

# Selection and Integration of a Signal Processing Package for a SystemVerilog/VMM Verification Environment

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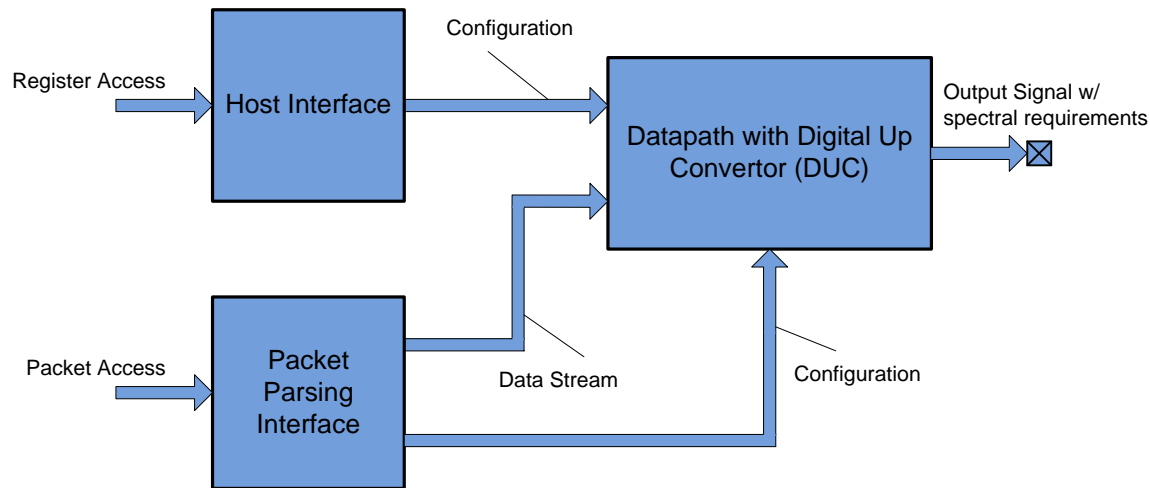
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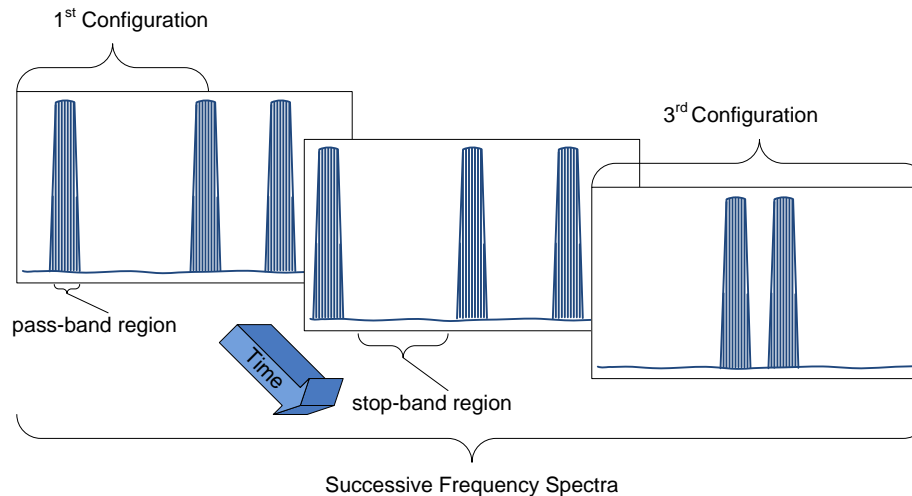
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## Device Under Test Background



- High Bit Rate GSM/LTE Wireless System
- Dynamic Spectral Requirements
- Time and Frequency Domain Requirements

# Dynamic Frequency Spectrum



- System timing controls characteristics of successive frequency spectra
- Simplified spectra shown, could vary in bandwidth, magnitude, roll-off

## Verification Environment Requirements

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- Random and dynamic frequency spectrum and data
- Self checking, regression friendly
  - Multiple regression clusters with varying platforms
- Ease of integration, maintainability and reusability
  - Low LOE for environment development
- Closed loop operation, including Signal Processing functionality

## Signal Processing Package Comparison Summary

Feature	Matlab	Octave	IT++	GSL	SPUC
License Model	Proprietary	Open Source	Open Source	Open Source	Open Source
Interface Type	M-file	M-file	C/C++	C/C++	C/C++
M-file compatible	Yes	Mostly	Limited	No	No
Complex Data	Yes	Yes	Yes	Yes	Yes
FFT	Yes	Yes	Yes	Yes	Yes
FIR Filters	Yes	Yes	Yes	Yes	Yes
Comm Functions	Yes	Yes	Yes	No	Yes

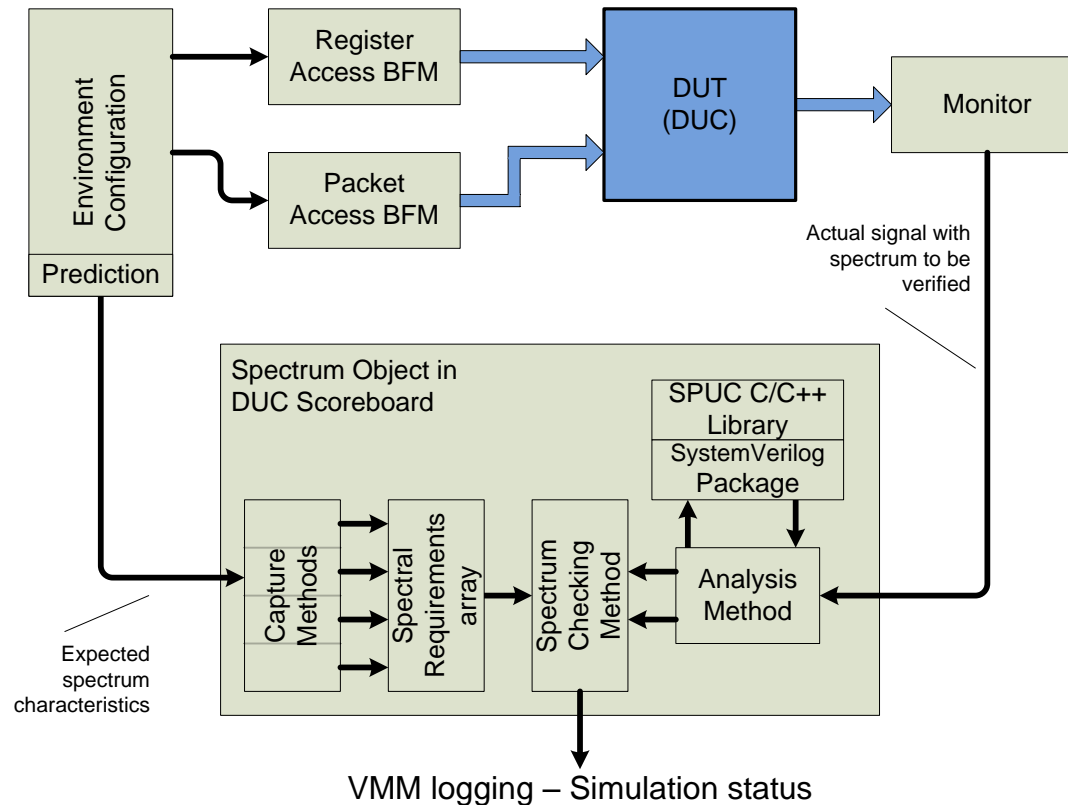
- Comparison circa May 2009
- SPUC Package selected

## Signal Processing Using C++ (SPUC) - Selected

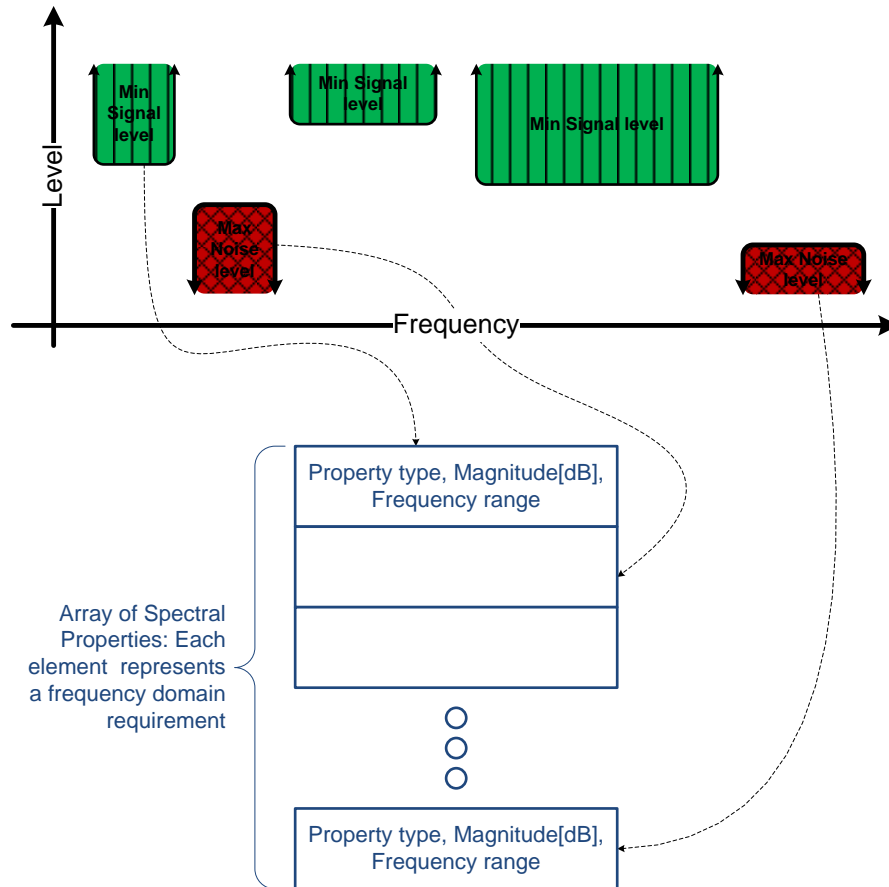
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- Can be compiled as a complete library, or usable as discrete modules
- Very portable – easily built on 3 different platforms
- Wide range of functionality
  - Complex Signal type
  - FFT, Windowing, Transcendentals
  - Modulation, Demodulation
- Templates (useful for bit width extensions)
- No structured methodology for conversion to/from Matlab
- SPUC: <http://spuc.sourceforge.net>

# Verification Environment Detail



# Spectral Requirement Properties



- Signal or Noise Magnitude
- Applicable Frequency Range
- Characteristic Type

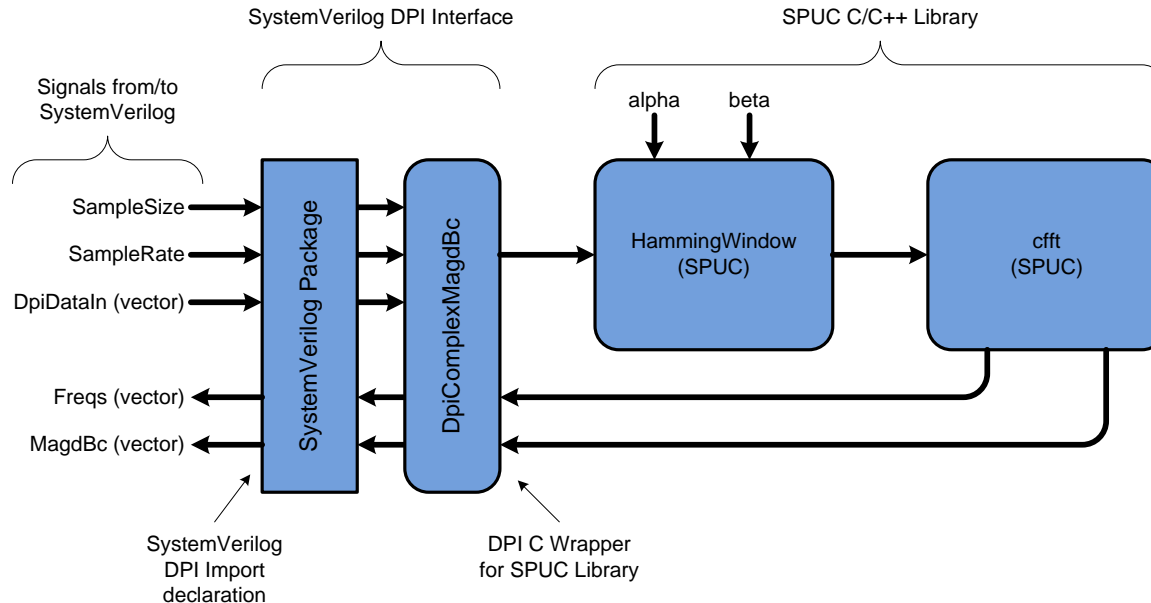


## Checking versus Generic Spectral Analysis

- Check to Specification simplification
  - No Filter roll-off verification (done at block level)
  - Easily integrates with SystemVerilog
- No Peak detection, Edge detection, etc.

```
// helper function, magnitude has to be less than threshold w/in range
function int CheckNoiseProperty ( int Magnitude, int FreqLoHz, int FreqHiHz );
int ErrorCount = 0;
`vmm_note(log,$psprintf("CheckNoiseProperty%0s: mag=%0d, range=[%0d,%0d]",
    SpectrumApplication, Magnitude, FreqLoHz, FreqHiHz));
for ( int f=GetFreqIndex(FreqLoHz,1); f<=GetFreqIndex(FreqHiHz,0); f++ ) begin
    if ( MagnitudeBc[f] > Magnitude ) begin
        ErrorCount++;
    end
    // only print out the first 10 or so measurements, otherwise too many at
    // end of spectrum check
    if ( SpectrumDebugPrintCheck && (f < GetFreqIndex(FreqLoHz,1) + 10) )
        `vmm_note(log,$psprintf("CheckNoise: %0d vs %0d @ %0d",
            Magnitude, MagnitudeBc[f], Frequencies[f] ));
end
if ( ErrorCount > 0 )
    `vmm_error(log,$psprintf("spectrum requirements not met in %0d freq bins",
        ErrorCount));
else
    `vmm_note(log,$psprintf("spectrum requirements were met"));
return ( ErrorCount );
endfunction : CheckNoiseProperty
```

## SPUC/DPI – Package Compile Unit



- DPI Import/Export Declarations and Common Type Declarations
- C/C++ File Manifest with Compile Options

## Class Definition for Re-usability

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- Extend vmm\_data
- Queue of Spectral characteristics
  - Magnitude
  - Frequency min/max
  - Type (noise, signal)
- Class properties to add signal/noise characteristics
  - Add Signal, Add Peak, Add Noise
- Analyze class property
- Check class property

## Verification Environment Merits and Tradeoffs

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Benefits	Disadvantages
Easy to integrate, minimal impact to environment development cost	Doesn't directly reuse Matlab M-file or Simulink collateral
Maintains simulation performance, impact not measurable	C/C++ SPUC library implementation not always familiar to verification engineers
Moderately extensible (compared to Matlab for example)	SPUC library methods sometimes have insufficient documentation
Straightforward incorporation with SystemVerilog/VMM, aiding reusability	
Open source license model, can easily be fanned out in a regression environment	