Channel Analysis Tool Application Programming Interface (API) Specification

Version 1.1.2

PulsON® 400 Series

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Table of Contents

1 Introduction

The Channel Analysis Tool is a software package that interfaces with both PulsON 400 (P400) and PulsON 410 (P410) Ultra Wideband (UWB) platforms. It allows the user to transmit and receive data packets and collect, display, and log received waveforms as well as a variety of communications statistics that characterize the communications link. The waveform capture capability also allows the user to operate the P400 and P410s as bistatic and multistatic radars.

This manual specifies the programmer's interface between the user's Host processor and both P400 and P410 platforms.

Since the P400 and P410 software interfaces are functionally equivalent, this manual refers to these devices interchangeably as P410s. Any platform related differences are specifically identified.

The primary software interface difference between the two devices is that a P400 supports USB, Ethernet and Serial connections, while a P410 supports only USB and Serial. The primary hardware difference is that a P400 supports a high power pulser while a P410 can have either a low power or high power pulser. The UWB waveform produced by the P400 also has a marginally different shape than the one produced by a P410.

This document also provides a reference of the message structures and bit patterns in an Ethernet UDP/IP programming interface. A separate application note, *Using the USB and Serial Interfaces*, describes the extended header bytes and protocol required to support both the USB and 3.3V TTL Serial UART interfaces.

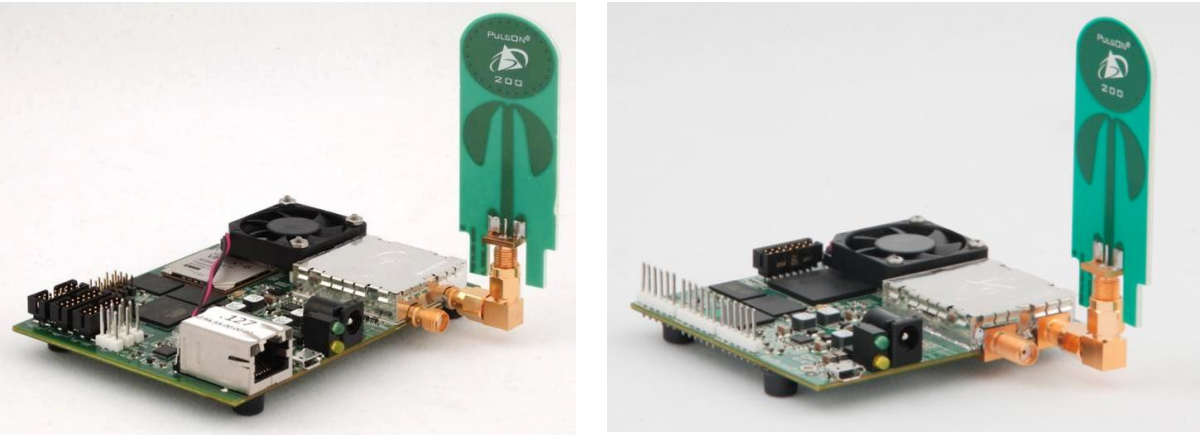

Fig. 1: P400 RCM (left) and P410 RCM (right), both with attached Broadspec Antenna

We recommend the software developer become familiar with the API through use of the Channel Analysis Tool (CAT). This MS Windows PC application provides a graphical representation of the interface data structures and allows the user to quickly become familiar with Host behaviors. This application is described in detail in the *CAT User Guide*.

The *CAT Quick Start Guide* provides instructions for getting up and running quickly with CAT. The user should reference and build upon the sample applications delivered with the CAT Kit.

All of these documents can be found at the following link: http://www.timedomain.com/cat.php

Usage Notes

This section provides a short overview of key facts relative to P410 behavior and interfaces. Much of this information is covered in the *CAT Quick Start Guide*. Key differences concern the Ethernet vs. USB interface.

1. Upon power-up, with or without a Host connection, the P410 automatically will enter the state last requested by the user. The three possible states are: transmit, receive, and idle. In the idle state the unit is neither transmitting nor receiving.
2. Upon successful power-up, the amber Power LED and the green Status LED on the board edge should be lit with a steady glow. If the unit is transmitting or receiving then the green led will toggle on packet transmission or reception. The green on board LEDs should blink at a fast rate (~10Hz) while the amber on board LED should blink at approximately 1 Hz. Other conditions indicate hardware/firmware failure.

The user connects to the UWB platforms either through an Ethernet (P400 only) or USB (P400 and P410) interface. The process is different for the two cases.

Items 3-4 describe the USB connection process.

3. Connect the P410 to the Host using a USB 2.0 A to Micro-B cable (supplied in the P410 Development Kit).
4. As described in the *CAT Quick Start Guide*, the user can access the P410 using CAT. If CAT is not used, then review the document entitled *Using the USB and Serial Interfaces.*

Items 5-9 describe the process using Ethernet.

5. Connect the P400 to the Host PC using either a crossover Ethernet cable (supplied in the P400 RCM or MRM Development Kits) or through an Ethernet switch (some laptops have auto-sensing).
6. The user must configure the Host PC's TCP/IPv4 properties to a static IP address such as 192.168.1.1 with Subnet mask 255.255.255.0. The Windows Firewall must be disabled, at least for the P400 addresses of interest.
7. Determine the IP address of the P400 connected to the Host. This number is written on a label attached to the Ethernet connector on the P400. The default UWB Node IDs will correlate with the default IP addresses. For instance, P400s with UWB Node IDs of 100, 101, 102, and 103 will have default IP addresses of 192.168.1.100, 192.168.1.101, 192.168.1.102, and 192.168.1.103, respectively. The P400 Node ID can be changed through this API.
8. If connecting with the P400 through CAT, enter the IP address of the P400 in the field entitled "Network IP Address" and click on the Connect button. If connecting through windows, the user should "ping" the P400's Ethernet address using a command window (or terminal).
9. The user's code should create a UDP socket targeting port 21210 on the P400. The P400 will respond to the port that sent the message.

Miscellaneous items:

10. Data transferred to/from the P410 is big-endian (network byte order). Code developed on Intel processors must swap bytes (see example code).
11. All P410 devices are slaved to their respective Hosts. There is no mechanism built into the P410 to coordinate transmissions. The Hosts are responsible for coordinated transmissions

(i.e., Media Access Control). Please contact Time Domain with special requests.

Sample Host interfacing software is available in C and MATLAB to help users begin developing their own UWB-enabled applications.

All product documentation is posted at www.timedomain.com.

2 The P400/P410 Interface

This is a high-level description of the data passed between a Host processor and the RCM.

On power up, the P410 will check to determine if it was last directed to transmit or receive on power up. If so, then it will transmit or receive using the parameters last provided to it. In any event it will then wait for commands from the Host.

Figure 2 illustrates a system of 2 P410s, one with a Host and one without. A high-level data flow interface is graphically depicted between the Host and its co-located P410. (Note that a single Host with Ethernet switch and/or multiple USB inputs could support multiple P410s.)

The HOST<->P410 interface consists of 10 REQUEST messages from Host to P410 with their associated CONFIRM messages. In addition, there is one INFO message that is sent to the Host upon receiving UWB packets from other P410s.

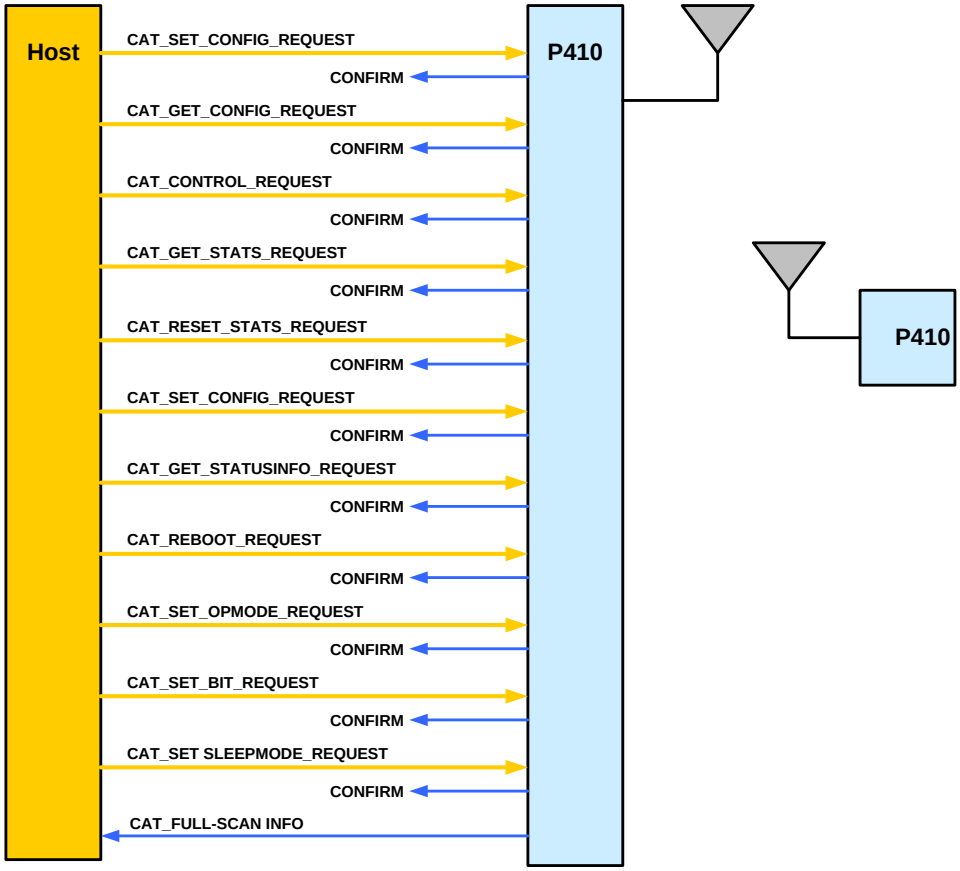

Fig. 2: Message flow between Host to P410

P410s with connected Hosts will automatically send data and scan information to the Host. The format of these messages is described in this document. The REQUEST and INFO messages are described in the next subsection. **Appendix A** contains additional description of some key parameters and concepts.

3 CAT API Messages

3.1 CAT_SET_CONFIG_REQUEST (0x2001)

API: CATAPI
Message type: REQUEST (Host)
Corresponding Message type: CAT_SET_CONFIG_CONFIRM (Radio)

Purpose: This message configures the basic parameters in the P410, thereby defining radio operation.

Packet Definition:

#	Parameter	Type	Definition
0	CAT_SET_CONFIG_REQUEST (0x2001)	UINT16	Message type
1	Message ID	UINT16	Associates request to confirm and info messages
2	Node ID	UINT32	UWB ID of this radio (used for UWB range targeting.) Valid values are 1 - 2^32-2. Do not use 0 or 2^32-1. These ideas have special meaning for other UWB programs such as RangeNet and RCM (the Ranging and Communications Module).
3	Mode of Operation	UINT8	Identifies the current operating mode of the radio. Valid values are 1 (transmit mode) and 2 (receive mode).
4	Antenna Mode	UINT8	Specifies the default antenna for transmission and reception. Valid values are [0=A, 1=B, 2=TXA,RXB, 3=TXB,RXA]. The default value is 0x00.
5	Code Channel	UINT8	Specifies the active UWB channel. Multiple ranging conversations can occur simultaneously if multiple code channels are used. Both the requester and responder radios must be configured to the same code channel for successful communication. Possible values are [0-10]. The default value is 0.
6	Transmit Gain	UINT8	Specifies the pulser transmit gain from 0 (lowest) to 63 (highest). The relationship between transmit gain setting and transmit power (power to the base of the antenna) is provided in the P400 and P410 data sheets. Actual transmit ranges are provided below: P400 standard: -14.5 to +2.1dBm P410 standard: -31.6 to -12.64 dBm P410 optional amps: -14.5 to 0.71 dBm

7	Power Up Mode	UINT8	Determines what the radio will do after power up. Valid values are 0 (enter idle mode), 1 (begin transmitting data) and 2 (begin receiving packets).
8	Unused	UINT8	Reserved
9	Unused	UINT16	Reserved
10	Number of packets to transmit	UINT32	Specifies how many packets the node will transmit before halting. A value of 0 will cause the radio to transmit continuously. Applicable only when the Mode of Operation is Transmit.
11	Number of words to transmit	UINT16	Specifies how many 32-bit words the node will transmit in a packet. Valid values are 0 through 1000. Applicable only when the Mode of Operation is Transmit.
12	Delay between packets	UINT16	Specifies the number of milliseconds between packets. A value of 0 will cause the radio to transmit as fast as possible. Applicable only when the Mode of Operation is Transmit.
13	Unused	UINT16	Reserved
14	Acquisition Integration Index	UINT8	Specifies an index, which configures the number of pulses per acquisition symbol. Valid values are [5-11]. The default is 7 meaning 2^7 = 128 pulses per symbol.
15	Auto Thresholding	UINT8	A value of 1 enables automatic thresholding in the radio's acquisition logic. A value of 0 disables automatic thresholding (in which case the manual threshold below will be used). The default is 1 (enabled).
16	Manual Threshold	UINT32	Specifies the manual threshold which will be used when auto thresholding is disabled. For a discussion of manual thesholding strategies see the *CAT User Guide*.
17	RX Filter	UINT32	If set to all ones (0xFFFFFFFF), the node will receive packets from any source transmitter ID. If set to any other value, the node will receive packets (and compute statistics on) only packets from that transmitter ID. Note: This feature does not currently function properly. No filtering is currently performed. This bug will be addressed in the next release. Users needing immediate use of this feature should contract Sales/Technical support.

18	Acquisition PRI	UINT32	The Pulse Repetition Interval (PRI) in ps of the acquisition code. This number is calculated by the radio and is ignored when setting the configuration.
19	Acquisition preamble length	UINT32	The duration of the acquisition preamble in us. This number is calculated by the radio and is ignored when setting the configuration.
20	Unused	UINT8	Reserved
21	Auto Integration	UINT8	If set to 1, the radio will select a data integration index one less than the acquisition integration index. If set to 0, the data integration index that will be used is the value in the following field.
22	Data integration Index	UINT8	Specifies an index which configures the number of pulses per data symbol. Valid values are [4-11]. This field is ignored if auto integration is enabled.
23	Data type	UINT8	Specifies the data pattern sent by the transmitter. Valid values are 0 (send all zeroes), 1 (send all ones), and 2 (send bit error rate pattern).
24	Payload PRI	UINT32	The Pulse Repetition Interval (PRI) in ps of the payload code. This number is calculated by the radio and is ignored when setting the configuration.
25	Payload Duration	UINT32	The duration of the payload in us. This number is calculated by the radio and is ignored when setting the configuration.
26	Scan Start	INT32	The start position of the waveform scan in picoseconds relative to the radio lock point. See note 1.
27	Scan Stop	INT32	The stop position of the waveform scan in picoseconds relative to the radio lock point. See note 1.
28	Scan Step Size	UINT16	The waveform scan step size in bins. A bin is approximately 1.907 ps. The rake receiver has been optimized to take scans at a step size of 32, 64, 128, or 256. Setting the Scan Step Size to any other value will increase the time required to collect a scan by a factor of 12.
29	Scan Integration Index	UINT8	Specifies an index which configures the number of data symbols per scan symbol. Valid values are [0-5]. This value is relative to the Data Integration Index. In other words, if the user selects PII 5 for Data Integration Index and PII 5 for Scan Integration Index, then the effective Scan Integration will be 2^(5+5) or 1024:1.

30	Unused	UINT8	Reserved
31	Flags	UINT16	Reserved
32	Unused	UINT8	Reserved
33	Persist Flag	UINT8	Specifies whether this configuration record will persist through power cycling (write to FLASH memory.) Possible values are 0 (will not persist) or 1 (will persist.)

Note 1: Because picoseconds can only be requested in increments of bins and the rake receiver has a minimum length, the P410 may interpret these two parameters differently. A complete explanation is provided in the *CAT User Guide*, Section 4.2, Parameter Settings, Waveform Capture Settings.

3.2 CAT_SET_CONFIG_CONFIRM (0x2101)

API: CAT API
Message type: CONFIRM (Radio)
Corresponding Message type: CAT_SET_CONFIG_REQUEST (Host)

Purpose: This message is sent by the radio to the Host in response to a CAT_SET_CONFIG_REQUEST message previously received from the Host. Its purpose is to confirm successful operation of the CAT_SET_CONFIG_REQUEST.

Packet Definition:

#	Parameter	Type	Definition
0	CAT_SET_CONFIG_CONFIRM (0x2101)	UINT16	Message type
1	Message ID	UINT16	Associates request to confirm packets
2	Status	UINT32	0 = Successful. For error codes see Table 3-1 at the end of this section

3.3 CAT_GET_CONFIG_REQUEST (0x2002)

API: CAT API
Message type: REQUEST (Host)
Corresponding Message type: CAT_GET_CONFIG_CONFIRM (Radio)

Purpose: This is a request message sent by the Host to the radio to retrieve the current radio configuration.

Packet Definition:

#	Parameter	Type	Definition
0	CAT_GET_CONFIG_REQUEST (0x2002)	UINT16	Message type
1	Message ID	UINT16	Associates request to confirm packets

3.4 CAT_GET_CONFIG_CONFIRM (0x2102)

API: CAT API
Message type: CONFIRM (Radio)
Corresponding Message type: CAT_GET_CONFIG_REQUEST (Host)

Purpose: This message is sent by the radio in response to a CAT_GET_CONFIG_REQUEST from the Host. It provides the current CAT configuration information.

Packet Definition:

#	Parameter	Type	Definition
0	CAT_GET_CONFIG_CONFIRM (0x2102)	UINT16	Message type
1	Message ID	UINT16	Associates request to confirm and info messages
2	Node ID	UINT32	UWB ID of this radio (used for UWB range targeting.) Valid values are 1 - 2^32-2.
3	Mode of Operation	UINT8	Identifies the current operating mode of the radio. Valid values are 1 (transmit mode) and 2 (receive mode).
4	Antenna Mode	UINT8	Specifies the default antenna for transmission and reception. Valid values are [0=A, 1=B, 2=TXA,RXB, 3=TXB,RXA]. The default value is 0x00.
5	Code Channel	UINT8	Specifies the active UWB channel. Multiple ranging conversations can occur simultaneously if multiple code channels are used. Both the requester and responder radios must be configured to the same code channel for successful communication. Possible values are [0-10]. The default value is 0.

6	Transmit Gain	UINT8	Specifies the pulser transmit gain from 0 (lowest) to 63 (highest). The relationship between transmit gain setting and transmit power (power to the base of the antenna) is provided in the P400 and P410 data sheets. Actual transmit ranges are provided below: P400 standard: -14.5 to +2.1dBm P410 standard: -31.6 to -12.64 dBm P410 optional amps: -14.5 to 0.71 dBm
7	Power Up Mode	UINT8	Determines what the radio will do after power up. Valid values are 0 (enter idle mode), 1 (begin transmitting data) and 2 (begin receiving packets).
8	Unused	UINT8	Reserved
9	Unused	UINT16	Reserved
10	Number of packets to transmit	UINT32	Specifies how many packets the node will transmit before halting. A value of 0 will cause the radio to transmit continuously. Applicable only when the Mode of Operation is Transmit.
11	Number of words to transmit	UINT16	Specifies how many 32-bit words the node will transmit in a packet. Valid values are 0 through 1000. Applicable only when the Mode of Operation is Transmit.
12	Delay between packets	UINT16	Specifies the number of milliseconds between packets. A value of 0 will cause the radio to transmit as fast as possible. Applicable only when the Mode of Operation is Transmit.
13	Unused	UINT16	Reserved
14	Acquisition Integration Index	UINT8	Specifies an index, which configures the number of pulses per acquisition symbol. Valid values are [5-11]. The default is 7 meaning 2^7 = 128 pulses per symbol.
15	Auto Thresholding	UINT8	A value of 1 enabled automatic thresholding in the radio's acquisition logic. A value of 0 disables automatic thresholding (in which case the manual threshold below will be used). The default is 1 (enabled).
16	Manual Threshold	UINT32	Specifies the manual threshold which will be used when auto thresholding is disabled. For a discussion of manual thesholding strategies see the *CAT User Guide*.

17	RX Filter	UINT32	If set to all ones (0xFFFFFFFF), the node will receive packets from any source transmitter ID. If set to any other value, the node will receive packets (and compute statistics on) only packets from that transmitter ID. Note: This feature does not currently function properly. No filtering is currently performed. This bug will be addressed in the next release. Users needing immediate use of this feature should contract Sales/Technical support
18	Acquisition PRI	UINT32	The Pulse Repetition Interval (PRI) in ps of the acquisition code. This number is calculated by the radio and is ignored when setting the configuration.
19	Acquisition preamble length	UINT32	The duration of the acquisition preamble in us. This number is calculated by the radio and is ignored when setting the configuration.
20	Unused	UINT8	Reserved
21	Auto Integration	UINT8	If set to 1, the radio will set the data integration index to one less than the acquisition integration index. If set to 0, the data integration index that will be used is the value in the following field.
22	Data Integration Index	UINT8	Specifies an index which configures the number of pulses per data symbol. Valid values are [4-11]. This field is ignored is auto integration is enabled.
23	Data type	UINT8	Specifies the data pattern sent by the transmitter. Valid values are 0 (send all zeroes), 1 (send all ones), and 2 (send bit error rate pattern).
24	Payload PRI	UINT32	The Pulse Repetition Interval (PRI) in ps of the payload code. This number is calculated by the radio and is ignored when setting the configuration.
25	Payload Duration	UINT32	The duration of the payload in us. This number is calculated by the radio and is ignored when setting the configuration.
26	Scan Start	INT32	The start position of the waveform scan in ps relative to the lock spot. See note 2.
27	Scan Stop	INT32	The stop position of the waveform scan in ps relative to the lock spot. See note 2.

28	Scan Step Size	UINT16	The waveform scan step size in bins. A bin is approximately 1.907 ps. The rake receiver has been optimized to take scans at a step size of 32, 64, 128, or 256. Setting the Scan Step Size to any other value will increase the time required to collect a scan by a factor of 12.
29	Scan Integration Index	UINT8	Specifies an index which configures the number of data symbols per scan symbol. Valid values are [0-5]. This value is relative to the Data Integration Index. In other words, if the user selects PII 5 for Data Integration Index and PII 5 for Scan Integration Index, then the effective Scan Integration will be 2^(5+5) or 1024:1.
30	Unused	UINT8	Reserved
31	Flags	UINT16	Reserved
32	Unused	UINT8	Reserved
33	Persist Flag	UINT8	Unused
34	Timestamp	UINT32	Milliseconds since radio power-up. Note this implies a rollover approximately every 50 days.
35	Status	UINT32	0 = Successful. For error codes see Table 3-1 at the end of this section

Note 2: Because picoseconds can only be requested in increments of bins and the rake receiver has a minimum length, the P410 may interpret these two parameters differently than requested and report back slightly different values than requested. A complete explanation is provided in the *CAT User Guide*, Section 4.2 Parameter Settings, Waveform Capture Settings.

3.5 CAT_CONTROL_REQUEST (0x2003)

API: CAT API
Message type: REQUEST (Host)
Corresponding Message type: CAT_CONTROL_CONFIRM (Radio)

Purpose: This message commands the radio to start or stop receiving or transmitting packets, depending on the current configuration.

Packet Definition:

#	Parameter	Type	Definition
0	CAT_CONTROL_REQUEST (0x2003)	UINT16	Message type
1	Message ID	UINT16	Associates request to confirm packets
2	Start or Stop Flag	UINT32	A value of 1 causes the radio to begin transmitting or receiving packets. A value of 0 stops radio operation

3.6 CAT_CONTROL_CONFIRM (0x2103)

API: CAT API
Message type: CONFIRM (Radio)
Corresponding Message type: CAT_CONTROL_REQUEST (Host)

Purpose: This message is sent by the radio to the HOST in response to a CAT_CONTROL_REQUEST command.

Packet Definition:

#	Parameter	Type	Definition
0	CAT_CONTROL_CONFIRM (0x2103)	UINT16	Message type
1	Message ID	UINT16	Associates request to confirm packets
2	Status	UINT32	0 = Successful. For error codes see Table 3-1 at the end of this section

3.7 CAT_GET_STATS_REQUEST (0x2004)

API: CAT API
Message type: REQUEST (Host)

Corresponding Message type: CAT_GET_STATS_CONFIRM (Radio)

Purpose: This is a request message sent by the Host to the radio to retrieve the current radio statistics.

Packet Definition:

#	Parameter	Type	Definition
0	CAT_GET_STATS_REQUEST (0x2004)	UINT16	Message type
1	Message ID	UINT16	Associates request to confirm packets

3.8 CAT_GET_STATS_CONFIRM (0x2104)

API: CAT API
Message type: CONFIRM (Radio)
Corresponding Message type: CAT_GET_STATS_REQUEST (Host)

Purpose: This message is sent from the radio to the Host in response to a CAT_GET_STATS_REQUEST command. This response contains the current radio statistics.

Packet Definition:

#	Parameter	Type	Definition
0	CAT_GET_STATS_CONFIRM (0x2104)	UINT16	Message type
1	Message ID	UINT16	Associates request to confirm packets
2	Reserved	UINT32	Unused
3	Current Mode of Operation	UINT8	The radio's current mode: 0 – idle (stopped), 1 – receiving, 2 - transmitting
4	Reserved	UINT8	Unused
5	Reserved	UINT16	Unused
6	Temperature	INT32	The temperature as measured by the radio's temperature sensor, in 0.25 degC.
7	Number of Bit Errors	UINT64	The number of bits received in error since the radio was started or since the statistics were reset. Applicable only in receive mode.

8	Number of Bits	UINT64	The number of bits sent or received since the radio was started or since the statistics were reset.
9	Number of Packets	UINT64	The number of packets sent or received since the radio was started or since the statistics were reset.
10	Number of Dropped Packets	UINT64	The number of dropped packets sent or received since the radio was started or since the statistics were reset.
11	Number of Error Packets	UINT64	The number of packets that were received and contained bit errors since the radio was started or since the statistics were reset. Applicable only in receive mode.
12	Run Time	UINT64	The run time in secs since the radio was started or since the statistics were reset.
13	Status	UINT32	0 = Successful. For error codes see Table 3-1 at the end of this section

3.9 CAT_RESET_STATS_REQUEST (0x2006)

API: CAT API
Message type: REQUEST (Host)
Corresponding Message type: CAT_RESET_STATS_CONFIRM (Radio)

Purpose: This message is sent from the Host to the radio to reset the radio's statistics.

Packet Definition:

#	Parameter	Type	Definition
0	CAT_RESET_STATS_REQUEST (0x2006)	UINT16	Message type
1	Message ID	UINT16	Associates request to confirm packets

3.10 CAT_RESET_STATS_CONFIRM (0x2106)

API: CAT API
Message type: CONFIRM (Radio)
Corresponding Message type: CAT_RESET_STATS_REQUEST (Host)

Purpose: This message is sent by the radio to the Host in response to a

CAT_RESET_STATS_REQUEST command to indicate that the radio statistics have been reset.

Packet Definition:

#	Parameter	Type	Definition
0	CAT_RESET_STATS_CONFIRM (0x2106)	UINT16	Message type
1	Message ID	UINT16	Associates request to confirm packets
2	Status	UINT32	0 = Successful. For error codes see Table 3-1 at the end of this section

3.11 CAT_GET_STATUSINFO_REQUEST (0xF001)

API: CAT API
Message type: REQUEST (Host)
Corresponding Message type: CAT_GET_STATUSINFO_CONFIRM (Radio)

Purpose: This message prompts the radio to send the Host a data structure describing the hardware and software version numbers as well as other status information.

Packet Definition:

#	Parameter	Type	Definition
0	CAT_GET_STATUSINFO_REQUEST (0xF001)	UINT16	Message type
1	Message ID	UINT16	Associates request to confirm packets

3.12 CAT_GET_ STATUSINFO_CONFIRM (0xF101)

API: CAT API
Message type: CONFIRM (Radio)
Corresponding Message type: CAT_GET_STATUSINFO_REQUEST (Host)

Purpose: This message is sent by the radio to the Host in immediate response to a CAT_GET_STATUSINFO_REQUEST command. This response provides a list of the hardware and software version numbers as well as other status information.

Packet Definition:

#	Parameter	Type	Definition

0	CAT_GET_STATUSINFO_CONFIRM (0xF101)	UINT16	Message type
1	Message ID	UINT16	Associates request to confirm packets
2	CAT Version Major	UINT8	CAT embedded major version number
3	CAT Version Minor	UINT8	CAT embedded minor version number
4	CAT Version Build	UINT16	CAT embedded build version number
5	UWB Kernel Major	UINT8	Kernel code major version number
6	UWB Kernel Minor	UINT8	Kernel code minor version number
7	UWB Kernel Build	UINT16	Kernel code build version number
8	FPGA Firmware Version	UINT8	Firmware version number represented in Hexadecimal
9	FPGA Firmware Year	UINT8	Firmware year encoded. Use (year >> 4) * 10 + (year % 16) to get decimal value
10	FPGA Firmware Month	UINT8	Firmware month encoded. Use (month >> 4) * 10 + (month % 16) to get decimal value
11	FPGA Firmware Day	UINT8	Firmware day encoded. Use (day >> 4) * 10 + (day % 16) to get decimal value
12	Serial Number	UINT32	Device serial number represented in Hexadecimal
13	Board Revision	UINT8	PCB revision – a single ASCII character
14	Power-On BIT Test Result	UINT8	Built-in Test Results, non-zero indicates BIT failure.
15	Board Type	UINIT8	1 – P400, 2 – P410
16	Transmitter Configuration	UINT8	0 – FCC compliant 1 – FCC compliant, transmit amplifiers installed 2 – EU compliant
17	Temperature	INT32	Board temp in 0.25 ^{o}C (divide this number by 4 to produce floating point ^{o}C.).
18	Package Version	CHAR[32]	Human-readable string that identifies the embedded package release version. The actual package version string is typically less than 32 bytes; the rest of this field is zero-filled.

19	Status	UINT32	0 = Successful. For error codes see Table 3-1 at the end of this section

3.13 CAT_REBOOT_REQUEST (0xF002)

API: CAT API
Message type: REQUEST (Host)
Corresponding Message type: CAT_REBOOT_CONFIRM (Radio)

Purpose: This message causes the radio to reboot, reloading configuration parameters saved to flash.

Packet Definition:

#	Parameter	Type	Definition
0	CAT_REBOOT_REQUEST (0xF002)	UINT16	Message type
1	Message ID	UINT16	Associates request to confirm packets

3.14 CAT_REBOOT_CONFIRM (0xF102)

API: CAT API
Message type: CONFIRM (Radio)
Corresponding Message type: CAT_REBOOT_REQUEST (Host)

Purpose: This message is sent by the radio to the Host in immediate response to a CAT_REBOOT_REQUEST command. Immediately after sending this message to the Host, the radio will reboot.

Packet Definition:

#	Parameter	Type	Definition
0	CAT_REBOOT_CONFIRM (0xF102)	UINT16	Message type
1	Message ID	UINT16	Associates request to confirm packets

3.15 CAT_SET_OPMODE_REQUEST (0xF003)

API: CAT API
Message type: REQUEST (Host)
Corresponding Message type: CAT_SET_OPMODE_CONFIRM (Radio)

Purpose: This message can be used to transition the radio to CAT mode.

Packet Definition:

#	Parameter	Type	Definition
0	CAT_SET_OPMODE_REQUEST (0xF003)	UINT16	Message type
1	Message ID	UINT16	Associates request to confirm packets
2	Operational Mode	UINT32	3: CAT

3.16 CAT_ SET_OPMODE _CONFIRM (0xF103)

API: CAT API
Message type: CONFIRM (Radio)
Corresponding Message type: CAT_SET_OPMODE_REQUEST (Host)

Purpose: This message is sent by the radio to the Host in response to a CAT_SET_OPMODE_REQUEST command indicating the status of the request.

Packet Definition:

#	Parameter	Type	Definition
0	CAT_SET_OPMODE_CONFIRM (0xF103)	UINT16	Message type
1	Message ID	UINT16	Associates request to confirm packets
2	Operational Mode	UINT32	New Operational Mode
2	Status	UINT32	0 = Successful. For error codes see Table 3-1 at the end of this section

3.17 CAT_BIT_REQUEST (0xF008)

API: CAT API
Message type: REQUEST (Host)
Corresponding Message type: CAT_BIT_CONFIRM (Radio)

Purpose: This message prompts the radio to perform a BIT (Built-In-Test), returning results in the CAT_BIT_CONFIRM message.

Packet Definition:

#	Parameter	Type	Definition
0	CAT_BIT_REQUEST (0xF008)	UINT16	Message type
1	Message ID	UINT16	Associates request to confirm packets

3.18 CAT_ BIT_CONFIRM (0xF108)

API: CAT API
Message type: CONFIRM (Radio)
Corresponding Message type: CAT_BIT_REQUEST (Host)

Purpose: This message is sent by the radio to the Host in response to a CAT_BIT_REQUEST command. This response provides the status of the BIT (Built-In-Test).

Packet Definition:

#	Parameter	Type	Definition
0	CAT_BIT_CONFIRM (0xF108)	UINT16	Message type
1	Message ID	UINT16	Associates request to confirm packets
2	BIT Status	UINT32	Return status of the Built-In-Test. Zero indicates no errors detected.

3.19 CAT_SET_SLEEPMODE_REQUEST (0xF005)

API: CAT API
Message type: REQUEST (Host)
Corresponding Message type: CAT_SET_SLEEPMODE_CONFIRM (Radio)

Purpose: This message causes the RCM to transition to a low power mode.

Packet Definition:

#	Parameter	Type	Definition
0	CAT_SET_SLEEPMODE_REQUEST (0xF005)	UINT16	Message type
1	Message ID	UINT16	A tracking number used to associate Host REQUEST messages to CONFIRM messages.
2	Sleep Mode	UINT32	Specifies the transition state. 0: ACTIVE (required for transition out of any low-power state.) 1: IDLE (turns off UWB acquisition. Leaves all interfaces active.) 2: ETHERNET (power down most components but leave the Ethernet interface enabled.) 3: SERIAL (power down most components including the Ethernet interface.)

3.20 CAT_SET_SLEEPMODE_CONFIRM (0xF105)

API: CAT API
Message type: CONFIRM (Radio)
Corresponding Message type: CAT_SET_SLEEPMODE_REQUEST (Host)

Purpose: This message is sent by the radio to the Host in immediate response to a CAT_SET_SLEEPMODE_REQUEST command. This response verifies the radio received the request.

Packet Definition:

#	Parameter	Type	Definition
0	CAT_SET_SLEEPMODE_REQUEST (0xF005)	UINT16	Message type
1	Message ID	UINT16	A tracking number used to associate Host REQUEST messages to CONFIRM messages.

2	Status	UINT32	0 = Successful. For error codes see Table 3-1 at the end of this section

3.21 CAT_FULL_SCAN_INFO (0xF201)

API: CAT API
Message type: INFO (Radio)
Corresponding Message type: none

Purpose: This message is sent by the radio to the Host whenever it receives a packet and contains the waveform scan. Due to the number of samples that may compose a full waveform scan, the waveform scan data may be split into many CAT_FULL_SCAN_INFO messages.

Packet Definition:

#	Parameter	Type	Definition
0	CAT_FULL_SCAN_INFO (0xF201)	UINT16	Message type
1	Message ID	UINT16	Identifier used to correlate transmissions with info messages
2	Source ID	UINT32	Node ID of the transmitting radio
3	Timestamp	UINT32	Milliseconds from boot to time of data reception.
4	Channel Rise	UINT16	A relative measure of the amount of time from start of the leading edge of the received channel to a local maximum. Short rise times indicate line-of-sight channels while long (slow) rise times indicate non-line of sight channels. A zero or 1 indicates line of sight. Increasing values indicate increasing non-line of sight. While values higher than 100 are possible, values greater than 5 indicate significant blockages.
5	Vpeak	UINT16	The absolute maximum value in the leading edge window of the received waveform. This value is used to determine the Coarse Range Estimate (CRE).

6	Linear Scan SNR	FLOAT	Linear signal-to-noise ratio in scan waveform. Taking 10*log10(Linear Scan) will give the SNR/Eb/No of the Scan. The SNR/EbNo of the data can be computed by subtracting from this value 3*Scan Integration Index. For example if the Scan Eb/No is 40 dB and the Scan Integration Index is 5, then the Eb/No of the data equals 40-3*5 or 25dB.
7	Leading Edge Offset	INT32	Offset in scan steps from the point where the radio found leading edge of the pulse.
8	Lock Spot Offset	INT32	Offset from first sample where radio locked on the pulse.
9	Scan Start	INT32	The start position of the waveform scan relative to the lock spot in picoseconds.
10	Scan Stop	INT32	The stop position of the waveform scan relative to the lock spot in picoseconds.
11	Scan Step	UINT16	The amount of time between each sample in bins. By default this is 32 bins equating to about 61 picoseconds between samples.
12	Reserved	UINT16	Reserved
13	Antenna ID	UINT8	Designator of receiving antenna (0=A, 1=B)
14	Operational Mode	UINT8	Specifies the mode of the radio when this scan was collected. [CAT=3]
15	Number of Samples in this Message	UINT16	The number of samples that follow in this message (UDP or Serial).
16	Total Number of Scan Samples	UINT32	The total number of samples in the full scan.
17	Message Index	UINT16	The index of this message within the sequence of CAT_FULL_SCAN_INFO messages.
18	Total Number of Messages	UINT16	The total number of CAT_FULL_SCAN_INFO messages in the entire scan.
19	Scan Data	350*INT32	Scan values collected by the radio.

Table 3-1: CONFIRM Message Status Codes

0	Success	The REQUEST message was processed successfully
1	Generic Failure	Catch-all for uncategorized failures
2	Wrong Op Mode	The REQUEST message cannot be acted upon in the current op mode
3	Unsupported Value	The REQUEST message contained an unsupported value in one or more of its fields
4	Invalid During Sleep	The REQUEST message cannot be acted upon in the current sleep mode
5	Wrong Message Size	The number of bytes in the REQUEST message did not match the expected number of bytes for the message type
6	Not Enabled	The feature used by the REQUEST message is currently disabled
7	Wrong Buffer Size	The specified size of a buffer in the REQUEST message, or the size of the buffer itself, did not match the expected number of bytes for the message type
8	Unrecognized Message Type	The REQUEST Message Type was not recognized
0x80000000	Internal Error Code	An internal error code was generated. This status is or'ed with the internal error code itself and should be used in communication with Time Domain

Appendix A: Parameter Descriptions

The following sections provide additional UWB or system-level detail for API parameters described in Section 3.

A.1 Message ID

The Message ID parameter is a tracking number for each message sent. It serves as a convenient way for the system integrator to keep track of messages and associated responses.

The user typically specifies a unique Message ID for each command sent to one or more local P410s. The P410 will echo this Message ID in each of its responses.

A.2 Pulse Integration Index (PII)

This value determines the number of pulses that are coherently integrated to produce a radio symbol or scan point. Larger PII values result in a higher Signal to Noise ratio (SNR) with longer distance operation at the expense of slower ranging and data rates. All P410 nodes must be pre-configured with identical PII values in order to establish communication.

The user configures the "power of 2" of the pulse integration value. For example, a configured value of PII=7 results in the transmitting node sending 128 pulses per symbol and the receiving node expecting 128 pulses per symbol. If the user needs distance more than speed, he or she can reconfigure PIIs of both transmitter and receiver to 8. This will increase the SNR by 3dB resulting in approximately 40% more distance in line-of-sight conditions. The conversation time will roughly double with each increment of PII. For details on the operating range and data rates please refer to the P400 or P410 data sheet.

A.3 Antenna Mode

The P410 supports two antenna ports. The port nearest the corner of the board is typically designated as the "A" port. By default the P410 uses the A port. The user can define which port is to be used for transmit and which is to be used for receive. It is possible to use the same antenna for both transmission and reception.

This definition is specified in the following Host to P410 commands:

- CAT_SET_CONFIG_REQUEST
- CAT_GET_CONFIG_CONFIRM

The following table illustrates the values:

Mode Value	Transmit Port	Receive Port
0	A	A
1	B	B
2	A	B
3	B	A

Table A-1: Antenna mode configuration settings for the P410

A.4 Code Channel

Seven separate and independent communications channels have been provided. P410s only support one channel at a time. P410s receiving on a particular code channel will not hear those transmitting on a different channel. The channels are designated as channels 0 through 6. The default channel is channel 0. These channels allow the user to implement a code-division multiple access (CDMA) network supporting up to 7 different "cells," or a unique beacon code used for coordination which does not interfere with sub-cells.

The user is responsible for coordinating these code channels. Many more code channels are possible. The user should contact Time Domain for additional or unique code channel enhancements.

A.5 Timestamp

Timestamp is the number of milliseconds that have elapsed since the latest P410 power up. This parameter is not used by the P410, but is provided to enable the system integrator to establish when a message was collected or data was received.

Note this is an interrupt-driven CMOS timestamp with millisecond accuracy. It is not based on picosecond timing triggers in the RF front end.