**The Samplisizer**

(Technical Paper)

**Residential Microgrids in the United States**

(STS Paper)

A Thesis Prospectus Submitted to the
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On my honor as a University Student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments

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## Introduction

The invention of digital audio samplers in the mid-1970s drastically altered the music industry and helped shape modern music into what we know today. Most current pop, hip-hop, and electronic artists rely heavily on samplers in their songs: in today's music world, a sampler is usually considered just as important as any other instrument (Jones, n.d.). Audio sampler devices allow for the creation of music from any recorded sound, be it a user's voice or the clicking of computer keys, for people with any level of musical ability. Sampling technology has also enabled artists to sample portions of songs from other artists and incorporate them into their own songs, simultaneously paying tribute to previous musicians and creating an entirely new sound of their own (McNamee, 2009).

While audio samplers have such a prolific role in the music industry, many people do not know what they are or how they function. Unless someone is a musician or musically inclined, they have never interacted with an audio sampler before. In order to engage more people in making music and educate them on the functionality of audio samplers in a fun and interactive way, the technical Capstone component of this prospectus will be an easy-to-use audio sampling instrument. This instrument, called "The Samplisizer," will provide entry-level access for interested musicians and non-musicians alike to an interactive audio sampling microphone and keyboard interface. Users will have the opportunity to record any sounds or noises into a microphone and play pitch-shifted versions on a piano keyboard, thus allowing for the world around them to be turned into music.

The STS research project is unrelated to the technical capstone and will focus on the rising trend of home microgrids in the United States. A home microgrid is an independent electricity grid within a residential home or community that creates and stores energy (Miranda,

2021). The research will explore what is causing the rise in popularity of microgrids as well as the technological advances that have allowed microgrids to become a feasible option for many homeowners. The positive and negative externalities relating to home microgrids will be explored as well in order to examine the overall impact on the environment and the economy.

**The Samplisizer: An Audio Sampling Instrument**

As described in the introduction above, my Capstone group is designing, programming, and building a pitch-shifting audio instrument we are calling "The Samplisizer." The instrument will allow a user to record sound bites in a microphone (such as speaking a word or strumming a guitar) and play pitch-shifted versions of that sound with an electronic piano keyboard (Rai & Barkana, 2019). Pressing the center key of the piano will trigger the original unmodified recorded sound to play, and all the keys above or below that one will each play the same sound pitch-shifted by the corresponding number of musical half-steps higher or lower.

We are sourcing a microphone, a speaker, and a keyboard for this project as our design is focused on the custom hardware and software that will implement audio processing and a pitch-shifting algorithm to connect the three components into a playable instrument. All of the custom hardware for this project will be encased in a central box as shown in Figure 1 below with an input plug for the analog microphone jack, an input for the USB cable to the piano keyboard, and an output auxiliary connection for a speaker. Inside of the box will be the custom printed circuit board (PCB) designed for this project, the Raspberry Pi microcontroller, and all other hardware.

In order to interact with the instrument a user will hold down the record button while making or playing sounds into the microphone for a maximum of 5-10 seconds or until the

record button is released. While recording the red LED will light up. Then the sound file is transmitted to the PCB and converted to digital format for processing and pitch shifting. The algorithms for this process are written in the Python programming language on a Raspberry Pi 4 (Hollingworth, 2022). While this is happening the orange LED will light up. Once the original sound has been shifted accordingly and transposed to map to each piano key, the green LED will light up. At this point the user can play the piano keys to trigger the sounds to come from a connected speaker.

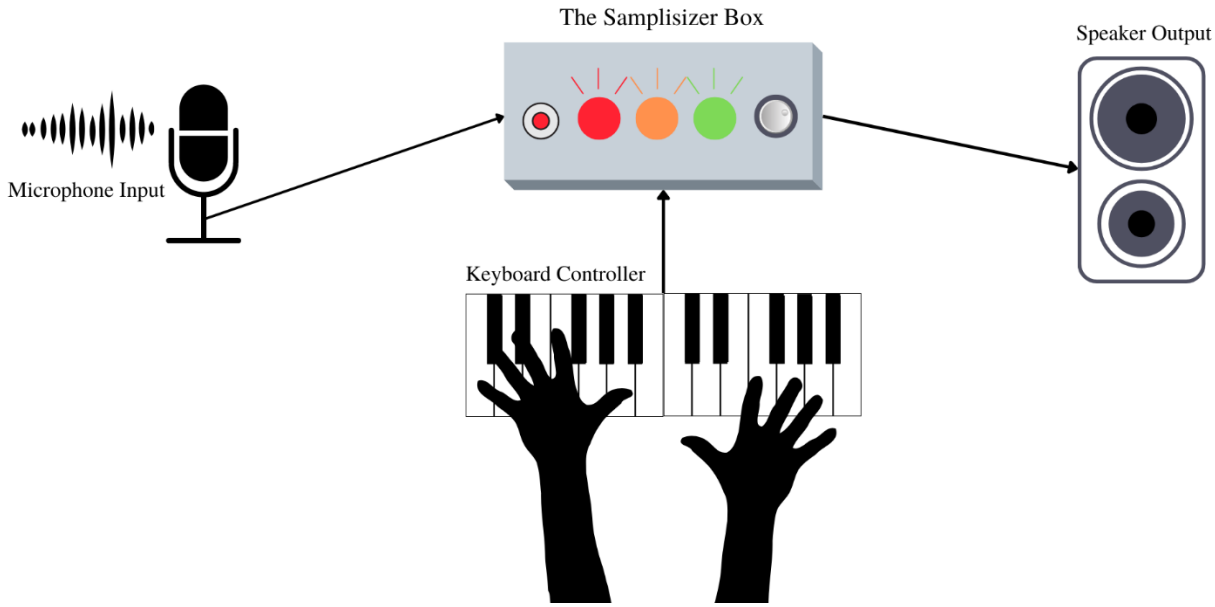


*Figure 1. Samplisizer Inputs/Outputs and Usage Overview*

Overall, this project draws on software and electrical engineering knowledge gained from previous courses to create a fun and entertaining new type of instrument. The project will be completed by early December. My technical advisor for this project is Harry C. Powell Jr. who is a Professor in the Electrical and Computer Engineering department as well as the Associate Chair for Undergraduate Programs.

**Residential Microgrids in the United States**

In recent years there has been a growing trend of turning homes into microgrids in the United States. Home microgrids are local energy grids on your property, powered by batteries or renewable resources, which connect to the traditional power grid. If said traditional power grid fails, then the home will continue to have power (Wild, 2017). Many microgrids are even set up to send excess electricity back into the grid, sometimes in exchange for utility rebates (Murphy, 2022). The rise in homes-as-microgrids popularity is due in large part to the growing number and intensity of natural disasters and the aging American power grid (Miranda, 2021). In August of this year, hundreds of thousands of residents in California faced imposed blackouts during a record heat wave due to inadequate energy supplies (Deliso, 2022). California's power grid is currently very centralized and requires substantial amounts of energy to be transported far distances on a limited number of transmission lines, leading to insufficient supply distribution. Moving some of this electricity usage to home microgrids could reduce the weight on the grid by decentralizing portions (*With Fire Season Approaching, Let's Talk Microgrids*, 2022).

Recent groundbreaking renewable energy technological advancements have helped the microgrid movement to gain momentum. For one, the cost of renewable energies has been decreasing steadily and thus are more accessible to people of all socioeconomic backgrounds than before. There still is a long way to go, however, and full microgrids for homes cost tens of thousands of dollars (Ro, n.d.).

I was first introduced to the concept of microgrids during my previous summer internship at a local start-up Lumin which is creating smart home electrical panels. In their words, Lumin is "advancing the adoption of green energy with one of the first solutions to provide direct, circuit-level control of your home's electricity use" (*Meet Lumin*, n.d.). In my research, I will focus on

the various implementations of home microgrids, including the benefits and drawbacks of each of the most popular options. I will also evaluate the impacts of microgrids on local economies and the environment, as well as the potential future ramifications of mass adoption.

**Conclusion**

Although the topics of my technical project and STS research are unrelated, both are of equal and great interest to me. Designing and building the Samplisizer instrument, which I will complete this semester, requires many computer engineering skills, and incorporates the fun musical component into the work. On the other side, the topics of renewable energies and the American power grid through the lens of home microgrids are issues currently in the spotlight that could have a tremendous impact on the future.

**References**


Deliso, M. (2022, September 9). *Why California has blackouts: A look at the power grid*. ABC News. https://abcnews.go.com/US/california-blackouts-power-grid/story?id=89460998

Hollingworth, G. (2022, February 2). Raspberry Pi OS. *Raspberry Pi*. https://www.raspberrypi.com/news/raspberry-pi-os-64-bit/

Jones, J. (n.d.). *How Sampling Transformed Music and Created New Tapestries of Sound: An Interactive Demonstration by Producer/DJ Mark Ronson | Open Culture*. Retrieved September 25, 2022, from https://www.openculture.com/2018/04/how-sampling-transformed-music-and-created-new-tapestries-of-sound.html

McNamee, D. (2009, September 28). Hey, what's that sound: Sampler. *The Guardian*. https://www.theguardian.com/music/2009/sep/28/whats-that-sound-sampler

*Meet Lumin*. (n.d.). Lumin. Retrieved September 30, 2022, from https://www.luminsmart.com/about

Miranda, L. (2021, March 10). *The new must-have for those who can afford it? Their very own electrical grid.* NBC News. https://www.nbcnews.com/business/business-news/after-blackouts-texas-elsewhere-private-electrical-grids-are-soaring-popularity-n1260306

Murphy, L. (2022, September 26). *Solar Tax Credit By State In 2022: What You Need To Know*. Forbes Home. https://www.forbes.com/home-improvement/solar/solar-tax-credit-by-state/

Rai, A., & Barkana, B. D. (2019). Analysis of three pitch-shifting algorithms for different musical instruments. *2019 IEEE Long Island Systems, Applications and Technology Conference (LISAT)*, 1–6. https://doi.org/10.1109/LISAT.2019.8817334

Ro, C. (n.d.). *Renewable Energy Costs Have Dropped Much Faster Than Expected, But There's A Catch*. Forbes. Retrieved October 31, 2022, from https://www.forbes.com/sites/christinero/2022/09/14/renewable-energy-costs-have-dropped-much-faster-than-expected-but-theres-a-catch/

Wild, M. (2017, May 15). *Residential Microgrids: What You Need to Know About Going Off the Grid*. Redfin | Real Estate Tips for Home Buying, Selling & More. https://www.redfin.com/blog/residential-microgrids-what-you-need-to-know-about-going-off-the-grid/

*With Fire Season Approaching, Let's Talk Microgrids*. (2022, March 24). Dot.LA. https://dot.la/microgrids-in-california-2657027200.html