Cantor Digitalis 1.1

DOCUMENTATION

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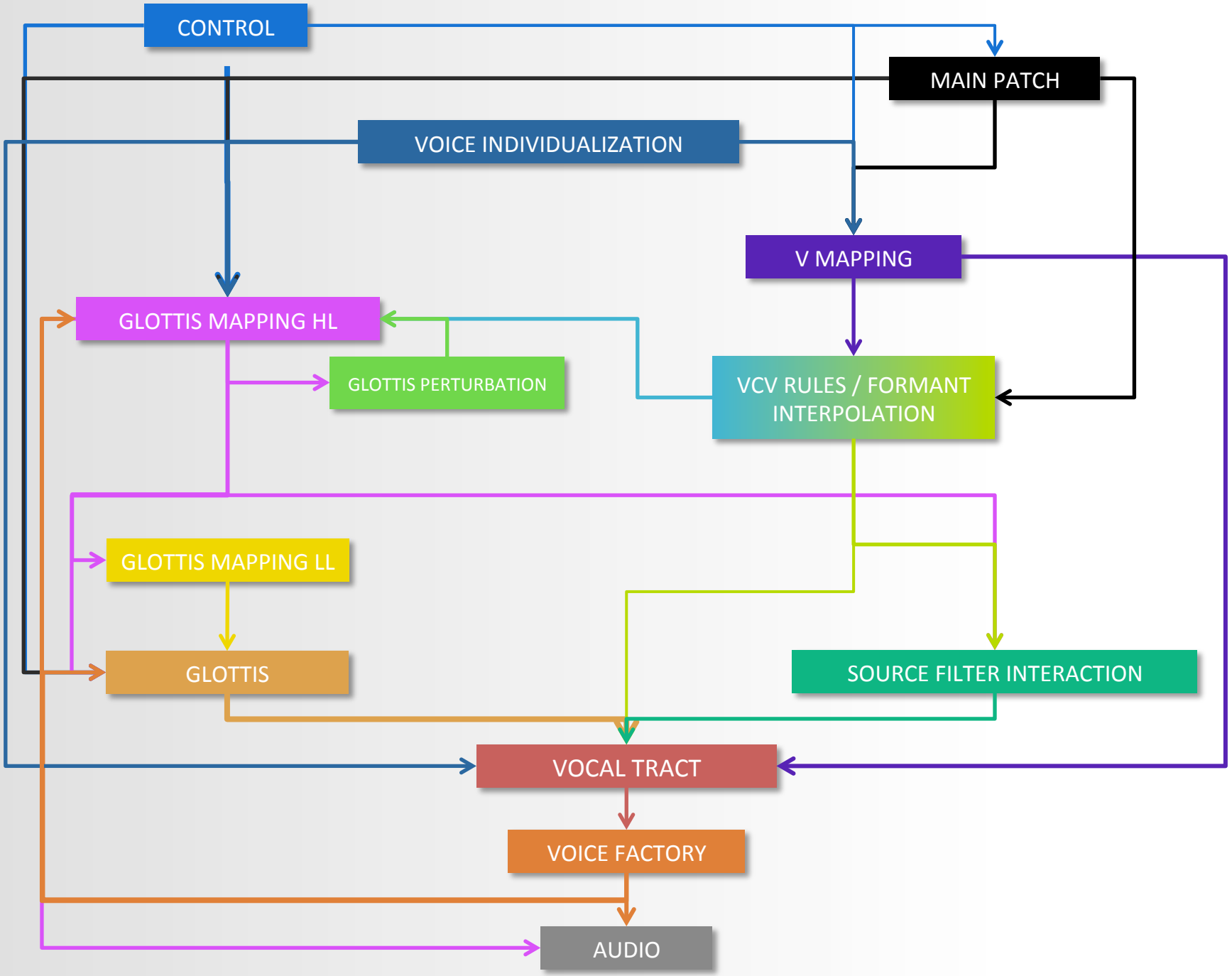
This technical documentation is aimed at Max 6 developers and it describes the main Max sub-patches of the Cantor Digitalis synthesizer. These sub-patches are accessible from the *CantorDigitalis-Synth* Max program.

Each main sub-patch is described by:

- Its functions
- Its inputs / outputs
- Its relations between inputs and outputs
- A general chart summarizing the patch

The patches considered are those presented in the Cantor Digitalis' operating diagram of the next page.

For a musician point of view ("simple user"), see the user manual.


CONTROL
MAIN PATCH
VOICE INDIVIDUALIZATION
V MAPPING
GLOTTIS MAPPING HL
GLOTTIS PERTURBATION
VCV RULES / FORMANT INTERPOLATION
GLOTTIS MAPPING LL
GLOTTIS
SOURCE FILTER INTERACTION
VOCAL TRACT
VOICE FACTORY
AUDIO

From devices data to synthesizer parameters

CONTROL

Functions

- CONTROL gets data from external devices and maps them to the synthesizer parameters
- Data from Wacom Graphic Tablets is received through UDP packets sent by the application *CantorDigitalis-Tab*
- Data from Joystick is received directly from the function *hi*
- The data is mapped to six raw high level parameters (see mappings)

Inputs / Outputs

Inputs

Name	Description	From
Mode	Select the appropriate mapping	Main Patch
Joystick activation	Activate the joystick	
WacomUDPReceive	Data from Wacom tablet	Other devices
Hi	Data from Joystick	
LCD	Data from mouse	
Key	Data from Keyboard	

Outputs

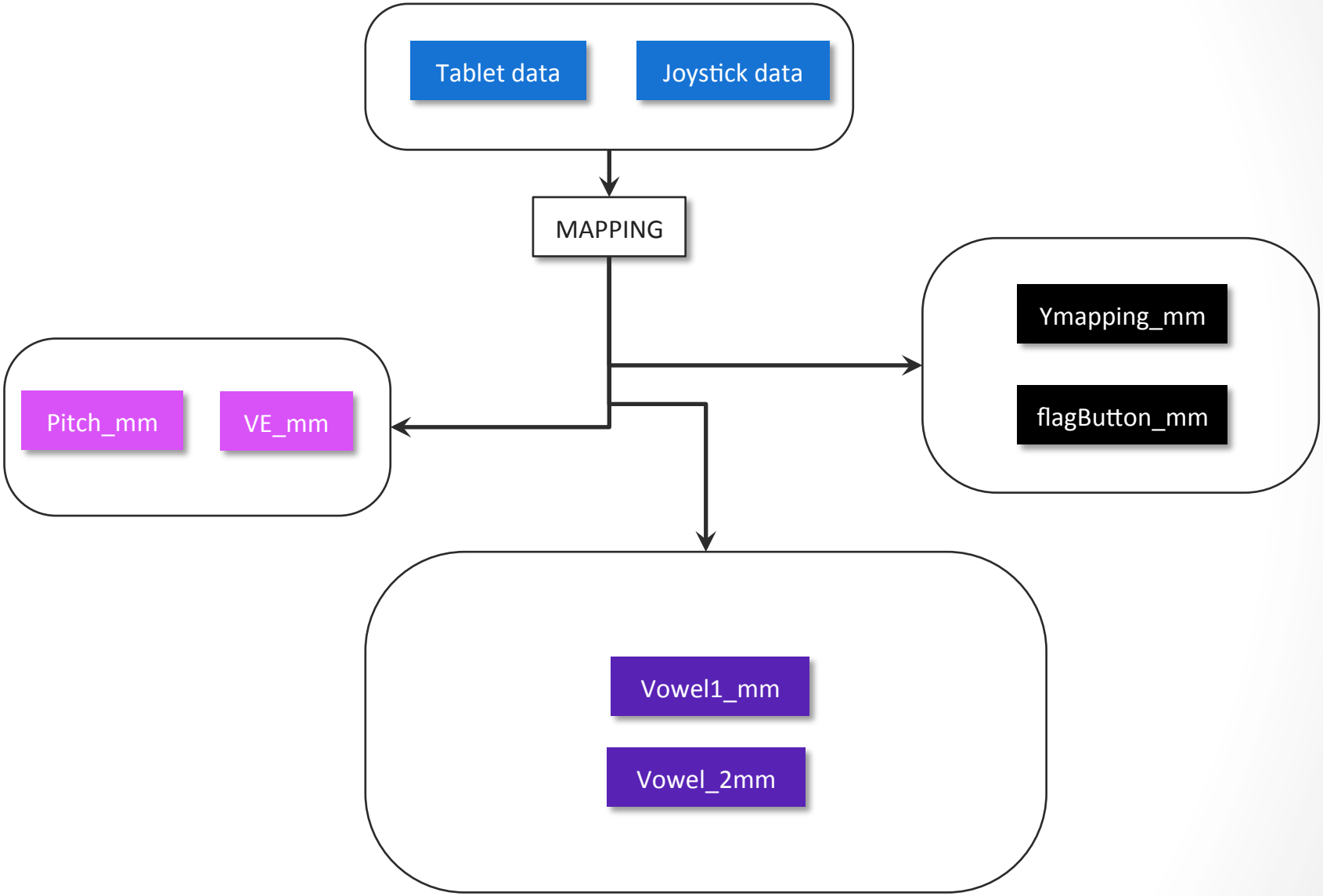
Name	Description	To
Pitch_mm	Raw pitch	Glottis Mapping HL
VE_mm	Raw vocal effort	
Vowel1_mm	Raw vowel dimension	V Mapping
Vowel2_mm	Raw vowel dimension	
flagButton_mm	Stylus button flag	Main Patch
Ymapping_mm	Raw Y dimension	

Mappings

A one-to-many mapping is applied between devices parameters and synthesizer parameters.

Device parameter	Vocalic rectangle	Vocalic axis	Demo
X position (stylus or finger) – hand 1	Pitch	Pitch	
Y position (stylus or finger) – hand 1	Y mapping	Vowels	
Stylus pressure P – hand 1	Vocal effort	Vocal effort	
Stylus buttons – hand 1	Accuracy correction	Accuracy correction	
X position (stylus or finger) – hand 2	Vowel 1		
Y position (stylus or finger) – hand 2	Vowel 2		
X position mouse on LCD			Pitch
Y position mouse on LCD			Vocal effort
Keyboard			Vowels

General chart



Tablet data

Data from Wacom Graphic Tablets is received through UDP packets sent by the application *CantorDigitalis-Tab.* The patch WacomUDPreceive receive the packets.

- The default port for UDP is [7400 + the tablet number specified in p Control]
- The packets must be sent to the application in the following format :

  [tablet_name parameter_name parameter_value]

- The *tablet_name* is specified in p Control
- The list of *parameter_name* is given in the following table.

Parameter_name	Type	Description
coords	List of two floats	Coordinates of stylus position
finger1	List of two floats	Coordinates of first finger position
finger2	List of two floats	Coordinates of second finger position
mode	Int	Indicates if tablet is in stylus or finger mode
speeds	List of two floats	X and Y values of stylus speed
pressure	Float	Pressure of the stylus
xytilts	List of two floats	Tilt of the stylus on X and Y axis
rttilts	List of two floats	Tilt of the stylus expressed in radius and angle
buttons	Int	Flag of the stylus buttons
proximity	Int	Boolean flag indicating the proximity of the stylus
fingerID	Int	ID of current finger
fingerCount	Int	Number of fingers on the tablet

Manually change vocal high level parameters

VOICE INDIVIDUALIZATION

Functions

- VOICE INDIVIDUALIZATION enables the user to set manual synthesizer parameters

1. Setting of voice type and source high level parameters
2. Formant value presets
3. Setting of glottis parameters
4. Setting of formant values

Inputs / Outputs

Inputs

Name	Description	From
Voice Preset	Selected voice type	Main Patch
Values	Change values of parameters	User
F0	Final Pitch	Glottis Mapping HL
Fx_Ar	Frequencies of formants before interaction	Formant Interactions
BPx	Bandwidth of formants	
Ax_Ar	Amplitude of formants before interaction	
Fx	Frequencies of formants after interaction	Source Filter Interaction
Ax	Amplitude of formants after interaction	

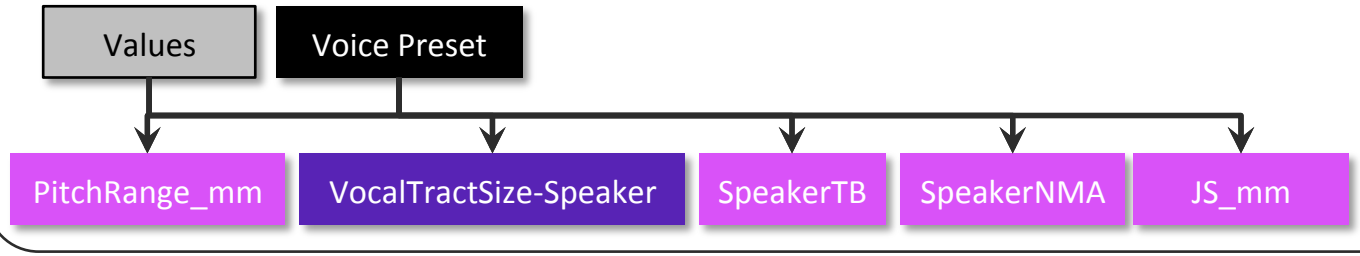
Inputs / Outputs

Outputs

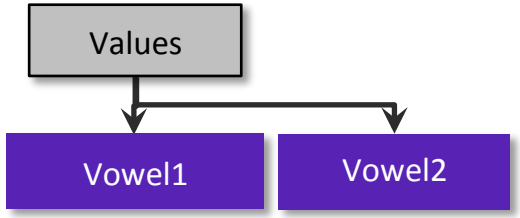
Name	Description	To
Vowel1	Linear mapping of vowels dimension 1	V Mapping
Vowel2	Linear mapping of vowels dimension 2	
VocalTractSize-Speaker	Static vocal tract size	
SpeakerTB	Speaker tension	Glottis Mapping HL
SpeakerNMA	Speaker aspiration	
PitchRange_mm	Speaker pitch range	
JS_mm	Speaker aperiodicity	
Pitch_mm	Raw pitch	
VE_mm	Raw vocal effort	
BPx	Bandwidth of formants	Filter Formant Glottis
Fx_Ar	Frequencies of formants before interaction	Source Filter Interaction
Ax_Ar	Amplitude of formants before interaction	

General chart

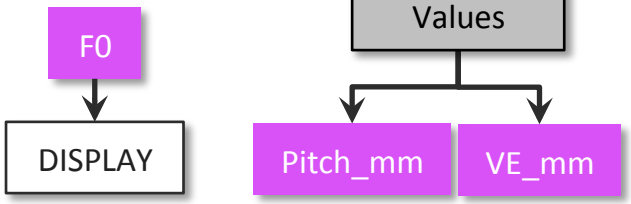
1. Setting of voice type and source high level parameters



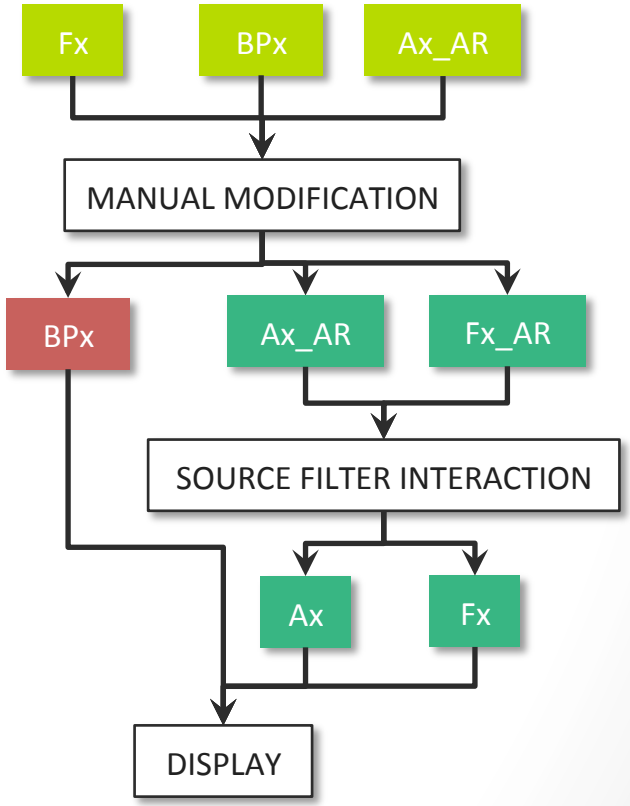
2. Formant value presets



3. Setting of glottis parameters



4. Setting of formant values



From raw articulation data to synthesizer parameters

V MAPPING

Functions

- V MAPPING gets raw data from CONTROL, VOICE INDIVIDUALIZATION and MAIN PATCH and maps them to high level articulation parameters

1. Interface data mapped to articulation parameters
   - Maps a vocalic rectangle on the tablet for mode 2D
   - Maps linear vowels for mode 1D

2. Maps vocal tract size

Inputs / Outputs

Inputs

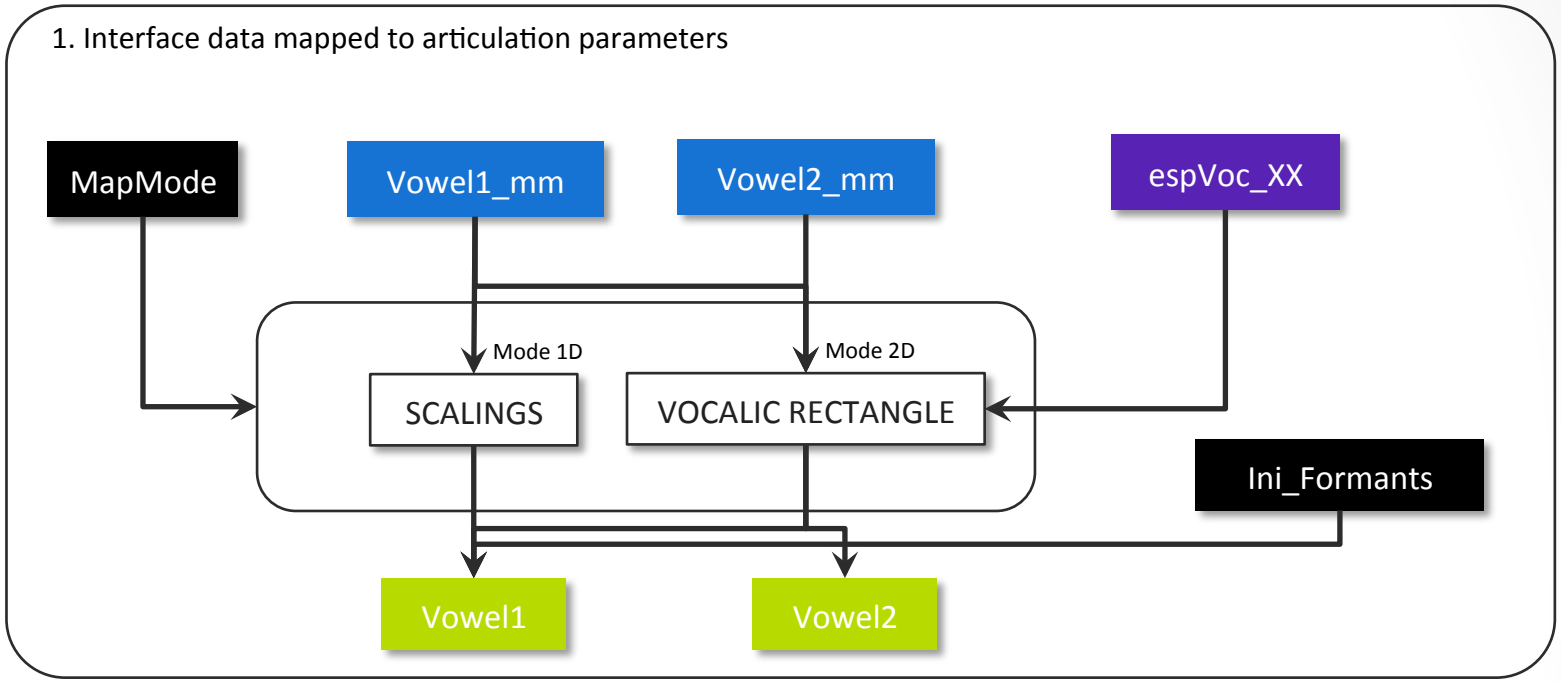
Name	Description	From
Vowel1_mm	Raw vowel dimension 1	Control
Vowel2_mm	Raw vowel dimension 2	
MapMode	Flag mode vowel 2D / 1D	Main Patch
VocalTractSizeSmallModif_mm	Dynamic vocal tract modifications	
Ini_formants	Bang to initialize formants	
VocalTractSize-Speaker	Static vocal tract size	Voice Individualization

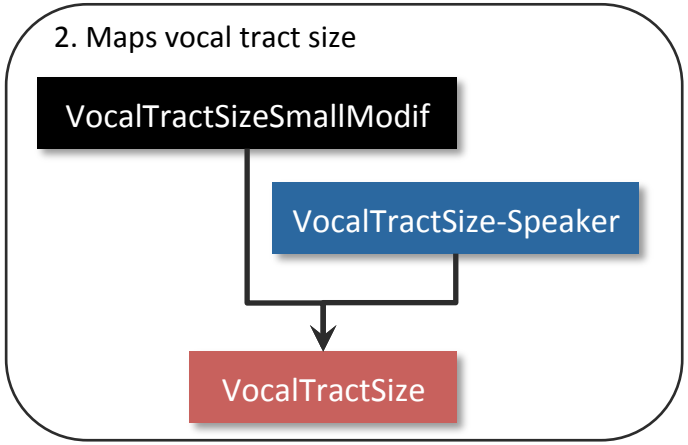
Inputs / Outputs

Outputs

Name	Description	To
Vowel 1	Linear mapping of vowels dimension 1	Formant Interpolation
Vowel 2	Linear mapping of vowels dimension 2	
VocalTractSize	Dynamically modified vocal tract size	Filter Formant Glottis

General chart





From raw devices parameters to high level glottis parameters

GLOTTIS MAPPING HL

Functions

- GLOTTIS MAPPING HL gets raw data from CONTROL, VOICE INDIVIDUALIZATION, VCV RULES and MAIN PATCH and maps them to high level glottis parameters

1. Generation of Tenseness and Breathiness
2. Generation of Jitter and Shimmer
3. Generation of Pitch with automatic correction
4. Generation of Vocal Effort

Inputs / Outputs

Inputs

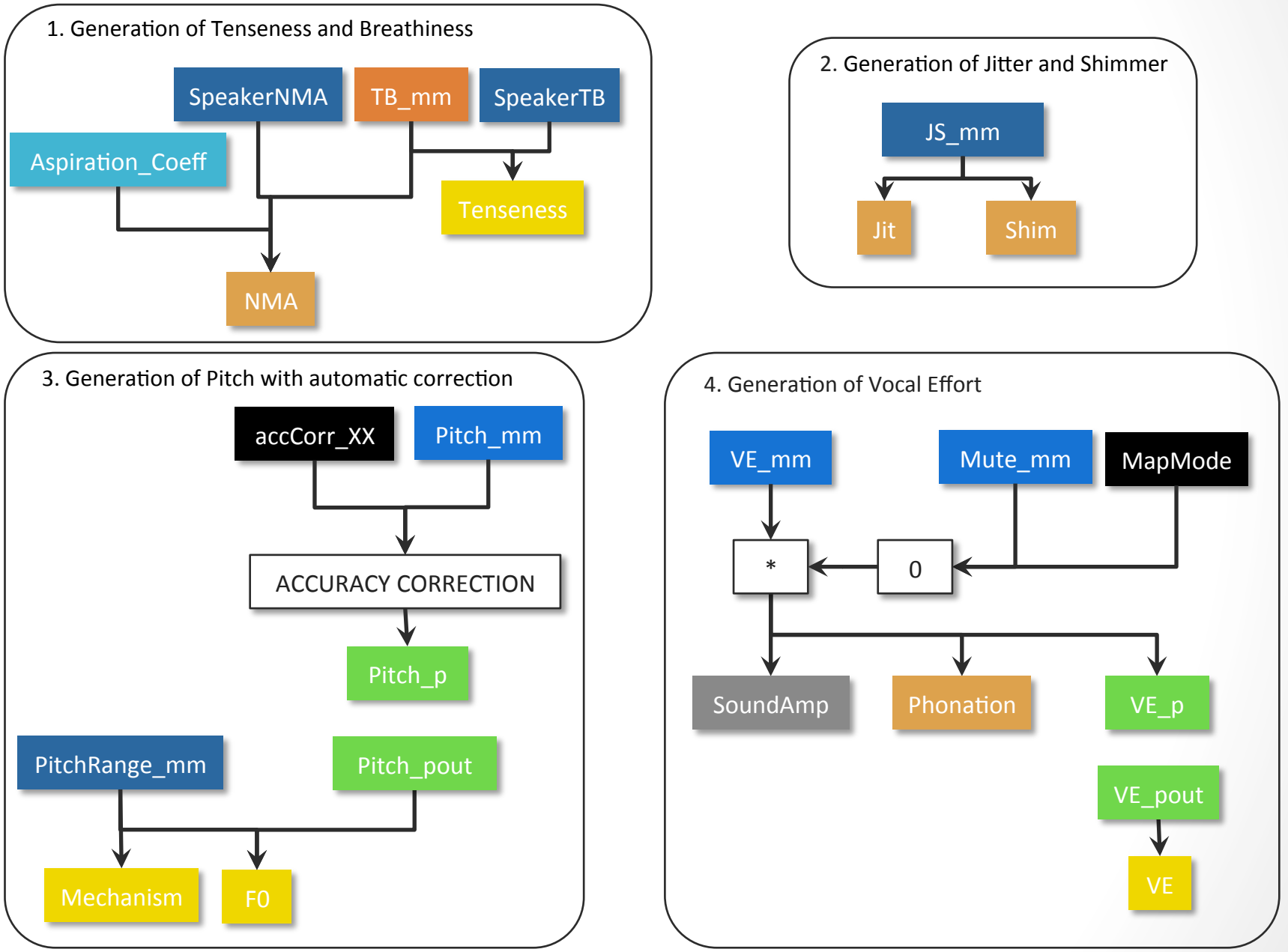
Name	Description	From
Pitch_mm	Raw pitch	Control
VE_mm	Raw vocal effort	
VEcoeffOnC_mm	Raw VE coefficient	
Mute_mm	Flag to mute the instrument	
SpeakerTB	Speaker tension	Voice Individualization
SpeakerNMA	Speaker aspiration	
PitchRange_mm	Speaker pitch range	
JS_mm	Speaker aperiodicity	
Aspiration_Coeff	Consonant aspiration	V Rules
Pitch_pout	Pitch perturbated	Glottis Perturbation
VE_pout	Vocal effort perturbated	
TB_mm	Voice tension	Voice Factory
accXX / autotune_XX / static_XX	All accuracy correction parameters	Main Patch
MapMode	Flag mode vowel 2D / 1D	

Inputs / Outputs

Outputs

Name	Description	To
Pitch_p	Corrected pitch	Glottis Perturbation
VE_p	Vocal effort	
VE	Final vocal effort	Glottis Mapping LL
Tenseness	Voice tenseness	
Mechanism	Voice mechanism	
F0	Final pitch	
NMA	Amount of breathiness / Apiration	Glottis
Shim	Shimmer	
Jit	Jitter	
Phonation	Phonation threshold	
SoundAmp	Volume	Audio

General chart



Add natural perturbations to pitch and vocal effort

GLOTTIS PERTURBATION

Functions

- GLOTTIS PERTURBATION simulates the natural perturbations of the heart pulse to the pitch and vocal effort, as well as others

1. Generation of several perturbations depending on the vocal effort

2. Add perturbation to pitch and vocal effort

Inputs / Outputs

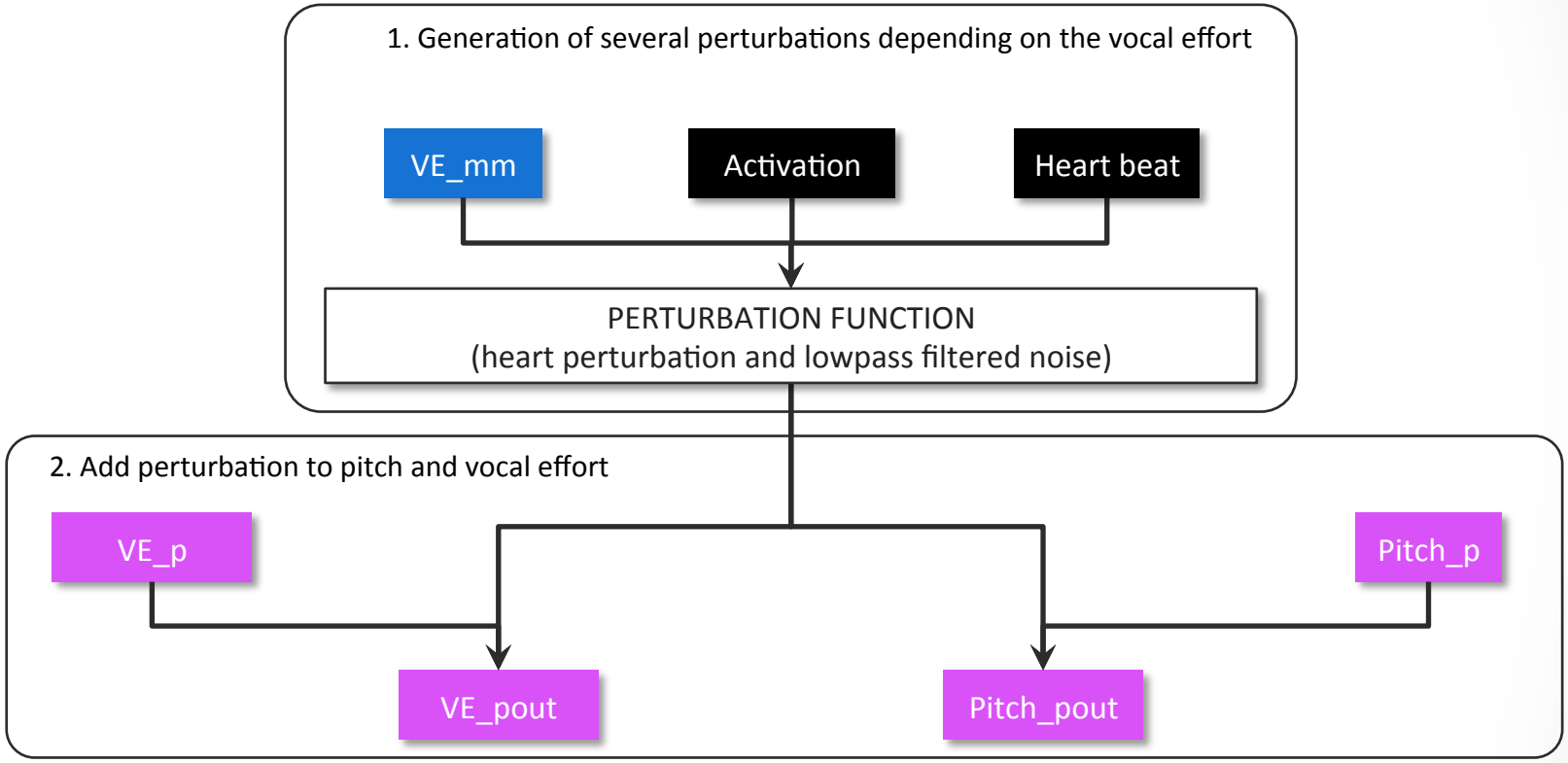
Inputs

Name	Description	From
VE_mm	Raw vocal effort	Control
Activation	Activation flag of the perturbations	Main Patch
Heart beat	Heart beat in b.p.m	
VE_p	Vocal effort	Glottis Mapping HL
Pitch_p	Scaled pitch	

Outputs

Name	Description	To
VE_pout	Pertubated vocal effort	Glottis Mapping HL
Pitch_pout	Pertubated pitch	

General chart



Vocal dimension to vocal source parameters

GLOTTIS MAPPING LL

Functions

➲ GLOTTIS MAPPING LL calculates low level voice parameters given high level voice controllers

1. Generation of low level parameters
   - Spectral tilt from Vocal Effort
   - Opening Quotient From Vocal Effort, Mechanism and Tenseness
   - Asymmetry coefficient from mechanism and tenseness

Inputs / Outputs

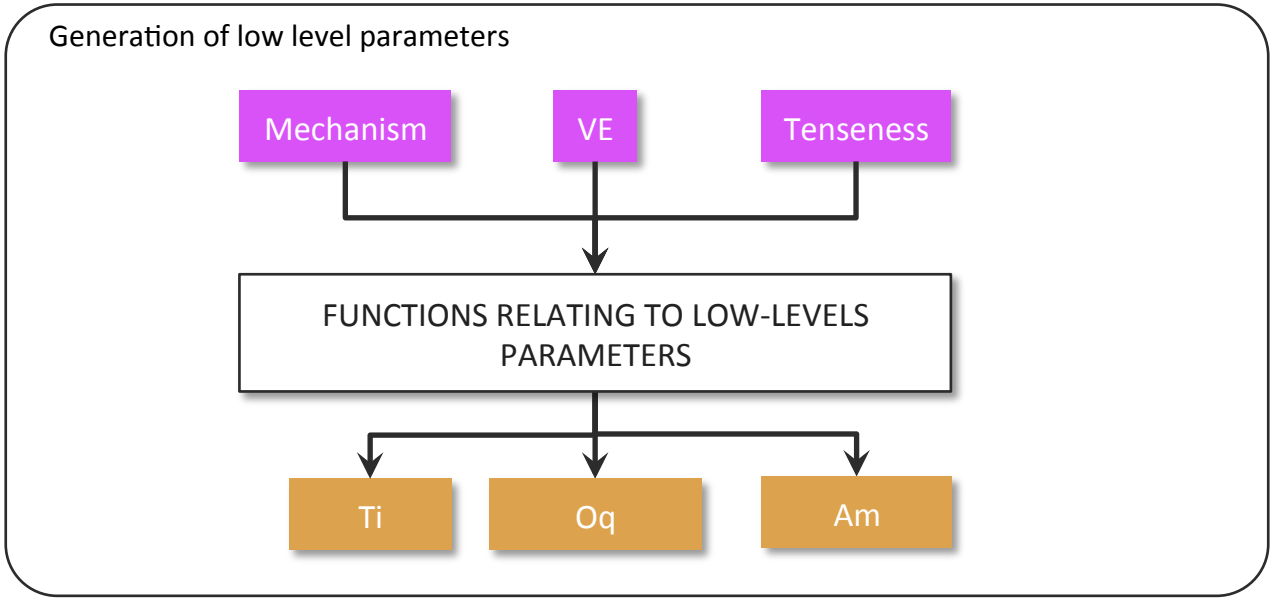
Inputs

Name	Description	From
VE	Final vocal effort	Glottis Mapping HL
Tenseness	Voice tenseness	
Mechanism	Voice mechanism	

Outputs

Name	Description	To
Tl	Spectral tilt	Glottis
Oq	Open quotient	
Am	Asymmetry coefficient	

General chart



Generate source signal

GLOTTIS

Functions

➲ GLOTTIS generates a synthesized glottis signal given the low level parameters of the voice

1. Generation of voiced signal
   - Create signal using RTCALM
   - Modeling of the diffusion at the lips with a high pass filter
   - Suppression of high frequencies with a low pass filter
   - Modeling of the spectral tilt depending on the vocal effort
   - Modeling of phonation threshold

2. Generation of noise
   - Modulation of noise with source amplitude

Inputs / Outputs

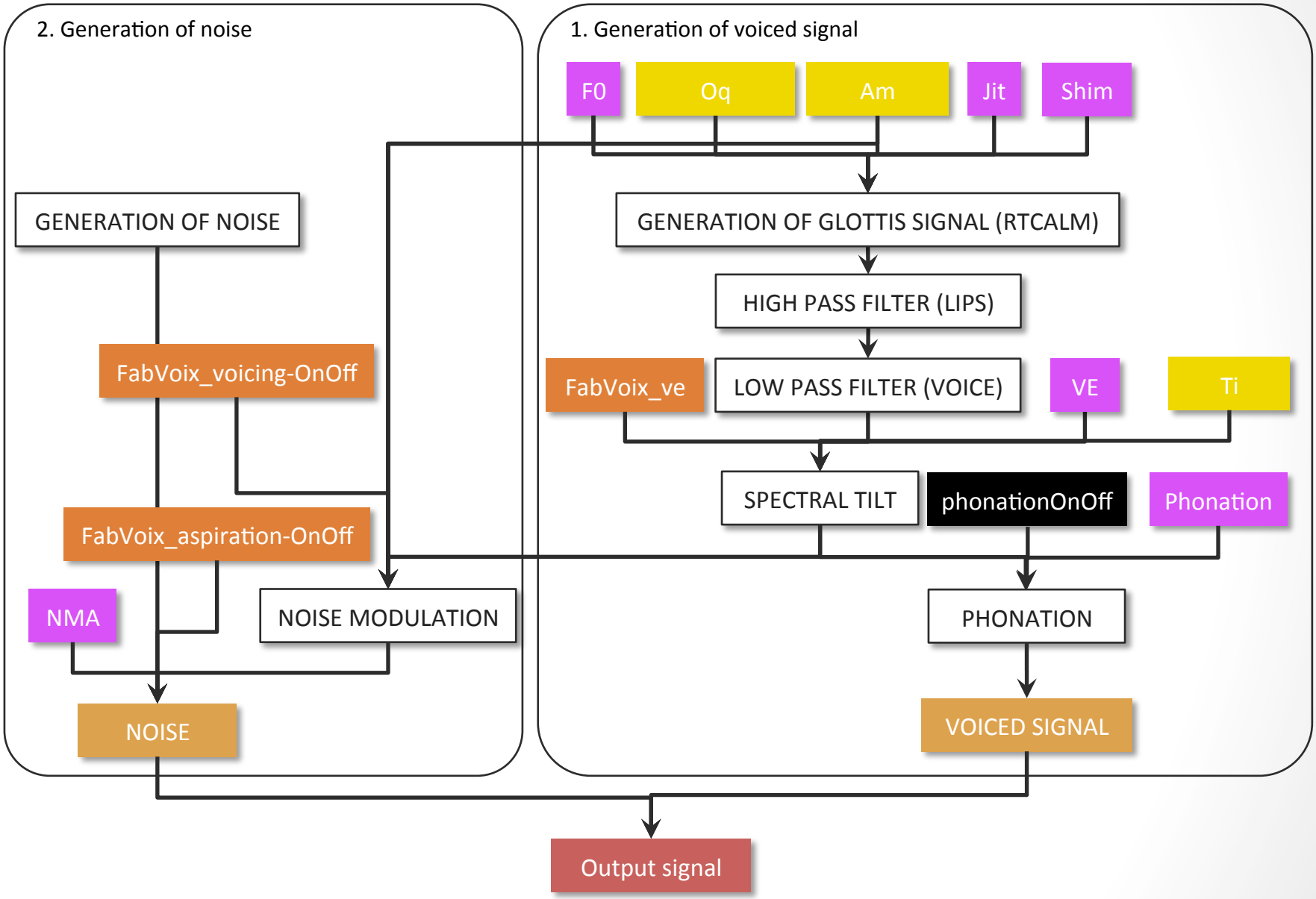
Inputs

Name	Description	From
NMA	Amount of breathiness / Apiration	Glottis Mapping HL
Shim	Shimmer	
Jit	Jitter	
Phonation	Phonation threshold	
F0	Final pitch	
VE	Final vocal effort	
Tl	Spectral tilt	Glottis Mapping LL
Oq	Open quotient	
Am	Asymmetry coefficient	
phonationOnOff	Flag for phonation threshold activation	Main Patch
FabVoix_voicing-OnOff	Flag allow voicing	Voice Factory
FabVoix_aspi-OnOff	Flag allow aspiration	
FabVoix_ve	Flag type of vocal effort control	

Outputs

Name	Description	To
Output signal	Source signal	Filter Formant Glottis

General chart



Compute the formant values

V RULES - FORMANT INTERPOLATION

Functions

- FORMANT INTERPOLATION computes the formant values given the vowel and consonant to play

1. Compute central frequencies of formants
2. Compute bandwidths of formants
3. Compute amplitudes of formants

Inputs / Outputs

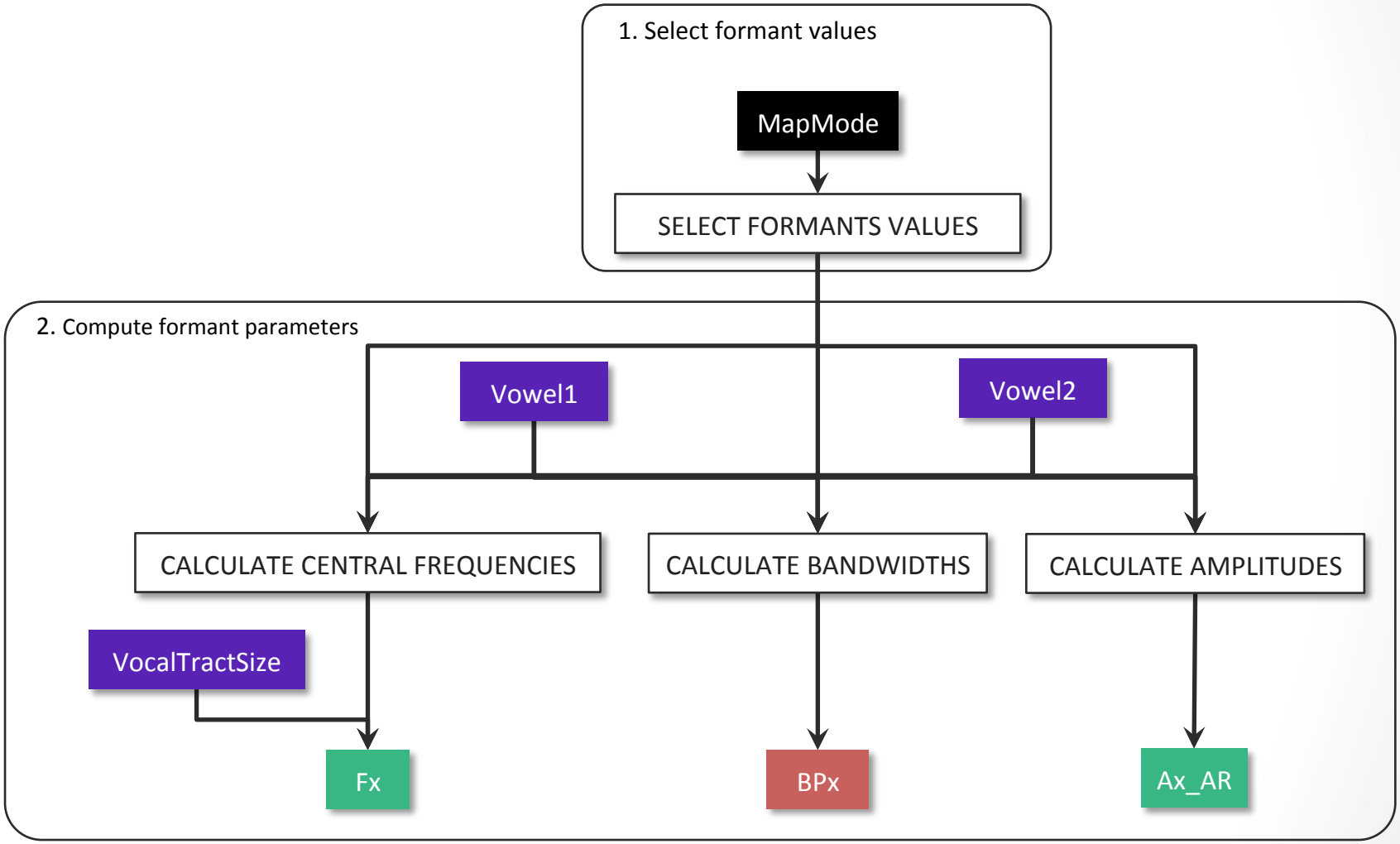
Inputs

Name	Description	From
MapMode	Flag mode vowel 2D / 1D	Main Patch
Vowel 1	Linear mapping of vowels dimension 1	V Mapping
Vowel 2	Linear mapping of vowels dimension 2	
VocalTractSize	Dynamically modified vocal tract size	

Outputs

Name	Description	To
Fx_Ar	Frequencies of formants before interaction	Source Filter Interaction
Ax_Ar	Amplitude of formants before interaction	
BPx	Bandwidth of formants	Filter Formant

General chart



Adapt formant amplitude depending on F0

SOURCE FILTER DEPENDENCIES

Functions

- SOURCE FILTER INTERACTION moves the formant amplitudes when F0 is closed to the formant frequency

1. Apply Fi dependency with F0

2. Apply F1 dependency with VE

3. Apply Ai dependency with F0
   - Anti-resonance on formants F1, F2, F3 if necessary

Inputs / Outputs

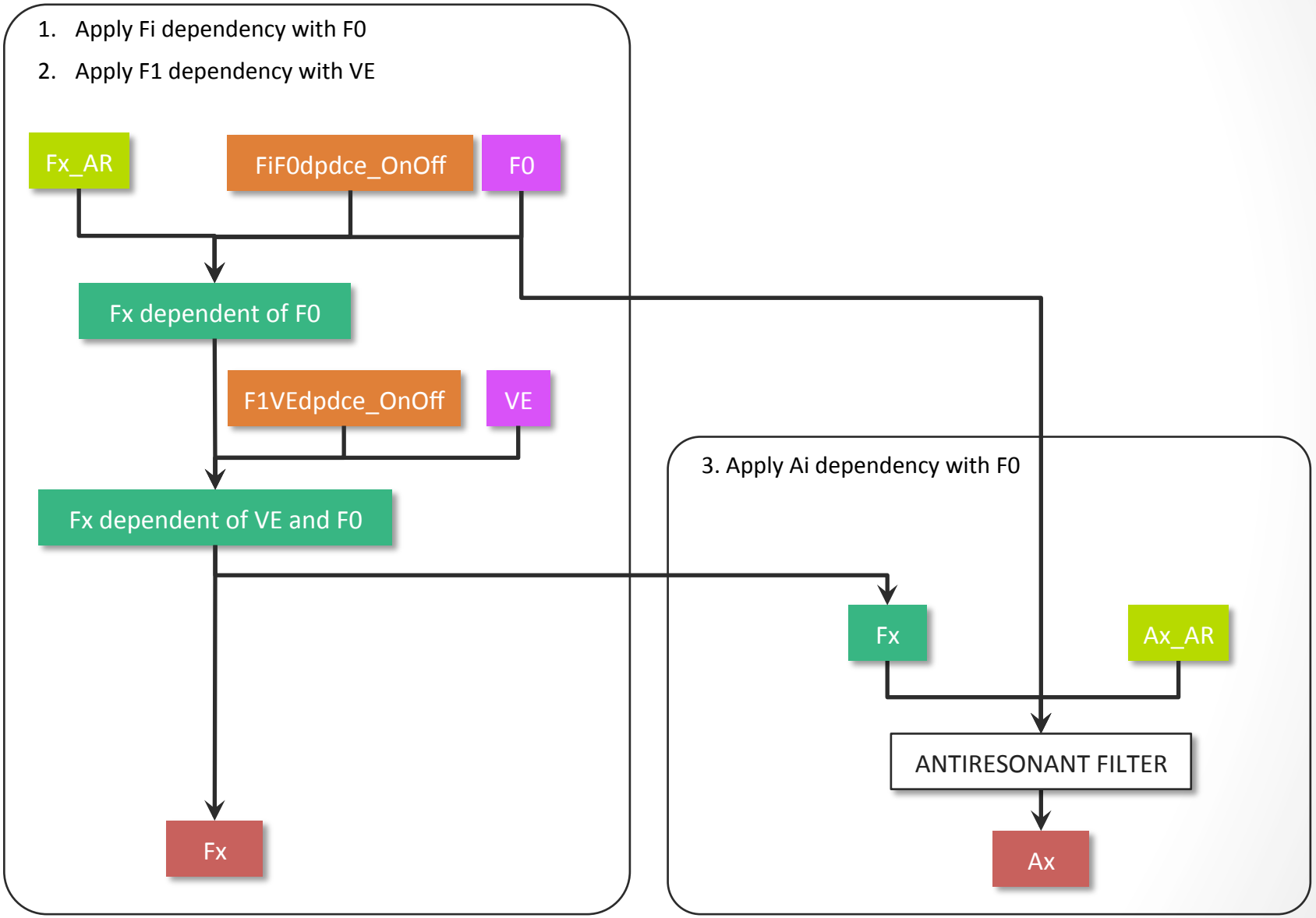
Inputs

Name	Description	From
Ax_Ar	Amplitude of formants before interaction	Formant Interpolation
F0	Final pitch	Glottis Mapping HL
VE	Final vocal effort	
FiF0dpdce_OnOff	Flag F1, F2 follow F0	Voice Factory
F1VEdpdce_OnOff	Flag F1 VE dependency	
FormantAttenuation	Flag Ai F0 dependency	

Outputs

Name	Description	To
Fx	Frequencies of formants after interaction	Filter Formant
Ax	Amplitude of formants after interaction	

General chart



Filter the glottis signal with vocal tract resonances

VOCAL TRACT

Functions

➲ FILTER FORMANT GLOTTIS creates the resonant and anti-resonant filters of the vocal tract and filters the glottis signal

1. Filter by bandpass filters in parallel for vocal tract resonances
   - Use resonant filters
   - Described by central frequency, bandwidth and amplitude

2. Filter by stopband filter for nasal anti-resonance

3. Filter by stopband filter for periform fossea anti-resonance

4. Filter by a lowpass filter for voiced plosives

Inputs / Outputs

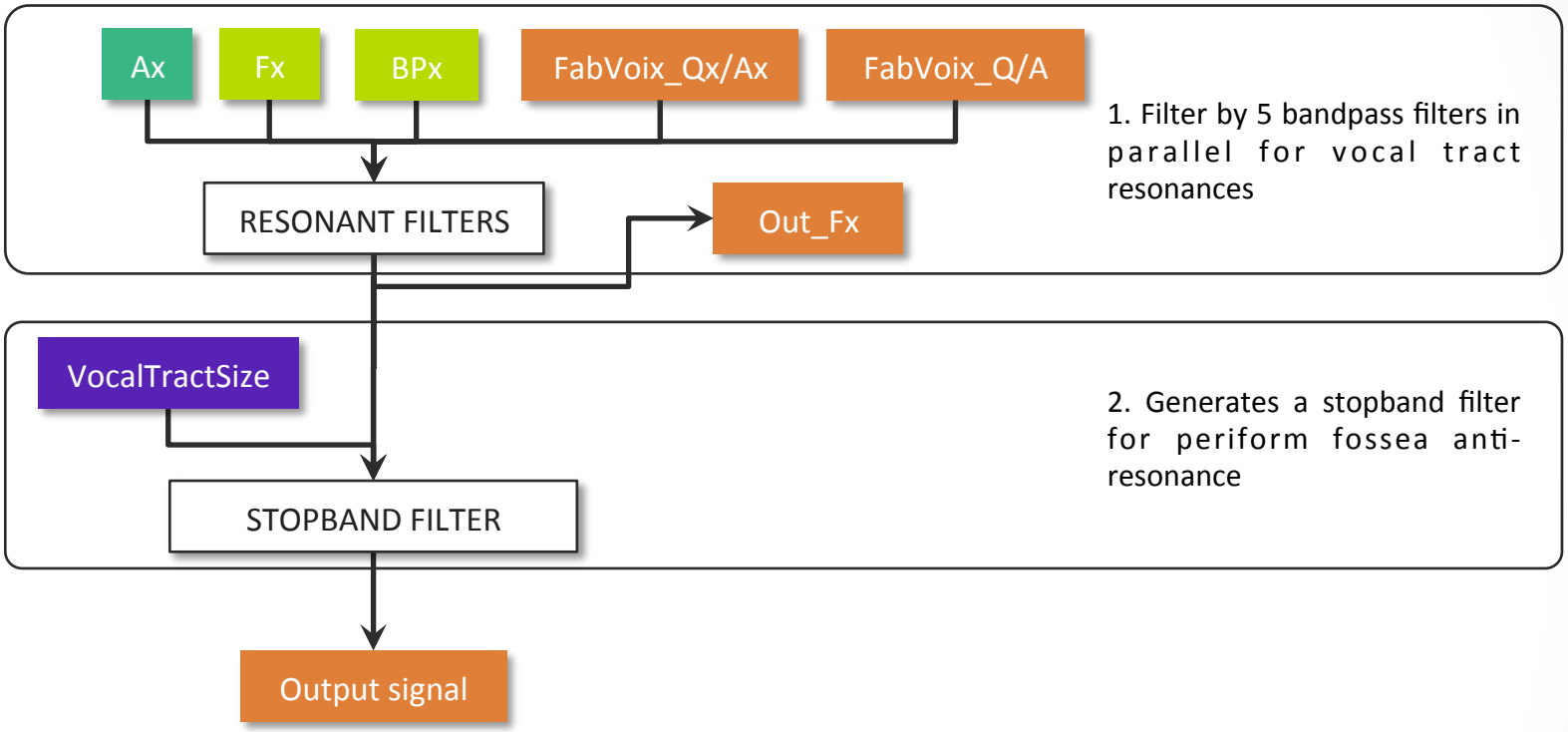
Inputs

Name	Description	From
VocalTractSize	Dynamically modified vocal tract size	V Mapping
FabVoix_Qx / Ax	Flag allow individual control Q / A	Voice Factory
FavVoix_Q / A	New value of Q (bandwidth) / A (amplitude)	
Ax	Amplitude of formants after interaction	Source Filter Interaction
Fx	Frequencies of formants	Formant Interactions
BPx	Bandwidth of formants	

Outputs

Name	Description	To
Output signal	Voice signal	Voice Factory
Out_Fx	Glottis filtered by combination of formants	

General chart



Deconstruction of source filter model

VOICE FACTORY

Functions

➲ VOICE FACTORY provides options to deconstruct the source filter model

1. Configuration of source
   - Allow voicing
   - Allow aspiration
   - Allow vocal effort control

2. Selection of formants
   - Apply formants individually
   - Apply formant successively

3. Source-filter interaction
   - Apply Ai and F0 dependency
   - Apply F1 and VE dependency
   - Apply F1, F2 and F0 dependency

Inputs / Outputs

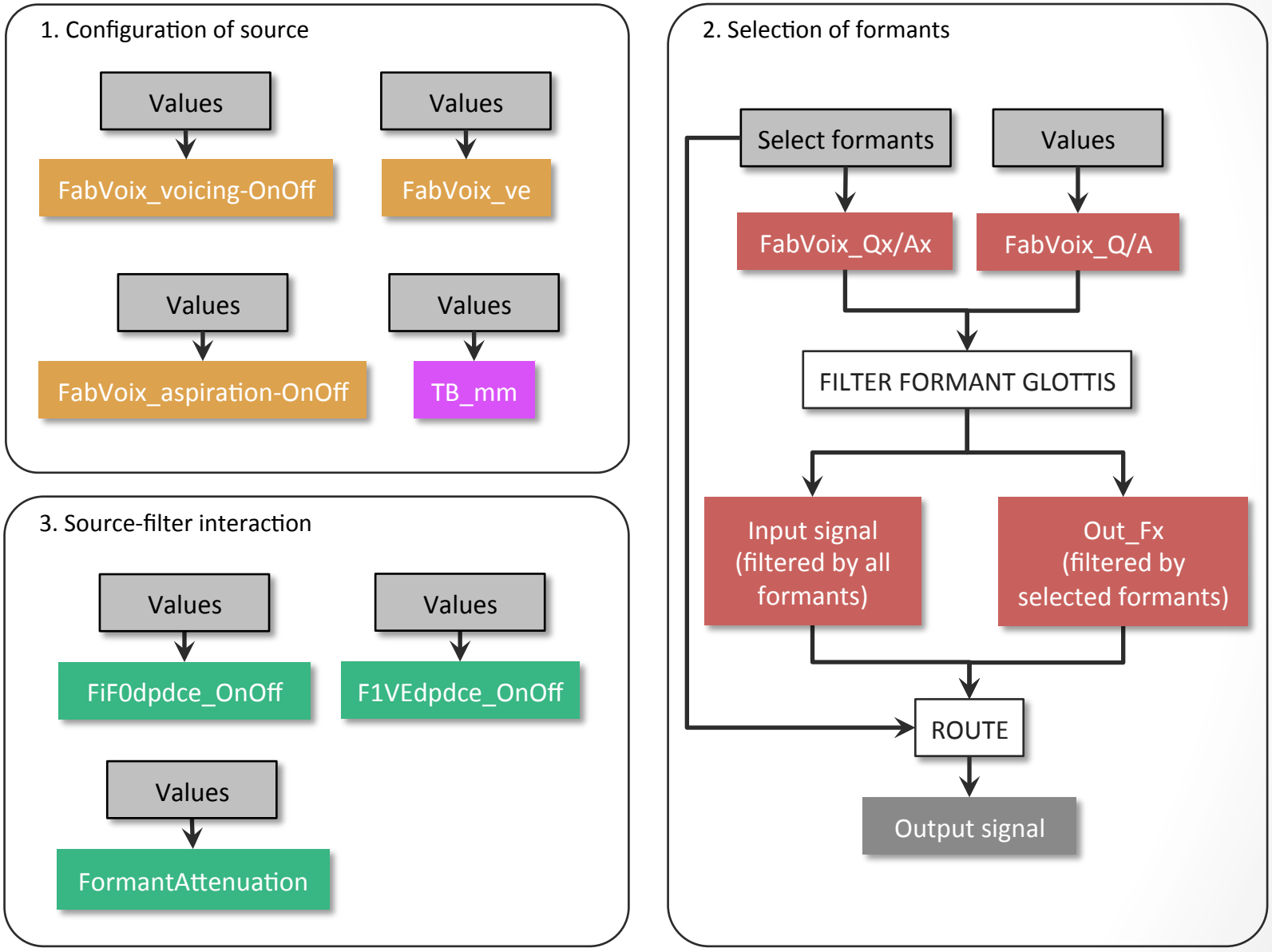
Inputs

Name	Description	From
Input signal	Voice signal	Filter Formant Glottis
Out_Fx	Glottis filtered by combination of formants	
Values	Change values of parameters	User

Outputs

Name	Description	To
TB_mm	Voice tension	Glottis Mapping HL
FiF0dpdce_OnOff	Flag F1, F2 follow F0	Formant Interpolation
F1VEdpdce_OnOff	Flag F1 VE dependency	
FormantAttenuation	Flag allow source filter interaction	Main Patch
FabVoix_voicing-OnOff	Flag allow voicing	Glottis
FabVoix_aspi-OnOff	Flag allow aspiration	
FabVoix_ve	Flag type of vocal effort control	
FabVoix_Qx / Ax	Flag allow individual control Q / A	Filter Formant Glottis
FavVoix_Q / A	New value of Q (bandwidth) / A (amplitude)	
Output signal	Audio signal	Audio

General chart



Add signals and adjust volume

AUDIO

Functions

- AUDIO get the glottis signal and the occlusive and plosive signals, mix them and adjust the main volume depending on the vocal effort

1. Calculates main volume from vocal effort

2. Apply a reverb to the sound

3. Apply a compression to the sound

Inputs / Outputs

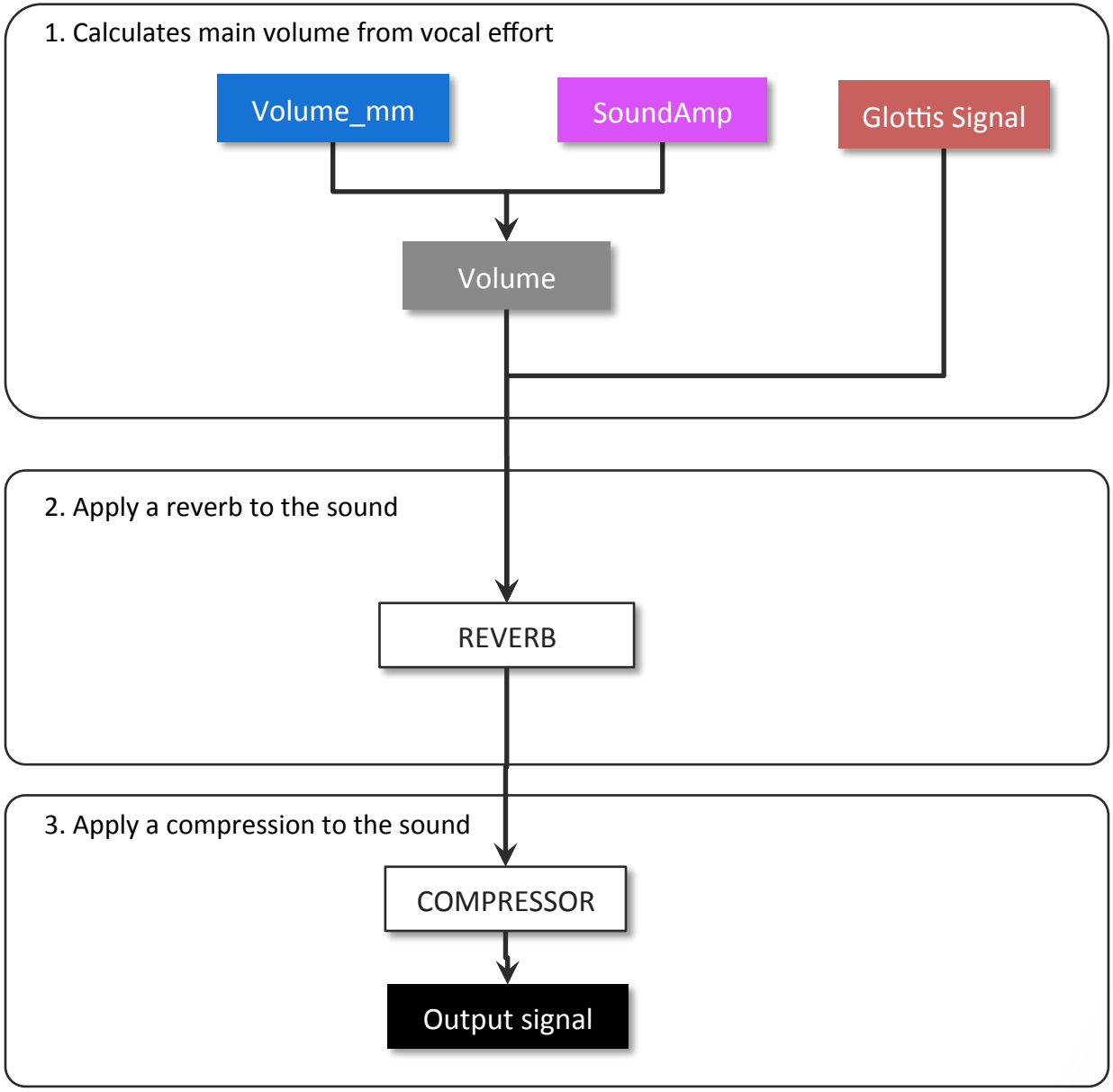
Inputs

Name	Description	From
SoundAmp	Volume	Glottis Mapping HL
Volume_mm	Main volume	Control
Glottis signal	Glottis signal	Filter Formant Glottis

Outputs

Name	Description	To
Output signal	Final signal	Main Patch

General chart



License – 1

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Cantor Digitalis

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This software is a singing synthesis computer program made of a digital formant synthesizer driven by one or several control interfaces. It is composed of a suite of Max patches. At runtime, the user interacts with the two following Max programs: CantorDigitalis-Tab and CantorDigitalis-Synth.

CantorDigitalis-Tab is used to receive the data from the graphic tablet and send them to the synthesis engine.

CantorDigitalis-Synth is the synthesis engine. It is a performative parametric voice synthesizer. CantorDigitalis-Synth implements the linear acoustic source-filter model of voice production. The "filter" or "vocal tract" part of the system is computed using a parallel structure made of digital second-order resonators. Vowels are controlled according to synthesis rules. The "source" or "glottal flow derivative" part of the system is computed using the Causal-Anticausal Linear Model CALM. The CALM parameters are combined for controlling four vocal dimensions: voice tension, breathiness, roughness, and vocal effort. CantorDigitalis-Synth includes presets for voice categories (baritone, tenor, alto, soprano), voice range profiles, source-filter interactions (formant and harmonic tuning), high F0 resolution, vocal tract size, vocalic space and voice quality control.

The software can be downloaded at the following URL:
http://cantordigitalis.limsi.fr/

License – 2

CantorDigitalis-Tab uses S2M.WACOM and S2M.WACOMTOUCH, Max externals and C sources for the tablet data reception.

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S2M.WACOM and S2M.WACOMTOUCH
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The software was developed during the métason project (ANR-10-CORD-0003) and can be downloaded at the following URL:
http://metason.cnrs-mrs.fr/Resultats/MaxMSP/index.html

[s2m.wacom] is based on the design of the [wacom] object whose history is :
- Version 3. (for OSX) by Jean-Michel Couturier, CNRS-LMA, France, 2003.
- wacom object for os9 (version 2) by Richard Dudas. Copyright (c) 1999, the Regents of the University of California.
Special thanks to Atau Tanaka for suggesting this object back in the Bionic days. Thanks to CNMAT for sponsoring the version 2.

- -
s2m.wacom has been done with ObjectiveMax - A framework for creating Max objects using Objective-C

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