

Beamforming Subarray Active Antenna Systems

Active Antenna System

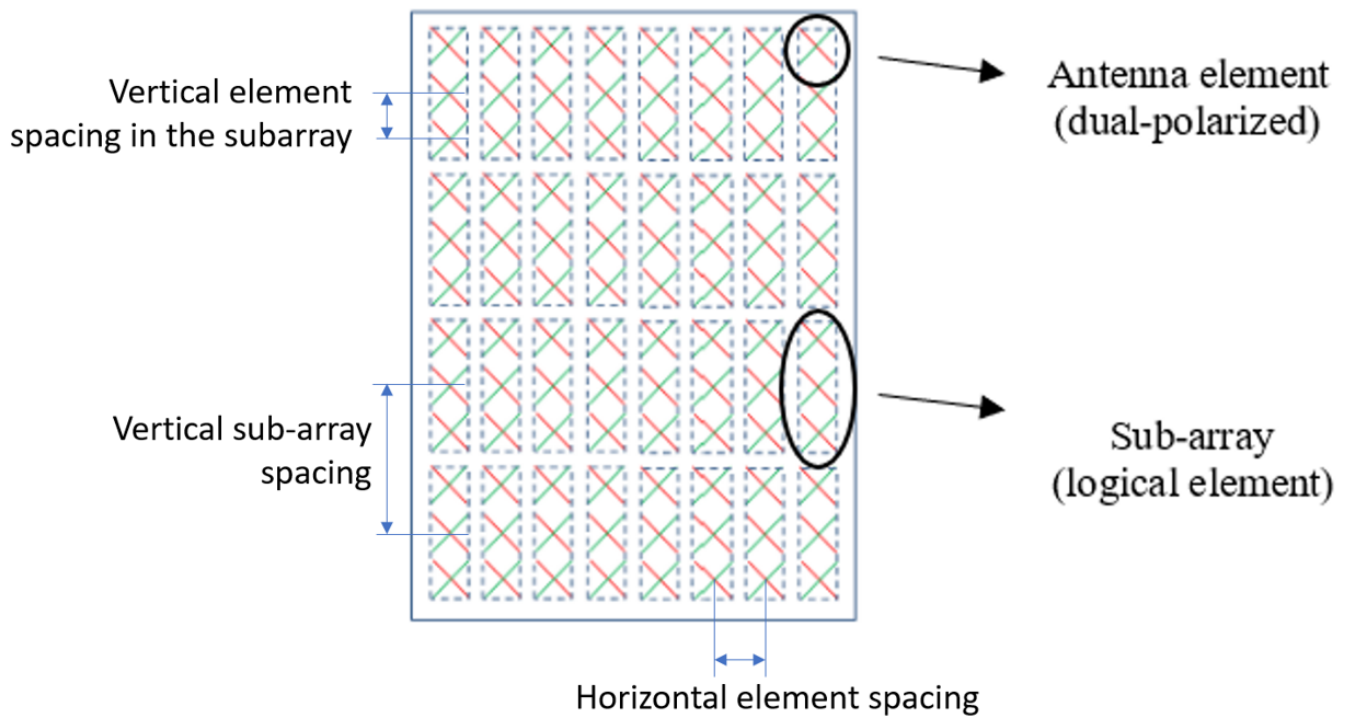
Active Antenna System are described in Recommendation ITU-R M.2101 and the extended sub-array AAS model with suggested parameters in ITU-R Working Party 5D Chairman's Report in Chapter 4 Annex 4.4 [ITU-R WP5D document 5D/716](#) "Characteristics of terrestrial component of IMT for sharing and compatibility studies in preparation for WRC-23" or 3GPP TR 38.803 Section 5.2.3.2.4. The background information for the AAS model can be found in [ITU-R WP5D document 5D/701-E](#).

Sub-array AAS plugin parameters

For the **sub-array AAS plugin** the following parameters can be set:

- **Azimuth additional offset**, see A11.3
- **Elevation additional offset**, see A11.4. The mechanical downtilt depends on the deployment scenario, see in [ITU-R WP5D document 5D/716](#) or 3GPP TR 38.803 Section 5.2.3.2.4.
- **Number of elements in horizontal direction, number of subarrays in vertical direction** and **number of elements per sub-array in vertical direction** (positive integers), see example figure below. The figure is from [ITU-R WP5D document 5D/701-E](#) showing AAS panel with 8 columns (number of elements in horizontal direction), 4 rows (number of subarrays in vertical direction) and of 3x1 sub-arrays (logical elements).

AAS panel with 4 rows and 8 columns of 3x1 sub-arrays (logical elements).



The **horizontal element spacing**, **vertical sub-array spacing** (centre-to-centre) and **vertical element spacing in the subarray** (positive real numbers) are expressed relative to the wavelength ($d_{h,v}/\lambda$). The "vertical sub-array spacing" has to be greater than or equal to the default value corresponding to the product of the "vertical element spacing in the subarray" and the "number of elements per sub-array in the vertical direction".

- **Pre-set sub-array downtilt** is an electrical fixed downtilt in the sub-array. The pre-set sub-array downtilt depends on the deployment scenario, see in [ITU-R WP5D document 5D/716](#) or 3GPP TR 38.803 Section 5.2.3.2.4.
- **Limit coverage range** selected will enable the selection for:
 - **Minimum and maximum vertical coverage range** limit for the beamforming. Typical value for macro coverage scenarios are in the range from 0 to -10 degrees and for micro coverage from 0 to -30 degrees (see in [ITU-R WP5D document 5D/716](#) or 3GPP TR 38.803 Section 5.2.3.2.4). They are expressed in SEAMCAT coordinate system with the horizontal plane fixed at zero degree elevation. This setting is independent of the set mechanical antenna tilt. The minimum value must be smaller than the maximum value.
 - **Minimum and maximum horizontal coverage range** is typically ± 60 degrees from the antenna boresight for a three-sector base station site.
 - **Minimise system link gain outside coverage range**. If selected this will effectively set the coupling loss to the UEs that are not within the vertical coverage range to infinite. If not selected, the gain to these UEs will be the resulting gain of the antenna gain envelope with the maximum gain limited to the maximum

coverage range.

- For **Element antenna setting**, see below.
- Adjacent channel simulation "use composite antenna pattern" for fully correlated beamforming within the band and adjacent band and "sub-array antenna pattern" for adjacent bands. See TR 37.840 on correlated and uncorrelated beamforming. Beamforming will be less correlated if frequency separation between wanted signal (interferer) and victim increases.

The pre-set typical values in the antenna plugin are for suburban macro case in 1 710-4 990 MHz frequency range. For other configurations see ITU-R Working Party 5D Chairman's Report in [Chapter 4 Annex 4.4](#).

Single-element AAS setting without multiple elements in sub-array

For **single-element AAS without multiple elements in a sub-array** (e.g. for micro cell with 8x8 elements) the following parameters can be used (see in [ITU-R WP5D document 5D/716](#), Table 9):

- Number of elements in horizontal direction: 8
- Number of subarrays in vertical direction: 8
- Horizontal element spacing: 0.5

Same settings as used in "BeamFormingComposite" antenna plugin for AAS with 8x8 elements. For the sub-array the following values need to be set

- Number of elements per sub-array in vertical direction: 1
- Vertical element spacing in the subarray: 0.7
- Pre-set sub-array downtilt = 0

The elevation additional offset with e.g. -10 degrees.

Beamforming element antenna parameters for sub-array AAS

For the **Beamforming Element Antenna** the following parameters can be set

- **Antenna peak gain** with typical value is 6.4 dBi includes the array ohmic loss of 2 dB and some normalisation of the antenna gain over the sphere. The element antenna gain is per polarisation
- **Azimuth 3dB beamwidth** typical value with 90 degrees for sub-array AAS
- **Vertical 3dB beamwidth** typical value with 65 degrees for sub-array AAS
- **Front to back ratio and side-lobe level limit** can be set to e.g. 30 dB to consider practical limits

Element antenna [Beam Forming Element Antenna] Edit

Macro Base Station

Azimuth additional offset [deg] i [Constant(0.0)] Distribution

Elevation additional offset [deg] i [Constant(-6.0)] Distribution

Library ↔ ↔ ↔

Name

Description 3GPP Beamforming vertical BS Subarray according to parameters specified in ECC PT1(21)160

Notes

Antenna Peak Gain [dBi] 23.1

Number of elements in horizontal line ⓘ

Number of elements in vertical line ⓘ

Horizontal element spacing (d_h/λ); ⓘ

Vertical element spacing (d_v/λ); ⓘ

Number of sub-array elements in vertical line ⓘ

Vertical sub-array element spacing ($d_{v,sub}/\lambda$); ⓘ

Pre-set sub-array down-tilt [deg] i ⓘ

Limit coverage range

Minimum vertical coverage range [deg] i ⓘ

Maximum vertical coverage range [deg] i ⓘ

Minimum horizontal coverage range [deg] i ⓘ

Maximum horizontal coverage range [deg] i ⓘ

Minimise system link gain outside coverage range

Element antenna [Beam Forming Element Antenna] Edit

Adjacent channel simulation use element antenna pattern ▼

Show gain plot

Element antenna

Library

Name

Description The beamforming element antenna pattern is derived from 3GPP TR 36.814. Plugin is intended to be used as element antenna for beamforming array plugins and not as the main antenna for the scenario

Notes

Antenna Peak Gain [dBi]	<input type="text" value="5.0"/>	5.0
Azimuth 3dB beamwidth [degree]	<input type="text" value="65.0"/>	65.0
Elevation 3dB beamwidth [degree]	<input type="text" value="65.0"/>	65.0
Front to back ratio [dB]	<input type="text" value="30.0"/>	30.0
Side-lobe level limit [dB]	<input type="text" value="30.0"/>	30.0

SEAMCAT equations for limiting sub-array coverage range

φ : Azimuth angle (0 to 360°)

θ : Elevation angle (-90 to 90°, negative = down)

A: origin point (ILT,ILR,VLT,VLR)

B: target point (ILT,ILR,VLT,VLR)

$\varphi_{hA \rightarrow B}$: Antenna azimuth from A to B in horizontal plane

$\theta_{hA \rightarrow B}$: Antenna elevation from A to B with respect to in horizontal plane

$\varphi_{A \rightarrow B}$: Transformed antenna azimuth from A to B in the plane perpendicular to boresight

$\theta_{A \rightarrow B}$: Transformed antenna elevation from A to B with respect to boresight

$\theta_{cov,min}$: Minimum vertical coverage range with respect to horizontal plane

$\theta_{cov,max}$: Maximum vertical coverage range with respect to horizontal plane

$\varphi_{cov,min}$: Minimum horizontal coverage range in horizontal plane

$\varphi_{cov,max}$: Maximum horizontal coverage range in horizontal plane

$\theta_{cov,min}$: Minimum vertical coverage range with respect to boresight

$\theta_{cov,max}$: Maximum vertical coverage range with respect to boresight

$\varphi_{cov,min}$: Minimum horizontal coverage range in the plane perpendicular to boresight

$\varphi_{cov,max}$: Maximum horizontal coverage range in the plane perpendicular to boresight

β : mechanical downtilt (positive = down)

$\theta_{i,etilt}$: elevation beam steering angle with respect to mechanical boresight (positive=down)

$\varphi_{i,escan}$: azimuth beam steering angle in the plane perpendicular to mechanical boresight

Angle transformations:

$$\theta_{cov,min} = \theta_{hcov,min} + \beta$$

$$\theta_{cov,max} = \theta_{hcov,max} + \beta$$

$$\varphi_{(cov,min)} = \cos^{-1} \left(\frac{\cos \varphi_{hcov,min} \cos \beta}{\cos(\sin^{-1}(\cos \varphi_{hcov,min} \sin \beta))} \right)$$

$$\varphi_{cov,max} = \cos^{-1} \left(\frac{\cos \varphi_{hcov,max} \cos \beta}{\cos(\sin^{-1}(\cos \varphi_{hcov,max} \sin \beta))} \right)$$

The beam steering angles are limited to the minimum and maximum coverage angles as follows:

$$\theta_{i,etilt} = \begin{cases} -\theta_{cov,min} & \theta_{A \rightarrow B} \leq \theta_{cov,min} \\ -\theta_{A \rightarrow B} & \theta_{cov,min} < \theta_{A \rightarrow B} < \theta_{cov,max} \\ -\theta_{cov,max} & \theta_{cov,max} \leq \theta_{A \rightarrow B} \end{cases}$$

Alternatively:

$$\theta_{i,etilt} = -\max(\min(\theta_{cov,max}, \theta_{A \rightarrow B}), \theta_{cov,min})$$

$$\varphi_{i,escan} = \varphi_{A \rightarrow B} \leq \varphi_{A \rightarrow B} < \varphi_{cov,max} \varphi_{cov,max} \varphi_{cov,max} \leq \varphi_{A \rightarrow B} < 180^\circ \varphi_{cov,min} 180^\circ \leq \varphi_{A \rightarrow B} < \varphi_{cov,min} \varphi_{A \rightarrow B} \varphi_{cov,min} \leq \varphi_{A \rightarrow B} < 360^\circ$$

Alternatively:

$$\varphi_{i,escan} = \min \varphi_{A \rightarrow B}, \varphi_{cov,max} 0 \leq \varphi_{A \rightarrow B} < 180^\circ \max \varphi_{A \rightarrow B}, \varphi_{cov,min} 180^\circ \leq \varphi_{A \rightarrow B} < 360^\circ$$

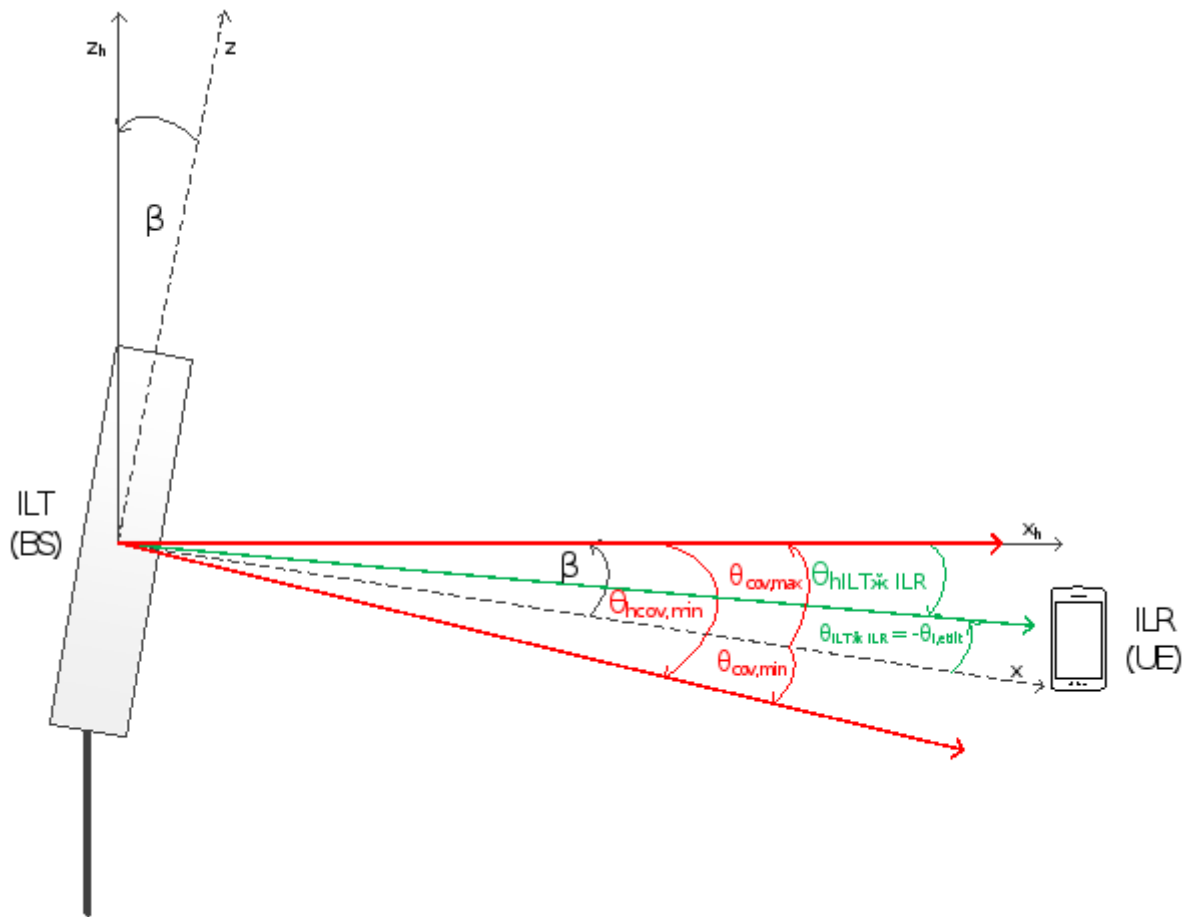


Figure 1: Elevation example of ILT→ILR link with ILR (UE) within vertical coverage range ($\theta_{cov,min} < \theta_{ILT \rightarrow ILR} < \theta_{cov,max}$)

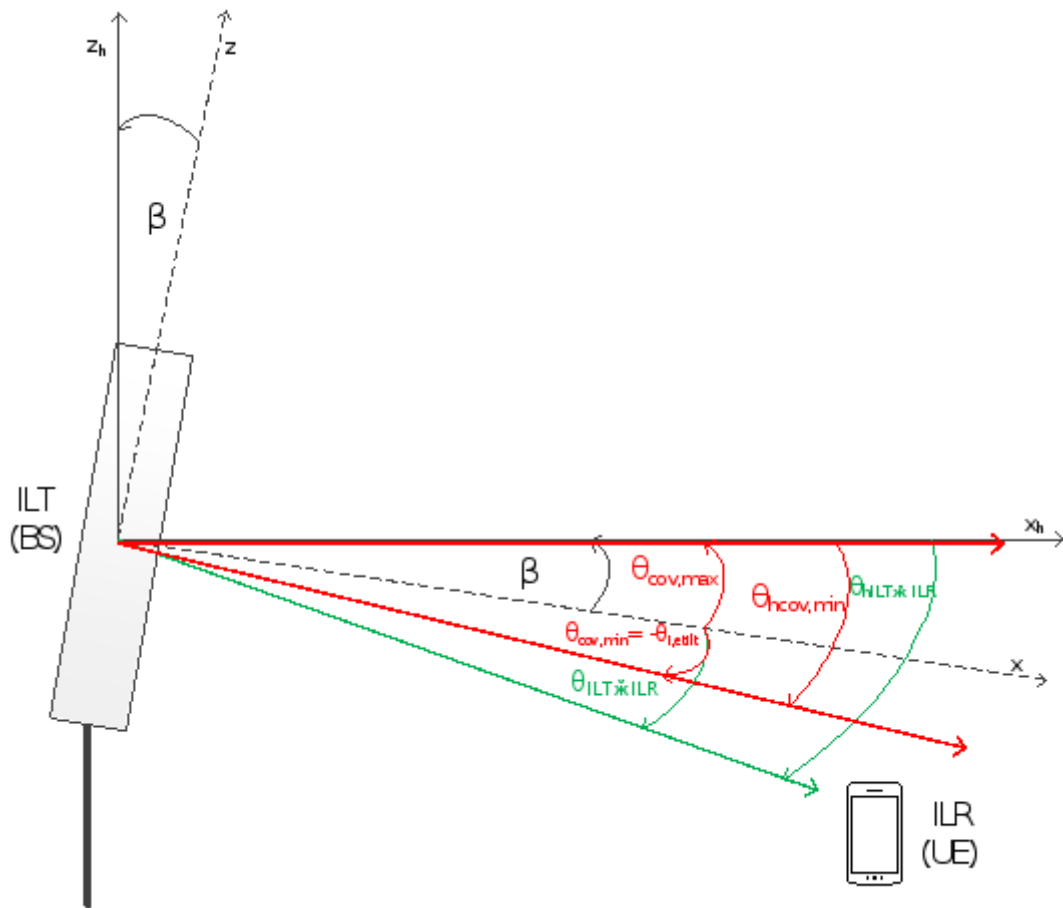


Figure 2: Elevation example of ILT→ILR link with ILR (UE) outside vertical coverage range ($\theta_{ILT \rightarrow ILR} < \theta_{cov,min}$)

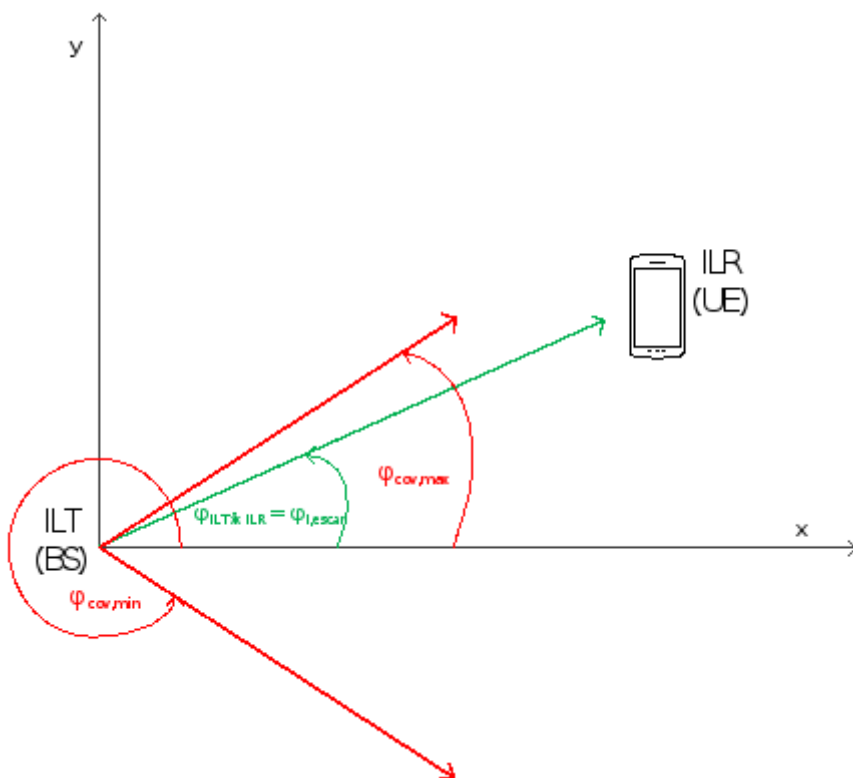


Figure 3: Azimuth example of ILT→ILR link with ILR (UE) within horizontal coverage range ($0 \leq \phi_{ILT \rightarrow ILR} < \phi_{cov,max}$)

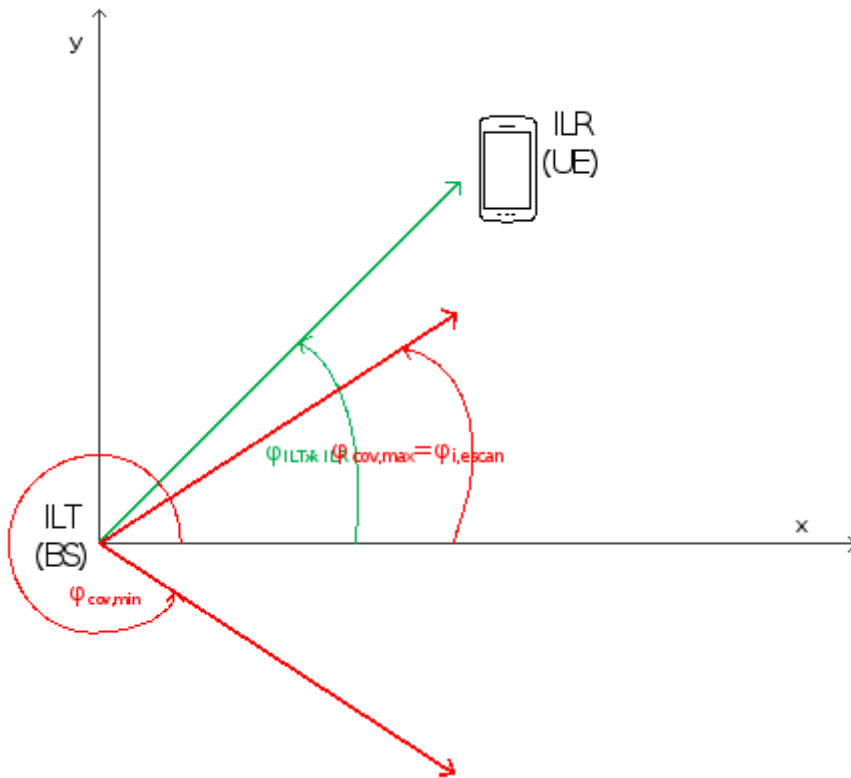


Figure 4: Azimuth example of ILT→ILR link with ILR (UE) outside horizontal coverage range ($\phi_{cov,max} \leq \phi_{ILT \rightarrow ILR} < 180$)

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