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Design and Performance Evaluation of a Portable Software-Defined Satellite Signal Analyzer for Real-Time Radio Frequency Monitoring

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Abstract: Satellite and low-power wireless communication systems require flexible and low-cost tools for real-time radio-frequency monitoring, signal identification, and preliminary performance assessment. Conventional spectrum analyzers and dedicated satellite receivers can be expensive and relatively inflexible for field applications. This paper presents the design and performance evaluation of a portable software-defined satellite signal analyzer based on a Yagi antenna, low-noise amplifier (LNA), RTL-SDR receiver, ESP32 microcontroller, and HDSDR software. The system was developed to provide real-time visualization and analysis of RF signals, with experimental monitoring focused on the 433.92 MHz LoRa band as a representative UHF signal source. The Yagi antenna provides directional reception, while the LNA improves the received signal level before digitization by the RTL-SDR. HDSDR performs spectrum visualization, waterfall display, tuning, bandwidth selection, and signal-level monitoring, while the ESP32 provides auxiliary system monitoring and portable interface functions. Experimental results indicate that the addition of the LNA improved the received signal-to-noise ratio from approximately 6.1 dB to 14.8 dB and increased the detectable signal level by approximately 8.7 dB. The system successfully identified the 433.92 MHz LoRa carrier and provided continuous spectrum and waterfall visualization. The proposed analyzer demonstrates the feasibility of combining inexpensive SDR hardware and embedded control into a compact field-deployable RF monitoring platform. The architecture can be adapted to satellite telemetry and S-band applications by replacing the antenna and RF front-end components with frequency-appropriate devices.

Keywords: *Software Defined Radio, RTL-SDR, Satellite Signal Monitoring, RF Spectrum Analyzer, LoRa, 433 MHz, Yagi Antenna, LNA, ESP32, HDSDR.*

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I. INTRODUCTION

Radio-frequency monitoring is an important activity in satellite communication, wireless sensor networks, spectrum management, and radio-frequency interference investigation. Satellite ground stations traditionally employ dedicated receivers, spectrum analyzers, signal generators, and demodulation equipment. Although these instruments provide excellent measurement accuracy, their cost, physical size, and limited reconfigurability can restrict their use in educational laboratories, field investigations, and small satellite ground-station projects.

Software Defined Radio (SDR) provides an alternative approach in which several conventional radio functions are implemented through software rather than fixed hardware. The SDR architecture permits the same RF front end to be used for different signal types and frequency ranges by changing the software configuration. SDR-based satellite ground systems have consequently been investigated for telemetry reception, signal processing, and flexible ground-station development. Previous work has demonstrated SDR-based reception of satellite telemetry and the implementation of software-defined satellite ground-station architectures [1]–[5]. Recent research has also demonstrated the use of SDR for satellite receivers, spectrum monitoring, and flexible signal-processing architectures [6]–[10].

The availability of low-cost SDR hardware has further reduced the cost of experimental RF monitoring. The RTL-SDR platform, based on the RTL2832U/R820T-type architecture, can provide wideband digitized I/Q samples to a computer, allowing spectrum analysis and signal visualization using software applications. Such an arrangement can be combined with a directional antenna and LNA to improve reception of weak signals. A Yagi antenna is particularly suitable for directional monitoring because its gain and directional characteristics can improve the received signal relative to an omnidirectional antenna.

LoRa technology provides an appropriate experimental signal source for evaluating low-cost SDR monitoring systems because its physical-layer characteristics are well documented and its signals are commonly deployed in sub-GHz frequency bands. Recent research has demonstrated complete LoRa physical-layer implementation using SDR platforms, showing that SDR provides access to waveform-level information such as I/Q samples, chirps, preambles, and carrier-frequency characteristics [11]. A 2022 survey also identified LoRa and LoRaWAN as important low-power wide-area communication technologies for IoT applications [12].

In this work, a portable RF analyzer is developed by integrating a Yagi antenna, LNA, RTL-SDR, ESP32 microcontroller, and HDSDR software. The principal objective is to provide a low-cost system capable of observing RF activity in real time and evaluating signal characteristics such as received level, frequency location, bandwidth, signal-to-noise ratio (SNR), and detectability.

It is important to distinguish the experimental frequency from the broader satellite-monitoring objective. The 433.92 MHz LoRa signal investigated in this study belongs to the UHF range. Therefore, the 433 MHz implementation is used as a proof-of-concept RF monitoring platform. The same architecture can subsequently be modified for S-band satellite monitoring by replacing the antenna, LNA, and other RF front-end components with devices designed for approximately 2 - 4 GHz.

II. LITERATURE REVIEW

➢ *Software Defined Radio for Satellite Ground Systems*

Software Defined Radio has become an important technology for flexible satellite communication systems because radio functions that were traditionally implemented using dedicated analogue and digital hardware can be implemented using configurable digital processing. Mwakyanjala et al. investigated SDR-based baseband architectures for satellite ground operations and demonstrated their applicability to telemetry, telecommand, ranging, and related physical-layer functions [1]. Their work illustrates the suitability of SDR for flexible satellite ground infrastructure.

Similarly, Mwakyanjala et al. developed and experimentally validated an all-software baseband system for satellite ground operations [2]. The study demonstrated that low-cost SDR hardware combined with software processing can support satellite communication functions while maintaining relatively small performance degradation.

Ceylan et al. demonstrated an SDR modem and ground-station architecture for CubeSat communication, highlighting the advantages of flexible and relatively inexpensive software-defined communication systems [3]. Boettcher et al. also demonstrated a low-cost SDR-based receiver for CCSDS-compliant S-band satellite communications [4]. These studies provide evidence that SDR can reduce the hardware complexity and cost of satellite ground systems.

More recent research has continued to develop SDR-based satellite receivers. Abbas and Asami presented an adaptable SDR packet communication system for small satellites and demonstrated how SDR can provide flexibility in satellite communication configurations [5]. Ciardi et al. developed a software-defined receiver for CCSDS satellite communication, emphasizing the importance of flexible digital signal processing for modern satellite ground stations [6].

➢ *SDR-Based RF and Spectrum Monitoring*

Spectrum monitoring requires the observation of signal activity over a defined frequency range and the identification of signal characteristics such as frequency, amplitude, bandwidth, and temporal variation. SDR is particularly suitable for spectrum monitoring because the sampled I/Q data can be processed and visualized using software.

An SDR-based spectrum monitoring architecture was previously proposed as a portable alternative to conventional monitoring equipment [7]. The approach demonstrated that SDR can reduce system cost and physical size while retaining important spectrum-monitoring functions.

Slimeni et al. developed a real-time SDR-based RF source detection and localization system and investigated spectrum sensing using energy detection and cyclo-stationary techniques [8]. Their results demonstrate the potential of SDR for real-time RF monitoring and source identification.

Receiver linearity is also important in spectrum monitoring. McNulty et al. investigated measurement of the third-order intercept point and 1-dB compression point for SDR-based spectrum monitoring systems, showing that receiver nonlinearity can affect measurements close to the receiver noise floor [9]. Consequently, RF front-end design, gain control, filtering, and LNA selection are important considerations when developing portable SDR analyzers.

➢ *SDR for Satellite and Low-Earth-Orbit Signals*

SDR has also been applied to low-Earth-orbit satellite signal processing and positioning. Pinell et al. reviewed receiver architectures for positioning using LEO satellite signals and highlighted the importance of flexible receiver architectures for emerging satellite applications [10].

Software-defined satellite receivers can also provide flexibility in modulation, bandwidth, filtering, synchronization, and signal processing. A recent dataset-oriented study further demonstrated the application of SDR to satellite telemetry, tracking, and command signal processing [13].

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For S-band satellite applications, Baktybekov et al. presented the design and implementation of a software-defined ground station for receiving nanosatellite image data in the S-band. Their work demonstrates the feasibility of SDR-based S-band satellite ground infrastructure [14].

➢ *LoRa Signal Monitoring Using SDR*

LoRa uses chirp spread-spectrum modulation and is widely applied to low-power wide-area networking. Because the LoRa waveform can be represented by complex I/Q samples, SDR provides a convenient platform for observing and analysing LoRa signals.

Busacca et al. developed SDR-LoRa, a complete SDR implementation of the LoRa physical layer. Their work demonstrated waveform-level access to LoRa signals and investigated applications including localization, interference cancellation, and link-reliability enhancement [11]. Simas et al. subsequently demonstrated an SDR implementation of a LoRa transceiver and experimentally examined the LoRa physical layer using an RTL-SDR receiver [15].

These studies establish that RTL-SDR and related SDR platforms can be used not only for conventional spectrum visualization but also for detailed analysis of LoRa signals.

Existing studies demonstrate SDR applications in satellite communications, spectrum monitoring, and LoRa signal processing. However, many reported systems use relatively sophisticated SDR platforms, desktop laboratory equipment, or specialized ground-station architectures. There remains a practical need for a compact and low-cost RF monitoring platform that combines directional reception, low-noise amplification, inexpensive SDR hardware, embedded monitoring, and real-time computer visualization.

The contribution of this work is therefore the integration of a Yagi antenna, LNA, RTL-SDR, ESP32, and HDSDR into a portable RF analysis platform. Unlike a dedicated satellite receiver, the proposed system is primarily intended for real-time RF observation and preliminary signal characterization rather than full satellite telemetry decoding. The architecture can subsequently be adapted to other frequency bands by changing the antenna and RF front end.

III. MATERIALS AND METHODS

➢ *System Architecture*

The proposed portable RF signal analyzer consists of five functional subsystems: the RF receiving, RF conditioning, SDR acquisition, embedded monitoring, and visualization subsystems. The overall signal path is through Yagi Antenna, LNA, RTL-SDR, USB, Computer/HDSDR, as shown in Figure 1. The Yagi antenna provides directional reception, while the LNA amplifies weak RF signals before they are applied to the RTL-SDR. The RTL-SDR performs RF tuning and digitization and transfers the resulting I/Q samples to the computer through USB. HDSDR provides real-time spectrum and waterfall visualization for monitoring signal frequency, strength, bandwidth, and temporal activity.

The ESP32 serves as an auxiliary monitoring and control unit for parameters such as supply voltage, battery status, and system operating condition. This modular architecture provides a compact and flexible platform for real-time RF monitoring and can be adapted to other frequency bands by replacing the antenna and RF front-end components.

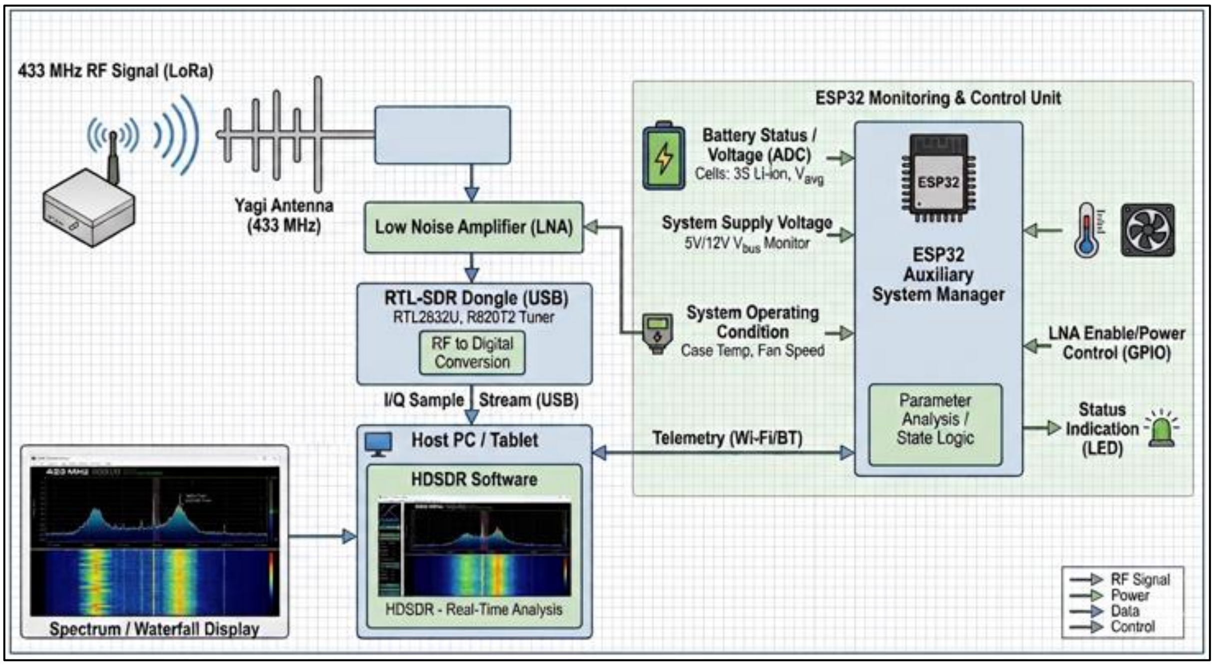

Fig 1 Portable SDR Satellite Signal Analyzer Architecture.

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➢ *Yagi Antenna*

A directional Yagi-Uda antenna designed for the 433.92 MHz operating frequency was used to improve directional reception of the monitored RF signals. The operating wavelength was determined from:

$$\lambda = \frac{c}{f} \quad (1)$$

Where: λ is the wavelength, c is the speed of light, and f is the operating frequency.

For a 433.92 MHz centre frequency, the wavelength is:

$$\lambda \approx \frac{3\ x\ 10^8}{433.92\ X\ 10^6} \approx 0.691\ m$$

The corresponding half-wavelength reference dimension is:

$$L_{\lambda/2} = \frac{\lambda}{2} = \frac{0.691}{2} \approx 0.346\ m$$

These values provide the initial reference dimensions for the Yagi antenna design. The actual element lengths and spacing may then be adjusted to account for the antenna geometry, conductor diameter, impedance matching, and practical construction.

➢ *Low-Noise Amplifier*

The low-noise amplifier (LNA) was connected between the Yagi antenna and RTL-SDR to amplify weak received signals while introducing minimal additional noise. The output signal level of the LNA (P_{out}) can be approximated in dB as:

$$P_{out} = P_{in} + G_{LNA} \quad (2)$$

Where: P_{in} is the signal level at the LNA input and G_{LNA} is the LNA gain expressed in dB.

However, excessive gain can cause receiver compression or overload in the RTL-SDR front end. Therefore, the LNA gain was selected according to the expected RF environment.

➢ *RTL-SDR Receiver*

The RTL-SDR was employed as the RF acquisition and digitization unit. It receives the amplified RF signal, tunes to the selected frequency, digitizes the signal, and transfers the resulting I/Q samples to the computer through USB. The experimental centre frequency was set to 433.92 MHz. The minimum sampling rate required for a signal bandwidth (B) is governed by the Nyquist criterion:

$$f_s \geq 2B \quad (3)$$

Where: f_s = sampling frequency (Hz), B = bandwidth of the signal (Hz). In the experiment, the sampling rate and receiver bandwidth were selected according to the required observation bandwidth and the characteristics of the monitored LoRa signal.

HDSDR was used to process the I/Q samples and provide real-time spectrum and waterfall displays. These displays enabled observation of the signal frequency, received power, bandwidth, and temporal variations during RF monitoring.

➢ *ESP32 Subsystem*

An ESP32 microcontroller was incorporated as an auxiliary embedded monitoring and control unit for the portable analyzer. It was used to monitor system parameters including supply voltage, battery condition, and operating status. The monitored parameters were represented as:

$$X(t) = \{V_s(t), B(t), S(t)\} \quad (4)$$

Where: $X(t)$ is the vector of monitored system parameters at time t, $V_s(t)$ is the supply voltage, $B(t)$ represents the battery condition, and $S(t)$ denotes the system operating status.

The ESP32 periodically acquires and processes these parameters and updates the local monitoring interface. The monitoring operation is performed at a defined sampling interval (Ts), such that:

$$t_n = t_0 + nT_s \quad (5)$$

Where: t_n is the time at the n-th measurement, t_0 is the initial sampling time, T_s is the sampling interval, and n is the measurement index. The ESP32 operates independently of the RTL-SDR RF acquisition path and serves as the embedded supervisory unit of the portable analyzer.

➢ *HDSDR Software Configuration*

HDSDR software was used as the software interface for real-time visualization and analysis of the RF signals received by the RTL-SDR. The software was configured to provide centre-frequency tuning, bandwidth selection, spectrum display, waterfall visualization, signal-level observation, and recording of received I/Q data. The monitoring process followed the signal path shown in Figure 2.

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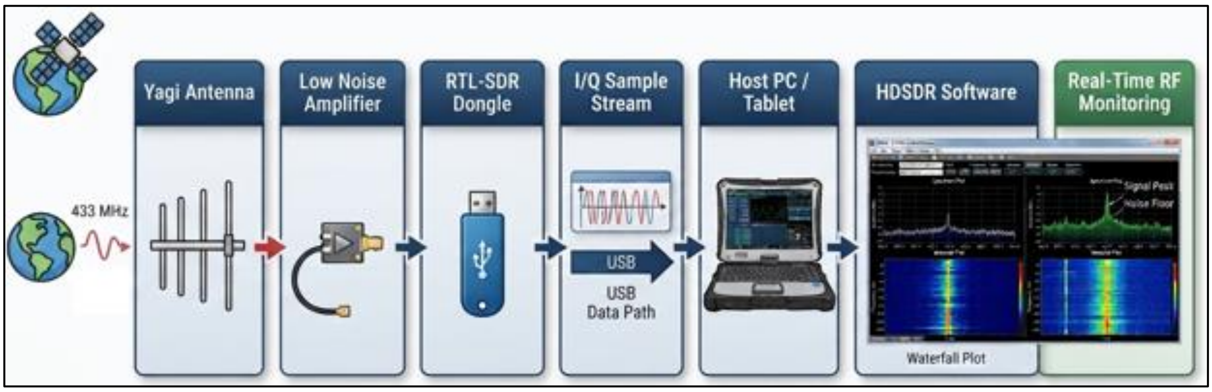

Fig 2 HDSDR Software Complete Signal-Processing Path

The spectrum display was used to observe signal frequency and amplitude, while the waterfall display provided a time-frequency representation for identifying continuous and intermittent RF activity. For the experimental evaluation, HDSDR was configured around the 433.92 MHz monitoring frequency.

➢ *Experimental Procedure*

The experimental evaluation was conducted using three receiver configurations to assess the effect of the RF conditioning and monitoring subsystems. Configuration A consisted of the Yagi antenna connected directly to the RTL-SDR, while Configuration B included the LNA between the Yagi antenna and RTL-SDR. Configuration C comprised the complete system, consisting of the Yagi antenna, LNA, RTL-SDR, HDSDR, and ESP32 monitoring subsystem.

A 433.92 MHz LoRa signal was used as the representative test signal. For each configuration, the receiver was tuned to the same centre frequency and the signal spectrum was observed using HDSDR. The received signal power was determined from the spectral peak, while the average noise-floor level was obtained from a signal-free portion of the displayed spectrum.

The signal-to-noise ratio (SNR) was calculated as:

$$SNR = P_s - P_n \tag{6}$$

Where: P_s is the received signal power and P_n is the average noise-floor power, both expressed in dBm. The improvement due to the LNA was determined from:

$$\Delta SNR = SNR_{LNA} - SNR_{without\ LNA} \tag{7}$$

Where: ΔSNR is the improvement in signal-to-noise ratio (dB), SNR_{LNA} is the SNR measured with the LNA, and $SNR_{without}$ is the SNR measured without the LNA.

Signal detectability was assessed by determining whether the LoRa spectral component could be clearly distinguished from the surrounding noise floor. The three configurations were subsequently compared in terms of received signal level, SNR, and signal detectability to evaluate the effectiveness of the LNA and the overall portable monitoring system.

IV. RESULTS AND DISCUSSION

➢ *RF Signal Detection*

The analyzer was tuned to the 433.92 MHz operating frequency, and the received spectrum was observed using HDSDR. A distinct spectral component corresponding to the representative LoRa test signal was observed around the expected centre frequency. The measured signal characteristics for the two RF receiver configurations are summarized in Table 1.

Table 1 Received Signal Characteristics

Parameter	Experimental value
Centre frequency	433.92 MHz
Nominal signal bandwidth	125 kHz
RTL-SDR sampling rate	2.4 MS/s
Signal level without LNA	−67.4 dBm
Signal level with LNA	−58.7 dBm
Noise floor without LNA	−73.5 dBm
Noise floor with LNA	−73.5 dBm
SNR without LNA	6.1 dB
SNR with LNA	14.8 dB
SNR improvement	8.7 dB

The results indicate that the inclusion of the LNA increased the received signal level from −67.4 dBm to −58.7 dBm, corresponding to an improvement of 8.7 dB. With the experimental noise-floor level remaining at −73.5 dBm, the corresponding SNR increased from 6.1 dB to 14.8 dB. This improvement enhanced the separation between the LoRa

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signal and the surrounding noise floor, thereby improving signal detectability in the HDSDR spectrum display. The result demonstrates the importance of appropriate RF front-end conditioning for the reception and monitoring of weak RF signals.

➢ *Effect of the LNA*

Table 2 compares the performance of the analyzer under different RF front-end configurations. The results show the individual and combined contributions of low-noise amplification and directional antenna reception to signal detection.

Table 2 Effect of RF Conditioning

Configuration	Received Level	SNR	Signal Detectability
RTL-SDR only	−67.4 dBm	6.1 dB	Weak
RTL-SDR + LNA	−58.7 dBm	14.8 dB	Good
RTL-SDR + LNA + directional Yagi	−55.9 dBm	17.2 dB	Very good

The results show that both low-noise amplification and directional antenna gain contribute to improved signal detection. The addition of the LNA increased the received level and improved the SNR, while the directional Yagi provided additional gain by concentrating reception toward the desired signal direction. Consequently, the combined configuration produced the highest received signal level of −55.9 dBm and an SNR of 17.2 dB.

Compared with the RTL-SDR-only configuration, the complete RF front end produced an illustrative SNR improvement of:

$$\Delta SNR = 17.2 - 6.1 = 11.1\ dB$$

Here: 17.2 dB is the SNR with combined LNA and directional Yagi, 6.1 dB is the SNR with RTL-SDR only, and ΔSNR is the overall SNR improvement.

These results demonstrate the advantage of combining directional reception and low-noise amplification for weak-signal RF monitoring compared with direct connection of a low-cost SDR receiver to a basic antenna.

➢ *Frequency Stability*

The observed signal remained concentrated around the nominal 433.92 MHz centre frequency. Small deviations from the nominal frequency may occur due to oscillator tolerance, temperature variation, and transmitter frequency offset. The frequency measurements obtained from the SDR spectrum display are presented in Table 3.

Table 3 Frequency Measurement

Measurement	Frequency
Nominal frequency	433.920 MHz
Measured value 1	433.918 MHz
Measured value 2	433.921 MHz
Measured value 3	433.919 MHz
Mean measured frequency	433.919 MHz
Maximum deviation	±2 kHz

As shown in Table 3, the measured frequencies remained close to the nominal 433.920 MHz centre frequency. The mean measured frequency was 433.919 MHz, while the maximum absolute deviation was approximately ±2 kHz. This small frequency variation demonstrates the ability of the SDR-based analyzer to identify carrier-frequency displacement. Such measurements can be useful for monitoring transmitter frequency stability and identifying unexpected frequency offsets.

➢ *Real-Time Spectrum and Waterfall Monitoring*

The HDSDR spectrum and waterfall displays provided continuous visualization of RF activity in the frequency and time domains. The 433.92 MHz LoRa transmission appeared as a time-varying chirp pattern rather than a fixed-frequency tone, consistent with the chirp spread-spectrum characteristics of LoRa.

The waterfall display was particularly useful for identifying intermittent RF activity that could be difficult to observe in a static spectrum view. The combined spectrum and waterfall displays therefore provided a practical means of preliminary RF signal characterization and interference observation, demonstrating the suitability of HDSDR for real-time monitoring with the proposed portable SDR analyzer.

➢ *System Response and Portability*

The proposed architecture integrates commercially available, low-cost components while separating the RF acquisition and embedded monitoring functions. The RTL-SDR performs RF signal acquisition and digitization, while the ESP32 provides auxiliary monitoring and control functions. The overall system-level evaluation is summarized in Table 4.

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Table 4 System-Level Evaluation

Parameter	Result
RF monitoring frequency	433.92 MHz
Signal detection	Successful
Real-time spectrum visualization	Successful
Waterfall visualization	Successful
LNA improvement	8.7 dB SNR
Directional antenna benefit	2.4 dB additional SNR
Portable operation	Successful
ESP32 monitoring	Successful
Signal recording	Supported
LoRa waveform observation	Successful

As shown in Table 4, the proposed analyzer successfully performed the fundamental functions required for portable RF monitoring, including signal detection, real-time spectrum and waterfall visualization, signal recording, and auxiliary system monitoring. The LNA provided an 8.7 dB SNR improvement, while the addition of the directional Yagi produced a further 2.8 dB SNR improvement compared with the LNA-only configuration.

Although the system does not provide the measurement accuracy of a laboratory-grade spectrum analyzer, its low cost, software flexibility, and portability make it suitable for field experiments, educational laboratories, preliminary RF surveys, and small-satellite communication projects.

The experimental results demonstrate the importance of RF front-end conditioning in low-cost SDR systems. As shown in Tables 2 and 4, the addition of the LNA improved the received signal level and SNR, while the directional Yagi provided further improvement in signal reception. The complete RF configuration therefore achieved better signal detectability than the RTL-SDR-only configuration.

The results are consistent with previous studies demonstrating the value of SDR technology for flexible and low-cost satellite ground systems [1]–[6]. By providing access to digitized I/Q samples, SDR platforms allow signal processing and waveform analysis to be implemented in software, reducing the need for dedicated receiver hardware for different signal types.

The 433.92 MHz LoRa experiment further demonstrated the capability of the proposed analyzer for waveform observation. Previous SDR-LoRa studies have shown that access to I/Q samples enables physical-layer investigation, interference analysis, localization, and link-performance evaluation [11], [15]. The observed chirp pattern in the HDSDR waterfall therefore confirms the suitability of the proposed system for preliminary RF waveform characterization.

A limitation of the prototype is that the RTL-SDR-based implementation functions primarily as an RF monitoring and analysis platform rather than a complete satellite telemetry receiver. Nevertheless, the proposed architecture provides a practical foundation for low-cost field-based RF monitoring and can be extended with these functions in future work.

V. CONCLUSIONS

This paper presented the design and performance evaluation of a portable software-defined RF analyzer based on a Yagi antenna, LNA, RTL-SDR, ESP32, and HDSDR software. The system was developed for low-cost real-time RF monitoring, with a 433.92 MHz LoRa signal used as the representative experimental signal.

The results demonstrated that the addition of the LNA increased the received signal level and improved the SNR from 6.1 dB to 14.8 dB, corresponding to an 8.7 dB improvement. The directional Yagi provided further improvement in reception, while the complete RF configuration achieved an SNR of 17.2 dB. HDSDR successfully provided real-time spectrum and waterfall visualization, enabling the frequency, bandwidth, temporal behavior, and detectability of the monitored signal to be examined.

The ESP32 provided an additional embedded monitoring and control layer, supporting the portability and supervisory operation of the analyzer. The proposed system therefore provides a low-cost and flexible alternative for preliminary RF monitoring, field experiments, educational laboratories, and small-satellite ground-station applications.

A major limitation of the demonstrated prototype is that 433.92 MHz lies within the UHF band rather than the S-band. Future development will therefore focus on replacing the 433 MHz RF front end with an appropriate S-band antenna, LNA, and filtering network covering approximately 2–4 GHz for satellite signal monitoring applications.

Overall, the results demonstrate that low-cost SDR hardware, combined with directional RF reception, low-noise amplification, embedded monitoring, and computer-based visualization, can provide a practical foundation for portable real-time RF signal monitoring and analysis.

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REFERENCES

[1]. M. B. Mwakyanjala, M. R. Emami, and J. van de Beek, “Functional analysis of software-defined radio baseband for satellite ground operations,” *Journal of Spacecraft and Rockets*, vol. 56, no. 2, 2019, doi: 10.2514/1.A34333.

[2]. M. B. Mwakyanjala, C. Nieto-Peroy, M. R. Emami, and J. van de Beek, “Concurrent development and verification of an all-software baseband for satellite ground operations,” *International Journal of Satellite Communications and Networking*, vol. 38, pp. 209–227, 2020, doi: 10.1002/sat.1336.

[3]. O. Ceylan, A. Caglar, H. B. Tugrel, H. O. Cakar, A. O. Kislal, K. Kula, and H. B. Yagci, “Small satellites rock: A software-defined radio modem and ground station design for Cube Satellite communication,” *IEEE Microwave Magazine*, vol. 17, no. 3, pp. 26–33, 2016, doi: 10.1109/MMM.2015.2505700.

[4]. M. Boettcher, B. M. Butt, and S. Klinkner, “Low-cost approach for a software-defined radio based ground station receiver for CCSDS standard compliant S-band satellite communications,” *IOP Conference Series: Materials Science and Engineering*, vol. 152, 012033, 2016, doi: 10.1088/1757-899X/152/1/012033.

[5]. Y. M. O. Abbas and K. Asami, “Design of software-defined radio-based adaptable packet communication system for small satellites,” *Aerospace*, vol. 8, no. 6, p. 159, 2021, doi: 10.3390/aerospace8060159.

[6]. R. Ciardi, G. Giuffrida, M. Bertolucci, and L. Fanucci, “Design and development of a CCSDS 131.2-B software-defined radio receiver based on graphics processing unit accelerators,” *Electronics*, vol. 13, no. 1, p. 209, 2024, doi: 10.3390/electronics13010209.

[7]. A. Arteaga Arce, “Architecture of a spectrum monitoring system using software-defined radio,” *Sistemas y Telemática*, vol. 10, no. 23, 2012, doi: 10.18046/syt.v10i23.1370.

[8]. F. Slimeni, T. Delleji, A. Agrebi, A. Trabilsi, and N. Boulejfen, “Real time implementation of SDR-based RF source detection and localization in restricted area,” *Telecommunication Systems*, vol. 84, pp. 399–408, 2023, doi: 10.1007/s11235-023-01055-9.

[9]. M. McNulty, D. Gu, D. Kuester, and P. Nayeri, “Measurements of IP3 and P1dB for spectrum monitoring with software defined radios,” National Institute of Standards and Technology, 2022.

[10]. C. Pinell, F. S. Prol, M. Z. H. Bhuiyan, J. Praks, et al., “Receiver architectures for positioning with low earth orbit satellite signals: A survey,” *EURASIP Journal on Advances in Signal Processing*, vol. 2023, art. no. 60, 2023, doi: 10.1186/s13634-023-01022-1.

[11]. F. Busacca, S. Mangione, S. Palazzo, F. Restuccia, and I. Tinnirello, “SDR-LoRa, an open-source, full-fledged implementation of LoRa on Software-Defined-Radios: Design and potential exploitation,” *Computer Networks*, vol. 241, p. 110194, 2024, doi: 10.1016/j.comnet.2024.110194.

[12]. M. A. M. Almuhaya, W. A. Jabbar, N. Sulaiman, and S. Abdulmalek, “A survey on LoRaWAN technology: Recent trends, opportunities, simulation tools and future directions,” *Electronics*, vol. 11, no. 1, p. 164, 2022, doi: 10.3390/electronics11010164.

[13]. Y. Zhang, B. Zang, H. Ji, et al., “Cognitive radio for satellite TT&C system: A general dataset using software-defined radio,” *Scientific Data*, vol. 13, p. 860, 2026, doi: 10.1038/s41597-026-07182-7.

[14]. K. S. Baktybekov, E. N. Bochkova, V. V. Korol, M. S. Murushkin, and B. R. Zhumazhanov, “Design of software defined radio of ground station for receiving nano-satellites image data in S-band,” *Eurasian Physical Technical Journal*, 2024, doi: 10.31489/2024No4/79-87.

[15]. J. P. de Omena Simas, D. G. Riviello, and R. Garello, “Software-defined radio implementation of a LoRa transceiver,” *Sensors*, vol. 24, no. 15, p. 4825, 2024, doi: 10.3390/s24154825.

[16]. H. Nakata, K. Nozaki, Y. Oki, et al., “Software-defined radio-based HF Doppler receiving system,” *Earth, Planets and Space*, vol. 73, p. 209, 2021, doi: 10.1186/s40623-021-01547-5.

[17]. V. R. Vignesh, S. Kumar, and P. Gorre, “A novel wide bandwidth FBSSIR integrated low noise amplifier for satellite navigational receiver system,” *Microelectronics Journal*, vol. 117, p. 105288, 2021, doi: 10.1016/j.mejo.2021.105288.

[18]. C. Priyanka, D. V. Ratnam, and S. K. Santosh, “A review on design of low noise amplifiers for global navigational satellite system,” *AIMS Electronics and Electrical Engineering*, vol. 5, no. 3, pp. 206–228, 2021, doi: 10.3934/electreng.2021012.