8.1.3 SRS agreements till RAN1#106bis-e

Clarification: The following includes all the agreements and conclusions made in Rel-17, including the texts which are crossed out. The crossed out texts are just not directly relevant to the change of specification. New agreements made in RAN1#107e are marked in blue.

## Triggering offset enhancement

**Agreements**

~~Enhance the determination of aperiodic SRS triggering offset, with at least one of the following alternatives~~

* ~~Alt 1: Delay the SRS transmission to an available slot later than the triggering offset defined in current specification, including possible re-definition of the triggering offset~~
* ~~Alt 2: Indicate triggering offset in DCI explicitly or implicitly~~
* ~~Alt 3: Update triggering offset in MAC CE~~
* ~~Further consideration aspects may include the cost v.s. the total combinations PDCCH and SRS locations for gNB to choose, DCI overhead, multi-UE SRS multiplexing, CA aspect, whether to have multiple opportunities to transmit SRS, etc.~~

A given aperiodic SRS resource set is transmitted in the (t+1)-th available slot counting from a reference slot, where t is indicated from DCI, or RRC (if only one value of t is configured in RRC), and the candidate values of t at least include 0. ~~Adopt at least one of the following options for the reference slot.~~

* ~~Opt. 1: Reference slot is the slot with the triggering DCI.~~
* ~~Opt. 2: Reference slot is the slot indicated by the legacy triggering offset.~~
* ~~FFS the detailed definition of “available slot” considering UE processing complexity and timeline to determine available slot, potential co-existence with collision handling, etc., e.g.,~~
  + ~~Based on only RRC configuration, “available slot” is the slot satisfying: there are UL or flexible symbol(s) for the time-domain location(s) for all the SRS resources in the resource set and it satisfies the minimum timing requirement between triggering PDCCH and all the SRS resources in the resource set~~
* ~~FFS explicit or implicit indication of t~~
* ~~FFS whether updating candidate triggering offsets in MAC CE may be beneficial~~

Confirm the following working assumption with modifications

An “available slot” is a slot satisfying there are UL or flexible symbol(s) for the time-domain location(s) for all the SRS resources in the resource set and it satisfies UE capability on the minimum timing requirement between triggering PDCCH and all the SRS resources in the resource set.

* From the first symbol carrying the SRS request DCI and the last symbol of the triggered SRS resource set, UE does not expect to receive SFI indication, UL cancellation indication or dynamic scheduling of DL channel/signal(s) on flexible symbol(s) that may change the determination of “available slot”.
* Note: Collision handling between the triggered SRS and any other UL channel/signal is performed after the determination of available slot.
* ~~FFS: Rules to handle the case of multiple SRS resource sets with overlapping symbols and/or triggered by a same DCI~~

A list of t values is configured in RRC for each SRS resource set. ~~Adopt at least one of the following for DCI indication of t.~~

* ~~In DCI format 0\_1/0\_2 without data and without CSI request,~~ 
  + ~~Alt 1-1: Reuse the same scheme used for DCI format 0\_1/0\_2/1-1/1-2 that schedules a PDSCH or PUSCH~~
  + ~~Alt 1-2: Re-purpose unused DCI field to indicate t~~
  + ~~Alt 1-3: t is indicated by a configurable DCI field, where the DCI field may contain bits from unused fields and additional bits configured by gNB~~
    - ~~FFS design details with other potential field(s)~~
  + ~~FFS: whether t can be slot offset~~
* ~~In DCI format 0\_1/0\_2/1-1/1-2 that schedules a PDSCH or PUSCH~~
  + ~~Alt 2-1: t is indicated by adding a new configurable DCI field~~
  + ~~Alt 2-2: t is indicated without adding DCI payload~~
* ~~Note: The size of DCI payload does not change dynamically~~
* ~~Note: RAN1 should strive for unified solution for different DCI formats.~~
* ~~FFS: The number of RRC configured t values per SRS resource set and DCI bit field size.~~

Confirm the following WA:

For DCI indication of “t” in Rel-17 SRS triggering offset enhancement

* For both DCI that schedules a PDSCH/PUSCH and DCI 0\_1/0\_2 without data and without CSI request
  + t is indicated by adding a new configurable DCI field (up to 2 bits)
    - Applies only when there are multiple candidate values of t configured
  + ~~No further enhancement to indicate “t” for DCI 0\_1/0\_2 without data and without CSI request at least when the new DCI field is configured~~

Up to 4 “t” values can be configured per SRS resource set.

Support Opt. 2: Reference slot is the slot indicated by the legacy triggering offset.

* If DCI is transmitted in slot n, and k is the legacy triggering offset, reference slot is slot n+k.
* Note: the legacy triggering offset can be 0, if slotOffset is absent.

Bit width of SOI depends on the maximum number of “t” values configured for any of the aperiodic SRS resource sets ~~(FFS: across all CCs or across a CC/BWP)~~

* The SOI field is 0 bit if the maximum number of ‘t’ values is one
* If at least one resource set has “t” configured
  + For the resource sets with “t” value configured, each of them is configured with K values of “t”, where 1<=K<=4
  + t=0 applies for the resource set(s) without “t” configured in RRC
* If none of the resource sets is configured with “t” values, follow Rel-15 approach to determine slot offset

When *ca-SlotOffset* is configured, reference slot to use the Rel-17 mechanism for determining the SRS offset is slot , otherwise reference slot is, where , , and are determined by *ca-SlotOffset* configurations of the PDCCH carrier and SRS carrier.

For a CC with t value configured, SOI bit width depends on the maximum number of t values configured for all the resource sets across all configured BWPs in a CC for SRS transmission.

* For the CCs without any t value configured, follow Rel-15/16 mechanism to determine the SRS slot offset, where SOI bit width is 0

**~~Conclusion~~**

~~MAC CE for t value update in Rel-17 is not supported.~~

## Triggering DCI enhancement

**Agreements**

~~Study the following two alternatives in the scope to enhance at least one DCI format for aperiodic SRS triggering~~

* ~~Alt 1: Use UE-specific DCI, e.g., extending DCI 0\_1 without uplink data and without CSI~~
* ~~Alt 2: Use group-common DCI, e.g., extending DCI 2\_3 for cases other than carrier switching~~
* ~~Further consideration aspects may include simultaneous or CC-specific SRS triggering for multiple CCs, dynamic indication of SRS frequency resources, etc..~~

~~For SRS overhead reduction, study reusing same resources among multiple usages, at least for “codebook” and “antenna switching”. Study aspects include~~

* ~~Whether implementation approach based on legacy SRS configuration is sufficient~~
  + ~~If not, and if there are benefits other than RRC overhead reduction, study further on the case that antenna switching and PUSCH have different number of Tx antennas, whether UL BWP for different SRS usages is the same or different, whether and how to ensure UE to use same virtualization, the set of applicable usages, UE implementation complexity and overhead, etc..~~

Support at least DCI 0\_1 and 0\_2 to trigger aperiodic SRS without data and without CSI.

* ~~FFS whether/how to re-purpose the unused fields, e.g., the triggering offset(s) and the frequency resources for triggering A-SRS on one or more component carriers, SFI-index, etc.~~
* ~~FFS UL/DL DCI with data for aperiodic SRS~~
* ~~FFS group common DCI~~

~~Further study whether and if needed, how to achieve further enhancements on aperiodic SRS triggering and resource management based on repurposing unused fields in DCI format 0\_1/0\_2 without data and without CSI. Consider the following examples~~

* ~~CAT A: Time-domain parameters~~
  + ~~A-1: Indication of available slot position, i.e., the t values~~
  + ~~A-2: Indication of slot offset~~
  + ~~A-3: Indication of SRS symbol-level offset~~
  + ~~A-4: Indication of time-domain behavior for SRS transmission over multiple OFDM symbols, e.g., repetition, hopping, and/or splitting~~
* ~~CAT B: Frequency-domain parameters~~
  + ~~B-1: Indication of a group of CCs for SRS transmission~~
  + ~~B-2: Indication of frequency domain resource in a BWP for SRS transmission~~
  + ~~B-3: Indication of whether DL/UL BWP is applied for SRS transmission~~
* ~~CAT C: Power control parameters~~
  + ~~C-1: Re-purpose ‘TPC command for PUSCH’ as ‘TPC command for SRS’~~
    - ~~FFS impact on power control, impact from triggering a group of CCs for SRS~~
  + ~~C-2: Indication of open loop power control parameter e.g., p0.~~
* ~~CAT D: Spatial-domain parameters, i.e., indication of SRS port and beamforming~~
* ~~CAT E: Extend the number of DCI codepoints for aperiodic SRS trigger states~~
* ~~Other examples are not precluded~~

## Antenna switching for up to 8Rx

**Agreements**

~~For SRS antenna switching up to 8Rx, study the configuration of {1T6R, 1T8R, 2T6R, 2T8R, 4T6R, 4T8R}.~~

* ~~Study points may include CSI latency, performance considering aspects like insertion loss, use cases, antenna structure, UE power saving, SRS resource configuration, etc..~~

For antenna switching up to 8Rx, support SRS resource configurations for {1T6R, 1T8R, 2T6R, 2T8R, [4T6R], 4T8R}.

For aperiodic antenna switching SRS, support to configure N <=N\_max resource sets, where totally K resources are distributed in the N resource sets flexibly based on RRC configuration.

* For 1T6R, K=6, N\_max = [4], and each resource has 1 port.
* For 1T8R, K=8, N\_max = [4], and each resource has 1 port.
* For 2T6R, K=3, N\_max = [3], and each resource has 2 ports.
* For 2T8R, K=4, N\_max = [4], and each resource has 2 ports.
* (Working Assumption) For 4T8R, K=2, N\_max = [2], and each resource has 4 ports.
* ~~FFS the number of supported candidate values of N for each xTyR.~~

~~FFS extension to increase N\_max for 1T4R, 2T4R, T=R and 1T2R cases for aperiodic, periodic and semi-persistent SRS resources~~

~~FFS the number of resources and resource sets for semi-persistent and periodic antenna switching SRS~~

~~Note: SRS could be transmitted over the last 6 OFDM symbols, or over any OFDM symbols within the slot subject to UE capability.~~

On aperiodic SRS configuration for antenna switching with > 4Rx, support the following N\_max values

* 1T6R: N\_max = 3
* 1T8R: N\_max = 4
* 2T6R: N\_max = 3
* 2T8R: N\_max = 4
* [4T8R: N\_max = 2]
* ~~The support of N\_max value does not imply the support of N value that is smaller than N\_max. This is FFS.~~
* ~~FFS whether further enhancement for single-DCI or multi-DCI based MTRP is needed~~

~~On supported values of N for Rel-17 aperiodic SRS antenna switching with >4Rx, down-select at least one of the following alternatives in RAN1#105e~~

* ~~Alt 1: All the non-zero integer values <= N\_max are supported for N~~
* ~~Alt 2: Support N=N\_max only~~
* ~~Alt 3: Support specific N values <= N\_max~~
* ~~FFS whether different alternatives may be selected for the same xTyR configuration subject to the UE capability on maximum number of symbols that can be used for SRS in a slot~~
* ~~FFS: whether different alternatives may be selected for different xTyR configuration~~

On aperiodic SRS configuration for antenna switching with 4T8R, support N\_max = 2

~~For antenna switching, support one of the following~~

* ~~Alt 1: Support maximum one SRS resource set for periodic SRS and maximum one SRS resource set for semi-persistent SRS~~
* ~~Alt 2: Support up to two semi-persistent SRS resource sets in addition to a periodic SRS resource set~~
  + ~~Note: the two SP-SRS resource sets are not activated at the same time.~~
* ~~FFS whether further enhancement for single-DCI or multi-DCI based MTRP is needed~~
* ~~FFS whether configurations on SRS repetitions have impact~~
* ~~FFS relevant UE capability design~~

For aperiodic xTyR antenna switching SRS, where xTyR is from {1T6R, 1T8R, 2T6R, 2T8R, 4T8R}, support all the non-zero integer values N<=N\_max except N=1 for 1T8R

* For each xTyR configuration, UE does not expect multiple SRS resource sets are configured or triggered in one slot
* UE does not expect that the OFDM symbols contained in one SRS resource set exceed UE capability on which OFDM symbols can be used for SRS taking guard period into account

For antenna switching SRS, support maximum one SRS resource set for periodic SRS and maximum 2 SRS resource sets for semi-persistent SRS.

* Note: the two SP-SRS resource sets are not activated at the same time
  + For xTyR where y>4, if UE does NOT support this feature, support maximum one SRS resource set for periodic SRS and maximum one SRS resource set for semi-persistent SRS
* Applies for all supported xTyR where y<=8
* For each xTyR antenna switching (except for 4T6R if supported), each periodic or semi-persistent resource set contains y/x resources.

This feature is UE optional: For UEs that do not support this feature, follow Rel-15 on the number of resource sets for periodic and semi-persistent SRS

Support 4T6R SRS antenna switching in Rel-17.

~~On the presence of guard symbols in Rel-17 for SRS antenna switching, down-select one of the following~~

* ~~Alt 1-0: Guard symbols are always-on, which is same as Rel-15~~
* ~~Alt 1-1: Guard symbols are configurable subject to UE capability~~

~~On whether to introduce guard symbols between SRS resource sets for antenna switching, down-select one of the following~~

* ~~Alt 2-0: Do not introduce guard symbols between SRS resource sets, i.e., guard symbols only appears between SRS resources in a resource set~~
* ~~Alt 2-1: Introduce guard symbols between two sets mapped to consecutive slots~~

Note: Rel-15 guard period symbols are supported if none of the above enhancements is agreed

For two SRS resource sets of an xTyR antenna switching located in two consecutive slots, if UE is capable of transmitting SRS in all symbols in one slot, a minimum gap period of Y symbols exists between the last OFDM symbol occupied by the SRS resource set in the first slot and the first OFDM symbol occupied by the SRS resource set in the second slot

* The value of Y is same as the inter-resource GP defined in Rel-15
* ~~FFS: Whether or not the minimum GP exists can be RRC configurable subject to UE capability~~
* ~~Whether this inter-set GP is needed for 4T6R can be discussed later per the decision on 4T6R configuration.~~
* ~~FFS: How/Whether to handle the case where the interval between SRS resource sets is larger than Y~~

For extension of aperiodic antenna switching SRS configurations for <=4Rx, support N=4 for 1T4R and N=2 for 1T2R/2T4R.

* The above extension is UE optional

~~On SRS configuration for 4T6R, select at least one from the following three alternatives in RAN1#107e~~

* ~~Alt 1: 4 + 2~~
* ~~Alt 2: 2+2+2~~
  + ~~Alt 2-1:~~ 
    - ~~No guard symbols exist between the 1~~~~st~~ ~~and the 2~~~~nd~~ ~~transmission. Y guard symbol(s) exist between 2~~~~nd~~ ~~and 3~~~~rd~~ ~~transmission, where Y is same as the value defined in the current specification for different SCSs~~
  + ~~Alt 2-2:~~ 
    - ~~For SCS=15, 30 and 60KHz: No guard symbols exist~~
    - ~~For SCS=120 KHz: No guard symbols exist between the 1~~~~st~~~~and the 2~~~~nd~~ ~~transmission, and 1 guard symbol exists between the 2~~~~nd~~ ~~and 3~~~~rd~~ ~~transmission~~
* ~~Clarification on the notation: means totally K resources are needed, where the k-th resource contains ports, 1<=k<=K~~

**Conclusion**

In Rel-17, SRS 4T6R is not supported

## Coverage and capacity enhancements

**Agreements**

~~For SRS coverage/capacity enhancements, evaluate and, if needed, specify one or more from three categories based on the following definition.~~

* ~~Class 1 (Time bundling): Utilize relationship among two or more occasions of one or more SRS resources in one or more slots to enable joint processing within time domain.~~
  + ~~Study aspects include the issue of phase discontinuity, interruption of SRS transmission by other UL signals, etc..~~
* ~~Class 2 (Increase repetition): Change the legacy SRS pattern in one resource and one occasion from time domain by increasing SRS symbols for repetition.~~ 
  + ~~Study aspects include to use TD-OCC to compensate the negative impact on SRS capacity, inter-cell interference randomization, whether these SRS symbols are in one slot or consecutive slots, etc..~~
* ~~Class 3 (Partial frequency sounding): Support more flexibility on SRS frequency resources to allow SRS transmission on partial frequency resources within the legacy SRS frequency resources.~~
  + ~~Study aspects include the partial frequency resources are with RB level or subcarrier level (e.g., larger comb, partial bandwidth), PAPR issue, etc..~~

~~In Rel-17 SRS coverage and capacity enhancement, support at least one scheme from Class 2 and Class 3, and deprioritize Class 1.~~

* ~~Note: Extensions of Rel-15/16 frequency hopping are included in Classes 2 and 3, e.g. where UE hops once per symbol within a Rel-17 SRS resource.~~

~~Candidate schemes for Class 2:~~

* ~~Scheme 2-0: Increase the number of repetition symbols in one slot~~
* ~~Scheme 2-1: Inter-slot repetition on consecutive symbols or non-consecutive symbols across slots~~
* ~~Scheme 2-2: Repetition with TD-OCC~~
* ~~Scheme 2-3: Repetition with CS hopping~~

~~Candidate schemes for Class 3:~~

* ~~Scheme 3-1: RB-level partial frequency sounding~~
* ~~Scheme 3-2: Subcarrier-level partial frequency sounding~~
* ~~Scheme 3-3: Subband-level partial frequency sounding~~
* ~~Scheme 3-4: Partial-frequency sounding schemes assisted with CSI-RS, where SRS is transmitted in a subset of RBs of the original SRS frequency resource~~
* ~~Scheme 3-5: Dynamic change of SRS bandwidth with RB-level subband size scaling~~
* ~~Note: Consider issues like gNB receiver complexity, PAPR, etc., with above schemes~~
* ~~Note: Joint operation between Class 2 and Class 3 schemes can be considered~~

For Rel-17 SRS capacity and coverage enhancement, support the following

* Increase the maximum number of repetition symbols in one slot and one SRS resource to S
  + ~~Support at least one S value from {8, 10, 12, 14}~~
    - ~~FFS other candidate values~~
* Support to transmit SRS only in  contiguous RBs in one OFDM symbol, where   indicates the number of RBs configured by BSRS and CSRS
  + ~~Support at least one P~~~~F~~~~value from {2, [3], 4, 8}~~
    - ~~FFS other candidate values, e.g., non-integer values for P~~~~F~~
  + Note: SRS sequence shorter than the minimum length supported in the current specification is not pursued.
  + No new sequence including length is introduced
  + ~~FFS it is applicable to frequency hopping and non-frequency hopping~~
  + ~~FFS detailed signaling mechanism to determine PF and the location of the  RBs~~
* Support Comb 8
  + Note: SRS sequence shorter than the minimum length supported in the current specification is not pursued.
* ~~FFS whether and if needed, how to use harmonized approach to define the three supported schemes~~
* Note: other schemes for SRS capacity and coverage enhancements are not supported in Rel-17.

**For increased repetition in Rel-17**, support the following N\_symbol (number of OFDM symbols in one SRS resource) and R (repetition factor) values

* N\_symbol = 8, R = {1, 2, 4, 8}
* N\_symbol = 12, R = {1, 2, [3], 4, 6, 12}
* ~~FFS the following configurations~~
  + ~~N\_symbol = 10, R = {1, 2, 5, 10}~~
  + ~~N\_symbol = 14, R = {1, 2, 7, 14}~~
* ~~FFS options to reduce SRS BW for R>1~~

For SRS increased repetitions in Rel-17, support the following configurations, and no other values are supported.

* (N\_symbol, R) = {(8, 1), (8, 2), (8, 4), (8, 8), (12, 1), (12, 2), (12, 3), (12, 4), (12, 6), (12, 12), (10, 1), (10, 2), (10, 5), (10,10), (14, 1), (14, 2), (14, 7), (14, 14)}
* Note: N\_symbol SRS symbols are adjacent in a slot.

**For RB-level partial frequency sounding (RPFS) in Rel-17**

* The start RB index of the RBs in the RBs is , where kF = {0, …, PF-1}
  + ~~FFS support start RB location (N~~~~offset~~~~) hopping in different SRS occasions, symbols or frequency hopping periods, and if supported, detailed hopping pattern~~
* Support to determine PF and Noffset at least via RRC configuration per SRS resource.
  + ~~FFS whether to introduce DCI and/or MAC CE in addition~~

For RPFS in Rel-17, support PF = {2, 4}.

* ~~FFS 3, 8, 12, 16 or fractional numbers~~
* ~~Support at least one of the following alternatives (to be decided in RAN1#105-e)~~
  + ~~Alt 1: is an integer value~~
  + ~~Alt 2: is an integer value with minimum value 4~~
  + ~~Alt 3: is a multiple of 4~~
  + ~~Alt 4: Round to a multiple of 4 in case of Alt 1 or Alt 2~~

~~For RPFS SRS in Rel-17, adopt one of the following alternatives for sequence generation, where no new sequence length other than the ones supported in the current spec is introduced (to be decided in RAN1#105-e)~~

* ~~Alt 1: Generate length- ZC sequence~~
* ~~Alt 2: Truncate from legacy length- sequence according to the location of RPFS SRS~~

Support start RB location (Noffset) hopping in different SRS frequency hopping periods for RPFS and at least periodic/semi-persistent SRS, where Noffset is the start RB index of the RBs in the RBs.

* For a given SRS transmission occasion, , where khopping is same for all SRS occasions within a legacy FH period but changes across legacy FH periods, kF and PF are at least configured by RRC signaling (kF = {0, 1, …, PF-1}).
  + ~~Support at least one pattern for k~~~~hopping~~ ~~in time domain, FFS detailed pattern~~
  + Note: the legacy FH period is the period to sound the full SRS hopping bandwidth across the different subbands of RBs each.
* This start RB location hopping is enabled or disabled by RRC signaling.
  + ~~FFS whether MAC CE or DCI can be additionally used~~
  + When this start RB location hopping is disabled, khopping is fixed to be 0 for all SRS symbols
* This start RB location hopping is UE optional.
* ~~FFS whether start RB location hopping is also applicable on SRS occasion(s) within one FH period (e.g., when R>1) and/or on aperiodic SRS, if so, how~~

For RPFS SRS sequence generation, support

* Alt 1: Generate length- ZC sequence.

For the detailed pattern of when start RB location hopping across legacy FH periods is enabled, support the following

* For PF = 2, = {0, 1}
* For PF = 4, = {0, 2, 1, 3}
* Note: means for the (n+1)-th legacy FH period, where n = {0, 1, 2, 3, …}

For aperiodic SRS, support same start RB location hopping approach as for P/SP SRS if there are multiple frequency hopping period in the slot

**Conclusion**

No consensus to have further restriction on the number of RBs for RPFS in Rel-17.

* No introduction of new sequence length

**For Comb-8 in Rel-17**

~~Study the maximum number of cyclic shifts for Comb-8 in Rel-17, with the following alternatives as starting points~~

* ~~Alt 1: The maximum number of CSs for Comb-8 is 6~~
* ~~Alt 2: The maximum number of CSs for Comb-8 is 12, and introduce a rule to restrict applicable CSs when SRS sequence is shorter than the maximum number of CSs~~

~~For Comb-8 SRS in Rel-17, down-select one of the following in RAN1#106bis-e~~

* ~~Alt 1: The maximum number of CSs for Comb-8 is 6~~
* ~~Alt 2: The maximum number of CSs for Comb-8 is 12, and introduce a rule to restrict applicable CSs when SRS sequence is shorter than the maximum number of CSs~~

For comb-8 SRS in Rel-17, the maximum number of CSs is 6.

* ~~FFS: Whether a maximum number of 12 CSs is supported~~

**Working assumption**

To support 4 ports with Max CS = 6,

* Port 0 and Port 2 locate in n\_CS and (n\_CS+3) mod 6 in comb offset k\_TC, respectively.
* Port 1 and Port 3 locate in n\_CS and (n\_CS+3) mod 6 in comb offset (k\_TC + 4) mod 8, respectively.
* Note: n\_CS and k\_TC are the configured CS and comb offset values.
* Note: This working assumption can be revisited if Max CS = 12 is agreed.

**Conclusion**

There is no consensus in RAN1 to support Max CS = 12 for comb-8 in Rel-17.