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Appendix A Information Stream Specification – Example

Appendix B Context Field Examples

The sections in this appendix contain examples that illustrate the use of several fields in the IF Context Packet Class. Each example contains a block diagram of the system begin described. The blocks in these diagrams that correspond to VRT packet stream generators contain symbols that are a visual shorthand for VRT packet stream generators. An example of this shorthand is shown in Figure B.1-1.

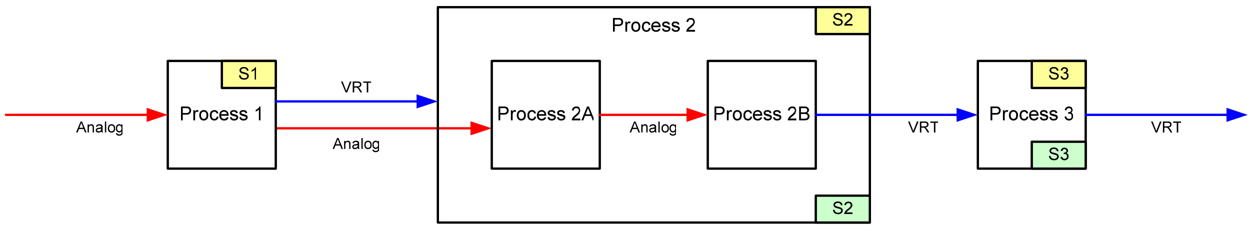


Figure B.1-1: Example block diagram with VRT Packet Stream generator symbols shown

The presence of a yellow (green) rectangle in the upper (lower) right hand corner of a process indicates that this process generates Context (Data) Packet Streams.

In this example there are three processes that generate VRT packet streams. Process 1 does not generate any Data Packet Streams, it has an analog input and analog output. But it does generate an IF Context Packet Stream with a Stream Identifier that is represented by the characters “S1”. In the block diagram, this Context Packet Stream is represented by the yellow rectangle containing “S1” in the upper right corner of the Process 1 block.

Process 2 is composed of two sub-processes. Neither of these sub-processes generates VRT packet streams. However, the encapsulating Process 2 sends an IF Context Packet Stream that contains context about both sub-processes. As before, this is represented by the yellow rectangle containing “S2” in the upper right corner of the Process 2 block. This block also generates an IF Data Packet Stream. This is represented by the green rectangle containing “S2” in the lower right corner of the Process 2 block. Note that both the yellow Context rectangle and the green Data rectangle have the same Stream Identifier, “S2”. This indicates that the Data and Context packet streams from this process are directly associated as described in Section 7.1.2. Process 2 may also forward the Context packets it receives from Process 1, or it may absorb this contextual information and present it in its own Context packet stream.

Finally, Process 3 generates both IF Context and IF Data Packet Streams, indicated by the two rectangles containing “S3”.

In the examples in the following sections, the symbolic Stream Identifiers “ S1”, “S2”, and ”S3” are replaced with actual 32-bit numbers.

Sometimes it is not only useful to show which types of packet streams a process is generating, but to also show some of the details of the packet streams. In these cases, the block diagram is augmented with representations of the packet streams as shown in Figure B.1-2.

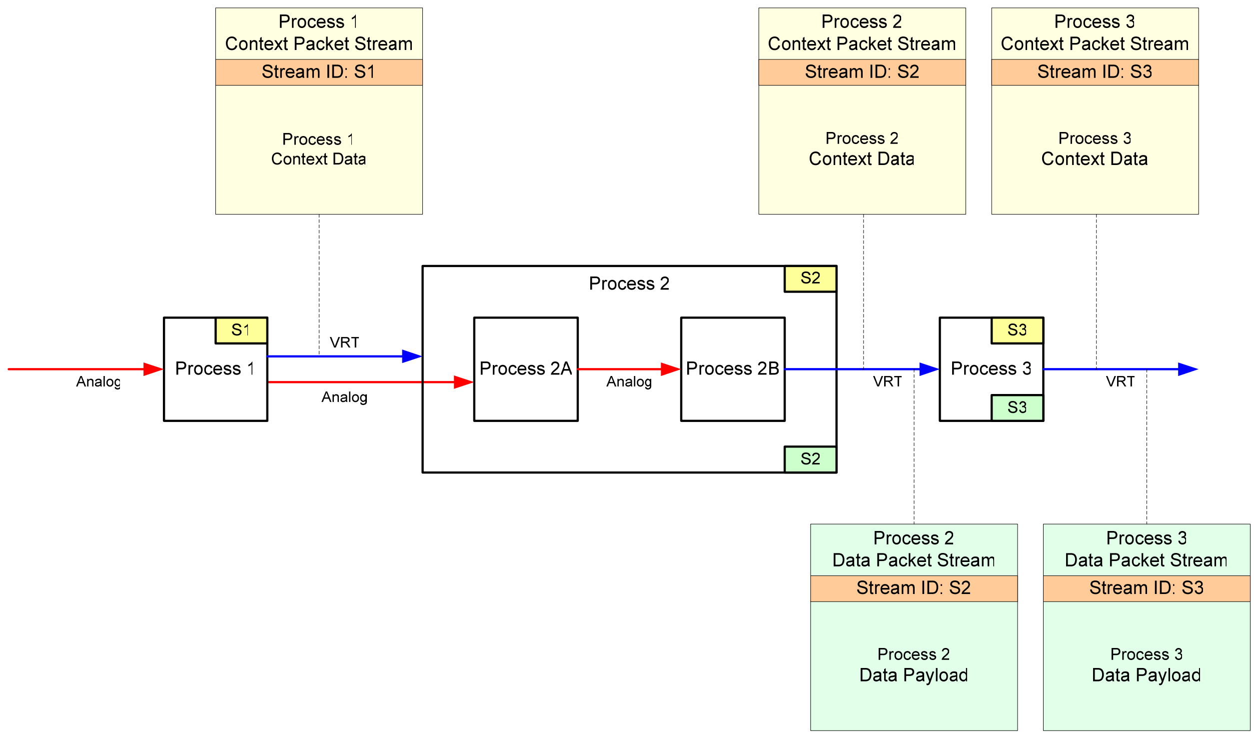


Figure B.1-2: Example block diagram with VRT Packet Stream details shown
Details of the Context Packet Streams are shown in yellow boxes.
Details of the Data Packet Streams are shown in green boxes.

Here Context Packet Streams are represented with yellow boxes and Data Packet Streams are represented with green boxes. In this figure, the Stream Identifier for each of the packet streams is shown. Other fields will be shown as necessary.

Appendix B.1 Reference Point Identifier Example

Figure B.1-1 shows a block diagram of a VRT system that uses the Reference Point Identifier field. In this example there are three processes, a Digital Receiver, a DDC, and a Demodulator, each of which generates a Data Packet Stream and a Context Packet Stream. The Context Packet Streams coming from the Tuner, DDC, and Demodulator, have Stream Identifiers 100, 200, and 300 respectively, and each form a direct association with their respective Data Packet Streams.

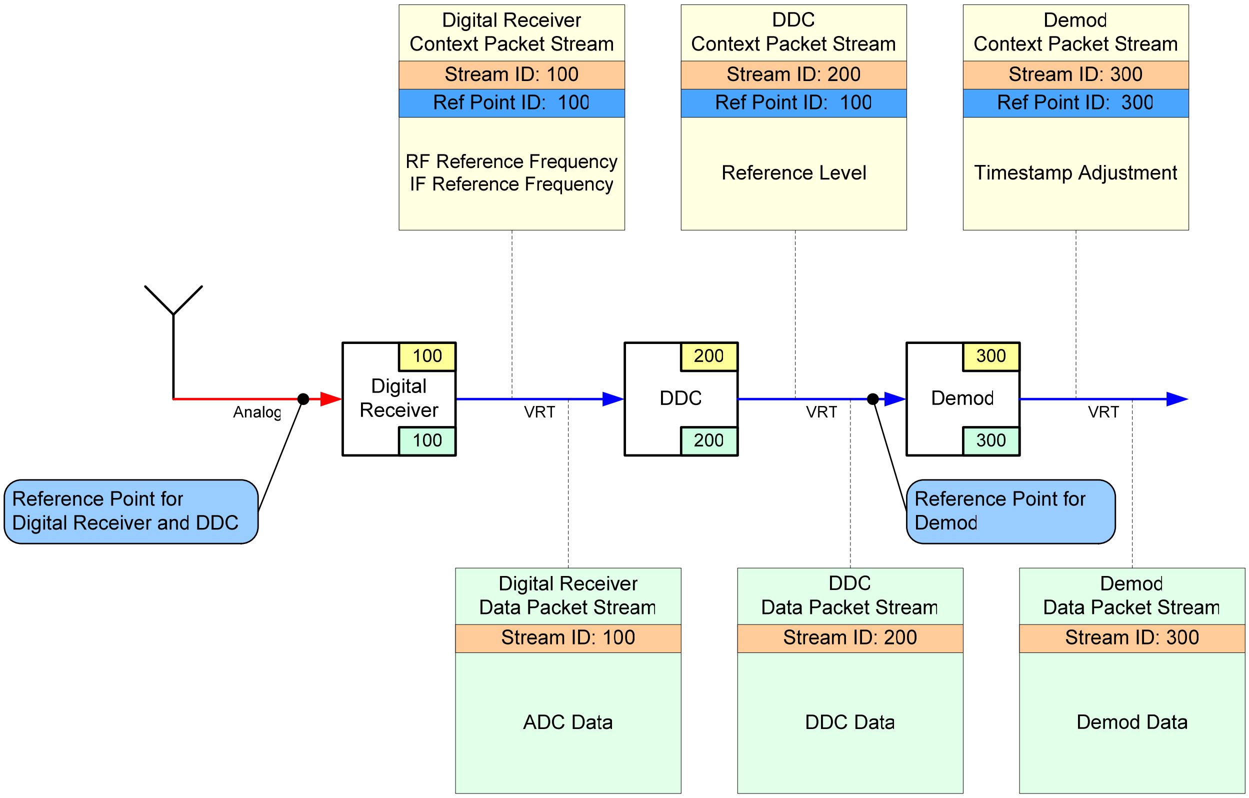


Figure B.1-1: Reference Point Identifier Example

The reference point for the Digital Receiver and DDC Data is the Receiver input.
The reference point for the Demodulator is the Demodulator input.

Each of the Context Packet Streams contains a Reference Point ID field that specifies the reference point for each process. In this example, both the Receiver and DDC Context Packet Streams include a Reference Point IDs equal to 100. This specifies that the reference point for both the Receiver and DDC are at the input to the Digital Receiver. The Demodulator, however, has 300 as its Reference Point ID, which specifies its own input as its reference point.

Therefore, the RF Reference Frequency field in the Digital Receiver's Context Packet Stream will indicate the frequency at the input to the Digital Receiver that was translated to the IF Reference Frequency. Also, the Reference Level field in the DDC's Context Packet Stream will indicate the power of a tone at the input to the Digital Receiver that will create a unit-scale sinusoid in the payload of the DDC's Data Packet. Similarly, the sum of the Timestamp in the Demodulator's Data Packet and the Timestamp Adjustment in the Demodulator's Context Packet Stream will indicate the time that the first sample of the Data Packet was present at the input to the Demodulator.

Appendix B.2 Spectral Fields Example

This section presents an example using the Bandwidth, IF Reference Frequency, RF Reference Frequency, and Spectral Inversion Indicator fields. This example also illustrates how context information can relate to analog signals. Subsequent examples will illustrate how these same fields relate to digital signals.

The block diagram for this example contains only one process, an analog tuner, as shown in Figure B.2-1. The tuner translates spectral energy from a high frequency RF band to a lower frequency IF band.

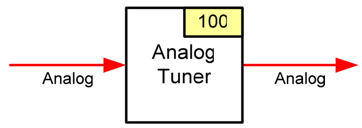


Figure B.2-1: Block diagram for Spectral Fields example

In this example the tuner generates an IF Context Packet Stream, with a Stream Identifier value of 100. The Context Packet contains the Reference Point Identifier field which also has value 100 to indicate that the reference point is at the input to the tuner. The Context Packet also contains Bandwidth, IF Reference Frequency, and RF Reference Frequency fields. The Bandwidth Frequency Offset and RF Reference Frequency Offset fields are not present in the Context Packet Stream (examples using these two fields are given in subsequent sections).

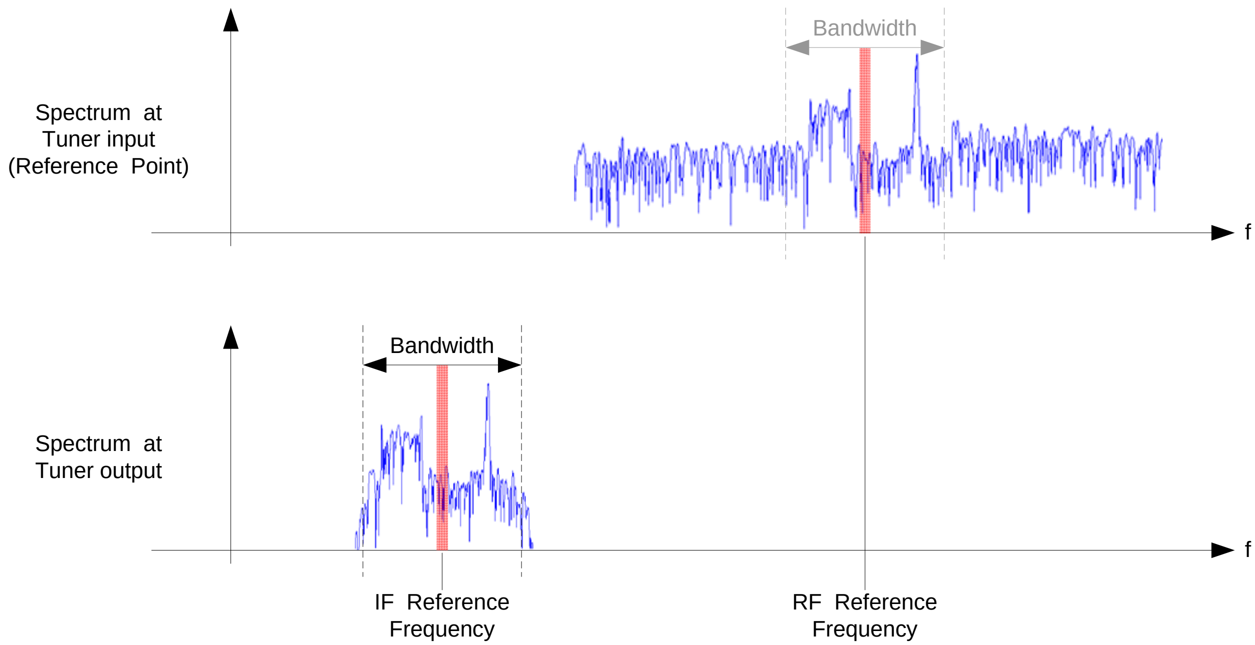


Figure B.2-2: Original and Translated Spectra and Spectral Parameters

The spectrum of the analog signals at the input and output of the Tuner. The Bandwidth field gives the bandwidth of the output signal. The IF Reference Frequency marks the center of the output band, and the RF Reference Frequency marks the frequency that was translated to the IF Reference Frequency.

Figure B.2-2 shows the RF spectrum at the tuner input (the reference point) and the IF spectrum at the tuner output. In this example the Bandwidth field contains the 3dB bandwidth at the tuner output. The IF center frequency, which is the nominal center of the output band the tuner, is marked with a wide bar in the figure. The IF Reference Frequency field in the Context Packet specifies this value. The frequency at the tuner input that translates to the IF Reference Frequency would be specified by the RF Reference Frequency field. Assuming the spectrum is not inverted from the RF to the IF band, the Spectral Inversion Indicator bit in the State and Event Indicator field would be zero.

If the tuner were tuned to 2 GHz and downconverted a 30 MHz band to a 70 MHz IF, without inverting its spectrum, then the spectral fields would contain the following values:

Analog Tuner Context Packet Stream	
Stream ID	100
Bandwidth	30 MHz
IF Reference Frequency	70 MHz
RF Reference Frequency	2 GHz
Spectral Inversion Indicator	0

Figure B.2-3: Context Packet Stream contents for Spectral Fields Example

Appendix B.3 RF Reference Frequency Offset Example

The example in this section expands upon the example given in Appendix B.2, to illustrate how the RF Reference Frequency Offset field is used to efficiently convey frequency translation information in channelized systems. This field is typically used with channelizers, where a large number of narrowband signals are created from portions of a wideband input signal. Figure B.3-1 shows such a system, where a Digital Receiver is followed by a bank of 64 DDCs. In this example, the digital receiver is dynamically tuned across a spectral region of interest. The DDCs are configured to examine portions of the receiver's output band in greater detail. The tuning frequency of each DDC channel remains fixed as the receiver's tuning frequency is changed.

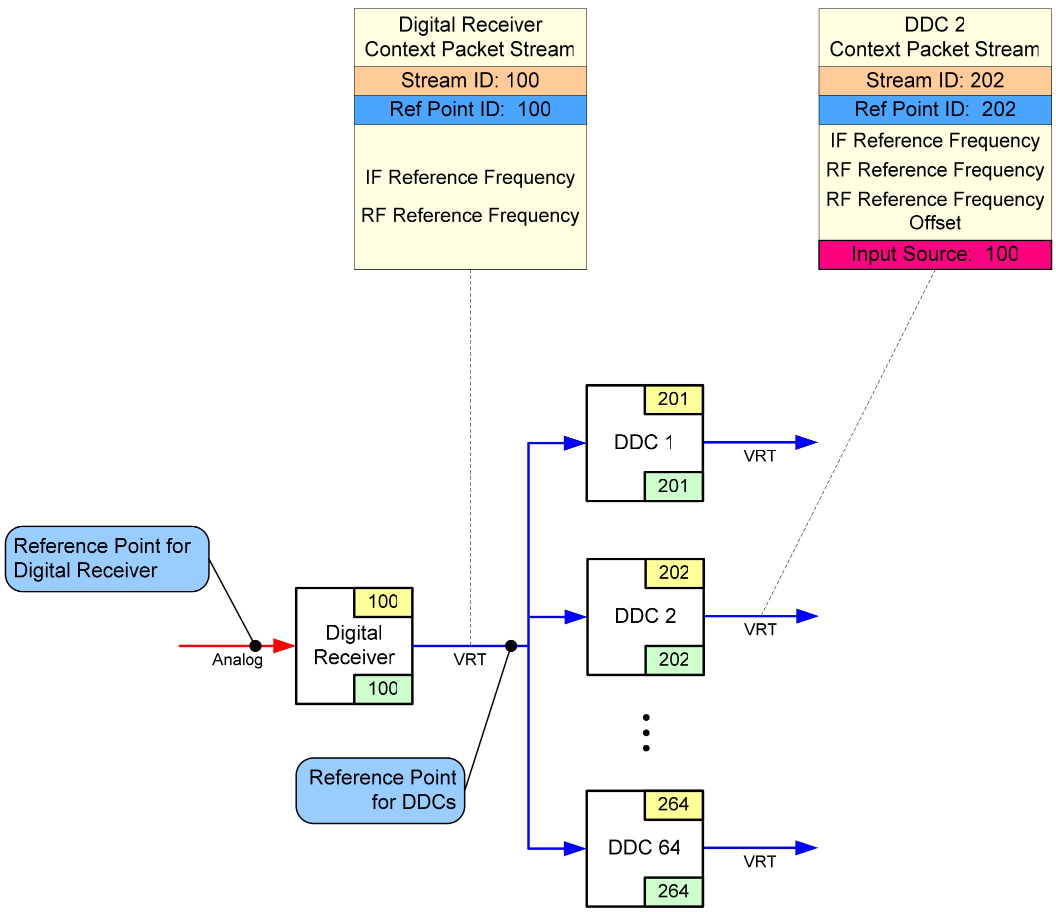


Figure B.3-1: Block diagram for RF Reference Frequency Offset Example
The RF Reference Frequency Offset field is typically used with channelizers

The Context Packet Stream for the Digital Receiver contains a Reference Point ID that specifies the input to the receiver as the reference point. The Receiver's Context Packet Stream also contains entries for IF Reference Frequency and RF Reference Frequency, as explained in Appendix B.2.

The DDC Context Packet Streams each contain a Reference Point ID and an Input Source Stream Association List. The Reference Point ID specifies the input to each DDC as its reference point. An entry in each of the Input Source Stream Association Lists contains Stream ID 100, which denotes that the receiver is the input source for each of the DDCs. The DDC Context Packet Streams also contains entries for IF Reference Frequency and RF Reference Frequency, and RF Reference Frequency Offset.

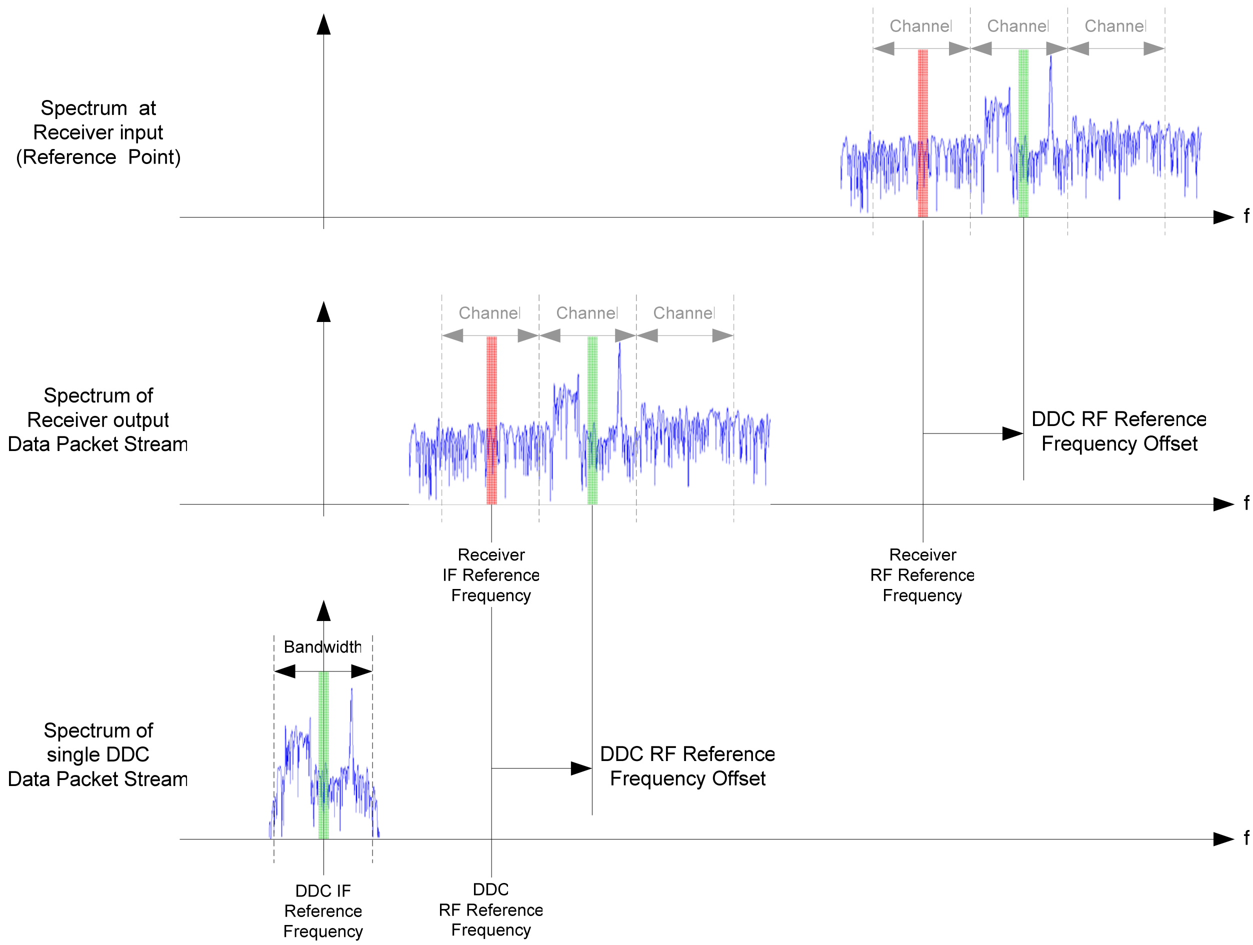


Figure B.3-2: Original and Translated Spectra for a single DDC
The red and green bars indicate which frequencies get translated to the
IF Reference Frequency for the Digital Receiver, and DDC 2, respectively.

Figure B.3-2 illustrates how the DDC's RF Reference Frequency Offset field is used. The original spectrum at the input to the digital receiver is shown in the top axis. The bands for several DDC channels are shown overlaid upon the RF spectrum. In addition, a red bar (leftmost bar) is shown at the receiver's RF Reference Frequency. This is the frequency that gets converted to the receiver's IF Reference Frequency. Also shown is a green bar (rightmost bar) at the frequency that gets translated to the DDC's IF Reference Frequency. The calculation to determine this original frequency is discussed shortly.

The middle axis shows the spectrum of the receiver's Data Packet Stream, which is also the input to each of the DDCs. The same channel bands and colored bars are shown with this translated spectrum. The bottom axis shows the spectrum of a single DDC's Data Packet Stream. The original frequency marked by the green bar is translated to DC, and the spectrum for all other channels, including the one marked by the red bar, is filtered out.

As stated in Section 7.1.5.5, the sum of the DDC's RF Reference Frequency Offset and the some RF Reference Frequency gets translated to the DDC's IF Reference Frequency. Additionally, the RF Reference Frequency for any associated upstream process can be used in this calculation. The RF Reference Frequency for the DDC or the receiver can be used in this example.

When the DDC's RF Reference Frequency Offset is summed with the <u>DDC's</u> RF Reference Frequency, this sum specifies a frequency at the Reference Point related to that RF Reference Frequency. In this case, the reference point is the input to the DDC itself. At this location, the following relationship holds. Note that the left hand side of this relationship refers to the green bar in the middle axis.

$$\underbrace{\text{DDC RF Reference Frequency} + \text{DDC RF Reference Frequency Offset}}_{\text{At the DDC's Reference Point (DDC's input, or Receiver's output)}} \xleftrightarrow{\textit{Frequency Translation}} \text{DDC IF Reference Frequency}$$

When the DDC's RF Reference Frequency Offset is summed with the receiver's RF Reference Frequency, the relationship holds at the receiver's reference point, which is the input to the receiver. At this location, the following relationship holds. In this case, the left hand side of this relationship refers to the green bar in the top axis.

$$\underbrace{\text{Receiver RF Reference Frequency} + \text{DDC RF Reference Frequency Offset}}_{\text{At the Receiver's Reference Point (Receiver's input)}} \xleftrightarrow{\textit{Frequency Translation}} \text{DDC IF Reference Frequency}$$

Consider this system when the receiver translates a 320 MHz band centered at 9 GHz down to an IF frequency of 1 GHz and the bank of 64 DDCs breaks this band into 5 MHz-wide channels with a channel spacing that is also 5 MHz. If DDC 2 converted the band centered at 1005 MHz down to baseband, then the following parameters would be sent in their respective Context Packet Streams.

Digital Receiver Context Packet Stream	
Stream ID	100
Reference Point ID	100
Bandwidth	320 MHz
IF Reference Frequency	1 GHz
RF Reference Frequency	9 GHz

DDC 2 Context Packet Stream	
Stream ID	202
Reference Point ID	202
Bandwidth	5 MHz
IF Reference Frequency	0 Hz
RF Reference Frequency	1 GHz
RF Reference Frequency Offset	5 MHz
Input Source Stream Assoc. List	100

Figure B.3-3: Context Packet Stream contents for RF Reference Frequency Offset Example

Given these Context Packet Streams, a VRT processor could calculate that, of the spectrum at the DDC input, the band centered at 1005 MHz was translated to 0 Hz at the DDC output, and that, of the spectrum at the receiver input, the band centered at 9005 MHz was translated to 0 Hz at the DDC output.

To see why the additional computation required by the RF Reference Frequency Offset is useful, note that if the receiver sweeps its tuned frequency to 9032 MHz, then 9064 MHz, and so on, that only one Context Packet for the receiver needs to be sent per frequency step. The 64 Context Packets for the 64 DDCs do not need to be sent at each frequency step. This could significantly reduce the chance of link congestion in some systems.

Appendix B.4 Bandwidth Frequency Offset Example

The Bandwidth field is used to describe the amount of usable signal spectrum at the output of a process. For many systems, the center of this signal band will be at the IF Reference Frequency. For those systems where the IF Reference Frequency is not at the center of the signal band, the Bandwidth Frequency Offset field is used to specify the difference between the true center of the band and the IF Reference Frequency. For example, for the digital receiver shown in Figure B.4-1, assume that it is necessary to have the IF Reference Frequency describe the lower band edge.

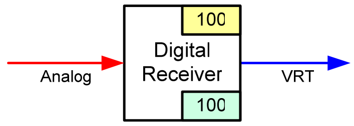


Figure B.4-1: Block diagram for Bandwidth Frequency Offset Example

Figure B.4-2 shows the signal spectrum at the input and output of the receiver. The IF Reference Frequency is at the lower band edge, and the Bandwidth Frequency Offset specifies the amount to add to the IF Reference Frequency value to get the true center of the band described by the Bandwidth field.

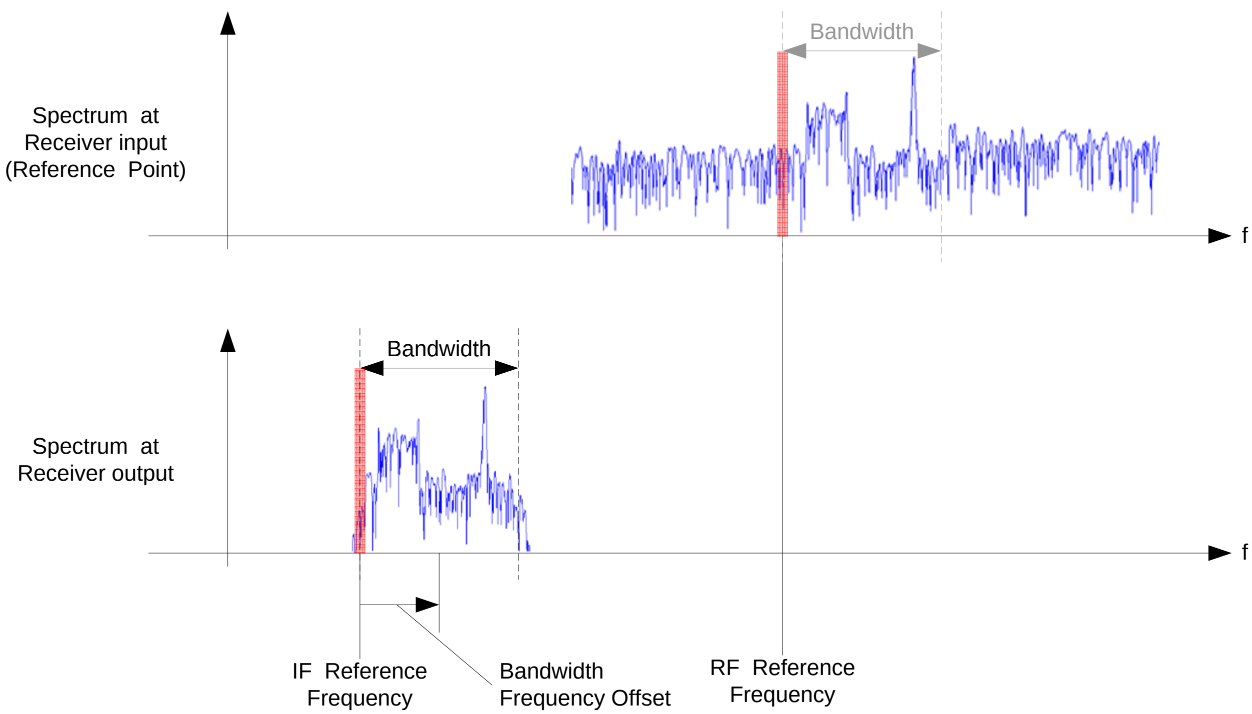


Figure B.4-2: Original and Translated Spectra for Bandwidth Frequency Offset Example

The IF Reference Frequency marks the lower band edge. The sum of the IF Reference Frequency and Bandwidth Frequency Offset gives the band center frequency.

The following numerical example is the same as that given in Appendix B.2, but with the IF Reference Frequency at the lower band edge instead of the band center.

If the tuner were tuned to 2 GHz and downconverted a 30 MHz band to a 70 MHz IF, without inverting its spectrum, then the spectral fields would contain the following values:

Digital Receiver Context Packet Stream	
Stream ID	100
Reference Point ID	100
Bandwidth	30 MHz
IF Reference Frequency	55 MHz
RF Reference Frequency	1.985 GHz
Bandwidth Frequency Offset	15 MHz
Spectral Inversion Indicator	0

Figure B.4-3: Context Packet Stream contents for Bandwidth Frequency Offset Example

Appendix B.5 Frequency Translation Example

In many applications, equipment from different vendors will connected together to perform a particular task. For some systems, the context from each individual component may not be useful, but the combined settings of the entire system are of interest to the end user. Therefore the system designer may choose to aggregate the context from each component and generate a summary context packet stream for the entire system, to be sent along with the system's final data packet stream.

Aggregating context from a cascade of components is generally a straight-forward procedure. For the system delay parameter, the sum of the individual Timestamp Adjustment fields will usually suffice. For the system level parameter, the gain of each component can be added to the Reference Level of the digitizer. The system bandwidth will typically be the bandwidth of the final bandlimiting process. The determination of the original RF frequency, however, is complicated when the input and output center frequencies of neighboring process are mismatched, or spectral inversion is encountered.

Consider the VRT-enabled components shown in Figure B.5-1 which were combined to form a surveillance system. The SHF tuner downconverts a 500 MHz band from a center frequency of 10 GHz to an IF center frequency of 1200 MHz. The UHF tuner converts a 30 MHz portion of this band centered at 1400 MHz down to an IF center frequency of 20 MHz. There the signal is digitized and a DDC is used to downconvert a 1 MHz band from a center frequency of 30 MHz to baseband.

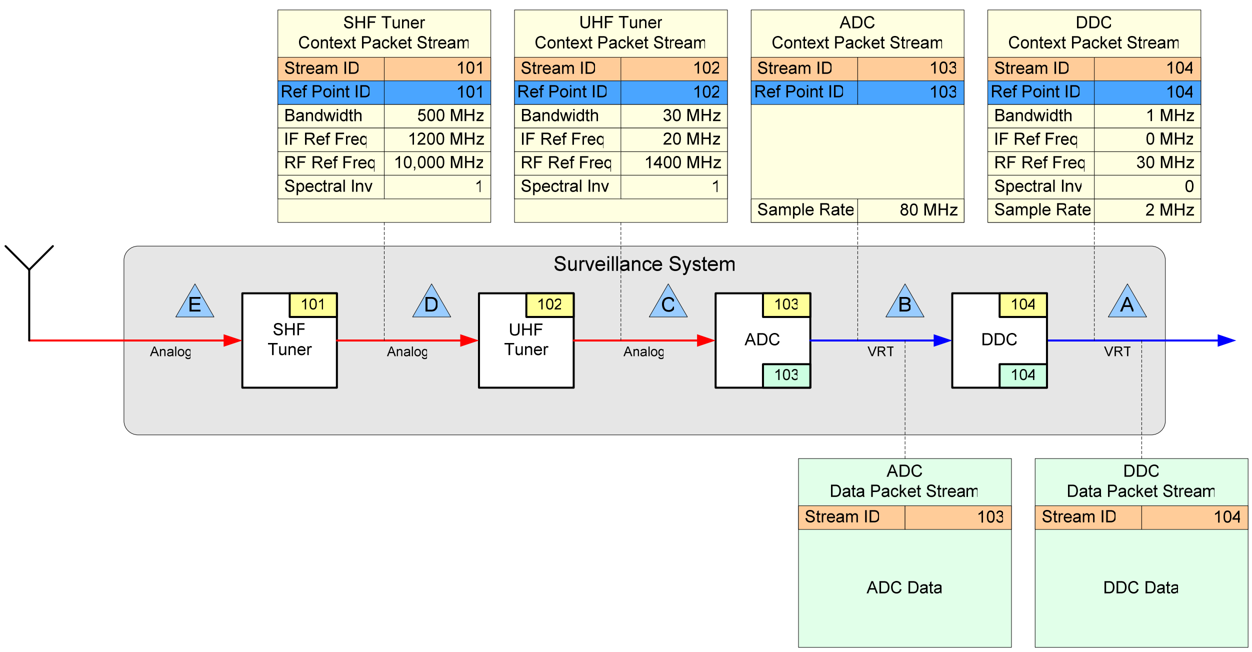


Figure B.5-1: Surveillance System Components for Frequency Translation Example

VRT Context Packet Streams are generated by each of these components (or their controllers) and VRT Data Packet Streams are generated by the ADC and DDC. The end user of the system, however, would like to be presented with only the DDC data packet stream and a context packet stream that describes the settings of the combined system, as shown in Figure B.5-2. In other words, the end user would like the data and context for only the DDC process, but with the reference point for the DDC context moved up to the antenna.

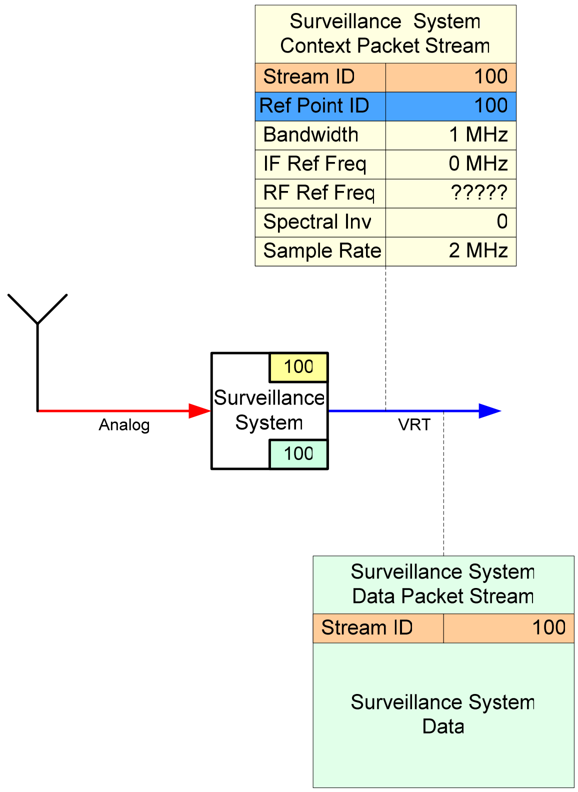


Figure B.5-2: Surveillance System

As shown in Figure B.5-2, several context parameters for the aggregate surveillance system are easy to determine. The Bandwidth, IF Reference Frequency, and Sample Rate fields for the system are the same as those for the final DDC process. There are two spectral inversions (in the SHF and UHF tuners) between the original DDC input reference point and the desired antenna reference point. Therefore the spectral inversion indicator for the system is the same as that for the DDC. The final parameter to determine is the RF Reference Frequency, which requires calculation.

This calculation is made simpler by first determining the translation frequency for each process in the signal path. The translation frequency is the difference between the frequency of the original RF signal and the frequency of the upright spectral image after frequency conversion. In terms of VRT parameters, shown in Figure B.5-3, the translation frequency is the difference between the RF Reference Frequency and the IF Reference Frequency if no spectral inversion occurs, and the difference between the RF Reference Frequency and the negative IF Reference Frequency if spectral inversion does occur during the frequency conversion.

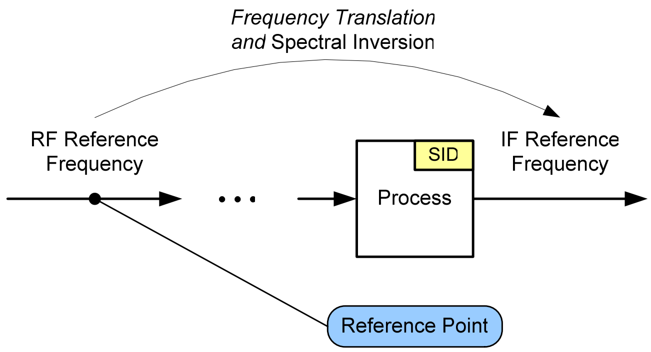


Figure B.5-3: VRT Parameters and Frequency Conversion

The translation frequency is shown graphically for the spectrally inverting and non-inverting cases in Figure B.5-4.

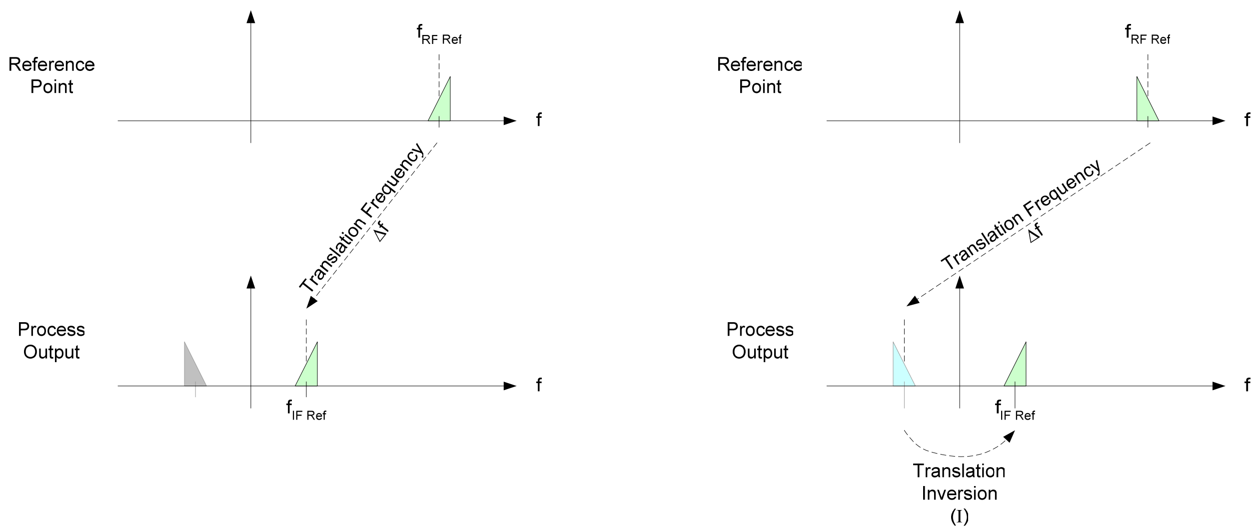


Figure B.5-4: The translation frequency for spectral inversion and non-inversion

The translation frequency is the difference between the original spectra at the reference point and the upright spectra after frequency conversion. For the non- inverting downconversion shown on the left, the translation frequency is simply the difference between the RF and IF Reference Frequencies. For the inverting downconversion, it is the difference between the RF Reference Frequency and the negative IF Reference Frequency.

The equation relating these VRT fields is

$$f_{\text{RF Ref}} + \Delta f = I \cdot f_{\text{IF Ref}} \tag{1}$$

where Δf is the translation frequency and I is related to the Spectral Inversion Indicator. I is +1 for non-inverting translations, and -1 for inverting translations.

Once the translation frequencies for each process is known, it is straight-forward to determine the relationship between the IF Reference Frequency and the RF Reference Frequency for any reference point in the signal path. For the example shown in Figure B.5-1, the translation frequencies are:

$$\begin{aligned}
\Delta f_{\text{SHF}} &= I_{\text{SHF}} \cdot f_{\text{SHF IF Ref}} - f_{\text{SHF RF Ref}} = (-1)\cdot 1200MHz - 10GHz = -11{,}200MHz \\
\Delta f_{\text{UHF}} &= I_{\text{UHF}} \cdot f_{\text{UHF IF Ref}} - f_{\text{UHF RF Ref}} = (-1)\cdot 20MHz - 1400MHz = -1{,}420MHz \\
\Delta f_{\text{ADC}} &= 0Hz \\
\Delta f_{\text{DDC}} &= I_{\text{DDC}} \cdot f_{\text{DDC IF Ref}} - f_{\text{DDC RF Ref}} = (+1)\cdot 0MHz - 30MHz = -30MHz
\end{aligned}$$

Figure B.5-1 has five triangle symbols at the inputs and outputs of the system components. The relationships between these five points can be expressed using equation (1) as:

$$\begin{aligned}
f_B &= I_{DDC}\, f_A - \Delta f_{DDC} \\
f_C &= I_{ADC}\, f_B - \Delta f_{ADC} \\
f_D &= I_{UHF}\, f_C - \Delta f_{UHF} \\
f_E &= I_{SHF}\, f_D - \Delta f_{SHF}
\end{aligned}$$

Using substitution, the frequency relationship between points A and E is:

$$\begin{aligned}
f_E &= I_{SHF}\left(I_{UHF}\left(I_{ADC}\left(I_{DDC}\, f_A - \Delta f_{DDC}\right) - \Delta f_{ADC}\right) - \Delta f_{UHF}\right) - \Delta f_{SHF} \\
f_E &= I_{SHF} I_{UHF} I_{ADC} I_{DDC}\, f_A - I_{SHF} I_{UHF} I_{ADC} \Delta f_{DDC} - I_{SHF} I_{UHF} \Delta f_{ADC} - I_{SHF} \Delta f_{UHF} - \Delta f_{SHF}
\end{aligned}$$

Points A and E are the IF and RF Reference Frequency points for the aggregate system. Therefore the RF Reference Frequency for the system is calculated as:

$$\begin{aligned}
f_{\text{System RF Ref}} &= I_{SHF} I_{UHF} I_{DDC}\, f_{\text{System IF Ref}} - I_{SHF} I_{UHF} \Delta f_{DDC} - I_{SHF} \Delta f_{UHF} - \Delta f_{SHF} \\
f_{\text{System RF Ref}} &= 0Hz + 30MHz - 1{,}420MHz + 11{,}200MHz \\
f_{\text{System RF Ref}} &= 9{,}810MHz
\end{aligned}$$

The translation frequency for the entire system can be found as:

$$\begin{aligned}
f_{\text{System RF Ref}} &= I_{\text{System}}\, f_{\text{System IF Ref}} - \Delta f_{\text{System}} = I_{SHF} I_{UHF} I_{DDC}\, f_{\text{System IF Ref}} - I_{SHF} I_{UHF} \Delta f_{DDC} - I_{SHF} \Delta f_{UHF} - \Delta f_{SHF} \\
I_{\text{System}} &= I_{SHF} I_{UHF} I_{DDC} = +1 \\
\Delta f_{\text{System}} &= I_{SHF} I_{UHF} \Delta f_{DDC} + I_{SHF} \Delta f_{UHF} + \Delta f_{SHF} = -9810MHz
\end{aligned}$$

The frequency translations and spectral inversions are also be shown graphically in Figure B.5-5.

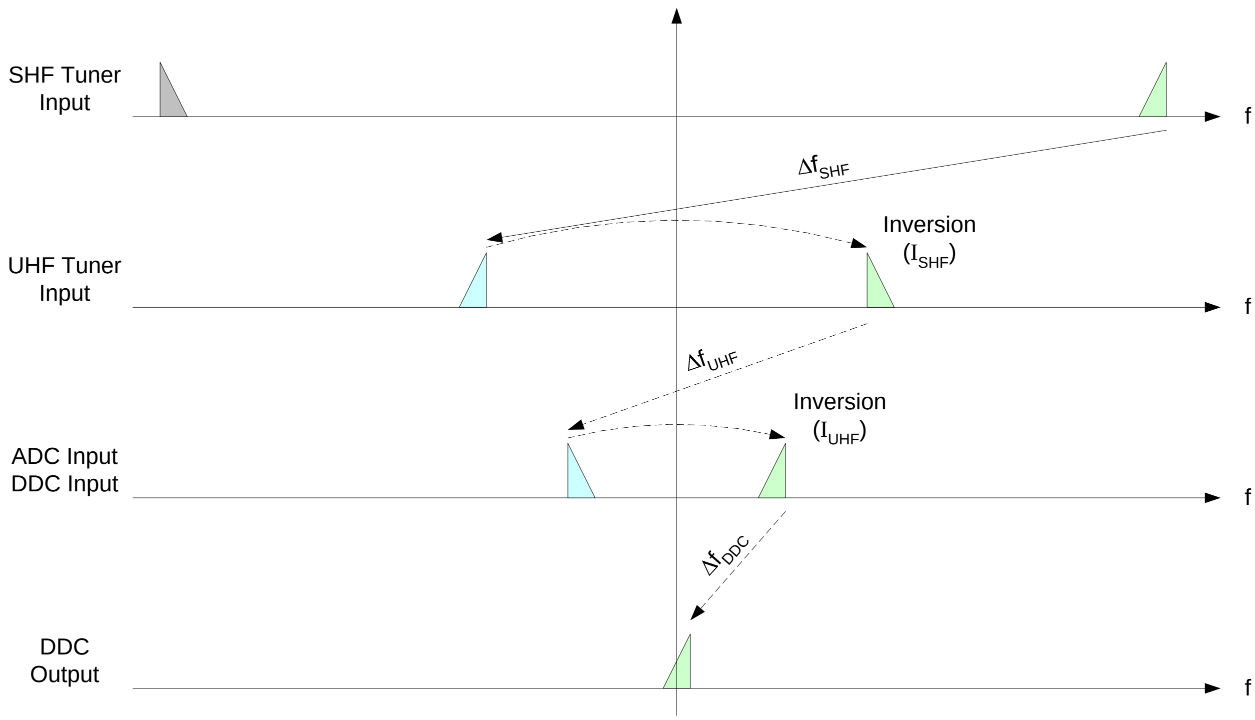


Figure B.5-5: Frequency Translations within System

The frequency translation for the entire system simplifies to that shown in Figure B.5-6.

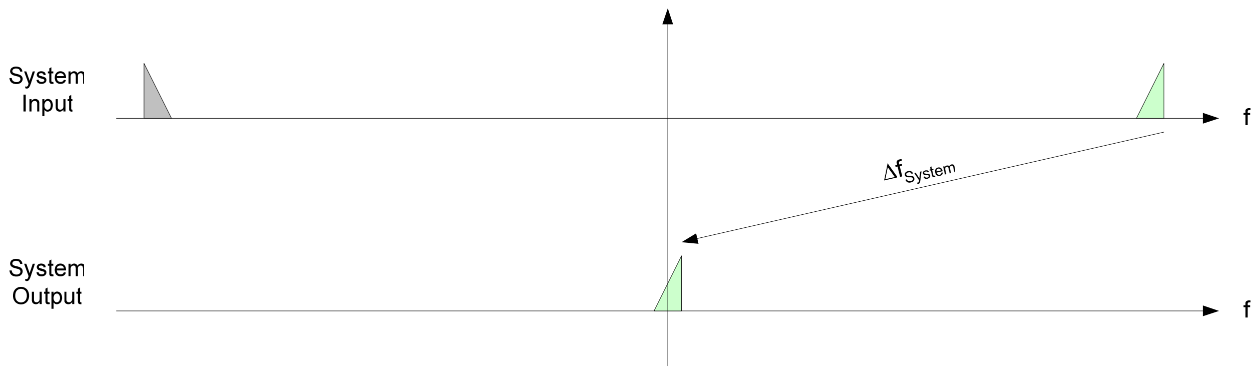


Figure B.5-6: Frequency Translation for cascaded System

The RF and IF Reference Frequencies within the system are shown in Figure B.5-7

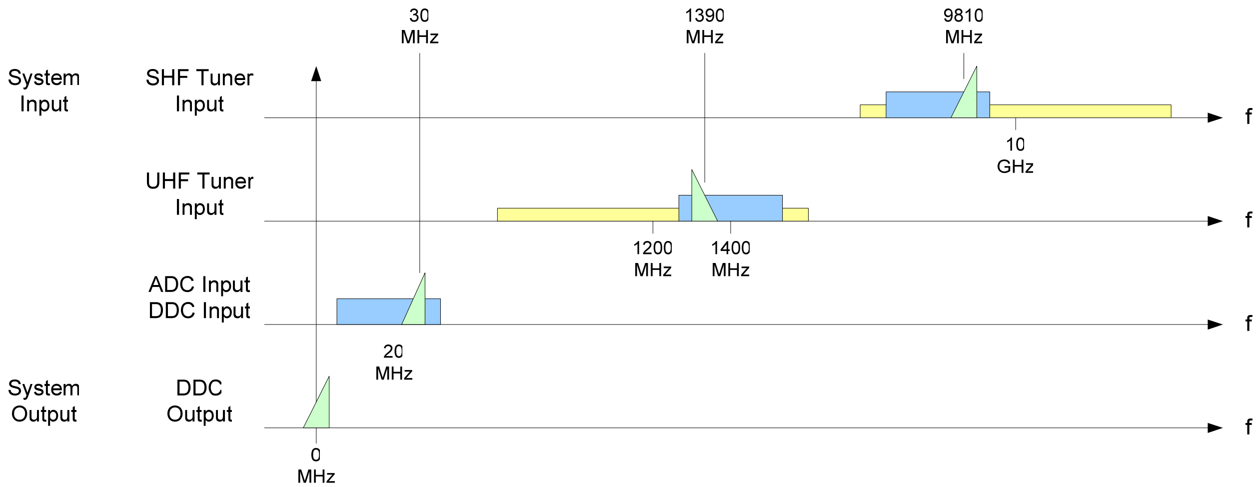


Figure B.5-7: RF and IF Reference Frequencies within System

Appendix B.6 Reference Level and Gain Example

This section contains an example illustrating the use of the Reference Level and Gain fields. Figure B.6-1 shows an example system with a microwave tuner, a digital receiver, and a DDC.

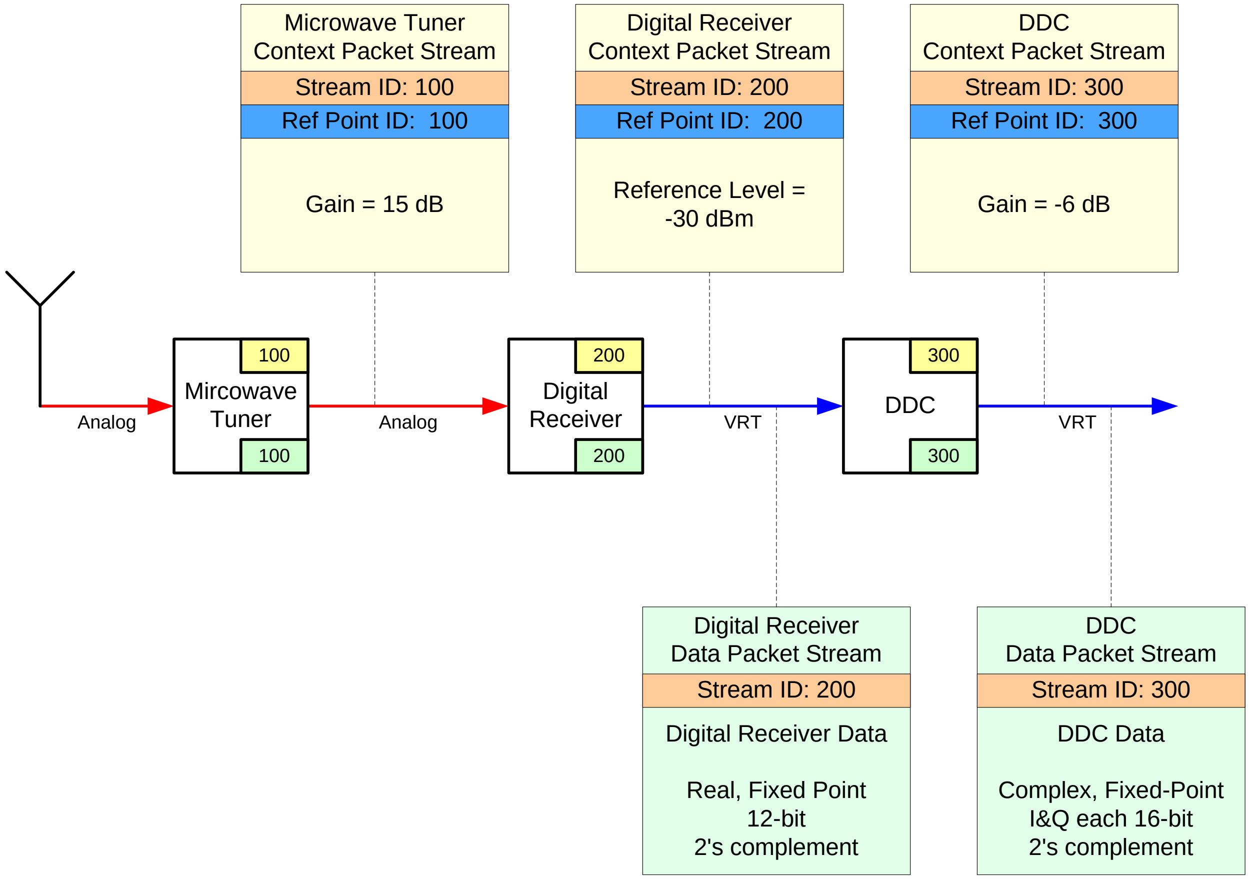


Figure B.6-1: Block diagram for Gain and Reference Level Example

The microwave tuner has an analog input and an analog output, and the gain between the input and output is 15 dB.

The digital receiver has an analog input, and generates IF Data Packets with 12-bit two's-complement real samples. A -30 dBm tone at the input to the digital receiver will cause the signal within the IF Data Packet Stream to range from positive to negative full scale. Therefore a -45 dBm signal at the input to the microwave tuner will also generate a full-scale signal at the digital receiver output. Figure B.6-2 shows the full-scale output of the Digital Receiver

Need rules regarding behavior of Gain field for digital processes? (See next page)

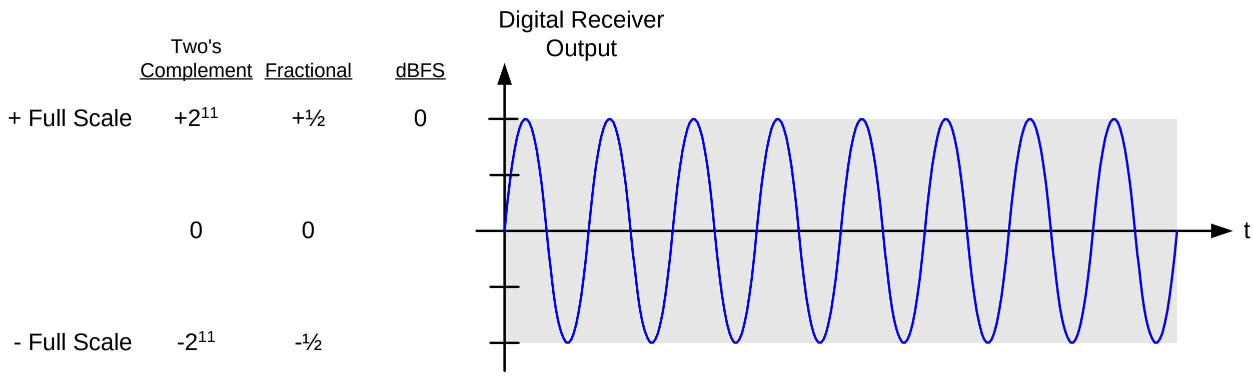


Figure B.6-2: Level of Digital Receiver samples

When stimulated with a -30 dBm tone at its input, the Digital Receiver will generate a sample stream where the signal ranges the full 12-bit scale.

The DDC processes the 12-bit real samples from the receiver and generates complex samples, where both the real and imaginary components use a 16-bit two's-complement format. The DDC has a gain of -6 dB because a tone that is full-scale at its input will cause it to generate a packet stream with complex samples where both the real and imaginary components have peak amplitudes 6 dB below full-scale (-6 dBFS). Figure B.6-3 shows the -6 dBFS output of the DDC.

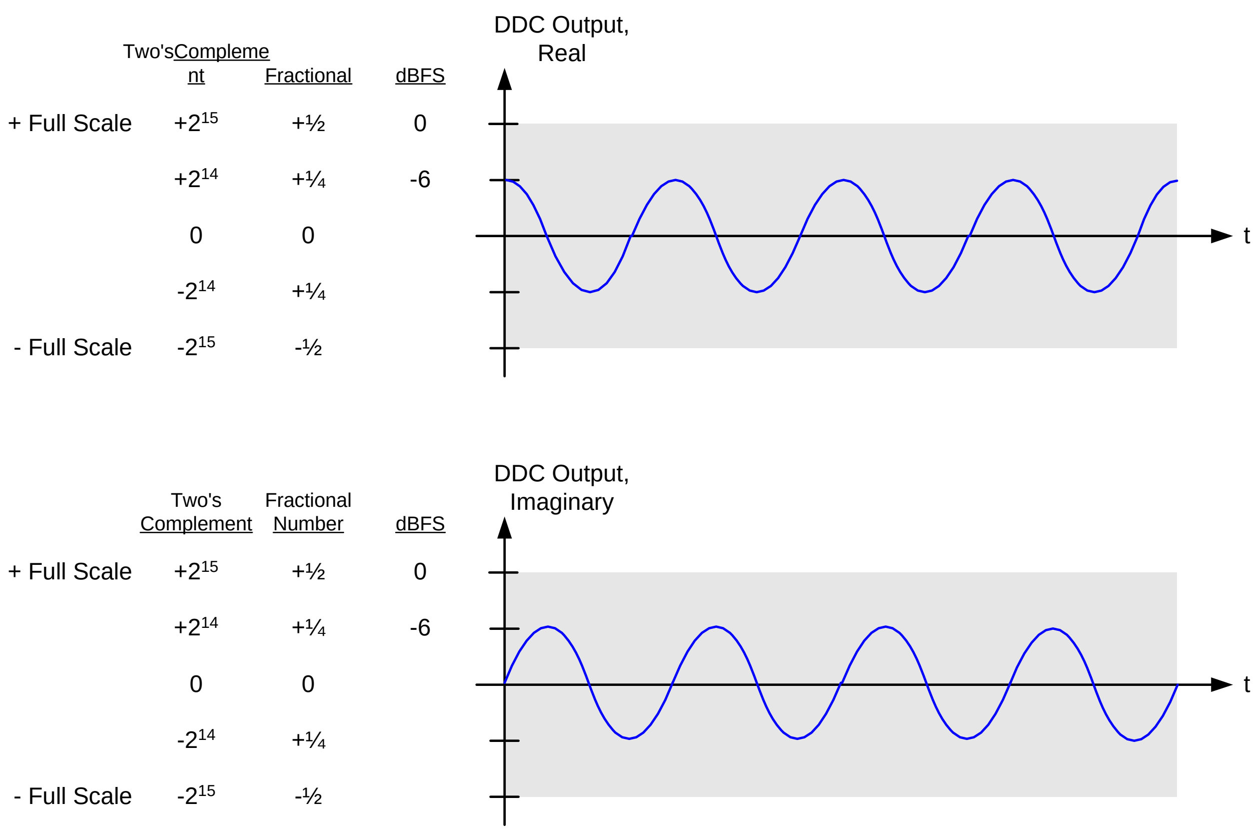


Figure B.6-3: Level of DDC samples

When stimulated with a full-scale tone at its input, such as that in Figure B.6-2, the DDC will generate a complex sample stream where the real and imaginary components range one-half of full-scale, or 6 dB below full-scale.

Appendix B.7 Timestamp Adjustment Example

The example in this section illustrates the use of the Timestamp Adjustment field to make corrections to the value contained in the Timestamp field, and to enable the correlation of events at different reference points in the system. Figure B.7-1 shows a system with an antenna followed by a digital receiver and a DDC processor. In this system, the group delay from the input of the antenna to the digital receiver input is 10 ns, the group delay from the input of the digital receiver to the its digitizer is 5 ns, and the group delay through the DDC filter is 1 µs.[1]

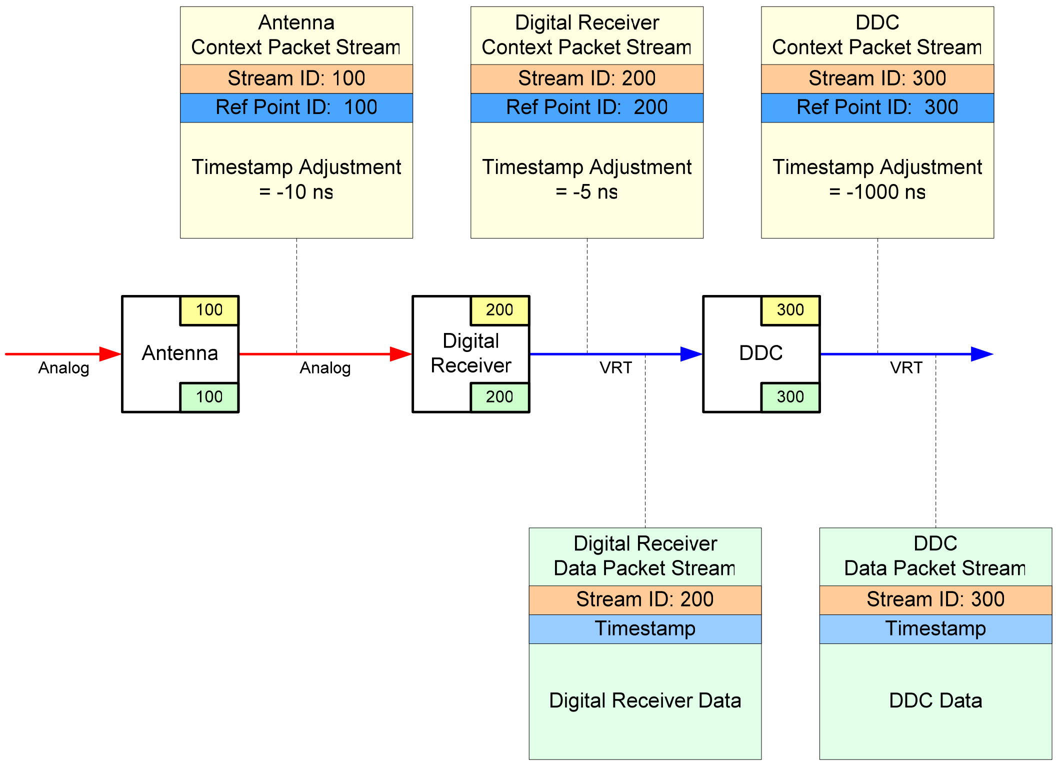


Figure B.7-1: Block diagram for Timestamp Adjustment Example

Note that in the above figure, each process specifies its own input as its reference point for the Timestamp Adjustment. Consider this system where the end user is interested in determining the timing of features of a signal in the DDC data packet at the input to the antenna. In this system, each process may take the Timestamp Adjustment of the process that precedes it and use this value to determine a new value of Timestamp Adjustment for the antenna input reference point. For example, the Digital Receiver adds its internal 5 ns of delay to the -10 ns Timestamp Adjustment of the Antenna process and generates an IF Context Packet with a Timestamp Adjustment of -15ns and a Reference Point ID that is the Stream ID of the Antenna, 100. Likewise, the DDC generates an IF Context Packet with a Timestamp Adjustment of -1015 ns and a Reference Point ID of 100.

Another option for this system is for the Timestamp in the IF Data Packets to be adjusted to account for the group delay in each process. Figure B.7-2 shows several of these options for the DDC process.

---

[1] Note that though group delay varies with frequency, the Timestamp Adjustment field can only convey a single delay value. It is therefore most useful in those applications where the group delay can be considered constant over a particular band of interest.

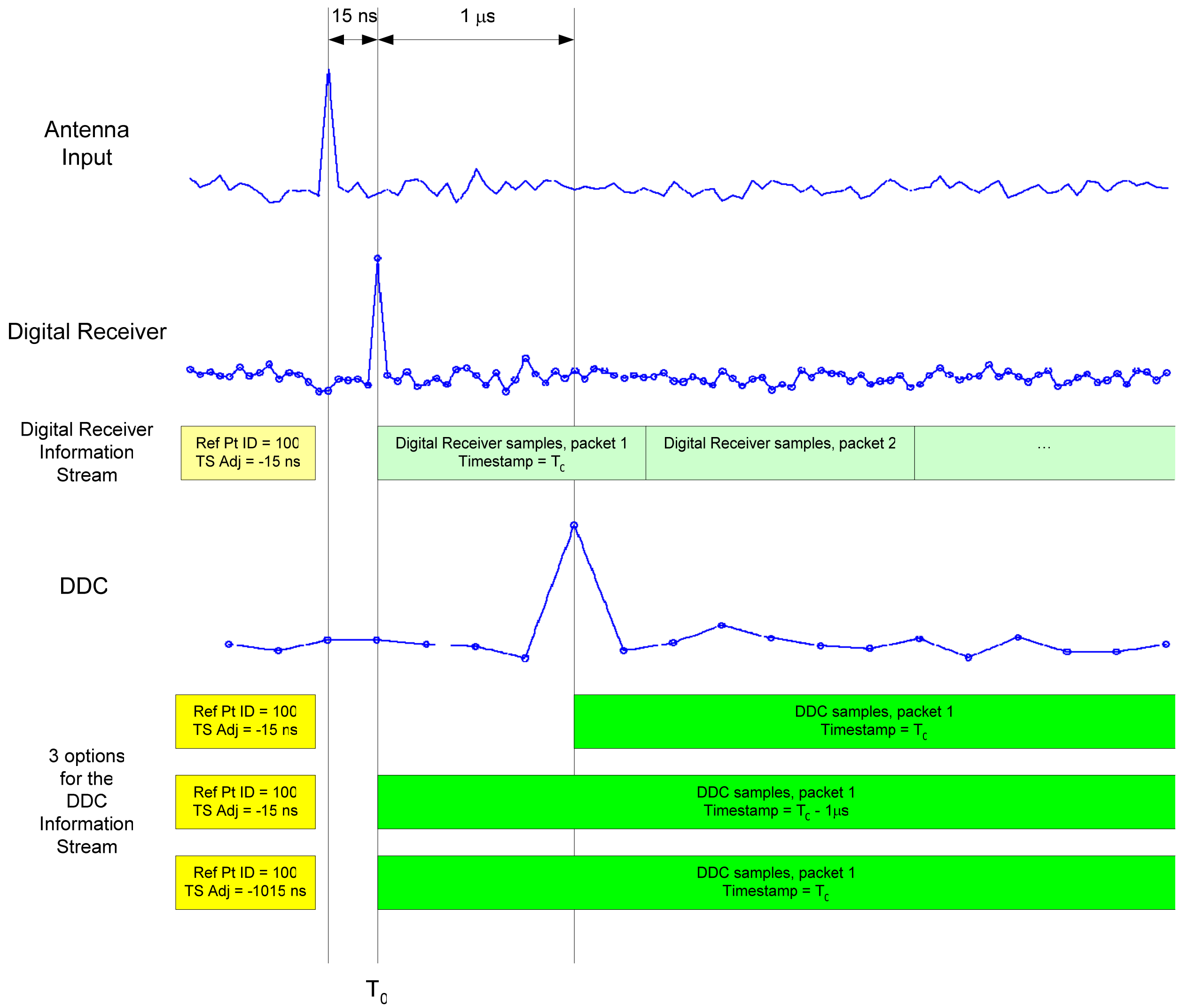


Figure B.7-2 : Timing diagram for Timestamp Adjustment Example

The signal at the top of this figure shows the signal as it was at the input of the antenna. An impulse is shown near the beginning of this signal trace. The second signal shows the sample stream at the output of the digital receiver, which is delayed 15 ns from the input of the antenna. The Data and Context Packet Streams for the digital receiver are shown below the digital receiver sample stream. The data packets shown contain the samples displayed directly above them. The first sample of the receiver data packet corresponds to the time the impulse was digitized, T_0, which is 15 ns after the impulse arrived at the antenna input. Therefore the timestamp of the first packet is T_0, and the Timestamp adjustment sent in the receiver's Context Packet is -15 ns.

The DDC process filters and decimates the signal. The Timestamp and Timestamp Adjustment fields for the DDC can be arranged in several ways. First, the DDC data packets can be timed to account for the group delay of the DDC, as shown in the first row. Here the impulse becomes the first sample of the DDC packet, and the Timestamp plus Adjustment is T_0–15 ns. The second and third rows show options where the DDC packets are not retimed. In these cases, the impulse occurs 1 µs later in the data packet than it did in the first case. Therefore the Timestamp plus Timestamp Adjustment is T_0-1015 ns.

Appendix B.8 Data Packet Payload Format Examples

This section presents several examples of the Data Packet Payload Format field and shows the corresponding packing of the Data Packet payload. There are a very large number of permutations of payload formats. The aim of this section is to show the use of each subfield within the Data Packet Payload Format rather than show every permutation of subfields.

The figures in the remainder of this section have two parts. The (a) part at the top of each figure contains valid values of the Data Packet Payload Format field for a variety of Data Item Formats. The (b) part at the bottom of each figure shows a the first few packing fields in the resulting Data Packet Payload.

Figure B.8-2 through Figure B.8-7 show the payload packing for the common 32, 16 and 8-bit data item sizes, for both real and complex formats.

In these first few examples, note that there are several permutations of the Complex Polar format. They are summarized in Table B.8-1.

Data Sample Type	**Data Item Type**	**Format of the Amplitude Component**	**Format of the Phase Component**
Complex Polar, Signed Phase	Any unsigned fixed-point format	Unsigned fixed-point	Signed fixed-point for normalized phase as per Rule 6.1.5.4-12
	Any signed fixed-point format	Signed fixed-point (but always positive)	Signed fixed-point for normalized phase as per Rule 6.1.5.4-12
	Any floating-point format	Floating-point (but always positive)	Floating-point value in radians in the range $[-\pi, \pi)$
Complex Polar, Unsigned Phase	Any unsigned fixed-point format	Unsigned fixed-point	Unsigned fixed-point for normalized phase as per Rule 6.1.5.4-13
	Any signed fixed-point format	Signed fixed-point (but always positive)	Unsigned fixed-point for normalized phase as per Rule 6.1.5.4-13
	Any floating-point format	Floating-point (but always positive)	Floating-point value in radians in the range $[0, 2\pi)$

Table B.8-1: Complex Polar Component Formats

Figure B.8-1 shows the organization of the Data Packet Payload Field, which is a useful reference when analyzing the format codes given in this section.

<table>
<tr><td>Word</td><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>1</td><td>Pack</td><td colspan="6">Item Packing Field Size</td><td colspan="6">Data Item Size</td><td colspan="3">Event-Tag Size</td><td colspan="4">Channel-Tag Size</td><td colspan="4">Reserved</td><td colspan="8">Vector Size</td></tr>
<tr><td>2</td><td colspan="16">Repeat Count</td><td>Rpt</td><td colspan="10">Reserved</td><td colspan="2">Real/ Cmplx</td><td colspan="3">Data Item Format</td></tr>
</table>

Figure B.8-1: Data Packet Payload Format Field

Data Packet Payload Format	Real/Complex	Format
3EF80000 00000000	Real	Unsigned Fixed Pt.
3EF80000 00000010	Real	Signed Fixed Pt.
3EF80000 0000001E	Real	Double-Precison Floating Pt.

(a)

<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="32">Data Item 1 (Sample 1)</td></tr>
<tr><td colspan="32">Data Item 2 (Sample 2)</td></tr>
<tr><td colspan="32">Data Item 3 (Sample 3)</td></tr>
<tr><td colspan="32">Data Item 4 (Sample 4)</td></tr>
</table>

(b)

Figure B.8-2: 32-bit Real Format

Data Packet Payload Format	Real/Complex	Cartesian Format	Polar Amplitude Format	Polar Phase Format
3EF80000 00000030	Complex Cartesian	Signed Fixed Pt.	n/a	n/a
3EF80000 00000060	Complex Polar	n/a	Unsigned Fixed Pt.	Unsigned Fixed Pt.
3EF80000 00000040	Complex Polar	n/a	Unsigned Fixed Pt.	Signed Fixed Pt.
3EF80000 0000007E	Complex Polar	n/a	Double-Precision Floating Pt.	Double-Precision Floating Pt. (Unsigned)
3EF80000 0000005E	Complex Polar	n/a	Double-Precision Floating Pt.	Double-Precision Floating Pt. (Signed)

(a)

<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="32">Data Item 1 (Sample 1 Real/Ampl)</td></tr>
<tr><td colspan="32">Data Item 2 (Sample 1 Imag/Phase)</td></tr>
<tr><td colspan="32">Data Item 3 (Sample 2 Real/Ampl)</td></tr>
<tr><td colspan="32">Data Item 4 (Sample 2 Imag/Phase)</td></tr>
</table>

(b)

Figure B.8-3: 32-bit Complex Format

Data Packet Payload Format	Real/Complex	Format
1E780000 00000000	Real	Unsigned Fixed Pt.
1E780000 00000010	Real	Signed Fixed Pt.
1E780000 0000001D	Real	Single-Precison Floating Pt.

(a)

<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="16">Data Item 1 (Sample 1)</td><td colspan="16">Data Item 2 (Sample 2)</td></tr>
<tr><td colspan="16">Data Item 3 (Sample 3)</td><td colspan="16">Data Item 4 (Sample 4)</td></tr>
<tr><td colspan="16">Data Item 5 (Sample 5)</td><td colspan="16">Data Item 6 (Sample 6)</td></tr>
<tr><td colspan="16">Data Item 7 (Sample 7)</td><td colspan="16">Data Item 8 (Sample 8)</td></tr>
</table>

(b)

Figure B.8-4: 16-bit Real Format

Data Packet Payload Format	Real/Complex	Cartesian Format	Polar Amplitude Format	Polar Phase Format
1E780000 00000030	Complex Cartesian	Signed Fixed Pt.	n/a	n/a
1E780000 00000060	Complex Polar	n/a	Unsigned Fixed Pt.	Unsigned Fixed Pt.
1E780000 00000040	Complex Polar	n/a	Unsigned Fixed Pt.	Signed Fixed Pt.
1E780000 0000007D	Complex Polar	n/a	Single-Precision Floating Pt.	Single-Precision Floating Pt. (Unsigned)
1E780000 0000005D	Complex Polar	n/a	Single-Precision Floating Pt.	Single-Precision Floating Pt. (Signed)

(a)

<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="16">Data Item 1 (Sample 1 Real/Ampl)</td><td colspan="16">Data Item 2 (Sample 1 Imag/Phase)</td></tr>
<tr><td colspan="16">Data Item 3 (Sample 2 Real/Ampl)</td><td colspan="16">Data Item 4 (Sample 2 Imag/Phase)</td></tr>
<tr><td colspan="16">Data Item 5 (Sample 3 Real/Ampl)</td><td colspan="16">Data Item 6 (Sample 3 Imag/Phase)</td></tr>
<tr><td colspan="16">Data Item 7 (Sample 4 Real/Ampl)</td><td colspan="16">Data Item 8 (Sample 4 Imag/Phase)</td></tr>
</table>

(b)

Figure B.8-5: 16-bit Complex Format

Data Packet Payload Format	Real/Complex	Format
0E380000 00000000	Real	Unsigned Fixed Pt.
0E380000 00000010	Real	Signed Fixed Pt.

(a)

<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="8">Data Item 1
(Sample 1)</td><td colspan="8">Data Item 2
(Sample 2)</td><td colspan="8">Data Item 3
(Sample 3)</td><td colspan="8">Data Item 4
(Sample 4)</td></tr>
<tr><td colspan="8">Data Item 5
(Sample 5)</td><td colspan="8">Data Item 6
(Sample 6)</td><td colspan="8">Data Item 7
(Sample 7)</td><td colspan="8">Data Item 8
(Sample 8)</td></tr>
<tr><td colspan="8">Data Item 9
(Sample 9)</td><td colspan="8">Data Item 10
(Sample 10)</td><td colspan="8">Data Item 11
(Sample 11)</td><td colspan="8">Data Item 12
(Sample 12)</td></tr>
<tr><td colspan="8">Data Item 13
(Sample 13)</td><td colspan="8">Data Item 14
(Sample 14)</td><td colspan="8">Data Item 15
(Sample 15)</td><td colspan="8">Data Item 16
(Sample 16)</td></tr>
</table>

(b)

Figure B.8-6: 8-bit Real Format

Data Packet Payload Format	Real/Complex	Cartesian Format	Polar Amplitude Format	Polar Phase Format
0E380000 00000030	Complex Cartesian	Signed Fixed Pt.	n/a	n/a
0E380000 00000060	Complex Polar	n/a	Unsigned Fixed Pt.	Unsigned Fixed Pt.
0E380000 00000040	Complex Polar	n/a	Unsigned Fixed Pt.	Signed Fixed Pt.

(a)

<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="8">Data Item 1
(Sample 1 Real/Ampl)</td><td colspan="8">Data Item 2
(Sample 1 Imag/Phase)</td><td colspan="8">Data Item 3
(Sample 2 Real/Ampl)</td><td colspan="8">Data Item 4
(Sample 2 Imag/Phase)</td></tr>
<tr><td colspan="8">Data Item 5
(Sample 3 Real/Ampl)</td><td colspan="8">Data Item 6
(Sample 3 Imag/Phase)</td><td colspan="8">Data Item 7
(Sample 4 Real/Ampl)</td><td colspan="8">Data Item 8
(Sample 4 Imag/Phase)</td></tr>
<tr><td colspan="8">Data Item 9
(Sample 5 Real/Ampl)</td><td colspan="8">Data Item 10
(Sample 5 Imag/Phase)</td><td colspan="8">Data Item 11
(Sample 6 Real/Ampl)</td><td colspan="8">Data Item 12
(Sample 6 Imag/Phase)</td></tr>
<tr><td colspan="8">Data Item 13
(Sample 7 Real/Ampl)</td><td colspan="8">Data Item14
(Sample 7 Imag/Phase)</td><td colspan="8">Data Item 15
(Sample 8 Real/Ampl)</td><td colspan="8">Data Item 16
(Sample 8 Imag/Phase)</td></tr>
</table>

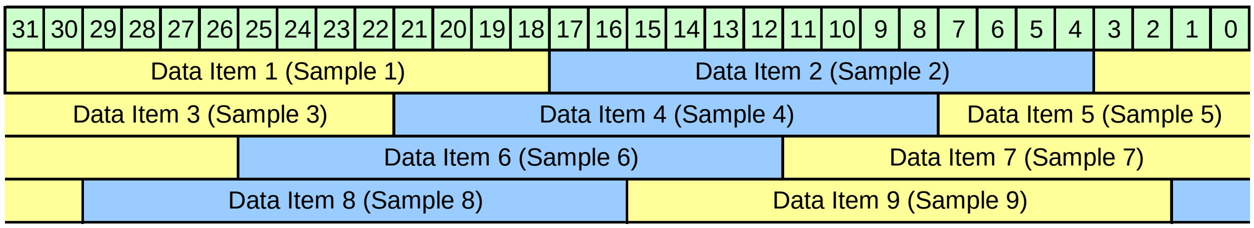
(b)

Figure B.8-7: 8-bit Complex Format

The next three examples illustrate several methods of link-efficient and processing-efficient payload packing. Figure B.8-8 shows 14-bit real data with link-efficient packing, Figure B.8-9 shows 14-bit data with processing-efficient packing, and Figure B.8-10 shows 14-bit data placed in 16-bit packing fields. This last example would have the same payload packing regardless of whether link- or processing-efficient packing was specified. Note that all packing fields are left-justified, so unused bits appear at the lsbs of the 32-bit word or the lsbs of the packing field.

Data Packet Payload Format	Real/Complex	Format
9A680000 00000000	Real	Unsigned Fixed Pt.
9A680000 00000010	Real	Signed Fixed Pt.

(a)

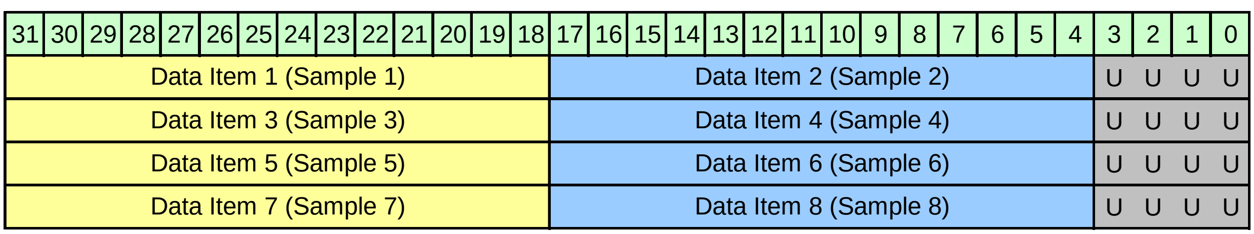


(b)

Figure B.8-8: Link-Efficient Packing

Data Packet Payload Format	Real/Complex	Format
1A680000 00000000	Real	Unsigned Fixed Pt.
1A680000 00000010	Real	Signed Fixed Pt.

(a)



(b)

Figure B.8-9: Processing-Efficient Packing

Data Packet Payload Format	Real/Complex	Format
1E680000 00000000	Real	Unsigned Fixed Pt.
1E680000 00000010	Real	Signed Fixed Pt.

(a)

<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="14">Data Item 1 (Sample 1)</td><td>U</td><td>U</td><td colspan="14">Data Item 2 (Sample 2)</td><td>U</td><td>U</td></tr>
<tr><td colspan="14">Data Item 3 (Sample 3)</td><td>U</td><td>U</td><td colspan="14">Data Item 4 (Sample 4)</td><td>U</td><td>U</td></tr>
<tr><td colspan="14">Data Item 5 (Sample 5)</td><td>U</td><td>U</td><td colspan="14">Data Item 6 (Sample 6)</td><td>U</td><td>U</td></tr>
<tr><td colspan="14">Data Item 7 (Sample 7)</td><td>U</td><td>U</td><td colspan="14">Data Item 8 (Sample 8)</td><td>U</td><td>U</td></tr>
</table>

(b)

Figure B.8-10: 14-bit Data Items in 16-bit Packing Fields

Figure B.8-11 illustrates the use of event tags. In this example, 8-bit data is packed into 10-bit packing fields. The two remaining bits are declared as event tags, denoted with "E". This example also illustrates processing-efficient packing for 10-bit packing fields, where 3 packing fields can fit in a single 32-bit word.

Data Packet Payload Format	Real/Complex	Format
123A0000 00000000	Real	Unsigned Fixed Pt.
123A0000 00000010	Real	Signed Fixed Pt.

(a)

<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="8">Data Item 1
(Sample 1)</td><td>E</td><td>E</td><td colspan="8">Data Item 2
(Sample 2)</td><td>E</td><td>E</td><td colspan="8">Data Item 3
(Sample 3)</td><td>E</td><td>E</td><td>U</td><td>U</td></tr>
<tr><td colspan="8">Data Item 4
(Sample 4)</td><td>E</td><td>E</td><td colspan="8">Data Item 5
(Sample 5)</td><td>E</td><td>E</td><td colspan="8">Data Item 6
(Sample 6)</td><td>E</td><td>E</td><td>U</td><td>U</td></tr>
<tr><td colspan="8">Data Item 7
(Sample 7)</td><td>E</td><td>E</td><td colspan="8">Data Item 8
(Sample 8)</td><td>E</td><td>E</td><td colspan="8">Data Item 9
(Sample 9)</td><td>E</td><td>E</td><td>U</td><td>U</td></tr>
<tr><td colspan="8">Data Item 10
(Sample 10)</td><td>E</td><td>E</td><td colspan="8">Data Item 11
(Sample 11)</td><td>E</td><td>E</td><td colspan="8">Data Item 12
(Sample 12)</td><td>E</td><td>E</td><td>U</td><td>U</td></tr>
</table>

(b)

Figure B.8-11: Event Tags

Figure B.8-12 demonstrates the use of sample vectors. In this example, 8-bit data is simultaneously collected from four sources. The first samples from each source are grouped at the beginning of the payload, followed by the group of second samples, and so on. This forms a 4-dimensional sample vector.

Data Packet Payload Format	Real/Complex	Format
0E380003 00000000	Real	Unsigned Fixed Pt.
0E380003 00000010	Real	Signed Fixed Pt.

(a)

<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="8">Data Item 1
(Sample 1, Component 1)</td><td colspan="8">Data Item 2
(Sample 1, Component 2)</td><td colspan="8">Data Item 3
(Sample 1, Component 3)</td><td colspan="8">Data Item 4
(Sample 1, Component 4)</td></tr>
<tr><td colspan="8">Data Item 5
(Sample 2, Component 1)</td><td colspan="8">Data Item 6
(Sample 2, Component 2)</td><td colspan="8">Data Item 7
(Sample 2, Component 3)</td><td colspan="8">Data Item 8
(Sample 2, Component 4)</td></tr>
<tr><td colspan="8">Data Item 9
(Sample 3, Component 1)</td><td colspan="8">Data Item 10
(Sample 3, Component 2)</td><td colspan="8">Data Item 11
(Sample 3, Component 3)</td><td colspan="8">Data Item 12
(Sample 3, Component 4)</td></tr>
<tr><td colspan="8">Data Item 13
(Sample 4, Component 1)</td><td colspan="8">Data Item 14
(Sample 4, Component 2)</td><td colspan="8">Data Item 15
(Sample 4, Component 3)</td><td colspan="8">Data Item 16
(Sample 4, Component 4)</td></tr>
</table>

(b)

Figure B.8-12: Sample Vector

Figure B.8-13 shows the use of channel tags with a 4-dimensional sample vector. This example is the same as the sample vector in example shown in Figure B.8-12, but each 8-bit sample is placed in a 10-bit packing field, with the remaining two bits used as channel tags. In this example the channel tags are used to identify each vector component.

Data Packet Payload Format	Real/Complex	Format
12382003 00000000	Real	Unsigned Fixed Pt.
12382003 00000010	Real	Signed Fixed Pt.

(a)

<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="8">Data Item 1
(Sample 1, Component 1)</td><td>0</td><td>0</td><td colspan="8">Data Item 2
(Sample 1, Component 2)</td><td>0</td><td>1</td><td colspan="8">Data Item 3
(Sample 1, Component 3)</td><td>1</td><td>0</td><td>U</td><td>U</td></tr>
<tr><td colspan="8">Data Item 4
(Sample 1, Component 4)</td><td>1</td><td>1</td><td colspan="8">Data Item 5
(Sample 2, Component 1)</td><td>0</td><td>0</td><td colspan="8">Data Item 6
(Sample 2, Component 2)</td><td>0</td><td>1</td><td>U</td><td>U</td></tr>
<tr><td colspan="8">Data Item 7
(Sample 2, Component 3)</td><td>1</td><td>0</td><td colspan="8">Data Item 8
(Sample 2, Component 4)</td><td>1</td><td>1</td><td colspan="8">Data Item 9
(Sample 3, Component 1)</td><td>0</td><td>0</td><td>U</td><td>U</td></tr>
<tr><td colspan="8">Data Item 10
(Sample 3, Component 2)</td><td>0</td><td>1</td><td colspan="8">Data Item 11
(Sample 3, Component 3)</td><td>1</td><td>0</td><td colspan="8">Data Item 12
(Sample 3, Component 4)</td><td>1</td><td>1</td><td>U</td><td>U</td></tr>
</table>

(b)

Figure B.8-13: Sample Vector with Channel Tags

Figure B.8-14 demonstrates Channel Repeating with a 4-deimensional sample vector, where several consecutive samples from the one source are grouped and packed in the payload before the same samples from the next source are grouped and packet in the payload. In this example, 4 consecutive samples from each source are repeated.

Data Packet Payload Format	Real/Complex	Format
0E380003 00030000	Real	Unsigned Fixed Pt.
0E380003 00030010	Real	Signed Fixed Pt.

(a)

<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="8">Data Item 1
(Sample 1, Component 1)</td><td colspan="8">Data Item 2
(Sample 2, Component 1)</td><td colspan="8">Data Item 3
(Sample 3, Component 1)</td><td colspan="8">Data Item 4
(Sample 4, Component 1)</td></tr>
<tr><td colspan="8">Data Item 5
(Sample 1, Component 2)</td><td colspan="8">Data Item 6
(Sample 2, Component 2)</td><td colspan="8">Data Item 7
(Sample 3, Component 2)</td><td colspan="8">Data Item 8
(Sample 4, Component 2)</td></tr>
<tr><td colspan="8">Data Item 9
(Sample 1, Component 3)</td><td colspan="8">Data Item 10
(Sample 2, Component 3)</td><td colspan="8">Data Item 11
(Sample 3, Component 3)</td><td colspan="8">Data Item 12
(Sample 4, Component 3)</td></tr>
<tr><td colspan="8">Data Item 13
(Sample 1, Component 4)</td><td colspan="8">Data Item 14
(Sample 2, Component 4)</td><td colspan="8">Data Item 15
(Sample 3, Component 4)</td><td colspan="8">Data Item 16
(Sample 4, Component 4)</td></tr>
<tr><td colspan="8">Data Item 17
(Sample 5, Component 1)</td><td colspan="8">Data Item 18
(Sample 6, Component 1)</td><td colspan="8">Data Item 19
(Sample 7, Component 1)</td><td colspan="8">Data Item 20
(Sample 8, Component 1)</td></tr>
<tr><td colspan="8">Data Item 21
(Sample 5, Component 2)</td><td colspan="8">Data Item 22
(Sample 6, Component 2)</td><td colspan="8">Data Item 23
(Sample 7, Component 2)</td><td colspan="8">Data Item 24
(Sample 8, Component 2)</td></tr>
</table>

(b)

Figure B.8-14: Channel Repeating

Figure B.8-15 shows Sample Component Repeating for complex data formats, where the real or amplitude component is for several consecutive samples is packed in the payload before the imaginary or phase component is packed for the same samples. This example demonstrates a sample component repeat count of four.

Data Packet Payload Format	Real/Complex	Cartesian Format	Polar Amplitude Format	Polar Phase Format
0E380003 00038020	Complex Cartesian	Signed Fixed Pt.	n/a	n/a
0E380003 00038060	Complex Polar	n/a	Unsigned Fixed Pt.	Unsigned Fixed Pt.
0E380003 00038040	Complex Polar	n/a	Unsigned Fixed Pt.	Signed Fixed Pt.

(a)

<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="8">Data Item 1
(Sample 1 Real/Ampl)</td><td colspan="8">Data Item 2
(Sample 2 Real/Ampl)</td><td colspan="8">Data Item 3
(Sample 3 Real/Ampl)</td><td colspan="8">Data Item 4
(Sample 4 Real/Ampl)</td></tr>
<tr><td colspan="8">Data Item 5
(Sample 1 Imag/Phase)</td><td colspan="8">Data Item 6
(Sample 2 Imag/Phase)</td><td colspan="8">Data Item 7
(Sample 3 Imag/Phase)</td><td colspan="8">Data Item 8
(Sample 4 Imag/Phase)</td></tr>
<tr><td colspan="8">Data Item 9
(Sample 5 Real/Ampl)</td><td colspan="8">Data Item 10
(Sample 6 Real/Ampl)</td><td colspan="8">Data Item 11
(Sample 7 Real/Ampl)</td><td colspan="8">Data Item 12
(Sample 8 Real/Ampl)</td></tr>
<tr><td colspan="8">Data Item 13
(Sample 5 Imag/Phase)</td><td colspan="8">Data Item 14
(Sample 6 Imag/Phase)</td><td colspan="8">Data Item 15
(Sample 7 Imag/Phase)</td><td colspan="8">Data Item 16
(Sample 8 Imag/Phase)</td></tr>
</table>

(b)

Figure B.8-15: Sample Component Repeating for Complex Data Formats

Appendix B.9 ECEF and Relative Ephemeris Example

This section presents an example where the Relative Ephemeris from one IF Context Packet is combined with the ECEF Ephemeris from another IF Context Packet. For simplicity, this example is limited to two dimensions.

Consider the aircraft platform shown in Figure B.9-1. The location of an antenna on the wing of this aircraft is known in the Relative Ephemeris Coordinate System (RCS). The origin of the RCS is chosen to be at the location of a GPS antenna near the rear of the aircraft. The x′ axis is directed along the heading of the aircraft. The y′ axis is at a right angle to the x′ axis in the plane of the aircraft. The antenna in question is located at the point $P'=(x_1', y_1')$ in the RCS. The antenna itself is directed at an angle α' from the x′ axis.

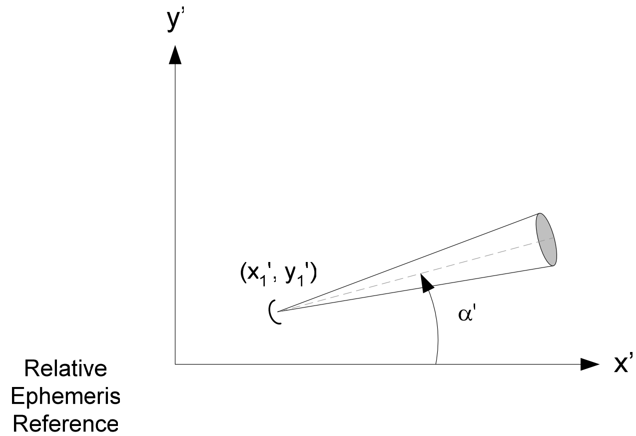


Figure B.9-1: Location and attitude of antenna in the Relative Ephemeris Coordinate System

The antenna is at coordinates (x_1', y_1') with respect to the aircraft GPS.

The GPS antenna is a convenient location for the RCS origin because the location of the GPS antenna can be determined in the ECEF Coordinate System (ECS). Consider the arrangement shown in Figure B.9-2 where the origin of the ECS is at the center of the earth. Because this is a two-dimensional example, aircraft is in the plane of the earth's equator. The GPS is located at the point $P_0=(x_0, y_0)$ in the ECS and the aircraft heading is at an angle of θ with respect to the prime meridian. With this information, the location of the antenna on the aircraft wing can be calculated with the proper transformation equation.

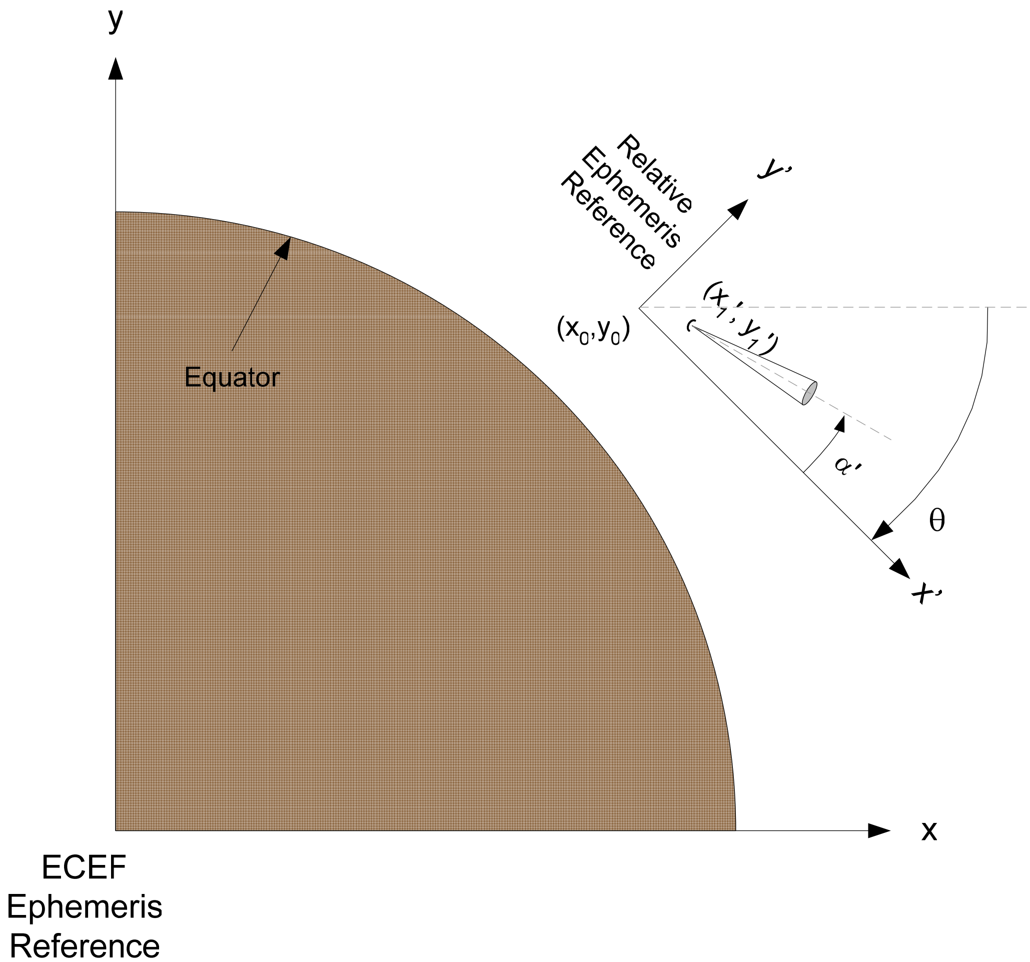


Figure B.9-2: Location and attitude of antenna in the ECEF Coordinate System

The GPS of the aircraft is at (x_0, y_0) and the aircraft has a heading of θ.

This aircraft platform carries the VRT system shown in Figure B.9-3. Here the coordinates of the antenna in the RCS are given in the IF Context Packet of the antenna. The coordinates for the GPS and heading of the aircraft in the ECS are given in the IF Context Packet for the GPS. To link the two coordinate systems together, the Antenna IF Context Packet Stream also contains the Ephemeris Reference ID field that contains the Stream ID of the GPS. The transformation between the RCS and ECS must also be provided in the Information Class documentation.

For this two-dimensional example, the transformation equations could be expressed as:

$$\underset{P}{\begin{bmatrix} x \\ y \\ 1 \end{bmatrix}} = \underset{T(P_0)}{\begin{bmatrix} 1 & 0 & x_0 \\ 0 & 1 & y_0 \\ 0 & 0 & 1 \end{bmatrix}} \underset{R(\theta)}{\begin{bmatrix} \cos\theta & -\sin\theta & 0 \\ \sin\theta & \cos\theta & 0 \\ 0 & 0 & 1 \end{bmatrix}} \underset{T(-P_0)}{\begin{bmatrix} 1 & 0 & -x_0 \\ 0 & 1 & -y_0 \\ 0 & 0 & 1 \end{bmatrix}} \underset{P'}{\begin{bmatrix} x' \\ y' \\ 1 \end{bmatrix}}$$

and

$$\alpha = \theta + \alpha'$$

which rotates the point $P'=(x', y')$ an angle of θ about the point $P_0=(x_0, y_0)$, where P and P′ are the location of the antenna in question in the RCS and ECS, respectively, P_0 is the location of the GPS in the ECS, and α is the heading of the aircraft in the ECS. T() is a translation matrix, and R() is a rotation matrix.

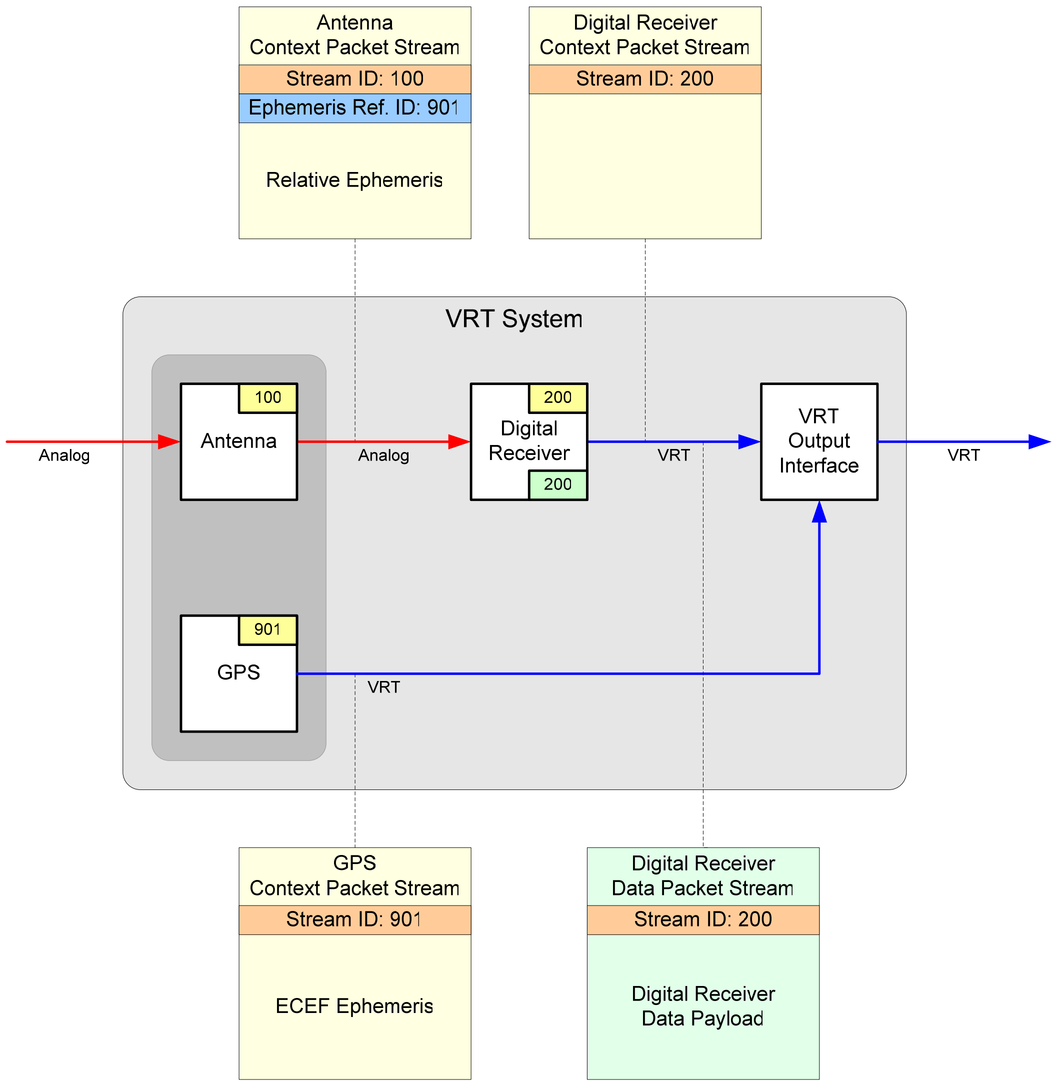


Figure B.9-3: Block diagram for ECEF and Relative Ephemeris Example

The Ephemeris Reference ID field of the Antenna contains a value of 901, the Stream ID of the GPS.

Appendix B.10 Input Source Stream Association List Example

The example in this section illustrates the use of the Input Source Stream Association List, also referred to as the Input Source List. Figure B.10-1 shows a system with three cascaded VRT processes: a digital receiver, a DDC, and a demodulator. The receiver is the source for the data the DDC uses as an input, and the DDC is the input source for the demodulator.

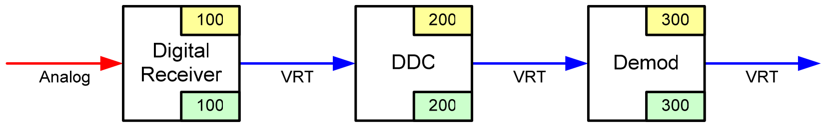


Figure B.10-1: Block diagram for Input Source List Example

Clearly the settings of the receiver, DDC, and demodulator would affect the interpretation of the data at the output of the demodulator. Therefore, one Information Stream for this system would contain the demodulator's Data Packet Stream and the Context Packet Streams of the upstream processes.

Figure B.10-2 shows the content of the Data and Context Packets in this Information Stream. The Stream ID for the demodulator Context Packet Stream, 300, matches the Stream ID for the demodulator Data Packet Stream. Therefore the demodulator Context Packet Stream is <u>directly associated</u> to the demodulator Data Packet.

The demodulator Context Packet Stream also contains an entry of 200 in its Input Source List, shown in blue, which is the Stream ID of the DDC Context Packet Stream. In this way, the Context Packet Stream of the DDC is associated to the Data Packet Stream of demodulator. Association through the Stream Association Lists is known as <u>contextual association</u>. Because contextual association is indirect, is not as strong as direct association.

The Context Packet Stream for the receiver is also attached to the demodulator's Data Packet Stream through the Input Source List in the DDC. The entire chain of Data Packet Stream and associated Context Packet Streams comprises the Information Stream.

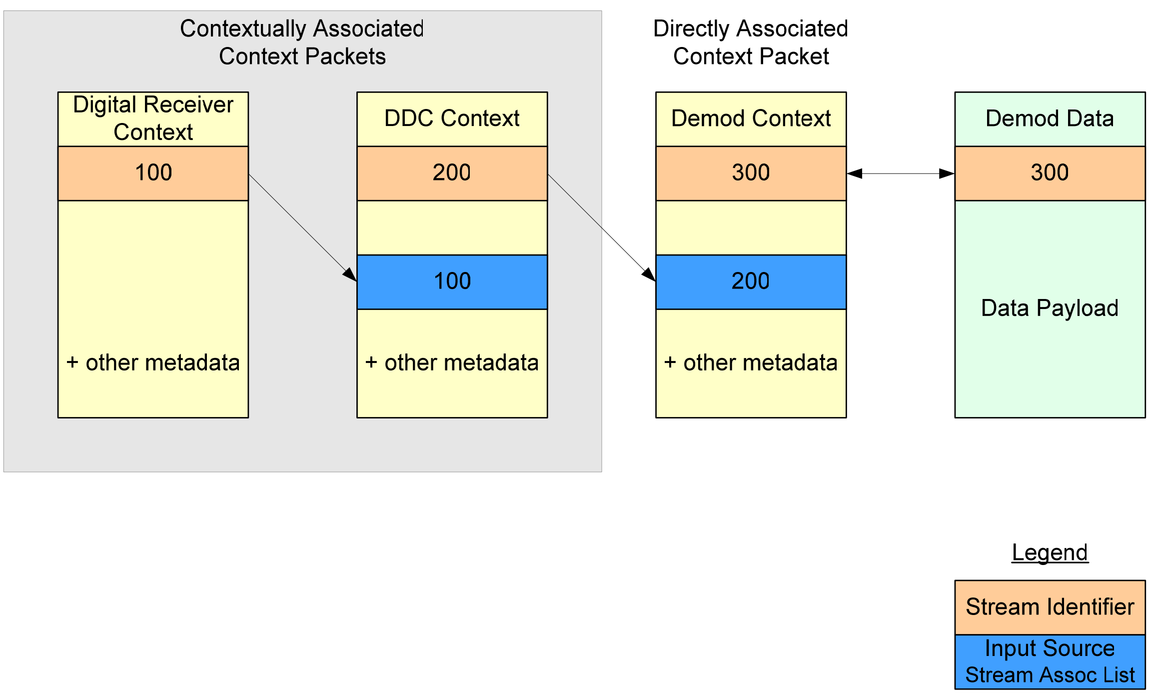


Figure B.10-2: Representation of Input Source Stream Associations

The demodulator Information Stream can also be represented with the association diagram shown in Figure B.10-3. Here the contents of each Context Packet Stream are not shown, only the associations between different packet streams.

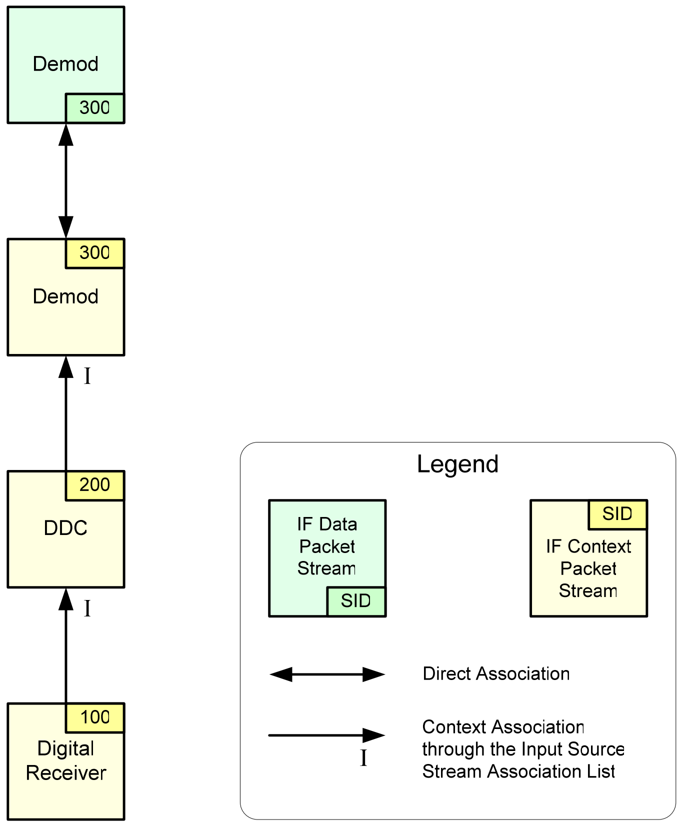


Figure B.10-3: Association Diagram for the Input Source List Example

The demodulator Data Packet Stream forms the head of this Information Class. The demodulator Context Packet Stream is directly to the Data Packet Stream, as indicated by the double-headed arrow and the matching Stream Identifiers of 300. The DDC's context is associated to this Information Stream by being included in the Input Source List of the demodulator. This is represented by the single-headed arrow with the "I" for Input Source. Similarly, the receiver's context is associated to the Information Stream by being included in the Input Source List of the DDC.

Appendix B.11 Vector Component Stream Association List Example

The example in this section illustrates the use of the Vector Component Stream Association List, also referred to as the Vector List. Figure B.11-1 shows a system with a digital receiver followed by a 64-channel channelizer.

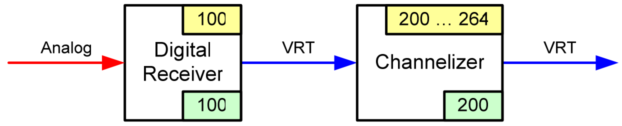


Figure B.11-1: Block diagram for Vector Component List Example

The channelizer creates an IF Data Packet Stream where the output of each of the 64 channels is interleaved following the rules in Section 6.1.5.3. This vectorized Data Packet Stream has a Stream ID of 200. The Channelizer also generates a directly associated IF Context Packet Stream with the same Stream ID of 200. This Context Packet Stream can contain context information that is common to all of the 64 channels, such as Reference Level or Bandwidth, if applicable.

More importantly for this example, the common channelizer Context Packet Stream contains the Vector Component Stream Association List. This list contains the ordered Stream IDs for the Context Packet Streams for each of the 64-channels. This associates a unique Context Packet Stream to each of the 64 components of the vector in the Data Packet Stream. The Context Packet Streams for the component channels have Stream IDs from 201 to 264. They contain context information that is specific to each channel, such as RF Reference Frequency Offset. Because the receiver is the input source to each of the channels of the channelizer, each contains an Input Source List with the stream ID of the receiver. The content of the Data and Context Packet Streams for this system is shown in Figure B.11-2.

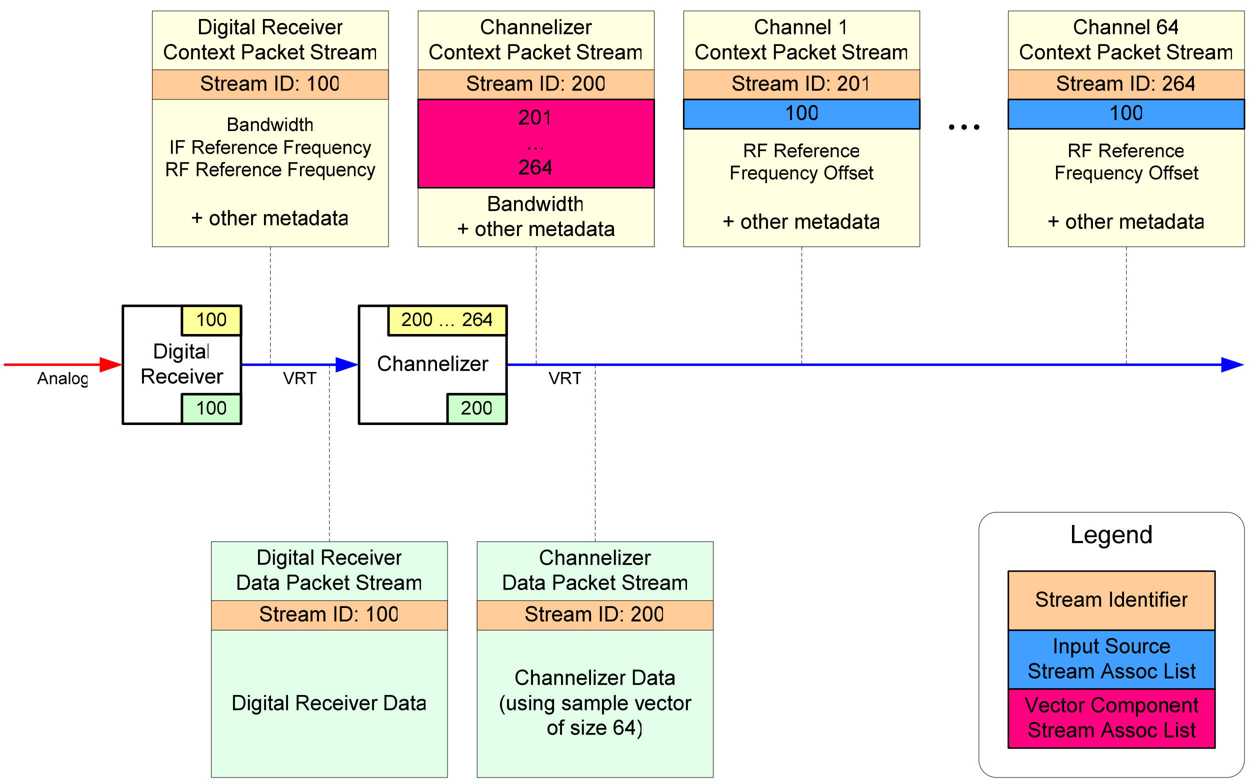


Figure B.11-2: Context Packet contents for the Vector Component List Example

The association diagram for the Digital Receiver and Channelizer Information Streams are shown in Figure B.11-3. Each vector component of the channelizer is associated to the common channelizer through the Vector Component Stream Association List, represented by the single-headed arrow marked with a “V”. Each of the component channels also associates in the receiver through the Input Source List.

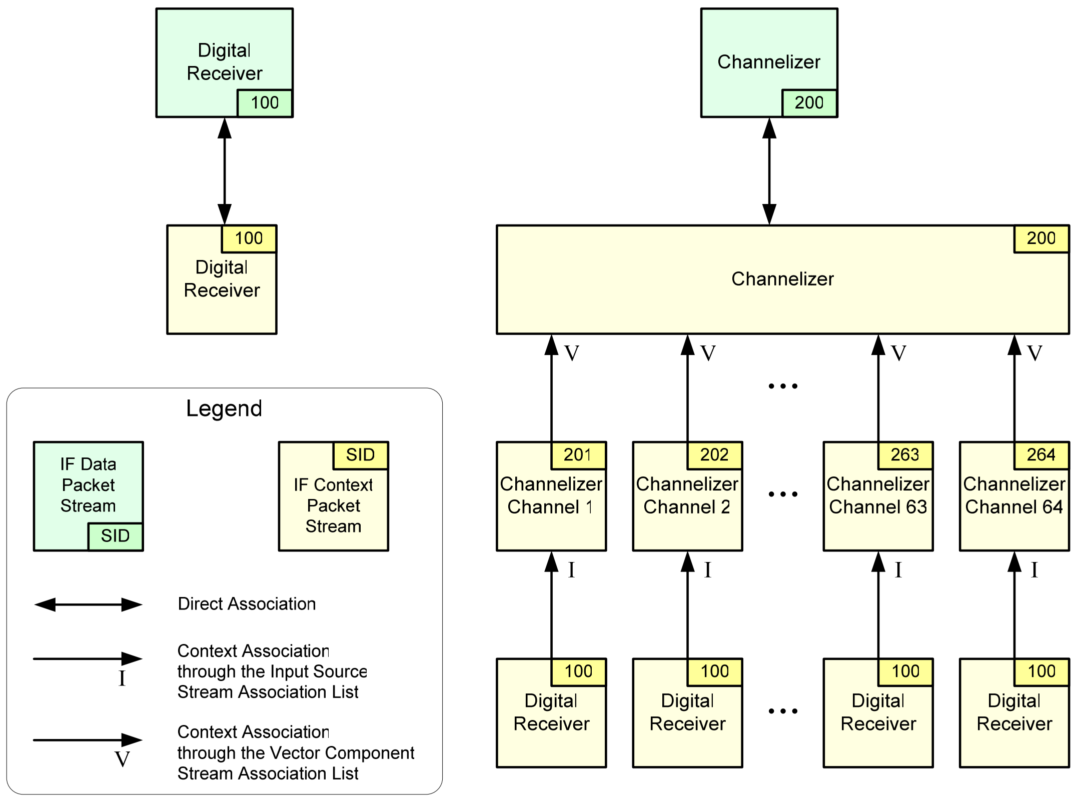


Figure B.11-3: Association Diagram for the Vector Component List Example

Appendix B.12 System Stream Association List Example

The example in this section illustrates the use of the System Stream Association List, also referred to as the System List. The Input Source and Vector Component List are used to associate context that is directly related to the signal path. The System List is used to associate context that is typically not in the signal path, and can't be associated using the other Stream Association Lists.

Figure B.12-1 shows a system where GPS equipment is co-located with a digital receiver, and a temperature sensor measures the heat in a DDC card. The GPS is associated to the receiver and the temperature sensor is associated to the DDC through the System List.

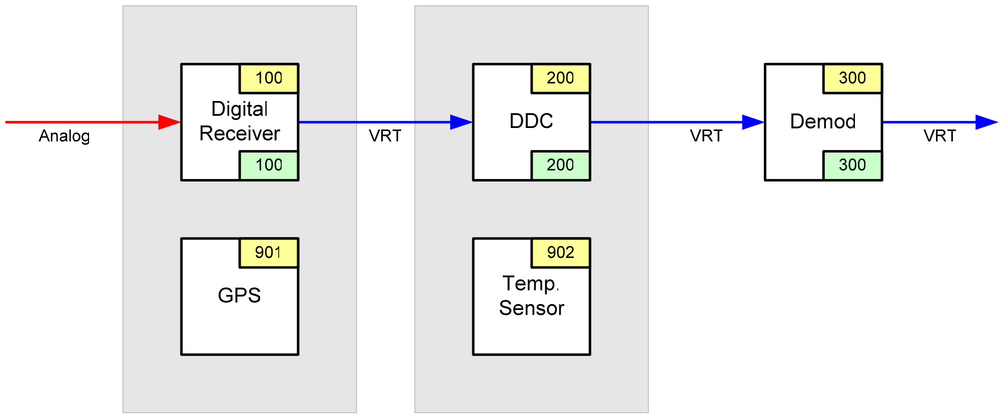


Figure B.12-1: Block diagram for System List Example

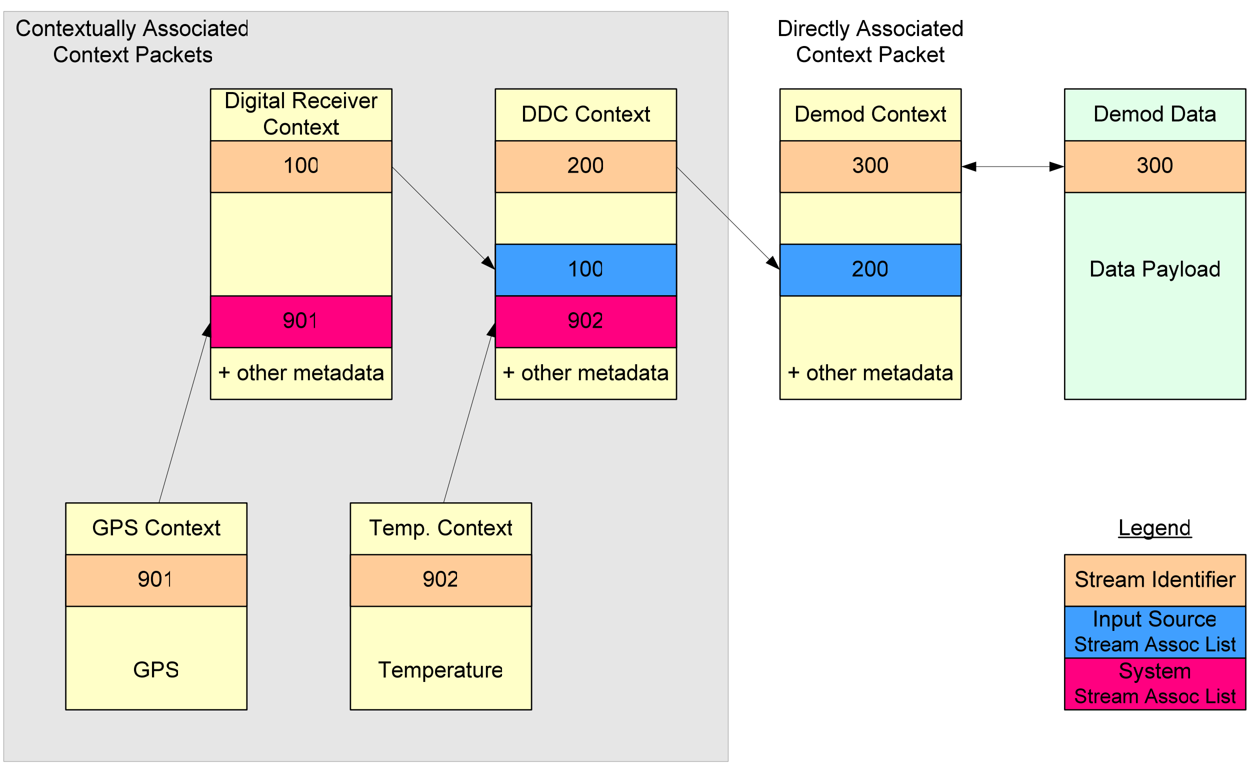


Figure B.12-2: Representation of System Stream Associations

Figure B.12-2 shows the content of the Data and Context Packet Streams in the demodulator's Information Stream. The receiver's Context Packet Stream contains a System List that includes the Stream ID of the GPS's Context Packet Stream, 901. The context of the temperature sensor is associated to the DDC in the same fashion. The Input Source List is also used as described in Appendix B.10.

The association diagram for this system is shown in Figure B.12-3. The GPS and temperature Context Packet Streams are associated into the Information Stream through the System Stream Association List, represented by the single-headed arrow marked with an "S". The Input Source List is used to associate the processes in the signal path.

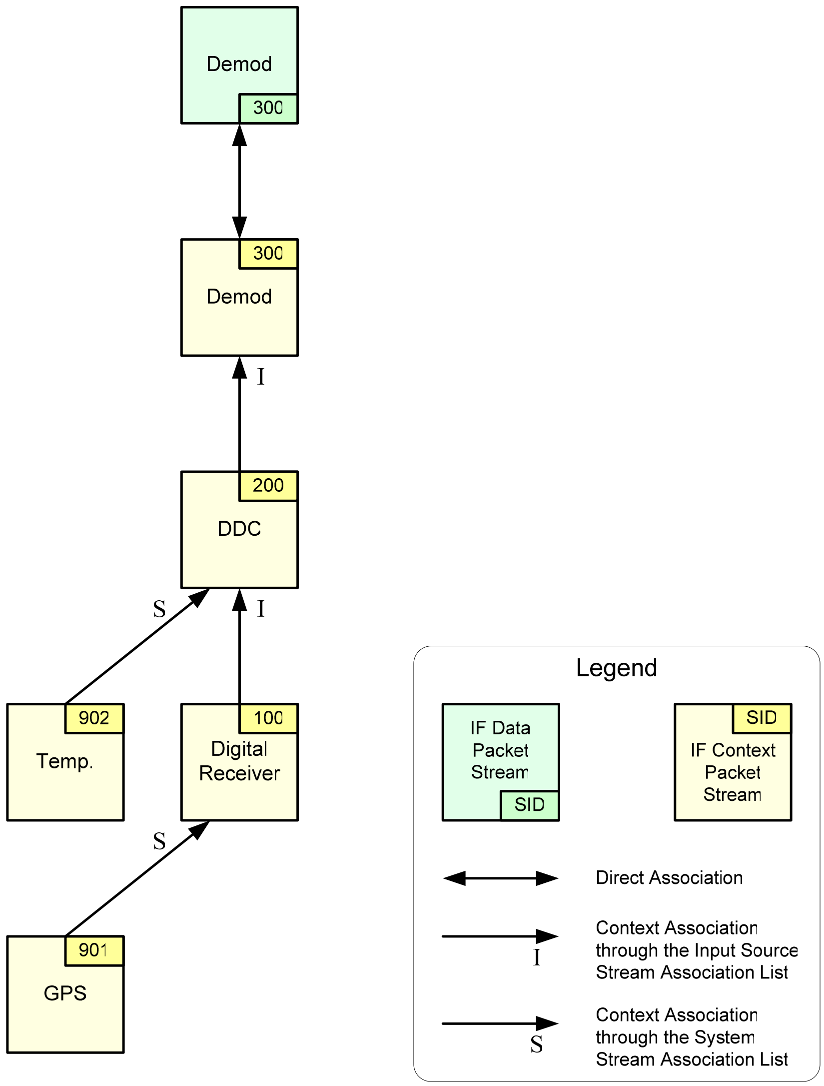


Figure B.12-3: Association Diagram of System List Example

Appendix B.13 Extension Context Packet Stream Example

Example showing a lot of reuse of the IF Context Packet to drive home the point. Is it worth it?