

```
In [3]: # -*- coding: utf-8 -*-
"""Untitled24.ipynb

Automatically generated by Colaboratory.

Original file is located at
    https://colab.research.google.com/drive/1JggIkAknS-upHbTHmWSKF9cDO_V-TNvv
"""

from PyEMD import EMD

import PyEMD;
print(PyEMD.__version__)

import numpy as np

from pandas import read_csv

TS=read_csv('newdataset.csv')

data = TS.values

emd = EMD()

#making data 1 dimensional
d1=np.reshape(data,(300,))

d1.shape

1.5.2
(300,)
```

Out[3]:

EMD

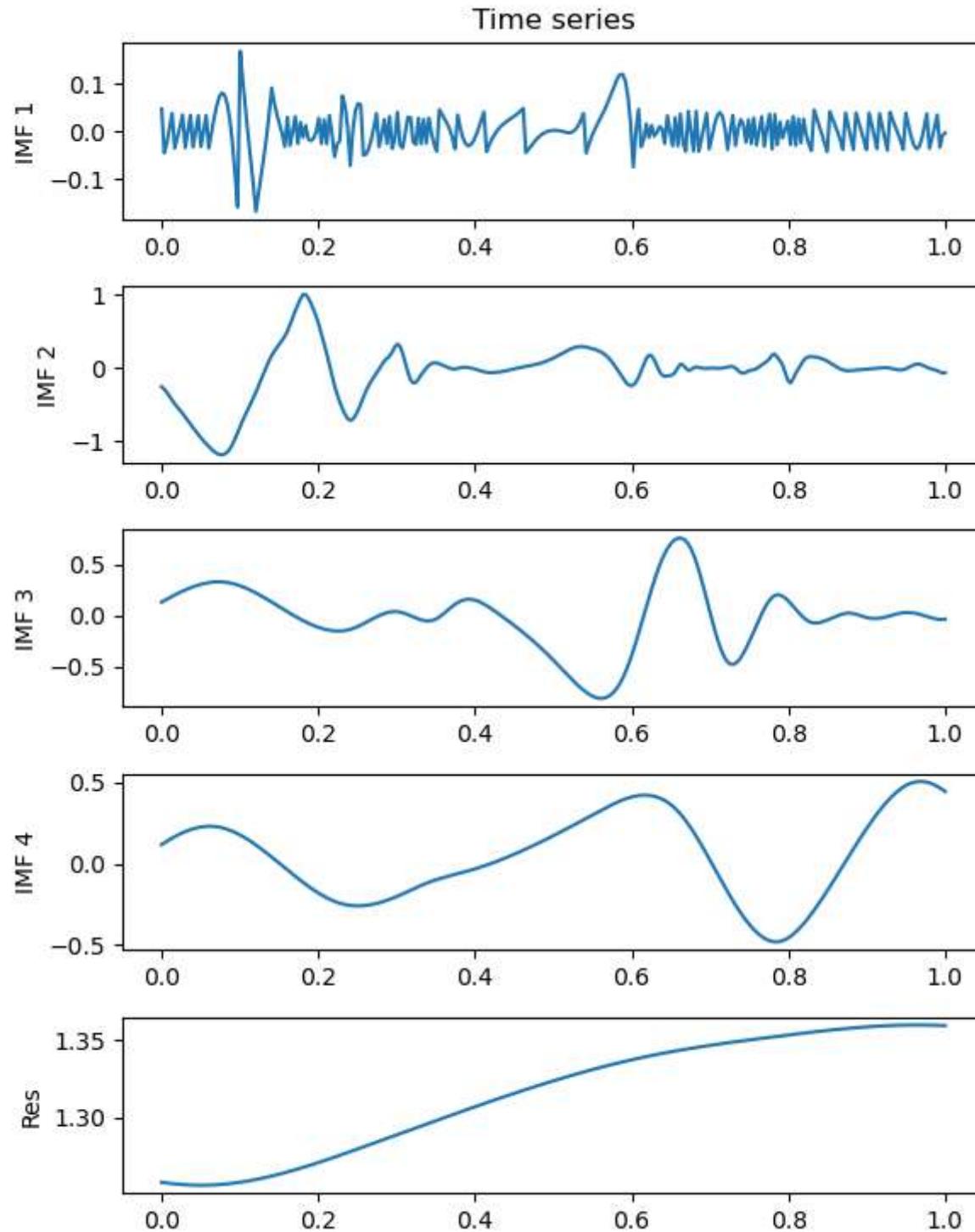
```
In [4]: signal=d1
t = np.linspace(0, 1, 300)
from PyEMD import EMD, Visualisation

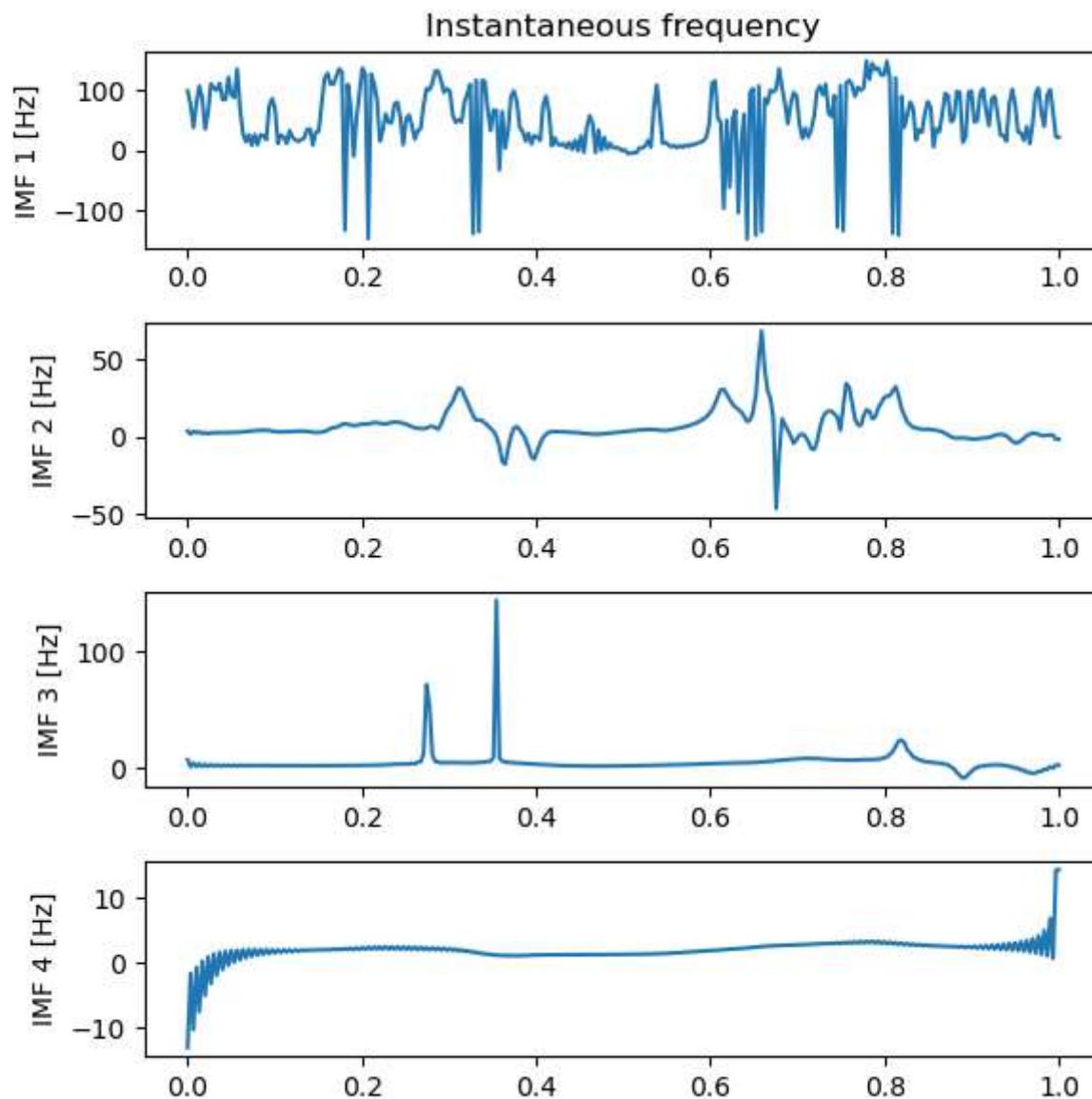
emd.emd(d1)
```

```
imfs, res = emd.get_imfs_and_residue()

vis = Visualisation()

vis.plot_imfs(imfs=imfs, residue=res, t=t, include_residue=True)
vis.plot_instant_freq(t, imfs=imfs)
vis.show()
```





EEMD

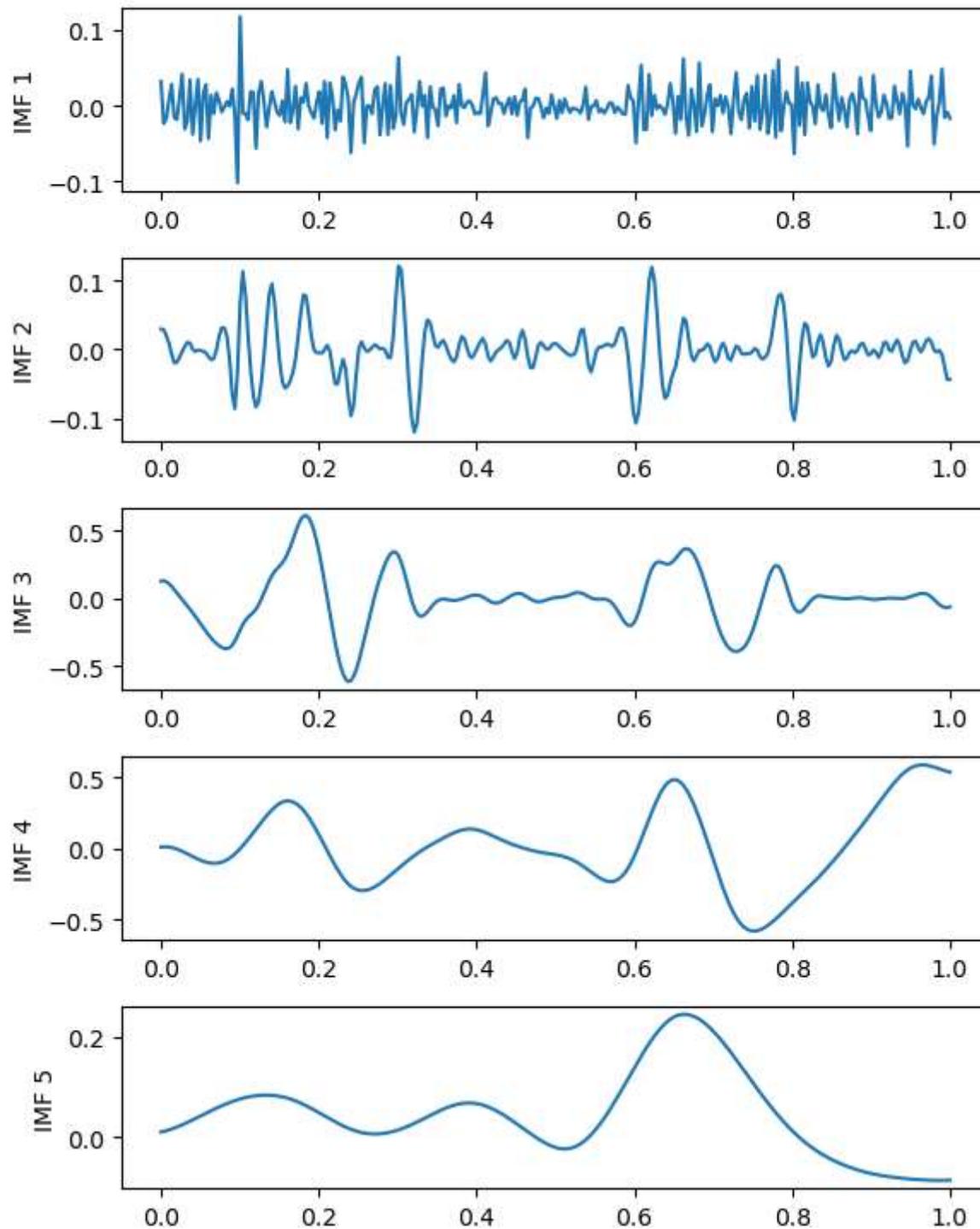
```
In [5]: from PyEMD import EEMD
import matplotlib.pyplot as plt
if __name__ == "__main__":
```

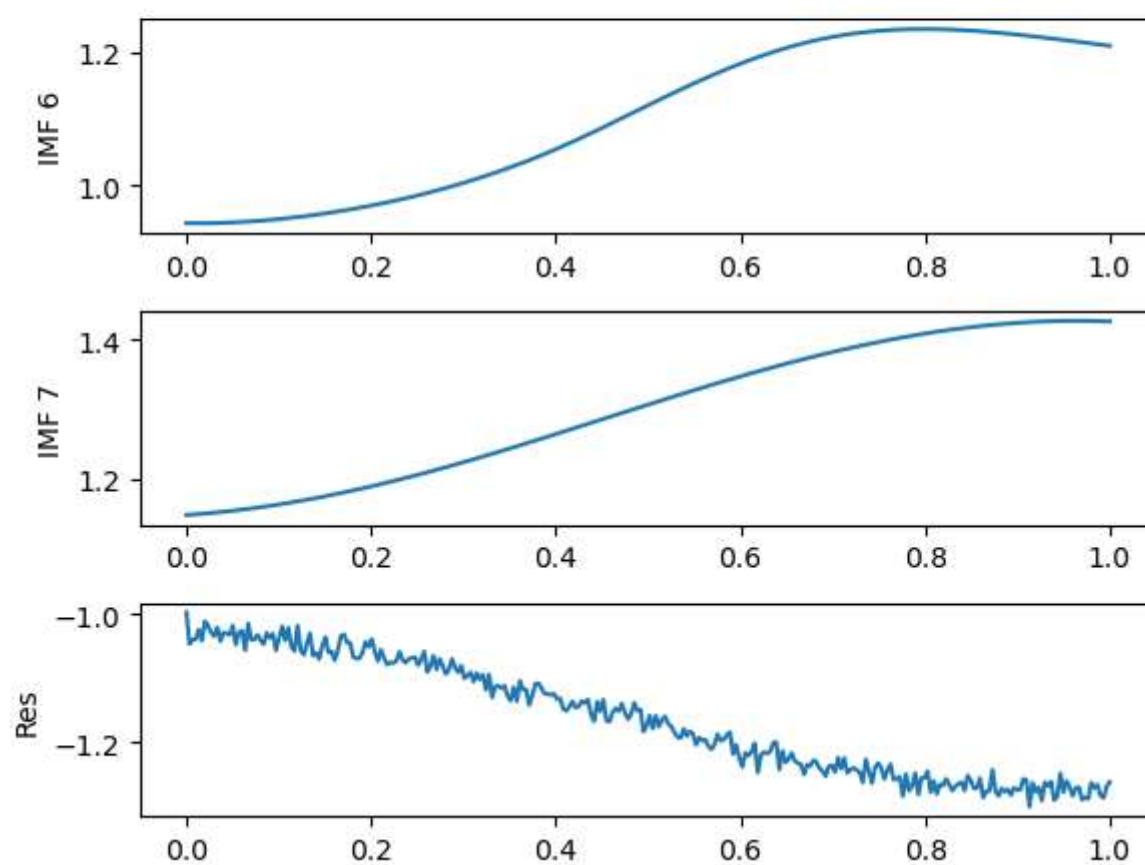
```
eemd = EEMD()
eIMFs = eemd(signal)

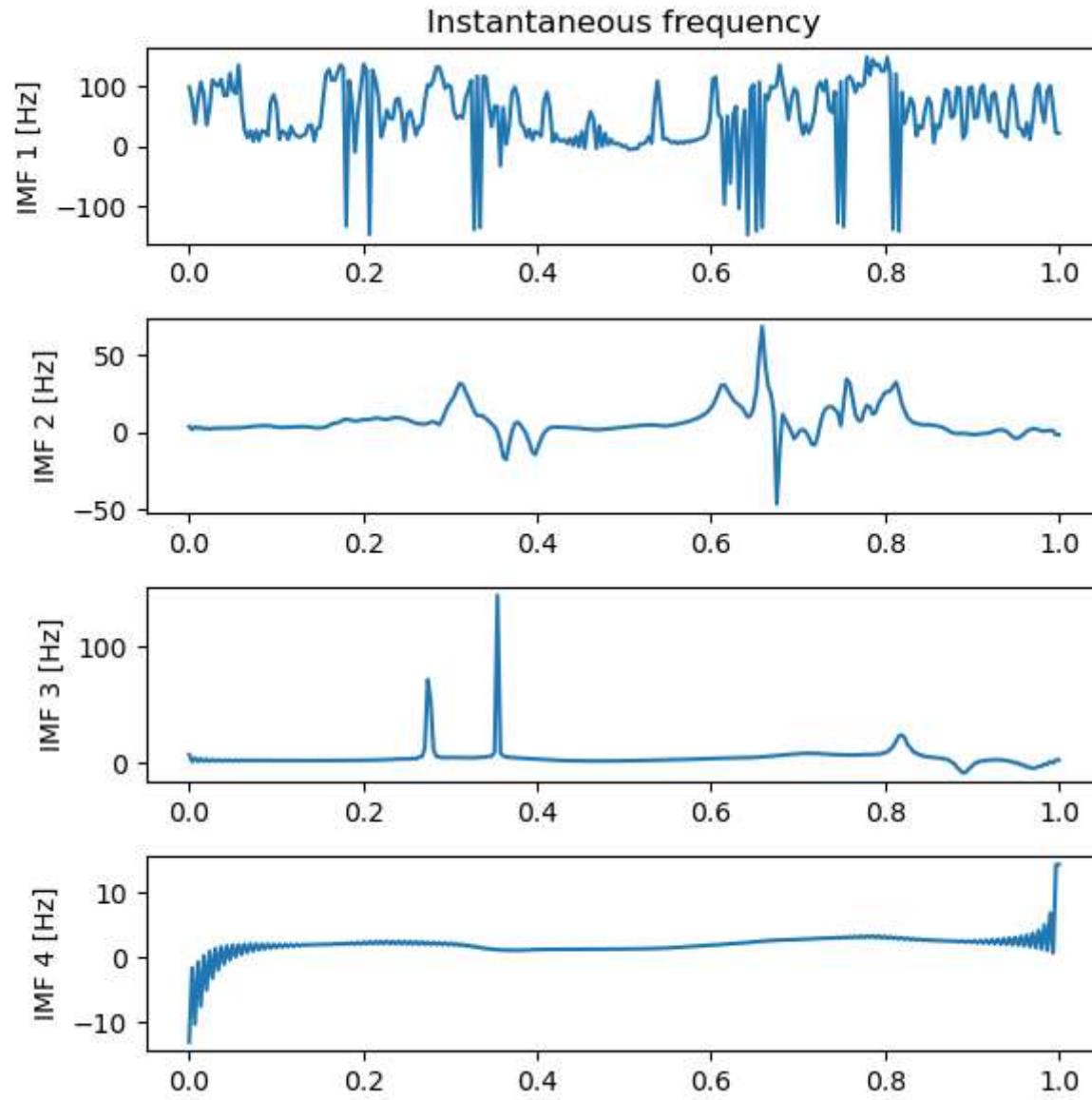
eimfs, res = eemd.get_imfs_and_residue()
# Plot the original signal, IMFs, and the residual component
plt.figure(figsize=(25, 30))
vis.plot_imfs(imfs=eimfs, residue=res, t=t, include_residue=True)
vis.plot_instant_freq(t, imfs=eimfs)
vis.show()
```

<Figure size 2500x3000 with 0 Axes>

Time series







CEEMDAN

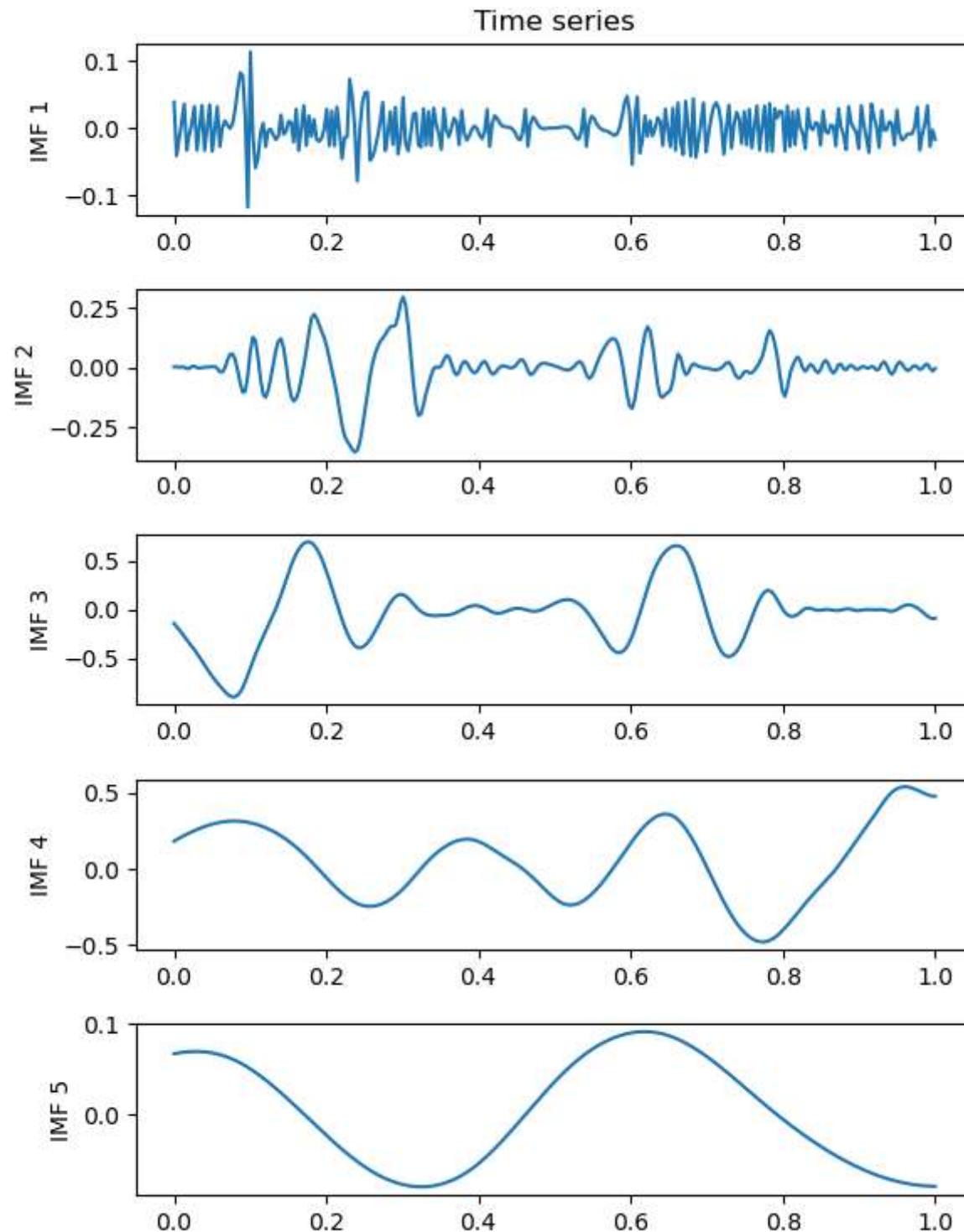
In [6]:

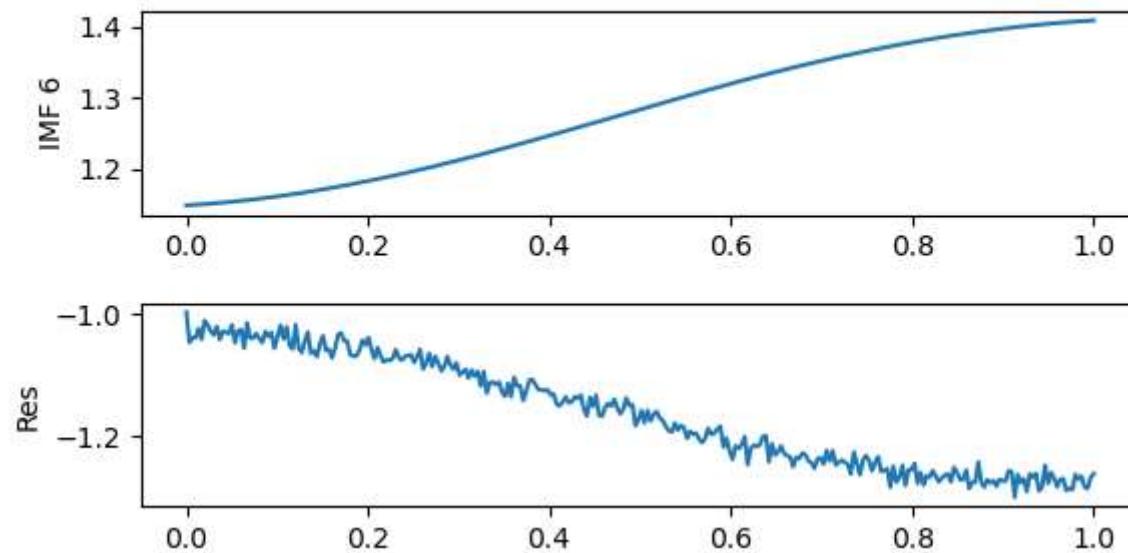
```
from PyEMD import CEEMDAN
ceemdan = CEEMDAN()
```

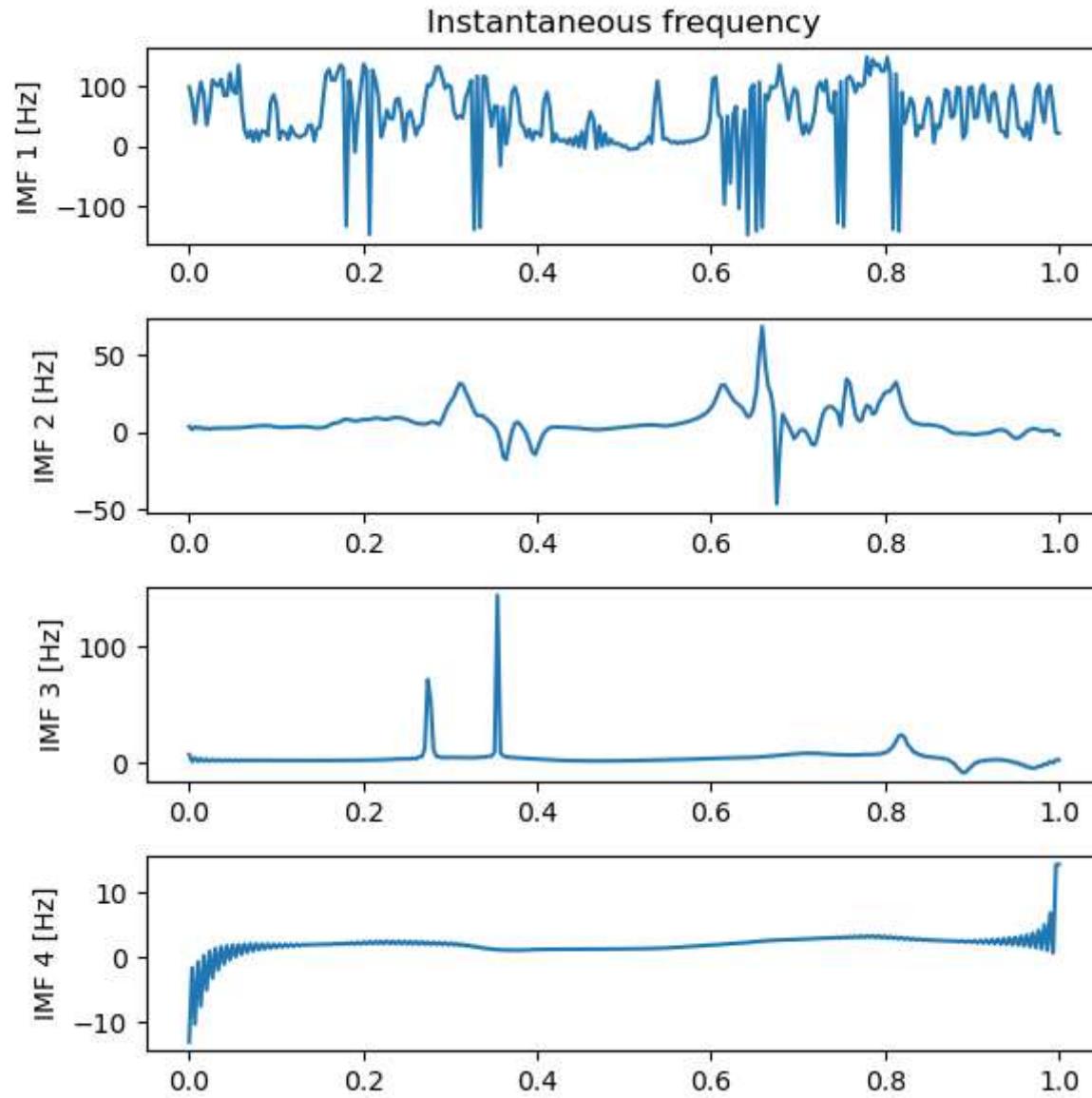
```
cIMFs = ceemdan(d1)

vis.plot_imfs(imfs=cIMFs, residue=res, t=t, include_residue=True)
vis.plot_instant_freq(t, imfs=imfs)
vis.show()

t = np.arange(0, 3, 0.01)
```







Dataset 2

```
In [7]: from PyEMD import EMD  
import PyEMD;
```

```
print(PyEMD.__version__)

import numpy as np
import pandas as pd

TS=pd.read_excel('windspeed.xlsx')

data = TS.values
```

1.5.2

In [8]: TS

Out[8]:

	Year	Month	Day	Hour	Minute	temperature at 100m (C)	wind direction at 100m (deg)	wind speed at 100m (m/s)	air pressure at 100m (Pa)	wind speed at 80m (m/s)	temperature at 80m (C)	wind direction at 80m (deg)
0	2014	1	1	0	30	17.45	65.52	2.58	95640	1.76	17.32	56.42
1	2014	1	1	1	30	17.16	82.82	2.01	95660	1.17	16.78	69.16
2	2014	1	1	2	30	17.02	115.11	1.80	95630	1.18	16.64	122.22
3	2014	1	1	3	30	16.46	83.15	1.63	95620	1.28	16.16	78.63
4	2014	1	1	4	30	15.88	69.40	1.84	95600	1.51	15.44	59.14
...
8755	2014	12	31	19	30	21.92	3.49	3.66	95650	3.28	21.85	4.50
8756	2014	12	31	20	30	20.40	359.17	3.40	95670	2.60	20.40	354.96
8757	2014	12	31	21	30	19.57	355.99	2.81	95670	2.04	19.44	343.87
8758	2014	12	31	22	30	19.16	16.27	2.73	95660	1.98	19.03	0.78
8759	2014	12	31	23	30	18.22	38.39	2.54	95630	1.81	18.26	29.41

8760 rows × 12 columns

In []:

windspeed

```
In [9]: windspeed=TS[["Day","wind speed at 80m (m/s)"]]
```

```
In [10]: windspeed
```

```
Out[10]:
```

	Day	wind speed at 80m (m/s)
0	1	1.76
1	1	1.17
2	1	1.18
3	1	1.28
4	1	1.51
...
8755	31	3.28
8756	31	2.60
8757	31	2.04
8758	31	1.98
8759	31	1.81

8760 rows × 2 columns

When day is a index

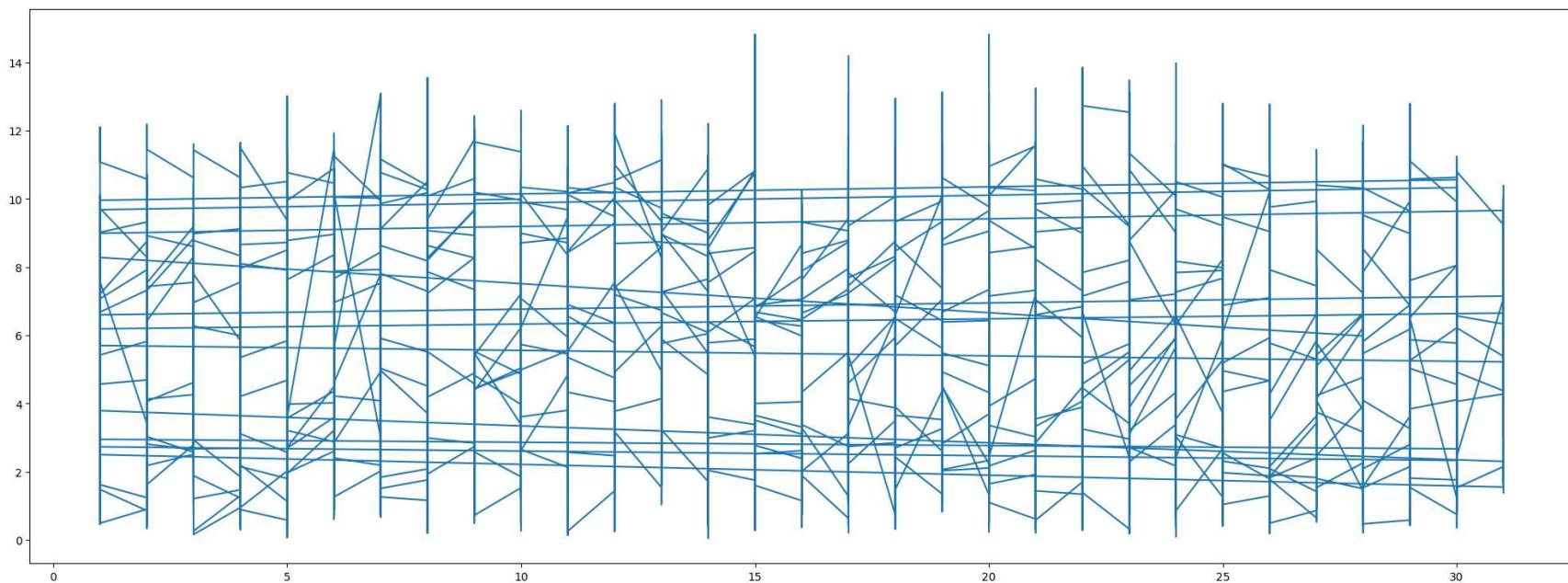
```
In [11]: windspeed=windspeed.set_index("Day")
windspeed
```

Out[11]: wind speed at 80m (m/s)

Day	
1	1.76
1	1.17
1	1.18
1	1.28
1	1.51
...	...
31	3.28
31	2.60
31	2.04
31	1.98
31	1.81

8760 rows × 1 columns

In [12]: `import matplotlib.pyplot as plt`In [13]: `plt.figure(figsize=(25,9))`
`plt.plot("wind speed at 80m (m/s)", data=windspeed)`Out[13]: [`<matplotlib.lines.Line2D at 0x2ba247ba850>`]



```
In [14]: signal=windspeed.values
```

```
In [15]: signal
```

```
Out[15]: array([[1.76],  
[1.17],  
[1.18],  
...,  
[2.04],  
[1.98],  
[1.81]])
```

```
In [16]: signal.shape
```

```
Out[16]: (8760, 1)
```

EMD

```
In [17]: import numpy as np  
from PyEMD import EMD  
import matplotlib.pyplot as plt
```

```
# Generate a sample signal
t = np.linspace(0, 1, 8760)
signal=TS[["wind speed at 80m (m/s)"]].values
#Making 1 D data
signal=np.reshape(signal,(8760,))

# Perform Empirical Mode Decomposition
emd = EMD()
emd.emd(signal)

# Get the IMFs and Residual
imfs, res = emd.get_imfs_and_residue()

# Plot the original signal, IMFs, and the residual component
plt.figure(figsize=(25, 30))

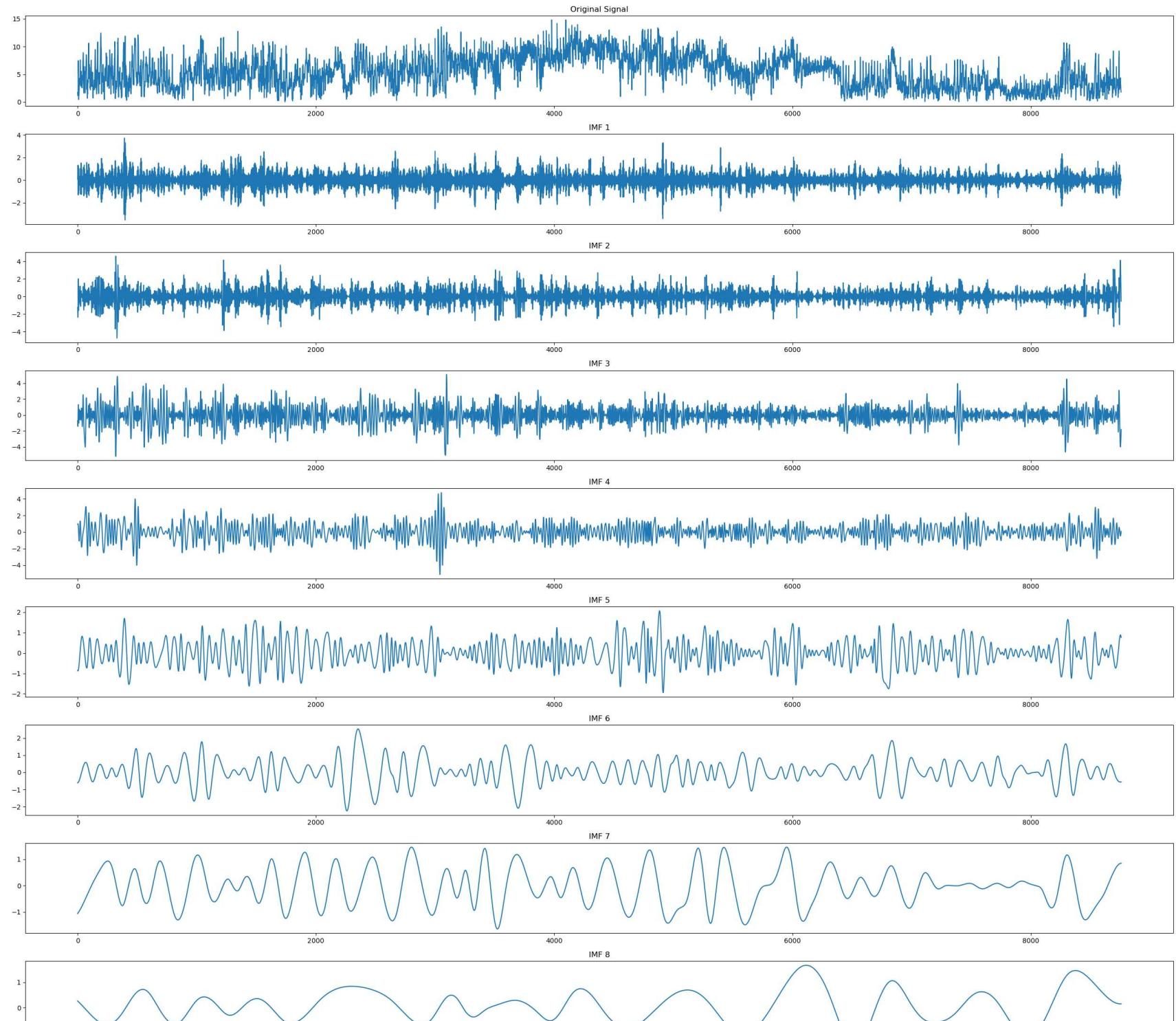
# Original Signal
plt.subplot(len(imfs)+2, 1, 1)
plt.plot(signal, label='Original Signal')
plt.title('Original Signal')

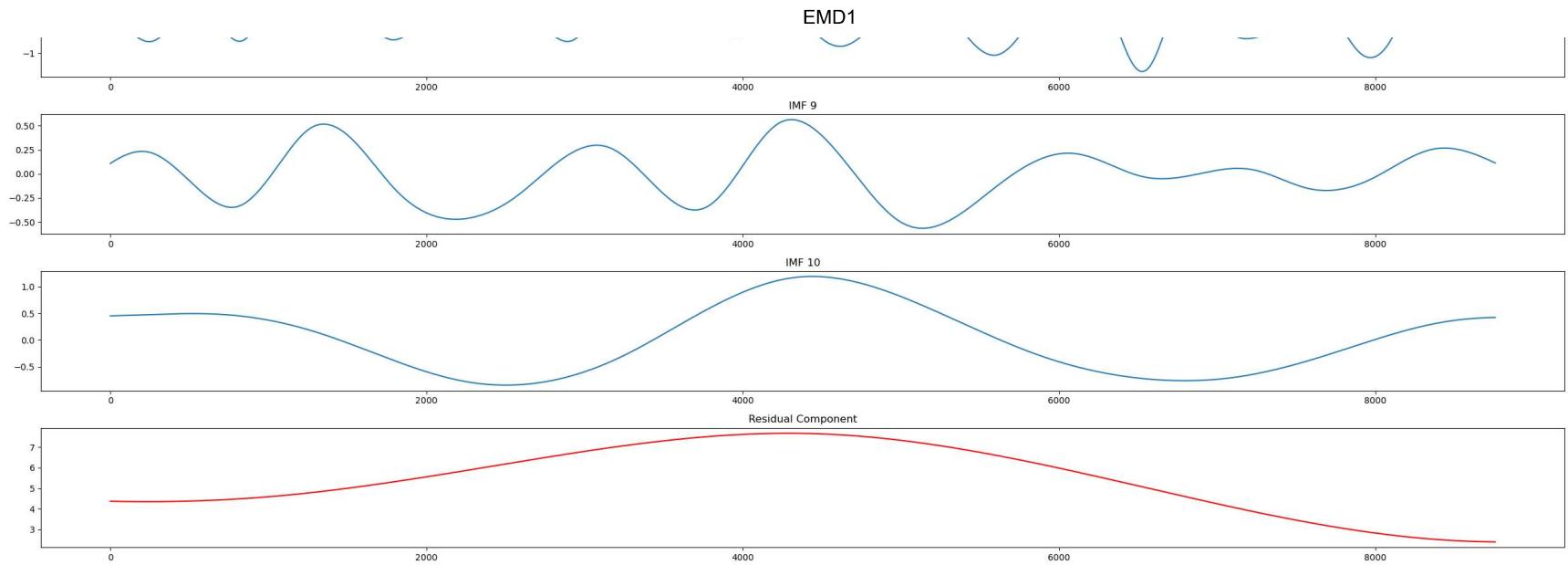
# IMFs
for i, imf in enumerate(imfs):
    plt.subplot(len(imfs)+2, 1, i+2)
    plt.plot(imf, label=f'IMF {i+1}')
    plt.title(f'IMF {i+1}')

# Residual Component
plt.subplot(len(imfs)+2, 1, len(imfs)+2)
plt.plot(res, label='Residual Component', color='red')
plt.title('Residual Component')

plt.tight_layout()
plt.show()
```

EMD1





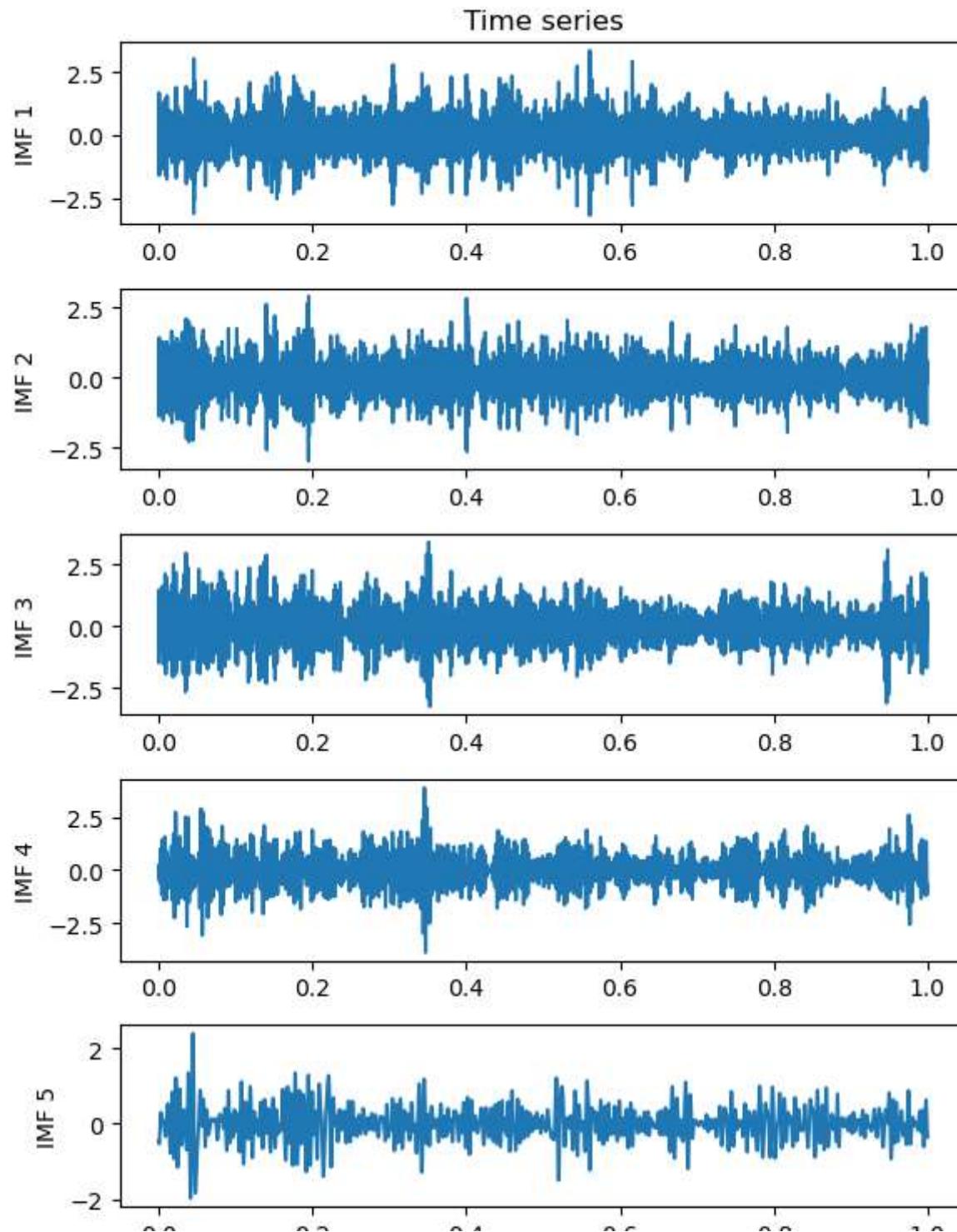
EEMD

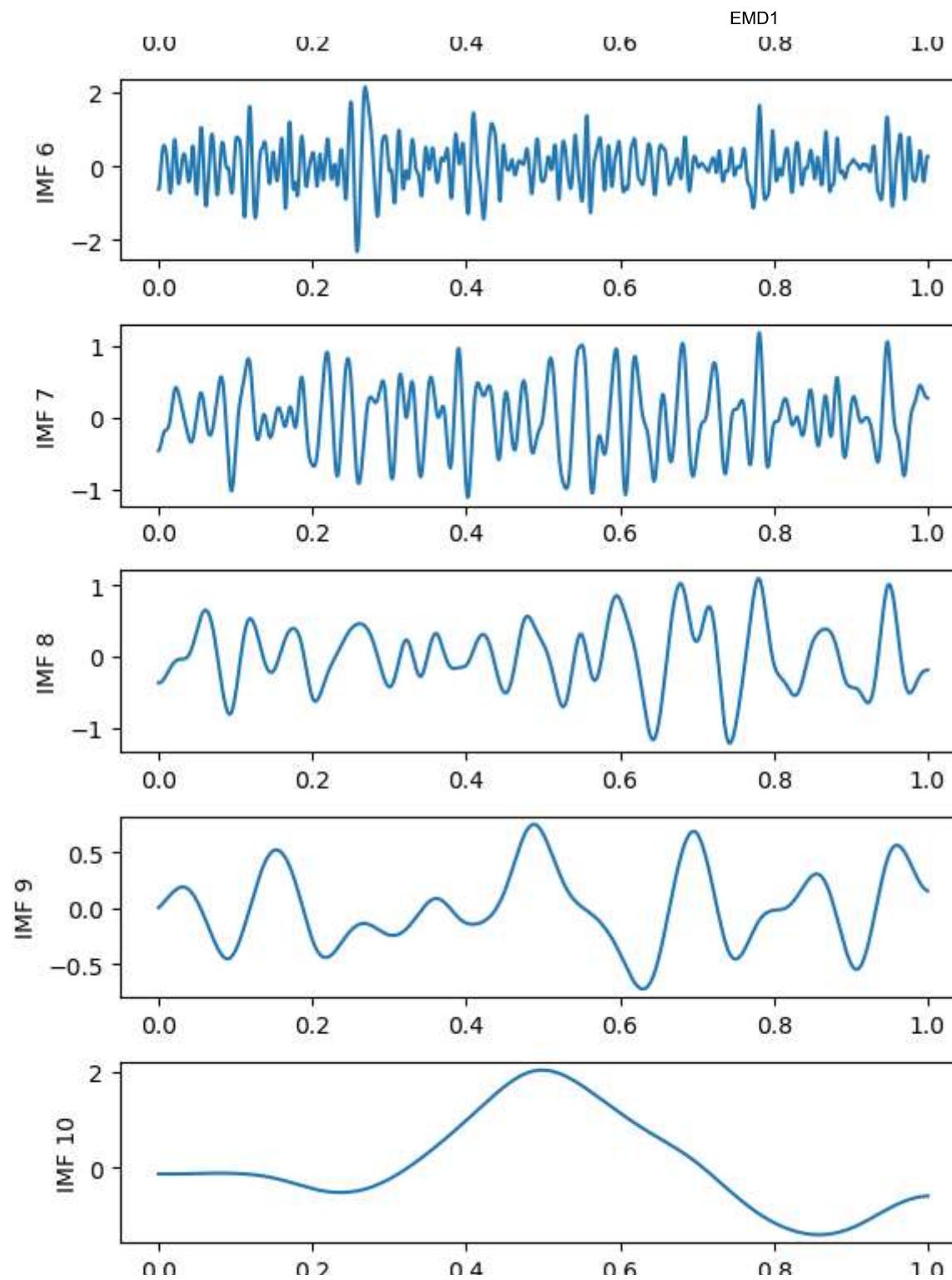
```
In [18]: from PyEMD import EEMD

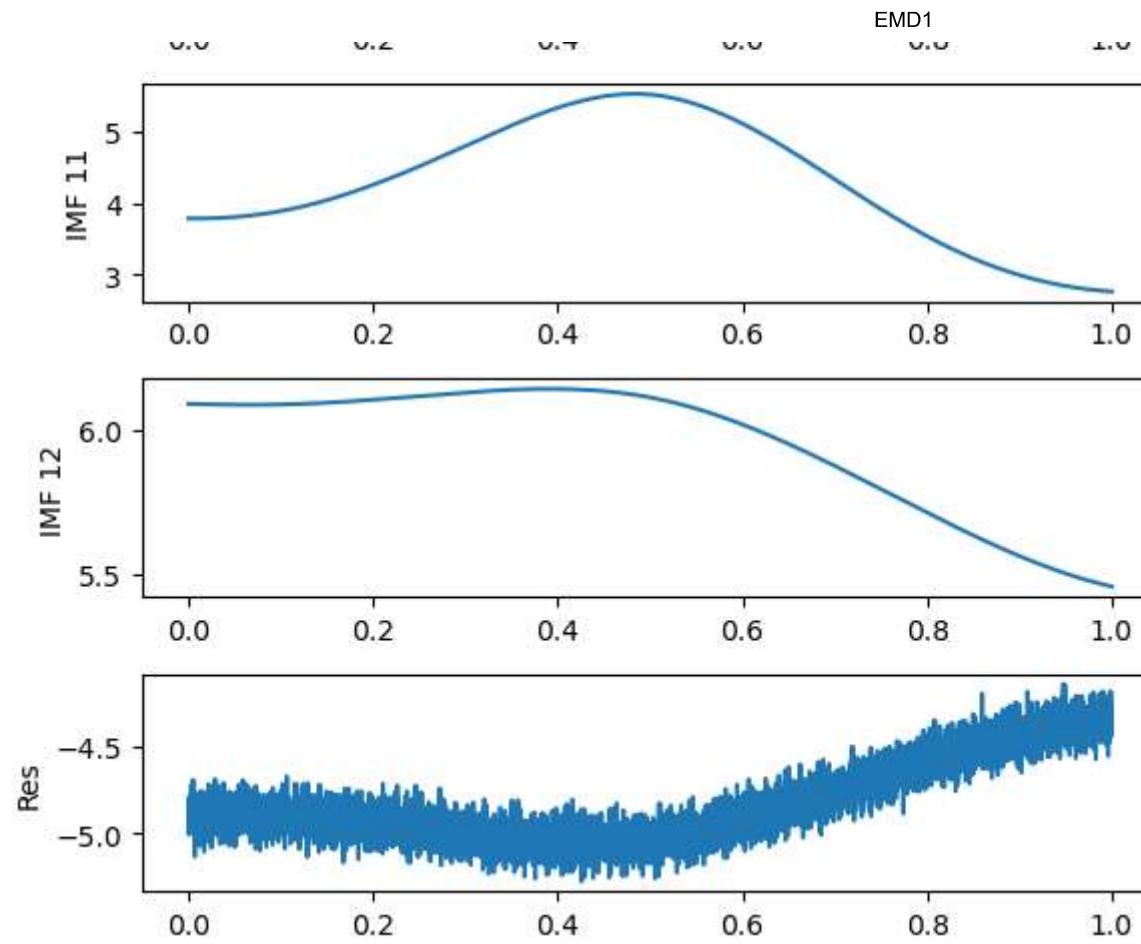
if __name__ == "__main__":
    eemd = EEMD()
    eIMFs = eemd(signal)

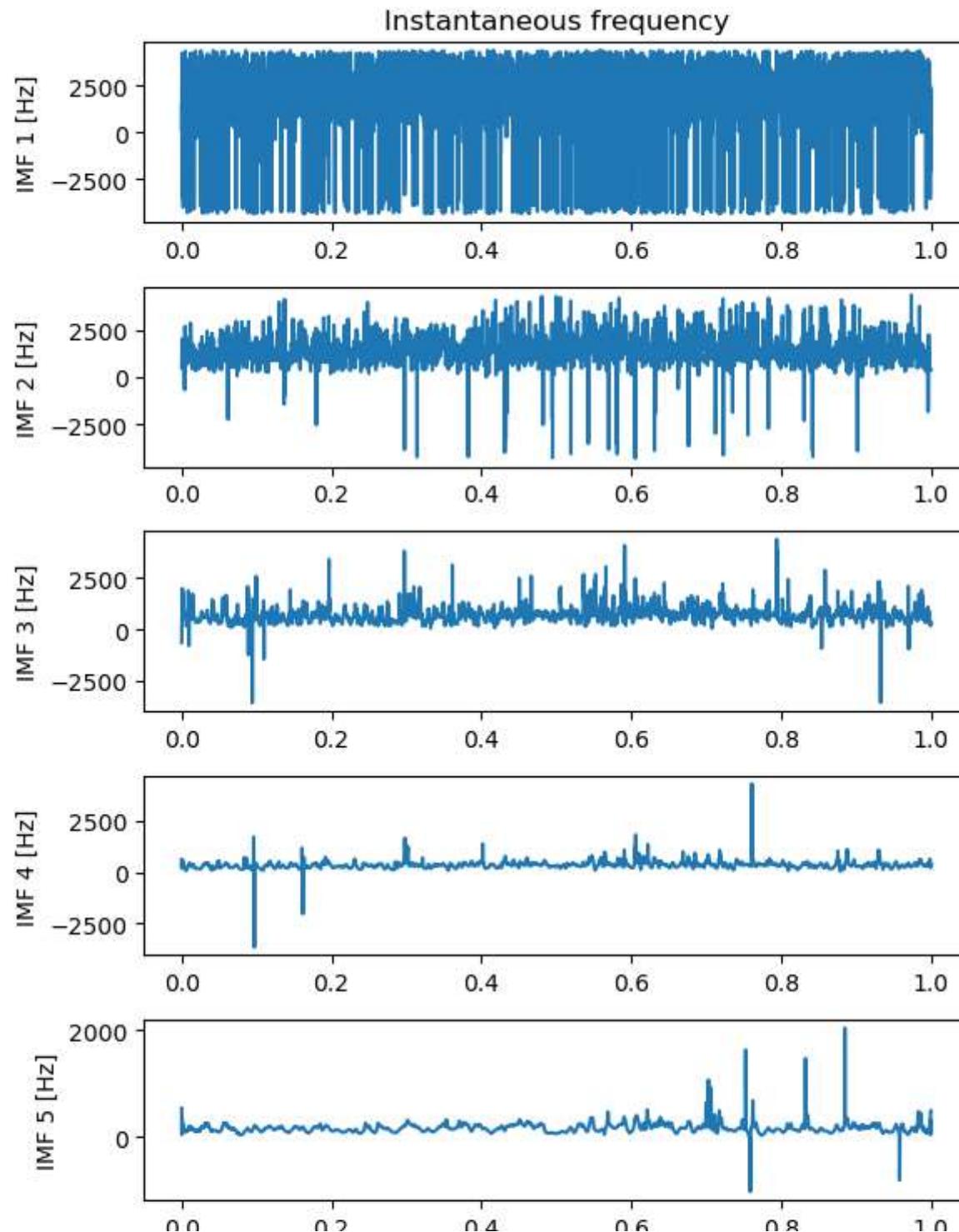
eimfs, res = eemd.get_imfs_and_residue()
# Plot the original signal, IMFs, and the residual component
plt.figure(figsize=(25, 30))
vis.plot_imfs(imfs=eimfs, residue=res, t=t, include_residue=True)
vis.plot_instant_freq(t, imfs=imfs)
vis.show()
```

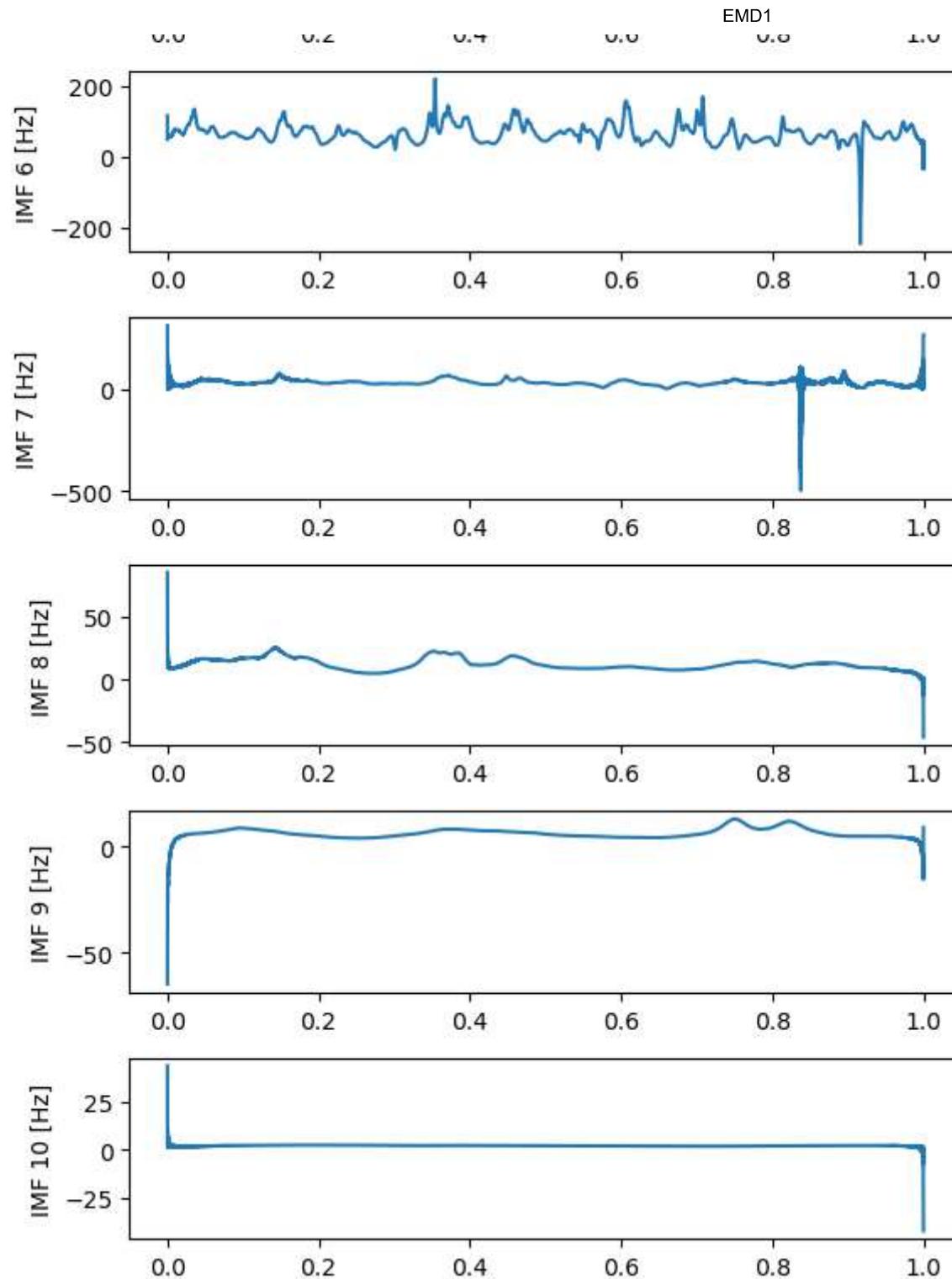
<Figure size 2500x3000 with 0 Axes>









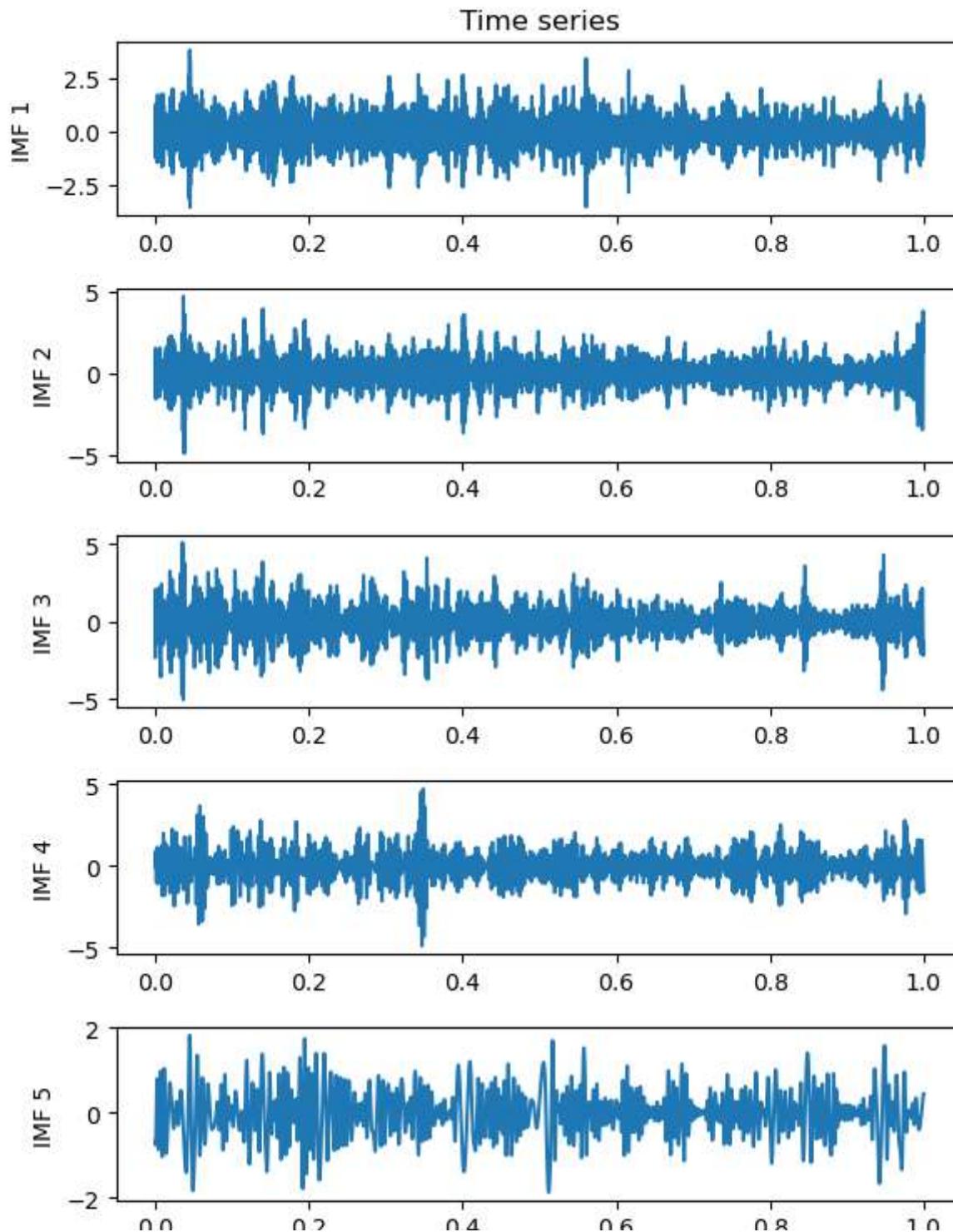


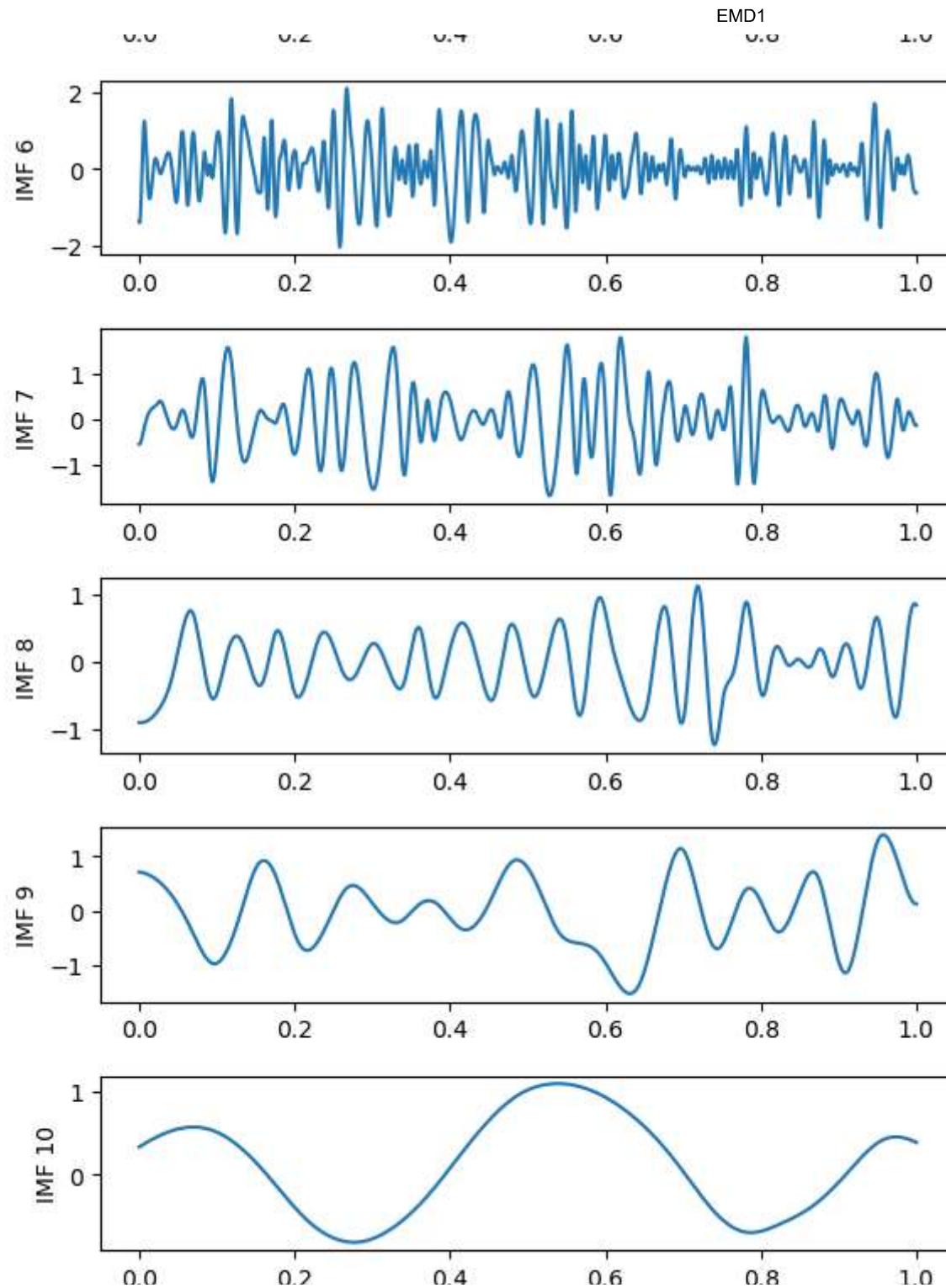
```
In [19]: from PyEMD import CEEMDAN

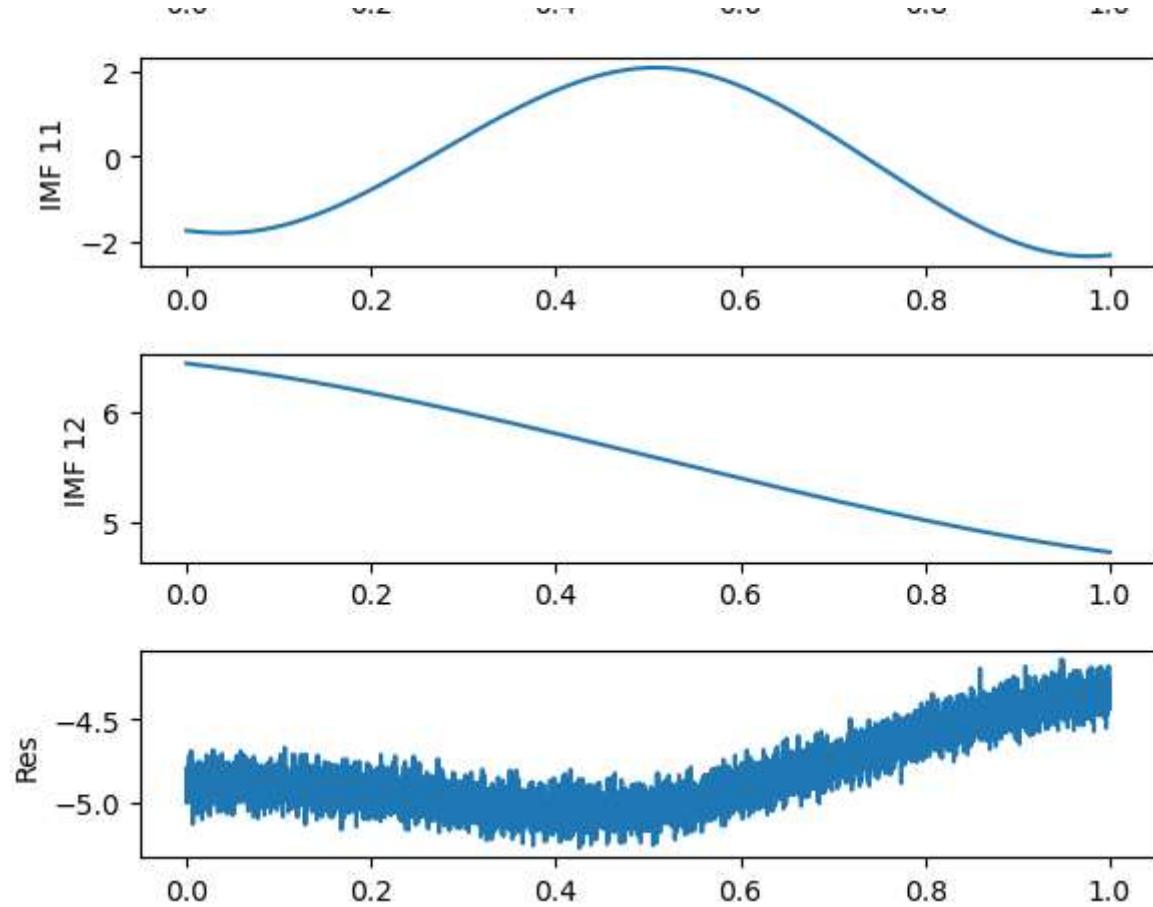
ceemdan = CEEMDAN()

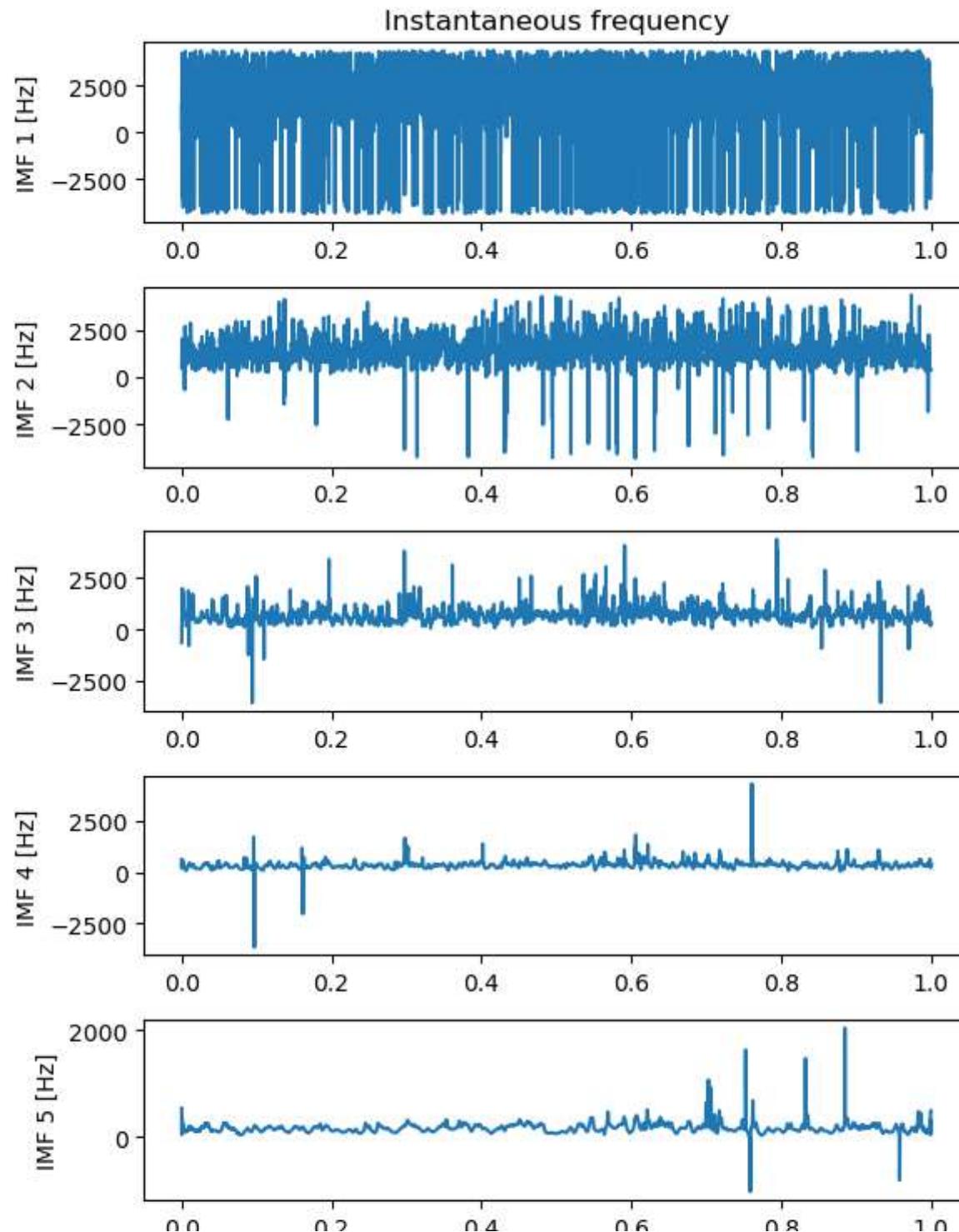
cIMFs = ceemdan(signal)
# Plot the original signal, IMFs, and the residual component
plt.figure(figsize=(25, 30))
vis.plot_imfs(imfs=cIMFs, residue=res, t=t, include_residue=True)
vis.plot_instant_freq(t, imfs=imfs)
vis.show()
```

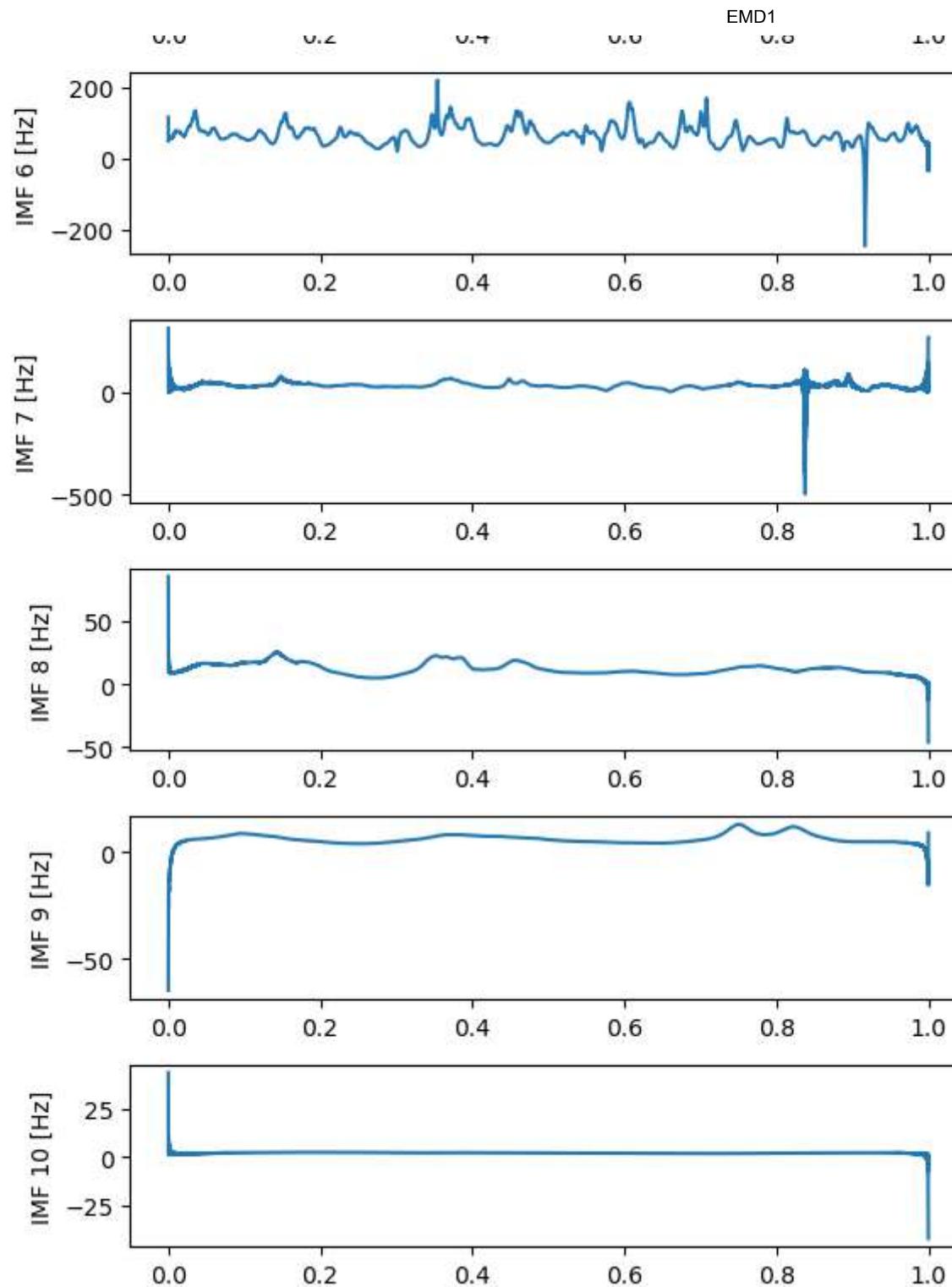
<Figure size 2500x3000 with 0 Axes>











With LSTM

In [24]:

```
import numpy as np
from PyEMD import EMD
import matplotlib.pyplot as plt
from keras.models import Sequential
from keras.layers import LSTM, Dense
from sklearn.preprocessing import MinMaxScaler

# Generate a sample signal
t = np.linspace(0, 1, 8760)
signal = TS["wind speed at 80m (m/s)"].values
signal = np.reshape(signal, (8760,))

# Perform Empirical Mode Decomposition
emd = EMD()
emd.emd(signal)

# Get the IMFs and Residual
imfs, res = emd.get_imfs_and_residue()

# Normalize each IMF separately
scalers = [MinMaxScaler(feature_range=(0, 1)) for _ in range(len(imfs))]
imfs_normalized = [scaler.fit_transform(imf.reshape(-1, 1)).flatten() for imf, scaler in zip(imfs, scalers)]

# Set the number of time steps for the LSTM
time_steps = 10

# Prepare the data for LSTM
def create_lstm_dataset(data, time_steps=1):
    dataX, dataY = [], []
    for i in range(len(data)-time_steps):
        a = data[i:(i+time_steps), :]
        dataX.append(a)
        dataY.append(data[i + time_steps, :])
    return np.array(dataX), np.array(dataY)

# Create LSTM model for each IMF
models = []
for imf_normalized in imfs_normalized:
    X, y = create_lstm_dataset(imf_normalized.reshape(-1, 1), time_steps)
    X = np.reshape(X, (X.shape[0], time_steps, 1))
```

```
model = Sequential()
model.add(LSTM(50, input_shape=(X.shape[1], X.shape[2])))
model.add(Dense(1))
model.compile(optimizer='adam', loss='mse')
model.fit(X, y, epochs=50, batch_size=32, verbose=1)

models.append(model)

# Make predictions for each IMF
predicted_values = [model.predict(X) for model, X in zip(models, X)]

# Inverse transform the predictions to get the original scale
predicted_values_original_scale = [scaler.inverse_transform(pred.reshape(-1, 1)).flatten() for pred, scaler in zip(predicted_values, scalers)]

# Plot the original signal, IMFs, Residual, and LSTM predictions for each IMF

plt.figure(figsize=(25, 30))

# Original Signal
plt.subplot(len(imfs) + 3, 1, 1)
plt.plot(signal, label='Original Signal')
plt.title('Original Signal')

# IMFs
for i, imf in enumerate(imfs):
    plt.subplot(len(imfs) + 3, 1, i + 2)
    plt.plot(imf, label=f'IMF {i + 1}')
    plt.title(f'IMF {i + 1}')

# Residual Component
plt.subplot(len(imfs) + 3, 1, len(imfs) + 2)
plt.plot(res, label='Residual Component', color='red')
plt.title('Residual Component')
```

```
Epoch 1/50
274/274 [=====] - 4s 5ms/step - loss: 0.0125
Epoch 2/50
274/274 [=====] - 1s 5ms/step - loss: 0.0085
Epoch 3/50
274/274 [=====] - 1s 5ms/step - loss: 0.0083
Epoch 4/50
274/274 [=====] - 1s 5ms/step - loss: 0.0082
Epoch 5/50
274/274 [=====] - 1s 5ms/step - loss: 0.0081
Epoch 6/50
274/274 [=====] - 1s 5ms/step - loss: 0.0078
Epoch 7/50
274/274 [=====] - 1s 5ms/step - loss: 0.0078
Epoch 8/50
274/274 [=====] - 1s 5ms/step - loss: 0.0078
Epoch 9/50
274/274 [=====] - 1s 5ms/step - loss: 0.0077
Epoch 10/50
274/274 [=====] - 1s 5ms/step - loss: 0.0077
Epoch 11/50
274/274 [=====] - 1s 5ms/step - loss: 0.0076
Epoch 12/50
274/274 [=====] - 1s 5ms/step - loss: 0.0076
Epoch 13/50
274/274 [=====] - 2s 6ms/step - loss: 0.0076
Epoch 14/50
274/274 [=====] - 2s 6ms/step - loss: 0.0075
Epoch 15/50
274/274 [=====] - 1s 5ms/step - loss: 0.0075
Epoch 16/50
274/274 [=====] - 1s 4ms/step - loss: 0.0074
Epoch 17/50
274/274 [=====] - 1s 4ms/step - loss: 0.0075
Epoch 18/50
274/274 [=====] - 1s 4ms/step - loss: 0.0074
Epoch 19/50
274/274 [=====] - 1s 4ms/step - loss: 0.0074
Epoch 20/50
274/274 [=====] - 1s 4ms/step - loss: 0.0074
Epoch 21/50
274/274 [=====] - 1s 4ms/step - loss: 0.0074
Epoch 22/50
274/274 [=====] - 1s 4ms/step - loss: 0.0074
Epoch 23/50
```

```
274/274 [=====] - 1s 4ms/step - loss: 0.0074
Epoch 24/50
274/274 [=====] - 1s 4ms/step - loss: 0.0074
Epoch 25/50
274/274 [=====] - 1s 4ms/step - loss: 0.0074
Epoch 26/50
274/274 [=====] - 1s 4ms/step - loss: 0.0074
Epoch 27/50
274/274 [=====] - 1s 4ms/step - loss: 0.0074
Epoch 28/50
274/274 [=====] - 1s 4ms/step - loss: 0.0075
Epoch 29/50
274/274 [=====] - 1s 4ms/step - loss: 0.0074
Epoch 30/50
274/274 [=====] - 1s 4ms/step - loss: 0.0074
Epoch 31/50
274/274 [=====] - 1s 4ms/step - loss: 0.0073
Epoch 32/50
274/274 [=====] - 1s 4ms/step - loss: 0.0074
Epoch 33/50
274/274 [=====] - 1s 4ms/step - loss: 0.0074
Epoch 34/50
274/274 [=====] - 1s 4ms/step - loss: 0.0074
Epoch 35/50
274/274 [=====] - 1s 4ms/step - loss: 0.0074
Epoch 36/50
274/274 [=====] - 1s 4ms/step - loss: 0.0073
Epoch 37/50
274/274 [=====] - 1s 4ms/step - loss: 0.0074
Epoch 38/50
274/274 [=====] - 1s 4ms/step - loss: 0.0073
Epoch 39/50
274/274 [=====] - 1s 4ms/step - loss: 0.0073
Epoch 40/50
274/274 [=====] - 1s 4ms/step - loss: 0.0073
Epoch 41/50
274/274 [=====] - 1s 4ms/step - loss: 0.0073
Epoch 42/50
274/274 [=====] - 1s 4ms/step - loss: 0.0073
Epoch 43/50
274/274 [=====] - 1s 4ms/step - loss: 0.0073
Epoch 44/50
274/274 [=====] - 1s 4ms/step - loss: 0.0073
Epoch 45/50
274/274 [=====] - 1s 4ms/step - loss: 0.0073
```

```
Epoch 46/50
274/274 [=====] - 1s 4ms/step - loss: 0.0073
Epoch 47/50
274/274 [=====] - 1s 4ms/step - loss: 0.0073
Epoch 48/50
274/274 [=====] - 1s 4ms/step - loss: 0.0073
Epoch 49/50
274/274 [=====] - 1s 4ms/step - loss: 0.0073
Epoch 50/50
274/274 [=====] - 1s 4ms/step - loss: 0.0073
Epoch 1/50
274/274 [=====] - 4s 4ms/step - loss: 0.0157
Epoch 2/50
274/274 [=====] - 1s 4ms/step - loss: 0.0074
Epoch 3/50
274/274 [=====] - 1s 4ms/step - loss: 0.0060
Epoch 4/50
274/274 [=====] - 1s 4ms/step - loss: 0.0045
Epoch 5/50
274/274 [=====] - 1s 4ms/step - loss: 0.0037
Epoch 6/50
274/274 [=====] - 1s 4ms/step - loss: 0.0029
Epoch 7/50
274/274 [=====] - 1s 4ms/step - loss: 0.0024
Epoch 8/50
274/274 [=====] - 1s 4ms/step - loss: 0.0020
Epoch 9/50
274/274 [=====] - 1s 4ms/step - loss: 0.0016
Epoch 10/50
274/274 [=====] - 1s 4ms/step - loss: 0.0015
Epoch 11/50
274/274 [=====] - 1s 4ms/step - loss: 0.0013
Epoch 12/50
274/274 [=====] - 1s 4ms/step - loss: 0.0013
Epoch 13/50
274/274 [=====] - 1s 4ms/step - loss: 0.0013
Epoch 14/50
274/274 [=====] - 1s 4ms/step - loss: 0.0012
Epoch 15/50
274/274 [=====] - 1s 4ms/step - loss: 0.0013
Epoch 16/50
274/274 [=====] - 1s 4ms/step - loss: 0.0012
Epoch 17/50
274/274 [=====] - 1s 4ms/step - loss: 0.0012
Epoch 18/50
```

```
274/274 [=====] - 1s 4ms/step - loss: 0.0012
Epoch 19/50
274/274 [=====] - 1s 4ms/step - loss: 0.0012
Epoch 20/50
274/274 [=====] - 1s 4ms/step - loss: 0.0012
Epoch 21/50
274/274 [=====] - 1s 4ms/step - loss: 0.0012
Epoch 22/50
274/274 [=====] - 1s 4ms/step - loss: 0.0012
Epoch 23/50
274/274 [=====] - 1s 4ms/step - loss: 0.0013
Epoch 24/50
274/274 [=====] - 1s 4ms/step - loss: 0.0012
Epoch 25/50
274/274 [=====] - 1s 4ms/step - loss: 0.0012
Epoch 26/50
274/274 [=====] - 1s 4ms/step - loss: 0.0012
Epoch 27/50
274/274 [=====] - 1s 4ms/step - loss: 0.0012
Epoch 28/50
274/274 [=====] - 1s 4ms/step - loss: 0.0012
Epoch 29/50
274/274 [=====] - 1s 4ms/step - loss: 0.0012
Epoch 30/50
274/274 [=====] - 1s 4ms/step - loss: 0.0012
Epoch 31/50
274/274 [=====] - 1s 4ms/step - loss: 0.0012
Epoch 32/50
274/274 [=====] - 1s 4ms/step - loss: 0.0012
Epoch 33/50
274/274 [=====] - 1s 4ms/step - loss: 0.0012
Epoch 34/50
274/274 [=====] - 1s 4ms/step - loss: 0.0012
Epoch 35/50
274/274 [=====] - 1s 4ms/step - loss: 0.0012
Epoch 36/50
274/274 [=====] - 1s 4ms/step - loss: 0.0012
Epoch 37/50
274/274 [=====] - 1s 4ms/step - loss: 0.0012
Epoch 38/50
274/274 [=====] - 1s 4ms/step - loss: 0.0012
Epoch 39/50
274/274 [=====] - 1s 4ms/step - loss: 0.0012
Epoch 40/50
274/274 [=====] - 1s 5ms/step - loss: 0.0012
```

```
Epoch 41/50
274/274 [=====] - 2s 6ms/step - loss: 0.0012
Epoch 42/50
274/274 [=====] - 1s 5ms/step - loss: 0.0012
Epoch 43/50
274/274 [=====] - 1s 5ms/step - loss: 0.0012
Epoch 44/50
274/274 [=====] - 1s 4ms/step - loss: 0.0012
Epoch 45/50
274/274 [=====] - 1s 4ms/step - loss: 0.0012
Epoch 46/50
274/274 [=====] - 1s 4ms/step - loss: 0.0012
Epoch 47/50
274/274 [=====] - 1s 4ms/step - loss: 0.0012
Epoch 48/50
274/274 [=====] - 1s 4ms/step - loss: 0.0012
Epoch 49/50
274/274 [=====] - 1s 4ms/step - loss: 0.0012
Epoch 50/50
274/274 [=====] - 1s 4ms/step - loss: 0.0012
Epoch 1/50
274/274 [=====] - 4s 4ms/step - loss: 0.0161
Epoch 2/50
274/274 [=====] - 1s 4ms/step - loss: 0.0045
Epoch 3/50
274/274 [=====] - 1s 4ms/step - loss: 0.0026
Epoch 4/50
274/274 [=====] - 1s 4ms/step - loss: 0.0014
Epoch 5/50
274/274 [=====] - 1s 4ms/step - loss: 6.6034e-04
Epoch 6/50
274/274 [=====] - 1s 4ms/step - loss: 4.7218e-04
Epoch 7/50
274/274 [=====] - 1s 4ms/step - loss: 3.7548e-04
Epoch 8/50
274/274 [=====] - 1s 4ms/step - loss: 3.4203e-04
Epoch 9/50
274/274 [=====] - 1s 4ms/step - loss: 2.6761e-04
Epoch 10/50
274/274 [=====] - 1s 4ms/step - loss: 2.2907e-04
Epoch 11/50
274/274 [=====] - 1s 4ms/step - loss: 2.0379e-04
Epoch 12/50
274/274 [=====] - 1s 4ms/step - loss: 1.9404e-04
Epoch 13/50
```

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274/274 [=====] - 1s 4ms/step - loss: 1.7367e-04
Epoch 14/50
274/274 [=====] - 1s 4ms/step - loss: 1.4814e-04
Epoch 15/50
274/274 [=====] - 1s 4ms/step - loss: 1.3575e-04
Epoch 16/50
274/274 [=====] - 1s 4ms/step - loss: 1.4203e-04
Epoch 17/50
274/274 [=====] - 1s 4ms/step - loss: 1.0921e-04
Epoch 18/50
274/274 [=====] - 1s 4ms/step - loss: 1.0386e-04
Epoch 19/50
274/274 [=====] - 1s 4ms/step - loss: 9.5856e-05
Epoch 20/50
274/274 [=====] - 1s 4ms/step - loss: 8.5474e-05
Epoch 21/50
274/274 [=====] - 1s 4ms/step - loss: 8.1441e-05
Epoch 22/50
274/274 [=====] - 1s 4ms/step - loss: 8.1066e-05
Epoch 23/50
274/274 [=====] - 1s 4ms/step - loss: 7.2721e-05
Epoch 24/50
274/274 [=====] - 1s 4ms/step - loss: 6.7526e-05
Epoch 25/50
274/274 [=====] - 1s 4ms/step - loss: 6.8237e-05
Epoch 26/50
274/274 [=====] - 1s 4ms/step - loss: 6.0123e-05
Epoch 27/50
274/274 [=====] - 1s 4ms/step - loss: 5.3048e-05
Epoch 28/50
274/274 [=====] - 1s 4ms/step - loss: 5.0299e-05
Epoch 29/50
274/274 [=====] - 1s 5ms/step - loss: 5.1568e-05
Epoch 30/50
274/274 [=====] - 1s 5ms/step - loss: 5.3775e-05
Epoch 31/50
274/274 [=====] - 1s 4ms/step - loss: 4.6546e-05
Epoch 32/50
274/274 [=====] - 1s 4ms/step - loss: 4.3112e-05
Epoch 33/50
274/274 [=====] - 1s 4ms/step - loss: 3.9504e-05
Epoch 34/50
274/274 [=====] - 1s 5ms/step - loss: 4.2531e-05
Epoch 35/50
274/274 [=====] - 1s 4ms/step - loss: 4.4210e-05
```

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Epoch 36/50
274/274 [=====] - 1s 4ms/step - loss: 4.2224e-05
Epoch 37/50
274/274 [=====] - 1s 5ms/step - loss: 4.0916e-05
Epoch 38/50
274/274 [=====] - 1s 5ms/step - loss: 3.9789e-05
Epoch 39/50
274/274 [=====] - 2s 6ms/step - loss: 4.2402e-05
Epoch 40/50
274/274 [=====] - 1s 5ms/step - loss: 3.9512e-05
Epoch 41/50
274/274 [=====] - 1s 5ms/step - loss: 4.2347e-05
Epoch 42/50
274/274 [=====] - 1s 5ms/step - loss: 3.7544e-05
Epoch 43/50
274/274 [=====] - 1s 5ms/step - loss: 4.3616e-05
Epoch 44/50
274/274 [=====] - 1s 5ms/step - loss: 4.1292e-05
Epoch 45/50
274/274 [=====] - 1s 4ms/step - loss: 4.2955e-05
Epoch 46/50
274/274 [=====] - 1s 4ms/step - loss: 4.1558e-05
Epoch 47/50
274/274 [=====] - 1s 5ms/step - loss: 4.0031e-05
Epoch 48/50
274/274 [=====] - 1s 5ms/step - loss: 3.6590e-05
Epoch 49/50
274/274 [=====] - 2s 6ms/step - loss: 3.8088e-05
Epoch 50/50
274/274 [=====] - 1s 5ms/step - loss: 4.0575e-05
Epoch 1/50
274/274 [=====] - 4s 5ms/step - loss: 0.0246
Epoch 2/50
274/274 [=====] - 1s 4ms/step - loss: 0.0036
Epoch 3/50
274/274 [=====] - 1s 5ms/step - loss: 0.0011
Epoch 4/50
274/274 [=====] - 1s 4ms/step - loss: 8.8697e-04
Epoch 5/50
274/274 [=====] - 1s 4ms/step - loss: 7.5990e-04
Epoch 6/50
274/274 [=====] - 1s 5ms/step - loss: 6.0273e-04
Epoch 7/50
274/274 [=====] - 1s 5ms/step - loss: 4.7325e-04
Epoch 8/50
```

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274/274 [=====] - 1s 5ms/step - loss: 3.2267e-04
Epoch 9/50
274/274 [=====] - 1s 5ms/step - loss: 2.1509e-04
Epoch 10/50
274/274 [=====] - 1s 5ms/step - loss: 1.8226e-04
Epoch 11/50
274/274 [=====] - 1s 4ms/step - loss: 1.3834e-04
Epoch 12/50
274/274 [=====] - 1s 5ms/step - loss: 1.1160e-04
Epoch 13/50
274/274 [=====] - 1s 5ms/step - loss: 1.0980e-04
Epoch 14/50
274/274 [=====] - 1s 4ms/step - loss: 9.1880e-05
Epoch 15/50
274/274 [=====] - 1s 4ms/step - loss: 7.8680e-05
Epoch 16/50
274/274 [=====] - 1s 5ms/step - loss: 6.6678e-05
Epoch 17/50
274/274 [=====] - 1s 5ms/step - loss: 6.7466e-05
Epoch 18/50
274/274 [=====] - 1s 5ms/step - loss: 6.7795e-05
Epoch 19/50
274/274 [=====] - 1s 5ms/step - loss: 5.4443e-05
Epoch 20/50
274/274 [=====] - 1s 5ms/step - loss: 5.2226e-05
Epoch 21/50
274/274 [=====] - 1s 4ms/step - loss: 4.3239e-05
Epoch 22/50
274/274 [=====] - 1s 4ms/step - loss: 4.6193e-05
Epoch 23/50
274/274 [=====] - 1s 4ms/step - loss: 3.8251e-05
Epoch 24/50
274/274 [=====] - 1s 4ms/step - loss: 3.5267e-05
Epoch 25/50
274/274 [=====] - 1s 4ms/step - loss: 3.7835e-05
Epoch 26/50
274/274 [=====] - 1s 4ms/step - loss: 3.2861e-05
Epoch 27/50
274/274 [=====] - 1s 4ms/step - loss: 2.9119e-05
Epoch 28/50
274/274 [=====] - 1s 4ms/step - loss: 2.3799e-05
Epoch 29/50
274/274 [=====] - 1s 4ms/step - loss: 2.4945e-05
Epoch 30/50
274/274 [=====] - 1s 4ms/step - loss: 3.0174e-05
```

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Epoch 31/50
274/274 [=====] - 1s 4ms/step - loss: 2.7193e-05
Epoch 32/50
274/274 [=====] - 1s 4ms/step - loss: 2.2213e-05
Epoch 33/50
274/274 [=====] - 1s 5ms/step - loss: 2.5583e-05
Epoch 34/50
274/274 [=====] - 1s 4ms/step - loss: 2.1255e-05
Epoch 35/50
274/274 [=====] - 1s 4ms/step - loss: 2.2761e-05
Epoch 36/50
274/274 [=====] - 1s 4ms/step - loss: 1.8299e-05
Epoch 37/50
274/274 [=====] - 1s 5ms/step - loss: 1.6500e-05
Epoch 38/50
274/274 [=====] - 1s 5ms/step - loss: 1.5305e-05
Epoch 39/50
274/274 [=====] - 1s 4ms/step - loss: 1.7325e-05
Epoch 40/50
274/274 [=====] - 1s 4ms/step - loss: 1.4797e-05
Epoch 41/50
274/274 [=====] - 1s 5ms/step - loss: 1.3071e-05
Epoch 42/50
274/274 [=====] - 1s 5ms/step - loss: 1.1726e-05
Epoch 43/50
274/274 [=====] - 1s 4ms/step - loss: 1.4132e-05
Epoch 44/50
274/274 [=====] - 1s 4ms/step - loss: 1.3723e-05
Epoch 45/50
274/274 [=====] - 1s 4ms/step - loss: 1.0919e-05
Epoch 46/50
274/274 [=====] - 1s 4ms/step - loss: 1.0689e-05
Epoch 47/50
274/274 [=====] - 1s 4ms/step - loss: 1.1554e-05
Epoch 48/50
274/274 [=====] - 1s 4ms/step - loss: 9.6341e-06
Epoch 49/50
274/274 [=====] - 1s 5ms/step - loss: 1.0158e-05
Epoch 50/50
274/274 [=====] - 1s 4ms/step - loss: 9.7131e-06
Epoch 1/50
274/274 [=====] - 4s 4ms/step - loss: 0.0097
Epoch 2/50
274/274 [=====] - 1s 4ms/step - loss: 0.0012
Epoch 3/50
```

```
274/274 [=====] - 1s 4ms/step - loss: 3.6633e-04
Epoch 4/50
274/274 [=====] - 1s 4ms/step - loss: 3.1764e-04
Epoch 5/50
274/274 [=====] - 1s 4ms/step - loss: 2.9743e-04
Epoch 6/50
274/274 [=====] - 1s 5ms/step - loss: 2.4591e-04
Epoch 7/50
274/274 [=====] - 1s 4ms/step - loss: 2.2098e-04
Epoch 8/50
274/274 [=====] - 1s 4ms/step - loss: 1.9840e-04
Epoch 9/50
274/274 [=====] - 1s 4ms/step - loss: 1.7223e-04
Epoch 10/50
274/274 [=====] - 1s 4ms/step - loss: 1.4335e-04
Epoch 11/50
274/274 [=====] - 1s 4ms/step - loss: 1.1997e-04
Epoch 12/50
274/274 [=====] - 1s 4ms/step - loss: 9.2653e-05
Epoch 13/50
274/274 [=====] - 1s 4ms/step - loss: 7.2701e-05
Epoch 14/50
274/274 [=====] - 1s 4ms/step - loss: 5.5299e-05
Epoch 15/50
274/274 [=====] - 1s 4ms/step - loss: 4.2686e-05
Epoch 16/50
274/274 [=====] - 1s 4ms/step - loss: 3.2916e-05
Epoch 17/50
274/274 [=====] - 1s 4ms/step - loss: 2.8311e-05
Epoch 18/50
274/274 [=====] - 1s 4ms/step - loss: 2.4361e-05
Epoch 19/50
274/274 [=====] - 1s 4ms/step - loss: 2.1615e-05
Epoch 20/50
274/274 [=====] - 1s 5ms/step - loss: 1.9968e-05
Epoch 21/50
274/274 [=====] - 1s 5ms/step - loss: 1.7699e-05
Epoch 22/50
274/274 [=====] - 1s 5ms/step - loss: 1.4853e-05
Epoch 23/50
274/274 [=====] - 1s 5ms/step - loss: 1.4797e-05
Epoch 24/50
274/274 [=====] - 1s 5ms/step - loss: 1.3625e-05
Epoch 25/50
274/274 [=====] - 1s 5ms/step - loss: 1.2791e-05
```

Epoch 26/50
274/274 [=====] - 1s 4ms/step - loss: 1.2098e-05
Epoch 27/50
274/274 [=====] - 1s 4ms/step - loss: 8.9624e-06
Epoch 28/50
274/274 [=====] - 1s 4ms/step - loss: 9.3816e-06
Epoch 29/50
274/274 [=====] - 1s 4ms/step - loss: 1.0162e-05
Epoch 30/50
274/274 [=====] - 1s 4ms/step - loss: 8.9256e-06
Epoch 31/50
274/274 [=====] - 1s 4ms/step - loss: 7.6019e-06
Epoch 32/50
274/274 [=====] - 1s 4ms/step - loss: 9.5520e-06
Epoch 33/50
274/274 [=====] - 1s 5ms/step - loss: 7.3703e-06
Epoch 34/50
274/274 [=====] - 1s 4ms/step - loss: 6.7784e-06
Epoch 35/50
274/274 [=====] - 1s 4ms/step - loss: 8.5375e-06
Epoch 36/50
274/274 [=====] - 1s 4ms/step - loss: 6.2369e-06
Epoch 37/50
274/274 [=====] - 1s 4ms/step - loss: 5.8516e-06
Epoch 38/50
274/274 [=====] - 1s 4ms/step - loss: 4.8876e-06
Epoch 39/50
274/274 [=====] - 1s 4ms/step - loss: 5.7207e-06
Epoch 40/50
274/274 [=====] - 1s 4ms/step - loss: 4.7892e-06
Epoch 41/50
274/274 [=====] - 1s 5ms/step - loss: 4.3927e-06
Epoch 42/50
274/274 [=====] - 1s 4ms/step - loss: 3.9156e-06
Epoch 43/50
274/274 [=====] - 1s 4ms/step - loss: 5.1703e-06
Epoch 44/50
274/274 [=====] - 1s 4ms/step - loss: 4.0829e-06
Epoch 45/50
274/274 [=====] - 1s 4ms/step - loss: 3.4914e-06
Epoch 46/50
274/274 [=====] - 1s 4ms/step - loss: 3.1771e-06
Epoch 47/50
274/274 [=====] - 1s 5ms/step - loss: 3.1759e-06
Epoch 48/50

```
274/274 [=====] - 1s 4ms/step - loss: 3.4895e-06
Epoch 49/50
274/274 [=====] - 1s 4ms/step - loss: 2.7624e-06
Epoch 50/50
274/274 [=====] - 1s 4ms/step - loss: 3.7085e-06
Epoch 1/50
274/274 [=====] - 4s 4ms/step - loss: 0.0061
Epoch 2/50
274/274 [=====] - 1s 4ms/step - loss: 7.2532e-04
Epoch 3/50
274/274 [=====] - 1s 4ms/step - loss: 5.3336e-04
Epoch 4/50
274/274 [=====] - 1s 4ms/step - loss: 2.2489e-04
Epoch 5/50
274/274 [=====] - 1s 4ms/step - loss: 4.4076e-05
Epoch 6/50
274/274 [=====] - 1s 4ms/step - loss: 3.0445e-05
Epoch 7/50
274/274 [=====] - 1s 4ms/step - loss: 2.5498e-05
Epoch 8/50
274/274 [=====] - 1s 4ms/step - loss: 2.0100e-05
Epoch 9/50
274/274 [=====] - 1s 4ms/step - loss: 1.4417e-05
Epoch 10/50
274/274 [=====] - 1s 4ms/step - loss: 1.4058e-05
Epoch 11/50
274/274 [=====] - 1s 5ms/step - loss: 1.2234e-05
Epoch 12/50
274/274 [=====] - 1s 5ms/step - loss: 1.1944e-05
Epoch 13/50
274/274 [=====] - 1s 5ms/step - loss: 1.1498e-05
Epoch 14/50
274/274 [=====] - 1s 4ms/step - loss: 1.2038e-05
Epoch 15/50
274/274 [=====] - 1s 4ms/step - loss: 9.4129e-06
Epoch 16/50
274/274 [=====] - 1s 4ms/step - loss: 9.4815e-06
Epoch 17/50
274/274 [=====] - 1s 4ms/step - loss: 1.1776e-05
Epoch 18/50
274/274 [=====] - 1s 4ms/step - loss: 1.1097e-05
Epoch 19/50
274/274 [=====] - 1s 4ms/step - loss: 9.7707e-06
Epoch 20/50
274/274 [=====] - 1s 4ms/step - loss: 8.1471e-06
```

Epoch 21/50
274/274 [=====] - 1s 4ms/step - loss: 1.0435e-05
Epoch 22/50
274/274 [=====] - 1s 4ms/step - loss: 7.0032e-06
Epoch 23/50
274/274 [=====] - 1s 4ms/step - loss: 8.1036e-06
Epoch 24/50
274/274 [=====] - 1s 4ms/step - loss: 6.3299e-06
Epoch 25/50
274/274 [=====] - 1s 4ms/step - loss: 8.3234e-06
Epoch 26/50
274/274 [=====] - 1s 4ms/step - loss: 7.0374e-06
Epoch 27/50
274/274 [=====] - 1s 5ms/step - loss: 7.5795e-06
Epoch 28/50
274/274 [=====] - 1s 4ms/step - loss: 6.5883e-06
Epoch 29/50
274/274 [=====] - 1s 4ms/step - loss: 6.3602e-06
Epoch 30/50
274/274 [=====] - 1s 4ms/step - loss: 6.3426e-06
Epoch 31/50
274/274 [=====] - 1s 4ms/step - loss: 5.4241e-06
Epoch 32/50
274/274 [=====] - 1s 5ms/step - loss: 5.9949e-06
Epoch 33/50
274/274 [=====] - 1s 5ms/step - loss: 6.0628e-06
Epoch 34/50
274/274 [=====] - 1s 5ms/step - loss: 6.7358e-06
Epoch 35/50
274/274 [=====] - 1s 4ms/step - loss: 4.6517e-06
Epoch 36/50
274/274 [=====] - 1s 4ms/step - loss: 4.4704e-06
Epoch 37/50
274/274 [=====] - 1s 4ms/step - loss: 3.8762e-06
Epoch 38/50
274/274 [=====] - 1s 4ms/step - loss: 3.3777e-06
Epoch 39/50
274/274 [=====] - 1s 4ms/step - loss: 4.9613e-06
Epoch 40/50
274/274 [=====] - 1s 4ms/step - loss: 3.2745e-06
Epoch 41/50
274/274 [=====] - 1s 4ms/step - loss: 3.1243e-06
Epoch 42/50
274/274 [=====] - 1s 4ms/step - loss: 3.2103e-06
Epoch 43/50

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274/274 [=====] - 1s 4ms/step - loss: 3.6879e-06
Epoch 44/50
274/274 [=====] - 1s 4ms/step - loss: 2.5872e-06
Epoch 45/50
274/274 [=====] - 1s 4ms/step - loss: 2.1890e-06
Epoch 46/50
274/274 [=====] - 1s 4ms/step - loss: 2.3254e-06
Epoch 47/50
274/274 [=====] - 1s 4ms/step - loss: 2.5501e-06
Epoch 48/50
274/274 [=====] - 1s 4ms/step - loss: 2.4967e-06
Epoch 49/50
274/274 [=====] - 1s 4ms/step - loss: 1.8491e-06
Epoch 50/50
274/274 [=====] - 1s 5ms/step - loss: 1.7203e-06
Epoch 1/50
274/274 [=====] - 4s 5ms/step - loss: 0.0094
Epoch 2/50
274/274 [=====] - 1s 4ms/step - loss: 7.5894e-04
Epoch 3/50
274/274 [=====] - 1s 4ms/step - loss: 6.5937e-04
Epoch 4/50
274/274 [=====] - 1s 4ms/step - loss: 5.5531e-04
Epoch 5/50
274/274 [=====] - 1s 4ms/step - loss: 4.2653e-04
Epoch 6/50
274/274 [=====] - 1s 4ms/step - loss: 2.4042e-04
Epoch 7/50
274/274 [=====] - 1s 5ms/step - loss: 8.2233e-05
Epoch 8/50
274/274 [=====] - 1s 4ms/step - loss: 3.0218e-05
Epoch 9/50
274/274 [=====] - 1s 4ms/step - loss: 2.8673e-05
Epoch 10/50
274/274 [=====] - 1s 4ms/step - loss: 2.1866e-05
Epoch 11/50
274/274 [=====] - 1s 4ms/step - loss: 2.0230e-05
Epoch 12/50
274/274 [=====] - 1s 4ms/step - loss: 1.5540e-05
Epoch 13/50
274/274 [=====] - 1s 4ms/step - loss: 1.4812e-05
Epoch 14/50
274/274 [=====] - 1s 4ms/step - loss: 1.1474e-05
Epoch 15/50
274/274 [=====] - 1s 4ms/step - loss: 9.8667e-06
```

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Epoch 16/50
274/274 [=====] - 1s 4ms/step - loss: 1.1112e-05
Epoch 17/50
274/274 [=====] - 1s 4ms/step - loss: 8.8532e-06
Epoch 18/50
274/274 [=====] - 1s 4ms/step - loss: 4.5750e-06
Epoch 19/50
274/274 [=====] - 1s 4ms/step - loss: 5.7414e-06
Epoch 20/50
274/274 [=====] - 1s 4ms/step - loss: 9.3012e-06
Epoch 21/50
274/274 [=====] - 1s 4ms/step - loss: 4.3324e-06
Epoch 22/50
274/274 [=====] - 1s 4ms/step - loss: 6.5831e-06
Epoch 23/50
274/274 [=====] - 1s 4ms/step - loss: 5.8384e-06
Epoch 24/50
274/274 [=====] - 1s 4ms/step - loss: 6.4525e-06
Epoch 25/50
274/274 [=====] - 1s 4ms/step - loss: 2.8236e-06
Epoch 26/50
274/274 [=====] - 1s 4ms/step - loss: 4.5130e-06
Epoch 27/50
274/274 [=====] - 1s 4ms/step - loss: 7.8969e-06
Epoch 28/50
274/274 [=====] - 1s 4ms/step - loss: 3.1270e-06
Epoch 29/50
274/274 [=====] - 1s 4ms/step - loss: 4.0034e-06
Epoch 30/50
274/274 [=====] - 1s 4ms/step - loss: 4.1141e-06
Epoch 31/50
274/274 [=====] - 1s 4ms/step - loss: 5.6003e-06
Epoch 32/50
274/274 [=====] - 1s 4ms/step - loss: 4.6842e-06
Epoch 33/50
274/274 [=====] - 1s 4ms/step - loss: 4.3879e-06
Epoch 34/50
274/274 [=====] - 1s 4ms/step - loss: 3.2143e-06
Epoch 35/50
274/274 [=====] - 1s 4ms/step - loss: 5.8774e-06
Epoch 36/50
274/274 [=====] - 1s 4ms/step - loss: 2.1513e-06
Epoch 37/50
274/274 [=====] - 1s 4ms/step - loss: 3.8024e-06
Epoch 38/50
```

```
274/274 [=====] - 1s 4ms/step - loss: 2.7502e-06
Epoch 39/50
274/274 [=====] - 1s 4ms/step - loss: 2.3835e-06
Epoch 40/50
274/274 [=====] - 1s 4ms/step - loss: 5.0093e-06
Epoch 41/50
274/274 [=====] - 1s 4ms/step - loss: 1.6707e-06
Epoch 42/50
274/274 [=====] - 1s 4ms/step - loss: 8.4767e-06
Epoch 43/50
274/274 [=====] - 1s 4ms/step - loss: 1.5334e-06
Epoch 44/50
274/274 [=====] - 1s 4ms/step - loss: 2.1638e-06
Epoch 45/50
274/274 [=====] - 1s 4ms/step - loss: 1.7738e-06
Epoch 46/50
274/274 [=====] - 1s 4ms/step - loss: 4.5208e-06
Epoch 47/50
274/274 [=====] - 1s 4ms/step - loss: 2.2807e-06
Epoch 48/50
274/274 [=====] - 1s 4ms/step - loss: 1.8858e-06
Epoch 49/50
274/274 [=====] - 1s 4ms/step - loss: 2.1299e-06
Epoch 50/50
274/274 [=====] - 1s 4ms/step - loss: 2.0114e-06
Epoch 1/50
274/274 [=====] - 4s 5ms/step - loss: 0.0069
Epoch 2/50
274/274 [=====] - 1s 4ms/step - loss: 1.0731e-04
Epoch 3/50
274/274 [=====] - 1s 4ms/step - loss: 8.4093e-05
Epoch 4/50
274/274 [=====] - 1s 4ms/step - loss: 7.8056e-05
Epoch 5/50
274/274 [=====] - 1s 5ms/step - loss: 7.6537e-05
Epoch 6/50
274/274 [=====] - 1s 4ms/step - loss: 7.3970e-05
Epoch 7/50
274/274 [=====] - 1s 5ms/step - loss: 7.0033e-05
Epoch 8/50
274/274 [=====] - 1s 5ms/step - loss: 7.0383e-05
Epoch 9/50
274/274 [=====] - 1s 5ms/step - loss: 6.5988e-05
Epoch 10/50
274/274 [=====] - 1s 5ms/step - loss: 6.3150e-05
```

```
Epoch 11/50
274/274 [=====] - 1s 5ms/step - loss: 5.6345e-05
Epoch 12/50
274/274 [=====] - 1s 5ms/step - loss: 5.5178e-05
Epoch 13/50
274/274 [=====] - 1s 5ms/step - loss: 4.7800e-05
Epoch 14/50
274/274 [=====] - 1s 5ms/step - loss: 4.4726e-05
Epoch 15/50
274/274 [=====] - 1s 5ms/step - loss: 4.0213e-05
Epoch 16/50
274/274 [=====] - 1s 5ms/step - loss: 2.7969e-05
Epoch 17/50
274/274 [=====] - 1s 4ms/step - loss: 2.3646e-05
Epoch 18/50
274/274 [=====] - 1s 5ms/step - loss: 2.5018e-05
Epoch 19/50
274/274 [=====] - 1s 5ms/step - loss: 1.8208e-05
Epoch 20/50
274/274 [=====] - 1s 4ms/step - loss: 1.1555e-05
Epoch 21/50
274/274 [=====] - 1s 5ms/step - loss: 7.8587e-06
Epoch 22/50
274/274 [=====] - 1s 5ms/step - loss: 5.1621e-06
Epoch 23/50
274/274 [=====] - 1s 5ms/step - loss: 6.7261e-06
Epoch 24/50
274/274 [=====] - 1s 5ms/step - loss: 1.4000e-05
Epoch 25/50
274/274 [=====] - 1s 5ms/step - loss: 3.5925e-06
Epoch 26/50
274/274 [=====] - 1s 4ms/step - loss: 2.6630e-06
Epoch 27/50
274/274 [=====] - 1s 5ms/step - loss: 1.1435e-05
Epoch 28/50
274/274 [=====] - 1s 5ms/step - loss: 3.8561e-06
Epoch 29/50
274/274 [=====] - 1s 5ms/step - loss: 2.5998e-06
Epoch 30/50
274/274 [=====] - 1s 5ms/step - loss: 3.9618e-06
Epoch 31/50
274/274 [=====] - 1s 4ms/step - loss: 2.7624e-06
Epoch 32/50
274/274 [=====] - 1s 4ms/step - loss: 2.3378e-06
Epoch 33/50
```

```
274/274 [=====] - 1s 4ms/step - loss: 4.6179e-06
Epoch 34/50
274/274 [=====] - 1s 4ms/step - loss: 2.5050e-06
Epoch 35/50
274/274 [=====] - 1s 4ms/step - loss: 2.6838e-06
Epoch 36/50
274/274 [=====] - 1s 4ms/step - loss: 2.1183e-06
Epoch 37/50
274/274 [=====] - 1s 4ms/step - loss: 3.4981e-06
Epoch 38/50
274/274 [=====] - 1s 4ms/step - loss: 9.2910e-07
Epoch 39/50
274/274 [=====] - 1s 4ms/step - loss: 2.4415e-06
Epoch 40/50
274/274 [=====] - 1s 4ms/step - loss: 3.1484e-06
Epoch 41/50
274/274 [=====] - 1s 4ms/step - loss: 1.9324e-06
Epoch 42/50
274/274 [=====] - 1s 4ms/step - loss: 1.9471e-06
Epoch 43/50
274/274 [=====] - 1s 4ms/step - loss: 1.3160e-06
Epoch 44/50
274/274 [=====] - 1s 5ms/step - loss: 2.1635e-06
Epoch 45/50
274/274 [=====] - 1s 5ms/step - loss: 5.6041e-07
Epoch 46/50
274/274 [=====] - 1s 4ms/step - loss: 1.8509e-06
Epoch 47/50
274/274 [=====] - 1s 4ms/step - loss: 1.6494e-06
Epoch 48/50
274/274 [=====] - 1s 4ms/step - loss: 1.9253e-06
Epoch 49/50
274/274 [=====] - 1s 4ms/step - loss: 4.7856e-07
Epoch 50/50
274/274 [=====] - 1s 4ms/step - loss: 2.3853e-06
Epoch 1/50
274/274 [=====] - 4s 5ms/step - loss: 0.0120
Epoch 2/50
274/274 [=====] - 1s 4ms/step - loss: 6.1859e-05
Epoch 3/50
274/274 [=====] - 1s 4ms/step - loss: 4.0940e-05
Epoch 4/50
274/274 [=====] - 1s 4ms/step - loss: 3.9556e-05
Epoch 5/50
274/274 [=====] - 1s 5ms/step - loss: 3.8162e-05
```

```
Epoch 6/50
274/274 [=====] - 1s 4ms/step - loss: 3.8733e-05
Epoch 7/50
274/274 [=====] - 1s 4ms/step - loss: 3.6166e-05
Epoch 8/50
274/274 [=====] - 1s 4ms/step - loss: 3.6453e-05
Epoch 9/50
274/274 [=====] - 1s 4ms/step - loss: 3.4078e-05
Epoch 10/50
274/274 [=====] - 1s 5ms/step - loss: 3.4576e-05
Epoch 11/50
274/274 [=====] - 1s 4ms/step - loss: 2.9829e-05
Epoch 12/50
274/274 [=====] - 1s 4ms/step - loss: 3.0795e-05
Epoch 13/50
274/274 [=====] - 1s 4ms/step - loss: 2.9477e-05
Epoch 14/50
274/274 [=====] - 1s 4ms/step - loss: 3.0582e-05
Epoch 15/50
274/274 [=====] - 1s 5ms/step - loss: 2.8012e-05
Epoch 16/50
274/274 [=====] - 1s 4ms/step - loss: 2.4561e-05
Epoch 17/50
274/274 [=====] - 1s 4ms/step - loss: 2.6166e-05
Epoch 18/50
274/274 [=====] - 1s 5ms/step - loss: 2.6287e-05
Epoch 19/50
274/274 [=====] - 1s 4ms/step - loss: 2.1259e-05
Epoch 20/50
274/274 [=====] - 1s 4ms/step - loss: 2.2820e-05
Epoch 21/50
274/274 [=====] - 1s 4ms/step - loss: 1.9805e-05
Epoch 22/50
274/274 [=====] - 1s 4ms/step - loss: 1.9119e-05
Epoch 23/50
274/274 [=====] - 1s 4ms/step - loss: 1.8432e-05
Epoch 24/50
274/274 [=====] - 1s 4ms/step - loss: 1.6483e-05
Epoch 25/50
274/274 [=====] - 1s 4ms/step - loss: 1.2324e-05
Epoch 26/50
274/274 [=====] - 1s 4ms/step - loss: 1.5056e-05
Epoch 27/50
274/274 [=====] - 1s 4ms/step - loss: 1.0632e-05
Epoch 28/50
```

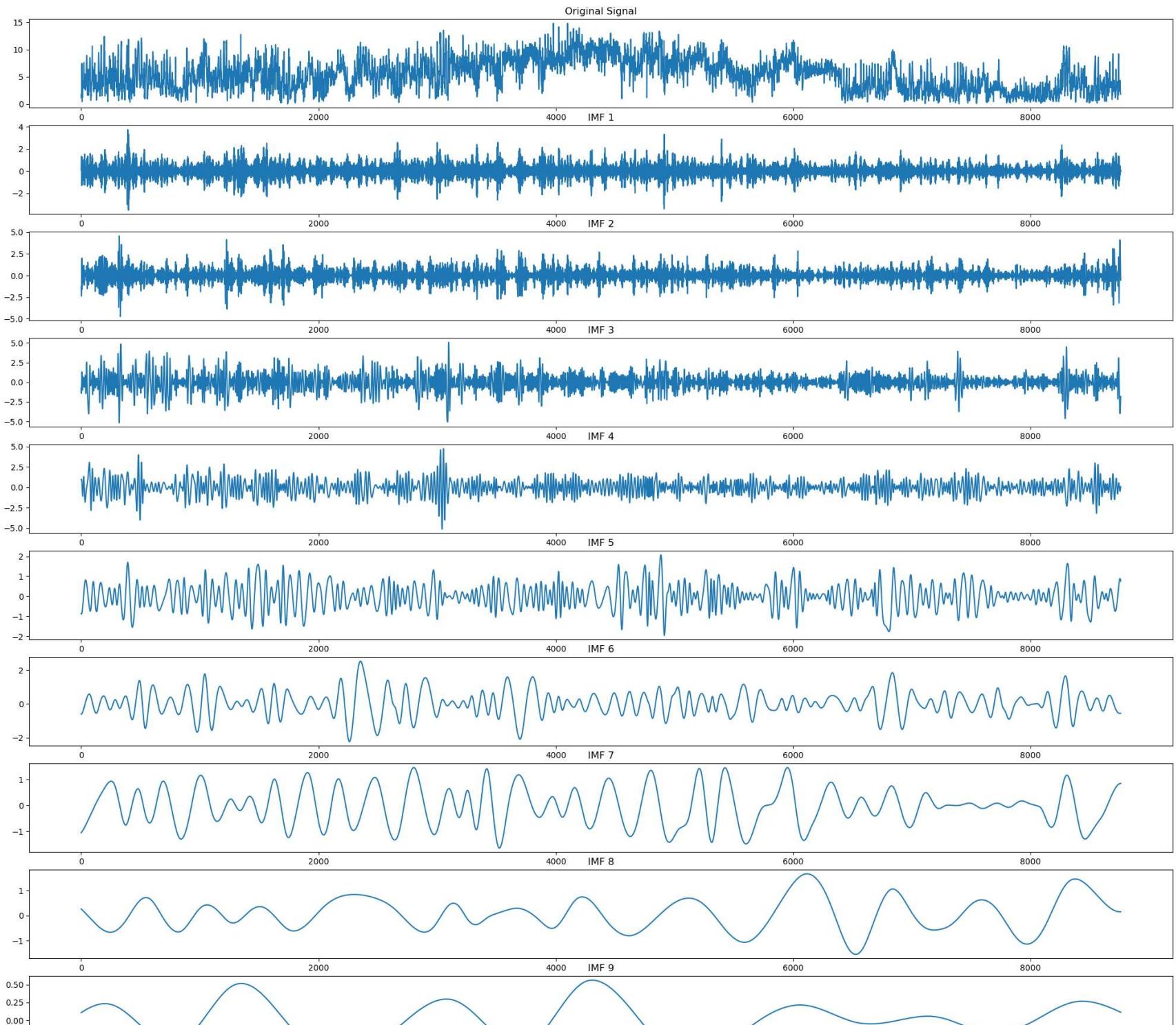
```
274/274 [=====] - 1s 4ms/step - loss: 8.4056e-06
Epoch 29/50
274/274 [=====] - 1s 4ms/step - loss: 6.7882e-06
Epoch 30/50
274/274 [=====] - 1s 5ms/step - loss: 5.0015e-06
Epoch 31/50
274/274 [=====] - 1s 4ms/step - loss: 6.6893e-06
Epoch 32/50
274/274 [=====] - 1s 4ms/step - loss: 5.1596e-06
Epoch 33/50
274/274 [=====] - 1s 4ms/step - loss: 4.6551e-06
Epoch 34/50
274/274 [=====] - 1s 5ms/step - loss: 3.7950e-06
Epoch 35/50
274/274 [=====] - 1s 4ms/step - loss: 3.1366e-06
Epoch 36/50
274/274 [=====] - 1s 4ms/step - loss: 2.2780e-06
Epoch 37/50
274/274 [=====] - 1s 4ms/step - loss: 2.0704e-06
Epoch 38/50
274/274 [=====] - 1s 4ms/step - loss: 3.6653e-06
Epoch 39/50
274/274 [=====] - 1s 4ms/step - loss: 3.5368e-06
Epoch 40/50
274/274 [=====] - 1s 4ms/step - loss: 1.9338e-06
Epoch 41/50
274/274 [=====] - 1s 4ms/step - loss: 5.5413e-06
Epoch 42/50
274/274 [=====] - 1s 4ms/step - loss: 1.3002e-06
Epoch 43/50
274/274 [=====] - 1s 4ms/step - loss: 1.1584e-06
Epoch 44/50
274/274 [=====] - 1s 4ms/step - loss: 1.8462e-06
Epoch 45/50
274/274 [=====] - 1s 4ms/step - loss: 3.8972e-07
Epoch 46/50
274/274 [=====] - 1s 4ms/step - loss: 2.9759e-06
Epoch 47/50
274/274 [=====] - 1s 5ms/step - loss: 3.4350e-06
Epoch 48/50
274/274 [=====] - 1s 4ms/step - loss: 3.6647e-07
Epoch 49/50
274/274 [=====] - 1s 4ms/step - loss: 9.9161e-07
Epoch 50/50
274/274 [=====] - 1s 4ms/step - loss: 6.5192e-06
```

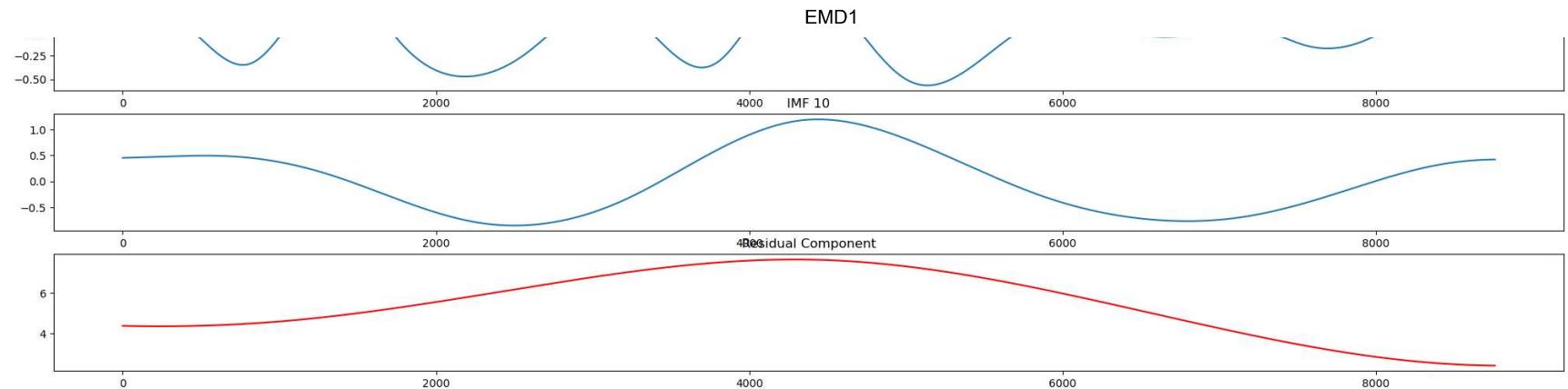
```
Epoch 1/50
274/274 [=====] - 4s 5ms/step - loss: 0.0106
Epoch 2/50
274/274 [=====] - 1s 5ms/step - loss: 1.8517e-05
Epoch 3/50
274/274 [=====] - 1s 5ms/step - loss: 1.4319e-05
Epoch 4/50
274/274 [=====] - 1s 4ms/step - loss: 1.3874e-05
Epoch 5/50
274/274 [=====] - 1s 4ms/step - loss: 1.3147e-05
Epoch 6/50
274/274 [=====] - 1s 4ms/step - loss: 1.2831e-05
Epoch 7/50
274/274 [=====] - 1s 4ms/step - loss: 1.1778e-05
Epoch 8/50
274/274 [=====] - 1s 4ms/step - loss: 1.1416e-05
Epoch 9/50
274/274 [=====] - 1s 4ms/step - loss: 1.0467e-05
Epoch 10/50
274/274 [=====] - 1s 4ms/step - loss: 9.6645e-06
Epoch 11/50
274/274 [=====] - 1s 4ms/step - loss: 9.0363e-06
Epoch 12/50
274/274 [=====] - 1s 4ms/step - loss: 8.7081e-06
Epoch 13/50
274/274 [=====] - 1s 4ms/step - loss: 8.1782e-06
Epoch 14/50
274/274 [=====] - 1s 4ms/step - loss: 7.5842e-06
Epoch 15/50
274/274 [=====] - 1s 4ms/step - loss: 6.9935e-06
Epoch 16/50
274/274 [=====] - 1s 4ms/step - loss: 7.1275e-06
Epoch 17/50
274/274 [=====] - 1s 4ms/step - loss: 7.1105e-06
Epoch 18/50
274/274 [=====] - 1s 4ms/step - loss: 8.0984e-06
Epoch 19/50
274/274 [=====] - 1s 4ms/step - loss: 7.4248e-06
Epoch 20/50
274/274 [=====] - 1s 4ms/step - loss: 8.7699e-06
Epoch 21/50
274/274 [=====] - 1s 4ms/step - loss: 6.1624e-06
Epoch 22/50
274/274 [=====] - 1s 4ms/step - loss: 8.0949e-06
Epoch 23/50
```

```
274/274 [=====] - 1s 5ms/step - loss: 9.4165e-06
Epoch 24/50
274/274 [=====] - 1s 4ms/step - loss: 7.1119e-06
Epoch 25/50
274/274 [=====] - 1s 4ms/step - loss: 7.3345e-06
Epoch 26/50
274/274 [=====] - 1s 5ms/step - loss: 8.3819e-06
Epoch 27/50
274/274 [=====] - 1s 5ms/step - loss: 8.1496e-06
Epoch 28/50
274/274 [=====] - 1s 4ms/step - loss: 5.9858e-06
Epoch 29/50
274/274 [=====] - 1s 4ms/step - loss: 8.0505e-06
Epoch 30/50
274/274 [=====] - 1s 4ms/step - loss: 7.5172e-06
Epoch 31/50
274/274 [=====] - 1s 4ms/step - loss: 5.3641e-06
Epoch 32/50
274/274 [=====] - 1s 4ms/step - loss: 7.2403e-06
Epoch 33/50
274/274 [=====] - 1s 4ms/step - loss: 6.6051e-06
Epoch 34/50
274/274 [=====] - 1s 4ms/step - loss: 5.7047e-06
Epoch 35/50
274/274 [=====] - 1s 4ms/step - loss: 9.1376e-06
Epoch 36/50
274/274 [=====] - 1s 4ms/step - loss: 5.1766e-06
Epoch 37/50
274/274 [=====] - 1s 4ms/step - loss: 4.6113e-06
Epoch 38/50
274/274 [=====] - 1s 4ms/step - loss: 4.3582e-06
Epoch 39/50
274/274 [=====] - 1s 4ms/step - loss: 3.8486e-06
Epoch 40/50
274/274 [=====] - 1s 4ms/step - loss: 4.5284e-06
Epoch 41/50
274/274 [=====] - 1s 4ms/step - loss: 8.3288e-06
Epoch 42/50
274/274 [=====] - 1s 4ms/step - loss: 3.4465e-06
Epoch 43/50
274/274 [=====] - 1s 4ms/step - loss: 3.9258e-06
Epoch 44/50
274/274 [=====] - 1s 4ms/step - loss: 4.3397e-06
Epoch 45/50
274/274 [=====] - 1s 4ms/step - loss: 5.2643e-06
```

```
Epoch 46/50
274/274 [=====] - 1s 5ms/step - loss: 3.3995e-06
Epoch 47/50
274/274 [=====] - 1s 4ms/step - loss: 7.2564e-06
Epoch 48/50
274/274 [=====] - 1s 4ms/step - loss: 2.8905e-06
Epoch 49/50
274/274 [=====] - 1s 4ms/step - loss: 2.8856e-06
Epoch 50/50
274/274 [=====] - 1s 5ms/step - loss: 3.0224e-06
1/1 [=====] - 1s 609ms/step
1/1 [=====] - 0s 490ms/step
1/1 [=====] - 0s 486ms/step
1/1 [=====] - 0s 484ms/step
1/1 [=====] - 0s 492ms/step
1/1 [=====] - 0s 484ms/step
1/1 [=====] - 0s 489ms/step
1/1 [=====] - 0s 488ms/step
1/1 [=====] - 0s 487ms/step
1/1 [=====] - 0s 486ms/step
Out[24]: Text(0.5, 1.0, 'Residual Component')
```

EMD1





```
In [28]: # Calculate the total number of subplots needed
total_subplots = len(imfs) + 3

# Plot the original signal, IMFs, Residual, and LSTM predictions for each IMF
fig, axes = plt.subplots(total_subplots, 1, figsize=(25, 30))

# Original Signal
axes[0].plot(signal, label='Original Signal')
axes[0].set_title('Original Signal')

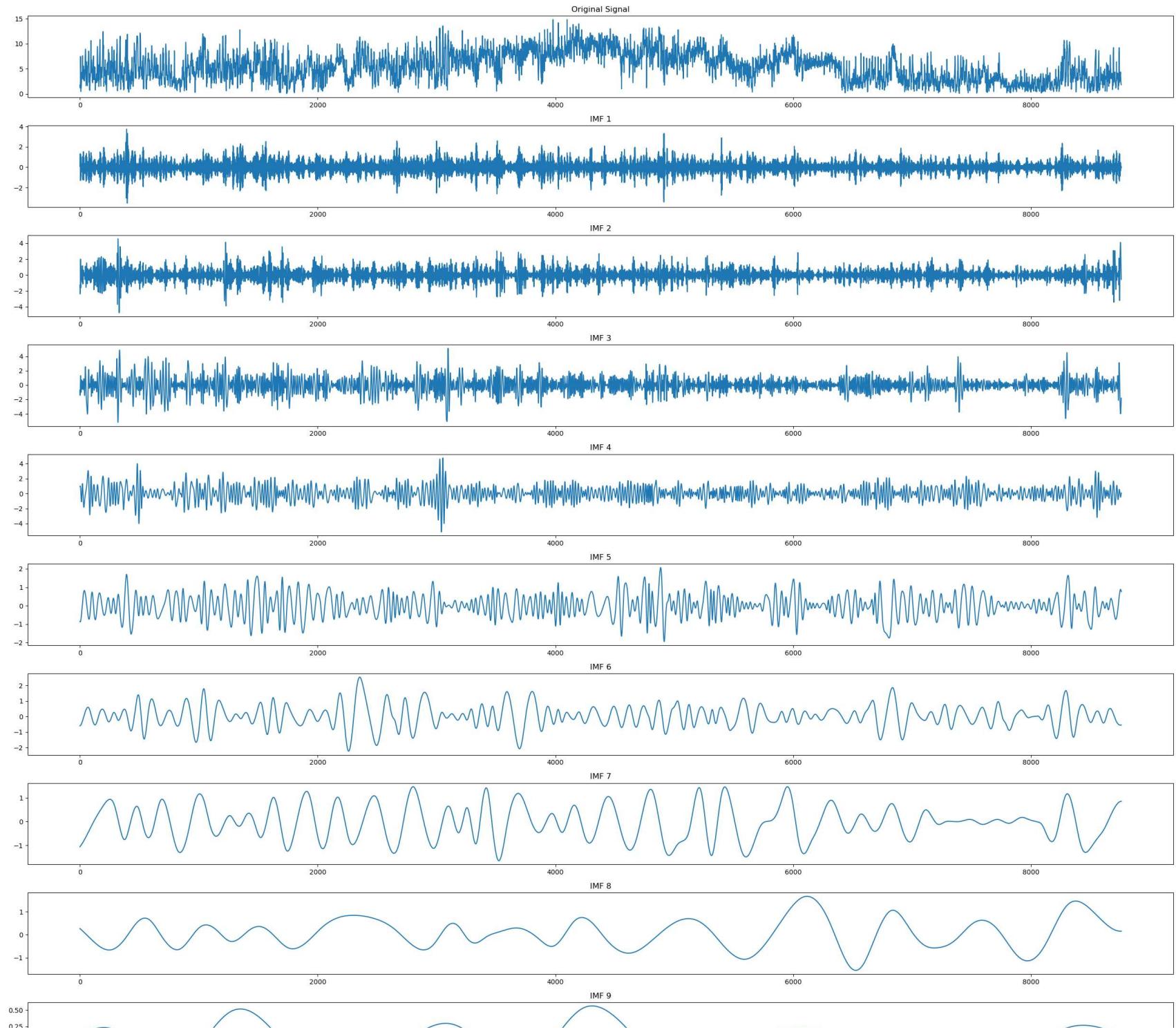
# IMFs
for i, imf in enumerate(imfs):
    axes[i + 1].plot(imf, label=f'IMF {i + 1}')
    axes[i + 1].set_title(f'IMF {i + 1}')

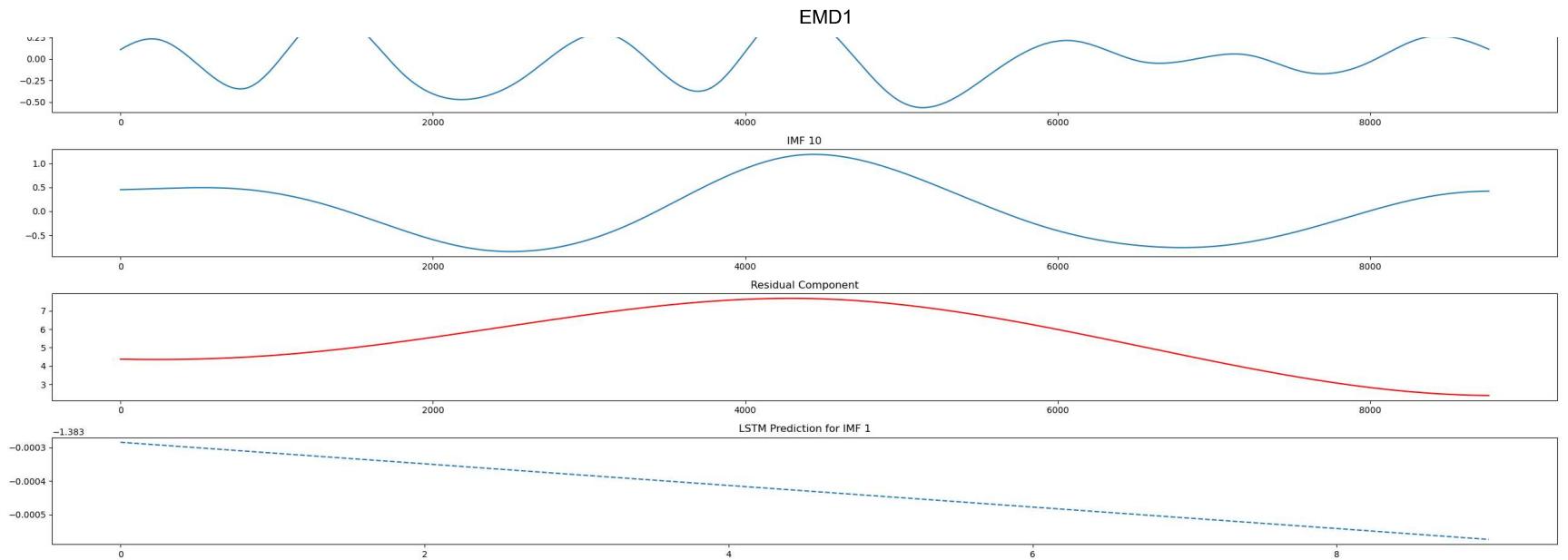
# Residual Component
axes[len(imfs) + 1].plot(res, label='Residual Component', color='red')
axes[len(imfs) + 1].set_title('Residual Component')

# LSTM Predictions for each IMF
for i, pred in enumerate(predicted_values_original_scale):
    if len(imfs) + 2 + i < total_subplots: # Check if index is within bounds
        axes[len(imfs) + 2 + i].plot(pred, label=f'LSTM Prediction for IMF {i + 1}', linestyle='dashed')
        axes[len(imfs) + 2 + i].set_title(f'LSTM Prediction for IMF {i + 1}')

plt.tight_layout()
plt.show()
```

EMD1





In []: