

Sintesi delle Aggregazioni Ottime in Antenne a Schiera Planari per Applicazioni WPT mediante Strategia CPM

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Abstract

In questo documento è riportata l'analisi di una tecnica customizzata basata sul metodo delle partizioni contigue (CPM: Contiguous Partition Method) per la sintesi di antenne a schiera planari mediante architetture a sub-array che permette di massimizzare la potenza radiata in una regione d'interesse rispetto alla potenza totale. Nel documento sono riportati alcuni risultati rappresentativi che mostrano l'efficacia della tecnica, anche considerando schiere di grandi dimensioni ed un numero limitato di sub-arrays per semplificare l'architettura dell'antenna.

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Part I

Risultati e simulazioni array planari

1 ARRAY PLANARE 10x10 ELEMENTI ($M \times N = 10 \times 10$; $Q = 2, \dots, 8$)

1.1 Descrizione del test case

- Schiera planare - Numero di elementi: $M \times N = 10 \times 10$
- Spaziatura tra gli elementi: $d = 0.5\lambda$
- Numero di subarray: $Q = 2, \dots, 8$
- Intervallo angolare $BCE_{max}(u, v) = [(0.2; 0.2), (0.3; 0.3), (0.4; 0.4)]$
- Beam Collection Efficiency massima $BCE_{max} = [96.56\%, 99.81\%, 99.90\%]$

1.2 Pattern di Riferimento $BCE 96.56\%$; $(u, v) = (0.2; 0.2)$

- Pattern somma di riferimento (Prasad, 1982)
- Efficienza di WPT: $BCE = 96.56\%$

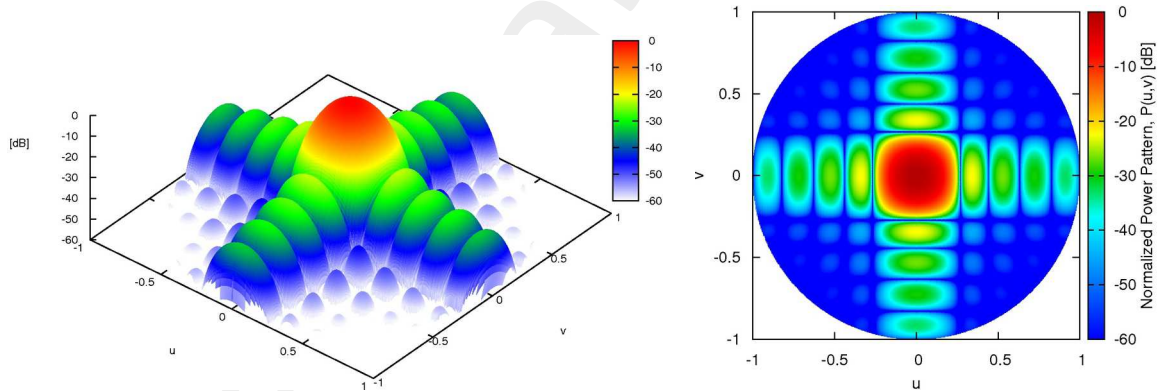


Figure 1: Pattern di riferimento

1.3 Pattern di Riferimento $BCE 99.81\%$; $(u, v) = (0.3; 0.3)$

- Pattern somma di riferimento (Prasad, 1982)
- Efficienza di WPT: $BCE = 99.81\%$

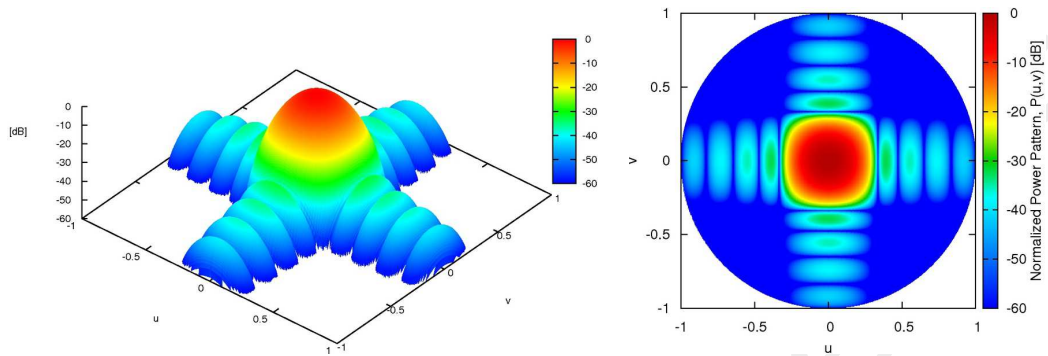


Figure 2: Pattern di riferimento

1.4 Pattern di Riferimento BCE 99.90%; $(u, v) = (0.4; 0.4)$

- Pattern somma di riferimento (Prasad, 1982)
- Efficienza di WPT: $BCE = 99.90\%$

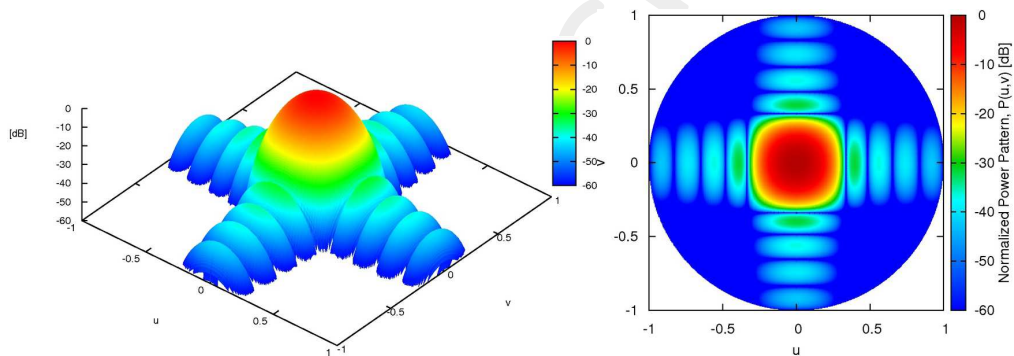


Figure 3: Pattern di riferimento

1.5 Parametri numerici pattern di riferimento

BCE	u, v	ϕ [rad]	SLL [dB]	$First\ Null$ [rad]	BW [rad]
96.56%	0.2; 0.2		-26.657699	0.273318	0.003777
99.81%	0.3; 0.3	0°	-35.423378	0.340862	0.004254
99.90%	0.4; 0.4		-36.6234245	-0.984889	0.001662

1.6 Risultati

1.6.1 Parametri vs Numero di subarray

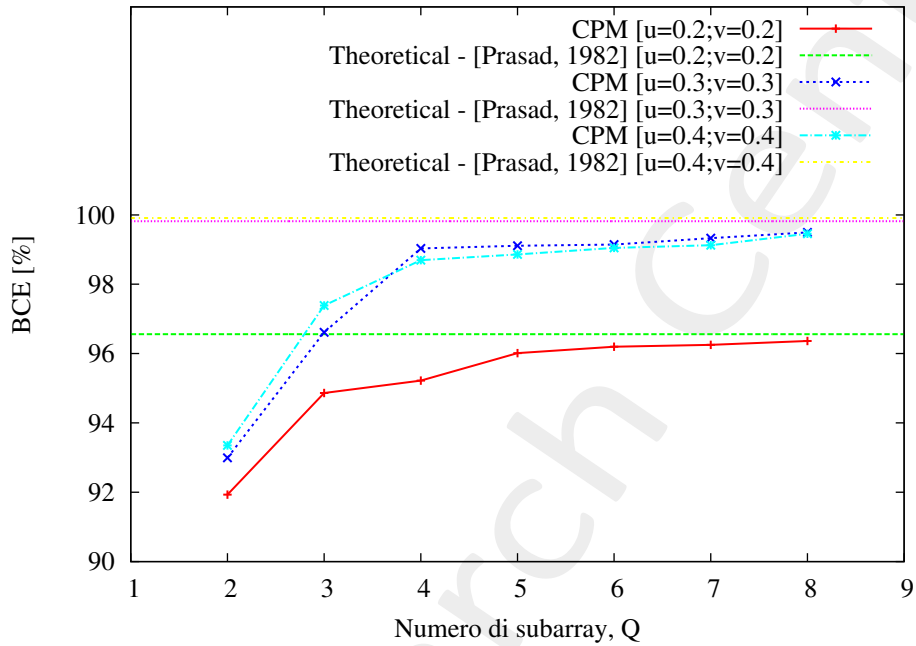
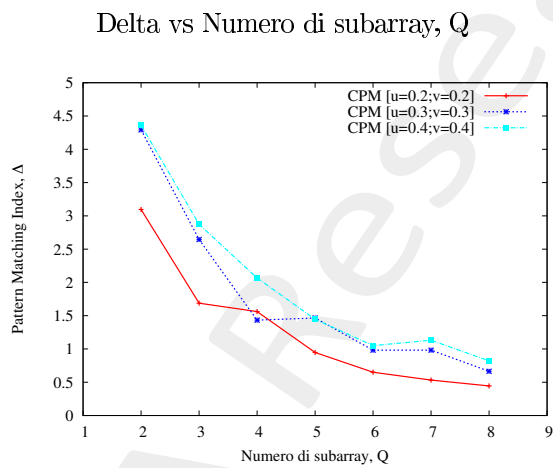
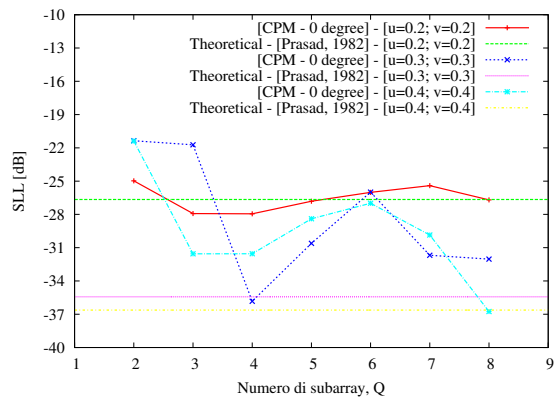


Figure 4: BCE vs Numero di subarray, Q



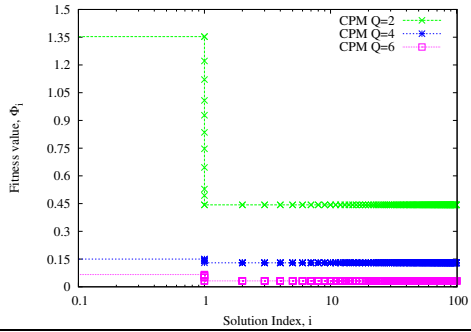
SLL vs Numero di subarray, Q



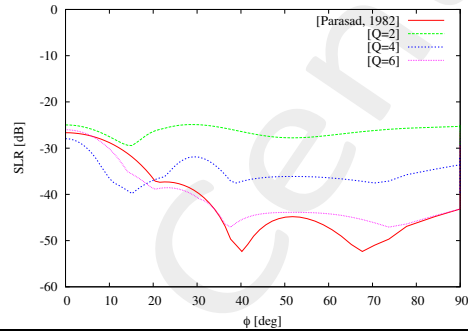
1.6.2 Studio casi significativi ($Q = 2, 4, 6$)

PARAMETRI CON TARGET BCE 96.56%; $(u, v) = (0.2; 0.2)$

Evoluzione funzionale di costo CPM

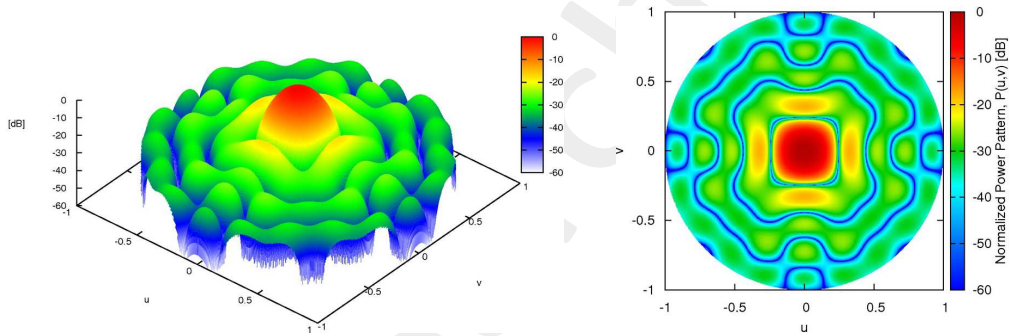


Side Lobe Ratio (SLR)

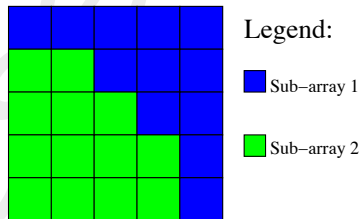


$Q=2$

BEAM PATTERN



CONFIGURAZIONE DELLE ECCITAZIONI



Legend:

■ Sub-array 1

■ Sub-array 2

Indice	Valore
Sub-array 1	0.271799
Sub-array 2	0.709301

PARAMETRI ANALITICI PATTERN

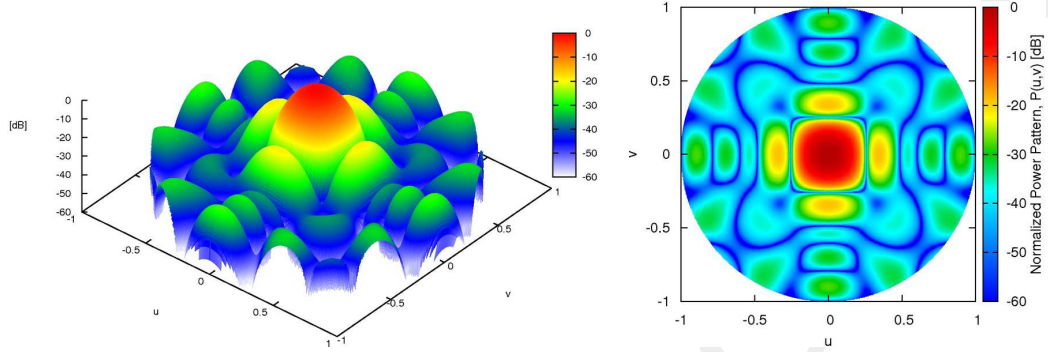
ϕ [rad]	SLL [dB]	First Null [rad]	BW [rad]	Δ_{norm}
0°	-24.977903	-0.988030	0.001230	0.135352
$\Delta_{Medio_{norm}}$			0.211403	
BCE [%]			91.93	

PRESTAZIONI BEM - CPM

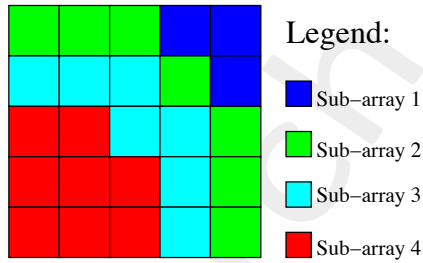
# iterazioni	swap	$\min\{Fitness\}$
100	13	0.443248

Q=4

BEAM PATTERN



CONFIGURAZIONE DELLE ECCITAZIONI



Indice	Valore	Indice	Valore
Sub-array 1	0.150006	Sub-array 3	0.504893
Sub-array 2	0.280513	Sub-array 4	0.816830

PARAMETRI ANALITICI PATTERN

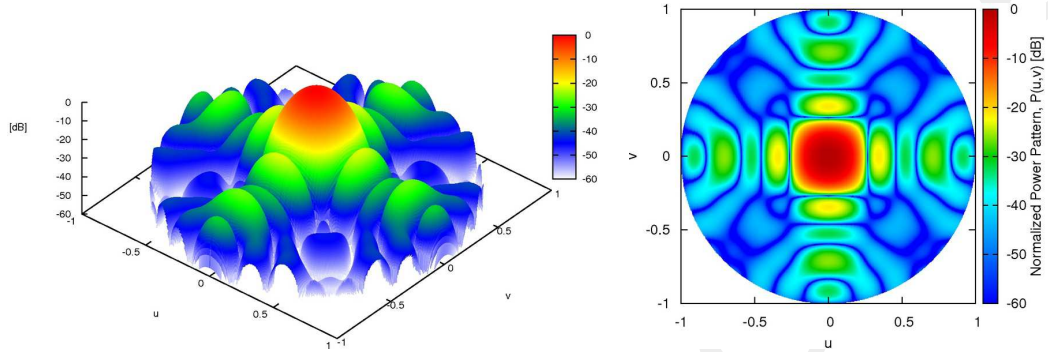
ϕ [rad]	SLL [dB]	First Null [rad]	BW [rad]	Δ_{norm}
0	-27.945690	-0.906349	0.001334	0.135461
$\Delta_{Medio_{norm}}$			0.105438	
BCE [%]			95.21	

PARAMETRI BEM

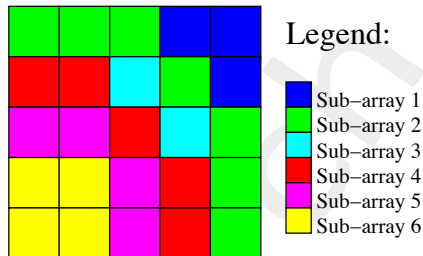
# iterazioni	swap	min {Fitness}
100	18	0.129724

Q=6

BEAM PATTERN



CONFIGURAZIONE DELLE ECCITAZIONI



Indice	Valore	Indice	Valore
Sub-array 1	0.150006	Sub-array 4	0.423987
Sub-array 2	0.280513	Sub-array 5	0.717193
Sub-array 3	0.537256	Sub-array 6	0.916467

PARAMETRI ANALITICI PATTERN

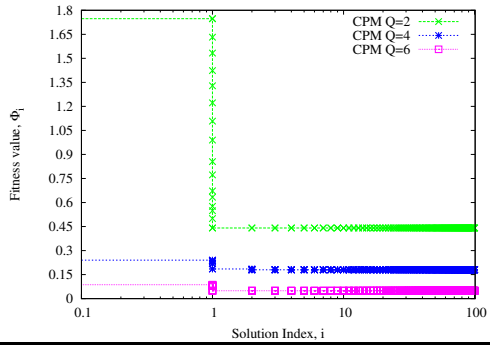
ϕ [rad]	SLL [dB]	$First\ Null$ [rad]	BW [rad]	Δ_{norm}
0°	-26.014368	-0.980176	0.001346	0.066983
$\Delta_{Medio_{norm}}$			0.043387	
BCE [%]			96.19	

PRESTAZIONI BEM - CPM

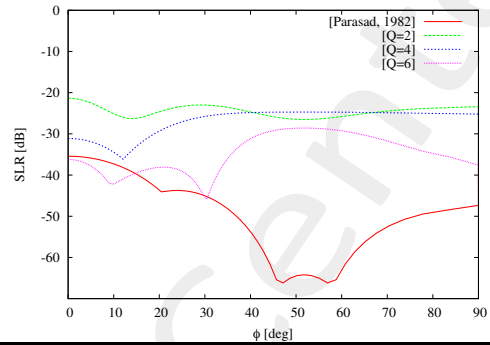
# iterazioni	swap	$\min\{Fitness\}$
100	22	0.031976

PARAMETRI CON TARGET BCE 99.81%; $(u, v) = (0.3; 0.3)$

Evoluzione funzionale di costo CPM

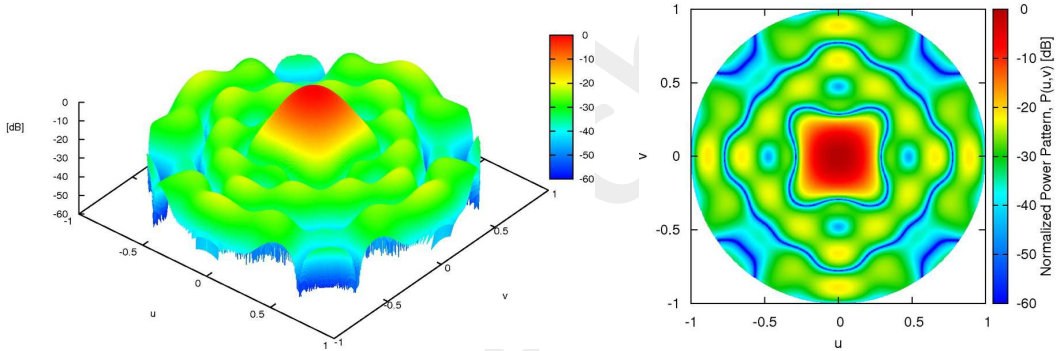


Side Lobe Ratio (SLR)

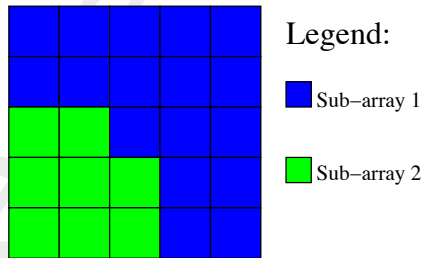


$Q=2$

BEAM PATTERN



CONFIGURAZIONE DELLE ECCITAZIONI



Legend:

■ Sub-array 1

■ Sub-array 2

Indice	Valore
Sub-array 1	0.191544
Sub-array 2	0.722048

PARAMETRI ANALITICI PATTERN

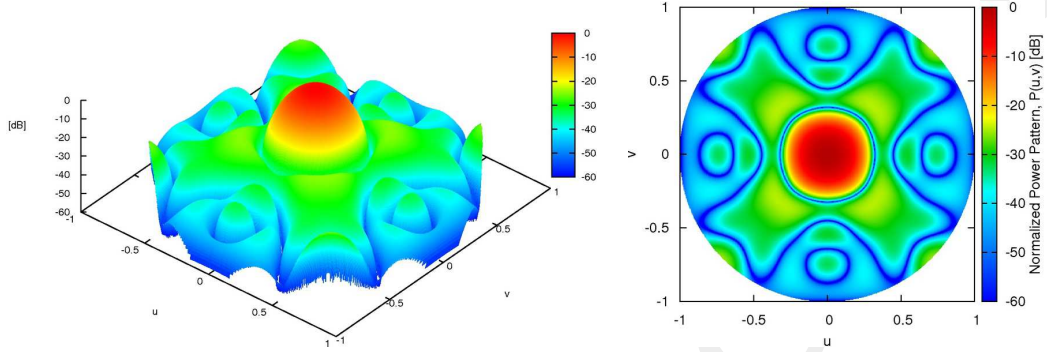
ϕ [rad]	SLL [dB]	$First\ Null$ [rad]	BW [rad]	Δ_{norm}
0°	-21.360549	0.293738	0.003843	0.338683
$\Delta_{Medio_{norm}}$			0.265773	
BCE [%]			92.99	

PRESTAZIONI BEM - CPM

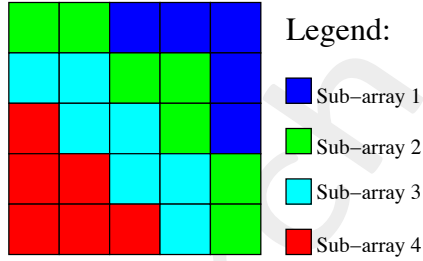
# iterazioni	swap	$\min\{Fitness\}$
100	18	0.441201

Q=4

BEAM PATTERN



CONFIGURAZIONE DELLE ECCITAZIONI



Indice	Valore	Indice	Valore
Sub-array 1	0.0649556	Sub-array 3	0.405792
Sub-array 2	0.166090	Sub-array 4	0.784112

PARAMETRI ANALITICI PATTERN

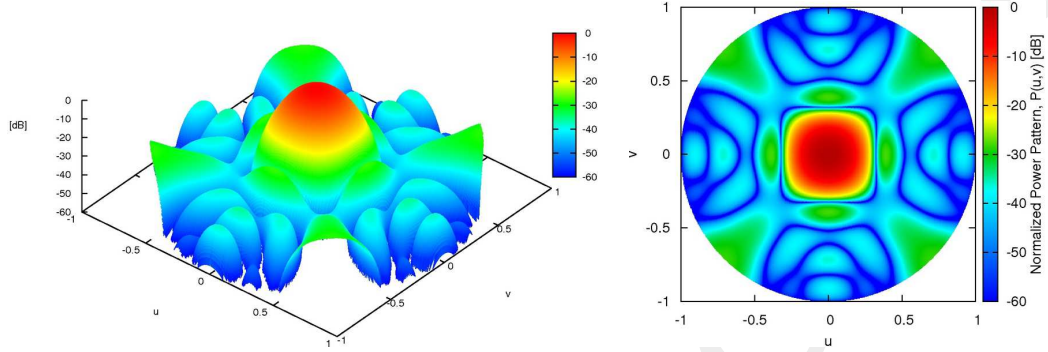
ϕ [rad]	SLL [dB]	First Null [rad]	BW [rad]	Δ_{norm}
0°	-31.112731	0.328296	0.004140	0.062973
$\Delta_{Medio_{norm}}$			0.126313	
BCE [%]			97.87	

PRESTAZIONI BEM - CPM

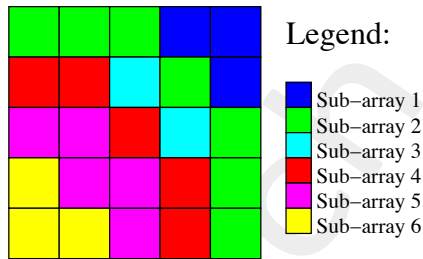
# iterazioni	swap	$\min\{Fitness\}$
100	20	0.179882

Q=6

BEAM PATTERN



CONFIGURAZIONE DELLE ECCITAZIONI



Indice	Valore	Indice	Valore
Sub-array 1	0.0454576	Sub-array 4	0.353767
Sub-array 2	0.126802	Sub-array 5	0.454576
Sub-array 3	0.231708	Sub-array 6	0.906691

PARAMETRI ANALITICI PATTERN

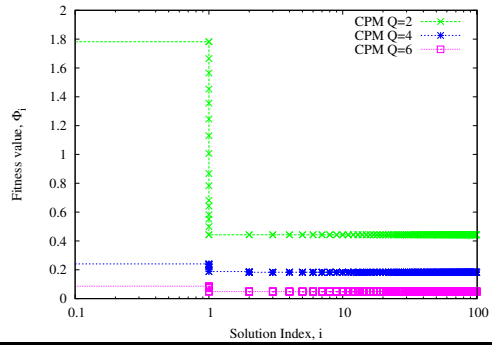
ϕ [rad]	SLL [dB]	$First\ Null$ [rad]	BW [rad]	Δ_{norm}
0°	-36.215751	0.328296	0.004214	0.049148
$\Delta_{Medio_{norm}}$			0.064949	
BCE [%]			99.22	

PARAMETRI BEM

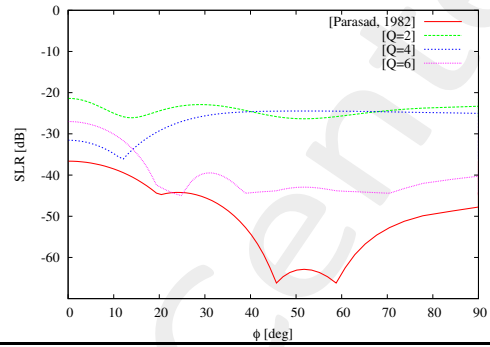
# iterazioni	swap	$\min\{Fitness\}$
100	23	0.0493828

PARAMETRI CON TARGET BCE 99.90%; $(u, v) = (0.4; 0.4)$

Evoluzione funzionale di costo CPM

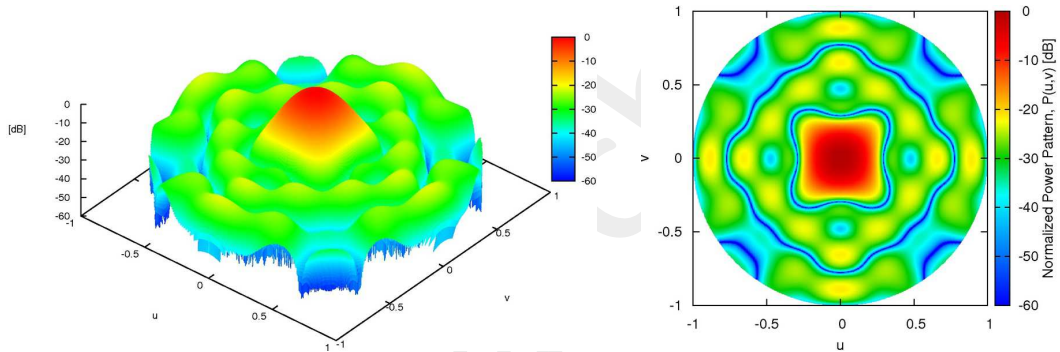


Side Lobe Ratio (SLR)

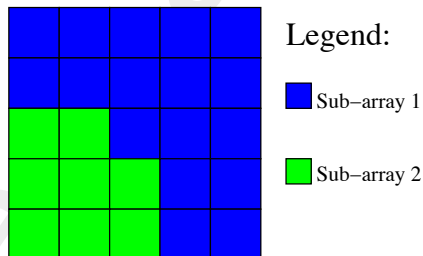


$Q=2$

BEAM PATTERN



CONFIGURAZIONE DELLE ECCITAZIONI



Legend:

■ Sub-array 1

■ Sub-array 2

Indice	Valore
Sub-array 1	0.187285
Sub-array 2	0.723488

PARAMETRI ANALITICI PATTERN

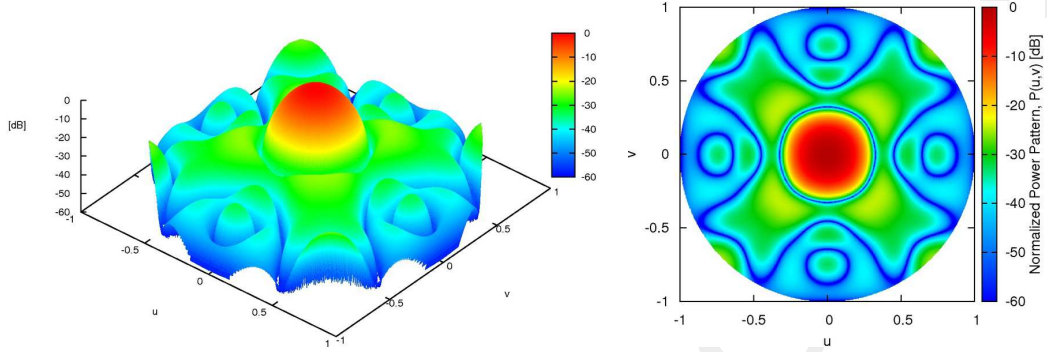
ϕ [rad]	SLL [dB]	First Null [rad]	BW [rad]	Δ_{norm}
0°	-21.386123	-0.884358	0.001397	0.343711
$\Delta_{Medio_{norm}}$			0.268766	
BCE [%]			93.35	

PARAMETRI BEM

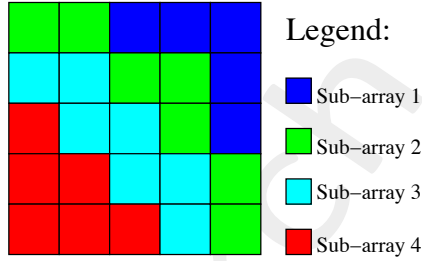
# iterazioni	swap	$\min\{Fitness\}$
100	18	0.442998

Q=4

BEAM PATTERN



CONFIGURAZIONE DELLE ECCITAZIONI



Indice	Valore	Indice	Valore
Sub-array 1	0.061188	Sub-array 3	0.404026
Sub-array 2	0.160697	Sub-array 4	0.785458

PARAMETRI ANALITICI PATTERN

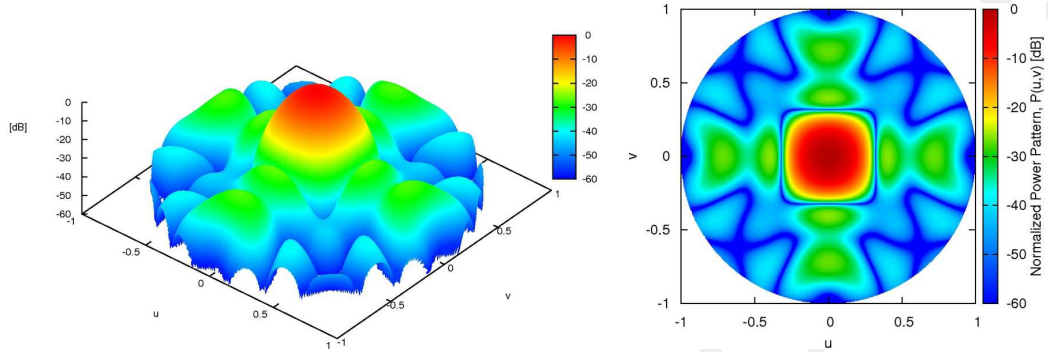
ϕ [rad]	SLL [dB]	First Null [rad]	BW [rad]	Δ_{norm}
0°	-31.545280	-1.107128	0.001561	0.064382
$\Delta_{Medio_{norm}}$			0.127094	
BCE [%]			98.69	

PRESTAZIONI BEM - CPM

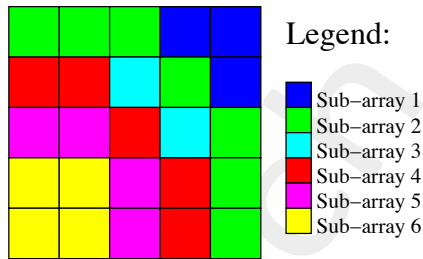
# iterazioni	swap	$\min\{Fitness\}$
100	20	0.182956

Q=6

BEAM PATTERN



CONFIGURAZIONE DELLE ECCITAZIONI



Indice	Valore	Indice	Valore
Sub-array 1:	0.0422572	Sub-array 4	0.350605
Sub-array 2	0.120900	Sub-array 5	0.580640
Sub-array 3	0.228872	Sub-array 6	0.866336

PARAMETRI ANALITICI PATTERN

ϕ [rad]	SLL [dB]	$First\ Null$ [rad]	BW [rad]	Δ_{norm}
0°	-26.997739	-1.567654	0.001622	0.115141
$\Delta_{Medio_{norm}}$			0.064696	
BCE [%]			99.04	

PRESTAZIONI BEM - CPM

# iterazioni	swap	$\min\{Fitness\}$
100	22	0.048980

Appendix

BEAM COLLECTION EFFICENCY (BCE)

Per un'antenna il quale lobo principale è lungo l'asse z ($\theta = 0^\circ$) definiamo BE come:

$$BCE = \frac{\text{Potenza trasmessa (o ricevuta) in un certo angolo } \theta_i}{\text{Potenza trasmessa (o ricevuta) dall'antenna}} \quad (1)$$

dove θ_i è metà dell'angolo del cono all'interno del quale si trova la maggior percentuale della potenza totale.

$$BCE = \frac{\int_0^{2\pi} \int_0^{\theta_i} U(\theta, \phi) \sin\theta d\theta d\phi}{\int_0^{2\pi} \int_0^\pi U(\theta, \phi) \sin\theta d\theta d\phi} \quad (2)$$

Solitamente θ_i è scelto corrispondente al primo nullo, quindi BE rappresenta il rapporto tra la potenza del lobo principale rispetto alla potenza totale.

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