Optimization of Full 3D Hierarchical Cascading Technique for Surface Acoustic Wave Device Simulations

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Outline of Presentation

• Introduction

• Full 3D Hierarchical Cascade

• Time Optimization

• Result and Conclusion
Introduction

The development of hierarchical cascading technique (HCT) has greatly reduced the computational load using the periodicity of SAW devices!!

- More accurate results
- More time and memory cost

- Full 3D HCT
- Full 3D FEM
- Periodic HCT
- Periodic FEM
Introduction

How to efficiently cascade 3D models?
Full 3D Hierarchical Cascade

1. \([K - \omega^2 M + i\omega D](x) = (F)\)

Reorganize

\[
\begin{bmatrix}
A_{EE} & A_{ER} & A_{EV} \\
A_{RE} & A_{RR} & A_{EV} \\
A_{VE} & A_{VR} & A_{VV}
\end{bmatrix}
\begin{bmatrix}
x_E \\
x_S \\
V
\end{bmatrix} =
\begin{bmatrix}
F_E \\
F_S \\
-Q
\end{bmatrix}
\]

Schur (SC)
Complement

2. \([BC][x_S] = (0)\)

3. \([B_{11} B_{12}][x_S] = (0)\)

Splice:

4. \[
\begin{bmatrix}
C_{11-N} & C_{12-N} & C_{13-N} \\
C_{21-N} & C_{22-N} & C_{23-N} \\
C_{31-N} & C_{32-N} & C_{33-N}
\end{bmatrix}
\begin{bmatrix}
x_{S-N} \\
V
\end{bmatrix} =
\begin{bmatrix}
0 \\
0 \\
-Q_N
\end{bmatrix}
\]

5. \[
\begin{bmatrix}
D_{11} & D_{12} \\
D_{21} & D_{22}
\end{bmatrix}
\begin{bmatrix}
x_S' \\
V
\end{bmatrix} = (0)
\]

\(x_E\): DOFs to be eliminated
\(x_S\): DOFs to be saved
Full 3D Hierarchical Cascade

Multidirectional cascade:
- Cascade in Z direction
- Cascade in Y direction
- Cascade in X direction

(Take ‘Z→Y→X cascade’ as an example)
Time Optimization

\[ n_x = 10 \]
\[ n_y = 30 \]
\[ DOF_x = 768 \]
\[ DOF_y = 168 \]
Time Optimization

\[ t_{X\rightarrow Y} = t_{1st\text{-}step} + t_{2nd\text{-}step} \]

\[ = \sum_{i=1}^{n_x} \tau_i + \tau_c \times n_y \]

\[ t_{Y\rightarrow X} = t_{1st\text{-}step} + t_{2nd\text{-}step} \]

\[ = \sum_{i=1}^{n_y} \tau_i + \tau_c \times n_x \]
We put forward the time optimized \( 'Z\rightarrow Y\rightarrow X' \) cascading method.
Full 3D HCT simulation reveals more details (spurious modes) compared to the other structures!
Thank you for your patience.