Overview of New NavIC L1 SPS Signal Structure & SBOC Modulation and Modified-CEMIC Multiplexing Scheme

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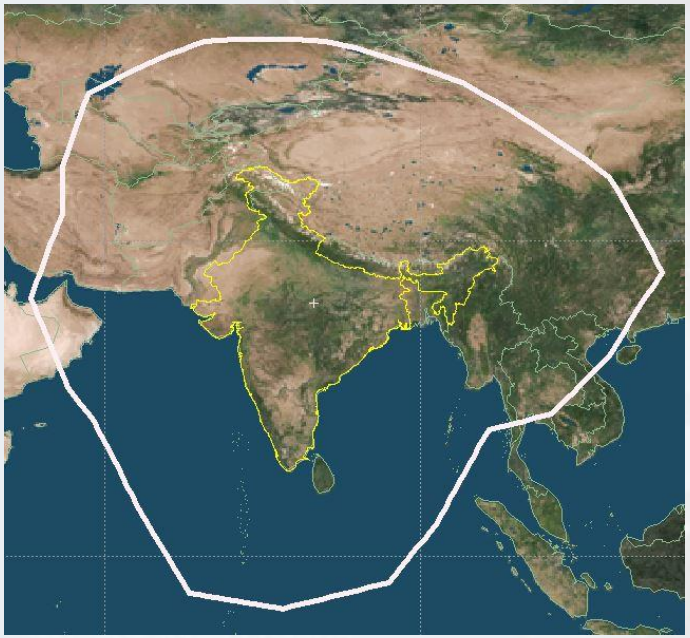
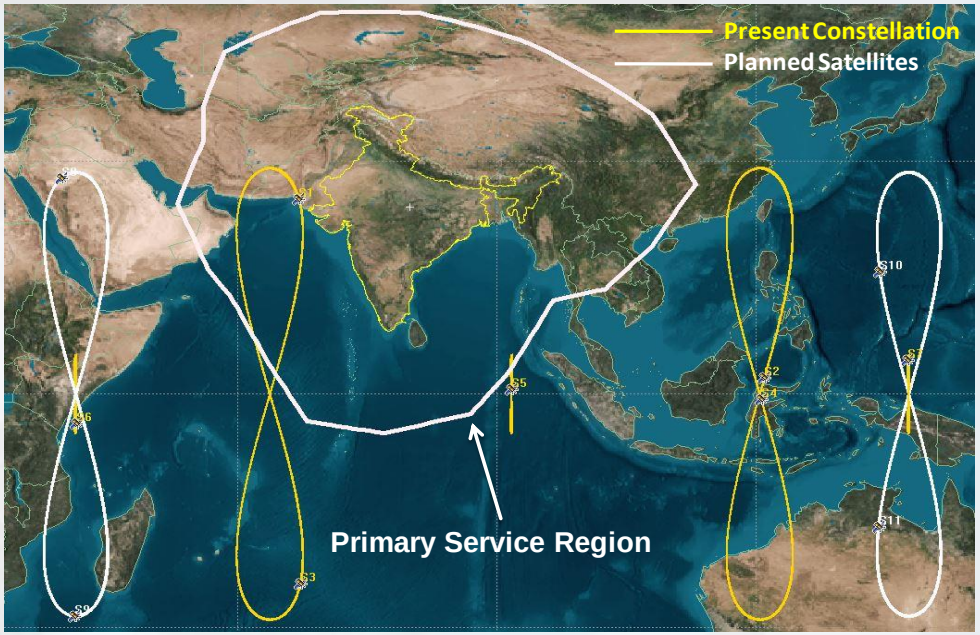
Overview of New NavIC L1 Band SPS Signal Structure and Synthesized Binary Offset Carrier (SBOC) Modulation

New NavIC L1 Band Coverage and Frequency Band Details



NavIC L1-Band SPS Signal Coverage



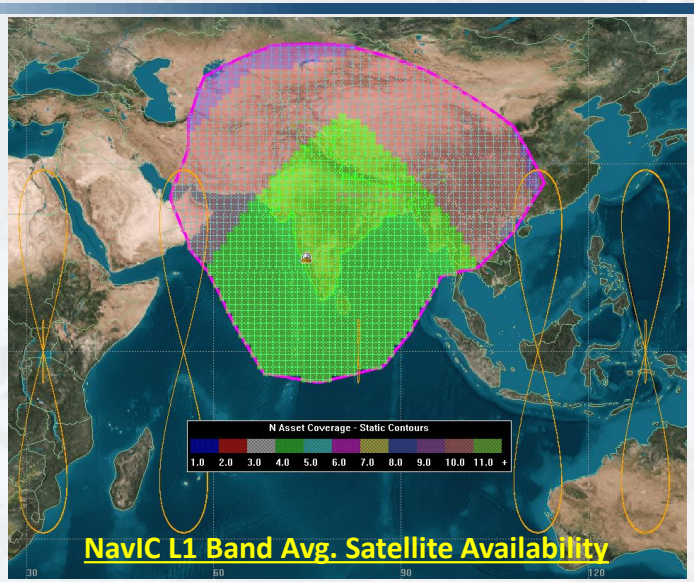
Extended NavIC Constellation [Add. 4# Sat.]

[32.5 & 129.5 E IGSO @ 29° – Two in Each Orbital Location]

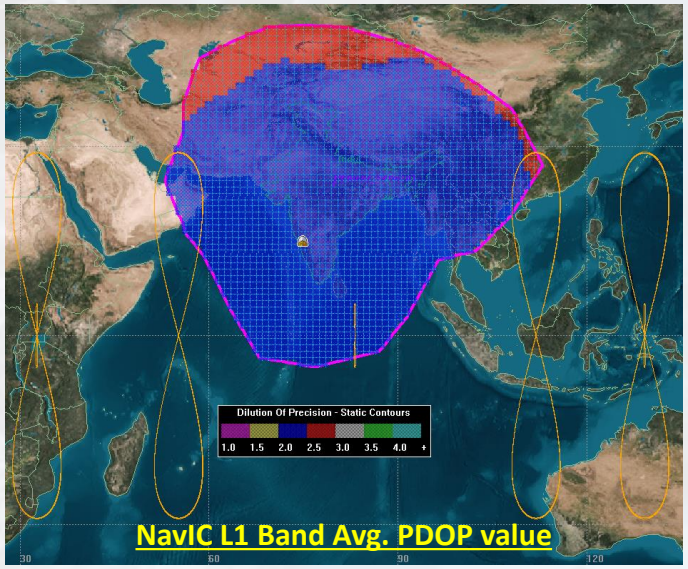
Service Area: Defined as area covered by 1500 km contour from Indian geopolitical boundary.

NavIC L1 Band SPS Details			
Signal Type	Modulation	Frequency Band	Polarization
SPS	SBOC (MBOC PSD)	1563.42-1587.42 MHz	RHCP

NavIC L1 Band Satellite Availability and SPS Interoperability



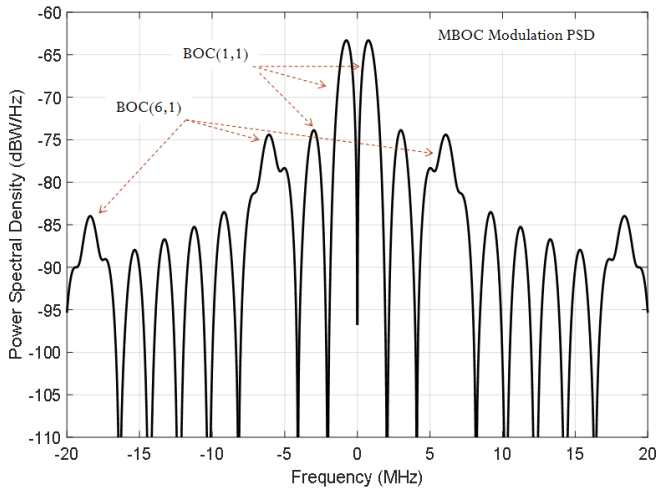
NavIC L1 Band Avg. Satellite Availability



NavIC L1 Band Avg. PDOP value

New L1 SPS Service in NavIC

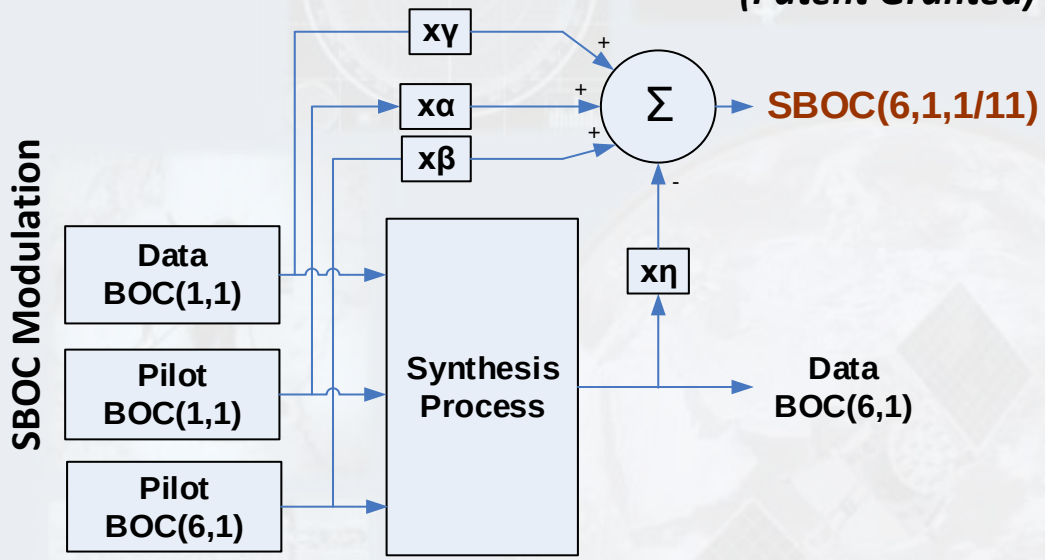
- L1 SPS is designed to be RF compatible with other L1C services:
  - MBOC (6,1,1/11) PSD
  - Max RIP Level: -152 dBW
- It is designed to be Interoperable with other L1C services.



NavIC New L1 band SPS (SBOC) Signal Spectrum

Synthesized Binary Offset Carrier (SBOC) Modulation Scheme*

(Patent Granted)



$$SBOC: S(t) = [\alpha S_{p1}(t) - \beta S_{p2}(t)] + j[\gamma S_{d1}(t) + \eta S_{p1}(t) S_{p2}(t) S_{d1}(t)]$$

$$SBOC: S(t) = [\alpha S_{p1}(t) - \beta S_{p2}(t)] + j[\gamma S_{d1}(t) + \eta S_{d2}(t)]$$

NavIC L1 SPS SBOC Signal Components			
Pilot Components		Data Components	
$S_{p1}(t)$	$S_{p2}(t)$	$S_{d1}(t)$	$S_{d2}(t)$
BOC(1,1)	BOC(6,1)	BOC(1,1)	BOC(6,1)

Signal Power: $\alpha^2 = 6/11$, $\beta^2 = 4/110$, $\gamma^2 = 4/11$, $\eta^2 = 6/110$

SBOC Modulation Scheme is a non-linear combining method to generate constant envelope composite signal with MBOC (6,1,1/11) PSD.

Advantages:

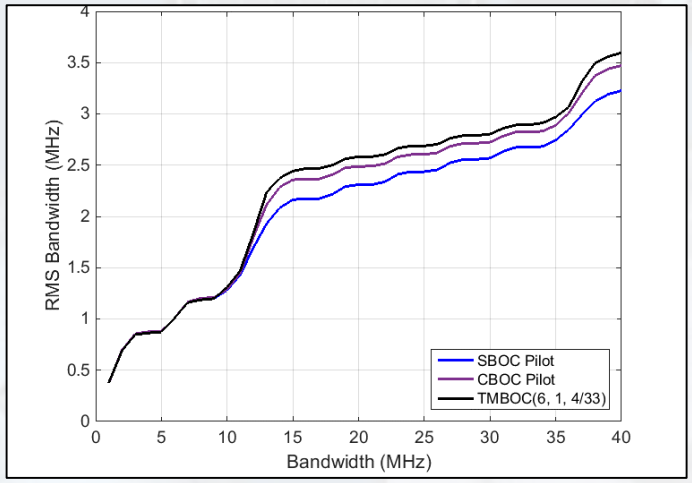
1. Synthesized signal has a Data component [BOC(6, 1)] with 6.138 MHz subcarrier.
2. Flexibility in allocating power ratio of data and pilot components while preserving the PSD & constant envelope.

*** SBOC Indian Patent (Appl. No. 202041022558):**

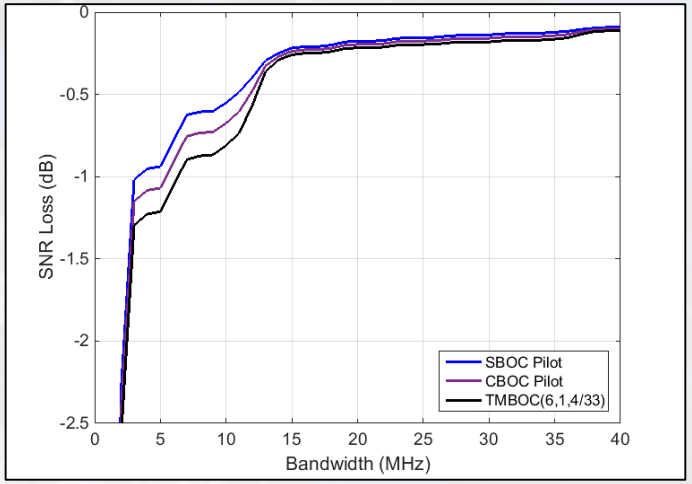
- **Patent Grant No.: 355353**
- **Granted on 06/01/2021**

SBOC PCT Appl. No. PCT/IN2021/050050 filed on 16/01/2021.

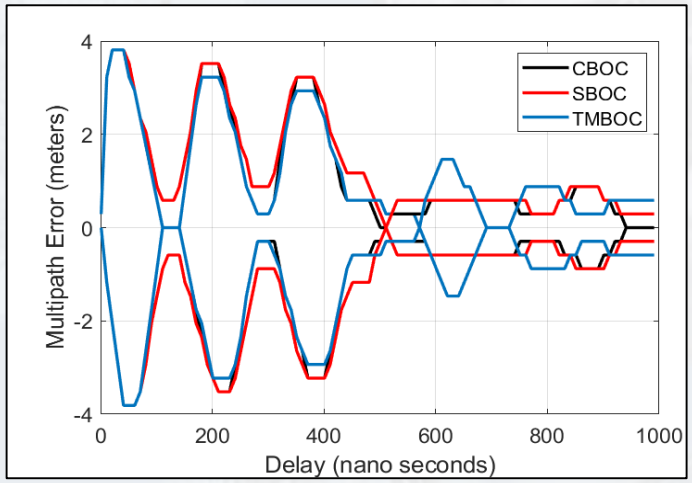
SBOC Modulation Performance



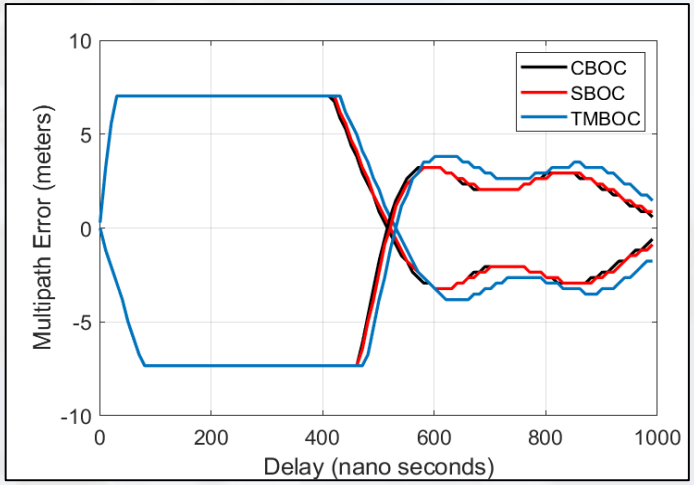
RMS Bandwidth vs Receiver Bandwidth



SNR Loss vs Receiver Bandwidth



Wide band Rx. Multipath Perf. (0.05 chip spacing)



Narrow band Rx. Multipath Perf. (0.05 chip spacing)

Performance of SBOC modulation is similar to the other modulations like TMBOC and CBOC.

NavIC New L1 Band SPS Signal Structure

No.	Parameters	Signal Details
1	Frequency	1575.42 MHz ± 12 MHz
2	Modulation	Scheme: Synthesized Binary Offset Carrier (SBOC) Pilot(Power: 58.18%): BOC(6,1) & BOC(1,1) Data(Power: 41.82%): BOC(6,1) & BOC(1,1)
3	Ranging Code • Primary • Overlay	 Interleaved Z4 (IZ4)-Linear Sequence Truncated Z4-Linear Sequence
4	Symbol Rate	100 sps
5	Frame Format	18 sec Master Frame SF-1: 52 sym., SF-2: 1200 sym., SF-3: 548 sym.
6	Channel Code • SF-1 • SF-2/SF-3	 BCH(52, 9) ½ Rate LDPC
7	Navigation Parameters	Primary Bits: 576
8	Ionospheric Messages	Grid based Ionospheric corrections and Klobuchar model coefficients
9	System Time Offset	NavIC time offset with respect to other GPS, GALILEO & GLONASS will be provided

Modulation scheme, primary/overlay ranging codes, channel coding schemes are indigenous designs.

Modified Constant Envelope Multiplexing with Inter-modulation Construction (CEMIC) Scheme for Multiplexing Signals over Single Frequency Band

Modified CEMIC Scheme

- Navigation payloads are configured to transmit multiple signals through common RF payload chain.
- The constituent signals are combined to generate a composite signal with a constant envelope.
- Combining three and more signals results in multiplexing loss & reduces desired signal power.
- We propose modified CEMIC method for generation of a constant modulus composite signal with minimal effect on current service signals.
- We present a case study of bi-level single carrier combining of present L5/S Band NavIC signals with an additional signal providing receiver transparent multiplexing.
- The proposed scheme will be extended to multiplex multi-level signals, such as SBOC modulation.

Optimization Criteria

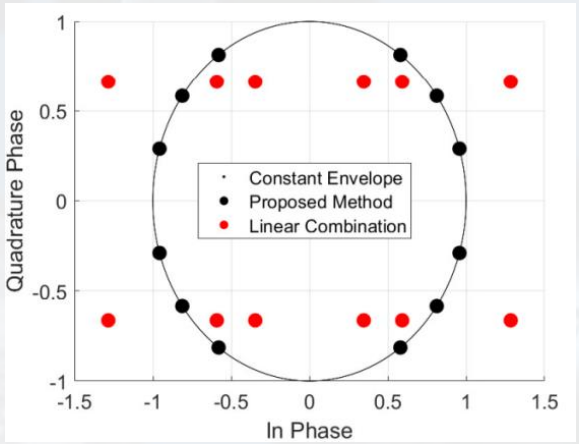
As a case study, the proposed method is evaluated for the present signal structure of the Indian Regional Navigation Satellite System (IRNSS). The proposed modified CEMIC scheme is optimized for IRNSS L5 and S-band signals with the following constraints:

- Better multiplexing efficiency.
- Maintaining the phasing of present SPS and RS signals, i.e., phase constraint.
- Minimum change in the power sharing of present SPS and RS signals, i.e., power sharing constraint.
- Minimum changes in present system configuration.
- Controlling inter-modulation products with desired phasing to minimize intra-system and inter-system interference.

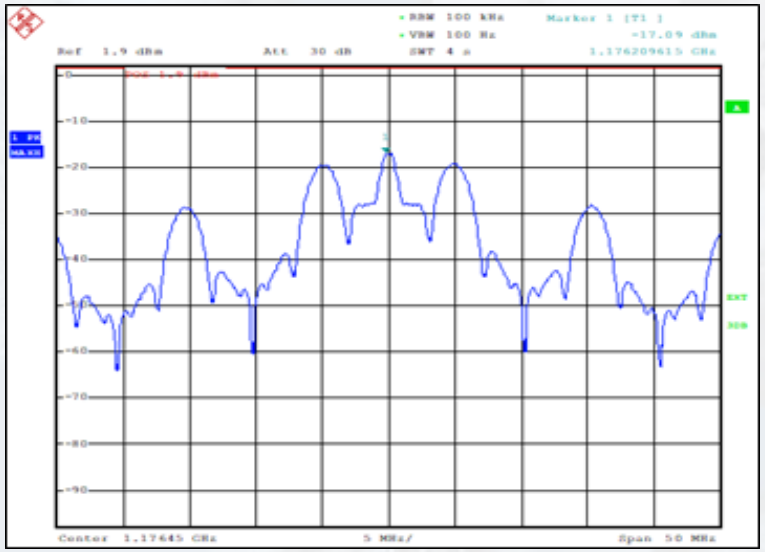
Simulation Result

Modified CEMIC Scheme

Signal	Power (%)	Change (dB)	Phase
RSP	39.12	-0.55	Q
RSD	19.57	-0.55	I
SPS	19.57	-0.55	I
Additional service Signal	10.65	-	I
Intermodulation signal	11.09	0.0	I & Q

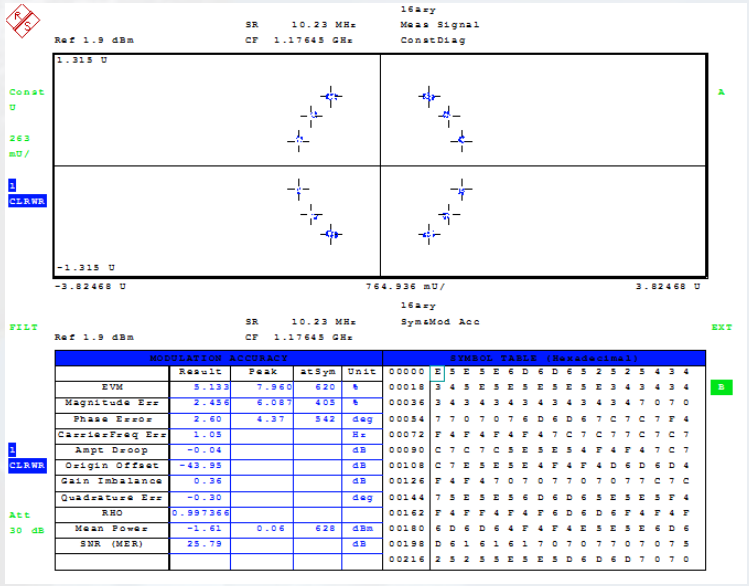


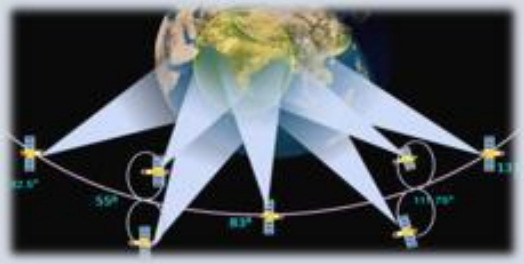
Theoretical Constellation



Measured Spectrum of Composite Signal

Measured Performance with Onboard Filter










Thank You