Genetically-designed thinned ring arrays for effective pattern nulling with directivity control

N. Anselmi, L. Poli, P. Rocca, and A. Massa

Abstract

This document deals with a strategy for thinning the radiating elements of ring arrays in order to suppress interfering signals arriving on the antenna sidelobes. The on-off status of the array element is changed according to the optimized binary sequences determined through an evolutionary algorithm suitably customized to provide solutions with a controlled percentage of the number of active bits with respect to its total number. The proposed technique is validated with a set of experiments where arrays of different size haved been considered.

TEST CASE - $N = 37$ -$Configuration = 3rings$ -$\eta \in [0.6, 0.6]$ - $N_I = 2$

Goal

Maximization of the SINR using genetic algorithms (GA) to determine the optimal thinned ring array configuration, considering a time-varying scenario with 2 interferences and a constraint on the number of elements excited.

Test Case Description

- Number of Elements $N = 37$
- Elements Spacing: $d = 0.5\lambda$
- Max Gain Pattern Direction : $\theta^d = 90°$, $\phi^d = 90°$
- Desired Signal Power: $0\,dB$
- Interference Power: $30\,dB$
- Noise Power: $-30\,dB$
- Number of Interferences: $N_I = 2$
- Interference Direction Of Arrival: $\theta_1^i = 146°$, $\phi_1^i = 80°$
- Interference Direction Of Arrival: $\theta_2^i = 41°$, $\phi_2^i = 167°$

Optimization Approach: GA

- Number of Variables: $X = 37$ (α_n, $n = 1, ..., N$)
- Population: 18
- Crossover Probability: 0.9
- Mutation Probability: 0.01
- Number of Generations: 200
- Minimum Thinning Coefficient: 0.6
- Maximum Thinning Coefficient: 0.6

GA - Multiple Interferences: $\theta_1^i = 146°$, $\phi_1^i = 80°$; $\theta_2^i = 41°$, $\phi_2^i = 167°$

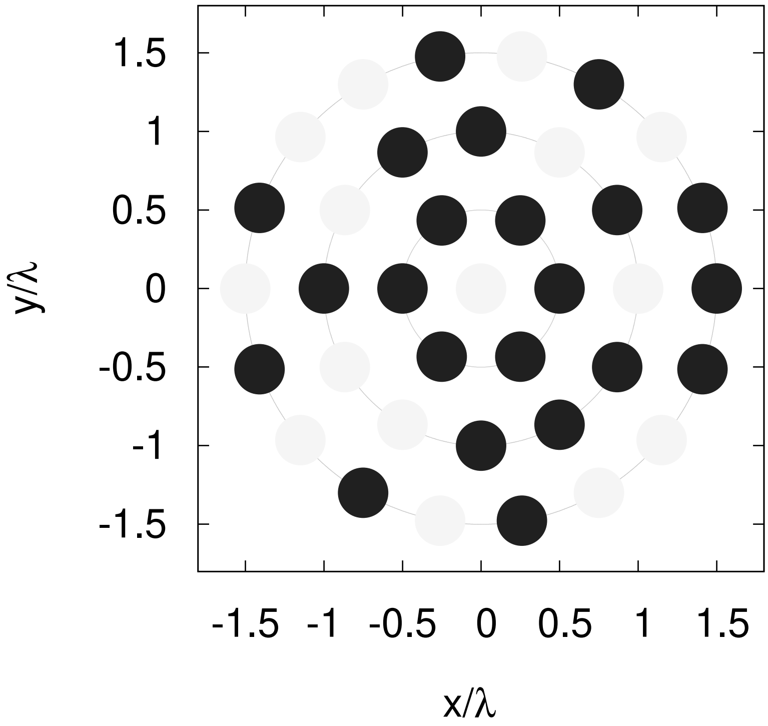


Fig.1 - Thinning Configuration

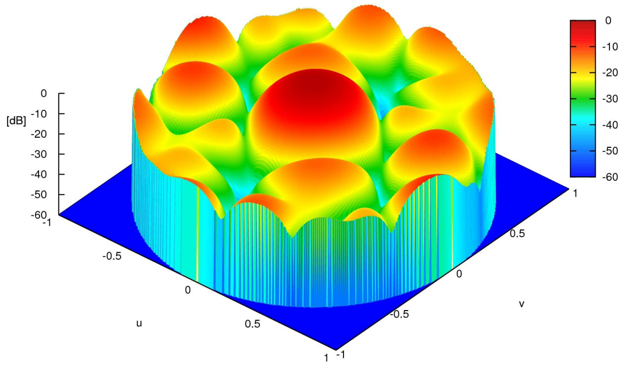


Fig.2 - Pattern

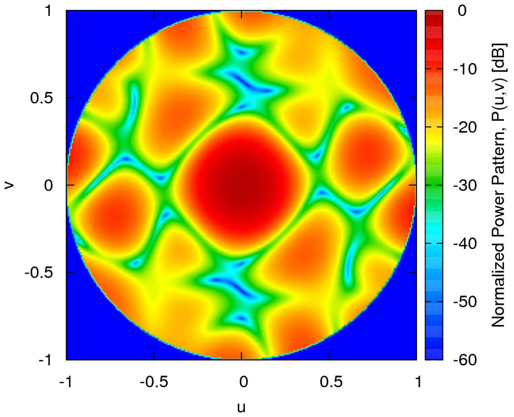


Fig.3 - Pattern projection

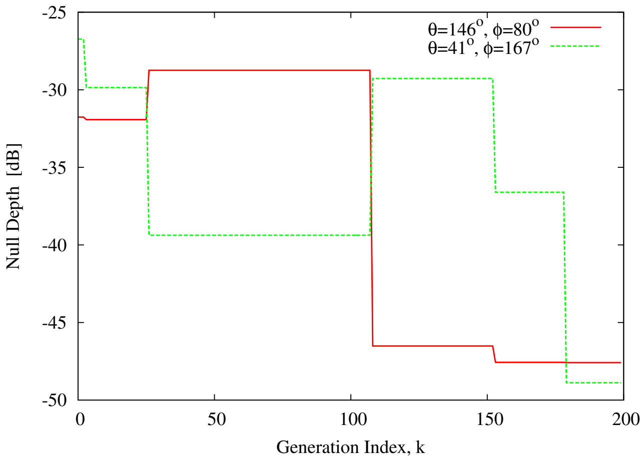


Fig.4 - Nulls Depth 1

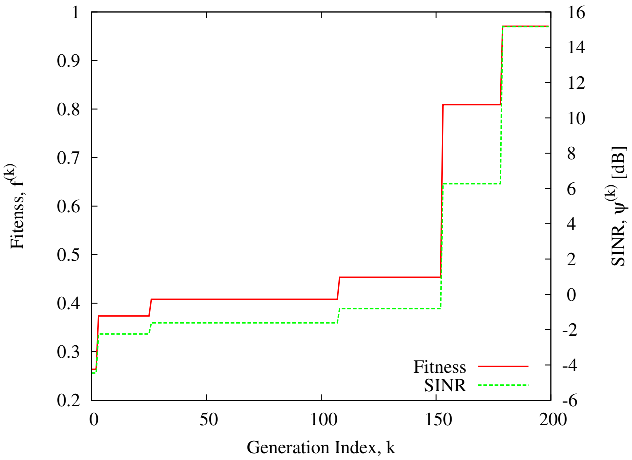


Fig.5 - Fitness SINR

SINR[dB]: 15.16

Null Depths[dB]: $[-47.58, -48.88]$

Number of Active Elements: 22

TEST CASE - $N = 37$ -$Configuration = 3rings$ -$\eta \in [0.6, 0.6]$ - $N_I = 3$

Goal

Maximization of the SINR using genetic algorithms (GA) to determine the optimal thinned ring array configuration, considering a time-varying scenario with 3 interferences and a constraint on the number of elements excited.

Test Case Description

- Number of Elements $N = 37$
- Elements Spacing: $d = 0.5\lambda$
- Max Gain Pattern Direction : $\theta^d = 90°$, $\phi^d = 90°$
- Desired Signal Power: $0\,dB$
- Interference Power: $30\,dB$
- Noise Power: $-30\,dB$
- Number of Interferences: $N_I = 3$
- Interference Direction Of Arrival: $\theta_1^i = 93°$, $\phi_1^i = 166°$
- Interference Direction Of Arrival: $\theta_2^i = 114°$, $\phi_2^i = 47°$
- Interference Direction Of Arrival: $\theta_3^i = 55°$, $\phi_3^i = 57°$

Optimization Approach: GA

- Number of Variables: $X = 37$ (α_n, $n = 1, ..., N$)
- Population: 18
- Crossover Probability: 0.9
- Mutation Probability: 0.01
- Number of Generations: 200
- Minimum Thinning Coefficient: 0.6
- Maximum Thinning Coefficient: 0.6

GA - Multiple Interferences: $\theta_1^i = 93°$, $\phi_1^i = 166°$; $\theta_2^i = 114°$, $\phi_2^i = 47°$; $\theta_3^i = 55°$, $\phi_3^i = 57°$

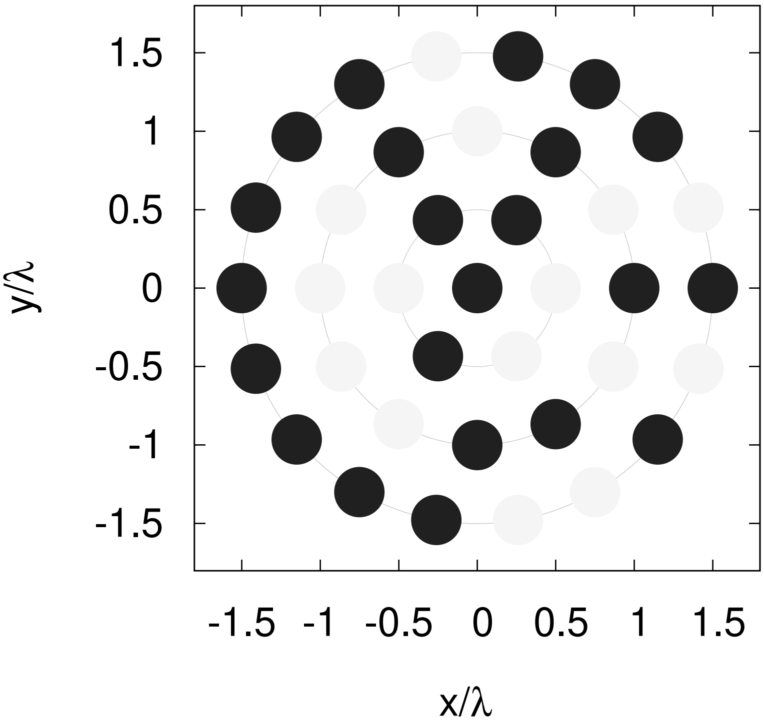


Fig.1 - Thinning Configuration

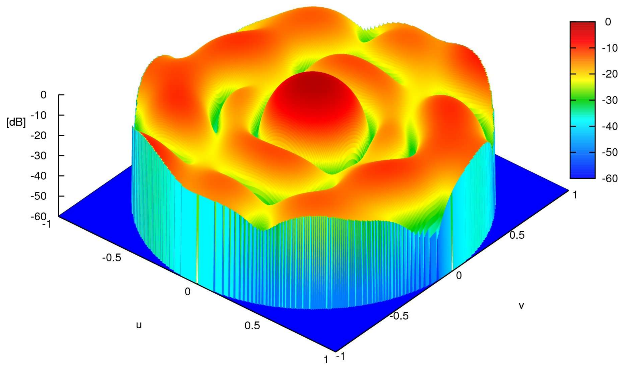


Fig.2 - Pattern

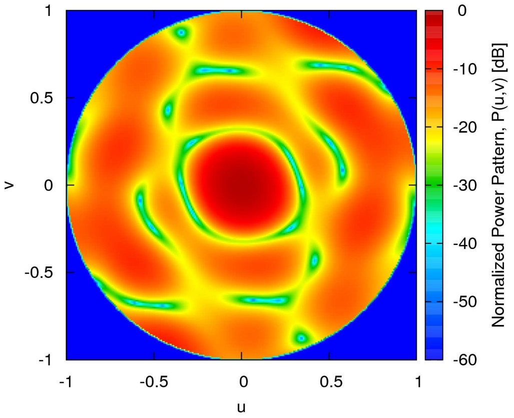


Fig.3 - Pattern projection

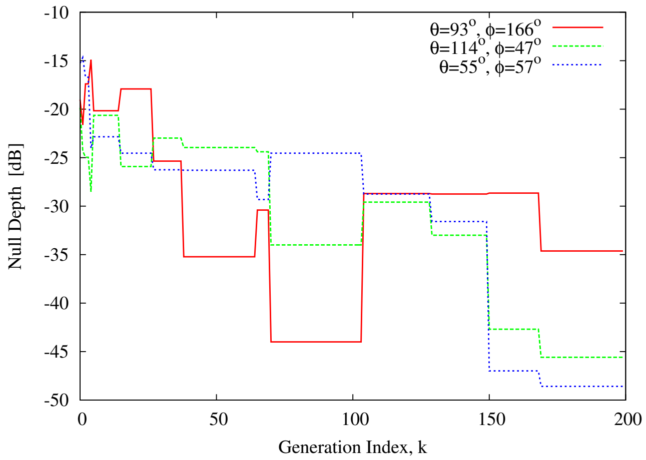


Fig.4 - Nulls Depth 1

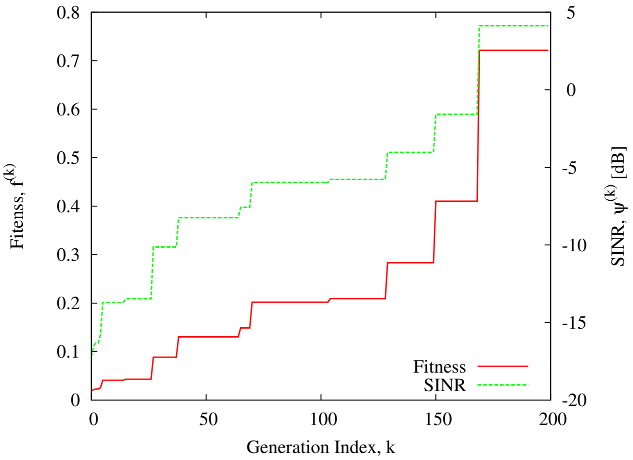


Fig.5 - SINR - Fitness

SINR[dB]: 4.13

Null Depths[dB]: $[-34.62, -45.58, -48.59]$

Number of Active Elements: 22

TEST CASE - $N = 37$ -$Configuration = 3rings$ -$\eta \in [0.6, 0.6]$ - $N_I = 4$

Goal

Maximization of the SINR using genetic algorithms (GA) to determine the optimal thinned ring array configuration, considering a time-varying scenario with 4 interferences and a constraint on the number of elements excited.

Test Case Description

- Number of Elements $N = 37$
- Elements Spacing: $d = 0.5\lambda$
- Max Gain Pattern Direction : $\theta^d = 90°$, $\phi^d = 90°$
- Desired Signal Power: $0\,dB$
- Interference Power: $30\,dB$
- Noise Power: $-30\,dB$
- Number of Interferences: $N_I = 4$
- Interference Direction Of Arrival: $\theta^i_1 = 105°$, $\phi^i_1 = 9°$
- Interference Direction Of Arrival: $\theta^i_2 = 106°$, $\phi^i_2 = 20°$
- Interference Direction Of Arrival: $\theta^i_3 = 134°$, $\phi^i_3 = 85°$
- Interference Direction Of Arrival: $\theta^i_4 = 130°$, $\phi^i_4 = 104°$

Optimization Approach: GA

- Number of Variables: $X = 37$ $(\alpha_n,\, n = 1, ..., N)$
- Population: 18
- Crossover Probability: 0.9
- Mutation Probability: 0.01
- Number of Generations: 200
- Minimum Thinning Coefficient: 0.6
- Maximum Thinning Coefficient: 0.6

GA - Multiple Interferences: $\theta_1^i = 105°$, $\phi_1^i = 9°$; $\theta_2^i = 106°$, $\phi_2^i = 20°$; $\theta_3^i = 134°$, $\phi_3^i = 85°$; $\theta_4^i = 130°$, $\phi_4^i = 104°$

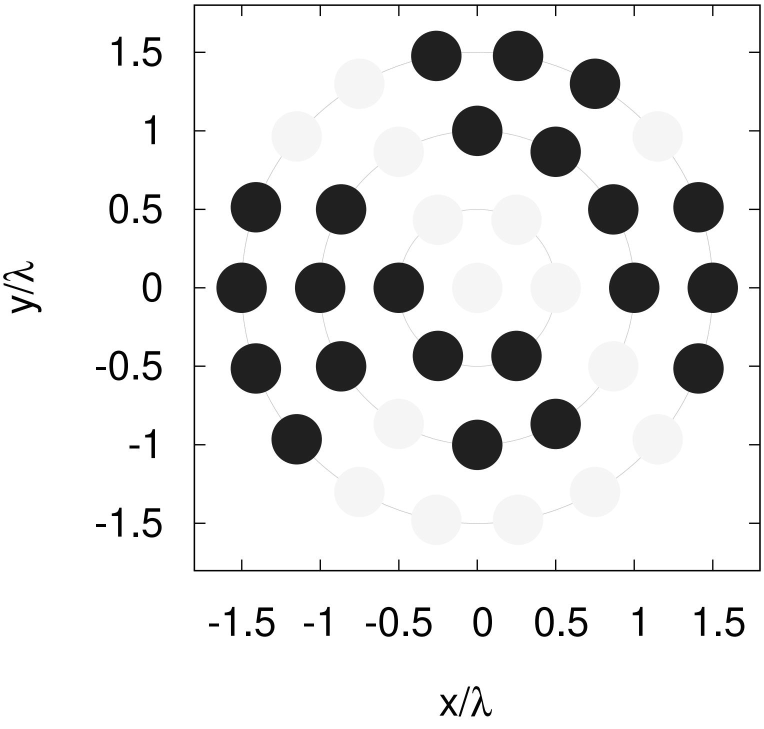


Fig.1 - Thinning Configuration

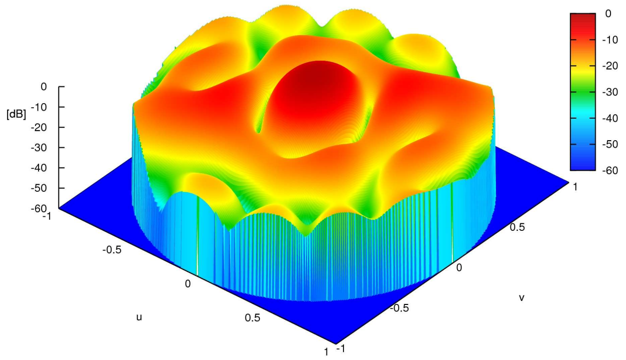


Fig.2 - Pattern

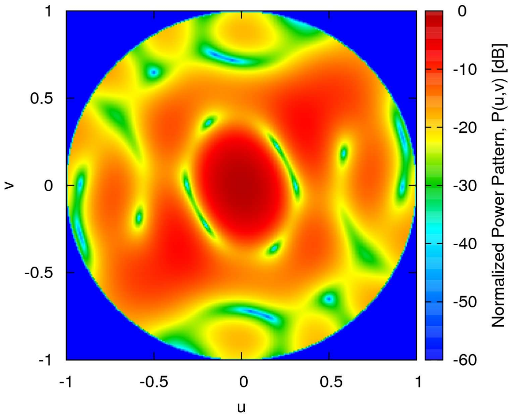


Fig.3 - Pattern projection

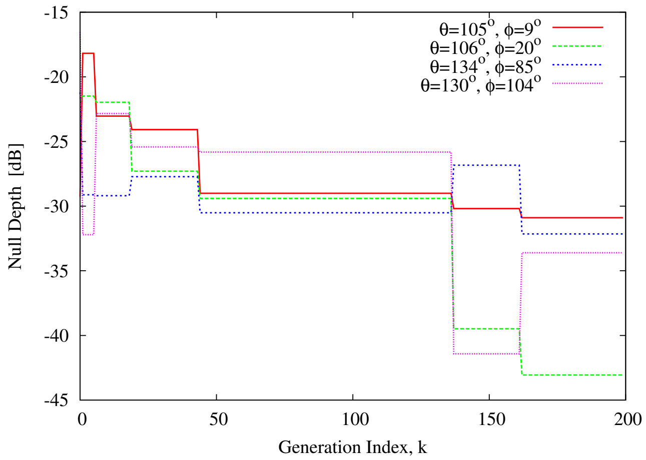


Fig.4 - Nulls Depth 1

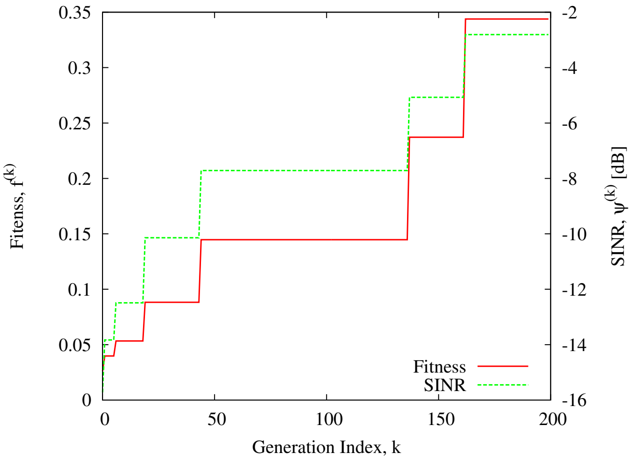


Fig.5 - SINR - Fitness

SINR[dB]: -2.8

Null Depths[dB]: $[-30.86, -43.06, -32.15, -33.6]$

Number of Active Elements: 22

TEST CASE - $N = 37$ **-**$Configuration = 3rings$ **-**$\eta \in [0.6, 0.6]$ **-** $N_I = 5$

Goal

Maximization of the SINR using genetic algorithms (GA) to determine the optimal thinned ring array configuration, considering a time-varying scenario with 5 interferences and a constraint on the number of elements excited.

Test Case Description

- Number of Elements $N = 37$
- Elements Spacing: $d = 0.5\lambda$
- Max Gain Pattern Direction : $\theta^d = 90°$, $\phi^d = 90°$
- Desired Signal Power: $0\,dB$
- Interference Power: $30\,dB$
- Noise Power: $-30\,dB$
- Number of Interferences: $N_I = 5$
- Interference Direction Of Arrival: $\theta_1^i = 20°$, $\phi_1^i = 175°$
- Interference Direction Of Arrival: $\theta_2^i = 133°$, $\phi_2^i = 4°$
- Interference Direction Of Arrival: $\theta_3^i = 131°$, $\phi_3^i = 90°$
- Interference Direction Of Arrival: $\theta_4^i = 86°$, $\phi_4^i = 61°$
- Interference Direction Of Arrival: $\theta_5^i = 129°$, $\phi_5^i = 128°$

Optimization Approach: GA

- Number of Variables: $X = 37$ (α_n, $n = 1, ..., N$)
- Population: 18
- Crossover Probability: 0.9
- Mutation Probability: 0.01
- Number of Generations: 200
- Minimum Thinning Coefficient: 0.6
- Maximum Thinning Coefficient: 0.6

GA - Multiple Interferences: $\theta_1^i = 20°$, $\phi_1^i = 175°$; $\theta_2^i = 133°$, $\phi_2^i = 4°$; $\theta_3^i = 131°$, $\phi_3^i = 90°$; $\theta_4^i = 86°$, $\phi_4^i = 61°$; $\theta_5^i = 129°$, $\phi_5^i = 128°$

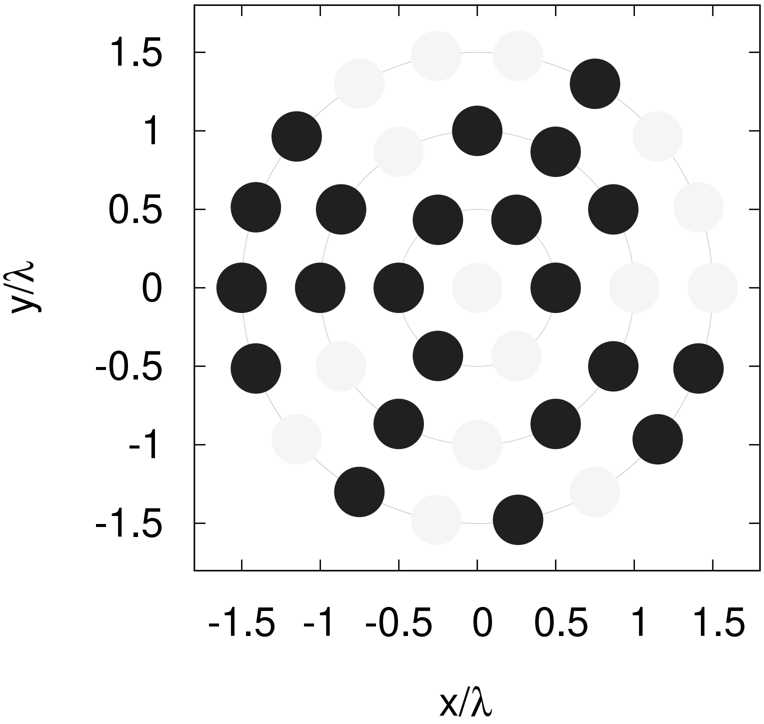


Fig.1 - Thinning Configuration

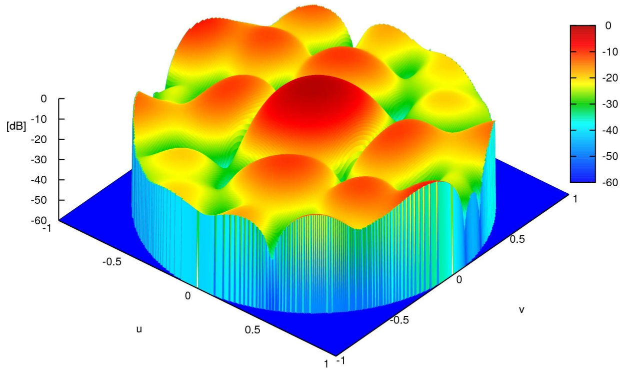


Fig.2 - Pattern

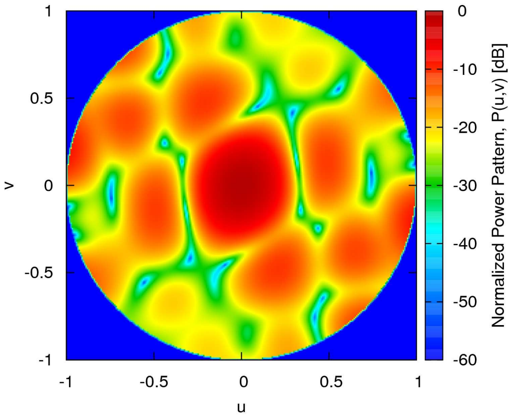


Fig.3 - Pattern projection

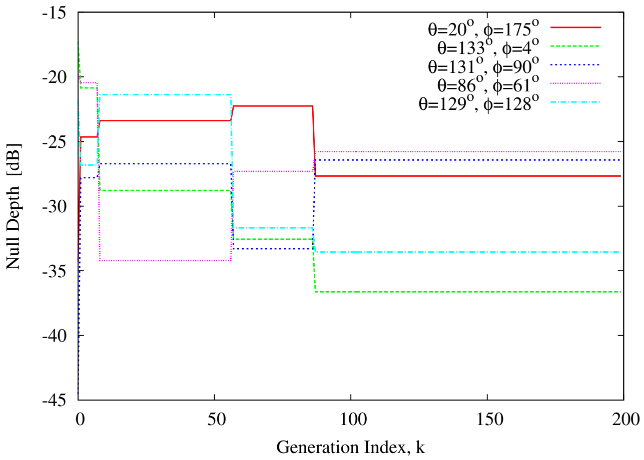


Fig.4 - Nulls Depth 1

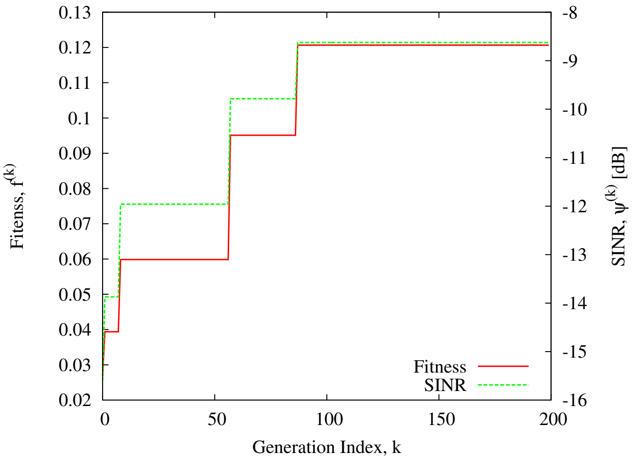


Fig.5 - SINR - Fitness

SINR[dB]: -8.62

Null Depths[dB]: $[-27.67, -36.62, -26.42, -25.77, -33.55]$

Number of Active Elements:22

TEST CASE - $N = 91$ -$Configuration = 5rings$ -$\eta \in [0.6, 0.6]$ - $N_I = 2$

Goal

Maximization of the SINR using genetic algorithms (GA) to determine the optimal thinned ring array configuration, considering a time-varying scenario with 2 interferences and a constraint on the number of elements excited.

Test Case Description

- Number of Elements $N = 91$
- Elements Spacing: $d = 0.5\lambda$
- Max Gain Pattern Direction : $\theta^d = 90°$, $\phi^d = 90°$
- Desired Signal Power: $0\,dB$
- Interference Power: $30\,dB$
- Noise Power: $-30\,dB$
- Number of Interferences: $N_I = 2$
- Interference Direction Of Arrival: $\theta_1^i = 46°$, $\phi_1^i = 147°$
- Interference Direction Of Arrival: $\theta_2^i = 10°$, $\phi_2^i = 178°$

Optimization Approach: GA

- Number of Variables: $X = 91$ (α_n, $n = 1, ..., N$)
- Population: 46
- Crossover Probability: 0.9
- Mutation Probability: 0.01
- Number of Generations: 200
- Minimum Thinning Coefficient: 0.6
- Maximum Thinning Coefficient: 0.6

GA - Multiple Interferences: $\theta_1^i = 46°$, $\phi_1^i = 147°$; $\theta_2^i = 10°$, $\phi_2^i = 178°$

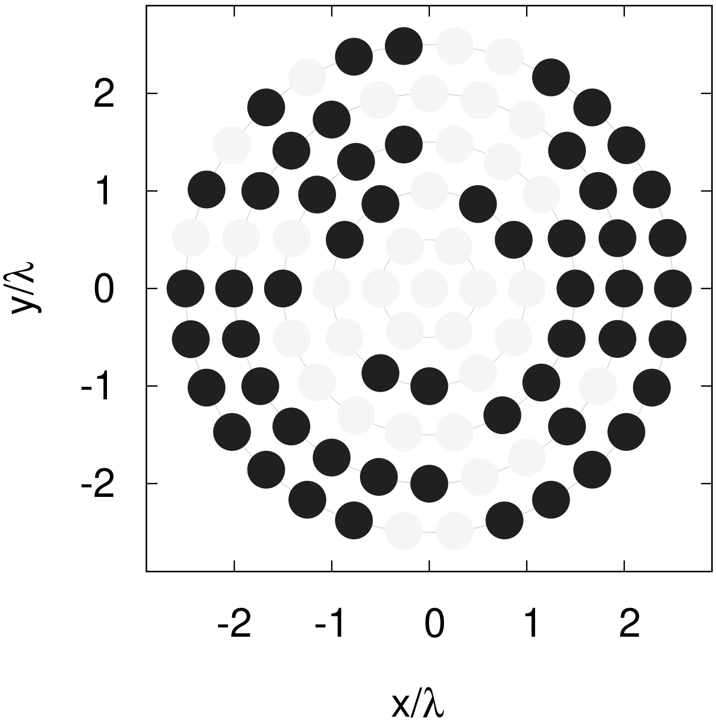


Fig.1 - Thinning Configuration

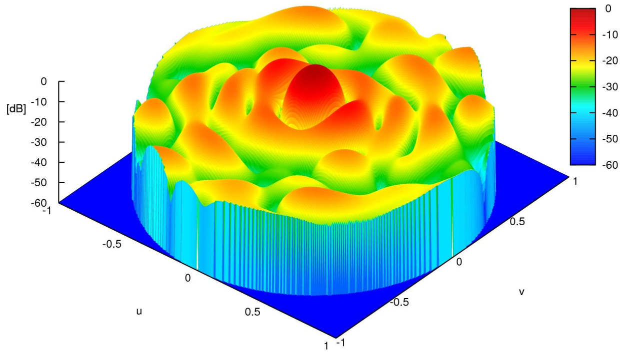


Fig.2 - Pattern

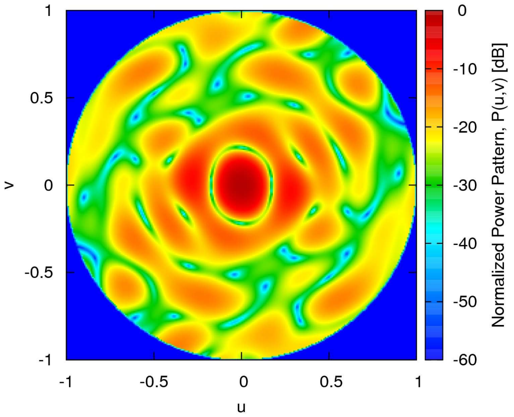


Fig.3 - Pattern projection

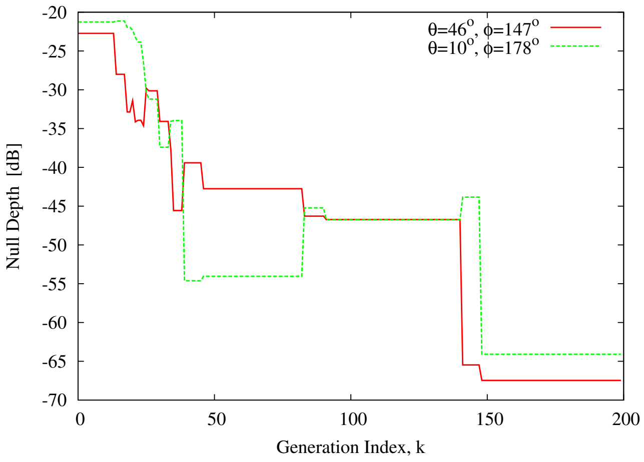


Fig.4 - Nulls Depth 1

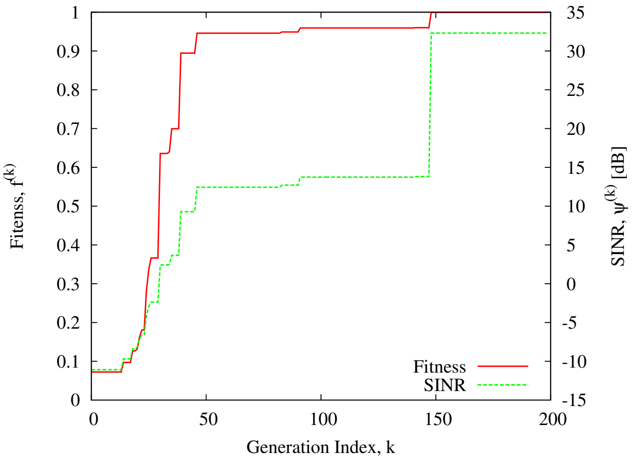


Fig.5 - Fitness SINR

SINR[dB]: 32.3

Null Depths[dB]: $[-67.46, -64.09]$

Number of Active Elements: 54

TEST CASE - $N = 91$ -$Configuration = 5rings$ -$\eta \in [0.6, 0.6]$ - $N_I = 3$

Goal

Maximization of the SINR using genetic algorithms (GA) to determine the optimal thinned ring array configuration, considering a time-varying scenario with 3 interferences and a constraint on the number of elements excited.

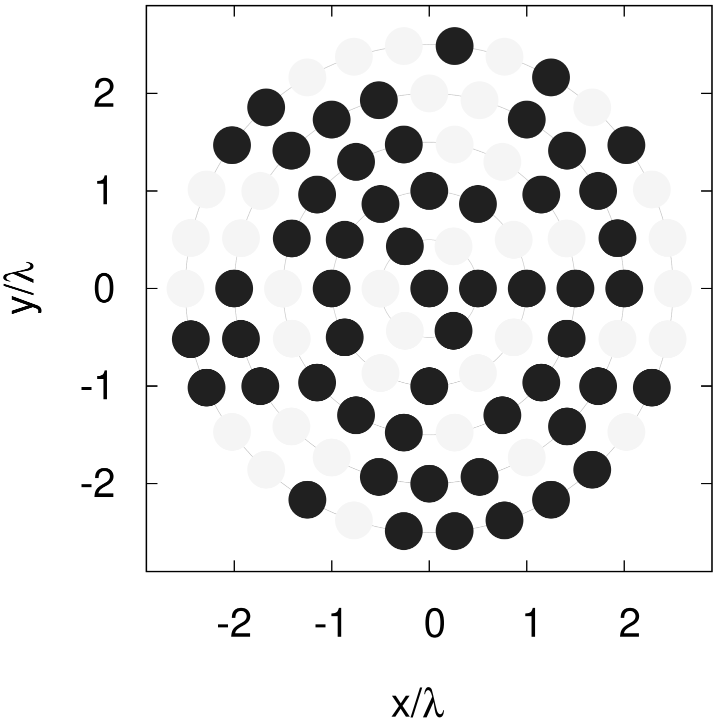
Test Case Description

- Number of Elements $N = 91$
- Elements Spacing: $d = 0.5\lambda$
- Max Gain Pattern Direction : $\theta^d = 90°$, $\phi^d = 90°$
- Desired Signal Power: $0\,dB$
- Interference Power: $30\,dB$
- Noise Power: $-30\,dB$
- Number of Interferences: $N_I = 3$
- Interference Direction Of Arrival: $\theta_1^i = 96°$, $\phi_1^i = 166°$
- Interference Direction Of Arrival: $\theta_2^i = 40°$, $\phi_2^i = 170°$
- Interference Direction Of Arrival: $\theta_3^i = 117°$, $\phi_3^i = 132°$

Optimization Approach: GA

- Number of Variables: $X = 91$ (α_n, $n = 1, ..., N$)
- Population: 46
- Crossover Probability: 0.9
- Mutation Probability: 0.01
- Number of Generations: 200
- Minimum Thinning Coefficient: 0.6
- Maximum Thinning Coefficient: 0.6

GA - Multiple Interferences: $\theta_1^i = 96°$, $\phi_1^i = 166°$; $\theta_2^i = 40°$, $\phi_2^i = 170°$; $\theta_3^i = 117°$, $\phi_3^i = 132°$



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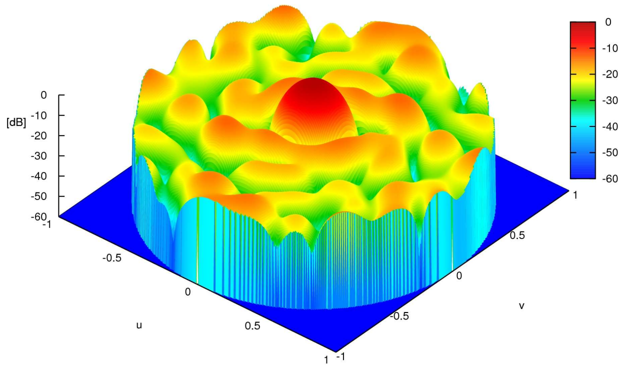

Fig.2 - Pattern

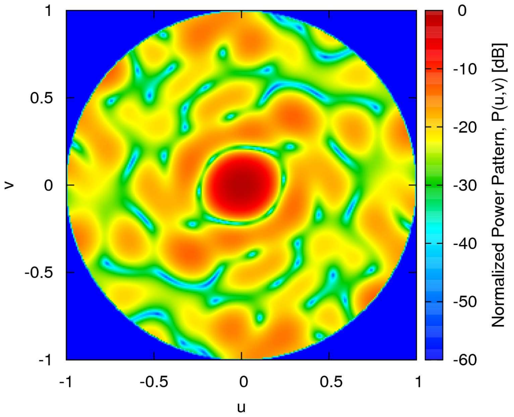

Fig.3 - Pattern projection

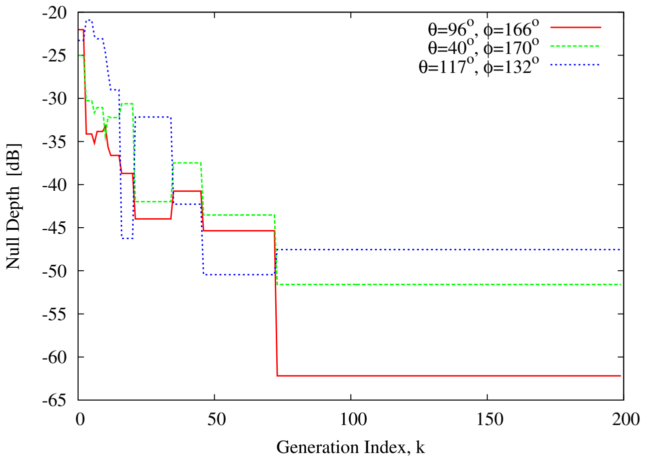

Fig.4 - Nulls Depth 1

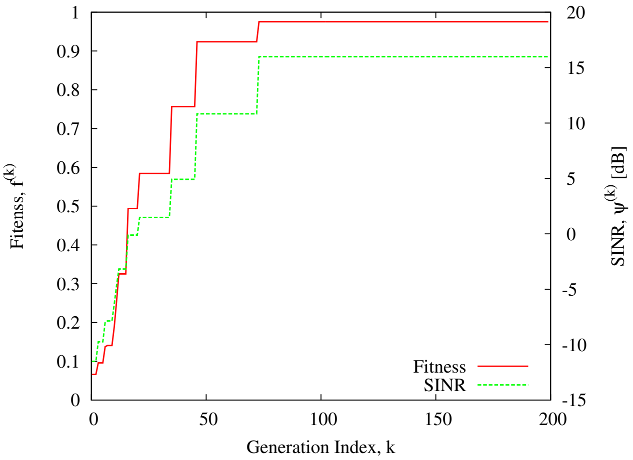

Fig.5 - SINR - Fitness

SINR[dB]: 16

Null Depths[dB]: $[-62.18, -51.58, -47.54]$

Number of Active Elements: 54

TEST CASE - $N = 91$ -$Configuration = 5rings$ -$\eta \in [0.6, 0.6]$ - $N_I = 4$

Goal

Maximization of the SINR using genetic algorithms (GA) to determine the optimal thinned ring array configuration, considering a time-varying scenario with 4 interferences and a constraint on the number of elements excited.

Test Case Description

- Number of Elements $N = 91$
- Elements Spacing: $d = 0.5\lambda$
- Max Gain Pattern Direction : $\theta^d = 90°$, $\phi^d = 90°$
- Desired Signal Power: $0\,dB$
- Interference Power: $30\,dB$
- Noise Power: $-30\,dB$
- Number of Interferences: $N_I = 4$
- Interference Direction Of Arrival: $\theta_1^i = 33°$, $\phi_1^i = 144°$
- Interference Direction Of Arrival: $\theta_2^i = 166°$, $\phi_2^i = 165°$
- Interference Direction Of Arrival: $\theta_3^i = 60°$, $\phi_3^i = 55°$
- Interference Direction Of Arrival: $\theta_4^i = 92°$, $\phi_4^i = 161°$

Optimization Approach: GA

- Number of Variables: $X = 91$ (α_n, $n = 1, ..., N$)
- Population: 46
- Crossover Probability: 0.9
- Mutation Probability: 0.01
- Number of Generations: 200
- Minimum Thinning Coefficient: 0.6
- Maximum Thinning Coefficient: 0.6

GA - Multiple Interferences: $\theta_1^i = 33°$, $\phi_1^i = 144°$; $\theta_2^i = 166°$, $\phi_2^i = 165°$; $\theta_3^i = 60°$, $\phi_3^i = 55°$; $\theta_4^i = 92°$, $\phi_4^i = 161°$

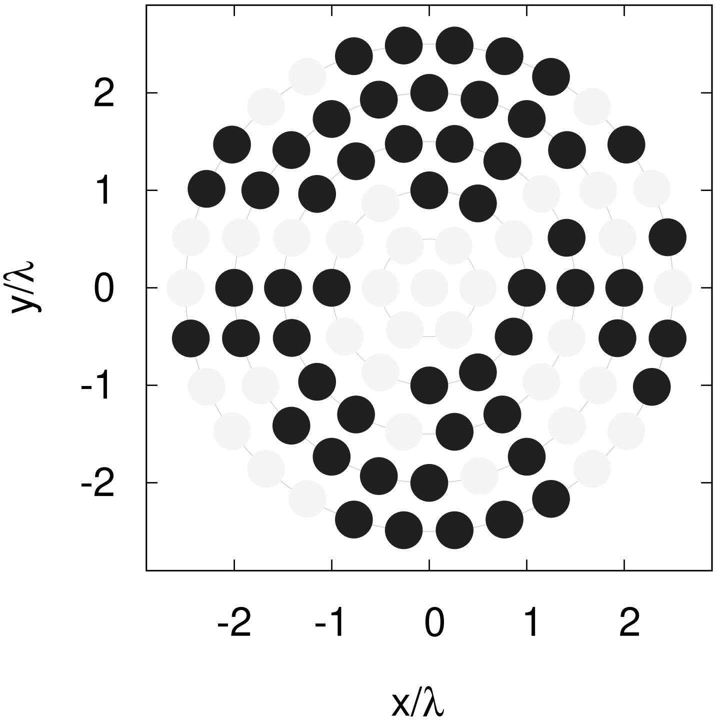

Fig.1 - Thinning Configuration

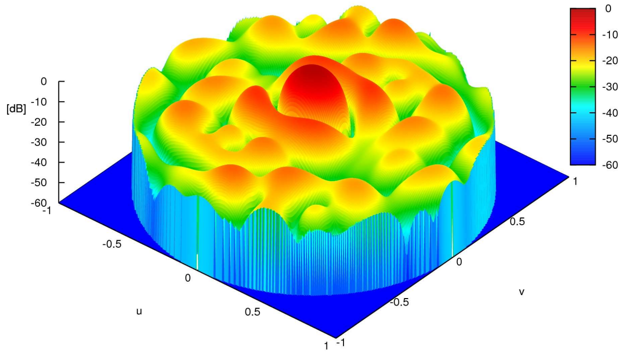

Fig.2 - Pattern

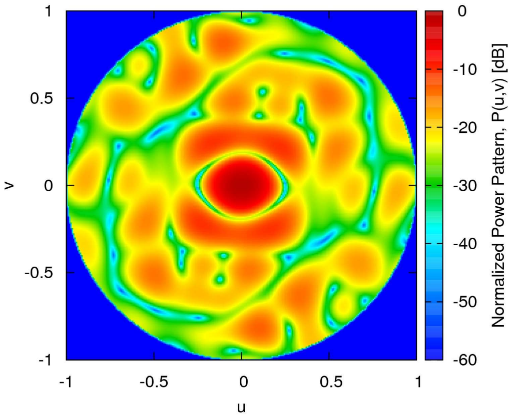

Fig.3 - Pattern projection

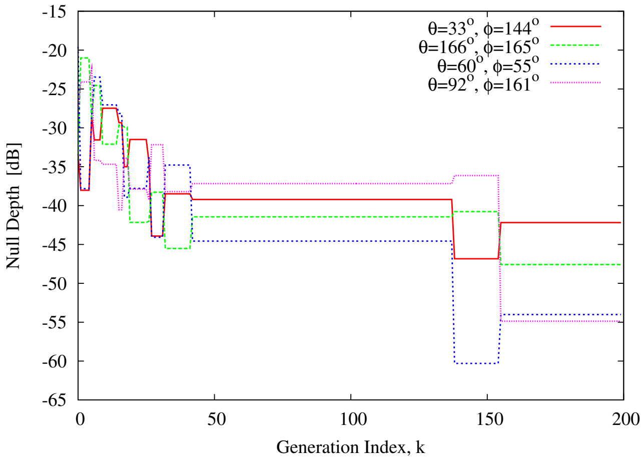

Fig.4 - Nulls Depth 1

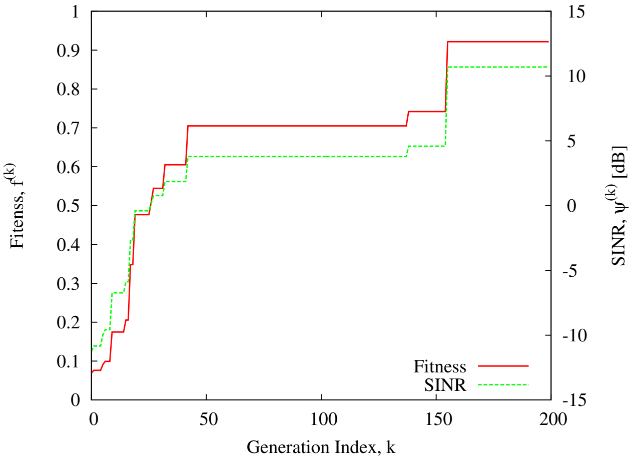

Fig.5 - SINR - Fitness

SINR[dB]: 10.69

Null Depths[dB]: $[-42.18, -47.58, -54.01, -54.86]$

Number of Active Elements: 54

TEST CASE - $N = 91$ **-**$Configuration = 5rings$ **-**$\eta \in [0.6, 0.6]$ **-** $N_I = 5$

Goal

Maximization of the SINR using genetic algorithms (GA) to determine the optimal thinned ring array configuration, considering a time-varying scenario with 5 interferences and a constraint on the number of elements excited.

Test Case Description

- Number of Elements $N = 91$
- Elements Spacing: $d = 0.5\lambda$
- Max Gain Pattern Direction : $\theta^d = 90°$, $\phi^d = 90°$
- Desired Signal Power: $0\,dB$
- Interference Power: $30\,dB$
- Noise Power: $-30\,dB$
- Number of Interferences: $N_I = 5$
- Interference Direction Of Arrival: $\theta^i_1 = 105°$, $\phi^i_1 = 137°$
- Interference Direction Of Arrival: $\theta^i_2 = 72°$, $\phi^i_2 = 90°$
- Interference Direction Of Arrival: $\theta^i_3 = 85°$, $\phi^i_3 = 40°$
- Interference Direction Of Arrival: $\theta^i_4 = 150°$, $\phi^i_4 = 66°$
- Interference Direction Of Arrival: $\theta^i_5 = 118°$, $\phi^i_5 = 7°$

Optimization Approach: GA

- Number of Variables: $X = 91$ (α_n, $n = 1, ..., N$)
- Population: 46
- Crossover Probability: 0.9
- Mutation Probability: 0.01
- Number of Generations: 200
- Minimum Thinning Coefficient: 0.6
- Maximum Thinning Coefficient: 0.6

GA - Multiple Interferences: $\theta_1^i = 105°$, $\phi_1^i = 137°$; $\theta_2^i = 72°$, $\phi_2^i = 90°$; $\theta_3^i = 85°$, $\phi_3^i = 40°$; $\theta_4^i = 150°$, $\phi_4^i = 66°$; $\theta_5^i = 118°$, $\phi_5^i = 7°$

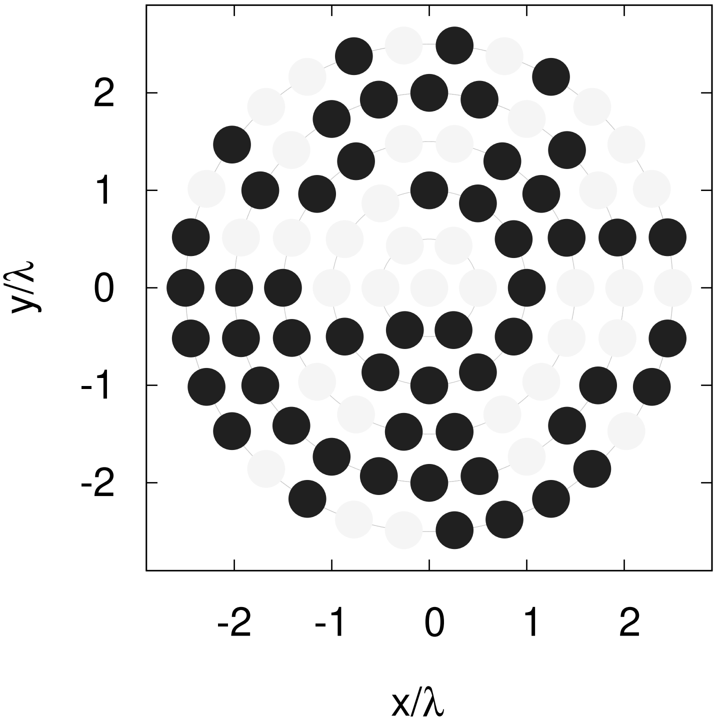

Fig.1 - Thinning Configuration

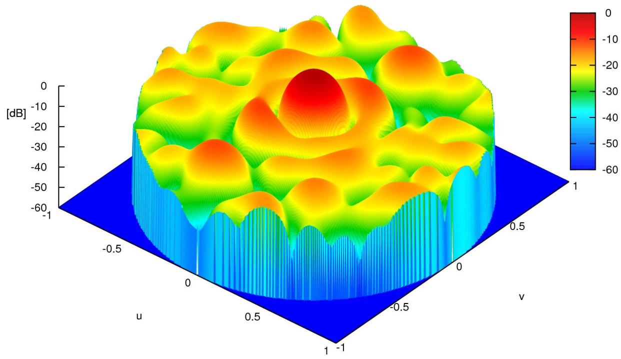

Fig.2 - Pattern

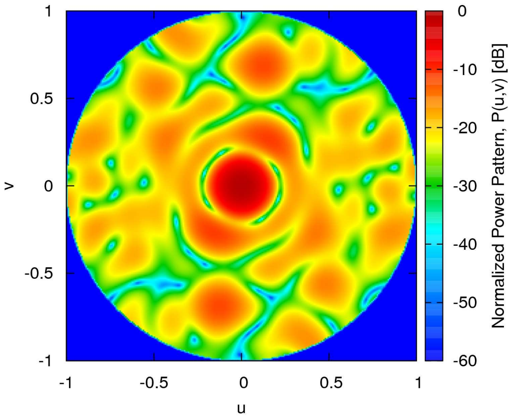

Fig.3 - Pattern projection

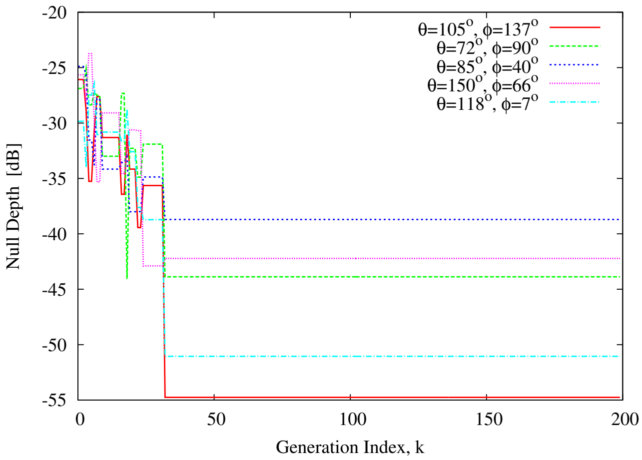

Fig.4 - Nulls Depth 1

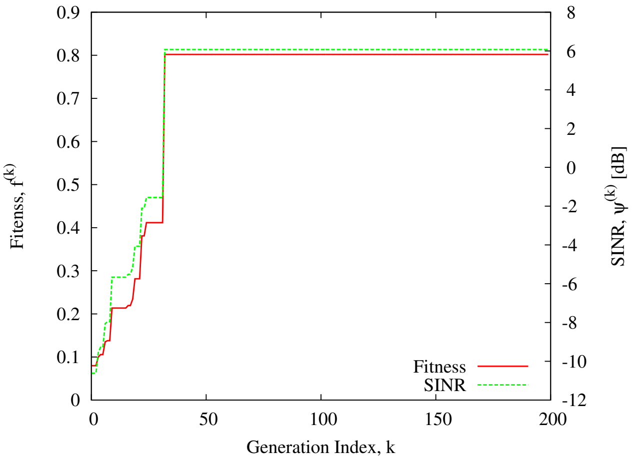

Fig.5 - SINR - Fitness

SINR[dB]: 6.07

Null Depths[dB]: $[-54.75, -43.87, -38.7, -42.22, -51.05]$

Number of Active Elements:54

TEST CASE - $N = 172$ -$Configuration = 7rings$ -$\eta \in [0.0, 1.0]$ - $N_I = 1$

Goal

Maximization of the SINR using genetic algorithms (GA) to determine the optimal thinned ring array configuration, considering a time-varying scenario with a single interference.

Test Case Description

- Number of Elements $N = 172$
- Elements Spacing: $d = 0.5\lambda$
- Max Gain Pattern Direction : $\theta^d = 90°$, $\phi^d = 90°$
- Desired Signal Power: $0\,dB$
- Interference Power: $30\,dB$
- Noise Power: $-30\,dB$
- Number of Interferences: $N_I = 1$
- Interference Direction Of Arrival: $\theta_1^i = 152°$, $\phi_1^i = 154°$

Optimization Approach: GA

- Number of Variables: $X = 172$ (α_n, $n = 1, ..., N$)
- Population: 86
- Crossover Probability: 0.9
- Mutation Probability: 0.01
- Number of Generations: 200
- Minimum Thinning Coefficient: 0.0
- Maximum Thinning Coefficient: 1.0

GA - Single Interference: $\theta_1^i = 152°$, $\phi_1^i = 154°$

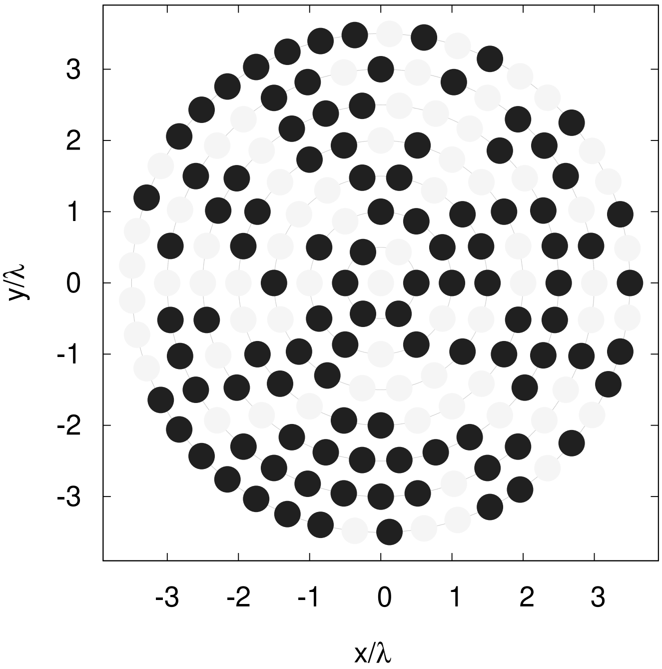

Fig.1 - Thinning Configuration

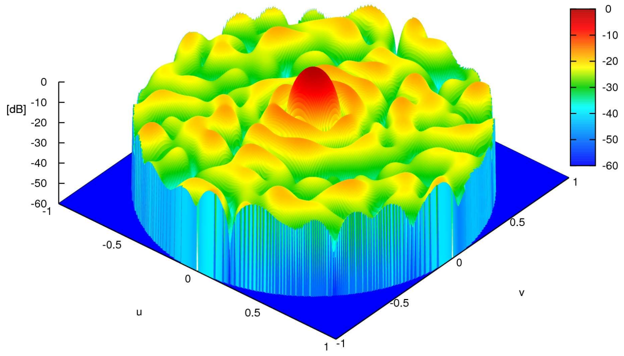

Fig.2 - Pattern

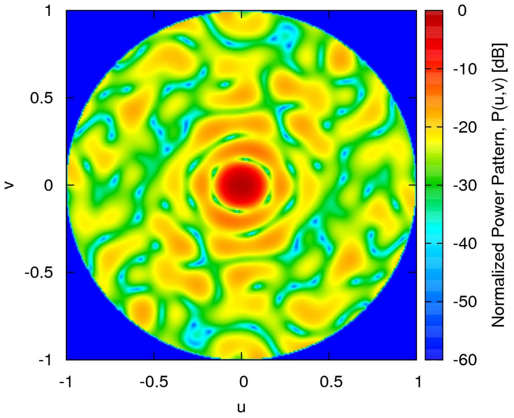

Fig.3 - Pattern projection

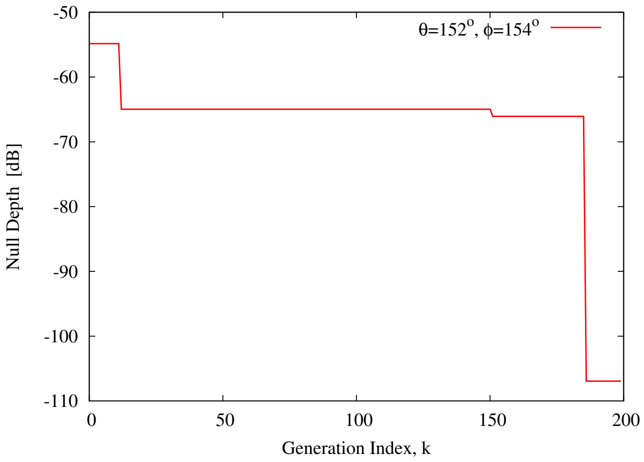

Fig.4 - Nulls Depth

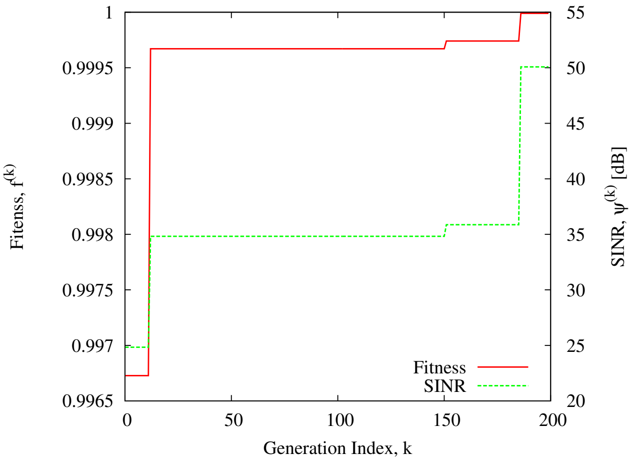

Fig.5 - Fitness - SINR

SINR[dB]: 50.07

Null Depths[dB]: -106.93

Number of Active Elements: 102

TEST CASE - $N = 172$ -$Configuration = 7rings$ -$\eta \in [0.59, 0.61]$ - $N_I = 2$

Goal

Maximization of the SINR using genetic algorithms (GA) to determine the optimal thinned ring array configuration, considering a time-varying scenario with 2 interferences and a constraint on the number of elements excited.

Test Case Description

- Number of Elements $N = 172$
- Elements Spacing: $d = 0.5\lambda$
- Max Gain Pattern Direction : $\theta^d = 90°$, $\phi^d = 90°$
- Desired Signal Power: $0\,dB$
- Interference Power: $30\,dB$
- Noise Power: $-30\,dB$
- Number of Interferences: $N_I = 2$
- Interference Direction Of Arrival: $\theta^i_1 = 93°$, $\phi^i_1 = 73°$
- Interference Direction Of Arrival: $\theta^i_2 = 45°$, $\phi^i_2 = 115°$

Optimization Approach: GA

- Number of Variables: $X = 172$ (α_n, $n = 1, ..., N$)
- Population: 86
- Crossover Probability: 0.9
- Mutation Probability: 0.01
- Number of Generations: 200
- Minimum Thinning Coefficient: 0.59
- Maximum Thinning Coefficient: 0.61

GA - Multiple Interferences: $\theta_1^i = 93°$, $\phi_1^i = 73°$; $\theta_2^i = 45°$, $\phi_2^i = 115°$

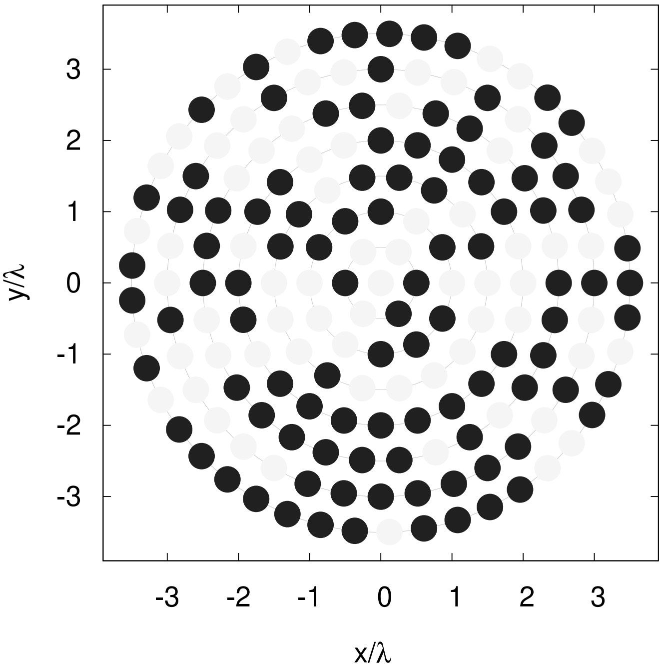

Fig.1 - Thinning Configuration

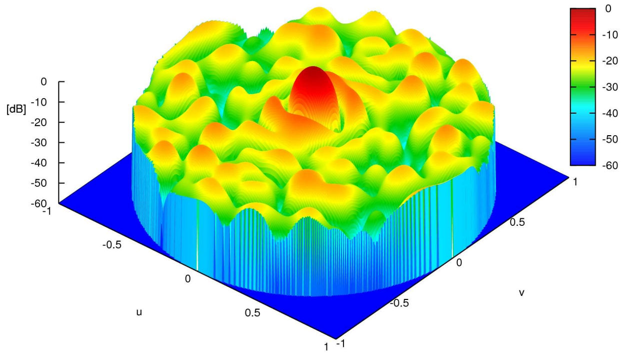

Fig.2 - Pattern

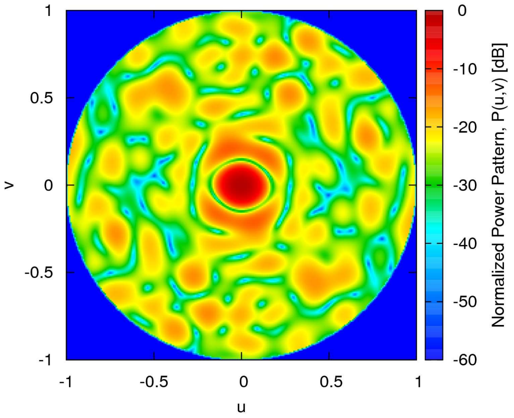

Fig.3 - Pattern projection

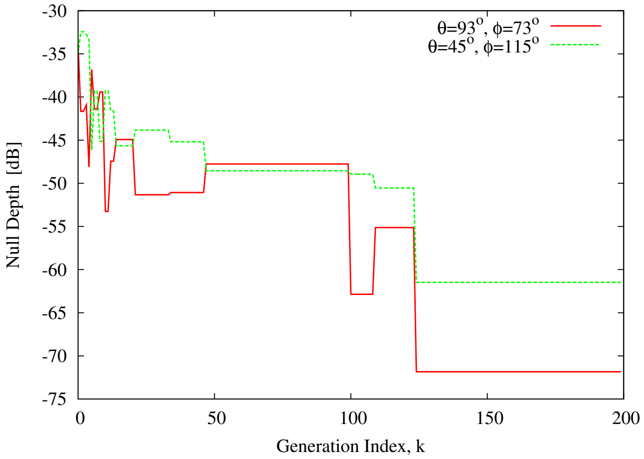

Fig.4 - Nulls Depth 1

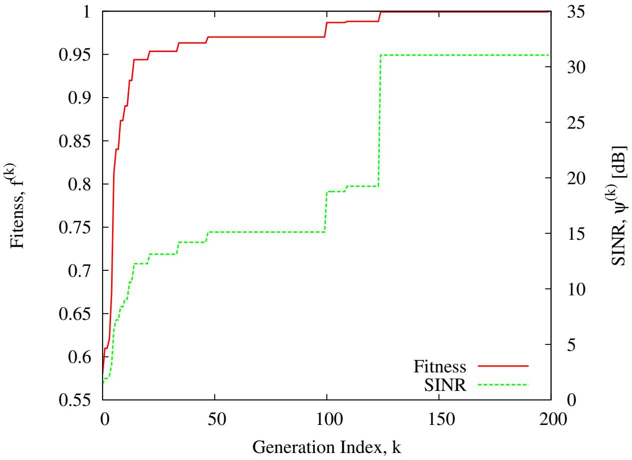

Fig.5 - Fitness SINR

SINR[dB]: 31.04

Null Depths[dB]: $[-71.83, -61.48]$

Number of Active Elements: 101

TEST CASE - $N = 172$ -$Configuration = 7rings$ -$\eta \in [0.59, 0.61]$ - $N_I = 3$

Goal

Maximization of the SINR using genetic algorithms (GA) to determine the optimal thinned ring array configuration, considering a time-varying scenario with 3 interferences and a constraint on the number of elements excited.

Test Case Description

- Number of Elements $N = 172$
- Elements Spacing: $d = 0.5\lambda$
- Max Gain Pattern Direction : $\theta^d = 90°$, $\phi^d = 90°$
- Desired Signal Power: $0\,dB$
- Interference Power: $30\,dB$
- Noise Power: $-30\,dB$
- Number of Interferences: $N_I = 3$
- Interference Direction Of Arrival: $\theta_1^i = 98°$, $\phi_1^i = 64°$
- Interference Direction Of Arrival: $\theta_2^i = 10°$, $\phi_2^i = 154°$
- Interference Direction Of Arrival: $\theta_3^i = 153°$, $\phi_3^i = 156°$

Optimization Approach: GA

- Number of Variables: $X = 172$ (α_n, $n = 1, ..., N$)
- Population: 86
- Crossover Probability: 0.9
- Mutation Probability: 0.01
- Number of Generations: 200
- Minimum Thinning Coefficient: 0.59
- Maximum Thinning Coefficient: 0.61

GA - Multiple Interferences: $\theta_1^i = 98°$, $\phi_1^i = 64°$; $\theta_2^i = 10°$, $\phi_2^i = 154°$; $\theta_3^i = 153°$, $\phi_3^i = 156°$

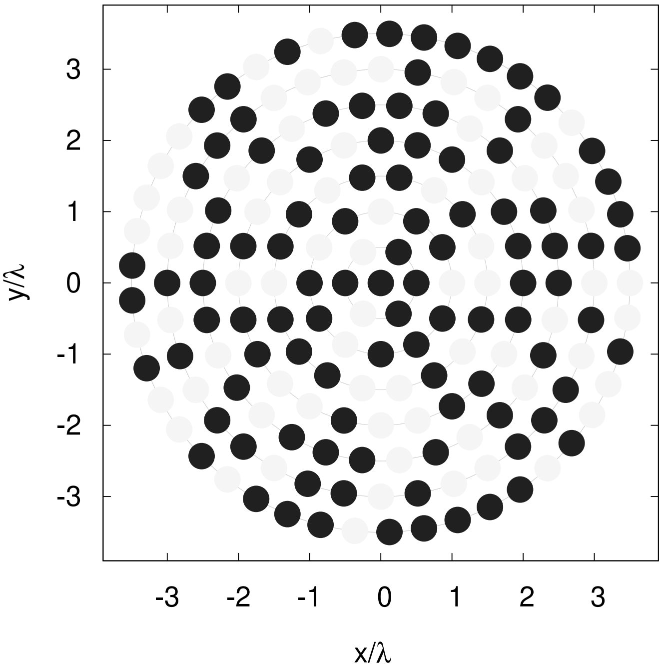

Fig.1 - Thinning Configuration

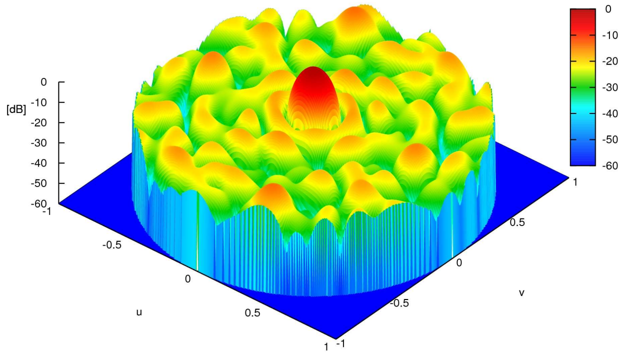

Fig.2 - Pattern

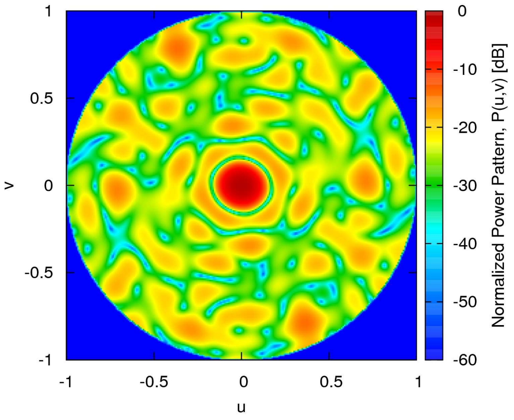

Fig.3 - Pattern projection

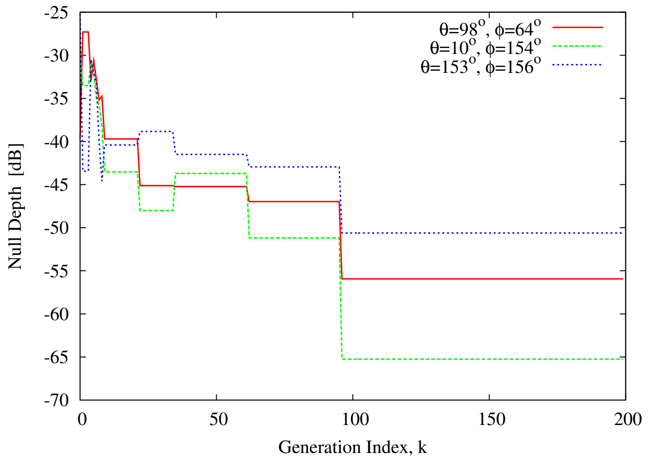

Fig.4 - Nulls Depth 1

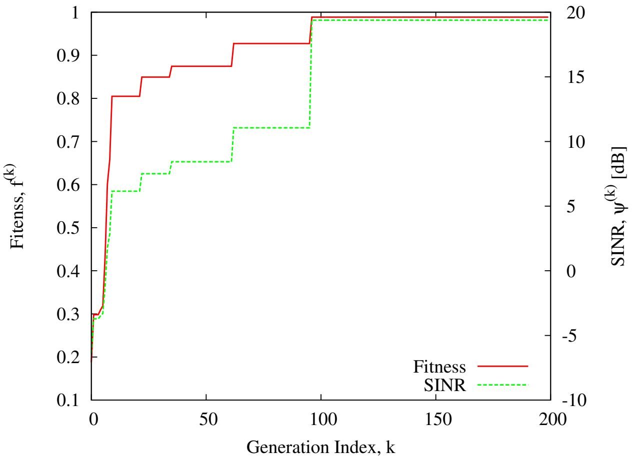

Fig.5 - Fitness SINR

SINR[dB]: 19.37

Null Depths[dB]: $[-55.93, -65.25, -50.61]$

Number of Active Elements: 102

TEST CASE - $N = 172$ **-**$Configuration = 7rings$ **-**$\eta \in [0.59, 0.61]$ **-** $N_I = 4$

Goal

Maximization of the SINR using genetic algorithms (GA) to determine the optimal thinned ring array configuration, considering a time-varying scenario with 4 interferences and a constraint on the number of elements excited.

Test Case Description

- Number of Elements $N = 172$
- Elements Spacing: $d = 0.5\lambda$
- Max Gain Pattern Direction : $\theta^d = 90°$, $\phi^d = 90°$
- Desired Signal Power: $0\,dB$
- Interference Power: $30\,dB$
- Noise Power: $-30\,dB$
- Number of Interferences: $N_I = 4$
- Interference Direction Of Arrival: $\theta_1^i = 88°$, $\phi_1^i = 65°$
- Interference Direction Of Arrival: $\theta_2^i = 115°$, $\phi_2^i = 143°$
- Interference Direction Of Arrival: $\theta_3^i = 52°$, $\phi_3^i = 16°$
- Interference Direction Of Arrival: $\theta_4^i = 165°$, $\phi_4^i = 90°$

Optimization Approach: GA

- Number of Variables: $X = 172$ $(\alpha_n,\, n = 1, ..., N)$
- Population: 86
- Crossover Probability: 0.9
- Mutation Probability: 0.01
- Number of Generations: 200
- Minimum Thinning Coefficient: 0.59
- Maximum Thinning Coefficient: 0.61

GA - Multiple Interferences: $\theta_1^i = 88°$, $\phi_1^i = 65°$; $\theta_2^i = 115°$, $\phi_2^i = 143°$; $\theta_3^i = 52°$, $\phi_3^i = 16°$; $\theta_4^i = 165°$, $\phi_4^i = 90°$

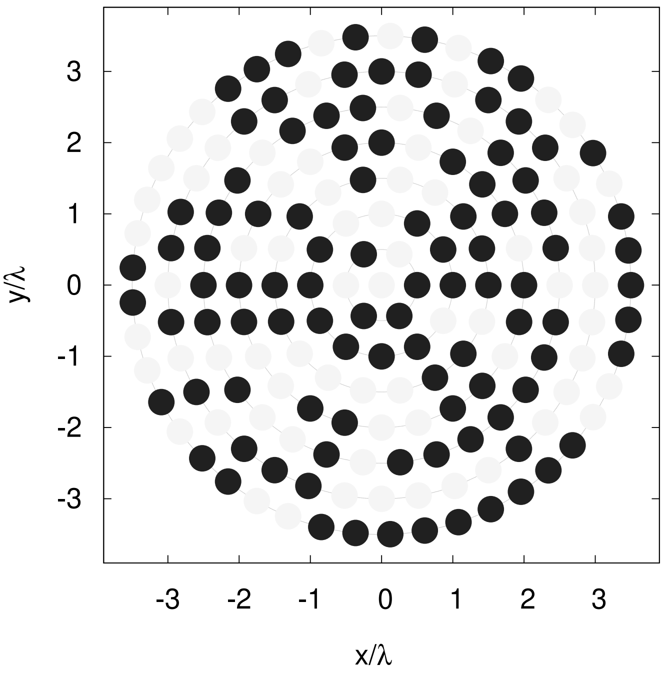

Fig.1 - Thinning Configuration

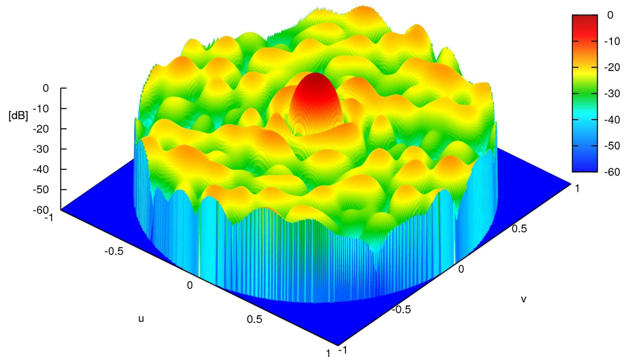

Fig.2 - Pattern

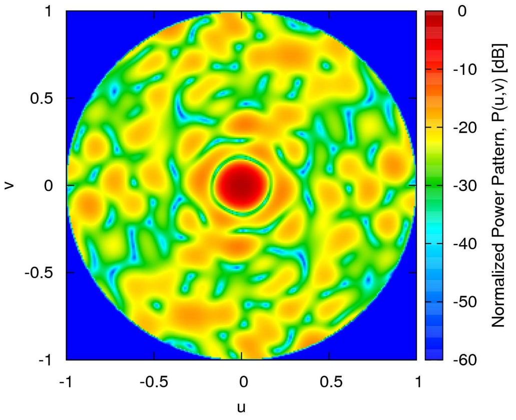

Fig.3 - Pattern projection

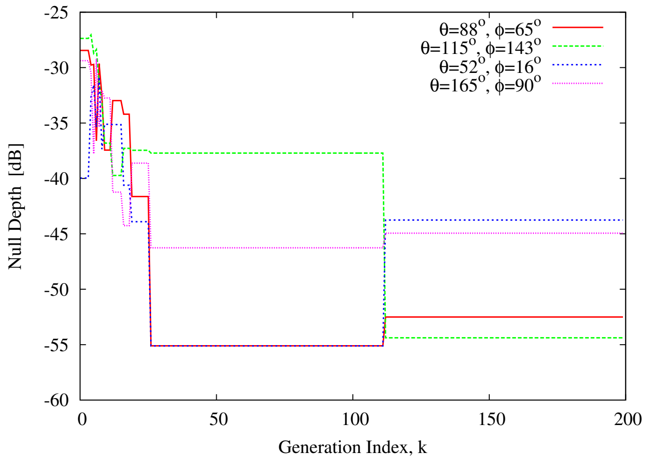

Fig.4 - Nulls Depth 1

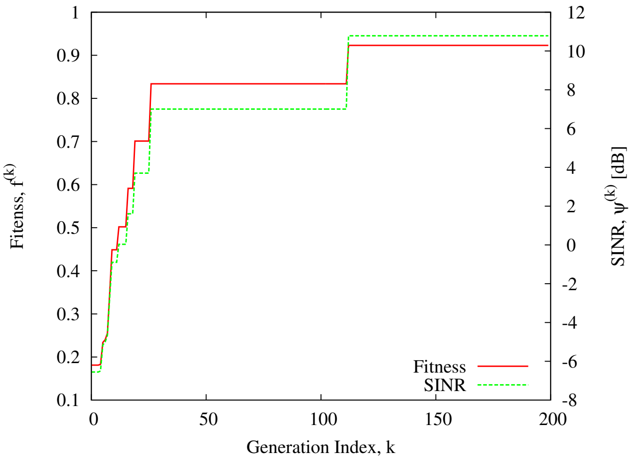

Fig.5 - Fitness SINR

SINR[dB]: 10.78

Null Depths[dB]: $[-52.50, -54.38, -43.75, -44.93]$

Number of Active Elements: 101

TEST CASE - $N = 172$ -$Configuration = 7rings$ -$\eta \in [0.59, 0.61]$ - $N_I = 5$

Goal

Maximization of the SINR using genetic algorithms (GA) to determine the optimal thinned ring array configuration, considering a time-varying scenario with 5 interferences and a constraint on the number of elements excited.

Test Case Description

- Number of Elements $N = 172$
- Elements Spacing: $d = 0.5\lambda$
- Max Gain Pattern Direction : $\theta^d = 90°$, $\phi^d = 90°$
- Desired Signal Power: $0\,dB$
- Interference Power: $30\,dB$
- Noise Power: $-30\,dB$
- Number of Interferences: $N_I = 5$
- Interference Direction Of Arrival: $\theta_1^i = 105°$, $\phi_1^i = 137°$
- Interference Direction Of Arrival: $\theta_2^i = 72°$, $\phi_2^i = 90°$
- Interference Direction Of Arrival: $\theta_3^i = 85°$, $\phi_3^i = 40°$
- Interference Direction Of Arrival: $\theta_4^i = 150°$, $\phi_4^i = 66°$
- Interference Direction Of Arrival: $\theta_5^i = 118°$, $\phi_5^i = 7°$

Optimization Approach: GA

- Number of Variables: $X = 172$ (α_n, $n = 1, ..., N$)
- Population: 86
- Crossover Probability: 0.9
- Mutation Probability: 0.01
- Number of Generations: 200
- Minimum Thinning Coefficient: 0.59
- Maximum Thinning Coefficient: 0.61

GA - Multiple Interferences: $\theta_1^i = 105°$, $\phi_1^i = 137°$; $\theta_2^i = 72°$, $\phi_2^i = 90°$; $\theta_3^i = 85°$, $\phi_3^i = 40°$; $\theta_4^i = 150°$, $\phi_4^i = 66°$; $\theta_5^i = 118°$, $\phi_5^i = 7°$

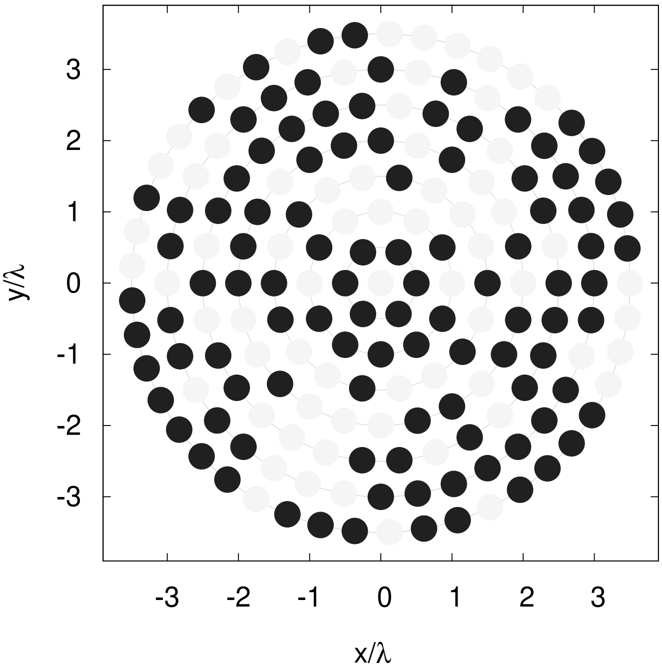

Fig.1 - Thinning Configuration

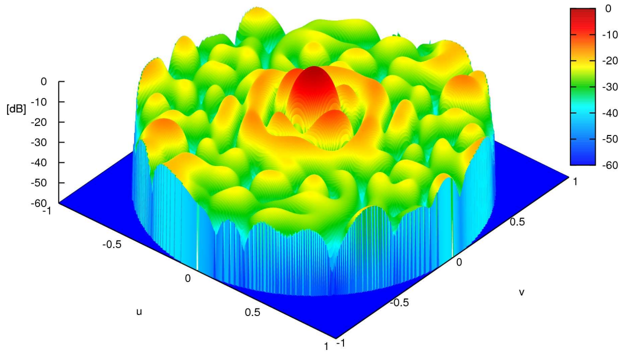

Fig.2 - Pattern

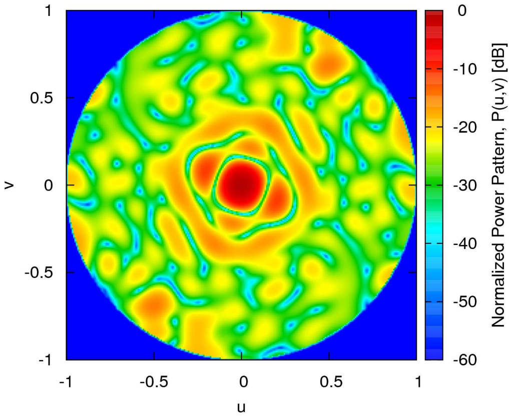

Fig.3 - Pattern projection

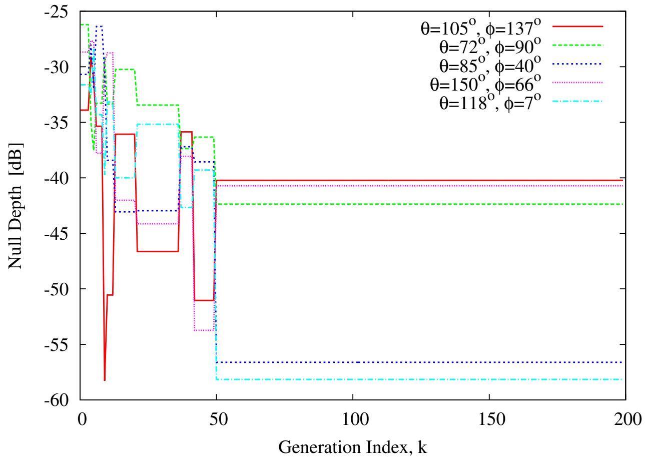

Fig.4 - Nulls Depth 1

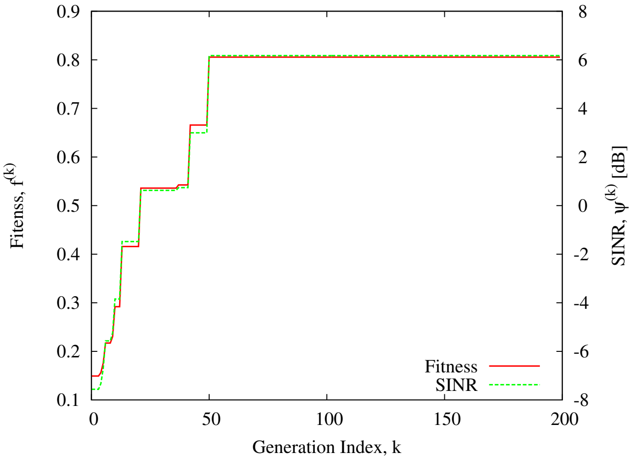

Fig.5 - Fitness SINR

SINR[dB]: 6.17

Null Depths[dB]: $[-40.22, -42.36, -56.60, -40.71, -58.15]$

Number of Active Elements:104

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

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