Modified CEMIC scheme to multiplex multi-frequency and multi-level signals

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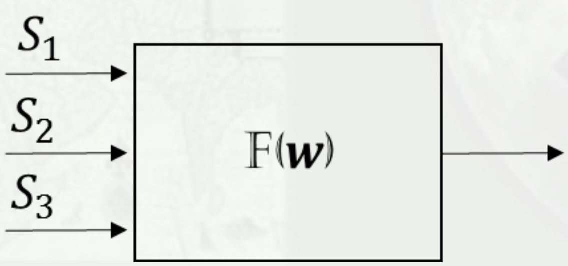
Outline

- Overview of Modified CEMIC (MCEMIC) Multiplexing Scheme
- Performance of MCEMIC for Signal Frequency Multiplexing
- Need for multiplexing scheme for multi-level and multi-frequency signal
- MCEMIC Scheme for Multi-level & Multi-carrier Signals

Overview of Modified CEMIC Scheme

- Waveform Domain Processing for generating constant envelope signal.
- Optimization for the maximization of efficiency as a cost function while maintaining constant envelope.
- Provides flexibility in allocating power sharing and relative phasing between signals.
- Allows to incorporate the receiver transparency constraints in the design.
- Signals S_1, S_2, and S_3, may have same or different center frequencies.
- No constraints on multiplexing of number of signals over different center frequencies.



LINEAR TERMS INTERMODULATION TERMS

$$S = w_1 S_1 + w_2 S_2 + w_3 S_3 + IM(S_1, S_2, S_3, \boldsymbol{w})$$

Intermodulation terms are added with desired signals to generate constant envelope composite signal.

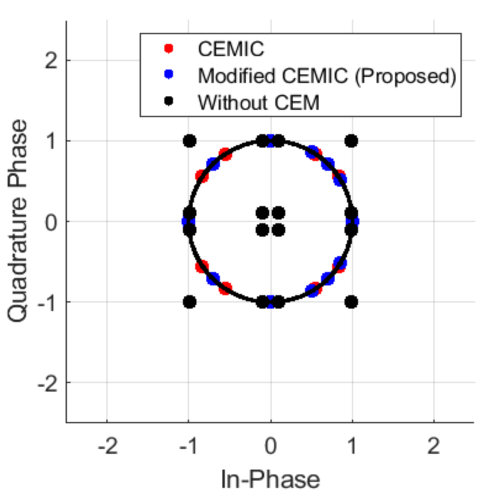
Modified CEMIC Scheme for Single Frequency

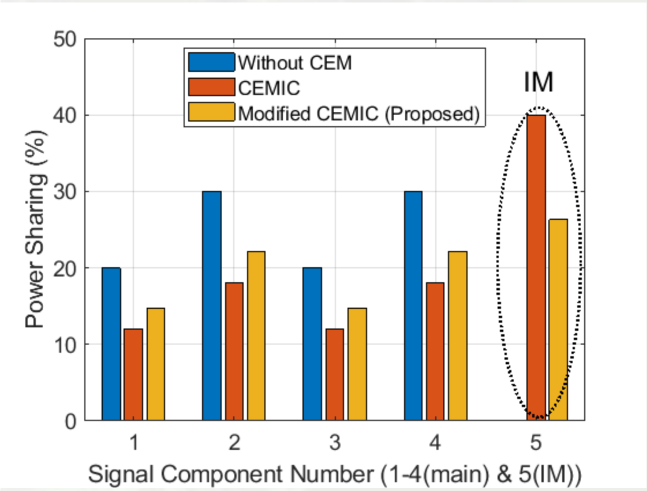
Desired power sharing and phasing configuration

Desired Signals Number	Initial Power Sharing (%)	Initial Relative Phasing
1	20	In-Phase
2	30	In-Phase
3	20	Quadrature Phase
4	30	Quadrature Phase

Designed to multiplex bi-level (BPSK or BOC type) signals over single frequency band.

Multiplexing efficiency of MCEMIC scheme is higher than CEMIC scheme.





Reference: Bhadouria V., Upadhyay D., Majithiya P., & Bera S. (2022) *Modified CEMIC scheme for multiplexing signals over single frequency band.* NAVIGATION, 69(3). https://doi.org/10.33012/navi.528

MCEMIC Scheme for Multi-level & Multi-carrier Signals

Need for multiplexing scheme for multi-level and multi-frequency signals

L1 Band as a case study

- Congestion in L1-band requires multi-frequency multiplexing of more than two service signals.
- Avoidance of inter and intra system interference to existing GNSS signals over L1 band.
- Presence of multi-level signals like SBOC and CBOC modulation in L1 band.

Optimization Criteria

Modulation Scheme	Cost Function	Constraints
Modified CEMIC	Multiplexing Loss + **Receiver transparency**	• Constant Envelope • Relative phasing of existing signal • Relative power sharing of existing signal
CEMIC	Multiplexing Loss	Constant Envelope

Reference: **Bhadouria V., Upadhyay D.**, Majithiya P., & Bera S. *Candidate Design of New Service Signals in NavIC L1 Frequency Band*. GPS Solutions (Under review).

Multilevel & Multi-carrier Multiplexing Results with MCEMIC

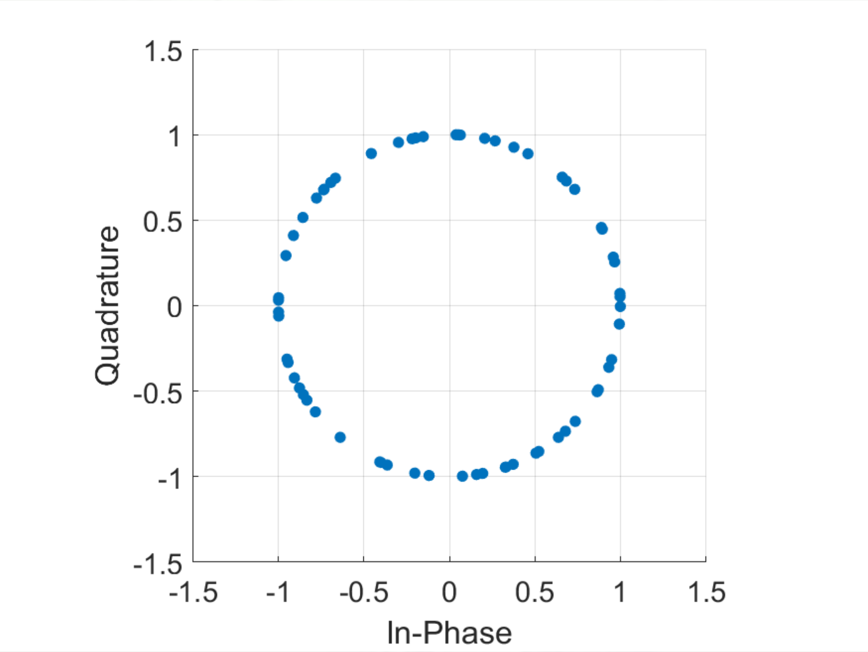
Option	Service-1 (Multi-level)		Service-2				Efficiency
	Power(%) (Q)	Power(%) (I)	Power (%) Signal Data	Phase Signal Data	Power(%) Signal Pilot	Phase Signal Pilot	
1	9.7	13.5	13.5	I	40.4	I	77.0
2	13.9	19.1	12.1	I	36.2	I	81.2
3	17.7	24.4	10.2	I	30.7	I	83.0
4	25.3	34.9	6.3	I	18.9	I	85.5
5	**10.7**	**14.8**	**14.5**	**I**	**43.5**	**Q**	**83.5**
6	13.9	19.1	12.1	I	36.2	Q	81.3
7	17.2	23.7	10.0	I	29.9	Q	80.7
8	24.5	33.8	6.1	I	18.3	Q	82.7
9	**10.5**	**14.6**	**14.6**	**Q**	**43.8**	**I**	**83.5**
10	13.8	19.1	12.0	Q	36.1	I	81.1
11	17.0	23.5	9.9	Q	29.6	I	80.0
12	24.5	33.8	6.1	Q	18.3	I	82.6
13	10.0	13.7	13.5	Q	40.4	Q	77.6
14	14.0	19.2	12.1	Q	36.4	Q	81.7
15	17.7	24.4	10.3	Q	30.8	Q	83.2
16	25.3	34.8	6.3	Q	18.8	Q	85.1

- **Case #5 & #9** result in optimum performance, considering **higher power of pilot signal of service-2 signal**. Hence, achieved efficiency of proposed multiplexing scheme is **83.5%** approx.

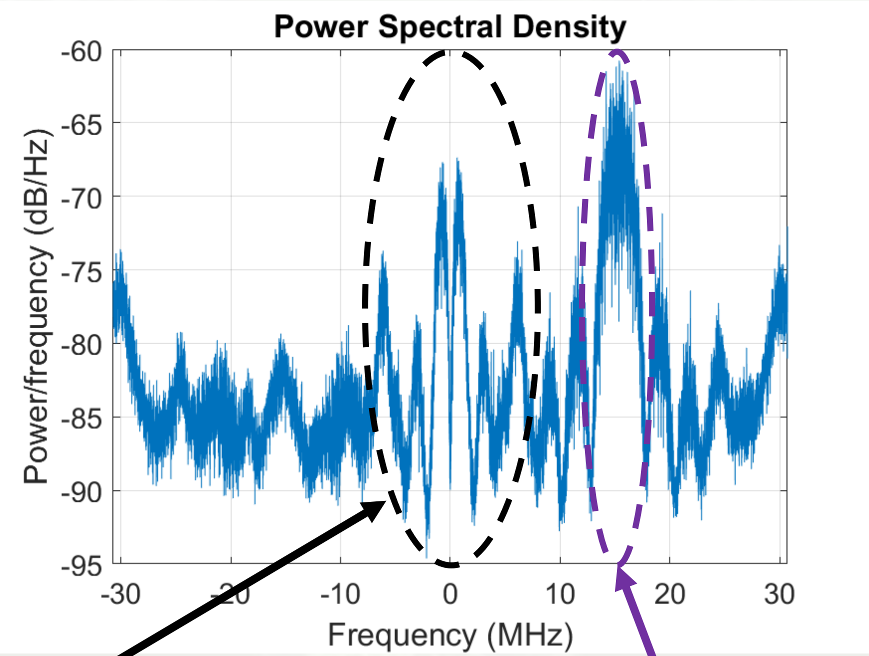
Multilevel & Multi-carrier Multiplexing Results with MCEMIC

Service-2 signal data and pilot component at Δf MHz offset

Constellation of Composite Signal

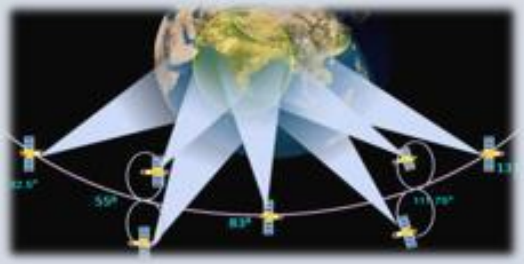


PSD of Composite Signal



Existing Sevice-1 Signal

Service-2 Signal

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