Firmware Quality Assurance Of Switcher

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***Abstract*—The HD-RX-4K-210-C-E Switcher is a sophisticated audiovisual device designed for seamless switching and distribution of high-definition signals. Firmware and hardware quality are crucial for optimal performance and customer satisfaction.**

Firmware quality assurance involves requirements analysis, design verification, code review, and rigorous testing. Design verification ensures robustness and scalability, while code reviews enhance coding standards and identify vulnerabilities. Hardware quality assurance evaluates physical components. Inspections ensure quality standards during manufacturing and assembly. Functional tests verify signal integrity, conversion accuracy, and power stability. Environmental testing assesses performance under different conditions.

Comprehensive testing, including functional, performance, and compatibility testing, verifies firmware reliability and compatibility with multimedia sources and destinations. Continuous monitoring and feedback loops address identified issues promptly. Collaboration between firmware and hardware teams ensures seamless integration between software and physical components.

***Index Terms*—Switcher, Compatible, Functionality, Reliable, HDMI, Audio , Specification , Testcase , Regression Testing , Performance degradation**

I. Introduction

The switcher, as a critical component in audiovisual systems, plays a crucial role in facilitating seamless signal switching and distribution. As multimedia environments become increasingly sophisticated, the need for high-quality and reliable switchers becomes paramount. This research paper aims to examine the testing methodologies and strategies employed in the evaluation of switchers, with a focus on their firmware and hardware components. By understanding and optimizing the testing process, manufacturers can ensure optimal performance and customer satisfaction.

The firmware quality assurance process encompasses various stages, including requirements analysis, design verification, code review, and rigorous testing. Each stage contributes to the overall reliability and functionality of the switcher. Requirements analysis helps identify and prioritize desired functionalities aligned with customer expectations and industry standards. Design verification ensures the robustness and scalability of the firmware architecture, while code reviews enhance coding standards and identify potential vulnerabilities or inefficiencies. Rigorous testing validates the firmware's performance and compatibility with different multimedia sources and destinations.

In parallel, the hardware quality assurance process focuses on the physical components of the switcher. Manufacturing and assembly inspections guarantee adherence to quality standards and specifications. Functional tests verify the operational capabilities, such as signal input/output integrity, conversion accuracy, and power supply stability. Additionally, environmental testing assesses the switcher's performance under various conditions, including temperature, humidity, and vibration.

II. HD-RX-4K-210-C-E Switcher

The HD-RX-4K-210-C-E is a versatile multiformat AV switch and receiver used in conference rooms, classrooms, and other settings. It supports HDMI video switching and audio presentation. It is compatible with DM Lite transmitters and has one DM Lite input.To transmit HDMI signals, a CATx twisted pair cable (CAT5e or higher) connects the transmitter to the HD-RX-4K-210-C-E. The maximum transmission distance is 230 ft (70 m) for resolutions up to 2K and 130 ft (40 m) for higher resolutions up to 4K. The HD-RX-4K-210-C-E Switcher in fig 1 offers advanced signal management features, including seamless switching between input sources, scaling and resolution conversion, audio embedding and de-embedding, and flexible routing options. It allows for dynamic and versatile multimedia setups in various environments such as conference rooms, classrooms, digital signage installations, and entertainment venues.

Fig. 1. HD-RX-4K-210-C-E Switcher

A. Specifications

The switcher is designed to operate within a temperature range of 32° to 104° F (0° to 40° C), ensuring reliable performance in various ambient conditions. It can effectively

handle humidity levels ranging from 10% to 90% RH (non-condensing), further enhancing its adaptability to different environments. Additionally, the switcher's heat dissipation rate is measured at 30.7 BTU/hr, demonstrating its ability to efficiently manage and dissipate heat generated during operation.

The switcher features a metal chassis with a black finish and vented sides. It comes with two mounting flanges attached, allowing for easy surface or rack rail mounting. With a height of 5.11 inches (130 mm) and a width of 10.53 inches (268 mm) including the mounting flanges, the switcher provides a compact and space-efficient solution for installation in various setups.

The audio specifications are mentioned in Table 2, to test a switcher include frequency response, signal-to-noise ratio, total harmonic distortion, and audio format compatibility.

Input Signal Types	HDMI (Dual-Mode DisplayPort compatible), DM Lite
Output Signal Types	HDMI, stereo analog
Digital Formats	2-channel LPCM
Analog Formats	Stereo 2-channel
Digital-to-Analog Conversion	24-bit 48 kHz
Output Impedance	200 ohms balanced, 100 ohms unbalanced
Maximum Output Level	4 Vrms balanced, 2 Vrms unbalanced
Output Volume	-80 to +20 dB level adjustment range plus
Mute	Enable or disable independently for HDMI and analog audio output
Acoustic Noise	Not applicable (fanless)

Fig. 2. Audio Specifications

III. Switcher Testing

A. Implementation

Regression testing focuses on retesting specific areas of a system to ensure that changes or updates haven't introduced new bugs or issues. For the HD-RX-4K-210-C-E, regression testing involves:

1) Identifying the test scope, such as video resolution and audio quality
2) Developing test cases with clear steps and expected outcomes
3) Executing tests, checking input/output compatibility, and verifying audio and video transmission
4) Reporting any encountered issues and retesting fixed areas, ensuring no new issues have emerged
5) Completing the regression testing cycle while recognizing the need for regular testing when updates are made.

B. Auto Routing

Auto routing is enabled by default."Locked" devices shall NOT switch host via auto or manual routing. Once configured as a locked device, it shall remain connected to the assigned host. No devices are locked by default. Platform will memorize following parameters:

- Input sync detection order
- Input sync detection states
- Selected output source
- Input priority order

For the designated testcase as shown in Fig 3, the initial step involves restoring the device to its default settings. Upon completion of the restoration process, it is imperative to observe and record the first active port that becomes available. Subsequently, as part of the test, HDMI 5 should be routed following the device restoration. This specific testcase aims to assess the behavior of the device after restoration, particularly focusing on the activation of the first port. It further emphasizes conducting the test with both the RX and TX components connected, ensuring comprehensive evaluation of the device's functionality.

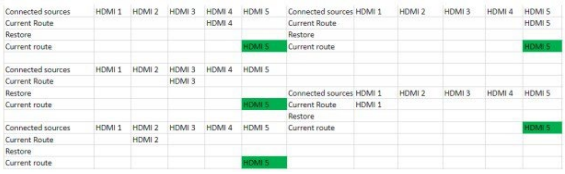

Fig. 3. Test Case Interface for Restore Behavior and Active Port Verification

C. HW Change Validation

In this testcase, power is supplied via PoE to the HD- RX-4K-210-POE while local power is connected to the TX. The objective is to evaluate the performance of different transmitters using the HD-RX-4K-210-POE. Tests conducted include 10 reboots, 10 power cycles, a 10-minute AV soak, and 5 rounds of DM Link with Rnr configuration. AV pass-through from TX to MD-210 ensures seamless audio and video transmission. An analog output speaker is connected to assess audio capabilities. Simultaneous charging of MD-210 and TX is tested alongside AV transmission.

	10 reboots	10 power cycles	10 mins AV soak	5 RnR DM Link
HD-TX-4KZ-201	Pass	Pass	Pass	Pass
HD-TX-4KZ-201-2G	Pass	Pass	Pass	Pass
HD-TX-4KZ-421-CHGR	Pass	Pass	Pass	Pass
HD-TX-4KZ-211-CHGR	Pass	Pass	Pass	Pass
HD-TX-4KZ-401	Pass	Pass	Pass	Pass
HD-TX-4KZ-101				
HD-TX-4KZ-101-1G				
HD-TX-4KZ-111-1G	Pass	Pass	Pass	Pass
HD-TX-4KZ-111-1G				
HD-TXCA-4KZ-101	Pass	Pass	Pass	Pass
HD-TXA-4KZ-101				
HD-TXA-4KZ-101-1G				
HD-TX-301-C-E	Pass	Pass	Pass	Pass
HDI-TX-301-C-2G				
HD-TX-201-C-2G				
HD-TX-201-C-E				
HD-TX-101-C-E	Pass	Pass	Pass	Pass
HD-TX-101-C-1G				

Fig. 4. Test Case Interface for Power and Performance Evaluation with HD-RX-4K-210-POE

D. Soak Testing

Soak testing of a switcher involves subjecting the device to continuous usage under normal operating conditions for

an extended period. The purpose of this test is to evaluate the switcher's performance, stability, and reliability over an extended duration. By simulating real-world usage scenarios, soak testing helps identify any potential issues such as memory leaks, resource depletion, or performance degradation that may occur over time. This type of testing provides valuable insights into the switcher's ability to handle sustained operation without any detrimental effects, ensuring its suitability for long-term usage in professional multimedia environments.

E. Input-Source Testing

In this testcase, inputs were connected to different sources, each with varying resolutions and HDCP (High-bandwidth Digital Content Protection) capabilities. The objective of this test was to evaluate the switcher's ability to handle and correctly display content from these diverse sources while maintaining HDCP compliance.

The test involved connecting inputs from various sources, such as computers, Blu-ray players, and gaming consoles, to the switcher. Each source was set to different resolutions, including 1080p, 4K, and beyond. Additionally, the HDCP capabilities of the sources were taken into consideration, ensuring that the switcher correctly detected and managed the HDCP encryption requirements for each input.

By conducting this testcase, the aim was to assess the switcher's compatibility with different sources, its ability to handle varying resolutions seamlessly, and its compliance with HDCP protocols to prevent any unauthorized content usage. The results of this test provide valuable insights into the switcher's performance and its ability to deliver high-quality, protected content across various sources and resolutions.

Inputs connected	Source	HDCP Receiver Capability	EDID	Resolutions	Source HDCP
TX HDMI 1	Apple TV	Auto	DM default 4k 60Hz 2CH	3840x2160@60	Active
TX HDMI 2	Dell precision laptop	Auto	DM default 4k 60Hz 2CH	3840x2160@60	Inactive
TX HDMI 3	Oppo Player	Auto	DM default 4k 60Hz 2CH	3840x2160@60	Active
TX HDMI 4	MAC PC	Auto	DM default 4k 60Hz 2CH	3840x2160@60	Active
RX HDMI 1	LG Player	Auto	DM default 4k 60Hz 2CH	3840x2160@24	Active

Fig. 5. Various Input-Source Testing

IV. Results and Discussion

The purpose of this testcase is to assess the behavior of the switcher in managing the plugin sequence and auto routing functionality. The observed issue indicates that there may be a need for further investigation and potential fixes to ensure the correct application of the plugin sequence when auto routing is disabled and then enabled again, with inputs being removed sequentially. This testcase serves as valuable feedback for the development team to address and enhance the switcher's auto routing capabilities for optimal performance and user experience.

A. Defects in Auto Routing and Priority Routing

The objective is to test the behavior of the switcher regarding the disabling of autoroute, managing plugin order, enabling auto route, and removing the last connected source. The test begins by disabling autoroute and connecting the inputs in the specified plugin order. Following that, auto route is enabled, and subsequently, the last connected source is removed. As per the test specifications, the expected outcome is that the second last connected source, following the plugin order, should be routed. This testcase aims to verify the switcher's ability to handle the dynamic routing of sources based on the plugin order and accurately adjust the routing when sources are added or removed.

B. Defects

During this testcase, an issue was identified with the plugin sequence when auto routing is disabled and then enabled again, while connected inputs are removed one after the other. The expected behavior was that the plugin sequence, initially established with auto routing disabled, would be maintained when auto routing is subsequently enabled. However, it was observed that the correct plugin sequence was not applied in this scenario. This discrepancy indicates a potential bug or inconsistency in the switcher's auto routing functionality.

The specific setup for this testcase involved the following topology: HD-TX-4KZ-401 as the transmitter, connected to the HD-RX-4K-210-C-E-POE via HDMI output. The HD-RX-4K-210-C-E-POE was further connected to a 4K TV. The firmware version of the HD-RX-4K-210-C-E-POE used in this setup was 1.0.5533.17100.

C. Output

- HDCP Transmitter Mode=Auto
- Resolution=Auto
- HDMI Out=4K TV
- TV=Samsung TV

In this testcase, the focus is on evaluating the device's ability to remember the plug-in order and correctly route to TX-HDMI 3. The objective is to verify whether the device can retain the order in which inputs are connected and consistently route the signal to the designated TX-HDMI 3 output.

To perform this test, inputs are connected to the device in a specific order, ensuring that TX-HDMI 3 is one of the connected inputs. After establishing the plug-in order, the device is monitored to ensure that it correctly remembers the sequence.

V. Conclusion

This paper focuses on Firmware Quality Assurance for the HD-RX-4K-210-C-E Switcher, including hardware modifications enabling power via new 4KZ transmitters. Testing encompasses evaluating Power over Ethernet (PoE) implementation changes across Crestron devices, facilitating combined power and data transmission through a single Ethernet cable. The Power Sourcing Equipment (PSE) ensures power delivery according to diverse PoE standards within Ethernet networks, with PoE technology poised for expansion due to convenience and ratified standards supporting smart devices. Continuous improvement driven by customer feedback and field testing fosters ongoing advancements and innovation in future firmware updates and hardware revisions. Defect rectification and mitigation of network attacks are achieved

through timely software and firmware updates, along with disabling unnecessary network services or ports. Previous firmware issues are diligently addressed prior to subsequent release builds. By adhering to best practices and prioritizing firmware updates, compatibility testing, performance optimization, user experience, security enhancements, automated testing, industry standards compliance, field testing, documentation, and continuous improvement, a host of benefits are realized, including enhanced stability and reliability, comprehensive compatibility testing across various input and output devices, optimized firmware and hardware components for maximum performance, refined video processing algorithms, reduced latency, improved response times, and heightened overall system efficiency.

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