```
import pandas as pd
import numpy as np
import seaborn as sns
from statsmodels.tsa.seasonal import seasonal_decompose
import os
import matplotlib.pyplot as plt
```

```
df=pd.read_csv('Electric_Production.csv')
```

```
df.head()
```

	DATE	IPG2211A2N
0	1/1/1985	72.5052
1	2/1/1985	70.6720
2	3/1/1985	62.4502
3	4/1/1985	57.4714
4	5/1/1985	55.3151

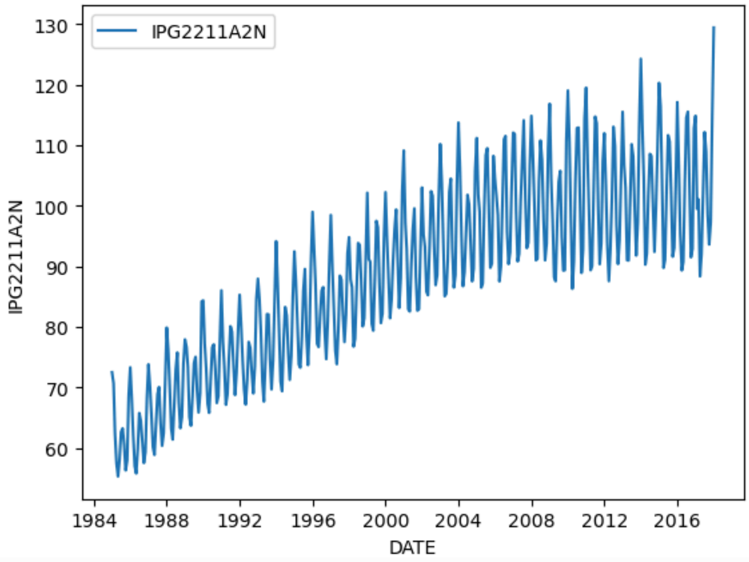
```
df['DATE']=pd.to_datetime(df['DATE'])
df=df.set_index('DATE')
```

```
df.head()
```

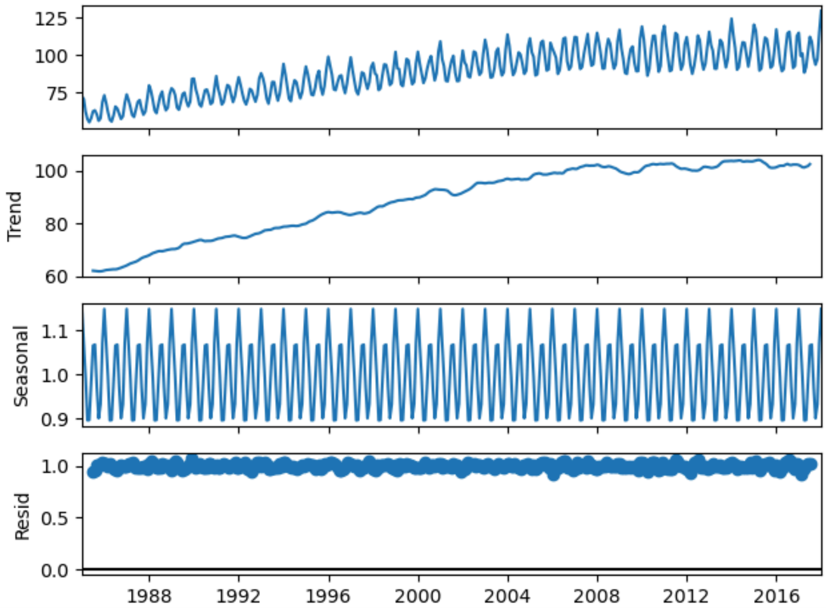
	IPG2211A2N
DATE	
1985-01-01	72.5052
1985-02-01	70.6720
1985-03-01	62.4502
1985-04-01	57.4714
1985-05-01	55.3151

```
sns.lineplot(df)
plt.ylabel('IPG2211A2N')
```

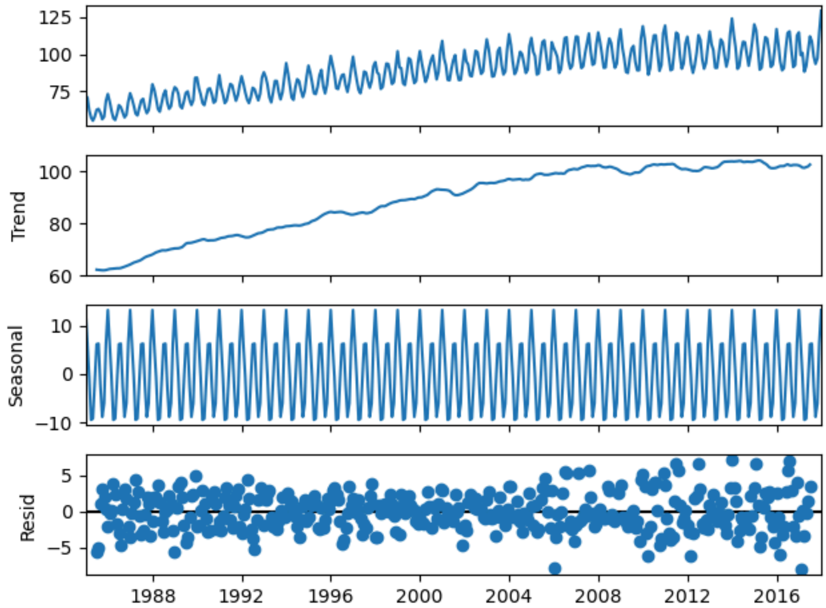
```
C:\ProgramData\anaconda3\Lib\site-packages\seaborn\_oldcore.py:1119: FutureWarning: use_inf_as_na option is deprecated and will be
  with pd.option_context('mode.use_inf_as_na', True):
C:\ProgramData\anaconda3\Lib\site-packages\seaborn\_oldcore.py:1119: FutureWarning: use_inf_as_na option is deprecated and will be
  with pd.option_context('mode.use_inf_as_na', True):
Text(0, 0.5, 'IPG2211A2N')
```



```
result=seasonal_decompose(df[['IPG2211A2N']],model='multiplicative')
result.plot()
plt.show()
```



```
result=seasonal_decompose(df[['IPG2211A2N']],model='additive')
result.plot()
plt.show()
```



```
pip install pymannkendall
```

```
Defaulting to user installation because normal site-packages is not writeable
Requirement already satisfied: pymannkendall in c:\users\nmims.student\appdata\roaming\python\python311\site-packages (1.4.3)
Requirement already satisfied: numpy in c:\programdata\anaconda3\lib\site-packages (from pymannkendall) (1.26.4)
Requirement already satisfied: scipy in c:\programdata\anaconda3\lib\site-packages (from pymannkendall) (1.11.4)
Note: you may need to restart the kernel to use updated packages.
```

```
import pymannkendall as mk
mk.original_test(df['IPG2211A2N'])
```

```
Mann_Kendall_Test(trend='increasing', h=True, p=0.0, z=19.125339232804578, Tau=0.6427499173091112, s=50524.0, var_s=6978466.0,
slope=0.11486610139860137, intercept=67.03601192307693)
```

```
train_df=df[:int(df.shape[0]*0.7)]
test_df=df[int(df.shape[0]*0.7):]
```

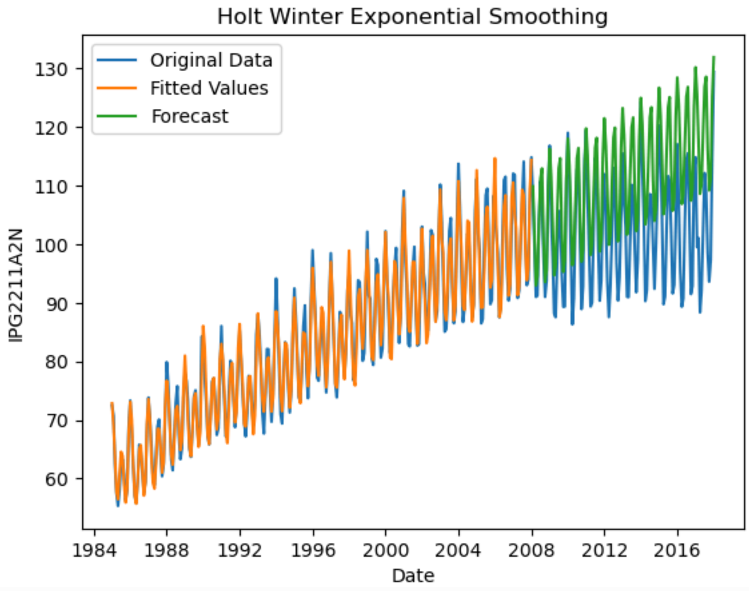
```
from statsmodels.tsa.api import ExponentialSmoothing
model_triple = ExponentialSmoothing(train_df, seasonal_periods=12, trend='add', seasonal='add')
model_triple_fit =model_triple.fit()
```

```
C:\ProgramData\anaconda3\Lib\site-packages\statsmodels\tsa\base\tsa_model.py:473: ValueWarning: No frequency information was provide
  self._init_dates(dates, freq)
```

```
forecast_triple= model_triple_fit.forecast(120)
print(forecast_triple)
```

```
2008-02-01    109.875492
2008-03-01    102.218329
2008-04-01     92.951407
2008-05-01     94.533240
2008-06-01    103.490456
                 ...
2017-09-01    116.297379
2017-10-01    109.190245
2017-11-01    111.197022
2017-12-01    125.175611
2018-01-01    131.934824
Freq: MS, Length: 120, dtype: float64
```

```
plt.plot(df, label='Original Data')
plt.plot(model_triple_fit.fittedvalues, label='Fitted Values')
plt.plot(forecast_triple, label='Forecast')
plt.xlabel('Date')
plt.ylabel('IPG2211A2N')
plt.title('Holt Winter Exponential Smoothing')
plt.legend()
plt.show()
```



```
from sklearn.metrics import mean_squared_error, mean_absolute_percentage_error
mape_train = mean_absolute_percentage_error(train_df['IPG2211A2N'], model_triple_fit.fittedvalues)
print('Mape_Train', mape_train)
```

```
Mape_Train 0.01985344246329941
```

```
test_df.shape
```

```
(120, 1)
```

```
mape_test = mean_absolute_percentage_error(test_df['IPG2211A2N'], forecast_triple)
print('Mape_Test', mape_test)
```

```
Mape_Test 0.09448179758628884
```

```
# ADF Test
# Ho : Series is non-stationary, or series has a unit root
# HA : Series is Stationary, or series has no unit root
# p-value < 0.05 - Reject Null Hypothesis (Ho)
```

```
from statsmodels.tsa.stattools import adfuller
print("Result of Dickey Fuller Test")
dftest = adfuller(df['IPG2211A2N'])
dfoutput = pd.Series(dftest[0:4], index=["Test Statistic", 'P-value', '#Lags Used', 'Number of Observations'])
for key,value in dftest[4].items():
    dfoutput['Critical Value (%s)' %key]=value
print(dfoutput)
```

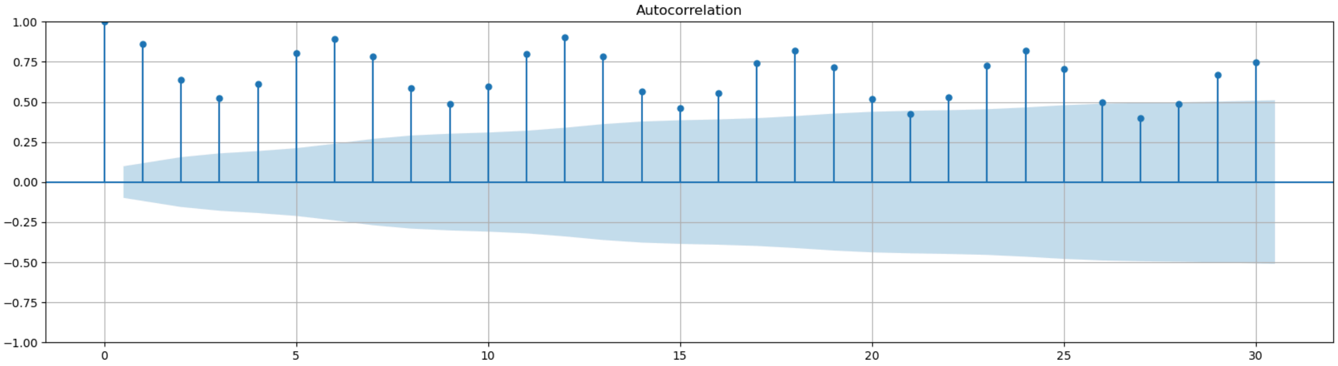
```
Result of Dickey Fuller Test
Test Statistic                  -2.256990
P-value                          0.186215
#Lags Used                      15.000000
Number of Observations         381.000000
Critical Value (1%)             -3.447631
Critical Value (5%)             -2.869156
Critical Value (10%)            -2.570827
dtype: float64
```

```
# KPSS Test
# Ho : Series is Trend Stationary, or series has no unit root
# HA : Series is non-stationary, or series has a unit root
# p-value < 0.05 - Reject Null Hypothesis (Ho)
```

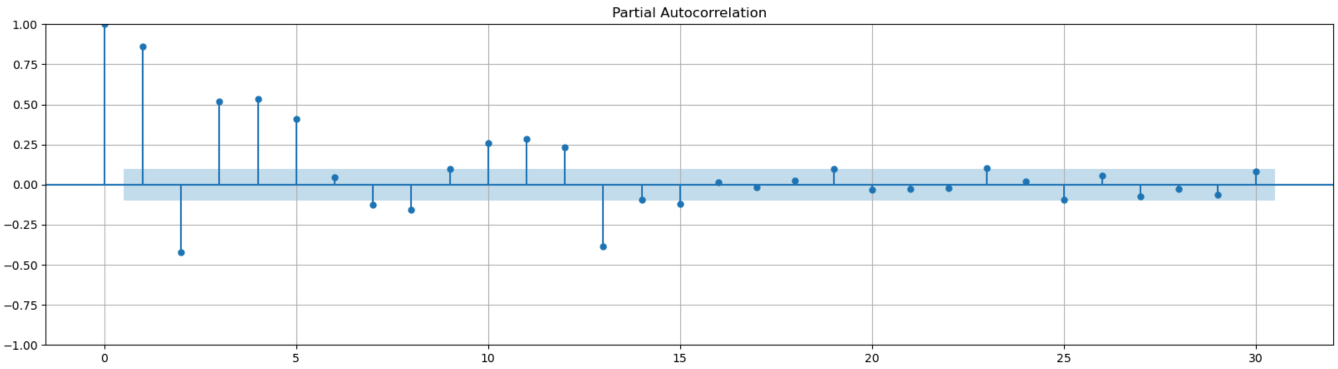
```
from statsmodels.tsa.stattools import kpss
kp = kpss(df['IPG2211A2N'])
p = kp[1]

print("p-value for KPSS Test (untransformed) = ", p)
```

```
p-value for KPSS Test (untransformed) =  0.01
C:\Users\nmims.student\AppData\Local\Temp\ipykernel_8372\1245037153.py:2: InterpolationWarning: The test statistic is outside of the
look-up table. The actual p-value is smaller than the p-value returned.

  kp = kpss(df['IPG2211A2N'])
```

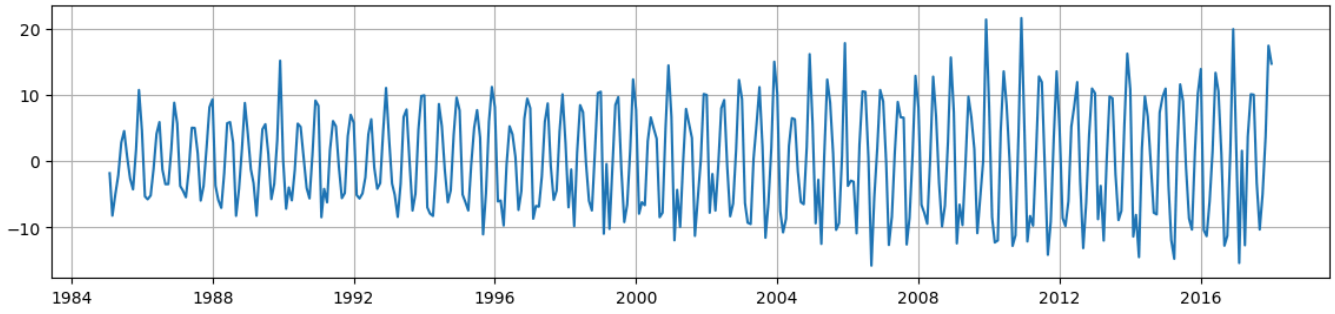
```
from statsmodels.tsa.stattools import acf,pacf
from statsmodels.graphics.tsaplots import plot_acf, plot_pacf
plt.figure(figsize=(20,5))
plt.grid()
plot_acf(df['IPG2211A2N'], ax = plt.gca(), lags=30)
plt.show()
```



```
plt.figure(figsize=(20,5))
plt.grid()
plot_pacf(df['IPG2211A2N'], ax = plt.gca(), lags=30)
plt.show()
```



```
# First Order Non Seasonal Differencing
diff = df['IPG2211A2N'].diff().dropna()      # Trying to make data Trend Stationary
plt.figure(figsize=(14,3))
plt.grid()
plt.plot(diff)
plt.show()
```



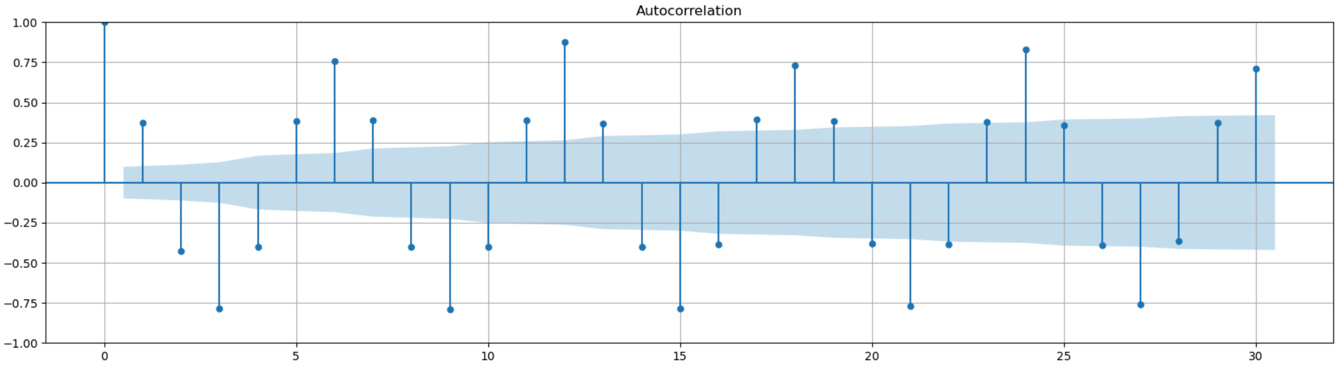
```
# ADF Test
from statsmodels.tsa.stattools import adfuller
print("Result of Dickey Fuller Test")
dftest = adfuller(diff)
dfoutput = pd.Series(dftest[0:4], index=["Test Statistic", 'P-value', '#Lags Used', 'Number of Observations'])
for key,value in dftest[4].items():
    dfoutput['Critical Value (%s)' %key]=value
print(dfoutput)
```

```
Result of Dickey Fuller Test
Test Statistic            -7.104891e+00
P-value                    4.077787e-10
#Lags Used                 1.400000e+01
Number of Observations     3.810000e+02
Critical Value (1%)       -3.447631e+00
Critical Value (5%)       -2.869156e+00
Critical Value (10%)      -2.570827e+00
dtype: float64
```

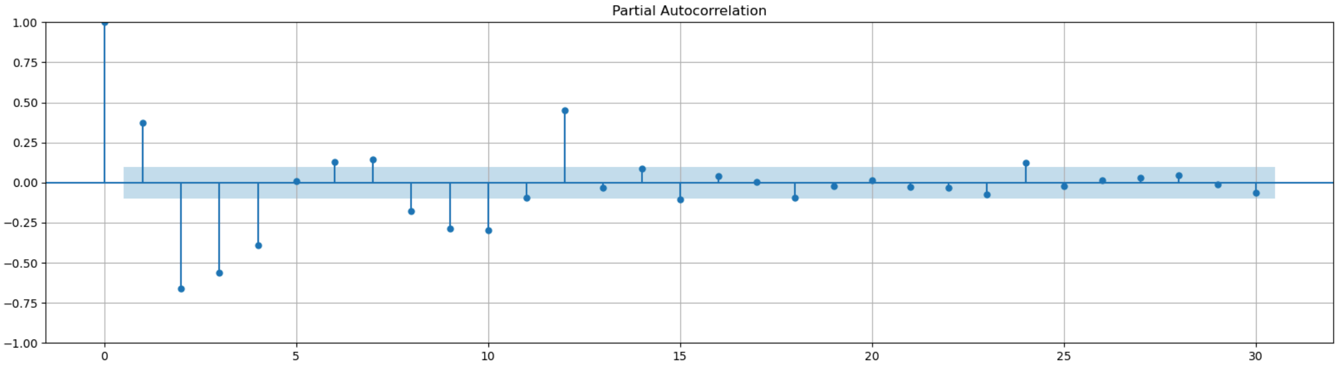
```
# KPSS Test
from statsmodels.tsa.stattools import kpss
kp = kpss(diff)
p = kp[1]

print("p-value for KPSS Test (untransformed) = ", p)
```

```
p-value for KPSS Test (untransformed) =  0.1
C:\Users\nmims.student\AppData\Local\Temp\ipykernel_8372\528972782.py:3: InterpolationWarning: The test statistic is outside of the
look-up table. The actual p-value is greater than the p-value returned.

  kp = kpss(diff)
```

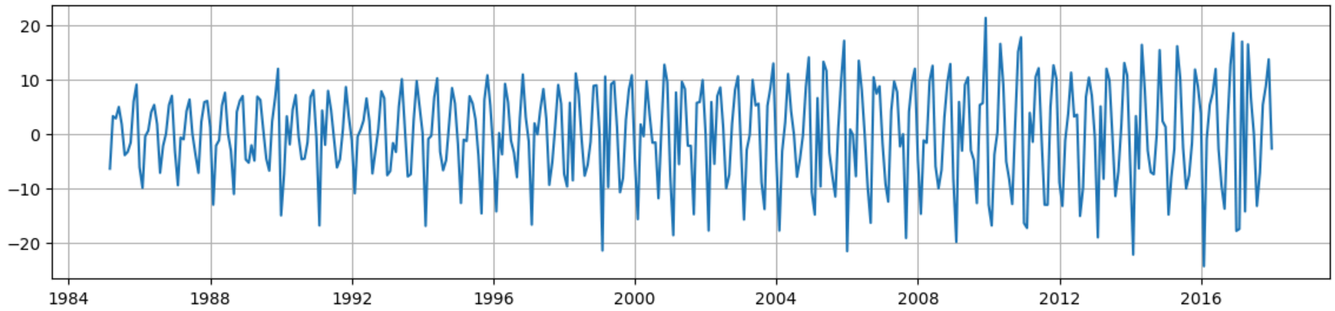
```
# ACF Plot
from statsmodels.tsa.stattools import acf,pacf
from statsmodels.graphics.tsaplots import plot_acf, plot_pacf
plt.figure(figsize=(20,5))
plt.grid()
plot_acf(diff, ax = plt.gca(), lags=30)
plt.show()
```



```
# PACF Plot
plt.figure(figsize=(20,5))
plt.grid()
plot_pacf(diff, ax = plt.gca(), lags=30)
plt.show()
```



```
# Second Order Non Seasonal Differencing
diff2 = df['IPG2211A2N'].diff().diff().dropna()      # Trying to make data Trend Stationary
plt.figure(figsize=(14,3))
plt.grid()
plt.plot(diff2)
plt.show()
```



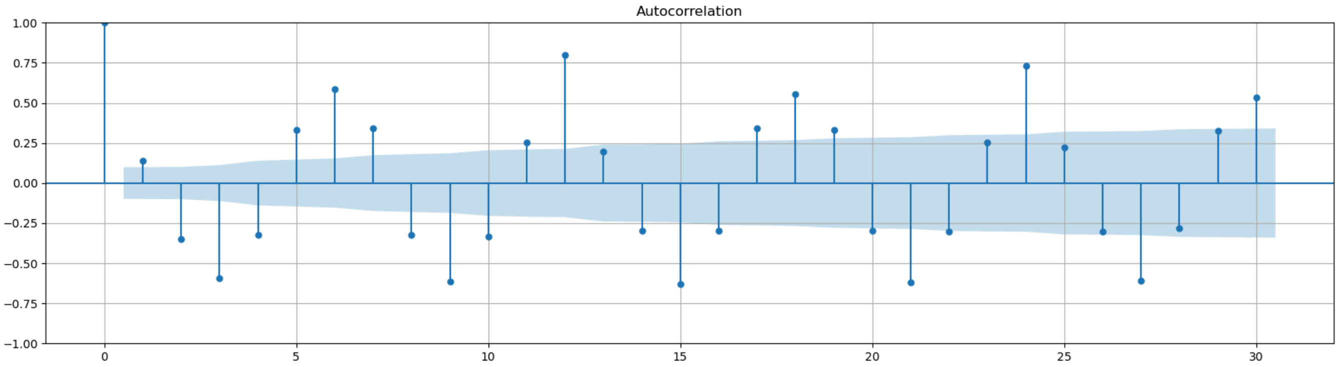
```
# ADF Test
from statsmodels.tsa.stattools import adfuller
print("Result of Dickey Fuller Test")
dftest = adfuller(diff2)
dfoutput = pd.Series(dftest[0:4], index=["Test Statistic", 'P-value', '#Lags Used', 'Number of Observations'])
for key,value in dftest[4].items():
    dfoutput['Critical Value (%s)' %key]=value
print(dfoutput)
```

```
Result of Dickey Fuller Test
Test Statistic           -9.863042e+00
P-value                   4.183694e-17
#Lags Used                1.700000e+01
Number of Observations    3.770000e+02
Critical Value (1%)      -3.447815e+00
Critical Value (5%)      -2.869237e+00
Critical Value (10%)     -2.570870e+00
dtype: float64
```

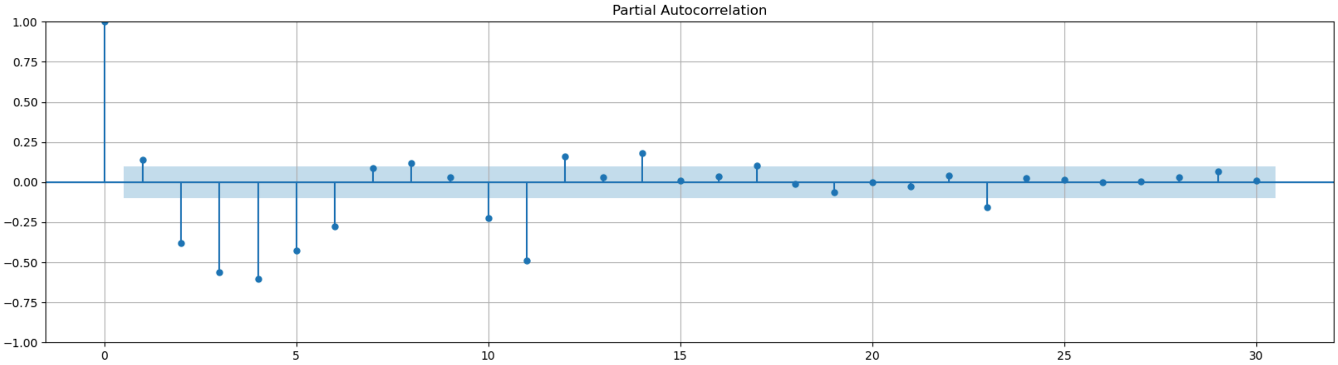
```
# KPSS Test
from statsmodels.tsa.stattools import kpss
kp = kpss(diff2)
p = kp[1]

print("p-value for KPSS Test (untransformed) = ", p)
```

```
p-value for KPSS Test (untransformed) =  0.1
C:\Users\nmims.student\AppData\Local\Temp\ipykernel_8372\1400720088.py:3: InterpolationWarning: The test statistic is outside of the
look-up table. The actual p-value is greater than the p-value returned.

  kp = kpss(diff2)
```

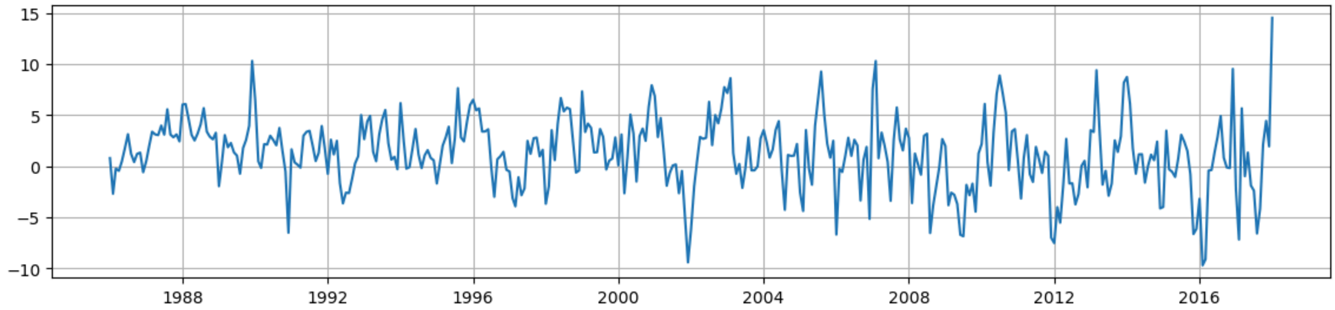
```
# ACF Plot
from statsmodels.tsa.stattools import acf,pacf
from statsmodels.graphics.tsaplots import plot_acf, plot_pacf
plt.figure(figsize=(20,5))
plt.grid()
plot_acf(diff2, ax = plt.gca(), lags=30)
plt.show()
```



```python
# PACF Plot
plt.figure(figsize=(20,5))
plt.grid()
plot_pacf(diff2, ax = plt.gca(), lags=30)
plt.show()
```



```python
# First Order Seasonal Differencing
sdiff = df['IPG2211A2N'].diff(periods=12).dropna()      # Trying to make data Trend Stationary
plt.figure(figsize=(14,3))
plt.grid()
plt.plot(sdiff)
plt.show()
```



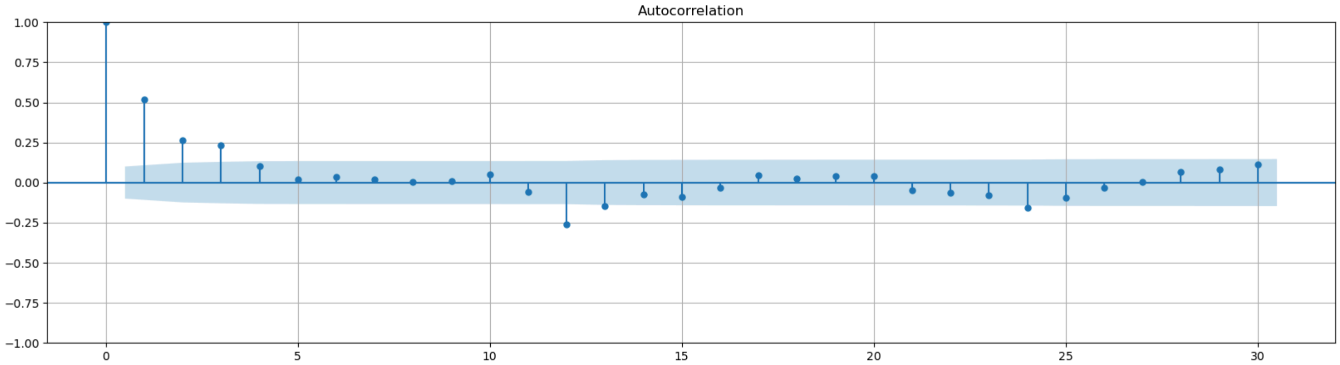
```python
# ADF Test
from statsmodels.tsa.stattools import adfuller
print("Result of Dickey Fuller Test")
dftest = adfuller(sdiff)
dfoutput = pd.Series(dftest[0:4], index=["Test Statistic", 'P-value', '#Lags Used', 'Number of Observations'])
for key,value in dftest[4].items():
    dfoutput['Critical Value (%s)' %key]=value
print(dfoutput)
```

```
Result of Dickey Fuller Test
Test Statistic           -5.673482e+00
P-value                   8.812645e-07
#Lags Used                1.200000e+01
Number of Observations    3.720000e+02
Critical Value (1%)      -3.448052e+00
Critical Value (5%)      -2.869341e+00
Critical Value (10%)     -2.570926e+00
dtype: float64
```

```
# KPSS Test
from statsmodels.tsa.stattools import kpss
kp = kpss(sdiff)
p = kp[1]

print("p-value for KPSS Test (untransformed) = ", p)
```

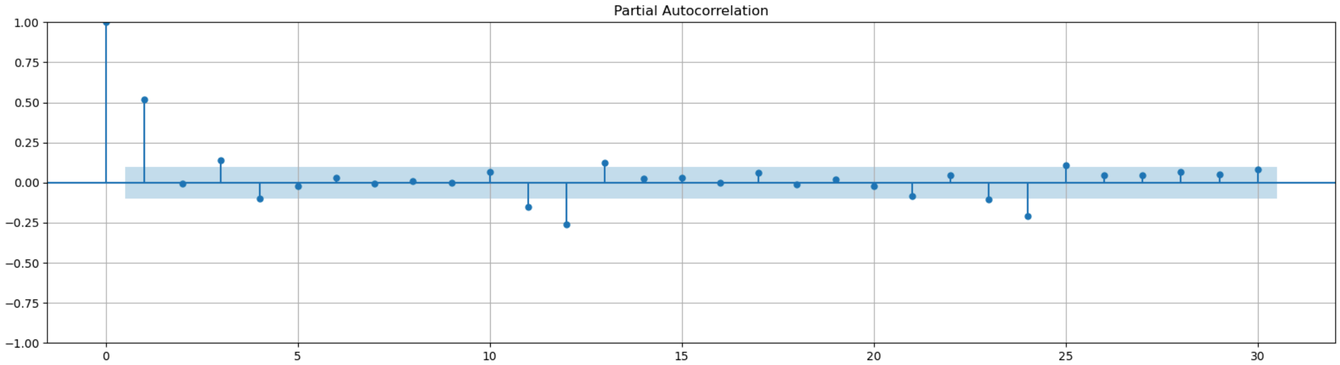
```
p-value for KPSS Test (untransformed) =  0.024345634791440068
```

```
# ACF Plot
from statsmodels.tsa.stattools import acf,pacf
from statsmodels.graphics.tsaplots import plot_acf, plot_pacf
plt.figure(figsize=(20,5))
plt.grid()
plot_acf(sdiff, ax = plt.gca(), lags=30)
plt.show()
```

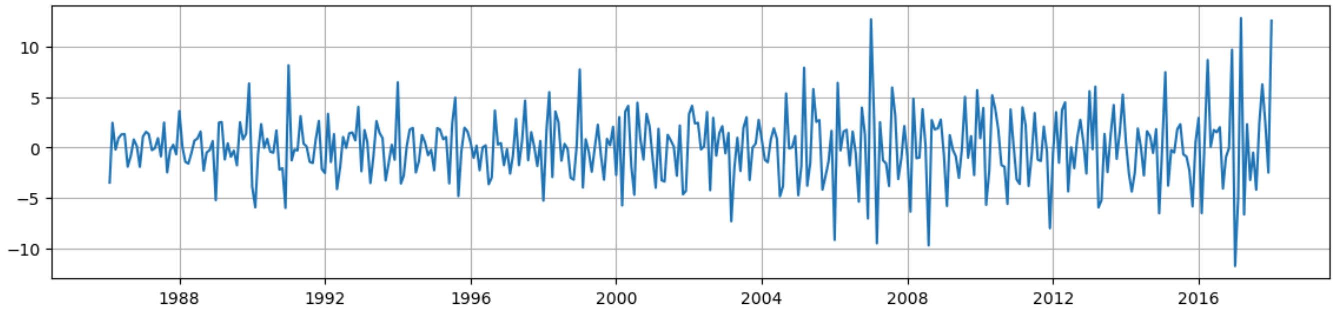


+ Code + Text

```
# PACF Plot
plt.figure(figsize=(20,5))
plt.grid()
plot_pacf(sdiff, ax = plt.gca(), lags=30)
plt.show()
```



```
# First Order Seasonal & Non-Seasonal Differencing
sdiff = df['IPG2211A2N'].diff(periods=12).dropna() # Seasonal Differencing
sddiff = sdiff.diff().dropna()                            # Non-Seasonal Differencing
plt.figure(figsize=(14,3))
plt.grid()
plt.plot(sddiff)
plt.show()
```



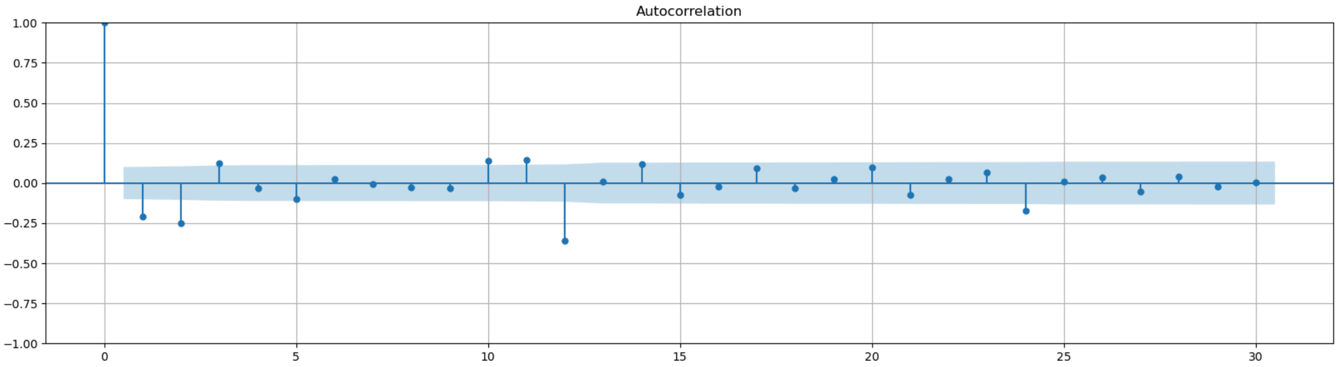
```
# ADF Test
from statsmodels.tsa.stattools import adfuller
print("Result of Dickey Fuller Test")
dftest = adfuller(sddiff)
dfoutput = pd.Series(dftest[0:4], index=["Test Statistic", 'P-value', '#Lags Used', 'Number of Observations'])
for key,value in dftest[4].items():
    dfoutput['Critical Value (%s)' %key]=value
print(dfoutput)
```

```
Result of Dickey Fuller Test
Test Statistic           -8.022039e+00
P-value                   2.063925e-12
#Lags Used                1.500000e+01
Number of Observations    3.680000e+02
Critical Value (1%)      -3.448245e+00
Critical Value (5%)      -2.869426e+00
Critical Value (10%)     -2.570971e+00
dtype: float64
```

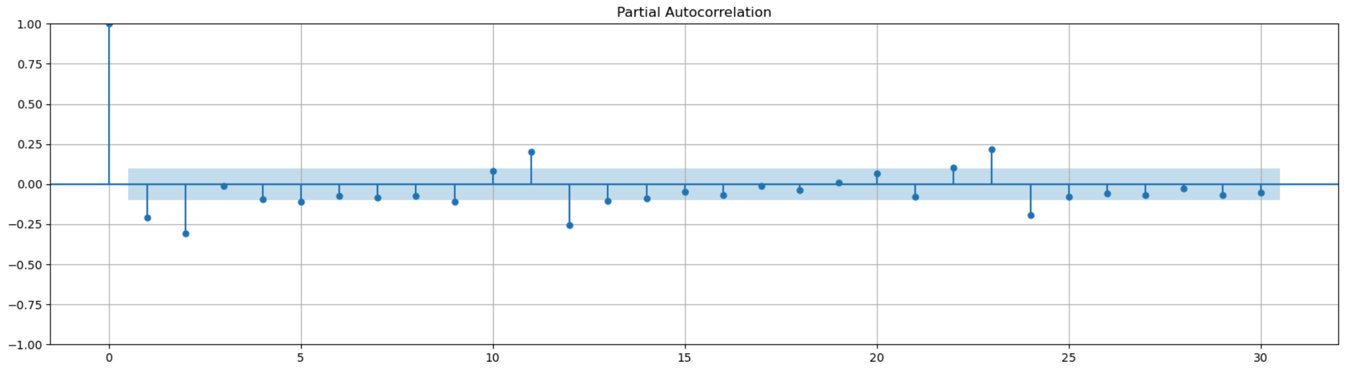
```
# KPSS Test
from statsmodels.tsa.stattools import kpss
kp = kpss(sddiff)
p = kp[1]

print("p-value for KPSS Test (untransformed) = ", p)
```

```
p-value for KPSS Test (untransformed) =  0.1
C:\Users\nmims.student\AppData\Local\Temp\ipykernel_8372\546374317.py:3: InterpolationWarning: The test statistic is outside of the
look-up table. The actual p-value is greater than the p-value returned.

  kp = kpss(sddiff)
```

```
# ACF Plot
from statsmodels.tsa.stattools import acf,pacf
from statsmodels.graphics.tsaplots import plot_acf, plot_pacf
plt.figure(figsize=(20,5))
plt.grid()
plot_acf(sddiff, ax = plt.gca(), lags=30)
plt.show()
```



```
# PACF Plot
plt.figure(figsize=(20,5))
plt.grid()
plot_pacf(sddiff, ax = plt.gca(), lags=30)
plt.show()
```



```
!pip install pmdarima
```

```
Defaulting to user installation because normal site-packages is not writeable
Requirement already satisfied: pmdarima in c:\users\nmims.student\appdata\roaming\python\python311\site-packages (2.0.4)
Requirement already satisfied: joblib>=0.11 in c:\programdata\anaconda3\lib\site-packages (from pmdarima) (1.2.0)
Requirement already satisfied: Cython!=0.29.18,!=0.29.31,>=0.29 in c:\users\nmims.student\appdata\roaming\python\python311\site-pack
Requirement already satisfied: numpy>=1.21.2 in c:\programdata\anaconda3\lib\site-packages (from pmdarima) (1.26.4)
Requirement already satisfied: pandas>=0.19 in c:\programdata\anaconda3\lib\site-packages (from pmdarima) (2.1.4)
Requirement already satisfied: scikit-learn>=0.22 in c:\programdata\anaconda3\lib\site-packages (from pmdarima) (1.2.2)
Requirement already satisfied: scipy>=1.3.2 in c:\programdata\anaconda3\lib\site-packages (from pmdarima) (1.11.4)
Requirement already satisfied: statsmodels>=0.13.2 in c:\programdata\anaconda3\lib\site-packages (from pmdarima) (0.14.0)
Requirement already satisfied: urllib3 in c:\programdata\anaconda3\lib\site-packages (from pmdarima) (2.0.7)
Requirement already satisfied: setuptools!=50.0.0,>=38.6.0 in c:\programdata\anaconda3\lib\site-packages (from pmdarima) (68.2.2)
Requirement already satisfied: packaging>=17.1 in c:\programdata\anaconda3\lib\site-packages (from pmdarima) (23.1)
Requirement already satisfied: python-dateutil>=2.8.2 in c:\programdata\anaconda3\lib\site-packages (from pandas>=0.19->pmdarima) (2
Requirement already satisfied: pytz>=2020.1 in c:\programdata\anaconda3\lib\site-packages (from pandas>=0.19->pmdarima) (2023.3.post
Requirement already satisfied: tzdata>=2022.1 in c:\programdata\anaconda3\lib\site-packages (from pandas>=0.19->pmdarima) (2023.3)
Requirement already satisfied: threadpoolctl>=2.0.0 in c:\programdata\anaconda3\lib\site-packages (from scikit-learn>=0.22->pmdarima
Requirement already satisfied: patsy>=0.5.2 in c:\programdata\anaconda3\lib\site-packages (from statsmodels>=0.13.2->pmdarima) (0.5
Requirement already satisfied: six in c:\programdata\anaconda3\lib\site-packages (from patsy>=0.5.2->statsmodels>=0.13.2->pmdarima)
```

```
pip install pymannkendall pmdarima
```

```
Defaulting to user installation because normal site-packages is not writeable
Requirement already satisfied: pymannkendall in c:\users\nmims.student\appdata\roaming\python\python311\site-packages (1.4.3)
Requirement already satisfied: pmdarima in c:\users\nmims.student\appdata\roaming\python\python311\site-packages (2.0.4)
Requirement already satisfied: numpy in c:\programdata\anaconda3\lib\site-packages (from pymannkendall) (1.26.4)
Requirement already satisfied: scipy in c:\programdata\anaconda3\lib\site-packages (from pymannkendall) (1.11.4)
Requirement already satisfied: joblib>=0.11 in c:\programdata\anaconda3\lib\site-packages (from pmdarima) (1.2.0)
Requirement already satisfied: Cython!=0.29.18,!=0.29.31,>=0.29 in c:\users\nmims.student\appdata\roaming\python\python311\site-pack
Requirement already satisfied: pandas>=0.19 in c:\programdata\anaconda3\lib\site-packages (from pmdarima) (2.1.4)
Requirement already satisfied: scikit-learn>=0.22 in c:\programdata\anaconda3\lib\site-packages (from pmdarima) (1.2.2)
Requirement already satisfied: statsmodels>=0.13.2 in c:\programdata\anaconda3\lib\site-packages (from pmdarima) (0.14.0)
Requirement already satisfied: urllib3 in c:\programdata\anaconda3\lib\site-packages (from pmdarima) (2.0.7)
Requirement already satisfied: setuptools!=50.0.0,>=38.6.0 in c:\programdata\anaconda3\lib\site-packages (from pmdarima) (68.2.2)
Requirement already satisfied: packaging>=17.1 in c:\programdata\anaconda3\lib\site-packages (from pmdarima) (23.1)
Requirement already satisfied: python-dateutil>=2.8.2 in c:\programdata\anaconda3\lib\site-packages (from pandas>=0.19->pmdarima) (2
Requirement already satisfied: pytz>=2020.1 in c:\programdata\anaconda3\lib\site-packages (from pandas>=0.19->pmdarima) (2023.3.post
Requirement already satisfied: tzdata>=2022.1 in c:\programdata\anaconda3\lib\site-packages (from pandas>=0.19->pmdarima) (2023.3)
Requirement already satisfied: threadpoolctl>=2.0.0 in c:\programdata\anaconda3\lib\site-packages (from scikit-learn>=0.22->pmdarima
Requirement already satisfied: patsy>=0.5.2 in c:\programdata\anaconda3\lib\site-packages (from statsmodels>=0.13.2->pmdarima) (0.5
Requirement already satisfied: six in c:\programdata\anaconda3\lib\site-packages (from patsy>=0.5.2->statsmodels>=0.13.2->pmdarima)
Note: you may need to restart the kernel to use updated packages.
```

```
import statsmodels.api as sm
model_1 = sm.tsa.statespace.SARIMAX(train_df['IPG2211A2N'], order = (1,1,1), seasonal_order = (1,1,1,12))
model_1_fit = model_1.fit()

print(model_1_fit.summary())
```

```
C:\ProgramData\anaconda3\Lib\site-packages\statsmodels\tsa\base\tsa_model.py:473: ValueWarning: No frequency information was provide
  self._init_dates(dates, freq)
C:\ProgramData\anaconda3\Lib\site-packages\statsmodels\tsa\base\tsa_model.py:473: ValueWarning: No frequency information was provide
  self._init_dates(dates, freq)
                                     SARIMAX Results
==========================================================================================
Dep. Variable:                        IPG2211A2N   No. Observations:                  277
Model:             SARIMAX(1, 1, 1)x(1, 1, 1, 12)   Log Likelihood                -575.211
Date:                           Mon, 03 Feb 2025   AIC                           1160.422
Time:                                   14:00:50   BIC                           1178.302
Sample:                               01-01-1985   HQIC                          1167.607
                                    - 01-01-2008
Covariance Type:                             opg
==============================================================================
                 coef    std err          z      P>|z|      [0.025      0.975]
------------------------------------------------------------------------------
ar.L1          0.4861      0.056      8.618      0.000       0.376       0.597
ma.L1         -0.9810      0.019    -52.984      0.000      -1.017      -0.945
ar.S.L12       0.0288      0.092      0.313      0.755      -0.152       0.209
ma.S.L12      -0.7279      0.080     -9.100      0.000      -0.885      -0.571
sigma2         4.3600      0.313     13.944      0.000       3.747       4.973
===================================================================================
Ljung-Box (L1) (Q):                   0.02   Jarque-Bera (JB):                55.34
Prob(Q):                              0.88   Prob(JB):                         0.00
Heteroskedasticity (H):               2.25   Skew:                            -0.29
Prob(H) (two-sided):                  0.00   Kurtosis:                         5.17
===================================================================================

Warnings:
[1] Covariance matrix calculated using the outer product of gradients (complex-step).
```

```
 from pmdarima.arima import auto_arima
 model_auto_arima = auto_arima(df['IPG2211A2N'], seasonal = True, trace = True, m=12)
```

```
Performing stepwise search to minimize aic
 ARIMA(2,1,2)(1,0,1)[12] intercept   : AIC=1953.424, Time=1.09 sec
 ARIMA(0,1,0)(0,0,0)[12] intercept   : AIC=2750.050, Time=0.02 sec
 ARIMA(1,1,0)(1,0,0)[12] intercept   : AIC=inf, Time=0.24 sec
 ARIMA(0,1,1)(0,0,1)[12] intercept   : AIC=2401.309, Time=0.22 sec
 ARIMA(0,1,0)(0,0,0)[12]             : AIC=2748.185, Time=0.01 sec
 ARIMA(2,1,2)(0,0,1)[12] intercept   : AIC=inf, Time=0.91 sec
 ARIMA(2,1,2)(1,0,0)[12] intercept   : AIC=inf, Time=0.95 sec
 ARIMA(2,1,2)(2,0,1)[12] intercept   : AIC=1955.636, Time=2.02 sec
 ARIMA(2,1,2)(1,0,2)[12] intercept   : AIC=inf, Time=2.13 sec
 ARIMA(2,1,2)(0,0,0)[12] intercept   : AIC=2105.437, Time=0.41 sec
 ARIMA(2,1,2)(0,0,2)[12] intercept   : AIC=2016.179, Time=1.69 sec
 ARIMA(2,1,2)(2,0,0)[12] intercept   : AIC=inf, Time=1.97 sec
 ARIMA(2,1,2)(2,0,2)[12] intercept   : AIC=inf, Time=3.66 sec
 ARIMA(1,1,2)(1,0,1)[12] intercept   : AIC=1866.763, Time=1.12 sec
 ARIMA(1,1,2)(0,0,1)[12] intercept   : AIC=2265.648, Time=0.42 sec
 ARIMA(1,1,2)(1,0,0)[12] intercept   : AIC=1985.835, Time=0.56 sec
 ARIMA(1,1,2)(2,0,1)[12] intercept   : AIC=1868.527, Time=2.71 sec
 ARIMA(1,1,2)(1,0,2)[12] intercept   : AIC=1868.082, Time=1.98 sec
 ARIMA(1,1,2)(0,0,0)[12] intercept   : AIC=2493.118, Time=0.16 sec
 ARIMA(1,1,2)(0,0,2)[12] intercept   : AIC=2179.668, Time=0.82 sec
 ARIMA(1,1,2)(2,0,0)[12] intercept   : AIC=1945.389, Time=1.69 sec
 ARIMA(1,1,2)(2,0,2)[12] intercept   : AIC=inf, Time=3.51 sec
 ARIMA(0,1,2)(1,0,1)[12] intercept   : AIC=1872.483, Time=0.87 sec
 ARIMA(1,1,1)(1,0,1)[12] intercept   : AIC=1869.005, Time=0.94 sec
 ARIMA(1,1,3)(1,0,1)[12] intercept   : AIC=1870.118, Time=1.30 sec
 ARIMA(0,1,1)(1,0,1)[12] intercept   : AIC=1923.996, Time=0.66 sec
 ARIMA(0,1,3)(1,0,1)[12] intercept   : AIC=1869.749, Time=1.10 sec
 ARIMA(2,1,1)(1,0,1)[12] intercept   : AIC=1870.511, Time=0.91 sec
 ARIMA(2,1,3)(1,0,1)[12] intercept   : AIC=1929.168, Time=1.29 sec
 ARIMA(1,1,2)(1,0,1)[12]             : AIC=inf, Time=1.27 sec

Best model:  ARIMA(1,1,2)(1,0,1)[12] intercept
Total fit time: 36.651 seconds
```

```
import statsmodels.api as sm
model_2 = sm.tsa.statespace.SARIMAX(train_df['IPG2211A2N'], order = (1,1,2), seasonal_order = (1,0,1,12))
model_2_fit = model_2.fit()

print(model_2_fit.summary())
```

```
---------------------------------------------------------------------------
NameError                                 Traceback (most recent call last)
Cell In[1], line 2
      1 import statsmodels.api as sm
----> 2 model_2 = sm.tsa.statespace.SARIMAX(train_df['IPG2211A2N'], order = (1,1,2), seasonal_order = (1,0,1,12))
      3 model_2_fit = model_2.fit()
      5 print(model_2_fit.summary())

NameError: name 'train_df' is not defined
```

```
test_predictions1 = model_1_fit.forecast(len(test_df))
forecast_further1 = model_1_fit.forecast(len(test_df['IPG2211A2N'])+90)
forecast_further1 = forecast_further1[test_df.index.max():]
forecast_further1
```

```
2018-01-01    131.233972
2018-02-01    126.187633
2018-03-01    119.036998
2018-04-01    109.462493
2018-05-01    110.648377
                 ...
2025-03-01    130.734526
2025-04-01    121.160021
2025-05-01    122.345905
2025-06-01    131.234333
2025-07-01    139.346525
Freq: MS, Name: predicted_mean, Length: 91, dtype: float64
```

```
test_predictions2 = model_2_fit.forecast(len(test_df))
forecast_further2 = model_2_fit.forecast(len(test_df['IPG2211A2N'])+90)
forecast_further2 = forecast_further2[test_df.index.max():]
forecast_further2
```

```
2018-01-01    129.028578
2018-02-01    124.299441
2018-03-01    117.562077
2018-04-01    108.577938
2018-05-01    109.695474
                 ...
2025-03-01    127.920577
2025-04-01    119.245520
2025-05-01    120.324609
2025-06-01    128.362982
2025-07-01    135.700235
Freq: MS, Name: predicted_mean, Length: 91, dtype: float64
```

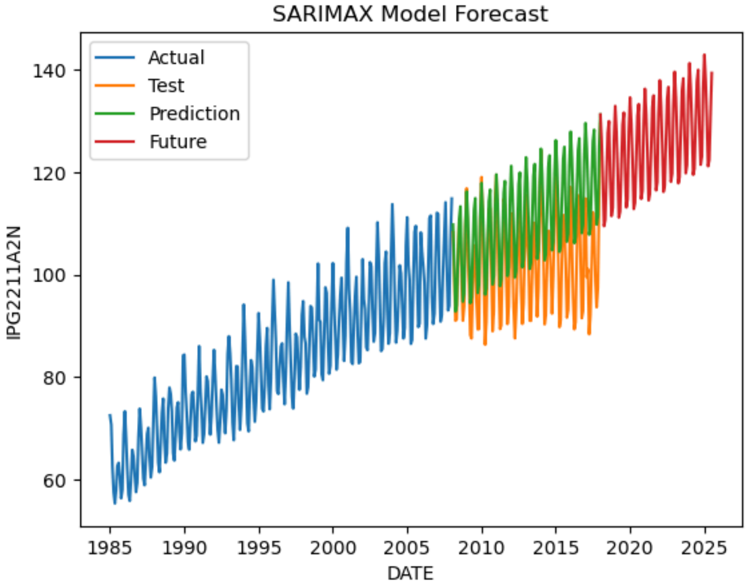
```
mape_test1 = mean_absolute_percentage_error(test_df['IPG2211A2N'], test_predictions1)
print('MAPE for TEST Data:', mape_test1)
```

```
MAPE for TEST Data: 0.09303131713801367
```

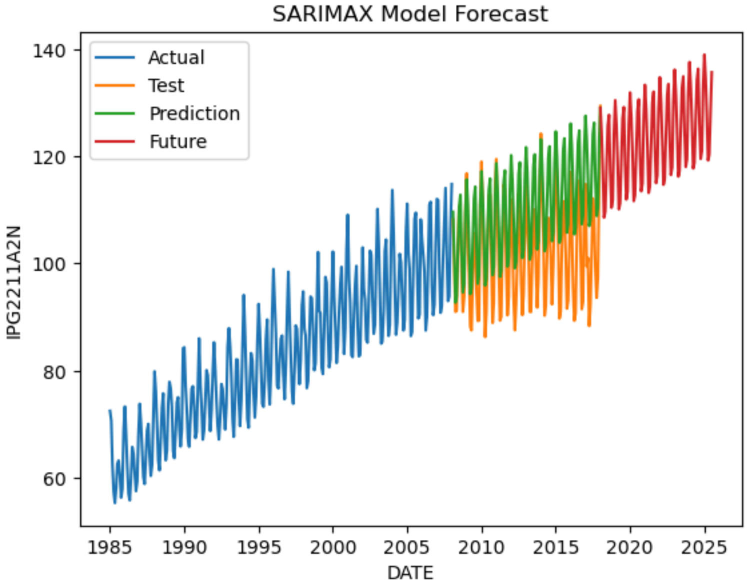
```
mape_test2 = mean_absolute_percentage_error(test_df['IPG2211A2N'], test_predictions2)
print('MAPE for TEST Data:', mape_test2)
```

```
MAPE for TEST Data: 0.0862379804230265
```

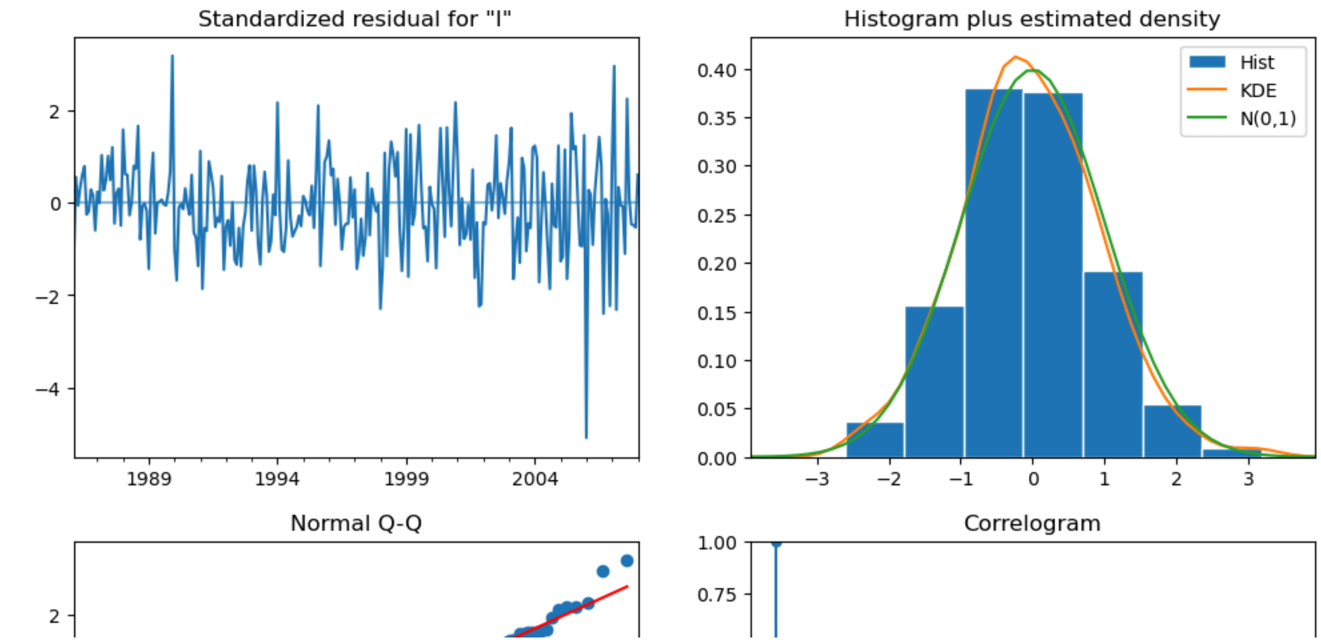
```
plt.plot(train_df['IPG2211A2N'], label = 'Actual')
plt.plot(test_df['IPG2211A2N'], label = 'Test')
plt.plot(test_predictions1, label = 'Prediction')
plt.plot(forecast_further1, label = 'Future')

plt.title('SARIMAX Model Forecast')
plt.xlabel('DATE')
plt.ylabel('IPG2211A2N')
plt.legend()

plt.show()
```



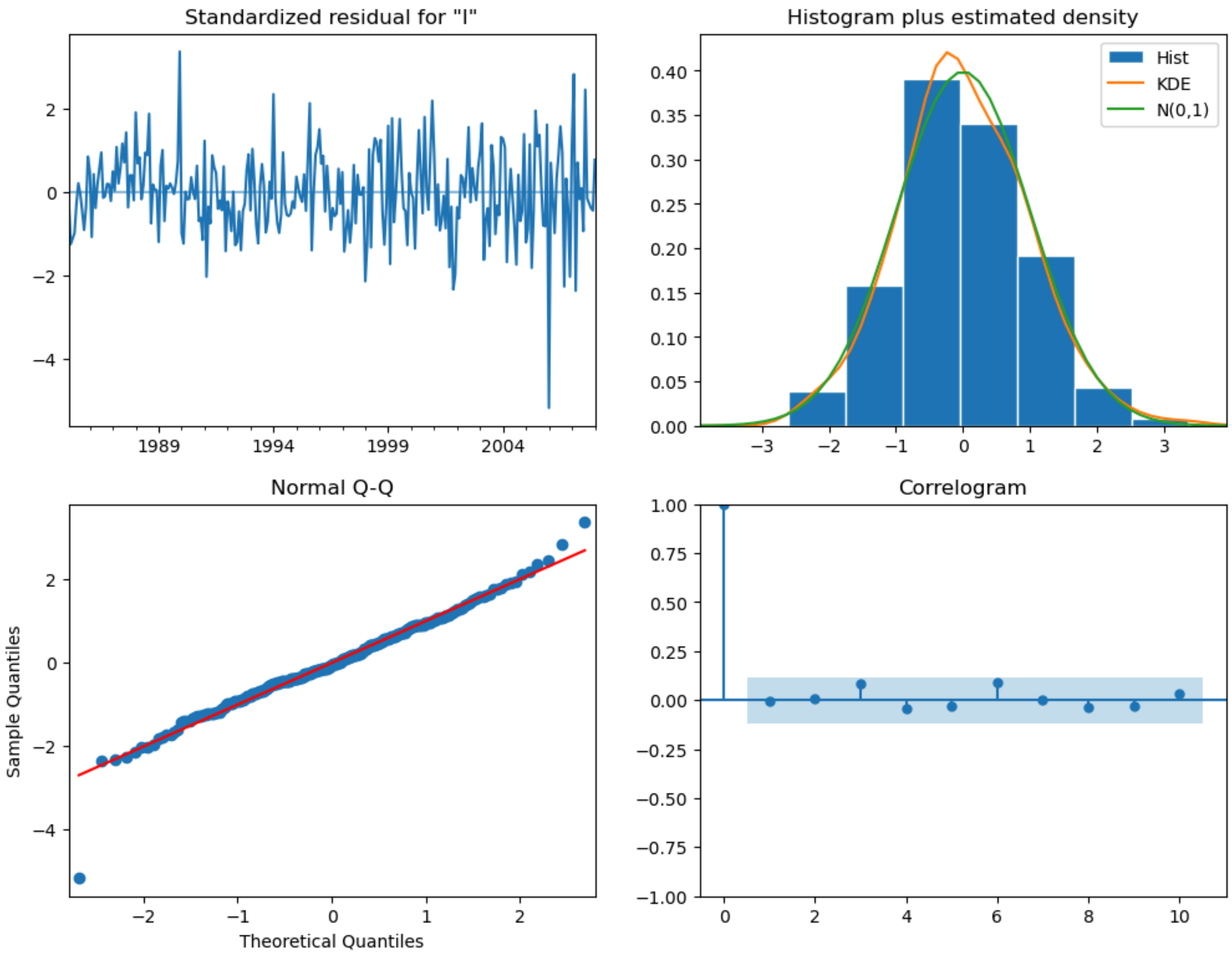
```
plt.plot(train_df['IPG2211A2N'], label = 'Actual')
plt.plot(test_df['IPG2211A2N'], label = 'Test')
plt.plot(test_predictions2, label = 'Prediction')
plt.plot(forecast_further2, label = 'Future')

plt.title('SARIMAX Model Forecast')
plt.xlabel('DATE')
plt.ylabel('IPG2211A2N')
plt.legend()

plt.show()
```



```
model_1_fit.plot_diagnostics(figsize=(12,9))
plt.show()
```



```
model_2_fit.plot_diagnostics(figsize=(12,9))
plt.show()
```



```
import pandas as pd
import matplotlib.pyplot as plt
import seaborn as sns

# Create some data for the table
models = ['Exponential Smoothing', 'SARIMAX (1,1,1)x(1,1,1,12)','SARIMAX (1,1,2)x(1,0,1,12)']
mape_test = [0.09448179758628884, 0.09303131713801367, 0.0862379804230265]
```