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Active Field Control in the Teatr Wielki—Opera Narodowa

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ABSTRACT

This opera house of 1,828 seats boasts one of Europe's largest stages and is highly reputed for its repertoire and acoustics. However, it presented a number of issues including poor communication between the singers and the orchestra pit, the insufficient loudness of the upstage singers for the audience, a lack of reverberation when the house was occupied, and insufficient loudness at the seats under the balconies. Due to these reasons, Active Field Control System (AFC) was adopted as a means to improve the acoustics while preserving the historical architecture of the opera house. This paper presents an overview of that system and the benefits achieved by its introduction.

1. INTRODUCTION

The Teatr Wielki, Polish national opera was built in 1825-1833. It was bombed during the siege of Warsaw in 1939 and almost completely destroyed. In 1965, the opera house was restored [1]. The current opera house of 1,828 seats has one of Europe's largest stages (30 m x 33 m), and because of its size, it was challenged by the issues of poor communication between the singers and the orchestra pit, and insufficient loudness of the upstage singers for the audience. Further, owing to the small volume of the house although most seats have sufficient sights and clarity of sound, reverberation in certain conditions was lacking in the audience area depending on the repertoire; and the early reflection from above was blocked from the audience seats below the balconies surrounding the main floor seating area, resulting in insufficient loudness—all issues whose resolution was desirable.

As a means to solve the above issues while preserving the architecture of this traditional opera house, it was decided to adopt the Active Field Control system (AFC). The system was implemented and tuned for an opera premier that started its new season on Oct. 2014. AFC is an acoustic enhancement system that was developed to change the acoustic conditions of a space to match the acoustic conditions required for a variety of different types of performance programs. This report summarizes the design of the installed system and the achieved results. Figure 1 shows the plan of the opera house.

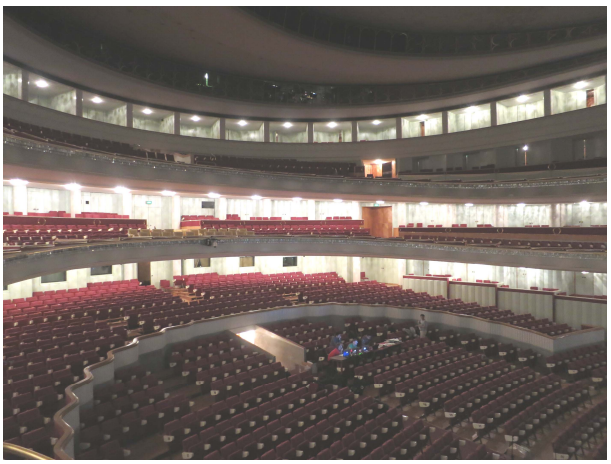


Photo 1: Teatr Wielki—Opera Narodowa.

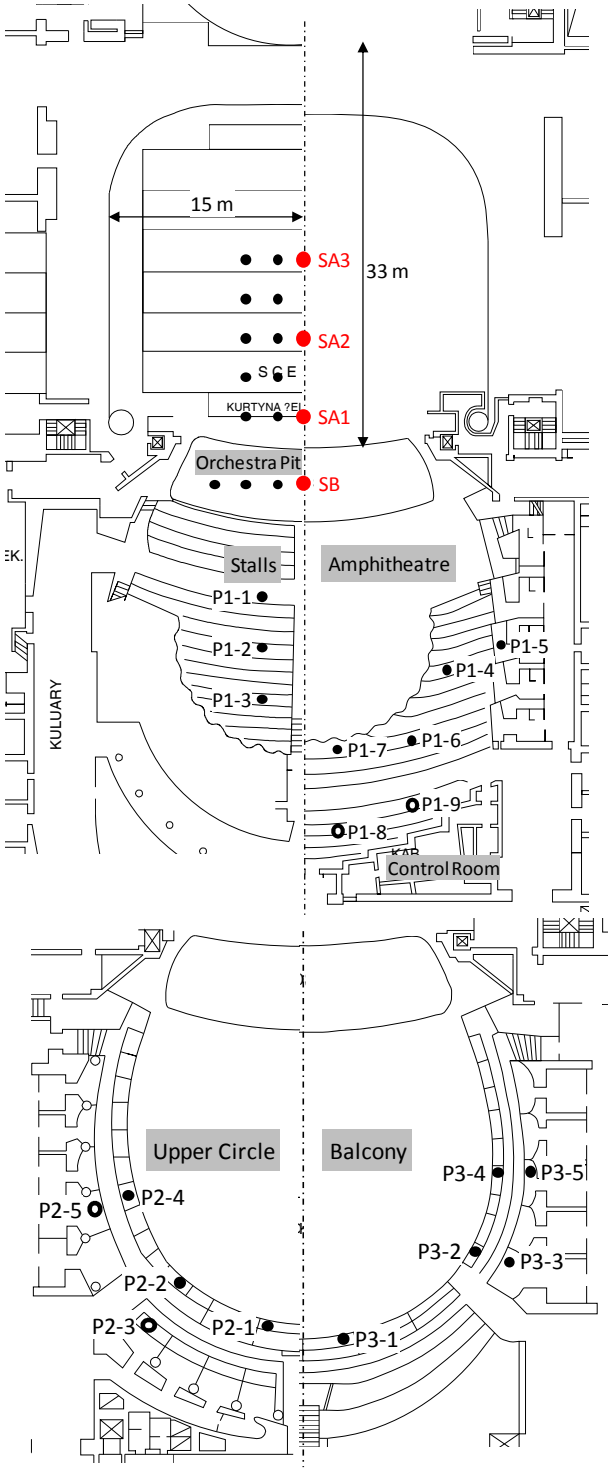
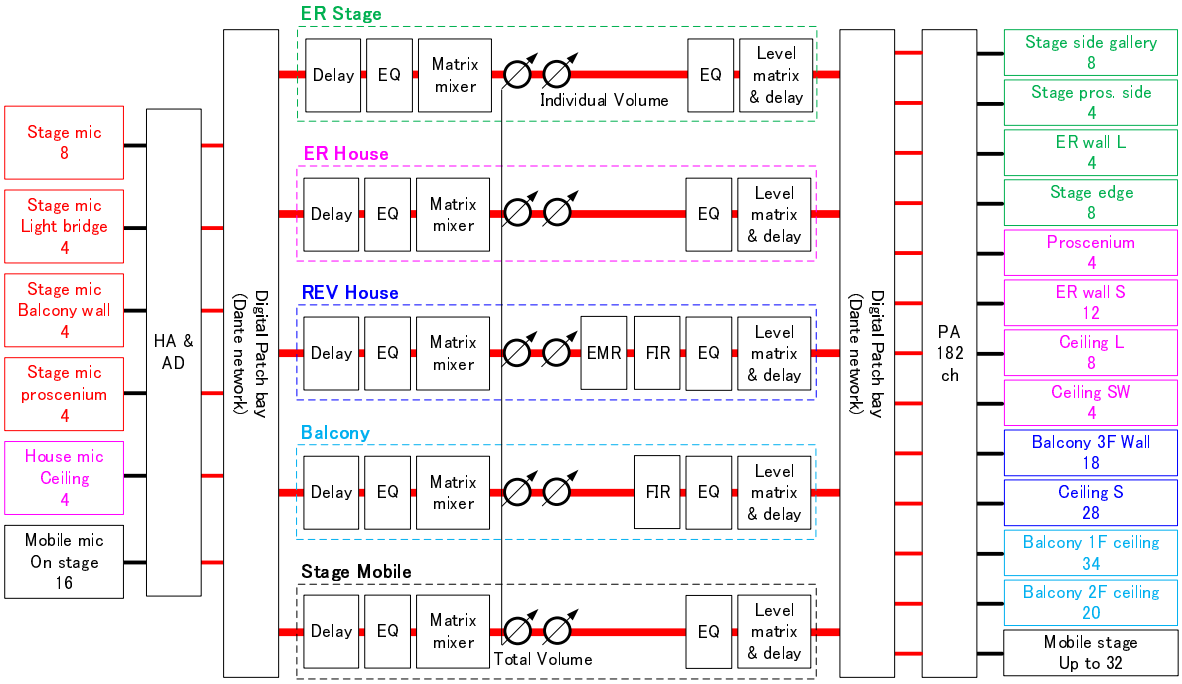


Figure 1: Plan of Teatr Wielki.



HA: Head Amp, EMR: Electronic Microphone Rotator, EQ: Equalizer, PA: Power Amp

Figure 2: Block diagram of the system.

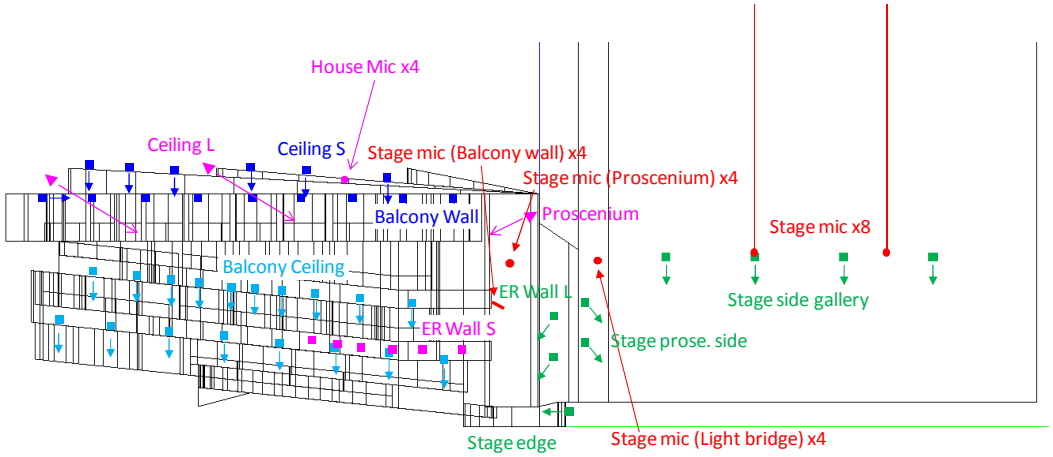


Figure 3: Equipment placement.

2. DESIGN CONCEPT OF AFC

2.1. Summary of AFC

This system, which is based on the use of acoustic feedback (re-generative system) is capable of achieving stability with a smaller number of channels by adopting the idea of spatial averaging. Another feature of this system is the high degree of control freedom it enables through the use of FIR filtering [2][3].

2.2. System Configuration

To solve the above-described issues, the system for this opera house consists of the following five components: 1) ER Stage, which increases support for the singers and improves communication between the orchestra and the chorus, 2) ER House, which increases the loudness of the upstage singers for the audience and is aimed at enhancing the early reflection level for the audience, 3) REV House, which aims to enhance reverberation in the audience area, 4) Balcony, which is intended to increase the loudness at the seats under the balconies, and 5) Stage Mobile, which compensates for the parts not covered by ER Stage depending on the repertoire. Figure 2 and 3 show the block diagram and the equipment placement respectively.

The opera house is mainly used for opera, ballet and orchestra concert, pop music, lecture and so on. Based on the usages, 7 presets of the system were created shown in table 1.

Table 1: System presets

	Preset	RT (sec)
Opera	3	2.0/2.2/2.3
Ballet	2	1.8/2.0
Concert	1	-
Opera "Merchant of Venice"	1	2.2

For the system control, an additional adjustment using system loop gain control is offered besides selecting the presets above. As shown in figure 2, there are two adjustments in the system. One is "Total Volume" which is total loop gain control while maintaining the relative relationship of the systems. The other is "Individual Volume" which can control the individual loop gain of each system. These functions can provide flexible control for the opera house even if the acoustical condition is different by each repertoire.

It is proposed that the usage of the "Stage Mobile" with other systems is beneficial to maximize the effectiveness of the system when an opera with large-scale sceneries is held. Although it requires additional tweaking of the system, the system can be adjusted in a short time by using the additional adjustments mentioned above.

2.3. Evaluation with an opera performance and fine tuning

During the tuning session, four sound sources were set on the stage and in the orchestra pit. The loudspeakers simulated singers and an orchestra for this evaluation. We selected the delay time, and level balance of each system loudspeaker and the balance of each system while listening to the sound field using music sources from each speaker or several speakers. After the tuning using simulation, we listened to actual opera rehearsals seven times and evaluated additional tweaking with performers, taking into consideration the directivity and the apparent width of the source, which cannot be confirmed with a loudspeaker. As a result, we could aurally confirm the improvement of the reverberance and loudness on stage and in the audience area. On the other hand, we had two specific issues of the opera house. One was the change of the microphone position to prevent noise pickup of a projector which was used in the production. The other was the requirement of muting the sound from the microphones on stage during intermissions as the microphones picked up noise of mobile equipment and the system reinforced the noise into the audience area.

3. MEASUREMENT

After the system was adjusted, acoustic measurements were made to evaluate the effect of implementing the system. Sound sources and the measurement points are shown in figure 1. First, to confirm the boosted support effect for the singers on the stage, we measured ST_{Early} corresponding to 'Ensemble Condition' and ST_{Late} corresponding to 'Perceived Reverberance' at 10 points on the stage. Table 2 shows the measured those parameters. As a result, we were able to observe respective improvements of 0.1 to 0.8 dB for ST_{Early} and 0.4 to 1.1 dB for ST_{Late} from the system's operation.

Table 2 Measured stage parameters.

	ST_{Early} (dB)	ST_{Late} (dB)
System On	-23.7 ~ -18.8	-20.8 ~ -18.8
System Off	-24.3 ~ -18.9	-21.8 ~ -19.4

Next, to verify the effect in terms of improving communication between the orchestra in the orchestra pit and the chorus on stage, we checked the equivalence of Strength G at a measurement point in the orchestra pit when a source was set on the stage, and at a measurement point on the stage when the sound source was set in the orchestra pit. Figure 4 shows the

measured results respectively. We were able to confirm a 2 dB increase in the orchestra pit from the sound source on the stage, and a 1 dB increase at the measurement point toward the upstage from the orchestra pit sound source, as the result of the system's operation.

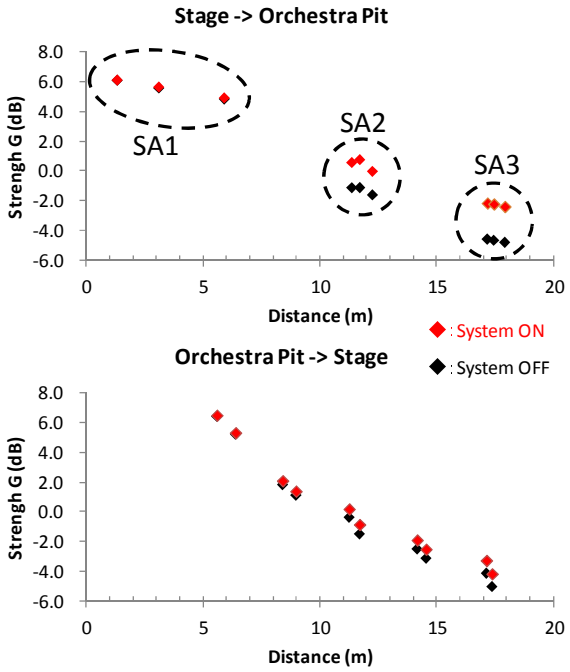


Figure 4: G value with/without AFC.

Regarding support of the singers for the audience area, we measured the Strength G in the audience area when the sound source located on each stage points (SA1-3). Figure 5 shows the Strength G measurement results. It showed an average rise of 2 dB even for a sound source located at the upstage (SA3), and as to variation among audience seats, a 0.4 dB improvement in standard deviation compared to when the system was off. Especially as regards to the measurement points under the balconies, there was a 5 dB increase for Strength G, confirming the enhancement of loudness.

Figure 6 shows reverberation time measurements. For reverberation time, extension from 1.6 seconds when the system is off to up to 2.3 seconds when the system is operating can be achieved thanks to the provision of a number of different patterns.

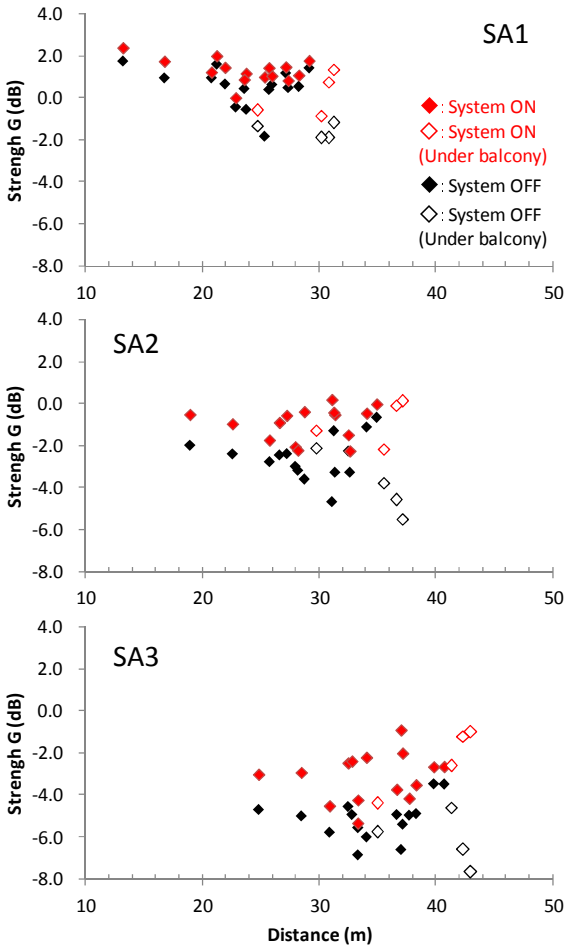


Figure 5: G value with/without AFC in the audience area.

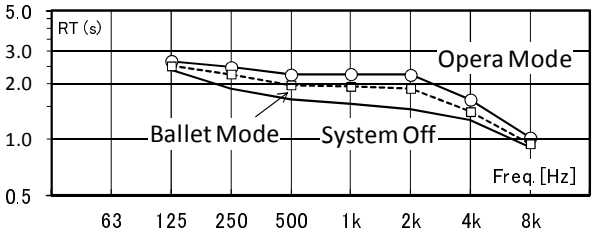


Figure 6: Reverberation time with/without AFC.

4. CONCLUSION

Opera premier "Merchant of Venice" was held using AFC on Oct. 24th, 2014. After that, the orchestra concert by Sinfonia Varsovia was held using concert preset. As

of February 2015, the opera "Onegin" has just finished using AFC.

The effectiveness of AFC in an opera house where acoustical condition is dramatically different by each repertoire was confirmed. On the other hand, adopting AFC in historical buildings like an opera house has exposed many issues. Below are important items to consider for the design and tuning of AFC in the future.

1) The demanding limitations to the number of loudspeakers and their sizes due to the architectural design.

2) Preliminary discussion of on-stage microphone placement with the stage scenery staff.

3) System stability during stage conversion.

4) The design criteria of the sound field in the orchestra pit.

5) Microphone directivity control method to prevent the restriction of the microphone placement.

6) Optimization and simplification of the tuning method for large scale system.

5. ACKNOWLEDGEMENTS

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6. REFERENCES

[1] http://www.teatrwielki.pl/en/teatr_wielki.html

[2] H. Miyazaki, et al., "Active Field Control (AFC)—Reverberation Enhancement System Using Acoustical Feedback Control," in Proc. of AES 115th Convention (2003)

[3] T. Watanabe, et al., "Various Applications of Active Field Control," in Proc. of AES 134th Convention (2013)