A Power Pattern Matching-Driven Clustering Method for Phased Array Design: The Linear Array Case

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Antenna configuration

- Isotropic Elements
- Number of Elements: $N = 16$
- Distance between Elements along x axis: $d_x = \lambda/2$

Target excitations

- Main Lobe Steering: $\theta_s = 20$ [deg]
- Taylor, $SLL = -20$ [dB], $\overline{n} = 3$

Sub-array generation

- number of clusters: $Q = 8$
- excitation matching strategy: EM K-Means
- power matching strategy: PM K-means

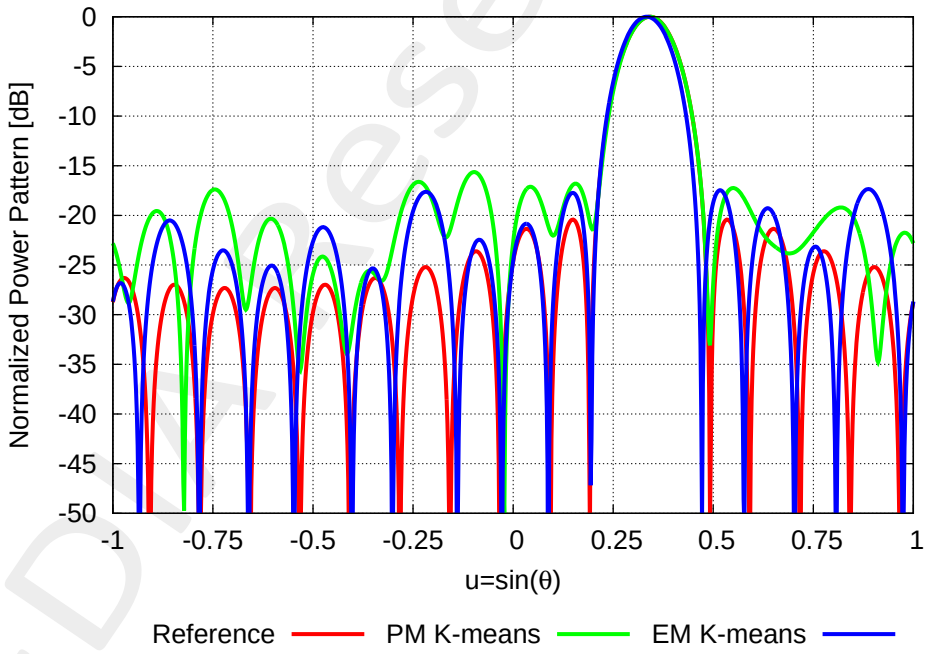

Figure 1: Power Pattern comparison PM K-means vs. EM K-means

Approach	Pattern Matching
PM K-means	9.33×10^{-2}
EM K-means	1.70×10^{-1}

Table I: Pattern Matching

1.1.2 $\mathbf{N = 32 \ - \ Q = N/2}$

Antenna configuration

- Isotropic Elements
- Number of Elements: $N = 32$
- Distance between Elements along x axis: $d_x = \lambda/2$

Target excitations

- Main Lobe Steering: $\theta_s = 20$ [deg]
- Taylor, $SLL = -20$ [dB], $\overline{n} = 3$

Sub-array generation

- number of clusters: $Q = 16$
- excitation matching strategy: EM K-Means
- power matching strategy: PM K-means

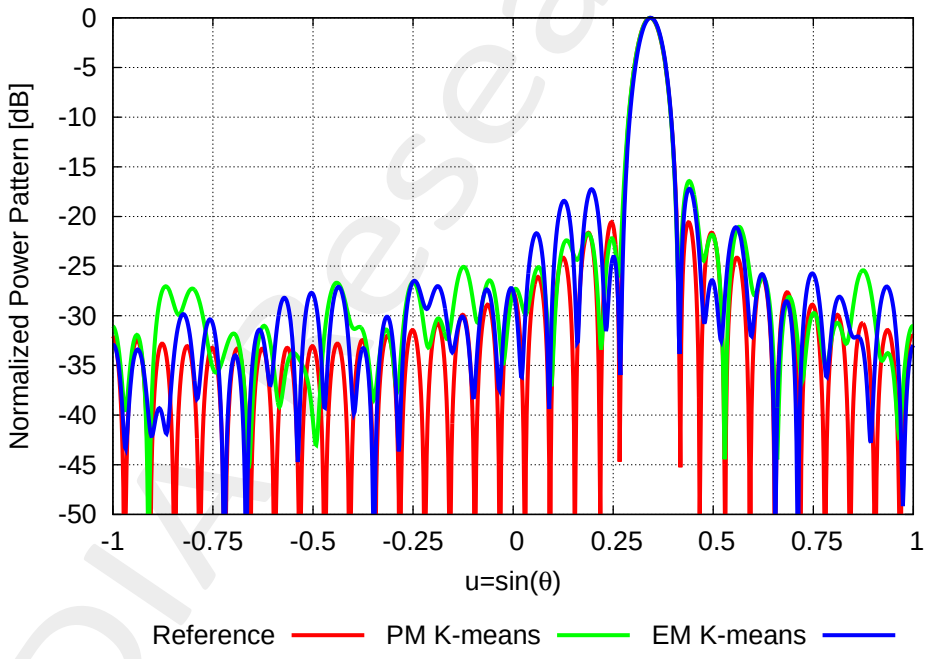

Figure 2: Power Pattern comparison PM K-means vs. EM K-means

Approach	Pattern Matching
PM K-means	3.78×10^{-2}
EM K-means	8.58×10^{-2}

Table II: Pattern Matching

1.1.3 $\mathbf{N = 48 \ - \ Q = N/2}$

Antenna configuration

- Isotropic Elements
- Number of Elements: $N = 48$
- Distance between Elements along x axis: $d_x = \lambda/2$

Target excitations

- Main Lobe Steering: $\theta_s = 20$ [deg]
- Taylor, $SLL = -20$ [dB], $\overline{n} = 3$

Sub-array generation

- number of clusters: $Q = 24$
- excitation matching strategy: EM K-Means
- power matching strategy: PM K-means

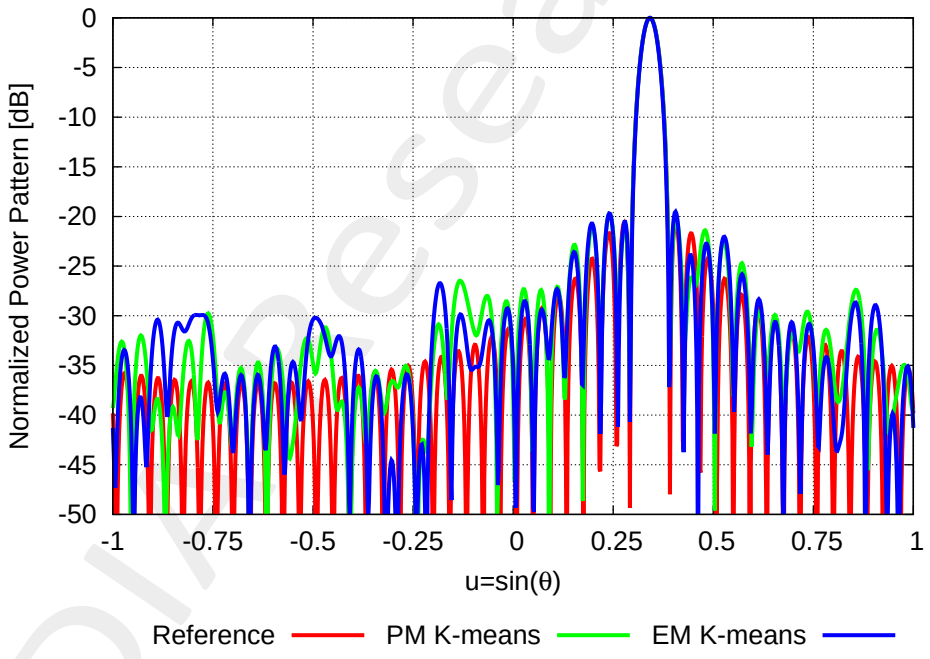

Figure 3: Power Pattern comparison PM K-means vs. EM K-means

Approach	Pattern Matching
PM K-means	2.86×10^{-2}
EM K-means	3.92×10^{-2}

Table III: Pattern Matching

1.1.4 $\mathbf{N = 64 \ - \ Q = N/2}$

Antenna configuration

- Isotropic Elements
- Number of Elements: $N = 64$
- Distance between Elements along x axis: $d_x = \lambda/2$

Target excitations

- Main Lobe Steering: $\theta_s = 20$ [deg]
- Taylor, $SLL = -20$ [dB], $\overline{n} = 3$

Sub-array generation

- number of clusters: $Q = 32$
- excitation matching strategy: EM K-Means
- power matching strategy: PM K-means

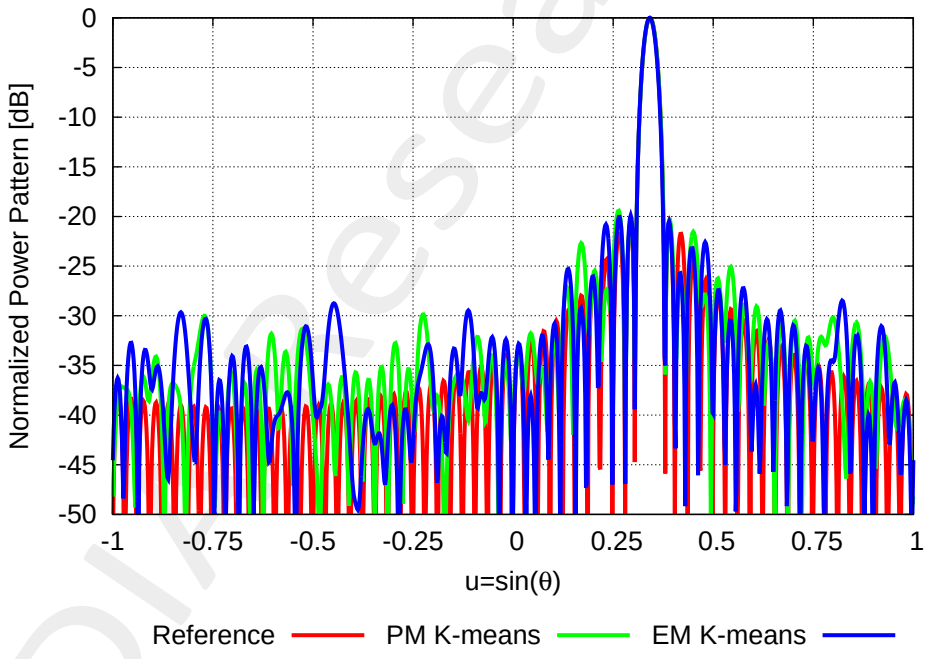

Figure 4: Power Pattern comparison PM K-means vs. EM K-means

Approach	Pattern Matching
PM K-means	3.02×10^{-2}
EM K-means	5.71×10^{-2}

Table IV: Pattern Matching

1.1.5 $\mathbf{N = 96 \ - \ Q = N/2}$

Antenna configuration

- Isotropic Elements
- Number of Elements: $N = 96$
- Distance between Elements along x axis: $d_x = \lambda/2$

Target excitations

- Main Lobe Steering: $\theta_s = 20$ [deg]
- Taylor, $SLL = -20$ [dB], $\overline{n} = 3$

Sub-array generation

- number of clusters: $Q = 48$
- excitation matching strategy: EM K-Means
- power matching strategy: PM K-means

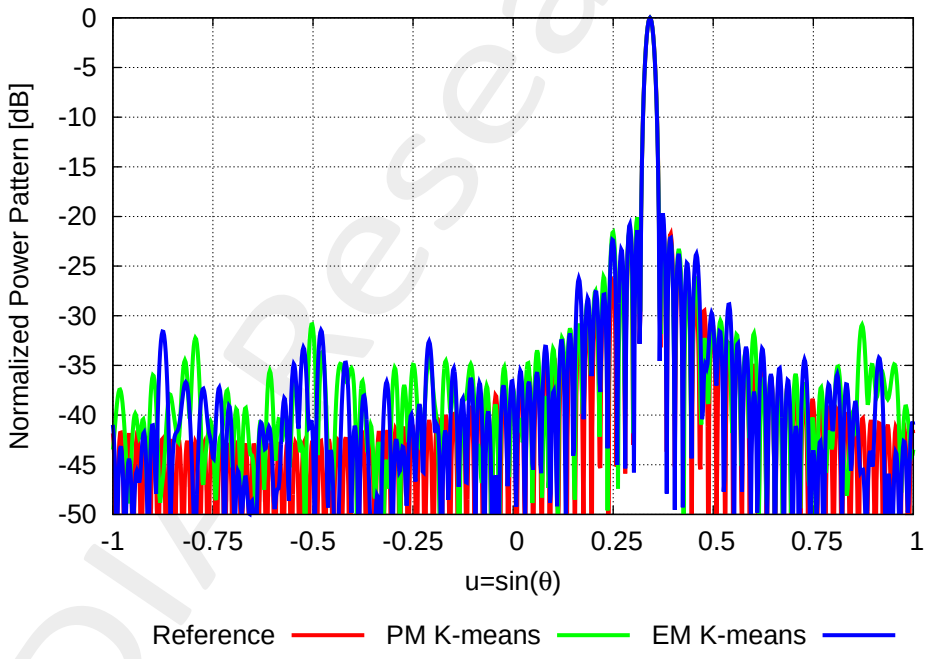

Figure 5: Power Pattern comparison PM K-means vs. EM K-means

Approach	Pattern Matching
PM K-means	2.32×10^{-2}
EM K-means	2.71×10^{-2}

Table V: Pattern Matching

1.1.6 $\mathbf{N = 128 \ - \ Q = N/2}$

Antenna configuration

- Isotropic Elements
- Number of Elements: $N = 128$
- Distance between Elements along x axis: $d_x = \lambda/2$

Target excitations

- Main Lobe Steering: $\theta_s = 15$ [deg]
- Taylor, $SLL = -20$ [dB], $\overline{n} = 3$

Sub-array generation

- number of clusters: $Q = 64$
- excitation matching strategy: EM K-Means
- power matching strategy: PM K-means

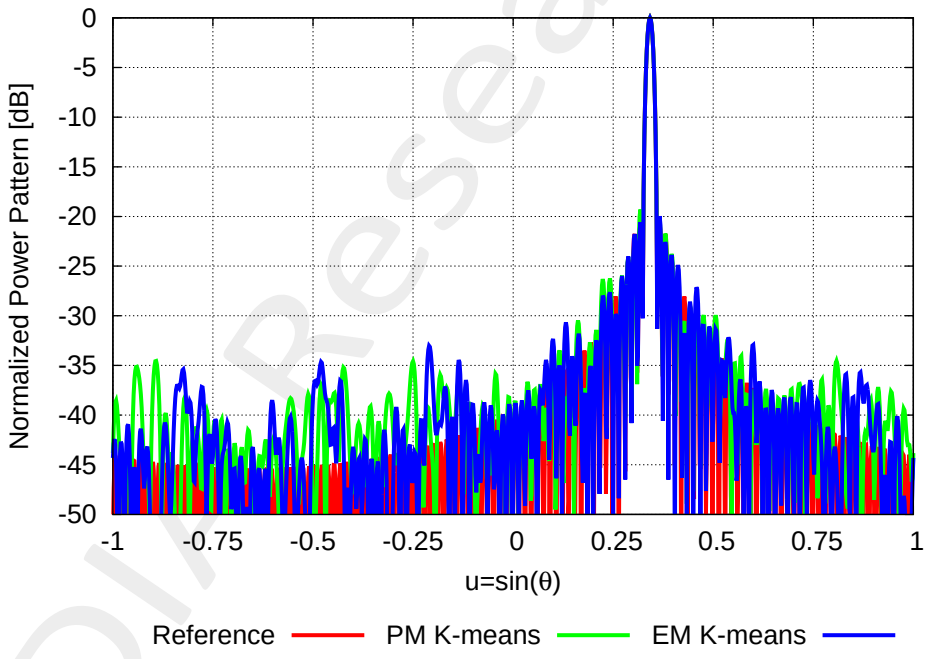

Figure 6: Power Pattern comparison PM K-means vs. EM K-means

Approach	Pattern Matching
PM K-means	1.65×10^{-2}
EM K-means	1.63×10^{-2}

Table VI: Pattern Matching

1.1.7 Pattern Matching Improvement vs. N

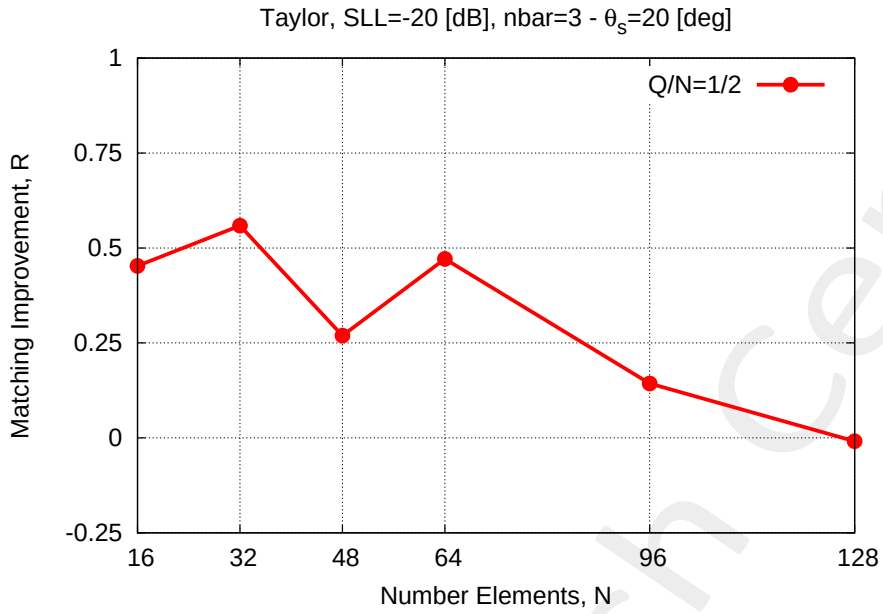

Figure 7: Analysis Matching Improvement vs. Number Elements for $Q/N = 1/2$

1.1.8 Pattern Matching vs. N

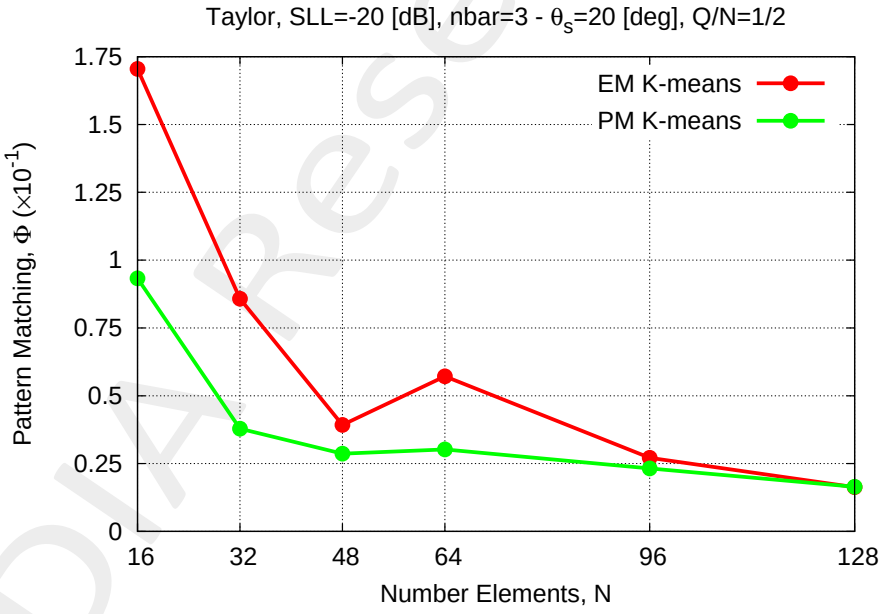

Figure 8: Pattern Matching comparison PM K-means vs. EM K-means varying the number of elements for $Q/N = 1/2$

1.2 Dolph-Chebyshev, $\mathbf{SLL = -20\ [dB]}$, $\boldsymbol{\theta_s = 15\ [deg]}$

1.2.1 $\mathbf{N = 16\ -\ Q = N/2}$

Antenna configuration

- Isotropic Elements
- Number of Elements: $N = 16$
- Distance between Elements along x axis: $d_x = \lambda/2$

Target excitations

- Main Lobe Steering: $\theta_s = 15$ [deg]
- Dolph-Chebyshev, $SLL = -20$ [dB]

Sub-array generation

- number of clusters: $Q = 8$
- excitation matching strategy: EM K-Means
- power matching strategy: PM K-means

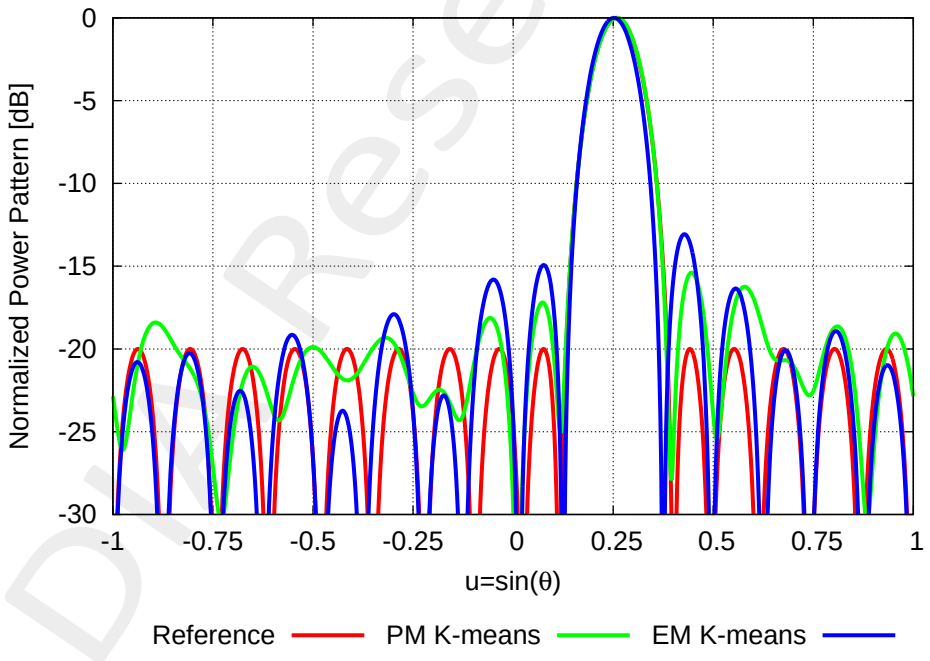

Figure 9: Power Pattern comparison PM K-means vs. EM K-means

Approach	Pattern Matching
PM K-means	7.58×10^{-2}
EM K-means	1.81×10^{-1}

Table VII: Pattern Matching

1.2.2 $\mathbf{N = 32 \ - \ Q = N/2}$

Antenna configuration

- Isotropic Elements
- Number of Elements: $N = 32$
- Distance between Elements along x axis: $d_x = \lambda/2$

Target excitations

- Main Lobe Steering: $\theta_s = 15$ [deg]
- Dolph-Chebyshev, $SLL = -20$ [dB]

Sub-array generation

- number of clusters: $Q = 16$
- excitation matching strategy: EM K-Means
- power matching strategy: PM K-means

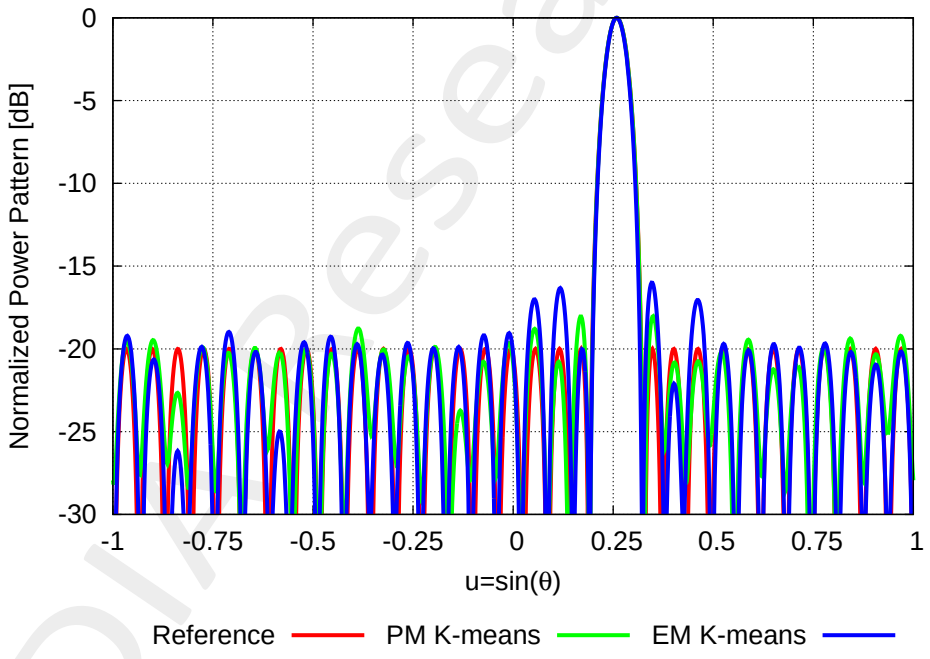

Figure 10: Power Pattern comparison PM K-means vs. EM K-means

Approach	Pattern Matching
PM K-means	4.56×10^{-2}
EM K-means	8.26×10^{-2}

Table VIII: Pattern Matching

1.2.3 $\mathbf{N = 48 \ - \ Q = N/2}$

Antenna configuration

- Isotropic Elements
- Number of Elements: $N = 48$
- Distance between Elements along x axis: $d_x = \lambda/2$

Target excitations

- Main Lobe Steering: $\theta_s = 15$ [deg]
- Dolph-Chebyshev, $SLL = -20$ [dB]

Sub-array generation

- number of clusters: $Q = 24$
- excitation matching strategy: EM K-Means
- power matching strategy: PM K-means

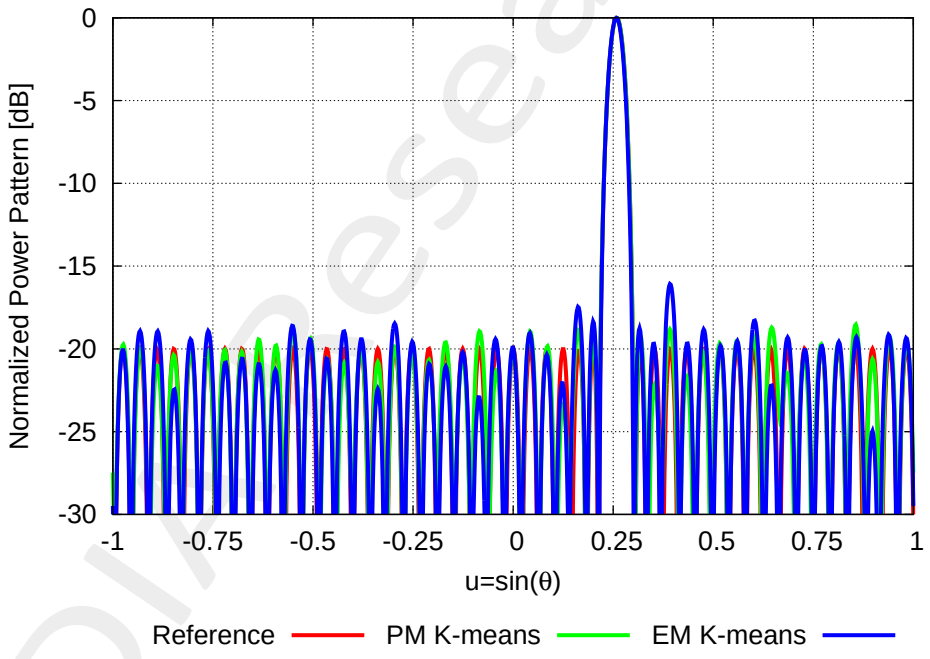

Figure 11: Power Pattern comparison PM K-means vs. EM K-means

Approach	Pattern Matching
PM K-means	4.58×10^{-2}
EM K-means	9.39×10^{-2}

Table IX: Pattern Matching

1.2.4 $\mathbf{N = 64 \ - \ Q = N/2}$

Antenna configuration

- Isotropic Elements
- Number of Elements: $N = 64$
- Distance between Elements along x axis: $d_x = \lambda/2$

Target excitations

- Main Lobe Steering: $\theta_s = 15$ [deg]
- Dolph-Chebyshev, $SLL = -20$ [dB]

Sub-array generation

- number of clusters: $Q = 32$
- excitation matching strategy: EM K-Means
- power matching strategy: PM K-means

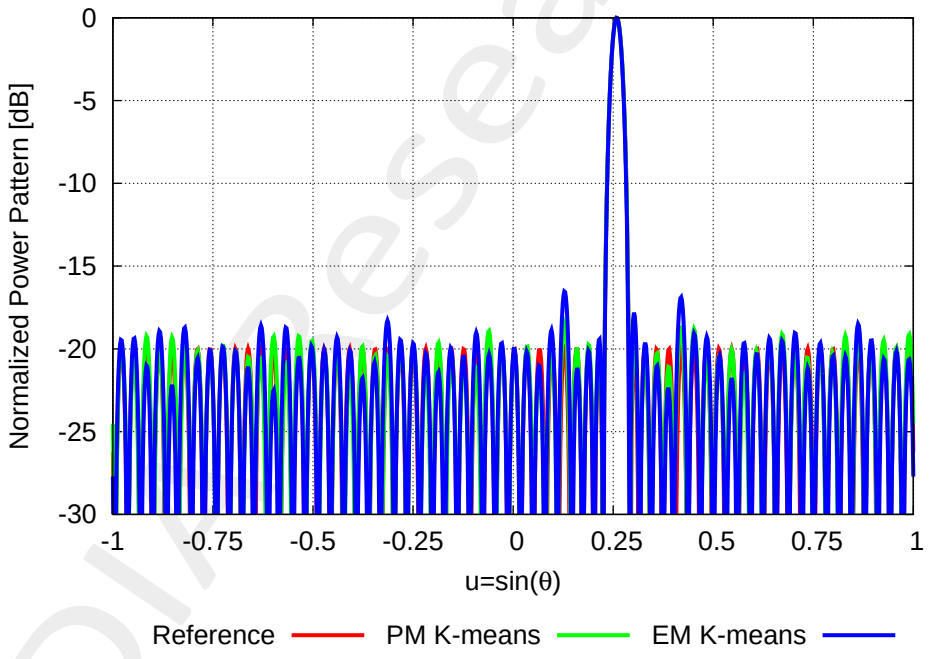

Figure 12: Power Pattern comparison PM K-means vs. EM K-means

Approach	Pattern Matching
PM K-means	4.43×10^{-2}
EM K-means	7.68×10^{-2}

Table X: Pattern Matching

1.2.5 $\mathbf{N = 96 \ - \ Q = N/2}$

Antenna configuration

- Isotropic Elements
- Number of Elements: $N = 96$
- Distance between Elements along x axis: $d_x = \lambda/2$

Target excitations

- Main Lobe Steering: $\theta_s = 15$ [deg]
- Dolph-Chebyshev, $SLL = -20$ [dB]

Sub-array generation

- number of clusters: $Q = 48$
- excitation matching strategy: EM K-Means
- power matching strategy: PM K-means

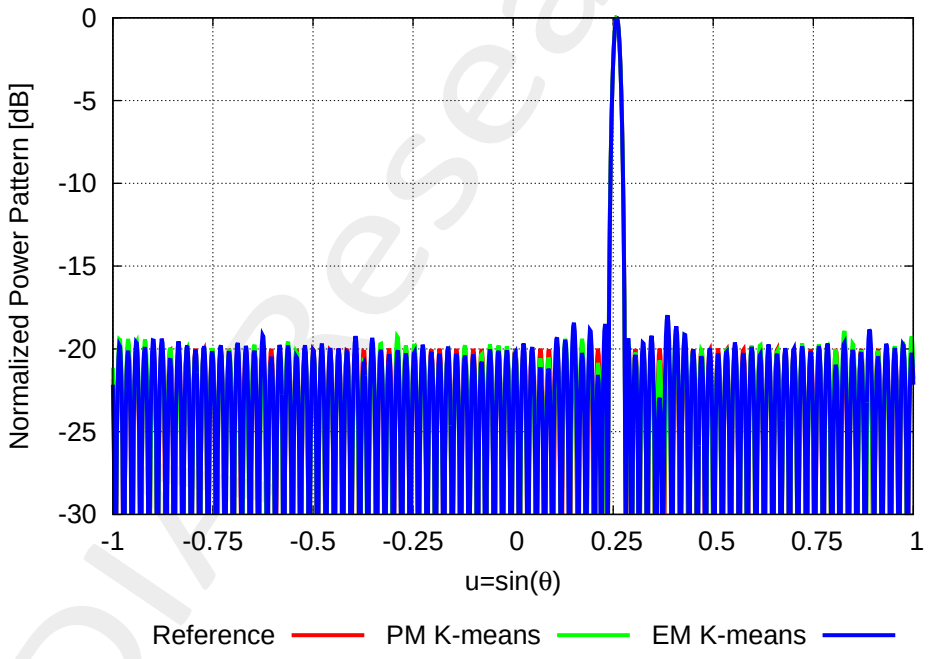

Figure 13: Power Pattern comparison PM K-means vs. EM K-means

Approach	Pattern Matching
PM K-means	4.04×10^{-2}
EM K-means	4.79×10^{-2}

Table XI: Pattern Matching

1.2.6 $\mathbf{N = 128 \ - \ Q = N/2}$

Antenna configuration

- Isotropic Elements
- Number of Elements: $N = 128$
- Distance between Elements along x axis: $d_x = \lambda/2$

Target excitations

- Main Lobe Steering: $\theta_s = 15$ [deg]
- Dolph-Chebyshev, $SLL = -20$ [dB]

Sub-array generation

- number of clusters: $Q = 64$
- excitation matching strategy: EM K-Means
- power matching strategy: PM K-means

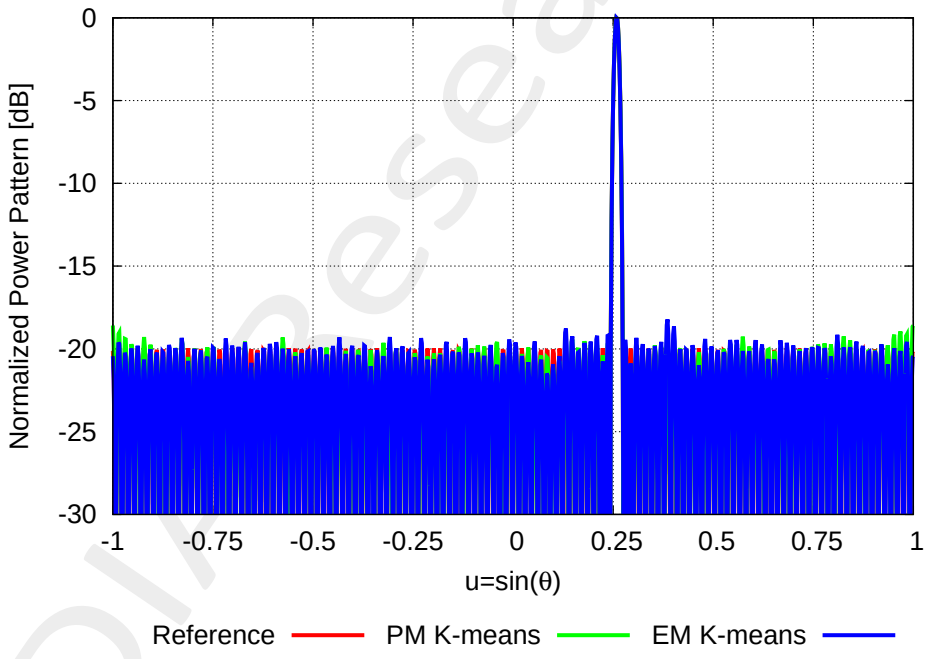

Figure 14: Power Pattern comparison PM K-means vs. EM K-means

Approach	Pattern Matching
PM K-means	4.70×10^{-2}
EM K-means	5.24×10^{-2}

Table XII: Pattern Matching

1.2.7 Pattern Matching Improvement vs. N

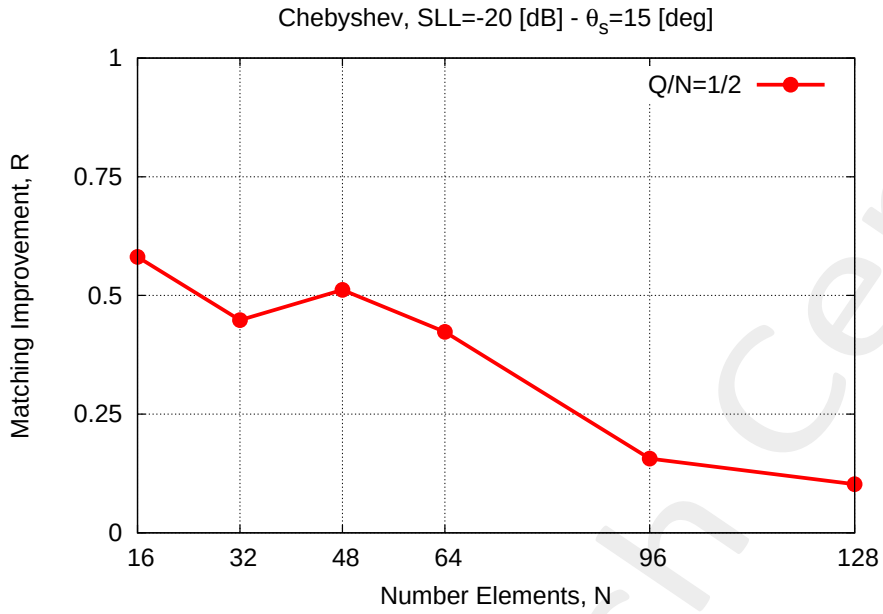

Figure 15: Analysis Matching Improvement vs. Number Elements for $Q/N = 1/2$

1.2.8 Pattern Matching vs. N

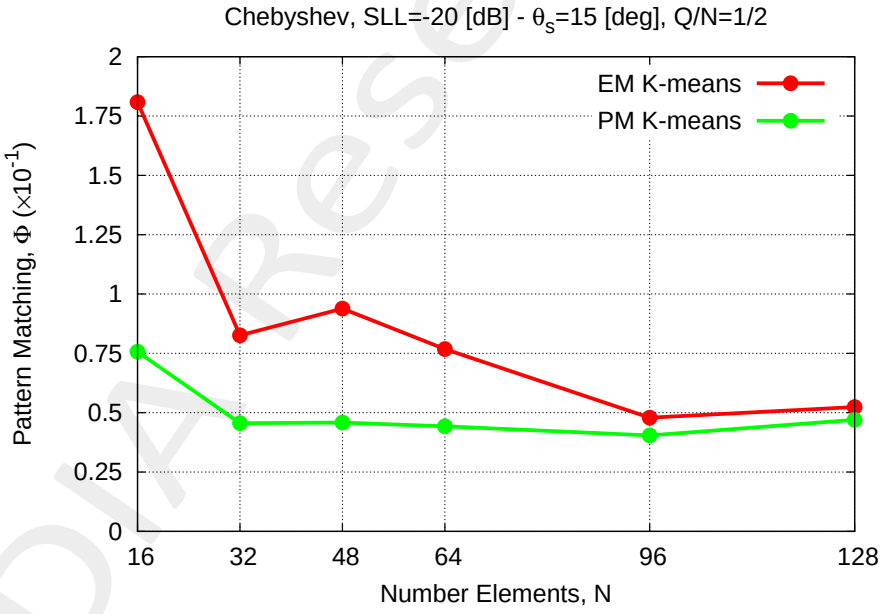

Figure 16: Pattern Matching comparison PM K-means vs. EM K-means varying the number of elements for $Q/N = 1/2$

1.3 Dolph-Chebyshev, $\mathbf{SLL = -20\ [dB]}$, $\boldsymbol{\theta_s = 20\ [deg]}$

1.3.1 $\mathbf{N = 16\ -\ Q = N/2}$

Antenna configuration

- Isotropic Elements
- Number of Elements: $N = 16$
- Distance between Elements along x axis: $d_x = \lambda/2$

Target excitations

- Main Lobe Steering: $\theta_s = 20$ [deg]
- Dolph-Chebyshev, $SLL = -20$ [dB]

Sub-array generation

- number of clusters: $Q = 8$
- excitation matching strategy: EM K-Means
- power matching strategy: PM K-means

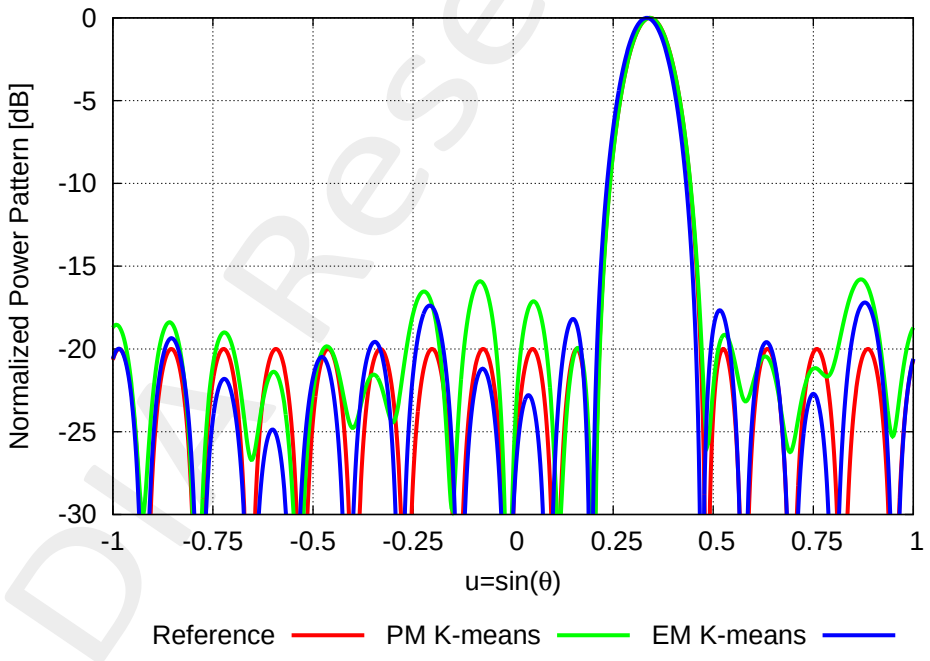

Figure 17: Power Pattern comparison PM K-means vs. EM K-means

Approach	Pattern Matching
PM K-means	5.91×10^{-2}
EM K-means	1.63×10^{-1}

Table XIII: Pattern Matching

1.3.2 $\mathbf{N = 32 \ - \ Q = N/2}$

Antenna configuration

- Isotropic Elements
- Number of Elements: $N = 32$
- Distance between Elements along x axis: $d_x = \lambda/2$

Target excitations

- Main Lobe Steering: $\theta_s = 20$ [deg]
- Dolph-Chebyshev, $SLL = -20$ [dB]

Sub-array generation

- number of clusters: $Q = 16$
- excitation matching strategy: EM K-Means
- power matching strategy: PM K-means

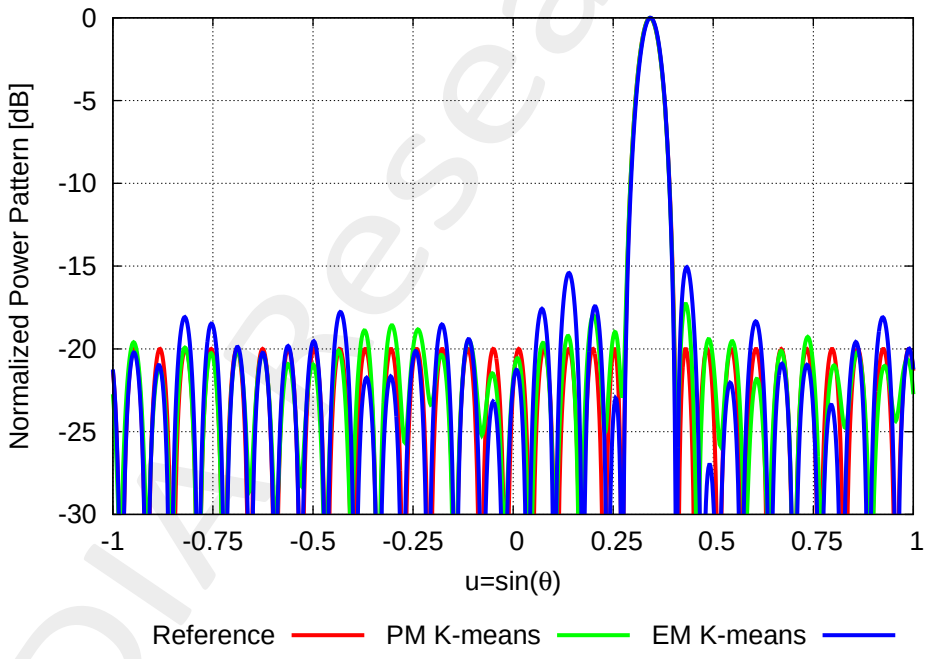

Figure 18: Power Pattern comparison PM K-means vs. EM K-means

Approach	Pattern Matching
PM K-means	4.94×10^{-2}
EM K-means	1.03×10^{-1}

Table XIV: Pattern Matching

1.3.3 $\mathbf{N = 48 \ - \ Q = N/2}$

Antenna configuration

- Isotropic Elements
- Number of Elements: $N = 48$
- Distance between Elements along x axis: $d_x = \lambda/2$

Target excitations

- Main Lobe Steering: $\theta_s = 20$ [deg]
- Dolph-Chebyshev, $SLL = -20$ [dB]

Sub-array generation

- number of clusters: $Q = 24$
- excitation matching strategy: EM K-Means
- power matching strategy: PM K-means

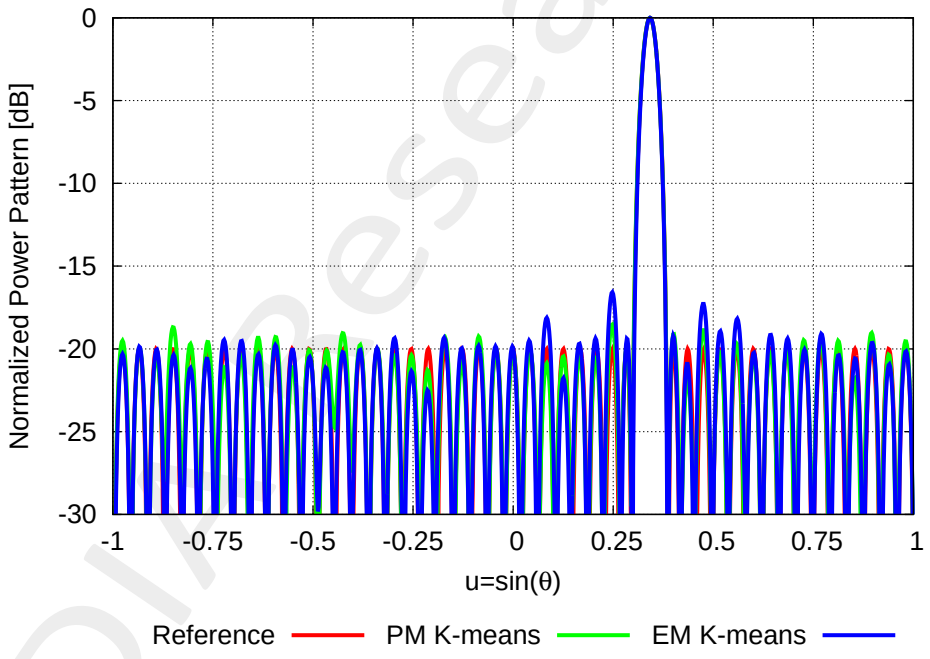

Figure 19: Power Pattern comparison PM K-means vs. EM K-means

Approach	Pattern Matching
PM K-means	4.37×10^{-2}
EM K-means	6.20×10^{-2}

Table XV: Pattern Matching

1.3.4 $\mathbf{N = 64 \ - \ Q = N/2}$

Antenna configuration

- Isotropic Elements
- Number of Elements: $N = 64$
- Distance between Elements along x axis: $d_x = \lambda/2$

Target excitations

- Main Lobe Steering: $\theta_s = 20$ [deg]
- Dolph-Chebyshev, $SLL = -20$ [dB]

Sub-array generation

- number of clusters: $Q = 32$
- excitation matching strategy: EM K-Means
- power matching strategy: PM K-means

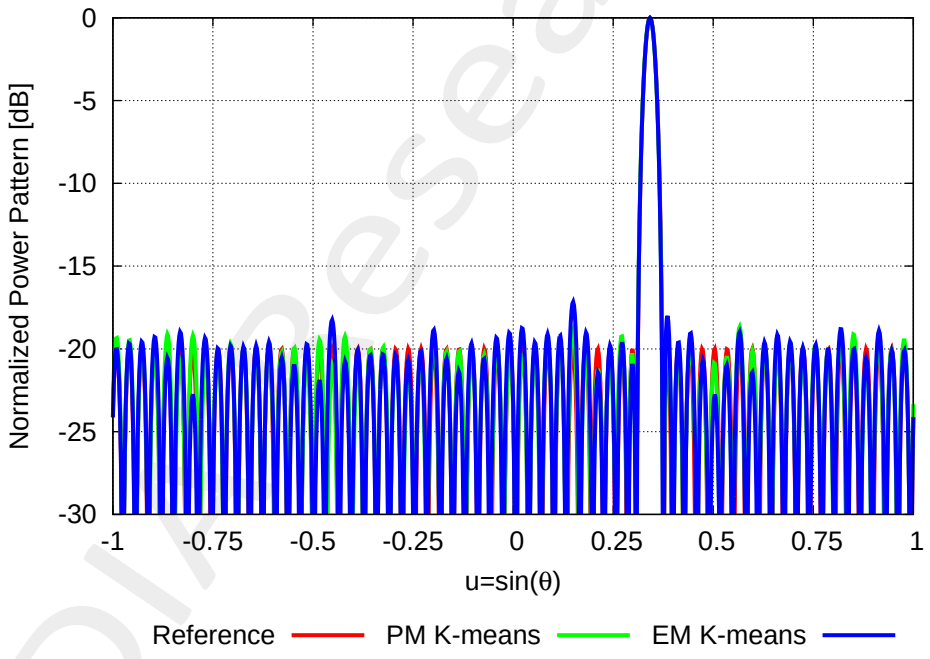

Figure 20: Power Pattern comparison PM K-means vs. EM K-means

Approach	Pattern Matching
PM K-means	5.31×10^{-2}
EM K-means	6.14×10^{-2}

Table XVI: Pattern Matching

1.3.5 $\mathbf{N = 96 \ - \ Q = N/2}$

Antenna configuration

- Isotropic Elements
- Number of Elements: $N = 96$
- Distance between Elements along x axis: $d_x = \lambda/2$

Target excitations

- Main Lobe Steering: $\theta_s = 20$ [deg]
- Dolph-Chebyshev, $SLL = -20$ [dB]

Sub-array generation

- number of clusters: $Q = 48$
- excitation matching strategy: EM K-Means
- power matching strategy: PM K-means

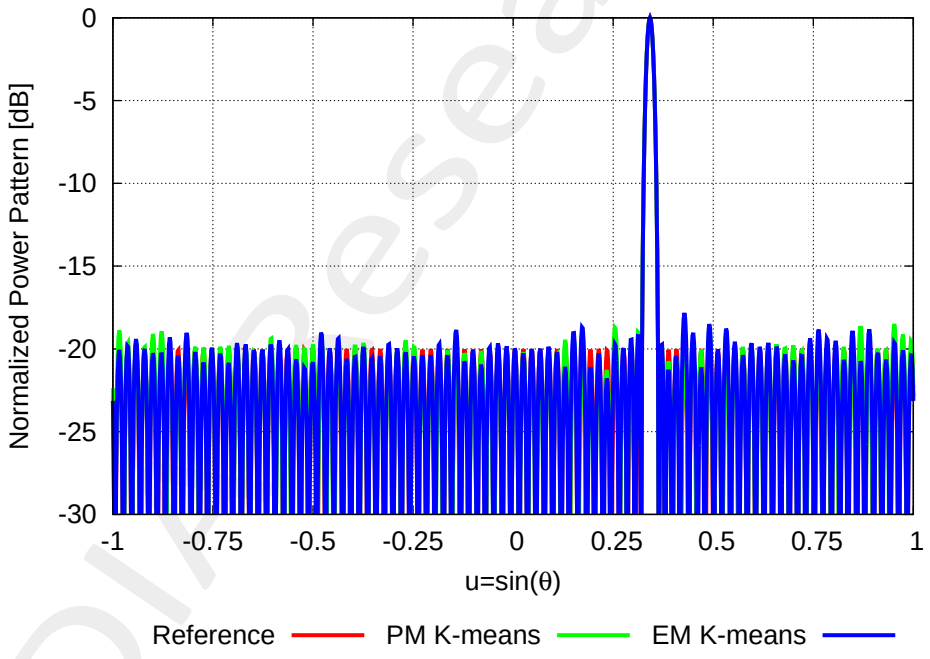

Figure 21: Power Pattern comparison PM K-means vs. EM K-means

Approach	Pattern Matching
PM K-means	5.38×10^{-2}
EM K-means	5.90×10^{-2}

Table XVII: Pattern Matching

1.3.6 $\mathbf{N = 128 \ - \ Q = N/2}$

Antenna configuration

- Isotropic Elements
- Number of Elements: $N = 128$
- Distance between Elements along x axis: $d_x = \lambda/2$

Target excitations

- Main Lobe Steering: $\theta_s = 20$ [deg]
- Dolph-Chebyshev, $SLL = -20$ [dB]

Sub-array generation

- number of clusters: $Q = 64$
- excitation matching strategy: EM K-Means
- power matching strategy: PM K-means

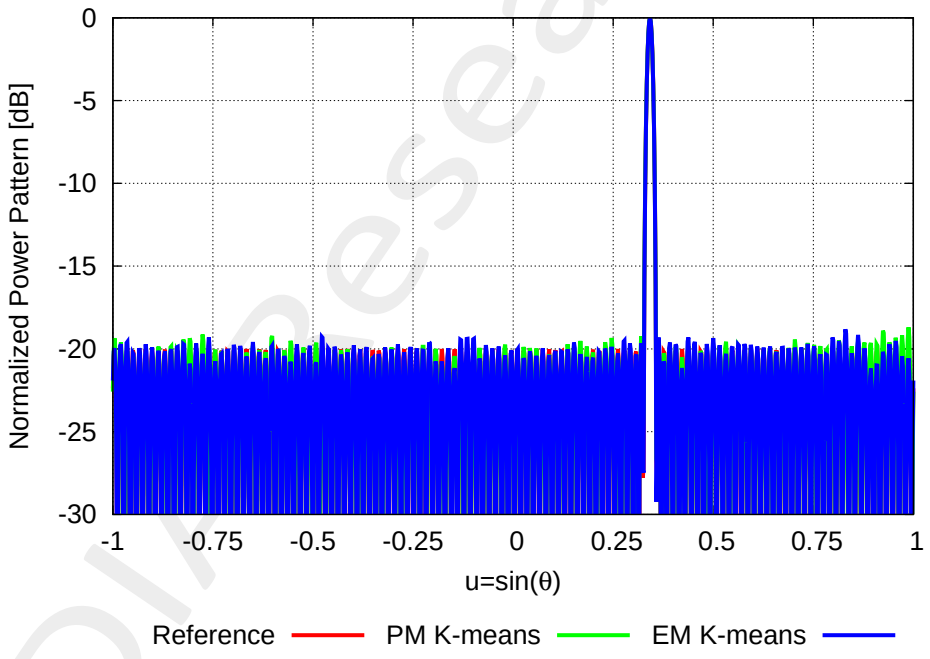

Figure 22: Power Pattern comparison PM K-means vs. EM K-means

Approach	Pattern Matching
PM K-means	5.23×10^{-2}
EM K-means	4.65×10^{-2}

Table XVIII: Pattern Matching

1.3.7 Pattern Matching Improvement vs. N

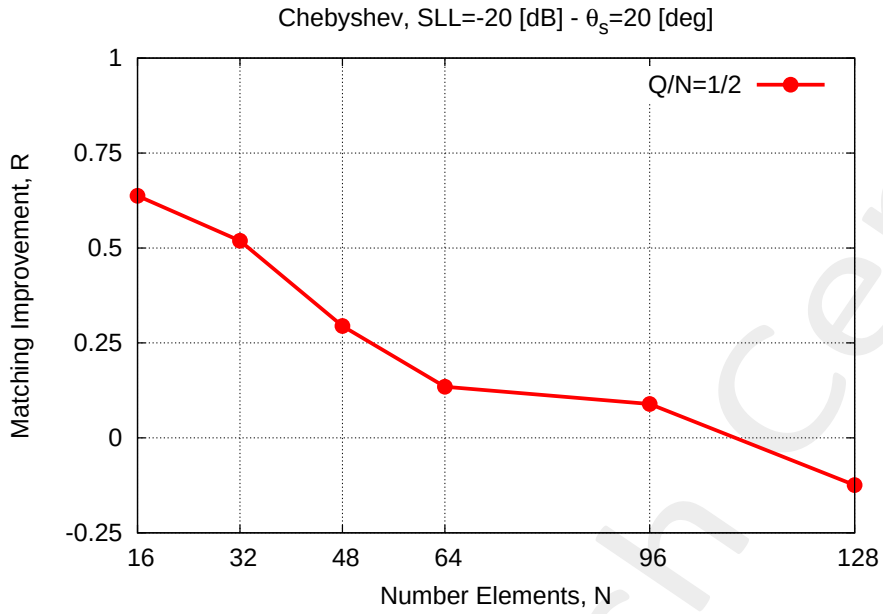

Figure 23: Analysis Matching Improvement vs. Number Elements for $Q/N = 1/2$

1.3.8 Pattern Matching vs. N

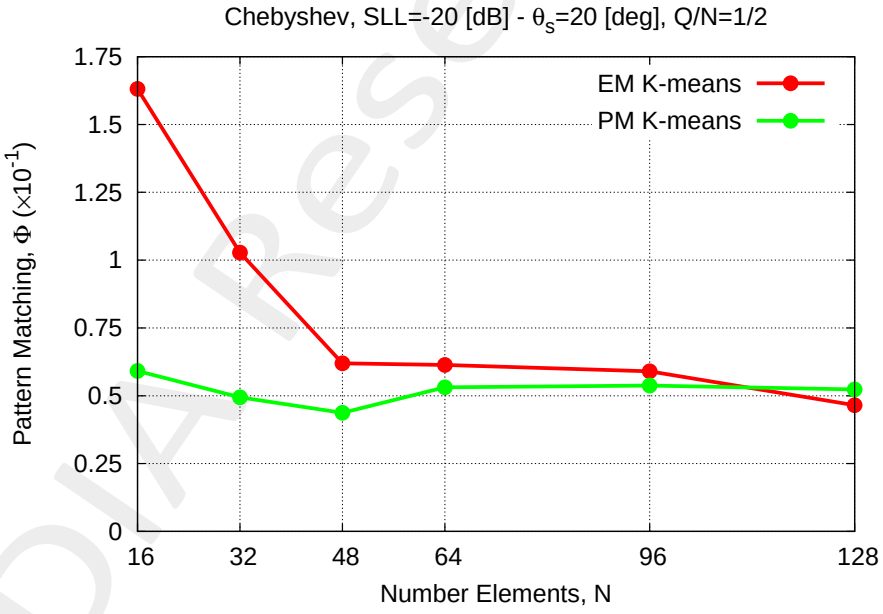

Figure 24: Pattern Matching comparison PM K-means vs. EM K-means varying the number of elements for $Q/N = 1/2$

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

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[1] N. Anselmi, L. Tosi, P. Rocca, G. Toso, and A. Massa, "A self-replicating single-shape tiling technique for the design of highly modular planar phased arrays - The case of L-shaped rep-tiles," *IEEE Trans. Antennas Propag.*, vol. 71, no. 4, pp. 3335-3348, Apr. 2023 (DOI: 10.1109/TAP.2023.3243793).

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