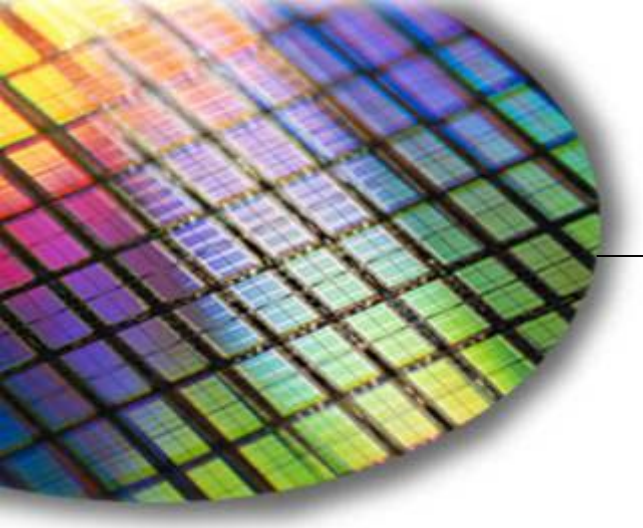

The World Leader in High Performance Signal Processing Solutions

VisualAudio Advanced Features

Presented by:

Paul Beckmann

Analog Devices CPSG

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About this Module

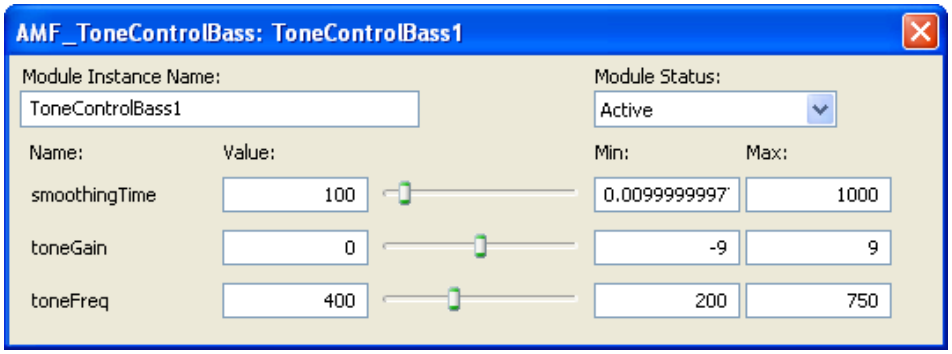
- **This module provides advanced training on VisualAudio. Examples and demonstrations will be based on the ADSP-BF533 EZ-KIT. You will learn about:**
  - **Advanced tool features such as high and low-level variables, the expression language, and presets.**
  - **How to use the external interface to control VisualAudio from other applications, such as MATLAB.**
  - **The basics of writing audio modules.**
- **Target Audience**
  - **Audio algorithm developers**
  - **Comfortable writing C code**
  - **Some familiarity with Blackfin processors and the VisualDSP++ development environment**

Module Outline

- VisualAudio Designer advanced features
  - High and low-level parameters
  - The expression language
  - Presets
- Using the external interface
- Writing custom audio modules
- Conclusion

VisualAudio Designer Advanced Features

High and Low-Level Module Variables



High-level variables appear on a module's inspector

```
typedef struct {

   AMF_Module b;

   float ampSmoothing, ampTarget, b0;
   float amp, state;

} AMF_ToneControlBass;
```

Low-level (or render) variables appear within the module's data structure

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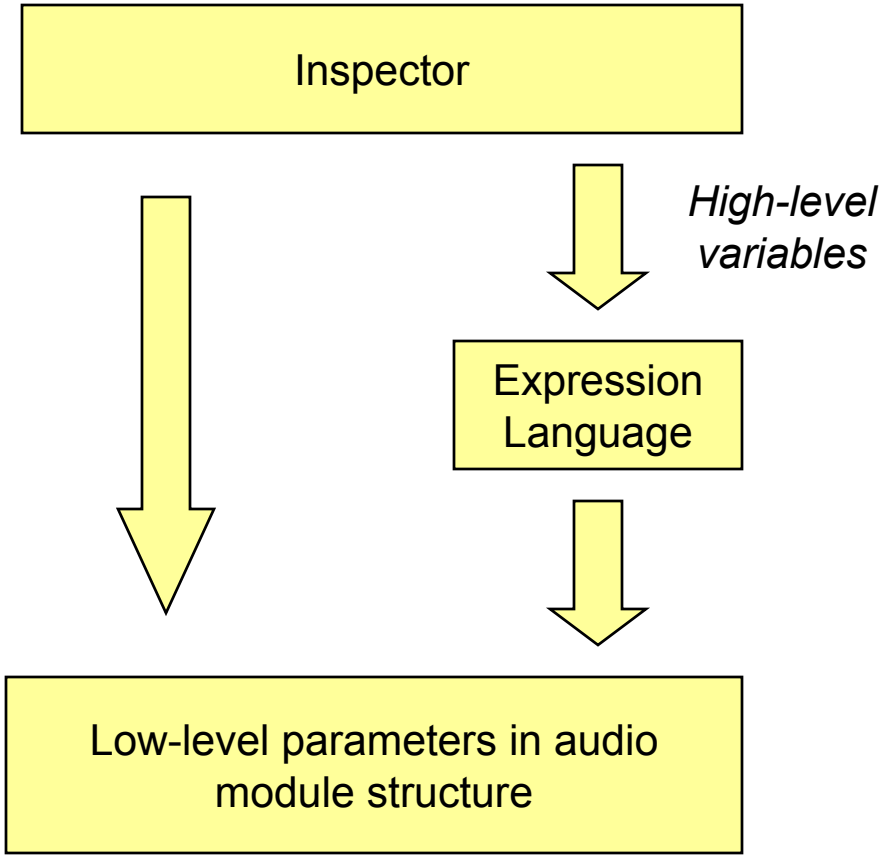
Expression Language



The expression language converts between high-level and low-level parameters

Expression language examples:

1. Convert from smoothing time (msecs) to coefficient
2. Convert from dB to linear units.
3. Convert a balance control setting into 2 separate gains

Presets

- Convenient mechanism for managing audio module parameter sets
- Step 1 – Tune the system to a desired state
  - Inspectors
  - External interface
- Step 2 – Capture the preset
- Step 3 – Apply the preset from the Tool
- Step 4 – Optionally compile the preset with the application.
- Presets are written in Intel hex format
- Can be stored on host and downloaded to the DSP
- Typical uses
  - Dealing with multiple sample rates
  - Preserving default EQ settings
  - Making A/B comparisons to fine tune system performance

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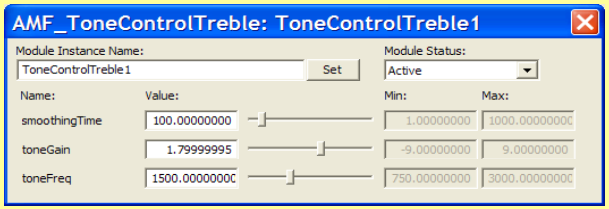
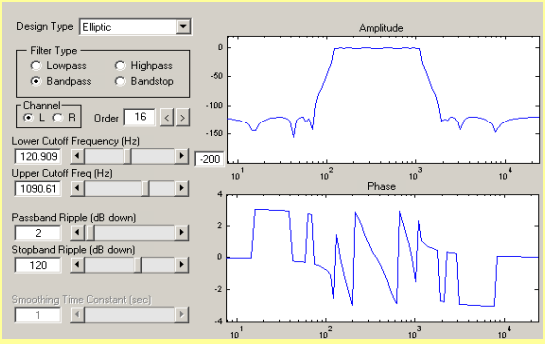
Inspectors



External Interface



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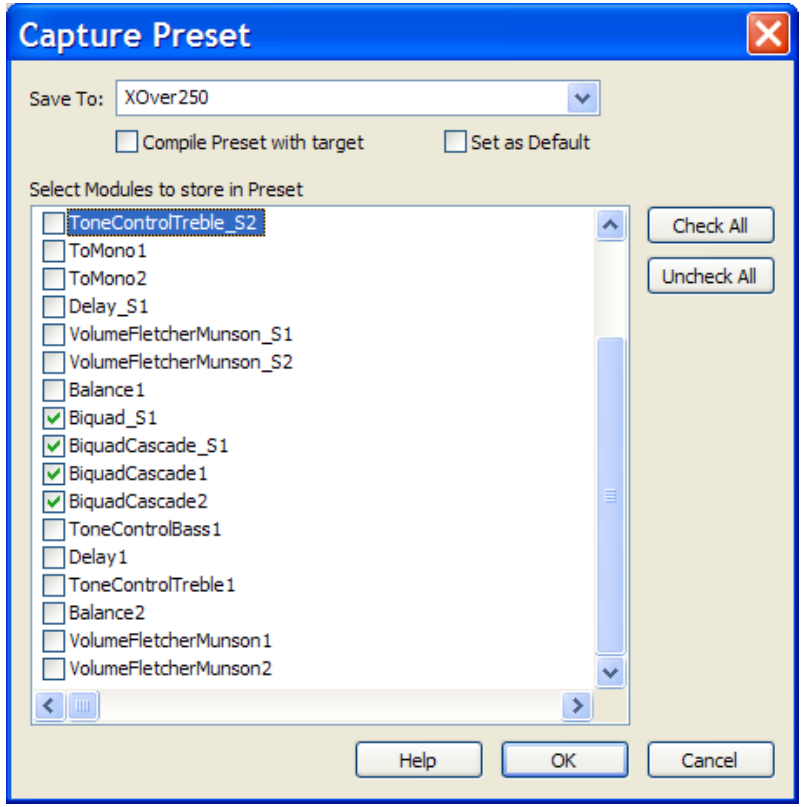

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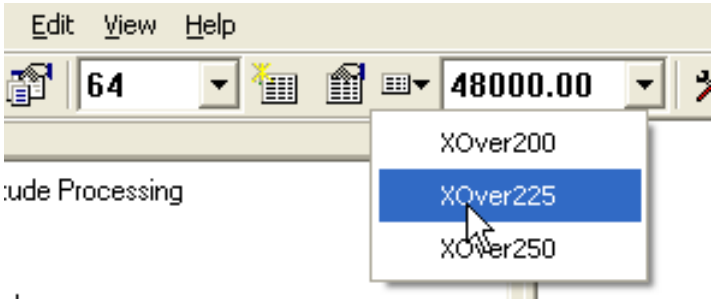

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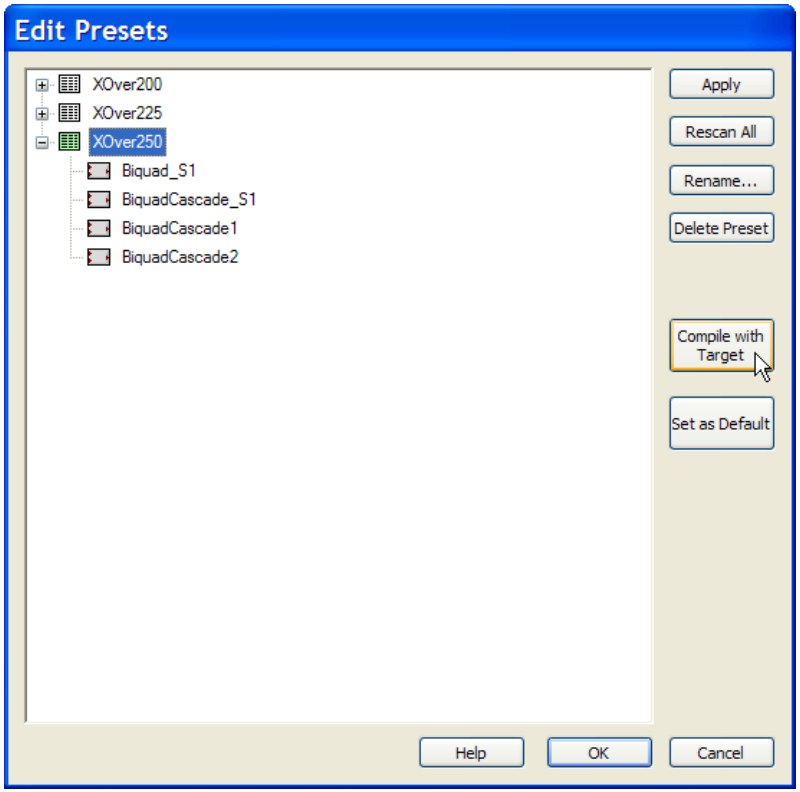

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The External Interface

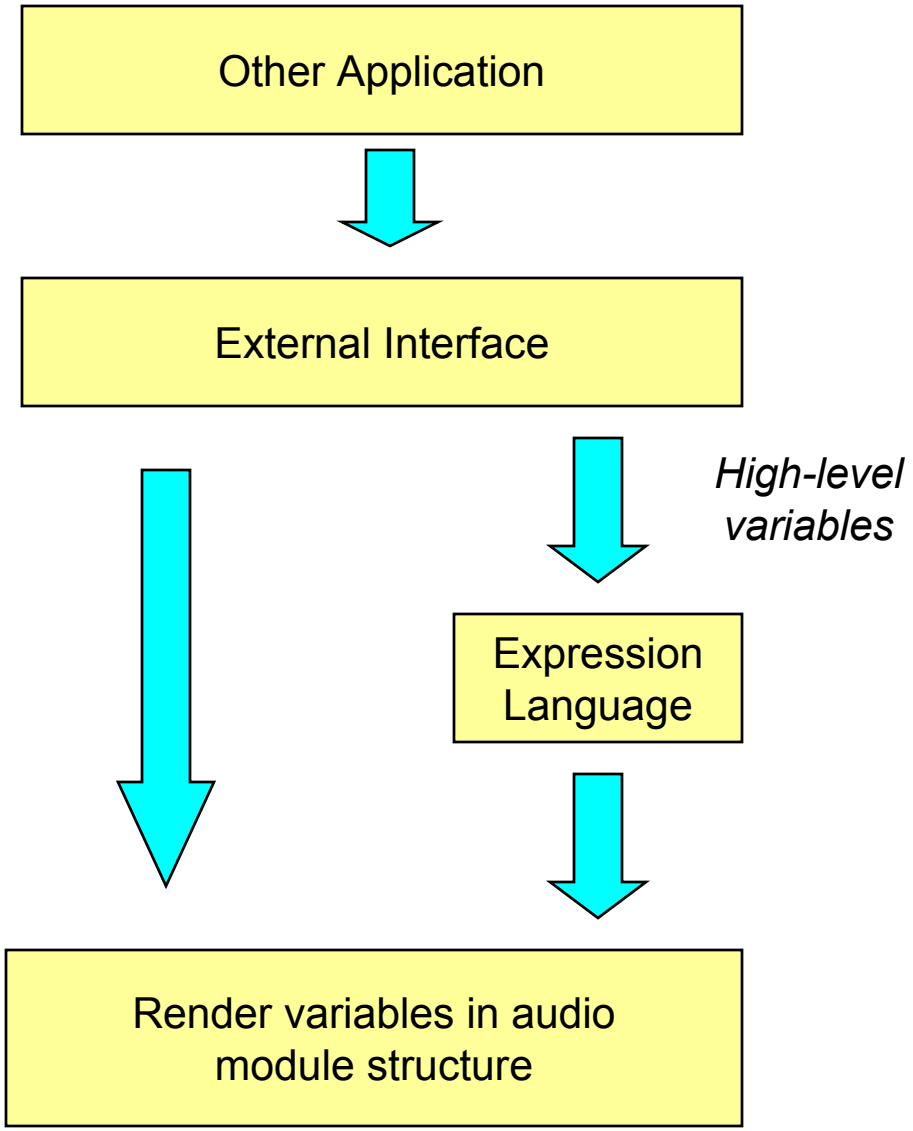
External Interface

- **Works in both Design Mode and Tuning Mode**
  - **Design mode → module data structures**
  - **Tuning mode → module data structures AND sent to the DSP in real-time**
- **Capabilities**
  - **Manipulating audio module parameters**
  - **Basic control of the system (loading, saving, building, capturing presets, etc.) is also supported**
  - **Advanced control (instantiating and wiring modules)**
  - **Exchanging audio data with the target processor.**
    - Block-by-block
    - Non-real-time
    - Speed is determined by the speed of the tuning interface
- **Implemented as a local COM server (housed in an EXE)**
  - **Accessible by any COM compliant language/application (C/C++, Excel, VisualBasic, etc.)**
  - **Total of 53 APIs supported**
  - **Prog-ID is 'VisualAudioDesigner'**

Uses of the External Interface

- Creating custom audio module design functions
- Creating custom GUIs
  - Control panels
  - Full or restricted functionality
- Leveraging existing design tools and methodologies
- Automating system design and tuning
- Regression testing of audio modules and systems

Expression Language is Included

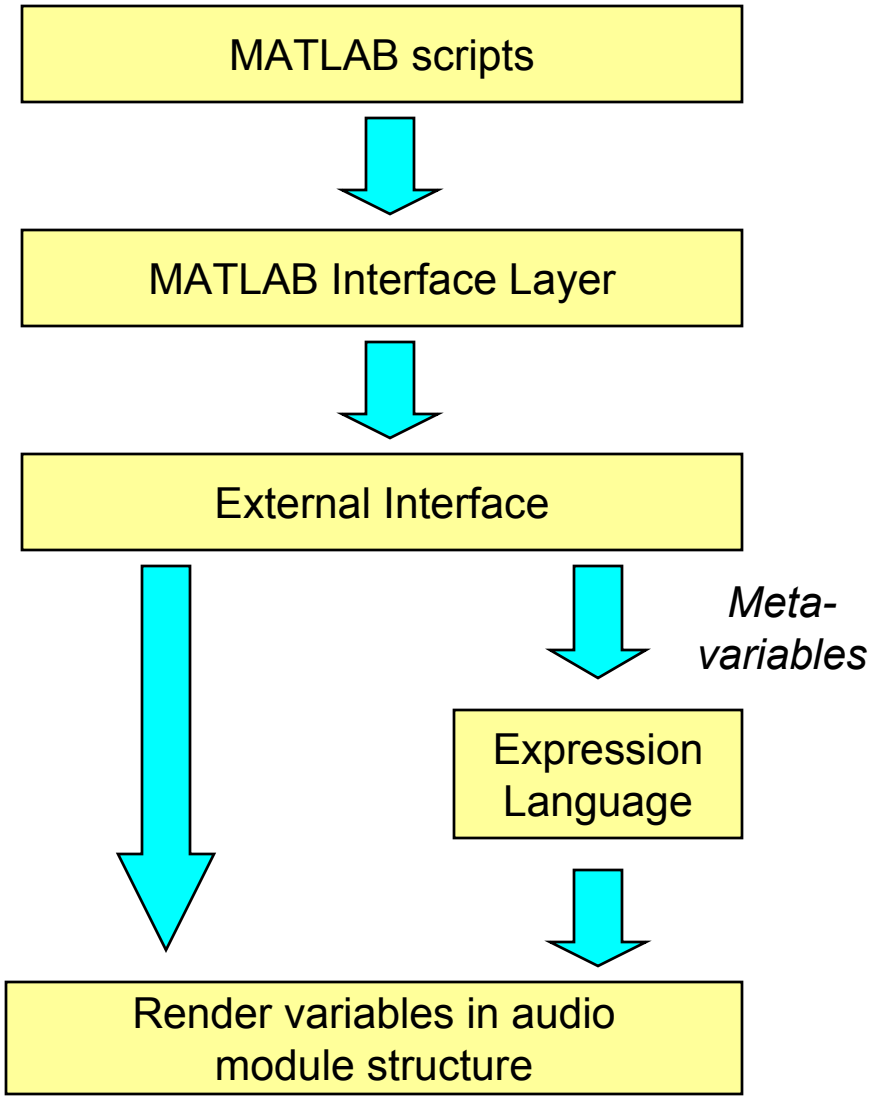


External applications can access the high-level and low-level render variables.

Changes to high-level variables invoke the expression language.

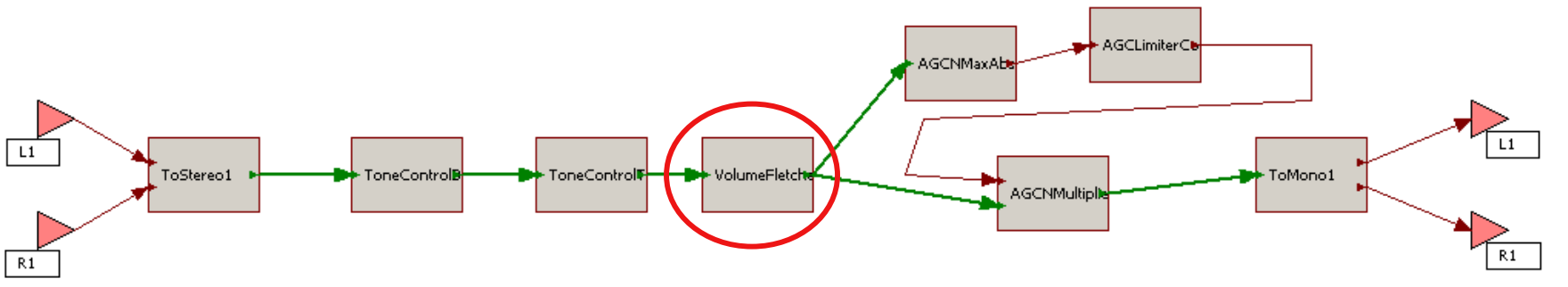
Low-level accesses bypass the expression language and manipulate DSP variables directly.

MATLAB Interface Layer



- **Simplifies usage with MATLAB**
- **Each audio module appears as a MATLAB object**
- **Objects can be manipulated as if they were MATLAB structures**

Querying a Single Audio Module



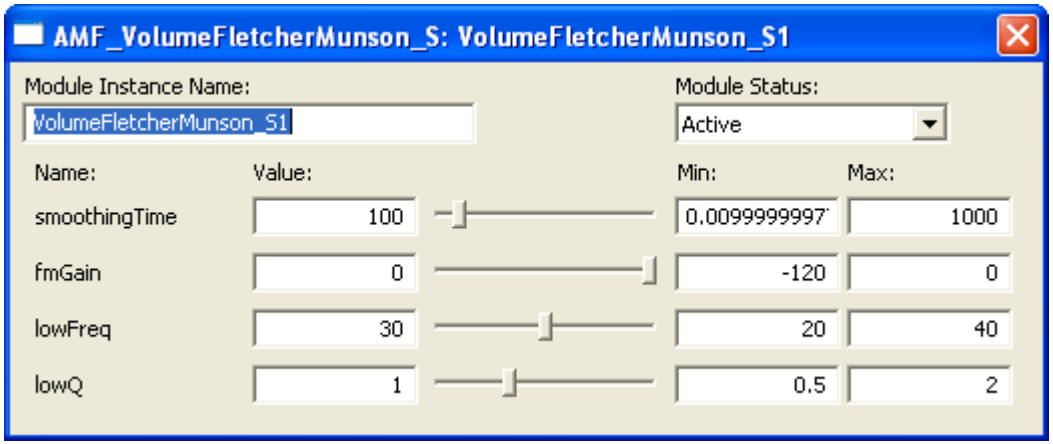

```
>> S=va_module('VolumeFletcherMunson_S1');
```

- Queries VisualAudio for information regarding this audio module
  - Variables names
  - Data types
  - Sizes
- Generates and returns a MATLAB object

Comparison with the Inspector

```
S =

    smoothingTime: [ 100]
           fmGain: [ 0]
          lowFreq: [ 30]
             lowQ: [ 1]
```



One-to-one correspondence between MATLAB structure members and interface variables shown on the inspector

Manipulating Module Parameters

- Treat them as if they were standard MATLAB structures:

```
VolumeFletcherMunson_S1.smoothingTime=50;
VolumeFletcherMunson_S1.fmGain=-3;
VolumeFletcherMunson_S1.lowFreq=40;
VolumeFletcherMunson_S1.lowQ=1.1;
```

- Often used to initialize parameters in a repeatable method using a script file.

Accessing Low-Level Render Variables

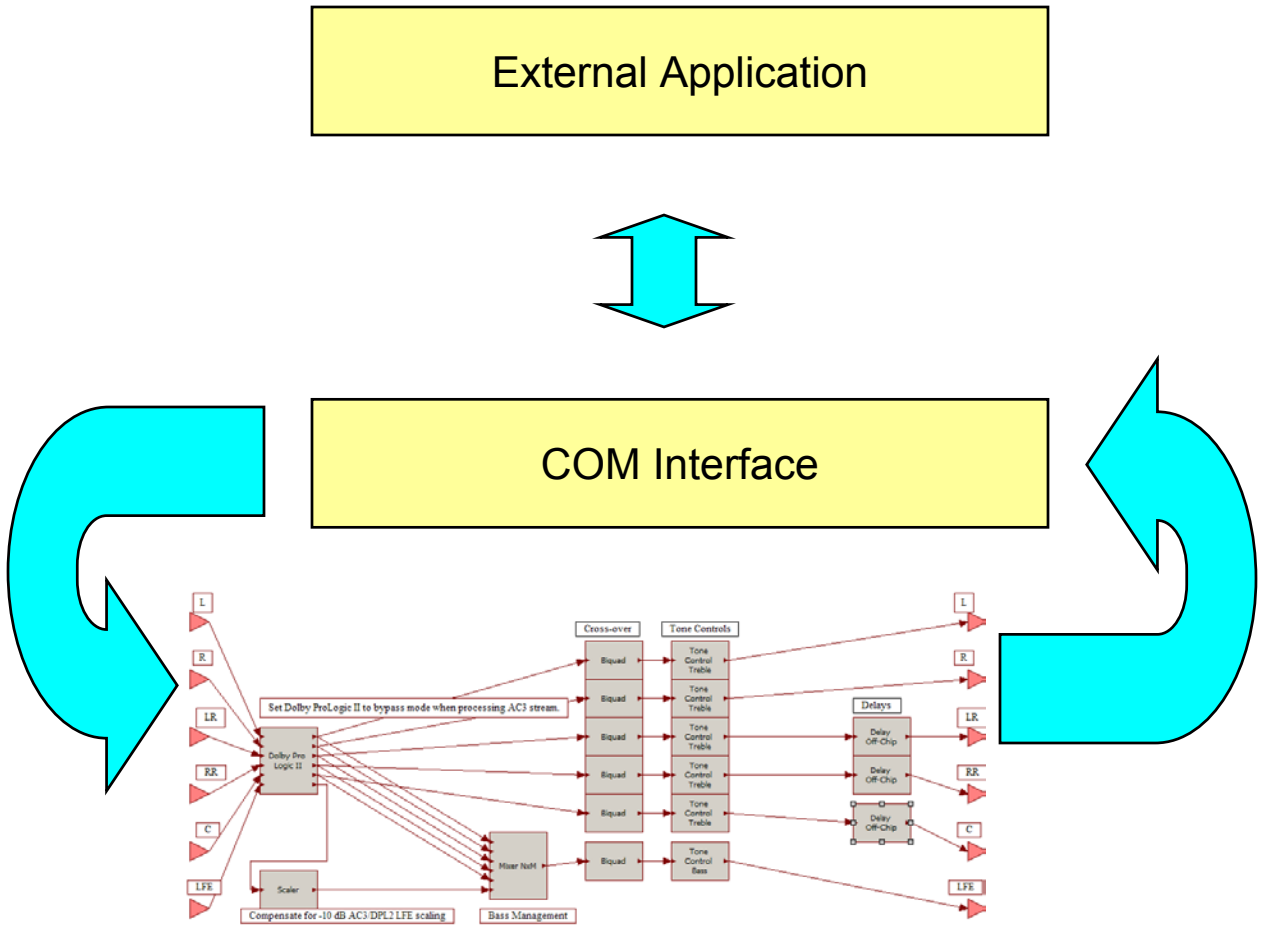
- The previous example demonstrated how to access the high-level variables shown on the inspector.
- To access low-level render variables in Tuning Mode, issue the command:

```
va_module('VolumeFletcherMunson_S1',0)
```

```
VolumeFletcherMunson_S1 =

          ampSmoothing:  [ 0.002081]
             ampTarget:  [ 1.000000]
          lowAmpTarget:  [ 1.000000]
                    b0:  [ 0.996081]
                    b1:  [ -1.996061]
                   amp:  [ 1.000000]
                lowAmp:  [ 1.000000]
            aux_state1:  [ 777.399841
                          -438.739838]
            aux_state2:  [ -21.297104
                           177.371170]
```

Regression Testing Capabilities



Platform operates in "demand render mode"

External application generates data.

Audio passed block-by-block through the tuning interface.

External application analyzes data for correctness.

MATLAB examples are provided.

MATLAB Testing API

- Place platform into “demand render” mode

```
va_demandrender('begin');
```

- Send and receive individual blocks of data

```
DATA_OUT=va_demandrender('process', DATA_IN)
```

DATA_IN=TickSize x NumberOfInputs

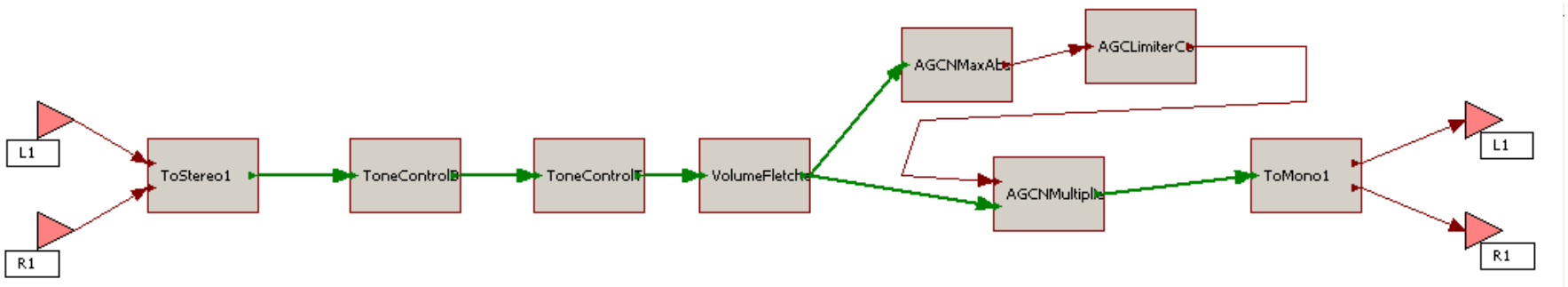
DATA_OUT=TickSize x NumberOfOutputs

- Repeat for multiple blocks

- Exit demand render mode and resume real-time processing

```
va_demandrender('end');
```

Tone Control Example



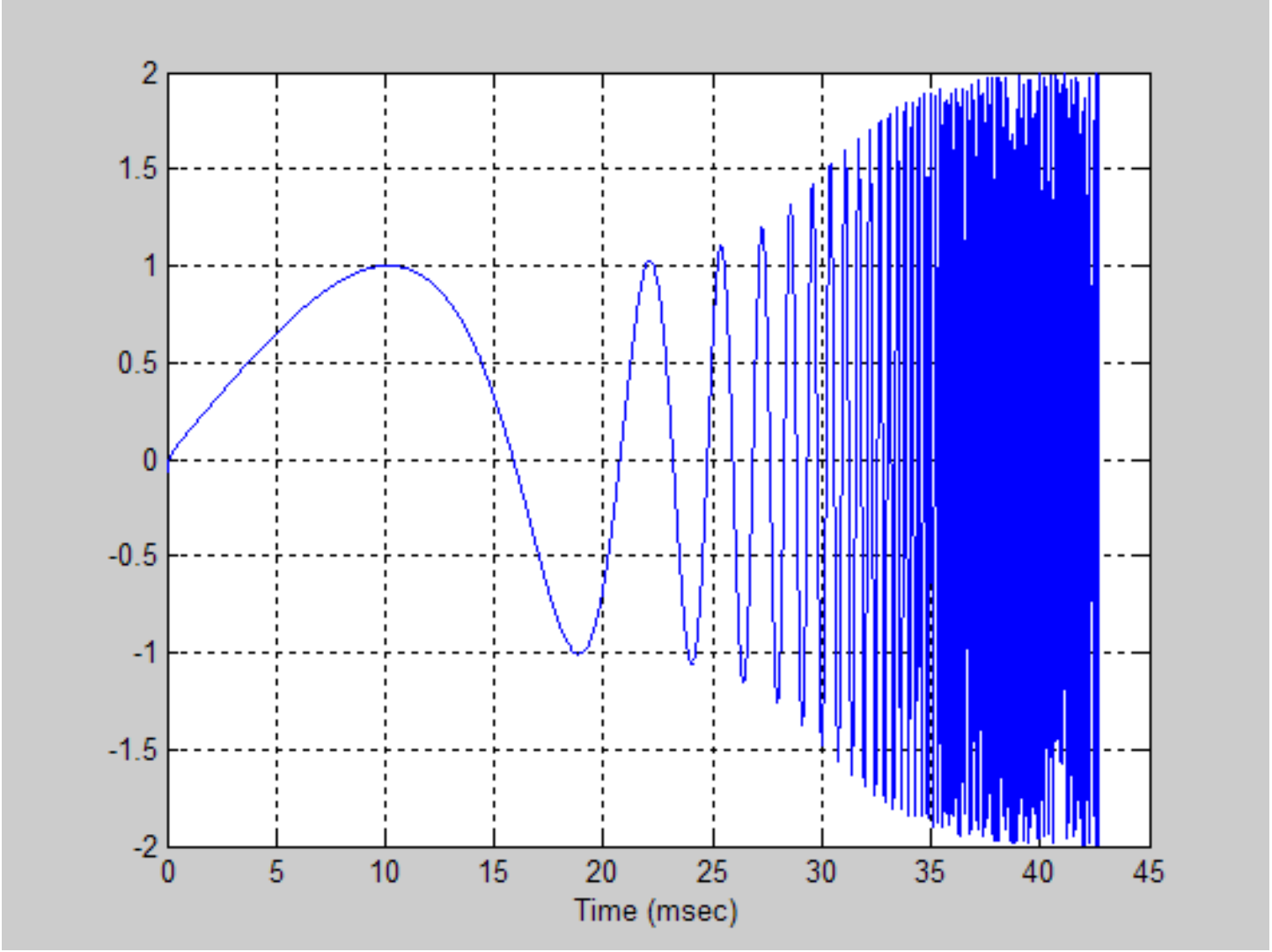
- **Place all modules into bypass mode except the treble tone control**
- **Generate input data in MATLAB**

```
t=((0:2047)/48000).';
DATA_IN=chirp(t, 20, t(end), 24000, 'logarithmic', -90)*ones(1,2);
```

- **Process the data**

```
va_demandrender('begin');
DATA_OUT=va_demandrender('process', DATA_IN);
va_demandrender('end');
```

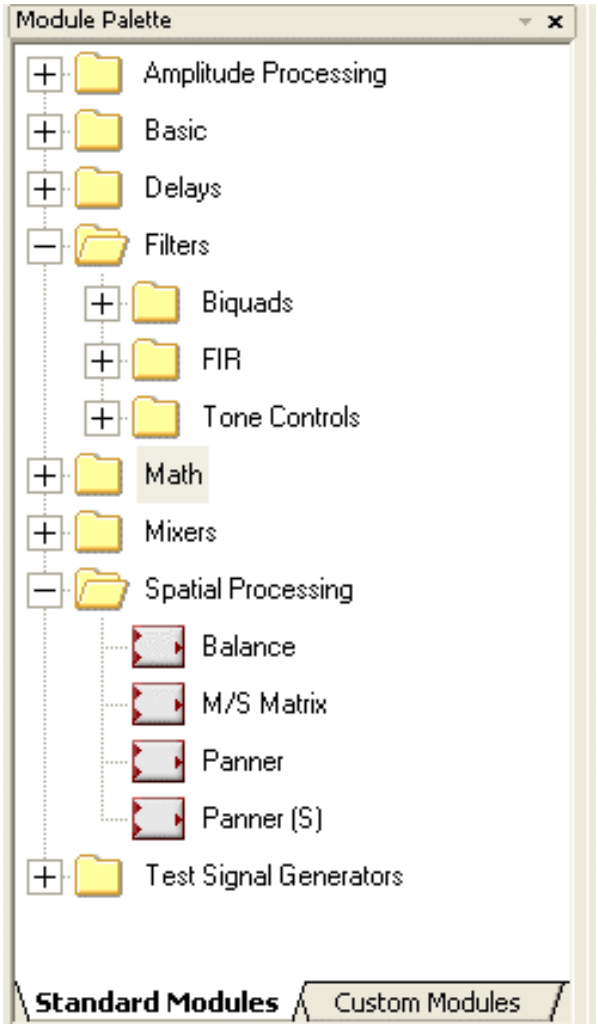
Tone Control Results



Writing Custom Audio Modules

Standard vs. Custom Modules

- Standard modules are supplied with VisualAudio
- Custom modules are written by the user
- Standard and custom modules appear on separate tabs within VisualAudio Designer. <u>This is the only distinction between standard and custom modules</u> – no limitations or cost overhead associated with custom modules
- Source code is provided for all standard modules. This serves as a starting point for creating custom modules



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3 Components of an Audio Module

- A header file which contains the module's run-time interface and a description of the associated data structure
- The module's run-time function ("render function"). This can be:
  - C code
  - ASM code
  - Object or library
- An XML file that describes the module in detail to VisualAudio
  - Elements of its data structure
  - Inspector interface
  - Memory allocation rules

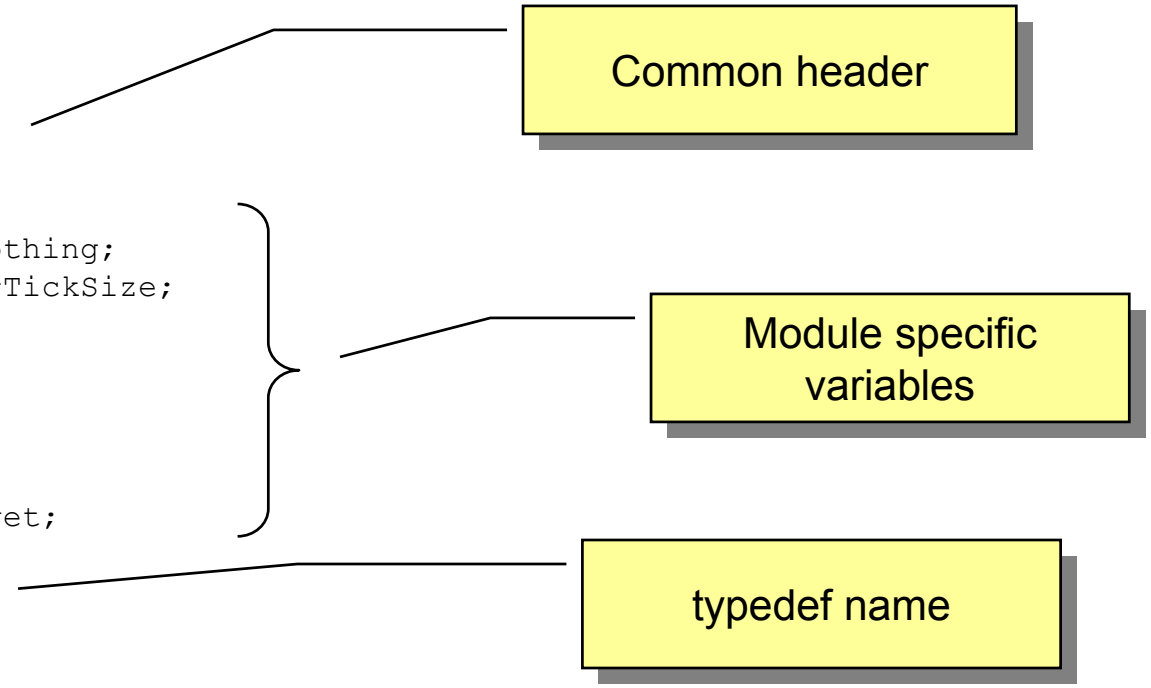
Instance Data Structure

- Each instance of an audio module has an associated C data structure
- All data structures start with the same set of fields
  - These contain elements common to all audio modules
  - Describe the “base class” of the “object”
- This is followed by module specific fields

AMF_ScalerSmoothed.h

- **Defines the data structure associated with the audio module**

```
#include "AudioProcessing.h"

typedef struct
{

    AMF_Module b;

    // parameters
    fract32 ampSmoothing;
    fract32 oneOverTickSize;

    // state
    fract32 amp;

    // parameters
    fract16 ampTarget;
}
AMF_ScalerSmoothed;
```



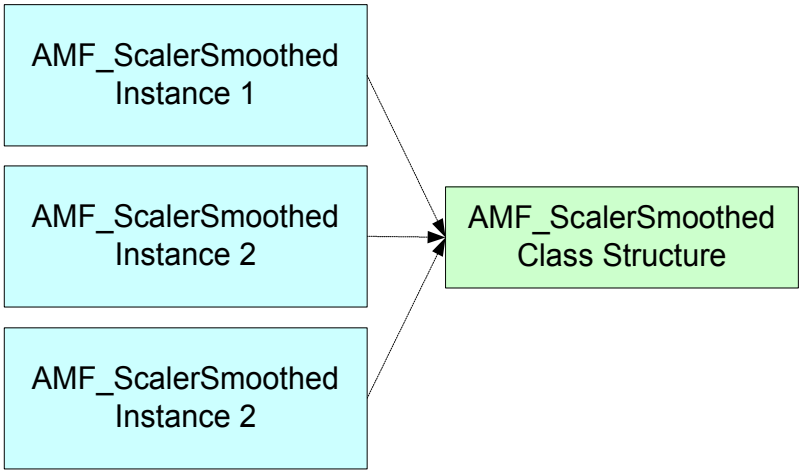
AMF_ScalerSmoothed.c – Render Function
(C example. Actual code is in ASM.)

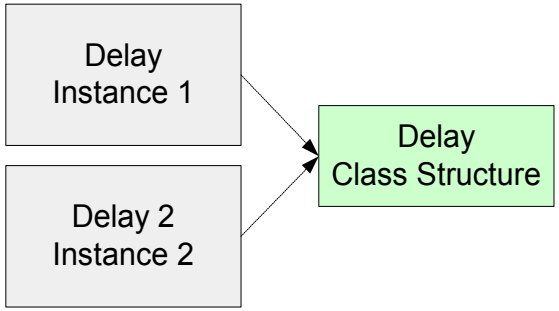
```
SEG_MOD_FAST_CODE void AMF_ScalerSmoothed_Render(AMF_ScalerSmoothed * instance,
                AMF_Signal ** buffers, int tickSize) {
    int i;
    fract32 amp = instance->amp;
    fract16 ampTarget = instance->ampTarget;
    fract32 ampSmoothing = instance->ampSmoothing;
    AMF_Signal *in = buffers[0];
    AMF_Signal *out = buffers[1];
    fract32 diff, slew;

    /* compute smoothing filter only once per tick, and derive a linear
     * slew for the per-sample update */

    diff = sub_fr1x32(mult_fr1x32x32NS(ampSmoothing, L_deposit_h(ampTarget)),
                      mult_fr1x32x32NS(ampSmoothing, amp));
    instance->amp = add_fr1x32(amp, diff);
    slew = mult_fr1x32x32NS(diff, instance->oneOverTickSize);

    for (i=0; i<tickSize; i++) {
        out[i] = mult_fr1x32x32NS(in[i], amp);
        amp = add_fr1x32(amp, slew);
    }
}
```

- **Same arguments passed to all render functions:**
  - Pointer to instance structure
  - Array of buffer pointers ordered as inputs, outputs, and scratch
  - tickSize = block size

Class Structure Declaration

- All audio modules of the same type share a single “Class Structure”
- Describes the behavior of the module to VisualAudio’s run-time interface
  - Number of inputs and outputs
  - Mono input and mono output
  - Name of render function
  - Bypass behavior
- Typically declared within the module’s C file
  - If the module’s render function is in assembly, there will be two files: an .ASM file containing the render function, and a C file with the class structure declaration





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AMF_ScalerSmoothed – Class Structure

```
SEG_MOD_SLOW_CONST const AMF_ModuleClass AMFClassScalerSmoothed =
{
    /** Flags. */
    0,

    /** Reference to render function. */
    (AMF_RenderFunction) AMF_ScalerSmoothed_Render,

    /* Default bypass */
    (void *)0,

    /* Input descriptor - 1 input, and it is mono. */
    1, 0,

    /* Output descriptor - 1 output, and it is mono. */
    1, 0,
};
```

Audio Module XML

- **Describes the audio module to VisualAudio Designer**
  - Module name and palette location
  - Input and output pins
  - Compatible processors
  - Instance data structure
  - High-level variables and expressions
  - Memory allocation rules
  - Other usage rules

Conclusion

- VisualAudio's design features simplify the development of advanced audio features
  - High and Low-level variables
  - Expression language
  - Presets
- Open API's allow VisualAudio's capabilities to be extended by
  - Interfacing to external COM compliant applications
  - Interfacing to MATLAB
  - Writing custom audio modules

For Additional Information

- A free download is available at the VisualAudio product page
  - http://www.analog.com/en/prod/0,2877,VISUALAUDIO,00.html
- Additional examples and tutorials can be found at the VisualAudio Developer's Web site:
  - www.visualaudiodeveloper.com
- Specific technical questions can be sent to:
  - visualaudio.support@analog.com
- Click the "Ask A Question" button