DIGITAL SIGNAL PROCESSING PROJECT

ACTIVE NOISE CANCELLATION

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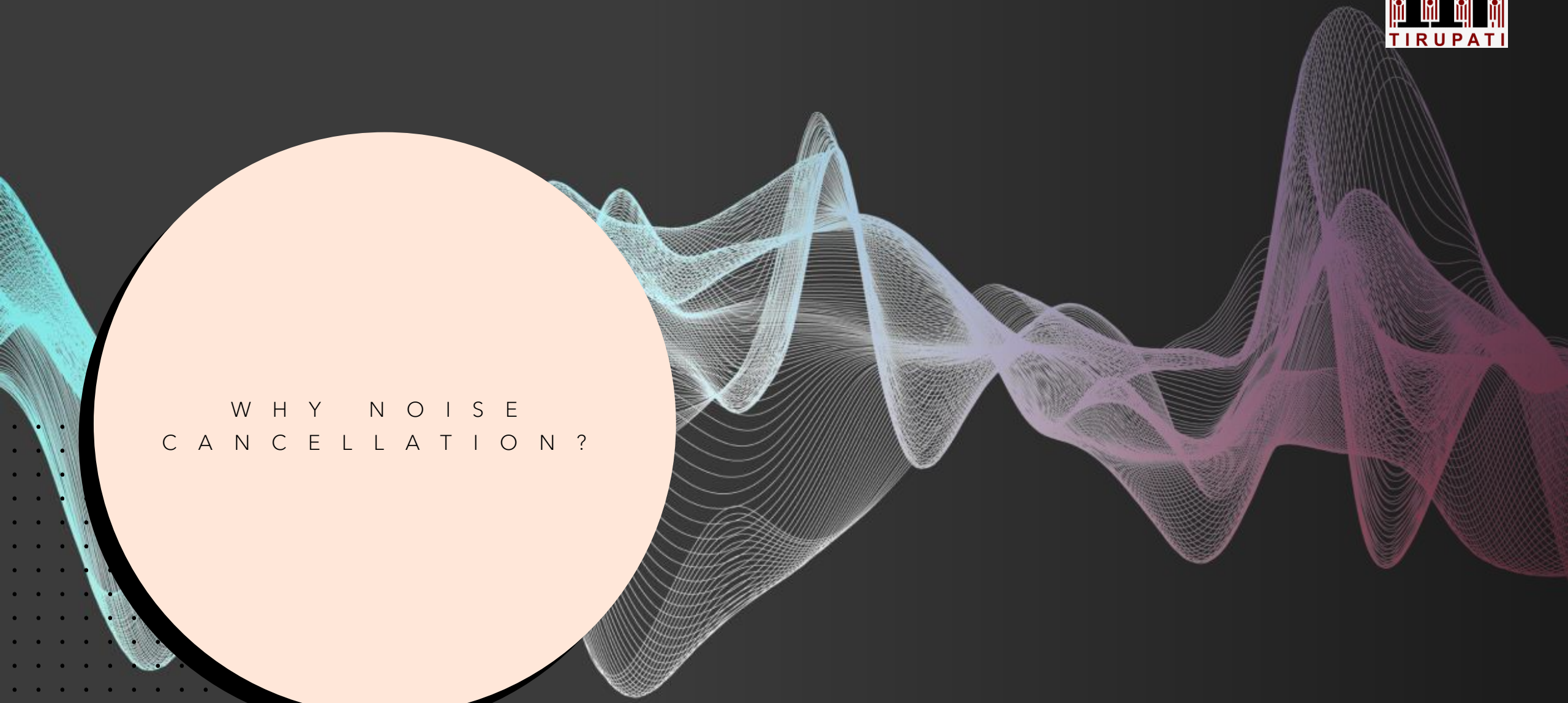
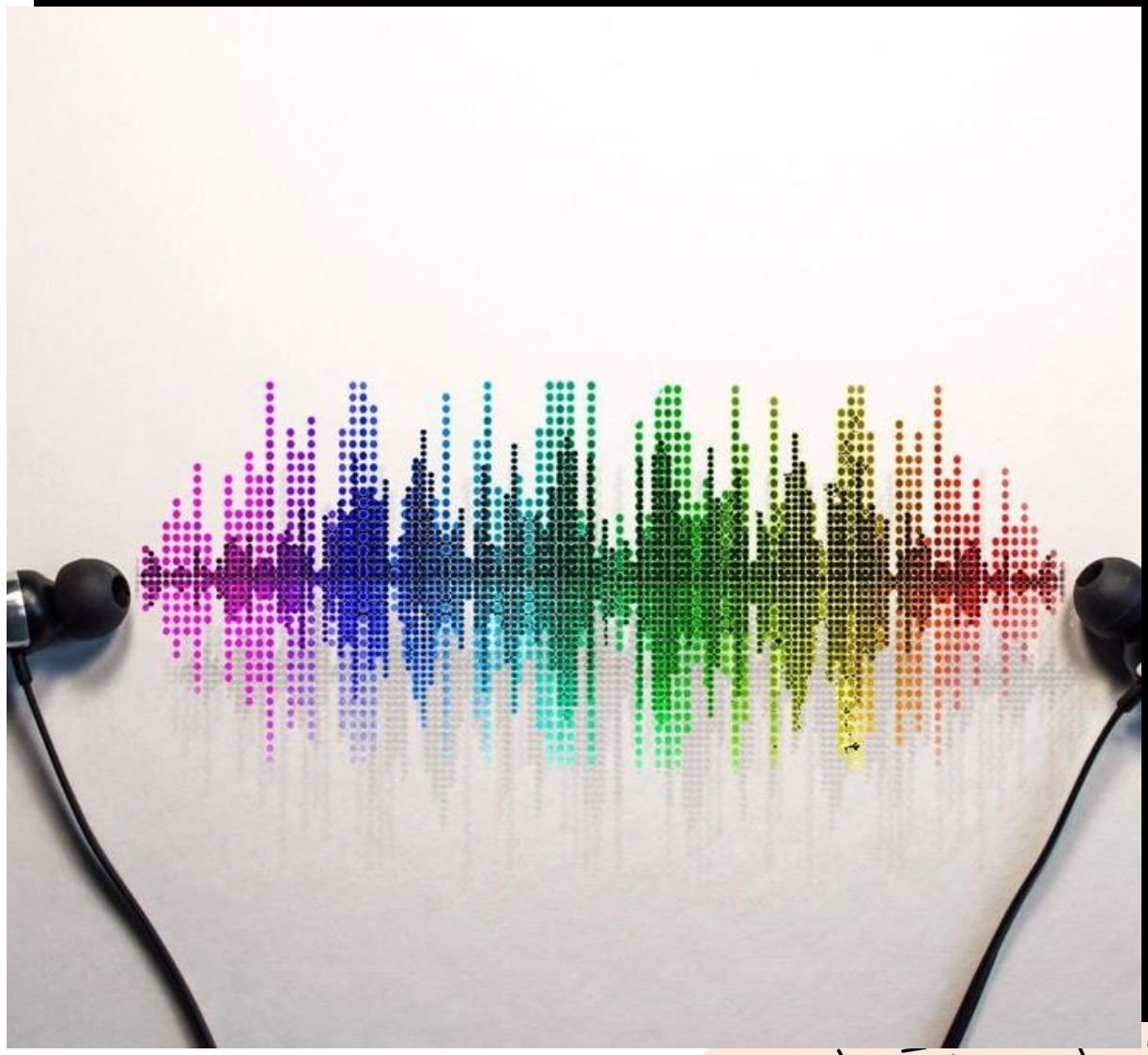

WHY NOISE
CANCELLATION?

NOISE

- Undesirable sounds that disrupt signals can be termed as noise.
- Generally, they are of 4 main types:
  - Continuous: Remains stable and constant over a period of time.
  - Intermittent: Variable noise or is a mix of noisy and quiet periods.
  - Impulsive: Short bursts of large noise
  - Low-frequency: Faint background sounds that can easily travel and spread over large distances.



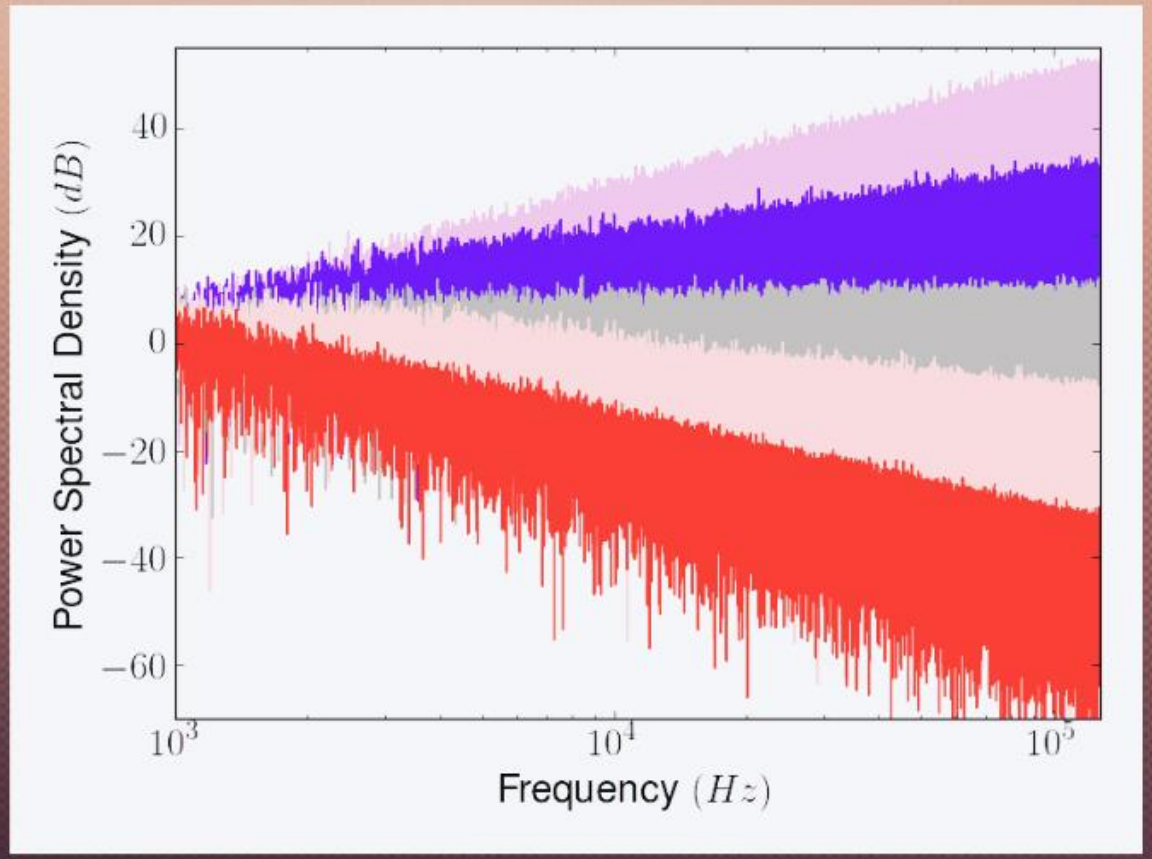
WHITE

equal power at all frequencies

tv static, fan

helps with tinnitus and sleep

The color of noise is the power spectrum of the noise signal.



BLUE

power increases as frequency increases

hissing garden hose

useful for dithering

PINK

linear power on a logarithmic scale

rain, wind, heartbeat

aids relaxation and sleep

BROWN

power decreases as frequency increases

distant thunder

aids focus

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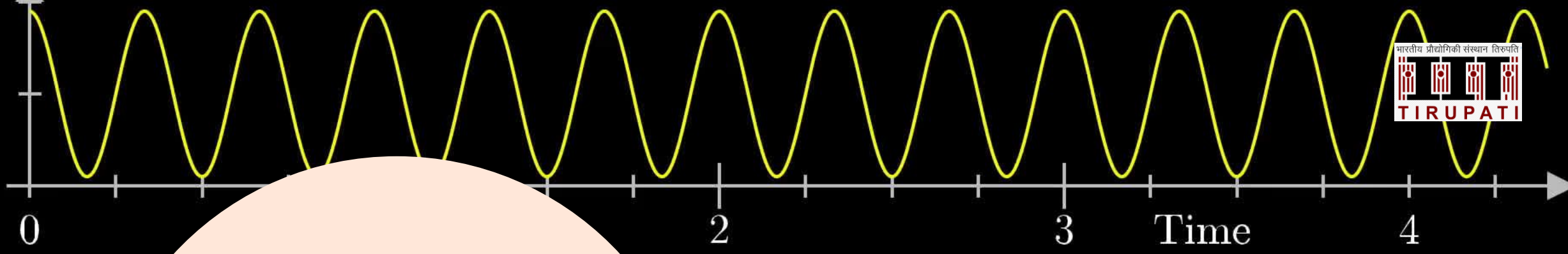
HARMFUL EFFECTS OF NOISE

- Though there are some useful effects of noise, in most cases they are undesired and cause a wide range of problems including but not limited to:
  - Health
    - Loss of Hearing, Tinnitus, Stress, Increased Blood Pressure.
    - Cardiovascular diseases
  - Economic
    - Costs of noise mitigation
    - Decreased Productivity and Quality of life
  - Environmental
    - Habitat Degradation
    - Drop in Air quality



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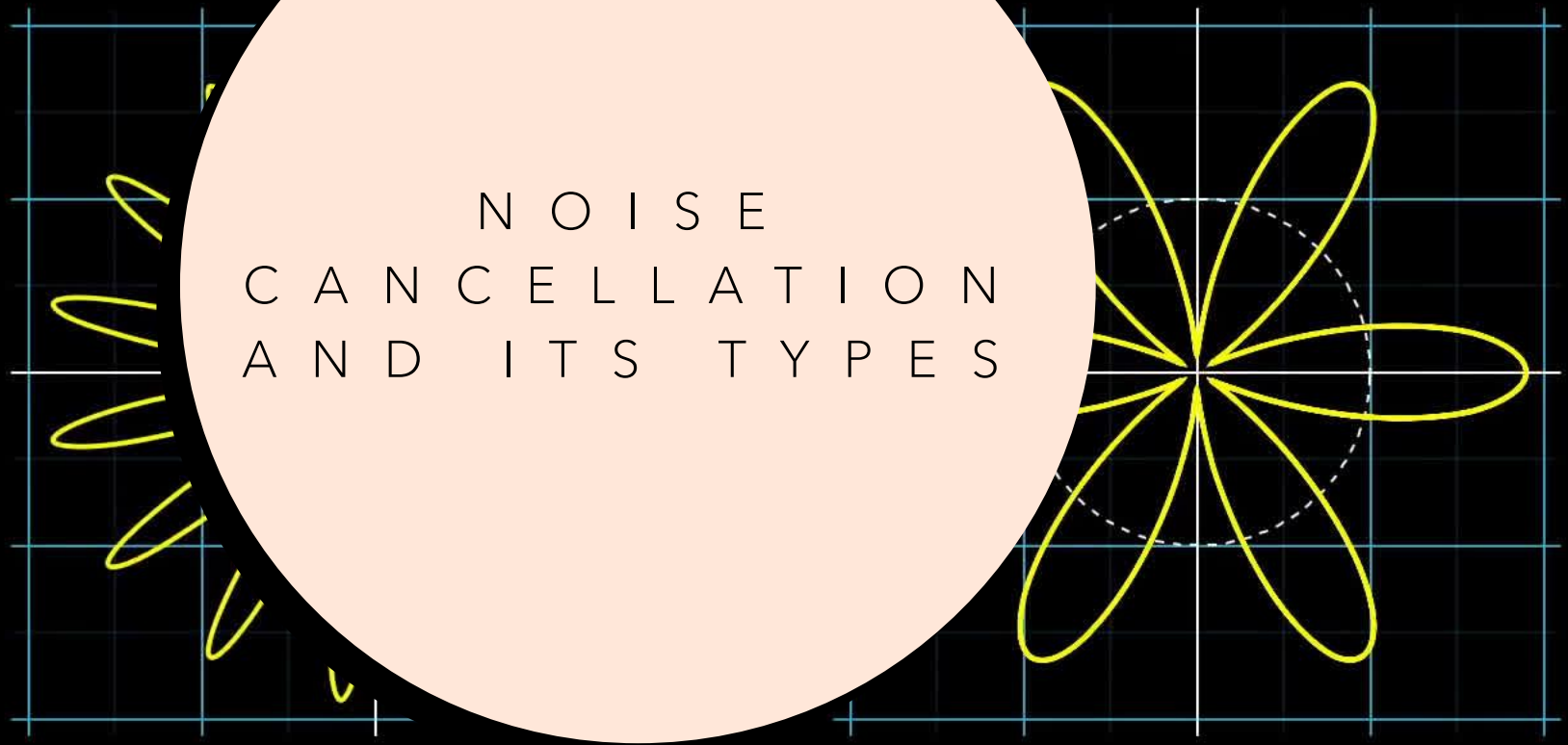
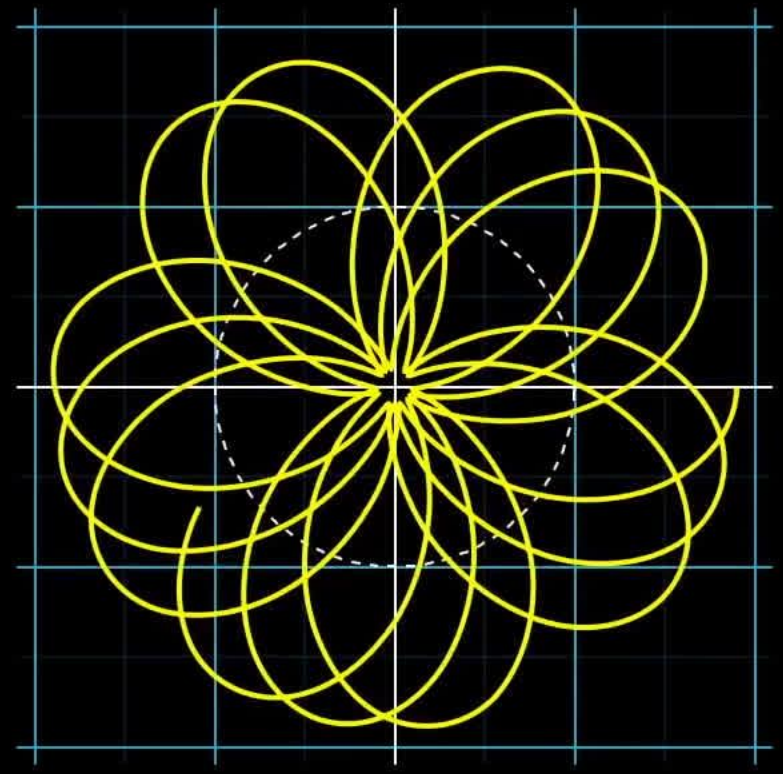
NOISE CANCELLATION AND ITS TYPES



0.20 cycles/second

0.50 cycles/second



1.23 cycles/second

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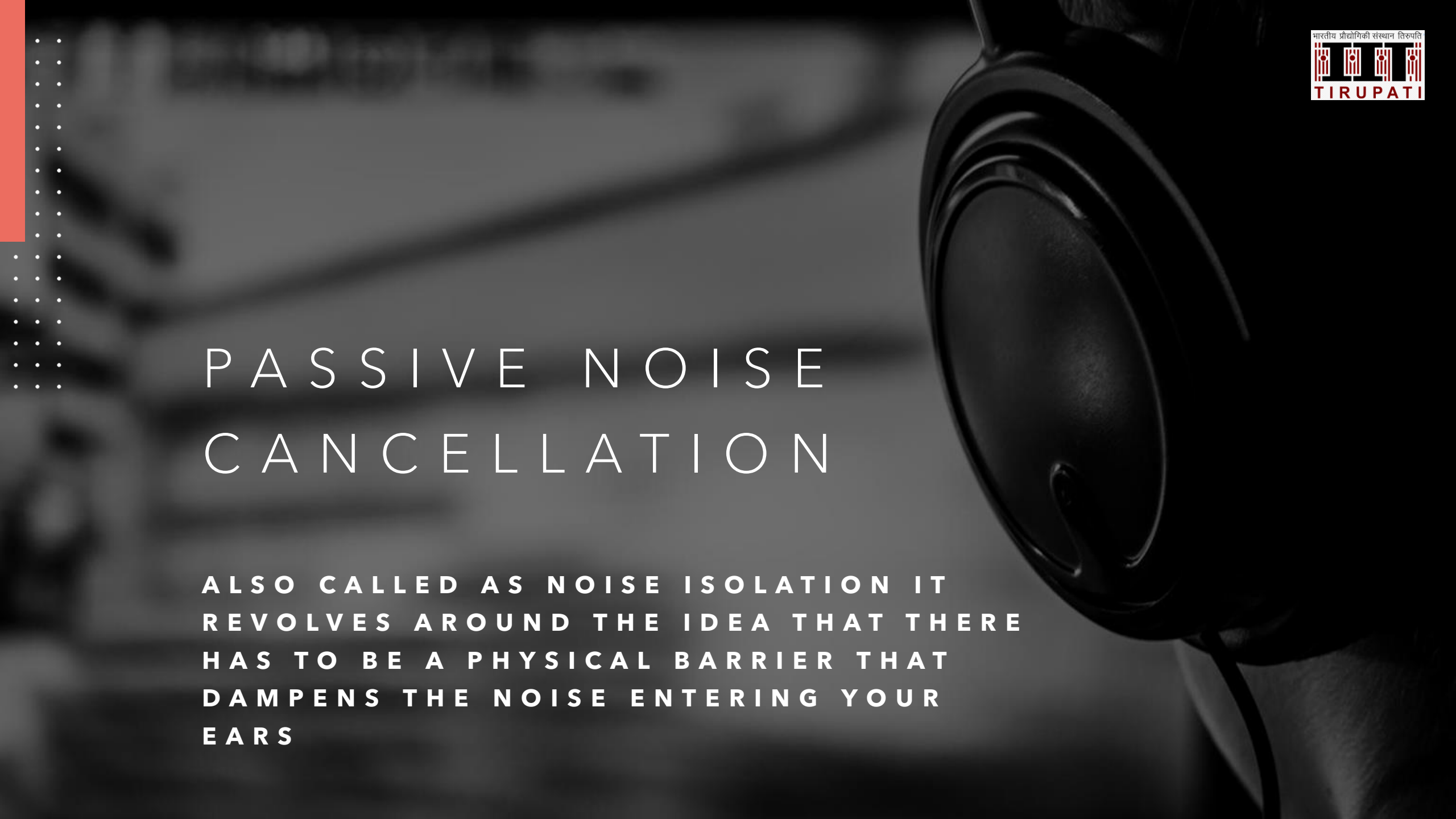
NOISE CANCELLATION

It is a method of reducing the ambient noise or unwanted sounds by the addition of a second sound added specifically to cancel the first.

TYPES OF NOISE CANCELLATION

Generally there are 3 types:

- Passive
- Active
- Adaptive



PASSIVE NOISE CANCELLATION

ALSO CALLED AS NOISE ISOLATION IT REVOLVES AROUND THE IDEA THAT THERE HAS TO BE A PHYSICAL BARRIER THAT DAMPENS THE NOISE ENTERING YOUR EARS

ACTIVE NOISE CANCELLATION

- First noise is detected from your immediate environment by a microphone located outside your headphones, then the noise is analyzed to break into machine-readable parts called sound waves.
- An anti-phase sound wave of equal magnitude but opposite shape is fed back into your headphones to cancel ambient noise.

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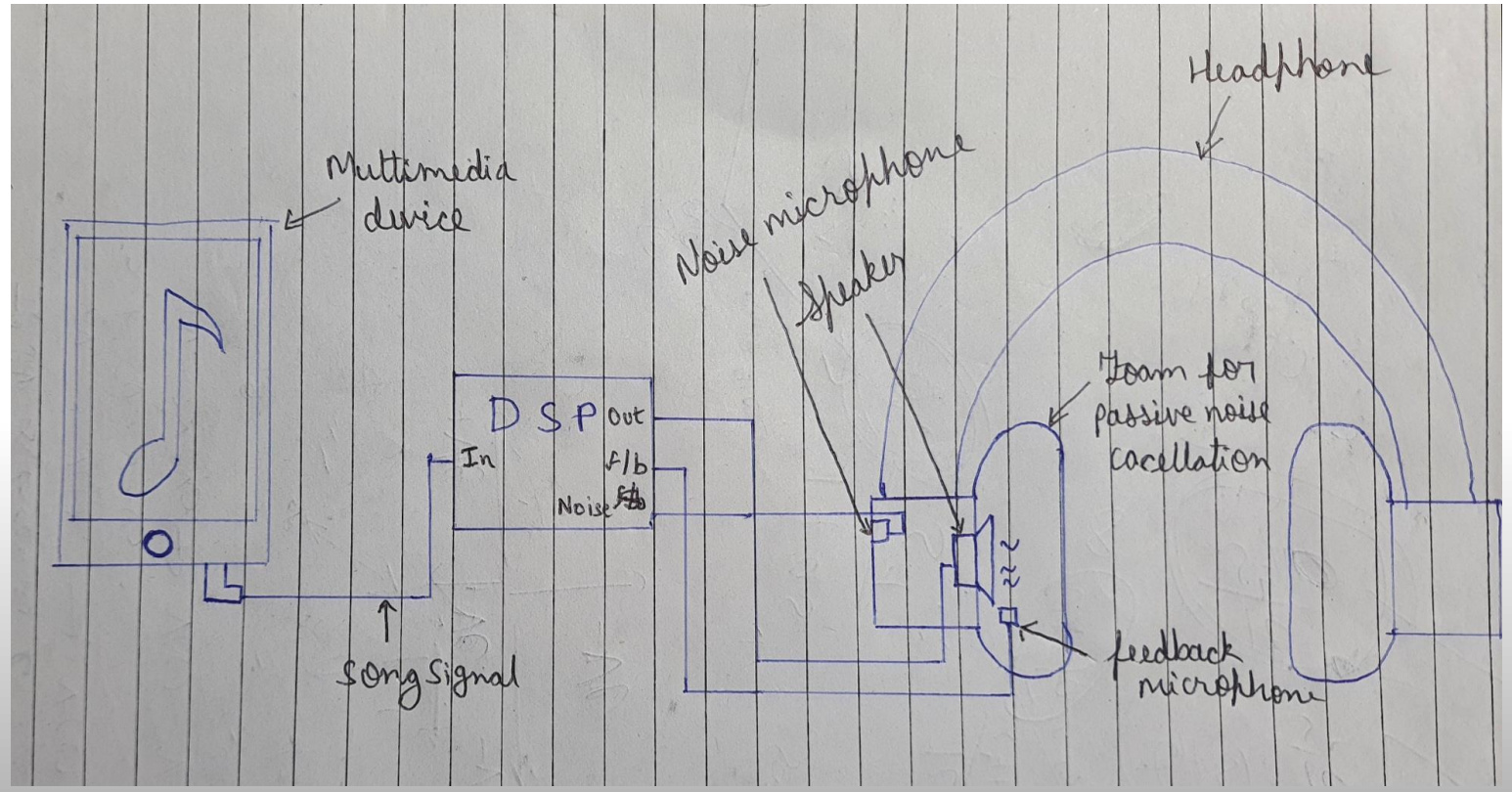
ADAPTIVE NOISE CANCELLATION

- Like active noise cancellation it also uses negative noise to cancel positive noise in a noisy environment.
- The difference is that adaptive noise cancellation uses advanced algorithms to produce near-perfect noise cancellation to best match the environment.

AIM



- In this project we aim to achieve Adaptive Noise Cancellation for varying passive noise attenuations.
- Design the system such that it's hardware implementable.

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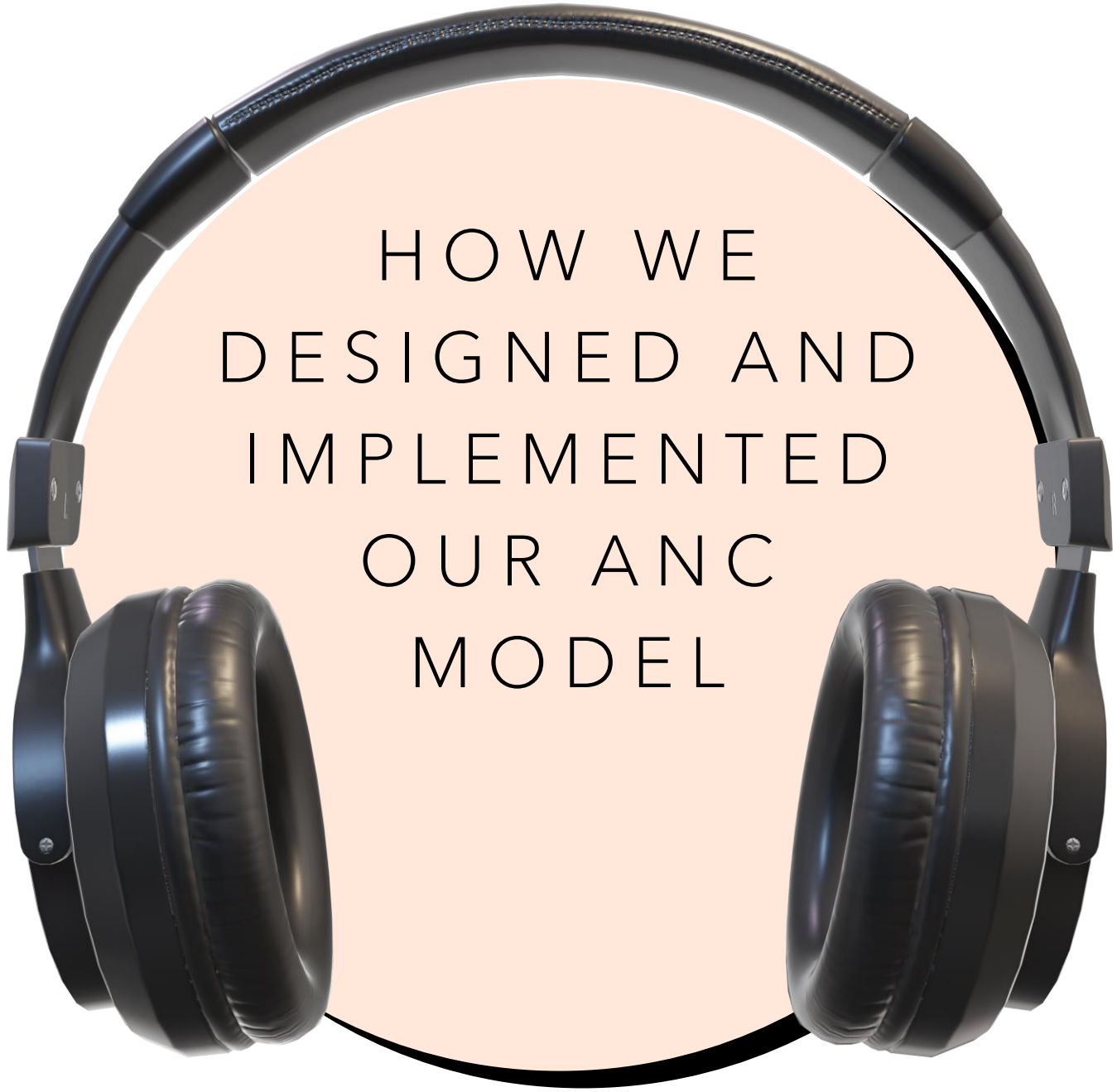


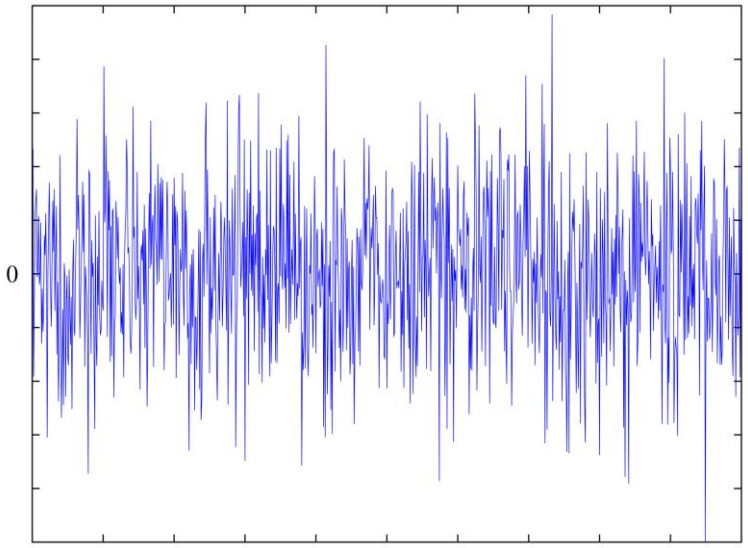
HOW WE DESIGNED AND IMPLEMENTED OUR ANC MODEL

SIMULINK

Simulink is a MATLAB-based graphical programming environment for modeling, simulating and analyzing multidomain dynamical systems. Its primary interface is a graphical block diagramming tool and a customizable set of block libraries. Here we are using it to mimic our system working in real life.

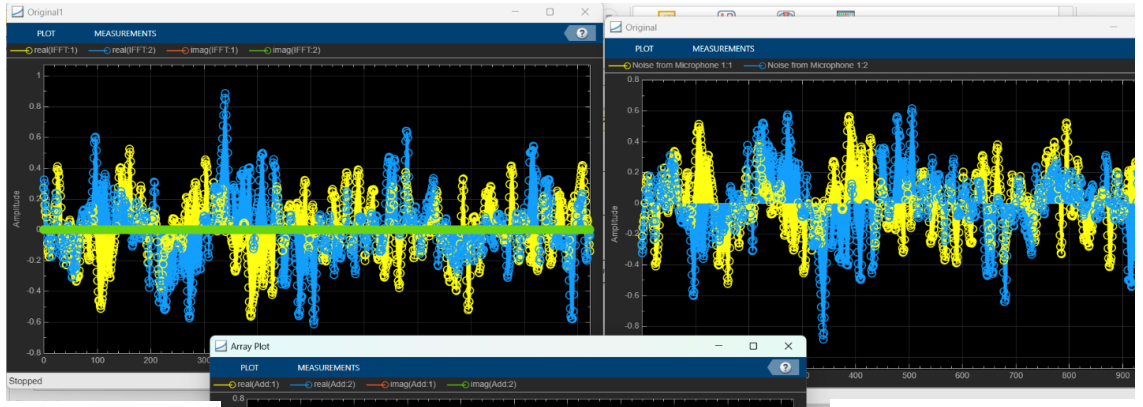
MATLAB
SIMULINK®

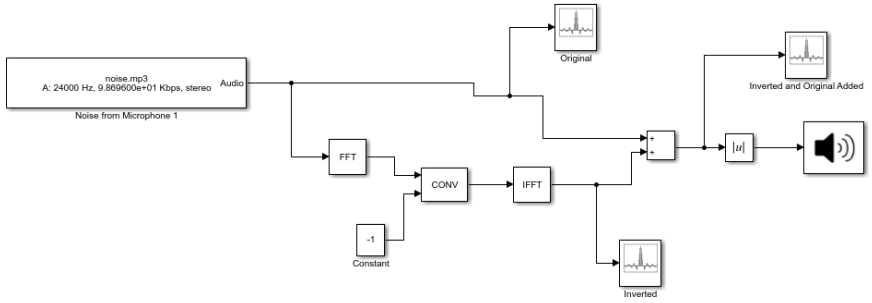
NOISE AND INPUT SIGNAL USED

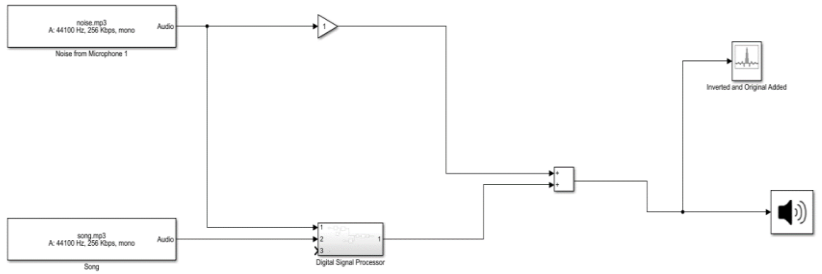


WORKFLOW

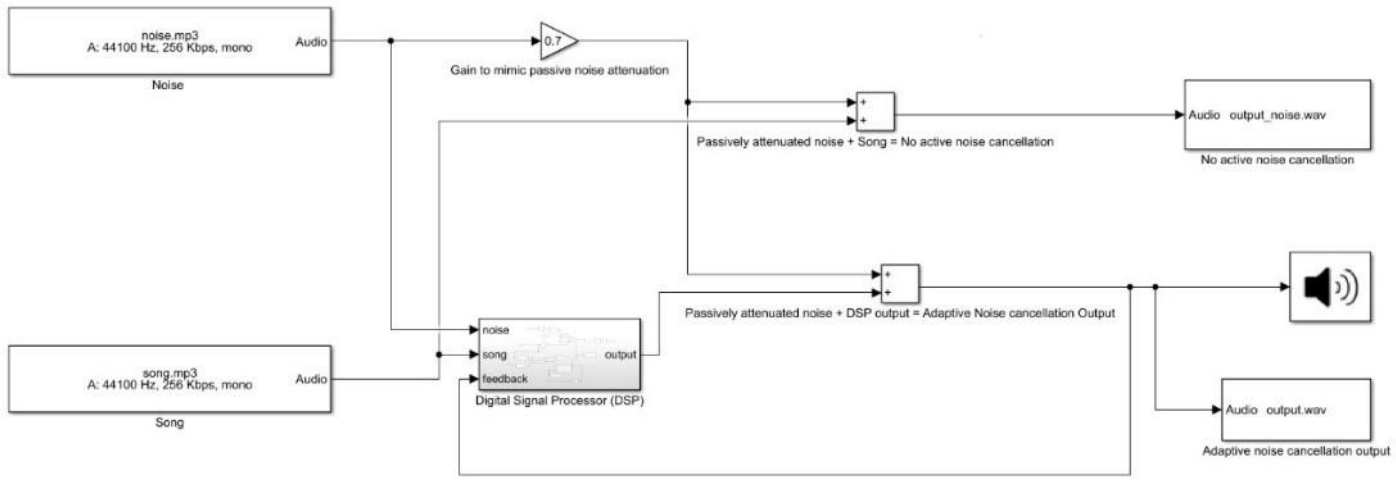
- Extracting data from the signal and plotting the signal.
- Generating the inverse of the signal
- Seeing the results of the superposition of normal signal and its inverted form
- Generating noise plus song with passive noise attenuation
- Cancelling the noise using a digital signal processor with known passive noise attenuation.
- Converting the system to adapt for any random passive noise attenuation using feedback from the feedback microphone.



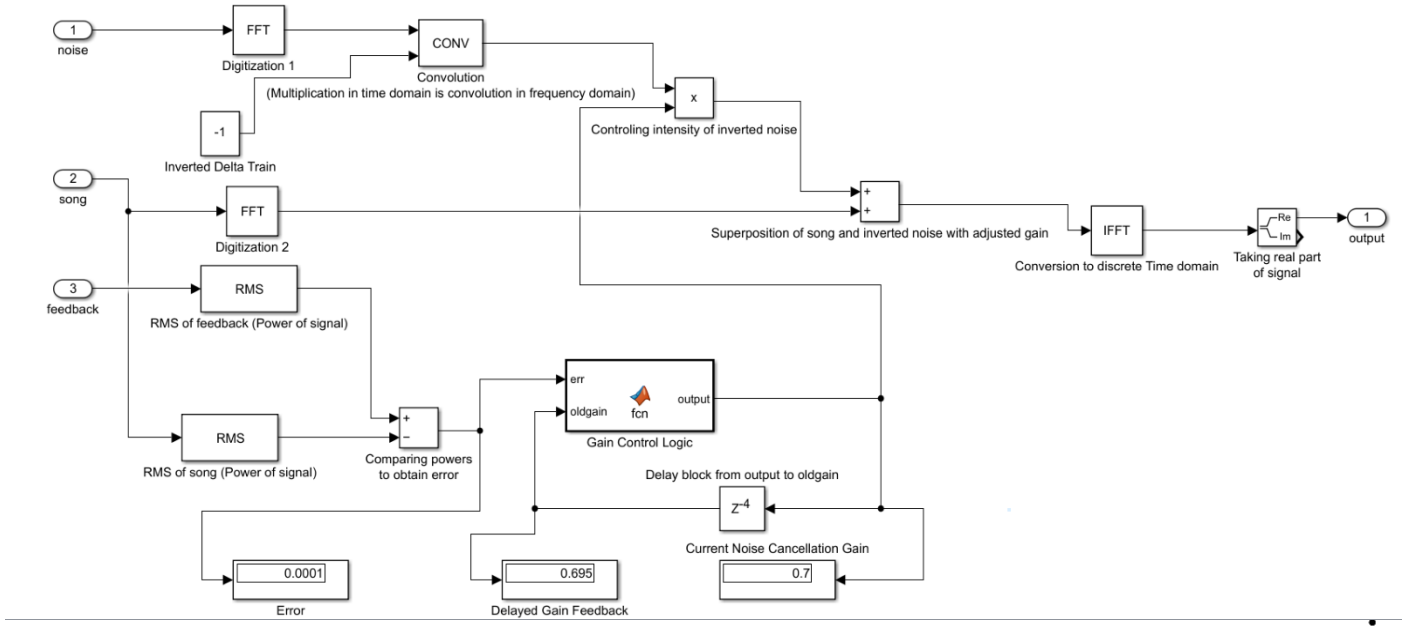




THE SIMULINK MODEL



The Complete System



DSP (Digital Signal Processor)

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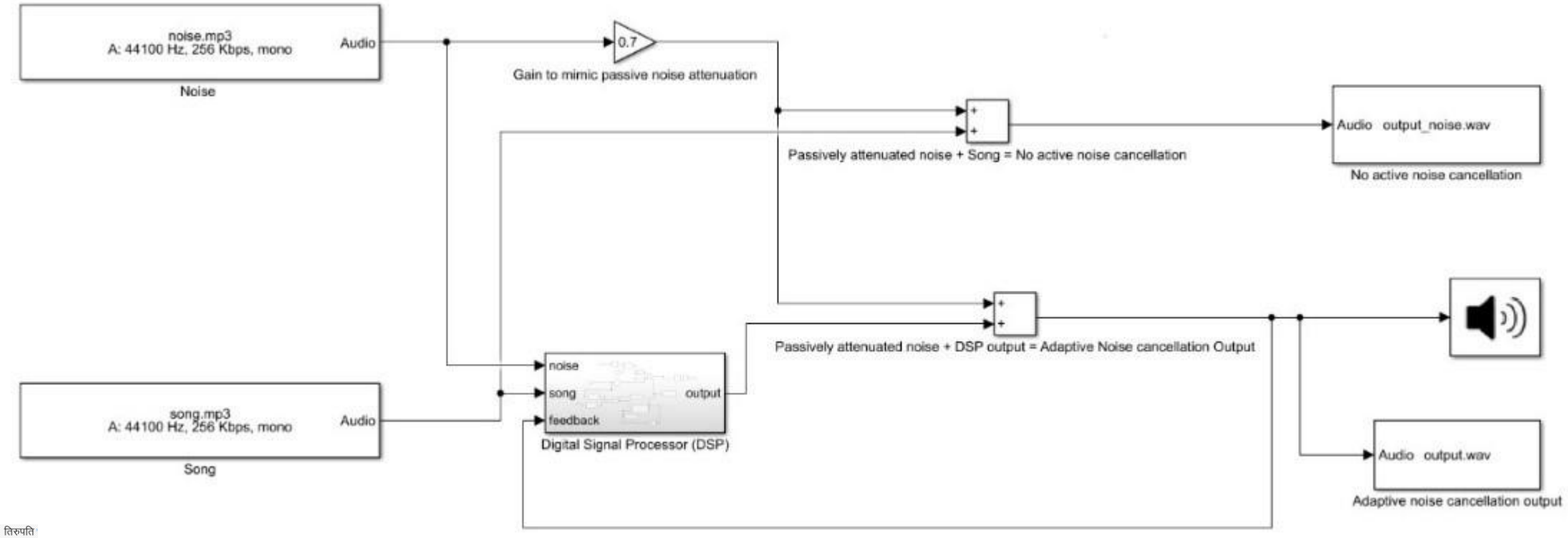
DETAILED DESCRIPTION OF MODEL

The Complete System



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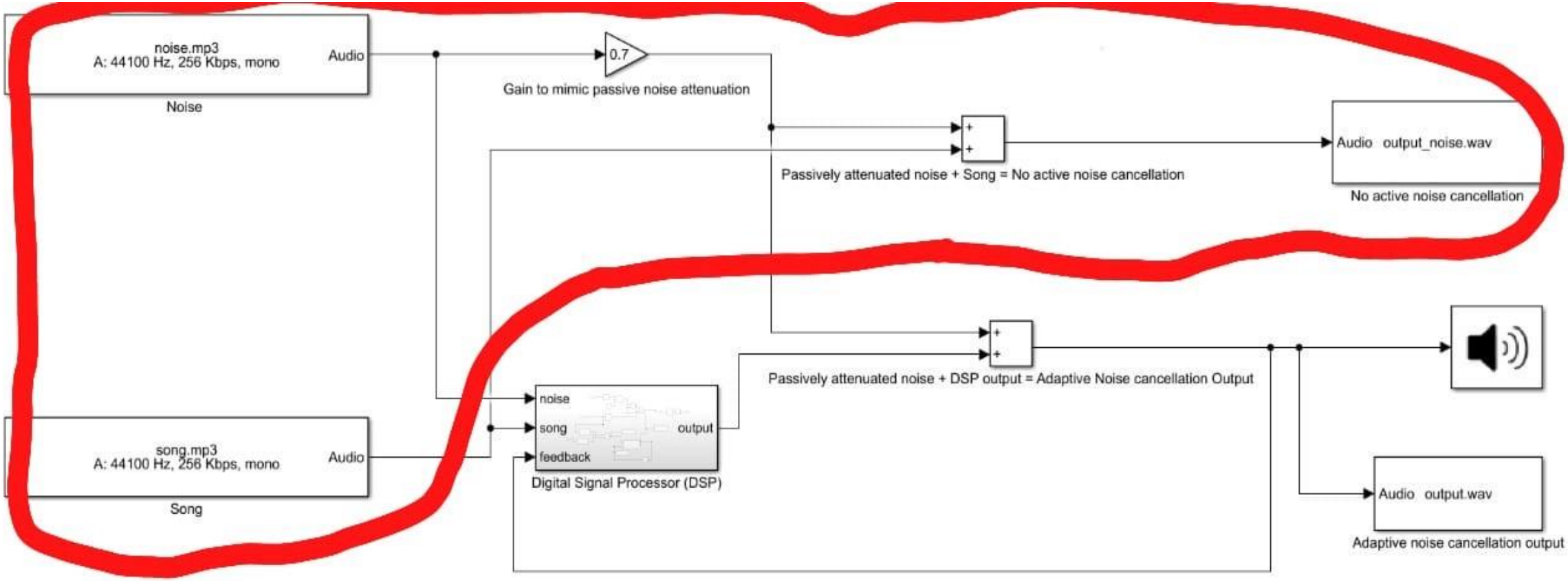
DETAILED DESCRIPTION OF MODEL

Passively attenuated noise + original song = Song heard without active noise cancellation



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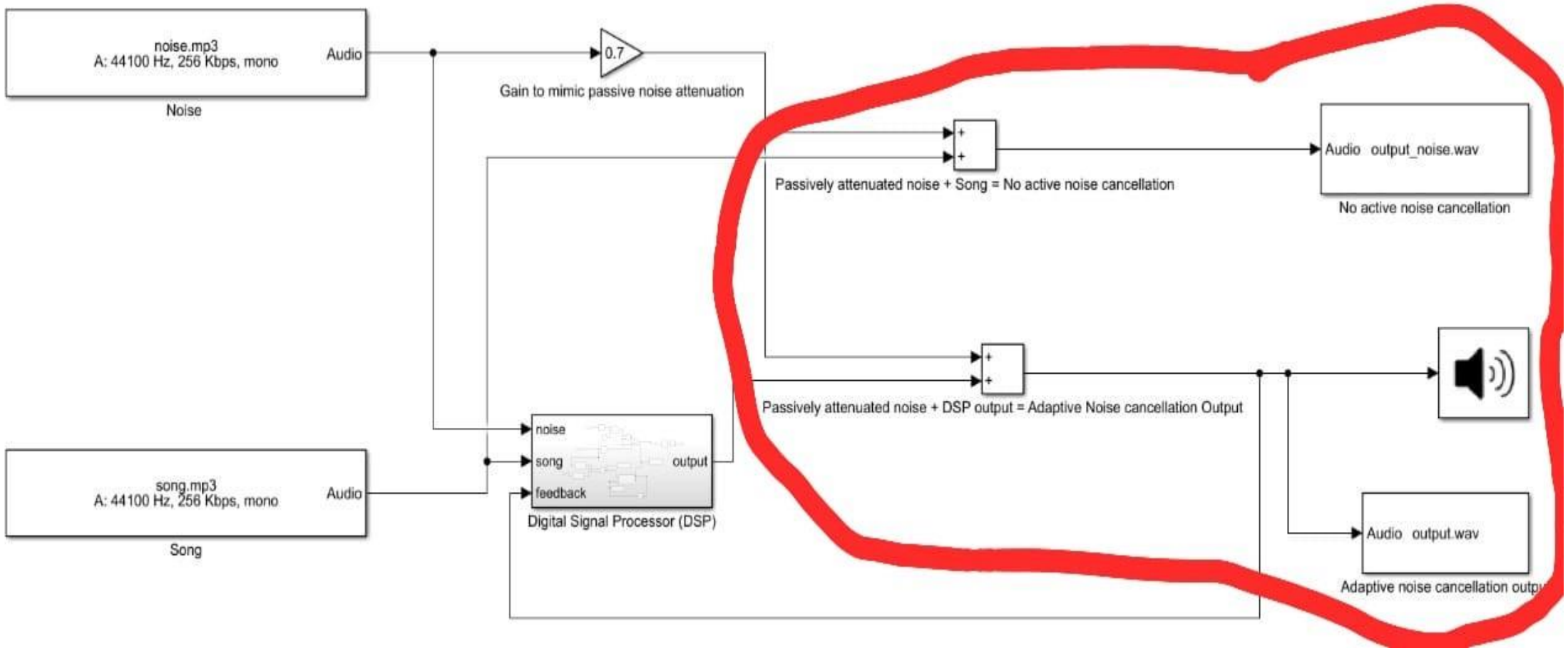
DETAILED DESCRIPTION OF MODEL

Outputs after superposition with their respective signals



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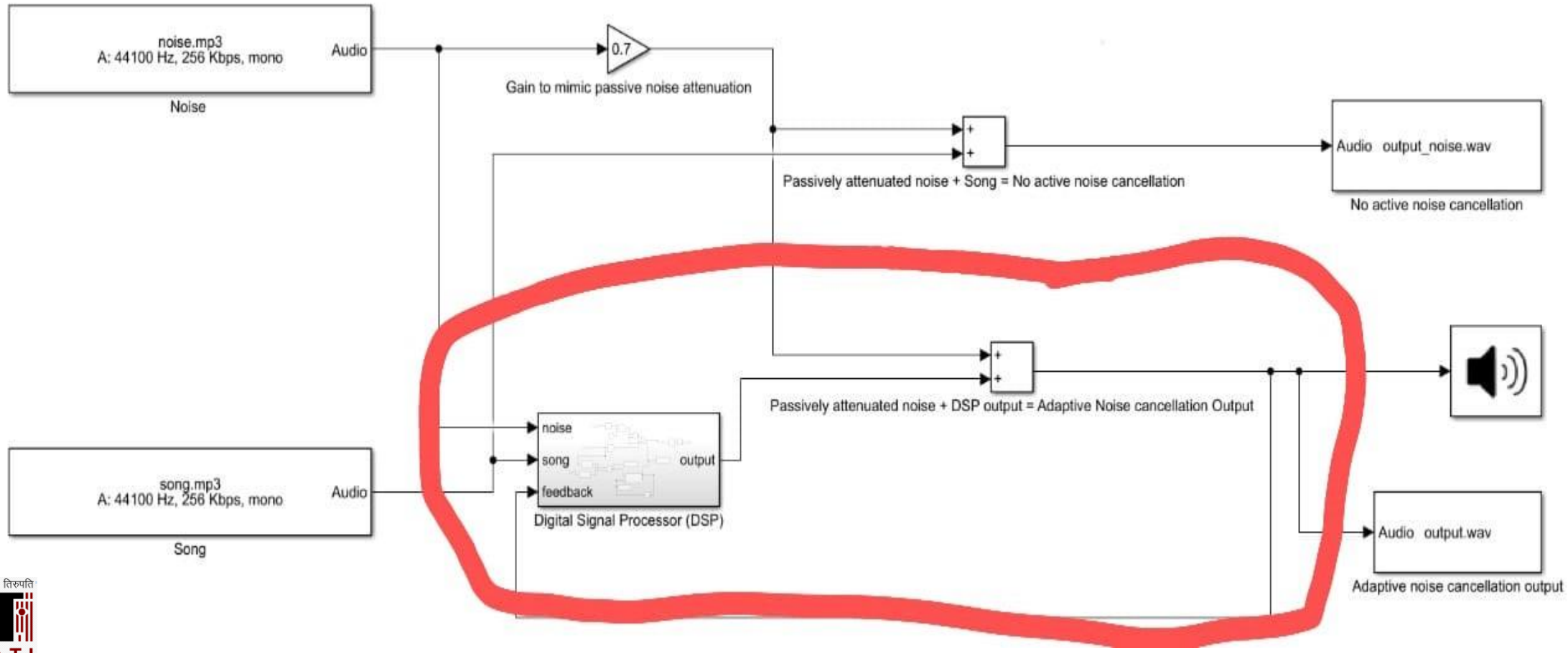
DETAILED DESCRIPTION OF MODEL

DSP (Digital Signal Processor) with feedback and Superposition of its output to noise



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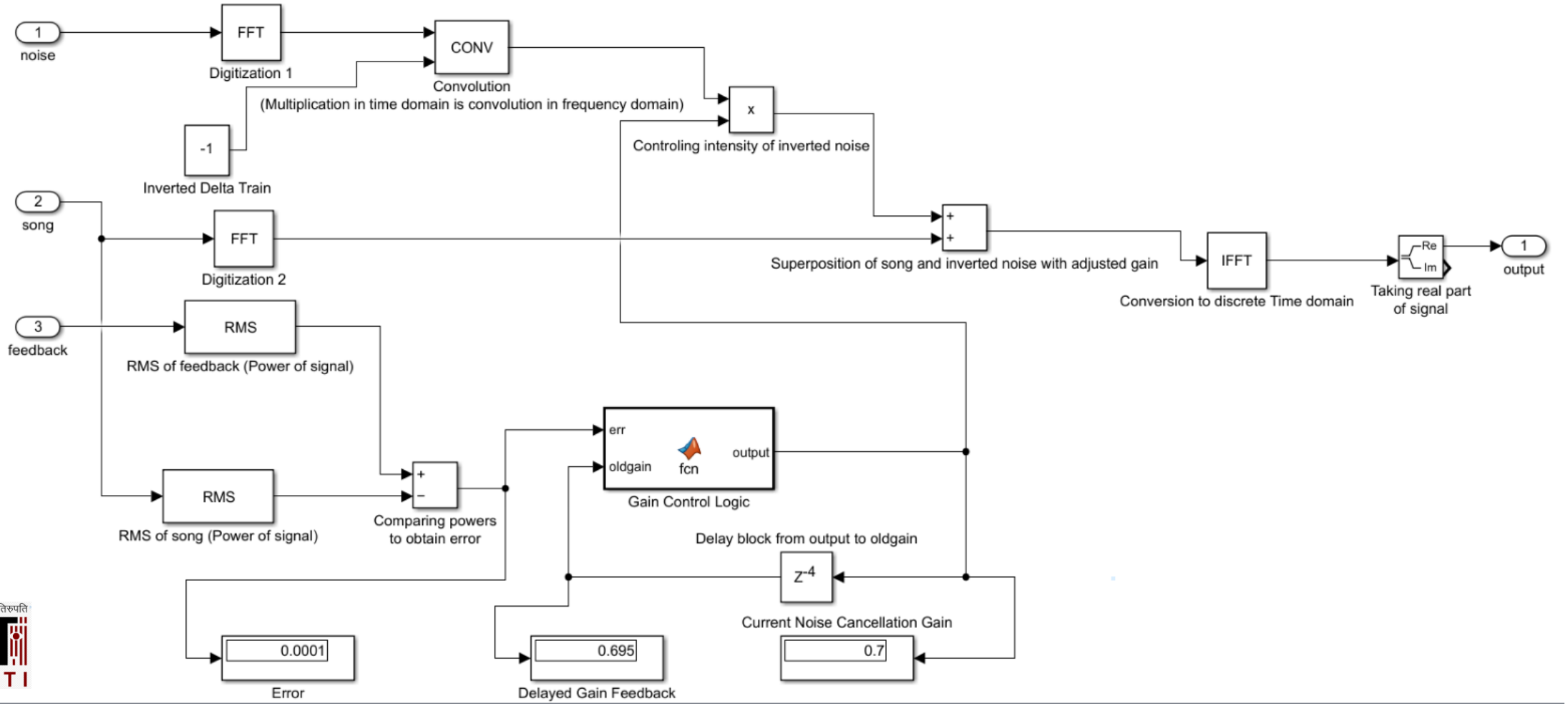
DETAILED DESCRIPTION OF MODEL

DSP (Digital Signal Processor)



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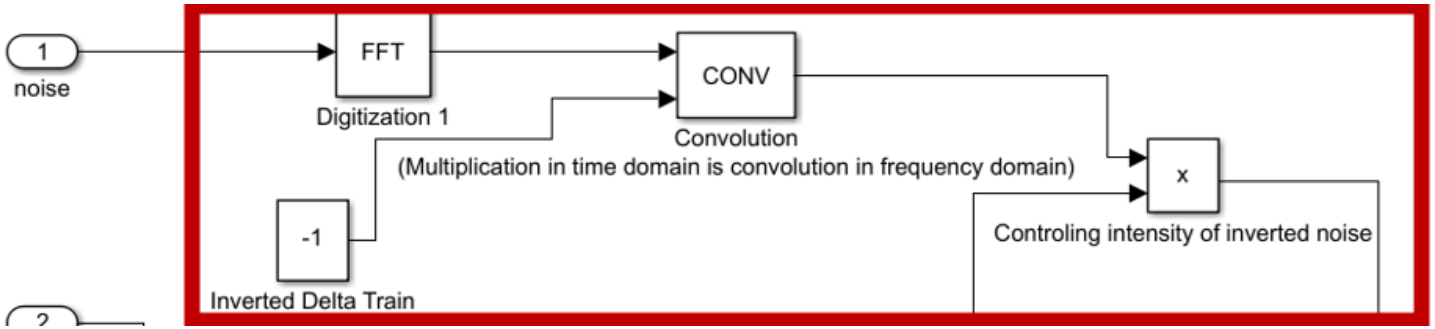
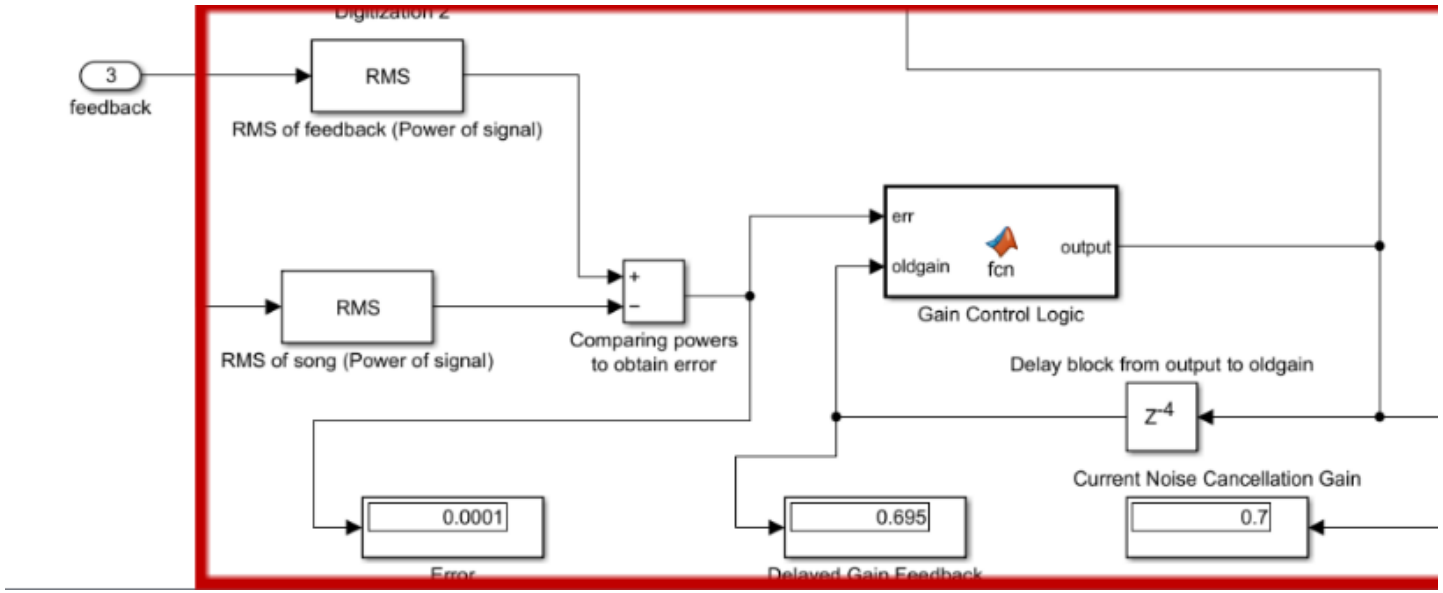
DETAILED DESCRIPTION OF MODEL

Inverting Noise Signal





Gain Calculation Using Feedback

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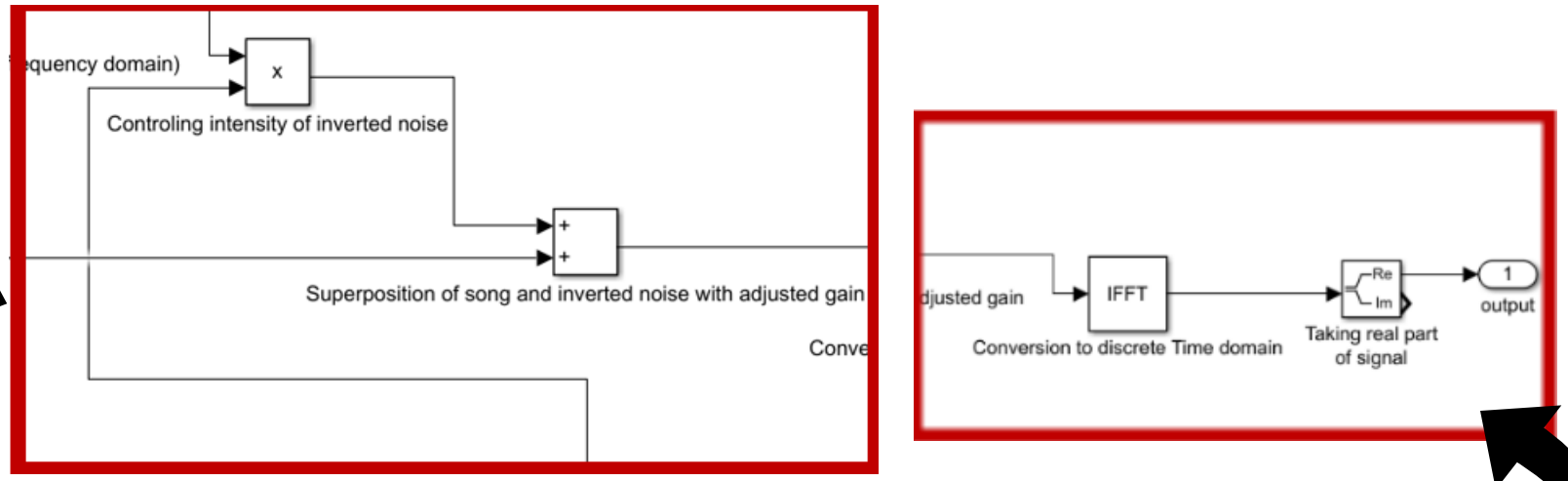
DETAILED DESCRIPTION OF MODEL

Controlling gain of inverted noise by multiplying it with adaptive gain and superposing it with song



Converting Digital signal to discrete time signals which can be feed to the speaker which converts it to continuous time signal (This conversion happens due to inertia of diaphragm of the speaker)

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DETAILED DESCRIPTION OF MODEL

Digital Signal Processor (DSP) ▸ Gain Control Logic

```
function output  = fcn(err,oldgain)
req_err = 0.0001;


if((req_err<=err))
output=oldgain+0.005;
else
output=oldgain;
end
end
```

Gain logic

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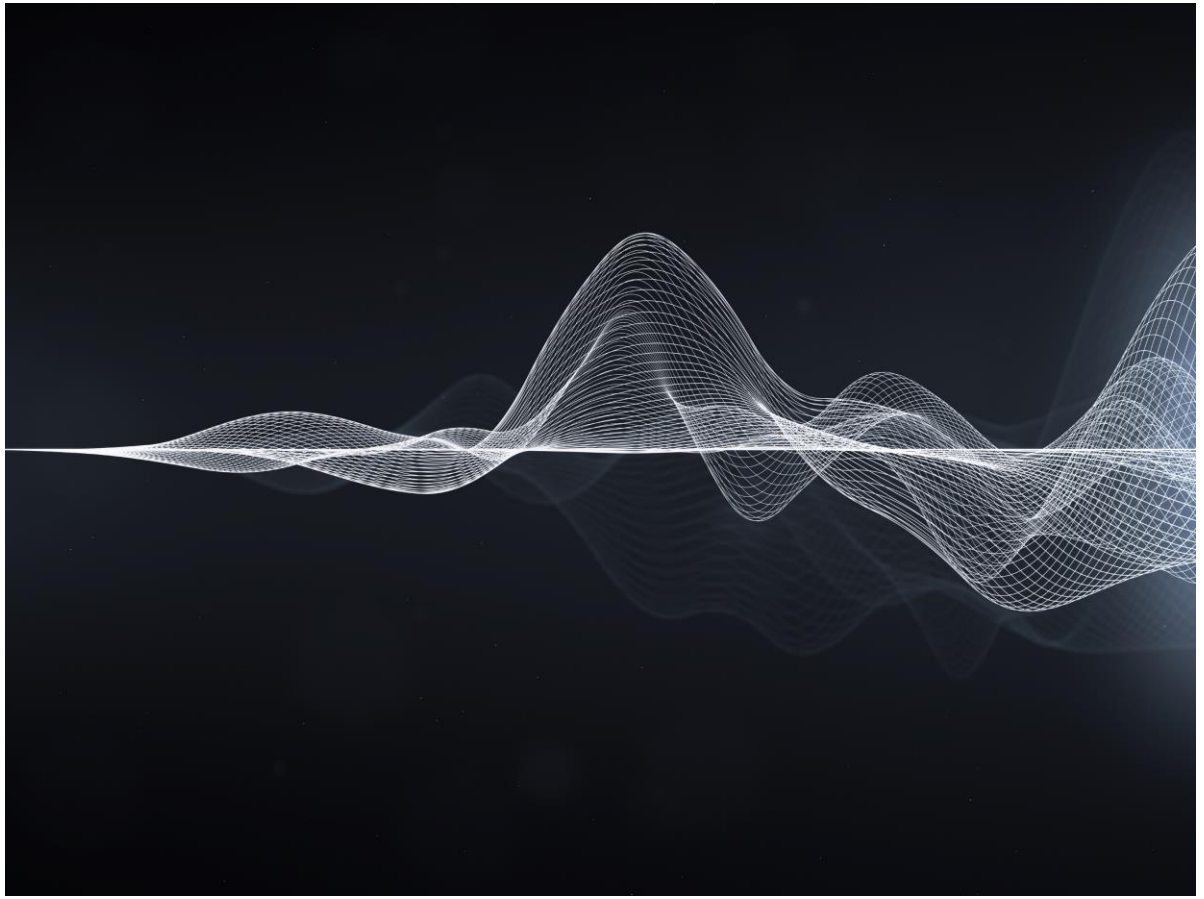
LET'S SEE SOME OUTPUTS



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FEATURES

The entire system is designed in such a way that it can be easily implemented with minimal components using digital processor and other electrical components.

The system adapts its noise cancellation gains automatically regardless of the passive noise attenuation due to physical isolation of ear from speaker using materials like foam. This has been achieved using a closed loop feedback.

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LIMITATIONS OF THE MODEL

- Due to the MATLAB's method of solving loops involving algebraic equations (Algebraic loops are solved using ODE and DAE in MATLAB which work using prediction algorithms and iterations due to which for very small error values the solver breaks), when the output reaches very close to desired output, the simulation breaks. The delay block used from output to old gain is added so that direct feedthrough loop can be avoided as simulation breaks in that case and the delay amount is calculated after many trial and error iterations.

- Due to the nature of logic written for changing gain, if in case passive noise attenuation changes considerably, the system needs to be restarted.

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Thankyou

-Chirag Kotian
-M Manukrishna