Assessment of Parameters in Integrated Photonic Systems Through the Analysis of Interdependencies with the MICMAC Technique

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Abstract: The integration of photonic components into embedded systems represents a transformative opportunity for the advancement of information processing and communication technologies. This study, titled, aims to identify and classify the critical parameters that impact the performance of integrated photonic systems. Through an exhaustive literature review, eleven key parameters were selected. The results of the MICMAC analysis revealed that parameters, keys, and determinants, are autonomous and dependent. These findings provide valuable insights for the design and development of more efficient and robust integrated photonic systems. The study concludes with recommendations for future research and practical strategies to optimize these parameters and improve overall system performance.

Keywords: Integrated systems, MICMAC, interdependencies, Crosstalk, dispersion.

1. Introduction

The growing demand for faster and more efficient communication technologies has driven the development of integrated photonic systems, which have emerged as a promising solution to overcome the limitations of conventional electronic systems (Pelucchi et al., 2022). These systems take advantage of the properties of light to transmit and process information, offering significant advantages in terms of speed, bandwidth, and energy efficiency. However, the complexity inherent in integrating multiple photonic components on a single chip presents substantial technical challenges that must be addressed to optimize the performance and commercial viability of these technologies (Thomson et al., 2016).

In this context, the assessment and optimization of the key parameters that influence the operation of integrated photonic systems is crucial. The MICMAC technique (Multiplication Cross Impact Matrix Applied to a Classification) is presented as a beneficial tool to identify and analyze the interdependencies between these parameters (Godde et al., 2021). This technique allows parameters to be categorized according to their influence and dependence, providing a clear view of the internal dynamics of the system and facilitating a holistic approach in the design and optimization of photonic components. Likewise, this technique has been used in various studies for this purpose. For example, Martelo et al. (2018) used it to identify the key variables necessary to develop programmatic proposals in universities, thus demonstrating its usefulness.

On the other hand, research in integrated photonic systems has advanced significantly in recent decades, driven by the need to improve the speed and efficiency of communication and information processing systems. For example, Roelkens et al. (2014) focused on photonic integration technologies for telecommunications applications. The authors analyzed the key parameters that impact signal quality (SQ) and transmission capacity. Similarly, Peltier et al. (2024), in their research examined the response speed and bandwidth of these devices. They identified that the response speed is strongly influenced by the capacitance and resistance of the device, which in turn affects the overall efficiency of the system. These studies show a clear evolution in the understanding and optimization of integrated photonic systems.

Therefore, this study aims to identify and classify the critical parameters that affect the performance of integrated photonic systems. Through this analysis, it is expected to provide practical guidance for researchers and developers, facilitating the design of more efficient and robust integrated photonic systems. The application of the MICMAC technique allows not only to identify critical parameters but also to understand the complex interrelationships that determine the overall performance of the system, thus promoting significant advances in the integration and application of photonic technologies.

2. Methodology

This study is descriptive and exploratory, focused on identifying and analyzing the key parameters of integrated photonic systems and evaluating their interdependencies. It was exploratory in nature because concepts or phenomena are defined or identified and a literature review is carried out to produce an initial knowledge base on the topic and identify important variables and possible relationships between them (Swedberg, 2020). It is descriptive because it focuses on accurately describing characteristics, behaviors, or phenomena, documenting and analyzing events as they are (Mohajan, 2018).

The methodological approach is mixed, combining qualitative and quantitative methods according to the proposal of Sampieri (2018), to provide a comprehensive understanding of the parameters of interest. In this context, qualitative methods were used to explore in depth the characteristics and definitions of key parameters, through extensive literature review and expert consultation through expert panels. This qualitative approach allowed the researchers to capture the richness and complexity of the concepts investigated, providing a robust conceptual framework.

On the other hand, quantitative methods were applied to measure and analyze the influence relationships between the identified parameters, using the MICMAC technique. This combination of approaches allowed the researchers not only to understand the parameters from a theoretical and conceptual perspective but also to quantify their interactions and dependencies precisely, offering an overview of the system studied.

The research design is non-experimental and transversal, considering that variables were not directly manipulated, but rather they were observed and analyzed in their natural context at a specific moment in time (Maier et al., 2023). This means that the data was collected at a single point in time, providing a snapshot of the current conditions and interrelationships between the parameters of the integrated photonic systems. This approach allows descriptive and exploratory analyses to be carried out without the influence of manipulated external variables, ensuring that the findings faithfully reflect the natural state of the system under study. This design is especially suitable for initial or exploratory studies such as this one because it facilitates the identification of trends and patterns without requiring longitudinal follow-up.

In this sense, the purpose of this study was to identify and select the key parameters of integrated photonic systems. To achieve this, a search was carried out for scientific articles, books, theses, and technical reports in academic databases such as IEEE Xplore, Scopus, and Google Scholar, among others, using specific search terms and defined search dates. Clear criteria were defined to include relevant studies, such as those analyzing the efficiency, stability, and compatibility of integrated photonic systems, and non-relevant studies were excluded.

Key parameters mentioned in the literature were identified, noting their definitions, application contexts, and measurement methods. Those most frequently mentioned and most relevant were selected, and experts in integrated photonics were consulted to validate the relevance of the selected parameters. The experts were selected based on their experience and recognition in the field, ensuring strong validation.

With the final list of parameters, a matrix was established in which the direct influence relationships between each pair of parameters were evaluated. The scale defined in the MICMAC technique was used to measure the degree of influence: 0: no influence, 1: weak influence, 2: moderate influence, 3: strong influence. The expert consultation method was used to fill out the cross-impact matrix. Similarly, the sums of the columns and rows of the matrix were calculated to determine the dependencies and influences of each parameter, classifying them into four categories (keys, determinants, autonomous, and results) based on their influence and dependence values.

3. Results

The findings of the assessment of parameters in integrated photonic systems through the analysis of interdependencies using the MICMAC technique are presented below. Initially, the results obtained from the bibliographic review and consultations with experts are described, which allowed the identification and selection of the 11 most relevant parameters. Subsequently, the process of constructing the cross-impact matrix and the analysis of the influences and dependencies of each parameter is detailed. Finally, a classification of these parameters into the four MICMAC categories (key, determinant, autonomous, and dependent) is provided, providing a comprehensive view of their interactions and their impact on the overall performance of the integrated photonic system. These results are fundamental to understand the internal dynamics of the system and to guide future efforts in design and optimization.

Firstly, the bibliographic review made it possible to identify the 15 most frequently mentioned and most relevant parameters. Table 1, composed of four columns, shows the list of these parameters. Column 1 indicates the parameter number, column 2 the parameter name, while columns 3 and 4 refer to the description and relevance of the parameters, respectively.

Table 1. Lists of parameters identified in the literature.

#	Parameter	Description	Relevance
1	Insertion loss	Measurement of signal loss when light passes through a photonic component.	It affects the overall efficiency of the system.
2	Attenuation	Reduction in signal intensity as it propagates through the photonic medium.	Crucial for long distance transmission.
3	Quantum efficiency	Fraction of incident photons that generate a carrier (electron or hole) in a photonic detector.	Important for the sensitivity of detectors and communication systems.
4	Bandwidth	Frequency range in which the photonic system can operate efficiently.	Determines the data transmission capacity.
5	Response speed	Time it takes for a photonic component to react to an input signal.	It affects the speed of processing and communication.
6	Signal-to-noise ratio	Measurement of the relationship between signal power and background noise power.	Affects data transmission quality and detection accuracy
7	Dispersion	Propagation of different components of an optical signal at different speeds.	It may cause distortion in the transmitted signal.
8	Thermal stability	Ability of photonic components to maintain their performance in the face of temperature variations.	Important for system reliability and consistency in different environmental conditions.
9	Device size	Physical space occupied by photonic components.	Important for miniaturization and integration density.
10	CMOS support	Ability to integrate photonic components with CMOS technology for mass production.	Facilitates the integration and scalability of photonic systems.
11	Manufacturing cost	Expenses associated with the production of photonic components.	It influences the commercial viability and adoption of technology.
12	Operating Wavelength	Specific wavelength at which the photonic component operates efficiently.	Alignment with standard telecom windows (e.g. 1550 nm).
13	Crosstalk	Interference between adjacent optical channels.	It affects the quality and reliability of data transmission.
14	Loss-dependent polarization	Variation in insertion loss with respect to light polarization.	Affects signal consistency in communication systems.
15	Energy consumption	Amount of energy used by photonic components during operation.	Crucial for the energy efficiency and sustainability of the system.

Source: Authors

On the other hand, with the help of experts, 11 of the 15 identified parameters were selected to be subjected to structural analysis using the MICMAC technique. Table 2 shows the 11 selected parameters. Each parameter was assigned a short name to facilitate the application of the technique. For example, parameter 1, "Insertion loss", was assigned the short name "P1". In this way, a key name was assigned to each parameter.

Table 2. Selected parameters to apply MICMAC

#	Parameter	Short Name
1	Insertion loss	P1
2	Attenuation	P2
3	Quantum efficiency	P3
4	Bandwidth	P4
5	Response speed	P5
6	Signal-to-noise ratio	P6
7	Dispersion	P7
8	Thermal stability	P8
9	CMOS support	P9
10	Energy consumption	P10
11	Crosstalk	P11

Source: Authors

Once the parameters were selected, an 11 x 11 matrix was constructed and, with the support of a panel of six experts, the MICMAC matrix was assessed through collective reflection. In this analysis, the direct influence and dependence relationships between the selected parameters were evaluated.

For example, the relationship of parameter P1 (Insertion loss) to itself is null. However, the relationship of P1 with P2 (Attenuation) is moderate (valued at 2). Similarly, P1 has a moderate relationship with P3 (Quantum efficiency), P4 (Bandwidth), and P5 (Response speed). In contrast, the relationship of P1 with parameter P6 (Signal-to-noise ratio) is strong (valued at 3). This assessment process was repeated for each parameter, determining the precise interactions between them.

The influence or direct dependence relationships between each parameter are represented in Figure 1, which shows the Matrix of direct influence or dependence. This figure provides a clear visualization of how each parameter influences and is influenced by the others, offering a detailed understanding of the structure of interdependencies within the evaluated system.

Influence ↱	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11
P1	0	2	2	2	2	3	3	2	2	2	0
P2	1	0	1	3	2	3	2	3	1	1	2
P3	3	2	0	0	2	1	2	2	0	1	1
P4	3	2	1	0	2	2	3	0	1	3	2
P5	2	2	1	2	0	2	1	1	2	1	0
P6	2	3	2	3	2	0	2	0	2	1	1
P7	1	3	2	2	3	3	0	2	1	2	2
P8	0	2	3	1	0	2	1	0	1	0	0
P9	1	2	3	2	2	2	3	1	0	2	1
P10	2	2	1	2	1	3	2	2	2	0	1
P11	1	2	3	2	1	2	2	0	1	1	0

Figure 1. Matrix of direct influence or dependence

Source: Authors

After filling out the MICMAC matrix, the next step in the structural analysis involves several key stages to interpret and exploit the information obtained. Below are the steps that follow:

First, the influence and dependence indices are calculated for each parameter by adding the rows and columns of the MICMAC matrix. The influence index is obtained by adding the relations in the row corresponding to a parameter, while the dependence index is obtained by adding the relations in the corresponding column. In this sense, Table 3 shows the sum of the relationships of each parameter.

Table 3. The sum of influence dependence relationships of each parameter

#	Parameter	Total of lines	Total columns
1	P1 (Insertion loss)	20	16
2	P2 (Attenuation)	19	22
3	P3 (Quantum efficiency)	14	19
4	P4 (Bandwidth)	19	19
5	P5 (Response speed)	14	17
6	P6 (Signal-to-noise ratio)	18	23
7	P7 (Dispersion)	21	21
8	P8 (Thermal stability)	10	13
9	P9 (CMOS support)	19	13
10	P10 (Energy consumption)	18	14
11	P11 (Crosstalk)	15	10
Totals		**187**	**187**

Source: Authors

As can be seen, the sum of the row (influence relations) of parameter P1 (Insertion loss) is 20, while the sum of the column (dependency relations) is 16. Which gives rise to its location in the plane of direct influence/dependence and in turn its classification. On the other hand, following the previous logic, the parameter P2 (Attenuation) obtains a sum of 19 in the row and 22 in the column, which makes it unique and classifies it in the plane of direct influence/dependence. In this sense, the parameters are classified into four basic categories based on their influence and dependence indices:

Keys: parameters with high influence and high dependence (they interact strongly with other parameters and can be key in the dynamics of the system). Determinants: parameters with high influence and low dependence (drive the system). Autonomous: parameters with low influence and low dependence. (they have little interaction with other parameters). Dependent (or results): parameters with low influence and high dependence (they are affected by other parameters).

The next step is to prepare a scatter plot (influence-dependence diagram) where the parameters are represented based on their influence and dependence indices. This helps visualize the position and role of each parameter within the system. Below, Figure 2 shows the direct influence/dependence diagram or plane.

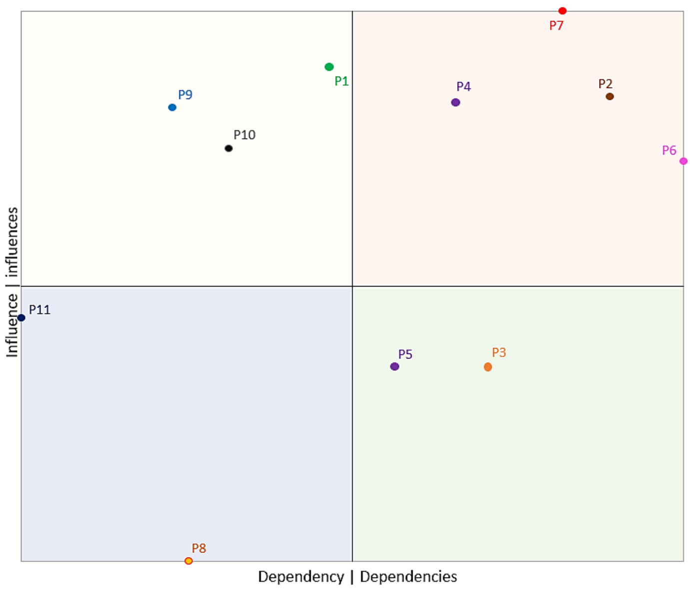

Figure 2. Plane of direct influence/dependence

Source: Authors

Table 4 provides a detailed explanation of the acquired results, offering a clear and organized representation of the data. It breaks down the selected parameters along with their respective classifications, allowing for a more precise and accessible interpretation of the findings. By presenting the information in a structured way, Table 4 facilitates the understanding of the analysis, helping to identify the classification of each parameter quickly.

Table 4. Classification of Factors by Direct Dependencies Influences

Parameter Type	Parameter	Code
Key, strategic, or challenge parameters	Attenuation	P2
	Bandwidth	P4
	Signal-to-noise ratio	P6
	Dispersion	P7

Determinant or "influencing" parameters	Insertion loss	P1
	CMOS support	P9
	Energy consumption	P10
Autonomous or independent parameters	Thermal stability	P8
	Crosstalk	P11
Dependent or result parameters	Quantum efficiency	P3
	Response speed	P5

Source: Authors

As seen in Table 4, the parameters classified with high influence and high dependence (key) were Attenuation, Width, Signal-to-noise ratio, and Dispersion.

In the case of Attenuation, given its interconnection and influence with various critical parameters of the photonic system, it is reasonable to classify it as a parameter with high influence and high dependence. Its high influence is due to its direct impact on the SQ and the need for signal amplification or regeneration in case of high attenuation. On the other hand, its high dependence is explained by its sensitivity to the characteristics of the transmission medium and the operating conditions of the system. This result highlights the complexity of managing attenuation and the need for a comprehensive approach to minimize its adverse effects.

Attenuation refers to the reduction in signal intensity as it propagates through the photonic medium. According to Nellore & Polasi (2022), high attenuation can significantly degrade the SQ, affecting critical parameters such as the signal-to-noise ratio (SNR). While for Ali & Farhood (2019), an increase in attenuation reduces transmission efficiency, which may force the use of optical amplifiers or signal regeneration techniques, thus increasing energy consumption and operating costs. On the other hand, according to Shukla et al. (2019), attenuation depends largely on the physical properties of the transmission medium, such as the type of optical fiber (OF) used, the quality of the material, and the operating wavelength, so variations in these factors directly impact the degree of attenuation.

Regarding the classification of Bandwidth as a key parameter, it was due to its ability to determine the data transmission rate and SQ, which gives it a high influence, while its susceptibility to factors such as dispersion, attenuation, and the characteristics of the materials demonstrate their high dependence. This duality underscores the need for careful and balanced bandwidth management in the design and operation of photonic systems, ensuring that both individual components and the interactions between them are optimized to achieve optimal performance.

Bandwidth directly affects SQ. According to Kaushik et al. (2023), insufficient bandwidth can cause information loss and signal distortion, affecting the reliability and accuracy of transmission. While for Torres & Weiner (2014), the ability of the photonic system to operate within certain bandwidth ranges determines its compatibility with technological and communication standards. These aspects make this parameter very influential. On the other hand, its dependence lies in the fact that parameters such as attenuation affect the signal intensity through the system bandwidth, and dispersion can limit the usable bandwidth by causing pulse widening and temporal distortion.

For its part, the classification of Signal-to-noise ratio (SNR) as a parameter with high influence and high dependence reflects its central importance in the performance of integrated photonic systems. Its ability to determine the SQ and reliability of data transmission gives it high influence. At the same time, its sensitivity to variations in attenuation, dispersion, insertion loss, and other factors demonstrates its high dependence.

SNR is a direct measure of the received SQ compared to the background noise. Xu et al (2020) state that a high SNR indicates a clear and discernible signal, which is essential for accurate and efficient data transmission. According to Alam et al. (2011), a low SNR can result in transmission errors, data loss, and the need for retransmissions, affecting system reliability and performance. While Coddington et al (2010) state that a good SNR allows the effective use of a wider bandwidth, improving data transmission rates. Regarding dependence, the SNR depends on the attenuation of the system, since higher attenuation reduces the signal power and can increase the noise ratio. Likewise, a higher insertion loss can reduce the SNR, because the signal becomes weaker and the relative noise becomes more significant.

Regarding the classification of Dispersion as a key parameter, it suggests that this parameter has a critical role in the operation of integrated photonic systems. Its high influence is due to its ability to distort signals and limit effective bandwidth, affecting the quality and speed of data transmission. At the same time, its high dependence reflects how factors such as OF type, wavelength, and system design determine the degree of dispersion.

According to Eggleton et al. (2013), dispersion causes the widening of optical pulses as they travel through the transmission medium, which can cause overlapping of adjacent pulses, leading to signal distortion and errors in interpretation. of the data. For Liang, et al. (2022), dispersion limits the effective bandwidth capacity of the system. While for Illienko et al. (2024), dispersion affects SQ by increasing temporal noise and reducing the clarity of optical pulses. Regarding the dependence, for Röhlig et al. 2023), the dispersion depends on the architecture of the photonic system, the type of OF used, and the properties of the material, including the layout and type of optical components.

Regarding parameters with high influence and low dependence (Determinants). They significantly affect other parameters and are key to the operation of the system. Among those classified as such, there are: Insertion loss, CMOS support, Energy consumption.

The classification of Insertion loss as a determining parameter is because it is a crucial parameter in the efficiency and overall performance of the integrated photonic system. Its high influence on SQ, transmission efficiency, and power requirement underlines its importance in the design and operation of these systems. At the same time, its relative independence from other parameters allows it to be optimized in a targeted manner, making it a key point of attention to improve the reliability and efficiency of photonic systems. Manipulating insertion loss effectively can have a significant positive impact on system performance, allowing for better signal management, greater power efficiency, and greater compatibility with advanced technologies such as CMOS. For these reasons, it is considered a determining parameter in the MICMAC analysis of integrated photonic systems.

According to Garcia-Rodriguez et al. (2017), a high insertion loss reduces the signal power available for transmission, decreasing the overall efficiency of the system. While for Hiari &

Mesleh (2018), the insertion loss has a cascade effect on other parameters of the system. For example, it affects overall attenuation, dispersion (by requiring higher signal powers that can exacerbate dispersion problems), and compatibility with CMOS technology (where insertion loss management is critical to maintaining system efficiency). Regarding dependence, according to Zhu et al. (2023), although insertion loss can be influenced by the operating environment (such as temperature), it generally does not depend directly on other operating parameters of the system.

Regarding the classification of CMOS support as a determinant parameter, it reflects its strategic importance for the integration, manufacturing, and marketing of integrated photonic systems. Its high influence is due to its ability to enable the integration of photonic technology with advanced electronics, improve scalability, and reduce production costs, as well as ensure operational reliability in standard electronic environments. On the other hand, the low dependence on this parameter indicates that, although it is critical for the initial design and manufacturing of the components, it is not significantly affected by variations in other operating parameters of the system.

According to Tong (2014), CMOS support allows the integration of photonic components with electronic circuits on the same platform, facilitating the creation of hybrid optoelectronic systems. Likewise, Stojanović et al. (2018), state that this parameter allows taking advantage of economies of scale and existing advanced manufacturing techniques, which is essential for the mass production of photonic components efficiently and economically. Regarding dependency, although CMOS support has specific requirements, once it is achieved, it does not depend significantly on other operating parameters of the system, similarly, CMOS support is achieved by optimizing manufacturing processes and used materials.

In reference to the classification of Energy consumption as a determinant parameter, it reflects its central importance in the operation and viability of integrated photonic systems. Its high influence is manifested in its ability to increase operational efficiency, reduce costs, comply with environmental regulations, and simplify thermal design, which is crucial for long-term reliability. While its relative independence from other operating parameters allows energy consumption to be optimized directly and specifically during the design and component selection phase. The above ensures that the system can operate efficiently and sustainably, regardless of variations in other parameters.

According to Thraskias et al. (2018), energy consumption is a determinant factor in the operational efficiency of photonic systems. While Mahgerefteh et al. (2016), state that lower energy consumption reduces operational costs, which is significant for the commercial viability of photonic systems. Regarding dependency, although energy consumption is influenced by system design and choice of components, once it is optimized for low energy, it does not depend strongly on other operating parameters.

On the other hand, the parameters with low influence and low dependence (Autonomous). They are generally independent and do not significantly affect other parameters. In this category, 2 parameters were classified: Crosstalk, and Thermal stability.

The classification of crosstalk as an autonomous parameter reflects its specific nature and relative independence from interactions with other parameters in integrated photonic systems.

Although crucial for SQ and data integrity in adjacent channels, its management and optimization can be done in isolation, focusing directly on physical design and isolation techniques. This allows crosstalk to be treated as a specialized problem that can be solved without the added complexity of interdependence with other critical system parameters. This autonomy in its optimization ensures that the photonic systems can operate efficiently, maintaining the SQ and minimizing interference between channels without affecting other operational aspects of the system.

According to Bassam et al. (2009), it is a specific and localized phenomenon, which mainly impacts the SQ within the channels directly involved. Likewise, Prince et al. (2022) state that while crosstalk can affect the SQ in terms of noise and interference, its effect does not extend significantly to other parameters such as dispersion, attenuation, or energy consumption. Regarding the low dependency, the physical proximity of the channels and the quality of the isolation determine the level of crosstalk, and these characteristics can be designed and optimized independently of other system parameters.

Classifying Thermal stability as an autonomous parameter suggests its relative independence from other parameters in integrated photonic systems. Although crucial for reliable operation under temperature variations, its management and optimization can be directly focused on thermal design and material selection. The autonomy of this parameter allows thermal stability to be addressed as a specialized aspect of the design, which can be improved without the need to make complex adjustments to other operating parameters of the system. By addressing thermal stability autonomously, it is ensured that the photonic system can maintain optimal performance under various thermal conditions, thus ensuring reliability and consistency of performance over time.

According to Ou et al. (2024), thermal stability has a rather localized effect on the thermal behavior of specific materials and components, rather than directly influencing a wide range of other operating parameters such as crosstalk, dispersion, or attenuation. On the other hand, Healy (2020) states that thermal stability is largely subject to the design of the components and the selection of materials. Materials with adequate thermal expansion coefficients and components designed to operate within a wide temperature range are essential to achieve good thermal stability. These factors can be optimized independently, without requiring changes to other operating parameters.

Finally, the parameters with high dependence and low influence (Dependent or Results). They are affected by many other parameters, but do not significantly influence others. The classification of Quantum efficiency as a dependent parameter reflects its close interrelationship with other parameters and factors of the photonic system. Its high dependence on the quality of materials, device design, operating wavelength, temperature, and pumping energy shows that it cannot be considered in isolation. To optimize quantum efficiency, it is necessary to take into account and possibly adjust a variety of other system parameters.

According to Zada et al (2020), quantum efficiency, which measures the proportion of photons converted to electrons (or vice versa) in a photonic device, is strongly influenced by the quality of the materials used in the detectors and emitters. Impurities, defects, and the quality of interfaces can significantly affect quantum efficiency. Likewise, Guo et al. (2021) state that the quantum efficiency varies with the wavelength of the light used. Photonic devices are typically optimized to operate at specific wavelengths, and quantum efficiency can be significantly reduced outside of these optimal ranges.

Regarding the classification of Response speed as a dependent parameter, it reflects its strong interrelationship with several other critical parameters in integrated photonic systems. Its optimal performance requires careful consideration and adjustment of materials, component design, quantum efficiency, capacitance, resistance, and thermal conditions. Likewise, response speed cannot be optimized in isolation, since it depends on a set of factors that must be balanced and optimized together.

According to Jiang et al. (2021), the response speed of a photonic system is largely subject to the properties of the materials used and the design of the components. Materials with fast response times, such as certain semiconductors, and optimized device designs, such as photodetectors and modulators, are essential to achieving high response speeds. Likewise, quantum efficiency directly affects response speed. While temperature affects the mobility of charge carriers in semiconductor materials, which influences response speed. Therefore, Response speed is considered a dependent parameter in the MICMAC analysis of integrated photonic systems, highlighting the need for a careful and coordinated integration of multiple factors to achieve optimal performance.

4. Conclusions

This study has provided a comprehensive assessment of critical parameters in integrated photonic systems using the MICMAC technique, identifying interdependencies and categorizing each parameter according to its influence and dependence. The main and most relevant conclusions of the analysis are presented below:

11 key parameters have been identified that affect the performance and viability of integrated photonic systems: Bandwidth, Attenuation, CMOS support, Energy consumption, Crosstalk, Dispersion, Quantum efficiency, Thermal stability, Insertion loss, Signal-to-noise ratio, and Response speed.

The MICMAC classification has allowed a clear understanding of the interrelationships between these parameters, highlighting those that are key, determinant, autonomous, and dependent. On the other hand, this study establishes a basis for future research in the field of integrated photonics. The methodologies and conclusions presented here can guide researchers and developers in creating more efficient, scalable, and sustainable systems. Adopting a systematic approach to parameter optimization will enable significant advances in the integration of photonic systems into practical applications, from telecommunications to advanced computing and sensors.

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