R18 MIMO Post-RAN1-114 Agreements

9.1.3.2 SRS

Dark gray: superseded by later agreements and not supported

Light gray: covered by later agreements and can be replaced fully by later agreements

Yellow: open issues in RAN1 (including UE feature design)

# R18 MIMO SRS

[110] **Agreement**

For Rel-18 reference signal enhancements, support and specify the following features (the agreed WID scopes apply):

* SRS enhancement to manage inter-TRP cross-SRS interference targeting TDD CJT via SRS capacity enhancement and/or interference randomization;
	+ RAN1 should strive to minimize the number of schemes supported in Rel-18
* SRS enhancements to enable 8 Tx UL operation and 8T8R SRS for DL operation.
	+ Target usage includes antenna switching, codebook/non-codebook based SRS

## SRS comb offset hopping and cyclic shift hopping

[109] **Agreement**

Study the following for SRS enhancement to manage inter-TRP cross-SRS interference targeting TDD CJT via SRS interference randomization and/or capacity enhancement

* Randomized frequency-domain resource mapping for SRS transmission
	+ E.g., further enhancements to frequency hopping, comb hopping
* Randomized code-domain resource mapping for SRS transmission
	+ E.g., cyclic shift hopping/randomization, sequence hopping/randomization, per-hop sequence from a long SRS sequence
* Randomized transmission of SRS
	+ - E.g., pseudo-random muting of SRS transmission for periodic and semi-persistent SRS
* Per-TRP power control and/or power control of one SRS towards to multiple TRPs
* SRS TD OCC
* Increasing the maximum number of cyclic shifts
	+ E.g., multiplying mask sequence to the legacy SRS sequence to effectively increase the maximum cyclic shifts
* Precoded SRS for DL CSI acquisition
* Enhanced signaling for flexible SRS transmission
	+ E.g., dynamic update of SRS parameters
* Partial frequency sounding extensions
	+ E.g., larger partial frequency sounding factor, starting RB location hopping enhancements, partial frequency hopping on other bandwidths corresponding to , besides the last bandwidth
* Enhanced configuration of SRS transmission to enable more efficient SRS parameter assignment
	+ E.g., configuration of $v$ (sequence index within a group) per SRS resource
	+ E.g., configuration of cyclic shift per SRS port per SRS resource.
* Resource mapping for SRS transmission based on network-provided parameters or system parameters
	+ E.g., SRS resource mapping based on network-provided parameters (e.g., configurable indexes) or system parameters (e.g., slot index)

Note: PAPR performance and maintaining DFT waveform property should be considered when deciding the enhancement for Rel-18.

[110bis-e] **Agreement**

Support at least one of the following for SRS interference randomization

* Randomized code-domain resource mapping for SRS transmission by introducing cyclic shift hopping / randomization to SRS resource
* Comb offset hopping for SRS
	+ The comb offset is determined pseudo-randomly as a function of time (e.g., slot index, symbol index) and/or NW configured ID with a certain UE-specific initialization.
	+ FFS: Other details, e.g., how the comb offset value is determined by the parameters for each SRS port of a SRS resource for a SRS transmission occasion.

[110bis-e] **Agreement**

For comb offset hopping for SRS and for randomized code-domain resource mapping for SRS transmission via cyclic shift hopping / randomization, further study the following:

* The hopping pattern (e.g., the pseudo-random sequence, time-domain granularity for hopping)
* The time-domain parameter and/or behavior (e.g., slot index, symbol index, re-initialization behavior)
* Network-configured ID for UE-specific initialization
* How the comb offset / cyclic shift value is determined by the parameters for each SRS port of a SRS resource for a SRS transmission occasion
* Potential issue on multiplexing with legacy UEs if CS hopping and/or comb offset hopping are enabled
* Applicability to periodic/semi-persistent/aperiodic SRS

Other details are not excluded

[111] Agreement

For SRS comb offset hopping and/or cyclic shift hopping, for each SRS port,

* FFS: Hopping pattern
* Support at least hopping based on slot index, OFDM symbol index
	+ FFS: Use of symbol group based on repetition factor
	+ FFS: Additional details on intra-slot hopping based on OFDM symbol index, inter-slot hopping based on slot index, per occasion of SRS resource
	+ FFS: Re-initialization periodicity
* Applicable to at least periodic/semi-persistent SRS with usage antennaSwitching
	+ FFS: Other types of SRS
* FFS: Configuring a subset of comb offsets / cyclic shifts for comb offset hopping / cyclic shift hopping, respectively
* FFS: Combined comb offset hopping and cyclic shift hopping, supporting both, or down selecting one

[111] Agreement

For SRS comb offset hopping and/or cyclic shift hopping, for each SRS port, the hopping pattern is determined based on:

* Option 1: The hopping pattern is based on the pseudo-random sequence c(i), initialized with a network-configured ID.
	+ FFS: The ID could be cell ID $n\_{ID}^{cell}$, SRS sequence identity $n\_{ID}^{SRS}$, C-RNTI, or a new ID
	+ FFS: The relation between the legacy group / sequence hopping and the new hopping

[111] Agreement

For SRS interference randomization, support one from the following options (to be decided in RAN1#112):

* Opt. 1: Cyclic shift hopping
* Opt. 2: Comb offset hopping
* Opt. 3: Both cyclic shift hopping and comb offset hopping
	+ FFS: details including whether to support separate and/or combined hopping
	+ FFS: details on UE capability and signaling

[112] Agreement

For SRS interference randomization, support:

* Opt. 3: Both cyclic shift hopping and comb offset hopping.
	+ At least the two features can be separately configured
	+ FFS: Combined cyclic shift hopping and comb offset hopping for a UE
	+ FFS: Separate or combined with SRS sequence group hopping / sequence hopping
	+ FFS: Associated UE capability

[112] Agreement

For SRS comb offset hopping and/or cyclic shift hopping, for each SRS port, the hopping pattern is determined based on the pseudo-random sequence c(i), initialized with one of the following IDs.

* Option 1: Reuse the SRS sequence identity $n\_{ID}^{SRS}$.
* Option 2: Introduce new ID(s).
	+ FFS: the value range, one new ID or two separate new IDs, default ID(s)

[112] Agreement

For SRS comb offset hopping and/or cyclic shift hopping, the time-domain hopping behavior depends on at least the slot index $n\_{s,f}^{μ}$ within a radio frame and OFDM symbol index $l'$, and select at least one of the following options:

* Option 1: Within a slot, hopping based on the repetition factor $R$ and symbol index that is the same across the R repetitions.
* Option 2: Within a slot, hopping based on only the symbol index $l'$.
* Option 3: No intra-slot hopping.
* FFS: Time domain hopping behaviour further depends on system frame number (SFN) $n\_{f}$.
	+ FFS: reinitialization periodicity of N radio frames or reinitialization based on system frame number.
* FFS: Whether to adopt the same option(s) for comb offset hopping and cyclic shift hopping (if supported separately)
* FFS: At least support reinitialization at the beginning of each radio frame.

[112bis-e] **Agreement**

For SRS comb offset hopping and/or cyclic shift hopping, for a SRS resource, the hopping pattern initialization ID determined by $c\_{init}=n\_{ID}^{hop}$, where $n\_{ID}^{hop}$ is a new ID for cyclic shift hopping and/or comb offset hopping.

* The range of the new ID is from 0 to 1023

[112bis-e] **Agreement**

For a SRS resource configured with comb offset hopping and/or cyclic shift hopping,

* If the repetition factor R = 1, within a slot, the time-domain hopping behavior depends on the OFDM symbol index $l'$ of each symbol.
* If the repetition factor R > 1,
	+ For cyclic shift hopping, within a slot, the time-domain hopping behavior depends on the OFDM symbol index $l'$ of each symbol.
	+ For comb offset hopping, within a slot, the time-domain hopping behavior depends on one of the following alternatives:
		- Alt1: The OFDM symbol index $l'$ of the first symbol across the R repetitions.
		- Alt2: The OFDM symbol index $l'$ of each symbol.
		- Alt3: The OFDM symbol index $l'$ of each symbol or the first symbol across the R repetitions based on configuration, and FFS configuration details.

[112bis-e] **Agreement**

For a SRS resource configured with comb offset hopping, if the repetition factor R > 1, within a slot, the time-domain hopping behavior depends on the OFDM symbol index l' of each symbol or the first symbol across the R repetitions based on RRC configuration, and FFS configuration details.

* UE can indicate whether it supports one or both the options. Details to be discussed in UE feature.

[112bis-e] **Agreement**

For SRS comb offset hopping / cyclic shift hopping, support reinitialization at the beginning of every N radio frame(s), where N ≥ 1.

* FFS: N is fixed or configurable.

[112bis-e] **Agreement**

Whether SRS comb offset hopping can be combined with one of group / sequence hopping on a SRS resource depends on UE feature/capability design.

* FFS: Whether SRS cyclic shift hopping can be combined with one of group / sequence hopping on a SRS resource depends on UE feature/capability design.

FFS: UE feature/capability design details.

[113] **Agreement**

For SRS comb offset hopping / cyclic shift hopping reinitialization periodicity of N radio frame(s):

* N = 128

[113] **Agreement**

Support configuring a subset of comb offsets when comb offset hopping is configured, and configuring a subset of cyclic shifts when cyclic shift hopping is configured.

* The subset configuration applies to all the port(s) in the SRS resource, and all the port(s) in the SRS resource has (have) the same hopping offset value $k\_{hopping}^{(p\_{i})}$ on an OFDM symbol.
* This is a UE-optional feature.

[113] **Agreement**

For SRS cyclic shift hopping, support finer time-delay-domain granularity, e.g., $α\_{i}=2π\frac{n\_{SRS}^{cs,i}}{n\_{SRS}^{cs,max}}+2π\frac{n\_{SRS}^{cs,offset}}{K×n\_{SRS}^{cs,max}}$, where $n\_{SRS}^{cs,offset}$ can be randomly chosen from $\left\{0,1,…K×n\_{SRS}^{cs,max}-1\right\}$ at each SRS transmission.

* Note: The finer granularity above only applies to the cyclic shift offsets when cyclic shift hopping is enabled.

If a subset for cyclic shifts is configured, this feature cannot be configured.

Above is a UE optional feature.

[113] **Agreement**

SRS comb offset hopping / cyclic shift hopping can be configured for aperiodic SRS.

[113] **Agreement**

Whether SRS cyclic shift hopping can be combined with one of group / sequence hopping on a SRS resource depends on UE feature/capability design.

[113] **Agreement**

SRS comb offset hopping and cyclic shift hopping can be configured for a SRS resource at the same time as a separate UE capability. No joint hopping scheme is supported.

[114] **Agreement**

When finer time-delay-domain granularity for SRS cyclic shift hopping is configured, K is 2

* + FFS (to be decided this week) Support of K=4

[114] **Agreement**

For the SRS hopping formula in cyclic shift hopping or comb offset hopping except for SRS configured with TDM, let and :

* For cyclic shift hopping: , where , and

* + ,

* + If *cyclicShiftHoppingSubset* is not configured, .

* + - If *cyclicShiftHoppingFinerGranularity* is not configured, and .

* + - If *cyclicShiftHoppingFinerGranularity* is configured, , and

* + If *cyclicShiftHoppingSubset* is configured, denotes the th element of the configured subset, is the number of elements in the subset, and .

* For comb offset hopping: , where , and

* + ,

* + - if or UE is provided with *combOffsetHoppingWithRepetition*=Per-symbol; otherwise, is the OFDM symbol index of the first symbol across the R repetitions within the slot.

* + If *combOffsetHoppingSubset* is not configured, , and .

* + If *combOffsetHoppingSubset* is configured, denotes the th element of the configured subset, and is the number of elements in the subset.

[114] **Agreement**

When a subset of comb offsets for comb offset hopping is configured, and when a subset of cyclic shifts for cyclic shift hopping is configured, support the following option for configuring the subset S={S(0), S(1), …, S(z-1)} with , where for comb offset hopping and for cyclic shift hopping, and:

* + Option 1b: S(0), S(1), …, S(z-1) are configured via a Z-length bitmap with S(i-1) being the i-th bit set as 1.

## 8-port SRS

[109] **Agreement**

Study the potential enhancements for SRS of 8T8R with usage *antennaSwitching*.

[109] **Agreement**

Study the potential enhancements for SRS for 8 Tx operation

* SRS resource(s) with 8 ports are configured for codebook-based PUSCH
* Up to 8 single-port SRS resources are configured for non-codebook-based PUSCH

[109] **Agreement**

For SRS enhancements to enable 8 Tx UL operation to support 4 and more layers per UE in UL targeting CPE/FWA/vehicle/Industrial devices, study aspects include, for SRS for CB/NCB/AS,

* Design parameters, including the maximum number of SRS resource sets, number of SRS resource sets, number of SRS resources, number of ports per resource, number of OFDM symbols, the allowed configurations for comb / comb shifts / cyclic shifts, number of simultaneous ports / resources / resource sets per OFDM symbol
* For the next decision point, study
	+ Whether to support 8 ports in one or multiple resources
	+ Whether to support 8 ports in one or multiple OFDM symbols
	+ The maximum number of SRS resource sets.
* Note: For SRS for NCB, number of ports per SRS resource is still 1 (same as R15)

[110] **Agreement**

For 8 Tx SRS, at least support

* 8 ports in 1 SRS resource for ‘antennaSwitching’;
	+ FFS 8 ports in one or multiple SRS resources for ‘codebook’

Above does not imply support for 8 ports in one or multiple OFDM symbols

[110] **Agreement**

For the maximum number of SRS resource sets for SRS with 8T8R with ‘*antennaSwitching’*, keep the existing value of the maximum number of SRS resource sets (as provided in Rel-17 antenna switching nTnR)

[110] **Agreement**

For an 8-port SRS resource in an SRS resource set with usage antennaSwitching (i.e., for 8T8R antenna switching), the 8-port SRS resource is transmitted in at least one OFDM symbol.

* FFS: the resource transmitted in multiple OFDM symbols where different ports are mapped to different symbols.

[110] **Agreement**

For SRS resource set(s) with usage ‘nonCodebook’ support 8 1-port SRS resources in one or multiple OFDM symbols.

* Note: The maximum number of simultaneous SRS resources is determined via UE-capability signalling.

### 8-port SRS without TDM

[110bis-e] **Agreement**

For an 8-port SRS resource in a SRS resource set ‘antennaSwitching’ (i.e., for 8T8R antenna switching), when the SRS resource is configured with m OFDM symbols (m >= 1), at least support the 8 ports mapped onto each of the m OFDM symbols using legacy schemes (repetition, frequency hopping, partial sounding, or a combination thereof).

* m takes the legacy values, i.e., 1,2,4,8,10,12,14.

[110bis-e] **Agreement**

For one single SRS resource in a SRS resource set with usage ‘codebook’ for 8Tx PUSCH, when the SRS resource is configured with n ports (n <= 8) and m OFDM symbols (m >= 1), at least support the n ports mapped onto each of the m OFDM symbols using legacy schemes (repetition, frequency hopping, partial sounding, or a combination thereof).

* n can be 8
* m takes the legacy values, i.e., 1,2,4,8,10,12,14.

[111] Agreement

For an 8-port SRS resource in a SRS resource set with usage ‘codebook’ or ‘antennaSwitching’, when the 8 ports are mapped onto one or more OFDM symbols using legacy schemes (repetition, frequency hopping, partial sounding, or a combination thereof), at least support:

* For comb 2, support 1 and 2 comb offsets
* For comb 4, support 2 and [4] comb offset
* For comb 8, support 4 comb offsets

[112] Agreement

For an 8-port SRS resource in a SRS resource set with usage ‘codebook’ or ‘antennaSwitching’, when the 8 ports are mapped onto one or more OFDM symbols using legacy non-TDMed schemes (repetition, frequency hopping, partial sounding, or a combination thereof),

* Option 2: For comb 4, do not support 4 comb offsets.

[112bis-e] **Agreement**

For an 8-port SRS resource in a SRS resource set with usage ‘codebook’ or ‘antennaSwitching’, when the 8 ports are mapped onto one or more OFDM symbols using legacy schemes (repetition, frequency hopping, partial sounding, or a combination thereof), and when the resource is assigned with $k\_{TC}$*>1* comb offsets, determine the mapping from the ports to comb offsets as follows:

* If $k\_{TC}$=2, ports {1000, 1002, 1004, 1006} are mapped on the first comb offset, and {1001, 1003, 1005, 1007} on the second comb offset
* If $k\_{TC}$=4, ports {1000, 1004} are mapped on the first comb offset, {1001, 1005} on the second comb offset, {1002, 1006} on the third comb offset, and {1003, 1007} on the fourth comb offset.

[112bis-e] **Agreement**

For an 8-port SRS resource in a SRS resource set with usage ‘codebook’ or ‘antennaSwitching’, when the 8 ports are mapped onto one or more OFDM symbols using legacy schemes (repetition, frequency hopping, partial sounding, or a combination thereof), and when the resource is configured with comb $K\_{TC}=2$ and with maximum $n\_{SRS}^{cs,max}=8$ cyclic shifts per comb offset, the number of comb offset(s) and the cyclic shift locations are determined based on the one RRC configured cyclic shift location $n\_{SRS}^{cs}$ as follows:

* If $n\_{SRS}^{cs}<n\_{SRS}^{cs,max}/2$, then 1 comb offset is used, otherwise 2 comb offsets are used.
* The 8 cyclic shift locations for the 8 ports are {$n\_{SRS}^{cs}, (n\_{SRS}^{cs}+1$) mod $n\_{SRS}^{cs,max}, …,(n\_{SRS}^{cs}+7$) mod $n\_{SRS}^{cs,max}\}$, reusing the existing equation $n\_{SRS}^{cs,i}=\left(n\_{SRS}^{cs}+\frac{n\_{SRS}^{cs,max}\left(p\_{i}-1000\right)}{N\_{ap}^{SRS}}\right) mod n\_{SRS}^{cs,max}$ in 38.211 6.4.1.4.2.

[112bis-e] **Agreement**

For an 8-port SRS resource in a SRS resource set with usage ‘codebook’ or ‘antennaSwitching’, when the 8 ports are mapped onto one or more OFDM symbols using legacy schemes (repetition, frequency hopping, partial sounding, or a combination thereof), and when the resource is assigned with comb 4 or comb 8, decide one of the following options:

* Option 1: the cyclic shift positions are completely aligned across the comb offsets on the same OFDM symbol.
	+ For comb $K\_{TC}$=4, $k=2$. For comb $K\_{TC}$=8, $k=4$. For port $p\_{i}$, $n\_{SRS}^{cs,i}=\left(n\_{SRS}^{cs}+\frac{n\_{SRS}^{cs,max}\left⌊{\left(p\_{i}-1000\right)}/{k}\right⌋}{N\_{ap}^{SRS}/k}\right) mod n\_{SRS}^{cs,max}$.
* Option 2: the cyclic shift positions are unaligned across the comb offsets on the same OFDM symbol for comb 4, and the cyclic shift positions are aligned on only 2 of the 4 comb offsets on the same OFDM symbol for comb 8.
	+ For comb $K\_{TC}$=4, $k=2$. For comb $K\_{TC}$=8, $k=4$.  Example: For port $p\_{i}$, $n\_{SRS}^{cs,i}=\left(n\_{SRS}^{cs}+(\left(p\_{i}-1000\right)mod k)+\frac{n\_{SRS}^{cs,max}\left⌊{\left(p\_{i}-1000\right)}/{k}\right⌋}{N\_{ap}^{SRS}/k}\right) mod n\_{SRS}^{cs,max}$. FFS equation details.
* FFS: potential impact on PAPR, if any.

[113] **Agreement**

For an 8-port SRS resource in a SRS resource set with usage ‘codebook’ or ‘antennaSwitching’, when the 8 ports are mapped onto one or more OFDM symbols using legacy schemes (repetition, frequency hopping, partial sounding, or a combination thereof), and when the resource is assigned with comb 4 on 2 comb offsets ($K\_{TC}$=4, $k\_{TC}=2$) or comb 8 on 4 comb offsets ($K\_{TC}$=8, $k\_{TC}=4$), the cyclic shift positions are completely aligned across the comb offsets on the same OFDM symbol.

* For port $p\_{i}$, $n\_{SRS}^{cs,i}=\left(n\_{SRS}^{cs}+\frac{n\_{SRS}^{cs,max}\left⌊{\left(p\_{i}-1000\right)}/{k\_{TC}}\right⌋}{N\_{ap}^{SRS}/k\_{TC}}\right) mod n\_{SRS}^{cs,max}$.

### 8-port SRS with TDM

[111] Agreement

For single SRS resource in a SRS resource set with usage ‘codebook’ for 8Tx PUSCH or ‘antennaSwitching’ (i.e., for 8T8R antenna switching), when the SRS resource is configured with 8 ports and m OFDM symbols (m > 1), support the case of 8 ports mapped onto the m OFDM symbols

* Option 1: Different SRS ports are mapped onto different OFDM symbols (i.e., TDM)
* FFS: m can be legacy values, i.e., 2,4,[8,10,12,14].

[112] Agreement

For an 8-port SRS resource in a SRS resource set with usage ‘codebook’ or ‘antennaSwitching’ and resource mapping based on TDM onto m ≥ 2 OFDM symbols in a slot and with TDM factor s, support the 8 ports equally partitioned into s subsets with each subset having 8/s different ports.

* At least s = 2.
	+ FFS: s = 4, s = 8.
* m = 2,4,8, 10,12,14, and m is a multiple of s.
* Each of the m OFDM symbols has only one subset. Reuse the existing resource mapping designed for 8/s ports on each OFDM symbol.
	+ Including frequency-domain resource allocation and mapping to cyclic shifts. FFS port indexing within the subset of 8/s ports.
	+ FFS: down selection from existing resource mapping designs
* FFS: which subset of 8/s ports are mapped onto each OFDM symbol.
* FFS: the TDM factor s is configured as an explicit RRC parameter or determined implicitly from other parameters.

[112] Agreement

For an 8-port SRS resource in a SRS resource set with usage ‘codebook’ or ‘antennaSwitching’ and resource mapping based on TDM onto m ≥ 2 OFDM symbols in a slot and with TDM factor s ≥ 2, the m OFDM symbols are adjacent, and select one of the following options regarding the TDM pattern:

* Option 2-1: the s subsets of ports are mapped cyclically as {1, 2, …, s,1, 2, …, s} on the m OFDM symbols.
* Option 2-2: the s subsets of ports are mapped sequentially as {1, …, 1, 2, …, 2, s, …, s} on the m OFDM symbols.

[112bis-e] **Agreement**

For an 8-port SRS resource in a SRS resource set with usage ‘codebook’ or ‘antennaSwitching’ and resource mapping based on TDM onto m ≥ 2 OFDM symbols in a slot and with TDM factor s, the s subsets of ports are mapped cyclically as {{1, 2, …, s}, …, {1, 2, …, s}} on the m OFDM symbols.

[112bis-e] **Agreement**

For an 8-port SRS resource in a SRS resource set with usage ‘codebook’ or ‘antennaSwitching’ and resource mapping based on TDM with TDM factor s, when the s subsets of ports are mapped onto m ≥ 2 OFDM symbols in a slot according to the pattern {{1, 2, …, s}, …, {1, 2, …, s}} (totally m/s groups of {1, 2, …, s}), the SRS transmissions within each of the m/s groups of {1, 2, …, s} use the same set of subcarriers. If consecutive groups of {1, 2, …, s} are configured as repetition, then the SRS transmissions of the consecutive groups use the same set of subcarriers.

* Note: applicable to the SRS resource with or without FH/RPFS.
* FFS the scenario where comb offset hopping is configured for the SRS resource.

[112bis-e] **Agreement**

For an 8-port SRS resource in a SRS resource set with usage ‘codebook’ or ‘antennaSwitching’ and with TDM factor s > 1, when the s subsets of ports are mapped onto m ≥ 2 OFDM symbols in a slot according to the pattern {{1, 2, …, s}, …, {1, 2, …, s}} (totally m/s groups of {1, 2, …, s}), and when the SRS transmission on a subset of the s OFDM symbols within a group of {1, 2, …, s} is dropped, study at least the following solutions:

* Whether or not a UE drops the SRS transmission on the rest of OFDM symbols within the group of {1, 2, …, s}, based on, for example, the usage, coherency, and/or repetition configuration.
* Whether or not a UE changes the transmission order of the subsets of ports.

[113] **Agreement**

For an 8-port SRS resource in a SRS resource set with usage ‘codebook’ or ‘antennaSwitching’ and with TDM factor s > 1, the UE splits a linear value $\hat{P}\_{SRS}$ of SRS transmission power equally across the SRS ports configured on each OFDM symbol, if the UE is capable of transmitting at $P\_{CMAX}$ per OFDM symbol with 8/s ports, where $P\_{CMAX}$ is specified in the current specifications.

* Note: This may be captured in the specification in a few different but equivalent ways, and it is up to the editor to decide.

[114] **Agreement**

For an 8-port SRS resource in a SRS resource set with usage ‘codebook’ or ‘antennaSwitching’ and resource mapping based on TDM with TDM factor s = 2, when the s subsets of ports are mapped onto m ≥ 2 OFDM symbols in a slot the port, down select from the following options:

* + Option 1: The first subset includes ports {1000, 1001, 1004, 1005}, and the second subset includes {1002, 1003, 1006, 1007}.

[114] **Conclusion**

**For an 8-port SRS resource in a SRS resource set with usage ‘codebook’ or ‘antennaSwitching’ and resource mapping based on TDM with TDM factor s and repetition factor R, when the s subsets of ports are mapped onto m ≥ 2 OFDM symbols in a slot according to the pattern {{1, 2, …, s}, …, {1, 2, …, s}} (totally m/s groups of {1, 2, …, s}), and when** cyclic shift **hopping is configured for the SRS resource,**

* Option A4: Do not support cyclic shift hopping for 8-port SRS with TDM.

[114] **Conclusion**

**For an 8-port SRS resource in a SRS resource set with usage ‘codebook’ or ‘antennaSwitching’ and resource mapping based on TDM with TDM factor s and repetition factor R, when the s subsets of ports are mapped onto m ≥ 2 OFDM symbols in a slot according to the pattern {{1, 2, …, s}, …, {1, 2, …, s}} (totally m/s groups of {1, 2, …, s}), and when** comb offset **hopping is configured for the SRS resource,**

* + Option B5: Do not support comb offset hopping for 8-port SRS with TDM.

[114] **Agreement**

**For an 8-port SRS resource in a SRS resource set with usage ‘codebook’ or ‘antennaSwitching’ and resource mapping based on TDM with TDM factor s, when** sequence/group **hopping is configured for the SRS resource, t**he time-domain behavior of hopping depends only on the OFDM symbol index l’ of each symbol.

## Agreements that are superseded by later conclusions and the conclusions (NO spec impact)

[110bis-e] **Agreement**

For SRS TD OCC for SRS enhancements for TDD CJT, study:

* Comparison against SRS on 1 OFDM symbol
* Comparison against SRS repeated on multiple OFDM symbols
* Study the following aspects: evaluation performance, SRS overhead, per-symbol per-port transmission power, impact of channel delay, dropping rules of collision with other uplink resource, etc.

[110bis-e] **Agreement**

For per-TRP power control and/or power control of one or multiple SRS transmission occasions towards to multiple TRPs, study the options for an SRS resource set:

* Option 1:
	+ Same power control process for all SRS resources of an SRS resource set where the power control process is based on one Po value and one closed loop state and jointly on more than one DL pathloss RS and/or more than one alpha
	+ Each transmission occasion of the SRS resource is towards multiple TRPs
* Option 2:
	+ More than 1 power control processes each for a subset of SRS resource of an SRS resource set where each of the power control process is based on a different UL power control parameter set (Po, alpha, and closed loop state) associated with a different DL pathloss RS
	+ Different transmission occasions of the SRS resource can be towards different TRPs

[110bis-e] **Conclusion**

The discussion of resource mapping for SRS transmission based on network-provided parameters or system parameters is merged into the discussions of other SRS enhancements for TDD CJT.

[110bis-e] **Conclusion**

* No further discussion of increasing the maximum number of cyclic shifts for CJT SRS.
* No further discussion of partial frequency sounding extensions for CJT SRS.

[111] Conclusion

No consensus on enhanced signaling for flexible SRS transmission in Rel-18

[112] **Conclusion**

No consensus to support the following for TDD CJT SRS enhancement in Rel-18:

* Further enhancements to frequency hopping
* Sequence hopping/randomization, per-hop sequence from a long SRS sequence
* Enhanced configuration of SRS transmission to enable more efficient SRS parameter assignment
* Precoded SRS for DL CSI acquisition
* Pseudo-random muting of SRS transmission for periodic and semi-persistent SRS
* Configuration of (sequence index within a group) per SRS resource

* Multiplying mask sequence to the legacy SRS sequence

[112] **Conclusion**

No consensus to support SRS TD OCC for TDD CJT SRS enhancement in Rel-18.

[112bis-e] **Conclusion**

No consensus on enhanced per-TRP power control and/or power control of one SRS towards to multiple TRPs in Rel-18.

[113] **Conclusion**

There is no consensus on the support of the following feature in RAN1:

*For an 8-port SRS resource in a SRS resource set with usage ‘codebook’ or ‘antennaSwitching’ and resource mapping based on TDM, support TDM factor s = 4.*

[114] **Conclusion**

When finer time-delay-domain granularity for SRS cyclic shift hopping is configured, K = 4 is not supported.

## EVM (NO spec impact)

[109] **Agreement**

For SRS EVM, adopt combined relevant parts from Rel-17 SRS EVM and Rel-18 FDD CJT EVM as starting point

* Details are provided in Appendix 3 of R1-2205330 for system-level simulations
* Details are provided in Appendix 4 of R1-2205330 for link-level simulations.

[109] **Agreement**

For 8 Tx SRS, a starting point of UE antenna configurations can be:

* (M, N, P; Mg,Ng; Mp, Np) = (2,2,2; 1,1; 2,2), (dH, dV) = (0.5, 0.5)λ, or
* (M, N, P; Mg,Ng; Mp, Np) = (1,4,2; 1,1; 1,4), (dH, dV) = (0.5, 0.5)λ.
* FFS other 8 Tx UE antenna configuration and alignment with outcomes from other agenda items.

[109] **Agreement**

For SRS EVM, consider additional EVM as follows

* Realistic channel estimation based on sequence generation for SRS modelling, at least for TDD CJT SRS LLS and 8 Tx SRS LLS as baseline
* Evaluation metrics for 8 Tx SRS LLS can be MSE , BLER or throughput
* TDL-C for TDD CJT SRS LLS can be included as optional.

[109] **Agreement**

Consider the scenario where there exists SRSs sent by a UE and utilized by multiple TRPs for channel estimation, and the pathlosses between the UE and the TRPs differ by at least x dB in Rel-18 SRS study

* x can be {3,6,10}, and other values can be used.

##### Appendix 3: R18 TDD CJT EVM

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| Rel-18 SLS Assumptions for TDD CJT SRS |
| Parameter | Value |
| Duplex, Waveform  | TDD, OFDM  |
| Multiple access  | OFDMA  |
| Scenario |

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| Companies can simulate from the following 2 layouts. 1) Outdoor (typical 57-sector, or 21-sector, SLS): OptionA: 1 TRP per sector, 3 sectors per site. N\_TRP (#TRPs): 2, 3, 4 (N\_TRP is semi-statically chosen based on, e.g. RSRP). The N\_TRP TRPs can be selected either only from the same site (intra-site - limited to 3 TRPs), or also from other sites (inter-site) - company should describe what is assumed OptionB: N\_TRP co-located (at BS) panels per sector - companies describe how the panels are (azimuthally) oriented- Dense Urban (macro only) 200m ISD or Urban Macro 500m ISD2) Indoor Hotspot: model in TS 38.802- N\_TRP (#TRPs): 2, 3, 4 (N\_TRP is semi-statically chosen based on, e.g. RSRP)**Outdoor OptA** |

 |
| Frequency Range | FR1 only, 3.5GHz |
| Inter-BS (site) distance | Outdoor: 200m or 500mIndoor Hotspot: per TS 38.802 |
| Channel generation model | According to the TR 38.901 Difference in propagation delays between UE and N\_TRP TRPs is taken into account in the composite Channel Impulse Response (CIR) for CJT.Otherwise, company should state if per-TRP delay offset (to "zero") is performed in the simulation.Per WID, ideal synchronization and backhaul should be assumed. Optionally, companies may present results with phase/frequency error and should state the assumed frequency error models and values. |
| Antenna setup and port layouts at gNB | - 8 ports: (4,4,2,1,1,1,4), (dH,dV) = (0.5, 0.8)λ- 16 ports: (8,4,2,1,1,2,4), (dH,dV) = (0.5, 0.8)λ- 32 ports: (8,8,2,1,1,2,8), (dH,dV) = (0.5, 0.8)λ - 64 ports: (8,8,2,1,1,4,8), (dH,dV) = (0.5, 0.8)λ Total #ports = N\_TRP x {8,16,32,64} |
| Antenna setup and port layouts at UE | 4RX: (1,2,2,1,1,1,2), (dH,dV) = (0.5, 0.5)λ for rank > 2 |
| BS Tx power  | Dense Urban or Urban Macro:- Per TRP: 44 dBm for 20MHz, 47dBm for 40MHz, 51dBm for 100MHzIndoor: per TRP 24dBm |
| BS antenna height  | Depending on scenarios (cf. table A.2.1-1 of TS 38.802): DU (25m), UMa (25m), Indoor Hotspot (3m) |
| UE antenna height & gain | Follow TR36.873  |
| UE receiver noise figure | 9dB |
| Modulation  | Up to 256QAM  |
| Coding on PDSCH  | LDPCMax code-block size=8448bit  |
| Numerology | Slot/non-slot  | 14 OFDM symbol slot |
| SCS  | 30kHz  |
| Number of RBs | 52RB for 20MHz, 104RB for 40MHz, 272RB for 100MHz |
| Frame structure  | DSUDD, or companies to state the used frame structure |
| MIMO scheme | SU/MU-MIMO with rank adaptation is a baseline For low RU, SU-MIMO or SU/MU-MIMO with rank adaptation are assumed For medium/high RU, SU/MU-MIMO with rank adaptation is assumed  |
| MIMO layers | For all evaluation, companies to provide the assumption on the maximum MU layers  |
| Overhead  | Companies shall provide the downlink overhead assumption |
| Traffic model | FTP 1 or FTP 3 with 20%, 50% or 70% traffic load |
| UE distribution | According to TS 38.802- DU and UMa: 80% indoor (3km/h), 20% outdoor (30km/h) - Indoor Hotspot: 100% indoor (3km/h) |
| UE receiver | MMSE-IRC as the baseline receiver |
| DL Channel estimation | Realistic |
| Evaluation Metric | DL throughput |
| Baseline for performance evaluation | R17 SRS design |
| SRS modeling for UL channel estimation | Companies to state the used SRS periodicity.Companies to state the SRS channel estimation modeling Number of ports = 2 or 4Tx power = 23 dBm |

##### Appendix 4: R18 TDD CJT EVM for LLS

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| Rel-18 LLS Assumptions for TDD CJT SRS |
| Parameter | Value |
| Scenario | N\_TRP (#TRPs): 2, 3, 4 |
| Carrier frequency and subcarrier spacing  | 3.5 GHz with 30 kHz SCS |
| System bandwidth | 20MHz, 40MHz, 100MHz |
| Channel model | CDL-B or CDL-C in TR 38.901 with 30ns or 300ns delay spread as baseline for MU-MIMO and SU-MIMO Note: Other delay spread is not precluded. Difference in propagation delays between UE and N\_TRP TRPs is taken into account in the composite Channel Impulse Response (CIR) for CJT.Otherwise, company should state if per-TRP delay offset (to "zero") is performed in the simulation.Per WID, ideal synchronization and backhaul should be assumed. Optionally, companies may present results with phase/frequency error and should state the assumed frequency error models and values. |
| UE velocity | 3km/h |
| Antennas at UE | 1T4R, 2T4R, 4T4R |
| Antennas at gNB | 64 ports: (8,8,2,1,1,4,8), (dH,dV) = (0.5, 0.8)λ 32 ports: (8,8,2,1,1,2,8), (dH,dV) = (0.5, 0.8)λ 16 ports: (8,4,2,1,1,2,4), (dH,dV) = (0.5, 0.8)λ |
| Rank and MCS | Rank/MCS can be adaptive or fixed. |
| Evaluation metrics | MSE, BLER or throughput |
| Baseline | R17 SRS design |
| Precoding granularity | Fixed: 2, 4 or wideband for DL, wideband for UL. |
| SRS configurations  | Companies to state the used SRS periodicity.Frequency hopping：Companies to state whether SRS frequency hopping is enabled and the hopping pattern if so. |
| DL SNR | Companies to state the used difference between DL SNR and UL SNR |