Clustered Arrays Design via an Advanced Power Pattern Matching Method

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1.1.1 $\mathrm{SLL}_2 = -20$ [dB]

Antenna configuration

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

Target excitations

- Asymmetric Flat Top, $SLL_1 = -20$ [dB] - $SLL_2 = -20$ [dB]

Sub-array generation

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

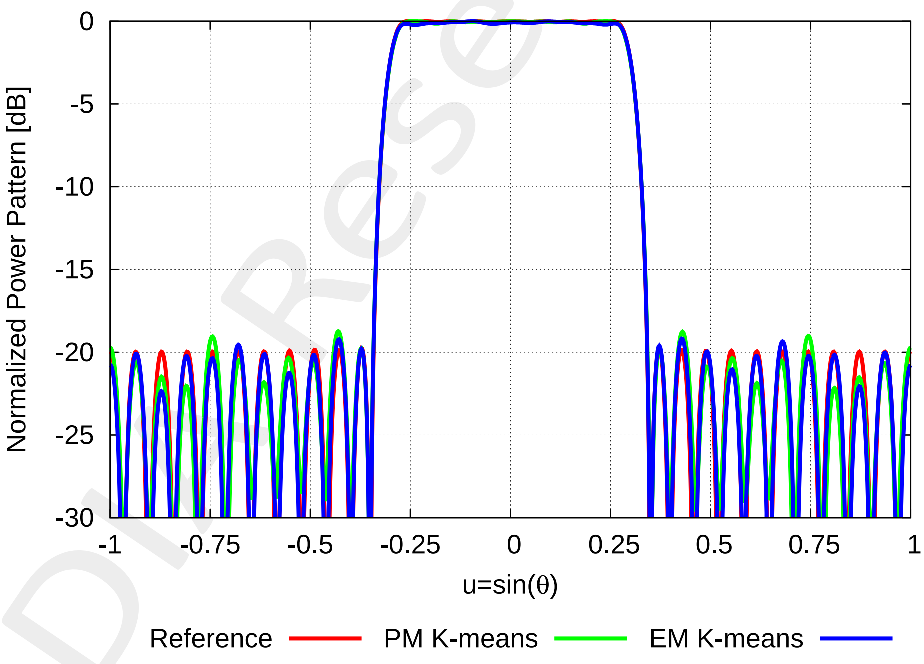

Figure 1: Power Pattern comparison PM K-means vs. EM K-means

Approach	Pattern Matching
PM K-means	1.15×10^{-2}
EM K-means	1.95×10^{-2}

Table I: Pattern Matching

1.1.2 $SLL_2 = -25$ [dB]

Antenna configuration

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

Target excitations

- Asymmetric Flat Top, $SLL_1 = -20$ [dB] - $SLL_2 = -25$ [dB]

Sub-array generation

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

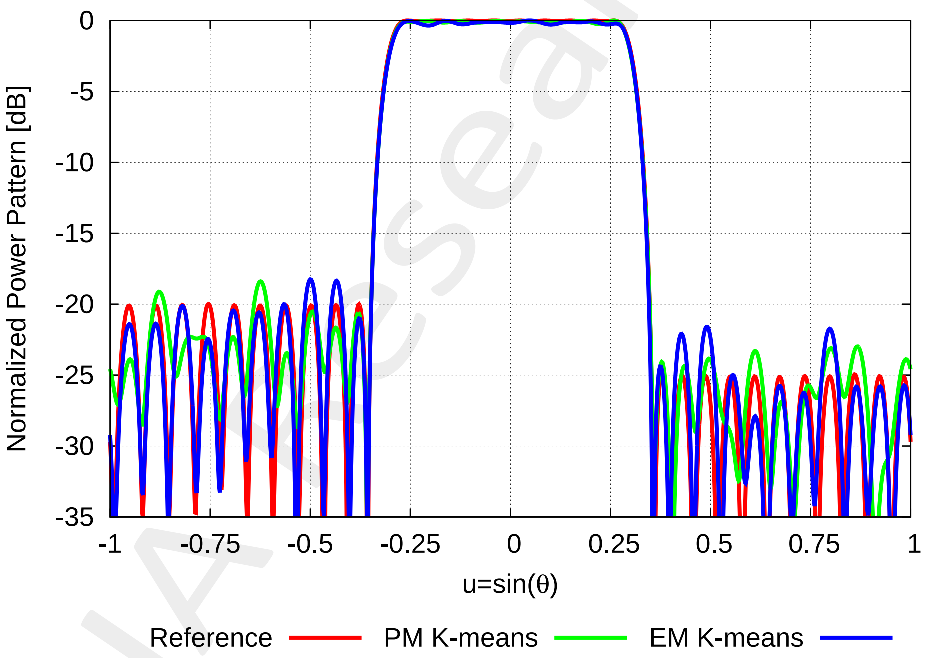

Figure 2: Power Pattern comparison PM K-means vs. EM K-means

Approach	Pattern Matching
PM K-means	2.48×10^{-2}
EM K-means	3.58×10^{-2}

Table II: Pattern Matching

1.1.3 $\mathbf{SLL_2 = -30}$ [dB]

Antenna configuration

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

Target excitations

- Asymmetric Flat Top, $SLL_1 = -20$ [dB] - $SLL_2 = -30$ [dB]

Sub-array generation

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

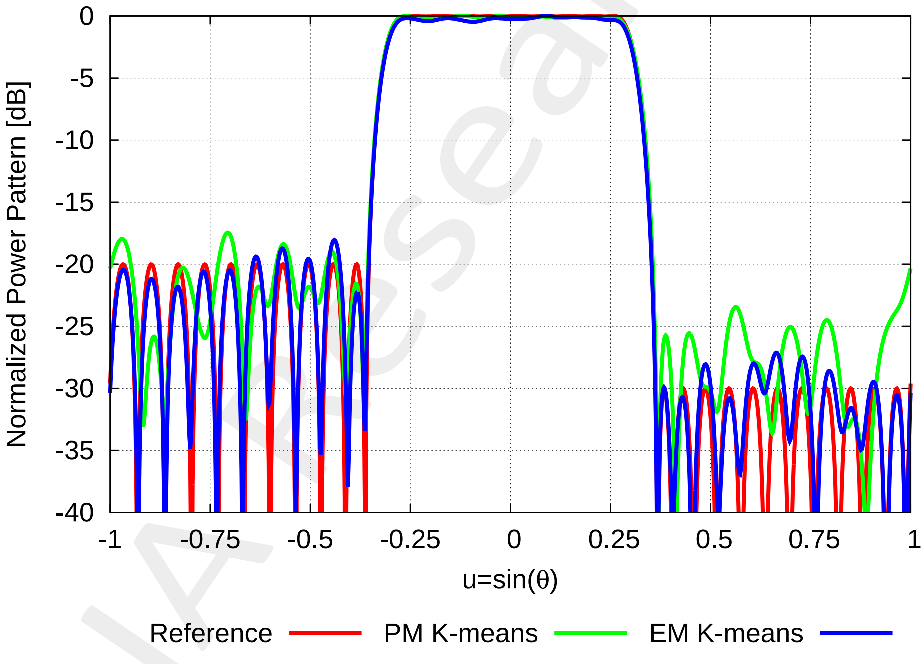

Figure 3: Power Pattern comparison PM K-means vs. EM K-means

Approach	Pattern Matching
PM K-means	2.58×10^{-2}
EM K-means	4.97×10^{-2}

Table III: Pattern Matching

1.1.4 $\mathbf{SLL_2 = -35}$ [dB]

Antenna configuration

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

Target excitations

- Asymmetric Flat Top, $SLL_1 = -20$ [dB] - $SLL_2 = -35$ [dB]

Sub-array generation

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

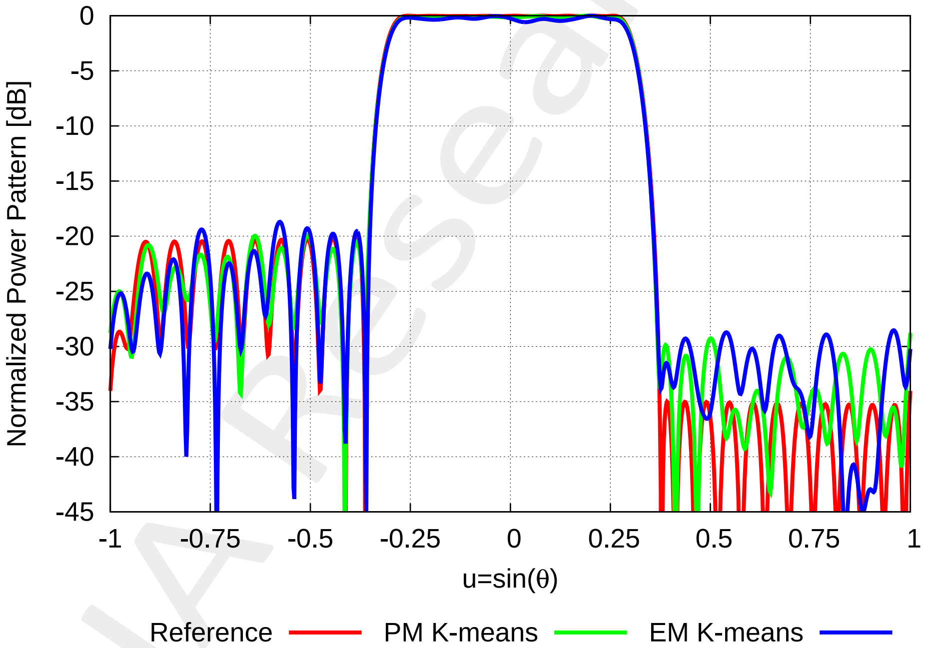

Figure 4: Power Pattern comparison PM K-means vs. EM K-means

Approach	Pattern Matching
PM K-means	2.84×10^{-2}
EM K-means	5.85×10^{-2}

Table IV: Pattern Matching

1.1.5 $\text{SLL}_2 = -40$ [dB]

Antenna configuration

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

Target excitations

- Asymmetric Flat Top, $SLL_1 = -20$ [dB] - $SLL_2 = -40$ [dB]

Sub-array generation

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

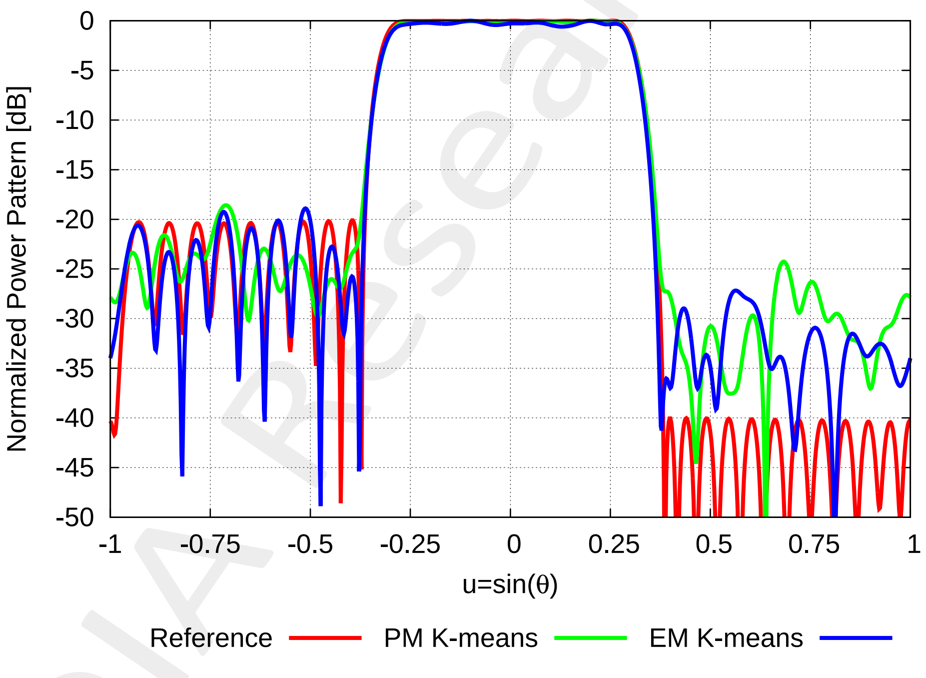

Figure 5: Power Pattern comparison PM K-means vs. EM K-means

Approach	Pattern Matching
PM K-means	3.40×10^{-2}
EM K-means	6.59×10^{-2}

Table V: Pattern Matching

1.1.6 Analysis vs. SLL

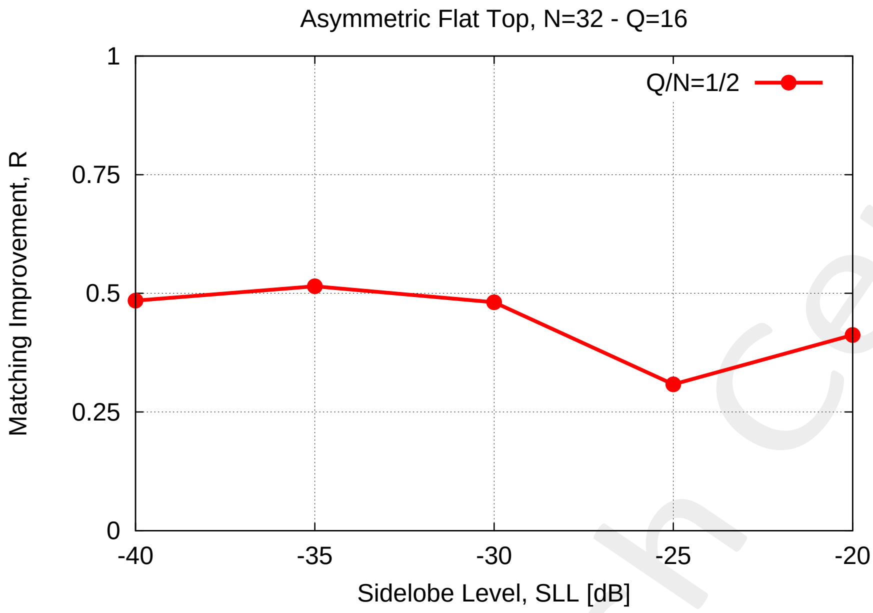

Figure 6: Analysis Matching Improvement vs. SLL

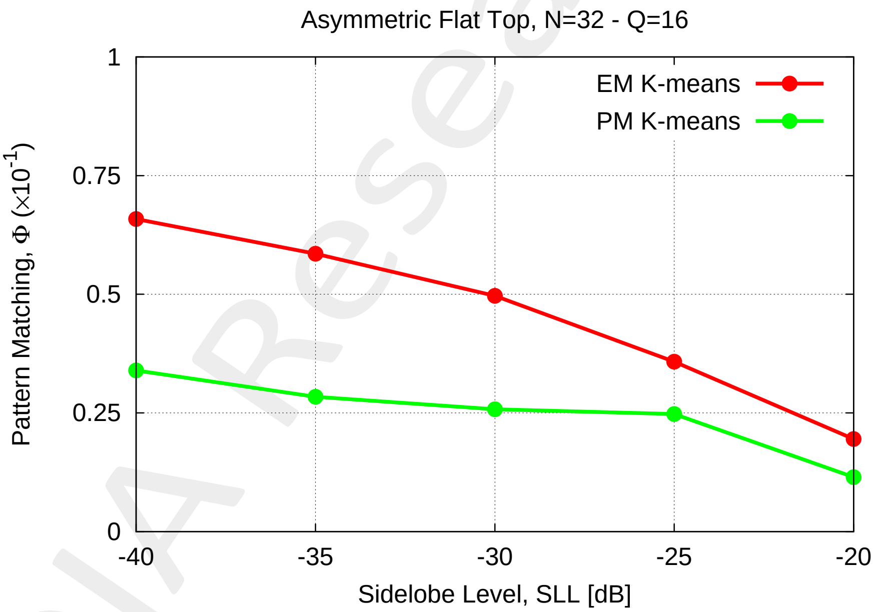

Figure 7: Pattern Matching comparison PM K-means vs. EM K-means for the different SLL for $Q/N = 1/2$

1.2 Asymmetric Flat Top, $\mathbf{SLL_1 = -20}$ [dB] - Analysis $\mathbf{SLL_2}$, $\mathbf{N = 32}$ - $\mathbf{Q = \frac{3}{4}N}$

1.2.1 $\mathbf{SLL_2 = -20}$ [dB]

Antenna configuration

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

Target excitations

- Asymmetric Flat Top, $SLL_1 = -20$ [dB] - $SLL_2 = -20$ [dB]

Sub-array generation

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

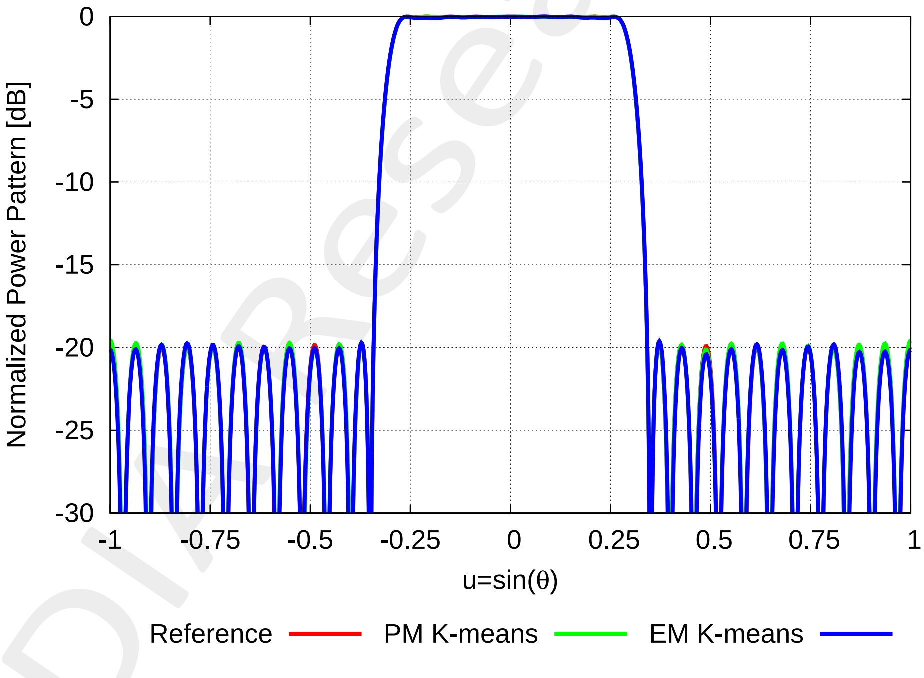

Figure 8: Power Pattern comparison PM K-means vs. EM K-means

Approach	Pattern Matching
PM K-means	2.85×10^{-3}
EM K-means	6.05×10^{-3}

Table VI: Pattern Matching

1.2.2 $\mathbf{SLL_2 = -25}$ [dB]

Antenna configuration

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

Target excitations

- Asymmetric Flat Top, $SLL_1 = -20$ [dB] - $SLL_2 = -25$ [dB]

Sub-array generation

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

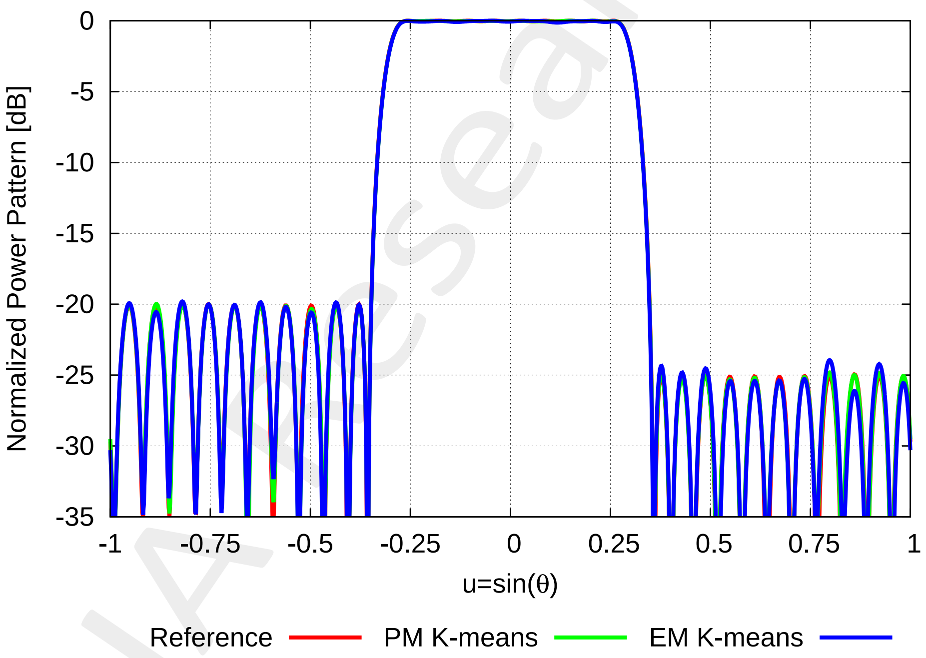

Figure 9: Power Pattern comparison PM K-means vs. EM K-means

Approach	**Pattern Matching**
PM K-means	3.50×10^{-3}
EM K-means	7.87×10^{-3}

Table VII: Pattern Matching

1.2.3 $\mathbf{SLL_2 = -30}$ [dB]

Antenna configuration

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

Target excitations

- Asymmetric Flat Top, $SLL_1 = -20$ [dB] - $SLL_2 = -30$ [dB]

Sub-array generation

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

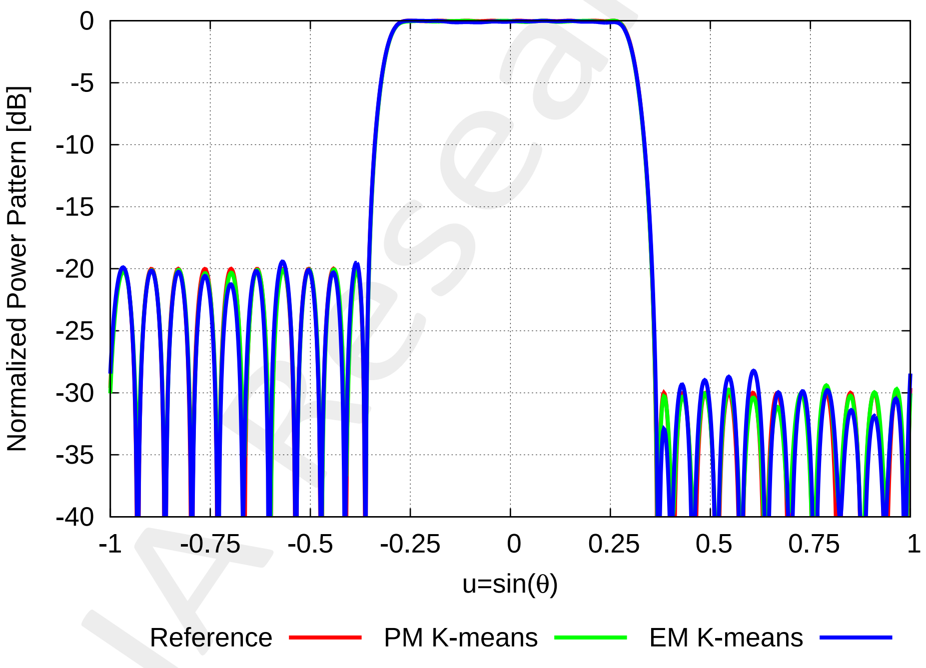

Figure 10: Power Pattern comparison PM K-means vs. EM K-means

Approach	Pattern Matching
PM K-means	8.35×10^{-3}
EM K-means	1.15×10^{-2}

Table VIII: Pattern Matching

1.2.4 $\mathrm{SLL}_2 = -35$ [dB]

Antenna configuration

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

Target excitations

- Asymmetric Flat Top, $SLL_1 = -20$ [dB] - $SLL_2 = -35$ [dB]

Sub-array generation

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

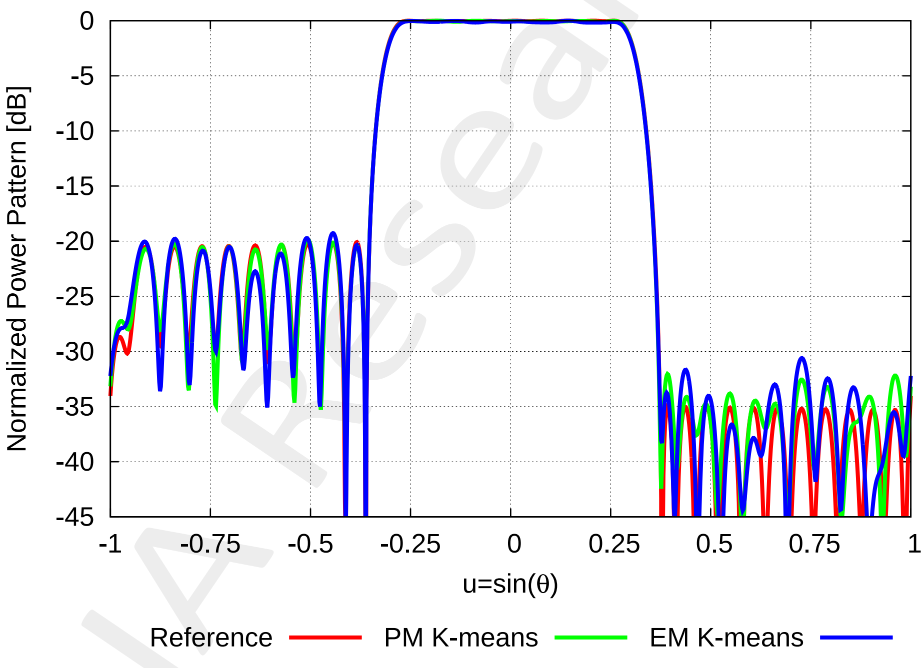

Figure 11: Power Pattern comparison PM K-means vs. EM K-means

Approach	Pattern Matching
PM K-means	8.95×10^{-2}
EM K-means	2.01×10^{-2}

Table IX: Pattern Matching

1.2.5 $SLL_2 = -40$ [dB]

Antenna configuration

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

Target excitations

- Asymmetric Flat Top, $SLL_1 = -20$ [dB] - $SLL_2 = -40$ [dB]

Sub-array generation

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

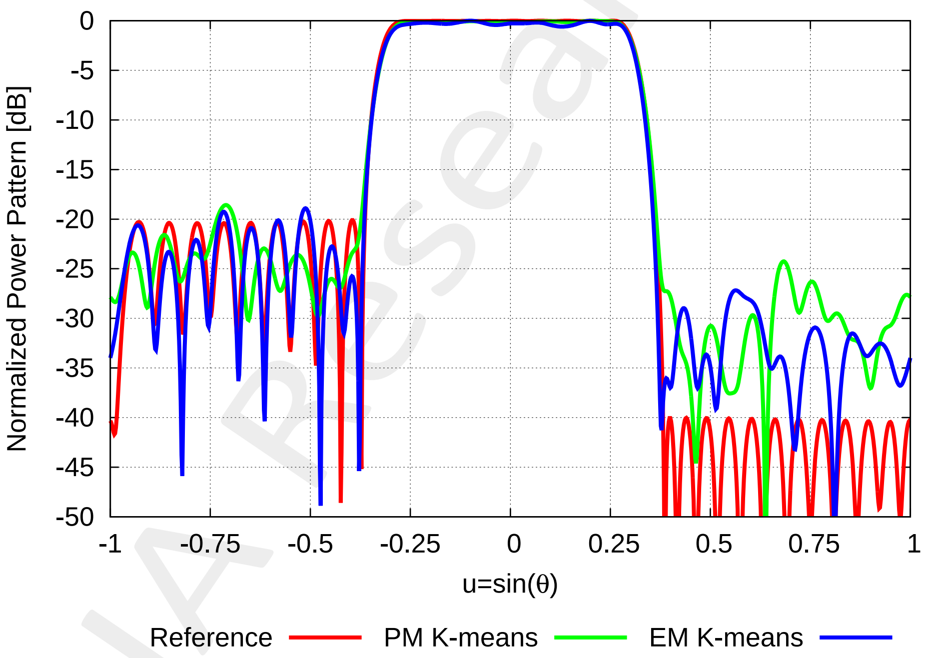

Figure 12: Power Pattern comparison PM K-means vs. EM K-means

Approach	Pattern Matching
PM K-means	1.06×10^{-2}
EM K-means	1.43×10^{-2}

Table X: Pattern Matching

1.2.6 Analysis vs. SLL

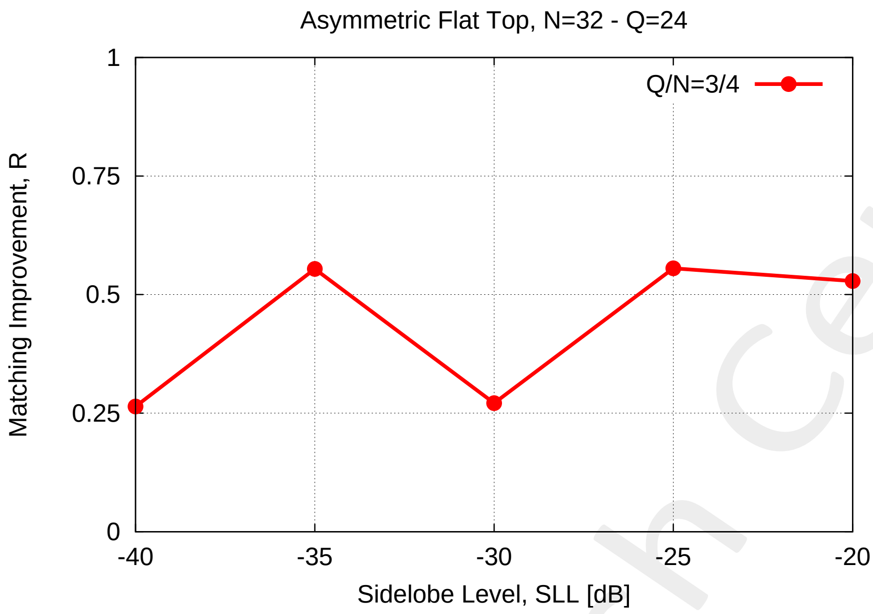

Figure 13: Analysis Matching Improvement vs. SLL

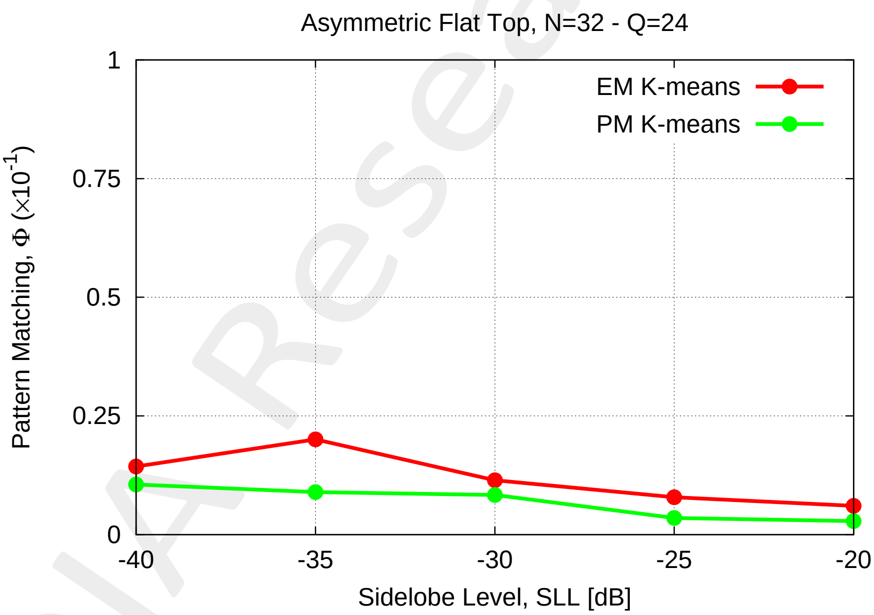

Figure 14: Pattern Matching comparison PM K-means vs. EM K-means for the different SLL for $Q/N = 3/4$

1.3 Pencil Beam with Notch, SLL $= -20$ [dB], Analysis vs. Notch SLL

1.3.1 $\mathrm{SLL_{notch}} = -25$ [dB]

Antenna configuration

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

Target excitations

- Pencil Beam Pattern, $SLL = -20$ [dB]
- Main Lobe Steering: $\theta_s = 10$ [deg]
- Notch Sidelobe Level: $SLL_{notch} = -25$ [deg]

Sub-array generation

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

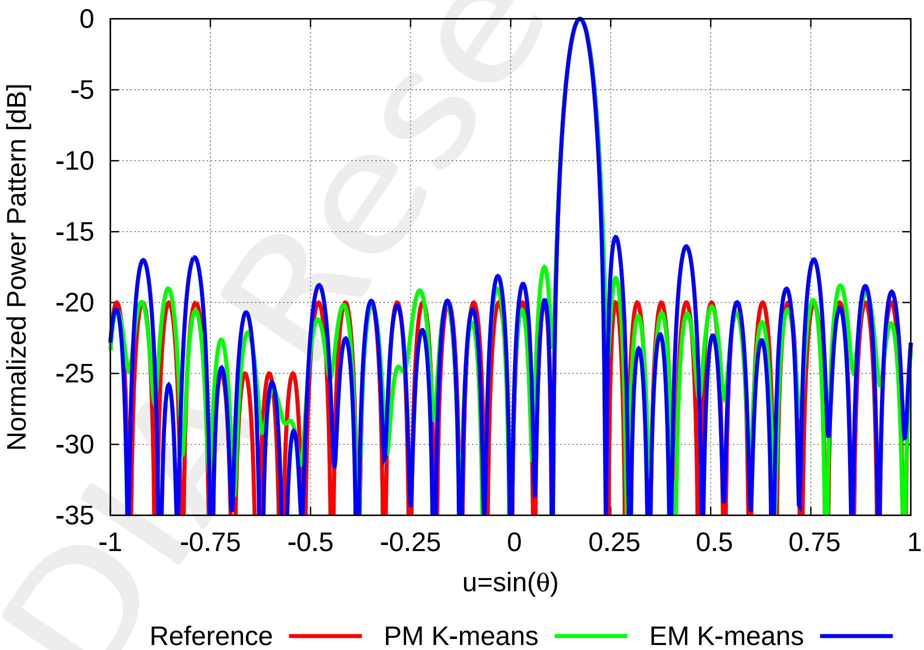

Figure 15: Power Pattern comparison PM K-means vs. EM K-means

Approach	Pattern Matching
PM K-means	5.53×10^{-2}
EM K-means	1.04×10^{-1}

Table XI: Pattern Matching

1.3.2 $\mathbf{SLL_{notch} = -30}$ [dB]

Antenna configuration

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

Target excitations

- Pencil Beam Pattern, $SLL = -20$ [dB]
- Main Lobe Steering: $\theta_s = 10$ [deg]
- Notch Sidelobe Level: $SLL_{notch} = -30$ [deg]

Sub-array generation

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

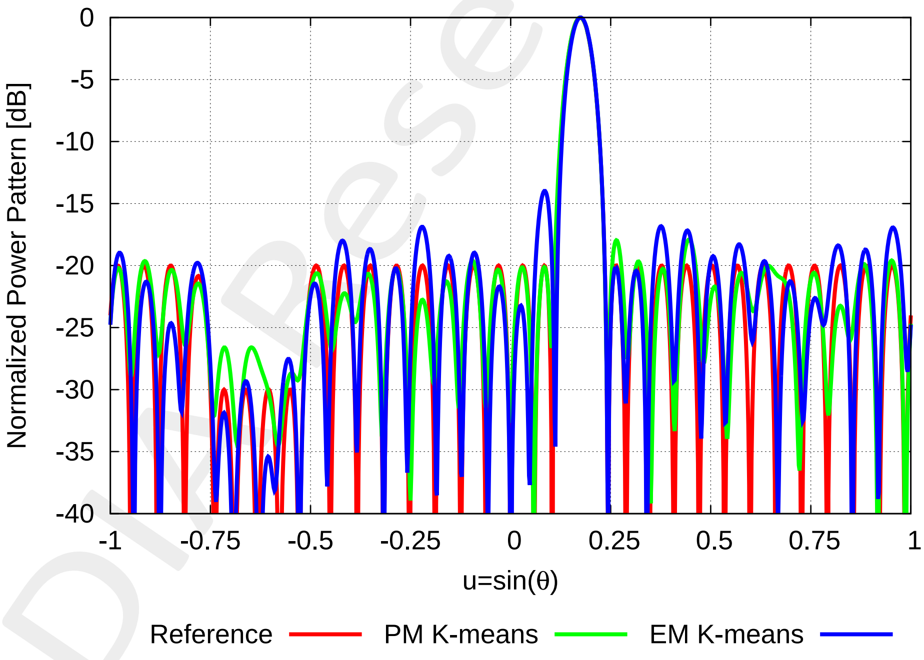

Figure 16: Power Pattern comparison PM K-means vs. EM K-means

Approach	**Pattern Matching**
PM K-means	5.17×10^{-2}
EM K-means	1.19×10^{-1}

Table XII: Pattern Matching

1.3.3 $\mathbf{SLL_{notch}} = -35$ [dB]

Antenna configuration

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

Target excitations

- Pencil Beam Pattern, $SLL = -20$ [dB]
- Main Lobe Steering: $\theta_s = 10$ [deg]
- Notch Sidelobe Level: $SLL_{notch} = -35$ [deg]

Sub-array generation

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

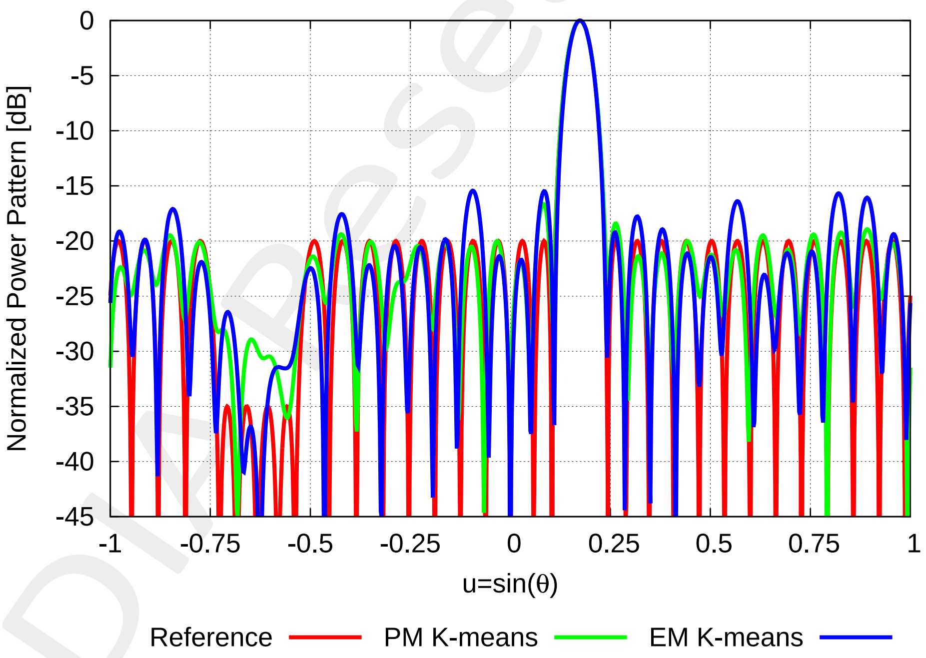

Figure 17: Power Pattern comparison PM K-means vs. EM K-means

Approach	Pattern Matching
PM K-means	5.66×10^{-2}
EM K-means	1.18×10^{-1}

Table XIII: Pattern Matching

1.3.4 $\mathbf{SLL_{notch} = -40}$ [dB]

Antenna configuration

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

Target excitations

- Pencil Beam Pattern, $SLL = -20$ [dB]
- Main Lobe Steering: $\theta_s = 10$ [deg]
- Notch Sidelobe Level: $SLL_{notch} = -40$ [deg]

Sub-array generation

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

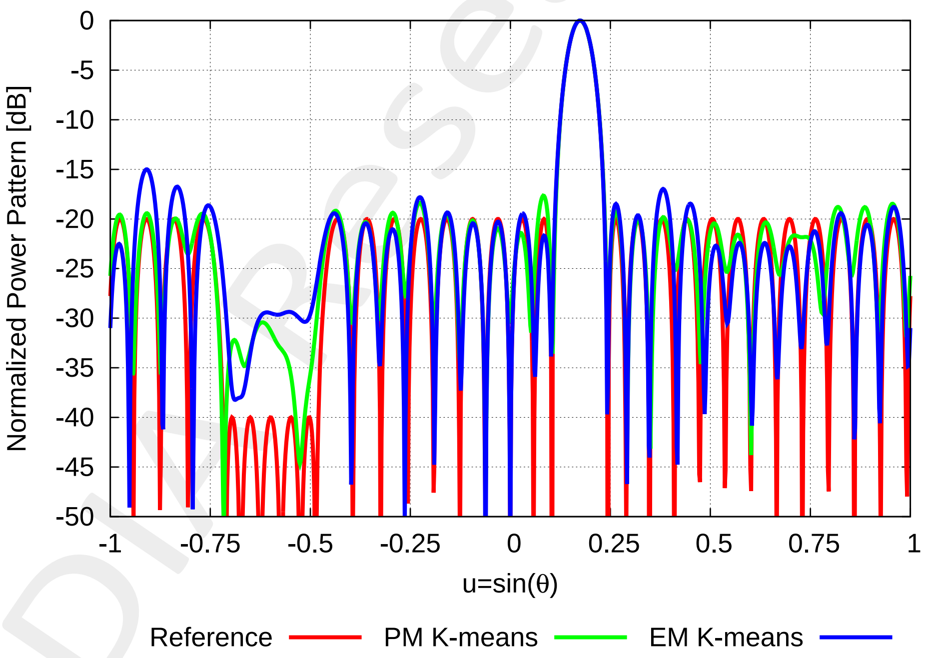

Figure 18: Power Pattern comparison PM K-means vs. EM K-means

Approach	Pattern Matching
PM K-means	4.81×10^{-2}
EM K-means	7.61×10^{-2}

Table XIV: Pattern Matching

1.3.5 $\mathbf{SLL_{notch} = -45}$ [dB]

Antenna configuration

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

Target excitations

- Pencil Beam Pattern, $SLL = -20$ [dB]
- Main Lobe Steering: $\theta_s = 10$ [deg]
- Notch Sidelobe Level: $SLL_{notch} = -45$ [deg]

Sub-array generation

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

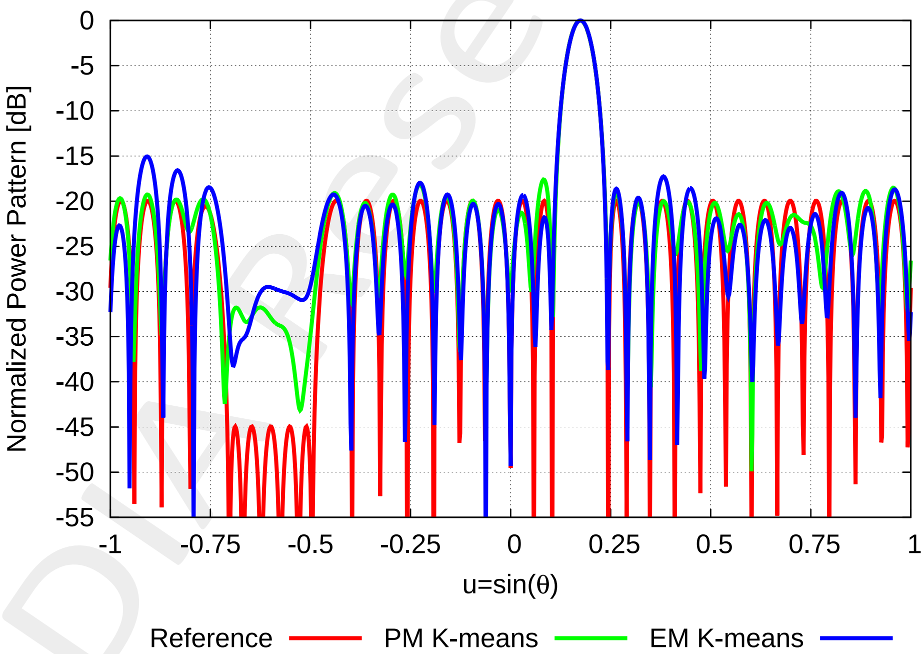

Figure 19: Power Pattern comparison PM K-means vs. EM K-means

Approach	Pattern Matching
PM K-means	4.76×10^{-2}
EM K-means	7.50×10^{-2}

Table XV: Pattern Matching

1.3.6 Analysis vs. Notch SLL

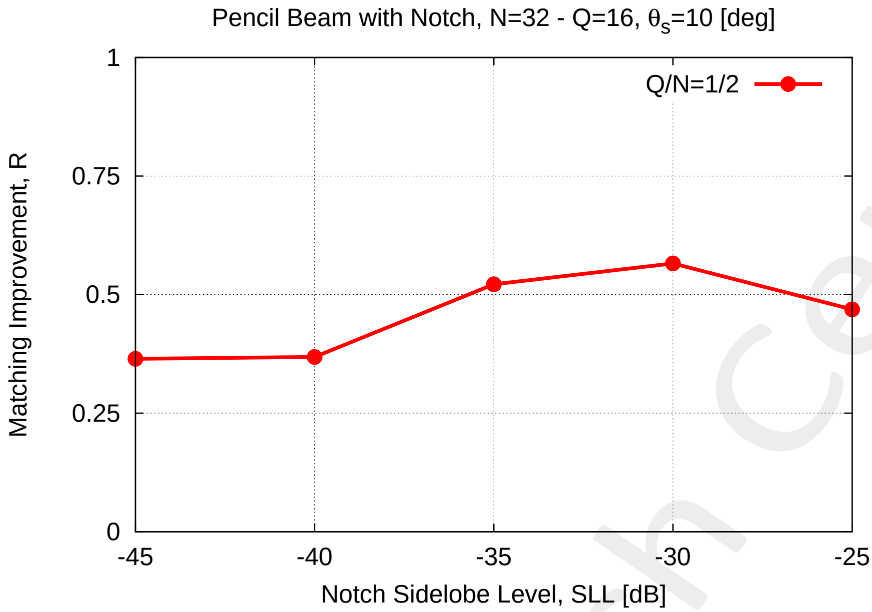

Figure 20: Analysis Matching Improvement vs. Notch Sidelobe Level for $Q/N = 1/2$

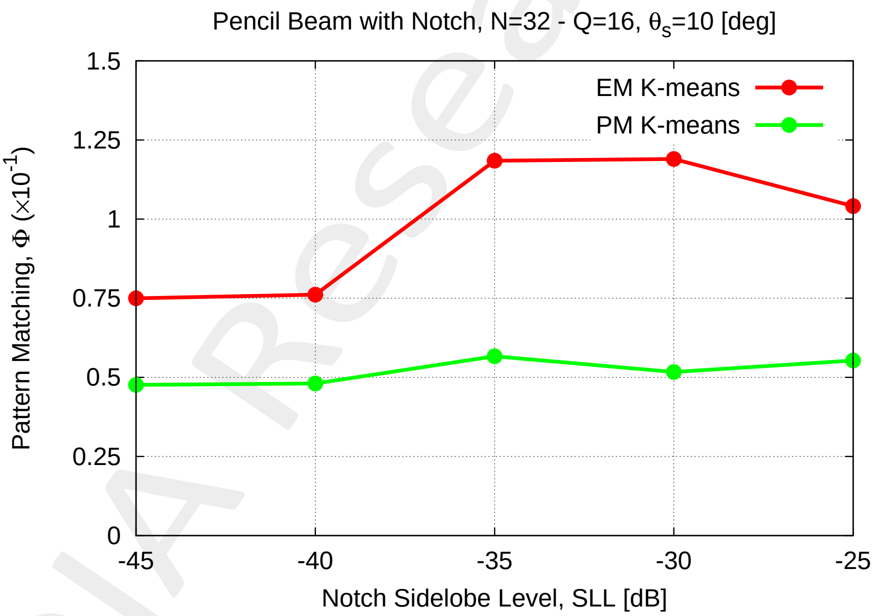

Figure 21: Pattern Matching comparison PM K-means vs. EM K-means varying the Notch SLL for $Q/N = 1/2$

Observations

Let us consider the matching error improvement, defined as:

$$R = \frac{\Phi_{EM}\left(\underline{I}\right) - \Phi_{PM}\left(\underline{I}\right)}{\Phi_{EM}\left(\underline{I}\right)} \tag{1}$$

being $\Phi_{EM}\left(\underline{I}\right)$ and $\Phi_{PM}\left(\underline{I}\right)$ the power pattern matching of the *EM* K-means and the *PM* K-means and the pattern matching of the PM K-means.

From the analysis, it emerges that a good matching improvement can be reach when:

- $R > 0.5$;
- $\Phi_{PM}\left(\underline{I}\right) \rightarrow 10^{-2}$.

Moreover, from the analysis it is possible to see a greater improvement when we are dealing with shaped patterns or pencil been patterns with the presence of a notch.

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

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