Durgadeens Audio Design Center
6500 Vocal Avenue.
New York, NY 10022

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| Date: | April 25th, 2020 |
| To: | Crystal Rodwell<br>City College of New York |
| From: | Durgadeens Audio Design Center<br>Nicholas C. Durgadeen, President |
| Subject: | Proposal to Create a Higher Ohm Resistor in the SHURE SLX2 Microphone |

## Purpose

The purpose of our proposal is to request funding of the experiment being conducted at our facilities to determine the best course of action to eliminate feedback produced by SHURE Microphones, especially the SLX2/SM58.

## Summary

On April 5th, 2020, Crystal Rodwell, Professor of English, asked us to develop a plan to use our innovations to solve a problem, modify the item if necessary, and determine the solution.

Currently, DADC has a particular complication with our SHURE Vocal Microphones; the unpleasant sound that everyone knows, feedback. Feedback is a positive gain loop between a microphone and a loudspeaker. The speakers amplify the mic signal then the microphone picks up the sound from the speakers. This positive gain loop continues and the system overloads, resulting in the terrible screech of microphone feedback. Feedback is a phenomenon that can be a problem for any microphone in general.

Therefore, DADC proposes to research and present our findings on how to eliminate feedback production. To perform these tasks, we would need secondary and primary research. We would study the literature on common feedback inducers and short-term/long-term solutions.

Nicholas C. Durgadeen, the President, has been with DADC since it opened its doors to business and has overseen numerous audiology feasibility studies.
If this proposal is authorized, we would begin our research immediately by submitting to Crystal Rodwell a progress report on April 27th, 2020, including a recommendation report. The report would include the details of our research and recommendations regarding the issue at hand and how to proceed with the feasibility study.

## Introduction

Shure set the worldwide industry standard for superior, reliable products. Shure offers audio products ranging from wired microphones and wireless microphone systems to DJ mixers and listening products.

In the 1950s, the Shure SLX2/SM58 Microphone was invented by Shure Engineer Ernie Seeler and his team that wanted to create the ideal vocal microphone. Studio microphones are notoriously fragile, therefore the challenge to solve studio mic durability and design problems was no easy feat for Seeler and his creative team. The microphone's ball-shaped and lined grille reduces wind, breathe noise, and plosive popping, making the microphone better suited for vocal applications.

The Shure SM58 gave singers the freedom to roam the stage, but this created new issues of feedback and handling noise. The SM58’s consistent cardioid polar pattern, high gain-before-feedback, and groundbreaking integrated pneumatic shock mount greatly eliminated these problems, allowing vocalists to focus on connections with their fans without worrying about their mics. However, this wasn’t a long-term solution.

Feedback only happens when the microphone picks up a critical level of sound from the loudspeaker that projects the microphone’s signal.

- The microphone captures the sound and turns it into an audio signal.
- The audio signal is sent to the loudspeaker and is amplified as sound.
- The microphone picks up the sound from the loudspeaker.
- A greater signal is sent to the loudspeaker and it gets louder.
- This creates even more sound to be picked up from the microphone.
- The cycle continues and turns into feedback.

## Proposed Tasks

With Crystal Rodwell’s approval, it will take approximately two and a half months to be executed. The budget that’ll be most worthwhile is approximately $800 - $1,000. This budget

includes the purchase of (3) Shure SLX2/SM58 Vocal Microphones, Higher Ohm Resistors, Wiring, and Operating Costs.
Resistor values are carefully selected by the circuit designer to allow the circuit to work correctly. While there is some allowable tolerance, it won't usually be as much as a different value in the series. However, with the right wiring and increased allowable power in the microphone, it is possible.

The solution is to implement a higher resistor inside the microphone circuitry to increase impedance. Many microphones have a limited impedance of 300 ohms. But, if a resistor with higher resistance can be fitted in, a trial and error experiment can be conducted. This problem can be eliminated entirely and possibly save lives.

The following tasks are to help determine the best course of action for integrating the higher ohm resistor into the Shure Vocal Microphone:

**Task A - Physical Evaluation of the Microphone**

The Shure SM58 is a unidirectional (cardioid) dynamic vocal microphone for professional vocal use in sound reinforcement and studio recording. To explain, unidirectional means the microphone can only pick up sound with high gain from a specific side or direction. Cardioid means the microphone picks up sound with high gain from the front and sides, making this microphone style ideal for performers.

A highly effective, built-in, spherical filter minimizes wind and breath noises. A cardioid pickup pattern isolates the main sound source while minimizing unwanted background noise. The SM58 has a tailored vocal response for a sound which is a world standard. Rugged construction, a proven shock-mount system, and a steel mesh grille ensure that even with rough handling, the SM58 will perform consistently. Outdoors or indoors, singing or speech, the SM58 is the preferred choice for professionals worldwide.

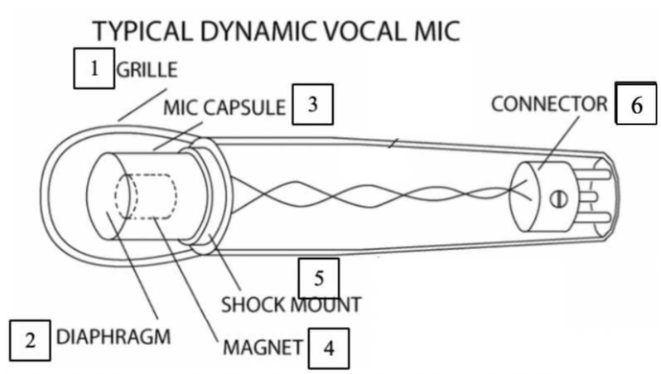


Figure 4

Above, Figure #4 shows a schematic drawing of a Typical Dynamic Vocal Microphone. Item #1 is the grille of the microphone. The grille is the solid metal mesh we find around the capsule, and it's designed to protect the microphone's sensitive capsule from physical harm. Additionally, grilles often have an interior acoustic foam layer that will help to absorb moisture protecting the capsule. Item #2 is the diaphragm. A microphone diaphragm is the thin, movable part of the mic capsule that moves sympathetically with the sound waves around the mic. Diaphragm movement is caused by sound pressure differences between the front and back of the diaphragm and begins the transduction, in most microphone designs. In dynamic microphones, moving-coil diaphragms are typically made of BoPET (biaxially-oriented polyethylene terephthalate). BoPET material is preferably used for its high tensile strength, stability, and flexibility. These diaphragms have conductive coils attached to their backsides, typically made of a tiny diameter insulated copper wire that is wound many times around.

Item #3 is the microphone capsule. A microphone capsule is a mechanism that acts as an electroacoustic transducer, changing sound waves (mechanical wave energy) into microphone signals (electrical energy). Capsules are often labeled by transducer type and polar pattern. In this particular model, it's a cardioid condenser capsule. A condenser capsule is a transducer with a parallel-plate capacitor capsule that requires a steady electrical charge to produce a mic signal. The diaphragm moves according to sound waves, causing a variation in capacitance and, therefore voltage (mic signal). Item #4 is the microphone magnet. Magnets are crucial components in dynamic microphones since mics convert sound waves to mic signals via electromagnetic induction, a voltage across an electric conductor in a changing magnetic field. It is the working principle of dynamic mics, where the conductor (coil) moves within a permanent magnetic field and, therefore, induces voltage (the mic signal).

Item #5 is the shock mount. A shock mount is designed to hold and isolate a microphone, protecting it from shock. A shock mount is a mechanical fastener that elastically connects a microphone to a threaded mic stand. The elastic connection is critical, providing secure mounting for the microphone and, at the same time, the freedom for the microphone to move independently of the mic stand. This reduces the amount of mechanically transmitted noise (shock) the microphone will be susceptible to. Shock mounts elastically isolate microphones from their solid environment. The isolation drastically decreases the severity of mechanically transmitted noise and external vibrations present in the microphone. Which, in turn, lessens the noise in the microphone signal.

Lastly, Item #6 is the connector. For the Shure SLX2/SM58, it has a 3-pin XLR Connector. XLR connectors were originally patented by Cannon as part of their X series cables/connectors. XLR proved to be the best of the series. Canon no longer has the patent, but professional mics nearly all have XLR outputs and XLR cables carry their balanced audio signals from mic output to preamp, an electronic amplifier designed to amplify mic level signals to line-level signals. Preamplifiers are essential if the user wants to use the microphone with any mixing console or digital audio workstation.

## Task B - The Influencing Factors of Feedback

So, we know what feedback is and the basics of what causes it, but there are other indirect factors that influence microphone feedback. The factors that influence microphone feedback are:

- **Amplification of the Microphone Signal**
  - Increasing the amplification (gain) of the microphone preamp sends more signal level to the loudspeakers while also raising the microphone's sensitivity and noise floor. The risk of feedback goes up.
- **Volume of the Microphone Channel**
  - After gain is applied, live audio mixers also have channel volumes that adjust the amount of signal that gets sent to the loudspeakers and monitors. Sliding the microphone volume too high will also result in microphone feedback if we're not careful.
- **Volume of the Loudspeakers**
  - Turning up the volume of the loudspeakers creates greater sound intensity in the air. This, in turn, causes the microphone to produce more signal. Boost the loudspeaker volume too much and the microphone pickup will surpass the feedback threshold and cause feedback.
- **Distance between the Microphone and Loudspeaker**
  - The Inverse Square Law states that (in free fields) sound level intensity diminishes by 75% for each doubling of distance. Of course, conditions are never ideal, but this law is useful in estimating sound intensity as it propagates through air. Therefore, the further the microphone is from a loudspeaker, the smaller the risk of feedback. As the distance between the mic and speaker grows, both the amplification of the mic and volume of the loudspeakers can be increased!
- **Directionality and Sensitivity of the Microphone**
  - The directionality of a microphone plays a crucial role in managing feedback. Typical sound reinforcement microphones have a cardioid polar pattern. They are the most sensitive to where they point, less sensitive to the sides, and barely sensitive at all to the rear.
  - Here is a polar graph of the cardioid pattern with a Shure SLX2/SM58 Vocal Mic for reference:

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  Shure SM58 Overlaid On A Cardioid Polar Response Graph
- Pointing a directional microphone at a loudspeaker is a surefire way to get microphone feedback. The directional microphone is most sensitive where it points and the loudspeaker passes the greatest amount of sound where it "points."

  
- For this reason, foldback monitors can be placed in front of singers. The directional microphone should point away from the monitor speakers. In this scenario, the feedback threshold is quite high.

- **Frequency Response or "Tone" of the Microphone**
  - A microphone with poor high-end frequency response is less sensitive to high-end sounds and will effectively handle more high-frequency sound before feeding back.
  - A microphone with poor low-end frequency response is less sensitive to low-end sounds will effectively handle more low-frequency sound before feeding back.
  - Dynamic microphones typically have high-frequency roll-offs well in the audible range of human hearing. Perhaps this is another reason why dynamics are the go-to's of live sound!

## Conclusion

The primary goal of this project is to prove feedback produced through microphones can be prevented. Changing the ohm resistor in the microphone circuit increases the impedance, eliminating feedback. These newly engineered microphones will be tested at Durgadeens Audio Design Center in our laboratories and data will be gathered to determine the efficient and success of this experiment. We need to initiate the program as soon as possible in order to accurately test the microphones, and the funding and support from Crystal Rodwell for this project are essential.

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