CloudSDR/CloudIQ
I/Q Mode
Interface Specification

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www.rfspace.com

This specification describes the protocol used to communicate with the CloudSDR/IQ digital receiver. A brief description of the CloudSDR/IQ architecture is provided along with a detailed description of the various command and data message formats is given.

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1. CloudSDR/IQ Architecture

1.1. Functionality

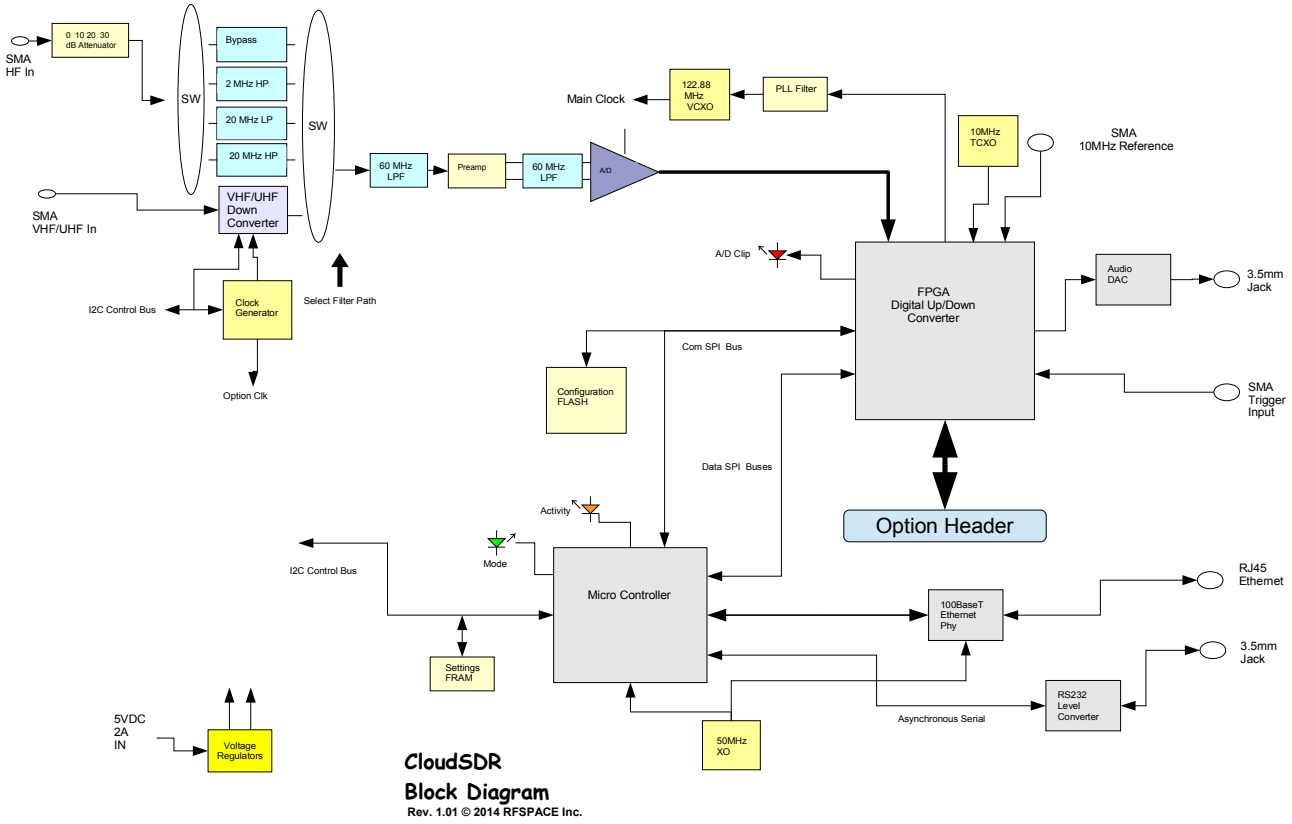
The CloudSDR/IQ is a hardware device whose basic operation is to digitize RF signals, perform various operations on the digitized data and send it back to a client application over an Ethernet network. The CloudSDR/IQ has two modes of operation. This document describes the I/Q mode of operation where the CloudSDR/IQ operates as a base band RF capture device and a PC is used to perform all the receiver demodulation and display functions.

1.2. Block Diagrams

A more detailed block diagram showing the various internal hardware function blocks of the two versions.

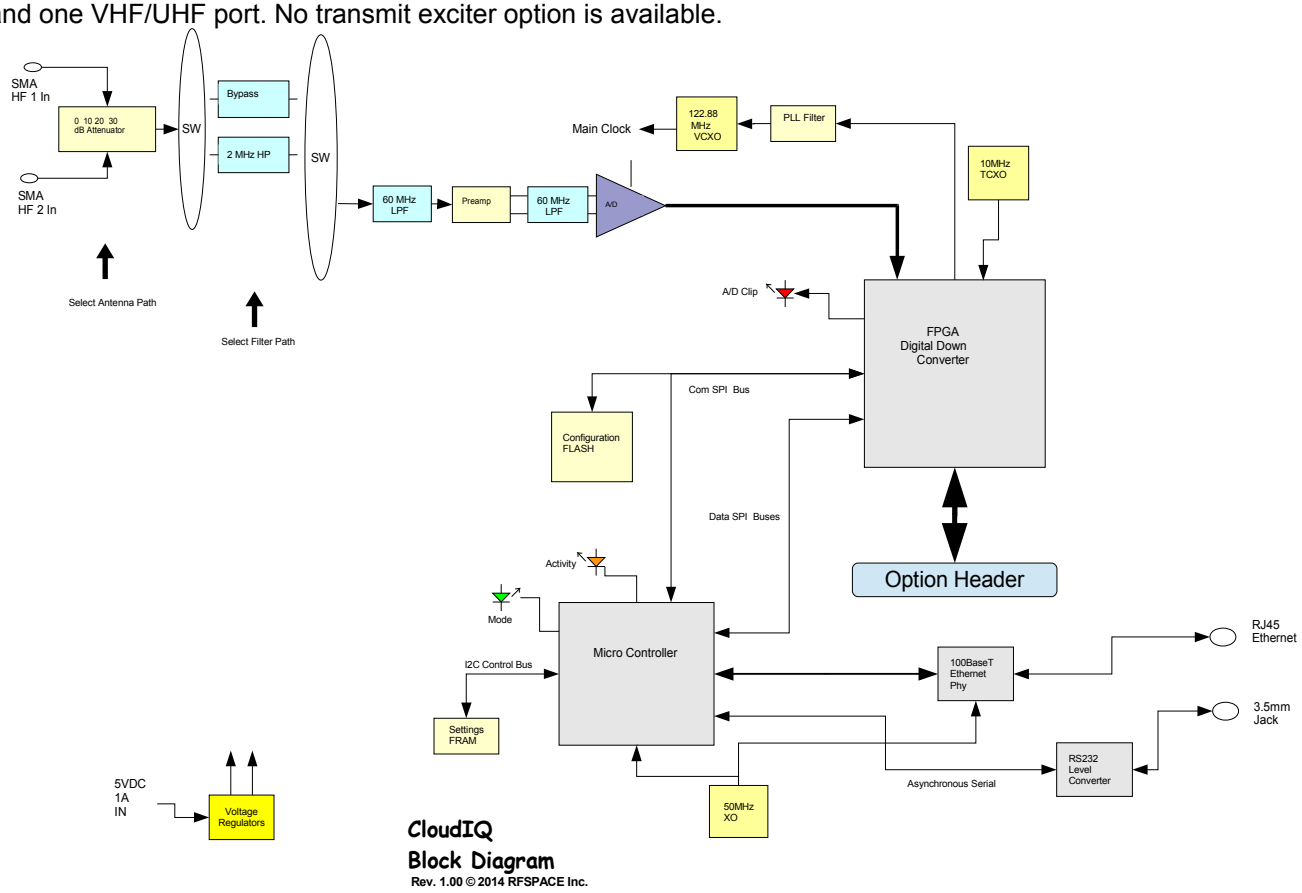
1.2.1 CloudSDR

The CloudSDR has a VHF/UHF down converter to extend the frequency range to over 1GHz. It also has inputs for a 10MHz reference, a trigger input to synchronize RF capture, and an audio DAC output for local monitoring. An option header is available for a transmit exciter option plugin.



1.2.2 CloudIQ

The CloudIQ is a smaller version of the CloudSDR and does not have the VHF/UHF down converter, external reference input, DAC output, 20MHz filters, or trigger input. It has two HF Input ports whereas the CloudSDR has one HF port and one VHF/UHF port. No transmit exciter option is available.



1.3. CloudSDR/IQ Ethernet Interface

The CloudSDR/IQ runs as a TCP/IP Server allowing a single client connection. The CloudSDR/IQ primarily communicates at the “Transport Layer” or Layer 4 of the OSI Reference Model.

The *IQMODE* uses raw 24 bit base band I/Q data and uses both TCP and UDP to provide command and data interfaces back to the client. This mode requires a high bandwidth LAN connection and can provide up to 1MHz of continuous baseband I/Q RF bandwidth.

A non-continuous mode allows viewing I/Q baseband spectrum up to 10MHz as 16k 16bit I/Q data blocks.
A non-continuous real data mode allows viewing up to 60MHz as 32k 16bit real data blocks.

Even though there is only one physical Ethernet connection, one can think of the CloudSDR/IQ interface as multiple logical connections. The primary control and status messaging is done on a single TCP socket that provides guaranteed delivery of the control and status messages. In the *IQMODE,* a separate high speed UDP path from the CloudSDR/IQ back to the Client is used.

A DHCP client may also be enabled that uses broadcast UDP to automatically obtain network configuration from a local DHCP server. There is also a custom broadcast UDP system for setting up network, setting the IQMODE or CLOUDMODE, and other parameters as well as finding an unknown SDR on a local network.

2. Basic Protocol Concepts

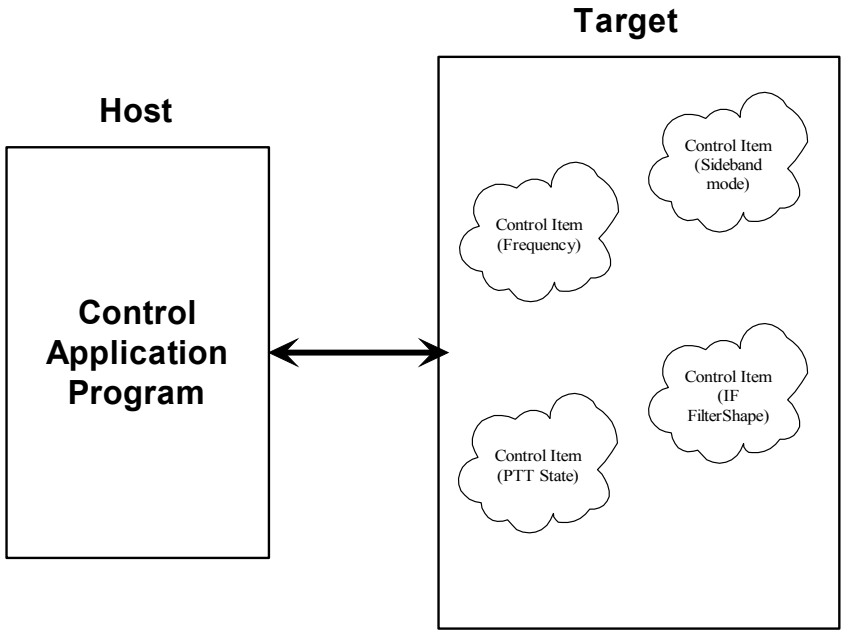
2.1. Definitions used in this specification

In the case of the CloudSDR/IQ, the host is the PC and the Target device is the CloudSDR/IQ hardware.

Host == The main initiator of communications. Typically would be a PC or other computer system such as a custom user interface controller.

Target == The device that is to be controlled or monitored by the Host in this case the CloudSDR/IQ.

Control Item == The value, setting, or state of the target that is to be controlled or monitored by the Host. For example Frequency, Sample Rate, Attenuation, Receiver state, etc.

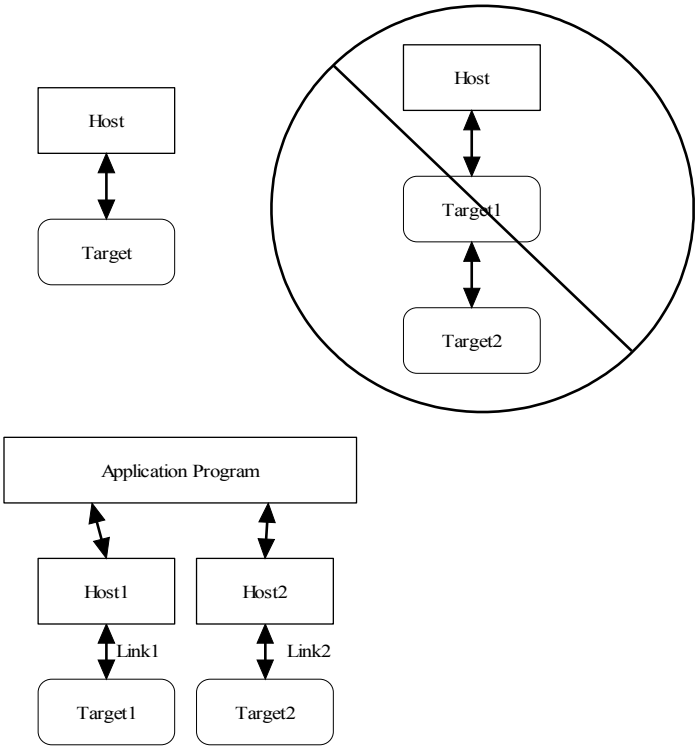


Data Item == Digital data associated with the received signal or other digital data such as firmware update.

Message Block == A contiguous block of bytes comprising a single Control Item or Data Item transfer from target to host or host to target.

2.2. Host and Target Examples

To simplify the protocol, the link can only comprise one host and one target. The Host is the only one that can set or request Control items. This means a Target device cannot connect to another target device or daisy chain to other targets. The Host can control multiple Targets by utilizing multiple links such as multiple TCP/IP Sockets.



The protocol allows a Target to send unsolicited Control Item messages to the Host. This is desirable for updating the Host when a something changes in the Target without the need for polling by the Host.

Message blocks contain the block length in the message header. This is useful to aid in decoding messages as well as being able to support variable length Control Items. For example, a Control Item containing the text string for the Target's manufacturer and model number can be different lengths.

Target devices are not required to implement all the functionality of the protocol. Any unimplemented message will return a NAK response.

The Data Item message blocks allow various raw data blocks to be sent and received along with the Control Items over the same physical link or separate physical links. The Header type allows up to 4 logical channels of data to be specified in each direction. This permits sending digitized audio, digitized I/Q IF data, etc. to and from a target over the same physical connection.

Note that there is no synchronization or error handling mechanism in this protocol. This layer of protocol assumes that the block synchronization and error handling is done at a lower level. This is a reasonable assumption since Ethernet, USB, IEEE 1394, and most other modern physical links provide error recovery.

3. General Message Format

The basic message structure starts with a 16 bit header that contains the length of the block in bytes and also a 3 bit type field. If the message is a Control Item, then a 16 bit Control Item code follows the header and contains the code describing the object of the message block. This is followed by an optional number of parameter or data bytes associated with this message. The byte order for all fields greater than 8 bits is "Little Endian" or least significant byte first.

Control Item Message block format:

16 bit Header(lsb msb)	16 bit Control Item(lsb msb)	Parameter Bytes

Data Item Message block format:

16 bit Header(lsb msb)	N-Data Bytes

The 16 bit header is defined as follows:

8 bit Length lsb	3 bit type	5 bit Length msb

The 13 bit Length parameter value is the total number of bytes in the message including this header. The range of the message Length is 0 to 8191 bytes.

A special case for Data Items is that a message length of Zero is used to specify an actual message length of 8194 bytes(8192 data bytes + 2 header bytes). This allows data blocks of a power of 2 to be used which is useful in dealing with FFT data.

The message type field is used by the receiving side to determine how to process this message block. It has a different meaning depending upon whether the message is from the Host or Target.

3 bit Msg Type field	Message Source	Message Type
000	Host	Set Control Item
001	Host	Request Current Control Item
010	Host	Request Control Item Range
011	Host	Data Item ACK/REQ from Host to Target
100	Host	Host Data Item 0
101	Host	Host Data Item 1
110	Host	Host Data Item 2
111	Host	Host Data Item 3
000	Target	Response to Set or Request Current Control Item
001	Target	Unsolicited Control Item
010	Target	Response to Request Control Item Range
011	Target	Data Item ACK/REQ from Target to Host
100	Target	Target Data Item 0
101	Target	Target Data Item 1
110	Target	Target Data Item 2
111	Target	Target Data Item 3

3.1. Detailed Description of the Message Block Types and Their Purpose

3.1.1 Set Control Item

This Message type is sent from the Host to the Target requesting that the Target change the specified Control Item to the new value supplied in this message. A request to change to a new frequency would be an example of this type of message. The Target must respond to this message either with a NAK or it returns the response message(just a copy of the received Set message).

3.1.2 Request Control Item

This Message type is sent from the Host to the Target requesting that the Target respond with its current state or value of the specified Control Item of this message. A request to get the current AGC settings would be an example of this message type. The Target must respond to this message either with a NAK or it returns the current requested control item value(s).

3.1.3 Request Control Item Range

This Message type is sent from the Host to the Target requesting that the Target respond with the acceptable range of values of the Control Item supplied in this message. A request for the targets frequency range(s) and step sizes would be an example of this message type. The Target must respond to this message either with a NAK or it returns the current control item range(s). (The CloudSDR/IQ implements this message type on a few select Control Items.)

3.1.4 Response to Set or Request Current Control Item

This Message type is sent from the Target to the Host in response to a request from the Host to either set or just return the current value of the Control Item supplied in this message. This message contains the current value of the Control Item. It is sent in response to either the "Set Control Item" or "Request Control Item" message.

3.1.5 Unsolicited Control Item

This Message type can be sent from the Target to the Host without any request from the Host. It contains the current value of the Control Item supplied in this message. This message can be sent at any time to the Host. It can be used to update the Host to any changes that have occurred in the Target Control Items. An example would be if the user changed frequency using the Targets frequency knob, then the Target could send the new Control Item value to the Host without having to wait for the Host to ask for it. There is no response back from the Host when this message is received.

3.1.6 Response to Request Control Item Range

This Message is sent from the Target to the Host in response to a "Request Control Item Range" message from the Host. It contains the allowable range the Control Item supplied in this message. (The CloudSDR/IQ implements this message type on a few select Control Items.)

3.1.7 Data Item Messages

Data Item message allow data messages to be allocated to different logical "channels". Different types of data blocks may be interleaved together and this mechanism allows each end to keep the data separated. For example, Data Item 0 blocks may be digitized audio from a Target receiver that needs to be processed and sent to a speaker. Data Item 3 Blocks may be serial port data from the Target receiver that needs to be sent to the Host applications display screen.

The current scheme allows up to four different logical channels for each data direction.

3.2. The ACK, REQ, and NAK Messages and Their Purpose

A "NAK" message is a 16 bit header without a Control Item or parameters (Message length of 2) [02][00] . When the NAK message block is returned by the Target, it indicates that the specified Control Item is not supported. This allows a target to implement only the Control Items it actually needs. Any Host message requesting an unimplemented Control Item will be returned the NAK message. The Host can then exclude this Control Item from its list of Items to control or monitor.

As an example, suppose a Host requests the elevation setting from a rotor Target controller that only supports azimuth readings. The Target controller would just return the NAK header.

Implementation on the Target side is easily done by simply decoding only the Control Item messages that it supports and returning the NAK for all others.

On the Host side, one could initially poll the Target for all the Control Items it may use and then tag the ones that return NAK for exclusion.

A Data Item "ACK" message is a 16 bit header with a Message Type = 011b with a single parameter byte specifying the Data Item (0 to 3). The 16 bit header is a fixed value (0110 0000 0000 0011 = 0x6003). The parameter byte following the header specifies which Data Item block that is being ACK'd.

For example if the Target received a block of Data Item 2 data correctly it could send the following back to the Host:
[03][60] [02]

The ACK response messages is to provide handshaking to data item transfers. If a data item message is received correctly then an ACK response message could be sent back to the sender. This implementation is optional as one may want to stream data without error checking or only ACK periodically the data stream.

A Data Item "REQ" message is a 16 bit header with a Message Type = 011b with a single parameter byte specifying the Data Item (0 to 3) followed by optional number of parameters such as number of bytes requested.

For example if the Target is requesting a block of 500 bytes of Data Item 2 data it could send the following to the Host:
[05][60] [02] [F4] [01]

4. CloudSDR/IQ Control Item Definitions

These are all the command and control messages that are sent/received over the TCP socket connection of the CloudSDR/IQ.

All examples use hexadecimal notation within brackets [] for the individual byte values.

4.1. General Control Items

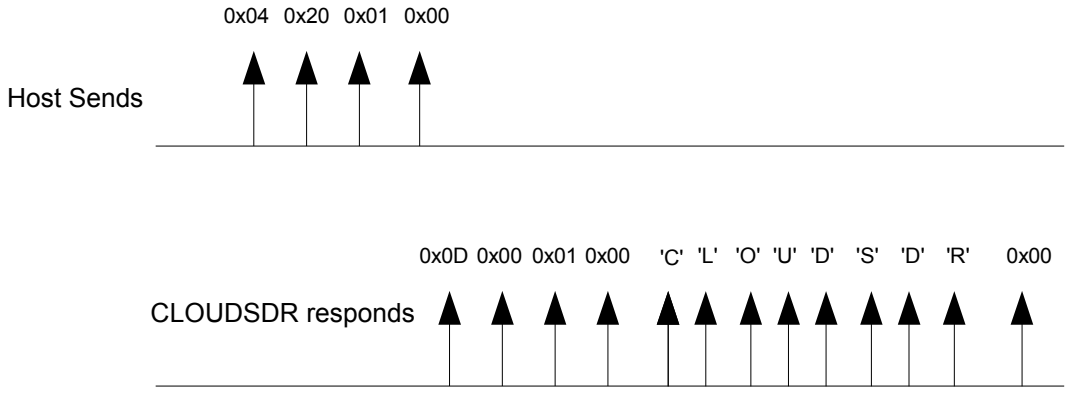
4.1.1 CloudSDR/IQ Name

Purpose: Returns an ASCII string describing the CloudSDR/IQ device.
Control Item Code : 0x0001
Control Item Parameter Format: The data is a NULL(zero) terminated character byte string.

Request Only Message.

Example, to request the CloudSDR/IQ, the host sends:
[04][20] [01][00]
The CloudSDR responds with "CloudSDR" :
[0D][00] [01]00] [43][6C][6F][75][64] [53][44][52][00]
The CloudIQ responds with "CloudIQ" :
[0C][00] [01]00] [43][6C][6F][75][64] [49][51][00]

Example Message sequence of request and response



4.1.2 CloudSDR/IQ Serial Number

Purpose: Contains an ASCII string containing the CloudSDR/IQ device serial number.
Control Item Code : 0x0002
Control Item Parameter Format: The data is a NULL(zero) terminated character byte string.

Request Only Message.

Example, to request the CloudSDR/IQ serial number the host sends:
[04][20] [02][00]
The CloudSDR/IQ responds with "MT123456" or the serial number the particular device:
[0D][00] [02]00] [4D][54][31][32]33][34[35[36][00]

4.1.3 Interface Version

Purpose: Contains the version number of the CloudSDR/IQ's implemented Interface. This allows the CloudSDR/IQ to display or adapt to different versions of the interface.

Control Item Code: 0x0003

Control Item Parameter Format: The data is a 2 byte 16 bit unsigned variable equal to the version times 100. For example the value 123 would be version 1.23.

Request Only Message.

Example, to request the CloudSDR/IQ interface version the host sends:
[04][20] [03][00]
The CloudSDR/IQ with an interface version of 5.29 responds with:
[06][00] [03]00] [11][02]

4.1.4 Hardware/Firmware Versions

Purpose: Contains the Firmware or Hardware version information of the Target.
Control Item Code: 0x0004
Control Item Parameter Format:
The first parameter is a 1 byte Firmware ID specifying which firmware or hardware version to retrieve.
ID=0 returns the CloudSDR/IQ boot code version.
ID=1 returns the CloudSDR/IQ currently loaded application firmware version.
ID=2 returns the CloudSDR/IQ Hardware version.
ID=3 returns the CloudSDR/IQ currently loaded FPGA Configuration version.

ID=4 returns the CloudSDR/IQ application firmware version for ROM_0.
ID=5 returns the CloudSDR/IQ application firmware version for ROM_1.
ID=6 returns the CloudSDR/IQ application firmware version for ROM_2.
ID=7 returns FPGA Configuration version for Config_01
ID=8 returns FPGA Configuration version for Config_02
..
ID=32 returns FPGA Configuration version for Config_26

The firmware/hardware version data is a 2 byte 16 bit unsigned variable equal to the version times 100. For example the value 123 would be version 1.23.

Example, to request the CloudSDR/IQ firmware version host sends:
[05][20] [04][00] [01]
The CloudSDR/IQ with a firmware version of 5.29 responds with:
[07][00] [04]00] [01] [11][02]

Example, to request the CloudSDR/IQ boot code version host sends:
[05][20] [04][00] [00]
The CloudSDR/IQ with a boot code version of 5.29 responds with:
[07][00] [04]00] [00] [11][02]

The current FPGA configuration information consists of a one byte ID and a one byte version.

The ID identifies the configuration type as the CloudSDR/IQ can have various configurations performing different functions or customizations. An ID of 0 is predefined as a development/beta configuration. An ID of 1 to 30 is the configuration currently being used.

The version number is just value from 0 to 255 indicating the release level of that particular configuration ID.

Example, to request the CloudSDR/IQ current configuration revision the host sends:
[05][20] [04][00] [03]
A CloudSDR/IQ with an FPGA configuration ID of 3 and revision 28 responds with:
[07][00] [04]00] [03] [03] [1C]

4.1.5 Status/Error Code

Purpose: Contains the Error/Status code(s) of the CloudSDR/IQ. This item is used to notify the Host of any error or status change using a list of code values.
Control Item Code: 0x0005

Request Only Message.

Control Item Parameter Format: The data is a list of 1 byte unsigned variable equal to the error number associated with a particular error. There can be multiple error codes returned by the CloudSDR/IQ.
0x0B = CloudSDR/IQ Idle
0x0C = CloudSDR/IQ Busy (running)
0x0E = CloudSDR/IQ Boot mode Idle
0x0F = CloudSDR/IQ Boot mode busy programming
0x20 = CloudSDR/IQ A/D overload occurred
0x80 = CloudSDR/IQ Boot mode programming error

Example, host request status:
[04][20] [05][00]
The idle CloudSDR/IQ responds with
[05][00] [05][00] [0B]

If an A/D overload occurs, the CloudSDR/IQ will send an unsolicited status message back to the host.
[05][20] [05] [00] [20]

4.1.6 Custom Name

Purpose: Returns a user settable ASCII string describing the device.
Control Item Code : 0x0008
Control Item Parameter Format: The data is a NULL(zero) terminated character byte string.

Maximum String size is 32 characters plus zero termination

Example, to request the custom name string, the host sends:
[04][20] [08][00]
The CloudSDR/IQ responds with "MySDR" (or whatever string the user set):
[0A][00] [08]00] [4D][79][53][44][52]00]

4.1.7 Product ID

Purpose: Returns the 4 byte product ID for the CloudSDR/IQ used in firmware update validation.
Control Item Code: 0x0009
Control Item Parameter Format:

Request Only Message.

The value returned identifying the CloudSDR.
Example, host request product ID:
[04][20] [09][00]
The CloudSDR responds with
[08][00] [09][00] [43][4C][53][44]

The value returned identifying the CloudIQ.
Example, host request product ID:
[04][20] [09][00]
The CloudIQ responds with
[08][00] [09][00] [43][4C][49][51]

4.1.8 Options

Purpose: Returns information on installed options for the CloudSDR/IQ.
Control Item Code: 0x000A
Control Item Parameter Format:

Request Only Message.

The first parameter is 1 byte option data with the following bit definitions:
Bits 0-7 not defined

The second parameter is 1 byte custom option data with the following definitions:
Bits 0-7 custom options not currently defined

The third parameter is 4 bytes of option detail data with the following 4 bit field definitions:
Bits 0-31 Not defined

Read only values specifying what options are available in the CloudSDR/IQ.
Example, host request Options:
[04][20] [0A][00]
The CloudSDR/IQ may respond with this:
[08][00] [0A][00] [01] [00] [00][00][00][00]

4.1.9 Security Code

Purpose: Returns 32 bit Security code based on 32 bit security key.
Control Item Code: 0x000B
Control Item Parameter Format:
The first parameter is 4 byte security key provided by host. CloudSDR/IQ then returns a 4 security code that is formed by an encryption algorithm unique to the CloudSDR/IQ. Please contact RFSPACE for details on the algorithm. This is a way to protect host software from being used on other hardware.

Example, host requests Security code for a key of 0x12345678:
[08][20] [0B][00] [78] [56] [34] [12]
The CloudSDR/IQ responds with a 4 byte security code
[08][00] [0B][00] [xx][xx][xx][xx]

4.1.10 FPGA Configuration

Purpose: Set or Request the current FPGA Configuration.
Control Item Code: 0x000C
Control Item Parameter Format:

This is a Request message only.

The Response form of this message from the CloudSDR/IQ contain:
Parameter 1 == one byte value of the FPGA configuration selected. (0,1,2..30)
Parameter 2 == one byte value of the FPGA configuration ID. (0-255)
Parameter 3 == one byte value of the FPGA configuration Revision. (0-255)
Parameter 4 == A NULL(zero) terminated character byte string which contains a description of the FGPA code selected.

To Request the currently selected FPGA Configuration information the host sends:
[04][20] [0A][00]
The CloudSDR/IQ responds with its current FPGA configuration information such as:
[18][00] [0A][00] [01] [02] [09] [53] [74] [64] [20] [46] [50] [47] [41] [20] [43] [6F] [6E] [66] [69] [67] [20] [00]
which is FPGA configuration # 1 , ID is 2, and revision is 9 with a description of “Std FPGA Config ”

4.2. CloudSDR/IQ Receiver Control Items

4.2.1 Receiver State

Purpose: Controls the operational state of the CloudSDR/IQ Receiver and Output data format.
Control Item Code: 0x0018
Control Item Parameter Format:

This is the main “Start/Stop” command to start or stop data capture by the CloudSDR/IQ. Several other control items need to be set first before starting the capture process such as output sample rate, packet size, etc. See the “Examples” section for typical start-up sequences.

The first parameter is a 1 byte data type specifier:
Bit 7 == 1 specifies complex base band data 0 == real A/D samples
The remaining 7 bits are for future expansion and should be ignored or set to zero.
0xxx xxxx = real A/D sample data mode
1xxx xxxx = complex I/Q base band data mode

The second parameter is a 1 byte Receiver run/stop control byte defined as:
0x01 = Idle(Stop) stops UDP data streaming
0x02 = Run starts UDP data streaming

The following parameters are required:
The third parameter is a 1 byte parameter specifying the capture mode.
Bit 7 == 1 specifies 24 bit data 0 == specifies 16 bit data
Bit [1:0] Specify the way in which the CloudSDR/IQ captures data
Bit [1:0] == 00 -Contiguously sends data as long as the CloudSDR/IQ is running.
Bit [1:0] == 01 -FIFO mode captures data into FIFO then sends data to the host then repeats.
Bit [1:0] == 11 -Hardware triggered mode where start and stop is controlled by HW trigger input

The following modes are currently defined:
0x00 = 16 bit I/Q Contiguous mode where the data is contiguously sent back to the Host.
0x80 = 24 bit I/Q Contiguous mode where the data is contiguously sent back to the Host.
0x01 = Continuous FIFO mode where N samples of data is captured in a FIFO then sent back to the Host.
0x03 = 16 bit Hardware Triggered Pulse mode.(start/stop controlled by HW trigger input)
0x83 = 24 bit Hardware Triggered Pulse mode.(start/stop controlled by HW trigger input)

The fourth parameter is a 1 byte parameter N specifying the number of 4096 16 bit data samples to capture in the FIFO block capture modes.

The parameter N specifies number of 4096 16 bit samples of data to be placed in the internal FIFO before being sent back to the host. In real mode the maximum value of N is 8(32768 samples). In 16 bit I/Q block mode the maximum value of N is 4(16384 samples)

Note: Some CloudSDR/IQ setup commands must be sent prior to sending this START command such as sample rate, Trigger mode, etc that are needed prior to start of capturing data.

Example: Request to start the CloudSDR/IQ receiver sending complex 24 bit I/Q base band data over UDP.
The host sends:
[08][00] [18][00] [80] [02] [80] [00]
The CloudSDR/IQ responds with:
[08][00] [18]00] [80] [02] [80] [00]

Example: IRequest to start the CloudSDR/IQ sending real 16 bit I/Q FIFO block data over UDP in blocks of (4 x 4096 = 16384) samples.
The host sends:
[08][00] [18][00] [80] [02] [01] [04]
The CloudSDR/IQ responds with:
[08][00] [18]00] [80] [02] [01] [04]

Example: Request to start the CloudSDR/IQ sending real 16 bit A/D FIFO data over UDP in blocks of (8 x 4096 = 32768) samples.
The host sends:
[08][00] [18][00] [00] [02] [01] [08]
The CloudSDR/IQ responds with:
[08][00] [18]00] [00] [02] [01] [08]

Example: Request to stop the CloudSDR/IQ sending/receiving data.
The host sends:
[06][00] [18][00] [00] [01] //parameter 1 is ignored for the stop command.
//parameter 3 and 4 do not have to be sent.
The CloudSDR/IQ responds with:
[06][00] [18][00] [00] [01]

4.2.2 Receiver Frequency

Purpose: Controls the CloudSDR/IQ Receiver NCO center frequency.
Control Item Code: 0x0020
Control Item Parameter Format:
The first parameter is a 1 byte channel ID and is ignored.
Followed by a 5 byte frequency value in Hz (40 bit unsigned integer LSB first)

Example, To set The CloudSDR/IQ Receiver NCO frequency to 14.010 MHz.
The host sends this:
[0A][00] [20][00] [00] [90][C6][D5][00][00]
The CloudSDR/IQ responds with:
[0A][00] [20][00] [00] [90][C6][D5][00][00]

Example, To get the current Receiver NCO frequency :
The host sends this:
[05][20] [20][00] [00]
The CloudSDR/IQ responds with:
[0A][00] [20][00] [00] [90][C6][D5][00] [00]

Example, To get the available receiver frequency range for channel 0:
The host sends this:
[05][40] [20][00] [00]

The CloudSDR/IQ responds with:
1 byte channel ID
1 byte number of frequency ranges

List of frequency ranges each consisting of 10 bytes
5 byte Frequency min
5 byte Frequency max

Example:
CloudSDR with a 0 Hz to 1500MHz capability responds with min and max frequency :
Band 1min 0 Hz = 0x0000000000
Band 1max 1500 MHz = 0x0059682F00
[10][40] [20][00] [00] [01] [00][00][00][00][00] [00][2F][68][59][00]

CloudIQ with a 0 Hz to 56MHz capability responds with min and max frequency :
Band 1min 0 Hz = 0x0000000000
Band 1max 56 MHz = 0x0003567E00
[10][40] [20][00] [00] [01] [00][0][00][00][00] [00][7E][56][03][00]

4.2.3 RF Input Port Select (CloudIQ only)

Purpose: Controls which RF input port to use.
Control Item Code: 0x0030
Control Item Parameter Format:
The first parameter is a 1 byte channel ID and is ignored.
Parameter 2 is a 1 byte value that can have values of (0,1,2)
0 == Automatic mode where the RF port is selected based on a programmable frequency range.
1 == Use RF Port #1
2 == Use RF Port #2

Example, to set the receiver to use RF Port # 2.
The host sends this:
[06][00] [30][00] [00] [02]
The CloudIQ responds with:
[06][00] [30][00] [00] [02]

4.2.4 RF Input Port Range (CloudIQ only)

Purpose: Controls the automatic frequency range of RF input Ports.
Control Item Code: 0x0032
Control Item Parameter Format:

Sets the minimum and maximum frequency in Hz that will automatically select RF Input Port # 2. All frequencies outside this range will use port #1.
Parameter 1 is a 4 byte minimum frequency in Hz.
Parameter 2 is a 4 byte maximum frequency in Hz.

Example to set the automatic port selection range to 30MHz to 56MHz:
The host sends this:
[0C][00] [32][00] [80][C3][C9][01] [00][7E][56][03]
The CloudIQ responds with:
[0C][00] [32][00] [80][C3][C9][01] [00][7E][56][03]

Example to request the automatic port selection frequencies:
The host sends this:
[04][20] [32][00]
The CloudIQ with responds with:
[0C][00] [32][00] [80][C3][C9][01] [00][7E][56][03]

4.2.5 RF Gain

Purpose: Controls the Level of RF gain(or attenuation) of the receiver.
Control Item Code: 0x0038
Control Item Parameter Format:
The first parameter is a 1 byte channel ID and is ignored.

Parameter 2 is a 1 byte signed value whose value may be (0 , -10, -20-, -30 dB).
In Hex notation these values are (0x00, 0xF6, 0xEC, 0xE2).

NOTE: When the CloudSDR is tuned above 54MHz these four attenuation settings map to the following gain settings(unless the VHF/UHF down converter Gain message is used to override):

0 == Highest gain
-10 == Medium gain
-20 == Low gain
-30 == Auto AGC mode

Example, to set the receiver RF Gain to -20 dB (-20 is 0xEC).
The host sends this:
[06][00] [38][00] [00] [EC]
The CloudSDR/IQ responds with:
[06][00] [38][00] [00] [EC]

The host sends this to request the current RF Gain setting:
[05][20] [38][00] [00]
The CloudSDR/IQ responds with:
[06][00] [38][00] [00] [EC]

4.2.6 VHF/UHF Down Converter Gain (CloudSDR only)

Purpose: Controls the various RF gains for the VHF/UHF Down Converter used above 54MHz.
Control Item Code: 0x003A
Control Item Parameter Format:
The first parameter is a 1 byte AUTO AGC mode
0 == Manual gain control
1 == Auto AGC (LNA and Mixer gain settings are ignored)

Parameter 2 is a 1 byte value(0 to 15) that sets the LNA gain.
Parameter 3 is a 1 byte value(0 to 15) that sets the Mixer gain.
Parameter 4 is a 1 byte value(0 to 15) that sets the IF output level.(set level so doesn't A/D doesn't clip)
Parameter 5 is a 1 byte value(0 ,1) that enables the spur avoidance algorithm. Set to zero to disable if faster frequency changes are desired)

NOTE: If you wish to use the built in mapping of converter gain to the four normal RF gain settings(0.-10,-20,-30) then do not issue this message as it over rides the default mapping.

Example, to set the Converter to manual Mode, LNA gain to 14, the Mixer gain to 8, IF level to 5, Spur avoidance On.
The host sends this:
[09][00] [3A][00] [00] [0E] [08] [05] [01]
The Target responds with:
[09][00] [3A][00] [00] [0E] [08] [05] [01]

The host sends this to request the current VHF/UHF Converter settings:
[04][20] [3A][00]
The Target responds with:
[09][00] [3A][00] [00] [0E] [08] [05] [01]

4.2.7 RF Filter Selection

Purpose: Controls the Analog RF Filter selection.
Control Item Code: 0x0044
Control Item Parameter Format:
The first parameter is a 1 byte channel ID and is ignored.

Parameter 2 is a 1 byte value whose range is (0 to 13).
0 = Automatically select filter based on NCO frequency.(default)
1 = Select 2.0 MHz HP Filter
2 = Select 20 MHz LP Filter
3 = Select 2 MHz HP Filter 20 MHz LP Filter
4 = Select 20 MHz HP Filter
5 = Select 2 MHz HP Filter 20 MHz HP Filter
6 = Select 20 MHz LP Filter 20 MHz HP Filter
7 = Select 2 MHz HP Filter 20 MHz LP Filter 20 MHz HP Filter
8 = Bypass Filters
(9-255) not defined

Normally this command is not used and the default Auto mode is sufficient.

Example, to select the 20 MHz Low Pass filter:
The host sends this:
[06][00] [44][00] [00] [02]
The CloudSDR/IQ responds with:
[06][00] [44][00] [00] [02]

4.2.8 A/D Modes

Purpose: Controls various A/D Modes.
Control Item Code: 0x008A
Control Item Parameter Format:
The first parameter is a 1 byte channel ID and is ignored.

Parameter 2 is a 1 byte value whose bits are defined as follows:
Bit 1 --- 1 = A/D gain 1.5 0 = A/D gain 1.0

Example, to set A/D mode to A/D gain 1.5:
The host sends this:
[06][00] [8A][00] [00] [02]
The CloudSDR/IQ responds with:
[06][00] [8A][00] [00] [02]

4.2.9 Input Sync Modes

Purpose: Controls various Hardware Input Synchronization Modes.
Control Item Code: 0x00B4
Control Item Parameter Format:
The first parameter is a 1 byte channel ID and is ignored.

Parameter 2 is a 1 byte value specifying the sync mode:
0 = No Hardware input synchronization (default)
1 = Negative Edge Start Trigger (capture starts on negative edge and runs till packet count reached)
2 = Positive Edge Start Trigger (capture starts on positive edge and runs till packet count reached)
3 = Low Level Start Trigger (capture starts on high to low transition and runs until Trigger goes high)
4 = High Level Start Trigger (capture starts on low to high transition and runs until Trigger goes low)
5 = Not Used
6 = Not Used
7 = Internal Trigger Mode. Use “Internal Trigger Frequency,Phase Offset” messages to adjust.

Parameter 3,4 is a 2 byte 16bit value specifying the number of UDP packets to send for sync modes 1 to 4.
This 16 bit value N specifies 8*N number of UDP packets that are sent, or for example, if N = 3, then 24 UDP packets will be sent .

If the 16 bit packet count value is zero, then the SDR will trigger and run continuously until stopped.

Example, to set the Input Sync mode to Neg edge mode and to send 8000 (1000*8) UDP packets:
The host sends this:
[08][00] [B4][00] [00] [01] [E8][03]
The Target responds with:
[08][00] [B4][00] [00] [01] [E8][03]

4.2.10 Internal Trigger Frequency

Purpose: Internal trigger frequency when internal frequency trigger mode is active.
Control Item Code: 0x00B2
Control Item Parameter Format:
The first parameter is a 1 byte channel ID and is ignored.

Parameter 2 is a 8 byte (64 bit) value representing the trigger frequency in nano Hz.

Example, to set the Internal Trigger Frequency to 1.000000001 Hz → 1000000001 nHz → 0x0000 0000 3B9A CA01:
The host sends this:
[08][00] [B2][00] [00] [01][CA][9A][3B][00][00][00][00]

The Target responds with:
[08][00] [B2][00] [00] [01][CA][9A][3B][00][00][00][00]

4.2.11 Internal Trigger Phase Offset

Purpose: Internal trigger Phase Offset when internal frequency trigger mode is active.
Control Item Code: 0x00B3
Control Item Parameter Format:
The first parameter is a 1 byte channel ID and is ignored.
Parameter 2 is a 2 byte (16 bit) signed integer value representing the trigger phase offset in hundredths of a degree.
Range is +/- 180.00 deg.

Example, to set the Internal Trigger Phase Offset to -152.68 deg → -15268 hundredths of a deg → 0xC45C
The host sends this:
[08][00] [B3][00] [00] [5C][C4]
The Target responds with:
[08][00] [B3][00] [00] [5C][C4]

4.2.12 Receiver I/Q Output Data Sample Rate

Purpose: Specifies the CloudSDR/IQ receiver I/Q data output sample rate.
Control Item Code: 0x00B8
Control Item Parameter Format:
The first parameter is a 1 byte channel ID and is ignored.

The following 4 byte parameter specifies the CloudSDR/IQ receiver I/Q Data sample rate in Hz.
This parameter limited to frequencies that are integer divisions by 4 of the 122.88MHz A/D sample rate.

There are limits to the range of I/Q sample rates that are supported depending on the capture modes:
The maximum contiguous sample rate supported is 1,807,058.8 Hz in the 16 bit I/Q base band mode.(122.88MHz/(4*17))
The maximum contiguous sample rate supported is 1,228,800 Hz in the 24 bit I/Q base band mode.(122.88MHz/(4*25))
The minimum contiguous sample rate supported is 3750.45782 Hz in the in the 24 bit or 16 bit I/Q baseband mode.(122.88MHz/(4*8191)
Valid contiguous Sample rates are == 122.88 MHz / (4*N), where N is 25 to 8191

If the I/Q sample rate is greater than 1,228,800 Hz then the CloudSDR/IQ changes to a 16 bit I/Q block capture mode where the data can be used for displaying spectrum but cannot be used for demodulation since it is not contiguous.

The maximum sample rate supported is 15,360,000 Hz in the 16bit I/Q base band block.(122.88MHz/(2*4))
The minimum sample rate supported is 2,560,000 Hz in the in the 24 bit I/Q baseband mode.(122.88MHz/(2*24)
Valid /Q block sample rates are == 122.88 MHz / (2*N), where N is 4 to 24

Example, to set the CloudSDR/IQ receive data sample rate to 48KHz (122.88MHz/(4*640)
The host sends:
[09][00] [B8][00] [00] [80][BB][00][00]
The CloudSDR/IQ would reply with the following:(this will return the actual sample rate that will be used in the case of a value not a multiple of 122.88MHz/(4*N))
[09][00] [B8][00] [00] [80][BB][00][00]

4.3. CloudSDR Transmit Control Items (CloudSDR only)

4.3.1 Transmitter State

Purpose: Controls the operational state of the CloudSDR transmitter if present.
Control Item Code: 0x0118
Control Item Parameter Format:

This message is used to turn on and off the transmitter of the CloudSDR. The transmitter is independent of the receiver so can operate in full duplex mode otherwise the receiver must be turned off and on to implement a half-duplex system.

The first parameter is a 1 byte channel ID and is ignored.

The second parameter is a 1 byte PTT state byte defined as:
0x00 = Tx Off stops the transmitter
0x01 = Tx On starts the transmitter

Example, to set the transmitter state to ON:
The host sends this:
[06][00] [18][01] [00] [01]
The CloudSDR responds with:
[06][00] [18][01] [00] [01]

4.3.2 Transmit Frequency

Purpose: Controls the CloudSDR Transmit center frequency.
Control Item Code: 0x0120
Control Item Parameter Format:
The first parameter is a 1 byte channel ID and is ignored.
Followed by a 5 byte frequency value in Hz (40 bit unsigned integer LSB first)

Example, To set The CloudSDR Transmit center frequency to 14.010 MHz.
The host sends this:
[0A][00] [20][01] [00] [90][C6][D5][00][00]
The CloudSDR responds with:
[0A][00] [20][01] [00] [90][C6][D5][00][00]

Example, To get the current transmit center frequency :
The host sends this:
[05][20] [20][01] [00]
The CloudSDR responds with:
[0A][00] [20][01] [00] [90][C6][D5][00] [00]

Example, To get the available transmit frequency ranges:
The host sends this:
[05][40] [20][01] [00]

The CloudSDR responds with:
1 byte channel ID
1 byte number of frequency ranges
List of frequency ranges each consisting of 10 bytes
5 byte Frequency min
5 byte Frequency max
Example:
Transmitter with a 100KHz to 54MHz and 140MHz to 150MHz capability responds with min and max frequency for each band :

Band 1 100 KHz = 0x00000186A0
Band 1 54 MHz = 0x000337F980

Band 2 140 MHz = 0x0008583B00
Band 2 150 MHz = 0x0008F0D180

[1A][40] [20][01] [00] [02] [A0][86][01][00][00] [80][F9][37][03][00]
[00][3B][58][08][00] [80][D1][F0][08][00]

4.3.3 Transmitter I/Q Input Data Sample Rate

Purpose: Specifies the CloudSDR transmitter I/Q data sample rate when in IQMODE only.
Control Item Code: 0x01B8
Control Item Parameter Format:
The first parameter is a 1 byte channel ID and is ignored.

The following 4 byte parameter specifies the CloudSDR transmitter I/Q Data sample rate in Hz.
This parameter limited to frequencies (TBD).

Example, to set the CloudSDR transmitter data sample rate to 16kHz (0x3E80)
The host sends:
[09][00] [B8][01] [00] [80][3E][00][00]
The CloudSDR would reply with the following:
[09][00] [B8][01] [00] [80][3E][00][00]

4.4. CloudSDR/IQ Calibration Control Items

4.4.1 Sample Rate Calibration

Purpose: Specifies the CloudSDR/IQ A/D input/output sample rate for calibration purposes.
Control Item Code: 0x00B0
Control Item Parameter Format:
The first parameter is a 1 byte channel ID and is ignored.

The following 4 byte parameter specifies the sample rate in Hz.
The CloudSDR/IQ nominally has a sample rate of 122,880,000 Hz. This command can be used to specify the actual sample rate so that the frequency can be set more accurately. This value is saved in the CloudSDR/IQ internal memory so does not need to be set unless a new calibration value is needed.
Note, this does not change the sample rate but is a way to tell the CloudSDR/IQ what its actual sample rate is so it can accurately set its NCO frequencies.

Example, suppose the actual sample rate is 122,880,123Hz.

To set the CloudSDR/IQ sample rate to 122,880,123Hz.
The host sends:
[09][00] [B0][00] [00] [7B][00][53][07]
The CloudSDR/IQ would reply with the following:
[09][00] [B0][00] [00] [7B][00][53][07]

4.5. CloudSDR/IQ Misc Control Items

4.5.1 Data Output Packet Size

Purpose: Sets the UDP data packet size for the CloudSDR/IQ.
Control Item Code: 0x00C4
Control Item Parameter Format:
The first parameter is a 1 byte value specifying the UDP Packet size(0 or 1).
Setting to a smaller packet size(MTU) may aid in routing over low speed Internet connections.

0 == Large UDP packets (1444 bytes(24bit data) or 1028 bytes(16bit data)) (default)
1 == Small UDP packets (388 bytes(24bit data) or 516 bytes(16bit data))

To set the UDP packet size to small the host sends:
[05][00] [C4][00] [01]
The Target responds with:
[05][00] [C4][00] [01]

4.5.2 Data Output UDP IP and Port Address

Purpose: Sets the UDP IP address and Port number for the CloudSDR/IQ data output in IQMODE.
Control Item Code: 0x00C5
Control Item Parameter Format:

If this command is not sent, the CloudSDR/IQ will use the same IP address of the TCP Client that is connecting to it.
The first parameter is a 4 byte Little Endian value specifying the UDP destination IP Address.

The second parameter is a 16 bit port number in little endian format from 0 to 65535 that gets used by the UDP instead of the Port number of the TCP socket. This value is volatile and not saved on power down so should be set after connecting to the CloudSDR/IQ and before running.

To set the UDP IP address to 192.168.3.123 and port to 12345:
[0A][00] [C5][00] [7B][03][A8]C0] [39][30]
The CloudSDR/IQ responds with:
[0A][00] [C5][00] [7B][03][A8]C0] [39][30]

4.5.3 Serial Port Open

Purpose: Specifies and opens the CloudSDR/IQ Serial Port.
Control Item Code: 0x0200
Control Item Parameter Format:

The CloudSDR/IQ serial port is opened with the following parameters. Data is received and transmitted via the Data Item 2 messages.

Parameter 1 == Port number (not used)
Parameter 2 == Data Item Number (not used, always uses Data Item 2)
Parameter 3 == Number data bits (not used, always 8)
Parameter 4 == Parity 0==no parity, 1==Odd, 2 == Even
Parameter 5 == Stop bits
Parameter 6 == Flow Control(not used)
Parameter 7,8,9,10 == 32 bit bit rate value

Example, to open the CloudSDR/IQ USB Virtual Serial port to 9600 bps, odd parity, 2 stop bits.
The host sends:
[0E][00] [00][02] [00] [02] [08] [01] [02] [00] [80][25][00][00]

The CloudSDR/IQ would reply with the following:
[0E][00] [00][02] [00] [02] [08] [01] [02] [00] [80][25][00][00]

4.5.4 Serial Port Close

Purpose: Specifies and closes the CloudSDR/IQ Serial Port.
Control Item Code: 0x0201
Control Item Parameter Format:

This message closes the CloudSDR/IQ serial port.
Parameter 1 == Port number (not used)

Example, to close the CloudSDR/IQ RS232 port.
The host sends:
[05][00] [01][02] [00]
The CloudSDR/IQ would reply with the following:
[05][00] [01][02] [00]

4.5.5 Change Boot Serial Port Rate

Purpose: Specifies Boot mode Serial Port rate.
Control Item Code: 0x0202
Control Item Parameter Format:

This message changes the CloudSDR/IQ boot mode serial port rate.
Parameter 1 == Port number (not used)
Parameter 2,3,4,5 == 32 bit bit rate value

Example, to change the CloudSDR/IQ RS232 port boot mode rate to 460800bps.
The host sends:
[09][00] [02][02] [00] [00][08][07][00]
The CloudSDR/IQ would reply with the following:
[09][00] [02][02] [00] [00][08][07][00]

4.5.6 Auxiliary Signal Mode (CloudIQ only)

Purpose: Specifies a special tone mode for CloudIQ with optional HW board.
Control Item Code: 0x0280
Control Item Parameter Format:

This message sets up a special two tone audio output mode for custom applications. The UDP I/Q data packet is a different format with 4 extra bytes in the header containing the 16 bit phase of each of the two audio tones referenced to the first I/Q sample in that packet. See UDP data packet format section for details. Only the 24 bit I/Q data mode is supported when this is mode is enabled.
Parameter byte 1 == Enable/Disable 1==on 0== off
Parameter bytes 2,3 == 16 bit bit Tone1 rate in Hz lsb first (range 0 to 20000 Hz)
Parameter bytes 4,5 == 16 bit bit Tone2 rate in Hz lsb first (range 0 to 20000 Hz)

Example, to enable a 321 Hz tone1 and a 1038 Hz tone2
The host sends:
[09][00] [80][02] [01] [41][01] [0E][04]
The CloudIQ would reply with the following:
[09][00] [80][02] [00] [41][01] [0E][04]

4.5.7 Error Log

Purpose: Requests some error log information from CloudSDR/IQ.
Control Item Code: 0x0410
Control Item Parameter Format:

Request only message.
Parameter 1 == 1 byte value Error log Data 1
Parameter 2 == 2 byte value Error log Data 2

4.6. CloudSDR/IQ Data Item 0 Definitions

Purpose: This is the main data item message that is used to send I/Q data to and from the host to the CloudSDR/IQ is running.

Data 0 Item Parameter Format:

The size and data format of the packet depends upon several settings and modes of the CloudSDR/IQ. All multiple byte data values are sent in little endian byte order.

4.6.1.1 Real 16 Bit FIFO Data

If the large MTU packet is specified:

0x04	0x84	16bit Sequence Number	1024 Data Bytes (512 16bit data samples)

If the small MTU packet is specified:

0x04	0x82	16bit Sequence Number	512 Data Bytes (256 16bit data samples)

4.6.1.2 Complex 16 Bit Data

If the large MTU packet is specified:

0x04	0x84	16bit Sequence Number	1024 Data Bytes (256 16bit I/Q data samples)

If the small MTU packet is specified:

0x04	0x82	16bit Sequence Number	512 Data Bytes (128 16bit I/Q data samples)

4.6.1.3 Complex 24 Bit Data

If the large MTU packet is specified:

0xA4	0x85	16bit Sequence Number	1440 Data Bytes (240 24bit I/Q data samples)

If the small MTU packet is specified:

0x84	0x81	16bit Sequence Number	384 Data Bytes (64 24bit I/Q data samples)

4.6.1.4 Complex 24 Bit Data when Auxiliary Tone mode is Active

If the large MTU packet is specified:

0xA8	0x85	16bit Sequence Number	16bit Tone1 Phase	16 bit Tone 2 Phase	1440 Data Bytes (240 24bit I/Q data samples)

If the small MTU packet is specified:

0x88	0x81	16bit Sequence Number	16bit Tone1 Phase	16 bit Tone 2 Phase	384 Data Bytes (64 24bit I/Q data samples)

The 16 bit phase is a number from 0 to 65535 representing the tone phase 0 to 360 degrees.

4.6.2 Data Packet Sequence Number Details

The 16 bit Sequence Number used in the IQMODE UDP I/Q data packets starts with zero then increments by one for each packet that is sent up to 65535 (0xFFFF) then starts with the value of one and increments by one again. The Sequence Number value of zero is only sent on the very start of a capture sequence. This is useful in the Hardware Sync modes to indicate in the data stream when the trigger event occurred.

Trigger/Start	1st pkt	2nd pkt		65535th pkt	65536th pkt	65537th pkt
0x0000	0x0001	0x0002	.....	0xFFFF	0x0001	0x0002

4.6.3 Data Format Details

The data bytes represent either two 16 bit sample values representing the I and Q data or 1 real 16 bit sample value. The byte breakdown for the 16 bit real FIFO data block mode:

R1 lsb	R1 msb	R2 lsb	R2 msb	R3 lsb	R3 msb	R4 lsb	R4 msb	……

The byte breakdown for the 16 bit I/Q data block mode:

I1 lsb	I1 msb	Q1 lsb	Q1 msb	I2 lsb	I2 msb	Q2 lsb	Q2 msb	……

The byte breakdown for the 24 bit I/Q data continuous stream mode:

I1 b0	I1 b1	I1 b2	Q1 b0	Q1 b1	Q1 b2	I2 b0	I2 b1	I2 b2	Q2 b0	Q2 b1	Q2 b2	….....

4.6.4 Transmit Data Request Messages

When the CloudSDR is in the transmit mode, the Host must send it data at the same rate that the CloudSDR consumes the data. To help manage this, a Data request message is sent periodically(TBD) to the Host that tells how many data bytes can be accepted by the CloudSDR's buffer.

The REQ message is has a 16 bit header followed by a single byte of '0' specifying the Data 0 data stream, followed by a 16 bit number representing the number of bytes free in the CloudSDR transmit buffer.

For example if the CloudSDR is requesting a new block of data and it has 500 bytes available in its buffer it would send the following to the Host:
[05][60] [00] [F4] [01]

4.7. Serial Port Data Item 2

Purpose: This data message is used to send and receive Serial Port data to and from the CloudSDR/IQ.

Data 2 Item Parameter Format:

H(lsb)	H(msb)	data byte 1	data byte 2	data byte 3	data byte 4	data byte N-1	data byte N

Where the 16 bit header H is the total number of bytes in the message(N+2) OR'ed with 0xC0.

The Port must be opened and configured first using the message described in section 4.4.5. The port can be closed after the host is done or just left open for future use.

Example, to send 5 bytes 0x12, 0x34, 0x56, 0x78, 0x9A to the CloudSDR/IQ serial port:
The host sends this:
[07][C0] [12] [34] [56] [78] [9A]
The SDR-IQ does not respond to this message.

Example, if SDR-IQ receives 3 bytes 0x55, 0xAA, 0x01on the CloudSDR/IQ serial port:
The SDR-IQ sends this back to the Host:
[05][C0] [55] [AA] [01]

4.8. CloudSDR/IQ Firmware Update Item Definitions

This set of items is used to update the CloudSDR/IQ firmware or FPGA code.

4.8.1 Update Mode Control

Purpose: Controls the Updating of Software or Firmware code.
Control Item Code: 0x0300
Control Item Parameter Format:
The first parameter is a 1 byte device ID (0 to 255).
This byte specifies the device or bank to program.

Parameter 2 is a 1 byte the Mode command.
0x00 == ENTER (Enter boot loader code if it is not running in it currently)
0x01 == START (Begin the update process)
0x02 == END (End update process and jump back into user code)
0x03 == ABORT (Abort update process)
0x04 == ERASE_UP (erase uP flash) disabled command
0x05 == ERASE_CFG (erase Cfg Flash) disabled command

Parameter 3,4,5, and 6 is a 4 byte password to protect against inadvertent programming.

4.8.2 Update Mode Parameters

Purpose: Request programming parameters from the CloudSDR/IQ device.
Control Item Code: 0x0302
Control Item Parameter Format:
The first parameter is a 1 byte device ID (0 to 255).
This byte specifies the device or bank to program.
There are only two values defined:
0 == Processor application Flash Code
1 == FPGA configuration data
There are multiple FPGA configurations that are stored at different addresses

The response contains these additional bytes:
Parameter 2,3,4,5 is the Flash size in bytes (32 bit unsigned integer LSB first)

Parameter 6,7,8,9 is the Flash programming page size in bytes (32 bit unsigned integer LSB first)

Parameter 10,11,12,13 is the Flash Sector size in bytes (32 bit unsigned integer LSB first)

The host sends this to request the programming parameters from the CloudSDR/IQ device 0:
[05][20] [02][03] [00]
The CloudSDR/IQ responds with: (2M byte FLASH, 256 byte page, 16384 byte sector)
[11][00] [02][03] [00] [00] [00] [20] [00] [00] [01] [00] [00] [00] [40] [00] [00]

4.8.3 Update Mode Data Item 0 or 1 Block

Purpose: This is the main data item message that is sent to the CloudSDR/IQ containing device programming data.
Data 0,1 Item Parameter Format:

Data blocks sent to the CloudSDR/IQ from the host are a fixed size containing a 4 byte address, followed by "Flash Programming Page Size" bytes of data with the 2 byte data item 0 or 1 header.

Hdr1	Hdr2	4 byte Starting address for this data block	“Flash Programming Page Size” data Bytes

Example 1, to program a block of data at address 0x12345 in the CloudSDR/IQ processor flash. Assume the flash programming page size is 256. Uses Data Item 0 so 16 bit Hdr is 0x8106

The host sends this: 2 hdr bytes + 4 address bytes + 256 data bytes = 262 bytes
[06][81] [45] [23] [01] [00] [9A] [78] [56] [34] [12] .....[37]

The CloudSDR/IQ responds after programming the block into flash with:
[03][60] [00]

The host can now send another data block after receiving the ack message from the CloudSDR/IQ.

Example 2, to program a block of data at address 0x60000 in the CloudSDR/IQ FPGA Configuration flash. Assume the flash programming page size is 256. Uses Data Item 1 so 16 bit Hdr is 0x8106

The host sends this: 2 hdr bytes + 4 address bytes + 256 data bytes = 262 bytes
[06][A1] [45] [23] [01] [00] [9A] [78] [56] [34] [12] .....[37]

The CloudSDR/IQ responds after programming the block into flash with:
[03][60] [01]

The host can now send another data block after receiving the ack message from the CloudSDR/IQ.

5. Examples of Basic CloudSDR/IQ I/Q Mode Operations

5.1. 24bit I/Q Contiguous Capture Setup Example

5.2. 16bit I/Q Block Mode Setup Example

5.3. 24bit I/Q HW Triggered Capture Setup Example

6. Change Log

Rev 0.03
- Initial Release

Rev 0.04
- Added new 16 bit I/Q data mode

Rev 0.05
- Corrected Product ID example values

Rev 0.06
- Expanded firmware/fpga revision msg

Rev 0.07
- Added Small I/Q packet support
- Added trigger support

Rev 0.08
- Added Change Boot Serial Port Rate

Rev 0.09
- Added auxiliary Audio tone mode for CloudIQ