Coherent Combining of Subframes in Interoperable L1 Band GNSS Signals

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Introduction

- Coherent combining
  - Adding the symbols of successive blocks of noisy signal.
  - Improves the Eb/No of the signal.
  - Useful in low SNR conditions.
  - Information of the signal should remain constant for the duration of combining.

Block 1 $y_1\ y_2\ \dots\dots\dots\ y_n$

+

Block 2 $y_1\ y_2\ \dots\dots\dots\ y_n$

+

+

Block k $y_1\ y_2\ \dots\dots\dots\ y_n$

y_m - symbol of the noisy signal
m = 1,2,3….n

$y_1\ y_2\ \dots\dots\dots\ y_n$

- Energy per bit of each block is Eb.
- On combining k blocks coherently, the energy per bit of combined block will be kEb.

Why in L1 GNSS ?

- Core navigation data
  - Satellite clock and ephemeris (CED) parameters
  - Position calculation
  - Accurate

L1 signals

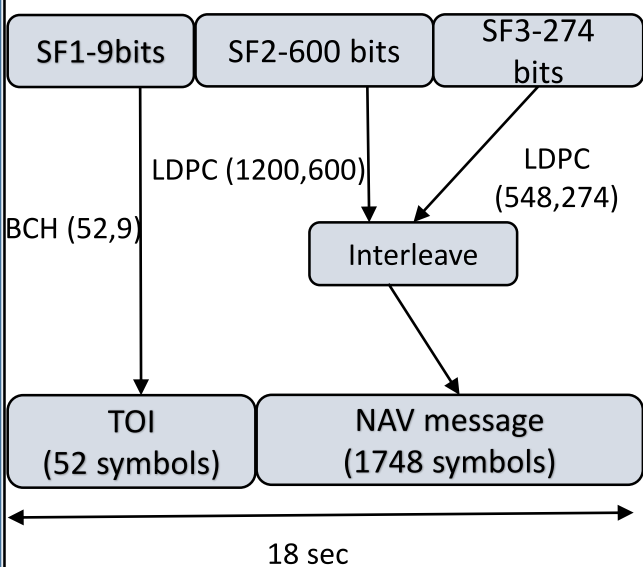
- CED data in subframe 2
- Data remain constant until data cut over
- Systems : GPS, Beidou, NavIC, QZSS

- Low SNR condition scenario
  - Semi-indoor
  - Foliage
  - Subframe block discarded due to CRC failure

Frame structure of L1 signals

GPS L1C

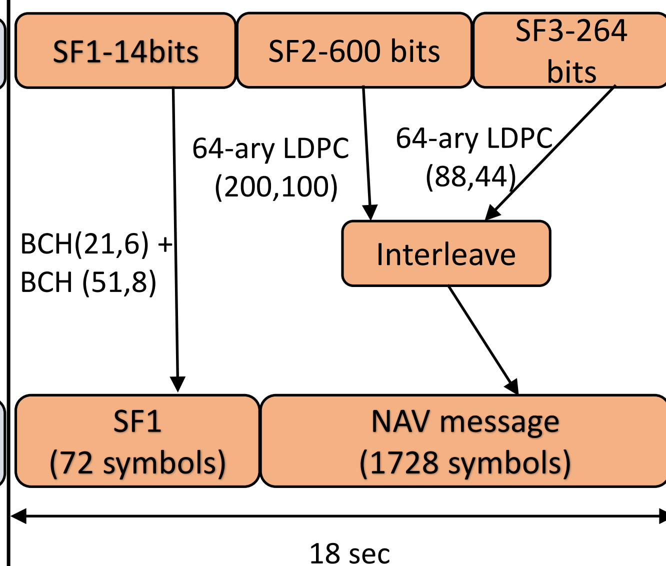
- Each frame contains three subframes.



- FEC used in SF2 is LDPC.

BeiDou B1C

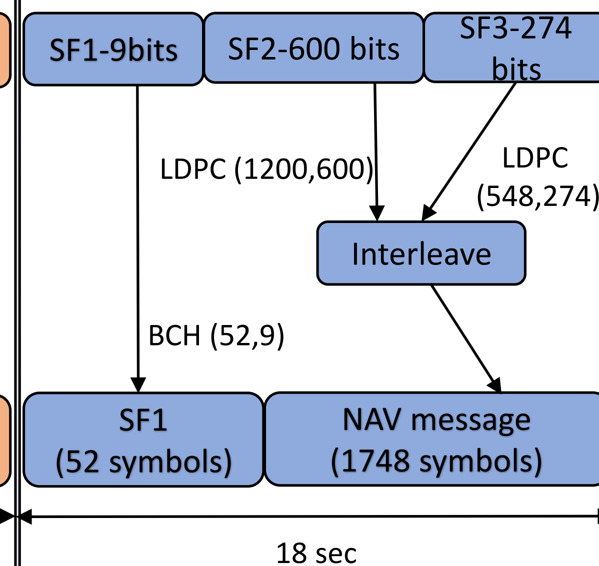
- Each frame contains three subframes.



- FEC used in SF2 is NB-LDPC.

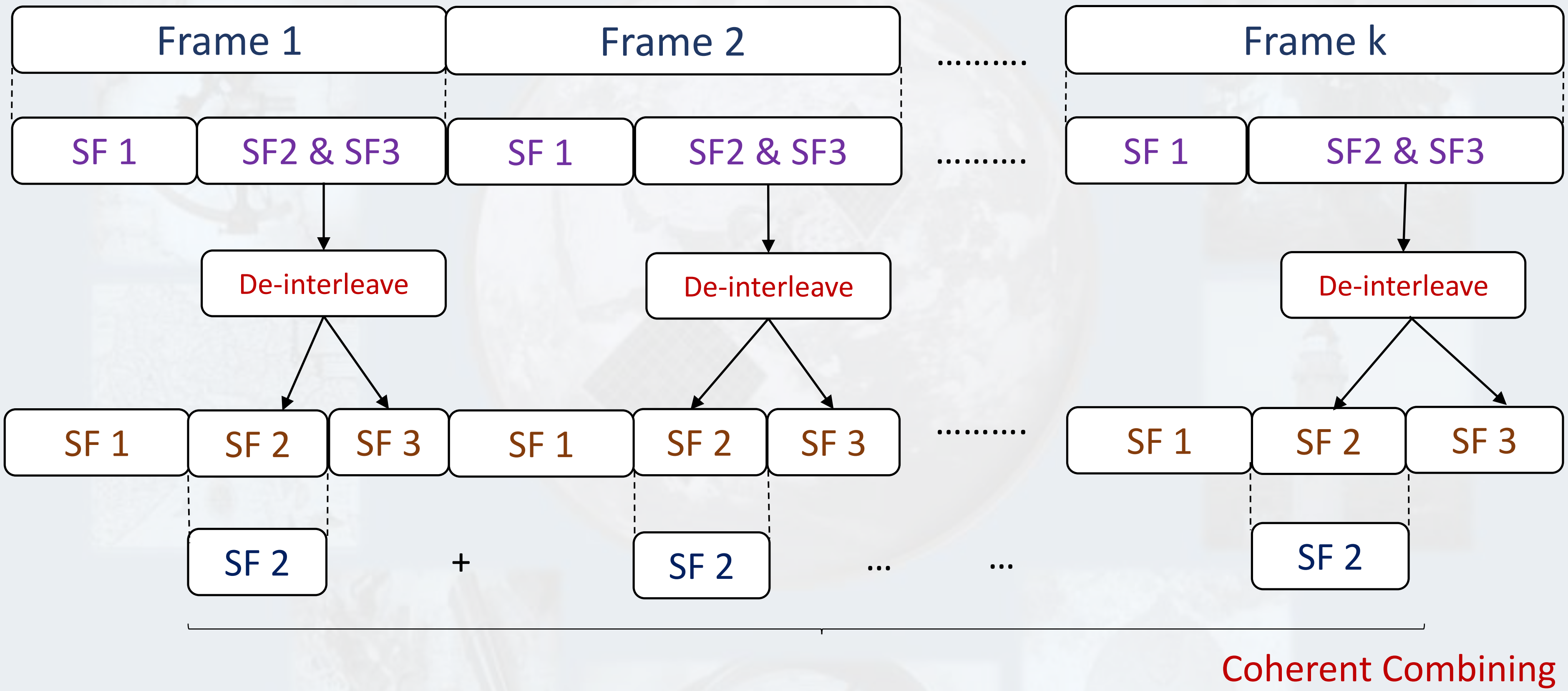
NavIC L1C

- Each frame contains three subframes.

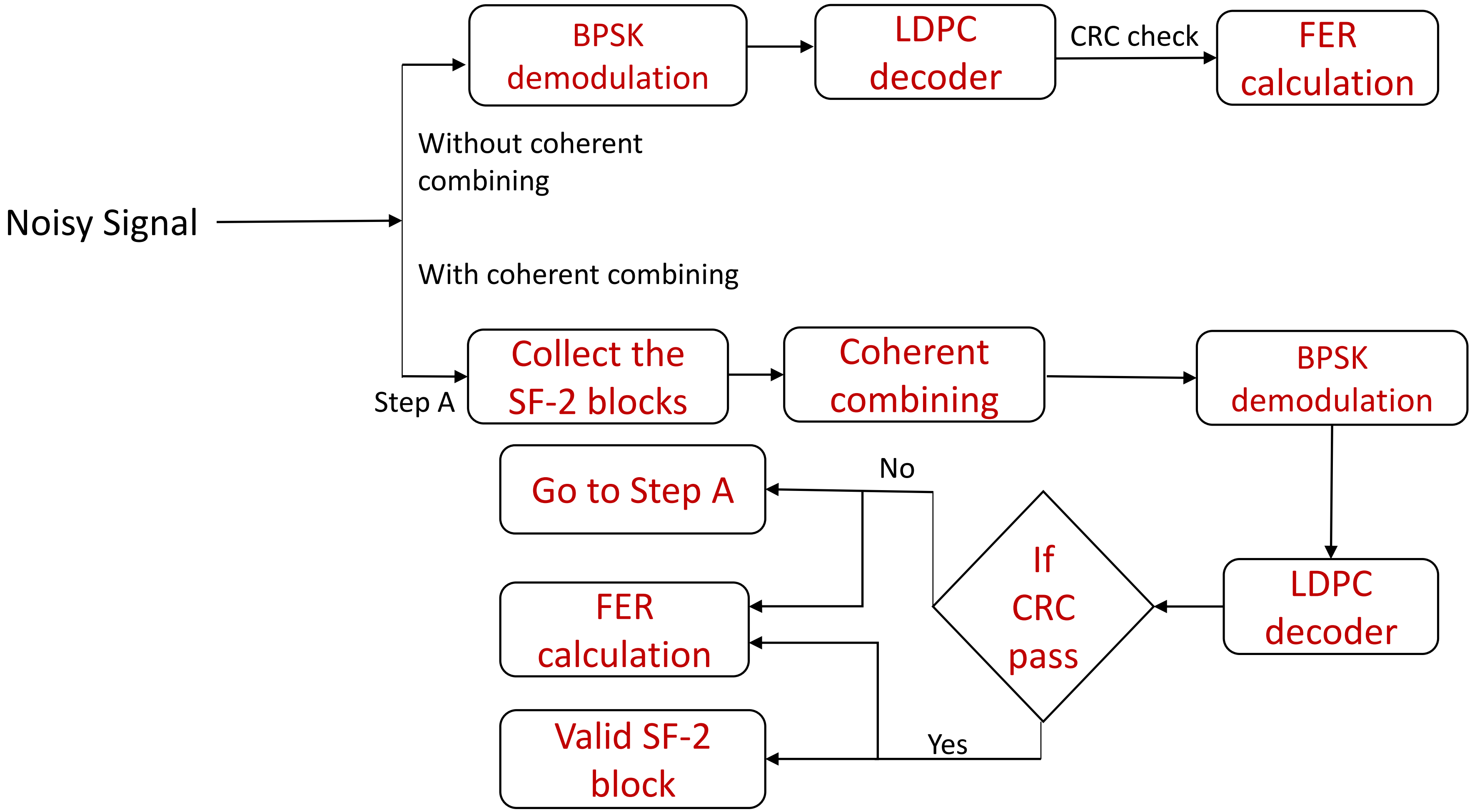


- FEC used in SF2 is LDPC.

Coherent Combining in L1 GNSS



Simulation flow



Simulation results

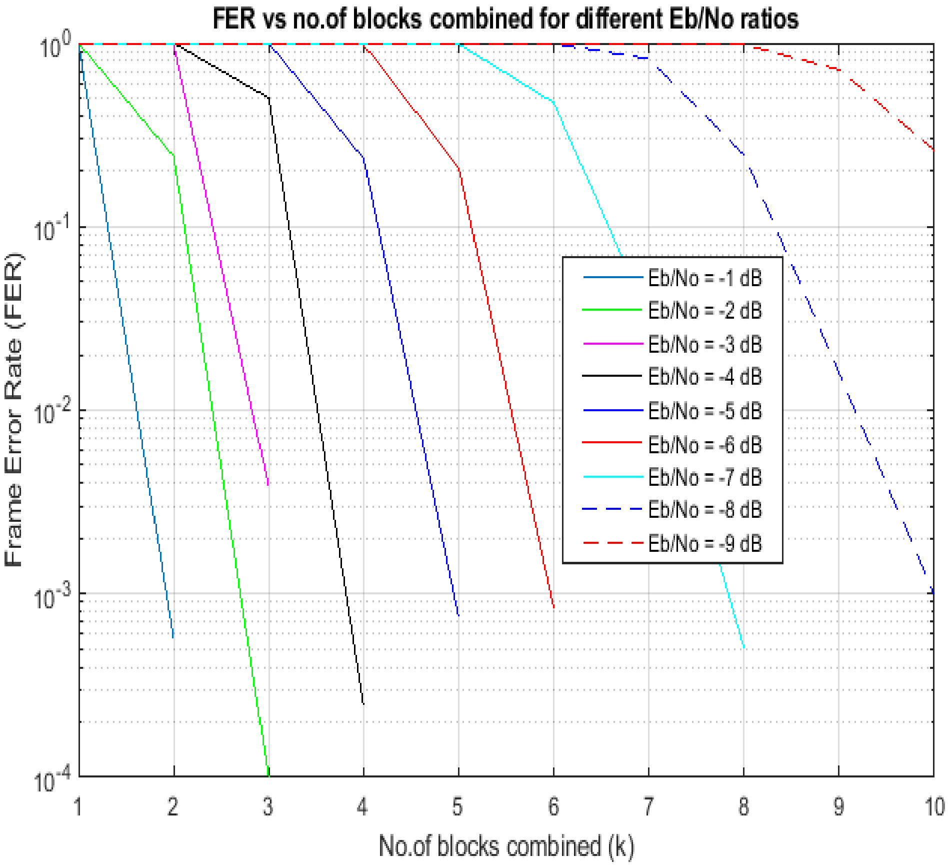
Target FER = 1e-3

Table 1. FER of SF2 without coherent combining

Eb/No (dB)	FER
2	1e-3

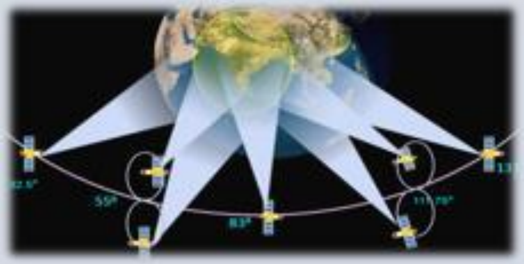
Table 2. FER of SF2 with coherent combining

Eb/No (dB)	FER (w/o coherent combining)	No. of blocks combined	FER (with coherent combining	Coherent combining gain (dB)
-3	0.92	3	1e-3	5 dB
-6	0.9	6	1e-3	8 dB
-8	0.87	10	1e-3	10 dB



Summary

- In low SNR conditions, due to failure of CRC, subframe discarded.
- By coherent combining, Eb/No of the subframe block can be increased, resulting in improvement in FER, hence availability of navigation data is improved.
- Tracking thresholds are at low level for low SNR conditions, the corresponding data demodulation thresholds can also be lowered by using this technique.
- In addition to AWGN channel, simulations is being further extended to fading channels.


Thank You