

Foshan LPL Spring Finals Wireless Transmission System Analysis and Design Postprint

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Abstract

[Objective] On April 21, 2024, the LPL League of Legends Professional League Spring Finals were held in Foshan, Guangdong. During the broadcast, camera stabilizers were required for roving camera positions with extensive movement. This necessitated the use of microwave wireless video transmission for coordination. For such a large-scale event, the electromagnetic environment within the venue became considerably complex, wherein high-power audio systems, large display screens, in-house wireless intercom systems, and even walkie-talkies used by various departments such as security and fire safety would all cause a certain degree of interference to the microwave video transmission. To ensure the smooth progress of the live broadcast, it was necessary to meticulously design the wireless transmission system, analyze the generated interference, and circumvent these interferences.

[Methods] Through multiple optimization approaches including antenna design, system redundancy, interference detection and elimination, the broadcast was ensured to proceed smoothly.

[Results] After optimization through various means, the video return transmission quality was significantly improved, and the live broadcast was successfully completed.

[Conclusion] Throughout the entire broadcast event, a professional brand of walkie-talkies, which was originally considered the least likely to cause interference to microwave video transmission, turned out to be the primary source of interference. For broadcast operations with relatively stringent requirements, when using microwave video transmission, it is advisable to have a spectrum analyzer available for continuous frequency monitoring to ensure safe broadcasting.

Full Text

Preamble

Analysis and Design of Wireless Transmission System for the Foshan LPL Spring Finals

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Abstract

[Objective] On April 21, 2024, the LPL (League of Legends Pro League) Spring Finals were held in Foshan, Guangdong. The broadcast required Steadicam stabilizers for mobile camera positions with extensive range of motion, necessitating the use of microwave wireless video transmission. For an event of this scale, the electromagnetic environment within the venue became extremely complex, with high-power audio systems, large LED screens, wireless intercom systems, and even walkie-talkies used by security and fire safety personnel all potentially causing interference to microwave transmission. To ensure a smooth live broadcast, the wireless transmission system required careful design, interference analysis, and mitigation strategies. **[Methods]** Optimization was achieved through multiple approaches including antenna design, system redundancy, interference detection, and elimination. **[Results]** Following optimization through various methods, video return transmission quality improved significantly, enabling successful completion of the live broadcast. **[Conclusion]** During the entire broadcast, a professional brand of walkie-talkies—originally considered the least likely source of interference—turned out to be the primary interference source. For broadcast applications with stringent requirements, microwave video transmission should ideally be accompanied by a spectrum analyzer for continuous frequency monitoring to ensure safe transmission.

Keywords: wireless transmission; wireless reverse control; microwave; spectrum monitoring; interference elimination

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1. Background and Technical Requirements

On April 21, 2024, the LPL Spring Finals were held in Foshan, Guangdong. As one of the most anticipated events in professional esports, the tournament featured top-tier teams and players, attracting thousands of live spectators and millions of online viewers. The venue utilized two Steadicam systems for mobile

camera positions, both equipped with wireless microwave transmission systems to capture dynamic, high-quality video footage, enabling camera operators to move freely throughout the arena without cable constraints. Simultaneously, camera parameters were controlled from the OB van's technical area via OCP (Operation Control Panel), allowing real-time adjustment of aperture, color balance, and other critical video parameters. Since the two microwave systems did not require tally or synchronization signals, the reverse control design was relatively simple. Camera operators used wireless beltpack intercom systems for communication.

For this broadcast, the technical team selected the Vislink wireless transmission system—a widely acclaimed industry solution known for its reliability and high performance. Operating in the 7GHz band, this system specifically avoids the more commonly used unlicensed 2.4GHz and 5GHz bands, which typically suffer from channel congestion due to Wi-Fi networks, Bluetooth, Zigbee, and other consumer electronics. The 7GHz band more directly and effectively avoids conventional wireless signal interference. Each microwave transmission system consisted of an integrated encoder/modulator/microwave transmitter, a receiver/demodulator/decoder, four 7GHz microwave receiving antennas, and four L3025-6471 active downconverters (which convert 7GHz microwave signals to the UHF band for transmission via SDI coaxial cable to the receiver). This conversion ensured reliable signal transmission over long distances without significant attenuation.

The reverse control system employed the Vislink FocalPoint system, a compatible solution from the same manufacturer. Each system included a CCIU (Camera Control Interface Unit) to connect with the camera's proprietary OCP. The CCIU converted the camera OCP's control protocol into a Vislink-compatible protocol for transmission. The system also comprised an active wireless transmitter and an omnidirectional whip antenna. The CCIU connected to the microwave receiver via a Lemo cable, receiving status information from the camera transmitted back by the microwave transmitter. This status information was then sent to the camera's OCP, enabling correct display of technical parameters such as aperture values and color temperature, thereby achieving closed-loop control of the reverse control system.

Since the OB van was parked outside the venue, direct SDI coaxial connections would have required at least four 150-200m SDI cables per system—exceeding coaxial transmission limits. To address coaxial attenuation and cabling complexity, a Boya Weiyuan microwave optical transmission system (model RTP-5) was deployed between the OB van and the interior. This system utilized camera hybrid fiber-optic cables, offering several advantages: backup camera hybrid cables are routinely carried for each broadcast, ensuring ample connection lines; using standard camera cables guaranteed compatibility and universality; and only one interior-to-exterior hybrid cable was needed instead of multiple coaxial lines. A single optical terminal at each end connected the microwave receivers and downconverters, while also linking the CCIU to the reverse control wireless

transmitter. The system connection diagram is shown in [Figure 1: see original paper].

2. Design Scheme

The Steadicam operating ranges within the venue are indicated by red boxes in [Figure 2: see original paper], with the blue section representing the player entrance corridor. Steadicam operators would enter this area to track players during their entrance, which consisted of an aluminum alloy frame with wooden boards covered by gypsum board and black stickers. Since 7GHz microwave frequencies have high penetration and diffraction characteristics, signal transmission performance in this corridor would be significantly compromised. Therefore, antenna placement should prioritize optimizing signal reception in this area. Due to the extensive Steadicam operating range and the need to ensure stable video transmission, the receiver employed quad-diversity microwave reception—each receiver configured with four antennas receiving signals from different angles. If one direction experienced interference, other antennas could still receive strong signals, preventing signal loss from single-point interference. The receiving antennas were positioned separately to ensure good signal quality throughout the entire Steadicam movement path.

Each microwave receiver was equipped with four antennas: two omnidirectional whip antennas and two directional panel antennas. The high gain of directional antennas enabled stronger signal reception in specific directions, particularly in areas with frequent camera movement and partially shielded zones like the player entrance corridor. This improved anti-interference capability and ensured stable video return. Omnidirectional antennas provided broad signal coverage for areas where cameras might move randomly. The combination of directional and omnidirectional antennas maintained signal stability in critical areas while providing extensive coverage. The directional antenna model was Vislink L3490, with 80° beamwidth in both vertical and horizontal directions. The two directional and two omnidirectional antennas were arranged diagonally to ensure balanced signal strength across all zones.

Due to the poor penetration and diffraction capabilities of 7GHz millimeter waves, signal reception strength at the player entrance corridor needed enhancement. A directional antenna was positioned diagonally in the corridor, oriented toward the entire passage to improve signal reception quality, as shown in [Figure 3: see original paper]. In this figure, red antennas correspond to the left Steadicam position, green to the right, and yellow lines indicate the beam angles of the four directional antennas. The diagram shows that directional antennas primarily cover blind spots and enhance signals in open areas, while omnidirectional antennas provide broad coverage.

Video signals transmitted via microwave typically employ modulation schemes to achieve higher transmission efficiency within limited spectrum resources. The Vislink microwave transmission system supports two common modulation meth-

ods: QPSK (Quadrature Phase Shift Keying) and QAM (Quadrature Amplitude Modulation). QPSK offers relatively lower carrier efficiency, transmitting only one carrier signal, but provides strong anti-interference capability. Conversely, QAM offers higher carrier efficiency, simultaneously transmitting multiple carrier signals through phase division, but with weaker anti-interference capability than QPSK. The appropriate modulation scheme should be selected based on the application scenario. For this event, since the 7GHz microwave frequency avoided most channel interference and benefited from directional antenna support, QAM modulation was adopted to ensure efficient transmission of high-definition video.

In large-scale events, any equipment failure can disrupt broadcasting. Therefore, system design must incorporate redundancy and backup mechanisms. As a wireless transmission system, it must also consider microwave transmitter roaming coverage and signal transmission performance across different zones, with particular attention to optimizing weak signal areas. The equipment setup structure is shown in [Figure 4: see original paper].

Following principles of clean cabling and equipment redundancy, we employed cross-wiring for interior cabling. In [Figure 4: see original paper], one microwave optical transmitter was placed at each middle position on the upper and lower sides of the stadium. Each side's microwave optical transmission system connected to two antennas for the left Steadicam and two for the right. This ensured that even if one microwave optical transmission system failed, the other could guarantee at least two diversity reception antennas for each Steadicam, maintaining continuous and stable transmission. The blue markers in the diagram illustrate this cross-connection approach.

At the OB van end, cross-wiring was similarly implemented for hot standby between the two microwave optical transmission systems, as shown in [Figure 5: see original paper]. Since the reverse control system had only one RS485 data line connecting to the microwave optical transmission system, and RS485 transmission distance limitations prevented cross-connection between the two reverse control systems, backup for the reverse control system was not possible. If the microwave optical transmission system failed, reverse control functionality might be affected, though video transmission would not be directly impacted. This design limitation was acceptable for event broadcasting, as stable video transmission remained the priority. Reverse control failure would not directly cause broadcast interruption, and in emergencies, camera operators could be notified via intercom to manually adjust aperture as a contingency measure.

4. On-site Problems and Solutions

The primary on-site issue was electromagnetic interference from various sources. High-power audio and large-screen equipment, though not wireless transmitters themselves, generated substantial low-frequency electromagnetic radiation and spurious noise that interfered with microwave transmission systems. Walkie-

talkies and wireless intercom systems, typically operating in the UHF band (400MHz-470MHz), could produce harmonic interference despite their frequency separation from microwave systems. Venue Wi-Fi and Bluetooth devices, primarily operating at 2.4GHz and 5GHz, generated high-order harmonic interference when numerous devices operated simultaneously, affecting the 7GHz microwave signals.

After equipment installation and commissioning, the electromagnetic environment grew increasingly complex during rehearsals as new equipment was continuously added. The spectrum analyzer showed substantial spurious interference near 6.9GHz and significant walkie-talkie interference in the 450MHz reverse control band. As rehearsals continued over subsequent days with additional walkie-talkies and stage equipment occupying wireless frequencies, dedicated personnel had to continuously monitor the MER (Modulation Error Rate, expressed in dB with higher values indicating better signal quality) on microwave receivers, ensuring at least one antenna maintained good reception at all times. During Steadicam operation, all antennas were kept at maximum signal strength. When two or more antennas showed MER values below 25dB, technicians used a spectrum analyzer on-site to check for interference near the corresponding antenna frequencies. If interference was detected, the receiver, transmitter, or reverse control system frequencies were adjusted to avoid interference bands. Consequently, microwave video transmission and reverse control system frequencies were continuously adjusted throughout the rehearsal process.

On the final competition day, the microwave transmission frequencies were set at 6.448GHz and 6.790GHz, with corresponding reverse control frequencies at 463MHz and 443MHz. Spectrum management plays a crucial role in modern wireless transmission systems. Large events require not only pre-planned spectrum allocation but also real-time monitoring and emergency response. When signal quality degrades in a particular band, technicians must quickly adjust transmission frequencies to less interfered bands. This real-time adjustment strategy proves highly effective in complex electromagnetic environments but demands high agility and experience from the technical team. They must promptly identify interference sources, make rapid judgments, and adjust frequencies according to equipment characteristics—critical capabilities for ensuring uninterrupted broadcasts.

During the entire broadcast, a professional brand of walkie-talkies—originally considered the least likely interference source—proved to be the primary culprit. Walkie-talkies typically operate in the 400MHz-470MHz band, offering optimal penetration and propagation distance. Microwave video transmission operates in the relatively interference-free 6.425GHz-7.125GHz range. Although both belong to UHF, one in megahertz and the other in gigahertz, theoretical analysis suggested no possible interference. However, continuous spectrum monitoring revealed that when walkie-talkies operated within the venue, numerous interference spurs appeared between 6.83GHz and 7.1GHz—an unexpected finding from theoretical analysis. Therefore, for broadcast applications with stringent

requirements, microwave video transmission should be accompanied by a spectrum analyzer for continuous frequency monitoring to ensure safe transmission.

Additionally, the microwave optical transmission system incorporated redundant links, allowing rapid switching to backup links if a fiber link failed. This redundancy not only improved system reliability but also provided technical teams with more operational options during emergencies. In the future, with further development of 5G, artificial intelligence, and new antenna technologies, wireless transmission systems will achieve significant improvements in transmission quality, anti-interference capability, and automation. This will not only advance live event broadcasting technology but also provide audiences with more immersive viewing experiences.

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Note: Figure translations are in progress. See original paper for figures.

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