Zlinx Radio Modem

ZP Series

Documentation Number: ZP24D-250RM-SR-0812
pn#7337R4

*This product designed and manufactured in Ottawa, Illinois USA
of domestic and imported parts by*

B&B ELECTRONICS

707 Dayton Road -- P.O. Box 1040 -- Ottawa, IL 61350 USA
Phone (815) 433-5100 -- General Fax (815) 433-5105

Phone (815) 433-5100 -- **General Fax** (815) 433-5105
Website: **www.bb-elec.com**

European Headquarters

B&B Electronics

Westlink Commercial Park -- Oranmore, Co. Galway, Ireland

Phone +353 91-792444 -- **Fax** +353 91-792445
Website: **www.bb-europe.com**

B&B Electronics Mfg. Co. Inc. -- June 2008

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B&B Electronics Mfg Co Inc – 707 Dayton Rd - PO Box 1040 - Ottawa IL 61350 - Ph 815-433-5100 - Fax 815-433-5104 – *www.bb-elec.com*
B&B Electronics – Westlink Commercial Park – Oranmore, Galway, Ireland – Ph +353 91-792444 – Fax +353 91-792445 – *www.bb-europe.com*

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Introduction

Easy to install, up to 1 mile range. No wires, no cables! Zlinx radio modems get your data moving farther, easier, and at less cost than running cable. Plug-n-play, Modbus compatible, signal strength indicator, space saving DIN rail mounting. Heavy-duty, wide temperature design handles most industrial power configurations and tough indoor/outdoor environments.

| Model #	Frequency	Radio Power	RF Data Rate
ZP24D-250RM-SR	2.4GHz	Configurable Up To 100mW	250Kbps

Check Package Contents
- Radio Modem
- Antenna
- Software CD
- Manual (On CD)
- Will require separate 18-30VAC or 10-48VDC Power Supply

ZP24D-250RM-SR = 2.0W max
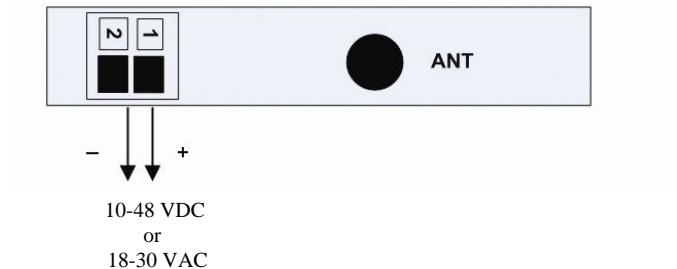
Hardware Installation

Dip switch Settings

Dipswitch	OFF	ON
1	4-wire	2-wire
2	4-wire	2-wire
3	No termination	Termination
4	RS-422	RS-485
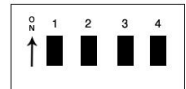
Mounting and Power

- Install on properly grounded DIN rail
  - Operating Temperature is -40 to 85C
  - Operating Humidity is 10-90% non-condensing
- Connect Power Supply
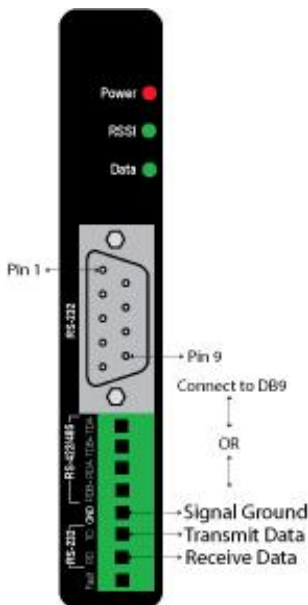 - Power supply is 10-48 VDC or 18-30 VAC

10-48 VDC
or
18-30 VAC

Serial Connections

RS-232

RS-232 always present on DB9

| DB9F Pin	Signal Name	Direction
1	Data Carrier Detect*	---
2	Receive Data	Out
3	Transmit Data	In
4	Data Terminal Ready	In
5	Signal Ground	---
6	Data Set Ready*	---
7	Request To Send	In
8	Clear To Send	Out
9	Not used	---

* - Pins 1 & 6 are not used. They are tied together

Note: The DTR input is used to put the radio into sleep mode. The radio sleep option must be enabled first using the configuration software. Once enabled, lowering the DTR signal will put the radio in sleep mode and raising the DTR signal will put the radio in idle mode, ready to receive or transmit data.

RS-232

RS-422/485
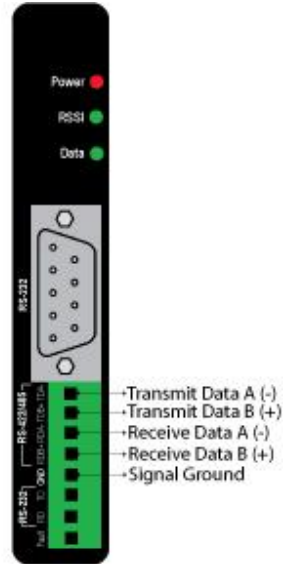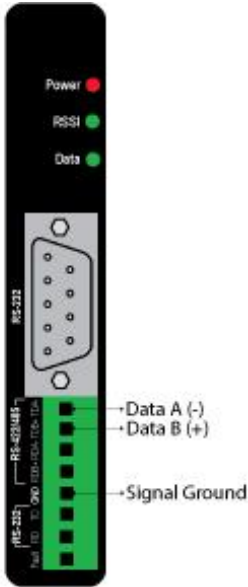
RS-485 (2-Wire)   **RS-422/485 (4-Wire)**

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Wireless Link Failure Output

- Zlinx Radio modems offer a source (PNP)transistor output when the wireless signal strength drops below a critical level (link failure or miss packets)
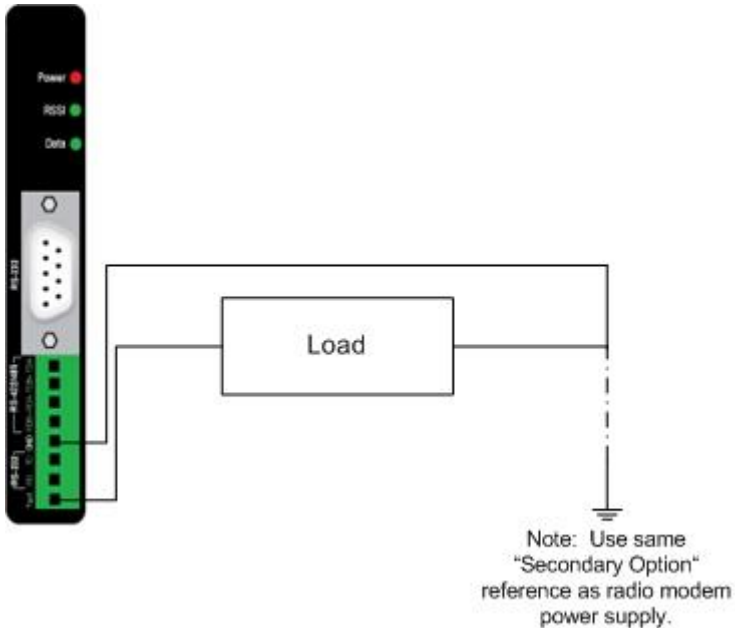- 40 mA max current

Note: Use same "Secondary Option" reference as radio modem power supply.

Note: In order for the RSSI LED to continuously indicate the signal strength, set the RP command (RSSI PWM Timer) to FF.

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B&B Electronics – Westlink Commercial Park – Oranmore, Galway, Ireland – Ph +353 91-792444 – Fax +353 91-792445 – *www.bb-europe.com*

LED Indicators

Front Panel LED	Status
Power	Red = ON OFF = No Power
RSSI (Signal Strength)	Green = Strong Yellow = OK Red = Weak OFF = No Signal
Wireless Data	Green = Blink ON with data

Note: In order for the RSSI LED to continuously indicate the signal strength, set the "RP" command (RSSI PWM Timer) to FF.

Radio Frequency Information

- The ZP24D-250RM-SR has an indoor range up to 300 feet and an outdoor range up to one mile.
- These ranges are for line of sight installations using the supplied antenna. Performance may vary depending on your particular installation.
- The antenna connection on the radio modem is an RPSMA female plug.
- B&B Electronics has a wide variety of accessory antennas. Visit www.bb-elec.com for more information.

Model #	Frequency	Radio Power	RF Data Rate
ZP24D-250RM-SR	2.4GHz	Configurable Up To 100mW	250Kbps

Zlinx Manager Software

Installation

- The Zlinx Manager Software is contained CD.
- Insert the CD into the drive.
- The installation program should auto start.
- Follow the on screen prompts.

Set Up

1. Connect your PC to the modem using a straight through serial cable.
2. Start the Zlinx Manage Software and click on the radio modem button.

3. The radio modem launcher screen will appear

3. Click on the Radio Modem Configuration button to configure the modem on-line or the Radio Modem Configuration Button (offline) to configure the modem offline. Follow the on screen directions to configure the modem. Note: using the off-line configuration button skips the auto modem discovery process.

On-Line Configuration

1. Click the Radio Modem Configuration Button. The following screen will appear.
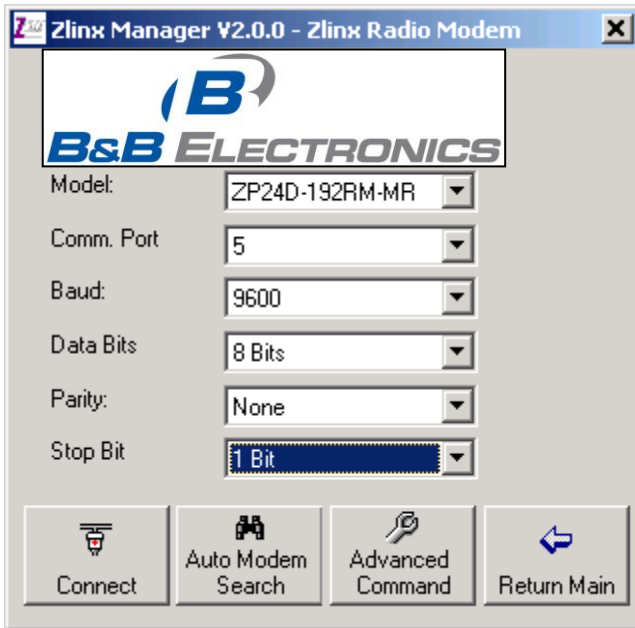
2. Use the pull down menu items to set up the communication parameters.

3. Click the Auto Modem Search button. The Zlinx Manager software will find the radio modem. If the modem is not found, the following screen will appear.
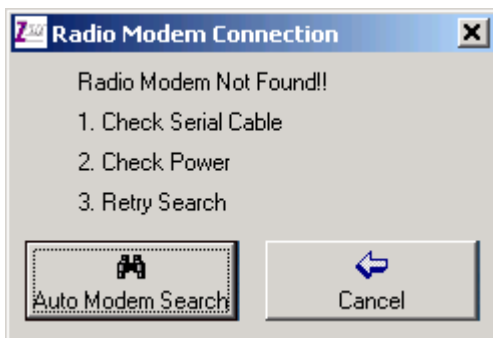
4. When the modem is found, the following screen will appear.
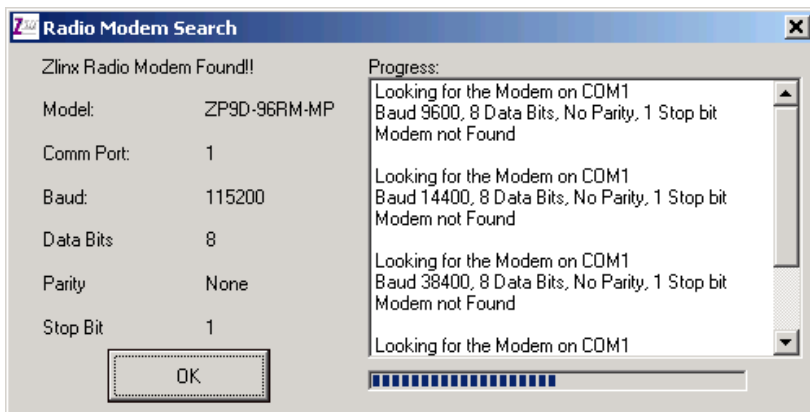
5. Click OK. The following screen will appear.
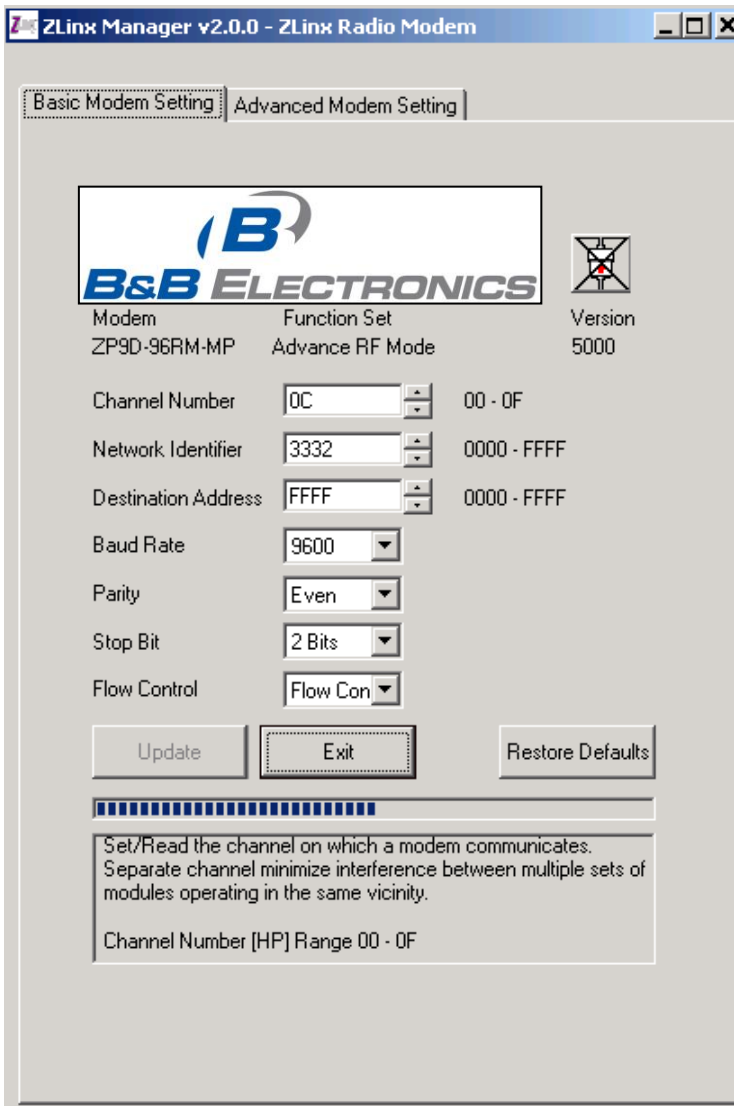
5. On the Basic Modem setting tab, configure a unique channel number, network identifier, and destination address. This will prevent interference from other modems. Click the Update

button to save the parameters. Click the Restore Defaults button to revert to the default configuration.

6. Use the advanced tab to configure additional parameters. When each option is highlighted, the text box will display an explanation of the command and the associated hex range. Click the update button to save the parameters. Click the Restore Defaults button to revert to the default configuration.
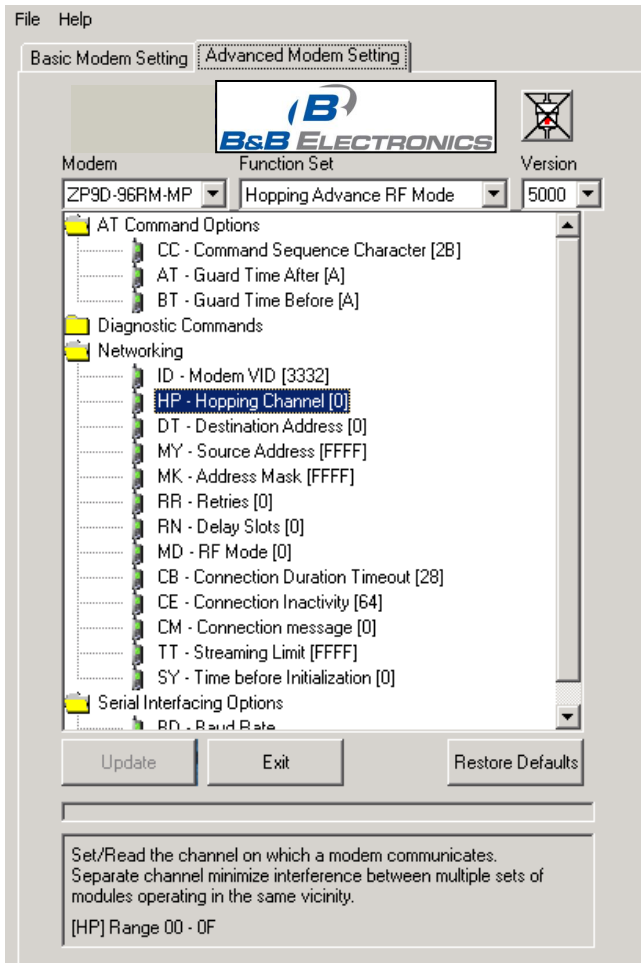
Test / Troubleshoot

1. The RSSI Range Test allows you test your installation. Cross connect TD and RD on the remote modem before running the test.
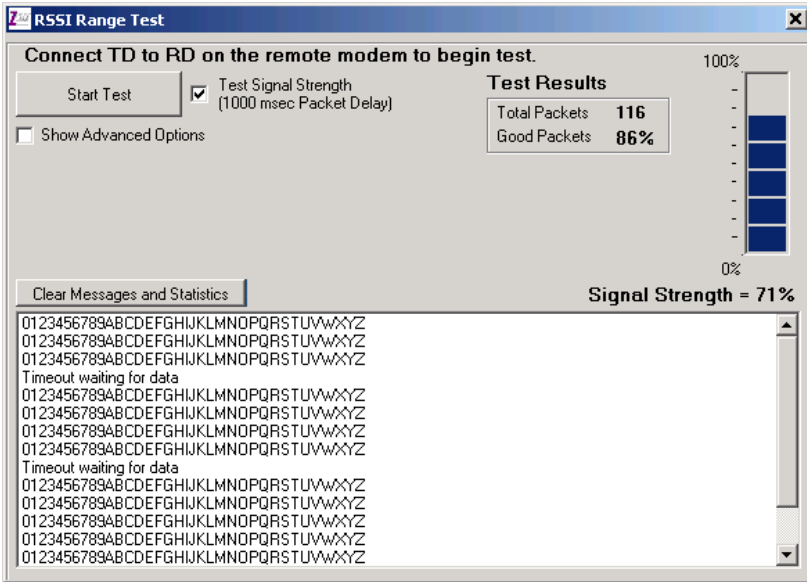
2. The basic screen shows test results and signal strength. Check the Show Advanced Option Box to customize the test.

RSSI Range Test

Connect TD to RD on the remote modem to begin test.

Start Test   ☑ Test Signal Strength
              (1000 msec Packet Delay)

☑ Show Advanced Options

Packet Delay   `1000` msec

Receive Timeout `2000` msec

Test Mode
- ◉ Continuous Test
- ○ Send `50` Packets
- ○ Stop on error

Test Results

Total Packets	**116**
Good Packets	**86%**

100%

0%

Signal Strength = 71%

Transmit Test Data

`0123456789ABCDEFGHIJKLMNOPQRSTUVWXYZ`

Clear Messages and Statistics

```
0123456789ABCDEFGHIJKLMNOPQRSTUVWXYZ
0123456789ABCDEFGHIJKLMNOPQRSTUVWXYZ
0123456789ABCDEFGHIJKLMNOPQRSTUVWXYZ
Timeout waiting for data
0123456789ABCDEFGHIJKLMNOPQRSTUVWXYZ
0123456789ABCDEFGHIJKLMNOPQRSTUVWXYZ
0123456789ABCDEFGHIJKLMNOPQRSTUVWXYZ
0123456789ABCDEFGHIJKLMNOPQRSTUVWXYZ
Timeout waiting for data
0123456789ABCDEFGHIJKLMNOPQRSTUVWXYZ
0123456789ABCDEFGHIJKLMNOPQRSTUVWXYZ
0123456789ABCDEFGHIJKLMNOPQRSTUVWXYZ
0123456789ABCDEFGHIJKLMNOPQRSTUVWXYZ
0123456789ABCDEFGHIJKLMNOPQRSTUVWXYZ
```

Firmware Update

1. Connect your PC to the radio modem using a straight through serial cable and the auto connect function. The new firmware must be stored on the PC's local drive.

2. From the Zlinx Manager Radio Modem launch screen, click the firmware update button.

3. Once connected, the software will determine which firmware versions are available on the PC and what version is loaded in the modem. The following screen allows you to chose which firmware version to load.
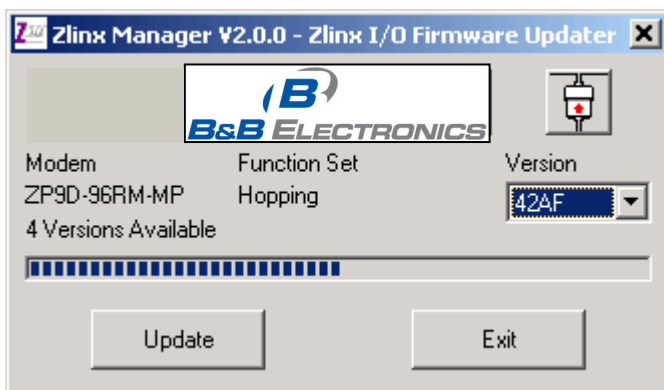
4. Select the firmware version to load from the pull down menu and click the update button.

Specifications

RF Properties	
Physical Standard	IEEE 802.15.4
Range	up to 300 feet indoor or 1 mile outdoor
Frequency	2.4GHz
Transmit Power	100mW
Software	Zlinx Manager
Support	Windows 2000, 2003 Server, XP, and Vista
Antenna Options	External Reverse Polarity SMA male jack connector, omni directional (included with product)
Radio Address	Defaulted at factory, set by software otherwise
Serial settings	
Baud	1200, 2400, 4800, 9600, 19200, 38400, 57600, 115200
Data bit	8 only
Parity	None only
Stop bit	1 only
RS-232	
Connector	DB9F DCE
Lines	TX, RX, RTS, CTS, DTR, RI, GND
Connector	Removable terminal block
Lines	TX, RX, GND
RS-422	
Connector	Removable terminal block
Lines	2 or 4 wire – TX+, TX-, RX+, RX-, GND (2 or 4 wire dipswitch selectable)
Termination	120 Ohm Dipswitch selectable
RS-485	
Connector	Removable terminal block
Lines	2 or 4 wire with SD control – TX+, TX-, RX+, RX-, GND (2 or 4 wire dipswitch selectable)
SD control	Bit wise

Termination	120 Ohm Dipswitch selectable
Transistor link failure	No wireless signal or RSSI LED off
Connector	Removable terminal block with RS-422/485
Output type	Open collector, dry contact, 40mA
Power Supply	
Connector	Removable terminal block
Input Voltage	10–48VDC, 18-30VAC
Power Consumption	2.0W max
Dimensions	1.2W x 3.3D x 4.7H
Environmental	Intended for indoor use only
Operating Temperature	-40 to 85ºC (-40 to 185ºF)
Storage Temperature	-40 to 85ºC (-40 to 185ºF)
Operating Humidity	10 to 90% non-condensing
Enclosure Rating	
Rating	IP30
Mounting	DIN rail mount, 35mm
LED Status	

Front Panel LED	Status
Power	Red = On OFF = No Power
RSSI (Signal Strength)	Green = Strong Yellow = OK Red = Weak OFF = No Signal
Wireless Data	Green = Blink on with data

Note: In order for the RSSI LED to continuously indicate the signal strength, set the RP command (RSSI PWM Timer) to FF.

Certifications	
FCC	FCC Part 15 Class B
CE	CISPR (EN55022) Class B
	EN61000-6-1 Generic Standards for Residential, Commercial, & Light Industrial
	EN61000-4-2 ESD

	EN61000-4-3 RFI
	EN61000-4-4 EFT
	EN61000-4-5 Surge
	EN61000-4-6 CI
	EN61000-4-8 Power Frequency Magnetic
	EN61000-4-11 Voltage Dips & Interruptions
UL	UL, cUL

Advanced Programming

Setup

The programming examples in this section require the installation of a hyper terminal program and a serial connection to a PC. (B&B stocks RS-232 and USB boards to facilitate interfacing with a PC.)

> Mount the RF module to an interface board, then connect the module assembly to a PC.
> Launch the terminal software and select the 'PC Settings' tab. Verify the baud and parity settings of the Com Port match those of the RF module.
> NOTE: Failure to enter AT Command Mode is most commonly due to baud rate mismatch. Ensure the 'Baud' setting on the 'PC Settings' tab matches the interface data rate of the RF module. By default, the BD parameter = 3 (which corresponds to 9600 bps).

Sample Config: Modify RF Destination Address

'CR' stands for carriage return:

Method 1 (One line per command)

Send AT Command	System Response_
+++	OK <CR> (Enter into Command Mode)
ATDL <Enter>	{current value} <CR> (Read Destination Address Low)
ATDL1A0D <Enter>	OK <CR> (Modify Destination Address Low)
ATWR <Enter>	OK <CR> (Write to non-volatile memory)
ATCN <Enter>	OK <CR> (Exit Command Mode)

Method 2 (Multiple commands on one line)

Send AT Command_	System Response_
+++	OK <CR> (Enter into Command Mode)
ATDL <Enter>	{current value} <CR> (Read Destination Address Low)
ATDL1A0D,WR,CN <Enter>	OK, OK, OK <CR> (Command execution is triggered upon each instance of the comma)

Command Reference Table

Zlinx Radio Modems expect numerical values in hexadecimal. Hexadecimal values are designated
by a "0x" prefix. Decimal equivalents are designated by a "d" suffix. Commands are contained
within the following command categories (listed in the order that their tables appear):
• Special
• Networking & Security
• RF Interfacing
• Sleep (Low Power)
• Serial Interfacing
• I/O Settings
• Diagnostics
• AT Command Options
All modules within a PAN should operate using the same firmware version.

Commands-Special

AT_ Command	Command_ Category	Name and Description	Parameter Range	Default
WR	Special	**Write**. Write parameter values to non-volatile memory so that parameter modifications persist through subsequent power-up or reset. Note: Once WR is issued, no additional characters should be sent to the module until after the response "OK\r" is received.	-	-
RE	Special	**Restore Defaults**. Restore module parameters to factory defaults.	-	-
FR (v1.x80*)	Special	**Software Reset**. Responds immediately with an OK then performs a hard reset ~100ms later.	-	-

*Firmware version in which the command was first introduced (firmware versions are numbered in hexadecimal notation.)

Commands-Networking & Security (Sub categories designated within {brackets})

AT_ Command	Command_ Category	Name and Description	Parameter Range	Default
CH	Networking {Addressing}	**Channel**. Set/Read the channel number used for transmitting and receiving data between RF modules (uses 802.15.4 protocol channel numbers).	0x0B - 0x1A 0x0C - 0x17	0x0C (12d)
ID	Networking {Addressing}	**PAN ID**. Set/Read the PAN (Personal Area Network) ID._ Use 0xFFFF to broadcast messages	0 - 0xFFFF	0x3332_ (13106d)

		to all PANs.		
DH	Networking {Addressing}	**Destination Address High**. Set/Read the upper 32 bits of the 64-bit destination address. When combined with DL, it defines the destination address used for transmission. To transmit using a 16-bit address, set DH parameter to zero and DL less than 0xFFFF. 0x000000000000FFFF is the broadcast address for the PAN.	0 - 0xFFFFFFFF	0
DL	Networking {Addressing}	**Destination Address Low**. Set/Read the lower 32 bits of the 64-bit destination address. When combined with DH, DL defines the destination address used for transmission. To transmit using a 16-bit address, set DH parameter to zero and DL less than 0xFFFF. 0x000000000000FFFF is the broadcast address for the PAN.	0 - 0xFFFFFFFF	0
MY	Networking {Addressing}	**16-bit Source Address.** Set/Read the RF module 16-bit source address. Set MY = 0xFFFF to disable reception of packets with 16-bit addresses. 64-bit source address (serial number) and broadcast address (0x000000000000FFFF) is always enabled.	0 - 0xFFFF	0
SH	Networking {Addressing}	**Serial Number High**. Read high 32 bits of the RF module's unique IEEE 64-bit address. 64-bit source address is always enabled.	0 - 0xFFFFFFFF [read-only]	Factory-set
SL	Networking {Addressing}	**Serial Number Low**. Read low 32 bits of the RF module's unique IEEE 64-bit address. 64-bit source address is always enabled.	0 - 0xFFFFFFFF [read-only]	Factory-set
RR (v1.xA0*)	Networking {Addressing}	**Retries**. Set/Read the maximum number of retries the module will execute in addition to the 3 retries provided by the 802.15.4 MAC. For each retry, the 802.15.4 MAC can execute up to 3 retries.	0 - 6	0
RN	Networking {Addressing}	**Random Delay Slots.** Set/Read the minimum value of the back-off exponent in the CSMA-CA algorithm that is used for collision avoidance. If RN = 0, collision avoidance is disabled during the first iteration of the algorithm (802.15.4 - macMinBE).	0 - 3 [exponent]	0

		MAC Mode. Set/Read MAC Mode value. MAC Mode enables/disables the use of a B&B header in the 802.15.4 RF packet. When Mode 0 is enabled (MM=0), duplicate packet detection is enabled as well as certain AT commands. Modes 1 and 2 are strict 802.15.4 modes.	0 – 2 0 = 1 = B&B Mode 1 = 802.15.4 (no ACKs) 2 =802.15.4 (with ACKs)	
MM (v1.x80*)	Networking {Addressing}			0
NI (v1.x80*)	Networking {Identification}	**Node Identifier.**Stores a string identifier. The register only accepts printable ASCII data. A string can not start with a space. Carriage return ends command. Command will automatically end when maximum bytes for the string have been entered. This string is returned as part of the ND (Node Discover) command. This identifier is also used with the DN (Destination Node) command.	20-character ASCII string	-
ND (v1.x80*)	Networking {Identification}	**Node Discover.**Discovers and reports all RF modules found. The following information is reported for each module discovered (the example cites use of Transparent operation (AT command format) - refer to the long ND command description regarding differences between Transparent and API operation). MY<CR> SH<CR> SL<CR> DB<CR> NI<CR><CR> The amount of time the module allows for responses is determined by the NT parameter. In Transparent operation, command completion is designated by a <CR> (carriage return). ND also accepts a Node Identifier as a parameter. In this case, only a module matching the supplied identifier will respond.	Optional 20-character NI value	
NT (v1.xA0*)	Networking {Identification}	**Node Discover Time.**Set/Read the amount of time a node will wait for responses from other nodes when using the ND (Node Discover) command.	0x01 - 0xFC	0x19
DN (v1.x80*)	Networking {Identification}	**Destination Node.** Resolves an NI (Node Identifier) string to a physical address. The following events occur upon successful command execution:	20-character ASCII string	-

		1. DL and DH are set to the address of the module with the matching Node Identifier. 2. "OK" is returned. 3. RF module automatically exits AT Command Mode If there is no response from a module within 200 msec or a parameter is not specified (left blank), the command is terminated and an "ERROR" message is returned.		
CE (v1.x80*)	Networking {Association}	**Coordinator Enable**. Set/Read the coordinator setting.	0 - 1 0 = End Device_ 1 = Coordinator	0
SC (v1.x80*)	Networking {Association}	**Scan Channels**. Set/Read list of channels to scan for all Active and Energy Scans as a bitfield. This affects scans initiated in command mode (AS, ED) and during End Device Association and Coordinator startup: bit 0 - 0x0B bit 4 - 0x0F bit 8 - 0x13 bit12 - 0x17 bit 1 - 0x0C bit 5 - 0x10 bit 9 - 0x14 bit13 - 0x18 bit 2 - 0x0D bit 6 - 0x11 bit 10 - 0x15 bit14 - 0x19 bit 3 - 0x0E bit 7 - 0x12 bit 11 - 0x16 bit 15 - 0x1A	0 - 0xFFFF [bitfield]	0x1FFE
SD (v1.x80*)	Networking {Association}	**Scan Duration**. Set/Read the scan duration exponent. *End Device*- Duration of Active Scan during Association. On beacon system, set SD = BE of coordinator. SD must be set at least to the highest BE parameter of any Beaconing Coordinator with which an End Device or Coordinator wish to discover. *Coordinator*- If 'ReassignPANID' option is set on Coordinator [refer to A2 parameter], SD determines the length of time the Coordinator will scan channels to locate existing PANs. If 'ReassignChannel' option is set, SD determines how long the Coordinator will perform an Energy Scan to determine which channel it will operate on. 'Scan Time' is measured as (# of channels to scan] * (2 ^ SD) * 15.36ms). The number of channels to scan is set by the SC command. The modem can scan up to 16 channels (SC = 0xFFFF). Example: The values below show	0-0x0F [exponent]	4

		results for a 13 channel scan:
		If SD = 0, time = 0.18 sec
		  SD = 8, time = 47.19 sec
		  SD = 2, time = 0.74 sec
		  SD = 10, time = 3.15 min
		  SD = 4, time = 2.95 sec
		  SD = 12, time = 12.58 min
		  SD = 6, time = 11.80 sec
		  SD = 14, time = 50.33 min		

A1 (v1.x80*)	Networking {Association}	**End Device Association**. Set/Read End Device association options. bit 0 - ReassignPanID 0 - Will only associate with Coordinator operating on PAN ID that matches module ID 1 - May associate with Coordinator operating on any PAN ID bit 1 – ReassignChannel 0 - Will only associate with Coordinator operating on matching CH Channel setting 1 - May associate with Coordinator operating on any Channel bit 2 – AutoAssociate 0 - Device will not attempt Association 1 - Device attempts Association until success Note: This bit is used only for Non-Beacon systems. End Devices in Beacon-enabled system must always associate to a Coordinator bit 3 – PollCoordOnPinWake 0 - Pin Wake will not poll the Coordinator for indirect (pending) data 1 - Pin Wake will send Poll Request to Coordinator to extract any pending data bits 4 - 7 are reserved	0 - 0x0F [bitfield]	0

A2 (v1.x80*)	Networking {Association}	**Coordinator Association**.
		Set/Read Coordinator association options.
		bit 0 – ReassignPanID
		  0 - Coordinator will not perform Active Scan to locate available PAN ID. It will operate on ID (PAN ID).
		  1 - Coordinator will perform Active Scan to determine an available ID (PAN ID). If a PAN ID conflict is found, the ID parameter will
			0 - 7 [bitfield]	0

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		change.
		bit 1 - ReassignChannel –
		  0 - Coordinator will not perform Energy Scan to determine free channel. It will operate_ on the channel determined by the CH parameter.
		  1 - Coordinator will perform Energy Scan to find a free channel, then operate on that channel.
		bit 2 - AllowAssociation –
		  0 - Coordinator will not allow any devices to associate to it.
		  1 - Coordinator will allow devices to associate to it.
		bits 3 - 7 are reserved		

AI (v1.x80*)	Networking {Association}	**Association Indication**. Read errors with the last association request: 0x00 - Successful Completion - Coordinator successfully started or End Device association complete 0x01 - Active Scan Timeout 0x02 - Active Scan found no PANs 0x03 - Active Scan found PAN, but the CoordinatorAllowAssociation bit is not set 0x04 - Active Scan found PAN, but Coordinator and End Device are not configured to support beacons 0x05 - Active Scan found PAN, but the Coordinator ID parameter does not match the ID parameter of the End Device 0x06 - Active Scan found PAN, but the Coordinator CH parameter does not match the CH parameter of the End Device 0x07 - Energy Scan Timeout 0x08 - Coordinator start request failed_ 0x09 - Coordinator could not start due to invalid parameter 0x0A - Coordinator Realignment is in progress 0x0B - Association Request not sent 0x0C - Association Request timed out - no reply was received 0x0D - Association Request had	0 - 0x13 [read-only]	-

		an Invalid Parameter 0x0E - Association Request Channel Access Failure. Request was not transmitted - CCA failure 0x0F - Remote Coordinator did not send an ACK after Association Request was sent 0x10 - Remote Coordinator did not reply to the Association Request, but an ACK was received after sending the request 0x11 - [reserved] 0x12 - Sync-Loss - Lost synchronization with a Beaconing Coordinator 0x13 - Disassociated - No longer associated to Coordinator		
DA (v1.x80*)	Networking {Association}	**Force Disassociation**. End Device will immediately disassociate from a Coordinator (if associated) and reattempt to associate.	-	-
FP (v1.x80*)	Networking {Association}	**Force Poll**. Request indirect messages being held by a coordinator.	-	-

AS (v1.x80*)	Networking {Association}	**Active Scan**. Send Beacon Request to Broadcast Address (0xFFFF) and Broadcast PAN (0xFFFF) on every channel. The parameter determines the time the radio will listen for Beacons on each channel. A PanDescriptor is created and returned for every Beacon received from the scan. Each PanDescriptor contains the following information:
		CoordAddress (SH, SL)<CR>
		CoordPanID (ID)<CR>
		CoordAddrMode <CR>
		0x02 = 16-bit Short Address
		0x03 = 64-bit Long Address _
		Channel (CH parameter) <CR> _
		SecurityUse<CR> _
		ACLEntry<CR> _
		SecurityFailure<CR> _
		SuperFrameSpec<CR> (2 bytes):
		    bit 15 - Association Permitted (MSB)
		    bit 14 - PAN Coordinator
		    bit 13 – Reserved
		    bit 12 - Battery Life Extension
		    bits 8-11 - Final CAP Slot
		    bits 4-7 - Superframe Order
		    bits 0-3 - Beacon Order
		GtsPermit<CR>
		RSSI<CR> (RSSI is returned as -
			0 - 6	-

AT Command	Command Category	Name and Description	Parameter Range	Default
		dBm) TimeStamp<CR> (3 bytes) <CR> A carriage return <CR> is sent at the end of the AS command. The Active Scan is capable of returning up to 5 PanDescriptors in a scan. The actual scan time on each channel is measured as Time = [(2 ^SD PARAM) * 15.36] ms. Note the total scan time is this time multiplied by the number of channels to be scanned. Also refer to SD command description.		
ED (v1.x80*)	Networking {Association}	**Energy Scan**. Send an Energy Detect Scan. This parameter determines the length of scan on each channel. The maximal energy on each channel is returned & each value is followed by a carriage return. An additional carriage return is sent at the end of the command. The values returned represent the detected energy level in units of -dBm. The actual scan time on each channel is measured as Time = [(2 ^ED) * 15.36] ms. Note the total scan time is this time multiplied by the number of channels to be scanned (refer to SD parameter).	0 - 6	-
EE (v1.xA0*)	Networking {Security}	**AES Encryption Enable**. Disable/Enable 128-bit AES encryption support. Use in conjunction with the KY command.	0 - 1	0 (disabled)
KY (v1.xA0*)	Networking {Security}	**AES Encryption Key**. Set the 128-bit AES (Advanced Encryption Standard) key for encrypting/decrypting data. The KY register cannot be read.	0 - (any 16-Byte value)	-

*Firmware version in which the command was first introduced (firmware versions are numbered in hexadecimal notation.)

Commands-RF Interfacing

AT Command	Command Category	Name and Description	Parameter Range	Default
PL	RF Interfacing	**Power Level**. Select/Read the power level at which the RF module transmits conducted power.	0 - 4 0 = -10 / 10 dBm 1 = -6 / 12 dBm 2 = -4 / 14 dBm 3 = -2 / 16 dBm 4 = 0 / 18 dBm	4
CA (v1.x80*)	RF Interfacing	**CCA Threshold**. Set/read the CCA (Clear Channel Assessment) threshold. Prior to transmitting a packet, a CCA is	0 - 0x50 [-dBm]	0x2C (-44d dBm)

		performed to detect energy on the channel. If the detected energy is above the CCA Threshold, the module will not transmit the packet.		

*Firmware version in which the command was first introduced (firmware versions are numbered in hexadecimal notation.)

Commands-Sleep (Low Power)

AT_ Command	Command_ Category	Name and Description	Parameter Range	Default
SM	Sleep_ (Low Power)	**Sleep Mode**. <NonBeacon firmware> Set/Read Sleep Mode configurations.	0 – 5 0 = No Sleep 1 = Pin Hibernate 2 = Pin Doze 3 = Reserved 4 = Cyclic sleep remote 5 = Cyclic sleep remote w/ pin wake-up 6 = [Sleep Coordinator] for backwards compatibility w/ v1.x6 only; otherwise, use CE command.	0
ST	Sleep_ (Low Power)	**Time before Sleep.**<NonBeacon firmware> Set/Read time period of inactivity (no serial or RF data is sent or received) before activating Sleep Mode. ST parameter is only valid with Cyclic Sleep settings (SM = 4 - 5). Coordinator and End Device ST values must be equal. Also note, the GT parameter value must always be less than the ST value. (If GT > ST, the configuration will render the module unable to enter into command mode.) If the ST parameter is modified, also modify the GT parameter accordingly.	1 -0xFFFF [x 1 ms]	0x1388 (5000d)

AT Command	Command Category	Name and Description	Parameter Range	Default
SP	Sleep_ (Low Power)	**Cyclic Sleep Period.**<NonBeacon firmware> Set/Read sleep period for cyclic sleeping remotes. Coordinator and End Device SP values should always be equal. To send Direct Messages, set SP = 0. *End Device*- SP determines the sleep period for cyclic sleeping remotes. Maximum sleep period is 268 seconds (0x68B0). *Coordinator*- If non-zero, SP determines the time to hold an indirect message before discarding it. A Coordinator will discard indirect messages after a period of (2.5 * SP).	0 - 0x68B0 [x 10 ms]	0
DP (1.x80*)	Sleep_ (Low Power)	**Disassociated Cyclic Sleep Period.**<NonBeacon firmware> _ *End Device* - Set/Read time period of sleep for cyclic sleeping remotes that are configured for Association but are not associated to a Coordinator. (i.e. If a device is configured to associate, configured as a Cyclic Sleep remote, but does not find a Coordinator, it will sleep for DP time before reattempting association.) Maximum sleep period is 268 seconds (0x68B0). DP should be > 0 for NonBeacon systems.	1 - 0x68B0 [x 10 ms]	0x3E8_ (1000d)

*Firmware version in which the command was first introduced (firmware versions are numbered in hexadecimal notation.)

Commands-Serial Interfacing

AT Command	Command Category	Name and Description	Parameter Range	Default
BD	Serial Interfacing	**Interface Data Rate**. Set/Read the serial interface data rate for communications between the RF module serial port and host. Request non-standard baud rates with values above 0x80 using a terminal window. Read the BD register to find actual baud rate achieved.	0 - 7 (standard baud rates) 0 = 1200 bps 1 = 2400 2 = 4800 3 = 9600 4 = 19200 5 = 38400 6 = 57600 7 = 115200 0x80 - 0x1C200 (non-standard baud rates)	3
RO	Serial Interfacing	**Packetization Timeout**. Set/Read number of character times of inter-character delay required before	0 - 0xFF [x character times]	3

AT Command	Command Category	Name and Description	Parameter Range	Default
		transmission. Set to zero to transmit characters as they arrive instead of buffering them into one RF packet.		
AP (v1.x80*)	Serial _ Interfacing	**API Enable**. Disable/Enable API Mode.	0 - 2 0 = Disabled 1 = API enabled 2 = API enabled (w/escaped control characters)	0
PR (v1.x80*)	Serial _ Interfacing	**Pull-up Resistor Enable**. Set/Read bitfield to configure internal pull-up resistor status for I/O lines Bitfield Map: bit 0 - AD4/DIO4 (pin11) bit 1 - AD3 / DIO3 (pin17) bit 2 - AD2/DIO2 (pin18) bit 3 - AD1/DIO1 (pin19) bit 4 - AD0 / DIO0 (pin20) bit 5 - RTS / AD6 / DIO6 (pin16) bit 6 - DTR / SLEEP_RQ / DI8 (pin9) bit 7 - DIN/CONFIG (pin3) Bit set to "1" specifies pull-up enabled; "0" specifies no pull-up	0 - 0xFF	0xFF

*Firmware version in which the command was first introduced (firmware versions are numbered in hexadecimal notation.)

Commands-I/O Settings (sub category designated within {brackets})

AT_ Command	Command_ Category	Name and Description	Parameter Range	Default
D8	I/O Settings	**DI8 Configuration**. Select/Read options for the DI8 line (pin 9) of the RF module.	0 – 1 0 = Disabled 3 = DI (1,2,4 & 5 n/a)	0
D7 (v1.x80*)	I/O Settings	**DIO7 Configuration**. Select/Read settings for the DIO7 line (pin 12) of the RF module. Options include CTS flow control and I/O line settings.	0 – 1 0 = Disabled 1 = CTS Flow Control 2 = (n/a) 3 = DI 4 = DO low 5 = DO high	1

D6 (v1.x80*)	I/O Settings	**DIO6 Configuration**. Select/Read settings for the DIO6 line (pin 16) of the RF module. Options include RTS flow control and I/O line settings.	0 – 1 0 = Disabled 1 = RTS flow control 2 = (n/a) 3 = DI 4 = DO low 5 = DO high	0
D5 (v1.x80*)	I/O Settings	**DIO5 Configuration**. Configure settings for the DIO5 line (pin 15) of the RF module. Options include Associated LED indicator (blinks when associated) and I/O line settings.	0 – 1 0 = Disabled 1 = Associated indicator 2 = ADC 3 = DI 4 = DO low 5 = DO high	1
D0 - D4 (v1.xA0*)	I/O Settings	**(DIO4 -DIO4) Configuration**. Select/Read settings for the following lines: AD0/DIO0 (pin 20), AD1/DIO1 (pin 19), AD2/DIO2 (pin 18), AD3/DIO3 (pin 17), AD4/DIO4 (pin 11). Options include: Analog-to-digital converter, Digital Input and Digital Output.	0 – 1 0 = Disabled 1 = (n/a) 2 = ADC 3 = DI 4 = DO low 5 = DO high	0
IU (v1.xA0*)	I/O Settings	**I/O Output Enable.**Disables/Enables I/O data received to be sent out UART. The data is sent using an API frame regardless of the current AP parameter value.	0 – 1 0 = Disabled 1 = Enabled	1
IT (v1.xA0*)	I/O Settings	**Samples before TX.**Set/Read the number of samples to collect before transmitting data. Maximum number of samples is dependent upon the number of enabled inputs.	1 - 0xFF	1
IS (v1.xA0*)	I/O Settings	**Force Sample.**Force a read of all enabled inputs (DI or ADC). Data is returned through the UART. If no inputs are defined (DI or ADC), this command will return error.	8-bit bitmap (each bit represents the level of an I/O line setup as an output)	-
IO (v1.xA0*)	I/O Settings	**Digital Output Level.**Set digital output level to allow DIO lines that are setup as outputs to be changed through Command Mode.	-	-
IC (v1.xA0*)	I/O Settings	**DIO Change Detect.**Enables/Disables the monitoring of the change detect feature on DIO lines 0-7. If a change is detected, data is transmitted with DIO data only. Any samples queued and waiting for transmission will be sent first.	0 - 0xFF [bitfield]	0 (disabled)

IR (v1.xA0*)	I/O Settings	**Sample Rate.** Set/Read sample rate. When set, this parameter causes the module to sample all enabled inputs at a specified interval.	0 -0xFFFF [x 1 msec]	0
AV (v1.xA0*)	I/O Settings	**ADC Voltage Reference.** Set/Read ADC reference voltage switch.	0 – 1 0 = VREF pin 1 = Internal	0
IA (v1.xA0*)	I/O Settings {I/O Line Passing}	**I/O Input Address**. Set/Read addresses of module to which outputs are bound. Setting all bytes to 0xFF will not allow any received I/O packet to change outputs. Setting address to 0xFFFF will allow any received I/O packet to change outputs.	0 - 0xFFFFFFFFFFFFFFFF	0xFFFFFFFF FFFFFFFF
T0 - T7 (v1.xA0*)	I/O Settings {I/O Line Passing}	**(D0 - D7) Output Timeout.** Set/Read Output timeout values for lines that correspond with the D0 - D7 parameters. When output is set (due to I/O line passing) to a non-default level, a timer is started which when expired will set the output to it default level. The timer is reset when a valid I/O packet is received.	0 - 0xFF [x 100 ms]	0xFF
P0	I/O Settings {I/O Line Passing}	**PWM0 Configuration**. Select/Read function for PWM0 pin.	0 – 2 0 = Disabled 1 = RSSI 2 = PWM Output	1
P1 (v1.xA0*)	I/O Settings {I/O Line Passing}	**PWM1 Configuration**. Select/Read function for PWM1 pin.	0 – 2 0 = Disabled 1 = RSSI 2 = PWM Output	0
M0 (v1.xA0*)	I/O Settings {I/O Line Passing}	**PWM0 Output Level**. Set/Read the PWM0 output level.	0 - 0x03FF	-
M1 (v1.xA0*)	I/O Settings {I/O Line Passing}	**PWM1 Output Level**. Set/Read the PWM0 output level.	0 - 0x03FF	-
PT (v1.xA0*)	I/O Settings {I/O Line Passing}	**PWM Output Timeout.** Set/Read output timeout value for both PWM outputs. When PWM is set to a non-zero value: Due to I/O line passing, a time is started which when expired will set the PWM output to zero. The timer is reset when a valid I/O packet is received.]	0 - 0xFF [x 100 ms]	0xFF
RP	I/O Settings {I/O Line Passing}	**RSSI PWM Timer.** Set/Read PWM timer register. Set the duration of PWM (pulse width modulation) signal output on the RSSI pin. The signal duty cycle is updated with each received packet and is shut off when the timer expires.]	0 - 0xFF [x 100 ms]	0x28 (40d)

*Firmware version in which the command was first introduced (firmware versions are numbered in hexadecimal notation.)

Commands-Diagnostics

AT_ Command	Command_ Category	Name and Description	Parameter Range	Default
VR	Diagnostics	**Firmware Version**. Read firmware version of the RF module.	0 - 0xFFFF [read-only]	Factory-set
VL (v1.x80*)	Diagnostics	**Firmware Version - Verbose**. Read detailed version information (including application build date, MAC, PHY and bootloader versions).	-	-
HV (v1.x80*)	Diagnostics	**Hardware Version**. Read hardware version of the RF module.	0 - 0xFFFF [read-only]	Factory-set
DB	Diagnostics	**Received Signal Strength**. Read signal level [in dB] of last good packet received (RSSI). Absolute value is reported. (For example: 0x58 = -88 dBm) Reported value is accurate between -40 dBm and RX sensitivity.	0 - 0x64 [read-only]	-
EC (v1.x80*)	Diagnostics	**CCA Failures.**Reset/Read count of CCA (Clear Channel Assessment) failures. This parameter value increments when the module does not transmit a packet because it detected energy above the CCA threshold level set with CA command. This count saturates at its maximum value. Set count to "0" to reset count.	0 - 0xFFFF	-
EA (v1.x80*)	Diagnostics	**ACK Failures**. Reset/Read count of acknowledgment failures. This parameter value increments when the module expires its transmission retries without receiving an ACK on a packet transmission. This count saturates at its maximum value. Set the parameter to "0" to reset count.	0 - 0xFFFF	-
ED (v1.x80*)	Diagnostics	**Energy Scan**. Send 'Energy Detect Scan'. ED parameter determines the length of scan on each channel. The maximal energy on each channel is returned and each value is followed by a carriage return. Values returned represent detected energy levels in units of -dBm. Actual scan time on each channel is measured as Time = [(2 ^ SD) * 15.36] ms. Total scan time is this time multiplied by the number of channels to be scanned.	0 - 6	-

*Firmware version in which the command was first introduced (firmware versions are numbered in hexadecimal notation.)

Commands-AT Command Options

AT_ Command	Command_ Category	Name and Description	Parameter Range	Default
CT	AT Command Mode Options	**Command Mode Timeout.**Set/Read the period of inactivity (no valid commands received) after which the RF module automatically exits AT Command Mode and returns to Idle Mode.	2 - 0xFFFF [x 100 ms]	0x64 (100d)
CN	AT Command Mode Options	**Exit Command Mode**. Explicitly exit the module from AT Command Mode.	--	--
AC (v1.xA0*)	AT Command Mode Options	**Apply Changes**. Explicitly apply changes to queued parameter value(s) and re-initialize module.	--	--
GT	AT Command Mode Options	**Guard Times**. Set required period of silence before and after the Command Sequence Characters of the AT Command Mode Sequence (GT+ CC + GT). The period of silence is used to prevent inadvertent entrance into AT Command Mode.	2 - 0x0CE4 [x 1 ms]	0x3E8 (1000d)
CC	AT Command Mode Options	**Command Sequence Character**. Set/Read the ASCII character value to be used between Guard Times of the AT Command Mode Sequence (GT+CC+GT). The AT Command Mode Sequence enters the RF module into AT Command Mode.	0 - 0xFF	0x2B ('+' ASCII)

*Firmware version in which the command was first introduced (firmware versions are numbered in hexadecimal notation.)

Command Descriptions

Command descriptions in this section are listed alphabetically. Command categories are designated within "< >" symbols that follow each command title. Zlinx Radio Modems expect parameter values in hexadecimal (designated by the "0x" prefix). All modules operating within the same network should contain the same firmware version.

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B&B Electronics Mfg Co Inc – 707 Dayton Rd - PO Box 1040 - Ottawa IL 61350 - Ph 815-433-5100 - Fax 815-433-5104 – *www.bb-elec.com*
B&B Electronics – Westlink Commercial Park – Oranmore, Galway, Ireland – Ph +353 91-792444 – Fax +353 91-792445 – *www.bb-europe.com*

A1 (End Device Association) Command
<Networking {Association}> The A1 command is used to set and read association options for an End Device.

Use the table below to determine End Device behavior in relation to the A1 parameter.

AT Command: ATA1

Parameter Range: 0 - 0x0F [bitfield]

Default Parameter Value: 0

Related Commands: ID (PAN ID), NI (Node Identifier), CH (Channel), CE (Coordinator Enable), A2 (Coordinator Association)

Minimum Firmware Version Required: v1.x80

Bit number	End Device Association Option
0 - ReassignPanID	0 - Will only associate with Coordinator operating on PAN ID that matches Node Identifier
	1 - May associate with Coordinator operating on any PAN ID
1 - ReassignChannel	0 - Will only associate with Coordinator operating on Channel that matches CH setting
	1 - May associate with Coordinator operating on any Channel
2 - AutoAssociate	0 - Device will not attempt Association
	1 - Device attempts Association until success_ Note: This bit is used only for Non-Beacon systems. End Devices in a Beaconing system must always associate to a Coordinator
3 - PollCoordOnPinWake	0 - Pin Wake will not poll the Coordinator for pending (indirect) Data
	1 - Pin Wake will send Poll Request to Coordinator to extract any pending data
4 - 7	[reserved]

A2 (Coordinator Association) Command
<Networking {Association}> The A2 command is used to set and read association options of the Coordinator.

Use the table below to determine Coordinator behavior in relation to the A2 parameter.

AT Command: ATA2

Parameter Range: 0 - 7 [bitfield]

Default Parameter Value: 0

Related Commands: ID (PAN ID), NI (Node Identifier), CH (Channel), CE (Coordinator Enable), A1 (End Device Association), AS Active Scan), ED (Energy Scan)

Minimum Firmware Version Required: v1.x80

Bit number	End Device Association Option
0 - ReassignPanID	0 - Coordinator will not perform Active Scan to locate available PAN ID. It will operate on ID (PAN ID).
	1 - Coordinator will perform Active Scan to determine an available ID (PAN ID). If a PAN ID conflict is found, the ID parameter will change.
1 - ReassignChannel	0 - Coordinator will not perform Energy Scan to determine free channel. It will operate on the channel determined by the CH parameter.
	1 - Coordinator will perform Energy Scan to find a free channel, then operate on that channel.
2 -AllowAssociate	0 - Coordinator will not allow any devices to associate to it.
	1 - Coordinator will allow devices to associate to it.
3 - 7	[reserved]

AC (Apply Changes) Command

<AT Command Mode Options> The AC command is used to explicitly apply changes to module parameter values. 'Applying changes' means that the module is re-initialized based on changes made to its parameter values. Once changes are applied, the module immediately operates according to the new parameter values.

AT Command: ATAC

Minimum Firmware Version Required: v1.xA0

This behavior is in contrast to issuing the WR (Write) command. The WR command saves parameter values to non-volatile memory, but the module still operates according to previously saved values until the module is re-booted or the CN (Exit AT Command Mode) command is issued.

Refer to the "AT Command - Queue Parameter Value" API type for more information.

AI (Association Indication) Command

<Networking {Association}> The AI command is used to indicate occurrences of errors during the last association request.

Use the table below to determine meaning of the returned values.

AT Command: ATAI
Parameter Range: 0 - 0x13
[read-only]
Related Commands: AS (Active Scan), ID (PAN ID), CH (Channel), ED (Energy Scan), A1 (End Device Association), A2 (Coordinator Association), CE (Coordinator Enable)
Minimum Firmware Version Required: v1.x80

Returned Value (Hex)	Association Indication
0x00	Successful Completion - Coordinator successfully started or End Device association complete
0x01	Active Scan Timeout
0x02	Active Scan found no PANs
0x03	Active Scan found PAN, but the Coordinator Allow Association bit is not set
0x04	Active Scan found PAN, but Coordinator and End Device are not configured to support beacons
0x05	Active Scan found PAN, but Coordinator ID (PAN ID) value does not match the ID of the End Device
0x06	Active Scan found PAN, but Coordinator CH (Channel) value does not match the CH of the End Device
0x07	Energy Scan Timeout
0x08	Coordinator start request failed
0x09	Coordinator could not start due to Invalid Parameter
0x0A	Coordinator Realignment is in progress
0x0B	Association Request not sent
0x0C	Association Request timed out - no reply was received
0x0D	Association Request had an Invalid Parameter
0x0E	Association Request Channel Access Failure - Request was not transmitted - CCA failure
0x0F	Remote Coordinator did not send an ACK after Association Request was sent
0x10	Remote Coordinator did not reply to the Association Request, but an ACK was received _ after sending the request
0x11	[reserved]
0x12	Sync-Loss - Lost synchronization with a Beaconing Coordinator
0x13	Disassociated - No longer associated to Coordinator

AP (API Enable) Command

<Serial Interfacing> The AP command is used to
enable the RF module to operate using a framebased
API instead of using the default Transparent
(UART) mode.

AT Command: ATAP

Parameter Range:0 - 2

Parameter	Configuration
0	Disabled (Transparent operation)
1	API enabled
2	API enabled (with escaped characters)

Default Parameter Value:0

Minimum Firmware Version Required: v1.x80

Refer to the API Operation section when API operation is enabled
(AP = 1 or 2).

AS (Active Scan) Command

<AT Command Mode Options> The AS command is used to send a Beacon Request to a Broadcast Address (0xFFFF) and Broadcast PAN (0xFFFF) on every channel. The parameter determines the amount of time the RF module will listen for Beacons on each channel. A 'PanDescriptor' is created and returned for every Beacon received from the scan. Each PanDescriptor contains the following information:

AT Command: ATAS	
Parameter Range: 0 - 6	
Related Command: SD (Scan Duration), DL (Destination Low Address), DH (Destination High Address), ID (PAN ID), CH (Channel)	
Minimum Firmware Version Required: v1.x80	

CoordAddress (SH + SL parameters)<CR>
CoordPanID (ID parameter)<CR>
CoordAddrMode <CR>
0x02 = 16-bit Short Address
0x03 = 64-bit Long Address
Channel (CH parameter) <CR>
SecurityUse<CR>
ACLEntry<CR>
SecurityFailure<CR>
SuperFrameSpec<CR> (2 bytes):
bit 15 - Association Permitted (MSB)
bit 14 - PAN Coordinator
bit 13 - Reserved
bit 12 - Battery Life Extension
bits 8-11 - Final CAP Slot
bits 4-7 - Superframe Order
bits 0-3 - Beacon Order
GtsPermit<CR>
RSSI<CR> (- RSSI is returned as -dBm)
TimeStamp<CR> (3 bytes)
<CR> (A carriage return <CR> is sent at the end of the AS command.

The Active Scan is capable of returning up to 5 PanDescriptors in a scan. The actual scan time on each channel is measured as Time = [(2 ^ (SD Parameter)) * 15.36] ms. Total scan time is this time multiplied by the number of channels to be scanned.

NOTE: Refer the scan table in the SD description to determine scan times. If using API Mode, no <CR>'s are returned in the response. Refer to the API Mode Operation section.

AV (ADC Voltage Reference) Command

<Serial Interfacing> The AV command is used to set/read the ADC reference voltage switch.

AT Command: ATAV

Parameter Range:0 - 1

Parameter	Configuration
0	VREF Pin
1	Internal (on-board reference - VCC)

Default Parameter Value:0

BD (Interface Data Rate) Command

<Serial Interfacing> The BD command is used to set and read the serial interface data rate usedbetween the RF module and host. This parameterdetermines the rate at which serial data is sent to the module from the host. Modified interface data rates do not take effect until the CN (Exit AT Command Mode) command is issued and the system returns the 'OK' response.

When parameters 0-7 are sent to the module, the respective interface data rates are used (as shown in the table on the right).

The RF data rate is not affected by the BD parameter. If the interface data rate is set higher than the RF data rate, a flow control configuration may need to be implemented.

AT Command: ATBD

Minimum Firmware Version: 7 (standard rates) 0x80-0x1C200 (non-stndard rates)

Parameter Range:0 - 7(standard rates) 0x80-0x1C200 (non-stndard rates)

Parameter	Configuration (bps)
0	1200
1	2400
2	4800
3	9600
4	19200
5	38400
6	57600
7	115200

Default Parameter Value:3

Non-standard Interface Data Rates:

Any value above 0x07 will be interpreted as an actual baud rate. When a value above 0x07 is sent, the closest interface data rate represented by the number is stored in the BD register. For example, a rate of 19200 bps can be set by sending the following command line "ATBD4B00".

When the BD command is sent with a non-standard interface data rate, the UART will adjust to accommodate the requested interface rate. In most cases, the clock resolution will cause the stored BD parameter to vary from the parameter that was sent (refer to the table below). Reading the BD command (send "ATBD" command without an associated parameter value) will return the value actually stored in the module's BD register.

Parameters Sent Versus Parameters Stored

BD Parameter Sent (HEX)	Interface Data Rate (bps)	BD Parameter Stored (HEX)
0	1200	0
4	19,200	4
7	115,200	7
12C	300	12B
1C200	115,200	1B207

CA (CCA Threshold) Command
<RF Interfacing> CA command is used to set and read CCA (Clear Channel Assessment) thresholds.

Prior to transmitting a packet, a CCA is performed to detect energy on the transmit channel. If the detected energy is above the CCA Threshold, the RF module will not transmit the packet.

AT Command: ATCA	
Parameter Range: 0 - 0x50 [-dBm]	
Default Parameter Value: 0x2C □(-44 decimal dBm)	
Minimum Firmware Version Required: v1.x80	

CC (Command Sequence Character) Command
<AT Command Mode Options> The CC command is used to set and read the ASCII character used between guard times of the AT Command Mode

AT Command: ATCC	
Parameter Range: 0 - 0xFF	
Default Parameter Value: 0x2B (ASCII "+")	
Related Command: GT (Guard Times)	

Sequence (GT + CC + GT). This sequence enters the RF module into AT Command Mode so that data entering the module from the host is recognized as commands instead of payload.

The AT Command Sequence is explained further in the AT Command Mode section.

CE (Coordinator Enable) Command
<Serial Interfacing> The CE command is used to set and read the behavior (End Device vs. Coordinator) of the RF module.

AT Command: ATCE

Parameter Range:0 - 1

Parameter	Configuration
0	End Device
1	Coordinator

Default Parameter Value:0

Minimum Firmware Version Required: v1.x80

CH (Channel) Command

<Networking {Addressing}> The CH command is used to set/read the operating channel on which RF connections are made between RF modules. The channel is one of three addressing options available to the module. The other options are the PAN ID (ID command) and destination addresses (DL & DH commands).

AT Command: ATCH

Parameter Range: 0x0B - 0x1A

Default Parameter Value: 0x0C (12 decimal)

Related Commands: ID (PAN ID), DL (Destination Address Low, DH (Destination Address High)

In order for modules to communicate with each other, the modules must share the same channel number. Different channels can be used to prevent modules in one network from listening to transmissions of another. Adjacent channel rejection is 23 dB.

The module uses channel numbers of the 802.15.4 standard.
   Center Frequency = 2.405 + (CH - 11d) * 5 MHz   (d = decimal)

CN (Exit Command Mode) Command

<AT Command Mode Options> The CN command is used to explicitly exit the RF module from AT Command Mode.

AT Command: ATCN

CT (Command Mode Timeout) Command

<AT Command Mode Options> The CT command is used to set and read the amount of inactive time that elapses before the RF module automatically exits from AT Command Mode and returns to Idle Mode.

Use the CN (Exit Command Mode) command to exit AT Command Mode manually.

AT Command: ATCT

Parameter Range:2 - 0xFFFF [x 100 milliseconds]

Default Parameter Value: 0x64 (100 decimal (which equals 10 decimal seconds))

Number of bytes returned: 2

Related Command: CN (Exit Command Mode)

D0 - D4 (DIOn Configuration) Commands
<I/O Settings> The D0, D1, D2, D3 and D4 commands are used to select/read the behavior of their respective AD/DIO lines (pins 20, 19, 18, 17 and 11 respectively). Options include:
- Analog-to-digital converter
- Digital input
- Digital output

AT Commands: _ ATD0, ATD1, ATD2, ATD3, ATD4

Parameter Range:0 - 5

Parameter	Configuration
0	Disabled
1	n/a
2	ADC
3	DI
4	DO low
5	DO high

Default Parameter Value:0

Minimum Firmware Version Required: 1.x.A0

D5 (DIO5 Configuration) Command
<I/O Settings> The D5 command is used to select/read the behavior of the DIO5 line (pin 15). Options include:
- Associated Indicator (LED blinks when the module is associated)
- Analog-to-digital converter
- Digital input
- Digital output

AT Command: ATD5

Parameter Range:0 - 5

Parameter	Configuration
0	Disabled
1	Associated Indicator
2	ADC
3	DI
4	DO low
5	DO high

Default Parameter Value:1

Parameters 2-5 supported as of firmware version 1.xA0

D6 (DIO6 Configuration) Command
<I/O Settings> The D6 command is used to select/read the behavior of the DIO6 line (pin 16).
Options include:
- RTS flow control
- Analog-to-digital converter
- Digital input
- Digital output

AT Command: ATD6

Parameter Range:0 - 5

Parameter	Configuration
0	Disabled
1	RTS Flow Control
2	n/a
3	DI
4	DO low
5	DO high

Default Parameter Value:0

Parameters 3-5 supported as of firmware version 1.xA0

D7 (DIO7 Configuration) Command
<I/O Settings> The D7 command is used to select/read the behavior of the DIO7 line (pin 12).
Options include:
- CTS flow control
- Analog-to-digital converter
- Digital input
- Digital output

AT Command: ATD7

Parameter Range:0 - 5

Parameter	Configuration
0	Disabled
1	CTS Flow Control
2	n/a
3	DI
4	DO low
5	DO high

Default Parameter Value:1

Parameters 3-5 supported as of firmware version 1.x.A0

D8 (DI8 Configuration) Command
<I/O Settings> The D8 command is used to select/read the behavior of the DI8 line (pin 9).
This command enables configuring the pin to function as a digital input. This line is also used with Pin Sleep.

AT Command: ATD8

Parameter Range:0 - 5 _ (1, 2, 4 & 5 n/a)

Parameter	Configuration
0	Disabled
3	DI

Default Parameter Value:0

Minimum Firmware Version Required: 1.xA0

DA (Force Disassociation) Command

<(Special)> The DA command is used to immediately disassociate an End Device from a Coordinator and reattempt to associate.

AT Command: ATDA

Minimum Firmware Version Required: v1.x80

DB (Received Signal Strength) Command

<Diagnostics> DB parameter is used to read the received signal strength (in dBm) of the last RF packet received. Reported values are accurate between -40 dBm and the RF module's receiver sensitivity.

AT Command: ATDB

Parameter Range: 0 - 0x64 [read-only]

Absolute values are reported. For example: 0x58 = -88 dBm (decimal). If no packets have been received (since last reset, power cycle or sleep event), "0" will be reported.

DH (Destination Address High) Command

<Networking {Addressing}> The DH command is used to set and read the upper 32 bits of the RF module's 64-bit destination address. When combined with the DL (Destination Address Low) parameter, it defines the destination address used for transmission.

AT Command: ATDH

Parameter Range: 0 - 0xFFFFFFFF

Default Parameter Value: 0

Related Commands: DL (Destination Address Low), CH (Channel), ID (PAN VID), MY (Source Address)

An module will only communicate with other modules having the same channel (CH parameter), PAN ID (ID parameter) and destination address (DH + DL parameters).

To transmit using a 16-bit address, set the DH parameter to zero and the DL parameter less than 0xFFFF. 0x000000000000FFFF (DL concatenated to DH) is the broadcast address for the PAN.

DL (Destination Address Low) Command

<Networking {Addressing}> The DL command is used to set and read the lower 32 bits of the RF module's 64-bit destination address. When combined with the DH (Destination Address High) parameter, it defines the destination address used for transmission.

AT Command: ATDL

Parameter Range: 0 - 0xFFFFFFFF

Default Parameter Value: 0

Related Commands: DH (Destination Address High), CH (Channel), ID (PAN VID), MY (Source Address)

A module will only communicate with other modules having the same channel (CH parameter), PAN ID (ID parameter) and destination address (DH + DL parameters).

To transmit using a 16-bit address, set the DH parameter to zero and the DL parameter less than 0xFFFF. 0x000000000000FFFF (DL concatenated to DH) is the broadcast address for the PAN.

DN (Destination Node) Command

<Networking {Identification}> The DN command is used to resolve a NI (Node Identifier) string to a physical address. The following events occur upon successful command execution:

AT Command: ATDN

Parameter Range: 20-character ASCII String

Minimum Firmware Version Required: v1.x80

1. DL and DH are set to the address of the module with the matching NI (Node Identifier).
2. 'OK' is returned.
3. RF module automatically exits AT Command Mode.

If there is no response from a modem within 200 msec or a parameter is not specified (left blank), the command is terminated and an 'ERROR' message is returned.

DP (Disassociation Cyclic Sleep Period) Command

<Sleep Mode (Low Power)>

AT Command: ATDP

Parameter Range: 1 - 0x68B0 _ [x 10 milliseconds]

NonBeacon Firmware
End Device - The DP command is used to set and read the time period of sleep for cyclic sleeping remotes that are configured for Association but are not associated to a Coordinator. (i.e. If a device is configured to associate,

Default Parameter Value:0x3E8_ (1000 decimal)

Related Commands: SM (Sleep Mode), SP (Cyclic Sleep Period), ST (Time before Sleep)

Minimum Firmware Version Required: v1.x80

configured as a Cyclic Sleep remote, but does not find a Coordinator; it will sleep for DP time before reattempting association.) Maximum sleep period is 268 seconds (0x68B0). DP should be > 0 for NonBeacon systems.

EA (ACK Failures) Command

<Diagnostics> The EA command is used to reset and read the count of ACK (acknowledgement) failures. This parameter value increments when the module

AT Command: ATEA

Parameter Range:0 - 0xFFFF

Minimum Firmware Version Required: v1.x80

expires its transmission retries without receiving an ACK on a packet transmission. This count saturates at its maximum value.

Set the parameter to "0" to reset count.

EC (CCA Failures) Command

<Diagnostics> The EC command is used to read and reset the count of CCA (Clear Channel Assessment) failures. This parameter value increments when the RF module does not transmit a packet due to the detection of

AT Command: ATEC

Parameter Range:0 - 0xFFFF

Related Command: CA (CCA Threshold)

Minimum Firmware Version Required: v1.x80

energy that is above the CCA threshold level (set with CA command).
This count saturates at its maximum value.
Set the EC parameter to "0" to reset count.

ED (Energy Scan) Command

<Networking {Association}> The ED command is used to send an "Energy Detect Scan". This parameter determines the length of scan on each channel. The maximal energy on each channel is returned and each value is followed by a carriage return. An additional carriage return is sent at the end of the command.

AT Command: ATED	
Parameter Range:0 - 6	
Related Command: SD (Scan Duration), SC (Scan Channel)	
Minimum Firmware Version Required: v1.x80	

The values returned represent the detected energy level in units of -dBm. The actual scan time on each channel is measured as Time = [(2 ^ ED PARAM) * 15.36] ms.

Note: Total scan time is this time multiplied by the number of channels to be scanned. Also refer to the SD (Scan Duration) table. Use the SC (Scan Channel) command to choose which channels to scan.

EE (AES Encryption Enable) Command

<Networking {Security}> The EE command is used to set/read the parameter that disables/enables 128-bit AES encryption.

The Zlinx firmware uses the 802.15.4 Default Security protocol and uses AES encryption with a 128-bit key. AES encryption dictates that all modules in the network use the same key and the maximum RF packet size is 95 Bytes.

AT Command: ATEE

Parameter Range:0 - 1

Parameter	Configuration
0	Disabled
1	Enabled

Default Parameter Value:0

Related Commands: KY (Encryption Key), AP (API Enable), MM (MAC Mode)

Minimum Firmware Version Required: v1.xA0

When encryption is enabled, the module will always use its 64-bit long address as the source address for RF packets. This does not affect how the MY (Source Address), DH (Destination Address High) and DL (Destination Address Low) parameters work

If MM (MAC Mode) > 0 and AP (API Enable) parameter > 0:
With encryption enabled and a 16-bit short address set, receiving modules will only be able to issue RX (Receive) 64-bit indicators. This is not an issue when MM = 0.

If a module with a non-matching key detects RF data, but has an incorrect key: When encryption is enabled, non-encrypted RF packets received will be rejected and will not be sent out the UART.

Transparent Operation --> All RF packets are sent encrypted if the key is set.

API Operation --> Receive frames use an option bit to indicate that the packet was encrypted.

FP (Force Poll) Command
<Networking (Association)> The FP command is used to request indirect messages being held by a Coordinator.

AT Command: ATFP

Minimum Firmware Version Required: v1.x80

FR (Software Reset) Command
<Special> The FR command is used to force a software reset on the RF module. The reset simulates powering off and then on again the module.

AT Command: ATFR

Minimum Firmware Version Required: v1.x80

GT (Guard Times) Command
<AT Command Mode Options> GT Command is used to set the DI (data in from host) time-of-silence that surrounds the AT command sequence character (CC Command) of the AT Command Mode sequence (GT + CC + GT).

The DI time-of-silence is used to prevent inadvertent entrance into AT Command Mode.

AT Command: ATGT

Parameter Range:2 - 0x0CE4 [x 1 millisecond]

Default Parameter Value:0x3E8 _ (1000 decimal)

Related Command: CC (Command Sequence Character)

Refer to the Command Mode section for more information regarding the AT Command Mode Sequence.

HV (Hardware Version) Command
<Diagnostics> The HV command is used to read the hardware version of the RF module.

AT Command: ATHV

Parameter Range:0 - 0xFFFF [Read-only]

Minimum Firmware Version Required: v1.x80

IA (I/O Input Address) Command
<I/O Settings {I/O Line Passing}> The IA command is used to bind a module output to a specific address. Outputs will only change if received from this address. The IA command can be used to set/read both 16 and 64-bit addresses.

AT Command: ATIA

Parameter Range:0 - 0xFFFFFFFFFFFFFFFF

Default Parameter Value:0xFFFFFFFFFFFFFFFF_ (will not allow any received I/O packet to change outputs)

Minimum Firmware Version Required: v1.xA0

Setting all bytes to 0xFF will not allow the reception of any I/O packet to change outputs. Setting the IA address to 0xFFFF will cause the module to accept all I/O packets.

IC (DIO Change Detect) Command

<I/O Settings> The IC command is used to enable the monitoring of the change detect feature on DIO lines 0-7. If a change is detected, data is transmitted with DIO data only. Any samples queued and waiting for transmission are sent first.

AT Command: ATIC
Parameter Range:0 - 0xFF [bitfield]
Default Parameter Value:0 (disabled)
Minimum Firmware Version Required: 1.xA0

Refer to the "ADC and Digital I/O Line Support" sections of the "RF Module Operations" chapter for more information.

ID (Pan ID) Command

<Networking {Addressing}> The ID command is used to set and read the PAN (Personal Area Network) ID of the RF module. Only modules with matching PAN IDs can communicate with each other. Unique PAN IDs enable control of which RF packets are received by a module.

AT Command: ATID
Parameter Range: 0 - 0xFFFF
Default Parameter Value:0x3332 (13106 decimal)

Setting the ID parameter to 0xFFFF indicates a global transmission for all PANs. It does not indicate a global receive.

IO (Digital Output Level) Command

<I/O Settings> The IO command is used to set digital output levels. This allows DIO lines setup as outputs to be changed through Command Mode.

AT Command: ATIO
Parameter Range: 8-bit bitmap _ (where each bit represents the level of an I/O line that is setup as an output.)
Minimum Firmware Version Required: v1.xA0

IR (Sample Rate) Command

<I/O Settings> The IR command is used to set/read the sample rate. When set, the module will sample all enabled DIO/ADC lines at a specified interval. This command allows periodic reads of the ADC and DIO lines in a non-Sleep Mode setup.

AT Command: ATIR
Parameter Range: 0 - 0xFFFF [x 1 msec]_ (cannot guarantee 1 ms timing when IT=1)
Default Parameter Value:0
Related Command: IT (Samples before TX)
Minimum Firmware Version Required: v1.xA0

Example: When IR = 0x0A, the sample rate is 10 ms (or 100 Hz).

IS (Force Sample) Command

<I/O Settings> The IS command is used to force a read of all enabled DIO/ADC lines. The data is returned through the UART. When operating in Transparent Mode (AP=0), the data is retuned in the following format:

AT Command: ATIS
Parameter Range: 1 - 0xFF
Default Parameter Value:1
Minimum Firmware Version Required: v1.xA0

All bytes are converted to ASCII:
number of samples<CR>
channel mask<CR>
DIO data<CR> (If DIO lines are enabled<CR>
ADC channel Data<cr> <-This will repeat for every enabled ADC channel<CR>
<CR> (end of data noted by extra <CR>)

When operating in API mode (AP > 0), the command will immediately return an 'OK' response. The data will follow in the normal API format for DIO data.

IT (Samples before TX) Command

<I/O Settings> The IT command is used to set/read the number of DIO and ADC samples to collect before transmitting data.

AT Command: ATIT
Parameter Range: 1 - 0xFF
Default Parameter Value:1
Minimum Firmware Version Required: v1.xA0

One ADC sample is considered complete when all enabled ADC channels have been read. The module can buffer up to 93 Bytes of sample data. Since the module uses a 10-bit A/D converter, each sample uses two Bytes. This leads to a maximum buffer size of 46 samples or IT=0x2E.

When Sleep Modes are enabled and IR (Sample Rate) is set, the module will remain awake until IT samples have been collected.

IU (I/O Output Enable) Command

<I/O Settings> The IU command is used to disable/enable I/O UART output. When enabled (IU = 1), received I/O line data packets are sent out the UART. The data is sent using an API frame regardless of the current AP parameter value.

AT Command: ATIU	
Parameter Range:0 - 1	
Parameter	Configuration
0	Disabled -Received I/O line data packets will NOT sent out UART.
1	Enabled -Received I/O line data will be sent out UART
Default Parameter Value:1	
Minimum Firmware Version Required: 1.xA0	

KY (AES Encryption Key) Command

<Networking {Security}> The KY command is used to set the 128-bit AES (Advanced Encryption Standard) key for encrypting/decrypting data. Once set, the key cannot be read out of the module by any means.

AT Command: ATKY
Parameter Range:0 - (any 16-Byte value)
Default Parameter Value:0
Related Command: EE (Encryption Enable)
Minimum Firmware Version Required: v1.xA0

The entire payload of the packet is encrypted using the key and the CRC is computed across the ciphertext. When encryption is enabled, each packet carries an additional 16 Bytes to convey the random CBC Initialization Vector (IV) to the receiver(s). The KY value may be "0" or any 128-bit value. Any other value, including entering ATKY by itself with no parameters, will cause an error. A module with the wrong key (or no key) will receive encrypted data, but the data driven out the serial port will be meaningless. Likewise, a module with a key will receive unencrypted data sent from a module without a key, but the output will be meaningless. Because CBC mode is utilized, repetitive data appears differently in different transmissions due to the randomly-generated IV.

When queried, the system will return an 'OK' message and the value of the key will not be returned.

M0 (PWM0 Output Level) Command
<I/O Settings> The M0 command is used to set/read the output level of the PWM0 line (pin 6).

Before setting the line as an output:
1. Enable PWM0 output (P0 = 2)
2. Apply settings (use CN or AC)

AT Command: ATM0

Parameter Range:0 - 0x03FF [steps]

Default Parameter Value:0

Related Commands: P0 (PWM0 Enable), AC (Apply Changes), CN (Exit Command Mode)

Minimum Firmware Version Required: v1.xA0

The PWM period is 64 μsec and there are 0x03FF (1023 decimal) steps within this period. When M0 = 0 (0% PWM), 0x01FF (50% PWM), 0x03FF (100% PWM), etc.

M1 (PWM1 Output Level) Command
<I/O Settings> The M1 command is used to set/read the output level of the PWM1 line (pin 7).

Before setting the line as an output:
1. Enable PWM1 output (P1 = 2)
2. Apply settings (use CN or AC)

AT Command: ATM1

Parameter Range:0 - 0x03FF

Default Parameter Value:0

Related Commands: P1 (PWM1 Enable), AC (Apply Changes), CN (Exit Command Mode)

Minimum Firmware Version Required: v1.xA0

MM (MAC Mode) Command

<Networking {Addressing}> The MM command is used to set and read the MAC Mode value. The MM command disables/enables the use of a Max-Stream header contained in the 802.15.4 RF packet. By default (MM = 0), B&B Mode is enabled and the module adds an extra header to the data portion of the 802.15.4 packet. This enables the following features:

- ND and DN command support
- Duplicate packet detection when using ACKs

The MM command allows users to turn off the use of the extra header. Modes 1 and 2 are strict 802.15.4 modes. If the B&B header is disabled, ND and DN parameters are also disabled.

Note: When MM > 0, application and CCA failure retries are not supported.

AT Command: ATMM

Parameter Range:0 - 2

Parameter	Configuration
0	B&B Mode (802.15.4 + B&B header)
1	802.15.4 (no ACKs)
2	802.15.4 (with ACKs)

Default Parameter Value:0

Related Commands: ND (Node Discover), DN (Destination Node)

Minimum Firmware Version Required: v1.x80

MY (16-bit Source Address) Command

<Networking {Addressing}> The MY command is used to set and read the 16-bit source address of the RF module.

By setting MY to 0xFFFF, the reception of RF packets having a 16-bit address is disabled. The 64-bit address is the module's serial number and is always enabled.

AT Command: ATMY

Parameter Range: 0 - 0xFFFF

Default Parameter Value: 0

Related Commands: DH (Destination Address High), DL (Destination Address Low), CH (Channel), ID (PAN ID)

ND (Node Discover) Command

<Networking {Identification}> The ND command is used to discover and report all modules on its current operating channel (CH parameter) and PAN ID (ID parameter). ND also accepts an NI (Node Identifier) value as a parameter. In this case, only a module matching the supplied identifier will respond.

AT Command: ATND

Range: optional 20-character NI value

Related Commands: CH (Channel), ID (Pan ID), MY (Source Address), SH (Serial Number High), SL (Serial Number Low), NI (Node Identifier), NT (Node Discover Time)

Minimum Firmware Version Required: v1.x80

ND uses a 64-bit long address when sending and responding to an ND request. The ND command causes a module to transmit a globally addressed ND command packet. The amount of time allowed for responses is determined by the NT (Node Discover Time) parameter.

In AT Command mode, command completion is designated by a carriage return (0x0D). Since two carriage returns end a command response, the application will

receive three carriage returns at the end of the command. If no responses are received, the application should only receive one carriage return. When in API mode, the application should receive a frame (with no data) and status (set to 'OK') at the end of the command. When the ND command packet is received, the remote sets up a random time delay (up to 2.2 sec) before replying as follows:

Node Discover Response (AT command mode format - Transparent operation):
MY (Source Address) value<CR>
SH (Serial Number High) value<CR>
SL (Serial Number Low) value<CR>
DB (Received Signal Strength) value<CR>
NI (Node Identifier) value<CR>
<CR> (This is part of the response and not the end of command indicator.)

Node Discover Response (API format - data is binary (except for NI)):
2 bytes for MY (Source Address) value
4 bytes for SH (Serial Number High) value
4 bytes for SL (Serial Number Low) value
1 byte for DB (Received Signal Strength) value
NULL-terminated string for NI (Node Identifier) value (max 20 bytes w/out NULL terminator)

NI (Node Identifier) Command
<Networking {Identification}> The NI command is used to set and read a string for identifying a particular node.

Rules:
- Register only accepts printable ASCII data.
- A string can not start with a space.
- A carriage return ends command
- Command will automatically end when maximum bytes for the string have been entered.

AT Command: ATNI	
Parameter Range: 20-character ASCII string	
Related Commands: ND (Node Discover), DN (Destination Node)	
Minimum Firmware Version Required: v1.x80	

This string is returned as part of the ND (Node Discover) command. This identifier is also used with the DN (Destination Node) command.

NT (Node Discover Time) Command
<Networking {Identification}> The NT command is used to set the amount of time a base node will wait for responses from other nodes when using the ND (Node Discover) command. The NT value is transmitted with the ND command.

AT Command: ATNT	
Parameter Range: 0x01 - 0xFC [x 100 msec]	
Default: 0x19 (2.5 decimal seconds)	
Related Commands: ND (Node Discover)	
Minimum Firmware Version Required: 1.xA0	

Remote nodes will set up a random hold-off time based on this time. The remotes will adjust this time down by 250 ms to give each node the ability to respond before the base ends the command. Once the ND command has ended, any response received on the base would be discarded.

P0 (PWM0 Configuration) Command

<I/O Setting {I/O Line Passing}>
The P0 command is used to select/read the function for PWM0 (Pulse Width Modulation output 0). This command enables the option of translating incoming data to a PWM so that the output can be translated back into analog form.

With the IA (I/O Input Address) parameter correctly set, AD0 values can automatically be passed to PWM0.

AT Command: ATP0_ The second character in the command is the number zero ("0"), not the letter "O".

Parameter Range: 0 - 2

Parameter	Configuration
0	Disabled
1	RSSI
2	PWM0 Output

Default Parameter Value: 1

P1 (PWM1 Configuration) Command

<I/O Setting {I/O Line Passing}>
The P1 command is used to select/read the function for PWM1 (Pulse Width Modulation output 1). This command enables the option of translating incoming data to a PWM so that the output can be translated back into analog form.

With the IA (I/O Input Address) parameter correctly set, AD1 values can automatically be passed to PWM1.

AT Command: ATP1

Parameter Range: 0 - 2

Parameter	Configuration
0	Disabled
1	RSSI
2	PWM1 Output

Default Parameter Value: 0

Minimum Firmware Version Required: v1.xA0

PL (Power Level) Command

<RF Interfacing> The PL command is used to select and read the power level at which the RF module transmits conducted power.

WHEN OPERATING IN EUROPE: modem must be configured to operate at a maximum transmit power output level of 10 dBm. The PL parameter must equal "0" (10 dBm).

AT Command: ATPL

Parameter Range: 0 - 4

Parameter		
0	-10 dBm	10 dBm
1	-6 dBm	12 dBm
2	-4 dBm	14 dBm
3	-2 dBm	16 dBm
4	0 dBm	18 dBm

Default Parameter Value: 4

Additionally, European regulations stipulate an EIRP power maximum of 12.86 dBm (19 mW) for the modem and 12.11 dBm for the modem when integrating high-gain antennas.

PR (Pull-up Resistor Enable) Command

<Serial Interfacing> The PR command is used to set and read the bit field that is used to configure internal the pull-up resistor status for I/O lines. "1" specifies the pull-up resistor is enabled. "0" specifies no pull up.

AT Command: ATPR	
Parameter Range: 0 - 0xFF	
Default Parameter Value: 0xFF _ (all pull-up resistors are enabled)	
Minimum Firmware Version Required: v1.x80	

  bit 0 - AD4/DIO4 (pin 11)
  bit 1 - AD3/DIO3 (pin 17)
  bit 2 - AD2/DIO2 (pin 18)
  bit 3 - AD1/DIO1 (pin 19)
  bit 4 - AD0/DIO0 (pin 20)
  bit 5 - AD6/DIO6 (pin 16)
  bit 6 - DI8 (pin 9)
  bit 7 - DIN/CONFIG (pin 3)

For example: Sending the command "ATPR 6F" will turn bits 0, 1, 2, 3, 5 and 6 ON; and bits 4 & 7 will be turned OFF. (The binary equivalent of "0x6F" is "01101111". Note that 'bit 0' is the last digit in the bitfield.

PT (PWM Output Timeout) Command

<I/O Settings {I/O Line Passing}> The PT command is used to set/read the output timeout value for both PWM outputs.

AT Command: ATPT
Parameter Range: 0 - 0xFF [x 100 msec]
Default Parameter Value: 0xFF
Minimum Firmware Version Required: 1.xA0

When PWM is set to a non-zero value: Due to I/O line passing, a time is started which when expired will set the PWM output to zero. The timer is reset when a valid I/O packet is received.

RE (Restore Defaults) Command

AT Command: ATRE

<(Special)> The RE command is used to restore all configurable parameters to their factory default settings. The RE command does not write restored values to non-volatile (persistent) memory. Issue the WR (Write) command subsequent to issuing the RE command to save restored parameter values to non-volatile memory.

RN (Random Delay Slots) Command

<Networking & Security> The RN command is used to set and read the minimum value of the back-off

AT Command: ATRN
Parameter Range: 0 - 3 [exponent]
Default Parameter Value: 0

exponent in the CSMA-CA algorithm. The CSMA-CA algorithm was engineered for collision avoidance (random delays are inserted to prevent data loss caused by data collisions).

If RN = 0, collision avoidance is disabled during the first iteration of the algorithm (802.15.4 - macMinBE).

CSMA-CA stands for "Carrier Sense Multiple Access - Collision Avoidance". Unlike CSMA-CD (reacts to network transmissions after collisions have been detected), CSMA-CA acts to prevent data collisions before they occur. As soon as a module receives a packet that is to be transmitted, it checks if the channel is clear (no other module is transmitting). If the channel is clear, the packet is sent over-the-air. If the channel is not clear, the module waits for a randomly selected period of time, then checks again to see if the channel is clear. After a time, the process ends and the data is lost.

RO (Packetization Timeout) Command

<Serial Interfacing> RO command is used to set and read the number of character times of intercharacter delay required before transmission.

AT Command: ATRO

Parameter Range:0 - 0xFF [x character times]

Default Parameter Value: 3

RF transmission commences when data is detected in the DI (data in from host) buffer and RO character times of silence are detected on the UART receive lines (after receiving at least 1 byte).

RF transmission will also commence after 100 Bytes (maximum packet size) are received in the DI buffer.

Set the RO parameter to '0' to transmit characters as they arrive instead of buffering them into one RF packet.

RP (RSSI PWM Timer) Command

<I/O Settings {I/O Line Passing}> The RP command is used to enable PWM (Pulse Width Modulation) output on the RF

AT Command: ATRP

Parameter Range: 0 - 0xFF
                 [x 100 msec]

Default Parameter Value: 0x28 (40 decimal)

module. The output is calibrated to show the level a received RF signal is above the sensitivity level of the module. The PWM pulses vary from 24 to 100%. Zero percent means PWM output is inactive. One to 24% percent means the received RF signal is at or below the published sensitivity level of the module. The following table shows levels above sensitivity and PWM values.

The total period of the PWM output is 64 µs. Because there are 445 steps in the PWM output, the minimum step size is 144 ns.

PWM Percentages

dB above Sensitivity	PWM percentage (high period / total period)
10	41%
20	58%
30	75%

A non-zero value defines the time that the PWM output will be active with the RSSI value of the last received RF packet. After the set time when no RF packets are received, the PWM output will be set low (0 percent PWM) until another RF packet is

received. The PWM output will also be set low at power-up until the first RF packet is received. A parameter value of 0xFF permanently enables the PWM output and it will always reflect the value of the last received RF packet.

RR Command

<Networking {Addressing}> The RR command is used set/read the maximum number of retries the module will execute in addition to the 3 retries provided by the 802.15.4 MAC.

AT Command: ATRR	
Parameter Range: 0 - 6	
Default: 0	
Minimum Firmware Version Required: 1.xA0	

This values does not need to be set on all modules for retries to work. If retries are enabled, the transmitting module will set a bit in the B&B RF Packet header which requests the receiving module to send an ACK (acknowledgement). If the transmitting module does not receive an ACK within 200 msec, it will re-send the packet within a random period up to 48 msec. Each retry can potentially result in the MAC sending the packet 4 times (1 try plus 3 retries). Note that retries are not attempted for packets that are purged when transmitting with a Cyclic Sleep Coordinator.

SC (Scan Channels) Command

<Networking {Association}> The SC command is used to set and read the list of channels to scan for all Active and Energy Scans as a bit field.

This affects scans initiated in command mode [AS (Active Scan) and ED (Energy Scan) commands] and during End Device Association and Coordinator startup.

AT Command: ATSC	
Parameter Range: 0 - 0xFFFF	
Default Parameter Value: 0x1FFE	
Related Commands: ED (Energy Scan), SD (Scan Duration)	
Minimum Firmware Version Required: v1.x80	

bit 0 - 0x0B	bit 4 - 0x0F bit	8 - 0x13 bit	12 - 0x17
bit 1 - 0x0C	bit 5 - 0x10	bit 9 - 0x14	bit 13 - 0x18
bit 2 - 0x0D	bit 6 - 0x11	bit 10 - 0x15	bit 14 - 0x19
bit 3 - 0x0E	bit 7 - 0x12	bit 11 - 0x16	bit 15 - 0x1A

SD (Scan Duration) Command

<Networking {Association}> The SD command is used to set and read the exponent value that determines the duration (in time) of a scan.

End Device (Duration of Active Scan during Association) - In a Beacon system, set SD = BE of

AT Command: ATSD	
Parameter Range: 0 - 0x0F	
Default Parameter Value: 4	
Related Commands: ED (Energy Scan), SC (Scan Channel)	
Minimum Firmware Version Required: v1.x80	

the Coordinator. SD must be set at least to the highest BE parameter of any Beaconing Coordinator with which an End Device or Coordinator wish to discover.

Coordinator - If the 'ReassignPANID' option is set on the Coordinator [refer to A2 parameter], the SD parameter determines the length of time the Coordinator will scan channels to locate existing PANs. If the 'ReassignChannel' option is set, SD determines how long the Coordinator will perform an Energy Scan to determine which channel it will operate on.

Scan Time is measured as ((# of Channels to Scan) * (2 ^ SD) * 15.36ms). The number of channels to scan is set by the SC command. The modem can scan up to 16 channels (SC = 0xFFFF).

Examples: Values below show results for a 12 channel scan

If SD = 0, time = 0.18 sec	SD = 8, time = 47.19 sec
SD = 2, time = 0.74 sec	SD = 10, time = 3.15 min
SD = 4, time = 2.95 sec	SD = 12, time = 12.58 min
SD = 6, time = 11.80 sec	SD = 14, time = 50.33 min

SH (Serial Number High) Command
<Diagnostics> The SH command is used to read the high 32 bits of the RF module's unique IEEE 64-bit address.

AT Command: ATSH

Parameter Range: 0 - 0xFFFFFFFF [read-only]

Related Commands: SL (Serial Number Low), MY (Source Address)

The module serial number is set at the factory and is read-only.

SL (Serial Number Low) Command
<Diagnostics> The SL command is used to read the low 32 bits of the RF module's unique IEEE 64-bit address.

AT Command: ATSL

Parameter Range: 0 - 0xFFFFFFFF [read-only]

Related Commands: SH (Serial Number High), MY (Source Address)

The module serial number is set at the factory and is read-only.

SM (Sleep Mode) Command

 <Sleep Mode (Low Power)> The SM command is used to set and read Sleep Mode settings. By default, Sleep Modes are disabled (SM = 0) and the RF module remains in Idle/Receive Mode. When in this state, the module is constantly
ready to respond to either serial or RF activity.

SM command options vary according to the networking system type. By default, the module is configured to operate in a NonBeacon system.

* The Sleep Coordinator option (SM=6) only exists for backwards compatibility with firmware version 1.x06 only. In all other cases, use the CE command to enable a Coordinator.

AT Command: ATSM

Parameter Range: 0 - 6

Parameter	Configuration
0	Disabled
1	Pin Hibernate
2	Pin Doze
3	(reserved)
4	Cyclic Sleep Remote
5	Cyclic Sleep Remote (with Pin Wake-up)
6	Sleep Coordinator*

Default Parameter Value: 0

Related Commands: SP (Cyclic Sleep Period), ST (Time before Sleep)

SP (Cyclic Sleep Period) Command

<Sleep Mode (Low Power)> The SP command is used to set and read the duration of time in which a remote RF module sleeps. After the cyclic sleep period is over, the module wakes and checks for data. If data is not present, the module goes back to sleep. The maximum sleep period is 268 seconds (SP = 0x68B0).

AT Command: ATSP

Parameter Range:	NonBeacon Firmware: 1 - 0x68B0 [x 10 milliseconds]
Default Parameter Value:	NonBeacon Firmware: 0

Related Commands: SM (Sleep Mode), ST (Time before Sleep), DP (Disassociation Cyclic Sleep Period, BE (Beacon Order)

The SP parameter is only valid if the module is configured to operate in Cyclic Sleep (SM = 4-6). Coordinator and End Device SP values should always be equal.

To send Direct Messages, set SP = 0.

NonBeacon Firmware
End Device - SP determines the sleep period for cyclic sleeping remotes. Maximum sleep period is 268 seconds (0x68B0).

Coordinator - If non-zero, SP determines the time to hold an indirect message before discarding it. A Coordinator will discard indirect messages after a period of (2.5 * SP).

ST (Time before Sleep) Command

<Sleep Mode (Low Power)> The ST command is used to set and read the period of inactivity (no serial or RF data is sent or received) before activating Sleep Mode.

NonBeacon Firmware

Set/Read time period of inactivity (no serial or RF data is sent or received) before activating Sleep Mode. ST parameter is only valid with Cyclic Sleep settings (SM = 4 - 5).

AT Command: ATST	
Parameter Range:	NonBeacon Firmware: 1 - 0xFFFF [x 1 millisecond]
Default Parameter Value:	NonBeacon Firmware: 0x1388 (5000 decimal)
Related Commands: SM (Sleep Mode), ST (Time before Sleep)	

Coordinator and End Device ST values must be equal.

T0 - T7 ((D0-D7) Output Timeout) Command

<I/O Settings {I/O Line Passing}> The T0, T1, T2, T3, T4, T5, T6 and T7 commands are used to set/read output timeout values for the lines that correspond with the D0 - D7

AT Commands: ATT0 - ATT7
Parameter Range:0 - 0xFF [x 100 msec]
Default Parameter Value:0xFF
Minimum Firmware Version Required: v1.xA0

parameters. When output is set (due to I/O line passing) to a nondefault level, a timer is started which when expired, will set the output to its default level. The timer is reset when a valid I/O packet is received. The Tn parameter defines the permissible amount of time to stay in a non-default (active) state. If Tn = 0, Output Timeout is disabled (output levels are held indefinitely).

VL (Firmware Version - Verbose)

<Diagnostics> The VL command is used to read detailed version information about the RF module. The information includes: application build date; MAC, PHY and bootloader versions; and build dates.

AT Command: ATVL
Parameter Range: 0 - 0xFF [x 100 milliseconds]
Default Parameter Value: 0x28 (40 decimal)
Minimum Firmware Version Required: v1.x80

VR (Firmware Version) Command

<Diagnostics> The VR command is used to read which firmware version is stored in the module.

AT Command: ATVR
Parameter Range: 0 - 0xFFFF [read only]

Version numbers will have four significant digits. The reported number will show three or four numbers and is stated in hexadecimal notation. A version can be reported as "ABC" or "ABCD". Digits ABC are the main release number and
D is the revision number from the main release. "D" is not required and if it is not present, a zero is assumed for D. "B" is a variant designator. The following variants exist:
   • "0" = Non-Beacon Enabled 802.15.4 Code
   • "1" = Beacon Enabled 802.15.4 Code

WR (Write) Command

<(Special)> The WR command is used to write configurable parameters to the RF module's

AT Command: ATWR

nonvolatile memory. Parameter values remain in the module's memory until overwritten by subsequent use of the WR Command.

If changes are made without writing them to non-volatile memory, the module reverts back to previously saved parameters the next time the module is powered-on.

NOTE: Once the WR command is sent to the module, no additional characters should be sent until after the "OK/r" response is received.

API Operation

By default, Zlinx Radio Modems act as a serial line replacement (Transparent Operation) - all UART data received through the DI pin is queued up for RF transmission. When the module receives an RF packet, the data is sent out the DO pin with no additional information.

Inherent to Transparent Operation are the following behaviors:

- If module parameter registers are to be set or queried, a special operation is required for transitioning the module into Command Mode.
- In point-to-multipoint systems, the application must send extra information so that the receiving module(s) can distinguish between data coming from different remotes.

As an alternative to the default Transparent Operation, API (Application Programming Interface) Operations are available. API operation requires that communication with the module be done through a structured interface (data is communicated in frames in a defined order). The API specifies how commands, command responses and module status messages are sent and received from the module using a UART Data Frame.

API Frame Specifications

Two API modes are supported and both can be enabled using the AP (API Enable) command. Use the following AP parameter values to configure the module to operate in a particular mode:

- AP = 0 (default): Transparent Operation (UART Serial line replacement) API modes are disabled.
- AP = 1: API Operation
- AP = 2: API Operation (with escaped characters)

Any data received prior to the start delimiter is silently discarded. If the frame is not received correctly or if the checksum fails, the data is silently discarded.

API Operation (AP parameter = 1)
When this API mode is enabled (AP = 1), the UART data frame structure is
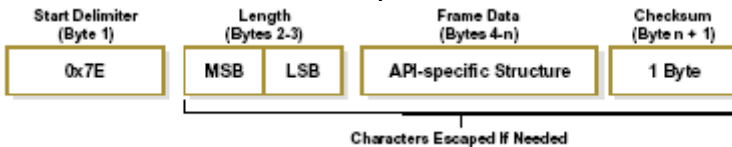defined as follows:

UART Data Frame Structure:

Start Delimiter (Byte 1)	Length (Bytes 2-3)		Frame Data (Bytes 4-n)	Checksum (Byte n + 1)
0x7E	MSB	LSB	API-specific Structure	1 Byte

MSB = Most Significant Byte, LSB = Least Significant Byte

API Operation - with Escape Characters (AP parameter = 2)
When this API mode is enabled (AP = 2), the UART data frame structure is
defined as follows:

UART Data Frame Structure with escape control characters:

Start Delimiter (Byte 1)	Length (Bytes 2-3)		Frame Data (Bytes 4-n)	Checksum (Byte n + 1)
0x7E	MSB	LSB	API-specific Structure	1 Byte

Characters Escaped If Needed

MSB = Most Significant Byte, LSB = Least Significant Byte

Escape characters. When sending or receiving a UART data frame, specific
data values must be escaped (flagged) so they do not interfere with the
UART or UART data frame operation. To escape an interfering data byte,
insert 0x7D and follow it with the byte to be escaped XOR'd with 0x20.

Data bytes that need to be escaped:
  • 0x7E – Frame Delimiter
  • 0x7D – Escape
  • 0x11 – XON
  • 0x13 – XOFF

Example - Raw UART Data Frame (before escaping interfering bytes):
         0x7E 0x00 0x02 0x23 0x11 0xCB
0x11 needs to be escaped which results in the following frame:
0x7E 0x00 0x02 0x23 0x7D 0x31 0xCB

Note: In the above example, the length of the raw data (excluding the checksum) is
0x0002 and the checksum of the non-escaped data (excluding frame delimiter and
length) is calculated as:
0xFF - (0x23 + 0x11) = (0xFF - 0x34) = 0xCB.

Checksum
To test data integrity, a checksum is calculated and verified on non-escaped data.

To calculate: Not including frame delimiters and length, add all bytes keeping only
the lowest 8 bits of the result and subtract from 0xFF.

To verify: Add all bytes (include checksum, but not the delimiter and length). If the checksum is correct, the sum will equal 0xFF.

3.4.2. API Types

Frame data of the UART data frame forms an API-specific structure as follows:

UART Data Frame & API specific Structure:
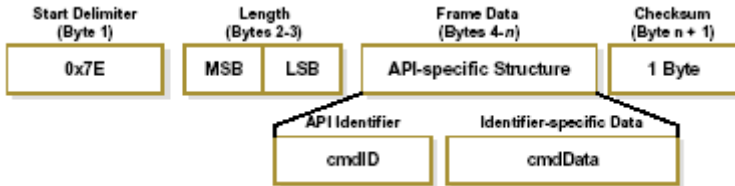
The cmdID frame (API-identifier) indicates which API messages will be contained in the cmdData frame (Identifier-specific data). Refer to the sections that follow for more information regarding the supported API types. Note that multi-byte values are sent big endian.

Modem Status
API Identifier: 0x8A
RF module status messages are sent from the module in response to specific conditions.
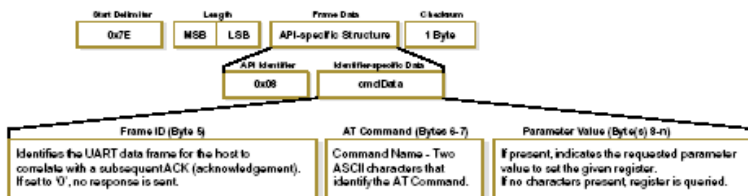
Modem Status Frames
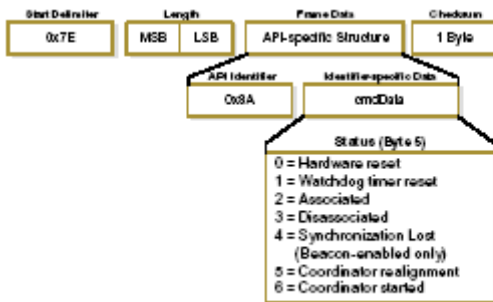
AT Command

API Identifier Value: 0x08
The "AT Command" API type allows for module parameters to be queried or set.
When using this command ID, new parameter values are applied immediately. This
includes any register set with the "AT Command - Queue Parameter Value" (0x09)
API type.

AT Command Frames

Example: API frames when reading the DL parameter value of the module.

* Length [Bytes] = API Identifier + Frame ID + AT Command

** "R" value was arbitrarily selected.

Example: API frames when modifying the DL parameter value of the module.

* Length [Bytes] = API Identifier + Frame ID + AT Command + Parameter Value

** "M" value was arbitrarily selected.

AT Command - Queue Parameter Value

API Identifier Value: 0x09
This API type allows module parameters to be queried or set. In contrast to the "AT
Command" API type, new parameter values are queued and not applied until either
the "AT Command" (0x08) API type or the AC (Apply Changes) command is issued.
Register queries (reading parameter values) are returned immediately.

AT Command Frames
**(Note that frames are identical to the "AT Command" API type except for the
API identifier.)**
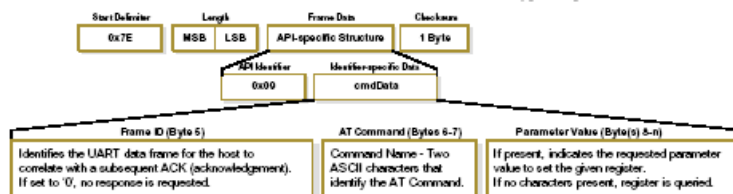
AT Command Response
API Identifier Value: 0x88
Response to previous command.

In response to an AT Command message, the module will send an AT Command Response message. Some commands will send back multipl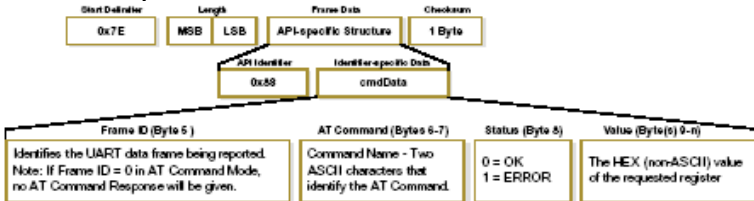e frames (for example, the ND (Node Discover) and AS (Active Scan) commands). These commands will end by sending a frame with a status of ATCMD_OK and no cmdData.
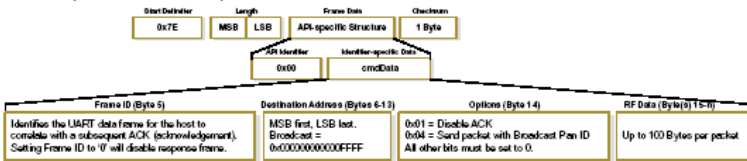
AT Command Response Frames.

Start Delimiter	Length		Frame Data	Checksum
0x7E	MSB	LSB	API-specific Structure	1 Byte

API Identifier	Identifier-specific Data
0x88	cmdData

Frame ID (Byte 5)	AT Command (Bytes 6-7)	Status (Byte 8)	Value (Byte(s) 9-n)
Identifies the UART data frame being reported. Note: If Frame ID = 0 in AT Command Mode, no AT Command Response will be given.	Command Name - Two ASCII characters that identify the AT Command.	0 = OK 1 = ERROR	The HEX (non-ASCII) value of the requested register

TX (Transmit) Request: 64-bit address
API Identifier Value: 0x00
A TX Request message will cause the module to send RF Data as an RF Packet.

TX Packet (64 bit address) Frames

Start Delimiter	Length		Frame Data	Checksum
0x7E	MSB	LSB	API-specific Structure	1 Byte

API Identifier	Identifier-specific Data
0x00	cmdData

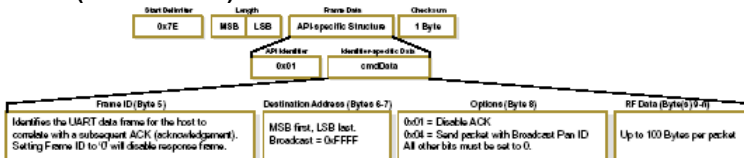| Frame ID (Byte 5)	Destination Address (Bytes 6-13)	Options (Byte 14)	RF Data (Byte(s) 15-n)
Identifies the UART data frame for the host to correlate with a subsequent ACK (acknowledgement). Setting Frame ID to '0' will disable response frame.	MSB first, LSB last. Broadcast = 0x000000000000FFFF	0x01 = Disable ACK 0x04 = Send packet with Broadcast Pan ID All other bits must be set to 0.	Up to 100 Bytes per packet

TX (Transmit) Request: 16-bit address
API Identifier Value: 0x01
A TX Request message will cause the module to send RF Data as an RF Packet.

TX Packet (16 bit address) Frames

Start Delimiter	Length		Frame Data	Checksum
0x7E	MSB	LSB	API-specific Structure	1 Byte

API Identifier	Identifier-specific Data
0x01	cmdData

| Frame ID (Byte 5)	Destination Address (Bytes 6-7)	Options (Byte 8)	RF Data (Byte(s) 9-n)
Identifies the UART data frame for the host to correlate with a subsequent ACK (acknowledgement). Setting Frame ID to '0' will disable response frame.	MSB first, LSB last. Broadcast = 0xFFFF	0x01 = Disable ACK 0x04 = Send packet with Broadcast Pan ID All other bits must be set to 0.	Up to 100 Bytes per packet

TX (Transmit) Status
API Identifier Value: 0x89
When a TX Request is completed, the module sends a TX Status message. This message will indicate if the packet was transmitted successfully or if there was a failure.

TX Status Frames
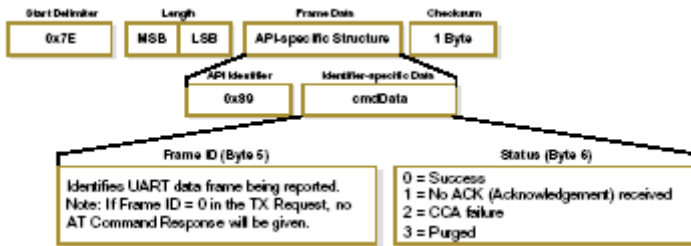
NOTES:

- "STATUS = 1" occurs when all retries are expired and no ACK is received.
- If transmitter broadcasts (destination address = 0x000000000000FFFF), only "STATUS = 0 or 2" will be returned.
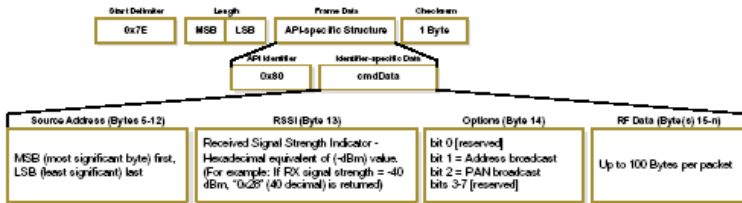- "STATUS = 3" occurs when Coordinator times out of an indirect transmission.

Timeout is defined as (2.5 x SP (Cyclic Sleep Period) parameter value).

RX (Receive) Packet: 64-bit Address
API Identifier Value: 0x80
When the module receives an RF packet, it is sent out the UART using this message type.

RX Packet (64 bit address) Frames

RX (Receive) Packet: 16-bit Address
API Identifier Value: 0x81
When the module receives an RF packet, it is sent out the UART using this message type.

RX Packet (16 bit address) Frames