEEE 802.15.4-compliant RF transceiver. IP-Link 1223 can operate over 16 channels in the unlicensed 2.4GHz frequency band (or ISM, short for *Industrial, Science and Medical*) across the world.

In addition to its IEEE-standard-based RF and PHY/MAC air interfaces, IP-Link 1223's embedded stack support a wide variety of useful networking features. IP-Link 1223's network support is designed to cover a whole range of application needs, ranging from a simple beaconing network to complicated multi-story full ad hoc networks.

Whether your applications need the robustness and simplicity of IEEE 802.15.4 standard or the versatility of ZigBee Compliance Platform, Helicomm's IP-Link 1223 is the vehicle to enable your applications to the power and cost advantages of standard-based short-range wireless networking. IP-Link 1223 is ideal for a wide range of remote monitoring and control applications such as home control, meter reading, industrial automation, building automation, and security monitoring.

This manual contains vital information about Helicomm IP-Link 1223 embedded wireless transceiver modules. It includes information on how the IP-Link 1223 can be easily provisioned, managed, and integrated into your existing products.

Following is the structure of this manual.

- Chapter 2 contains information on the IP-Link 1223 interface, performance and electrical specifications.
- Chapter 3 gives the absolute maximum ratings to warn users using the device in the proper circumstance.
- Chapter 4 specifies the IP-Link 1223 module's operating conditions.
- Chapter 5 offers a high-level description of the network operations supported by the IP-Link 1223, and how various network topologies can be configured to meet your application requirements.
- Chapter 6 gives the special notes on setting up a full mesh network and how to do a mesh topology configuration of module.
- Chapter 7 gives readers definitions and invocation mechanisms needed to develop their own host applications based on IP-Link 1223's flexible networking capabilities.
- Chapters 10 to 11 contain acronyms, mechanical dimensions, and manufacturing re-flow specification.

2 Module Specifications

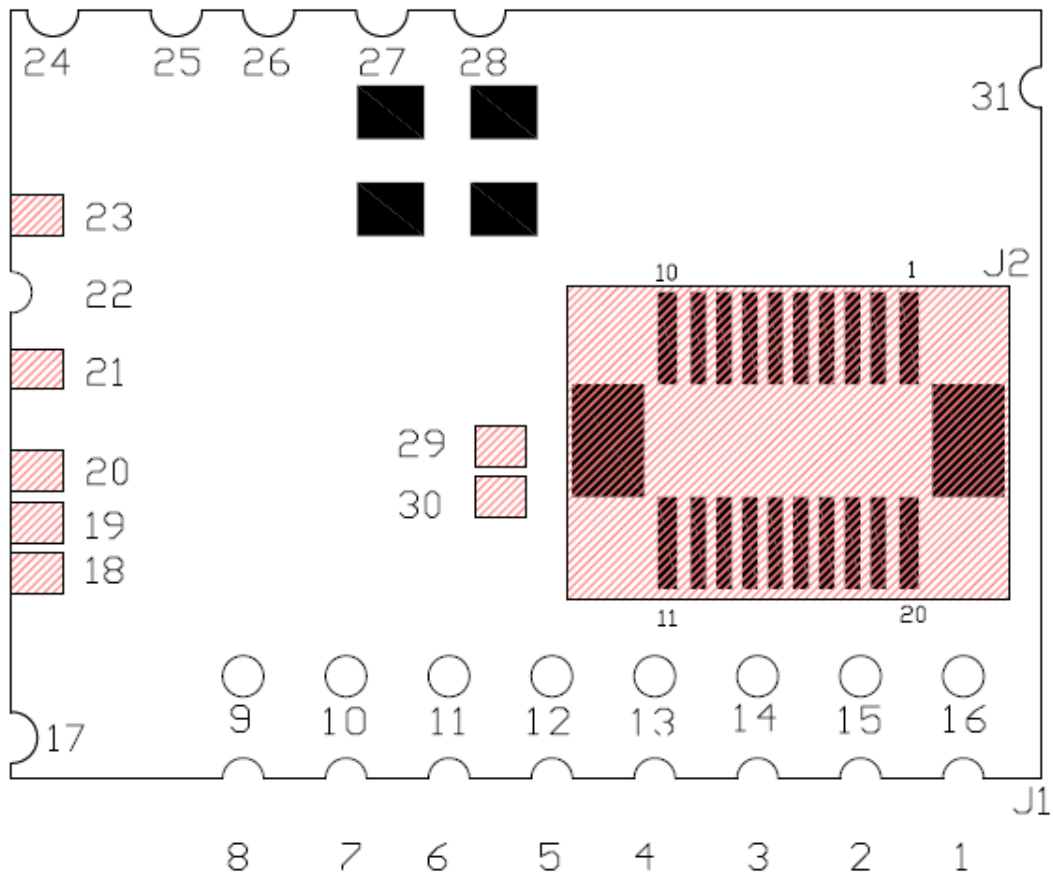
Micro-controller (MCU)	MCU Clock Rate	24.5MHz	
	FLASH ROM	64KB	
	RAM	4KB	
RF	Frequency	2.4 GHz	
	Receive Sensitivity	1223-50XX: -95 dBm 1223-51XX: -104 dBm	
	Air Data Rate	250 Kbps	
	Transmit Range	1223-50XX: 100 meters(LOS) 1223-51XX: 1200 meters(LOS)	
	RF Channels	16 (5MHz)	
	Transmit Power	1223-50XX: 0 dBm 1223-51XX: 22 dBm	
	Data Encryption	CRC and AES-128	
	Antenna	1223-5X1X: Non. Ant. 1223-5X2X: PCB Ant. 1223-5X3X: Chip Ant. 1223-5X4X: U.FL Ext. Ant.	
Power Consumption	Transmit/Receive	1223-50XX: 29mA/27mA 1223-51XX: 150mA/41mA	
	Sleep	1223-50XX: 4uA 1223-51XX: 60uA	
Input/Output	Physical Pins(Max.)	1223-5XX1: 31 1223-5XX2: 31 1223-5XX3: 51	
		Serial	One UART
		A-to-D(Max.)	9(10-bit ADC, two ADC in default status. It is used with IO together and the maximum is nine ADC. The more the number of ADC, the less the number of the available IO.)
	Comparators	Not support at present	
D-to-A	Not support		
# of Programmable GPIO(Max.)	9(Seven IO in default status. It is used with ADC together and the maximum is nine IO. The more the number of IO, the less the number of the available ADC.)		
Physical	Connector Type	1223-5XX1: Stamp Hold 1223-5XX2: Pin Header 1223-5XX3: Pin Header+B2B(Full IO Pin Out)	
	Dimension (in inches)	1223-50XX: 0.79 x 0.87 x 0.07 1223-51XX: 2 x 1.6 x 0.59	

	Dimension (in millimeters)	1223-50XX: 20 x 22 x 1.88 1223-51XX: 51 x 39.4 x 15
	Operating Temperature	-20°C to +70°C
	Humidity (non-condensing)	10% to 90%

2.1 IP-Link 1223 Interface Pin Definitions

Top View:

(Red block is bottom side)



IP-Link 1223

Pin No	Symbol	Type	Description
	J1	Hole	Stamp Hole and Through Hole
1	P0.0	DI/O	DIO (interrupt), ADC.
2	P0.1	DI/O	DIO (interrupt), ADC.
3	RX0	DI	Serial input of UART.
4	TX0	DO	Serial output of UART.
5	MCU_RESET	DI	MCU reset.

Pin No	Symbol	Type	Description
6	GND	G	Power Ground
7	VCC	P	3.3V power supply to the module.
8	P0.2	DI/O	DIO (interrupt), ADC.
9	P0.6	DI/O	DIO (interrupt), ADC,VREF
10	P2.7/C2D	DI/O	JTAG DATA.
11	P0.7	DI/O	DIO (interrupt), ADC
12	C2CK	DI/O	JTAG CLOCK.
13	P1.4	DI/O	DIO (interrupt), ADC
14	P1.5	DI/O	DIO (interrupt), ADC
15	P1.6	DI/O	DIO (interrupt), ADC.
16	P1.7	DI/O	DIO (interrupt), ADC.
17	GND	G	Power Ground
18	RX_EN	DI	UZ2400 RF RX Enable Control to the PA module.
19	PA_EN	DI	UZ2400 RF PA Power Enable Control to the PA module.
20	TX_EN	DI	UZ2400 RF TX Enable Control to the PA module.
21	GND	G	Power Ground
22	RF_OUT	RF	Antenna Tx/Rx Port (Option U.FL RF connector)
23	GND	G	Power Ground
24	GND	G	Power Ground
25	GND	G	Power Ground
26	GND	G	Power Ground
27	ANT	RF	Antenna Tx/Rx Port connect with Printing Antenna
28	GND	G	Power Ground
29	VCC	P	3.3V power supply to the PA module
30	GND	G	Power Ground
31	GND	G	Power Ground

Pin No	Symbol	Type	Description
	J2 (Opt.)	Conn	Board to Board connector for more I/O pins
1	VCC	P	3.3V power supply to the module
2	GND	G	Power Ground
3	P2.4	DI/O	DIO (polling), ADC
4	P2.3	DI/O	DIO (polling), ADC
5	P2.2	DI/O	DIO (polling), ADC.
6	N/C		
7	N/C		
8	N/C		
9	N/C		
10	N/C		
11	N/C		
12	N/C		
13	N/C		
14	N/C		
15	N/C		
16	N/C		
17	P2.1	DI/O	DIO (polling), ADC, SCL(for I2C).
18	P2.0	DI/O	DIO (polling), ADC
19	GND	G	Power Ground
20	VCC	P	3.3V power supply to the module

The following signal type codes are used in the tables:

DI=Digital Input.

DO=Digital Output

DI/O=Digital bi-directional input/output pin.

DO/D=Digital Open Drain.

AI=Analog input pin

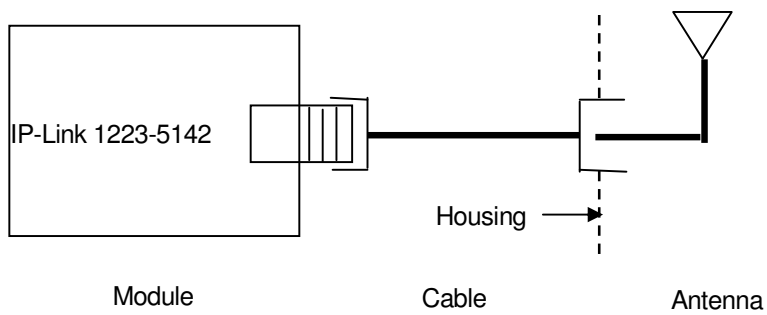
AO=Analog output pin

RF=RF signal I/O pin

P=Power pin

G=Ground pin

Note: IP-Link 1223-5142 is external antenna that must be connecting an extension low loss cable.



- Cable length: 330mm
- Cable Lose: 0.2 dB

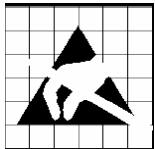
2.2 Firmware Capabilities Specification

Serial Port	Baud Rate	38400(factory default)
	Configuration	8/N/1
	Maximum Payload over Serial Port	97 Bytes
	Header Length	5
	Checksum	1-byte XOR
	Command Modes Supported	AT Mode (off-line provisioning) Binary Command Mode Binary Data Mode Transparent: RS-232/485 emulation
Networking	Maximum of Network Identifiers	65536 (0 ~ 65535)
	Range of Node Identifiers	0 ~ 65533 (0: Reserved for Network Master 65534: Reserved for self-loop back 65535: Reserved for broadcast)
	MAC Layer Blacklist	8 entries
	Routing Table	18-way
	RREQ Table	4-way
Sleep Mode	External Wakeup	RTC

3 Absolute Maximum Ratings

Parameter	Conditions	Min	Type	Max	Units
Voltage on any Pin		-0.3		3.6	V
Maximum Total Current through VCC, AV+, GND, and AGND,RFGND				500	mA
Maximum Output Current Sunk by any Port pin				100	mA
Maximum Output Current Sunk by any other I/O pin				100	mA
Maximum Output Current Sourced by any Port pin				100	mA
Maximum Output Current Sourced by any other I/O				100	mA
Storage Temperature		-40		+120	°C

*Note: The absolute maximum ratings given above should under no circumstances be violated. Stress exceeding one or more of the limiting values may cause permanent damage to the device.



Caution! ESD sensitive device. Precaution should be used when handling the device in order to prevent permanent damage.

4 Operating Conditions

Parameter	Conditions	Min	Type	Max	Units
Supply voltage (IP-Link 1223)		2.7		3.6	V
Operating ambient temperature range		-20		70	°C
Humidity(non-condensing)		10%		90%	

5 Theory of Networking Operations

IP-Link 1223 can be configured in a number of network topologies to meet different application needs. It allows the users to design a network that best matches their installation conditions and applications' needs. To design a network, it is empirical to understand how each individual IP-Link 1223 should be configured, and what each nodes individual capabilities as well as constrains are.

In this Chapter we discuss the theory of networking operation of IP-Link 1223's networking capabilities to lay the groundwork for later chapters. After reading this Chapter, users should have the system knowledge in assessing, configuring, deploying, and finally fine-tuning their IP-Link 1223 networks in real installations.

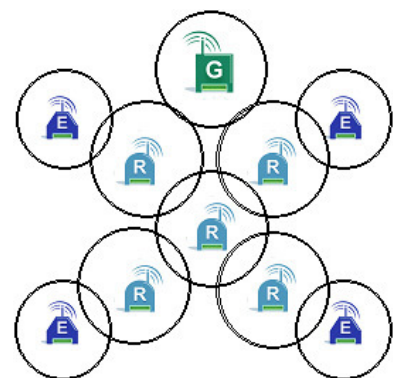
5.1 Wireless Networking Topologies

In this section, we describe the key distinction between “connectivity” and “routing” topologies to establish the basic framework of wireless network design. We then describe the working details, benefits, and constraints and recommended use case scenarios for the several routing options the IP-Link 1223 supports. This section provides a conceptual platform for readers before they use IP-Link 1223 to build wireless networks.

5.1.1 Connectivity Topology versus Routing Topology

While the generic phrase *network topologies* suggests wires or cables connecting a host with communicating nodes, wireless communication modules like the IP-Link 1223 use a wireless broadcast medium to communicate. The IP-Link 1223 is a low-power transceiver module optimized for low-cost and low power consumption. So rather than transmitting at high power or having a huge antenna to improve receiver sensitivity, a single IP-Link 1223 transmits at relatively low power and utilizes message routing capability to cover a larger area if necessary in some applications. And because of the broadcast nature of wireless transmission, it is important to realize the differences between *connectivity topology* and *messaging topology*.

Connectivity topology refers to the interconnect patterns at the Link level. In a wired network, topology refers to the physical wiring patterns among the nodes. Bus segments or point-to-point Links are some common connectivity topologies seen in Local Area Networks (LAN) or Wide Area Networks (WAN). In contrast, the connectivity pattern of a wireless network is usually visualized as overlapping radio circles or spheres, as illustrated here. The RF sphere implies both range and channelization, which means that nodes with overlapping bubbles are directly connected with one another.



So when considering a connectivity topology, the designer is usually concerned with design parameters such as overall coverage area, nodal density, and the transmission / reception characteristics of the transceiver modules. The characteristics could accidentally change due to varying external conditions and variables such as trucks, walls, trees, and other RF emitters.

On the other hand, a routing topology is a routing pattern over a multi-hop network. It describes an imaginary wiring diagram, weaving together all network nodes, allowing any arbitrary point to initiate a message (either unicast or multicast) to any fellow node in the network. A routing topology is constrained by the underlying connectivity topology. But for some connectivity topology patterns in which multiple routing options are available (like most wireless networks), selecting the optimal routing topology for your network can be a challenge. Two scenarios are presented here for demonstration.

- **Scenario 1: Linear Network**

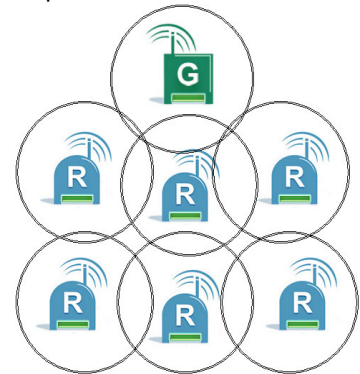


Let us examine a linear or “chain fence” scenario, in which any radio can only reach two immediate neighbors in opposite direction. In this extreme case, the choice of routing topology is constrained by the connectivity because there is only one deterministic way of getting a message from point A to point B in the whole network. This topology is common in pipeline monitoring applications and some traffic management and parking meter applications.

- **Scenario 2: Fully Meshed Network**

In this scenario, we increase the size of the RF sphere and make some changes to the relative position. Now one can see that the new connectivity topology offers a wider array of routing options. In this particular diagram, each node will have two or more paths to reach a particular destination. In this case, the routing topology is no longer a simple choice.

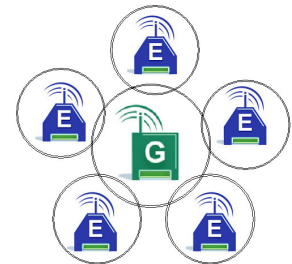
As illustrated in this scenario, routing topology decision for a low-power radio network involves the balance of many design objectives. The wireless network itself is a dynamic system, interacting with its environment incessantly. People movement, intermittent use of electrical appliances, and outside interference sources are all affecting the bubble size. Further complicating the decision process is the design objective to conserve battery consumption for battery-operated devices.



IP-Link 1223’s rich wireless routing algorithm is designed to simplify the decision process and expedite the deployment of a reliable, inexpensive wireless infrastructure. Its feature-rich and flexible networking capability aims to provide the network designers with sufficient alternatives and performance margin to easily come to a “just-right” routing topology to adapt to or even overcome the constraints imposed by underlying connectivity topologies.

5.1.2 Star Topology

As its name suggests, a star routing topology is actually a hub-and-spoke system in which data traffic and network commands are routed through a central node, the **Master**. In this routing topology, peripheral nodes require direct radio contact with the **Master**, and interference or the failure of a specific node can render the network less reliable, as each node provides a single point of failure. Especially, the failure of the master node will result in complete system crash. To construct a star network using IP-Link 1223, only one IP-Link 1223 module needs to be configured



as a **Master** node. The remaining IP-Link 1223 modules can be programmed as an **End** node.

The most significant benefit of a star routing topology is its simplicity. The simplicity translates into very low-overhead protocol implementation, much lower overall device cost, very low-overhead routing information, and ease of administration. The central **Master** node can also assume many administrative roles such as certificate authority for authentication, or remote management gateway.

However, the simplicity comes with a price of flexibility. Because of the requirement to put every single end node within the reach of the **Master** node, the overall network coverage is limited. And star topology networks cannot scale up easily to accommodate high-density deployment. The concentrated message routing towards the **Master** node can easily create a hot spot and lead to congestion, packet loss, and performance degradation, depending on the data traffic profile.

The star topology is by far the most common architecture deployed today, and it is well suited for a variety of remote monitoring and control applications that do not need or cannot afford the cost and complexity overhead of a more sophisticated network topology.

5.1.3 Peer-to-peer (Mesh) Topology

Peer-to-peer, also known as mesh networking, is a free-form topology designed to be highly adaptive to the environment. Each node in an IP-Link 1223 mesh network is a little router capable of re-assessing its routing decisions to provide the most robust, reliable network infrastructure possible. After configured as a mesh node, each IP-Link 1223 is capable of monitoring surrounding RF conditions, neighboring node activities, and end-to-end packet error rate statistics to adjust its local routing decisions on the fly. Such adaptability is extremely valuable to network designs that are facing uncertain or unpredictable Link conditions.

Mesh topology uses both the RF broadcast nature as well as a set of route inquiry and maintenance commands to dynamically update the distributed routing information across the entire network. The mesh protocol supported by IP-Link 1223 is similar to Ad hoc On-Demand Vector (AODV) routing, in which the node originating a message is responsible for establishing a suitable route by querying its immediate neighbors. The route queries process gradually ripples through the network until the destination confirms connectivity and initiates a reply. Such reply now ripples backwards toward the originator, accumulating vital routing statistics along its way. Finally, the originating node receives the most up-to-date route information and makes a routing decision based on that information. The newly computed routing information will age within a certain window and mandate new route computation after it expires to ensure route decision is based on fresh information.

Mesh is ideal for highly unstructured network deployment. When the deployment premise is open and potential interference sources or barriers are anticipated, mesh topology is a reliable way of ensuring wireless connectivity. Especially when deployment density is medium or high, the added redundancy by mesh topologies can add significant design margin and flexibility into the overall networks.

Given its more sophisticated capabilities, however, characterizing and validating a mesh network is more difficult and complicated compared to star or cluster tree networks. Unlike star or cluster tree, a mesh network dynamically adjusts the routing topologies and does not exhibit a fixed, predictable routing pattern. This makes the messaging latency highly dependent on the instantaneous Link quality and difficult to predict. More importantly, a qualitative comparison of mesh algorithms is always a challenging task even for the most savvy network designer.

Network designers usually deploy mesh for applications that require a highly reliable, highly available wireless infrastructure. Mesh networks should also be considered as a means to reduce initial network setup cost and post-installation maintenance needs by leveraging the self-configuring capabilities embedded inside IP-Link 1223 modules.

5.2 Topology Selection

IP-Link 1223's rich wireless routing algorithm is designed to simplify the decision process and expedite the deployment of a reliable, inexpensive wireless infrastructure. Its feature-rich and flexible networking capability aims to provide the network designers with sufficient alternatives and performance margin to easily come to a "just-right" routing topology to adapt to or even overcome the constraints imposed by underlying connectivity topologies.

Deciding the routing topology of your applications can be very easy with IP-Link 1223. The decision usually needs answers for the following series of questions:

1. Worst-case and average-case connectivity topologies: What type of installation density do your applications call for (e.g., what is the longest and average distance between your devices), and what is the surrounding environment's conditions in terms of RF interference, building structure and moving objects?
2. Evaluate routing alternatives: select from one of the topologies discussed in this chapter. Based on the information from (1), select a core routing topology that meets your design objectives.
3. Fine-tune routing alternatives by selectively upgrading potential weak spots and balancing against power/resource design constraints.

6 Quick Steps in Establishing an IP-Link 1223 Network

In this chapter we provide some special notes on forming an IP-Link 1223 network (The establishment of Mesh network please re. 6.1 and 6.2) .

6.1 Special Note: Establishing a Full Mesh Network

A full ad hoc mesh network is appealing to many users because of its ease of configuration. In this configuration, all nodes are viewed as equals, and each of them will be a “trustworthy” neighbor to any other nodes within its radio contact. And many users prefer to deploy a full mesh network without going through the sequential process of joining each and every device into the network. Rather than assigning Network Layer address one at a time via Master Node, some users choose to pre-configure address information. Pre-configure address assignment works particularly well for full mesh network, since run-time path is established dynamically rather than relying on static parent-child relationship.

1. It is quite straight-forward to configure your IP-Link 1223 devices into a full-mesh-capable device. You should prepare to setup every node with the following common configurations:
 - An identical RF Channel
 - An identical MAC Layer Network Identifier (from 0 to 65535)

Note: the particular configure information please re. 6.2

2. Now provision a unique MAC Node Identifier into each module. The unique Node Identifier can be selected from the range of 0 to 65533. Note that Node 0 in a full mesh network does not have any supremacy over other nodes any more. A full mesh network can operate even without Node 0.
3. Turning on devices: For a full mesh network, devices can be turned on at any arbitrary order.
4. Validating connection: It is strongly recommended that you “walk” the entire network from any node that has an external connection that accepts Helicomm's Binary Mode Command Set. For example, you can hook up a Personal Computer to any node and start querying the entire crew in the network. You can run such a “scan” continuously over an extended period to develop some ideas on your deployment environment as well as the network's stability.

6.2 About the Mesh Topology Configuration of Module

Introduce how to use binary command to configure mesh topology.

About the binary command, please reference to 7.2 **Binary Mode**.

The method is to set some related Registers, command code is 0x87

The registers need to be set are:

0X70: send power, range from 0 to 7, 0 is the max

0X72: channel, 0~15,

0X96: node type, master is 0, client is 1

0X99: set to 1

0X9A: set to 1

0X9E: 0

0X9F: 0xFF

0XA0: 0x00

0XB4: 0x01

0XB5: 0x01

0XB7: 0x00

0XBC: high bits of net node ID

0XBD: low bits of net node ID

0XBE: high bits of net ID

0XBF: low bits of net ID

0XC0: high bits of mac node ID, the same as 0xBC

0XC1: low bits of mac node ID, the same as 0xBD

For example, send command code: 81 00 FF FE 03 87 70 00 74, the function of this command is setting power to 0.

Return: C1 00 00 01 02 87 00 45

7 IP-Link 1223 Command Set

Helicomm IP-Link supports two categories of external command sets. One is the familiar AT command set that is similar to those supported by Hayes-compatible modems. The second category of commands consists of binary instructions that enable a host processor to use IP-Link 1223 as a wireless network interface.

Application developers usually use AT command set to query and set attributes on a standalone module. After the configuration completes, application software can then invoke a binary command set to issue commands and exchange data packets across the wireless network.

On the bases of these two command setting categories, IP-Link1223 supports two modes when it communicates to the outside applications: **AT Mode** and **Binary Mode**. When IP-Link 1223 powers up, it defaults to the binary mode. User issues special escape sequence to switch into AT Mode, and another special AT command to switch back into data mode.

This chapter is organized as follows:

- Section 7.1 presents the AT command set and detailed definitions on IP-Link 1223's S Register definitions.
- Section 7.2.1 introduces the structure of IP-Link 1223's generic frame format and field definitions.
- Sections 7.2.2 through 7.2.6 give detailed descriptions of the four types of command frames supported by IP-Link 1223.
- Section 7.3 provides detailed information on every command request and its corresponding responses.

7.1 AT Command Mode

IP-Link 1223 provides a host of AT commands to allow easy configuration of key attributes of an IP-Link 1223 module. The following texts describe the AT commands, their parameters, and the responses. You can use any terminal emulation utility or UART communication library on a particular host platform to issue these AT commands to IP-Link 1223.

AT String	Purpose	Parameter	Return String
+++	Escape sequence into AT Mode	N/A	Successful: no return value; returns O when a second "+++" is issued Error: Exxx
--N-	Escape sequence into transparent Mode	N = 0 ~ 65533, 65535, in decimal	N/A
===	Switch to Binary Mode	N/A	N/A

AT String	Purpose	Parameter	Return String
AT#n\r	Set MAC Layer Network Identifier	n = 0 ~ 65535	Successful: O Error: Exxx
AT@n\r	Set MAC Layer Node Identifier	n = 0 ~ 65534	Successful: O Error: Exxx
ATSxxx?\r	Query Register Value	xxx: S register index (in decimal)	Successful: ATSxxx=xxx Error: Exxx
ATSxxx=yyy\r	Set Register Value	xxx: register index (in decimal) yyy: register value (in decimal)	Successful: O Error: Exxx
AT\$r	Get IEEE MAC Address	N/A	LongMac=0xhhhhhhhhhhhhhhhh h
AT/B\r	Get module firmware built timestamp	N/A	Month dd yyyy hh:mm:ss
AT/#\r	Get MAC Layer Network Identifier	N/A	MacPanID=n
AT/@\r	Get MAC Layer Node Identifier	N/A	ShortMacAddress=n
AT/S\r	Query All Register Values	N/A	S100=aaa S101=bbb S102=8 ... S230=x
AT/V\r	Query Module Firmware Release Number	N/A	a.b.c
ATW\r	Write Back Settings	N/A	Successful: O Error: Exxx
ATR\r	Restore Default Settings	N/A	Successful: O Error: Exxx

7.1.1 AT Register Table

In this section we present a table of IP-Link 1223 S Registers and valid range for each register location. These register entries can be read and set through the commands described in the previous section. The exact Register indexes and acceptable input values are summarized in the table below.

For maintenance reasons, some of these S Registers should not be modified and are only displayed for informational purpose. These entries are labeled as “Reserved” under the field “Access Type.” Readers are strongly advised **NOT** to modify these S Register settings, or Helicomm cannot guarantee the firmware’s performance.

Register Name	S Register Index (decimal)	Access Type	Purpose	Range (decimal)	Manufacturer Default (decimal)
UART Baud Rate	101	R/W	UART Baud Rate	0:115200 bps 1: 57600 bps 2: 38400 bps 3: 19200 bps 4: 9600 bps 5:4800 bps 6:2400 bps 7:1200 bps 8:28800 bps 9:600 bps	2
UART Data Bit	102	R/W	Number of data bits	8:8 bit 9:9 bit	8
UART Parity	103	R/W	Parity bit	0:none 1:odd 2:even 3:mark 4:space	0
UART Timeout	104	R/W	Timeout value, in milliseconds, for UART	N/A	8
UART Buffer Size	105	Reserved	UART Buffer size in bytes		128
UART Flow control	106	R/W	UART Flow control	0:FALSE 1:TRUE	0
RF Baud Rate	111	R	RF Baud Rate	0: 250 Kbps	0
RF Send Power	112	R/W	RF Send Power select Register	0: 0 dBm 1: -1 dBm 2: -3 dBm 3: -5 dBm 4: -7 dBm 5: -10 dBm 6: -15 dBm 7: -25 dBm	0
RF Accept and Send buffer size	113	Reserved	RF Accept and Send buffer size		116
RF Channel	114	R/W	RF Channel Select Register	0 ~ 15 2.405 GHz	0: 4

Register Name	S Register Index (decimal)	Access Type	Purpose	Range (decimal)	Manufacturer Default (decimal)
				1: 2.410 GHz ... 14: 2.475 GHz 15: 2.480 GHz	
RF Frequency	115	R	RF Frequency	3: 2.4 GHz	3
Wait ACK TimeOut	141	R/W	Timeout, in 10 milliseconds	0 ~ 255	50
Retry Send Rreq For Myself	142	R/W	Number of retry times	0 ~ 255	1
Retry Send Mac Packet	143	R/W	Number of retry times	0 ~ 255	1
Wait Rrep TimeOut	144	R/W	Timeout, in milliseconds	0 ~ 255	100
Retry Send Rreq For Others	145	R/W	Number of retry times	0 ~ 255	1
Repeat MultiBroadCast	147	R/W	Number of repeat times	0 ~ 255	1
Node Type	150	R/W	Node Type Select Register	0: Master 1: RN+ 2: RN- 3: RFD 255: Unassigned	0
Routing Algorithm	158	R/W		0: AODV 1: Cluster Tree 2: CT/AODV	0
Table Expiration Value	159	Reserved	Expiration time, in seconds		255
Topology Type	160	R/W		0 ~ 255	97
Aodv TTL Value	163	R/W		0 ~ 255	100
Network State	170	R/W		0: Unassigned 1: JOIN NETWORK	0

Register Name	S Register Index (decimal)	Access Type	Purpose	Range (decimal)	Manufacturer Default (decimal)
				2: LEAVE NETWORK 3: REPORT ACCEPT CHILD 4: REPORT LOST CHILD	
Work Mode	173	R/W		0: HELICOMM FRAME MODE 1: AT COMMAND MODE 2: TRANSPARENT MODE	0
Transparent Mode destination, Upper Byte	174	R/W		0 ~ 255	255
Transparent Mode Destination, Low Byte	175	R/W		0 ~ 255	255
Transparent Mode LoopBack Flag	176	R/W		0: FALSE 1: TRUE	0
MAC Layer Ack Flag	180	R/W		0: FALSE 1: TRUE	1
NET Layer Ack Flag	181	R/W		0:FALSE 1:TRUE	1
Time Control	183	R/W	Control the time space of Net Link Checking, in seconds	0 ~ 255	0
Digital Input sleep gap	184	R/W	Refer to Digital Input Commands definition	0 ~ 20, in 100ms 0: Disable this function	0
Digital Input monitor's Node ID, Upper Byte	185	R/W		0 ~ 255	0
Digital Input monitor's Node ID, Lower Byte	186	R/W		0 ~ 255	0

Register Name	S Register Index (decimal)	Access Type	Purpose	Range (decimal)	Manufacturer Default (decimal)
Network Layer Node ID, Upper Byte	188	R/W		0 ~ 255	0
Network Layer Node ID, Lower Byte	189	R/W		0 ~ 255	0
MAC Layer PAN ID, Upper Byte	190	R/W		0 ~ 255	0
MAC Layer PAN ID, Lower Byte	191	R/W		0 ~ 255	0
MAC Layer Node ID, Upper Byte	192	R/W		0 ~ 255	0
MAC Layer Node ID, Lower Byte	193	R/W		0 ~ 255	0
MAC Layer Beacon Mode(reserved for future use)	194	R/W		0 ~ 255	0
MAC Layer Node Type(reserved for future use)	195	R/W		0 ~ 255	0
Security Mode(reserved for future use)	196	R/W		0 ~ 255	255
AppLocalizer Time	230	R/W	Control the time space of Tag request, in 0.1seconds	0 ~ 255 0: Disable this function	0
LED Flag	231	R/W	Set the ports used by LEDs free when this flag is FALSE, then they can be used as GPIOs	0: FALSE 1: TRUE	1
Remote Flash Flag	232	R/W	Allow writing remote flash or not	0: FALSE 1: TRUE	0
Sleep mode flag	233	R/W	Entry sleep mode	0:FALSE, 1:TRUE	0
Sleep base time	234	R/W	Sleep base time	1~40	2

Register Name	S Register Index (decimal)	Access Type	Purpose	Range (decimal)	Manufacturer Default (decimal)
Uart Tag	236	R/W	Entry Uart Tag mode or choose the tag table type	0~4	0
Set ADC Vref	242	R/W	Set ADC Vref	0~2	0
I/O Function	244	R/W	Set IO Function	0~255	0
I/O default State	245	R/W	Set IO default State	0~255	255
Disable Bootloader	246	R/W	Disable or enable bootloader	0:enable 1:disable	0

7.1.2 AT Command Error Codes

When AT commands execute successfully, IP-Link 1223 firmware returns a related marker (see the AT Commands Table in Page 16) as a success indication. In the case of execution failure, IP-Link 1223 firmware returns one of the following three error codes to indicate the condition.

Error Code	Error Diagnosis
100	Invalid Command
101	Invalid Register
102	Invalid Value

7.2 Binary Mode

In Binary Mode, host applications use binary-formatted command and responses to command the local modules as well as communicate to remote nodes across the network. This highlights the key utility of Binary Mode operations compared to AT Mode: to communicate and command remote modules over the network formed by multiple IP-Link modules. That said, there are still shortcut commands in Binary Mode to allow users to quickly perform local module access without forcing the application to go through mode switches. In the simplest terms, Binary Mode and AT Mode have overlapping functionalities and are designed to complement each other.

IP-Link 1223 supports four types of frames in its Binary Mode. **Command Request, Command Response, Data Request, and Acknowledgment.**

To use IP-Link 1223's Binary Mode, a Host Application starts with building **Command Request Frames** to query, configure, and command a remote IP-Link 1223 for networking-related functions. The remote IP-Link 1223 module will automatically return a **Command Response Frame** to notify the execution result to the command-issuing module. The sending application then parses the **Command**

Response Frame to take further actions. Some configuration records and sensor information natively supported by IP-Link1223 can also be retrieved using **Command Request** and **Command Response**. These commands are built-in to IP-Link 1223, and these **Commands** cannot be extended or modified by the users.

On the other hand, host applications use **Data Request** and **Acknowledgement Frames** to exchange user-specific data. IP-Link 1223's transport the data frames in an end-to-end fashion without interpreting or manipulating the payload in a **Data Request Frame**. The destination IP-Link 1223 will automatically generate an Acknowledgement Frame to report the reception status of the Data Request Frame. After the network topology is established, **Data Request Frame** is the main interface that application developers can use to exchange information among multiple IP-Link 1223 modules. These frames can also be used to carry user-defined network-wide commands, such that IP-Link 1223 can be extended to support any custom commands users desire.

All these frames can be exchanged from one IP-Link 1223 module to a peer module within the same network. The routing of these frames over any given topology is handled by IP-Link 1223's embedded firmware transparently.

7.2.1 Generic Frame Format

All four types of frames – Command Request, Command Response, Data Request, and Acknowledgment – use the same generic frame structure: five (5) bytes of packet header descriptor, 0 to 97 bytes of frame payload, and one (1) byte of XOR checksum at the end of packet.

All IP-Link 1223 binary frames follow the following variable-length frame structure:

Control Header (1)	Link Quality Indicator (1)	Destination Address (2)	Payload Length (1)	Payload (0 – 97)	XOR Checksum (1)
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Following is the detailed description of the common packet header descriptor.

7.2.1.1 Control Header Field

Length: one byte

Bit Field Definition:

Bit 7,6,5: Binary Frame Type:

100	command request
110	command response
101	data request
111	data acknowledgement

Bit 4: Reserved for future use. Default to 0.

Bit 3,2,1,0: Packet Sequence Number, modulo 16.

NOTE: This sequence number is specifically designed for user applications, the nearby packets must have different sequence numbers, for example, the sequence numbers change circularly from 0 to 15. IP-Link 1223's firmware maintains separate sequence numbers for data packets. They are transparent to Binary Mode users.

7.2.1.2 Link Quality Indicator

Length: one byte

Bit Field Definition:

Bit 7 ~ 0: A 8-bit hex value representing the incoming packet's Link Quality

Description: The Link Quality Indicator (LQI) is an estimate on the packet's signal integrity. Its value ranges from 0 to 255. The higher the value, the better the signal quality. This estimate is derived from IEEE 802.15.4 PHY layer processing performed by any compliant IEEE 802.15.4 transceiver. Users can use this information to assess the MAC-Link quality of a node's surrounding devices. This estimate can be used in conjunction with RSSI.

7.2.1.3 Destination Address Field

Length: two bytes

Bit Field Definition:

Bit 15 ~ 0: Destination Node's Network Address

Description: 0x0000, 0xFFFE, and 0xFFFF are all reserved address -- 0x0000 for Network Master, 0xFFFE for loopback (to the sender itself), and 0xFFFF for broadcast.

7.2.1.4 Payload Length Field

Length: one byte

Bit Field Definition:

Bit 7~0: Represents the payload length (excluding the 5-byte header and 1-byte XOR checksum) in hexadecimal.

Description: Its valid range should be from 0x00 to 0x61 (decimal 97).

7.2.1.5 Payload Field

Length: variable length from 0 to 97 bytes

Bit Definition: User defined.

Description: The magic number 97 is due to the limitation from IEEE 802.15.4 MAC Layer's maximum payload size.

7.2.1.6 XOR Checksum Field

Length: one byte

Bit Definition:

Bit 7~0: XOR Checksum

Description: The XOR checksum is calculated by perform a byte-wide XOR sum on the entire packet header and payload. If an XOR checksum fails, the frame will be discarded automatically.

7.2.2 User Command Request Frame

In Command Request Frame, an additional byte is used to denote a **Command Code** identifier. Helicomm provides a set of built-in command/responses to allow users to manage and retrieval information regarding the networks as well as the sensor information provided by Helicomm's hardware solution. Each command code identifier will possess its own syntax for both request and response.

Control Header (1)		Link Quality Indicator (1)	Destination Address (2)	Payload Length (1)	Command Code (1)	Parameters (0 – 96)	XOR Checksum (1)
Command Request (4-bit) b1000	Sequence Number (4-bit)						

When composing a Command Request Frame, user applications should supply the following information:

- A four-bit, user-defined packet sequence number: this number will be echoed back in receiver's Command Response Frame.
- Destination node's network address: Combined with the Packet Sequence Number, users can use these two numbers to uniquely match an incoming Response to a pending Command.

- The total payload length (up to 0x60)
- The command code: refer to the table in this section.
- The Command parameter: refer to Command Synopsis
- And the XOR checksum on all the bytes preceding the last

When sending a Command Request Frame, user applications should be ready to manage three possibilities:

1. First, the request completes successfully with the expected Response. In this case, the Command Response Frame will be available in the receiving buffer, and host applications can read the serial port input buffer to gather the Response frame.
2. The second condition is that a remote node returns an error indication. In this case, the end-to-end communication is working properly, but the command request is not accepted. Check command syntax and values to correct such problems.
3. The third condition is potentially a communication failure or invalid local command. For communication failure, users may experience continuing checksum error or timeout. In this case, check your communication quality and environment (e.g., moving the destination node closer to the transmitter, or switch to a simpler network topology.) For an invalid local command, verify that you are using the correct network address to address the local module, and the command is formatted correctly.

7.2.3 IP-Link 1223 Command Request Code Summary

Following is a summary of the Command Request set currently supported by IP-Link 1223, firmware release v7.0.00 and v7.0.01. Please refer to Command Request Frame Synopsis in Section 7.3, for complete, individual command's information.¹

Command Category	Command Name	Command Code (hex)
Sample and ADC	Get IP-Link 1223 ADC Sample	0x81
	Get IP-Link 1223 RSSI Sample	0x82
	Get IP-Link 1223 Temperature	0x83
Module Settings	Get AT Mode S Register Setting	0x86
	Set AT Mode S Register Setting	0x87
Module MAC Settings	Get MAC Address	0x8B
Power Management	Get Firmware Version Number	0x8C
	Get Module Type	0xC3
	Entry Power Down Mode	0x8D

¹ The command set can be subject to change without notice. Please refer to Helicomm's website for the latest documentation and firmware release.

Command Category	Command Name	Command Code (hex)
	Soft Reset Module	0x8F
	Hardware Reset Module	0XC0
	Enter sleep mode re. Local awakened sleep	0xB1
	Reset to Factory Default	0x90
Module Network Settings	Get Routing Table	0x95
	Get Black List Table	0x9C
	Set Black List Table	0x9D
	TRACERT	0xAA
	TRACERT with RSSI	0xBB
	Scan Neighbor	0xBC
	Get IO	0xAC
	Set IO	0xAD

7.2.4 Helicomm Command Response Format

Control Header (1)		Link Quality Indicator (1)	Destination Address (2)	Payload Length (1)	Command Code (1)	Response (0 – 96)	XOR Checksum (1)
Command Response (4-bit) b1100	Sequence Number (4-bit)						

Command Response Frame is used to indicate back to the originator the execution results of a Command Request Frame.

If the command executes correctly, first the Command Code field in the Response Frame will echo the original command code. Further, a destination node will return any result in the RESPONSE field. If there is no result to return to the sender a value of 0x00 will be placed in the RESPONSE field

If the command execution fails, the destination node will place a 0xFF into the Command Code field. Further the very first byte in Response field will contain an error code for diagnosis purpose. The following table is a summary of possible error codes.

Error Code	Value (hex)	Comments
ERROR_XOR_ERROR	0x01	Checksum error
ERROR_SEND_FAIL	0x02	Send failure
ERROR_COMMAND	0x03	Invalid Command

Error Code	Value (hex)	Comments
ERROR_CMD_PARAM	0x06	Invalid Command Parameter
ERROR_DEST_ERROR	0x07	Invalid Destination Address
ERROR_NET_BUSY	0x09	Network Busy

7.2.5 Helicomm Data Request Frame

Control Header (1)		Link Quality Indicator (1)	Destination Address (2)	Payload Length (1)	Data Payload (0–97)	XOR Checksum (1)
Data Request (4-bit) b1010	Sequence Number (4-bit)					

In this Data Request Frame, applications can deposit the application-specific data (of up to 97 bytes) into the Data Payload and transmit it to the target receiver. The receivers are expected to return an Acknowledgment Frame.

7.2.6 Helicomm Acknowledgment Frame

Control Header (1)		Link Quality Indicator (1)	Destination Address (2)	Payload Length (1)	Error Code (1)	Error Type (1)	XOR Checksum (1)
Data ACK (4-bit) b1110	Sequence Number (4-bit)						

If a Data Request Frame is received successfully, the receiver will return a Data Acknowledgement Frame, back to the originator, with 0x00 for both Error Code and Error Type fields. For error conditions, Error Code will be set to 0xFF and error type will contain one of the diagnostic error code shown in the table below.

Error Type	Value (hex)	Comments
ERROR_XOR_ERROR	0x01	Checksum Error
ERROR_SEND_FAIL	0x02	Transmission Failed
ERROR_DEST_ERROR	0x07	Invalid Destination Address
ERROR_NET_BUSY	0x09	Network Busy

7.3 Helicomm Command Synopsis

The following sections describe in detail the current command set available on IP-Link 1223. Users can refer to this information to build the command library for their particular host application platforms.

Get IP-Link 1223 ADC0 Sample

Read the sample from IP-Link 1223's ADC0

Command Code

0x81

Description

This command is used to retrieve the sample from IP-Link 1223's built-in analog-to-digital converter. IP-Link 1223 has a two 10-bit ADCs at ADC#1 and ADC#0 are available on IP-Link 1223's Pin #15(P1.6) and Pin #16(P1.7), respectively, to connect to user's analog signal source.

When returned successfully, the first and second byte should be concatenated together to get the 10-bit ADC sample.

S242=0 (1.68V input against core): The input signal voltage to ADC shall be in the range of 0~3.36VDC. Upon the READ_ADC command, firmware will add up 16 continuous samples, divide the sum by 16, and report the adjusted 10-bit sample.

S242=1 (external): The reference voltage will be taken from IP-Link 1223's PIN# 9. Upon the READ_ADC command, firmware will add up 16 continuous samples, divide the sum by 16, and report the average 10-bit sample. NOTE: user shall make sure that hardware reference design matches the S242 configuration, or the ADC samples might become unpredictable.

S242=2 (1.68V input against core): The input signal voltage to ADC shall be in the range of 0~1.68VDC. Upon the READ_ADC command, firmware will add up 16 continuous samples, divide the sum by 16, and report the adjusted 10-bit sample.

Command Parameters

ADC Channel	1 Byte	0x00: enable ADC#0 0x01: enable ADC#1
-------------	--------	--

Response

ADC High Byte	1 Byte	the most significant 2 bits of the sample (right-aligned)
ADC Low Byte	1 Byte	the 8 least significant bits of the sample

Get IP-Link 1223 RSSI Reading

Read IP-Link 1223 RSSI reading

Command Code

0x82

Description

This command retrieves the RSSI value, in dBm, from IPLink 1223. The dBm is a signed value. For instance, a reading of "B0" (hex) represents an RSSI value of -80dBm.

Command Parameters

N/A

Response

RSSI	1 Byte	RSSI value in hexadecimal, a signed value
------	--------	---

Get IP-Link 1223 Temperature

Read the temperature sample from a remote IP-Link 1223

Command Code

0x83

Description

Issue this command to retrieve the ambient temperature sensed by IPLink 1223. To derive at the actual temperature reading, the following conversion should be applied on the 10-bit sample S:

For IP-Link 1223: Celcius: $25 + ((S * 3.3 / 1023) - 1.025) / 0.0034$

Command Parameters

N/A

Response

Temperature High Byte	1 Byte	the most significant 2 bits of the sample (right-aligned)
Temperature Low Byte	1 Byte	the least significant 8 bits of the sample

Get AT Mode S Register Setting

Get a particular S Register's value under AT Mode

Command Code

0x86

Description

This is a shortcut for getting an S Register's value under AT Mode. It is equivalent to issuing AT\$xxx? under AT Mode. The difference is that now this capability now can be used across the network.

Command Parameters

S Register Location	1 Byte	S Register index in hexadecimal
---------------------	--------	---------------------------------

Response

S Register Value	1 Byte	Value in the requested S Register in hexadecimal
------------------	--------	--

Set AT Mode S Register Setting

Set a particular S Register's under AT Mode

Command Code

0x87

Description

This command can be used to set a remote or local module's S Register. Users are advised to use this command with caution. Improper use of this command can result in modules unable to communicate to the rest of the network. Note: This command can only be used to set the local module in default state. For the remote module, you should have the module enable remote configuring the Register if needed.

Command Parameters

S Register Location	1 Byte	S Register index in hexadecimal
S Register Value	1 Byte	Value for the S Register in hexadecimal

Response

Command Confirmation	1 Byte	0x00 (constant)
----------------------	--------	-----------------

Get MAC Address

Get MAC layer hardware address

Command Code

0x8B

Description

This command retrieves an IP-Link 1223 module's IEEE 64-bit MAC hardware address.

Command Parameters

N/A

Response

MAC Address	8 Byte	64-bit IEEE MAC address, MSB first
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Get Firmware Version Number

Get release number of IP-Link 1223 module firmware

Command Code

0x8C

Description

This command retrieves the firmware release number on the destination IP-Link 1223 module.

Command Parameters

N/A

Response

Major	1 Byte	Major release number, in hex
Minor	1 Byte	Minor release number, in hex
Revision	1 Byte	Revision number, in hex

Entry Power Down Mode

Power down IP-Link 1223 module

Command Code

0x8D

Description

This command powers down the remote IP-Link 1223 module. The target module will return a Command Response frame and shuts down. Once the module has entered this mode, it can only be waken by hardware reset.

Command Parameters

N/A

Response

Command Confirmation	1 Byte	0x00 (constant)
----------------------	--------	-----------------

Entry Sleep Mode

Make IP-Link 1223 module into sleep mode

Command Code

0x8E

Description

This command make the remote IP-Link 1223 module into sleep mode. The target module will return a Command Response frame and then sleep.

Command Parameters

Sleep interval time	1Byte	(unit: second)
---------------------	-------	----------------

Response

Command Confirmation	1 Byte	0x00 (constant)
----------------------	--------	-----------------

Soft Reset

Reset IP-Link 1223 module

Command Code

0x8F

Description

This command triggers a soft reset of the destination IP-Link 1223. The destination module will retain all its network settings and be able to communicate with the rest of the network after this soft reset.

Command Parameters

N/A

Response

Command Confirmation	1 Byte	0x00 (constant)
----------------------	--------	-----------------

Hardware Reset

Reset IP-Link 1223 module

Command Code

0xC0

Description

This command triggers a hardware reset of the destination IP-Link 1223. All of the destination module's information saved in the RAM will be lost after this hardware reset.

Command Parameters

N/A

Response

Command Confirmation	1 Byte	0x00 (constant)
----------------------	--------	-----------------

Reset to Factory Default

Reset all module attributes to factory default

Command Code

0x90

Description

This command restores the factory default settings on the destination IP-Link 1223 module.

After the reset, the destination IP-Link may need to be re-programmed with key communication attributes before it can connect with existing wireless network.

Command Parameters

N/A

Response

Command Confirmation	1 Byte	0x00 (constant)
----------------------	--------	-----------------

Get Routing Table

Retrieve Routing Table entries

Command Code

0x95

Description

This command retrieves the entire routing table entries from the destination IP-Link 1223 module.

Currently the routing table supports up to 180 entries. Each entry consists of 9 bytes with the following information:

Field	Length	Description
Destination	2 Byte	Network Layer Node ID
Status	1 Byte	0=Active 1=Discovery underway 2=Route failed 3=Route expired
Cost	1 Byte	Routing cost;
Next Hop	2 Byte	Next Hop's Node ID
Time To Live	1 Byte	Time until expiration, in seconds.
Be Retrieved Address	2 Byte	Be Retrieved Address

Destination:The destination Node ID that can communicate with the local node.

Status: It can be used to display whether the routing state is available or not. If the routing is existing, it will be in Active status which means the routing is valid.

Cost: It defines the link quality from the local node to the destination node.

Next Hop: The Next Hop's Node ID from the local Node to the destination Node.

Time To Live: The current routing's Time To Live. The value is 255 at present which means this routing will not expire until it fails to communicate.

Command Parameters

Routing Table Page location 1 Byte RoutingTable Page Index(1 ~ 18s)

Response

Routing entry 0	9 Byte	See above for field definition
...
Routing entry 9	9 Byte	See above for field definition

Special Note

In future releases, the capacity of this table may be subject to adjustment

Get Black List Table

Retrieve MAC layer Black List Table entries

Command Code

0x9C

Description

This command retrieves the Black List Table on the destination IP-Link 1223 module. Black List Table is a MAC Layer filtering mechanism that forces a module to ignore messages from those nodes listed on the Black List Table.

Currently the Black List Table supports up to 8 entries. Each entry consists of 4 bytes with the following information:

Field	Length	Description
Start	2 Byte	Starting MAC Layer Node ID, inclusive
End	2 Byte	Ending MAC Layer Node ID, inclusive

Command Parameters

N/A

Response

Black List entry 0	4 Byte	See above for field definition
...
Black List entry 7	4 Byte	See above for field definition

Special Note

In future releases, the capacity of this table may be subject to adjustment.

Set Black List Table

Program MAC layer Black List Table entries

Command Code

0x9D

Description

This command sets the Black List Table entries for the destination IP-Link 1223 module. Black List Table is a MAC Layer filtering mechanism to force a module to ignore messages from those nodes listed on the Black List Table.

Refer to **Get Black List Table** command in the previous page for Black List Table entry definition.

This command is a variable-length command. That is, it can accept a partial Black List Table. All unspecified entries on the destination module will be default to 0xff.

Black List Table can be provisioned on any type of nodes. Once set, its effect is permanent until changed.

Users are advised to use this command with caution. Improper use of this command can result in modules unable to communicate to the rest of the network.

Command Parameters

Black List entry 0	4 Byte	See the previous page for field definition
...
Black List entry K, K<8	4 Byte	See the previous page for field definition

Response

Command Confirmation 1 Byte 0x00 (constant)

Special Note

In future releases, the capacity of this table may be subject to adjustment.

TRACERT

Trace the routing path

Command Code

0xAA

Description

This command retrieves the outgoing path from local IP-Link 1223 module to the destination module and the returning path from the destination module to local module. Each path records the ordinal Network Layer Node IDs.

Command Parameters

N/A

Response

Marker(0xAA 0x55)	2 Byte
Outgoing Path	2 Byte per hop
Marker(0xAA 0x55)	2 Byte
Returning Path	2 Byte per hop

TRACERT with RSSI

Trace the routing path and come with the RSSI in each hop.

Command Code

0xBB

Description

This command retrieves the outgoing path from local IP-Link 1223 module to the destination module and the returning path from the destination module to local module. Each path records the ordinal Network Layer Node IDs and the RSSI in each hop.

Command Parameters

N/A

Response

Marker(0xAA 0x55)	2 Byte
Node 1	2 Byte
RSSI	1 Byte
Node 2	2 Byte
RSSI	1 Byte
Node 3	2 Byte
...	
Marker(0xAA 0x55)	2 Byte
...	
Node 3	2 Byte
RSSI	1 Byte
Node 2	2 Byte
RSSI	1 Byte
Node 1	2 Byte

e.g.:

Send: 84 00 00 01 01 BB 3F

Response:C4 6C 00 01 0F BB AA 55 00 00 C2 00 01 AA 55 00 01 C9 00 00 16

The response pack means that the RSSI value sending from node 00 to node 01 is C2, and from node 01 to node 00 is C9.

Get IO

Retrieve Port state

Command Code

0xAC

Description

This command retrieves the current state of corresponding port.

Input a number from 0x03 to 0x0A to get the current state of corresponding port. 0x03 ~ 0x05 means port P0.0 ~ P0.2, 0x06 ~ 0x07 means port P0.6~ P0.7, and 0x08 ~ 0x09 means port P1.4 ~ P1.5. 0x0A means port P2.7. It will return the state of all ports when the command parameter is 0xFF.

If the command parameter is a number from 0x03 to 0x0A, the LSB of the second Port state byte shows the state of the corresponding port. 0 means low state and 1 means high state.

If the command parameter is 0xFF, The 3 -10 bits of the two bytes' response value shows the IO state of the 8 IO. 0 means low state and 1 means high state.

Command Parameters

Port number	1 Byte	Range: 0 ~ 10
-------------	--------	---------------

Response

Port state	2 Byte
------------	--------

Set IO

Set Port state

Command Code

0xAD

Description

This command sets the state of corresponding port. It is a variable-length command. Users can set the state of one port with two bytes. The first byte specifies the port number, and the second byte sets the port state. 0 means low state and 1 means high state.

The IO definition refers to Get IO in previous page.

Command Parameters

Set Port state	2 Byte per port	The first byte: Port number(3 ~ 10) The second byte: Port state(0 or 1)
----------------	-----------------	--

Response

Command Confirmation	1 Byte	0x00 (constant)
----------------------	--------	-----------------

Scan Neighbor Table

Scan Neighbor Table

Command Code

0xBC

Description

This command is used to search the module who can communicate with the local module in no jump state. This command let the source module get the neighbor module's address and Rssi value, then send the Neighbor table to the serial port. And both the overtime of waiting for neighbor ack and the time of the right data response will be 10 second.

Command Parameters

N/A

Response

Address 0		2Byte;
Rssi	0	1Byte;
....	
....	
Address 9		2Byte
Rssi	9	1Byte

Example

This example will teach you how to use this cmd by MiniTool.

- 1.Startup the MiniTool and search module.
- 2.After the step of search module, choose the "Binary" in the operations frame,
- 3.Choose the "cmd" in the box named "Header", fill the "node id" in "Addr", and then fill the command code in "Payload" in this example we fill "BC" in "Payload"
- 4.Then click "send" to perform this cmd . You will see 7 byte data in the box named "Data Request Format" at once, And you will see the response data in this box after a while

5. The response data obey the same header with the other data format. The third byte and the fourth byte means the local node id. The fifth byte means payload length. The sixth byte means command node, if the fifth byte is "FF" means error. Follow the sixth byte is the neighbor module's address and Rssi value. The last byte is xor.

Response Data Example:

1. C6 00 00 07 07 BC 00 0A E3 00 04 F1 66

00 07 : source address

07 : payload length

BC : cmd code

00 0A : first address

E3 : first Rssi value

00 04 : second address

F1 : second Rssi value

66 : xor

2. E6 00 00 00 02 FF 02 19

FF : error

3. C7 00 00 07 01 BC 7D

This response data means module 7 have no neighbor module.

Get Module Type

Read the current module Type

Command Code

0xC3

Description

This command is used to get the destination IP-Link 1223 module's type.

1223-50XX	0x09
1223-51XX	0x0A

Command Parameters

N/A

Response

Command Confirm	1 Byte	0X09(IP-Link 1223-50XX)
		0X0A(IP-Link 1223-51XX)

7.4 Helicomm application mode synopsis

7.4.1 Tag mode application

This mode is mainly used for the position function. Give S230 a nonzero value this module can work in tag mode. For example, when S230=10 the module will send a landing kit every $10 \times 100\text{ms} = 1\text{S}$, the landing kit contains the sampling values of tag node's ADC0/1, this value have 16 bits, 2 bytes. The ADC value of 1223 is 10 bits. The most significant 6 bits is reserved.

In addition, under the tag mode the module can set into sleep mode. Besides S230 give S233 a nonzero value, and the module may work in sleep mode with low-loss when it is in free state. When it's the time to send packet it will be waken up to send packet, and will return sleep mode when it finishes sending.

7.4.2 Local awakened sleep

7.4.2.1 Enter into sleep mode

Awake the sleep mode from some local interrupts

Command Code

0xB1

Description

This command makes the module enter low-power sleep mode, if we want to awake the module from the sleep mode to normal work mode, can use some local operations. At present, can send a packet data from serial ports to awake the module.

Command Parameters

Awake origin	0: serial port awake
	1~255: reserved

Response

Command Confirmation	1 Byte	0x00 (constant)
----------------------	--------	-----------------

7.4.2.2 Exit sleep mode

After sending the wakeup packet, the mode will quickly return normal work state, and return a command packet from the serial ports to inform the upper layer. The format of return command is 5 bytes packet head, command code is 0XB2, followed by parameter 0.

8 Some additive commands and settings of module

8.1 The parity check of serial ports

Users can set up the parity check function of serial ports by setting S103. When S103 is not 0, the serial ports work in the parity check corresponding mode. If S103=1, they work in odd mode; If S103=2, they work in even mode.

8.2 The flow control of serial ports

In order to improve the corresponding quality of the module, we add the flow control in serial ports. Use two I/O to simulate the serial ports CTS, RTS, and the P3.4=RTS, P3.5=CTS. Uses the AT register S106 to control whether turn on the flow control. When S106=0, no flow control; S106=1, is the flow control with hardware.

8.3 Add loop back function in transparent mode

In order to make the user to test more convenient, we add loop back function in transparent mode. Use S176 to control it, S176=0, turn off; S176=1, turn on. If turn on the function in transparent mode, when the data send by origin node arrive target node, it will be packed again and then send back to origin node. So the origin node will know whether it have errors in target node.

9 Code of PC obtain the module's firmware version information

```
...

// Open com port

DCB    dcb  = {0};

HANDLE hCOM = CreateFile(_T("COM1"), GENERIC_READ | GENERIC_WRITE,
0, 0, OPEN_EXISTING, 0, NULL);

// Set baud rate

dcb.DCBlength = sizeof(DCB);

dcb.BaudRate  = 38400;

dcb.ByteSize  = 8;

dcb.StopBits  = ONESTOPBIT;

dcb.Parity    = NOPARITY;

SetCommState(hCOM, &dcb);

...

BYTE  btBuf[256];

int   i      = 0;

int   nXOR   = 0;

DWORD dwLen  = 0;
```

```
static int nSN;

// Build packet

nSN++;

btBuf[0] = 0X80 + (0X0F & nSN); // Packet head.

btBuf[1] = 0X00; // LQI °

btBuf[2] = 0X00; // High 8 bits of destination address

btBuf[3] = 0X01; // Low 8 bits of destination address

btBuf[4] = 0X01; // Payload length

btBuf[5] = 0X8C; // Payload. Obtain firmware version command

// Compute XOR bit by bit

for (i = 0, nXOR = 0; i < 6; i++)

{

    nXOR ^= btBuf[i];

}

btBuf[6] = nXOR; // XOR bit by bit

...

// Send packet

WriteFile(hCOM, btBuf, 7, &dwLen, NULL);

...
```

```
ZeroMemory(btBuf, sizeof(btBuf));

// Receive Packet

ReadFile(hCOM, btBuf, 10, &dwLen, NULL);

// Check length

if (dwLen != (btBuf[4] + 6))

{

    ...

}

// Compute XOR bit by bit

for (i = 0, nXOR = 0; i < dwLen; i++)

{

    nXOR ^= btBuf[i];

}

// Check parity

if (0 != nXOR)

{

    ...

}

// Check packet head

if (0XC0 != (btBuf[0] & 0XF0))
```

```
{  
    ...  
}  
  
// Check command code  
if (0XFF == btBuf[5])  
{  
    ...  
}  
  
...  
  
// btBuf[6] is main version  
  
// btBuf[7] is subsidiary version  
  
// btBuf[8] is revised version
```

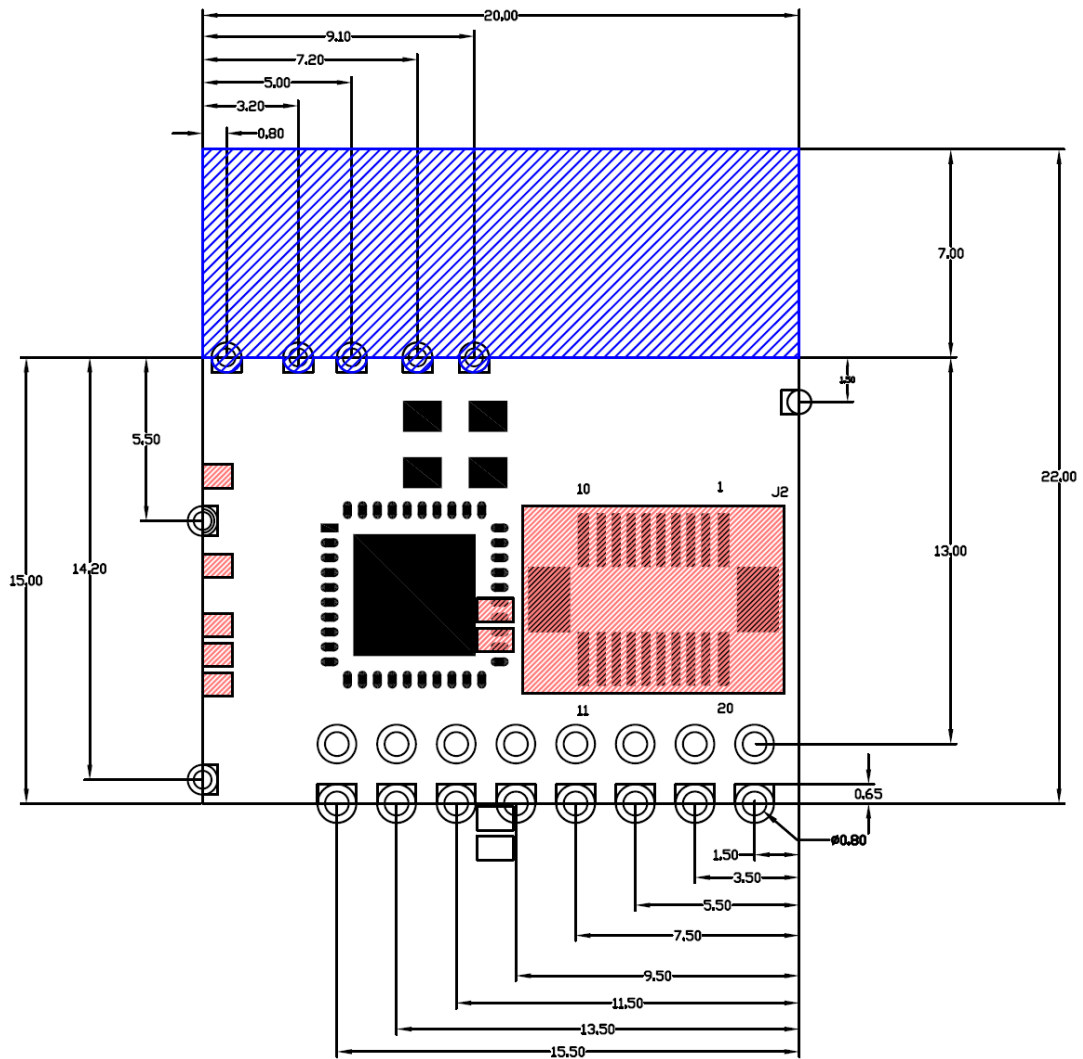

10 Terminologies and Acronyms

ADC	Analog to Digital Converter
AMR	Automatic Meter Reading
CFB	Cipher Feedback Mode
CMOS	Complementary Metal Oxide Semiconductor
CPU	Central Processor Unit
DES	Data Encryption Standard
FCC	Federal Communication Committee
FSK	Frequency Shift Keying
IDE	Integrated Development Environment
IF	Intermediate Frequency
ISM	Industrial Scientific Medical
ISR	Interrupt Service Routine
LOS	Line of Sight
LPF	Loop Filter
LQI	Link Quality Indicator
LSB	Least Significant Bit (or Byte)
MAC	Medium Access Layer
MSB	Most Significant Bit (or Byte)
PCB	Printed Circuit Board
PHY	Physical Layer
POR	Power On Reset
RAM	Random Access Memory
RF	Radio Frequency
RSSI	Received Signal Strength Indicator
RTC	Real-Time Clock
RX	Receive
SFR	Special Function Register
SPI	Serial Peripheral Interface
SRAM	Static Random Access Memory
SRD	Short Range Device
TQFP	Thin Quad Flat Pack
TX	Transmit
UART	Universal Asynchronous Receiver/Transmitter

11 Mechanical Specification

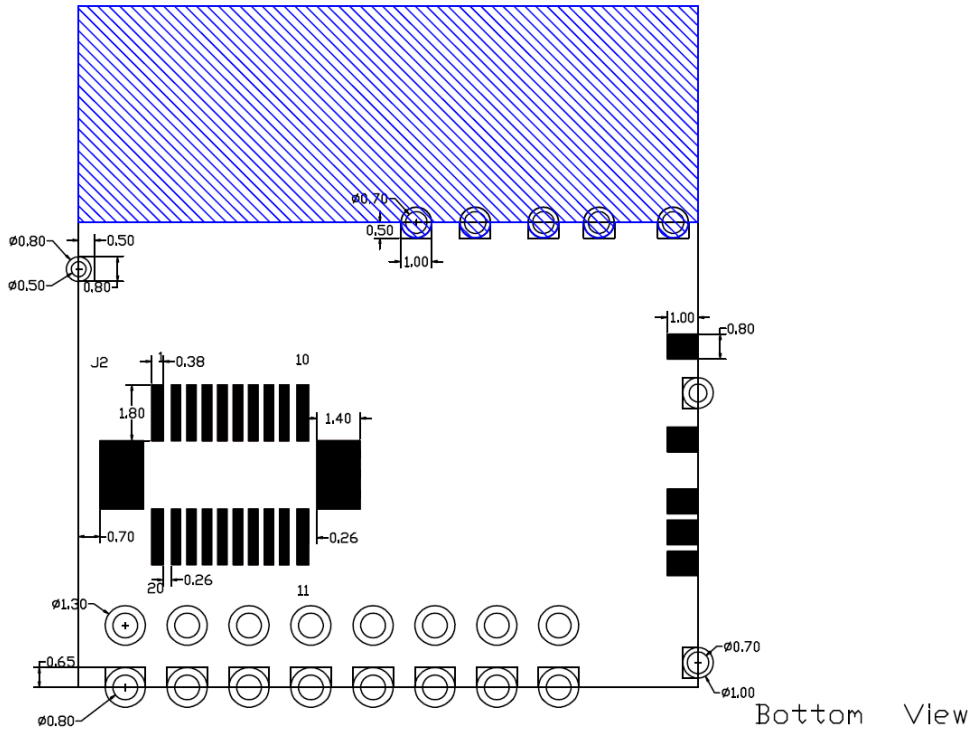
11.1 IP-Link 1223 Dimensions

(Blue block is Antenna domain.)



11.2 IP-Link 1223 PAD

(Blue block is Antenna domain, do not place any part and the line do not spread out on the ground.)



IP-Link 1223 Foot Print

11.3 Re-flow Temperature Specifications

Recommended soldering profile is according to IPC/JEDEC J-STD-020B.

	Ideal (°C)	Maximum (°C)
Maximum Re-flow Temperature	215	230

11.4 Solder Paste Recommendations

Recommended soldering profile is according to IPC/JEDEC J-STD-020B.

	Alloy Composition	Solidus (°C)	Liquidus (°C)	Shear MPa
Johnson Alloy #806	In/48Sn (e)	118	118	

12 Ordering Information

You can contact Helicomm and our resellers for additional modules or develop kit to grow your network. Please specify Product Part Number.

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