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Intelligent Time Varying Metasurface Transceiver for Index Modulation in 6G Wireless Network

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ABSTRACT: Index modulation (IM) is one of the candidate technologies for the upcoming sixth generation (6G) wireless communications networks. In this paper, we propose a space-time-modulated reconfigurable intelligent metasurface (RI-MTS) that is configured to implement various frequency-domain IM techniques in a multiple-input multiple-output (MIMO) array configuration. Unlike prior works which mostly analyze signal theory of general RI-MTS IM, we present novel electromagnetics-compliant designs of specific IMs such as sub-carrier index modulation (SIM) and MIMO orthogonal frequency-domain modulation IM (MIMO-OFDM-IM). Our full-wave electromagnetic simulations and analytical computations establish the programmable ability of these transceivers to vary the reflection phase and generate frequency harmonics for IM. Our experiments for bit error rate show that RI-MTS-based SIM and MIMO-OFDM-IM are lower than conventional MIMO-OFDM.

KEYWORDS: MIMO,RI-MTS,OFDM.

I. INTRODUCTION

TIME-modulated antenna arrays, whose radiated power pattern is steered by varying the width of the periodic pulses applied to each element, are long known to have applications in side-lobe reduction [1, 2], harmonic beamforming [3], and directional modulation in phased arrays [4]. Such arrays based on metasurfaces (MTSs) have drawn significant interest in the engineering community [5] because of their ability to control and manipulate electromagnetic (EM) waves in a sub-wavelength thickness through modified boundary conditions [6, 7]. The MTS, viewed as a two-dimensional (2-D) equivalent of metamaterials, is a synthetic electromagnetic surface composed of sub-wavelength patches, or meta-atoms, printed on one or more dielectric substrate layers [8]. Through careful engineering of each meta-atom, MTSs can transform an incident EM wave into an arbitrarily tailored transmitted or reflected wavefront [9–12]. Recent developments in spatio-temporally (ST) modulated MTSs have unlocked a new class of nonlinear and nonreciprocal behaviors, including direct modulation of carrier waves [5], programmable frequency conversion [13, 14], controllable frequency harmonic generation [15], and cloaking [15, 16]. These properties are very attractive for designing future low-cost and light-weight wireless communications systems where control of beam-pattern is key to enable reliable and efficient information delivery through massive multiple-input multiple-output (MIMO) antenna arrays [17]. Notably, reconfigurable intelligent MTSs (RI-MTSs) are capable of applying dynamic transformations of EM waves and have been recently proposed as sensors in fifth/sixth-generation (5G/6G) smart radio environments [18]. An RI-MTS employs an array of individually-controllable meta-atoms to scatter incident signals to maximize metrics such as receiver signal-to-noise ratio (SNR) [17]. While several theoretical studies analyze signal processing for 5G/6G RI-MTSs [18–20] and large intelligent surfaces (LISs) [21], their specific EM analyses remain unexamined. Contrary to these works, we focus on EM analysis and implementation of RI-MTSs for wireless communications. In particular, we consider transceiver for index modulation (IM) that is identified as one of the preferred 5G/6G technologies [22] largely because of better energy and spectral efficiencies than conventional modulations [23]. The information in IM is encoded through permutations of indices of spatial, frequency, or temporal media. Common IM techniques [24, 25] include spatial modulation [26] and subcarrier IM (SIM) [27]. Our prior work [28] introduced the concept of RIS-based spatial modulation. Motivated by recent research in ST-modulated MTSs, we hereby propose and demonstrate RIS-based designs for a variety of IM techniques such as frequency shift keying (FSK) [29], and orthogonal frequency-division multiplexing (OFDM) with IM (OFDM-IM) [22, 30], and MIMO-OFDM-IM [31]. We implement these frequency-domain IM techniques using the concepts of ST-modulated metamaterials and reflect-array antennas. Our full-wave EM simulations for meta-atom design validate the scattering radiation pattern of our finite RI-MTS array.

Finally, we validate the RIS performance using wireless communications model and establish that, despite occupying less spectrum, our proposed designs result in bit error rates (BERs) that are lower than traditional OFDM. multiple flat-fading subchannels of equal bandwidth [32]. Unlike standard frequency domain modulation where the carriers are non-overlapping and separated by additional guard bands, the gap between OFDM subcarriers is equal to the inverse of the symbol duration. The resulting overlap of subcarriers, with the peak of one coinciding with the nulls of the other, increases the spectral efficiency [33]. Each one of the N_s symbols independently modulates one of the equi-bandwidth OFDM subcarriers that are transmitted simultaneously. The sum of the modulated signals is the complex baseband OFDM signal

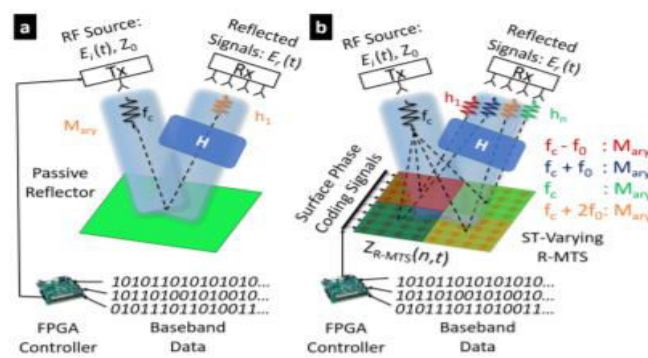


Fig. 1. (a) Simplified illustration of a conventional M-ary phase shift keying (PSK) system

II. LITERATURE SURVEY

Certain experiments have been Performed from past few years by different research and development groups . Here are some of the following groups:

- [1] J. Huang and J. Encinar, Reflectarray Antennas, ser. IEEE Press Series on Electromagnetic Wave Theory. Wiley, 2007. [42] R. C. Cumming, "The serrodyne frequency translator," Proceedings of the IRE, vol. 45, no. 2, pp. 175–186, 1957.
- [2] Z. Wu and A. Grbic, "Serrodyne frequency translation using time-modulated metasurfaces," IEEE Transactions on Antennas and Propagation, 2019.
- [44] MACOM. (2020) Solderable GaAs constant gamma flip-chip varactor diode. [Online]. Available: <https://www.macom.com/products/product-detail/MAVR-000120-14110P>
- [3] M. K. Samimi, G. R. MacCartney, S. Sun, and T. S. Rappaport, "28 GHz millimeter-wave ultrawideband small-scale fading models in wireless channels," in IEEE Vehicular Technology Conference, 2016, pp. 1–6.
- [4] Y. Han, W. Tang, S. Jin, C.-K. Wen, and X. Ma, "Large intelligent surface-assisted wireless communication exploiting statistical CSI," IEEE Transactions on Vehicular Technology, vol. 68, no. 8, pp. 8238–8242, 2019
- [5] A. M. Elbir and K. V. Mishra, "Joint antenna selection and hybrid beamformer design using unquantized and quantized deep learning networks," IEEE Transactions on Wireless Communications, vol. 19, no. 3, pp. 1677–1688, 2020

III. PROPOSED SYSTEM

The block diagram of the MIMO-OFDM-IM transceiver is shown. We consider a MIMO system employing transmit and receive antennas. As seen from, for the transmission of each frame, a total of information bits enter the MIMO-OFDM-IM transmitter. These bits are first split into groups and the corresponding bits are processed in each branch of the transmitter by the OFDM index modulators. The incoming information bits are used to form the OFDM-IM block , in each branch of the transmitter, where is the size of the fast Fourier transform (FFT) and . According to the OFDM-IM principle, these bits are split into groups each containing bits, which are used to form OFDM-IM sub blocks, of length N .

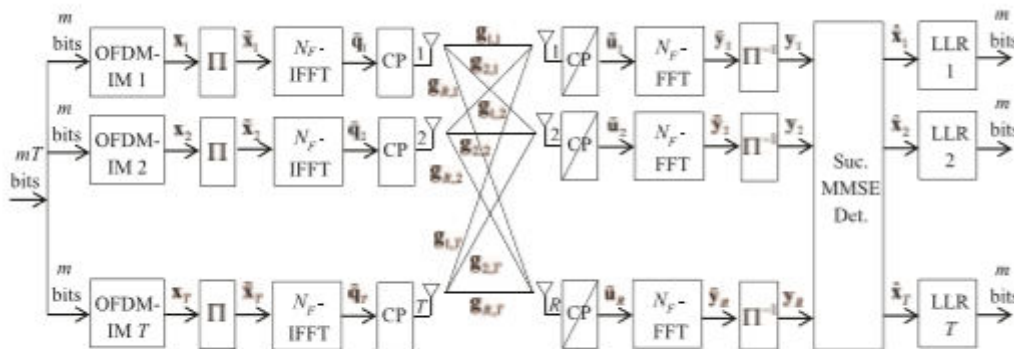


Fig. 1. Transceiver Structure of the MIMO-OFDM-IM Scheme for a $T \times R$ MIMO System.

to the corresponding bits, only out of available subcarriers are selected as active by the index selector at each sub block, while the remaining subcarriers are inactive and set to zero. On the other hand, the remaining bits are mapped onto the considered M-ary signal constellation. Therefore, unlike classical MIMO-OFDM, contains some zero terms whose positions carry information for MIMO-OFDM-IM. In this study, active subcarrier index selection is performed by the reference look-up tables at OFDM index modulators of the transmitter. The considered reference look-up tables for and are given in Tables I and II, respectively, where for. As seen from Table I, for and, the incoming bits can be used to select the indices of the two active subcarriers out of four available sub carriers according to the reference look-up table of size. The OFDM index modulators in each branch of the transmitter obtain the OFDM-IM sub blocks first and then concatenate these sub blocks to form the main OFDM blocks. In order to transmit the elements of the sub blocks from uncorrelated channels, block interleavers are employed at the transmitter. The block interleaved OFDM-IM frames are processed by the inverse FFT (IFFT) operators to obtain. We assume that the time-domain OFDM symbols are normalized to have unit energy, i.e., for all. After the addition of cyclic prefix of samples, parallel-to-serial and digital-to analog conversions, the resulting signals sent simultaneously from transmit antennas over a frequency selective Rayleigh fading MIMO channel, where represents the t -tap wireless channel between the transmit antenna and the receive antenna, whose elements are independent and identically distributed with. Assuming the wireless channels remain constant during the transmission of a MIMO-OFDM-IM frame and, after removal of the cyclic prefix and performing FFT operations in each branch of the receiver, the input-output relationship of the MIMO-OFDM-IM scheme in the frequency domain is obtained as (1) for, where is the vector of the received signals for receive antenna, represents the frequency response of the wireless channel between the transmit antenna and receive antenna, and is the vector of noise samples. The elements of and follow and distributions, respectively, where denotes the variance of the noise samples in the frequency domain, which is related to the variance of the noise samples in the time domain as. We define the signal-to-noise ratio (SNR) as where [joules/bit] is the average transmitted energy per bit. The spectral efficiency of the MIMO-OFDM-IM scheme is [bits/s/Hz], which is equal to times that of the OFDM-IM scheme.



IV. FLOWCHART

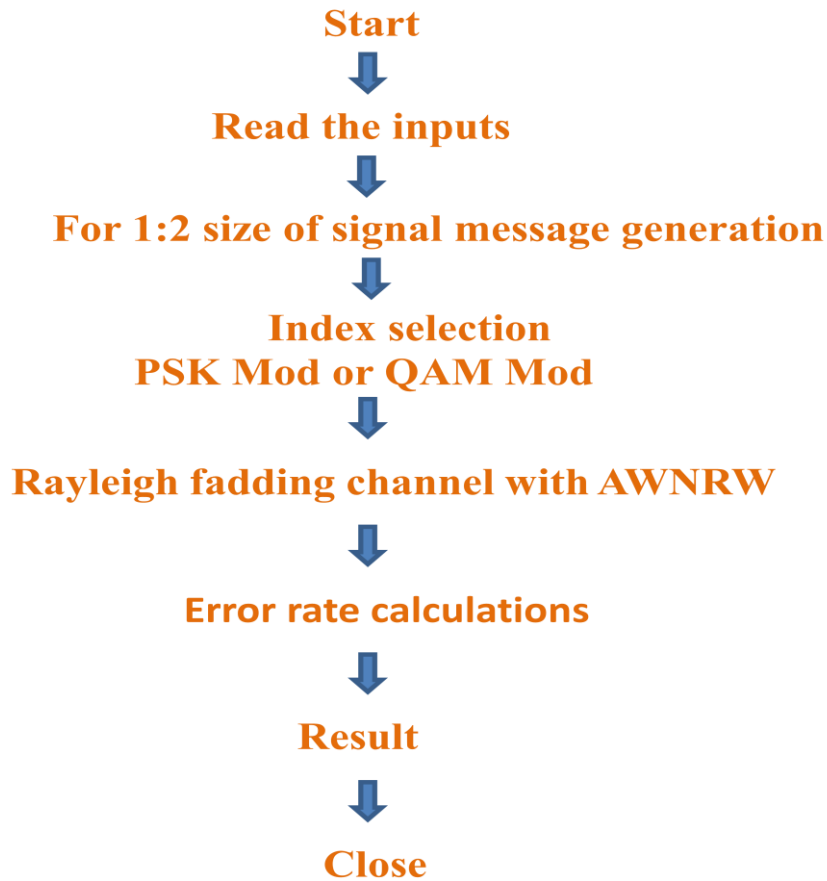


Figure 3.1: Flow chart of the Model.

V. RESULT

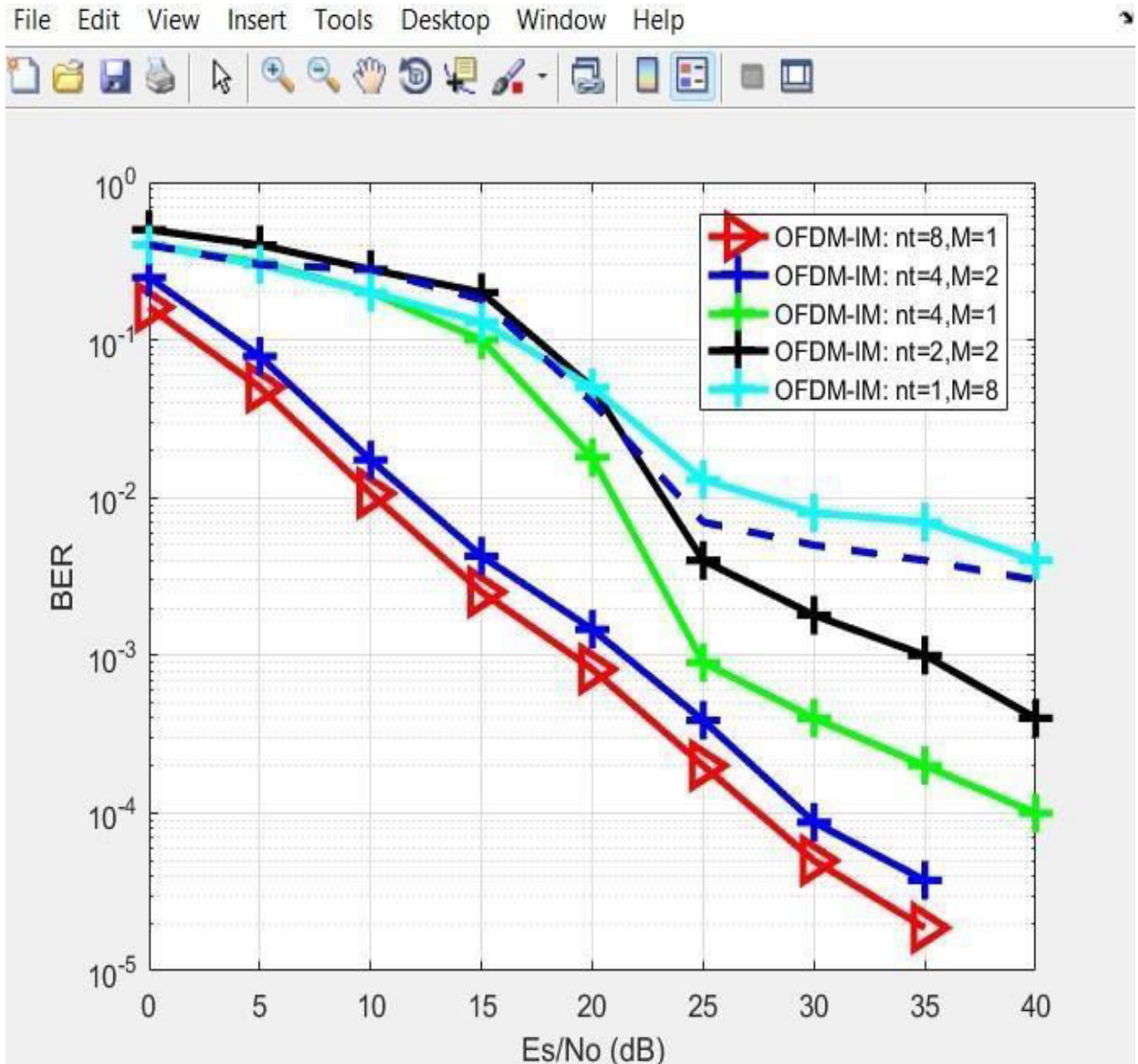
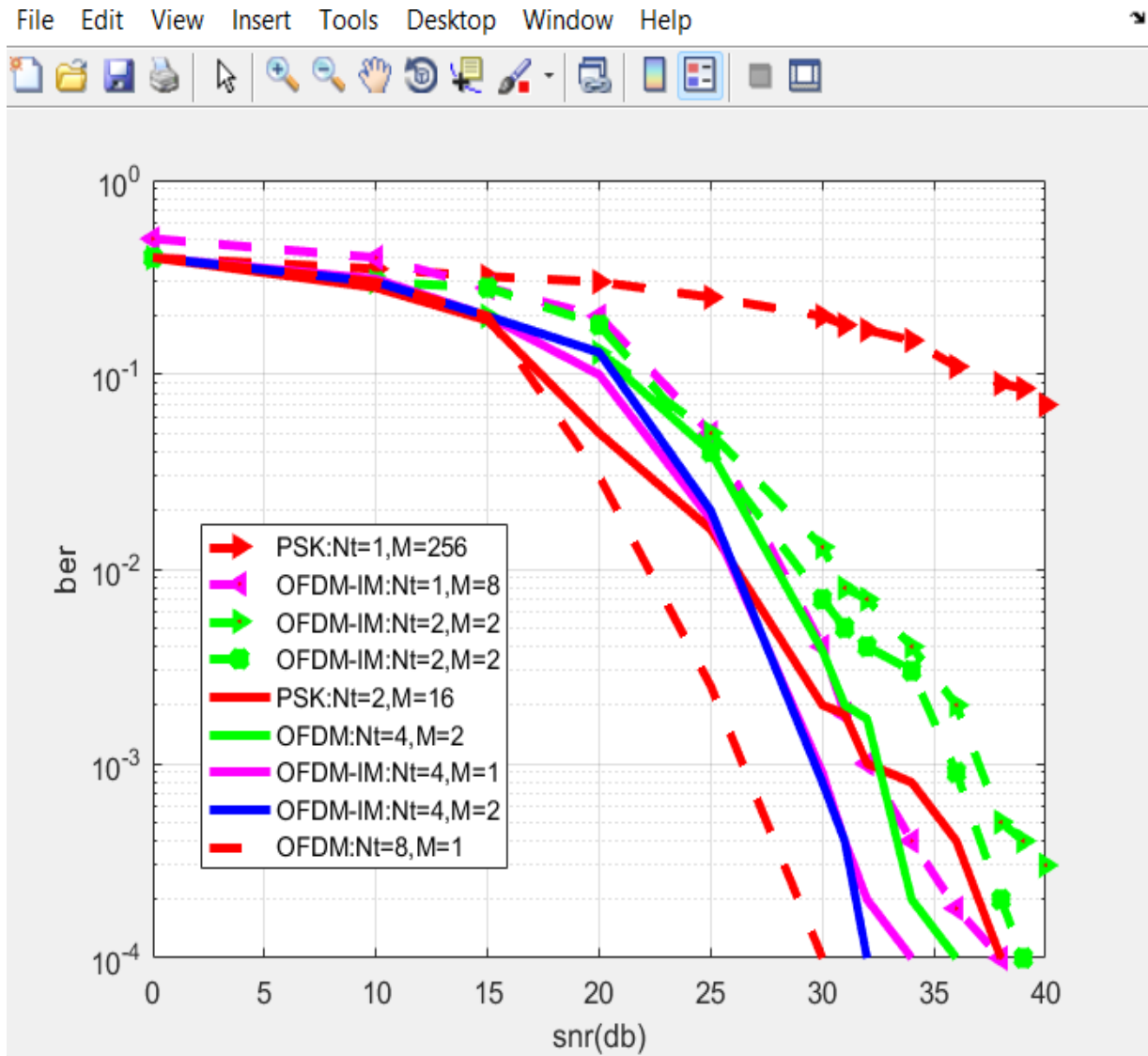


Figure 4.1 Graph compared with M and nt with enlarged lines



Figur 4.2 Graph compared with M and nt

VI. CONCLUSION

We modeled and demonstrated an ST-modulated RI-MTS to perform key IM schemes for 5G/6G wireless networks. Our RIS-based implementations do not require conventional phase shifters, mixers, or a lossy RF manifold network, but need a control network to individually address the antenna elements. Consequently, these RI-MTS architectures hold the promise to achieve direct frequency modulation and beam scanning in significantly less size, weight, and power consumption compared to conventional phased arrays.

FUTURE SCOPE:

Further minimization, bit error rate is resulted.
By using different optimization algorithms, it is possible to reduce power consumption.



REFERENCES

- [1] W. Kummer, A. Villeneuve, T. Fong, and F. Terrio, "Ultra-low sidelobes from time-modulated arrays," *IEEE Transactions on Antennas and Propagation*, vol. 11, no. 6, pp. 633–639, 1963.
- [2] S. Yang, Y. B. Gan, and A. Qing, "Sideband suppression in time-modulated linear arrays by the differential evolution algorithm," *IEEE Antennas and Wireless Propagation Letters*, vol. 1, pp. 173–175, 2002.
- [3] L. Poli, P. Rocca, G. Oliveri, and A. Massa, "Harmonic beamforming in time-modulated linear arrays," *IEEE Transactions on Antennas and Propagation*, vol. 59, no. 7, pp. 2538–2545, 2011.
- [4] M. P. Daly and J. T. Bernhard, "Directional modulation technique for phased arrays," *IEEE Transactions on Antennas and Propagation*, vol. 57, no. 9, pp. 2633–2640, 2009.
- [5] Y. Hadad, D. Sounas, and A. Alu, "Space-time gradient metasurfaces," *Physical Review B*, vol. 92, no. 10, p. 100304, 2015.
- [6] H.-T. Chen, A. J. Taylor, and N. Yu, "A review of metasurfaces: Physics and applications," *Reports on progress in physics*, vol. 79, no. 7, p. 076401, 2016.
- [7] S. B. Glybovski, S. A. Tretyakov, P. A. Belov, Y. S. Kivshar, and C. R. Simovski, "Metasurfaces: From microwaves to visible," *Physics Reports*, vol. 634, pp. 1–72, 2016.
- [8] Q. Nguyen, K. V. Mishra, and A. I. Zaghoul, "Retrieval of polarizability matrix for metamaterials," in *IEEE International Conference on Microwaves, Communications, Antennas and Electronic Systems*, 2019, pp. 1–5.
- [9] J. A. Hodge, K. V. Mishra, and A. I. Zaghoul, "RF metasurface array design using deep convolutional generative adversarial networks," in *IEEE International Symposium on Phased Array Systems and Technology*, 2019.
- [10] —, "Joint multi-layer GAN-based design of tensorial RF metasurfaces," in *IEEE International Workshop on Machine Learning for Signal Processing*, 2019, pp. 1–6.
- [11] —, "Multi-discriminator distributed generative model for multi-layer RF metasurface discovery," in *IEEE Global Conference on Signal and Information Processing*, 2019.
- [12] J. A. Hodge, Q. M. Nguyen, and A. I. Zaghoul, "Reflective beam steering of metasurface using circular interdigitated self-phased pixels/cells," in *General Assembly and Scientific Symposium (GASS) of the International Union of Radio Science (URSI)*, 2020, in-press.
- [13] M. M. Salary, S. Jafar-Zanjani, and H. Mosallaei, "Electrically tunable harmonics in time-modulated metasurfaces for wavefront engineering," *New Journal of Physics*, vol. 20, no. 12, p. 123023, 2018.
- [14] L. Zhang, X. Q. Chen, S. Liu, Q. Zhang, J. Zhao, J. Y. Dai, G. D. Bai, X. Wan, Q. Cheng, G. Castaldi, V. Galdi, and T. J. Cui, "Space-time-coding digital metasurfaces," *Nature Communications*, vol. 9, no. 1, p. 4334, 2018.
- [15] A. M. Shaltout, V. M. Shalaev, and M. L. Brongersma, "Spatiotemporal light control with active metasurfaces," *Science*, vol. 364, no. 6441, p. 3100, 2019.



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