IP•Link 122X
Embedded Wireless Module

User Manual

Version 2.1.05

Helicomm
WIRELESS SOLUTIONS•SIMPLIFIED™

Helicomm Inc.

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Revision and Iteration History

Version	Publication Date	Authors	Summary of Changes and Updates
1.0.0	08/31/2005	CCH	Document Creation
1.0.10	12/30/2005	SEAN	Verify and modify all AT Commands and Binary Commands
1.0.11	01/23/2006	QF	Modify ADC Commands and add DAC Commands
1.0.12	03/02/2006	QF	Modify AT register, Routing Table and I/O Commands
1.0.13	03/16/2006	SEAN	Add Digital Input function
1.0.14	04/17/2006	SEAN	Add RSSI value into Tag Neighbor entries
1.9.90	05/25/2006	SHJ	Add application mode,
2.0.00	06/21/2006	SHJ/WF	Add additive commands and local awakened sleep
2.0.13	01/19/2007	SHJ/STB/WF	Add Scan Neighbor Table Command.Verify and modify all document
2.1.00	06/25/2007	SHJ/STB	Modify ADC0 Sample, Modify new tag table mode
2.1.04	12/06/2007	WF	Fix a few bugs and optimized the firmware
2.1.05	12/13/2007	Wt.Wu	Verify module specifications and delete some AT registers.

FCC Information

Agency Identification Number	**RF2IPLinkP220**
FCC Notice	"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."
FCC Labeling Requirement Notice	If the FCC ID is not visible when the module is installed inside another device, the outside of the device into which the module is installed must also display a label referring to the enclosed module. This exterior label can use wording such as the following: "**Contains Transmitter Module FCC ID: RF2IPLinkP220**" "**Contains FCC ID: RF2IPLinkP220**."

Table of Contents

1 Overview

IP-Link 122X is Helicomm's first embeddable, Surface Mount Technology (SMT) IEEE 802.15.4/ZigBee-compliant wireless module. IP-Link 122X contains a powerful 8-bit 8051 microprocessor and a 2.4GHz IEEE 802.15.4-compliant RF transceiver. IP-Link 122X (both 2033 and 2134 models) 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 122X's embedded stack support a wide variety of useful networking features. IP-Link 122X'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 122X is the vehicle to enable your applications to the power and cost advantages of standard-based short-range wireless networking. IP-Link 122X 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 122X embedded wireless transceiver modules. It includes information on how the IP-Link 122X can be easily provisioned, managed, and integrated into your existing products.

Readers of this document should reference the *IP-Link ZigBee Development Kit 122X* (EZ-NET-122X) documentation, a development tool that facilitates rapid wireless system prototyping using the IP-Link 122X. The IP-Link ZigBee DevKit contains a wealth of detailed diagnostic and pre-built configurations ready to use on a desktop or laptop personal computer. Users will find it a useful tool to help get familiar with the details of IP-Link 122X.

Following is the structure of this document.

- Chapter 2 contains information on the IP-Link 122X 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 operating conditions.
- Chapter 5 offers a high-level description of the network operations supported by the IP-Link 122X, and how various network topologies can be configured to meet your application requirements.
- Chapter 6 contains step-by-step instructions on setting up an IP-Link 122X network. This network configuration guide is followed by a detailed description of the Helicomm Command Set.

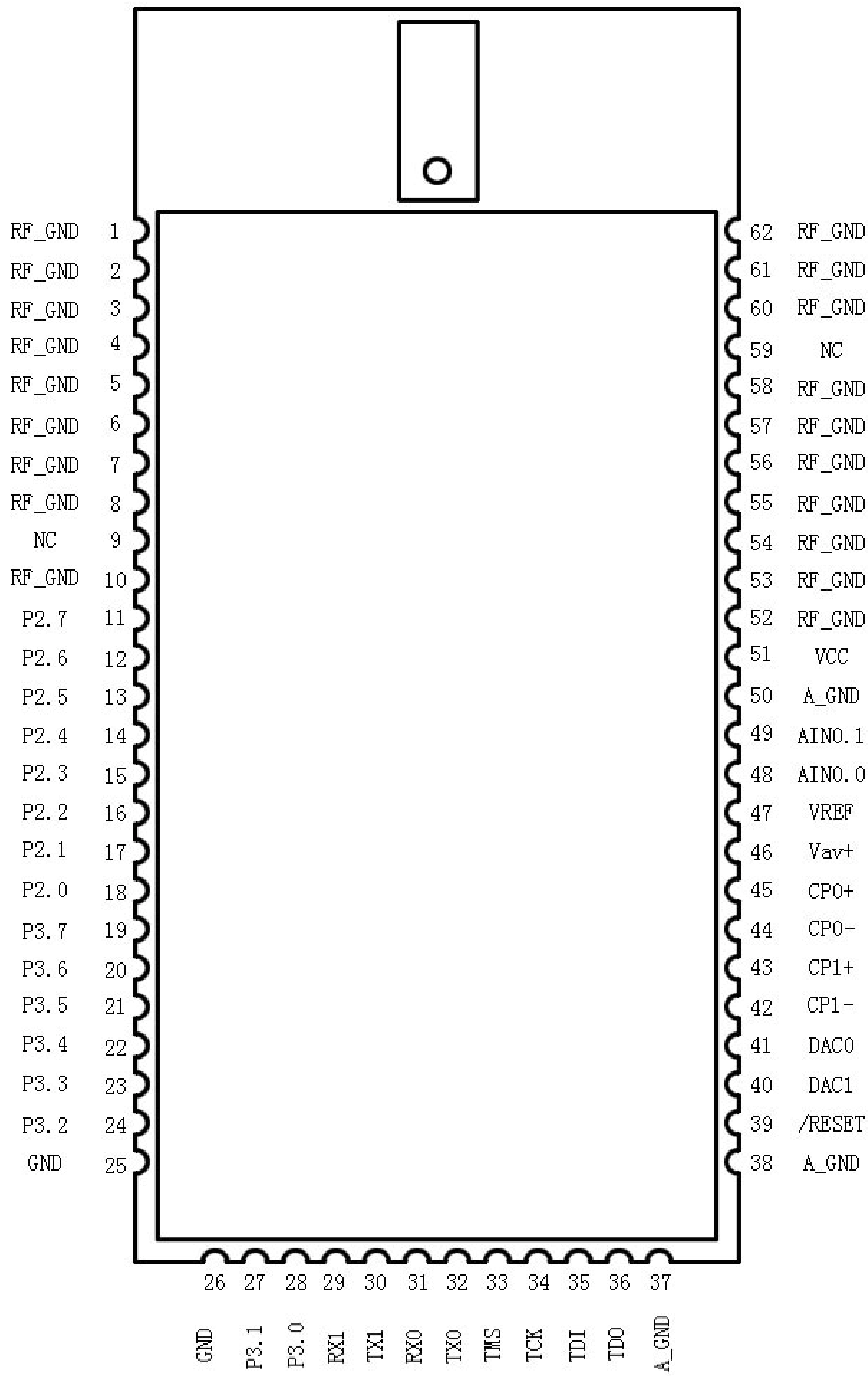
- Chapter 9 gives readers definitions and invocation mechanisms needed to develop their own host applications based on IP-Link 122X's flexible networking capabilities.
- Chapters 10 through 3 contain acronyms, mechanical dimensions, manufacturing re-flow specification, and part number information.

2 Module Specifications

Micro-controller (MCU)	MCU Clock Rate	24.5MHz
	FLASH ROM	1220- XXXX: 128 KB 1221- XXXX: 64 KB 1222- XXXX: 32KB
	RAM	1220- XXXX: 8 KB 1221- XXXX: 8 KB 1222-XXXX: 2 KB
RF	Frequency	2.4 GHz
	Receiver Sensitivity	122X-20XX: -94 dBm 122X-21XX: -94 dBm 122X-22X4: -104dBm
	Air Data Rate	250 Kbps
	Transmit Range	122X-20X4: ~100 meters (LOS) 122X-21X4: ~350 meters (LOS) 122X-22X4: ~1200 meters (LOS)
	RF Channels	16 (5MHz)
	Transmit Power	122X-20XX: -25 to 0 dBm 122X-21XX: -15 to 10 dBm 122X-22XX: -7 to 18 dBm
	Data Encryption	32, 64, 128-bit AES
	Antenna	Chip/Pin out
	Certification	FCC Part 15, CE
Power Consumption	Transmit/Receive	1222-2034: 23mA/27mA 122X-20XX: 37 mA/43mA 122X-21XX: 100 mA/43mA 122X-22XX: 290mA/50mA
	Sleep	1222-2034: 6uA 1221-2264:800uA 122X-2XX4:43uA 122X-2XX3:9mA
Input/Output	Physical Pins	122X-20XX: 62 122X-21XX: 70 122X-22XX: 70
	Serial	One RS-232
	A-to-D	1220-xxxx: Two 12-bit ADC 1221-xxxx: Two 10-bit ADC 1222-2034: Not support at present

	Comparators	1220-xxxx: Two 1221-xxxx: Two 1222-2034: Not support at present
	D-to-A	1220-xxxx: Two 12-bit DAC 1221-xxxx: N/A 1222-2034: Not support at present
	# of Programmable GPIO	1220-xxxx: 11 1221-xxxx: 11 1222-2034:11
Physical	Dimension (in inches)	122X-20X4: 1.6 x 0.7 x 0.2 122X-21X4: 1.8 x 0.7 x 0.2 122X-22X4: 1.8 x 0.7 x 0.2
	Dimension (in millimeters)	122X-20X4: 41 x 19 x 4 122X-21X4: 46 x 19 x 4 122X-22X4: 46 x 19 x 4
	Operating Temperature	-20ºC to +70ºC
	Humidity (non-condensing)	10% to 90%

2.1 IP-Link 122X-2034 Interface Pin Definitions



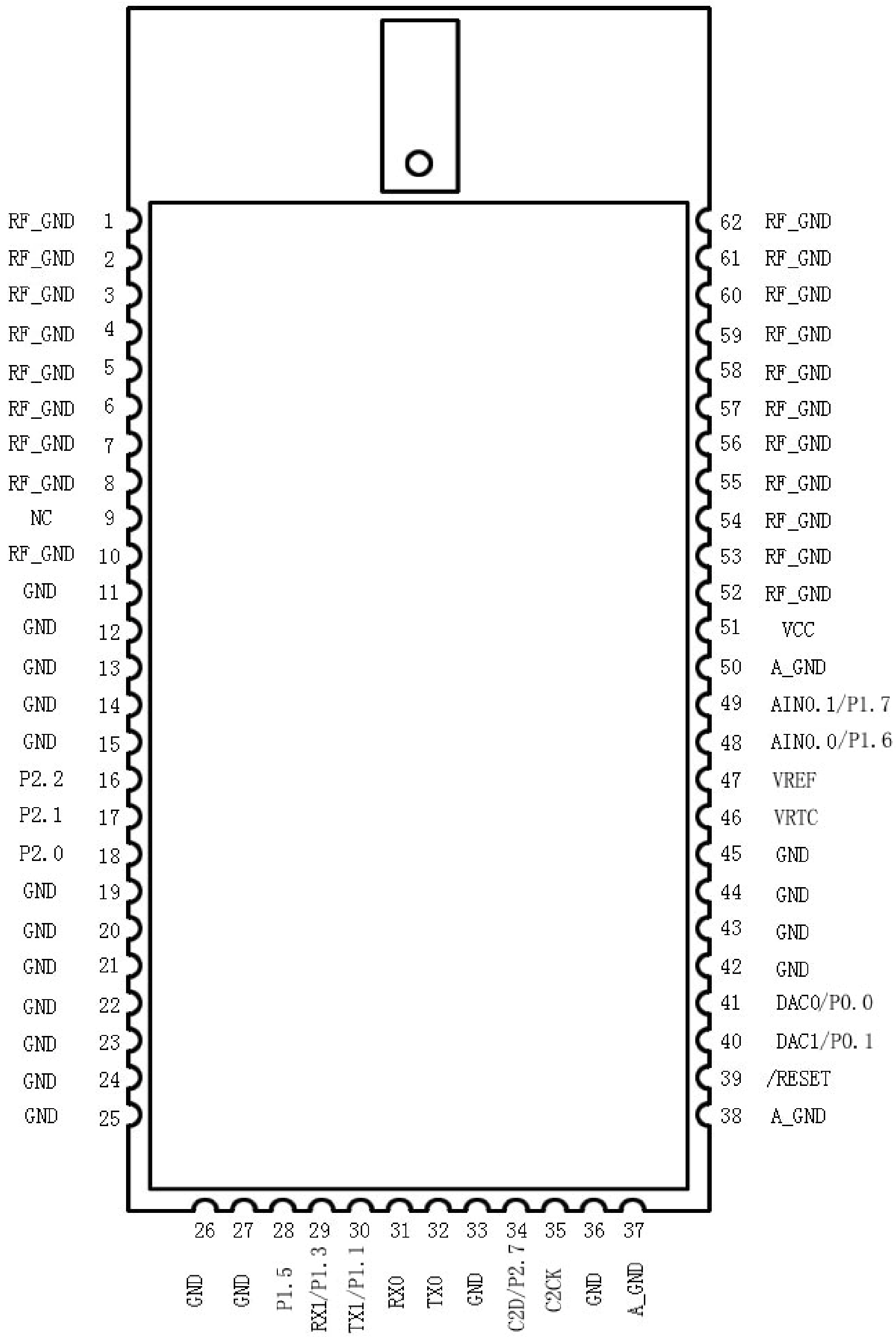
122X-2034

Pin No.	Name	Type	Function Description
1 ~ 8	RF_GND	Power	RF Ground pins
9	NC	RF	Not Connected (Note: This pin is reserved for a different antenna option on different SKUs.)
10	RF_GND	Power	RF Ground Pin
11	P2.7	Digital I/O	Port 2.7 Digital Input/Output (only available on IP-Link 122X-2034)
12	P2.6	Digital I/O	Port 2.6 Digital Input/Output (only available on IP-Link 122X-2034)
13	P2.5	Digital I/O	Port 2.5 Digital Input/Output (only available on IP-Link 122X-2034)
14	P2.4	Digital I/O	Port 2.4 Digital Input/Output Net link indication, set S183 to check the net connection，if connected P2.4 is high, or else is low
15	P2.3	Digital I/O	Port 2.3 Digital Input/Output Send fail indication，MAC ACK fail is low
16	P2.2	Digital I/O	Port 2.2 Digital Input/Output Send success indication，MAC send successfully is low
17	P2.1	Digital I/O	Port 2.1 Digital Input/Output Receive indication，MAC receive packet is low
18	P2.0	Memory Bus Digital I/O	Bit 8 of External Memory Bus (multiplexed mode) Bit 0 of External Memory Bus (non-multiplexed mode) Port 2.0 Digital Input/output Work indication，module work in binary mode，P2.0 alternated between high and low for 1s In transparent mode keep low for 100ms,high for 50ms In AT mode keep low for 50ms,high for 100ms，
19	P3.7	Digital I/O	Port 3.7 Digital Input/Output
20	P3.6	Digital I/O	Port 3.6 Digital Input/Output
21	P3.5	Digital I/O	Port 3.5 Digital Input/Output CTS for UART flow control(re. 6.2)
22	P3.4	Digital I/O	Port 3.4 Digital Input/Output RTS for UART flow control(re. 6.2)
23	P3.3	Digital I/O	Port 3.3 Digital Input/Output

Pin No.	Name	Type	Function Description
24	P3.2	Digital I/O	Port 3.2 Digital Input/Output Tag sleep wake up, keep P3.2 low for 500mS，the asleep module in waken up, and keep P3.2 low for another 500mS,the module work in sleep mode again,re.5.4.1。
25 ~26	GND	Power	Digital Ground
27	P3.1	Digital I/O	Port 3.1 Digital Input/Output In tag mode, Port 3.1 have Tag alarm function,re.5.4.1 In DIO mode, Port 3.1 can check the state of sub-IO, re.5.4.2
28	P3.0	Memory Bus Digital I/O	Bit 0 of External Memory Bus (multiplexed mode) Bit 8 of External Memory Bus (non-multiplexed mode) Port 3.0 Digital Input/output In tag mode, Port 3.0 have Tag alarm function re.5.4.1 In DIO mode, Port 3.0 can check the state of sub-IO,re.5.4.2
29	RX1	UART	UART #1 Data In(reserved port, for future use)
30	TX1	UART	UART #1 Data Out(reserved port, for future use)
31	RX0	UART	UART #0 Data In (used by IP-Link 122X firmware)
32	TX0	UART	UART #0 Data Out (used by IP-Link 122X firmware)
33	TMS	JTAG	JTAG Test Mode, internal pull-up
34	TCK	JTAG	JTAG Test Clock, internal pull-up
35	TDI	JTAG	JTAG Test Data Input, internal pull-up
36	TDO	JTAG	JTAG Test Data Output, internal pull-up
37-38	A_GND	Power	Analog ground pins
39	/RESET	Control	Device Reset Open-drain output of internal VDD monitor
40	DAC1	DAC	Digital-to-Analog Converter 1 Voltage Output Range: 0 ~ (V_{REF}-1) mV @ 12-bit resolution (only available on IP-Link 1220)
41	DAC0	DAC	Digital-to-Analog Converter 0 Voltage Output Range: 0 ~ (V_{REF}-1) mV @ 12-bit resolution (only available on IP-Link 1220)
42	CP1-	Comparators	Comparator 1 inverting input

Pin No.	Name	Type	Function Description
43	CP1+	Comparators	Comparator 1 non-inverting input
44	CP0-	Comparators	Comparator 0 inverting input
45	CP0+	Comparators	Comparator 0 non-inverting input
46	Vav+	Power	Power 2.7 to 3.6VDC analog supply
47	VREF		Reference voltage output
48	AIN0.0		ADC 0 Input Channel 0
49	AIN0.1		ADC 0 Input Channel 1
50	A_GND	Power	Analog ground pin
51	VCC		Power 3.0 to 3.6VDC digital supply
52-58	RF_GND		RF ground pins
59	NC		Not connected
60-62	RF_GND		RF ground pins

2.2 IP-Link 1222-2034 Interface Pin Definitions

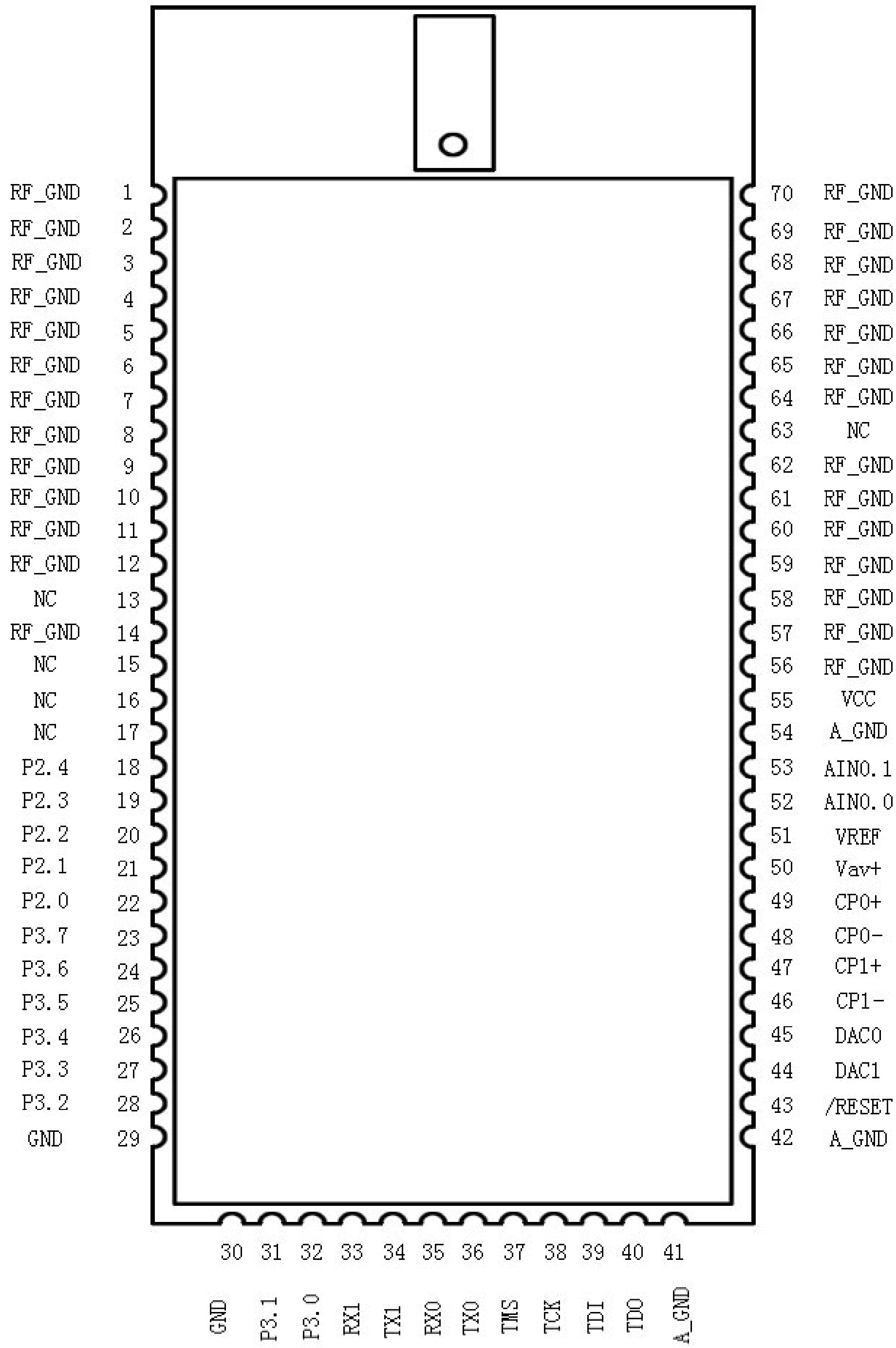


1222-2034

Pin No.	Name	Type	Function Description
1 ~ 8	RF_GND	Power	RF Ground pins
9	NC	RF	Not Connected (Note: This pin is reserved for a different antenna option on different SKUs.)
10	RF_GND	Power	RF Ground Pin
11~15	GND	Power	Digital Ground
16	P2.2	Digital I/O	Port 2.2 Digital Input/Output
17	P2.1	Digital I/O	Port 2.1 Digital Input/Output
18	P2.0	Digital I/O	Port 2.0 Digital Input/Output
19 ~27	GND	Power	Digital Ground
28	P1.5	Digital I/O	Port 1.5 Digital Input/Output
29	RX1 P1.3	UART Digital I/O	UART #1 Data In(reserved port, for future use) Port 1.3 Digital Input/Output
30	TX1 P1.1	UART Digital I/O	UART #1 Data Out(reserved port, for future use) Port 1.1 Digital Input/Output
31	RX0	UART	UART #0 Data In (used by IP-Link 122X firmware)
32	TX0	UART	UART #0 Data Out (used by IP-Link 122X firmware)
33	GND	Power	Digital Ground
34	C2D P2.7	JTAG Digital I/O	Data signal for the C2 Debug Interface. Port 2.7 Digital Input/Output
35	C2CK	JTAG	Clock signal for the C2 Debug Interface.
36	GND	Power	Digital Ground
37-38	A_GND	Power	Analog ground pins
39	/RESET	Control	Device Reset Open-drain output of internal VDD monitor
40	DAC1 P0.1	DAC Digital I/O	Digital-to-Analog Converter 1 Voltage Output Range: 0 ~ (VREF -1) mV @ 12-bit resolution

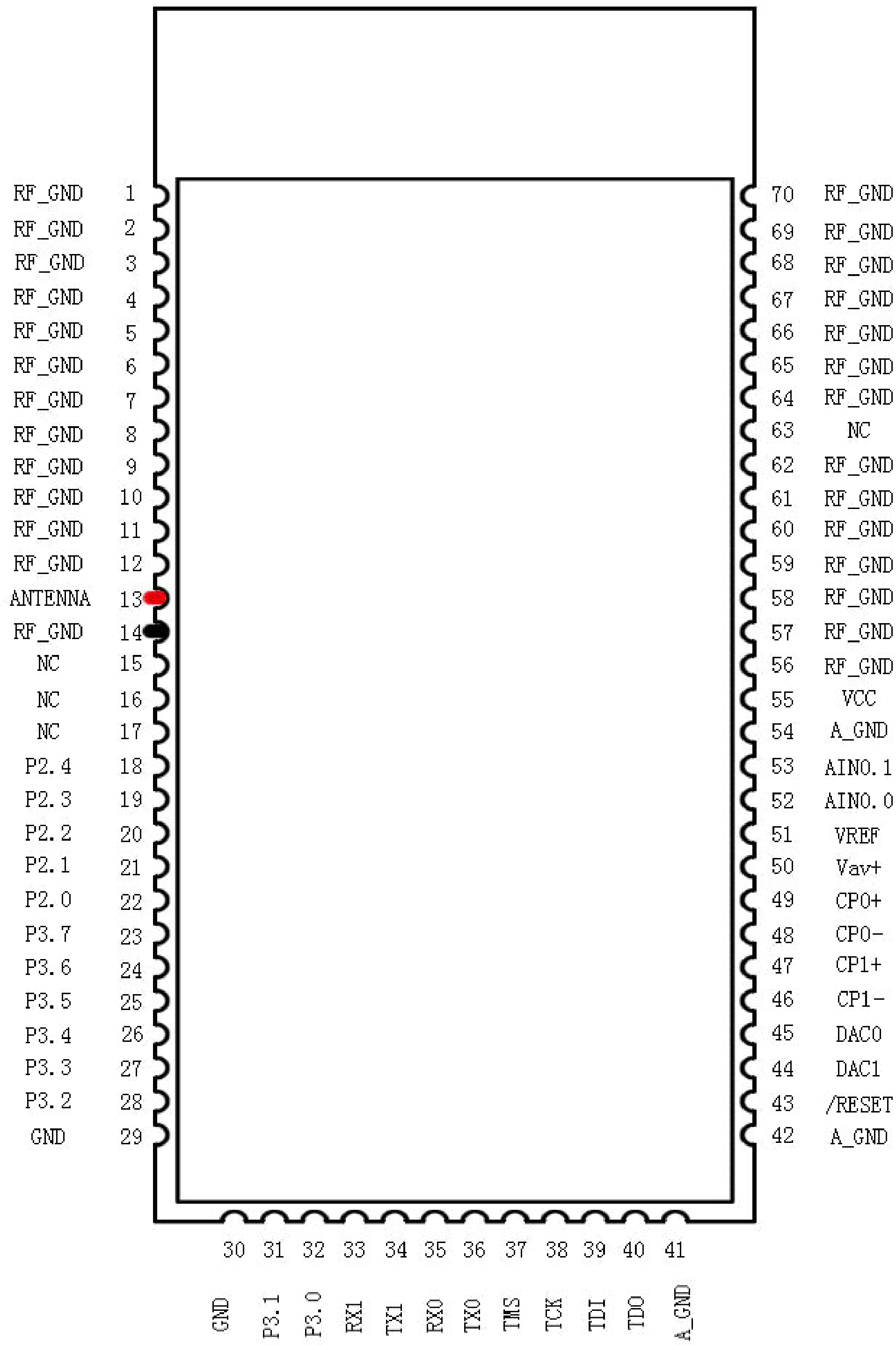
Pin No.	Name	Type	Function Description
			Port 0.1 Digital Input/Output
41	DAC0 P0.0.	DAC Digital I/O	Digital-to-Analog Converter 0 Voltage Output Range: 0 ~ (VREF -1) mV @ 12-bit resolution Port 0.0 Digital Input/Output
42~45	GND	Power	Digital Ground
46	VRTC	Power	Smart Clock Backup Supply Voltage.
47	VREF		Reference voltage Input
48	AIN0.0 P1.6	ADC Digital I/O	ADC 0 Input Channel 0 @ 12-bit resolution Port 1.6 Digital Input/Output
49	AIN0.1 P1.7	ADC Digital I/O	ADC 0 Input Channel 1 @ 12-bit resolution Port 1.7 Digital Input/Output
50	A_GND	Power	Analog ground pin
51	VCC		Power 3.0 to 3.6VDC digital supply
52-62	RF_GND		RF ground pins

2.3 IP-Link 122X-2134 Interface Pin Definitions



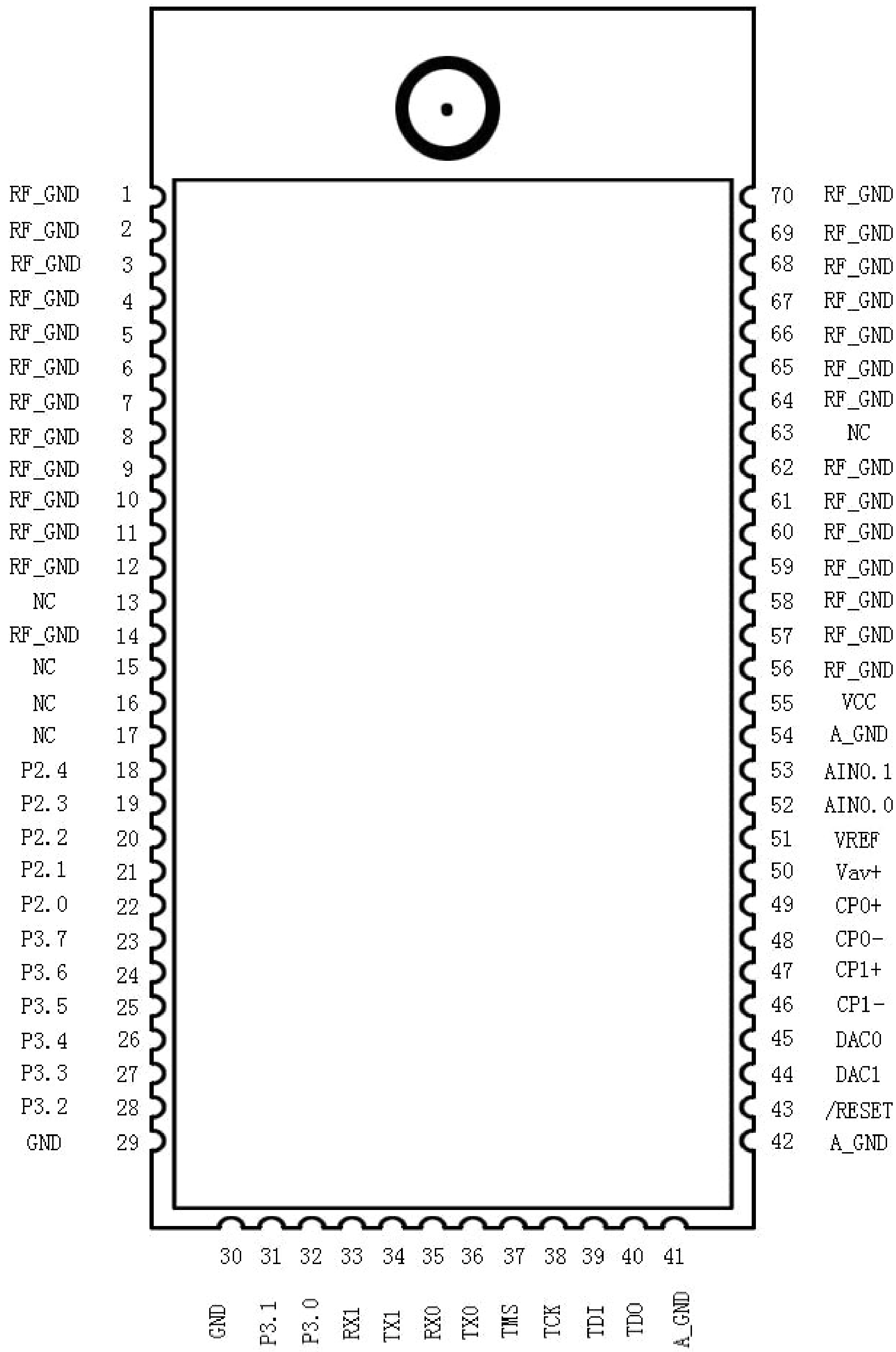
122X-2134

2.4 IP-Link 122X-2164 Interface Pin Definitions



122X-2164

2.5 IP-Link 122X-2264 Interface Pin Definitions



122X-2264

Pin No.	Name	Type	Function Description
1 ~ 12	RF_GND	Power	RF Ground pins
13	ANTENNA	RF	Not Connected (Note: This pin is reserved for a different antenna option on 1221-2164.)
14	RF_GND	Power	RF Ground Pin
15	NC	Digital I/O	NC
16	NC	Digital I/O	NC
17	NC	Digital I/O	NC
18	P2.4	Digital I/O	Port 2.4 Digital Input/Output Net link indication, set S183 to check the net connection，if connected P2.4 is high, or else is low
19	P2.3	Digital I/O	Port 2.3 Digital Input/Output Send fail indication，MAC ACK fail is low
20	P2.2	Digital I/O	Port 2.2 Digital Input/Output Send success indication，MAC send successfully is low
21	P2.1	Digital I/O	Port 2.1 Digital Input/Output Receive indication，MAC receive packet is low
22	P2.0	Memory Bus Digital I/O	Bit 8 of External Memory Bus (multiplexed mode) Bit 0 of External Memory Bus (non-multiplexed mode) Port 2.0 Digital Input/output Work indication，module work in binary mode，P2.0 alternated between high and low for 1s In transparent mode keep low for 100ms,high for 50ms In AT mode keep low for 50ms,high for 100ms
23	P3.7	Digital I/O	Port 3.7 Digital Input/Output
24	P3.6	Digital I/O	Port 3.6 Digital Input/Output
25	P3.5	Digital I/O	Port 3.5 Digital Input/Output CTS for UART flow control(re. 6.2)
26	P3.4	Digital I/O	Port 3.4 Digital Input/Output RTS for UART flow control(re. 6.2)
27	P3.3	Digital I/O	Port 3.3 Digital Input/Output

Pin No.	Name	Type	Function Description
28	P3.2	Digital I/O	Port 3.2 Digital Input/Output Tag sleep wake up, keep P3.2 low for 500mS， the asleep module in waken up, and keep P3.2 low for another 500mS,the module work in sleep mode again,re.5.4.1。
29 ~30	GND	Power	Digital Ground
31	P3.1	Digital I/O	Port 3.1 Digital Input/Output In tag mode, Port 3.1 have Tag alarm function,re.5.4.1 In DIO mode, Port 3.1 can check the state of sub-IO, re.5.4.2
32	P3.0	Memory Bus Digital I/O	Bit 0 of External Memory Bus (multiplexed mode) Bit 8 of External Memory Bus (non-multiplexed mode) Port 3.0 Digital Input/output In tag mode, Port 3.0 have Tag alarm function re.5.4.1 In DIO mode, Port 3.0 can check the state of sub-IO,re.5.4.2
33	RX1	UART	UART #1 Data In
34	TX1	UART	UART #1 Data Out
35	RX0	UART	UART #0 Data In (used by IP-Link 122X firmware)
36	TX0	UART	UART #1 Data Out (used by IP-Link 122X firmware)
37	TMS	JTAG	JTAG Test Mode, internal pull-up
38	TCK	JTAG	JTAG Test Clock, internal pull-up
39	TDI	JTAG	JTAG Test Data Input, internal pull-up
40	TDO	JTAG	JTAG Test Data Output, internal pull-up
41-42	A_GND	Power	Analog ground pins
43	/RESET	Control	Device Reset Open-drain output of internal VDD monitor
44	DAC1	DAC	Digital-to-Analog Converter 1 Voltage Output Range: 0 ~ (V_{REF}-1) mV @ 12-bit resolution (only available on IP-Link 1220)
45	DAC0	DAC	Digital-to-Analog Converter 0 Voltage Output Range: 0 ~ (V_{REF}-1) mV @ 12-bit resolution (only available on IP-Link 1220)
46	CP1-	Comparators	Comparator 1 inverting input

Pin No.	Name	Type	Function Description
47	CP1+	Comparators	Comparator 1 non-inverting input
48	CP0-	Comparators	Comparator 0 inverting input
49	CP0+	Comparators	Comparator 0 non-inverting input
50	Vav+	Power	Power 2.7 to 3.6VDC analog supply
51	VREF		Reference voltage output
52	AIN0.0		ADC 0 Input Channel 0
53	AIN0.1		ADC 0 Input Channel 1
54	A_GND	Power	Analog ground pin
55	VCC		Power 3.0 to 3.6VDC digital supply
56-62	RF_GND		RF ground pins
63	NC		Not connected
64-70	RF_GND		RF ground pins

2.6 Special Notes on Interface Pins

RXD — Receiving data pin for Universal Asynchronous Receiver Transmitter (UART1). Its level should be in accordance with the VDD voltage level. Factory default baud rate is 38400. The default configuration is 8-bit data, no parity, and 1 stop bit.

TXD — Transmitting data pin for Universal Asynchronous Receiver Transmitter (UART1). Its level should be in accordance with the VDD voltage level. The default configuration is 8-bit data, no parity, and 1 stop bit.

/RESET — Module reset signal, low active.

VCC — Supply voltage. All Vcc shall be connected to a power supply in the range of 3.3VDC +/- 10% and less than 20 mVp-p ripple voltages. Higher ripple voltage can significant reduce the transceiver’s performance and communication range.

TMS — JTAG Test Mode Select with internal pull-up

TCK — JTAG Test Clock with internal pull-up

TDI	JTAG Test Data Input with internal pull-up. TDI is latched on the rising edge of TCK
TDO	JTAG Test Data Output with internal pull-up. Data is shifted out on TDO on the falling edge of TCK. TDO output is a tri-state driver.

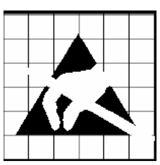
2.7 Firmware Capabilities Specification

Serial Port	Baud Rate	38400
	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: Reserved for Network Master 65534: Reserved for self-loop back 65535: Reserved for broadcast
	MAC Layer Blacklist	8 entries
	Neighbor Table	2-way
	Routing Table	40-way
	RREQ Table	4-way
Sleep Mode	External Wakeup	POR (Power On Reset) Comparators

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				800	mA
Maximum Output Current Sunk by any Port pin				100	mA
Maximum Output Current Sunk by any other I/O pin				50	mA
Maximum Output Current Sourced by any Port pin				100	mA
Maximum Output Current Sourced by any other I/O				50	mA
Storage Temperature		-40		150	°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 122X-X0XX）		2.7		3.6	V
Supply voltage （IP-Link 122X-X1XX）		3.0		3.6	V
Operating ambient temperature range		-20		70	°C
Humidity(non-condensing)		10%		90%	

5 Theory of Networking Operations

IP-Link 122X 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 122X 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 122X'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 122X networks in real installations.

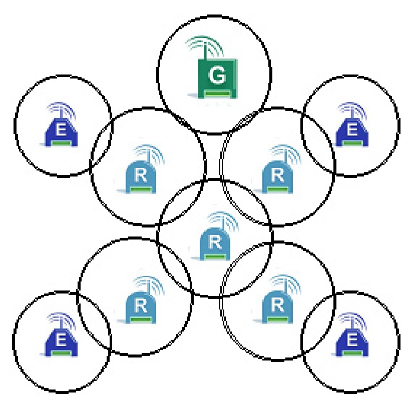
5.1 Wireless Networking Topologies

In this section, we describe the key distinctions 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 122X supports. This section provides a conceptual platform for readers before they use IP-Link 122X to build wireless networks.

5.1.1 Connectivity Topology Versus Routing Topology

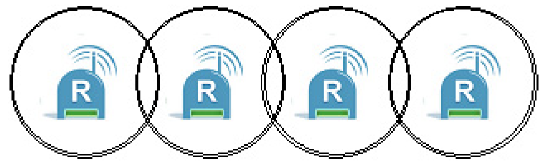
While the generic phrase *network topologies* suggests wires or cables connecting a host with communicating nodes, wireless communication modules like the IP-Link 122X use a wireless broadcast medium to communicate. The IP-Link 122X is a low-power transceiver module optimized for low-cost and low power consumption. So rather than transmitting at high power or having a huge antenna to improve receiver sensitivity, a single IP-Link 122X transmits at relatively low power (10mW) 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.

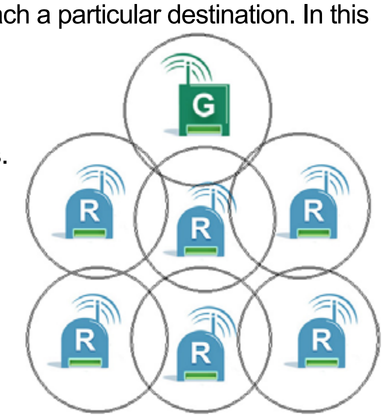


- **Scenario 1: Linear Network**

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 122X'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 122X, only one IP-Link 122X module needs to be configured as a **Master** node. The remaining IP-Link 122X 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 122X 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 (RN+ or Master), each IP-Link 122X 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 122X 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 122X modules.

5.2 Topology Selection

IP-Link 122X'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 122X. 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 122X Network

In this chapter we provide a simple guide to forming an IP-Link 122X network（The establishment of Mesh network please re. 6.1 and 6.2）. The generic flow of building an IP-Link 122X network consists of a series of steps provisioning the Master Node and non-Master nodes and making them recognize one another. The configuration procedure discussed in this chapter is based on those AT Mode or Binary Mode commands detailed in Chapter 7. This chapter also provides tips on verifying the connectivity of a newly formed network and describes procedures users should follow to reconfigure a network.

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 122X 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: 0x62

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 122X 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 122X 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.

Based on these two command set categories, IP-Link122X supports two modes when it communicates to the outside applications: **AT Mode** and **Binary Mode**. When IP-Link 122X 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 122X's S Register definitions.
- Section 7.2.1 introduces the structure of IP-Link 122X'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 122X.
- Section 7.3 provides detailed information on every command request and its corresponding responses.

7.1 AT Command Mode

IP-Link 122X provides a host of AT commands to allow easy configuration of key attributes of an IP-Link 122X 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 122X.

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: O 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
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	MacNetID=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 122X 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	1: 57600 bps 2: 38400 bps 3: 19200 bps 4: 9600 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	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		143
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 0: 2.405 GHz 1: 2.410 GHz ... 14: 2.475 GHz 15: 2.480 GHz	0
RF Frequency	115	R	RF Frequency	3: 2.4 GHz	3
Wait ACK	141	R/W	Timeout, in 10	0 ~ 255	50

Register Name	S Register Index (decimal)	Access Type	Purpose	Range (decimal)	Manufacturer Default (decimal)
TimeOut			milliseconds		
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	255
Routing Algorithm	158	R/W		0: AODV 1: Cluster Tree 2: CT/AODV	2
Table Expiration Value	159	Reserved	Expiration time, in seconds		255
Topology Type	160	R/W		0 ~ 255	255
Aodv TTL Value	163	R/W		0 ~ 255	21
Network State	170	R/W		0: Unassigned 1: JOIN NETWORK 2: LEAVE NETWORK 3: REPORT ACCEPT CHILD 4: REPORT LOST CHILD	0
Work Mode	173	R/W		0: HELICOMM FRAME	0

Register Name	S Register Index (decimal)	Access Type	Purpose	Range (decimal)	Manufacturer Default (decimal)
				MODE 1: AT COMMAND MODE 2: TRANSPARENT MODE	
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
Network Layer Node ID, Upper Byte	188	R/W		0 ~ 255	255

Register Name	S Register Index (decimal)	Access Type	Purpose	Range (decimal)	Manufacturer Default (decimal)
Network Layer Node ID, Lower Byte	189	R/W		0 ~ 255	255
MAC Layer PAN ID, Upper Byte	190	R/W		0 ~ 255	255
MAC Layer PAN ID, Lower Byte	191	R/W		0 ~ 255	255
MAC Layer Node ID, Upper Byte	192	R/W		0 ~ 255	255
MAC Layer Node ID, Lower Byte	193	R/W		0 ~ 255	255
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	0:FALSE,	0

Register Name	S Register Index (decimal)	Access Type	Purpose	Range (decimal)	Manufacturer Default (decimal)
			mode	1:TRUE	
Sleep base time	234	R/W	Sleep base time	1~40	4
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	0~3	0

7.1.2 AT Command Error Codes

When AT commands execute successfully, IP-Link 122X firmware returns an upper case “**O**” as a success indication. In the case of execution failure, IP-Link 122X 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 122X supports four types of frames in its Binary Mode. **Command Request, Command Response, Data Request, and Acknowledgment.**

To use IP-Link 122X’s Binary Mode, a Host Application starts with building **Command Request Frames** to query, configure, and command a remote IP-Link 122X for networking-related functions. The remote IP-Link 122X 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-Link122X can also be retrieved using **Command Request** and **Command Response**. These commands are built-in to IP-Link 122X, 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 122X'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 122X 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 122X modules. These frames can also be used to carry user-defined network-wide commands, such that IP-Link 122X can be extended to support any custom commands users desire.

All these frames can be exchanged from one IP-Link 122X module to a peer module within the same network. The routing of these frames over any given topology is handled by IP-Link122X'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 1220 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)

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 122X'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 122X Command Request Code Summary

Following is a summary of the Command Request set currently supported by IP-Link 122X, firmware release v2.1.05. 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)
Digital Input	DI Danger	0x3B
	DI Safe	0x3C
Sample and ADC	Get IP-Link 122X ADC Sample	0x81
	Get IP-Link 122X RSSI Sample	0x82
	Get IP-Link 122X Temperature	0x83
	Set IP-Link 122X DAC Value	0x85
Module Settings	Get AT Mode S Register Setting	0x86
	Set AT Mode S Register Setting	0x87

[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)
Module MAC Settings	Get MAC Address	0x8B
Power Management	Get Firmware Version Number	0x8C
	Entry Power Down Mode	0x8D
	Sensor Start	0xAE
	Sensor End	0xAF
	Wake Up	0xB0
	Soft Reset Module	0x8F
	Enter sleep mode re. Local awakened sleep	0xB1
	Reset to Factory Default	0x90
Module Network Settings	Get Routing Table	0x95
	Get Neighbor Table	0x97
	Get Children Table	0x99
	Get RREQ Table	0x9B
	Get Black List Table	0x9C
	Set Black List Table	0x9D
	TRACERT	0xAA
	Get TagNeighbor	0xAB
	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 Request (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_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)
Command 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)
Command Request (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 122X. Users can refer to this information to build the command library for their particular host application platforms.

Get IP-Link 122X ADC0 Sample

Read the sample from IP-Link 122X's ADC0

Command Code

0x81

Description

This command is used to retrieve the sample from IP-Link 122X's built-in analog-to-digital converter (ADC0). IP-Link 1220 has a two 12-bit ADCs (IP-Link1221 has a two 10-bit ADCs)at ADC#1 and ADC#0 are available on IP-Link 122X's Pin #52 and #53, respectively, to connect to user's analog signal source.

When returned successfully, the first and second byte should be concatenated together to get the 12-bit ADC sample. The 12-bit ADC sample should be reconstructed using the following C pseudo code:

```
ADC_Value = (ADC_High_Byte << 8 ) | (ADC_Low_Byte);
```

S242=0 (3.3V input against core): The input signal voltage to ADC shall be in the range of 0~3.3VDC. Reference voltage is taken from IP-Link's internal 2.4VDC core voltage. The ADC will be configured with a 0.5 prescaler, making the effective input range to become 0~4.8VDC. Upon the READ_ADC command, firmware will add up 16 continuous samples, divide the sum by 11 (a software multiplier of 16/11 = 1.454), and report the adjusted 10-bit sample.

S242=1 (external): The reference voltage will be taken from IPLink 1221's PIN 47, and the input signal will be sampled against this reference voltage without any firmware adjustment. 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 (2.4V input against core): The input signal voltage to ADC shall be in the range of 0~2.4VDC. Reference voltage is taken from IP-Link's internal 2.4VDC core voltage. The ADC will be configured with no prescaler, making the effective input range to become 0~2.4VDC. Upon the READ_ADC command, firmware will add up 16 continuous samples, divide the sum by 16, and report the average 10-bit sample.

S242=3 (4.8V input against core): The input signal voltage to ADC shall be in the range of 0~4.8VDC. Reference voltage is taken from IP-Link's internal 2.4VDC core voltage. The ADC will be configured with a 0.5 prescaler, making the effective input range to become 0~4.8VDC. Upon the READ_ADC command, firmware will sum up 16 continuous samples, divide the sum by 16, and report the average 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 4 bits of the sample (right-aligned)
ADC Low Byte	1 Byte	the 8 least significant bits of the sample

Set IP-Link 1220 DAC0 Value

Set IP-Link 1220's DAC0 value

Command Code

0x85

Description

This command is used to set the input digital value of IP-Link 1220's built-in digital-to-analog converter (DAC0). IP-Link 1220 has a two 12-bit voltage-mode DACs. Each DAC has an output swing of 0V to 2.4V(typical) for a corresponding input code range of 0x000 to 0xFFF. DAC#1 and DAC#0 output are available on IP-Link 1220's Pin #44 and #45, respectively, to connect to user's digital input.

Users can set the DAC Flag to enable or disable DAC.

When returned successfully, the output of IP-Link 1220's DAC is available at IP-Link 1220's Pin #45.

There is no DAC in IP-Link 1221 but only exist in IP-Link 1220.

Command Parameters

DAC High Byte	1Byte	The high byte of DAC digital input
DAC Low Byte	1Byte	The low byte of DAC digital input
DAC Flag	1Byte	0x01: enable DAC; 0x00: disable DAC

Response

Command Confirmation	1 Byte	0x00 (constant)

Get IP-Link 122X RSSI Reading

Read IP-Link 122X RSSI reading

Command Code

0x82

Description

This command retrieves the RSSI value, in dBm, from IPLink 122X. 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 122X Temperature

Read the temperature sample from a remote IP-Link 122X

Command Code

0x83

Description

Issue this command to retrieve the ambient temperature sensed by IPLink 122X. To derive at the actual temperature reading, the following conversion should be applied on the 12-bit (10-bit on IPLink 1221)sample **S**:

For 1220: Celcius: ((**S** * 2.4 / 4095) – 0.776) / 0.00286

For 1221: Celcius: ((**S** * 2.4 / 1023) – 0.776) / 0.00286

Farenheit: (Celcius * 1.8) + 32

Command Parameters

N/A

Response

Temperature High Byte	1 Byte	the most significant 4or2 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 ATSxxx? 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 hexidecimal

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 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.

Command Parameters

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

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 122X module's IEEE 64-bit MAC hardware address. For IP-Link 122X, this attribute is unused.

Command Parameters

N/A

Response

MAC Address	8 Byte	64-bit IEEE MAC address, MSB first

Get Firmware Version Number

Get release number of IP-Link 122X module firmware

Command Code

0x8C

Description

This command retrieves the firmware release number on the destination IP-Link 122X 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 122X module

Command Code

0x8D

Description

This command powers down the remote IP-Link 122X 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)

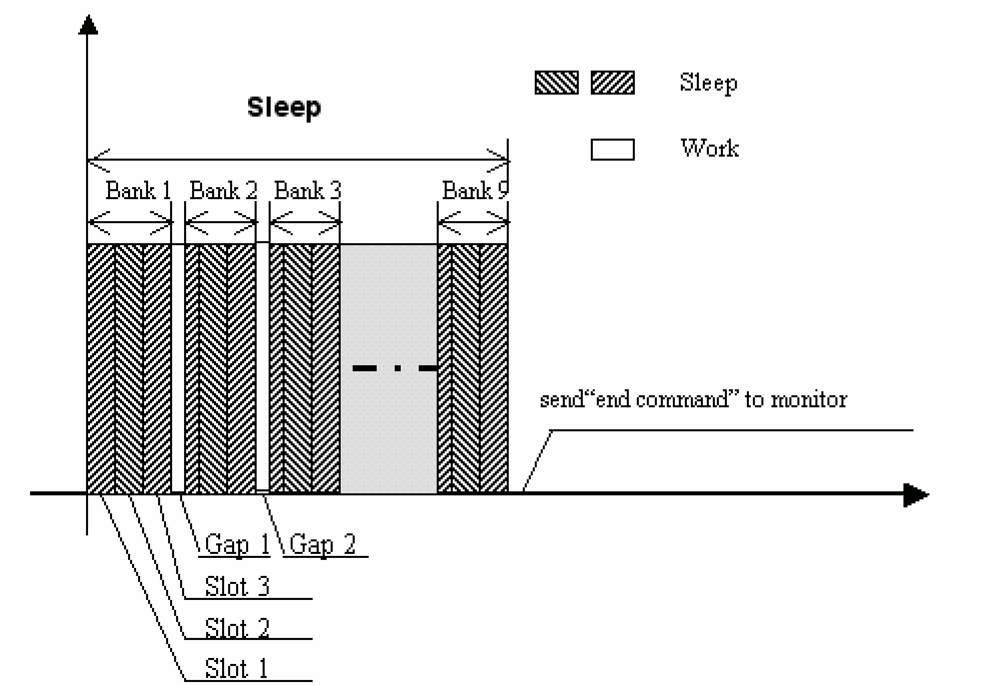
Sensor Start

Place IP-Link 122X module in sleep mode

Command Code

0xAE

Description



Graph 1. Sleep mode

As Graph 1 shows, "Sleep" is the total time length of sleep mode. "Bank" is the interval of sleep. The module will wake up to deal with some affairs (such as sampling ADC value after every "Bank") and monitor the channel, this interval is called a "Gap". Every Gap is reckoned in the Bank after it. The shortest length of interrupting unit is called "Slot", which ranges from 1ms to 65ms. Each bank could be made up of M Slots and Each Sleep time unit is made up of N Slots. Users can set the value of "Sleep", "Bank" and "Gap" according to their needs. In Graph 1, suppose every "Slot" is 50ms and every "Gap" is 20ms(the basic unit is 10ms), then:

Sleep = Slot × N = Slot × 3 × 9 = 1350ms

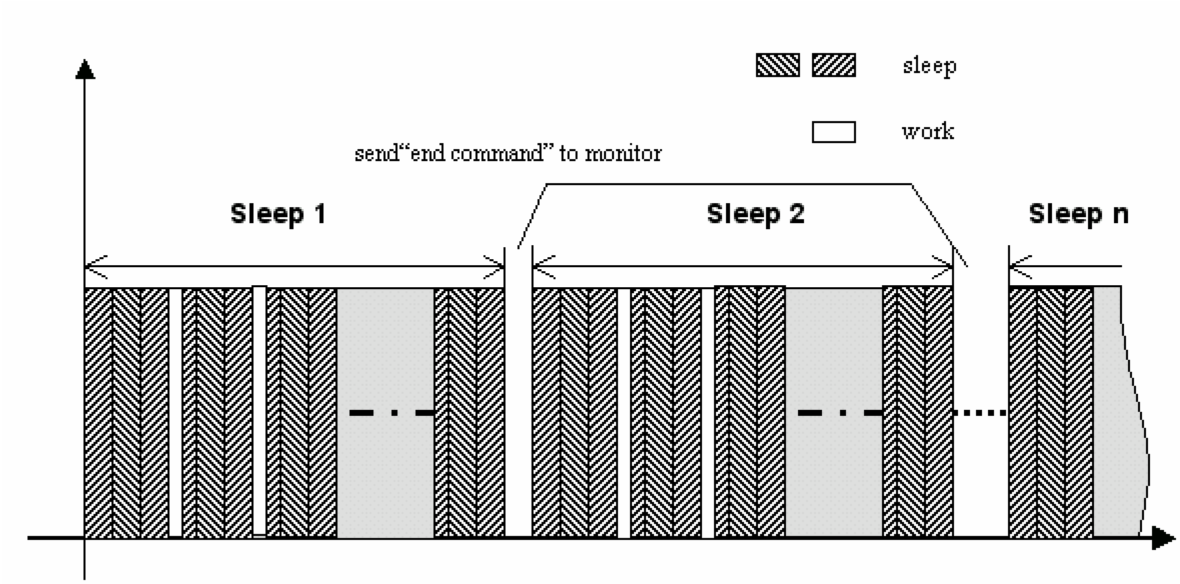
Bank = Slot × M = Slot × 3 = 150ms

Gap = 2×10ms = 20ms

If users are permitted to sample ADC value, then the module will wake up to sample the ADC value every 150 ms (one "Bank"). If the sample value exceeds the threshold value, the module would send a message as a warning to the specified node and quit the sleep mode (The threshold, alarm and the specified node could be set in the command format). If the sample value is valid, the module will keep the 20ms monitoring-channel state (one “Gap”) to wait for being waken by RF, then enter the next “Bank” to sleep.

When the total sleep time expires, the module will quit sleep mode and send the last ADC sample value and GPIO state value or Null message to the monitor node according to the user’s configuration.

Users can also configure the module to make it enter continuous sleep mode as Graph 2 shows, i.e. when sleep time expires, the module will send ADC sample value and GPIO state value to the monitor node and then continue to sleep.



Graph 2. Continuous Sleep mode

Control (1)	ADC threshold (2)	Gap (1)	M (1)	N (4)	Slot (1)	Monitor Node (2)

Command Format

Command Parameters

Control	1 Byte	Control byte, see Form 1 below
ADC threshold	2 Byte	Overflow threshold. Lower bits are available, decided by the number of bits of ADC value. For example, the ADC of IP-Link1221-2x33 is 10 bits, if the threshold is 512, then the corresponding value should be 0x0200. Range: 0 ~ 0x0FFF(ADC value of IP-Link1220-2x33 is 12 bits)
Gap	1 Byte	Length of working time When module is during the sleep period, it will wake up after every bank and decide whether

		to sample ADC or monitor the channel to wait to be waken according to Control.Bit1 and Control.Bit2. This interval is called a “Gap”. Range: 0 ~ 60 (10 ms). (The commended value is 3 during peer to peer communication.)
M	1 Byte	The number of “Slot” in one “Bank” Range: 0 < M ≤ N
N	4 Byte	The number of “Slot” in one sleep cycle(It is commended that Sleep > 500ms during peer to peer communication.) Range: M ≤ N ≤ 0xFFFFFFFF
Slot	1 Byte	Sleep time unit Range: 1 ~ 65 ms
Monitor Node	2 Byte	Monitor Node ID Range: 0 ~ 65535

Control	Function	Description
Bit0	Continuous sleep mode flag	0: Independent sleep mode 1: Continuous sleep mode
Bit1	ADC monitor flag	0: Disabled 1: Sample ADC value after every “Bank”
Bit2	Wireless wake flag	0: Disabled 1: Monitor the channel to wait to be waken
Bit3	ADC flag	0: Disabled after sleep 1:Return a Sampling ADC value after a “Sleep” period
Bit4	GPIO flag	0: Disabled 1: Return the IO state after a “Sleep” period
Bit5	Sensor End command flag	0: Disabled 1: Send Sensor End command after a “Sleep” period
Bit6~Bit7	reserved	1: Disabled

Form 1. Control byte

Response

Command Confirmation	1 Byte	0x00 (constant)

Sensor End

Report the end of sleep mode

Command Code

0xAF

Description

After a sleep period, the module sends this command to the monitor node.

Command Parameters

N/A

Response

Control	1 Byte	See the form below
ADC	2 Byte	Value of ADC0
GPIO	2 Byte	GPIO State

Control	Function	Description
Bit0	Flag of ADC	0: ADC disabled 1: ADC enabled
Bit1	Flag of GPIO	0: GPIO disabled 1: GPIO enabled
Bit2~Bit7	reserved	

Wake Up

Wake the module in the sleep mode

Command Code

0xB0

Description

This command wakes the module which is in the sleep mode and monitors the channel . The command will be continuously sent to the module every 0.5Gap until the module is waken. The maximum period to continuously send this command can last Slot×M(ms), i.e. a “Bank”.

Command Parameters

Gap	1 Byte	Equal to the Gap value of the module to be waken
M	1 Byte	Equal to the M value of the module to be waken
Slot	1 Byte	Equal to the Slot value of the module to be waken

Response

Command Confirmation	1 Byte	0x00 (constant)

Soft Reset

Reset IP-Link 122X module

Command Code

0x8F

Description

This command triggers a soft reset of the destination IP-Link 122X. 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)

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 122X 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 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 122X module. Black List Table is a MAC Layer filtering mechansim 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 definiton
…	…	…
Black List entry 7	4 Byte	See above for field definiton

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 122X module. Black List Table is a MAC Layer filtering mechansim 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 definiton
…	… …	
Black List entry K, K<8	4 Byte	See the previous page for field definiton

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 122X 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

Get IO

Retrieve Port state

Command Code

0xAC

Description

This command retrieves the current state of corresponding port.

Input a number from 0x00 to 0x0A to get the current state of corresponding port. 0x00 ~ 0x05 means port P3.0 ~ P3.5, 0x06 means port P3.7, and 0x07 ~ 0x0A means port P2.0 ~ P2.3. It will return the state of all ports when the command parameter is 0xFF.

If the command parameter is a number from 0x00 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 10 least significant bits of the 2 Port state bytes show the state of all ports. 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 fisrt byte specifise the port number, and the second byte sets the port state. 0 means low state and 1 means high state.

The IO definition refer to Get IO in previous page。

Command Parameters

Set Port state	2 Byte per port	The first byte: Port number(0 ~ 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.

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*100ms=1S, the landing kit contains the sampling values of tag node’s ADC0.1, this value have 16 bits, 2 bytes. The ADC value of 1220 is 12 bits, 1221 is 10 bits, so the two highest bits of the sampling values separately show the IO states of P3.1 and P3.0.

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. When the module work in sleep mode, it will wake up in period of 50 ms. If it find either P3.0 or P3.1 change from high electrical potential into low, the module will quit sleep mode and quickly send landing kits, before finish sending the packet the module will not return into sleep mode until the IO state return normal, then the module will turn into sleep tag mode again.

In order to operate conveniently, we cite one of the pins of P3.2 to switch the module’s sleep state. For example, when the module work in sleep tag mode, if you turn P3.2 down more than 500ms, the module will turn off sleep, but the function of tag remains. And if you remain to turn P3.2 down more than 500ms again or restart the module, the module will work in sleep tag mode again.

After the fixed node received the landing kits of tag, the fixed node will put the node number of tag, the value of ADC, RSSI, LQI, IO state and so on into its tag table, at present, there are three kinds of tag table,. We can change S236 value to choose which kind to use. When S236=0 the fixed node support 34 tag information at most. The format of tag table is as follows:

Field	Length	Description
MACAddr	2 Byte	Tag Neighbor's MAC Layer Node ID
LQI	1 Byte	Lind Quality Indicator
RSSI	1 Byte	RSSI value
ADCvalue & IO state	2 Byte	Tag Neighbor's ADC0 Value (the least significant 12 bits), state of P3.1 and P3.0 (the most significant 2 bits)

When S236=1 the fixed node support 50 tag information at most. The module of tag table is as follows:

Field	Length	Description
MACAddr	2 Byte	Tag Neighbor's MAC Layer Node ID
RSSI	1 Byte	RSSI value
Beacon Counter	1 Byte	Beacon Counter number

When S236=2 the fixed node support 34 tag information at most. The module of tag table is as follows:

Field	Length	Description
MACAddr	2 Byte	Tag Neighbor's MAC Layer Node ID
RSSI	1 Byte	RSSI value
ADCValue & IO state	2 Byte	Tag Neighbor's ADC0 Value (the least significant 12 bits), state of P3.1 and P3.0 (the most significant 2 bits)
Beacon Counter	1 Byte	Beacon Counter number

The command code of this tag table is 0xAB. The use is the same as the other command formats. When you use this command you can get a half of the tag table, so if you want to get all , you should use this command twice.

7.4.2 Digital IO mode application

When the module goes into a checked IO state mode and set S184 nonzero, the module will have position function. And S185、S186 set the destination node numbers, the S185 is in low byte, S186 is in high byte, the default is 0.

The main use is when set the module's S184 nonzero, the module can work in IO mode, so the module will check the IO port P3.0 and P3.1 periodically. The normal state is the IO ports are in high states, if any one of the IO ports appears low state more than 2S, the module is considered as abnormal. Then the states of these two IO ports which are regard as alarm signal (command code is 0X3B) will be send to the nodes which are prescribed by S185、S186. And if the IO ports are always in abnormal states, the node will resend periodically in 6S, until the IO ports are in high states more than 2S. Then the node will send a packet which means security to the nodes which are prescribed by S185、S186.

The same as tag mode, IO mode also can have sleep function at the same time. On the basis of upward if set S233 nonzero, the module will have sleep function. But if the IO state is in abnormal state, the module will not go into sleep mode, but work in normal state. The module will not go into the sleep IO state until the IO state resume normal state. In addition, IO mode introduces the pin P3.2 to switch sleep mode. For example, when mode work in sleep IO mode, if you turn P3.2 down more than 500ms the module will turn off sleep, but the function of IO remains. And if you remain to turn P3.2 down more than 500ms again or restart the module, the module will work in sleep IO mode again.

The specific format of alarm packet and security packet is as follows:

DI Danger

Show that the DI status is abnormal

Command Code

0x3B

Description：

This command is not sent by users but by IP-Link 122X itself.

Refer to 5.4.2 Digital IO mode application.

Command Parameters：

DI Status 1 Byte

Control	Function	Description
Bit0	Show the status of Digital Input 0	0: Safe 1: Dangerous
Bit1	Show the status of Digital Input 1	0: Safe 1: Dangerous
Bit2 – Bit7	reserved	

DI Value 1 Byte

Control	Function	Description
Bit0	Show the value of Digital Input 0	0: Low 1: High
Bit1	Show the value of Digital Input 1	0: Low 1: High
Bit2 – Bit7	reserved	

Response

Command Confirmation 1 Byte 0x00 (constant)

DI Safe

Show that the DI status is safe

Command Code

0x3C

Description

This command is not sent by users but sent by IP-Link 122X itself.

Command Parameters

Safe source 1 Byte

Control	Function	Description
Bit0	Whether Digital Input 0 sends this command	0: Not send 1: Send
Bit1	Whether Digital Input 1 sends this command	0: Not send 1: Send
Bit2 – Bit7	reserved	

DI Value 1 Byte

Control	Function	Description
Bit0	Show the value of Digital Input 0	0: Low 1: High
Bit1	Show the value of Digital Input 1	0: Low 1: High
Bit2 – Bit7	reserved	

Response

Command Confirmation 1 Byte the same with **Safe source**

7.4.3 Local awakened sleep

7.4.3.1 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)

7.4.3.2 Exit sleep mode

Divide it into two cases for the difference of external crystal

122X-2033/122X-2133：send a byte 0

122X-2034/122X-2134：send a packet 10 bytes 0

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

Change the default of S102 from 8 to 9, and when S103 is not 1, the serial ports work in the parity check corresponding mode. If S102=9 and S103=2, they work in even mode. If S103 is nonzero, but S102=8, the serial ports is not have parity chenk function, so must set S102 and S103 at the same time to have the parity chenk function.

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 weather turn on the flow control. When S106=0, no flow control; S106=1, is the flow control with hardware.

8.3 Add loop back fuction 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 weather 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];

}

// Chenk parity

if (0 != nXOR)

{

        ...

}

// Check packet head

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

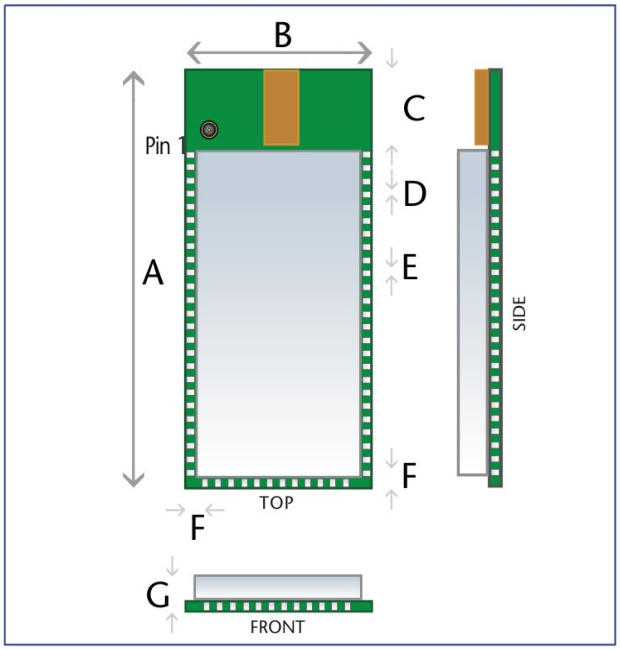
```
{
        ...
}
// Check command code
if (0XFF == btBuf[5])
{
        ...
}
...
// btBuf[6] is main version
// btBuf[7] is subsidiary version
// btBuf[8] is revised version
```

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 122X-2034 Dimensions

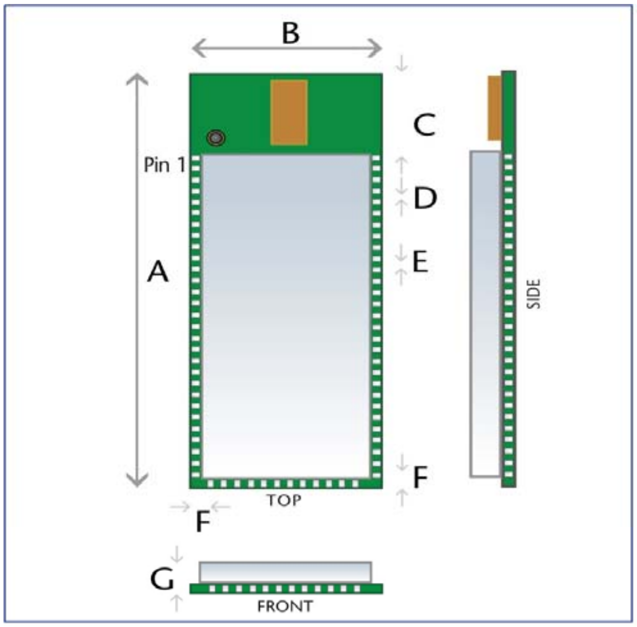


2.4GHz Module Dimensions See Table 2

Table 2: *2.4GHz Module Dimensions*

Module	Ref	Value (mm)	Description
2.4GHz	A	41	Length for Modules with NO PA
2.4GHz	B	19	Width for Module
2.4GHz	C	8.5	Antenna Area
2.4GHz	D	1.27	Distance Between Pin's
2.4GHz	E	0.812	Width of Pins
2.4GHz	F	2.1	Pin Distance from Edge
2.4GHz	G	4	Heigth for Module

11.2 IP-Link 122X-2134 Dimensions

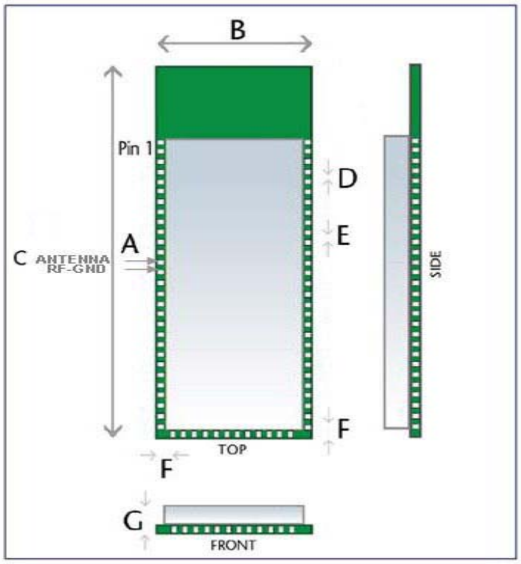


2.4GHz PA Module Dimensions See Table 3

Table 3: *2.4GHz PA Module Dimensions*

Module	Ref	Value (mm)	Description
2.4GHz	A	46	Length for Modules with PA
2.4GHz	B	19	Width for Module
2.4GHz	C	8.5	Antenna Area
2.4GHz	D	1.27	Distance Between Pin's
2.4GHz	E	0.812	Width of Pins
2.4GHz	F	2.1	Pin Distance from Edge
2.4GHz	G	4	Heigth for Module

11.3 IP-Link 122X-2164 Dimensions

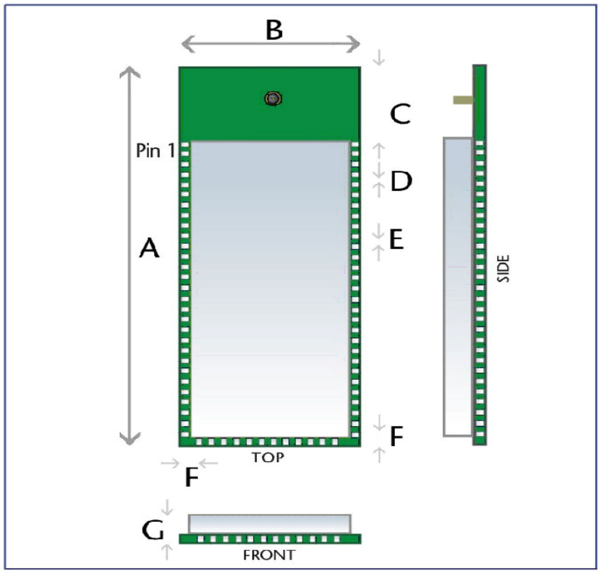


2.4GHz PA Module Dimensions See Table 3

Table 3: *2.4GHz PA Module Dimensions*

Module	Ref	Value (mm)	Description
2.4GHz	A	46	Length for Modules with PA
2.4GHz	B	19	Width for Module
2.4GHz	C		
2.4GHz	D	1.27	Distance Between Pin's
2.4GHz	E	0.812	Width of Pins
2.4GHz	F	2.1	Pin Distance from Edge
2.4GHz	G	4	Heigth for Module

11.4 IP-Link 122X-2264 Dimensions

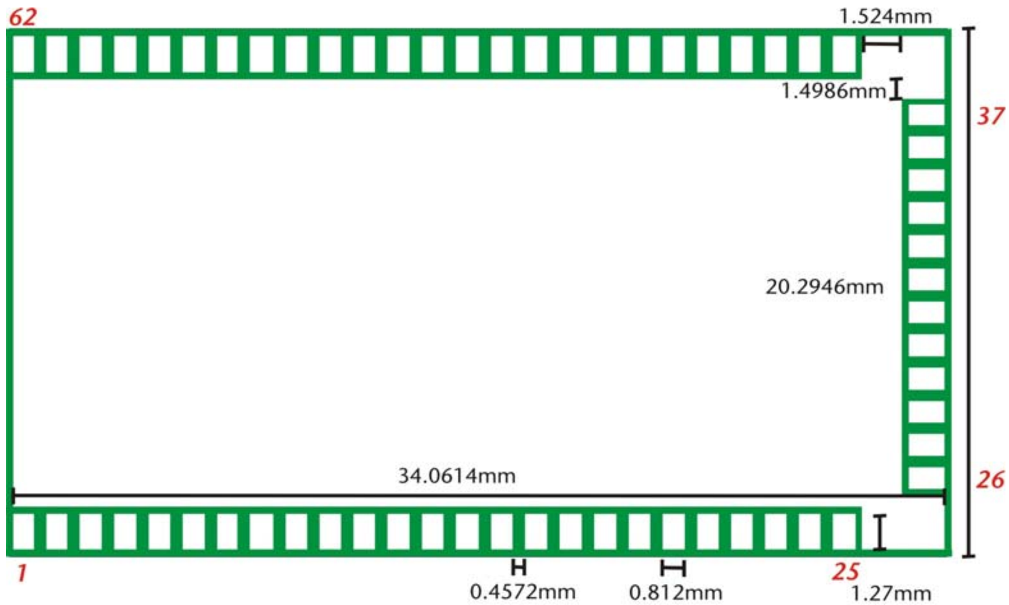


2.4GHz PA Module Dimensions See Table 3

Table 3: *2.4GHz PA Module Dimensions*

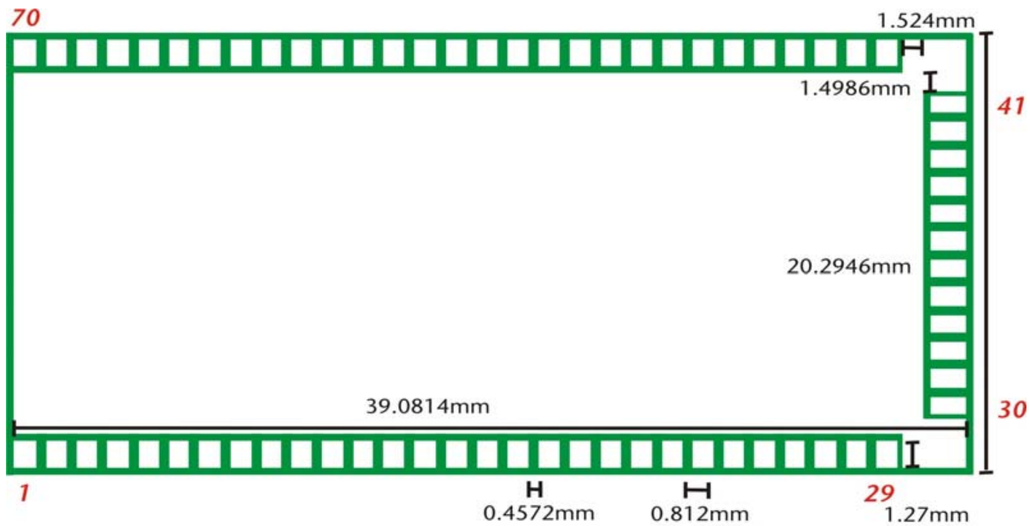
Module	Ref	Value (mm)	Description
2.4GHz	A	46	Length for Modules with PA
2.4GHz	B	19	Width for Module
2.4GHz	C	8.5	Antenna Area
2.4GHz	D	1.27	Distance Between Pin's
2.4GHz	E	0.812	Width of Pins
2.4GHz	F	2.1	Pin Distance from Edge
2.4GHz	G	4	Heigth for Module

11.5 IP-Link 122X-2034 PAD



122X-2034 Foot Print

11.6 IP-Link 122X-21XX/22XX PAD



122X-21XX/22XXPA Foot Print

11.7 Re-flow Temperature Specifications

We recommend low temperature lead-free solder paste rated at 118ºC.

	Ideal (ºC)	Maximum (ºC)
Maximum Re-flow Temperature	118	180

11.8 Solder Paste Recommendations

We recommend low temperature lead-free solder paste rated at 118ºC.

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

12 professional installation

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 instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one 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) Thisdevice may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

FCC Caution: Any changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate this equipment.

WARNING!
FCC Radiation Exposure Statement:

This portable equipment with its antenna complies with FCC’s RF radiation exposure limits set forth for an uncontrolled environment. To maintain compliance follow the instructions below;

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

2. Avoid direct contact to the antenna, or keep it to a minimum while using this equipment.

This transmitter module is authorized to be used in other devices only by OEM integrators under the following condition:

The transmitter module must not be co-located with any other antenna or transmitter.

As long as the above condition is met, further transmitter testing will not be required. However, the OEM integrator is still responsible for testing their end-product for any additional compliance requirements required with this module installed (for example, digital device emissions, PC peripheral requirements, etc.).

High Power Module usage limitation

The high power module variants are classified as ‘mobile’ device pursuant with FCC § 2.1091 and **must not** be used at a distance of < 20 cm (8”) from any nearby people.

IMPORTANT NOTE: In the event that these conditions can not be met (for certain configurations or co-location with another transmitter), then the FCC authorization is no longer considered valid and the

FCC ID can not be used on the final product. In these circumstances, the OEM integrator will be responsible for re-evaluating the end product (including the transmitter) and obtaining a separate FCC authorization.

The OEM integrator has to be aware not to provide information to the end user regarding how to install or remove thisRF module in the user manual of the end product.

The user manual for the end product must include the following information in a prominent location;

“To comply with FCC’s RF radiation exposure requirements, the antenna(s) used for this transmitter must not be collocated or operating in conjunction with any other antenna or transmitter.”

AN2400-0301TM is the recommended antenna for this module.

13 Ordering Information

You can contact Helicomm and our resellers for additional modules or develop kit to grow your network. Please specify Product Part Number: **IP-Link 122X-2034 or IP-Link 122X-2134(2X64).**

A six-node IP-Link 122X-2134 Development Kit with USB connector, demo sensors, and network management tool can be purchased to jump-start your first experiences with Helicomm's networking technologies. To order the Development Kit, Please specify Product Part Number: **EZDK 1220PA.**

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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.

NOTE: The manufacturer is not responsible for any radio or TV interference caused by unauthorized modifications to this equipment. Such modifications could void the user's authority to operate the equipment.

14 Index