© September 2025| IJIRT | Volume 12 Issue 4 | ISSN: 2349-6002

# Understanding The Role of BDH-SSR (Base Band Data Handling Solid State Recorder) and Theoretical Study on Electrical Interfacing in Satellite Systems

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**Abstract: This research examines the function of the Baseband Data Handling Solid State Recorder (BDH-SSR) and offers a theoretical investigation of electrical interfacing in satellites. The BDH-SSR is an essential element for high-capacity, high-speed data storage using NAND flash memory to handle big data sets generated from satellite payloads. The system uses advanced interleaving and error correction technologies to maintain data integrity under the extreme conditions of space. Electrical interfacing allows smooth communication between the BDH-SSR and other satellite subsystems, like transponders and command units, based on standardized protocols and hardy signal modulation. The work underscores the role played by the BDHSSR in assured data handling and the significance of optimized electrical interfaces for satellite mission efficiency and performance in space applications.**

## 1. INTRODUCTION

The Baseband Data Handling Solid State Recorder (BDH-SSR) is an essential part of today's satellite systems, responsible for handling the high-volume data output from sophisticated payloads like imaging sensors and science instruments. Featuring NAND flash memory, the BDH-SSR provides high-capacity, radiation hardened storage with strong error correction and interleaving methods to ensure data integrity in the hostile space environment. One of the major features of its inclusion in satellite systems is the electrical interfacing, which ensures effective communication among the BDH-SSR and other subsystems such as onboard computers, transponders, and telemetry units. In this research, two common electrical interfacing standards are investigated: Serializer/Deserializer (SerDes) and Low-Voltage Differential Signaling (LVDS). SerDes supports highspeed serialized data transmission through less wiring complexity, while LVDS delivers low-power, highspeed, and noise-immune signaling for high-strength data transfer. This opening discusses the BDH-SSR's function in satellite data processing and offers a theoretical examination of SerDes and LVDS as essential electrical interfacing technologies, highlighting their role in improving the efficiency and dependability of satellite mission.

## 2. BDH-SSR

BDH-SSR is a specialized, high-performance data storage and management system designed specifically for small satellite applications, with a focus on polar
Low Earth Orbit (LEO) missions involving hyperspectral imaging (HSI) and synthetic-aperture radar (SAR) payloads. The BDH-SSR addresses the unique challenges of small satellites, such as limited size, weight, power constraints, and the need for highspeed, high-capacity data handling in the harsh space environment. Below is a detailed description of its key features and functionalities:
The BDH-SSR is built around a NAND flash memory-based architecture, providing high-density, non-volatile storage to accommodate the large volumes of data generated by advanced payloads like HSI and SAR. These payloads produce high-resolution datasets, necessitating robust storage solutions capable of handling data rates up to several gigabits per second. The system achieves high-capacity storage while maintaining a compact and lightweight form factor, making it suitable for small satellite platforms, including CubeSats. A defining feature of the BDH-SSR is its highspeed data processing capability, enabled by a novel tri-level

parallel processing architecture. This design leverages interleaving at the controller, chip, and die levels to optimize read/write operations, significantly improving data throughput and reducing latency. This ensures the system can efficiently manage the high data rates associated with modern satellite payloads, supporting real-time or near-real-time data acquisition and storage.

To ensure data integrity in the radiation-heavy space environment, the BDH-SSR incorporates radiation-hardened components and advanced error correction techniques, such as ReedSolomon codes. These mechanisms mitigate the effects of cosmic radiation, which can cause bit errors or data corruption, thereby ensuring reliable storage and retrieval of mission-critical data. Additionally, the system employs redundancy mechanisms to further enhance data reliability, safeguarding against potential hardware failures.

The BDH-SSR is designed for seamless integration with other satellite subsystems through standardized high-speed electrical interfaces, such as Serializer/Deserializer (SerDes) and Low-Voltage Differential Signaling (LVDS). These interfaces enable efficient communication with onboard computers, transponders, and telemetry units, facilitating the transfer of stored data to ground stations during visibility windows. The system's ability to process and prepare data for transmission ensures timely delivery for ground-based analysis. Energy efficiency is a critical consideration for small satellites, and the BDH-SSR is optimized for low power consumption, extending mission lifespan in power-constrained environments. Its miniaturized design further reduces size and weight, aligning with the stringent requirements of small satellite platforms. The system's flexibility allows it to be tailored for various mission profiles, accommodating different data storage and processing needs.

In summary, the BDH-SSR, as described in the paper, is a compact, high-speed, and high-capacity data handling solution tailored for small satellite applications. Its radiation-tolerant design, advanced error correction, high-throughput processing, and efficient interfacing make it an essential component for managing the complex data demands of modern LEO missions, particularly those involving HSI and SAR payloads.

## 3. BLOCK DIAGRAM

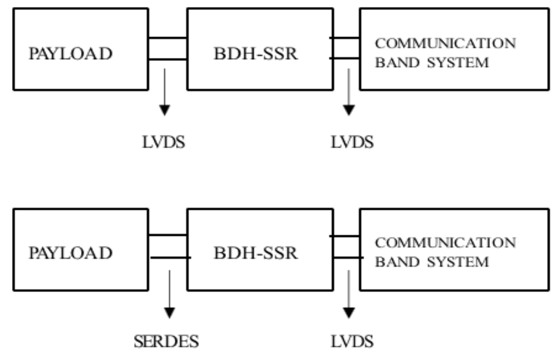



Fig 3.1: - Block Diagram

## 4. INTERFACING BETWEEN PAYLOAD, BDHSSR AND COMMUNICATION BAND SYSTEM

There are two methods to follow the interfacing to BDHSSR:

1. Using LVDS for payload to BDH-SSR and BDH-SSR to communication band system.
2. Using SERDES for payload to BDH-SSR and LVDS for BDH-SSR to communication band system.

### 4.1 Role of LVDS in BDH-SSR Interfacing:

LVDS is used as a primary electric interfacing protocol to enable smooth data exchange between the BDH-SSR and other satellite subsystems, such as the payload

(e.g., HSI and SAR sensors) and the communication band system (e.g., downlink data transponders to ground stations). LVDS is selected based on its high-speed data transfer, low power dissipation, and noise immunity, which are essential for the power- and space-limited environment of small satellites like CubeSats. The BDH-SSR, intended for processing high-volume data from sophisticated payloads, utilizes LVDS to provide effective and guaranteed communication to transfer large datasets without considerable latency and data loss.

### 4.2 LVDS Interfacing with Payload:

The SAR and HSI payloads produce high throughput, high-resolution data streams, typically ranging from a few gigabits per second, that must be acquired and stored by the BDHSSR. LVDS interfaces allow high-speed, point-to point data transfer of these payloads to the BDHSSR. The differential signaling character of LVDS, based on pairs of signals of opposite polarity, reduces electromagnetic interference (EMI) and maintains signal integrity, even when facing the radiation-induced noise of the space environment. The article highlights that the architecture of the BDH-SSR is designed to manage the high data rates from such payloads, and LVDS supplies the bandwidth and reliability necessary for real-time or near-real-time data acquisition. The low-voltage operation of LVDS (usually 1.2V to 3.3V) matches the requirements of power efficiency of small satellites, minimizing the energy used during data transfer from the payload to the BDH-SSR.

4.3 LVDS Interfacing with Communication Band System:

The communication band system, responsible for downloading stored data from the BDH-SSR to ground stations during visibility windows, also uses LVDS for unobstructed data exchange. The BDH-SSR formats and processes data for download, and LVDS interfaces are used for the transfer of this data to the communication subsystem (e.g., transponders) at high speeds with low error rates. The paper highlights that the high throughput architecture of the BDH-SSR, coupled with LVDS, enables the high-speed transfer of large datasets, which allows for timely downlinking of mission-critical data. LVDS's immunity to noise is particularly useful in this regard, as this allows for unobstructed communication in the electrically noisy satellite environment where multiple subsystems are in close proximity to one another.

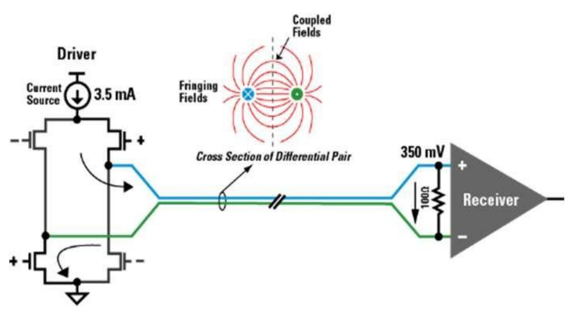
4.4 Role of SerDes in BDH-SSR and Payload Interfacing:

SerDes is used as a high-rate interfacing protocol to enable efficient data transfer between the BDH-SSR and high-resolution payloads, e.g., HSI and SAR, generating massive volumes of data at rates of up to a few gigabits per second. The SerDes interface serializes parallel payload data into a high-rate serial stream for transmission to the BDH-SSR and deserializes it back for processing and storage purposes. This reduces the number of physical connections required, simplifying cables and achieving size and weight specifications of small satellites, e.g., CubeSats. The paper focuses on SerDes's utility in enabling the BDH-SSR's ability to process high-throughput data streams without compromising reliability in the hostile space environment.

4.5 SerDes Interfacing to Payload:

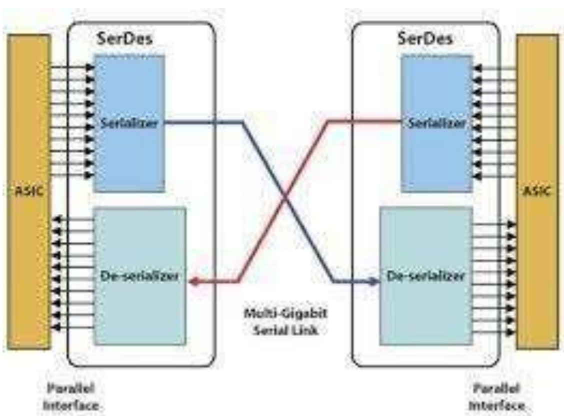
The SAR and HSI payloads provide high-resolution data sets for which the BDH-SSR must capture speedy and reliable data. SerDes interfaces facilitate this by providing a high-bandwidth, low-latency link between the payload and the BDH-SSR. Serialization bundles wide parallel data buses from the payload into a compact serial stream, transmitted over differential pairs, with minimal electromagnetic interference (EMI) and signal integrity in the face of radiation-induced noise. According to the paper, the tri-level parallel processing scheme of the BDH-SSR (controller, chip, and die-level interleaving) is optimized to utilize SerDes's high-speed capability, enabling the system to process and store incoming data efficiently. Deserialization in the BDHSSR reconstructs the data to store in its NAND flash memory, enabling seamless integration with the system's high-capacity storage infrastructure.

## 5. LVDS (LOW-VOLTAGE DIFFERENTIAL SIGNALING)



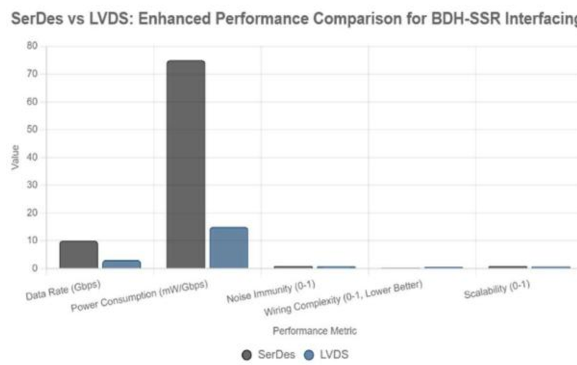

Low-Voltage Differential Signaling (LVDS) is a low-power and high-speed electrical interfacing standard for trustworthy data transmission in small satellites like the Baseband Data Handling Solid State Recorder (BDH-SSR). It operates by transmitting data on a pair of wires via differential signals—one signal and one inverse signal—so that the receiver can sense the voltage difference, usually 350 mV (1.0V to 1.4V), to decode data. The differential approach provides excellent immunity to noise caused by electromagnetic interference (EMI) and radiation, which are critical in the space environment. LVDS operates at data rates ranging from hundreds of Mbps to several Gbps and is a good choice to transfer highthruput data from payloads like hyperspectral imaging (HSI) and synthetic-aperture radar (SAR) to the BDH-SSR, and from the BDH-SSR to the communication band system for downlink. Its low power consumption is within the energy budget of small satellites, and its low wiring lowers complexity in tight designs. LVDS's reliability, scalability, and signal integrity retention in electrically noisy environments make it a perfect fit for intra-satellite communication, enabling efficient data handling in polar LEO missions.

## 6. SERDES (SERIALIZER/DESERIALIZER)




Serializer/Deserializer (SerDes) is a high-speed electrical interfacing standard utilized in small satellite systems, including the Baseband Data Handling Solid State Recorder (BDH-SSR), to enable efficient and dependable data transfer. SerDes operates by serializing parallel data from payloads, including hyperspectral imaging (HSI) and synthetic-aperture radar (SAR), into a high-speed serial data stream for transmission and deserializing it back into parallel data on the reception side, including the BDH-SSR. Serialization also reduces the number of physical connections, lowering the wiring complexity and physical space in tight satellite designs like CubeSats. SerDes supports multi-gigabit-per-second data rates, enabling high-throughput data streams generated by sophisticated payloads. SerDes utilizes differential signaling to offer robust noise immunity against electromagnetic interference (EMI) and radiation-induced noise, which is critical for data integrity in space. The low-latency, high-bandwidth operation of SerDes supports real-time or near-real-time data acquisition and processing by the BDH-SSR, while its low power consumption meets the energy constraints of small satellites. SerDes's scalability and flexibility make it an ideal candidate to interface with various types of payloads, which adds the BDH-SSR's flexibility to various mission requirements in polar Low Earth Orbit (LEO) missions.

## 7. SERDES VS LVDS GRAPH




Data Rate:
SerDes: Supports higher data rates, typically up to 10 Gbps or more, which can be used for high bandwidth payloads like hyperspectral imaging (HSI) and synthetic-aperture radar (SAR) in the BDH-SSR.

LVDS: Offers lower data rates, typically up to 3 Gbps, sufficient for intra-satellite communications but not practical for ultra-high bandwidth applications.

Power Consumption:
SerDes: Higher power consumption, approximately 50–100 mW/Gbps, due to complex serialization and deserialization functions, less power-efficient for power-constrained small satellites.
LVDS: More power-effective, around 10–20 mW/Gbps, in line with low-power demands of small satellites, as highlighted in the paper.
Noise Immunity:
SerDes: Provides better noise immunity (rated ~0.9 on a 0–1 scale) using differential signaling and

advanced equalization techniques, ensuring safe data transfer in the radiation-intensive space environment.
LVDS: Offers superior noise immunity (~0.8 on 0–1 scale) using differential signaling, less complex than SerDes but highly effective for intra-satellite communications.

Wiring Complexity:
SerDes: Lower wiring complexity (~0.3 on the 0–1 scale, lower is better) as it serializes the parallel data into one high-speed stream, reducing the number of signal lines and facilitating easier design in small satellites.
LVDS: Greater wiring complexity (~0.5 on a 0–1 scale) since it requires differential pairs per channel, greater connectivity compared to SerDes.

Scalability:
SerDes: Very scalable (~0.9 on a 0–1 scale), supporting a wide range of data rates and protocols, and thus capable of adapting to a range of payload types and mission requirements in the BDH-SSR.
LVDS: Mid-scalability (~0.7 on a scale of 0–1), more suited to fixed configurations but less flexible than SerDes for changing or variable mission needs.

Latency:
SerDes: Offers low latency with high-speed serialization, supporting real-time or near-real-time payload transfer to the BDH-SSR, critical to time-sensitive mission data. LVDS: Provides low latency throughout its data rate range, sufficient for most intra-satellite use but adds minimal delays to SerDes in high-throughput uses.

Implementation Complexity:
SerDes: More challenging to implement since it involves serializer and deserializer circuits, clock recovery, and equalization, which need sophisticated hardware design. LVDS: Less difficult to implement, using simple differential signaling, therefore easier to integrate into the BDH-SSR for mass market applications.

Appropriateness for Distance:
SerDes: More appropriate for longer distance data transfer within a satellite or even inter subsystem, as it can maintain signal integrity over longer links under proper equalization.
LVDS: Best suited for near-range communications (e.g., within a subsystem of a satellite), because its performance degrades at ranges greater than SerDes.

Cost:
SerDes: Normally more expensive due to the intricacy of its circuitry and higher data rate capability, which may impact the small satellite design cost.
LVDS: Cheaper, utilizing simpler-to-source and less costly components, which is suitable for the low-budget needs of small missions like CubeSats.

Implementation in BDH-SSR:
SerDes: Employed to connect high-data-rate payloads (e.g., SAR, HSI) and handle large sets of data, since it can satisfy the BDH-SSR's requirements for high-data-throughput, as explained in the paper.
LVDS: Applicable to intra-satellite data communication among the BDH-SSR, payloads, and communication systems and offers a performance versus power consumption trade-off for small satellite missions.

## 8. CONCLUSION

Research into the Baseband Data Handling Solid State Recorder (BDH-SSR) and its electronic interfacing through Serializer/Deserializer (SerDes) and Low-Voltage Differential Signaling (LVDS) in the context of small satellites, as it has been undertaken in the paper by Maitra et al. (2020), highlights their key positions in enhancing the efficiency of satellite missions. The BDH-SSR's radiation-hardened, high-capacity NAND flash memory and tri-level parallel processing architecture, coupled with its radiation-tolerant design, efficiently processes the large amount of data produced by polar Low Earth Orbit (LEO) hyperspectral imaging (HSI) and synthetic-aperture radar (SAR) payloads.
SerDes and LVDS are complementary interfacing standards, facilitating high-speed, power-efficient, and reliable data transfer between the BDH-SSR, payloads, and communication systems. SerDes is

superior in high-bandwidth scalable uses, handling multigigabit data rates and reduced wiring complexity, while LVDS delivers optimal power efficiency with strong noise immunity for intra-satellite communication. Combinations of these technologies provide unbroken data acquisition, storage, and transmission, satisfying the stringent size, weight, and power requirements of small satellites such as CubeSats. This integrated design improves the dependability and efficiency of data processing systems, making BDH-SSR an indispensable element for contemporary space missions.

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