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COBHAM Application Note - Spectral Stitching With the VST

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COBHAM White Paper VST Basics Programming Guide

1 Introduction

Spectral Stitching is the name for the technique of performing multiple vector digitizer captures and combining the IQ to provide a single spectral result.

Two reasons for doing spectral stitching exist the first being the case where the requested measurement span is greater than the digitizers actual span and the second being when LO leakage and aliasing problems need to be avoided.

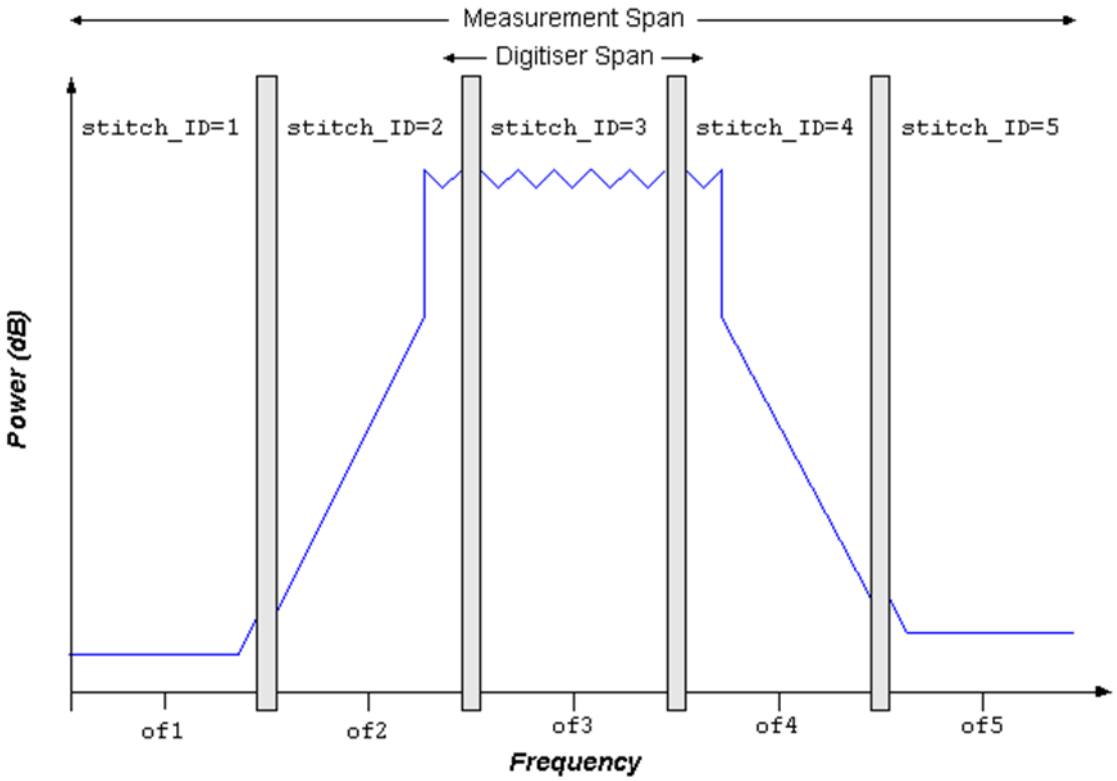


Figure 1- Spectral Stitching When the Measurement Span > Digitizer Span

This application note explains when to perform spectral stitching and how to do it with the National Instrument Vector Signal Tranciever (VST) 5644R/5645R and 5646R models.

1.1 The Purpose of this document

This document is intended to bring together in one document a simple explanation of using Cobham analysis libraries for stitched spectral measurement when using the NI VST.

1.2 Intended Audience

This application note is aimed at customers or Cobham Application engineers who are using Cobham analysis libraries in conjunction with the NI VST.

1.3 Scope

This document is relevant for any NI VST module 5644r/5645r/5646r although 5644r is used as an example throughout. The scope does not extend to any information about specific measurements you can make with Cobham analysis libraries. It extends only to the mechanics of making a stitched spectrum with a VST using Cobham analysis libraries.

1.4 Where Can I Get More Information?

The National Instrument RFSA help file provides information on programming to the VST while application notes "VST Basics Programming Guide" and "Using the VST with COBHAM Software" provide more information on programming to the VST and using Cobham software with the VST.
A C/C++ example is provided with this application showing in full how to do spectral stitching.

1.5 What Programming Languages Can I Use?

- C / C++

2 When to do Spectral Stitching

When using Cobham analysis libraries to make measurement of spectral parameters such as SEM and ACLR where because the bandwidth of the measurement it cannot be performed in a single capture. The Cobham Analysis libraries support making spectral measurements at the same time as non-spectral measurements such as 'Modulation Accuracy' but only if the spectral measurement can be achieved in a single capture. If the spectral measurement requires stitching and you still require making additional non-spectral measurements then additional IQ captures may be required.

2.1 Measurement Span is Greater Than Digitizer Span

In the case of the VST 5644R the instantaneous maximum band is limited to 80MHz. Therefore if a measurement span of 90 MHz is required then this could only be achieved by making multiple IQ captures and then performing spectral stitching. However to avoid LO leakage and aliasing issues an artificially lower instantaneous maximum bandwidth is used.

2.2 Avoiding LO Leakage and Aliasing

Before the VST reaches its maximum instantaneous bandwidth it can start to see LO leakage and aliasing issues in the spectral domain. Cobham recommend a small bandwidth, moving the position of the local oscillator (LO) to avoid these issues.

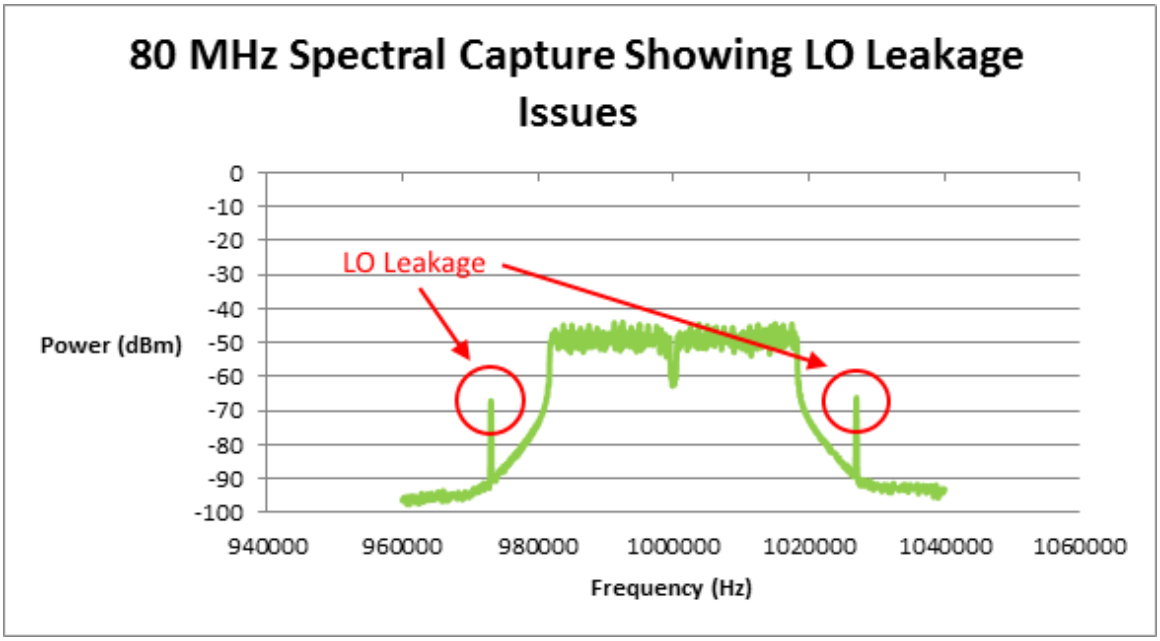


Figure 2 - 80 MHz Spectral Capture Showing LO Leakage Problem

3 How to do Spectral Stitching

Spectral stitching is performed by the Cobham analysis libraries on a series of IQ captures. All that is required is that these IQ captures are of the appropriate bandwidth at the correct frequency and with the LO positioned appropriately. The correct bandwidth and therefore correct LO position can be determined from the information in Table 1.

Model	Region 1		Region 2		Region 3	
	Frequency Range	Maximum Usable Span	Frequency Range	Maximum Usable Span	Frequency Range	Maximum Usable Span
5644R	65 MHz to 109 MHz	10 MHz	109 MHz to 6GHz	27 MHz	N/A	
5645R	65 MHz to 109 MHz	10 MHz	109 MHz to 6GHz	27 MHz	N/A	
5646R	65 MHz to 109 MHz	10 MHz	109 MHz to 200 MHz	27 MHz	200 MHz to 6 GHz	38 MHz

Table 1- Usable Bandwidth for Each Frequency Region for 5644/5/6R

3.1 Determine If Stitching is required

The Cobham analysis libraries can be used to determine if stitching is required by setting it up with the desired measurement span and a digitizer bandwidth appropriate for the center frequency of the signal. If the measurement span causes the capture span to be in a different region then the lowest bandwidth for all stitches will be used. A flow chart depicting the process can be seen in Spectral Stitching Flow Chart on page 8.

The following examples all make use of the Cobham Spectrum library but the principal is the same for all analysis libraries. Once setup a simple call to the `afSpectrumDll_Spectrum_NumStitches_Get(…)`method will return the number of stitches required.

3.1.1 C / C++ Example

```
double MeasurementSpan = 80e6;
double digitizerStitchingBw = 27e6;

// Set the measurement span. This is the entire spectrum that is to be measured.
afSpectrumDll_MeasurementSpan_Set(spectrumObj,MeasurementSpan);

// For the VST to avoid LO and aliasing issues we set the digitizer span to less than the
maximum to avoid LO and alias issues.
afSpectrumDll_DigitizerSpan_Set(spectrumObj, digitizerStitchingBw);

long numberOfStitches = 0;

// Work out how many stitches will be required.
afSpectrumDll_Spectrum_NumStitches_Get(spectrumObj,&numberOfStitches);
```

3.2 Determine the Capture Frequencies

Once the number of stitches has been determined the capture frequencies need to be calculated. This is done by setting the analysis library stitch index and then making a call to query the stitch offset from the center frequency.

3.2.1 C / C++ Example

```
// Set the Stitch index. (Indexing starts at 1 not 0)
afSpectrumDll_Spectrum_StitchIndex_Set(spectrumObj,stitchIndex+1);

// Set the Digitizer to the correct centre frequency for this stitch
double offsetFreqForStitch = 0;
afSpectrumDll_Spectrum_StitchOffsetFreq_Get(spectrumObj,&offsetFreqForStitch);
```

3.3 Determine the LO position for Each Capture

For each capture the LO position needs to be determined. As a general rule it can be set to Span + 2 MHz to the right of the center frequency of the capture with a call to the ‘NIRFSA_ATTR_DOWNCONVERTER_FREQUENCY_OFFSET’ attribute. However, if the capture starts in one region, and right-side placement puts the LO in a different region, we will use left-side placement. If the right-side placement places the LO to be above 6 GHz then it can be moved below the center frequency.

3.3.1 C / C++ Example

```
ViReal64 StitchFrequency  = 5e9;        // 5 GHz
ViReal64 Span             = 27e6;       // Assume we're using a 5644R
ViReal64 LoOffset         = Span + 2e6; // The Span plus 2 MHz
ViReal64 startFreq        = StitchFrequency - (CaptureSpan /2);

// Determine Correct LO offset value;
if (startFreq + LoOffset > 6e9 )
{
     // LO will be out of range so set LO below.
     LoOffset = LoOffset * -1;
}
else if ( startFreq  >= MinimumFrequencyRegion1 && startFreq <= MaximumFrequencyRegion1) // Reg 1
 {
     // We always try to place the LO to the right of the actual spectrum that we will
     // use, which means, in most cases VST LO frequency > RF Centre Frequency.
     // However, if the segment starts in one region, and right-side placement puts the
     // LO in a different region, we will use left-side placement.
      if (StitchFrequency  + LoOffset > MaximumFrequencyRegion1)
      {
           LoOffset = LoOffset * -1;
      }
      else
        {
                LoOffset = LoOffset * -1;
        }
 }

// Set the LO offset using the NIRFSA_ATTR_DOWNCONVERTER_FREQUENCY_OFFSET
niRFSA_SetAttributeViReal64(vsa, VI_NULL, NIRFSA_ATTR_DOWNCONVERTER_FREQUENCY_OFFSET, LoOffset);
```

Putting It All Together

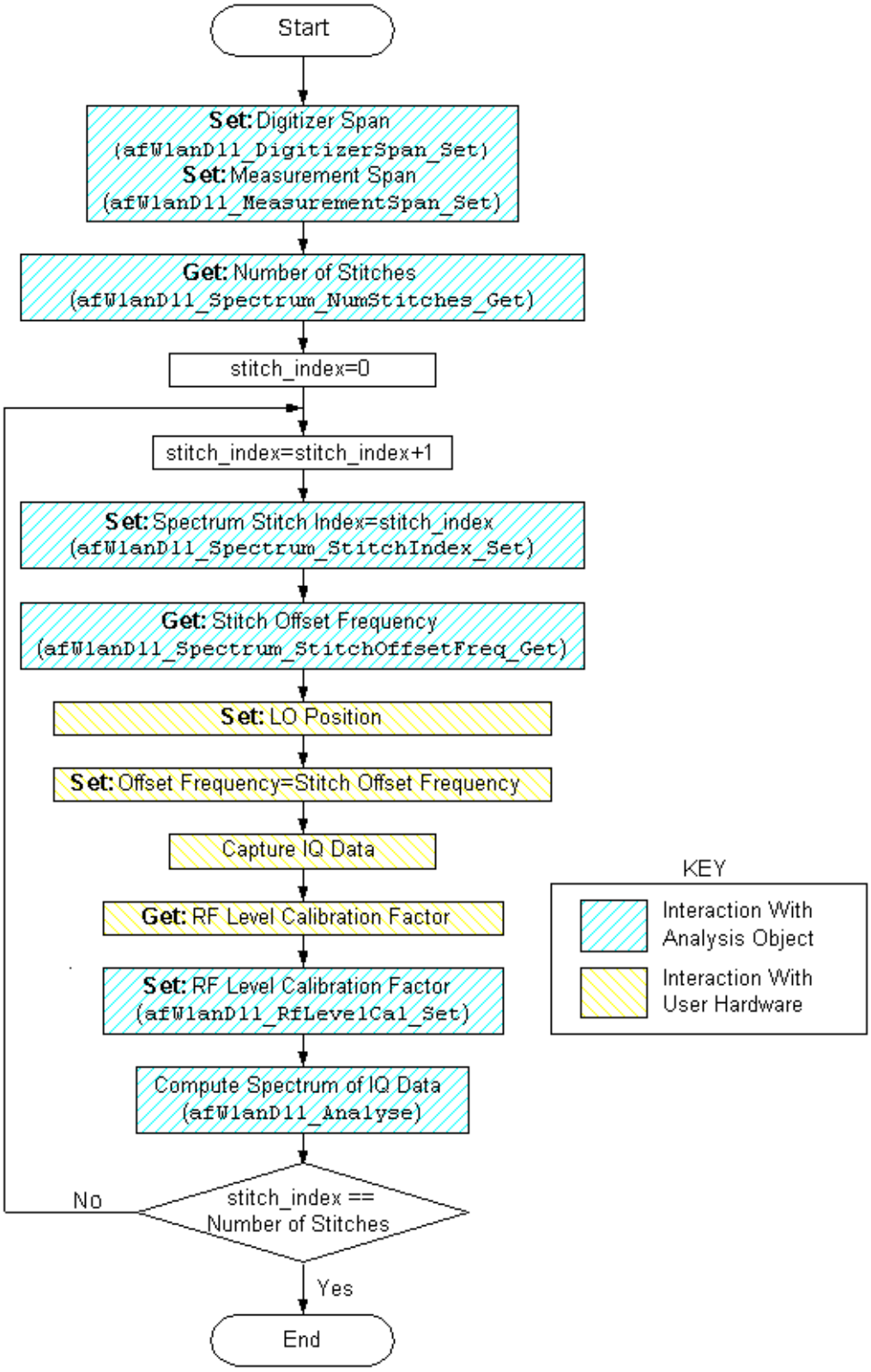
Each IQ Capture needs to be processed by the Cobham analysis library with the correct stitch index set. The approach typically taken is to perform the set stitch index step, calculate offset, step, calculate LO offset step, capture step and analyse steps in a loop until all stitches have been processed.

3.3.2 C / C++ Example

```
for (int stitchIndex = 0; stitchIndex < numberOfStitches; stitchIndex++)
{
        // Set the stitch index
        afSpectrumDll_Spectrum_StitchIndex_Set(spectrumObj,stitchIndex+1);

        // Set the Digitizer to the correct centre frequency for this stitch
        double offsetFreqForStitch = 0;
        afSpectrumDll_Spectrum_StitchOffsetFreq_Get(spectrumObj,&offsetFreqForStitch);

        // Perform the capture.
        Capture(vsa, CarrierFrequency + offsetFreqForStitch, ReferenceLevel,
numberOfSamples, sampleRate,LO_AUTO,digitizerStitchingBw, Model, iData,
qData,&key,&tag);

        // Call the analyse method passing in the measurements to make and the IQ.
        afSpectrumDll_Analyse(spectrumObj, measurements, iData, qData,numberOfSamples);
}

// Work out how many points in the trace we're going to pull back.
afSpectrumDll_GetTraceDataLength(spectrumObj,traces,&traceLength);

// Create an array to hold them
double *xTraceData = new double[traceLength];
double *yTraceData = new double[traceLength];

// Retrieve the trace
```

```
afSpectrumDll_GetTraceData(spectrumObj,traces,xTraceData,yTraceData,traceLength);
```

4 Spectral Stitching Flow Chart



5 Example Code

To accompany this Application Note an example has been written:

Example 6 – Playing out an IQCreator 802.11AC 40 MHz waveform out of the RFSG and performing a 80 MHz spectral measurement using multiple stitches to avoid LO leakage and alias issues using the RFSA and the Cobham Spectrum Analysis library.