ODI-2.1: High Speed Data Formats

Optical Data Interface

Revision 3.0

January 3, 2019

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Revision History

This section is an overview of the revision history of the ODI-2.1 specification.

Revision Number	Date of Revision	Revision Notes
1.0	October 2, 2017	Initial Version (Preliminary). In slide format.
2.0	April 20, 2018	In slide format (Preliminary). Updated to comply with V49.2. Added a table of common data formats along with their Class IDs. Added a common Control Packet. Context Packet fields changed to match fields in standard Control Packet. This includes the elimination of Device ID along with the inclusion of two null fields CIF1 and CIF2.
3.0	January 3, 2019	First formal textual specification. Expanded Glossary. Added content regarding mixing ODI-2.1 streams with non-ODI-2.1 packets and streams. Changed the term “Data Type” to “Item Type” in the Class ID field to more accurately denote the contents of the field. Narrowed the choice of recommended timestamp formats to four. Added options tables for each ODI-2.1 packet class.

Table 1-1: Architectural Specification Revisions

1. ODI Specification Organization and Requirements

1.1 Introduction

ODI is the abbreviation for Optical Data Interface, a high-speed interface for advanced instrumentation and embedded systems. ODI breaks speed and distance barriers by relying on optical communication between devices, over a simple pluggable optical cable.

With single port speeds up to 20 GBytes/s, and system speeds up to 80 GBytes/s, ODI is designed to address challenging applications in 5G communications, mil/aero systems, high-speed data acquisition, and communication research. Though managed by the AXIe Consortium, ODI is not specific to AXIe modular systems, and works equally well with any product format, whether AXIe, PXI, VPX, LXI, or a traditional bench instrument design. Standard ODI ports enable communication between instruments, processors, storage, and embedded devices.

ODI-1 describes the Physical Layer requirements for ODI-1 ports and cables, including the mechanical, optical, line rate, and protocol requirements. ODI-1 is designed to work together with other ODI specifications as shown in the diagram below. ODI-2, the Transport Layer, describes how VITA 49 packets are utilized and deployed, and how ports are aggregated to increase throughput. ODI-2.1 documents a specific set of high-speed data and metadata formats to deliver plug and play interoperability. ODI-A describes a common API for test and measurement equipment.

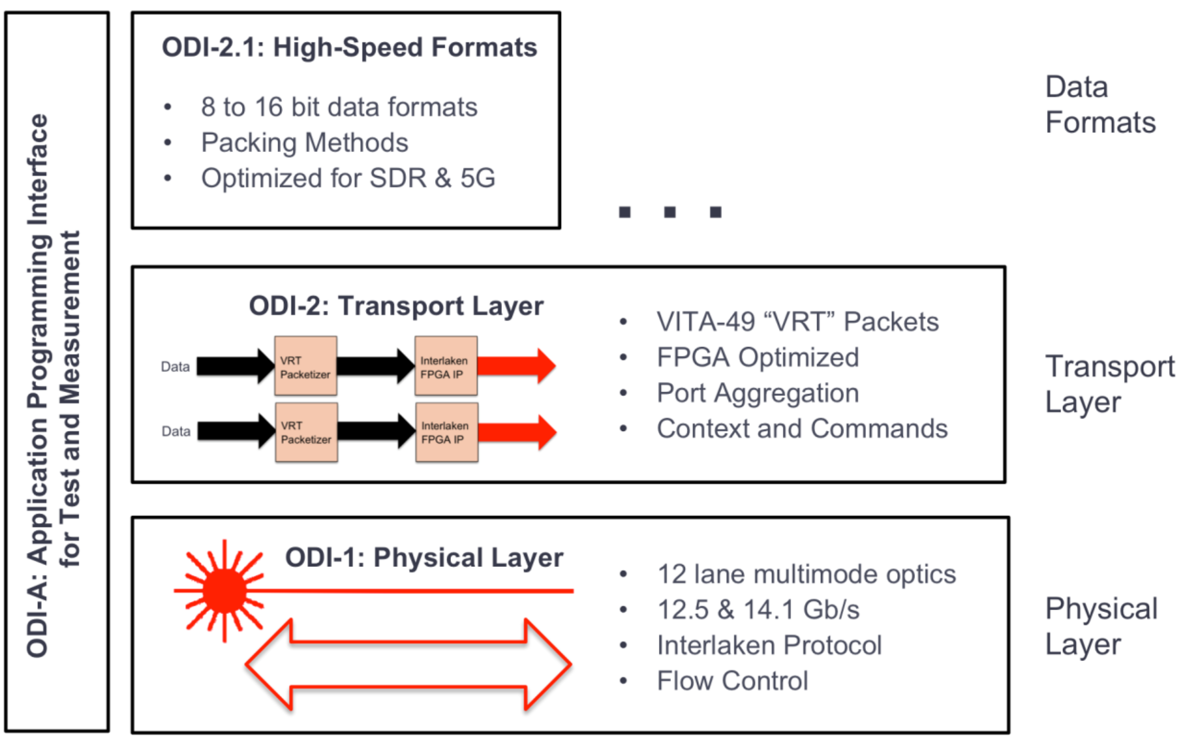

Figure 1-1: ODI Specification Structure

1.2 ODI-2.1 Compliance

ODI-2.1 High Speed Data Formats defines a subset of the ODI-2 Transport Layer to encourage interoperability between ODI devices. Common products include instruments and instrumentation modules, RF embedded systems and modules, storage and processing devices. For a device to claim conformance, it must comply with all applicable RULES in this document, including documentation requirements.

ODI-2.1 is designed for use with other ODI specifications. Compliance to each ODI specification is to be claimed independently.

1.3 Audience of Specification

This specification is primarily for the use by

- Instrumentation engineers designing ODI products
- Storage, processing, and similar design engineers creating ODI products
- Embedded system and module design engineers creating ODI products
- Component and cable suppliers offering ODI-compatible products

1.4 Organization of Specification

This specification consists of a system of numbered RULES, RECOMMENDATIONS, PERMISSIONS, and OBSERVATIONS, along with supporting text, tables, and figures.

RULEs outline the core requirements of the specification. They are characterized by the keyword "**SHALL**". Conformance to these rules provides the necessary level of compatibility to support the multi-vendor interoperability expected by system integrators and end users. Products that conform to this specification must meet all of the requirements spelled out in the various rules.

RECOMMENDATIONs provide additional guidance that will help ODI equipment suppliers improve their users' experiences with ODI systems. They are characterized by the keyword "**SHOULD**". Following the recommendations should improve the functionality, flexibility, interoperability, and/or usability of ODI products. Products are not required to implement the recommendations.

PERMISSIONs explicitly highlight some of the flexibility of the ODI specification. They are characterized by the keyword "**MAY**". The permissions generally clarify the range of design choices that are available to product and system designers at their discretion. They allow designers to trade off functionality, cost, and other factors in order to produce products that meet their users' expectations. Permissions are neutral and imply no preference as to their implementation.

OBSERVATIONs explicitly highlight some of the important nuances of the specification. They help the readers to fully understand some of the implications of the specification's requirements and/or the rationale behind particular requirements. They generally provide valuable design guidance.

All rules, recommendations, permissions, and observations must be considered in the context of the surrounding text, tables, and figures. Rules may explicitly or implicitly incorporate information from the text, tables, and figures. Although the authors of this specification have gone to significant effort to insure that all of the necessary requirements are spelled out in the rules, it is possible that some important requirements appear only in the specification's free text. Conservative design practice dictates that such embedded requirements be treated as rules.

The ODI specifications also rely on the Interlaken and VITA 49 specifications. The relevant Interlaken and VITA 49 requirements are explicitly referenced in ODI specifications' rules, recommendations, permissions, and observations. The ODI specifications do not duplicate the Interlaken and VITA 49 specifications, but reference them as appropriate. Successful implementation of ODI products and systems requires in-depth knowledge of Interlaken and VITA 49. Designers are encouraged to understand those specifications.

1.5 References

Several other documents and specifications are related to the ODI specifications. These include:

- Telecommunications Industry Association (TIA) standards:
  TIA-604-5-D, FOCIS 5 *Fiber Optic Connector Intermateability Standard- Type MPO,*
  TIA-568.3-D*, Optical Fiber Cabling Component Standard.*

  http://www.tiaonline.org
- Institute of Electrical and Electronics Engineers (IEEE)
  802.3-2016, *IEEE Standard for Ethernet*

  http://standards.ieee.org
- Interlaken Protocol Specification, v1.2. http://www.interlakenalliance.com
- VITA standards:
  VITA 49.2 *VITA Radio Transport (VRT) Standard for Electromagnetic Spectrum*, VITA 49A *Spectrum Survey Interoperability Specification*

  https://shop.vita.com/ANSI-VITA-Standards_c4.htm

1.6 Glossary

The ODI Glossary is organized into three sections:

- ODI Terms
- Interlaken Terms
- Packet Terms

1.6.1 Common ODI Terms

Here are the definitions of the common ODI terms:

- **Device –** A product or assembly that generates or receives data and has one or more optical ports
- **Port –** A single optical connector on a device, and the associated photonics and electronics.
- **Cable –** A multi-fiber optical cable that connects between two ports.
- **Link. -** A unidirectional connection between two ports, consisting of 12 lanes of multimode optical transmission. A bi-directional connection has two links, one in each direction.
- **Producer -** ODI device that generates data to be sent over one or more optical ports.
- **Consumer -** ODI device that receives data sent over one or more optical ports.
- **Transmitter –** Interlaken term for a producer.
- **Receiver –** Interlaken term for a consumer.
- **Emitter –** VITA 49 term for a producer.
- **Exciter –** VITA 49 term for an RF Signal Generator
- **Interlaken –** Interlaken is the name of a chip-to-chip interface specification that is used by ODI to transfer packets between two ODI ports. It is the primary communication protocol, and sits just above the optical layer. Interlaken does not define any structure to the packet at all, other than a SOP (Start of Packet) and EOP (End of Packet) signal. The ODI-1 Physical Layer specifications specify the use of Interlaken, but do not define the packet contents. Separately, the ODI-2 family of specifications defines packet contents and behaviors.
- **VRT –** VRT is an abbreviation for VITA Radio Transport, standardized in VITA 49.2, and enhanced by other VITA 49x specifications. VRT specifies the structure and behavior of VRT packets, which carry data, context, and control information about signals, and the data stream itself. VITA 49 may be abbreviated as V49, just as VITA 49.x may be abbreviated as V49.x
- **Channel –** "Channel" is used in two different contexts in ODI, Interlaken channel and signal channel. Channel is used by Interlaken to enable a completely different data stream with its own flow control. This is not envisioned to be widely used in ODI systems, but is permitted. ODI generally uses only a single Interlaken channel.

  Outside of the Interlaken context, ODI adopts the term "channel" to mean signal channel, and uses VITA 49 VRT packets to transmit one or multiple channels of digitized data. Synchronous signal channels are encoded into the VRT stream in a rotating sequence, and are referred to as a "sample vector" in VRT parlance. VRT Sample Vector Size field is the number of signal channels minus 1. This assumes synchronous channels, all at the same data rate and resolution.

- **Word –** An Interlaken Word is 8 bytes (64 bits). A VRT Word is 4 bytes (32 bits). ODI will specify the context if “Word” is used. ODI often uses “bytes” to avoid this confusion.

1.6.2 Interlaken Terms

ODI uses many Interlaken-specific terms. These include:

- **Burst –** In Interlaken, data is divided into data bursts, each delineated by one or more burst control words. One or more bursts are required to send a complete packet.
- **BurstMax –** An Interlaken parameter that determines the maximum number of data bytes sent for each burst. Consecutive bursts are used to stream data. ODI allows 256 and 2048 byte BurstMax.
- **BurstShort –** An Interlaken parameter that reflects the shortest burst allowed.
- **BurstMin –** An Interlaken parameter for the Optional Scheduling Enhancement that guarantees all packets are at least BurstMin in length, and no idle control words will be needed for long packets.
- **Packet –** A packet refers to the block of data sent between Interlaken SOP and EOP (Start of Packet and End of Packet) indicators. At the Interlaken layer, the format of the packet is unknown. ODI-2 has defined the packet to be VRT packets. The term “packet” within ODI may refer to either.

1.6.3 Packet Terms

ODI has adopted VITA 49 VRT packets as its standard packet framework. Packet terms include VRT terms and ODI terms related to packets:

- **Prologue** – The fields within a packet that precede the packet’s data payload. ODI defines a standard prologue for each VRT packet type.
- **Header** – The first field in the VRT prologue, 4 bytes in length. The header bits indicate packet type, optional fields within a packet, time stamp formats, a modulo-16 counter, and total packet size.
- **Trailer** – The fields within a packet that follow the data payload and conclude the content of the packet. In ODI, the trailer refers to the 4-byte field that follows the data payload within a VRT Data packet. There is no trailer associated with Context Packets or Command Packets.
- **Processing-efficient packing** – Processing-efficient packing refers to a data packing method within the VRT Packet data payload where the packed data is aligned to 32-bit boundaries.
- **Link-efficient packing** – Link-efficient packing refers to a data packing method within the VRT Packet data payload where the data is packed as tightly as possible, leading to the highest sample density and speed.
- **Stream** – A VRT term for a sequence of related packets. All packets of the same stream have the same Stream ID sent from the producer. A typical stream has consecutive Signal Data Packets, with optional Context Packets and/or Command Packets occasionally.

- **Signal Data Packets** – VRT term for a packet carrying digitized samples of one or more signals. This is the primary packet type of ODI. Many ODI systems will only include Signal Data Packets.
- **Context Packet** – VRT term for a packet carrying meta-data or “context” data related to the digitized signals in the same stream. This may include information such as reference level or sampling rate. Context Packets are optional in ODI, but a standard Context Packet is defined in ODI-2.1 if used.
- **Command Packet** – VRT packet type added in V49.2. Command Packets are used to control devices, and the control and acknowledgement process. The Control Packet is the only recommended Command Packet subtype in ODI, and has similar field types to the Context Packet, which are used for control. Control and other Command Packets are optional in ODI, but a standard Control Packet is defined in ODI-2.1 if used. The Control Packet is analogous to the Context Packet, as it is a way to send meta-data to a consumer, such as a signal generator, and has similar fields.
- **Extension Packet** – Extension Signal, Context, and Command packets are used when it is impossible to use the pre-defined data types. An example may be the sending of encrypted data.
- **Train** – For streaming applications, the Train refers to a series of packets, typically of the same size, sent sequentially from a producer, but not including the final packet, called the Caboose
- **Caboose** – For streaming applications, the Caboose refers to the final packet sent from the producer. It may or may not be the same size as the Train packets.
- **Sample Vector** – A Sample Vector is defined within V49.2 as a collection of synchronous Data Samples. This is the common method of transporting multi-channel sample data within the VRT data payload fields. Vector size describes the number of channels. However, the VRT Vector Size Field, used in V49.2 and ODI-2.1, is calculated as the vector size minus one. Therefore a two-channel stream has a vector size of two, but a Vector Size Field of 1.
- **V49.2** – Shorthand for VITA 49.2 specification.
- **ODI-2.1 Data Packet** – A standardized Signal Data Packet defined in ODI-2.1 with common data formats for interoperability.
- **ODI-2.1 Context Packet** – A standardized Signal Context Packet defined in ODI-2.1 with common context fields for interoperability.
- **ODI-2.1 Control Packet** – A standardized Control Packet subtype defined in ODI-2.1 with common control fields for interoperability.

2. Overview of the ODI-2.1 High Speed Data Formats Specification

ODI-2.1 is a data format specification designed to increase interoperability between ODI devices. These formats are chosen to optimize the transport of single or multi-channel high-speed signal data. ODI uses the AXIe OUI (Organizationally Unique Identifier) combined with an algorithmically defined Class ID2 field to unambiguously identify the packet and data formats used.

ODI-2.1 builds on top of the VITA 49.2 VITA Radio Transport (VRT) standard described in ODI-2. ODI-2.1 describes specific packet and data formats for improved interoperability between devices. The ODI-2.1 standard is at an equivalent level to VITA 49A-2015 Spectrum Survey Interoperability Specification, but focuses specifically on formats suitable for high speed streaming and FPGA processing.

The only mandated ODI-2.1 packet is a standardized VRT Signal Data Packet. Many ODI systems will be deployed using only this packet type. This packet type is optimized for high-speed streaming of multi-channel RF sample data. It supports up to 8192 signal channels per stream, with link-efficient packing to take advantage of the full bandwidth of ODI. In the specification, this standardized packet will be known as ODI-2.1 Data Packet.

ODI-2.1 also defines standard, but optional, Context Packets and Control Packets. Each is 96 bytes in length. These are used to describe meta-data about the RF signals, such as Reference Level or Sample Rate. Context Packets *report* meta-data about a signal, while Control Packets *command* a change in meta-data parameters about a signal. Context and Control Packets are used by signal receivers and signal generators respectively. Control Packets are a subtype of VRT Command Packets, but no other Command Packets are specified within ODI-2.1.

The Context and Control Packets share similar fields in similar locations, enabling a signal generator to interpret meta-data from each similarly. Though the Control Packet is the standard way to command a change in meta-data parameters, ODI-2.1 allows a signal generator to optionally execute Context Packets as well. This allows a signal to be recorded, including the associated Context Packets, and “played back” to recreate the original signal.

ODI-2.1 specifies the format and packing of real and complex signed binary data from 8 bits of resolution to 16 bits of resolution.

- ODI-2.1 mandates the handling of 8 and 16 bit item data
- ODI-2.1 describes the optional capability of handling of 9 through 15 bit link-efficient packed data
- ODI-2.1 describes the optional capability of indicating events, such as markers.
- ODI-2.1 optionally allows other VITA 49A data formats.

This range addresses applications in wireless communications, 5G cellular, radar, electronic warfare, and high-speed data acquisition.

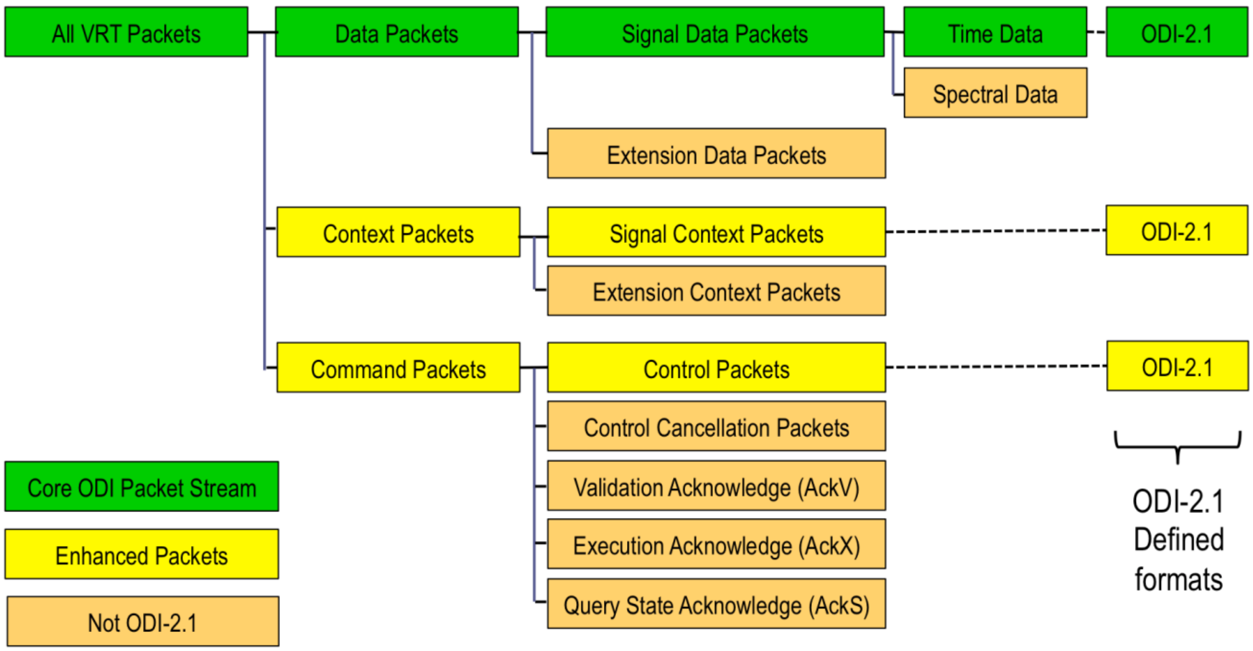

Figure 2-1: ODI-2.1 Packet Hierarchy

The figure above shows the packet hierarchy for ODI-2.1 devices. It follows the hierarchy for ODI-2 devices, but adds standard defined formats for Signal Data Packets, Signal Context Packets, and Control Packets. Only the ODI-2.1 Data Packet is required. The standardized Signal Context Packets and Control Packets are optional, and are known as ODI-2.1 Context Packets and ODI-2.1 Control Packets respectively. Several packet subtypes are not further defined in ODI-2.1, and are not recommended. They are shown in brown.

2.1 Scope of ODI-2.1

ODI-2.1 defines standard packets, formats, and behavior, including:

- Mandatory standard Signal Data Packet known as ODI-2.1 Data Packet
- Standard but optional Context Packet known as ODI-2.1 Context Packet
- Standard but optional Control Packet known as ODI-2.1 Control Packet
- Algorithmic method to generate a Class ID based on data formats used

2.2 ODI-2.1 Capability and Performance Summary

		Link Speed			
		ODI-1		ODI-1.1	ODI-1.2
		12.5G	**14.1G**	**28G**	**56G**
# of Ports	**1**	17.3GB/s	20GB/s	40GB/s	80GB/s
	2	34.6GB/s	40GB/s	80GB/s	160GB/s
	3	51.9GB/s	60GB/s	120GB/s	240GB/s
	4	69.3GB/s	80GB/s	160GB/s	320GB/s

Figure 2-2: Speed characteristics of ODI devices.

ODI devices can deliver continuous device-to-device streaming up to 20 GBytes/s when using a 14.1 Gb/s line rate, as shown in the figure above. 12.5 Gb/s devices can achieve 17.3 GBytes/s. Multiple ports may be aggregated together, further increasing the aggregated throughput.

ODI-2.1 allows a device to reach these rates for any data resolution from 8 bits to 16 bits. For 8 and 16 bit devices, these speeds are attained automatically, since the data values can be optimally packed within VRT packets, with the data boundaries aligned to Interlaken word boundaries. In this case the data is both processing efficient and link-efficient. Devices are required to implement 8 and 16 bit modes. For data values between 9 and 15 bits, ODI-2.1 allows the use of link-efficient packing. By definition, link-efficient packing allows the data to be transported at the above cardinal speeds.

ODI-2.1 allows the implementations of up to 8192 synchronous signal channels.

3. ODI-2.1 Packet Specifications

This section details the Packet requirements of ODI-2.1 devices.

RULE 3.1: All ODI-2.1 devices SHALL comply with all packet requirements specified in ODI-2.

PERMISSION 3-1: An ODI-2.1 device MAY use non-ODI-2.1 Packet definitions if the non-ODI-2.1 packets are documented.

OBSERVATION 3.1: The above Permission allows an ODI-2.1 device to also source non-ODI-2.1 packets. In this case, an OUI other than the AXIe OUI would be used for the non-ODI-2.1 packets.

There are two common use cases where non-ODI-2.1 packets may be used.

One is when associating an ODI-2.1 Data Packet stream to Context or Control Packets that have a different definition than the standard ODI-2.1 Context or Control Packets. In this case the Stream IDs are the same, but the Context or Control Packets have a different OUI/Class ID definition.

The second use case is when, for whatever reason, a completely non-ODI-2.1 stream is generated. In this case none of the packets in the stream are defined by ODI-2.1, but they must still meet the requirements of ODI-2.

3.1 ODI-2.1 Data Packets

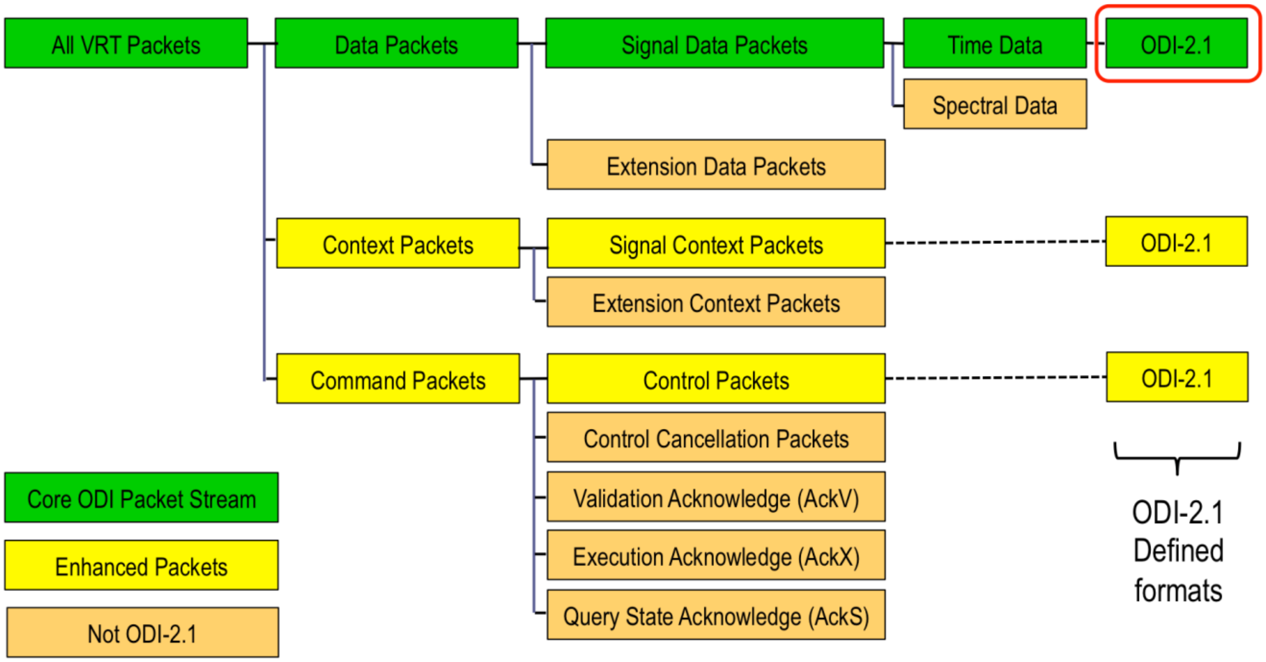

Figure 3-1: ODI-2.1 Data Packets

The standard ODI-2.1 Data Packet is a specific ODI-2 Signal Data Packet that uses the AXIe OUI combined with an algorithmically-generated Class ID to unambiguously identify the data formats used within the Data Payload.

Since an ODI-2.1 Data Packet complies with ODI-2, it has the following mandatory fields as shown in Figure 3-2.

- Header
- Stream ID
- Class ID1 and Class ID2
- Timestamp fields of TSI, TSF1, and TSF2
- Data Payload
- Trailer

As with ODI-2, the ODI-2.1 Data Payload must be an integer multiple of 32 bytes in length, ranging from 64 bytes to 262,144 bytes. The Data Payload is typically long to achieve maximum transport efficiency.

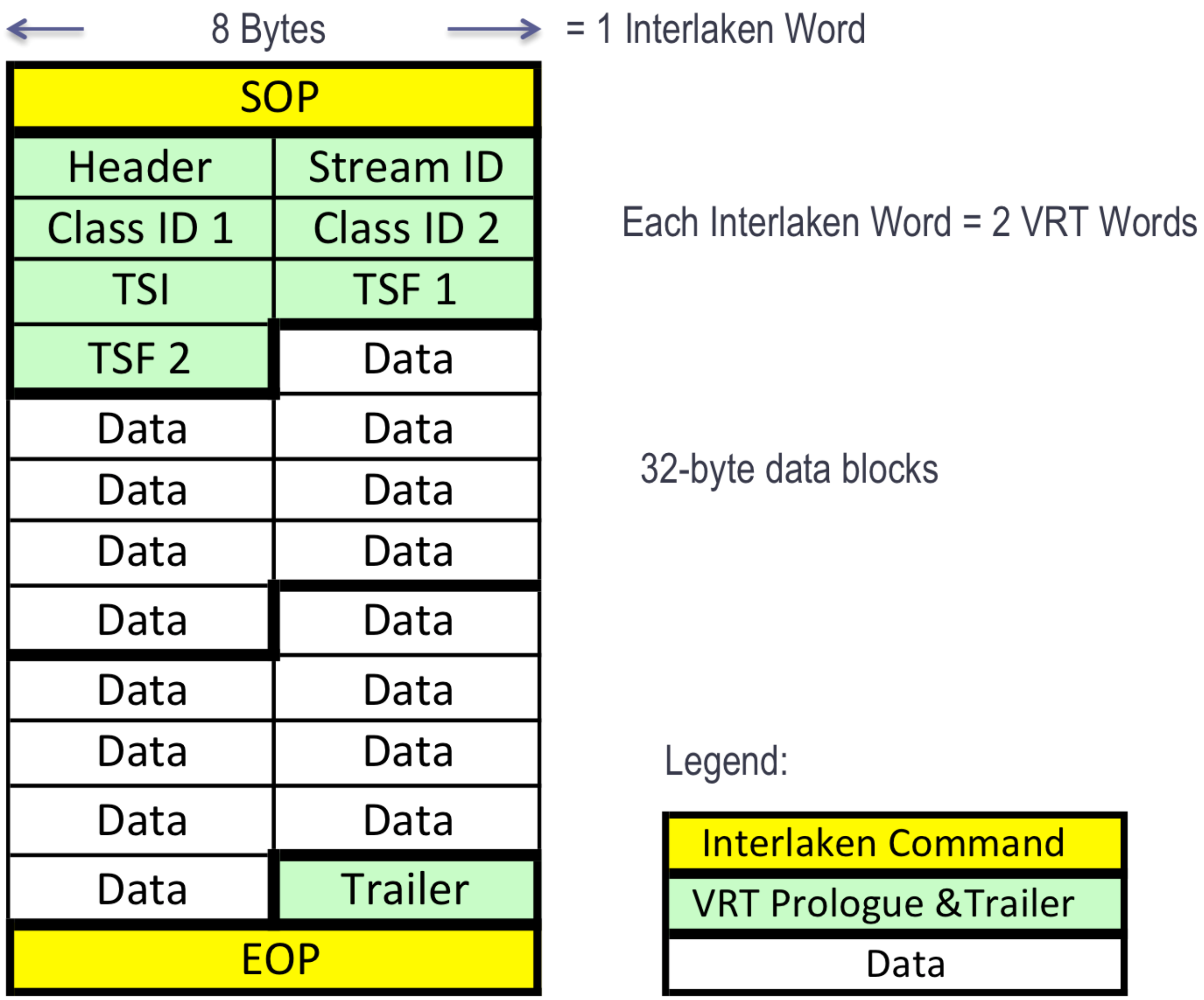

Figure 3-2: ODI-2.1 Data Packet Structure

ODI-2.1 Data Packets are described as shown in Figure 3-2, as a succession of Interlaken words, 64 bits wide each. Interlaken SOP (Start of Packet) is sent, followed by the Prologue, the Data Payload, and the Trailer. The packet end is indicated by Interlaken EOP (End of Packet). Since VRT words are 4 bytes, and Interlaken words 8 bytes, two VRT words are included within each Interlaken word, as shown above.

To meet the ODI-1 and ODI-2 requirement that all packets be an integer number of 32 bytes in length, the Data Payload is shown as an integer number of 32-byte data blocks.

As allowed in ODI-1, SOP and EOP may be indicated together in a single Interlaken word, and is commonly done so for streaming data with the highest efficiency.

3.1.1 ODI-2.1 Data Packet – Header

The figure below shows the content of the mandatory Header for ODI-2.1 Data Packets. Since it is a Signal Data Packet, it is functionally equivalent to ODI-2 Figure 3-12.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Packet Type				C	Indicators			TSI		TSF		Packet Count				Packet Size															
0	0	0	1	C	T	r	S	TSI		TSF		Pkt Count				Packet Size															

Figure 3-3: ODI-2.1 Data Packet – Header

RULE 3.2: All fields in an ODI-2.1 Data Packet Header SHALL comply with the requirements for the ODI-2 Signal Data Packet Header as specified in ODI-2 Sections 3.1.1 and 3.1.7.

3.1.2 ODI-2.1 Data Packet – Stream ID

Stream ID is an abbreviation for Stream Identifier. The Stream ID is a 32-bit field, whose value is the same for all Data, Context, and Command Packets associated with that stream.

RULE 3.3: The Stream ID in an ODI-2.1 Data Packet SHALL comply with the rules for Stream ID specified in ODI-2.

ODI-2 mandates that the Stream ID must be programmable by the user, and that the default Stream ID is 4096.

For multiple ports where the ports are being aggregated, ODI-2 mandates that the default Stream ID be incremented by 1024 by default. For a 4-port aggregation, the default Stream IDs are:

Port 1: 4096
Port 2: 5120
Port 3: 6144
Port 4: 7168

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0

Figure 3-4: Default Stream ID of 4096 for a single port device

3.1.3 ODI-2.1 Data Packet – Class ID

Class ID is a mandated field of 64 bits, typically shown as two 32-bit words. VITA 49.2 defines the fields as shown below:

<table>
<tr><td>31</td><td>30</td><td>29</td><td>28</td><td>27</td><td>26</td><td>25</td><td>24</td><td>23</td><td>22</td><td>21</td><td>20</td><td>19</td><td>18</td><td>17</td><td>16</td><td>15</td><td>14</td><td>13</td><td>12</td><td>11</td><td>10</td><td>9</td><td>8</td><td>7</td><td>6</td><td>5</td><td>4</td><td>3</td><td>2</td><td>1</td><td>0</td></tr>
<tr><td colspan="5">Pad Bit Count</td><td colspan="3">Reserved</td><td colspan="24">Organizationally Unique Identifier (OUI)</td></tr>
<tr><td colspan="16">Information Class Code</td><td colspan="16">Packet Class Code</td></tr>
</table>

Figure 3-5: Contents of the V49.2 Class ID Field

The ODI-2.1 Data Packet uses the AXIe OUI and algorithmically assigns values to the Information Class Code and Packet Class Code fields that reflect a number of attributes of the Data Packet stream. This allows a consumer of data to unambiguously identify the format being used. These attributes include:

- The number of signal channels
- The data format of each item, including resolution
- Real or complex data
- The number of event bits within an item packing field
- Optional Pad Word Count that indicates the number of pad words in the packet

ODI-2.1 Data Packets use the Class ID fields indicated in the diagram below.

<table>
<tr><td>31</td><td>30</td><td>29</td><td>28</td><td>27</td><td>26</td><td>25</td><td>24</td><td>23</td><td>22</td><td>21</td><td>20</td><td>19</td><td>18</td><td>17</td><td>16</td><td>15</td><td>14</td><td>13</td><td>12</td><td>11</td><td>10</td><td>9</td><td>8</td><td>7</td><td>6</td><td>5</td><td>4</td><td>3</td><td>2</td><td>1</td><td>0</td></tr>
<tr><td colspan="5">Pad Bit Count</td><td colspan="3">Reserved</td><td colspan="24">AXIe OUI of 24-5C-CB</td></tr>
<tr><td colspan="4">Pad Word Count</td><td colspan="2">ODI Reserved</td><td colspan="2">Fixed Value</td><td colspan="2">Event</td><td colspan="2">R/C</td><td colspan="7">Item Type</td><td colspan="13">Vector Size</td></tr>
</table>

Figure 3-6: Contents of the ODI-2.1 Data Packet Class ID Field

3.1.3.1 ODI-2.1 Data Packet - Class ID OUI Field

RULE 3.4: The OUI field of ODI-2.1 Data Packets SHALL be set to the AXIe OUI of 24-5C-CB

3.1.3.2 ODI-2.1 Data Packet - Class ID Reserved Field

OBSERVATION 3.2: To comply with ODI-2, the Reserved (24-26) field is set to 0.

3.1.3.3 ODI-2.1 Data Packet - Class ID Pad Bit Count Field

OBSERVATION 3.3: To comply with ODI-2, the Pad Bit Count (27-31) field is set per VITA 49.2.

3.1.3.4 ODI-2.1 Data Packet - Class ID Vector Size Field

The Vector Size field indicates the number of signal channels in the stream. Vector Size is a parameter defined in V49.2, and is adopted by ODI-2.

RULE 3.5: The ODI-2.1 Data Packet Class ID Vector Size (0-12) field SHALL indicate the number of signal channels through the formula: Vector Size = Signal Channels -1

OBSERVATION 3.4: If there is a single signal channel, the Vector Size will be set to 0.

OBSERVATION 3.5: The Vector Size field can indicate anywhere from 1 signal channel to 8192 signal channels.

3.1.3.5 ODI-2.1 Data Packet - Class ID Item Type Field

The Item Type field in the ODI-2.1 Data Packet Class ID is critical to defining the Item Packing fields in the Data Payload. To understand the relationship, it is important to understand Item Packing fields.

Data Payloads consist of consecutive Item Packing fields. An Item Packing field is defined in VITA 49.2 as a field that contains the Data Item (value of a data sample), optional Unused bits, optional Event Tags, and optional Channel Tags.

ODI-2.1 Data Packets do not use Channel Tags, but do use Data Items and Event Tags. ODI-2.1 Item Packing fields also contain Unused bits between the Data Item and the Event Tags if the Item Packing field length is greater than the Data Item length plus the number of Event Tags. Many ODI-2.1 systems will be deployed with only the Data Item in the Item Packing field. In that case, the Item Packing field is identical to the value of the data sample.

A diagram of an ODI-2.1 Item Packing field is shown below.

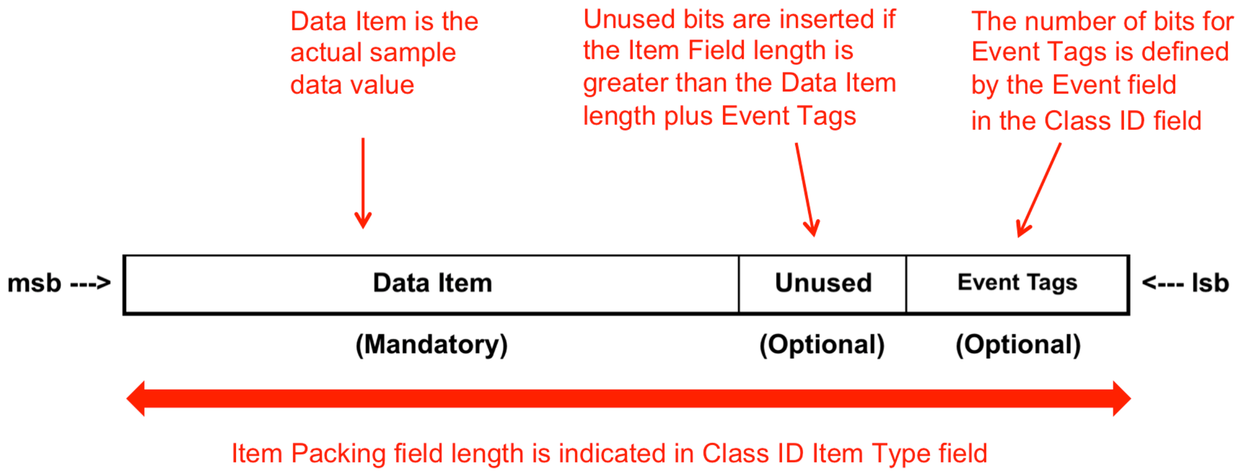

Figure 3-7: Contents of the ODI-2.1 Item Packing Field

The figure above shows the contents of the ODI-2.1 Item Packing field in the Data Payload. The Data Item represents the numerical value of the sample, and is the only mandated field. The Event Tags are optional bits that act as a marker, trigger signal, or other user defined event. ODI-2.1 allows 0, 1, 2, or 4 bits of Event Tags. If the length of the Item Packing field is greater than the number of bits in the Data Item plus the number of Event Tags, then Unused bits are placed to the right of the least significant bits of the Data Item, and set to zero.

The ODI-2.1 Item Type (13-19) field of the Class ID plays an important role in defining the Item Packing field used. It describes many attributes of the Item Packing field of the stream, including the length of the Item Packing field, the format of the data embedded within the item, and the packing method.

The ODI-2.1 Item Type field is similar to the Data Type field from VITA 49A, but adds three bits to add formats not included in VITA 49A. This allows the optional use of VITA 49A formats not mandated in ODI-2.1. Both may be used without conflict. The four most significant bits of the ODI-2.1 Item Type field are in the same positions of the Class ID as the Data Type field is in VITA 49A.

The table of Item Type fields is shown below.

Item Type		Item Length	Data Type Format	Packing Method	
0001	000	4-bit	Signed Fixed-Point	Processing-efficient	
0010	000	8-bit	Signed Fixed-Point	Processing-efficient	Mandated ODI-2.1 Formats
0011	000	16-bit	Signed Fixed-Point	Processing-efficient	
0100	000	32-bit	Signed Fixed-Point	Processing-efficient	
0101	000	64-bit	Signed Fixed-Point	Processing-efficient	
0110	000	32-bit	IEEE-754 Single-Precision	Processing-efficient	
0111	000	64-bit	IEEE-754 Double-Precision	Processing-efficient	V49A Formats
1000	000	1-bit	Unsigned Fixed-Point	Processing-efficient	
1001	000	4-bit	Unsigned Fixed-Point	Processing-efficient	
1010	000	8-bit	Unsigned Fixed-Point	Processing-efficient	
1011	000	16-bit	Unsigned Fixed-Point	Processing-efficient	
1100	000	32-bit	Unsigned Fixed-Point	Processing-efficient	
1101	000	64-bit	Unsigned Fixed-Point	Processing-efficient	
0000	001	9-bit	Signed Fixed-Point	Link-efficient	
0000	010	10-bit	Signed Fixed-Point	Link-efficient	
0000	011	11-bit	Signed Fixed-Point	Link-efficient	
0000	100	12-bit	Signed Fixed-Point	Link-efficient	Additional ODI-2.1 Link-efficient Formats
0000	101	13-bit	Signed Fixed-Point	Link-efficient	
0000	110	14-bit	Signed Fixed-Point	Link-efficient	
0000	111	15-bit	Signed Fixed-Point	Link-efficient	

Figure 3-8: ODI-2.1 Data Packet - Class ID Item Type Field

The table above relates the Item Type field contents within the ODI-2.1 Class ID to the Item Packing field within the Data Payload. The first 13 entries are identical to VITA 49A entries, with the addition of three 0-value bits to the right. These three least significant bits were used in VITA 49A for Vector Sizes larger than 8192, an extremely rare occurrence, and have been repurposed to expand the data types for ODI-2.1.

ODI-2.1 mandates the use of two formats, shown in green. They are 8-bit and 16-bit Signed Fixed-Point binary formats. All devices must support these modes unless it is functionally impossible.

Nine additional formats have been added by ODI-2.1, shown in yellow, and containing non-zero three least significant bits. These are the recommended formats if the 8-bit and 16-bit Signed Fixed Point formats do not have the needed packing efficiency for the application. They specify link-efficient packing of 9-bit through 15-bit data.

The Item Length specifies the length of the Item Packing field in the Data Payload. If there are no Event Tags, this will be equal to the Data Item length. However, if there are Event Tags, the Data Item length will be decreased by the number of Event Tags. For example, the Item Type 0011 000 specifies a 16-bit Item Length in Signed Fixed-Point format. If there are two Event Tags, the Item length would remain at 16 bits, but only the first 14 bits would refer to the Data Item, and the final two bits would be the Event Tags.

RULE 3.6: The ODI-2.1 Data Packet Item Type (13-19) field SHALL accurately indicate the Item Packing field length within the Data Payload as shown in Figure 3-18.

RULE 3.7: The ODI-2.1 Data Packet Item Type (13-19) field SHALL accurately indicate the Data Item format as shown in Figure 3-18.

RULE 3.8: The ODI-2.1 Data Packet Item Type (13-19) field SHALL accurately indicate the packing method of the Data Payload as shown in Figure 3-18.

OBSERVATION 3.6: The four Most Significant Bits of the ODI-2.1 Item Type field matches the definition and position of the 4-bit Data Type field in VITA 49A.

3.1.3.6 ODI-2.1 Data Packet - Class ID R/C Field

The R/C (20-21) field within an ODI-2.1 Data Packet indicates whether the data values are real or complex. For real values, only a single Item Packing field is needed per signal sample. For complex values, two Item Packing fields are sent consecutively for each signal sample, the first being the I (In-phase) value followed by the Q (Quadrature) value. The table of the R/C field is shown below.

Real/Complex Type	Meaning
00	Real
01	Complex, Cartesian

Figure 3-9: ODI-2.1 Data Packet - Class ID Real/Complex (R/C) Field

RULE 3.9: The R/C (13-19) indicator in the ODI-2.1 Data Packet Class ID field SHALL set to one of the values in Figure 3-9, as appropriate for the data contained in the packet.

3.1.3.7 ODI-2.1 Data Packet - Class ID Event Field

The Class ID Event (22-23) field of an ODI-2.1 Data Packet indicates the number of Event Tags within each Item Packing field of the Data Payload, as indicated in the table below.

Event Field	Meaning
00	0 Event Tags
01	1 Event Tag
10	2 Event Tags
11	4 Event Tags

Figure 3-10: ODI-2.1 Data Packet - Class ID Event Field

RULE 3.10: The Event (22-23) field in the ODI-2.1 Data Packet Class ID field SHALL accurately indicate the number of Event Tags in each Item Packing field of the Data Payload, as indicated in Figure 3-10.

3.1.3.8 ODI-2.1 Data Packet - Class ID Fixed Value Field

The Fixed Value (24-25) field of an ODI-2.1 Data Packet is set to zero. It is reserved for future use.

RULE 3.11: The Fixed Value (24-25) field in the ODI-2.1 Data Packet Class ID SHALL be set to zero.

3.1.3.9 ODI-2.1 Data Packet - Class ID Fixed Value Field

The Fixed Value (24-25) field in an ODI-2.1 Data Packet is set to zero. It is reserved for future use.

RULE 3.12: The Fixed Value (24-25) field in the ODI-2.1 Data Packet Class ID SHALL be set to zero.

3.1.3.10 ODI-2.1 Data Packet - Class ID ODI Reserved Field

The ODI Reserved (26-27) field in the ODI-2.1 Data Packet Class ID is set to zero. The intent is to reserve this field for future ODI specifications (e.g. ODI-2.n) using the same OUI.

RULE 3.13: The ODI Reserved (26-27) field in the ODI-2.1 Data Packet Class ID SHALL be set to zero.

RULE 3.14: An ODI-2.1 device that receives an ODI-2.1 Data Packet where the ODI Reserved bits are not set to zero, SHALL NOT execute the Data Payload.

OBSERVATION 3.7: The above rule prevents ODI-2.1 devices from erroneously executing non-ODI-2.1 packets. If either the ODI Reserved bits are set within an ODI-2.1 Data Packet Class ID, there is no guarantee that the Class ID field has the same meaning as ODI-2.1.

3.1.3.11 ODI-2.1 Data Packet - Class ID Pad Word Count Field

The Pad Word Count (28-31) field of the ODI-2.1 Data Packet Class ID is a 4-bit field whose binary value indicates the number of 32-bit Pad Words attached to valid data at the end of the Data Payload in order to make the Data Payload length an integer number of 32 bytes. It acts similarly to Pad Bit Count. The Most Significant Bit is Bit 31 and the Least Significant Bit is Bit 28.

For most streaming applications the Pad Word Count will be zero, as the Data Payload length can be made an integer value of 32 bytes by including an integer number of 256 samples of each signal channel. In the case where this cannot be guaranteed, such as a finite data sequence that isn't naturally divisible by 32 bytes, the Pad Word Count and the Pad Bit Count can be used together to explicitly indicate where valid data ends, but still have the Data Payload divisible by 32 bytes and followed by the Trailer in the proper location.

Since only three bits are needed to indicate the number of 32-bit Pad Words required to meet the 32-byte requirement, the Most Significant Bit of the Pad Word Count will always be zero. This extra bit was included for future expansion.

RULE 3.15: The ODI Pad Word Count (28-31) field in the ODI-2.1 Data Packet Class ID SHALL accurately indicate the number of 32-bit pad words at the end of valid data added to create a Data Payload length that is an integer number of 32 bytes.

RECOMMENDATION 3.1: An ODI-2.1 Data Packet SHOULD NOT add pad words to the Data Payload unless it is infeasible to make the Data Payload length an integer multiple of 32 bytes.

OBSERVATION 3.8: For streaming applications, the integer multiple of 32 bytes length requirement can be met by including an integer number of 256 samples of each signal channel.

3.1.4 ODI-2.1 Data Packet – Timestamp Fields TSI, TSF1, TSF2

Timestamp fields are mandatory for ODI-2.1, as they are in ODI-2. ODI-2.1 adds no additional rules or recommendations regarding timestamps. The figure below shows the recommended, permitted, and prohibited timestamp combinations from ODI-2.

As a reminder, though ODI-2 requires timestamp fields to always be present, ODI-2 has created special combinations of the TSI and TSF fields in the ODI-2 Data Packet Header that allow the timestamp fields to be present in the Prologue, but inoperable for those devices that don't generate timestamps.

TSF \ TSI	00	01	10	11
00	Prohibited	Prohibited	Prohibited	Prohibited
01	Prohibited	UTC time plus Sample Count	GPS time plus Sample Count	No Valid Timestamps
10	Prohibited	UTC time plus Picoseconds	GPS time plus Picoseconds	Picoseconds Timestamps
11	Prohibited	Free running Sample Count	Free running Sample Count	Free running Sample Count

Green = Recommended combinations
Yellow = Permitted
Red = Prohibited combinations

Figure 3-11: ODI-2.1 Data Packet - Timestamps

3.1.5 ODI-2.1 Data Packet – Data Payload

As with ODI-2, the Data Payload of an ODI-2.1 Data Packet occurs between the 28-byte Prologue and the 4-byte Trailer, as shown in Figure 3-2. The Data Payload is an integer multiple of 32 bytes in length, resulting in the entire Data Packet being an integer multiple of 32 bytes in length.

The ODI-2.1 Data Payload consists of consecutive Item Packing fields, which will be referred to as "items" in this section. As described in Figure 3-7, an item includes a single Data Item that represents the value of a sample. It may optionally include Event Tags and Unused bits.

Signal streams may contain data from multiple synchronous channels, but all channels must adopt the same data format (resolution, packing, and Event Tags)

If a Data Payload has multiple synchronous signal channels, the items for one point in time are sent first for all signal channels, followed by the items for the next point of time, and so forth in a "round-robin" manner. If the Data Type of an item is complex, the two I/Q samples are packed sequentially before addressing the next signal channel. Therefore a two-channel complex signal stream will be in the order of Channel 1-I T0, Channel 1-Q T0, Channel 2-I T0, Channel 2-Q T0, Channel 1-I T1, Channel 1-Q T1, Channel 2-I T1, Channel 2-Q T1, and so forth.

RULE 3.16: For single-signal channel ODI-2.1 devices, the items within the Data Payload SHALL be placed in order of their time sequence.

RULE 3.17: For multiple-signal channel ODI-2.1 devices, the items within the Data Payload SHALL be placed in the same channel order for all points of time.

RULE 3.18: For multiple-signal channel ODI-2.1 devices, sequential sets of multi-channel data SHALL be placed in order of their time sequence.

OBSERVATION 3.9: The above three rules specify a "round robin" packing process where the same sequence of channels is packed into the Data Payload sequentially over time.

OBSERVATION 3.10: The above technique works, and only works, with synchronous channels.

RULE 3.19: IF an ODI-2.1 device generates complex signal data from a signal channel, the device SHALL send the value as two consecutive items starting with the in-phase component, followed by the quadrature component.

ODI-2.1 Data Packet formats are typically signed fixed binary values from 8 bits of resolution to 16 bits of resolution, as shown in Figure 3-8. Binary formats were chosen to deliver the highest sample speed, though ODI-2.1 allows all V49A formats. ODI-2.1 mandates the use of 8-bit signed binary values for interoperability. The 16-bit format is also mandated if the ODI link has the bandwidth to send the 16-bit data.

For devices that have sample resolution greater than 8 bits, but cannot send their full resolution at full speed in 16-bit data mode, ODI-2.1 allows the sending of data as 10, 12, or 14-bit item size, using link-efficient packing. These item lengths are preferred, even if the samples are naturally of an odd bit-length. For devices with odd bit lengths that cannot attain their full speed with any of the even bit-length values, ODI-2.1 allows link-efficient packing of data at 9, 11, 13, or 15-bit lengths.

Link-efficient and processing-efficient packing reflect whether the data is aligned to 32-bit boundaries, or is aligned to the previous item.

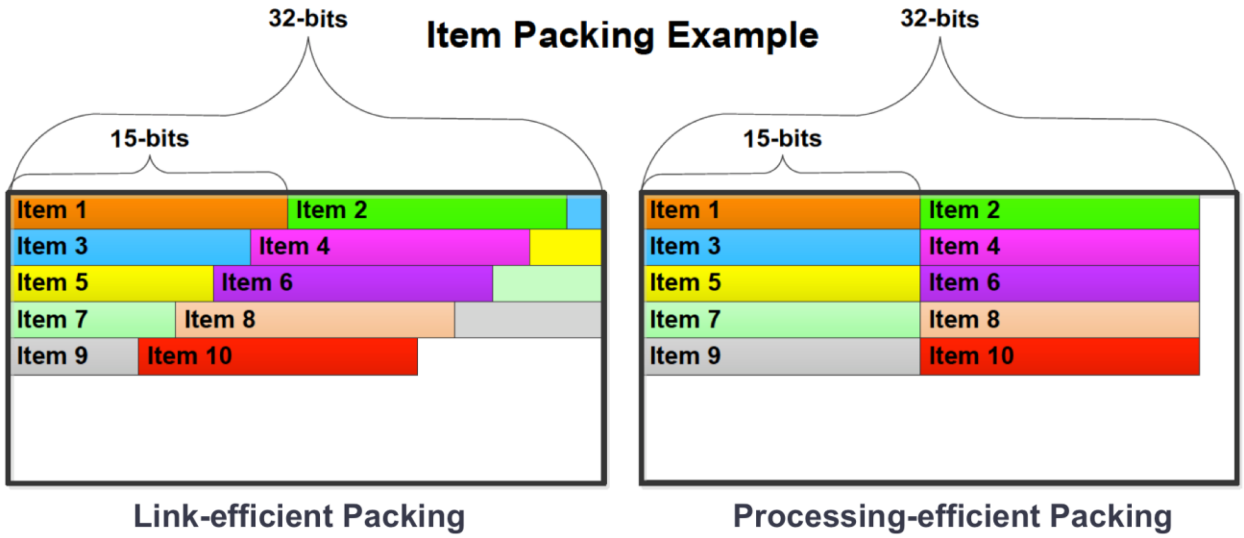

Figure 3-12: Item Packing Example

Figure 3-12 shows an example of packing 15-bit items. The left figure shows packing 15-bit items in a link-efficient manner. The data bandwidth of the link is optimally used, as there are no unused bits. The figure to the right shows packing the same 15-bit items using processing-efficient packing. Here, the items are aligned to 32-bit boundaries. This is efficient for processing, as the location of the items is the same for each 32-bit VRT word. However, there are two unused bits at the end of each 32-bit word, lowering the maximum data rate possible.

OBSERVATION 3.11: 8-bit items and 16-bit items are both link-efficient packed and processing-efficient packed.

RULE 3.20: An ODI-2.1 device SHALL support 8-bit Signed Fixed Point format, indicated by the Data Type field in the Class ID of 0010 000.

OBSERVATION 3.12: All ODI-2.1 devices that can attain full speed over the ODI link will be able to operate at 8-bit mode at full speed, since it is the fastest of all ODI-2.1 modes.

RULE 3.21: If an ODI-2.1 device can attain full bandwidth with 16-bit Signed Fixed Point format, THEN it SHALL support 16-bit Signed Fixed Point format, indicated by the Data Type field in the Class ID of 0011 000.

OBSERVATION 3.13: If an ODI-2.1 device can meet the speed requirement in 16-bit mode, then that mode is required too.

OBSERVATION 3.14: 8-bit mode preserves the speed element of a data stream containing 8-bit to 16-bit data, perhaps at the cost of resolution, while 16-bit mode preserves the resolution of the data stream, perhaps at the cost of speed or number of signal channels.

RECOMMENDATION 3.2: An ODI-2.1 device that cannot meet the speed requirement in 16-bit mode SHOULD offer 16-bit modes with reduced capability, such as a reduction in the number of signal channels.

OBSERVATION 3.15: For data samples between 9 bits and 15 bits, the data will be concatenated to fit into an 8-bit item field, and null data added to fit into a 16-bit item field.

ODI-2.1 offers the capability to use link-efficient packing of item lengths between 9 bits and 15 bits. In order to maximize interoperability, the following order of preference of link-efficient packing modes is specified:

- 8-bit and 16-bit
- 10, 12, and 14-bit link-efficient
- 9, 11, 13, and 15-bit link-efficient

RULE 3.22: IF an ODI-2.1 device cannot achieve its maximum resolution and speed using 8-bit or 16-bit packing but can achieve maximum resolution and speed using either 10, 12, or 14-bit link-efficient packing, THEN the device SHALL support the 10, 12, or 14-bit link-efficient packing mode respectively.

RULE 3.23: IF an ODI-2.1 device cannot achieve its maximum resolution and speed using 8, 10, 12, or 14-bit packing but can achieve maximum resolution and speed using either 9, 11, 13, or 15-bit link-efficient packing, THEN the device SHALL support the 9, 11, 13, or 15-bit link-efficient packing mode respectively.

PERMISSION 3-2: AN ODI-2.1 device MAY support any of the ODI-2.1 Data Types and packing techniques shown in Figure 3-8, whether those Data Types and packing techniques are needed to achieve the desired speed.

OBSERVATION 3.16: The above rules essentially mandate using 8-bit and/or 16-bit modes if that achieves the speed needed. If not, the device designer tries 10, 12, or 14-bit modes. If one of those meets the speed requirements, then that mode must be included within the ODI-2.1 device. If none of those modes delivers the necessary speed, the device designer tries 9, 11, 13, or 15-bit modes. The mode that delivers the needed speed must be included with the ODI-2.1 device.

OBSERVATION 3.17: The above permission allows an ODI-2.1 device to support any of the ODI-2.1 defined data formats, even if the data format wasn't necessary to meet the speed requirements. For example, a 10-bit device may be able to meet its speed requirement by using the mandated 16-bit mode, but may still offer 10-bit

link-efficient packing. In this case, 16-bit and 10-bit modes are supported. Similarly, if a 11-bit device can't deliver its speed in the 16-bit mode, but can in the 12-bit link-efficient mode, it must support the 12-bit mode but could also support the 11-bit link-efficient mode.

The above rules and permission mandate that ODI-2.1 allows other Data Type formats than Signed Fixed Point Binary. These include V49A-defined formats shown in Figure 3-8.

OBSERVATION 3.18: The above permission allows the optional capability of using any VITA 49A Data Type. What distinguishes ODI-2.1 data formats from VITA 49A is that ODI-2.1 mandates the use of 8-bit and 16-bit Data Types, the additional but optional 9-bit through 15-bit link-efficient formats, the optional inclusion of Event Tags, and the reduction of maximum signal channels from 65,568 channels to 8192 channels to allow the additional link-efficient formats.

3.1.6 ODI-2.1 Data Packet – Trailer

The Trailer remains as specified in ODI-2, consistent with the figure below.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Enables												State and Event Indicators												E	Associated Context Packet Count						

Enable Bit Position	Indicator Bit Position	Indicator Name
31	19	Calibrated Time Indicator
30	18	Valid Data Indicator
29	17	Reference Lock Indicator
28	16	AGC/MGC Indicator
27	15	Detected Signal Indicator
26	14	Spectral Inversion Indicator
25	13	Over-range Indicator
24	12	Sample Loss Indicator
23,22	11,10	Sample Frame Indicators, User-Defined
[21..20]	[9..8]	User-Defined Indicators

Figure 3-13: ODI-2.1 Data Packet - Trailer

3.2 ODI-2.1 Context Packets

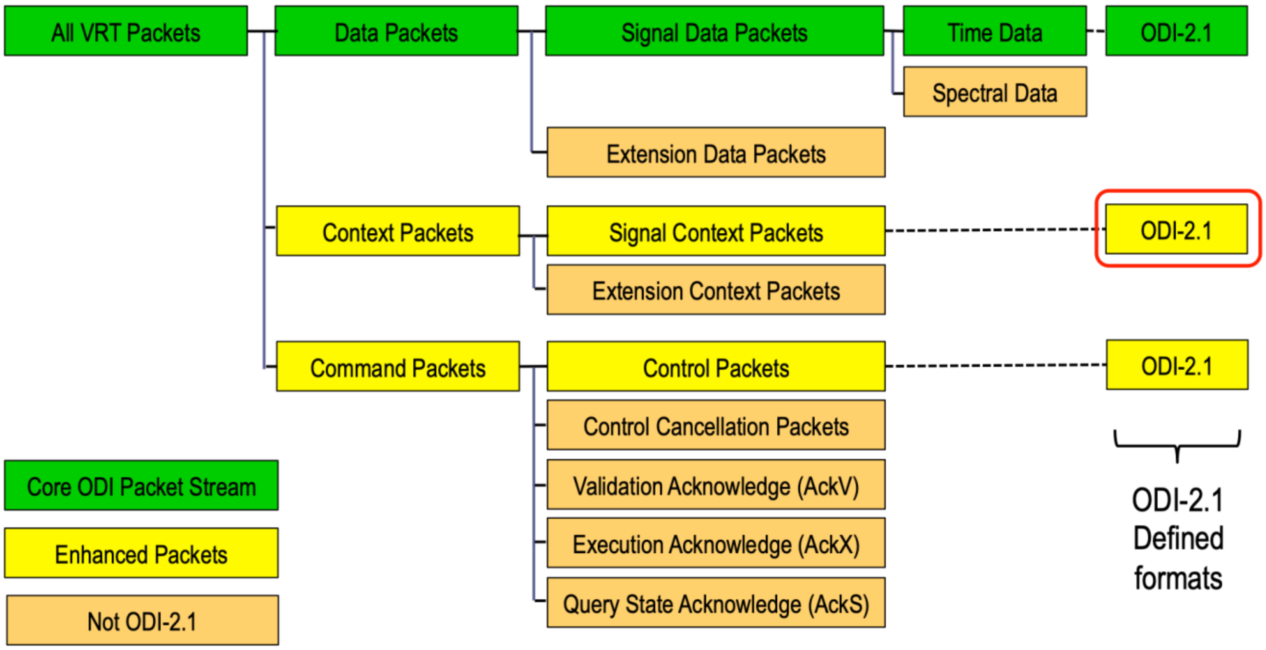

Figure 3-14: ODI-2.1 Context Packets

Context Packets convey metadata about the related signal stream. The standard ODI-2.1 Context Packet is a specific ODI-2 Signal Context Packet containing fields useful for RF signals. The ODI-2.1 Context Packet is 96 bytes in length. The included fields are:

- Bandwidth
- IF Reference Frequency
- RF Reference Frequency
- RF Reference Frequency Offset
- IF Band Offset
- Reference Level
- Over-range Count
- Sample Rate

The fields are in fixed positions to ease the use of FPGAs to handle the data. As with ODI-2, the handling of Context Packets in ODI-2.1 is optional. A producer is not required to generate Context Packets, but may do so. Similarly, a consumer is not required to act on Context Packets but may do so. As with ODI-2, an ODI-2.1 consumer that receives a Context Packet that it does not know how to process is required to continue normal operation. That is, the reception of Context Packets should not interfere with otherwise normal operation.

Context Packets and Command Packets have many similarities. VITA 49.2 has specified Context Packets as the standard method to report metadata related to a signal, and

Command Packets as the standard method to control metadata parameters. The Control Packet subtype is the specific method for controlling metadata parameters, while the other Command Packet subtypes optionally manage the control and acknowledgment process, including dry-runs and exceptions.

As with ODI-2, ODI-2.1 allows consumers to treat Context Packets as commands, allowing the playback of recorded data. ODI-2.1 also mandates that if a device can execute Context Packets, it must also execute Control Packets, the preferred method. The key metadata fields in ODI-2.1 Context and Control Packets are designed to be in the same location, easing FPGA implementation.

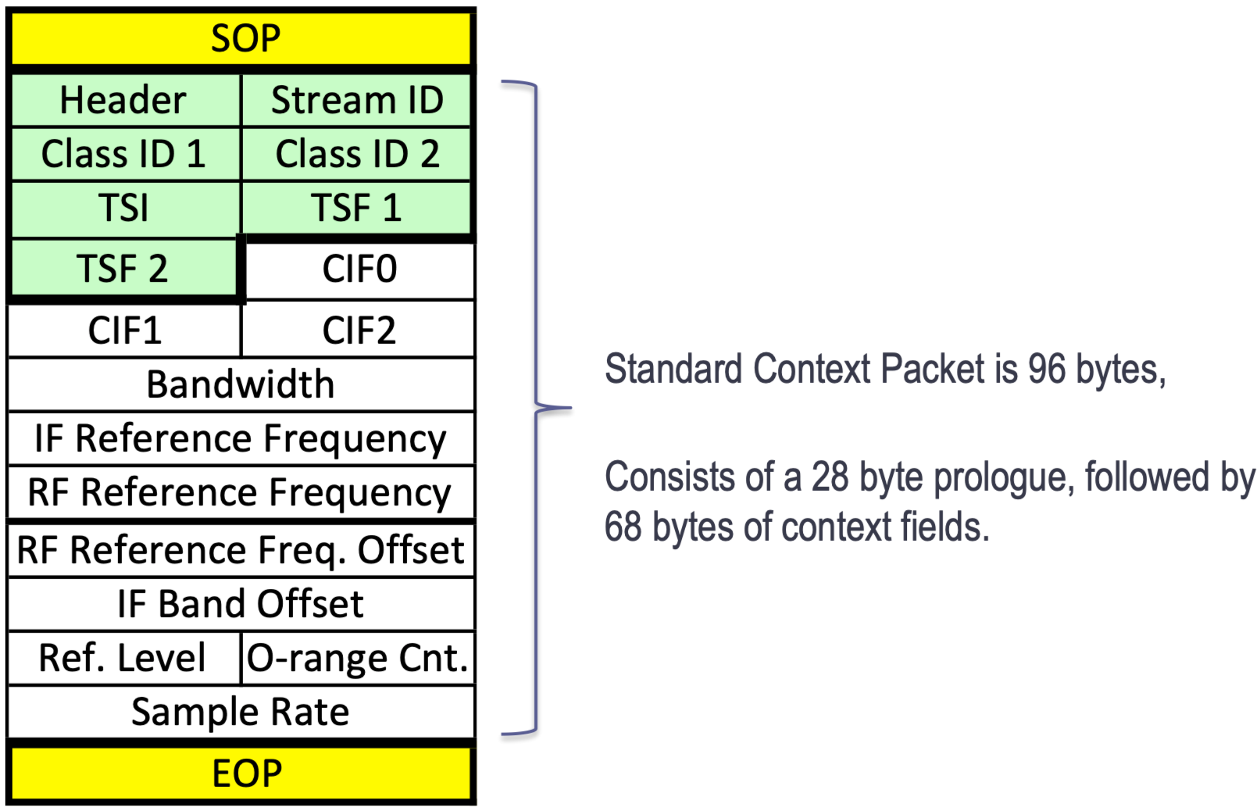

Figure 3-15: ODI-2.1 Context Packet Structure

RULE 3.24: A device that generates ODI-2.1 Context Packets SHALL include the Prologue fields and context data fields shown in Figure 3-15.

RULE 3.25: The context data fields of an ODI-2.1 Context packet SHALL comply with the requirements of each field as documented in VITA 49.2

3.2.1 ODI-2.1 Context Packet – Header

The figure below shows the content of the mandatory Header for ODI-2.1 Context Packets. Since it is a Signal Context Packet, it is functionally equivalent to ODI-2 Figure 3-21.

<table>
<tr><td>31</td><td>30</td><td>29</td><td>28</td><td>27</td><td>26</td><td>25</td><td>24</td><td>23</td><td>22</td><td>21</td><td>20</td><td>19</td><td>18</td><td>17</td><td>16</td><td>15</td><td>14</td><td>13</td><td>12</td><td>11</td><td>10</td><td>9</td><td>8</td><td>7</td><td>6</td><td>5</td><td>4</td><td>3</td><td>2</td><td>1</td><td>0</td></tr>
<tr><td colspan="4">Packet Type</td><td>C</td><td colspan="3">Indicators</td><td colspan="2">TSI</td><td colspan="2">TSF</td><td colspan="4">Packet Count</td><td colspan="16">Packet Size</td></tr>
<tr><td>0</td><td>1</td><td>0</td><td>0</td><td>C</td><td>Res</td><td>r</td><td>TSM</td><td colspan="2">TSI</td><td colspan="2">TSF</td><td colspan="4">Pkt Count</td><td colspan="16">Packet Size</td></tr>
</table>

Figure 3-16: ODI-2.1 Context Packet – Header

RULE 3.26: All fields in an ODI-2.1 Context Packet Header SHALL comply with the requirements for the ODI-2 Signal Context Packet Header as specified in ODI-2 Sections 3.2.1 and 3.2.6.

Packet Type (28-31). Packet Type is set to 0100, indicating a Signal Context Packet.

C bit (27) is set to 1. This indicates Class ID fields are present.

Res. Indicator bit (26) is set to 0. This is a Reserved bit.

r Indicator bit (25) is set to 1. This indicates NOT VITA 49.0. The implication is that the packet definitions comply with VITA 49.2 or later.

TSM Indicator bit (24) is set as described in V49.2 Section 7.1.1. Timestamp Mode (TSM) bit is used to indicate whether the Timestamp in the Signal Context Packet is being used to convey timing of Context events related to the Described Signal with fine or coarse resolution. TSM=0 indicates a precise resolution of when context changes occur. TSM=1 indicates a coarse resolution essentially equivalent to the time span of a packet.

TSI bits (22-23) will be set to 01, 10, or 11, depending on the VITA timestamp method chosen, as described in Section 3.1.4. When paired with a Data Packet stream, these bits match the TSI bits of the Data Packet Stream.

TSF bits (20-21) will be set to 01, 10, or 11, depending on the VITA timestamp method chosen, as described in Section 3.1.4. When paired with a Data Packet stream, these bits match the TSF bits of the Data Packet Stream.

Packet Count (16-19) is a modulo-16 counter that counts the number of VRT packets sent. Bit 16 is the LSB. Packet Count will increment for each packet sent. This is identical behavior for all packets types.

Packet Size (0-15) indicates how many VRT 32-bit (4-Byte) words are present in the entire Context Packet, including the mandatory 7 (seven) Prologue fields and any null data.

3.2.2 ODI-2.1 Context Packet – Stream ID

Stream ID is an abbreviation for Stream Identifier. The Stream ID is a 32-bit field, whose value is the same for Data and Context Packets associated with that stream. All ODI-2.1 packets include a Stream ID field.

RULE 3.27: The Stream ID for an ODI-2.1 Context Packet SHALL match the Stream ID for the related Data Packet stream.

OBSERVATION 3.19: ODI-2 specifies that Data Packet Stream IDs must be programmable by the user. Since related Context Packets must share the same Stream ID, they must also be programmable to the same value.

OBSERVATION 3.20: The default Stream ID is 4096, the same as for Data packets.

3.2.3 ODI-2.1 Context Packet – Class ID

Class ID is a mandated field of 64 bits, typically shown as two 32-bit words. VITA 49.2 defines the fields as shown below:

<table>
<tr><th>31</th><th>30</th><th>29</th><th>28</th><th>27</th><th>26</th><th>25</th><th>24</th><th>23</th><th>22</th><th>21</th><th>20</th><th>19</th><th>18</th><th>17</th><th>16</th><th>15</th><th>14</th><th>13</th><th>12</th><th>11</th><th>10</th><th>9</th><th>8</th><th>7</th><th>6</th><th>5</th><th>4</th><th>3</th><th>2</th><th>1</th><th>0</th></tr>
<tr><td colspan="5">Pad Bit Count</td><td colspan="3">Reserved</td><td colspan="24">Organizationally Unique Identifier (OUI)</td></tr>
<tr><td colspan="16">Information Class Code</td><td colspan="16">Packet Class Code</td></tr>
</table>

Figure 3-17: Contents of the V49.2 Class ID Field

RULE 3.28: The OUI value within the Class ID field of an ODI-2.1 Context Packet SHALL be set to the AXIe OUI of 24-5C-CB.

OBSERVATION 3.21: The OUI of an ODI-2.1 Context Packet is the same as for an ODI-2.1 Data Packet.

RULE 3.29: The Information Class Code and the Packet Class Code of an ODI-2.1 Context Packet SHALL be set to 2-0-1-7/0-0-1-0 respectively, each digit being a hexadecimal value.

OBSERVATION 3.22: The Information Class Code and the Packet Class code of an ODI-2.1 Context Packet is different from that of an ODI-2.1 Data Packet, and different from that of a VITA 49A Context Packet

3.2.4 ODI-2.1 Context Packet – Timestamp Fields TSI, TSF1, TSF2

Timestamp fields are mandatory for ODI-2.1, as they are in ODI-2. ODI-2.1 adds no additional rules or recommendations regarding timestamps. The same rules that apply to timestamps for ODI-2.1 Data Packets, as specified in Section 3.1.4, apply to ODI-2.1 Context Packets.

3.2.5 ODI-2.1 Context Packet – Context Indicator Fields

The Context Indicator Fields of CIF0, CIF1, and CIF2 are mandatory in an ODI-2.1 Context Packet. Context Indicator Fields indicate which fields follow, and if any data has changed since the previous Context Packet.

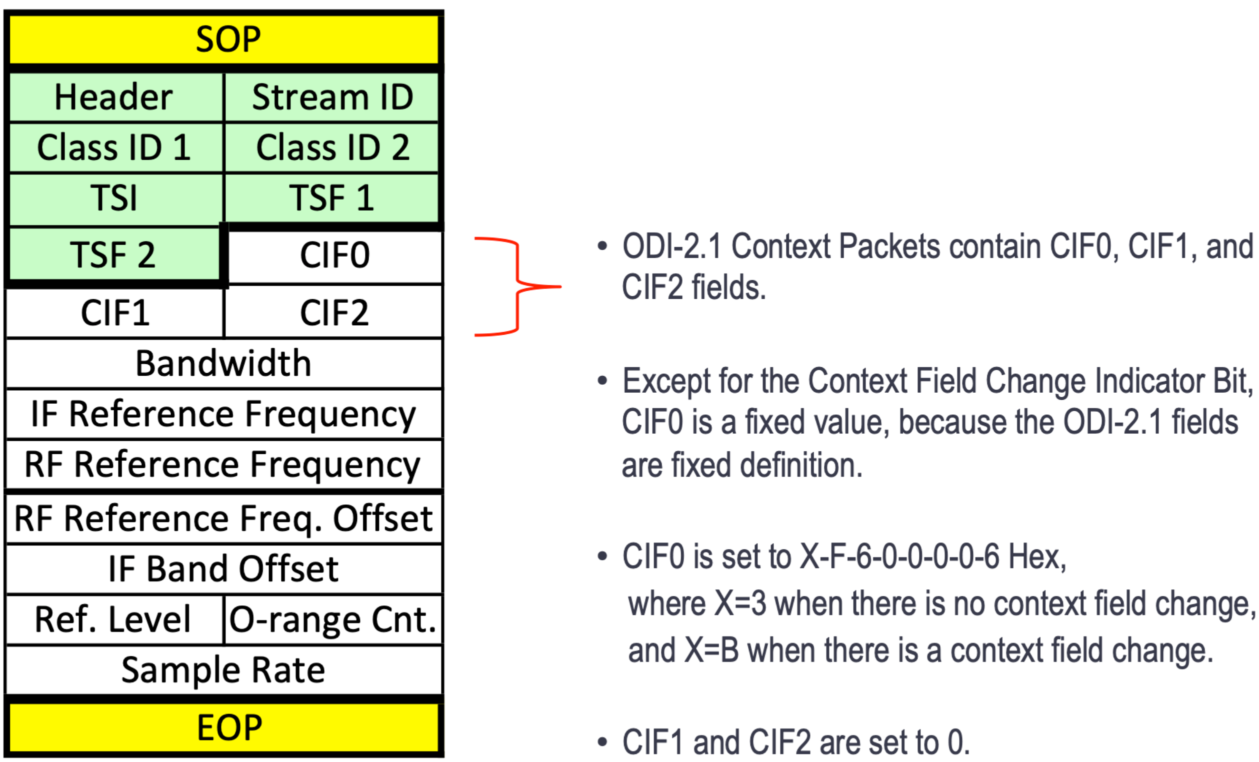

Figure 3-18: ODI-2.1 Context Packet – Context Indicator Fields

Control Packets have a prologue that is 8 bytes longer than that of a Context Packet. In order for context data to be in the same location in a Context Packet as in a Control Packet, an ODI-2.1 Context Packet adds two null fields, CIF1 and CIF2. The context data follows those null fields.

RULE 3.30: The CIF0 field of an ODI-2.1 Context Packet SHALL be set to Hexadecimal X-F-6-0-0-0-0-6, where X=3 when there is no context field change, and X=B when there is a context field change

OBSERVATION 3.23: The mandated value of the CIF0 value indicates the existence of CIF1 and CIF2 fields, as well as the eight specific context data fields.

RULE 3.31: The CIF1 and CIF2 fields of an ODI-2.1 Context Packet SHALL be set to 0.

OBSERVATION 3.24: Setting CIF1 and CIF2 to 0 indicates that there are no additional context data fields typically indicated by CIF1 and CIF2.

The derivation of the value of CIF0 for ODI-2.1 Context Packets is shown in the figure below.

	Bit Position	Context Indicator Field	
X	31	Context Field Change Indicator	
0	30	Reference Point Identifier	= 3 or B
1	29	Bandwidth	
1	28	IF Reference Frequency	
1	27	RF Reference Frequency	
1	26	RF Reference Frequency Offset	= F
1	25	IF Band Offset	
1	24	Reference Level	
0	23	Gain	
1	22	Over-range Count	= 6
1	21	Sample Rate	
0	20	Timestamp Adjustment	
0	19	Timestamp Calibration Time	
0	18	Temperature	= 0
0	17	Device Identifier	
0	16	State and Event Indicators	
0	15	Data Packet Payload Format	
0	14	Formatted GPS (Global Positioning System) Geolocation	= 0
0	13	Formatted INS (Inertial Navigation System) Geolocation	
0	12	ECEF (Earth-Centered, Earth-Fixed) Ephemeris	
0	11	Relative Ephemeris	
0	10	Ephemeris Reference Identifier	= 0
0	9	GPS ASCII	
0	8	Context Association Lists	
0	7..0	**CIF Enable bits**	= 0, 6

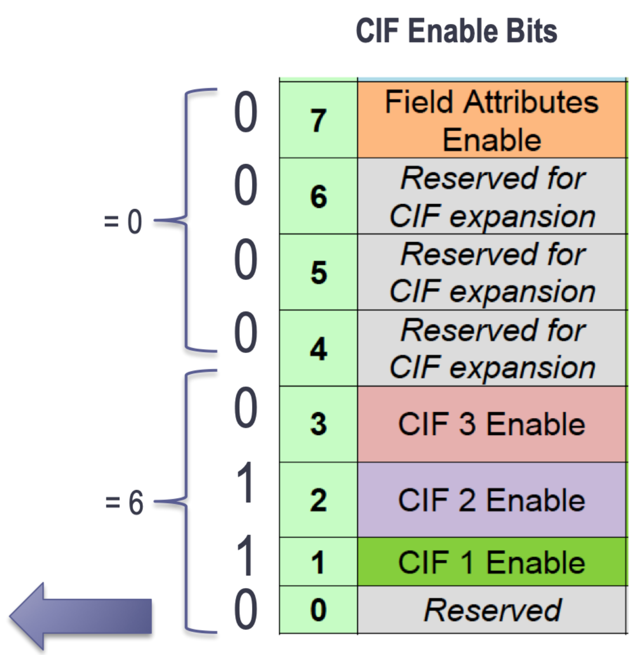

Figure 3-19: ODI-2.1 Context Packet – Derivation of CIF0

3.2.6 ODI-2.1 Context Packet – Context Data

There are eight context data fields in an ODI-2.1 Context Packet. These are mandatory, even if the data isn't known by the producer. For all fields other than the Reference Level, unknown values are indicated by zero. For the Reference Level field, an unknown value is represented as all ones, approximately -256dBm. The specific requirements of each of the context data fields follow.

3.2.6.1 ODI-2.1 Context Packet – Bandwidth, Reference Frequencies, and Offsets

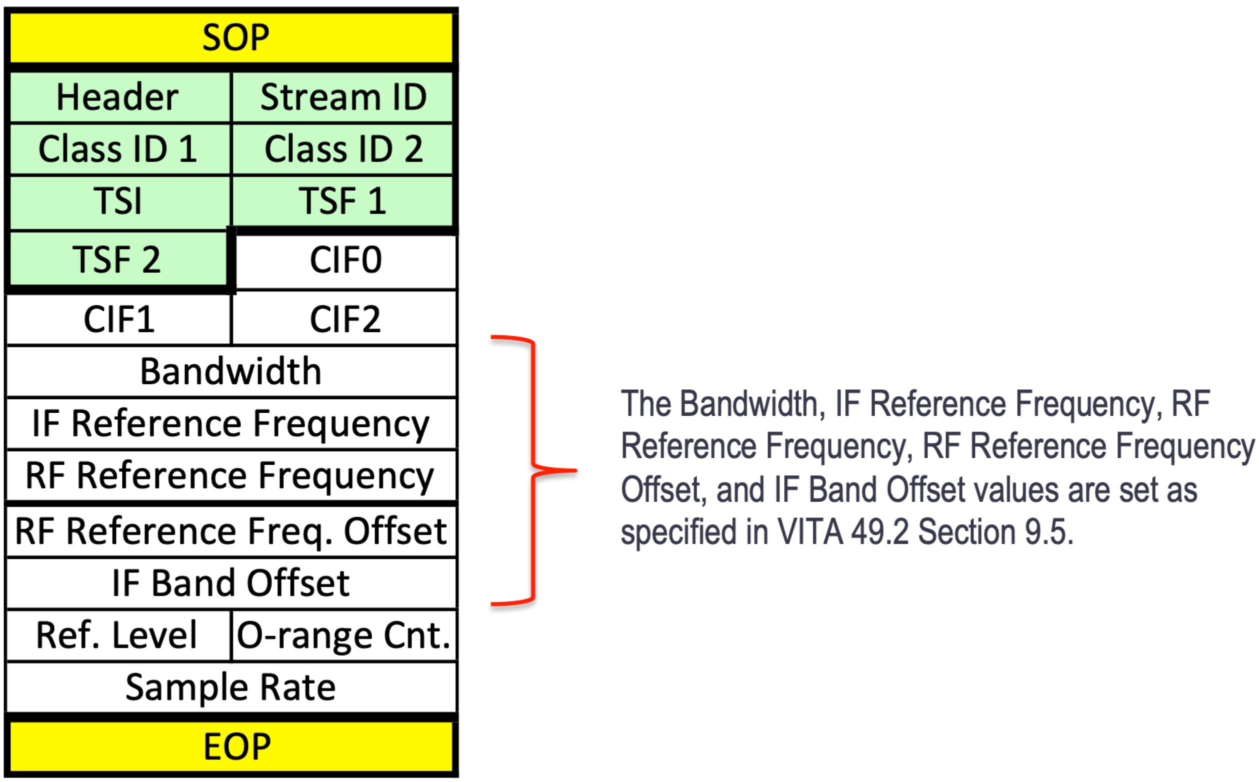

Figure 3-20: ODI-2.1 Context Packet – Bandwidth, Reference Frequencies, and Offsets

RULE 3.32: For ODI-2.1 Context Packets, the Bandwidth, IF Reference Frequency, RF Reference Frequency, RF Reference Frequency Offset, and IF Band Offset values SHALL be set as specified in VITA 49.2 Section 9.5.

RULE 3.33: If a producer of ODI-2.1 Context Packets doesn't know the actual value of the Bandwidth, IF Reference Frequency, RF Reference Frequency, RF Reference Frequency Offset, or IF Band Offset, it SHALL set the value of those unknown fields to 0 (zero).

3.2.6.2 ODI-2.1 Context Packet – Reference Level

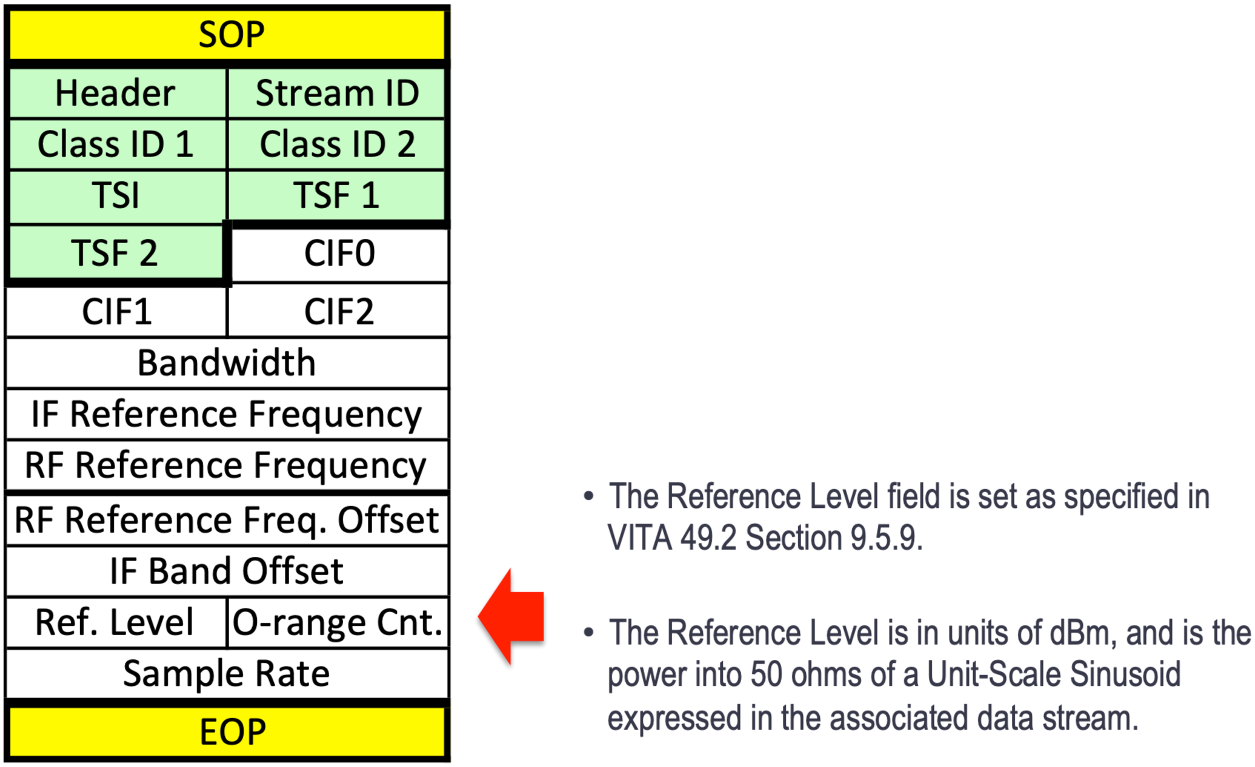

Figure 3-21: ODI-2.1 Context Packet – Reference Level

RULE 3.34: For ODI-2.1 Context Packets, the Reference Level value SHALL be set as specified in VITA 49.2 Section 9.5.9

OBSERVATION 3.25: Since ODI-2.1 specifies signed fixed-point binary values within ODI-2.1 Data Packets, Reference Level may be used to scale the data to absolute values.

OBSERVATION 3.26: Special care should be taken when calculation the Reference Level value. The Reference Level is in units of dBm, and represents the power into 50 ohms of a Unit Scale Sinusoid expressed in the associated data stream.

RULE 3.35: If a producer of ODI-2.1 Context Packets doesn't know the actual value of the Reference Level, it SHALL set the value of the Reference Level field to all 1s.

OBSERVATION 3.27: Setting the Reference Level to all 1s is equivalent to indicating approximately -256dBm, a very small value. This value is reserved for indicating "Reference Level unknown".

3.2.6.3 ODI-2.1 Context Packet – Over-range Count

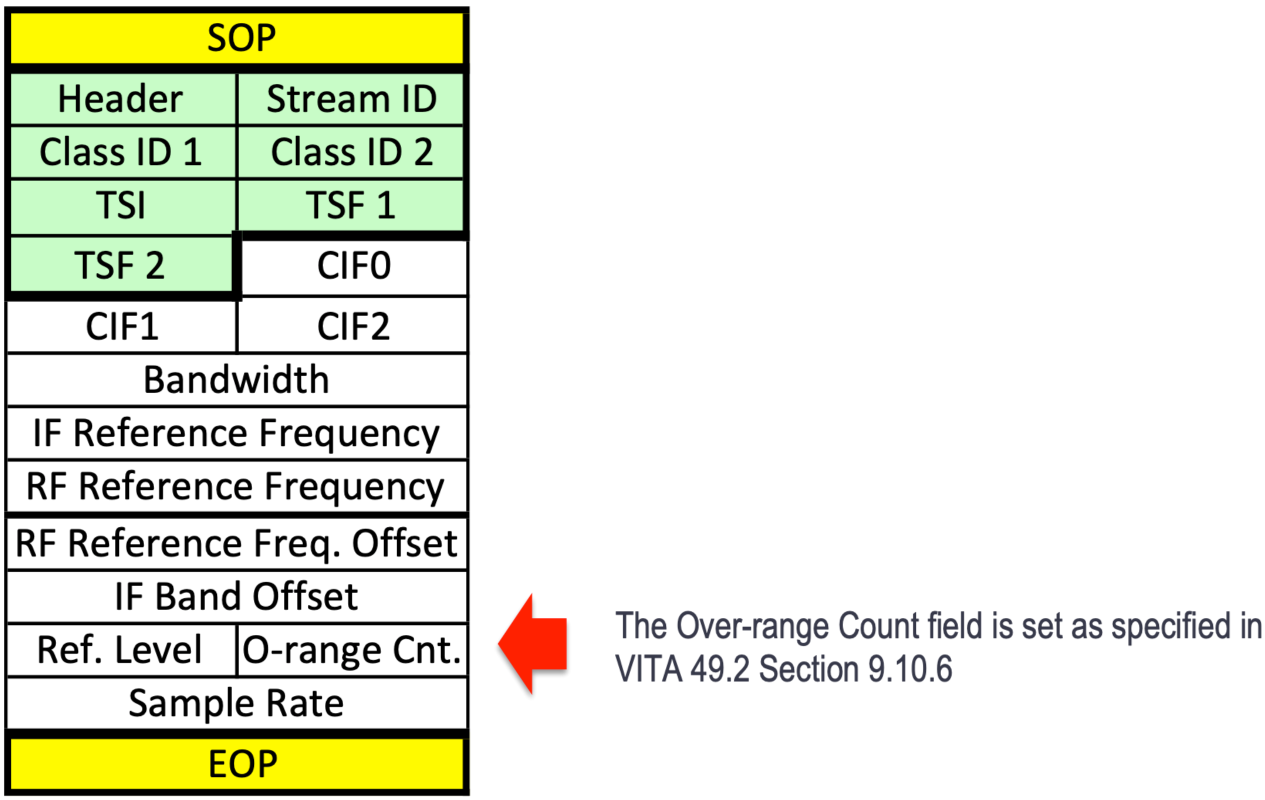

Figure 3-22: ODI-2.1 Context Packet – Over-range Count

RULE 3.36: For ODI-2.1 Context Packets, the Over-range Count value SHALL be set as specified in VITA 49.2 Section 9.10.6

RULE 3.37: If a producer of ODI-2.1 Context Packets doesn’t know the actual value of the Over-range Count, it SHALL set the value of the Over-range Count field to 0 (zero).

3.2.6.4 ODI-2.1 Context Packet – Sample Rate

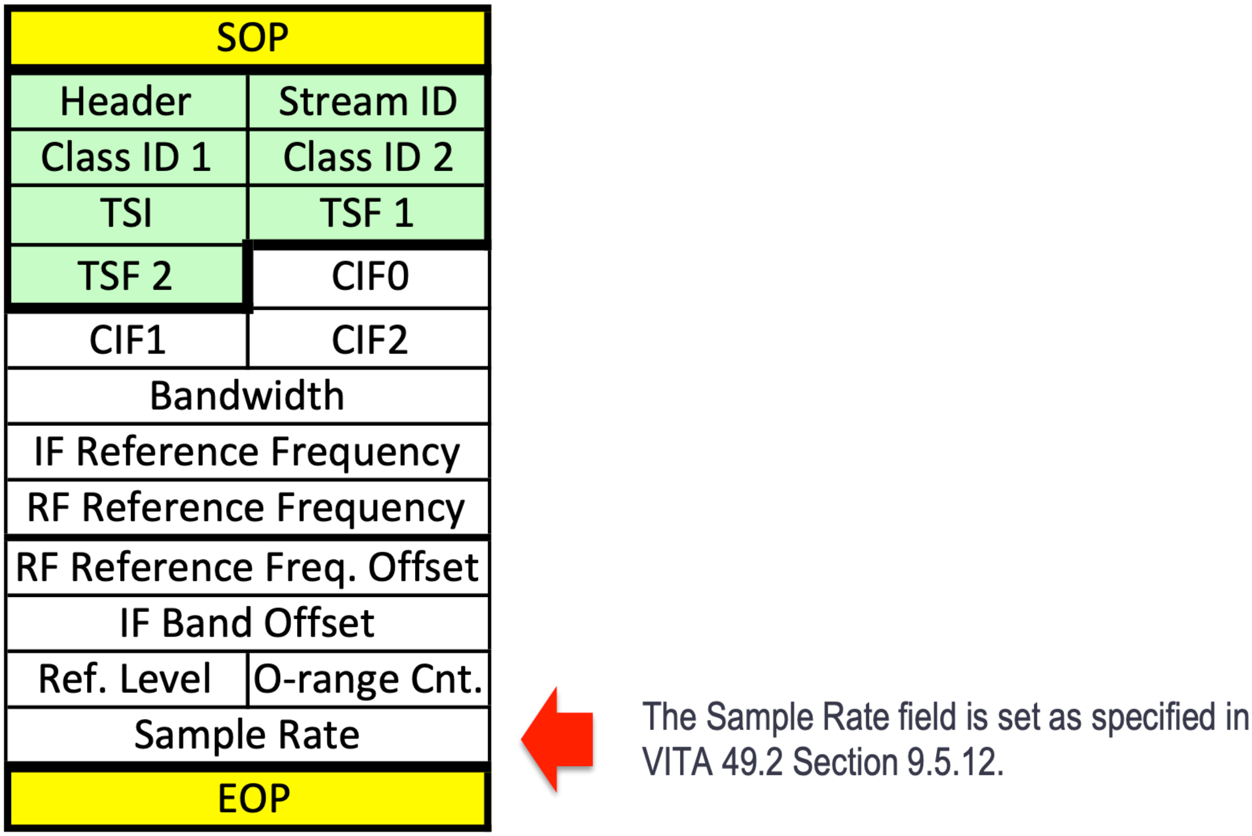

Figure 3-23: ODI-2.1 Context Packet – Sample Rate

RULE 3.38: For ODI-2.1 Context Packets, the Sample Rate value SHALL be set as specified in VITA 49.2 Section 9.5.12

RULE 3.39: If a producer of ODI-2.1 Context Packets doesn't know the actual value of the Sample Rate, it SHALL set the value of the Sample Rate field to 0 (zero).

3.3 ODI-2.1 Control Packets

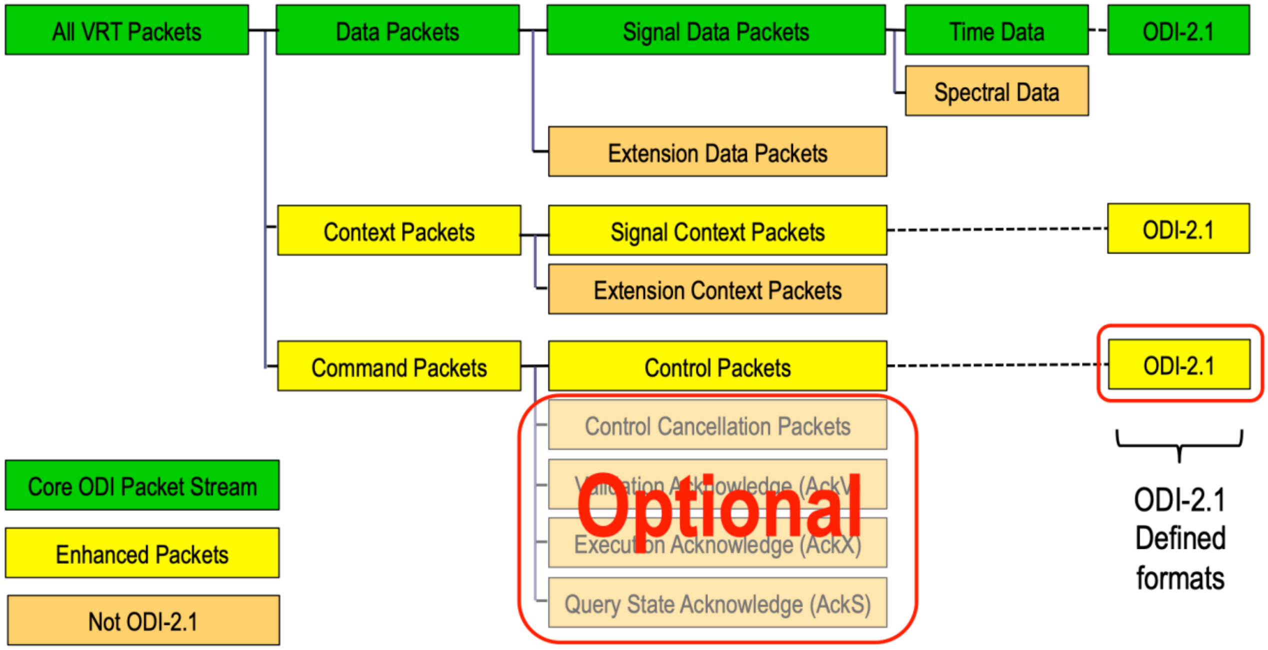

Figure 3-24: ODI-2.1 Control Packets

ODI-2.1 has only one standard Command Packet subtype, the ODI-2.1 Control Packet. All other Command Packet subtypes are optional, and not specified by ODI-2.1

Control Packets are analogous to Context Packets in that they convey metadata related to the signal. While Context Packets describe metadata about a digitized or recorded signal, Control Packets enable control of similar parameters to an exciter, such as a signal generator. While the execution of ODI-2.1 Control Packets is optional, it is a required capability if the consumer can execute ODI-2.1 Context Packets. In other words, Control Packets represent the standard method for controlling a consumer.

RULE 3.40: IF a consumer can execute ODI-2.1 Context Packets, then that consumer SHALL also execute ODI-2.1 Control Packets.

A consumer is not required to execute Control Packets, but may do so. A consumer that receives Control Packets, or any Command Packet subtype, that it does not know how to execute is required only to continue normal operation.

RULE 3.41: IF an ODI-2.1 consumer receives Command Packet subtypes that it does not understand or cannot execute, THEN that consumer SHALL continue normal operation.

Many ODI-2.1 devices may offer a method for controlling metadata parameters through a separate control interface other than ODI. Examples include an Ethernet connection or a backplane fabric connection for modular devices. This is allowed by ODI-2.1, and the existence of an alternate control port does not require an ODI-2.1 device to also offer control over the ODI port using Control Packets.

PERMISSION 3-3: An ODI-2.1 consumer MAY accept and execute commands sent over a non-ODI interface.

The standard ODI-2.1 Control Packet is a specific ODI-2 Control Packet containing fields useful for RF signals. The ODI-2.1 Control Packet is 96 bytes in length, and includes the same Context/Command fields as the standard ODI-2.1 Context Packet:

- Bandwidth
- IF Reference Frequency
- RF Reference Frequency
- RF Reference Frequency Offset
- IF Band Offset
- Reference Level
- Over-range Count
- Sample Rate

VITA 49.2 terminology describes these fields as Context/Command fields, since they have the same definition whether included in Context Packets or Command Packets. ODI-2.1 uses the term Context Indicator fields (CIFs) for both Context Packets and Command Packets. Similarly, ODI-2.1 uses the term context data and context fields when used in either Context Packets or Control Packets. This is done for simplicity, and is consistent with the permission that ODI-2 and ODI-2.1 devices may execute Context Packets.

The key metadata fields in ODI-2.1 Context and Control Packets are designed to be in the same fixed location, easing FPGA implementation.

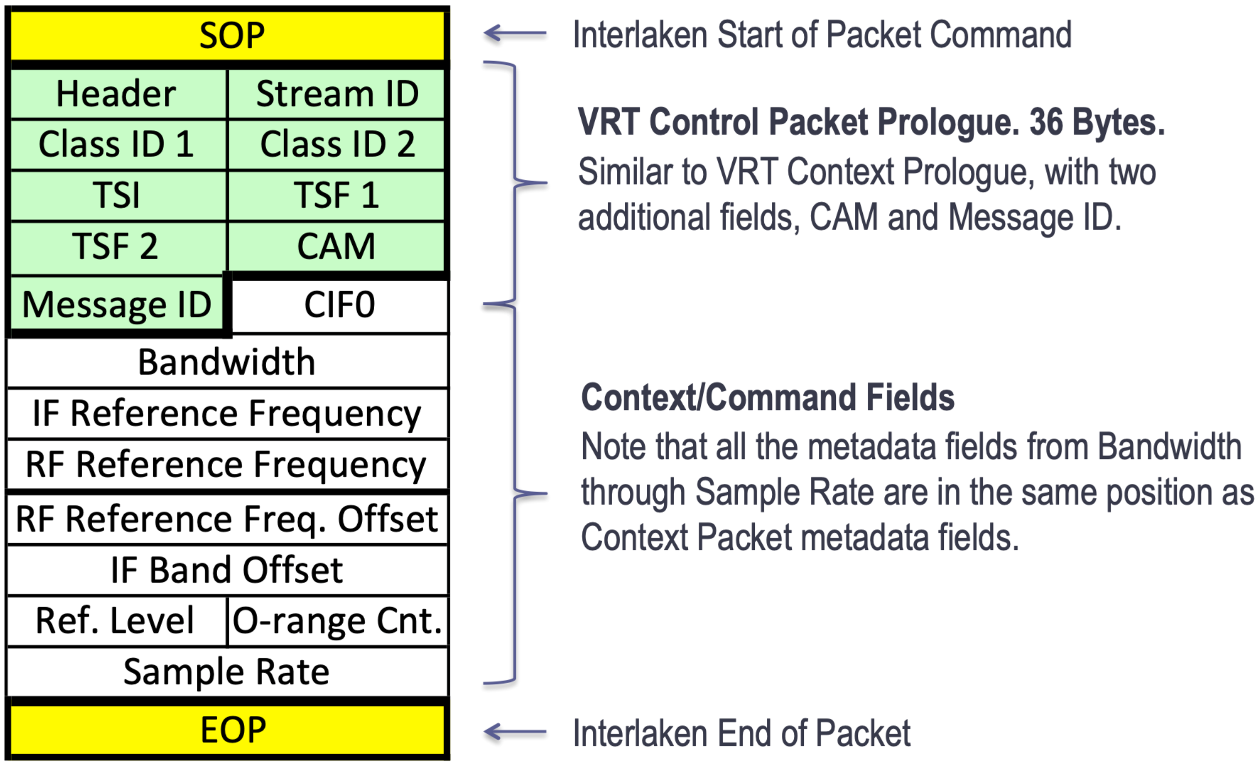

Figure 3-25: ODI-2.1 Control Packet Structure

The figure above shows the location of all fields in the ODI-2.1 Control Packet. The Prologue consists of seven mandated fields totaling 36 bytes. The Prologue fields are identical to those of an ODI-2.1 Context Packet with the addition of the CAM and Message ID fields. The subsequent context fields are identical to those of standard ODI-2.1 Context Packets, with the deletion of CIF1 and CIF2 fields. With the addition of CAM and Message ID fields and the deletion of CIF1 and CIF2 fields, ODI-2.1 Context and Control Packets have the same length with the context fields placed in the same location. This enables straightforward implementation of an FPGA-based device to execute either Context Packets or Control Packets.

RULE 3.42: A device that generates ODI-2.1 Control Packets SHALL include the Prologue fields and context data fields shown in Figure 3-25.

RULE 3.43: The context data fields of an ODI-2.1 Control packet SHALL comply with the requirements of each field as documented in VITA 49.2 and ODI-2.1 Section 3.2.6.

3.3.1 ODI-2.1 Control Packet – Header

The figure below shows the content of the mandatory Header for ODI-2.1 Control Packets. It is functionally equivalent to ODI-2 Figure 3-26.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Packet Type				C	Indicators			TSI		TSF		Packet Count				Packet Size															
0	1	1	0	C	A	R	L	TSI		TSF		Pkt Count				Packet Size															

Figure 3-26: ODI-2.1 Control Packet – Header

RULE 3.44: All fields in an ODI-2.1 Control Packet Header SHALL comply with the requirements for the ODI-2 Command Packet Header as specified in ODI-2 Section 3.3.1.

RULE 3.45: The Packet Type (28-31) of an ODI-2.1 Control Packet Header SHALL be set to 0110, indicating a Command Packet.

RULE 3.46: The C bit (27) of an ODI-2.1 Control Packet Header SHALL be set to 1, indicating Class ID fields are present.

RULE 3.47: The A bit (26) of an ODI-2.1 Control Packet Header SHALL be set to 0, indicating a Control Packet or Control Cancellation Packet.

RULE 3.48: The R bit (25) of an ODI-2.1 Control Packet Header SHALL be set to 0, indicating the bit position is reserved.

RULE 3.49: The L bit (24) of an ODI-2.1 Control Packet Header SHALL be set to 0, which in combination with the A bit indicates a Control Packet.

RULE 3.50: The TSI bits (22-23) of an ODI-2.1 Control Packet Header SHALL be set to 01, 10, or 11, depending on the VITA timestamp method chosen and described in Section 3.1.4.

RULE 3.51: The TSF bits (20-21) of an ODI-2.1 Control Packet Header SHALL be set to 01, 10, or 11, depending on the VITA timestamp method chosen and described in Section 3.1.4.

OBSERVATION 3.28: The TSI (22-23) and TSF (20-21) bits of an ODI-2.1 Control Packet will match those of the associated Data Packet.

OBSERVATION 3.29: The Packet Count (16-19) of an ODI-2.1 Control Header will behave as a modulo-16 counter as specified in VITA 49.2.

RULE 3.52: The Packet Size (0-15) of an ODI-2.1 Control Packet SHALL be set to 24 decimal, equivalent to 96 bytes.

3.3.2 ODI-2.1 Control Packet – Stream ID, Class ID, TSI, and TSF

Stream ID, Class ID, TSI and TSF fields are set similarly to when they are deployed in ODI-2.1 Context Packets.

RULE 3.53: The Stream ID, Class ID1, Class ID2, TSI, TSF 1, and TSF 2 fields of an ODI-2.1 Control Packet SHALL be set as with ODI-2.1 Context Packets as specified in Sections 3.2.2, 3.2.3, and 3.2.4.

3.3.3 ODI-2.1 Control Packet – CAM

CAM is an abbreviation of Control/Acknowledgment Mode. This field defines how and when the recipient of a Control packet should react to the controls, whether or not an Acknowledge packet or packets should be generated, and how warnings and errors should be handled. This includes the ability to designate a Control packet as a “dryrun” and settings on how to handle potential problems with the packet Control fields.

Since ODI-2.1 focuses Control Packets sent to a forgiving listener, the CAM field is defined as 0F00 000 Hexadecimal for the general case.

RULE 3.54: The CAM field for an ODI-2.1 Control Packet SHALL be set to Hexadecimal 0F00 0000.

	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
	Ctrl											Ctrl & Ack									Ack Only				Reserved							
	CE	IE	CR	IR	P	W	Er	A1	A0	Nack	Res	ReqV	ReqX	ReqS	ReqW	ReqEr	Res	CtrlT2	CtrlT1	CtrlT0	0	0	0	0	0	0	0	0	0	0	0	0
RULE:	0	0	0	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Figure 3-27: ODI-2.1 Control Packet – CAM

The derivation of the CAM field value is shown below.

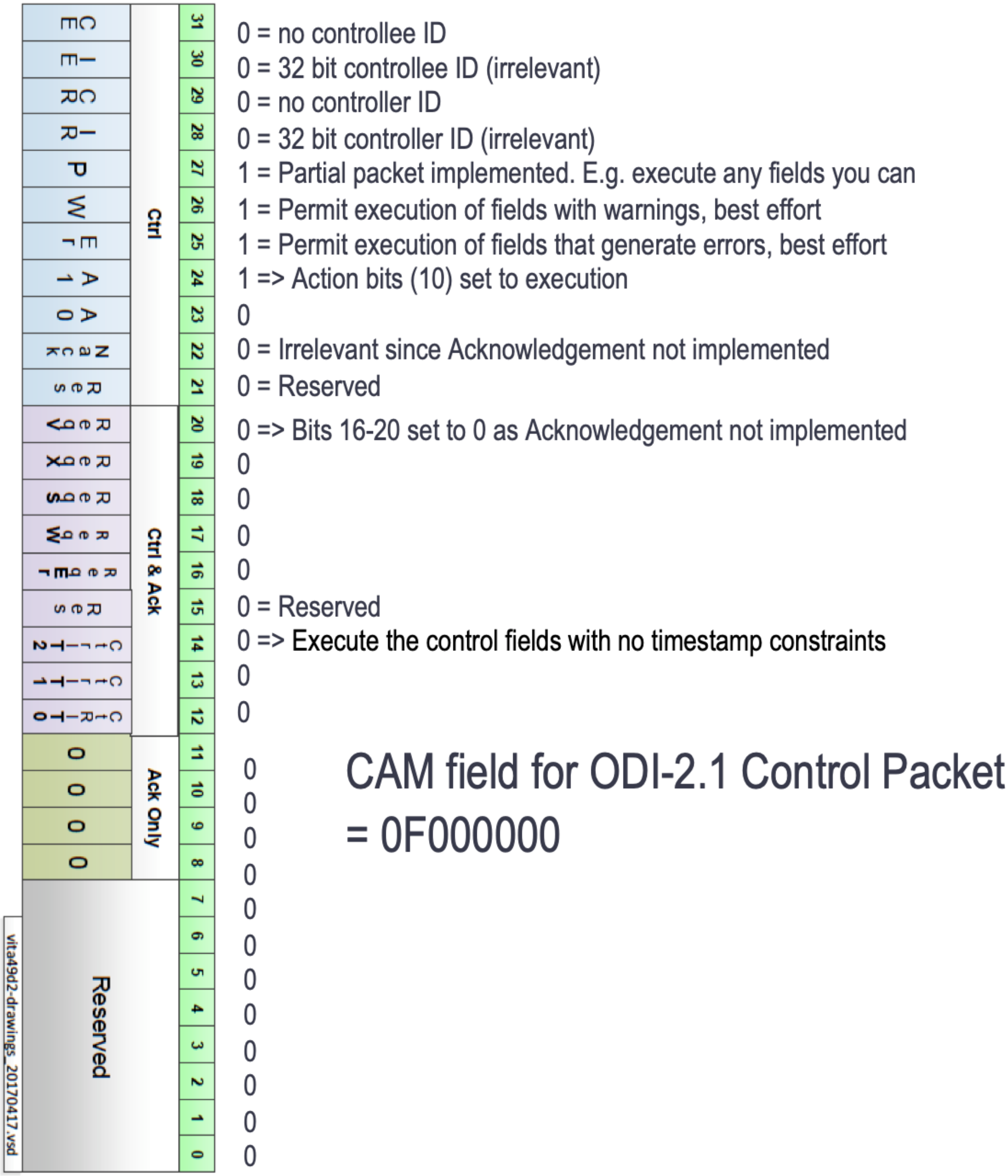

Figure 3-28: ODI-2.1 Control Packet – Derivation of CAM

3.3.4 ODI-2.1 Control Packet – Message ID

Message ID provides a numeric value for directly associating an Acknowledge Packet response with its associated Control Packet. Also, Message ID together with Stream ID provides a unique identifier for cancelling controls. Though acknowledgements and cancellations are not specified within ODI-2.1, the Message ID field remains mandatory.

RULE 3.55: Each new ODI-2.1 Control Packet SHALL have a unique Message ID.

OBSERVATION 3.30: A unique Message ID may be created by a counter that is incremented for each Control Packet.

3.3.5 ODI-2.1 Control Packet – Context Data

There are eight context data fields in an ODI-2.1 Control Packet, matching those of an ODI-2.1 Context Packet. These are mandatory, even if the data isn't known by the producer. The figure below shows the similarity between an ODI-2.1 Context Packet and an ODI-2.1 Control Packet.

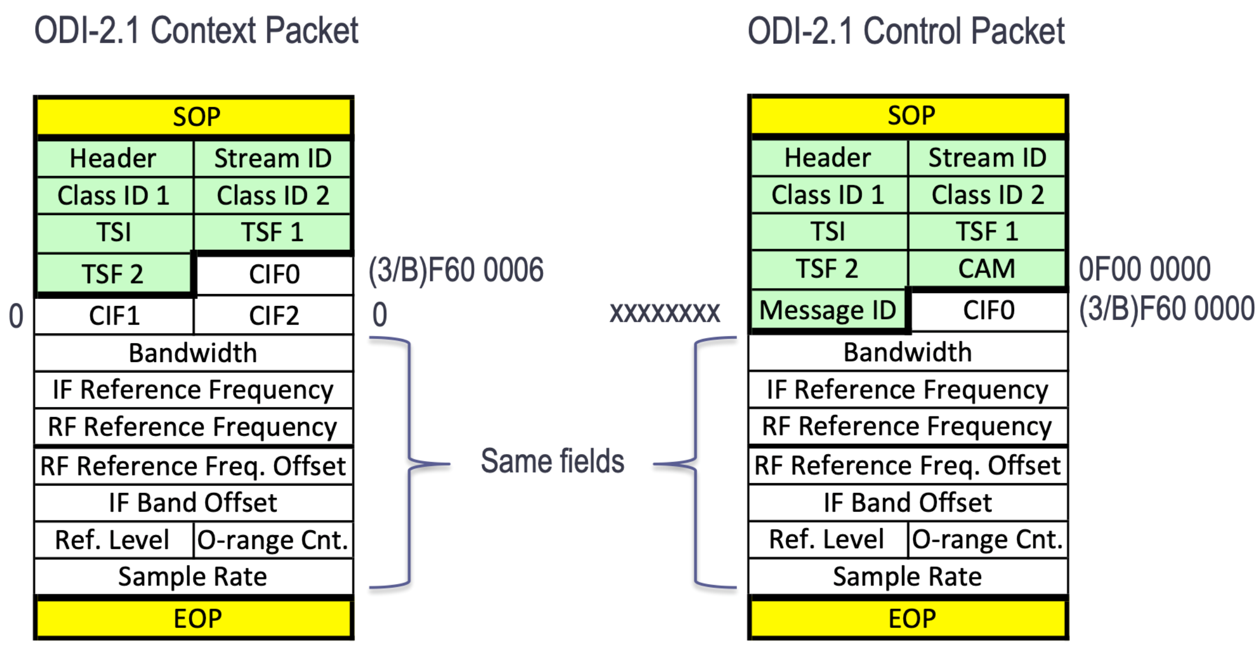

Figure 3-29: ODI-2.1 Context Packet vs. Control Packet

RULE 3.56: The CIF0 field of an ODI-2.1 Control Packet SHALL be set to Hexadecimal X-F-6-0-0-0-0-0, where X=3 when there is no context field change, and X=B when there is a context field change.

OBSERVATION 3.31: The mandated value of the CIF0 for ODI-2.1 Control Packets is the same as for ODI-2.1 Context Packets except that the CIF1 and CIF2 enable bits are set to zero, inserting no additional CIF indicators.

The derivation of the value of CIF0 for ODI-2.1 Control Packets is shown in the figure below.

	Bit Position	Context Indicator Field	
X	31	Context Field Change Indicator	= 3 or B
0	30	Reference Point Identifier	
1	29	Bandwidth	
1	28	IF Reference Frequency	
1	27	RF Reference Frequency	= F
1	26	RF Reference Frequency Offset	
1	25	IF Band Offset	
1	24	Reference Level	
0	23	Gain	= 6
1	22	Over-range Count	
1	21	Sample Rate	
0	20	Timestamp Adjustment	
0	19	Timestamp Calibration Time	= 0
0	18	Temperature	
0	17	Device Identifier	
0	16	State and Event Indicators	
0	15	Data Packet Payload Format	= 0
0	14	Formatted GPS (Global Positioning System) Geolocation	
0	13	Formatted INS (Inertial Navigation System) Geolocation	
0	12	ECEF (Earth-Centered, Earth-Fixed) Ephemeris	
0	11	Relative Ephemeris	= 0
0	10	Ephemeris Reference Identifier	
0	9	GPS ASCII	
0	8	Context Association Lists	
0	7..0	**CIF Enable bits**	= 0, 0

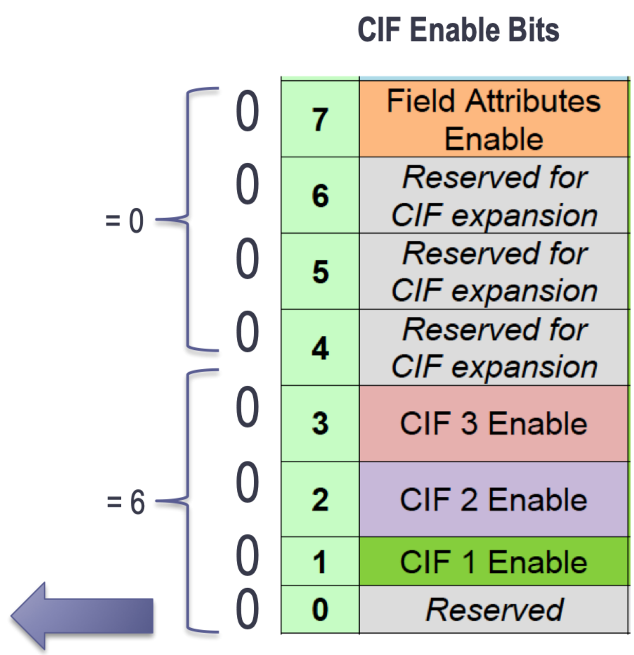

Figure 3-30: ODI-2.1 Control Packet – Derivation of CIF0

RULE 3.57: The context data fields of Bandwidth, IF Reference Frequency, RF Reference Frequency, RF Reference Frequency Offset, IF Band Offset, Reference Level, Over-range Count, and Sample Rate of an ODI-2.1 Control Packet SHALL be set for as specified for the same context data parameter as in ODI-2.1 Context Packets and specified in Section 3.2.6.

OBSERVATION 3.32: Since Over-range Count is never a programmable parameter, it will be set as zero for all ODI-2.1 Control Packets.

OBSERVATION 3.33: If the value of a context data field is unknown, it will be set to 0 (zero) or all 1s, depending on the parameter, for all ODI-2.1 Control Packets as specified in Section 3.2.6.

4. ODI-2.1 Documentation Requirements

ODI-2.1 includes documentation requirements for interoperability. This increases the chances of integrating compatible devices. Key among these are the ODI specification and revision numbers, ODI-2.1 packet types used, and non-ODI-2.1 packet types used. These are required by the rules below.

RULE 4.1: An ODI-2.1 device SHALL document which ODI specifications and associated revisions it complies to.

RULE 4.2: An ODI-2.1 device SHALL document all packet types used, and the contents of each of the packet fields.

RULE 4.3: An ODI-2.1 device SHALL document, as a list or range, all Class IDs supported.

OBSERVATION 4.1: RULE 4.2 may be met by using the templates published in VITA 49.2 Appendix A.2 Documenting Packet Classes.

OBSERVATION 4.2: For ODI-2.1 packets RULE 4.2 may be met by listing the following parameters for each ODI-2.1 packet type:

ODI-2.1 Data Packets

- **Signal Channel Count range (same as Vector Size range + 1)**
- **All supported Item Types**
- **Supported Real/Complex Types**
- **Number of Event Tags supported**
- **Any use of non-zero Pad Word Count or Pad Bit Count**
- **Timestamp modes supported**
- **List of Indicators supported within Trailer**
- **Any use of Associated Context Packets indicated in Trailer Associated Context Packet Count field**

ODI-2.1 Context Packets

- **List of context data fields actually reported (not default values)**
- **Timestamp modes supported**

ODI-2.1 Control Packets

- **List of context data fields executable (not ignored)**
- **Timestamp modes supported**

The options tables required for each of the Packet Classes by VITA 49.2 follow. These are convenient templates for reporting the required parameters above.

Signal Data Packet Class Option Table		
Class Name	"ODI-2.1 Data Packet"	
Packet Stream Purpose	To convey high-speed signal data in a standard format	
Packet Header		
Parameter	**Allowed Options**	**Comments**
Packet Type	Signal Data	
Stream Identifier	Used	
Class Identifier	24-5C-CB:0000.0000 through 24-5C-CB:7FFF.FFFF	See Section 3.1.3
Integer-seconds Timestamp	Used	See Section 3.1.4
Fractional-seconds Timestamp	Used	See Section 3.1.4
Packet Payload		
Parameter	**Allowed Options**	**Comments**
Packing Method	Processing and Link-efficient	See Section 3.1.5
Item Packing Field Size	1-64 bits	See Rule 3.6
Data Item Size	1-64 bits	See Section 3.1.3
Event-Tag Size	0, 1, 2, or 4 bits	See Section 3.1.3.7
Channel-Tag Size	0	
Vector Size	0-8191	See Section 3.1.3.4
Real/Complex Type	Real or Complex	See Section 3.1.3.6
Data Item Format	Several	See Section 3.1.3
Sample-/Channel-Repeating	Not Used	
Repeat Count	Not Used	
Packet Trailer		
Trailer is Required		
Parameter	**Allowed Options**	**Comments**
Calibrated Time Indicator	Sometimes Used	See Section 3.1.6
Valid Data Indicator	Sometimes Used	See Section 3.1.6
Reference Lock Indicator	Sometimes Used	See Section 3.1.6
AGC/MGC Indicator	Sometimes Used	See Section 3.1.6
Detected Signal Indicator	Sometimes Used	See Section 3.1.6
Spectral Inversion Indicator	Sometimes Used	See Section 3.1.6
Over-Range Indicator	Sometimes Used	See Section 3.1.6
Sample Loss Indicator	Sometimes Used	See Section 3.1.6
Sample Frame Indicator #11	Sometimes Used	See Section 3.1.6
Sample Frame Indicator #10	Sometimes Used	See Section 3.1.6
User-defined Indicators #9	Sometimes Used	See Section 3.1.6
User-defined Indicators #8	Sometimes Used	See Section 3.1.6
Associated Context Packet Count	Sometimes Used	See Section 3.1.6

Figure 4-1: ODI-2.1 Data Packet Options Table

Signal Context Packet Class Option Table		
Class Name	"ODI-2.1 Context Packet"	
Packet Stream Purpose	To convey high-speed signal context information in a standard format	
Packet Header		
Parameter	**Allowed Options**	**Comments**
Packet Type	Signal Context	
Stream Identifier	Used	
Class Identifier	24-5C-CB:2017.0010	
Integer-seconds Timestamp	Used	See Section 3.2.4
Fractional-seconds Timestamp	Used	See Section 3.2.4
Context Fields		
Parameter	**Allowed Options**	**Comments**
Context Field Change Indicator	Used	
Bandwidth	Used	See Section 3.2.6
IF Reference Frequency	Used	See Section 3.2.6
RF Reference Frequency	Used	See Section 3.2.6
RF Reference Frequency Offset	Used	See Section 3.2.6
IF Band Offset	Used	See Section 3.2.6
Reference Level	Used	See Section 3.2.6
Over-Range Count	Used	See Section 3.2.6
Sample Rate	Used	See Section 3.2.6
CIF 1	Used	
CIF 2	Used	
CIF 3	Not Used	
CIF 4	Not Used	
CIF 5	Not Used	
CIF 6	Not Used	
CIF 7	Not Used	
All other fields indicated by CIF 0	Not Used	
Fields indicated by CIF 1	Not Used	
Fields Indicated by CIF 2	Not Used	
Fields Indicated by CIF 3 through CIF 7	Not Used	

Figure 4-2: ODI-2.1 Context Packet Options Table

Command Packet Class Option Table		
Class Name	"ODI-2.1 Control Packet"	
Packet Stream Purpose	To convey high-speed signal control information in a standard format	
Packet Header		
Parameter	**Allowed Options**	**Comments**
Packet Type	Control	
Stream Identifier	Used	
Class Identifier	24-5C-CB:2017.0010	
Integer-seconds Timestamp	Used	See Section 3.3.2
Fractional-seconds Timestamp	Used	See Section 3.3.2
Control/Acknowledge Settings	• Control Packets only • No Acknowledge Packet requests • No Dry Run scenarios • No Controllee ID • No Controller ID • Partial Packet implemented (e.g. execute what can be executed) • Execution of fields with warnings permitted • Execution of fields with errors permitted • Action bits set to execution • Control fields executed with no timestamp constraints	See Section 3.3.3
Context Fields		
Parameter	**Allowed Options**	**Comments**
Context Field Change Indicator	Used	
Bandwidth	Used	See Section 3.3.5
IF Reference Frequency	Used	See Section 3.3.5
RF Reference Frequency	Used	See Section 3.3.5
RF Reference Frequency Offset	Used	See Section 3.3.5
IF Band Offset	Used	See Section 3.3.5
Reference Level	Used	See Section 3.3.5
Over-Range Count	Used	See Section 3.3.5
Sample Rate	Used	See Section 3.3.5
CIF 1 through CIF 7	Not Used	
All other fields indicated by CIF 0	Not Used	
Fields indicated by CIF 1	Not Used	
Fields Indicated by CIF 2	Not Used	
Fields Indicated by CIF 3 through CIF 7	Not Used	

Figure 4-3: ODI-2.1 Control Packet Options Table

5. Appendix A: ODI-2.1 Data Packet – Example Class IDs

Below are examples of Class IDs for ODI-2.1 Data Packets, dependent on the Item Packing width, number of Event Bits, Real or Complex data, and number of channels. These examples assume Pad Bit Count and Pad Word Count are zero.

Item Packing Field Width	Data Item (signed)	Event bits	Real or IQ	Channels	Class ID Hexadecimal Value
8	8-bit fixed pt.	0	Real	1	00245CCB 00020000
8	8-bit fixed pt.	0	Real	2	00245CCB 00020001
8	8-bit fixed pt.	0	Real	4	00245CCB 00020003
8	8-bit fixed pt.	0	IQ	1	00245CCB 00120000
10	10-bit fixed pt.	0	Real	1	00245CCB 00004000
10	10-bit fixed pt.	0	Real	2	00245CCB 00004001
12	12-bit fixed pt.	0	Real	1	00245CCB 00008000
14	14-bit fixed pt.	0	Real	1	00245CCB 0000C000
16	12-bit fixed pt.	4	Real	1	00245CCB 00C30000
16	14-bit fixed pt.	2	Real	1	00245CCB 00830000
16	14-bit fixed pt.	2	IQ	1	00245CCB 00930000
16	16-bit fixed pt.	0	Real	1	00245CCB 00030000
16	16-bit fixed pt.	0	Real	2	00245CCB 00030001
16	16-bit fixed pt.	0	Real	4	00245CCB 00030003
16	16-bit fixed pt.	0	IQ	1	00245CCB 00130000
32	32-bit IEEE-754 floating point	0	Real	1	00245CCB 00060000
32	32-bit IEEE-754 floating point	0	IQ	1	00245CCB 00160000

Figure 5-1: Example Class IDs for ODI-2.1 Data Packets

6. Appendix B: Example Item Packing with 12-bit Data Converters

The examples below show how the data from a 12-bit data converter may be used in the mandatory 8-bit and 16-bit Signed Fixed Point data formats for ODI-2.1 devices.

12-bit data into an 8-bit Item Packing Field

For the 8-bit Signed Fixed Point format, the 12-bit data converter has too many bits of resolution to fit in the Item Packing Field. In this case, the four LSBs of the data converter are eliminated, and only the eight MSBs are included in the field.

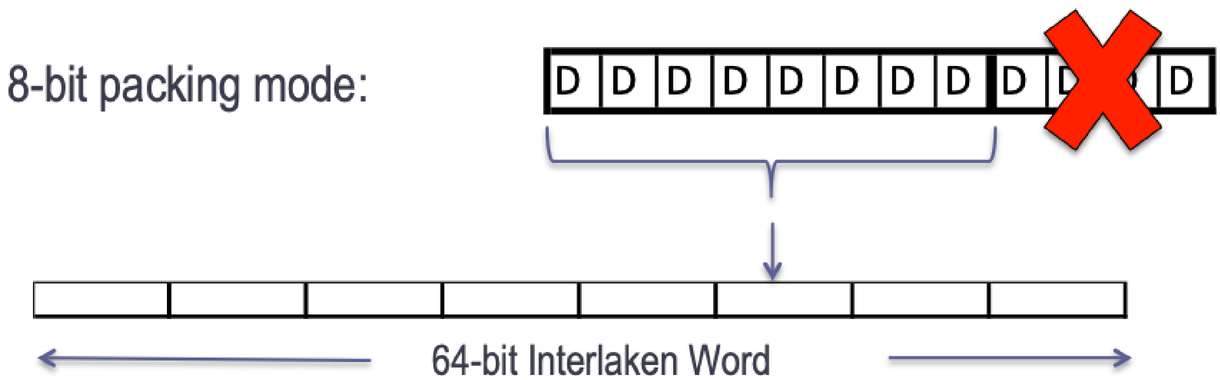

Figure 6-1: Packing of 12-bit data into 8-bit Item Packing Fields

In this case resolution is lost, as the four LSBs are discarded. If Event Bits are included, the resolution will decrease further, as the Event Bits will replace the LSBs of the Data Item.

12-bit data into a 16-bit Item Packing Field

For the 16-bit Signed Fixed Point format, the 12-bit data converter has fewer bits of resolution than the Item Packing Field. In this case, four "zeros" are concatenated onto the data to fill the Item Packing field.

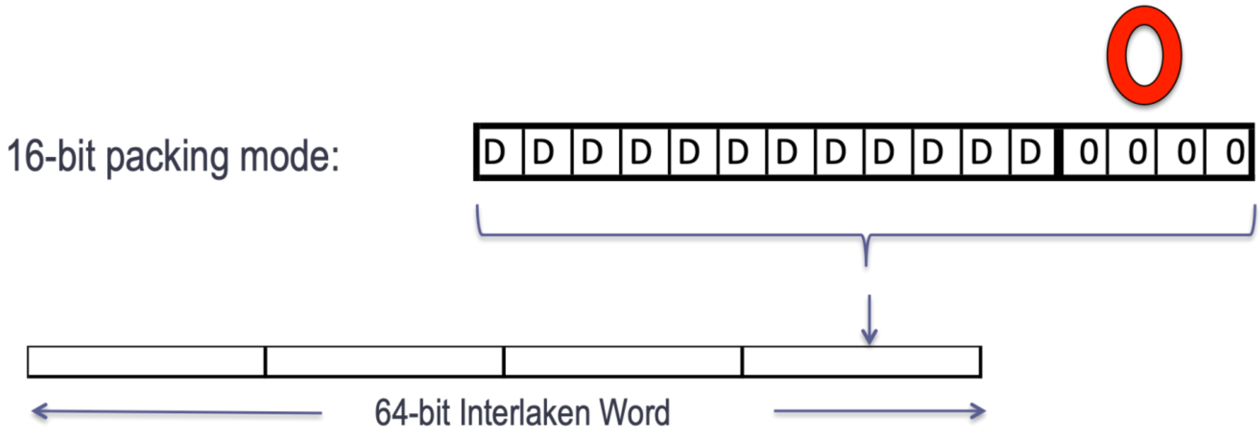

Figure 6-2: Packing of 12-bit data into 16-bit Item Packing Fields

In this case resolution is retained, as the full resolution of the 12-bit data converter can be packed into the Item Packing field. However, more bandwidth is required of the ODI link, as the data transferred over it has doubled. If Event Bits are included, the resolution will be retained, as the Event Bits are located in the LSBs of the Item Packing Field. Since up to four Event Bits may be indicated, all will fit within the null data appended onto the 12-bit signal data.