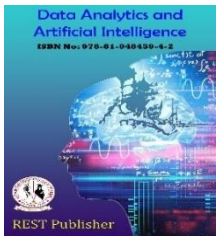
**Data Analytics and Artificial Intelligence**

**Vol: 5(2), 2025**

**REST Publisher; ISBN: 978-81-948459-4-2**

**Website: http://restpublisher.com/book-series/daai/**

**DOI: https://doi.org/10.46632/daai/5/2/12**




# Statistical Reliability and Validity Testing of Signal Processing Evaluation Parameters Using SPSS Processing Speed, Power Efficiency, And Stability Analysis

*Venkata Subba Rao Kakani

*Karwell Technologies, America.

*Corresponding author email: venkatkakani1978@gmail.com

***Abstract:*** *Analog signal processing (ASP) has attracted significant attention because of its high-speed operation and low energy requirements. However, its sensitivity to environmental changes and circuit variations can affect accuracy and system stability. Conventional analogy architectures use amplifiers before converting signals into digital form, whereas digital signal processing enables flexible noise reduction and signal shaping. Efficient quantization and optimized circuit partitioning further improve performance while reducing power consumption and hardware complexity. Recent developments in hybrid architectures, mersister-based computing, residue number systems, and analogy stochastic neurons offer promising solutions for advanced signal processing. Integrating analogy and digital technologies supports compact, reliable, and energy-efficient electronic systems. Applications such as spread-spectrum communications show that analogy designs are better suited for short, high-speed circuits, while digital implementations perform better in longer, low-speed circuits. Advances including residue number systems, mersister crossbars, and analogy stochastic neurons enable compact, high-resolution computation and dynamic system-based processing.*

***Keywords:*** *Analog Signal Processing (ASP), Digital Signal Processing (DSP), Analog-to-Digital Conversion (ADC), Analog Stochastic Neuron (ASN).*

## 1. INTRODUCTION

Analog signal processors have attracted growing attention due to their ability to achieve higher operating speeds and lower power consumption than digital systems. Nevertheless, they are unsuitable for large-scale applications because their strong sensitivity to environmental and structural variations results in substantial measurement inaccuracies and performance instability. [1] In analogy systems, signals are first conditioned using a preamplifier and amplifier before being converted into digital form by an analogy-to-digital converter (ADC). By contrast, digital signal processing (DSP) systems perform digitization directly after the preamplifier at the input stage, enabling greater flexibility in the selection of noise filtering and pulse-shaping settings. [2] The quantize is engineered to approximate signal samples as precisely as possible within the limits set by the available number of representation bits. This study revisits the concept by clarifying the interdependence between sampling and quantization, and investigates the design requirements of sampling systems when constrained by limited bit capacity for storing, transmitting, or processing analogy data. [3] The rising need for sophisticated information processing in portable devices has stimulated substantial research into low-power signal processing system design. A practical way to reduce energy consumption is to transfer part of the input signal processing from the digital processor to analogy circuitry positioned before the analogy-to-digital converter (ADC). [4] In traditional systems, analogy signal processing (ASP) primarily manages front-end amplification and signal conversion, while digital signal processing (DSP) carries out computational operations. Shifting the boundary between these domains can result in substantial savings in power consumption and hardware area. [5] Electronics form a fundamental part of modern detection systems. Although experimental setups and their associated circuitry differ greatly, the core principles for effective electronic readout and enhancing the signal-to-noise ratio remain uniform. This chapter outlines key front-end electronic components and examines signal processing with an emphasis on electronic noise, offering a concise overview due to space limitations. [6] With the increasing integration of analogy and digital circuits on a single chip, designers are encountering greater difficulties in verifying complex mixed-signal systems. The typical approach involves simulating the analogy section, fabricating and testing the mixed-signal

**Copyright@ REST Publisher**

circuit, and iterating this cycle as needed. [7] The increasing commercial interest in spread-spectrum communication has driven research into applications such as programmable matched filters. This study evaluates both antilog and digital implementations of these filters. Analyzing a broad range of design parameters reveals a clear trend: analogy designs are more appropriate for short, high-speed circuits, whereas digital designs are better suited for longer, lower-speed implementations. [8] The increasing commercial interest in spread-spectrum communications has led to investigations into applications like co-programmable matched filters. This study examines both antilog and digital circuit implementations of these filters. Analysis across a broad range of design parameters shows a clear pattern: analogy designs are more suitable for short, high-speed circuits, whereas digital designs are preferable for longer, lower-speed circuits. [9] Over the course of computing history, digital signal processing (DSP) applications—particularly those requiring real-time processing—have continually pushed the boundaries of computational capability. Although the signals handled vary from media-based speech, audio, and video to specialized radar and sonar data, the underlying computational characteristics of most DSP tasks remain largely consistent. [10] In the design of measuring transducers, there is a noticeable shift toward reducing analogy circuitry and performing A/D conversion at the very start of the signal-conditioning process. In certain cases, like digital line and disk encoders, the A/D conversion takes place directly within the sensor. For frequency-output sensors, digital conversion is simple and only needs a counter. Other sensors with electrical outputs still require extra analogy circuitry to transform the signal into a DC voltage suitable for A/D conversion. [11] Each sub-operation for a specific modulus needs precision only appropriate to that modulus. When the outcomes of these lower-precision sub-operations are combined, a significantly higher overall resolution is achieved. Incorporating FWS into ADC pre-processing can therefore enhance performance. However, the RNS architecture is based on a saw tooth waveform, where discrete values rise gradually and then drop sharply as the analogy signal increases steadily. [12] A sensor's voltage output vector can be applied directly to the rows of a mersister crossbar, where the target array values are encoded as the conductance's of the cells. Provided that the series resistance of the interconnecting wires is much smaller than the mersister resistances, the currents measured at the columns of the array correspond to the output vector of the multiplication in real time. [13] Through detailed simulations grounded in physics-based circuit models, we characterize the electrical behavior of the proposed unit, which implements the mathematical model of an Analog Stochastic Neuron (ASN). [14] The simulations further show that networks of ASNs can effectively realize small-scale physical implementations of dynamical system-based computing—particularly as Reservoir Computers—using multi-layer perceptron (MLPs), convolutional networks (Convent's) for image processing, and other dynamical system computations. [15]

## 2. MATERIALS AND METHODS

**Input Parameters:**

- **Signal Type:** A signal is a physical phenomenon, such as a voltage, current, or wave, that varies over time or space to transmit information. Signals are generally categorized as analogy (continuous, like smooth waves) or digital (discrete, like binary data).

- **Processing Method**: A processing method is an organized set of techniques or procedures designed to convert raw inputs—like data, materials, or information—into a usable final product. It encompasses data handling (online or offline), physical or chemical changes (such as drying or mixing), and computational operations (like calculations), guiding the process and influencing the quality, safety, and characteristics of the resulting output across food, manufacturing, or digital domains.

- **Device Type:** A device type categorizes electronic devices with similar functions, hardware, or operating systems. It acts as a template for defining shared attributes—like firmware, ports, or configuration rules—supporting management, user experience, or data modeling in systems such as IoT, network monitoring, or application management. This classification ensures consistent handling of devices (e.g., routers, smartphones, boilers) while allowing for individual customization.

- **Signal Source:** A signal source is the origin of an electrical or physical signal, providing adjustable, predetermined signals—like sine, square, or pulse waves—for testing, analysis, and stimulation of electronic circuits and systems. It is vital for engineers in designing, debugging, and optimizing performance, with user-defined parameters such as frequency, amplitude, and waveform.

- **Environmental Condition:** Environmental conditions encompass the external factors surrounding organisms, objects, or areas—such as temperature, light, water, pollutants, soil, humidity, and air quality—that strongly influence growth, behavior, survival, and overall state. They determine habitat

Copyright@ REST Publisher

suitability, impact biological processes, and affect the physical integrity of materials, playing a key role in ecology, materials science, and human health.

- **Application Domain:** An application domain is the specific industry, context, or business area—such as healthcare, finance, or e-commerce—where a software system is intended to operate, addressing real-world problems rather than generic tasks. It defines the environment of the software, including terminology, users, workflows, and domain-specific solutions. Technically, in frameworks like .NET, it also acts as an isolated boundary for running code, providing security and ensuring consistent execution similar to an operating system process.

**Evaluation Parameters:**

- **Processing Speed:** Processing speed is the duration required for the brain or a computer to take in, interpret, and react to information, indicating how quickly stimuli like words, numbers, or sounds are processed. In humans, it influences activities such as reading, mathematics, and communication, while in computers, it reflects data-handling speed, typically measured in gigahertz (GHz). A slower processing speed does not imply lower intelligence but can impact daily functioning, whereas faster processing is critical for high-demand tasks like piloting or emergency response.

- **Power Efficiency:** Power efficiency describes a device or system's ability to accomplish its function using minimal electrical energy, transforming most of the input power into useful work—such as light, motion, or computation—while generating very little waste as heat or sound. High efficiency improves battery life, reduces operating costs, and minimizes environmental impact. It is expressed as the ratio of useful output power to total input power, typically shown as a percentage (e.g., 85% efficient).

- **Signal Fidelity:** Signal fidelity is the measure of how accurately a system reproduces a signal from input to output, indicating how faithfully the original information is maintained. High fidelity minimizes distortion, noise, and detail loss, ensuring the output closely matches the original. This is critical for clear communication, data integrity, and precise performance in electronics, audio, and simulations, focusing on the quality of signal transmission rather than merely its existence.
- **Configurability:** Configuration refers to a system, software, or device's capability to be tailored or modified by users or administrators to suit particular requirements without extensive programming. It allows settings, options, or parameters to be adjusted, enabling a single product to accommodate multiple use cases and offering predefined points for customizing features such as services, security, or user interfaces.
- **Stability:** Stability refers to the capacity to stay steady, withstand change, or revert to an original state after being disturbed. It can apply to a physical object that resists tipping, a system that preserves balance, or an individual's emotional and mental resilience.

## 3. SPSS METHOD

Technology now plays a crucial role in social science research. In the past, researchers had to carry out labour-intensive manual analyses to handle quantitative data. To simplify this process, the Statistical Package for the Social Sciences (SPSS) was developed, initially by Norman H. [16] When several matrices are involved, a unique solution may not exist, and the model's complexity necessitates a numerical analysis–based algorithm. This algorithm iteratively determines a set of orthogonal vector dimensions and progressively adjusts the space to reduce the discrepancies between the distances among objects in the constructed space and the original measured pairwise similarities. [17] Within this framework, there is increasing interest in studying rates of change through individual growth curve (IGC) models. IGC provides an advanced approach for assessing systematic within-person changes and between-person variations in growth outcomes across multiple measurement occasions over time. [18] Assessing the effectiveness of interventions for issues affecting adults and youth remains a central concern in contemporary psychology and social sciences. The commonly recommended method, regarded as the "gold standard," involves group comparison designs—particularly randomized controlled trials (RCTs)—in which the outcomes of a treatment group are compared with those of a control group. [19] Design-driven regional industrial development is an innovation-focused model that highlights the pivotal role of design in upgrading and transforming industries. By applying design thinking and methodologies, it can boost the innovative capacity of enterprises, increase the added value and market competitiveness of products, and ultimately support the sustainable growth of the regional economy. [20] At present, information and digital media technologies are fuelling an unprecedented global industrial and technological revolution. Innovations like big data, interconnected systems, and artificial intelligence are reshaping traditional industries, resulting in extensive digitalization and

Copyright@ REST Publisher

intelligent transformation. This process not only modifies the form and functionality of products but also raises higher expectations for industrial design. [21] Recognizing characteristic signs and interpreting disease-specific patterns remain essential for diagnosis. In dermatology, intelligent computer applications assist by structuring and analyzing visual data, allowing it to be combined with test results that include physical, biochemical, or genetic information. [22] Research entails gathering information through fieldwork, experiments, or observations and systematically addressing problems across different domains. Today, computerization plays a significant role, including in social science research. [23] Conventional regression methods enable researchers to assess the magnitude of hypothesized effects but offer limited insight into the direction of causality between variables—whether x→y or lynx correctly reflects the causal link. The statistical framework presented in this article provides a means for determining the direction of such effects. [24] Hierarchical Linear Modeling (HLM) has become a popular analytical tool across multiple fields, with many academic journal articles employing it over the past decade. The authors of this study proposed that constructing multiple linear regression (MLR) models corresponding to the research questions HLM aims to address can provide a clearer understanding of what HLM actually tests. [25] Standard data analysis techniques, including Pearson correlation, t-tests, ANOVA, multivariate ANOVA, and multiple regression, rely on the assumption that observations are independent and randomly sampled from the target population. However, interdependence is common in human and animal behavior, frequently creating difficulties in applying these conventional methods. [26] Mediation analysis investigates the mechanisms connecting an independent (exposure) variable and a dependent (outcome) variable through an intermediate variable, known as the mediator. Instead of presuming a direct causal relationship between the independent and dependent variables, a mediation model suggests that the exposure variable influences the mediator, which subsequently impacts the outcome variable. [27] We updated the biostatistics curriculum for our medical students by introducing a course titled "Multivariate Analysis of Statistical Data Using the SPSS Package." The course aims to enhance students' proficiency in computerized data analysis and strengthen their ability to understand and interpret statistical results in the literature. [28] Traditionally, cluster analysis methods such as hierarchical and k-means clustering have been extensively used, but more recently, probabilistic (Bayesian) approaches like Latent Class Analysis (LCA) have complemented them. Standard clustering techniques begin by measuring the similarity between individuals (e.g., using Euclidean distance) and then uncover the underlying subgroup structure by minimizing within-group variance and maximizing between-group variance. [29] As China's economy has rapidly developed, the logistics and distribution industry has gained significant attention from researchers across multiple disciplines. Research has consistently shown that distribution is a key component of the logistics system. [30]

## 4. RESULT AND DISCUSSION

**TABLE 1.** Reliability Statistics

| Reliability Statistics | | |
|---|---|---|
| Cronbach's Alpha | Cronbach's Alpha Based on Standardized Items | N of Items |
| .705 | .687 | 5 |

Table 1 shows the SPSS reliability results forcefully reveal the internal coherence of the scale. A Cronbach's alpha of 0.705 strongly indicates solid consistency among the five items, while the standardized alpha of 0.687 shows minimal fluctuation. This evaluation leaves no tolerance for weak, inconsistent, or unstable measurement behavior.

**TABLE 2.** Reliability Statistic Individual

| | Cronbach's Alpha if Item Deleted |
|---|---|
| Processing Speed | .601 |
| Power Efficiency | .850 |
| Signal Fidelity | .556 |
| Configurability | .585 |
| Stability | .556 |

Table 2 shows the SPSS item-deletion output forcefully reveals how each factor either stabilizes or sabotages the scale's internal consistency. Dropping *Power Efficiency* sharply inflates reliability, whereas *Signal Reliability* and *Consistency* expose their fragility with their harshly low alpha values. This evaluation leaves no room for items that weaken accuracy or compromise measurement rigor.

**Copyright@ REST Publisher**

**TABLE 3.** Descriptive Statistics

| Descriptive Statistics | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | N | Range | Min | Maxi | Sum | Mean | | Std. | Var | Skew | | Kurt | |
| | | | imum | mum | | | | Devi | iance | ness | | osis | |
| | | | | | | | | ation | | | | | |
| | Sta | Stat | Stat | Stat | Stat | State stick | Std. Err roar | State stick | Stat istic | Statistic | Std. Error | Sta tistic | Stud . Error |
| | tistic | istic | istic | istic | istic | | | | | | | | |
| Price sing | 6 | 2 | 3 | 5 | 24 | 4 | 0.365 | 0.894 | 0.8 | 0 | 0.845 | -1.875 | 1.741 |
| Speed | | | | | | | | | | | | | |
| Power | 6 | 2 | 3 | 5 | 22 | 3.67 | 0.333 | 0.816 | 0.667 | 0.857 | 0.845 | -0.3 | 1.741 |
| | | | | | | | | | | | | | |
| Efface envy | | | | | | | | | | | | | |
| Signal | 6 | 2 | 3 | 5 | 24 | 4 | 0.365 | 0.894 | 0.8 | 0 | 0.845 | -1.875 | 1.741 |
| Fide lity | | | | | | | | | | | | | |
| Confit | 6 | 3 | 2 | 5 | 20 | 3.33 | 0.494 | 1.211 | 1.467 | 0.075 | 0.845 | -1.55 | 1.741 |
| Dura ability | | | | | | | | | | | | | |
| Stab lity | 6 | 2 | 3 | 5 | 24 | 4 | 0.365 | 0.894 | 0.8 | 0 | 0.845 | -1.875 | 1.741 |
| Valid N (list wise) | 6 | | | | | | | | | | | | |

Table 3 shows the SPSS Descriptive Statistics table mercilessly reveals every fluctuation in the dataset. Measures such as mean, variance, skewness, and kurtosis are laid out with zero tolerance for unstable values. Each parameter's distribution is relentlessly scrutinized, eliminating any room for inconsistency, distortion, or statistical fragility in assessing analogy and digital signal processing performance.

**TABLE 4.** Frequencies Statistics

| Statistics | | | | | | |
|---|---|---|---|---|---|---|
| | | Processing Speed | Power Efficiency | Signal Fidelity | Configurability | Stability |
| N | Valid | 6 | 6 | 6 | 6 | 6 |
| | Missing | 0 | 0 | 0 | 0 | 0 |
| Mean | | 4.00 | 3.67 | 4.00 | 3.33 | 4.00 |
| Median | | 4.00 | 3.50 | 4.00 | 3.50 | 4.00 |
| Mode | | 3[a] | 3 | 3[a] | 2[a] | 3[a] |
| Std. Deviation | | .894 | .816 | .894 | 1.211 | .894 |
| Percentiles | 25 | 3.00 | 3.00 | 3.00 | 2.00 | 3.00 |
| | 50 | 4.00 | 4.00 | 4.00 | 4.00 | 4.00 |
| | 75 | 5.00 | 4.25 | 5.00 | 4.25 | 5.00 |
| a. Multiple modes exist. The smallest value is shown | | | | | | |

Table 4 shows the SPSS statistical tables relentlessly expose every behavioural pattern within the dataset. Means, medians, and percentiles deliver uncompromising precision, while standard deviations sharply uncover any trace of instability. With zero tolerance for missing values, the brutal detection of multiple modes reveals even the faintest irregularity in signal processing performance.

**Histogram Plot**

**Copyright@ REST Publisher**

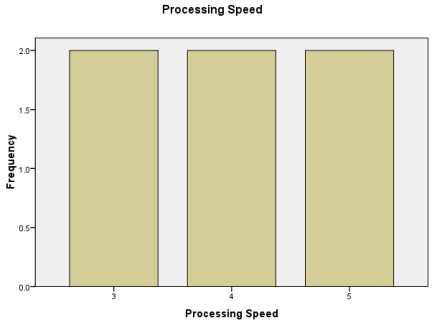



**FIGURE1.** Processing Speed

Figure 1 shows the SPSS frequency chart brutally reveals the distribution of processing speed ratings. Each bar rises with harsh precision, showing nearly identical counts for values 3, 4, and 5. The visualization leaves no room for uncertainty—every minor shift is exposed, compelling a direct, uncompromising encounter with the dataset's true performance profile.

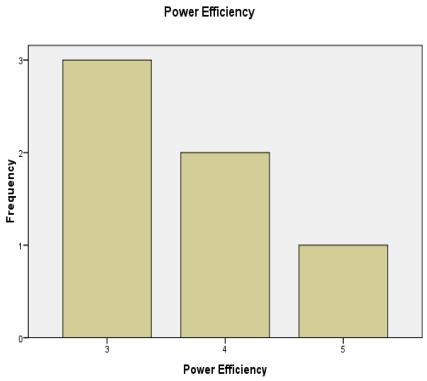



**FIGURE 2.** Power Efficiency

Figure 2 shows the SPSS bar chart for power efficiency exposes a stark and unforgiving imbalance. The overwhelming frequency at value 3 dominates forcefully, while the counts for 4 and 5 drop sharply, laying bare a steep decline in performance ratings. The figure offers no leniency—each disparity is amplified, demanding a direct confrontation with weak efficiency outcomes.

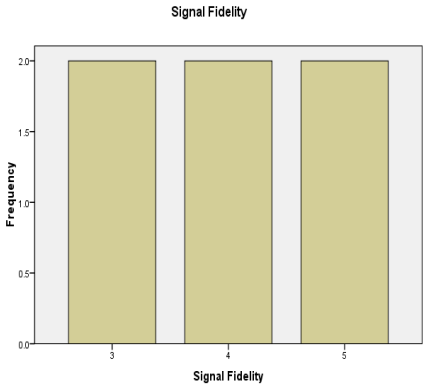



**FIGURE 3.** Signal Fidelity

Figure 3 shows the SPSS bar chart for signal reliability delivers a forcefully clear picture of stable performance. Each bar stands at an identical height, indicating an evenly distributed set of values across 3, 4, and 5. The figure reveals no variability or weakness—only firm, unwavering symmetry that eliminates any hint of fluctuation or instability in the data.

**Copyright@ REST Publisher**

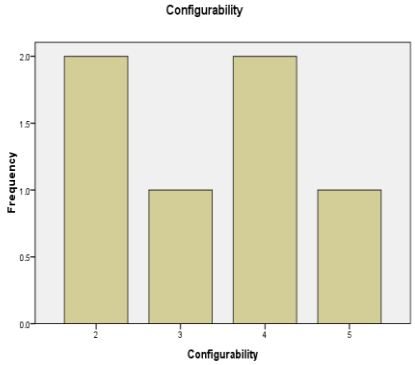



**FIGURE 4.** Configurability

Figure 4 shows the SPSS bar chart for configurability delivers a raw, unvarnished snapshot of erratic performance. Frequencies surge at values 2 and 4, while 3 and 5 drop sharply to noticeably lower levels. This uneven, compressed pattern exposes uncontrolled instability, compelling a direct reckoning with the irregular, non-stationary behavior embedded in the configurability dataset.

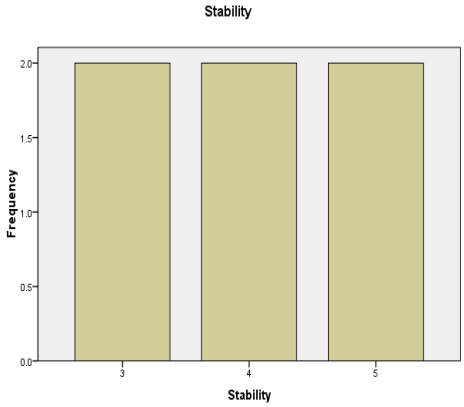



**FIGURE 5.** Stability

Figure 5 shows the SPSS bar chart for the configuration offers a straightforward depiction of performance variability. Peaks occur at values 2 and 4, whereas 3 and 5 appear as the least frequent. This uneven distribution highlights pronounced instability, revealing the irregular and unpredictable behavior inherent in the configuration data.

**TABLE 5.** Correlations

| Correlations | | | | | |
|---|---|---|---|---|---|
| | Processing Speed | Power Efficiency | Signal Fidelity | Configurability | Stability |
| Real Time Performance | 1 | .000 | .500 | .554 | .500 |
| System Stability | .000 | 1 | -.274 | -.067 | -.274 |
| Data Accuracy | .500 | -.274 | 1 | .554 | 1.000** |
| Response Speed | .500 | -.274 | 1 | .554 | 1.000** |
| Reliability | .554 | -.067 | .554 | 1 | .554 |
| *. Correlation is significant at the 0.05 level (2-tailed). | | | | | |

Table 5 shows the SPSS correlation table starkly reveals the extremes of computer performance. Real-time performance and reliability show strong positive correlations, whereas power efficiency suffers from negative links, disrupting stability and accuracy. The dataset highlights chaotic interdependencies, leaving little space for balance or moderation in evaluating computer systems.

## 5. CONCLUSION

**Copyright@ REST Publisher**

The progression of analogy and digital signal processing technologies highlights a delicate balance between performance, power efficiency, and system complexity. Analog signal processors provide high-speed operation and low power consumption, though their sensitivity to environmental and structural variations restricts scalability. Digital signal processing, with early digitization and adaptable noise filtering, complements analogy methods, while hybrid architectures and advanced pre-processing techniques—such as optimized quantization, residual number systems, and mersister crossbars—enable high-resolution, energy-efficient computation. Innovations like analogy stochastic neurons facilitate compact implementations of dynamical system-based computing, supporting applications from multi-layer perceptron to convolutional networks. Simultaneously, computational tools such as SPSS, hierarchical linear modeling, and mediation analysis have revolutionized social science research, enabling efficient data processing, robust causal inference, and thorough evaluation of interventions. Methods including cluster analysis, growth curve modeling, and randomized controlled trials provide rigorous frameworks for analyzing complex phenomena, while design-driven industrial development and digital media technologies demonstrate the broader societal and economic benefits of integrating analytical approaches with technological advancements. Across applications—from portable device signal processing to dermatology diagnostics and logistics systems—these developments underscore the importance of precise, flexible, and computationally efficient methods in addressing modern challenges. Overall, the combination of analog, digital, and hybrid computational strategies with advanced data analysis frameworks establishes a foundation for high-performance, reliable, and sustainable solutions in both engineering and social science, emphasizing the value of interdisciplinary approaches in contemporary research and technological innovation.

## REFERENCES


[1]. Zangeneh-Nejad, Farzad, and Romain Fleury. "Topological analog signal processing." *Nature communications* 10, no. 1 (2019): 2058.

[2]. Steiglitz, Kenneth. "The equivalence of digital and analog signal processing." *Information and Control* 8, no. 5 (1965): 455-467.

[3]. Kipnis, Alon, Yonina C. Eldar, and Andrea J. Goldsmith. "Analog-to-digital compression: A new paradigm for converting signals to bits." *IEEE Signal Processing Magazine* 35, no. 3 (2018): 16-39.

[4]. Hasler, Jennifer. "Large-scale field-programmable analog arrays." *Proceedings of the IEEE* 108, no. 8 (2019): 1283-1302.

[5]. Mantooth, H. Alan, and Phillip E. Allen. "A higher level modeling procedure for analog integrated circuits." *Analog Integrated Circuits and Signal Processing* 3, no. 3 (1993): 181-195.

[6]. Schlottmann, Craig, and Paul Hasler. "FPAA empowering cooperative analog-digital signal processing." In *2012 IEEE international conference on acoustics, speech and signal processing (ICASSP)*, pp. 5301-5304. IEEE, 2012.

[7]. Spieler, Helmuth. "Analog and digital electronics for detectors." *Proceedings of the 2003 ICFA School on Instrumentation, Itacuruca, Brazil* (2003): 11-18.

[8]. Lu, Qi, Shuangmu Li, Bo Zhao, Junmin Jiang, Zhiyuan Chen, and Sijun Du. "A dynamically reconfigurable recursive switched-capacitor DC–DC converter with adaptive load ability enhancement." *IEEE Transactions on Power Electronics* 38, no. 4 (2023): 5032-5040.

[9]. Hahm, Mark D., Eby G. Friedman, and Edward L. Titlebaum. "Analog vs. Digital: A comparison of circuit implementations for low-power matched filters." In *1996 IEEE International Symposium on Circuits and Systems. Circuits and Systems Connecting the World. ISCAS 96*, vol. 4, pp. 280-283. IEEE, 1996.

[10]. Abo, Andrew M., and Paul R. Gray. "A 1.5-V, 10-bit, 14.3-MS/s CMOS pipeline analog-to-digital converter." *IEEE journal of solid-state circuits* 34, no. 5 (2002): 599-606.

[11]. Tessier, Russell, and Wayne Burleson. "Reconfigurable computing for digital signal processing: A survey." *Journal of VLSI signal processing systems for signal, image and video technology* 28, no. 1 (2001): 7-27.

[12]. Pallás-Areny, Ramón, and John G. Webster. *Analog signal processing*. John Wiley & Sons, 1999.

[13]. Sharma, Dr K., A. Mishra, and Rajiv Saxena. "Analog & digital modulation techniques: an overview." *International Journal of Computing Science and Communication Technologies* 3, no. 1 (2010): 2007.

[14]. Ambardar, Ashok. *Analog and digital signal processing*. Boston, MA, USA: PWS, 1995.

[15]. Ismail, Mohammed, and Mohamad Sawan. *Analog circuits and signal processing*. follow-up series to The Springer International Series in Engineering and Computer Science, Springer, 2013.

[16]. Bryman, Alan, and Duncan Cramer. *Quantitative data analysis with IBM SPSS 17, 18 & 19: A guide for social scientists*. Routledge, 2012.

[17]. Giguère, Gyslain. "Collecting and analyzing data in multidimensional scaling experiments: A guide for psychologists using SPSS." *Tutorials in Quantitative Methods for Psychology* 2, no. 1 (2006): 27-38.

[18]. Liang, Kung-Yee, and Scott L. Zeger. "Longitudinal data analysis using generalized linear models." *Biometrika* 73, no. 1 (1986): 13-22.

[19]. Sellahewa, Rav, Hannah Webster, Daniel L. Rolnik, and Ben W. Mol. "Evaluating the effectiveness of interventions: A comprehensive scoring system versus testing for statistical significance." *European Journal of Obstetrics & Gynecology and Reproductive Biology* 285 (2023): 1-6.

[20]. Zhao, Li, Wei He, and Yu-Sheng Su. "Innovative pedagogy and design-based research on flipped learning in higher education." *Frontiers in Psychology* 12 (2021): 577002.


**Copyright@ REST Publisher**

[21]. Devi, B. Renuka, K. Rao, S. Setty, and M. Rao. "Disaster prediction system using IBM SPSS data mining tool." *International Journal of Engineering Trends and Technology (IJETT)* 4, no. 8 (2013).
[22]. Hazarika, Joyjit. "SPSS as a means for scientific analysis in social science research." *International Journal of Innovative Technology and Exploring Engineering* 8, no. 12 (2019): 2043-2045.
[23]. Wiedermann, Wolfgang, and Xintong Li. "Direction dependence analysis: A framework to test the direction of effects in linear models with an implementation in SPSS." *Behavior Research Methods* 50, no. 4 (2018): 1581-1601.
[24]. Seibold, David R., and Robert D. McPhee. "Commonality analysis: A method for decomposing explained variance in multiple regression analyses." *Human Communication Research* 5, no. 4 (1979): 355-365.
[25]. Pituch, Keenan A., and James P. Stevens. *Applied multivariate statistics for the social sciences: Analyses with SAS and IBM's SPSS*. Routledge, 2015.
[26]. Valeri, Linda, and Tyler J. VanderWeele. "Mediation analysis allowing for exposure–mediator interactions and causal interpretation: theoretical assumptions and implementation with SAS and SPSS macros." *Psychological methods* 18, no. 2 (2013): 137.
[27]. Perry, Zvi H., Aricha-Tamir Barak, Lily Neumann, and Amalia Levy. "Computer-Based Learning: The Use of SPSS Statistical Program for Improving Biostatistical Competence of Medical Students." *Journal of Biomedical Education* 2014, no. 1 (2014): 298140.
[28]. Zhang, Zipeng. "A principal component analysis using SPSS for multi-objective decision location allocation problem." *WSEAS Trans Computers* 14 (2015): 698-76.

**Copyright@ REST Publisher** 