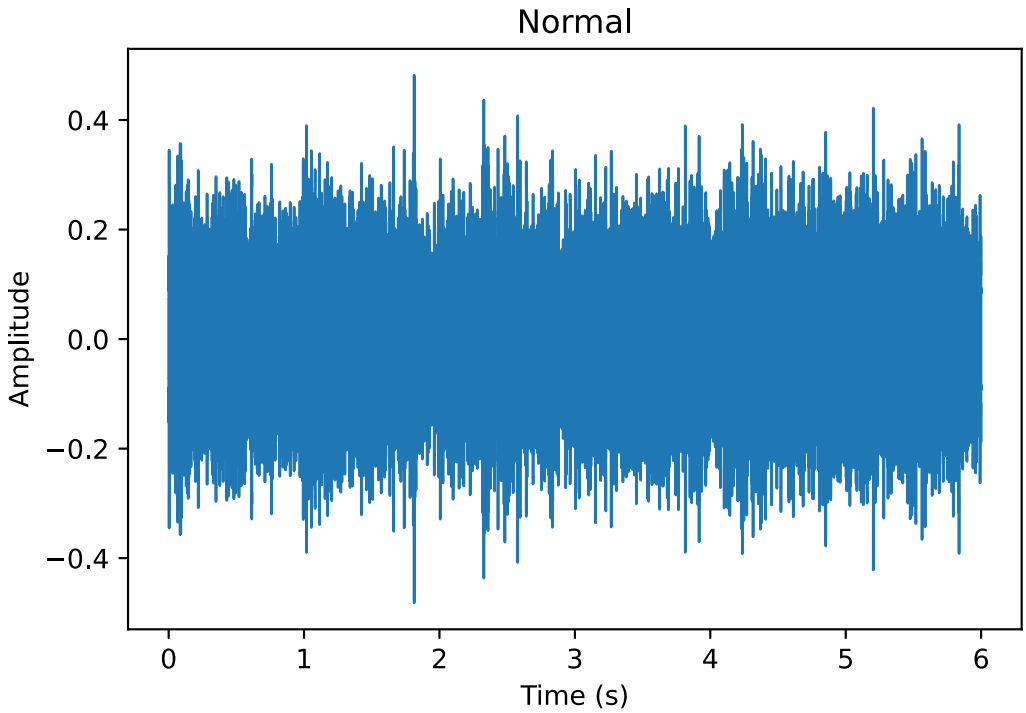
解析対象とする音源のロード

```
import pathlib
import librosa

DATASET_DIR        = '../dataset/analysis'

input_wav_path     = list(pathlib.Path(DATASET_DIR).glob('*wav'))
input_normal_path  = list(filter(lambda file_name: 'normal' in
str(file_name), input_wav_path))[0]
input_anomaly_path = list(filter(lambda file_name: 'ab'     in
str(file_name), input_wav_path))

anomaly_wav_list       = list()
anomaly_file_name_list = list()

print('[Input]')
print('Normal :', input_normal_path)
normal, sr = librosa.load(path=input_normal_path, offset=1.5, duration=6,
sr=None, mono=True)

for wav_path in input_anomaly_path:
    print('Anomaly:', wav_path)
    anomaly, _ = librosa.load(path=wav_path, offset=1.5, duration=6,
sr=None, mono=True)
    file_name  = '_'.join(str(wav_path).split('_')[1:]).strip('.wav')

    anomaly_wav_list.append(anomaly)
    anomaly_file_name_list.append(file_name)
```

```
[Input]
Normal : ../dataset/analysis/normal_0003.wav
Anomaly: ../dataset/analysis/ab02_over_voltage.wav
Anomaly: ../dataset/analysis/ab12_tail_pulley_excessive_tension.wav
Anomaly: ../dataset/analysis/ab06_belt_attached_metalic_object_2.wav
Anomaly: ../dataset/analysis/ab36_tension_pulley_excessive_tension.wav
Anomaly: ../dataset/analysis/ab72_tension_pulley_aging.wav
Anomaly: ../dataset/analysis/ab24_tail_pulley_removed.wav
```

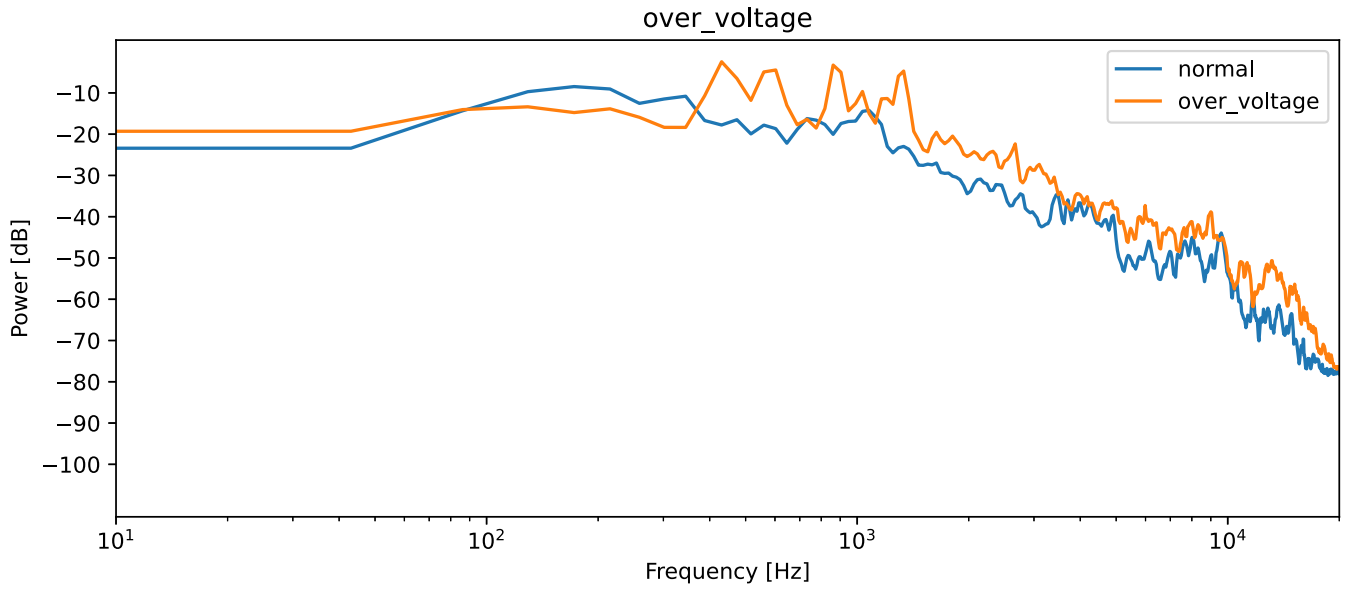
音源のロード状況の確認

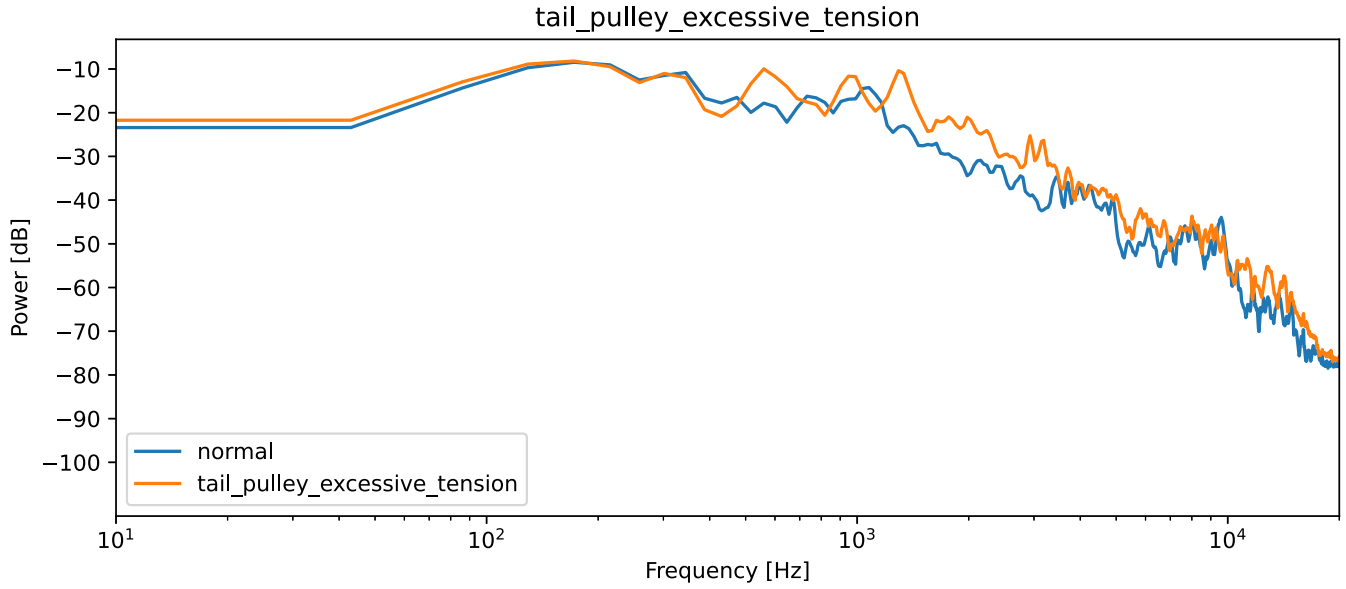
```
import librosa.display
import matplotlib.pyplot as plt

fig = plt.figure()
ax  = fig.add_subplot()
ax.set(title='Normal', ylabel='Amplitude')

librosa.display.waveshow(normal, sr, x_axis='s')
plt.show()
```

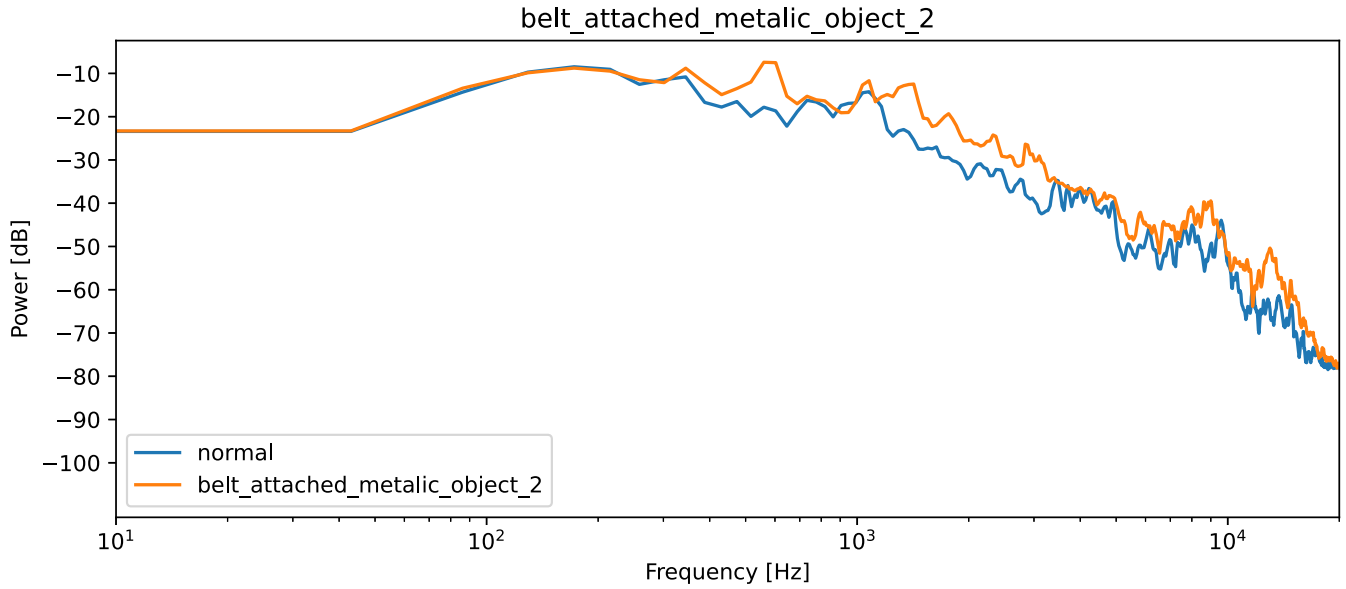


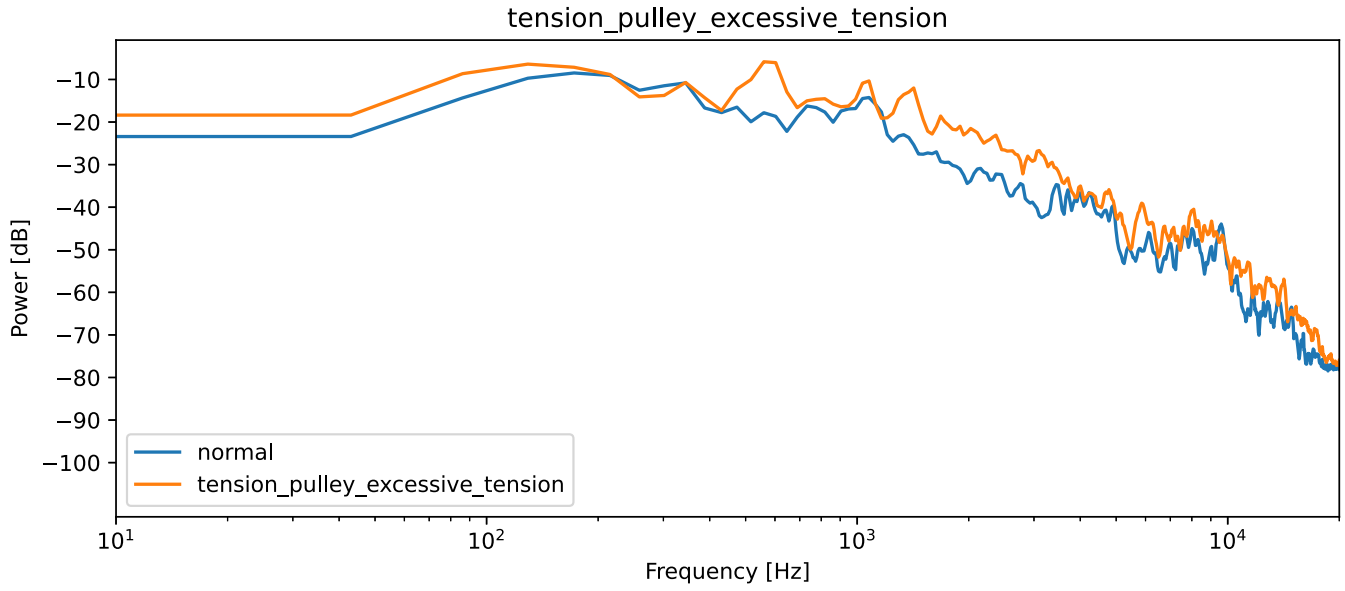
パワースペクトルによる可視化

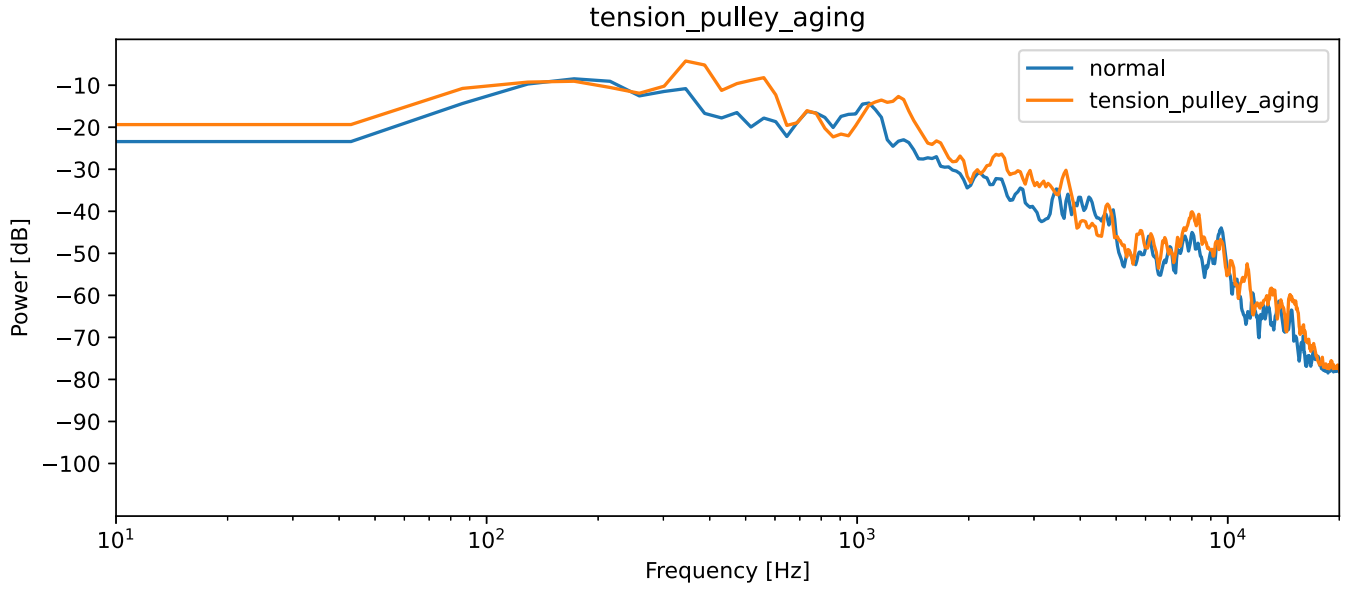
```
import numpy as np

WINDOW_SIZE = 1024

def do_fft(audio):

    audio_segment_list = list()
    window_function    = np.hanning(WINDOW_SIZE)
    while len(audio_segment_list) < (audio.size // WINDOW_SIZE):
        start_idx = len(audio_segment_list) * WINDOW_SIZE
        end_idx   = start_idx               + WINDOW_SIZE
        audio_segment_list.append(audio[start_idx : end_idx] *
window_function)

    fft_result = list()
    for audio_segment in audio_segment_list:
        fft          = np.fft.fft(audio_segment, norm='ortho')
        fft_power    = (np.abs(fft) ** 2)[:WINDOW_SIZE // 2]
        fft_power_db = 10 * np.log10(fft_power)
        fft_result.append(fft_power_db)

    return np.mean(fft_result, axis=0)

def show_spectrum(normal_y, anomaly_y, freq, file_name):
    plt.figure(figsize=(10, 4))
    plt.title(file_name)

    plt.plot(freq, normal_y,  label='normal')
    plt.plot(freq, anomaly_y, label=file_name)

    plt.xlabel('Frequency [Hz]')
    plt.xscale('log')
    plt.xlim(10,20000)

    plt.ylabel('Power [dB]')
    plt.yticks(np.arange(-100, 0, 10))

    plt.legend()
    plt.show()

freq = np.fft.fftfreq(WINDOW_SIZE, 1/sr)[:WINDOW_SIZE // 2]

for index, anomaly in enumerate(anomaly_wav_list):
    normal_y  = do_fft(normal)
    anomaly_y = do_fft(anomaly)
    file_name = anomaly_file_name_list[index]
    show_spectrum(normal_y, anomaly_y, freq, file_name)
```

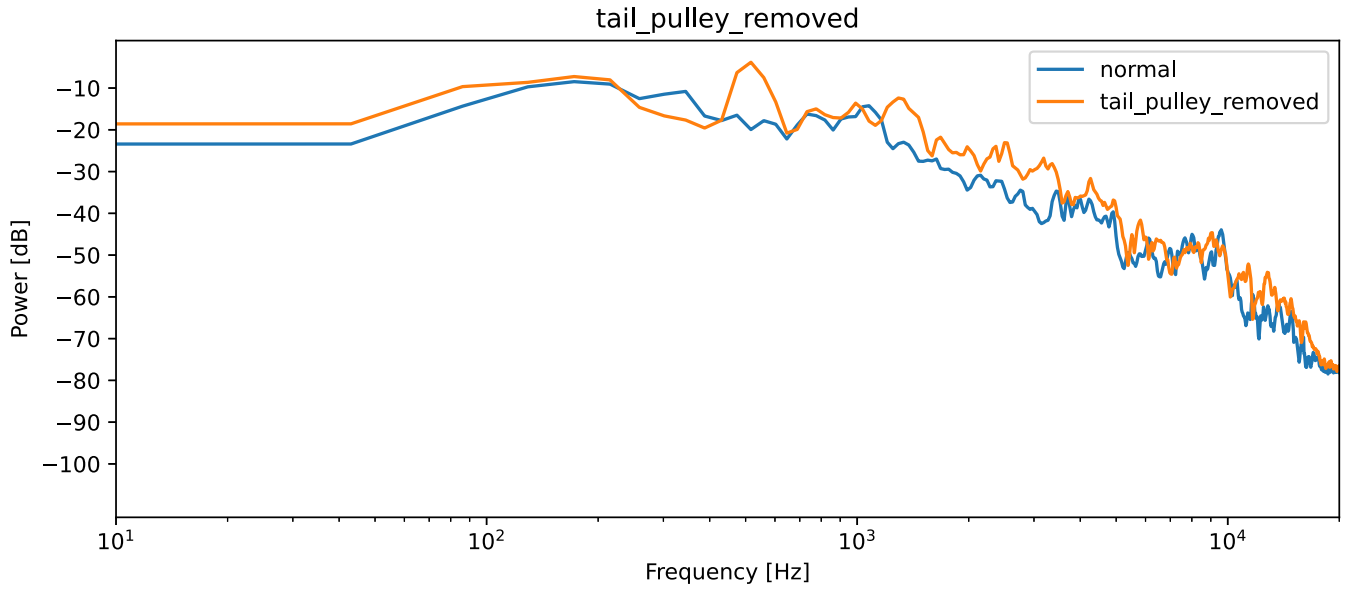

over_voltage
normal
over_voltage
Power [dB]
−10
−20
−30
−40
−50
−60
−70
−80
−90
−100
10^1
10^2
10^3
10^4
Frequency [Hz]


tail_pulley_excessive_tension
normal
tail_pulley_excessive_tension
Power [dB]
−10
−20
−30
−40
−50
−60
−70
−80
−90
−100
10^1
10^2
10^3
10^4
Frequency [Hz]


belt_attached_metalic_object_2
normal
belt_attached_metalic_object_2
Power [dB]
−10
−20
−30
−40
−50
−60
−70
−80
−90
−100
10^1
10^2
10^3
10^4
Frequency [Hz]

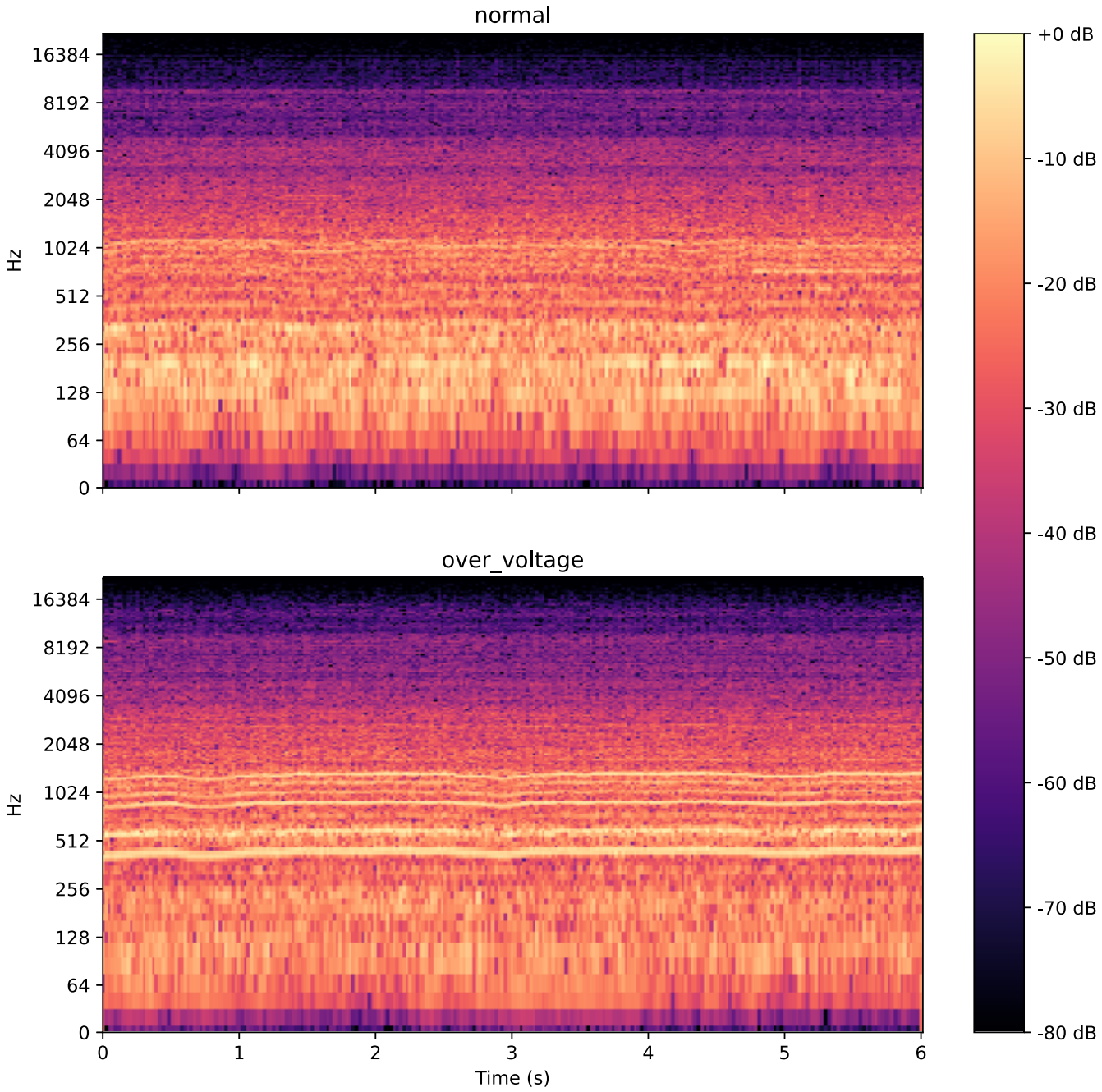

tension_pulley_excessive_tension
Power [dB]
−10
−20
−30
−40
−50
−60
−70
−80
−90
−100
normal
tension_pulley_excessive_tension
10^1
10^2
10^3
10^4
Frequency [Hz]

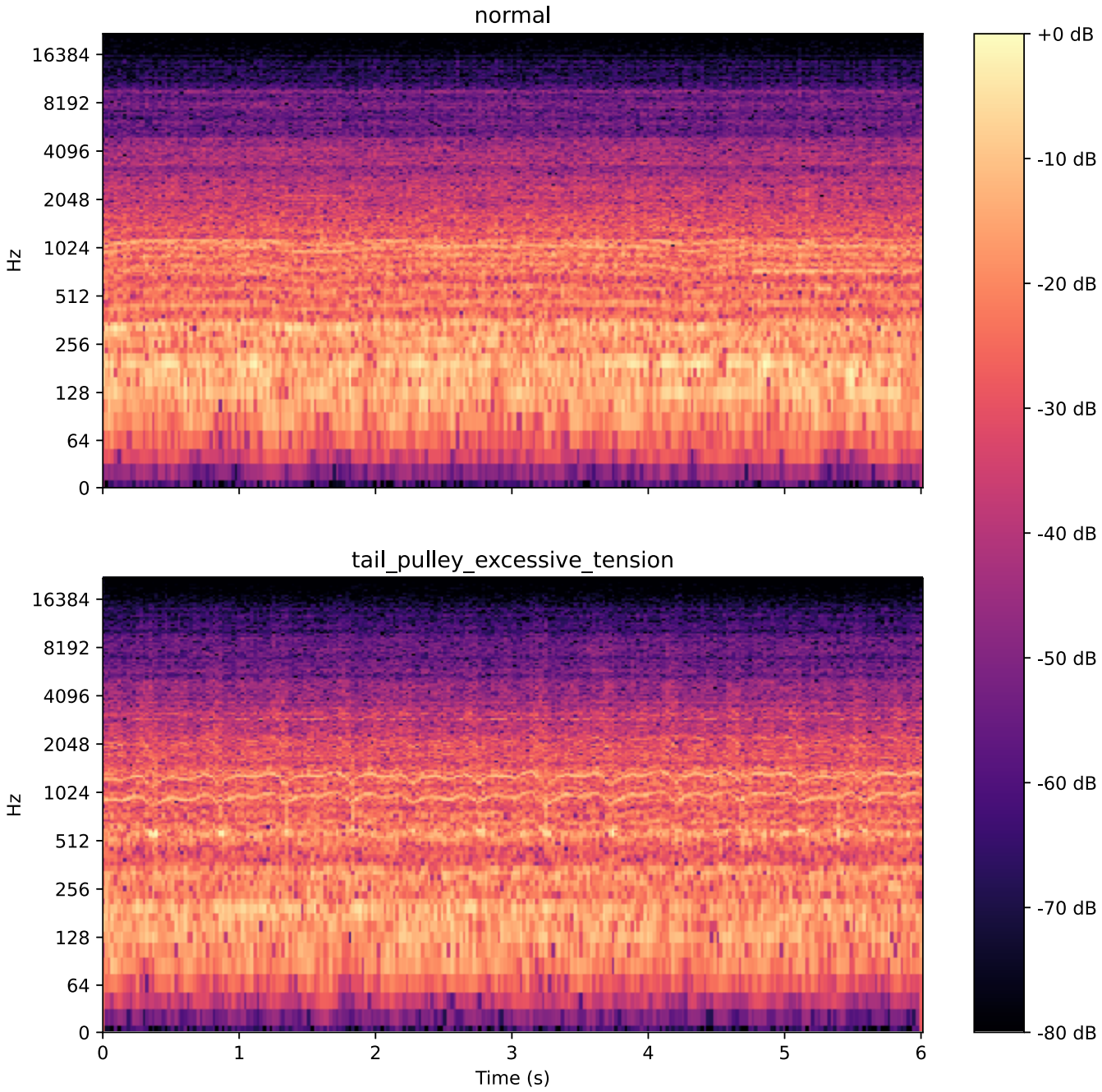

tension_pulley_aging
Power [dB]
−10
−20
−30
−40
−50
−60
−70
−80
−90
−100
normal
tension_pulley_aging
10^1
10^2
10^3
10^4
Frequency [Hz]

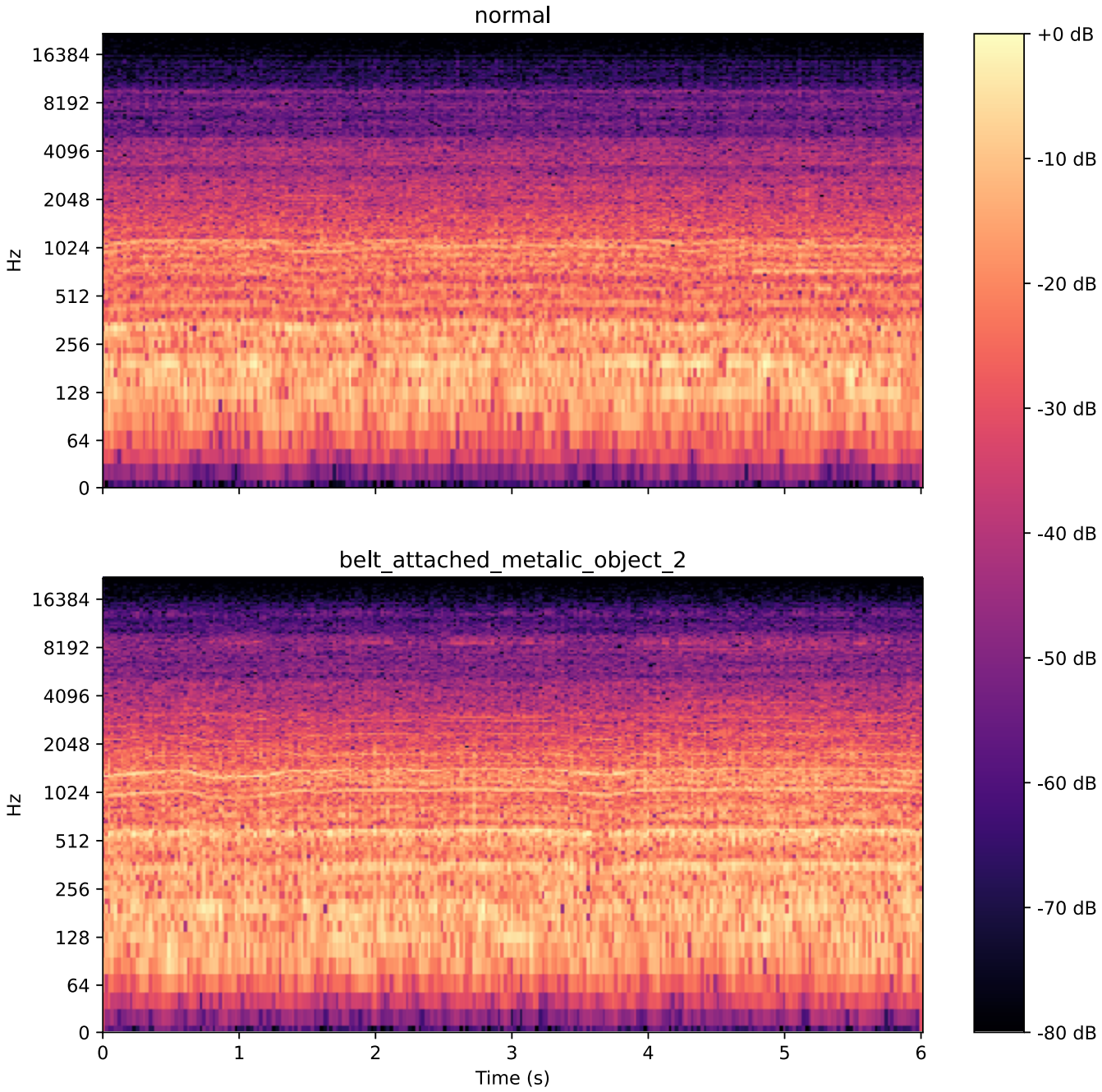

tail_pulley_removed
Power [dB]
−10
−20
−30
−40
−50
−60
−70
−80
−90
−100
normal
tail_pulley_removed
10^1
10^2
10^3
10^4
Frequency [Hz]

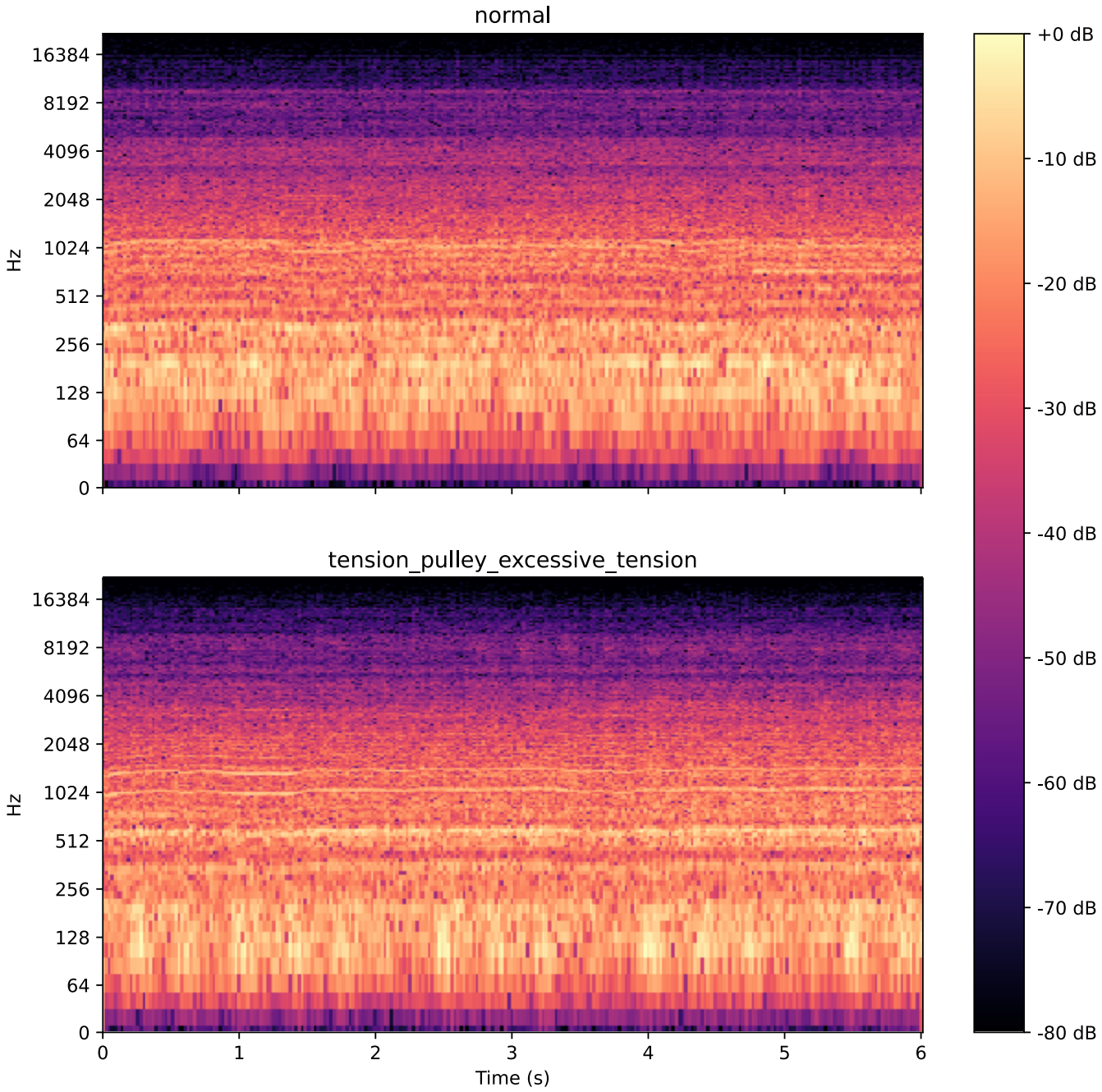
パワースペクトログラムによる可視化

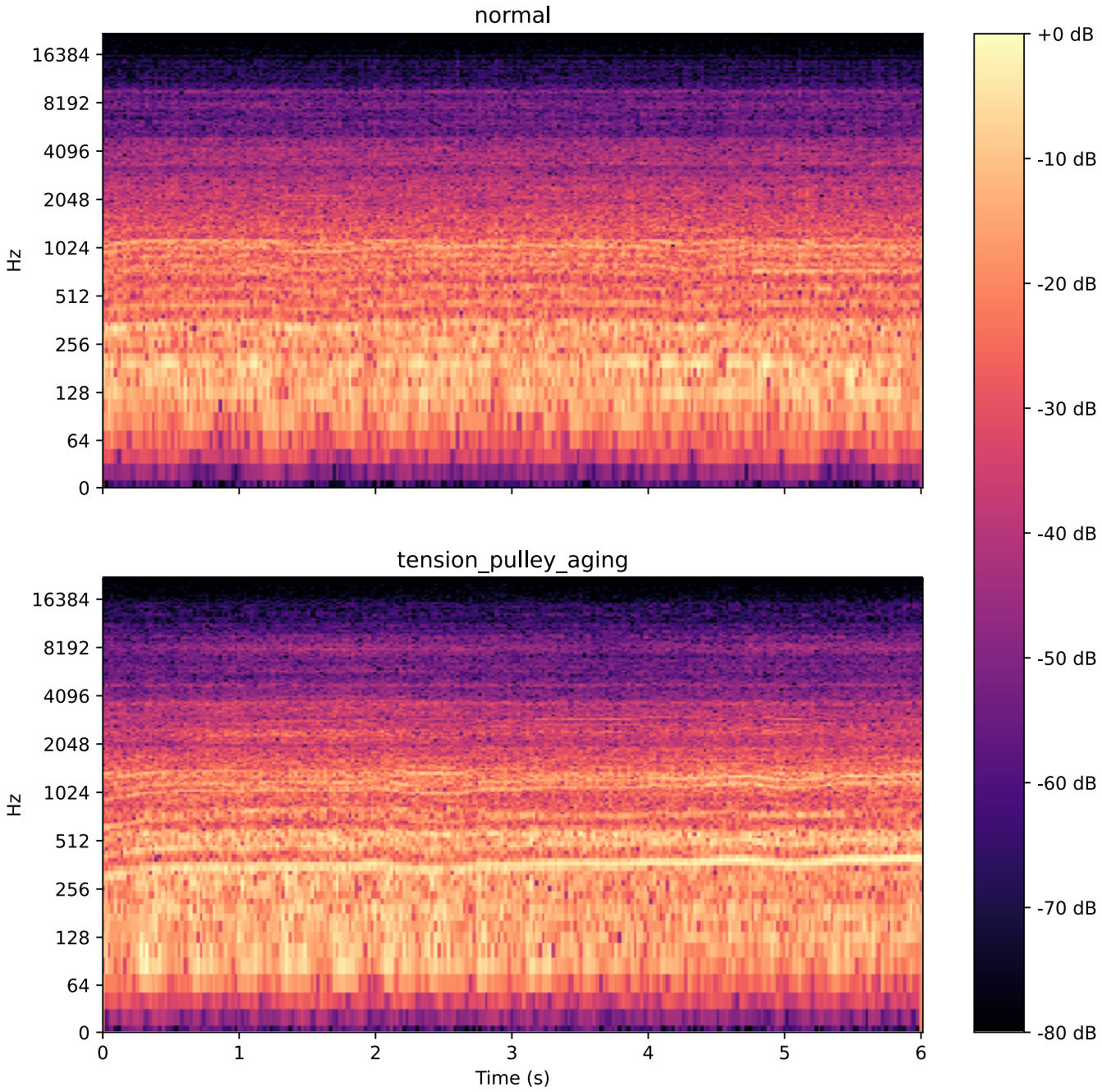
```
N_FFT       = 2048
HOP_LENGTH  = N_FFT // 2

def show_spectrogram(normal_spec, anomaly_spec, file_name):
    fig, ax = plt.subplots(nrows=2, ncols=1, figsize=(10,10))
    img     = librosa.display.specshow(normal_spec,  sr=sr,
hop_length=HOP_LENGTH, x_axis='s', y_axis='log', ax=ax[0])
    _       = librosa.display.specshow(anomaly_spec, sr=sr,
hop_length=HOP_LENGTH, x_axis='s', y_axis='log', ax=ax[1])

    ax[0].set(title='normal')
    ax[0].label_outer()
    ax[1].set(title=file_name)
    ax[1].label_outer()

    fig.colorbar(img, ax=ax, format='%+2.f dB')
    plt.show()

normal_spec = librosa.amplitude_to_db(np.abs(librosa.stft(normal,
n_fft=N_FFT, hop_length=HOP_LENGTH, center=True)), ref=np.max)

for index, anomaly in enumerate(anomaly_wav_list):
    anomaly_spec = librosa.amplitude_to_db(np.abs(librosa.stft(anomaly,
n_fft=N_FFT, hop_length=HOP_LENGTH, center=True)), ref=np.max)
    file_name    = anomaly_file_name_list[index]
    show_spectrogram(normal_spec, anomaly_spec, file_name)
```

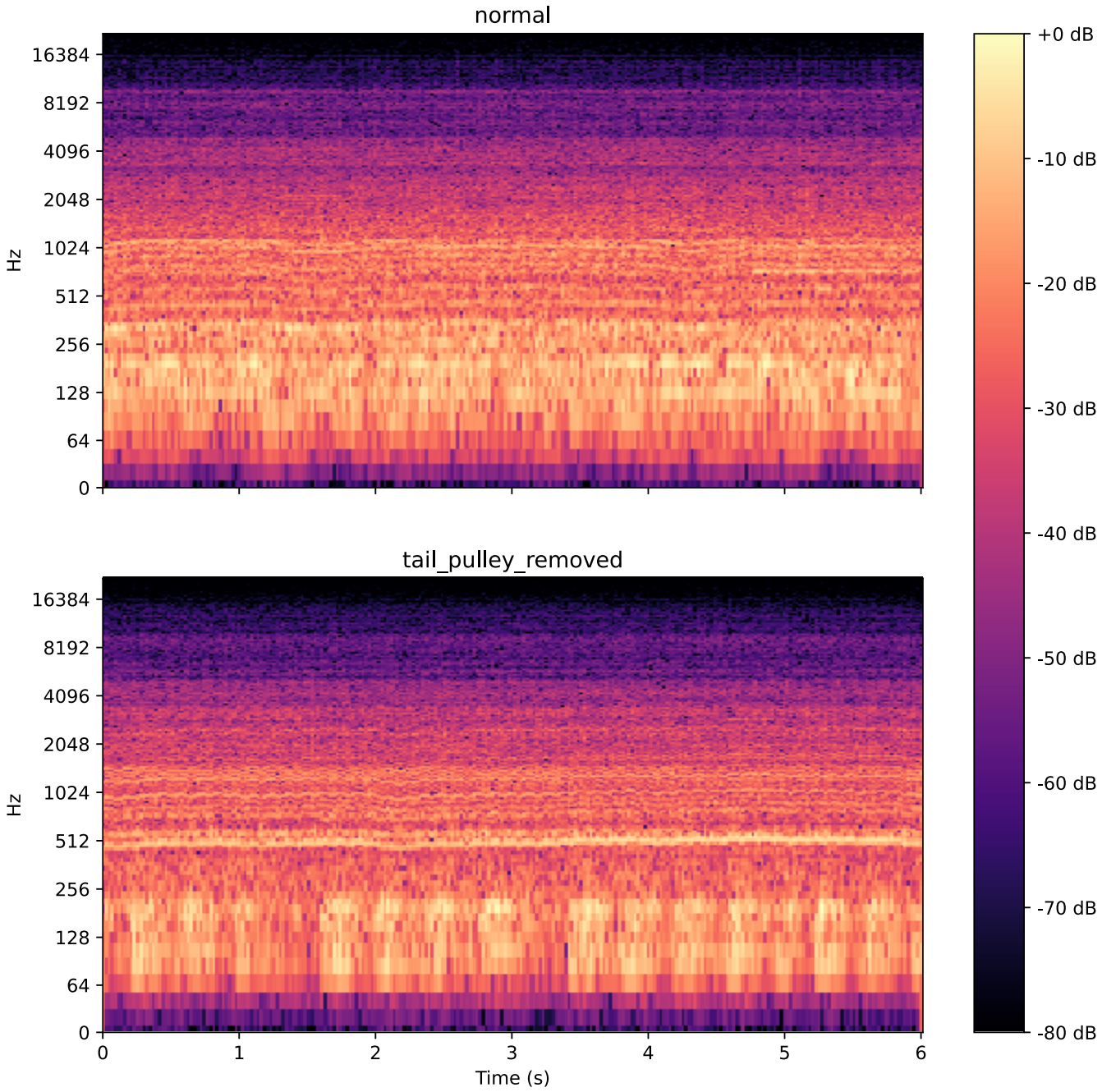

normal
over_voltage
16384
8192
4096
2048
1024
512
256
128
64
0
Hz
0
1
2
3
4
5
6
Time (s)
+0 dB
-10 dB
-20 dB
-30 dB
-40 dB
-50 dB
-60 dB
-70 dB
-80 dB


normal
16384
8192
4096
2048
1024
512
256
128
64
0
Hz
tail_pulley_excessive_tension
16384
8192
4096
2048
1024
512
256
128
64
0
Hz
0
1
2
3
4
5
6
Time (s)
+0 dB
-10 dB
-20 dB
-30 dB
-40 dB
-50 dB
-60 dB
-70 dB
-80 dB


normal
16384
8192
4096
2048
1024
512
256
128
64
0
Hz
belt_attached_metalic_object_2
16384
8192
4096
2048
1024
512
256
128
64
0
Hz
0
1
2
3
4
5
6
Time (s)
+0 dB
-10 dB
-20 dB
-30 dB
-40 dB
-50 dB
-60 dB
-70 dB
-80 dB

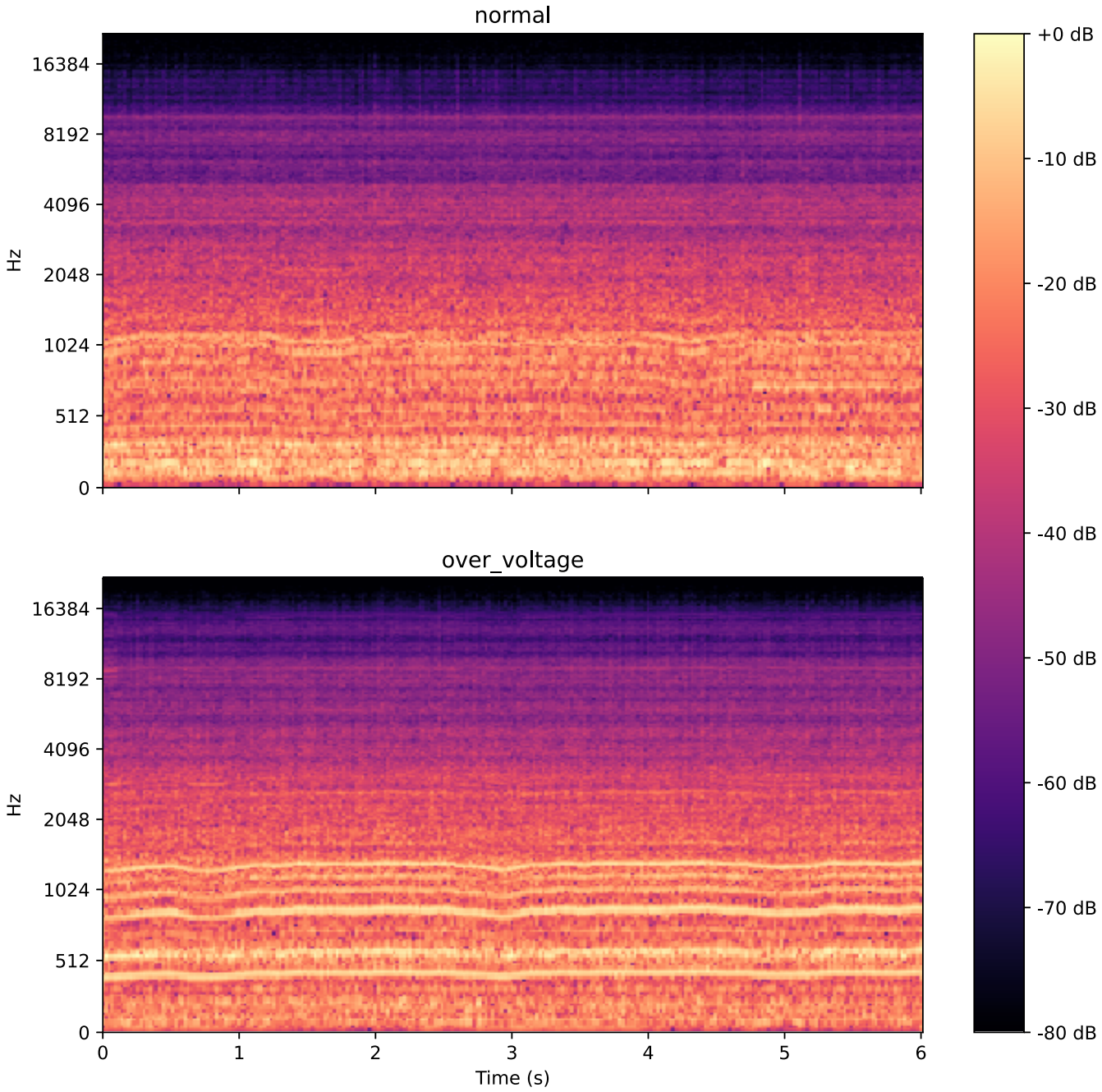

normal
tension_pulley_excessive_tension
Hz
16384
8192
4096
2048
1024
512
256
128
64
0
0
1
2
3
4
5
6
Time (s)
+0 dB
-10 dB
-20 dB
-30 dB
-40 dB
-50 dB
-60 dB
-70 dB
-80 dB

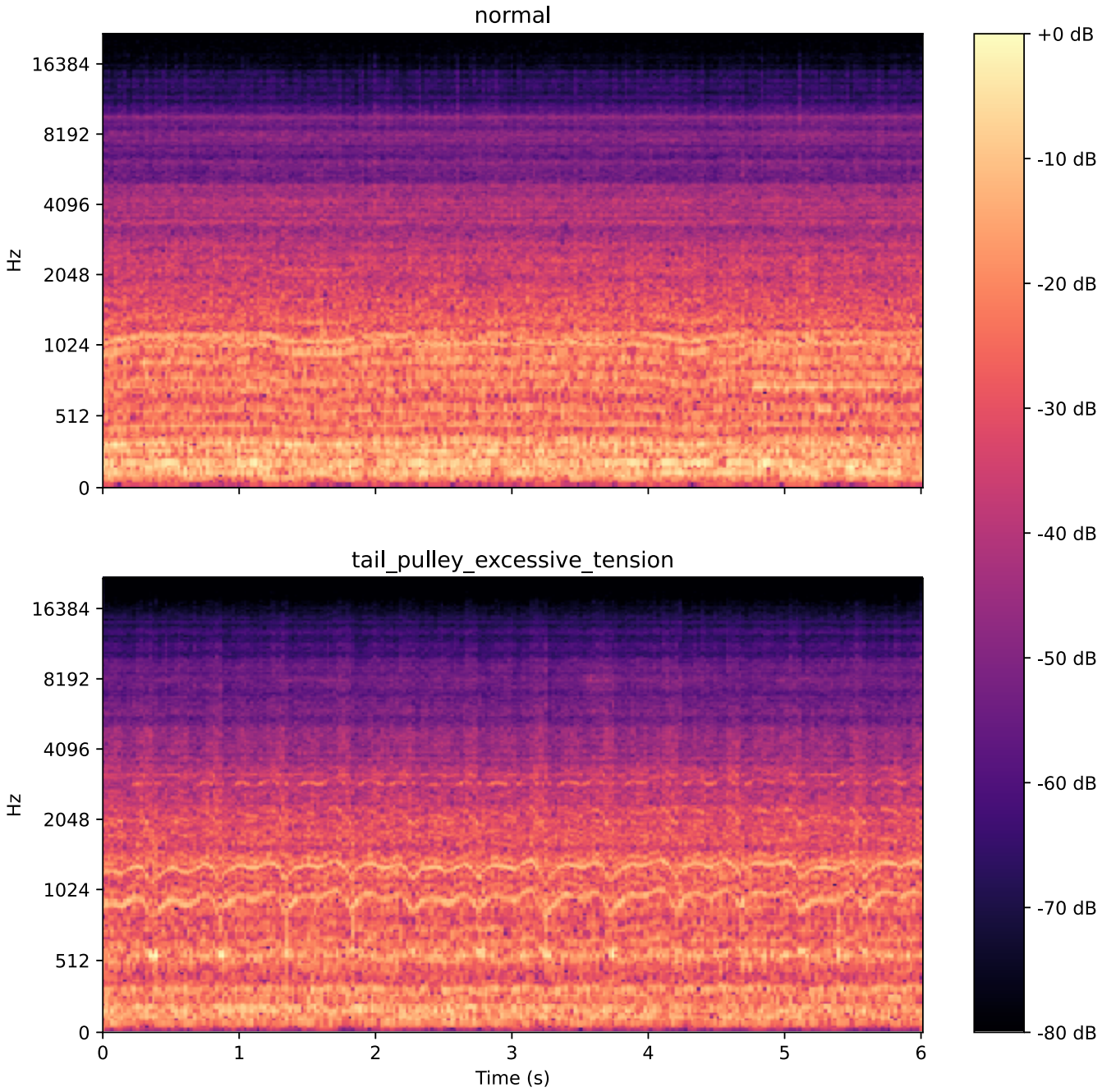

normal
tension_pulley_aging
Hz
16384
8192
4096
2048
1024
512
256
128
64
0
0
1
2
3
4
5
6
Time (s)
+0 dB
-10 dB
-20 dB
-30 dB
-40 dB
-50 dB
-60 dB
-70 dB
-80 dB

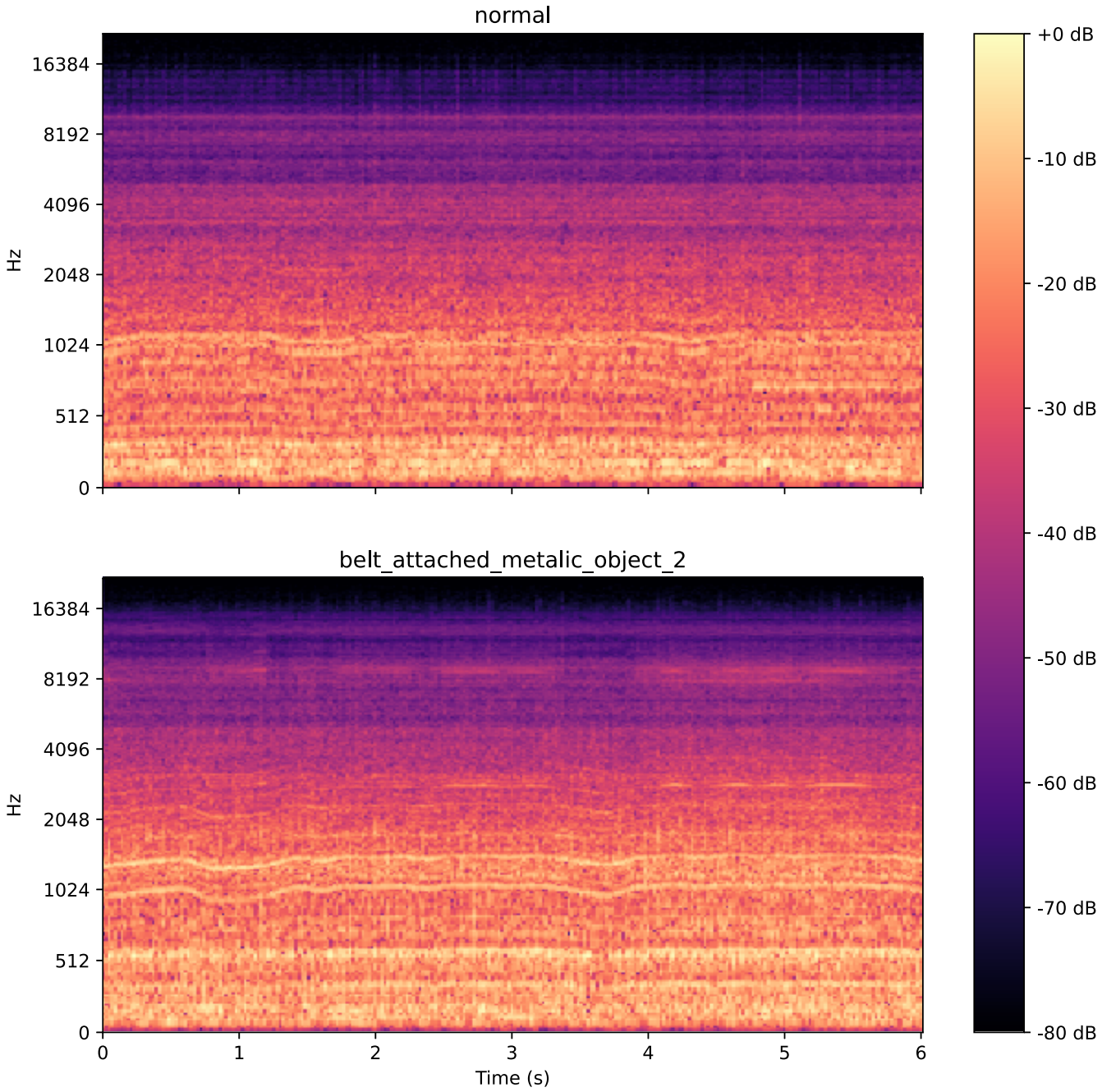

normal
tail_pulley_removed
Hz
16384
8192
4096
2048
1024
512
256
128
64
0
0
1
2
3
4
5
6
Time (s)
+0 dB
-10 dB
-20 dB
-30 dB
-40 dB
-50 dB
-60 dB
-70 dB
-80 dB

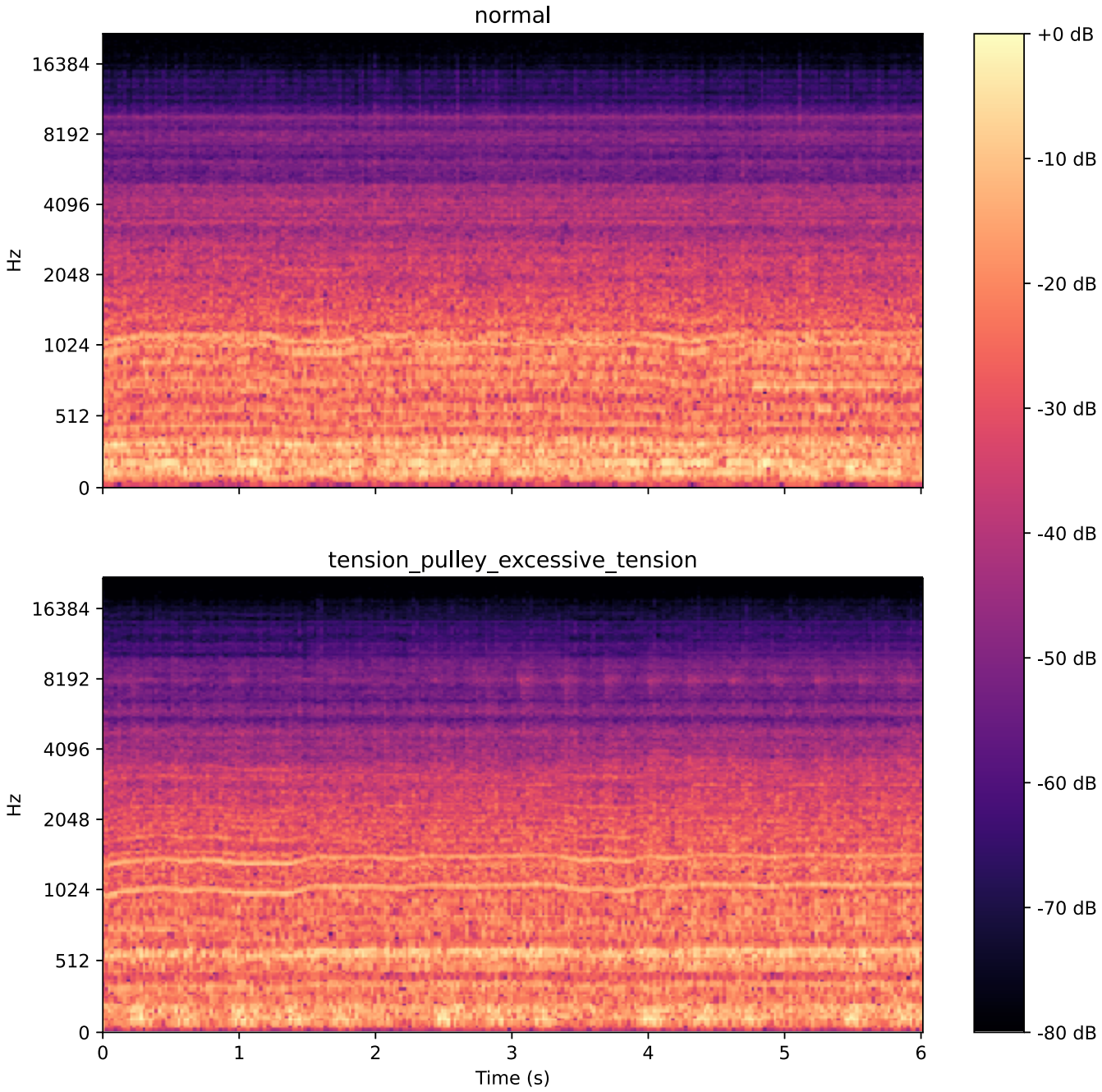
メルスペクトログラムによる可視化

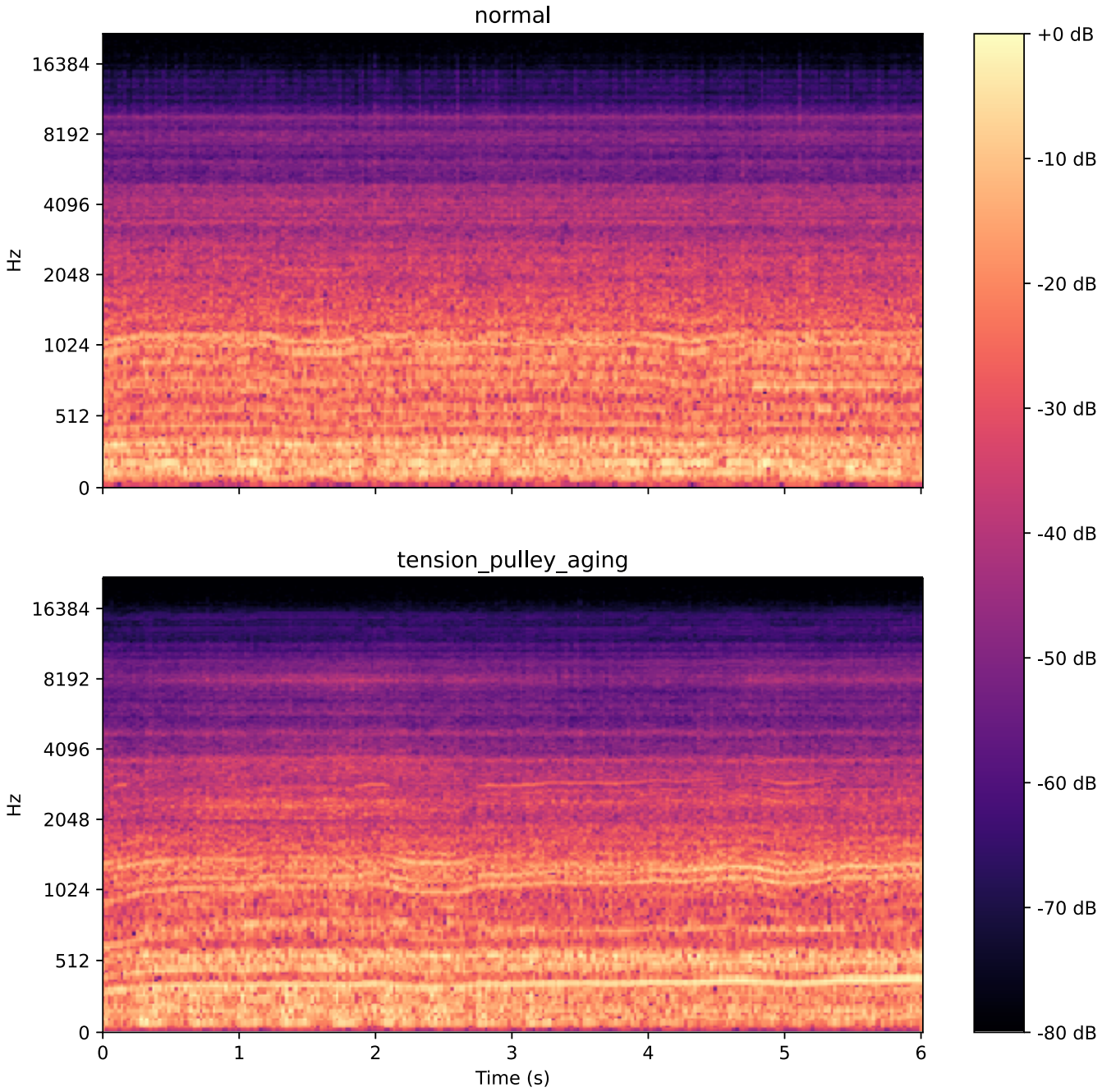
```
N_FFT       = 2048
HOP_LENGTH  = N_FFT // 2
N_MELS      = 256

def show_mel_spectrogram(normal_mel_spec, anomaly_mel_spec, file_name):
    fig, ax = plt.subplots(nrows=2, ncols=1, figsize=(10,10))
    img     = librosa.display.specshow(normal_mel_spec,  sr=sr,
hop_length=HOP_LENGTH, x_axis='s', y_axis='mel', ax=ax[0])
    _       = librosa.display.specshow(anomaly_mel_spec, sr=sr,
hop_length=HOP_LENGTH, x_axis='s', y_axis='mel', ax=ax[1])

    ax[0].set(title='normal')
    ax[0].label_outer()
    ax[1].set(title=file_name)
    ax[1].label_outer()

    fig.colorbar(img, ax=ax, format='%+2.f dB')
    plt.show()

normal_mel_spec =
librosa.power_to_db(librosa.feature.melspectrogram(normal, sr=sr,
n_fft=N_FFT, hop_length=HOP_LENGTH, center=True, power=2.0, n_mels=N_MELS),
ref=np.max)

for index, anomaly in enumerate(anomaly_wav_list):
    anomaly_mel_spec =
librosa.power_to_db(librosa.feature.melspectrogram(anomaly, sr=sr,
n_fft=N_FFT, hop_length=HOP_LENGTH, center=True, power=2.0, n_mels=N_MELS),
ref=np.max)
    file_name        = anomaly_file_name_list[index]
    show_mel_spectrogram(normal_mel_spec, anomaly_mel_spec, file_name)
```

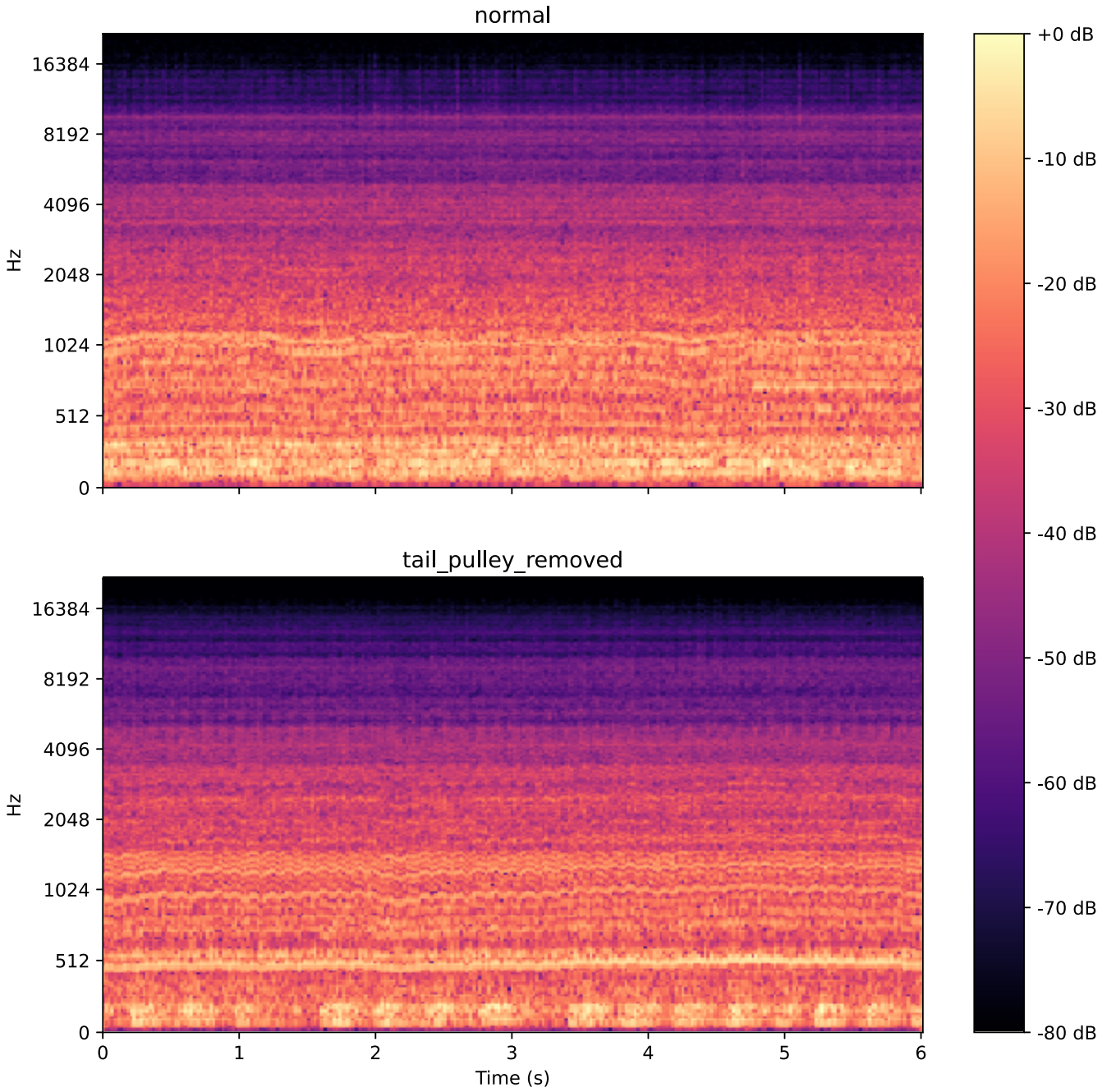

normal
16384
8192
4096
2048
1024
512
0
Hz
over_voltage
16384
8192
4096
2048
1024
512
0
Hz
0
1
2
3
4
5
6
Time (s)
+0 dB
-10 dB
-20 dB
-30 dB
-40 dB
-50 dB
-60 dB
-70 dB
-80 dB


normal
16384
8192
4096
2048
1024
512
0
Hz
tail_pulley_excessive_tension
16384
8192
4096
2048
1024
512
0
Hz
0
1
2
3
4
5
6
Time (s)
+0 dB
-10 dB
-20 dB
-30 dB
-40 dB
-50 dB
-60 dB
-70 dB
-80 dB


normal
16384
8192
4096
2048
1024
512
0
Hz
belt_attached_metalic_object_2
16384
8192
4096
2048
1024
512
0
Hz
0
1
2
3
4
5
6
Time (s)
+0 dB
-10 dB
-20 dB
-30 dB
-40 dB
-50 dB
-60 dB
-70 dB
-80 dB


normal
16384
8192
4096
2048
1024
512
0
Hz
tension_pulley_excessive_tension
16384
8192
4096
2048
1024
512
0
Hz
0
1
2
3
4
5
6
Time (s)
+0 dB
-10 dB
-20 dB
-30 dB
-40 dB
-50 dB
-60 dB
-70 dB
-80 dB


normal
16384
8192
4096
2048
1024
512
0
Hz
tension_pulley_aging
16384
8192
4096
2048
1024
512
0
Hz
0
1
2
3
4
5
6
Time (s)
+0 dB
-10 dB
-20 dB
-30 dB
-40 dB
-50 dB
-60 dB
-70 dB
-80 dB


normal
16384
8192
4096
2048
1024
512
0
Hz
tail_pulley_removed
16384
8192
4096
2048
1024
512
0
Hz
0
1
2
3
4
5
6
Time (s)
+0 dB
-10 dB
-20 dB
-30 dB
-40 dB
-50 dB
-60 dB
-70 dB
-80 dB