VRT Spectrum Survey Interoperability Specification (V49a) for Dummies

Volume 1: *Signal Data and Signal Context*

This document is not VITA or ANSI Approved[i]

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1 Contents

2 Introduction

The VITA Radio Transport (VRT), also known as the VITA 49 (V49) standard, defines a mechanism for the transport of digitized signal data and the accompanying contextual information. The V49 standards support a very broad range of applications and as such cannot be practically supported by a single Application Program Interface (API). It is expected that application-specific specifications be defined around the V49 framework and definitions provided in the V49 base standards.

Vita-49A is a specification that is applicable to spectrum-survey applications. It is a subset of the V49.0 specification and intended to foster high-throughput and adaptable processing in a large-scale environment by a reduced scope implementation of V49. It specifically considers the needs of devices based around 32-/64-bit general-purpose processors (GPP) and field programmable gate arrays (FPGAs) that utilize Internet Protocol (IP) as the underlying transport between processing devices.

This guide is intended to be used as a "quick-start" to understanding the V49A specification and references the official ANSI/Vita-49.0 and ANSI/Vita-49A standards. It is recommended that this guide be used in conjunction with the official ANSI/Vita standards whenever possible.

A brief description of the Vita-49 family of standards and taxonomy is shown below.

Standard	Common Name	Description	Status
ANSI/VITA 49.0-2015	VITA Radio Transport (VRT)	This standard defines a transport-layer protocol designed to promote interoperability between RF (radio frequency) receivers and signal processing equipment in a wide range of applications.	ANSI Ratified
ANSI/VITA 49.1-2015	VITA Radio Link Layer (VRL)	This standard specifies an optional encapsulation protocol for VITA-49.0 (VRT) packets.	ANSI Ratified
ANSI/VITA 49.2-2017	VITA Radio Transport (VRT) Electromagnetic Spectrum: Signals and Applications	This standard supports all of the features of V49.0 and provides additional features for enhanced spectrum sensing applications and precision control of RF emissions across distributed systems to include: spectral data, command/control, stimulus/exciter, enhanced context and diagnostics packets.	ANSI Ratified
ANSI/VITA 49a-2015	Spectrum Survey Interoperability	This specification describes an interoperability standard that is an application-specific subset of the ANSI/VITA 49 family of standards that specifically identifies the set of features that must be supported in order to meet the needs of a given application. Specifically the support of high-throughput systems utilizing 32-/64-bit general-purpose processors and FPGAs.	ANSI Ratified

Table 2-1: Vita-49 Family of Standards

It should also be noted that this document only covers *Vita-49A Signal and Context packets*. It does ***not*** cover Context geolocation (such as GPS, INS and Ephemeris) and Extension packets as these are covered in Volume 2 of this series.

3 VRT Packet Classes

A VRT Packet Class is the specification of the name, structure, and function of the packets in a VRT Packet Stream. Specifically, it specifies the name, numeric code, structure and function of the packet class. In Vita-49.0 there are four categories of packet classes: IF Data Packet Class, Extension Data Packet Class, IF Context Packet Class and Extension Context Packet Class. They are defined as follows:

IF Data Packet: a VRT Packet Stream that conveys IF Data.

Extension Data Packet: a VRT Packet Stream that conveys data in a user-defined format.

IF Context Packet Stream: a VRT Packet Stream that conveys information (context) about the corresponding IF Data Packet Stream.

Extension Context Packet Stream: a VRT Packet Stream that conveys information (context) about the corresponding Extension Data Packet Stream. The table below describes the four packet stream types.

Contents	**Standard Formats**	**Custom Formats**
Data	**IF Data** Conveys a digitized IF signal (IF Data) • Real/complex data • Fixed/floating-point formats	**Extension Data** Conveys any signal or any data derived from a signal • Any type of data • Custom packet format
Context	**IF Context Packet Stream** Conveys common Context for IF Data • Frequency • Power • Timing • Geolocation	**Extension Context** Conveys additional Context for IF Data or Extension Data. • Any kind of Context • Custom packet format

Table 3-1: Packet Stream Types in VRT

Of the four types of packet stream categories, only two will be addressed in this document as they are the most common encountered in practice. These are the **IF Data Packet** and **IF Context Packet** Streams.

4 IF Data Packet

The IF data packet is a VRT formatted packet that conveys digitized IF signal data such as in-phase and quadrature (I/Q) samples. The general format of the packet is shown below:

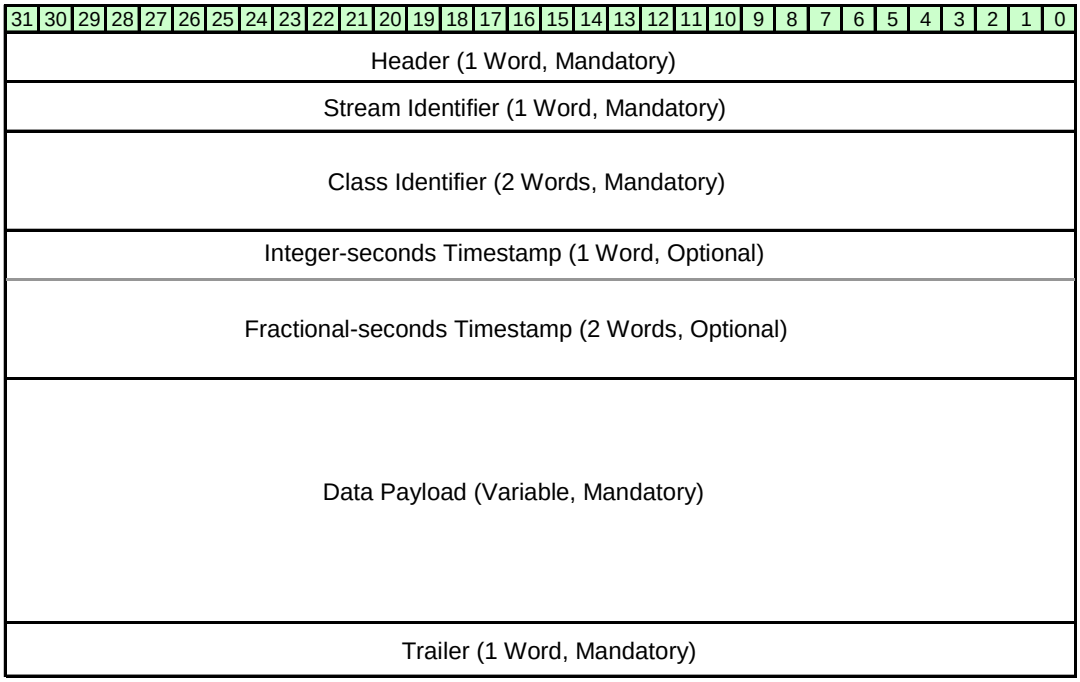

Figure 4-1: VRT IF Data Packet Format

Header

All VRT packets must have a properly formatted header as shown below.

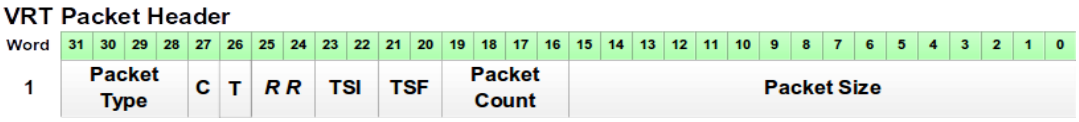

Figure 4-2: VRT IF Data Packet Header Detail

For VRT IF data packets the packet header, stream ID, class ID, payload and trailer are all mandatory in V49A. The bit fields are described in ***Table 4-1***.

Bits	Field	Value	Description
31-28	Type	0x0001, 0x0011	Signal or Extension Data packet with Stream ID
27	C	0x0, 0x1	0x0:Class ID not present, 0x1:Class ID present. Class ID **must** be present in Vita-49A
26	T	0x0, 0x1	0x0:Trailer is not present., 0x1:Trailer is present. Trailer **must** be present in Vita-49A
25-24	Reserved	0x0, 0x0	Reserved = set to zero by default
23-22	TSI		Time Stamp Integer Field (see Table 4-6)
21-20	TSF		Time Stamp Fractional Field (see Table 4-6)
19-16	Count	0x0 – 0xF	Rolling packet count (Rolls over from 0xF to 0x0)
15-0	Size	0x0 - 0xFFFF	Total number of 32-bit words in the IF Data packet, including the header, payload and any optional fields. A value of 0x0 indicates a "No Data" Packet[1].

Table 4-1: VRT Data Packet Header Bit Fields

The VRT packet header must indicate the type of packet shown below, the most common being Signal Data and Context. Note that a Stream Identifier is required for Vita-49A.

Packet Type	Meaning
0000 (0)	Signal Data Packet without Stream Identifier[2]
0001 (1)	Signal Data Packet with Stream Identifier
0010 (2)	Extension Data Packet without Stream Identifier [2]
0011 (3)	Extension Data Packet with Stream Identifier
0100 (4)	Context Packet
0101 (5)	Extension Context packet
0110 (6) – 1011 (11)	Reserved

Table 4-2: VRT Packet Types

Stream ID

A Stream Identifier (Stream ID) is a 32-bit number assigned to a VRT Packet Stream. Each packet in a Packet Stream contains the Stream ID for that Packet Stream. This identifies all the packets in the Packet Stream as belonging to it. In most cases each VRT Packet Stream will have a unique Stream ID, and the different Stream IDs used in different Packet Streams enable a receiver of those packets to separate them into their respective Packet Streams. The Stream ID **shall** be in the range of 0x00000001 and 0x7FFFFFFF inclusive.

Bits	Field	Value	Description
31-0	Stream ID	0xXXXXXXXX	Unique 32 bit Stream ID for each data stream

Table 4-3: Packet Stream ID

1 A "No Data" Packet must use the Class ID of FF-FF-FA:2011.0002 (See Rule 6.4-3 of VITA 49A-2015)
2 Not allowed in Vita-49A

Class ID

The Class Identifier (Class ID) field makes it possible for the receiver of a VRT Packet Stream to determine the identity of both the Information Class used for the application and the Packet Class from which each received packet was made. The generic Class ID field is shown in **Figure 4-3**.

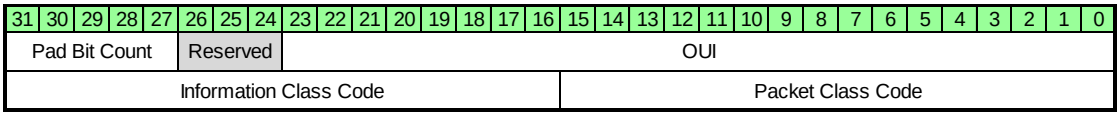

Figure 4-3: Generic Class Identifier Field

In an effort to facilitate interoperability Vita-49A defines a **Standard Data Packet**. The Standard Data Packet is a specific set of Class Identifiers in the range FF-FF-FA:0000.0000 to FF-FF-FA:00FF.FFFF that can be used with the IF Data and Extension Data packets that conform to this specification. Rather than enumerate all possible Class Identifiers that can be used, an algorithmic approach is taken to assign them. The Standard Data Packet **shall** be used with IF Data packets and Extension Data packets, the Class ID for the Standard Data packet is shown in **Figure 4-4**.

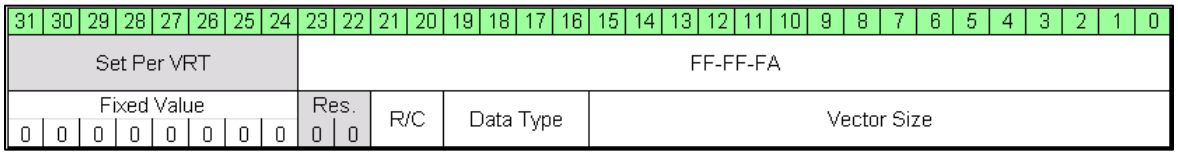

Figure 4-4: Standard Data Packet Class Identifier

Bits	Field	Value	Description (Word 1)
31-27	Pad Bit Count	0x0 - 0x1F	Number of Pad bits at the end of the payload.
26-24	Reserved		Reserved = set to zero by default
23 - 0	OUI	0xFFFFFA	OUI: FF-FF-FA

Bits	Field	Value	Description (Word 2)
31-24	Fixed Value	0x0	Fixed Value bits set to zero
23-22	Reserved	0x0 , 0x0	Reserved = set to zero by default
21-20	R/C	0x00. 0x01	0x00: Real, 0x01: Complex Cartesian
19-16	Data Type	0x1 - 0xD	See Table 4-5 for Data Type Codes
15-0	Vector Size		Unsigned that is one less than actual Vector Size[3]

Table 4-4: Standard Data Packet Class Identifier

[3] The Vector Size indicator is a 16-bit field to maintain consistency with that used with VRT (Vita-49.0) rule 7.1.5.18-11 on the Data Packet Payload Format

Data Type	Format	Data Type	Format
0001	4-bit Signed Fixed Point	1000	1-bit Unsigned Fixed Point
0010	8-bit Signed Fixed Point	1001	4-bit Unsigned Fixed Point
0011	16-bit Signed Fixed Point	1010	8-bit Unsigned Fixed Point
0100	32-bit Signed Fixed Point	1011	16-bit Unsigned Fixed Point
0101	64-bit Signed Fixed Point	1100	32-bit Unsigned Fixed Point
0110	32-bit IEEE 754 Single Precision	1101	64-bit Unsigned Fixed Point
0111	64-bit IEEE 754 Double Precision		

Table 4-5: Standard Data Packet Data Type Format Codes

Timestamp

The Timestamp in an IF Data packet is divided into two components: an integer-seconds component and a fractional-seconds component. Together these two components precisely specify the Reference-Point Time of the first Data Sample contained in the packet.

The *Integer-seconds Timestamp* specifies the Reference-Point Time only to one-second resolution, while the fractional-seconds part adds additional resolution. The *Integer-seconds Timestamp* consists of a single 32-bit word. It may be used to convey UTC time, GPS time, or some user-specified time-code. The type of time conveyed by this word is indicated by the value of the TSI bits.

The “TSI” (Time Stamp-Integer) field is an encoded field indicating which, if any, type of Integer-seconds Timestamp is present in the packet. The “TSF” (Time Stamp-Fractional) field is an encoded field indicating which, if any, type of Fractional-seconds Timestamp is present in the packet.

The *Fractional-seconds Timestamp* conveys the Reference-Point Time to a higher resolution than does the Integer-seconds Timestamp. There are three types of Fractional-second Timestamps:

- The “Sample-Count” Timestamp
- The “Real-Time” Timestamp
- The “Free-Running Count” Timestamp.

The first two of these typically serve to add resolution to the Integer-seconds Timestamp, so that together they provide a range of years and a precision down to either the sample-period or one picosecond respectively. The third Fractional-seconds Timestamp, the Free-Running Count Timestamp, provides an incrementing sample count from any chosen starting time. It has no constant relationship to the Integer-seconds Timestamp. Each of the three Fractional-seconds Timestamps consists of an unsigned 64-bit integer which occupies two consecutive 32-bit words.

The **Sample Count Timestamp** extends the resolution of the Integer-seconds Timestamp down to one Data Sample period. It accomplishes this by conveying the sample number, as counted at the Reference Point, of the first Data Sample in the IF Data packet relative to the time of the last Integer-seconds Timestamp increment. Thus it is reset to zero at each increment of the Integer-seconds Timestamp. In the case where the Integer-seconds Timestamp is not in use, this timestamp still resets to zero when it reaches the number of Data Samples in one second. The timing of these events is not specified in this case however.

The **Real-Time Timestamp** extends the resolution of the Integer-seconds Timestamp down to one picosecond. It accomplishes this by conveying the Reference-Point Time of the first Data Sample in the IF Data packet, in picoseconds, relative to the time of the last Integer-seconds Timestamp increment. Thus it is reset to zero at each increment of the Integer-seconds Timestamp. In the case where the Integer-seconds Timestamp is not in use, this timestamp still resets to zero when it reaches the number of picoseconds in one second. The timing of these events is not specified in this case however.

The **Free Running Count Timestamp** conveys the Reference-Point Time of the first Data Sample in the IF Data packet, in sample counts, relative to any chosen starting time. The Free Running Counter rolls over modulo-*N*, i.e. from *N*-1 to zero, where *N* can be any positive number up to 2^{64}. The Free Running Count has no constant relationship to the Integer-seconds Timestamp.

TSI Code	Meaning	TSF Code	Meaning
00	No Integer-seconds Timestamp field included	00	No Fractional-seconds Timestamp field included
01	UTC	01	Sample Count Timestamp
10	GPS time	10	Real-Time (Picoseconds) Timestamp
11	Other	11	Free Running Count Timestamp

Table 4-6: TSI and TSF Codes

Trailer

The IF Data packet trailer is a mandatory field whose presence is identified by the "T" bit in the header, as previously described. The trailer contains fields that indicate the validity of the Data and the status of the processes producing that Data. It also contains a field that indicates whether related Context is being sent in one or more separate "Context packets."

VRT Signal Data Packet Trailer

Word	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
1	Enables												State and Event Indicators												E	Associated Context Packet Count							

Figure 4-5: Signal Data Packet Trailer

Together, the Enables field and the State and Event Indicators field provide the capability to mark an IF Data packet with one or more Data events or state updates to be communicated from a VRT emitter to a VRT receiver. An Event Indicator might indicate a system synchronization signal or other event that affects some portion, or all, of the IF Data packet payload. A state update might be an indication of tuner phase-lock, for example. When these fields are used, no provision is made for indicating the precise time of the events or state changes. The Enables field contains an enable bit for each Indicator bit in the State and Event Indicators field. Some of the Indicators (and their enable bits) are predefined and some are user-defined.

Enable Bit Position	Indicator Bit Position[4]	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

Table 4-7: Trailer Enable and Indicator Bit Positions and Meanings

When the "E" bit (position 7 in Figure 4-5) is set to **one** the "Associated Context Packet Count" shall provide a count of all of the transmitted Context packets that are directly or indirectly associated with the IF Data packet, OR a count of some special subset of these. When the "E" bit is **zero**, the "Associated Context Packet Count" is undefined.

[4] Each Indicator functions as indicated, but only when the corresponding Enable bit is set otherwise, the Indicator bit is undefined.

5 IF Context Packet

The IF context packet is a VRT formatted packet that conveys information related to the described signal. The general format of the packet is shown below:

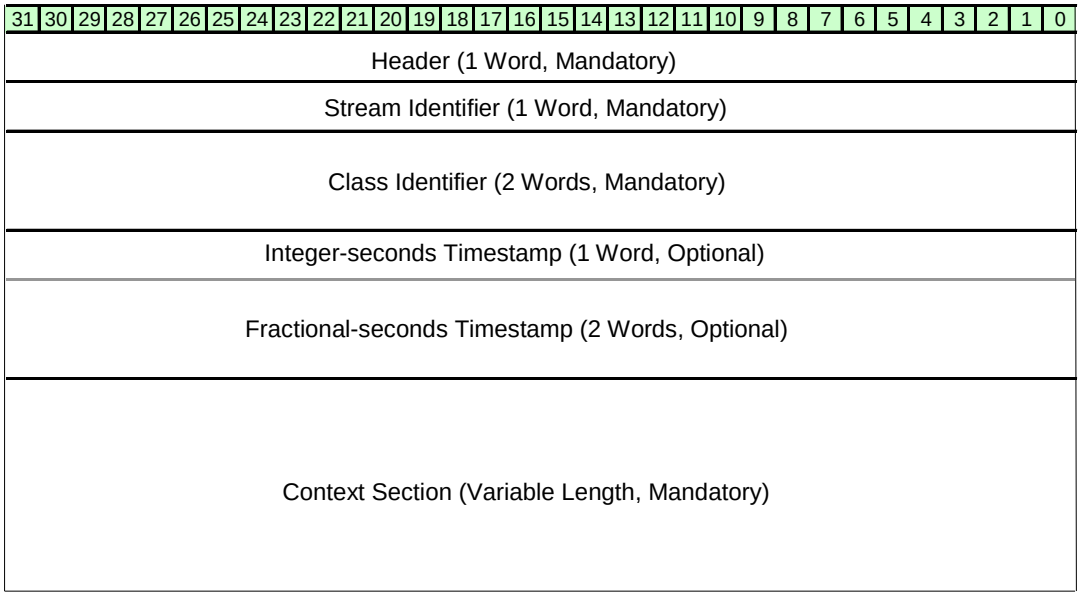

Figure 5-1: VRT Context Packet Format

Header

The header of the IF Context packet is the same as the header of the IF Data packet with the exception of the omission of the T bit and the addition of the TSM bit. The format of the IF Context packet header is shown below:

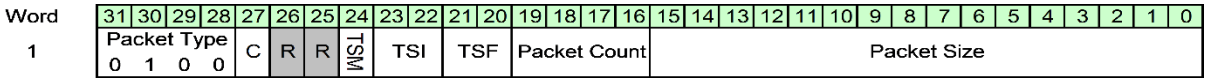

Figure 5-2: VRT Context Packet Header

Bits	Field	Value	Description
31-28	Type	0x0100	Context packet with Stream ID
27	C	0x0, 0x1	0x0: Class ID not present, 0x1 Class ID present
26-25	Reserved	0x0, 0x0	Reserved = set to zero by default
24	TSM	0x1, 0x0	Timestamp Mode - 0x0: precise event timing, 0x1: general event timing
23-22	TSI		Time Stamp Integer Field (see Table 4-6)
21-20	TSF		Time Stamp Fractional Field (see Table 4-6)
19-16	Count	0x0 – 0xF	Rolling packet count (Rolls over from 0xF to 0x0)
15-0	Size	0x0 - 0xFFFF	Total number of 32-bit words in the IF Data packet, including the header, payload and any optional fields. A value of 0x0 indicates a "No Data" Packet[5].

Table 5-1: VRT Context Packet Header Bit Fields

5 A "No Data" Packet must use the Class ID of FF-FF-FA:2011.0002 (See Rule 6.4-3 of VITA 49A-2015)

Stream ID

Stream Identifiers (Stream IDs) in the IF Context Packet Class are used in the same fashion as in IF Data Packet Classes to identify particular packets as belonging to certain Packet Streams. In addition, the Stream ID in a Context Packet Stream may serve to pair it with a Data Packet Stream or to associate it with another Context Packet Stream.

Class ID

The Class Identifier (Class ID) is used to identify the Information Class and Packet Class to which the IF Context packet belongs. It contains an OUI subfield which specifies the organization that specified the Information Class and Packet Class to which the IF Context Packet Stream belongs. It also contains codes that uniquely identify the Information Class and Packet Class from that organization.

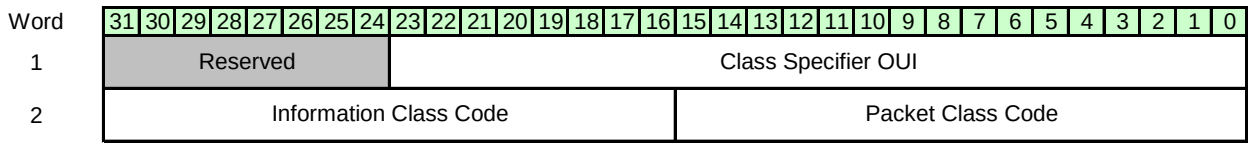

Figure 5-3: Context Class Identifier Field

The **Standard Context Packet** is an IF Context packet that can be used in any generic IF Context Stream that conforms to Vita-49A. For the Standard Context Packet the OUI is FF-FF-FA, Information Class Code is 0x2011 (8209), and Packet Class Code is 0x0003 (3).

Timestamp

The options and formats for IF Context packet Timestamp fields are identical to those in an IF Data packet. However, the interpretation of the Timestamp in the Context Packet is dependent on the TSM bit in the header. When the Timestamp Mode is set to fine resolution (the TSM bit is set to zero) the Context packet Timestamp conveys the *precise* timing of events related to the Described Signal. This timing may be as precise as the resolution of the Fractional-Seconds Timestamp supports, i.e. either sample-period or picosecond resolution. It may also be less precise than this if the timing of the event is not known to this level of precision.

When the TSM bit is set to coarse resolution (the TSM bit is set to one) the Context packet Timestamp conveys *general* timing of events related to the Described Signal. That is, the Context packet conveys events that occurred sometime within the Data Sampling Interval of some Data packet in the paired Data Packet Stream.[6] To identify which Data Sampling Interval, the Context packet Timestamp must match the Timestamp of that Data packet in the paired Data Packet Stream. The less precise timing indication available with this TSM mode might be used because more precise information about the time of an event is not available, or not necessary, or because multiple events that occurred at different times within the Data packet sampling interval are grouped into a single Context packet for the sake of simplicity or efficiency.

[6] *This mode cannot be used when the Described Signal is analog.*

Context (Payload) Section

The first word of the Context Section is the Context Indicator field. The bits in the Context Indicator field indicate which of the optional Context Fields are present in the Context packet. The remainder of the Context Section consists of the Context Fields which contain the metadata updates, i.e. Context updates.

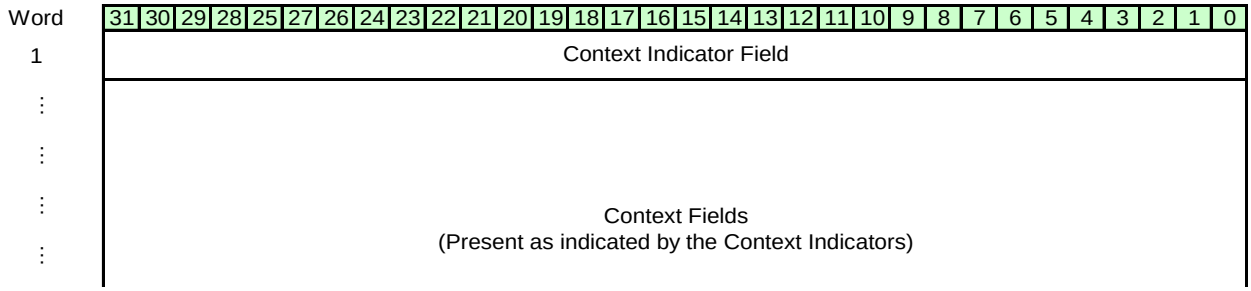

Figure 5-4: Format of the Context Section

The Context Indicator field contains bit fields, one for each Context Field, that indicate whether the corresponding optional Context field is present in the packet. The Context fields are described in the table below with examples of the most common indicator formats. Each Context field is optional.

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

Table 5-2: Context Indicator Field Bit Positions

All context indicator fields shall use 2's complement[7] format with the radix point located according to the bit positions in the table shown in ***Table 5-3***. The context indicator field (CIF) precedes the context payload and indicated which context fields are present in the payload. **Note**: CIFs 17 through 23 are *not* addressed in this volume.

CIF #	Context Field	Number of Words in Context Field	Period of Validity	Bit Positions
0	Context Field Change Identifier	0	N/A	N/A
1	Reference Point Identifier	1	Persistent	31-0
2	Bandwidth (see: **Figure 5-5**)	2	Persistent	Int: W1 31-0 W2 31-20 Frac: W2 19-0
3	IF Reference Frequency	2	Persistent	Int: W1 31-0 W2 31-20 Frac: W2 19-0
4	RF Reference Frequency	2	Persistent	Int: W1 31-0 W2 31-20 Frac: W2 19-0
5	RF Reference Frequency Offset	2	Persistent	Int: W1 31-0 W2 31-20 Frac: W2 19-0
6	IF Band Offset	2	Persistent	Int: W1 31-0 W2 31-20 Frac: W2 19-0
7	Reference Level (see: **Figure 5-6**)	1	Persistent	Res:31-16, Int:15-7 Frac. 6-0
8	Gain (see: **Figure 5-7**)	1	Persistent	Stage2 Int:31-23 Frac:22-16 Stage2 Int:51-7 Frac:6-0
9	Over-range Count	1	Single Data Packet	31-0
10	Sample Rate (see: **Figure 5-8**)	2	Persistent	Int: W1 31-0 W2 31-20 Frac: W2 19-0
11	Timestamp Adjustment	2	Persistent	63-0 (picoseconds)
12	Timestamp Calibration Time	1	Persistent	31-0
13	Temperature (see: **Figure 5-9**)	1	Persistent	Res:31-16 Int:51-6 Frac:5-0
14	Device Identifier (see: **Figure 5-10**)	2	Persistent	W1 Res:31-24 OUI:23-0 W2 Res:31-16,Code:15-0
15	State and Event Indicators (see: **Figure 5-11**)	1	See Table 5-4	Enable:31-20, Ind:19-8, User Def. 7-0
16	Data Packet Payload Format	2	Persistent	(see: **Figure 5-12**)
17	Formatted GPS Geolocation	11	Persistent	See VRT Figure 7.1.5.19-1
18	Formatted INS Geolocation	11	Persistent	See VRT Figure 7.1.5.19-1
19	ECEF Ephemeris	13	Persistent	See VRT Figure 7.1.5.21-2
20	Relative Ephemeris	13	Persistent	See VRT Figure 7.1.5.21-2
21	Ephemeris Reference Identifier	1	Persistent	See VRT Figure 7.1.5.23-1
22	GPS ASCII	Variable	Persistent	See VRT Figure 7.1.5.24-1
23	Context Association List	Variable	Persistent	See VRT Figure 7.1.5.25-1

Table 5-3: Context Indicator Fields

Below are examples of the various context fields allowed in Vita49A. These represent the most common context fields used in practice.

[7] 2's complement: invert bit-wise then add 1

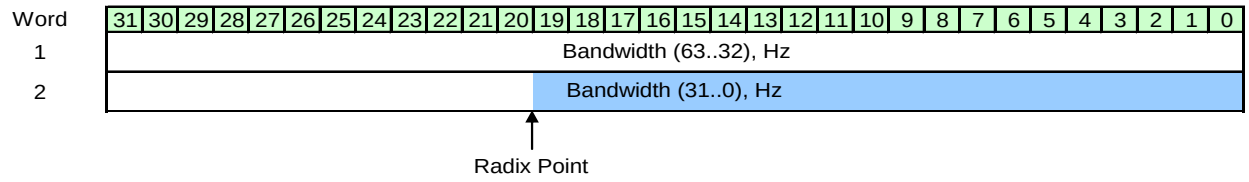

Figure 5-5: Bandwidth Context Field (Example)

The **Bandwidth** field is used to describe the amount of usable spectrum at the output of a process. The definition of usable spectrum is determined and specified by the VRT equipment provider. It is typically related to band-limiting filters, but may be limited by other criteria.

Example: Bandwidth value of 0x0000 0000 0010 0000 represents a bandwidth of 1 Hz. A Bandwidth value of 0x0000 0000 0000 0001 represents a bandwidth of 0.95 microhertz. Negative values of Bandwidth are not valid.

The **IF Reference Frequency, RF Reference Frequency, RF Reference Frequency Offse**t and **IF Band Offset** Fields all have the same format shown in **Figure 5-5**. Negative values are valid and represented by 2's compliment. An example follows.

Example: A Reference Frequency or Offset field value of 0x0000 0000 0010 0000 represents a frequency of +1 Hz. A Reference Frequency or Offset value of 0xFFFF FFFF FFF0 0000 represents a frequency of –1 Hz. A Reference Frequency or Offset value of 0x0000 0000 0000 0001 represents a frequency of +0.95 microhertz. A Reference Frequency or Offset value of 0xFFFF FFFF FFFF FFFF represents a frequency of –0.95 microhertz.

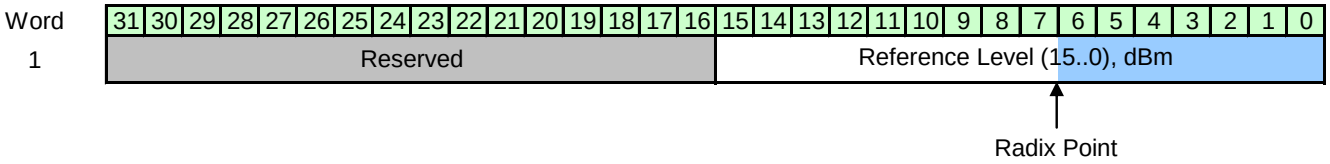

Figure 5-6: Reference Level Context Field

The purpose of the **Reference Level** field is to relate the physical signal amplitude at the Reference Point (as identified by the Reference Point ID) with the values of the Data Samples in an IF Data packet payload. The unit of measure for the Reference Level field is power, in dBm, since power is the preferred unit of measure when dealing with RF signals. The power value conveyed by the Reference Level field is the AC power of a single sine wave at the Reference Point that results in a digitized sine wave with peak amplitude of one[8], in the payload of the paired Data Packet Stream. Negative values are valid and represented by 2's compliment. An example follows.

Example: A Reference Level value of 0x0000 0080 represents a reference level of +1 dBm. A value of 0x0000 FF80 represents a reference level of -1 dBm. A value of 0x0000 0001 represents a reference level of +0.0078125 dBm. A Reference Level of 0x0000 FFFF represents a reference level of -0.0078125 dBm.

[8] This is true for signed fixed-point and VRT numbers. For unsigned fixed-point and VRT numbers the peak-to-peak amplitude is one. The Normalized Interpretation is assumed.

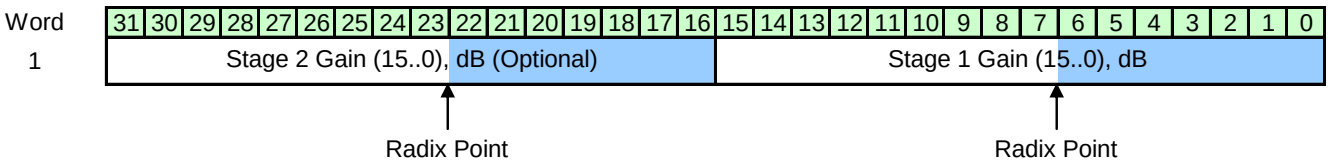

Figure 5-7: Gain Context Field

The **Gain** field describes the amount of signal gain or attenuation from the Reference Point to the Described Signal. It can be used in conjunction with the Reference Level field to infer the signal level at various locations.

The Gain Field contains two 16-bit subfields, Stage 1 Gain and Stage 2 Gain, which occupy the lower and upper 16 bits of the Gain Field, respectively. In RF equipment such as tuners and receivers, the total gain of the equipment is typically distributed to allow tradeoffs between noise power and linearity. For such equipment, Stage 1 Gain conveys the front-end or RF gain, and Stage 2 Gain conveys the back-end or IF gain. For equipment that does not require gain distribution, Stage 1 Gain provides the gain of the device, and Stage 2 Gain is set to zero. Negative values are valid and represented by 2's compliment. An example follows.

Example: A Gain value of 0x0000 0080 represents a gain of +1 dB. A Gain value of 0x0000 FF80 represents a gain of -1 dB. A Gain value of 0x0000 0001 represents a gain of +0.0078125 dB. A Gain value of 0x0000 FFFF represents a gain of -0.0078125 dB.

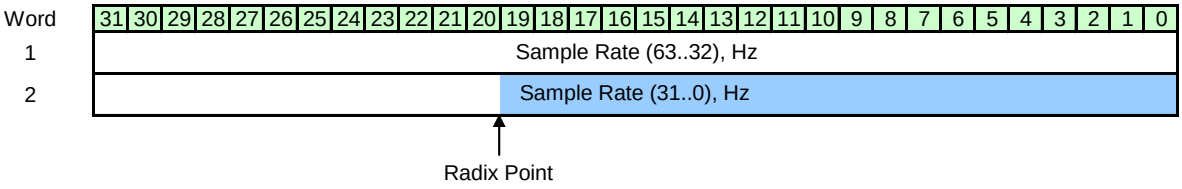

Figure 5-8: Sample Rate Field

The purpose of the Sample Rate field is to express the sample rate of the Data Samples in the payload of the paired Data Packet Stream. Negative values of the Sample Rate are not valid.

Example: A Sample Rate value of 0x0000 0000 0010 0000 represents a sample rate of 1 Hz. A Sample Rate value of 0x0000 0000 0000 0001 represents a sample rate of 0.95 microhertz Negative values are valid and represented by 2's compliment. An example follows.

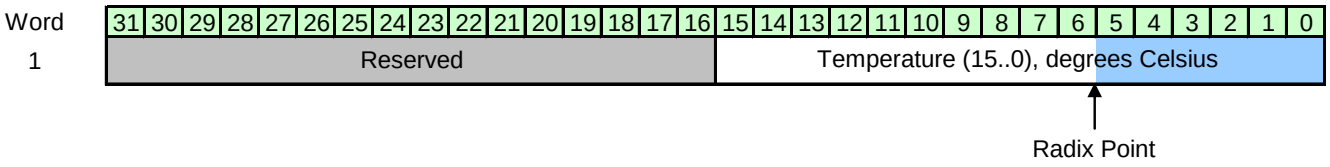

Figure 5-9: Temperature Context Field

The purpose of the **Temperature** field is to convey the temperature of some process or process component that may affect some aspect of the Described Signal. Negative values are valid and represented by 2's compliment. An example follows.

Example: A Temperature value of 0x0000 0040 represents a temperature of +1 °C. A Temperature value of 0x0000 FFC0 represents a temperature of -1°C. A Temperature value of 0x0000 0001 represents a temperature of +0.015625 °C. A Temperature value of 0x0000 FFFF represents a temperature of -0.015625 °C

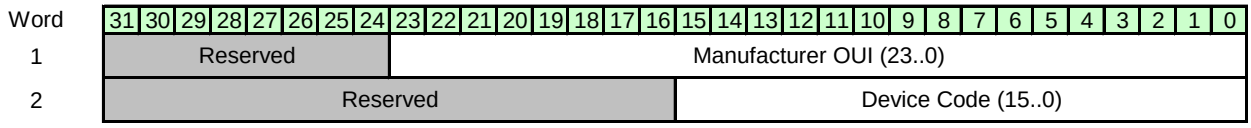

Figure 5-10: Device ID Context Field

The **Device Identifier** field is used to identify the manufacturer and model of the device generating an IF Context Packet Stream. It contains a manufacturer OUI subfield which specifies the manufacturer of the emitting device and a subfield that contains a code that uniquely identifies a particular model for that manufacturer. The Device Identifier field differs from the Class Identifier field optionally included in all packet types. The Device Identifier field specifies the manufacturer of the device emitting the VRT Packet Stream, whereas the Class Identifier field specifies the organization that defined the format of the VRT Packet Stream and a unique code to identify that format.

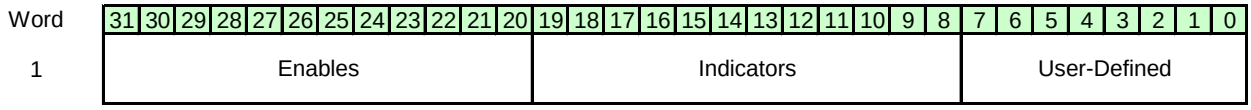

Figure 5-11: State and Event Indicator Context Field

The **State and Event Indicator** field is used to convey a set of binary indications and a limited number of non-binary state indications. It contains eight predefined Indicator bits, each with a corresponding enable bit that controls whether or not the indicator bit is valid. There are also a number of user-defined bits and bits reserved for future specification.

Enable Bit Position	Indicator Bit Position	Indicator Name	Period of Validity
31	19	Calibrated Time Indicator	Persistent
30	18	Valid Data Indicator	Persistent
29	17	Reference Lock Indicator	Persistent
28	16	AGC/MGC Indicator	Persistent
27	15	Detected Signal Indicator	Persistent
26	14	Spectral Inversion Indicator	Persistent
25	13	Over-range Indicator	Single Data Packet
24	12	Sample Loss Indicator	Single Data Packet
[23..20]	[11..8]	Reserved	N/A
Bit Position		Function	
[7..0]		User-Defined[9]	User-Defined

Table 5-4: State and Event Enable and Indicator Bit Positions

[9] Not allowed in Vita-49A

The *Calibrated Time Indicator*, when set to one, **shall** indicate that the Timestamps in the Context Packet Stream and in the associated Data Packet Stream are calibrated to some external reference. When set to zero this Indicator **shall** indicate that the Timestamps are free-running and may be inaccurate.

The *Valid Data Indicator*, when set to one, indicates that the Data in the associated Data packet is valid. When set to zero it indicates that some condition exists that may invalidate the Data.

The *Reference Lock Indicator*, when set to one, indicates that any phase-locked loops (PLL) affecting the Described Signal are locked and stable. When set to zero it indicates that at least one PLL is not locked and stable.

The *AGC/MGC Indicator*, when set to one, indicates that AGC (Automatic Gain Control) is active. When set to zero, it indicates MGC (Manual Gain Control).

The *Detected Signal Indicator*, when set to one, indicates that Described Signal contains some detected signal.

The *Spectral Inversion Indicator*, when set to one, indicates that the spectrum of the signal conveyed in the data payload is inverted with respect to the signal at the Reference Point.

When the Timestamp Mode is set to fine resolution (the TSM bit is set to zero) , the *Over-range Indicator*, when set to one, indicates that the Data Sample in the paired Data packet stream was over-range at the time given in the Context packet Timestamp. When the Timestamp Mode is set to coarse resolution (the TSM bit is set to one), the Over-range Indicator, when set to one, indicates that at least one Data Sample in the paired Data packet with corresponding Timestamp is over-range.

When the Timestamp Mode is set to fine resolution (the TSM bit is set to zero) , the *Sample Loss Indicator*, when set to one, indicates that the paired Data packet contains a Data Sample discontinuity due to processing errors and/or buffer overflow at the time given in the Context packet Timestamp. When the Timestamp Mode is set to coarse resolution (the TSM bit is set to one), the Sample Loss Indicator, when set to one, indicates that the paired Data packet with corresponding Timestamp contains at least one Data Sample discontinuity due to processing errors and/or buffer overflow.

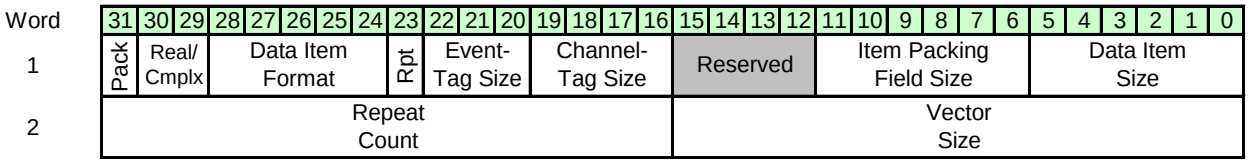

Figure 5-12: Data Packet Format Context Field

The **Data Packet Payload Format** field is used to convey the parameters that specify the packing and content of the payload of the paired Data Packet Stream.

The data payload of an IF Data packet contains a contiguous sequence of the Data Samples from an IF Data Sample stream. The number of words in the data payload is variable from packet to packet, and can be determined at the receiving end of the link from the Packet Size by subtracting the number of words dedicated to the header, trailer, and other additional fields. The presence or absence of these fields can be determined entirely from information in the header.

Bit Position	Field	Field Width (bits)
[31]	Packing Method=0[10]	1
[30..29]	Real/Complex Type	2
[28..24]	Data Item Format	5
[23]	Sample-Component Repeat Indicator[11]	1
[22..20]	Event-Tag Size=0	3
[19..16]	Channel-Tag Size=0	4
[15..12]	Reserved (set to zero)	4
[11..6]	Item Packing Field Size	6
[5..0]	Data Item Size	6

Table 5-5: Data Packet Format Context Bit Fields

The "Packing Method" field is set to one when link-efficient packing is used in the paired Data Packet Stream. It is set to zero when processing-efficient packing is used. Packing method **shall** be processing efficient in Vita-49A.

The "Real/Complex Type" field indicates whether the Data Samples are real or one of the complex types using the appropriate code listed below:

Code	Data Sample Type
00	Real
01	Complex, Cartesian
10	Complex, Polar[12]
11	Reserved

Table 5-6: Data Type Formats

The "Data Item Format" field contains the appropriate 5-bit code to indicate the type of Data Items used in the paired Data Packet Stream shown in Table 5-7***: Data Item Types***

The "Sample-Component Repeat Indicator" (bit position 23) is set to one when Sample Component Repeating is in use in the paired Data Packet Stream. Otherwise it is set to zero. Sample-Component Repeating is not allowed in V49A so this bit **shall** always be set to zero.

The "Event-Tag Size" field contains an unsigned number equal to the Event-Tag size used in the paired Data Packet Stream. An Event Tag is a bit used to indicate that a signal-related or processing-related event has occurred coincident with a Data Item in the payload. Event Tags are not used in V49A so this value **shall** always be set to zero.

The "Channel-Tag Size" field contains an unsigned number equal to the Channel-Tag size used in the paired Data Packet Stream. A Channel Tag is a label associating a Data Item with a particular signal conveyed by an IF Data packet. It supports demultiplexing of transported signals by the receiver of the Packet Stream when more than one signal is conveyed in each packet. Channel Tags are not used in V49A so this value **shall** always be set to zero.

[10] Packing method shall be processing efficient in Vita-49A
[11] Not allowed in Vita-49A
[12] Not allowed in Vita-49A

The “Item Packing Field Size” field contains an unsigned number that is one less than the actual Item Packing Field size used in the paired Data Packet Stream. The lsb of the field is the rightmost bit in the field. It **shall** be equal in size to the Data Item Size as shown in **Figure 5-13**.

An Item Packing Field is a virtual container for a Data Item, Event Tags, and a Channel Tag. It **shall** contain no unused bits and be equal in size to the Data Item Size as shown in **Figure 5-13**.

The “Data Item Size” field contains an unsigned number that is one less than the actual Data Item size in the paired Data Packet Stream. The lsb of the field is the rightmost bit in the field.

Code	Data Item Type	Code	Data Item Type
00000	Signed Fixed-Point	10000	Unsigned Fixed-Point
00001	Signed VRT, 1-bit exponent*	10001	Unsigned VRT, 1-bit exponent*
00010	Signed VRT, 2-bit exponent*	10010	Unsigned VRT, 2-bit exponent*
00011	Signed VRT, 3-bit exponent*	10011	Unsigned VRT, 3-bit exponent*
00100	Signed VRT, 4-bit exponent*	10100	Unsigned VRT, 4-bit exponent*
00101	Signed VRT, 5-bit exponent*	10101	Unsigned VRT, 5-bit exponent*
00110	Signed VRT, 6-bit exponent*	10110	Unsigned VRT, 6-bit exponent*
00111	Reserved	10111	Reserved
01000	Reserved	11000	Reserved
01001	Reserved	11001	Reserved
01010	Reserved	11010	Reserved
01011	Reserved	11011	Reserved
01100	Reserved	11100	Reserved
01101	IEEE-754 Half-Precision Floating-Point*	11101	Reserved
01110	IEEE-754 Single-Precision Floating-Point	11110	Reserved
01111	IEEE-754 Double-Precision Floating-Point	11111	Reserved

Table 5-7: Data Item Types

The “Repeat Count” field contains an unsigned number that is one less than the actual Repeat Count used in the paired Data Packet Stream. Repeating is not used in V49A so this value **shall** always be set to zero.

The “Vector Size” field contains an unsigned number that is one less than the actual Vector size in the paired Data Packet Stream. Vectors are not used in V49A so this value **shall** always be set to zero.

The use of Sample-Component Repeating is forbidden since most devices with built-in support for complex numbers support non-repeating form (e.g. “IQIQIQIQ”) and do not support an arbitrary repeating form (e.g. “IIIIQQQQ” or “IIQQIIQQ”).

In order to facilitate a wide range of payload packing methods and at the same time provide some commonality to these methods, VRT defines a type of payload field called an Item Packing Field. An Item Packing Field is a virtual container for up to three types of information: a Data Item, Event Tags, and a Channel Tag. The three types of information are defined below. When included in an Item Packing Field, the subfields are always packed in a certain order, as shown in **Figure 5-13**.

* Not allowed in Vita-49A

A Data Item is a binary number representing all or part of a Data Sample. This number may be a real-valued sample, or a real or imaginary component of a complex Cartesian sample, or an amplitude or phase component of a complex polar sample.

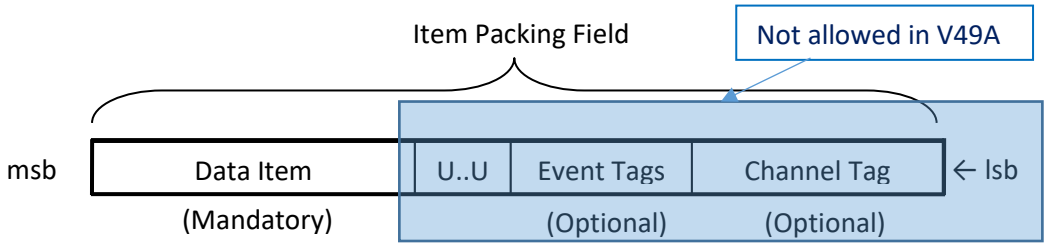

Figure 5-13: Relative Locations of Items within the Item Packing Field

6 Other Information

Data Type Option	Packet Class	Vector Size	Real/Complex	Data Type
0	No Data Packet	N/A	N/A	N/A
1	Standard Data Packet	1	Real	8-bit signed Fixed Point
2	Standard Data Packet	1	Real	16-bit signed Fixed Point
3	Standard Data Packet	1	Real	32-bit signed Fixed Point
4	Standard Data Packet	1	Complex, Cartesian	8-bit signed Fixed Point
5	Standard Data Packet	1	Complex, Cartesian	16-bit signed Fixed Point
6	Standard Data Packet	1	Complex, Cartesian	32-bit signed Fixed Point

Table 6-1: Interoperability Options

VRT (Vita-49A) emitters must support one or more of the data type options listed in Table 3-1. Vita-49A receivers/consumers must support **all** data type options listed in ***Table 6-1***.

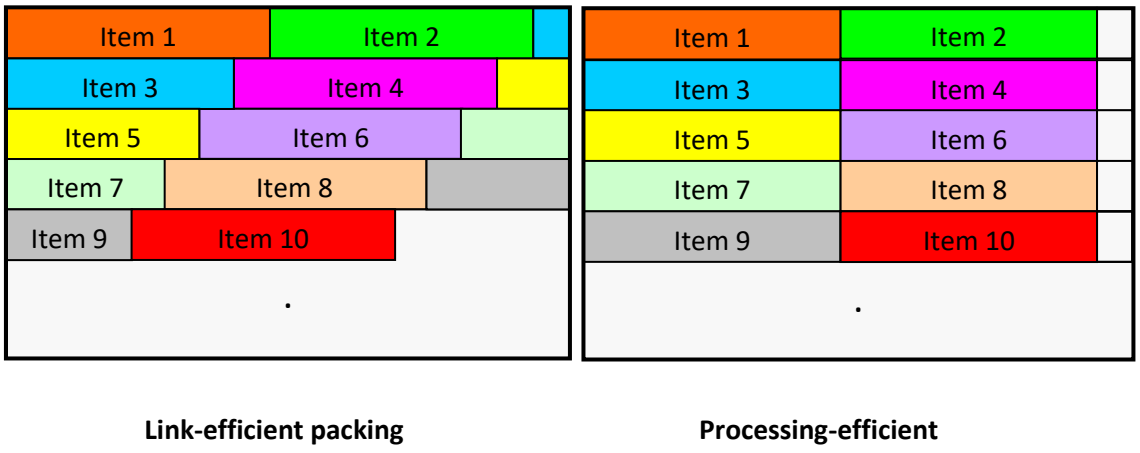

Figure 6-1: Link Efficient and Processing Efficient Packing types in 32-bit Words

The following publications are used in conjunction with this specification. In the event that one of these publications is revised, the revised publication should be used unless it conflicts with this specification.

- VRT – VITA Radio Transport Protocol, August 2015
- VRL – VITA Radio Link Layer, August 2015
- ANSI/VITA 49A-2015 Spectrum Survey Interoperability Specification, August 2015
- RFC 768 – User Datagram Protocol, IETF, 28 August 1980
- RFC 1112 – Host Extensions for IP Multicasting, IETF, August 1989
- RFC 2460 – Internet Protocol, Version 6 (IPv6) Specification, IETF, December 1998

7 Standard Packets

Standard packets provide a way to increase interoperability by providing a reduced set of options while maintaining core features or functionality.

IF Data or Extension Data Packet Class Options Table		
Class Name	"Standard Data Packet"	
Packet Stream Purpose	To convey signal data in a standard format	
Packet Header		
Parameter	**Allowed Options**	**Comments***
Packet Type	IF Data or Extension Data	
Stream Identifier	Used	
Class Identifier	FF-FF-FA:0000.0000 through FF-FF-FA:00FF.FFFF per Section 6.3	See Section 6.3
Integer-seconds Timestamp	Used	UTC or GPS preferred
Fractional-seconds Timestamp	Used	Real-time preferred
Timestamp Precision	As specified in "Timestamp Accuracy Packet"	
Packet Payload		
Parameter	**Allowed Options**	**Comments***
Packing Method	Processing Efficient	
Item Packing Field Size	Same as Data Item Size	
Data Item Size	As specified in paired IF Context Packet	See Rule 6.1.6-13
Event-Tag Size	0	Not used
Channel-Tag Size	0	Not used
Vector Size	As specified in paired IF Context Packet	
Real/Complex Type	As specified in paired IF Context Packet	See Rule 6.1.6-11
Data Item Format	As specified in paired IF Context Packet	See Rules 6.1.6-12 & 6.1.6-14
Sample-/Channel-Repeating	Not Used	
Repeat Count	As specified in paired IF Context Packet	
Packet Trailer		
Trailer is Used		
Parameter	**Allowed Options**	**Comments**
Calibrated Time Indicator	Sometimes Used	Used as specified in this specification
Valid Data Indicator	Sometimes Used	Used as specified in this specification
Reference Lock Indicator	Sometimes Used	Used as specified in this specification
AGC/MGC Indicator	Sometimes Used	Used as specified in this specification
Detected Signal Indicator	Sometimes Used	Used as specified in this specification
Spectral Inversion Indicator	Sometimes Used	Used as specified in this specification
Over-Range Indicator	Sometimes Used	Used as specified in this specification
Sample Loss Indicator	Sometimes Used	Used as specified in this specification
User-Defined Indicators #11	Not Used	Reserved for future use, set to zero
User-Defined Indicators #10	Not Used	Reserved for future use, set to zero
User-Defined Indicators #9	Not Used	Reserved for future use, set to zero
User-Defined Indicators #8	Not Used	Reserved for future use, set to zero
Associated Context Packet Count	Sometimes Used	

*All Rules refer to the Vita-49A specification

Table 7-1: Standard Data Packet

IF Context Packet Class Options Table		
Class Name	"Standard Context Packet"	
Packet Stream Purpose	To convey signal context information in a standard format.	
Packet Header		
Parameter	**Allowed Options**	**Comments***
Packet Type	IF Context	
Stream Identifier	Used	
Class Identifier	FF-FF-FA:2011.0003	
Integer-seconds Timestamp	Used	UTC or GPS preferred
Fractional-seconds Timestamp	Used	Real-time preferred
Timestamp Precision	As specified in “Timestamp Accuracy Packet”	
Context Fields		
Parameter	**Allowed Options**	**Comments***
Context Field Change Indicator	Used	
Reference Point Identifier	Sometimes Used	Used per Rule 7.1.1 and Rule 7.1.2
Bandwidth	Sometimes Used	Used per Rule 7.1.1 and Rule 7.1.2
IF Reference Frequency	Sometimes Used	Used per Rule 7.1.1 and Rule 7.1.2
RF Reference Frequency	Sometimes Used	Used per Rule 7.1.1 and Rule 7.1.2
RF Reference Frequency Offset	Sometimes Used	Used per Rule 7.1.1 and Rule 7.1.2
IF Band Offset	Sometimes Used	Used per Rule 7.1.1 and Rule 7.1.2
Reference Level	Sometimes Used	Used per Rule 7.1.1 and Rule 7.1.2
Gain	Sometimes Used	Used per Rule 7.1.1 and Rule 7.1.2
Over-Range Count	Sometimes Used	Used per Rule 7.1.1 and Rule 7.1.2
Sample Rate	Sometimes Used	Used per Rule 7.1.1 and Rule 7.1.2
Timestamp Adjustment	Sometimes Used	Used per Rule 7.1.1 and Rule 7.1.2
Timestamp Calibration Time	Sometimes Used	Used per Rule 7.1.1 and Rule 7.1.2
Temperature	Sometimes Used	Used per Rule 7.1.1 and Rule 7.1.2
Device Identifier	Sometimes Used	Used per Rule 7.1.1 and Rule 7.1.2
State and Event Indicators • **Calibrated Time Indicator** • **Valid Data Indicator** • **Reference Lock Indicator** • **AGC/MGC Indicator** • **Detected Signal Indicator** • **Over-Range Indicator** • **Sample Loss Indicator** • **User-Defined Bits**	Sometimes Used • Sometimes Used • Sometimes Used • Sometimes Used • Sometimes Used • Sometimes Used • Sometimes Used • Sometimes Used • Not Used	User-Defined bits are reserved for future use and set to zero, all other bits used per Rule 7.1.1 and Rule 7.1.2
Data Packet Payload Format	Used	
Formatted GPS Geolocation	Sometimes Used	Used per Rule 7.1.1 and Rule 7.1.2
ECEF Ephemeris	Sometimes Used	Used per Rule 7.1.1 and Rule 7.1.2
Relative Ephemeris	Sometimes Used	Used per Rule 7.1.1 and Rule 7.1.2
Ephemeris Reference Identifier	Sometimes Used	Used per Rule 7.1.1 and Rule 7.1.2
GPS ASCII	Sometimes Used	Used per Rule 7.1.1 and Rule 7.1.2
Context Association List	Sometimes Used	Used per Rule 7.1.1 and Rule 7.1.2

*All Rules refer to the Vita-49A specification

Table 7-2: Standard Context Packet

8 Key Rules for Vita-49A (Signal Data and Signal Context)

The key rules for Vita-49A (Signal Data and Signal Context) are summarized in this section. The rules are grouped into classes of compliance that facilitate different levels of interoperability. These compliance levels are defined as follows:

Major (substantive) Violation: violation of a rule to the degree that interoperability is not possible or is rendered incompatible with compliant Vita-49A devices. The following rules are nominated as such.

Rule 6.1.1-1: The Packet Type code 0000 **shall** not be used.[13]
Rule 6.1.2-1: All IF Data Packets **shall** include a Stream Identifier.
Rule 6.1.2-2: IF Data Packets **shall** use a Stream Identifier in the range of 1 (0x00000001) to 2,147,483,647 (0x7FFFFFFF) inclusive.
Rule 6.1.3-1: All IF Data Packets **shall** include a Class Identifier that is consistent with the Standard Data Packet described in V49A Section 6.3 (Figure 4-4 of this document).

Rule 6.1.6-1: The Pad Bit Count **shall** be reported in all cases where the number of pad bits required is greater than or equal to the size of the Data Item format.[14]
Rule 6.1.6-2: The paired IF Context packet **shall** include a Data Packet Payload Format Field that specifies how the data in the data payload is packed.
Rule 6.1.6-3: The Item Packing Field **shall not** include any bits for Event Tags.
Rule 6.1.6-4: The Item Packing Field **shall not** include any bits for Channel Tags.
Rule 6.1.6-7: The size of the item packing field **shall** be the minimum size required and **shall not** include any unused bits.
Rule 6.1.6-8: The IF Data packet **shall** use Processing-Efficient Packing.
Rule 6.1.6-9: The IF Data packet **shall not** use Sample-Component Repeating.[15]
Rule 6.1.6-10: The IF Data packet **shall not** use Channel Repeating[16].
Rule 6.1.6-11: The IF Data Packet Class **shall** use one of the following Data Sample formats:

1. Real samples
2. Complex Cartesian samples

Rule 6.1.6-12: The IF Data Packet Class **shall** use one of the following Data Item formats:

1. Fixed-point unsigned
2. Fixed-point signed
3. IEEE 754 single-precision (32-bit) floating-point
4. IEEE 754 double-precision (64-bit) floating-point

Rule 6.1.6-13: The IF Data Packet Class shall use one of the following Data Item sizes:

1. 1-bit
2. 4-bits

[13] Rule 6.1.1-1 derives from Rule 6.1.2-1 (i.e. the requirement to include a stream identifier precludes the use of packet types without a stream identifier).
[14] Failure to do this will result in a situation where it is ambiguous as to the number of valid data samples in the packet. Pad bit count defined in VRT Section 6.1.6, Rule 6.1.6-3 on p50.
[15] The use of Sample-Component Repeating is forbidden since most devices with built-in support for complex numbers support non-repeating form (e.g. "IQIQIQIQ") and do not support an arbitrary repeating form (e.g. "IIIIQQQQ" or "IIQQIIQQ"). VRT Definition 6.1.6.3-3 on p54.
[16] VRT Definition 6.1.6.3-4 on p54

3. 8-bits
4. 16-bits
5. 32-bits
6. 64-bits

Rule 6.1.6-14: If the IF Data Packet Class uses a 1-bit Data Item size, it **shall** use a Data Item format of "Fixed-point unsigned."
Rule 6.1.7-1: All Data Packets **shall** include a trailer.
Rule 6.3-1: The Standard Data Packet **shall** be used with IF Data packets and Extension Data packets
Rule 6.3-2: The first eight bits in the Class Identifier for the Standard Data Packet **shall** be set in accordance with the rules established in VRT (Vita-49.0).
Rule 6.3-3: The Class Identifier for the Standard Data Packet **shall** use the OUI FF-FF-FA.
Rule 6.3-4: The Class Identifier for the Standard Data Packet **shall** use the structure shown in Figure 6.3-1.
Rule 6.3-5: The Fixed Value in the Class Identifier for the Standard Data Packet **shall** have all bits set to zero.
Rule 6.3-6: The reserved bits in the Class Identifier for the Standard Data Packet **shall** be set to zero.
Rule 6.3-7: Recipients of a Standard Data Packet that contains a value other than zero for the reserved bits in the Class Identifier **shall** reject the packet.
Rule 6.3-8: The Real/Complex (R/C) indicator in the Class Identifier of the Standard Data Packet **shall** be set to one of the values from V49A Table 6.3-1 (Table 5-6 of this document), as appropriate for the data contained within the packet.
Rule 6.3-9: The Data Type indicator in the Class Identifier of the Standard Data Packet **shall** be set to one of the values from V49A Table 6.3-2 (Table 4-5 of this document), as appropriate for the data contained within the packet.
Rule 6.1.7-8: If gain is fixed, the AGC/MGC Indicator **shall** be enabled and set to 0.
Rule 6.4-2: The No Data Packet **shall** be an IF Data or Extension Data packet.
Rule 6.4-3: The No Data Packet **shall** use the Class Identifier FF-FF-FA:2011.0002.[17]
Rule 6.4-4: The No Data Packet **shall** have a payload that is zero words in length.
Rule 7.2-1: The Standard Context Packet **shall** be an IF Context Packet with the class identifier FF-FF-FA:2011.0003.[18]
Rule 7.3-1: The payload of the Timestamp Accuracy Packet **shall** be as shown in V49A Figure 7.3-1.
Rule 8-3: An Information Stream with no associated data in the Information Stream **shall** use the No Data Packet as defined in V49A Section 6.4. The No Data Packet is an IF Data packet that never contains data in the payload.

Minor (nominal) Violation: violation of a rule rendering non-compliance with V49A, but interoperability and compatibility with compliant Vita-49A devices can be maintained. The following rules are nominated as such.

Rule 6.1.7-5: The Calibrated Time Indicator **shall not** be enabled and set to 1 if any of the following requirements not satisfied:

1. Integer-Seconds is specified in UTC or GPS time,

[17] OUI is FF-FF-FA, Information Class Code is 0x2011 (8209), and Packet Class Code is 0x0002 (2).
[18] OUI is FF-FF-FA, Information Class Code is 0x2011 (8209), and Packet Class Code is 0x0003 (3).

2. Fractional-Seconds is specified in Real Time (picoseconds),
3. The time source is locked to a stable time reference that references time to the United States Naval Observatory (USNO) master clock (GPS time is referenced to the USNO master clock),
4. The time source used is operating normally and providing time information with a resolution that matches the specification of the time source,
5. Any operations performed on the data that affect the timestamp are accurately reflected in the Integer-Seconds and Fractional-Seconds with respect to the reference point,
6. The Information Stream contains a System Context stream that reports the Timestamp accuracy using a Timestamp Accuracy Packet stream as described in V49A Section 7.3, and
7. The accuracy of the timestamp matches, or exceeds, that reported in the Timestamp Accuracy packet.

Rule 6.3-10: The Vector Size indicator in the Class Identifier of the Standard Data Packet **shall** be an unsigned number that is one less than the actual vector size[19].
Rule 6.4-1: An Information Stream with no associated data in the Information Stream **shall** use the No Data Packet.
Rule 7.1-1: All persistent values in the IF Context, other than the GPS ASCII Field, Packet **shall** be filled in if their values are known.
Rule 7.3-2: The Timestamp Accuracy field **shall** contain a value between 1 and 10^{12} (inclusive) representing the timestamp accuracy in picoseconds.
Rule 7.3-3: If the time source is more accurate than 1 picosecond, the accuracy **shall** be reported as 1 picosecond.
Rule 7.3-4: If the timestamp is less accurate than 1 second (10^{12} picoseconds), the Calibrated Time Indicator **shall not** be set to 1.
Rule 8-1: Every IF Data Packet Stream **shall** be accompanied by a paired IF Context Packet Stream.[20]
Rule 8-2: Every Information Stream **shall** contain an IF Data Stream or an Extension Data Stream.
Rule 8-4: The emitter of the Data Stream **shall** emit data packets at a rate such that a minimum of one Data Packet is emitted per ten seconds of Actual Time.[21]
Rule 8-5: The emitter of each Context Stream **shall** emit periodic updates such that a minimum of one packet in each Context Stream is emitted per ten seconds of Actual Time.[22]

Warning: can be rendered compliant with proper documentation (Rule 5-4). The following rules are nominated as such.

Rule 9-1: Every sender or receiver of an Information Stream **shall** support at least one of the following transport protocols:

1. Multicast UDP/IP,
2. UDP/IP (unicast), and/or
3. TCP/IP.

Rule 9-2: Where practicable, Multicast UDP/IP **shall** be used for the transmission of Information Streams.

[19] The Vector Size indicator is a 16-bit field to maintain consistency with that used with VRT rule 7.1.5.18-11.
[20] For a discussion on Data-Context Pairing, please see VRT Section 4.1.3.2.8.
[21] "Actual Time" has the same meaning here as VRT Section B.8.
[22] "Actual Time" has the same meaning here as VRT Section B.8.

Rule 6.1.7-6: If no gain stage is present, the AGC/MGC Indicator **shall** be enabled and set to 0.
Rule 6.1.7-7: If no gain stage is present, the paired IF Context packet **shall** report a Stage 1 Gain of 0.0 dB and Stage 2 Gain of 0.0 dB.
Rule 6.1.7-9: If gain is fixed, the paired IF Context packet **shall** report the appropriate Stage 1 Gain and Stage 2 Gain.

Compliance Rules and Definitions

Compliance with V49A means adherence to all the rules in the specification. It also means following recommendations wherever practicable and documenting deviations from recommendations. Examples below illustrate instances where this may occur. The key compliance rules from V49A are as follows:

Rule 5-1: All implementations of this specification **shall** comply with all rules in this specification.
Rule 5-3: An implementation of this specification **shall** be considered compliant with the rules in VRT regarding the documentation of packet classes (see VRT Section 8.2.5) for those packet classes defined within this specification.
Rule 5-4: An implementation of VRT that does not conform with this specification, but which documents use of the packet classes defined within this specification **shall** be considered compliant with the rules in VRT regarding the documentation of packet classes (see VRT Section 8.2.5) for those packet classes defined within this specification.

Major (substantive) Violation: violation of a rule to the degree that interoperability is not possible or is rendered incompatible with compliant Vita-49A devices.

Examples:

- Streams without a Stream ID present a problem for systems with more than one information stream as it makes multiple streams impossible or difficult to identify. (**Rule 6.1.1-1, Rule 6.1.1-2)**
- Streams without a Class ID complicate parsing of the IF Data Packet payload and require prior processing of a corresponding IF Context packet to determine how to parse the data type. (**Rule 6.1.3-1)**
- **Rule 6.1.6-3, Rule 6.1.6-4 and Rule 6.1.6-13** ensure that Link-Efficient Packing and Processing-Efficient Packing will produce identical packets, and that the values in the payload will be naturally aligned (e.g. 64-bit values will be 64-bit aligned, 32-bit values will be 32-bit aligned, etc.). **Rule 6.1.6-8** is simply to ensure consistent usage.

Minor (nominal) Violation: violation of a rule rendering non-compliance with V49A, but interoperability and compatibility with compliant Vita-49A devices can be maintained.

Examples:

- Emitting an IF Data or Context packet at a minimum of no less than 1 per 10 seconds of actual time does not present a compatibility problem if not followed, but is not compliant with V49A and could trigger time-out mechanisms in some systems, for instance. (**Rule 8-4, Rule 8-5).**
- Emitting an IF Data packet where an event or change in the RF occurred (i.e. gain, bandwidth, etc.) in the middle of the packet without immediately following with an IF Context packet documenting the change or event. Each channel should be sent as a separate information stream. (**V49A Recommendation 6.1.6-1**)

Warning: can be rendered compliant with proper documentation (Rule 5-4).

Example(s):

- Use of a VRT packet class other than the Standard Data Packet Class ID or Standard Context Packet Class ID provided that the purpose, allowed fields and options and the meaning of the enabled fields are all properly documented would still be considered compliant with this specification. (**Rule 5-4** *and* **VRT Rules 8.2.5.1, 8.2.5.2).**

Definitions

VRT: Vita Radio Transport Standard 49.0-2015
V49A: Vita-49A-2015 Spectrum Survey Interoperability Specification (SSIS)

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