Pareto-Optimal Domino Tiling of Phased Arrays

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Contents

1 Introduction

This work presents an innovative tiling optimization strategy for arbitrary orthogonal-polygon shaped apertures. An exhaustive search approach, together with a multi-objective strategy, has been used in order to obtain optimal tiling configurations, jointly optimizing two different pattern features of interest. A simple example validating the proposed method has been finally reported.

2 Numerical Results

2.1 Orthogonal Polygon #4

Array Analysis Parameters:

- Total Number of Elements: $P = 40$
- Spacing: $d = \lambda/2$
- Number of Samples along u: 512
- Number of Samples along v: 512
- Steering θ Direction: $\theta_s = 0$
- Steering ϕ Direction: $\phi_s = 0$

Tiling Parameters:

- Number of Inner Lattice Points: $N_{inn} =$

2.1.1 ETM-MOP - CP Reference Excitations, Symmetric Mask, SLL = -30 [dB] - Mask Matching vs {SLL, D, HPBW}

Reference Fully-Populated Array:

- Number of Samples along u: $512\ -2 < u < 2$
- Number of Samples along v: $512\ -2 < v < 2$
- Steering θ Direction: $\theta_s = 0$
- Steering ϕ Direction: $\phi_s = 0$
- Tapering: CP Symmetric Mask
- Main Lobe Window Width along u: $MW_u = 0.32$ [u]
- Main Lobe Window Width along v: $MW_v = 0.60$ [v]
- Side Lobe levels: $SLL = -30.0$

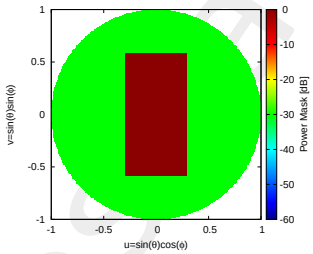

Figure 1: The power pattern mask used for the reference tapering optimization with CP.

Cost Function:

- $OBJ^{(1)} = SLL$
- $OBJ^{(2)} = HPBW_{AZ}$
- $OBJ^{(3)} = HPBW_{EL}$
- $OBJ^{(4)} = D$
- $OBJ^{(5)} = \int_{-1}^{1}\int_{-1}^{1}\left[M\left(u,v\right) - P\left(u,v;\underline{C}\right)\right]\mathcal{H}\left[P\left(u,v;\underline{C}\right) - M\left(u,v\right)\right]dudv$

RESULTS

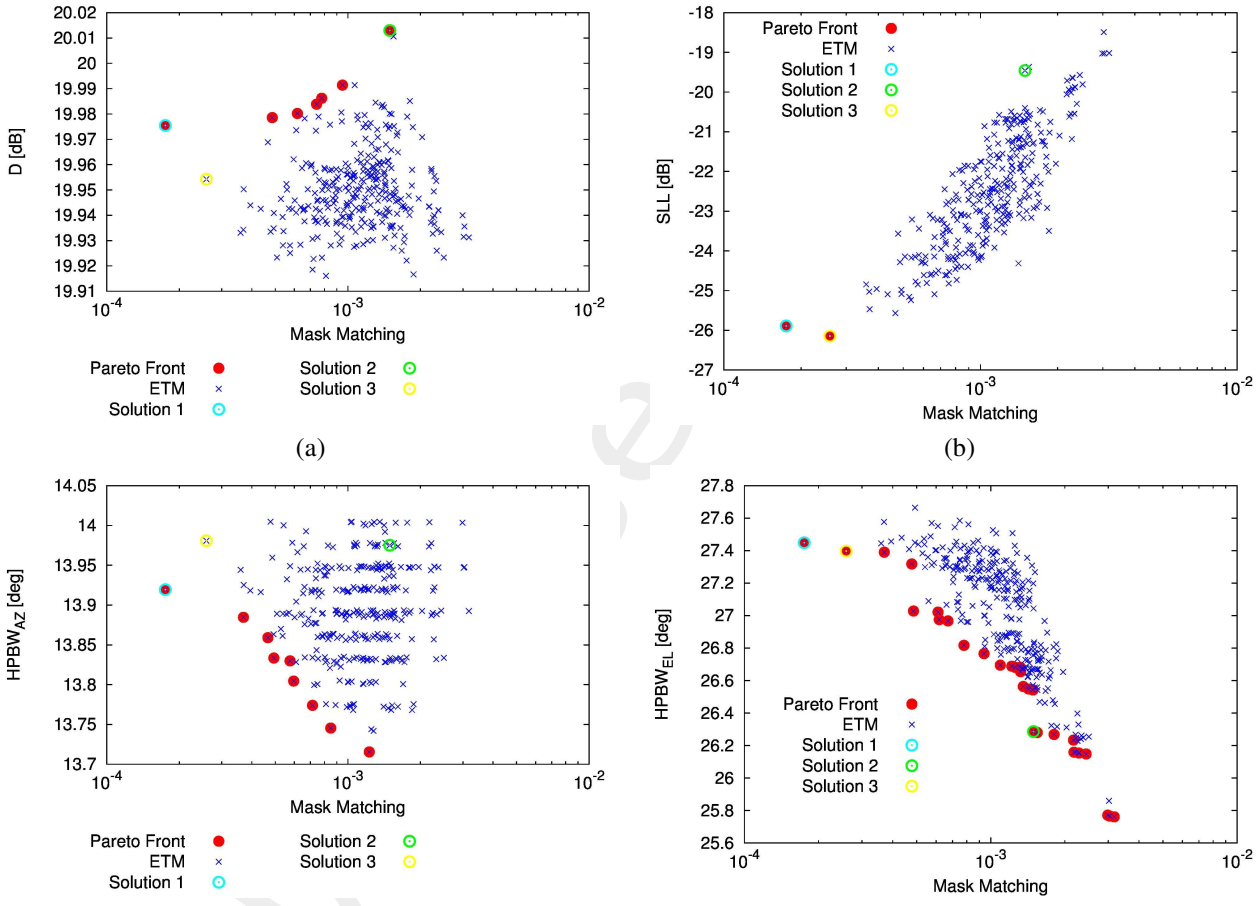

Figure 2: Pareto front of the ETM soutions.

	$Solution\,ID$	SLL [dB]	D [dBi]	$HPBW_{az}$ [deg]	$HPBW_{el}$ [deg]	$Mask\,Matching$
$Reference$	–	-30.00	19.99	13.90	27.56	0.00
$Solution-1$	573	-25.89	19.98	13.92	27.45	1.75×10^{-4}
$Solution-2$	483	-19.46	20.01	13.98	26.20	1.49×10^{-3}
$Solution-3$	111	-26.15	19.95	13.98	27.40	2.59×10^{-4}

Table I: Pattern descriptors and fitness values for the presented solutions.

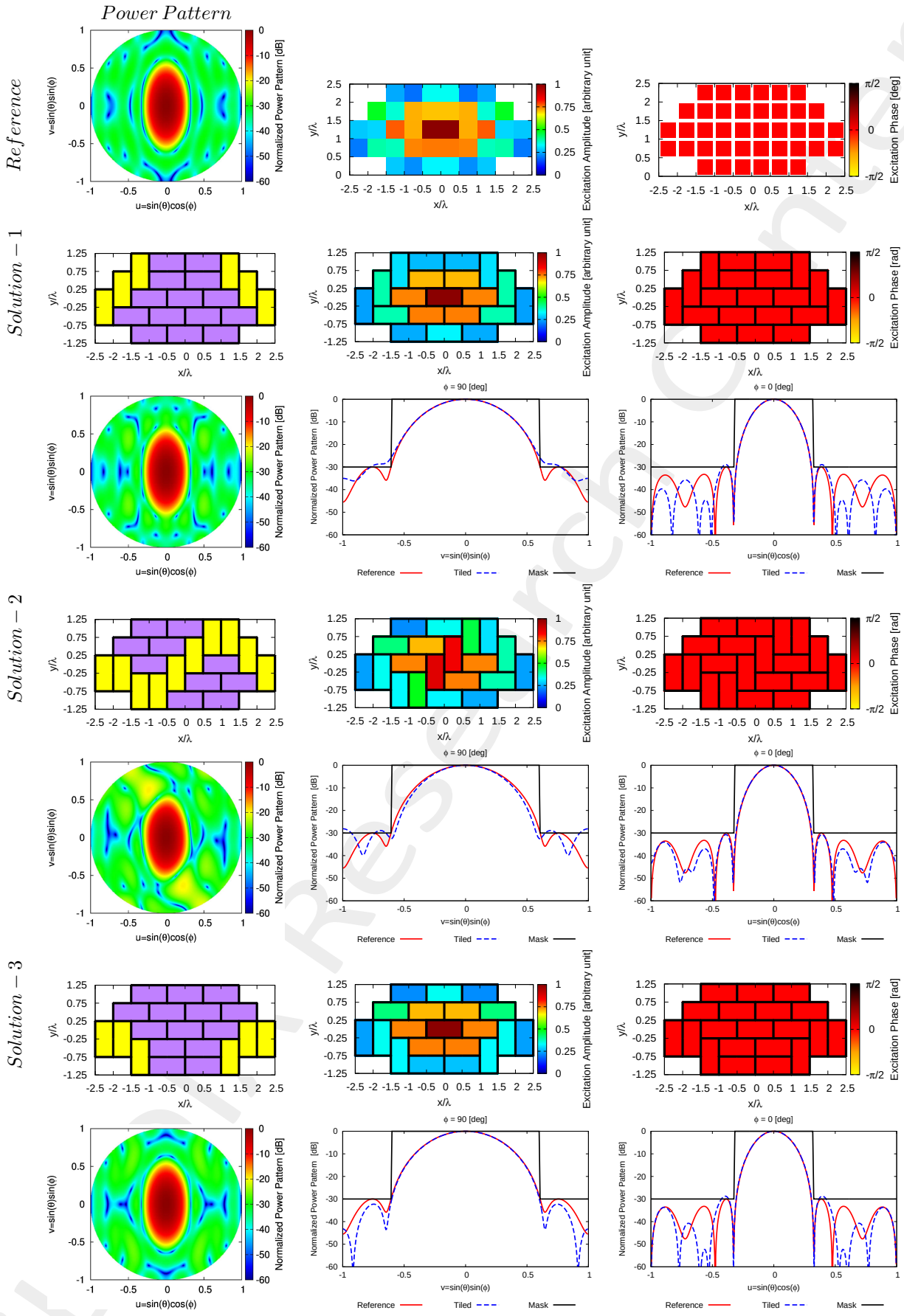

Figure 3: Power Patterns.

2.2 Orthogonal Polygon #6 (Ellipse Large)

2.2.1 OTM-MOP - CP Reference Excitations, Symmetric Mask, SLL = -32.7 [dB] - SLL vs {HPBW}

Array Analysis Parameters:

- Total Number of Elements: $P = 224$
- Spacing: $d = \lambda/2$
- Number of Samples along u: 512
- Number of Samples along v: 512
- Steering θ Direction: $\theta_s = 0$
- Steering ϕ Direction: $\phi_s = 0$
- Tapering: CP - Symmetric Mask:
- Main Lobe Window Width along u: $MW_u = 0.14$ [u]
- Main Lobe Window Width along v: $MW_v = 0.28$ [v]
- Side Lobe levels: $SLL = -32.7$

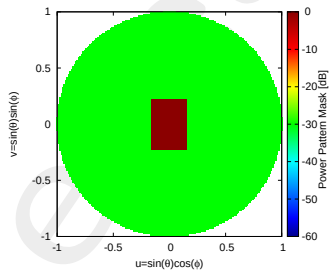

Figure 4: The power pattern mask used for the reference tapering optimization with CP.

Tiling Parameters:

- Tile: Domino
- Number of Elements in each Tile: $N_T = 2$
- Total Number of Configurations: $\Gamma > ...$
- Number of Inner Lattice Points: $N_{inn} = 187$

Cost Function:

- $OBJ^{(1)} = arg\left\{SLL\left[P\left(u,v\right)\right]\right\}$
- $OBJ^{(2)} = HPBW_{AZ}$
- $OBJ^{(3)} = HPBW_{EL}$

RESULTS - Pareto Fronts (MOP)

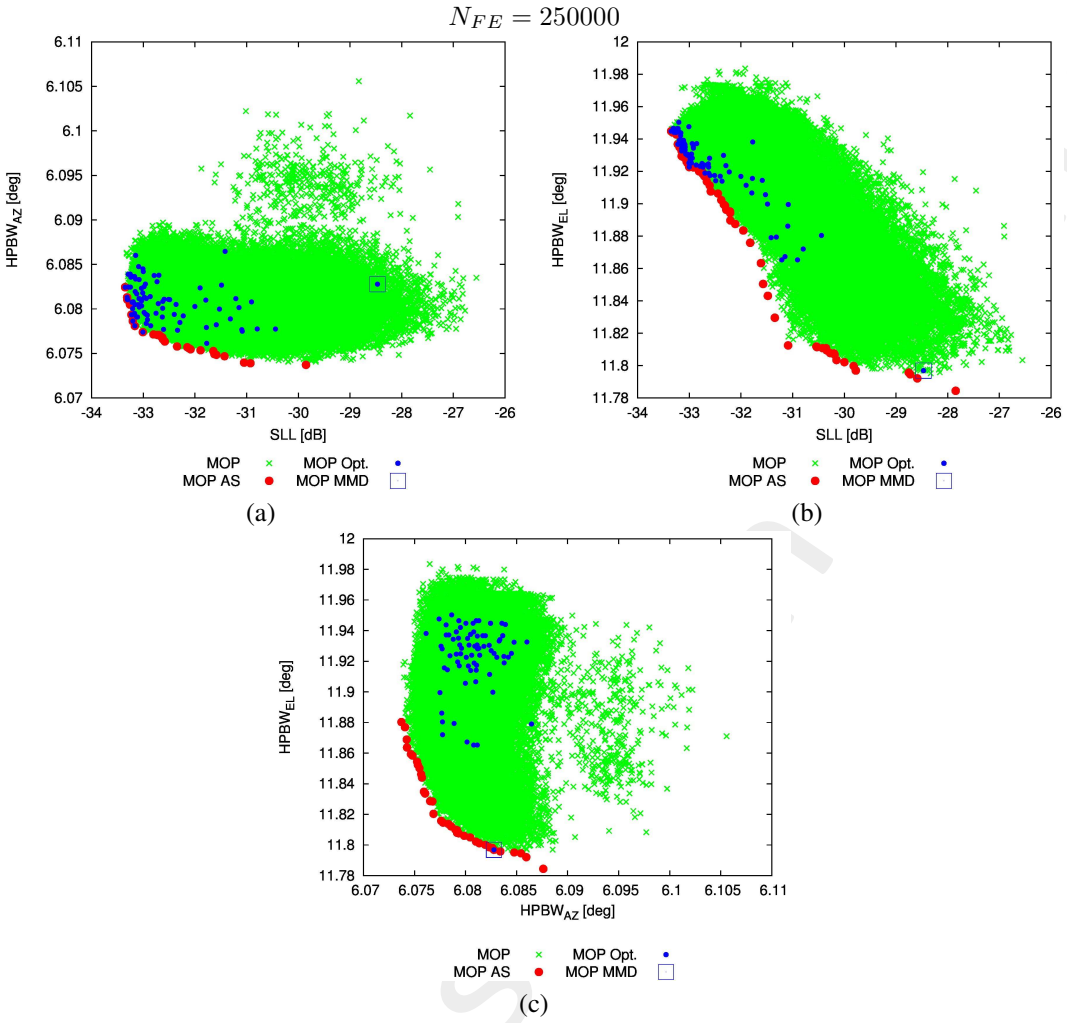

Figure 5: Exhaustive Pareto front as compared to the MOP Approximation Set considering: $OBJ^{(1)} = SLL$ vs $OBJ^{(2)} = HPBW_{AZ}$ (a), $OBJ^{(1)} = SLL$ vs $OBJ^{(3)} = HPBW_{EL}$(b), $OBJ^{(2)} = HPBW_{AZ}$ vs $OBJ^{(3)} = HPBW_{EL}$(c), for $N_{FE} = 250k$ fitness evaluations.

	SLL [dB]	D [dBi]	$HPBW_{az}$ [deg]	$HPBW_{el}$ [deg]
$Reference$	-32.69	27.15	6.11	12.03
$Solution - 722910$	-28.47	27.19	6.08	11.80
$Solution - 4797094$	-33.35	27.18	6.08	11.94
$Solution - 5044877$	-31.77	27.18	6.08	11.94

Table II: Pattern descriptors and fitness values for the presented solutions.

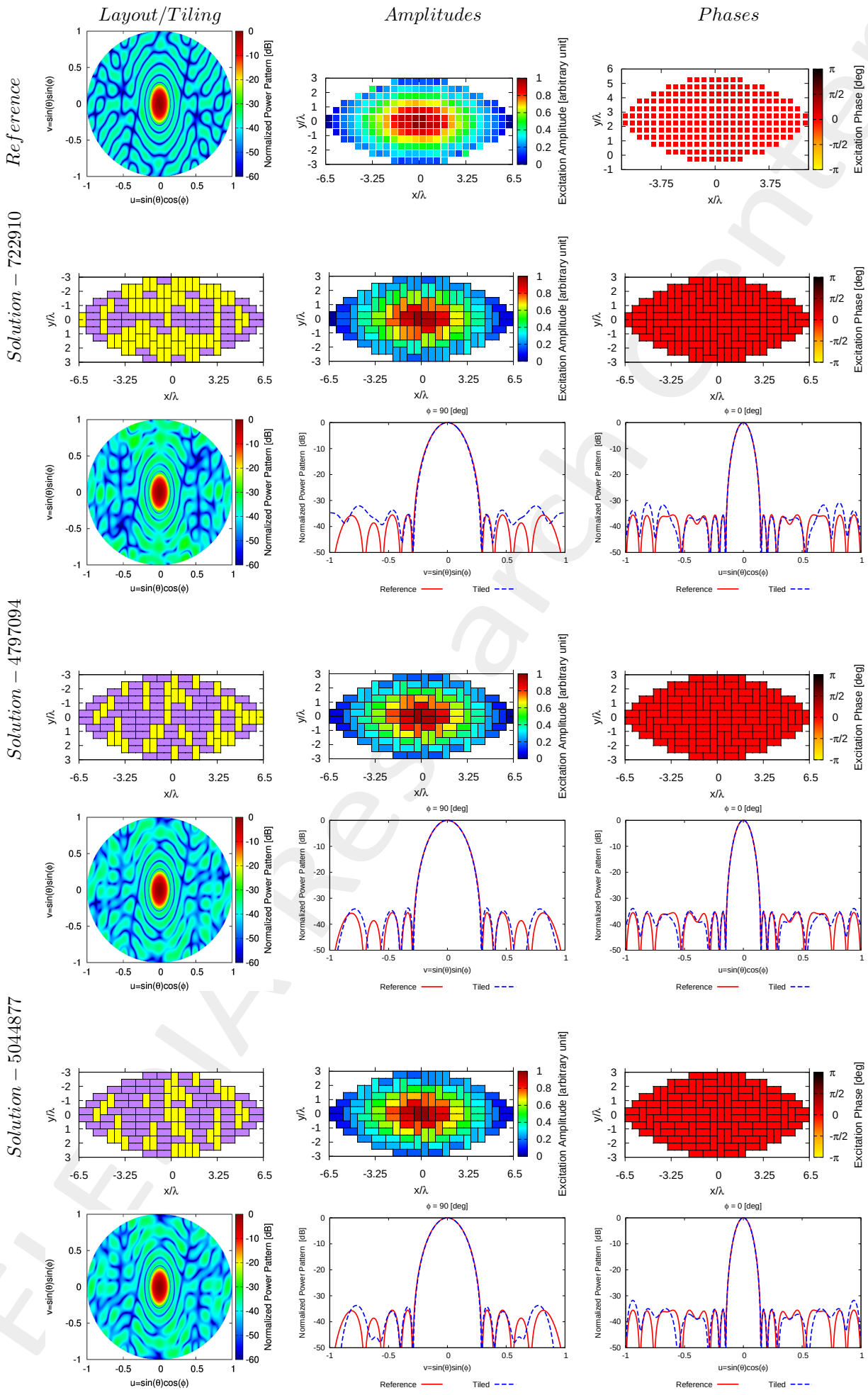

Figure 6: Tiling Configurations/Excitations.

OUTCOME:

- Solution-722910 (MMD) for the set of objectives $\{SLL, HPBW_{Az}, HPBW_{EL}\}$, $\{HPBW_{Az}, HPBW_{EL}\}$, $\{SLL, HPBW_{EL}\}$, $\{HPBW_{EL}\}$.
- Solution-4797094 (MMD) for the set of objectives $\{SLL\}$.
- Solution-5044877 (MMD) for the set of objectives$\{SLL, HPBW_{Az}\}$, $\{HPBW_{Az}\}$

More information on the topics of this document can be found in the following list of references.

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