

```
[3]: from google.colab import drive  
drive.mount('/content/drive')
```

Mounted at /content/drive

### 3 Import Libraries

```
[4]: import numpy as np  
import pandas as pd  
import matplotlib.pyplot as plt  
import seaborn as sns  
import scipy.stats as stats  
import pylab  
  
from sklearn.preprocessing import StandardScaler  
from sklearn.decomposition import PCA  
  
from sklearn.cluster import KMeans,AgglomerativeClustering,DBSCAN  
  
from sklearn.metrics import silhouette_score
```

### 4 Load Dataset

```
[5]: df = pd.read_csv("/content/drive/MyDrive/Datasets/CC General/CC GENERAL.csv")  
df.head()
```

```
[5]:    CUST_ID      BALANCE  BALANCE_FREQUENCY  PURCHASES  ONEOFF_PURCHASES  \  
0   C10001     40.900749          0.818182     95.40          0.00  
1   C10002    3202.467416          0.909091      0.00          0.00  
2   C10003    2495.148862          1.000000     773.17         773.17  
3   C10004    1666.670542          0.636364    1499.00        1499.00  
4   C10005     817.714335          1.000000      16.00         16.00  
  
    INSTALLMENTS_PURCHASES  CASH_ADVANCE  PURCHASES_FREQUENCY  \  
0                  95.4       0.000000        0.166667  
1                  0.0      6442.945483        0.000000  
2                  0.0       0.000000        1.000000  
3                  0.0      205.788017        0.083333  
4                  0.0       0.000000        0.083333  
  
    ONEOFF_PURCHASES_FREQUENCY  PURCHASES_INSTALLMENTS_FREQUENCY  \  
0                  0.000000        0.083333  
1                  0.000000        0.000000  
2                  1.000000        0.000000
```

```

3          0.083333          0.000000
4          0.083333          0.000000

    CASH_ADVANCE_FREQUENCY  CASH_ADVANCE_TRX  PURCHASES_TRX  CREDIT_LIMIT \
0          0.000000           0                 2            1000.0
1          0.250000           4                 0            7000.0
2          0.000000           0                12            7500.0
3          0.083333           1                 1            7500.0
4          0.000000           0                 1            1200.0

    PAYMENTS  MINIMUM_PAYMENTS  PRC_FULL_PAYMENT  TENURE
0   201.802084        139.509787        0.000000      12
1  4103.032597        1072.340217       0.222222      12
2   622.066742        627.284787        0.000000      12
3   0.000000           NaN              0.000000      12
4   678.334763        244.791237        0.000000      12

```

[6]: df.shape

[6]: (8950, 18)

[7]: df.info()

```

<class 'pandas.core.frame.DataFrame'>
RangeIndex: 8950 entries, 0 to 8949
Data columns (total 18 columns):
 #   Column           Non-Null Count  Dtype  
--- 
 0   CUST_ID          8950 non-null   object 
 1   BALANCE           8950 non-null   float64
 2   BALANCE_FREQUENCY 8950 non-null   float64
 3   PURCHASES         8950 non-null   float64
 4   ONEOFF_PURCHASES 8950 non-null   float64
 5   INSTALLMENTS_PURCHASES 8950 non-null   float64
 6   CASH_ADVANCE      8950 non-null   float64
 7   PURCHASES_FREQUENCY 8950 non-null   float64
 8   ONEOFF_PURCHASES_FREQUENCY 8950 non-null   float64
 9   PURCHASES_INSTALLMENTS_FREQUENCY 8950 non-null   float64
 10  CASH_ADVANCE_FREQUENCY 8950 non-null   float64
 11  CASH_ADVANCE_TRX 8950 non-null   int64  
 12  PURCHASES_TRX    8950 non-null   int64  
 13  CREDIT_LIMIT     8949 non-null   float64
 14  PAYMENTS          8950 non-null   float64
 15  MINIMUM_PAYMENTS 8637 non-null   float64
 16  PRC_FULL_PAYMENT 8950 non-null   float64
 17  TENURE            8950 non-null   int64  

dtypes: float64(14), int64(3), object(1)

```

memory usage: 1.2+ MB

[8]: df.columns

```
[8]: Index(['CUST_ID', 'BALANCE', 'BALANCE_FREQUENCY', 'PURCHASES',
       'ONEOFF_PURCHASES', 'INSTALLMENTS_PURCHASES', 'CASH_ADVANCE',
       'PURCHASES_FREQUENCY', 'ONEOFF_PURCHASES_FREQUENCY',
       'PURCHASES_INSTALLMENTS_FREQUENCY', 'CASH_ADVANCE_FREQUENCY',
       'CASH_ADVANCE_TRX', 'PURCHASES_TRX', 'CREDIT_LIMIT', 'PAYMENTS',
       'MINIMUM_PAYMENTS', 'PRC_FULL_PAYMENT', 'TENURE'],
      dtype='object')
```

[9]: df.describe()

```
[9]:          BALANCE  BALANCE_FREQUENCY     PURCHASES  ONEOFF_PURCHASES \
count    8950.000000        8950.000000    8950.000000    8950.000000
mean     1564.474828        0.877271    1003.204834     592.437371
std      2081.531879        0.236904    2136.634782    1659.887917
min      0.000000        0.000000     0.000000     0.000000
25%     128.281915        0.888889     39.635000     0.000000
50%     873.385231        1.000000    361.280000     38.000000
75%    2054.140036        1.000000   1110.130000    577.405000
max    19043.138560        1.000000   49039.570000   40761.250000

          INSTALLMENTS_PURCHASES  CASH_ADVANCE  PURCHASES_FREQUENCY \
count    8950.000000        8950.000000    8950.000000
mean     411.067645        978.871112     0.490351
std      904.338115        2097.163877     0.401371
min      0.000000        0.000000     0.000000
25%     0.000000        0.000000     0.083333
50%     89.000000        0.000000     0.500000
75%    468.637500        1113.821139    0.916667
max    22500.000000       47137.211760     1.000000

          ONEOFF_PURCHASES_FREQUENCY  PURCHASES_INSTALLMENTS_FREQUENCY \
count    8950.000000        8950.000000    8950.000000
mean     0.202458        0.364437
std      0.298336        0.397448
min      0.000000        0.000000
25%     0.000000        0.000000
50%     0.083333        0.166667
75%     0.300000        0.750000
max     1.000000        1.000000

          CASH_ADVANCE_FREQUENCY  CASH_ADVANCE_TRX  PURCHASES_TRX  CREDIT_LIMIT \
count    8950.000000        8950.000000    8950.000000    8949.000000
mean     0.135144        3.248827     14.709832    4494.449450
```

std	0.200121	6.824647	24.857649	3638.815725
min	0.000000	0.000000	0.000000	50.000000
25%	0.000000	0.000000	1.000000	1600.000000
50%	0.000000	0.000000	7.000000	3000.000000
75%	0.222222	4.000000	17.000000	6500.000000
max	1.500000	123.000000	358.000000	30000.000000

	PAYMENTS	MINIMUM_PAYMENTS	PRC_FULL_PAYMENT	TENURE
count	8950.000000	8637.000000	8950.000000	8950.000000
mean	1733.143852	864.206542	0.153715	11.517318
std	2895.063757	2372.446607	0.292499	1.338331
min	0.000000	0.019163	0.000000	6.000000
25%	383.276166	169.123707	0.000000	12.000000
50%	856.901546	312.343947	0.000000	12.000000
75%	1901.134317	825.485459	0.142857	12.000000
max	50721.483360	76406.207520	1.000000	12.000000

## 5 Univariate Analysis

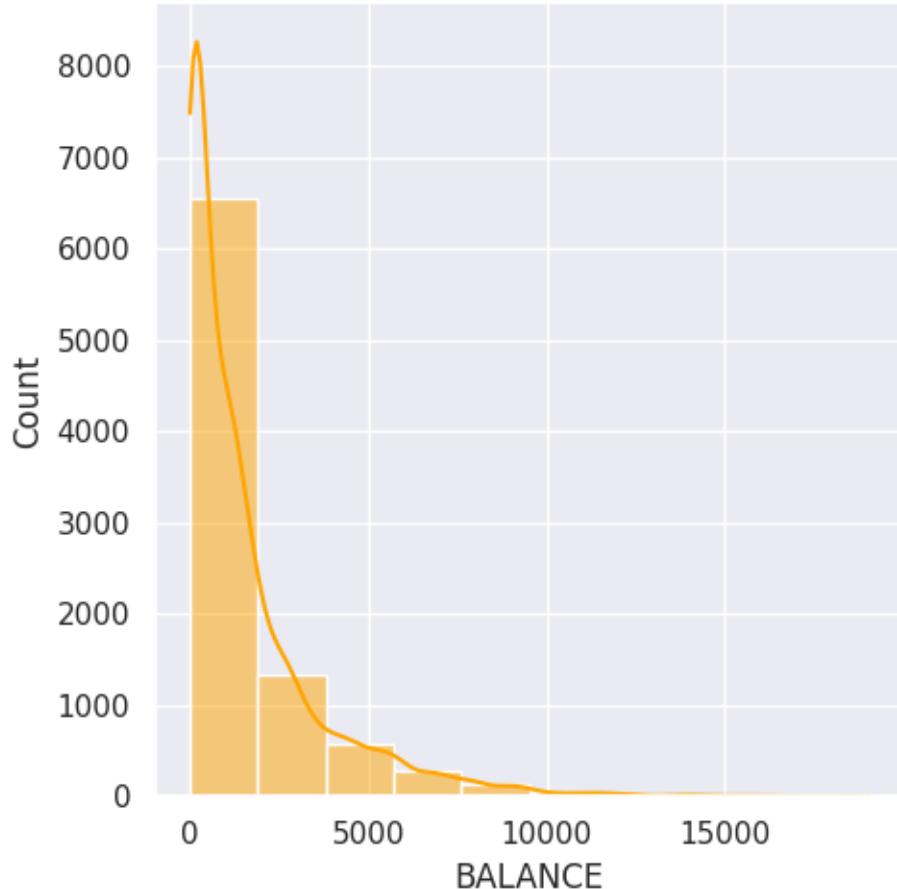
[10]: df.info()

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 8950 entries, 0 to 8949
Data columns (total 18 columns):
 #   Column           Non-Null Count  Dtype  
--- 
 0   CUST_ID          8950 non-null   object  
 1   BALANCE          8950 non-null   float64 
 2   BALANCE_FREQUENCY 8950 non-null   float64 
 3   PURCHASES        8950 non-null   float64 
 4   ONEOFF_PURCHASES 8950 non-null   float64 
 5   INSTALLMENTS_PURCHASES 8950 non-null   float64 
 6   CASH_ADVANCE     8950 non-null   float64 
 7   PURCHASES_FREQUENCY 8950 non-null   float64 
 8   ONEOFF_PURCHASES_FREQUENCY 8950 non-null   float64 
 9   PURCHASES_INSTALLMENTS_FREQUENCY 8950 non-null   float64 
 10  CASH_ADVANCE_FREQUENCY 8950 non-null   float64 
 11  CASH_ADVANCE_TRX 8950 non-null   int64   
 12  PURCHASES_TRX    8950 non-null   int64   
 13  CREDIT_LIMIT     8949 non-null   float64 
 14  PAYMENTS         8950 non-null   float64 
 15  MINIMUM_PAYMENTS 8637 non-null   float64 
 16  PRC_FULL_PAYMENT 8950 non-null   float64 
 17  TENURE           8950 non-null   int64   

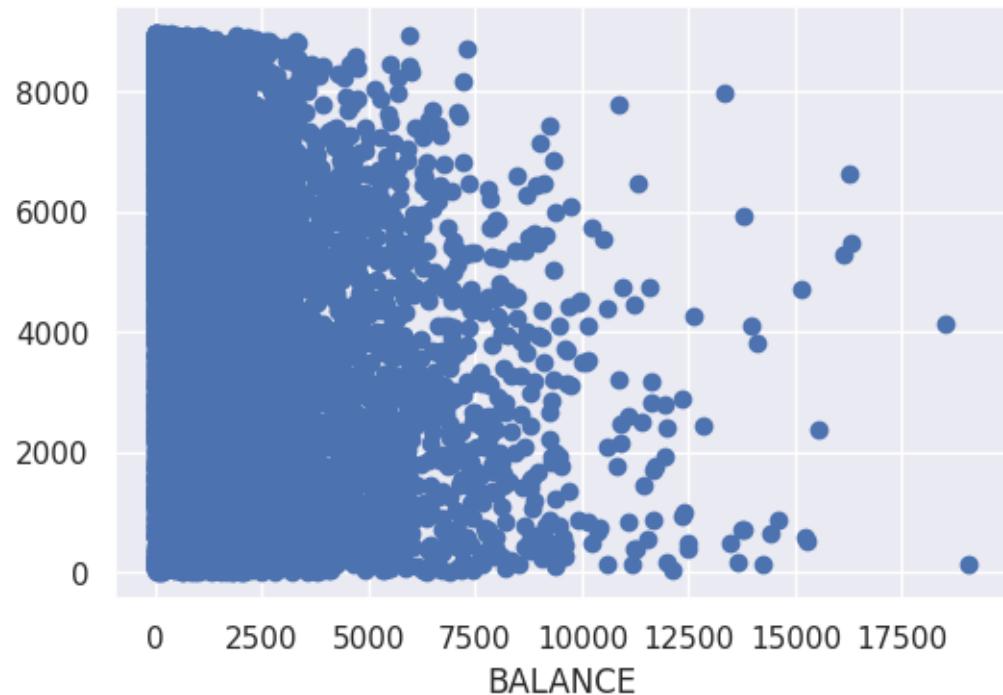
dtypes: float64(14), int64(3), object(1)
memory usage: 1.2+ MB
```

```
[11]: sns.set(rc={"figure.figsize":(6,4)})  
sns.displot(df["BALANCE"], kde=True, color="orange", bins=10)
```

```
[11]: <seaborn.axisgrid.FacetGrid at 0x78f2e1b73460>
```

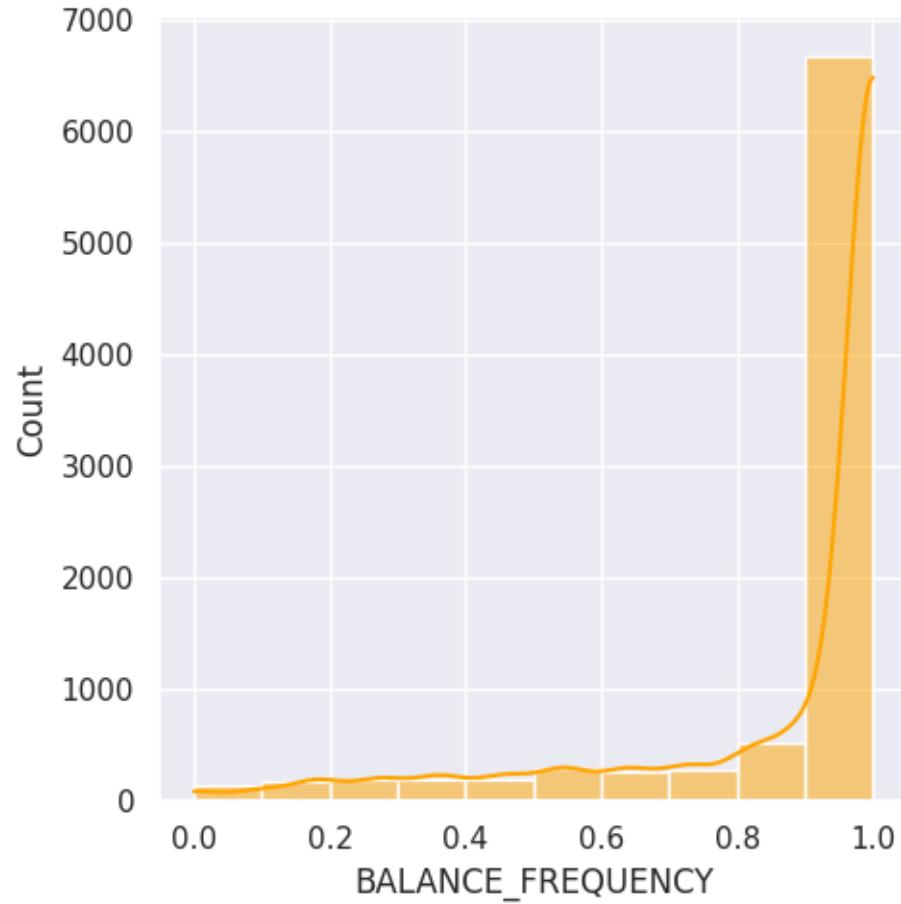


```
[12]: plt.figure(figsize=(6,4))  
plt.scatter(x=df['BALANCE'], y=df.index)  
plt.xlabel("BALANCE")  
plt.show()
```

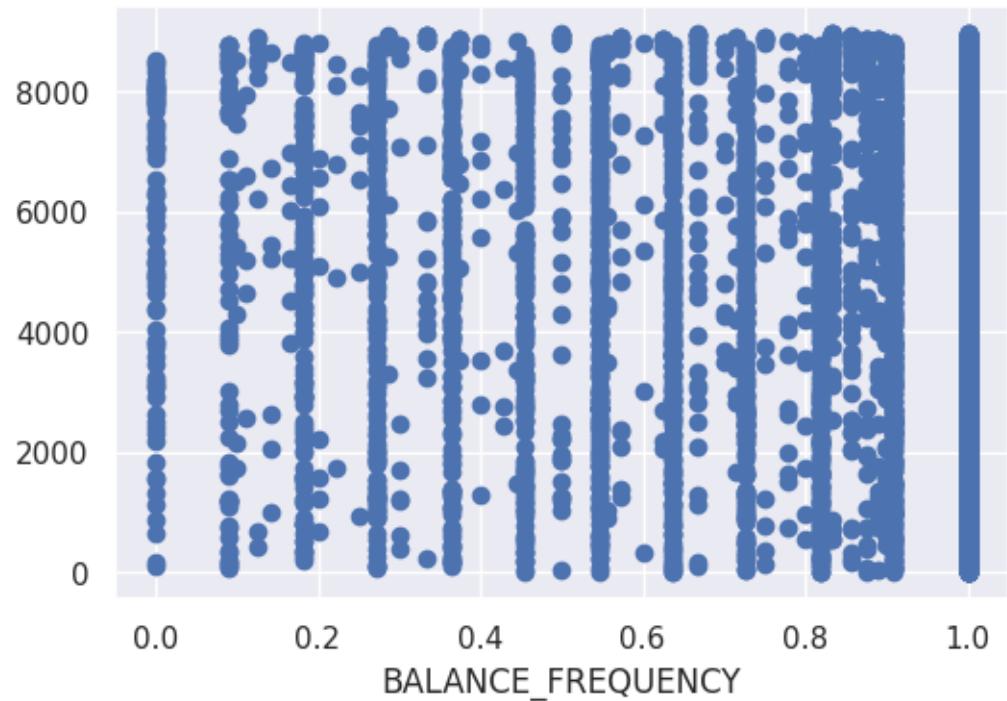


```
[13]: sns.set(rc={"figure.figsize":(6,4)})  
sns.displot(df["BALANCE_FREQUENCY"], kde=True, color="orange", bins=10)
```

```
[13]: <seaborn.axisgrid.FacetGrid at 0x78f2a1853700>
```

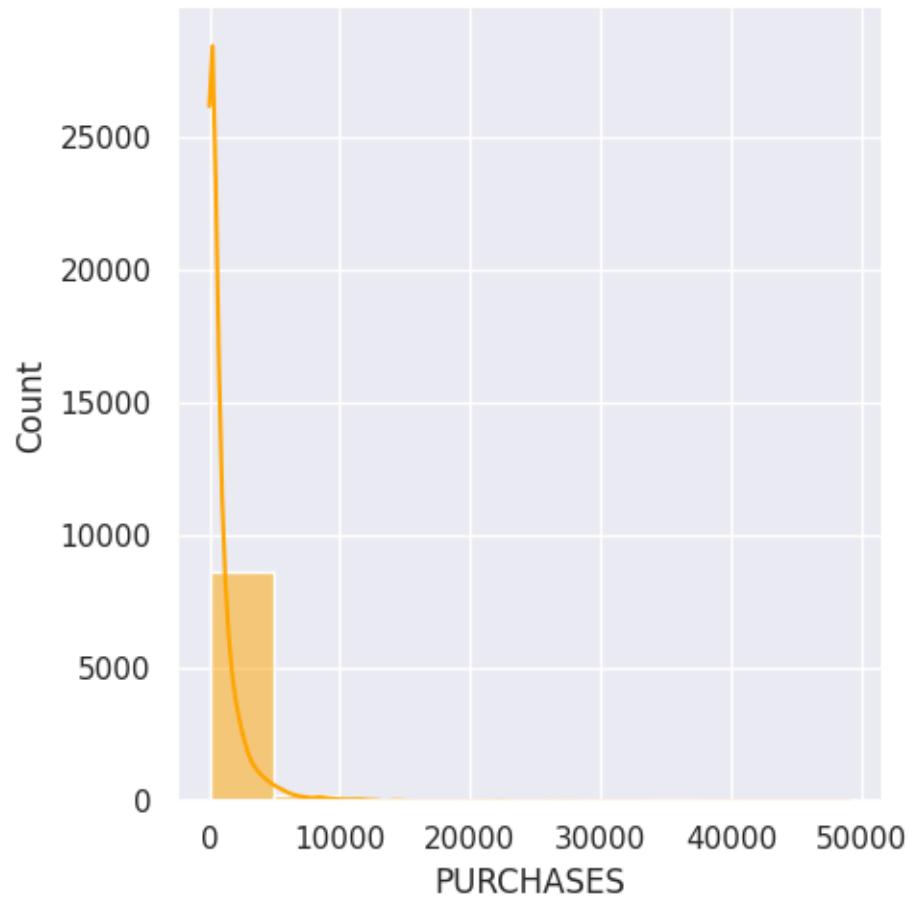


```
[14]: plt.figure(figsize=(6,4))
plt.scatter(x=df['BALANCE_FREQUENCY'], y=df.index)
plt.xlabel("BALANCE_FREQUENCY")
plt.show()
```

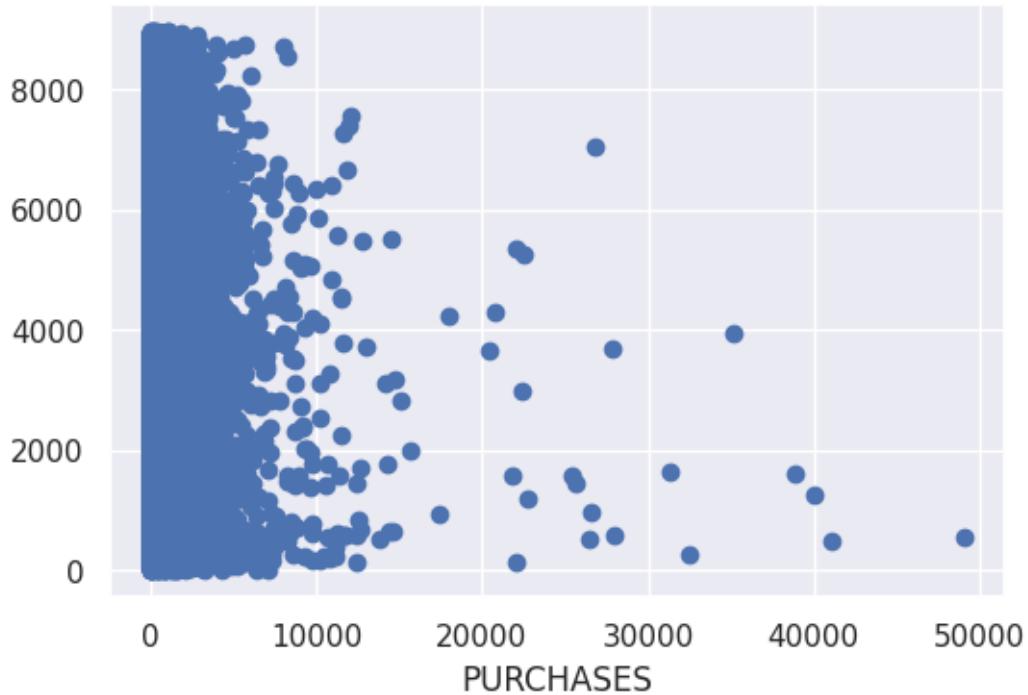


```
[15]: sns.set(rc={"figure.figsize":(6,4)})  
sns.displot(df["PURCHASES"], kde=True, color="orange", bins=10)
```

```
[15]: <seaborn.axisgrid.FacetGrid at 0x78f2a100a830>
```



```
[16]: plt.figure(figsize=(6,4))
plt.scatter(x=df['PURCHASES'], y=df.index)
plt.xlabel("PURCHASES")
plt.show()
```

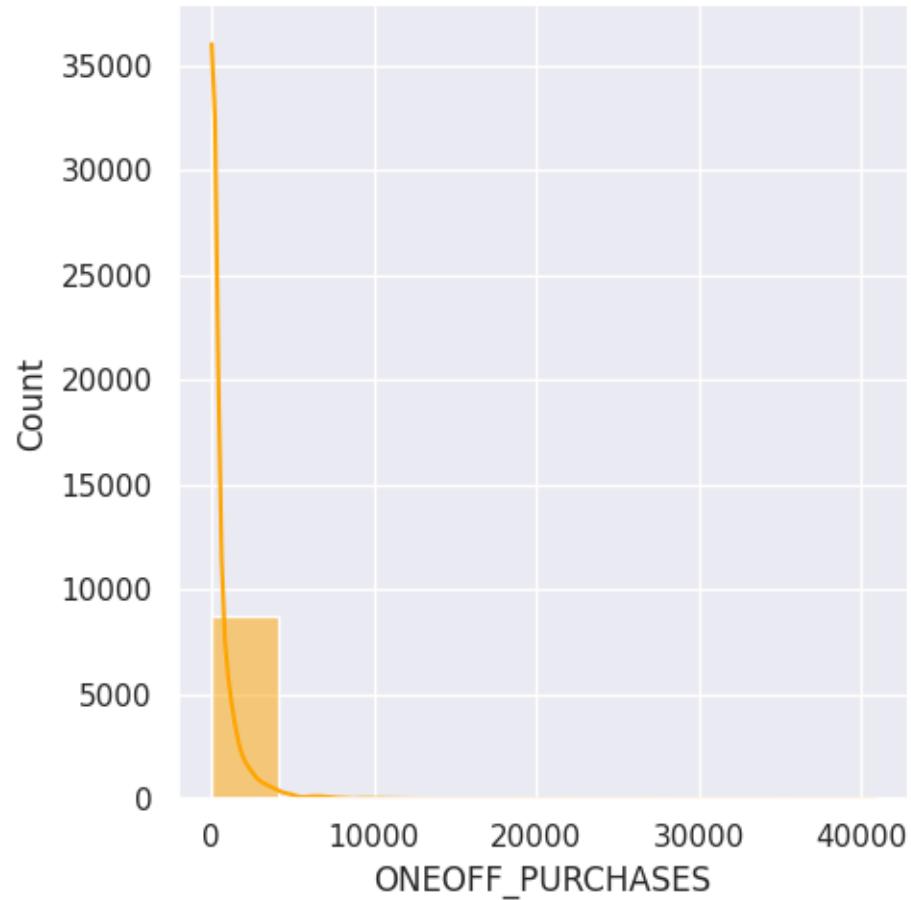


```
[17]: df["PURCHASES"].value_counts()
```

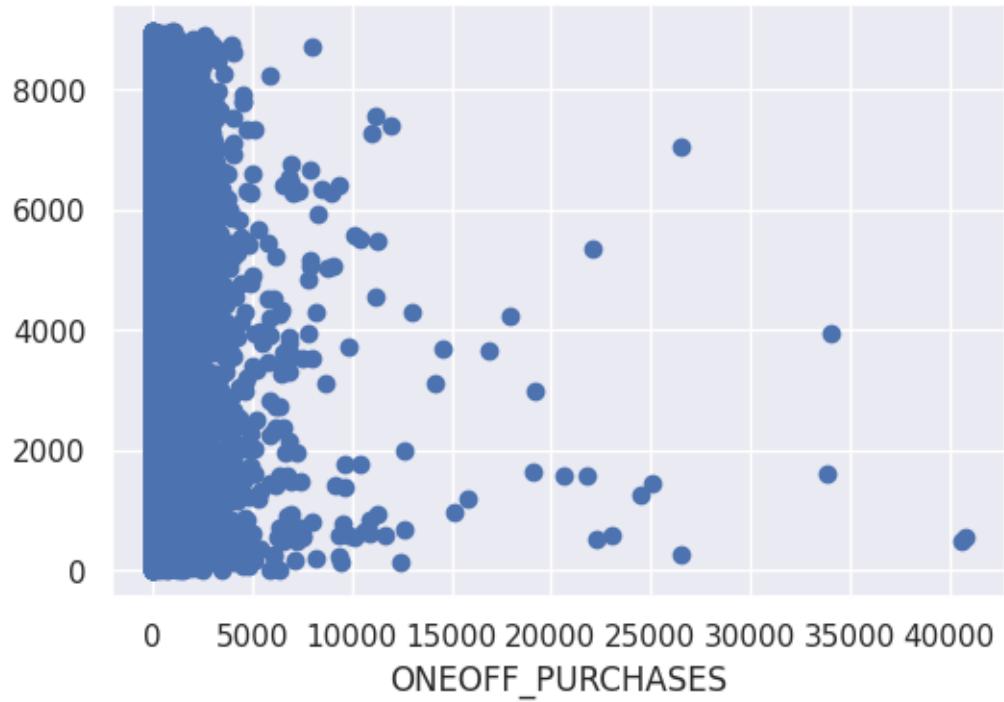
```
[17]: 0.00      2044
45.65      27
60.00      16
150.00     16
300.00     13
...
222.70      1
433.20      1
509.88      1
65.50      1
1093.25     1
Name: PURCHASES, Length: 6203, dtype: int64
```

```
[18]: sns.set(rc={"figure.figsize":(6,4)})
sns.displot(df["ONEOFF_PURCHASES"], kde=True, color="orange", bins=10)
```

```
[18]: <seaborn.axisgrid.FacetGrid at 0x78f29cd02f50>
```



```
[19]: plt.figure(figsize=(6,4))
plt.scatter(x=df['ONEOFF_PURCHASES'], y=df.index)
plt.xlabel("ONEOFF_PURCHASES")
plt.show()
```

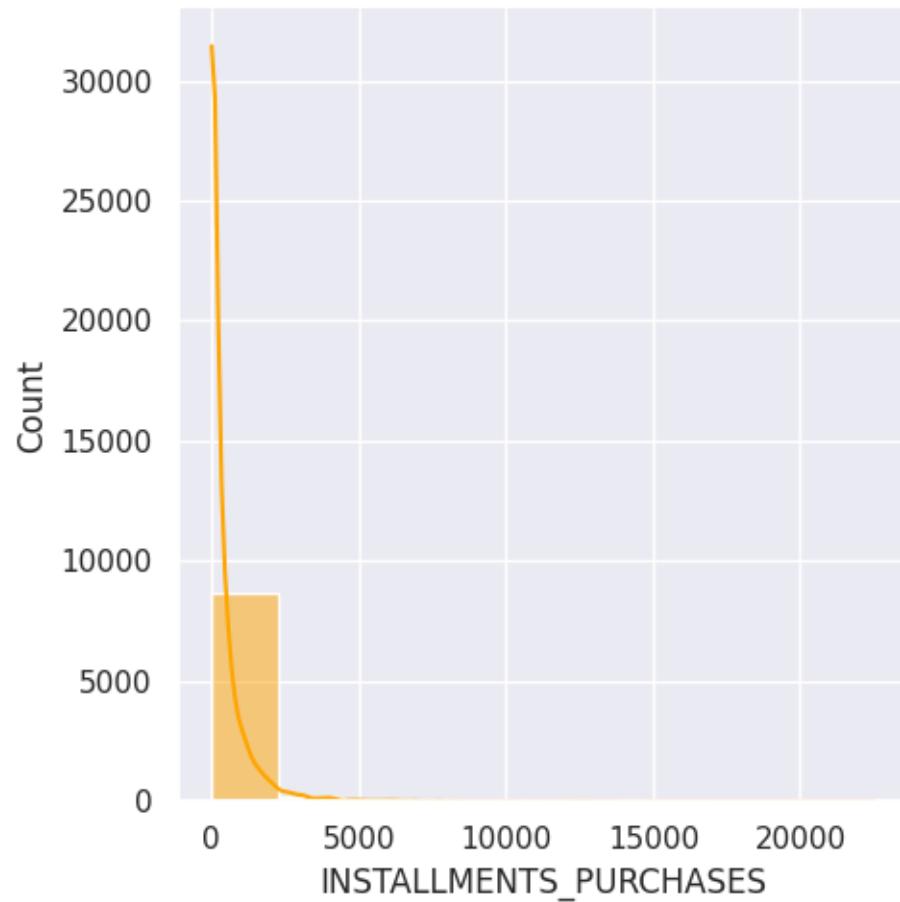


```
[20]: df["ONEOFF_PURCHASES"].value_counts()
```

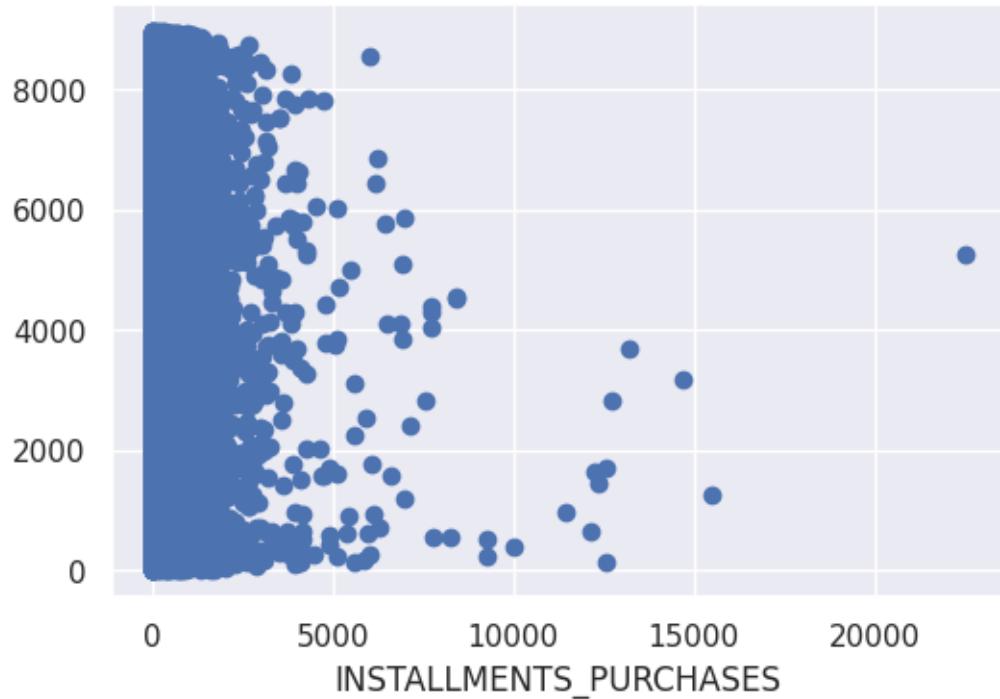
```
[20]: 0.00      4302
45.65      46
50.00      17
200.00     15
60.00      13
...
187.00      1
229.02      1
1020.00     1
75.50      1
1093.25     1
Name: ONEOFF_PURCHASES, Length: 4014, dtype: int64
```

```
[21]: sns.set(rc={"figure.figsize":(6,4)})
sns.displot(df["INSTALLMENTS_PURCHASES"], kde=True, color="orange", bins=10)
```

```
[21]: <seaborn.axisgrid.FacetGrid at 0x78f29c36af80>
```



```
[22]: plt.figure(figsize=(6,4))
plt.scatter(x=df['INSTALLMENTS_PURCHASES'], y=df.index)
plt.xlabel("INSTALLMENTS_PURCHASES")
plt.show()
```

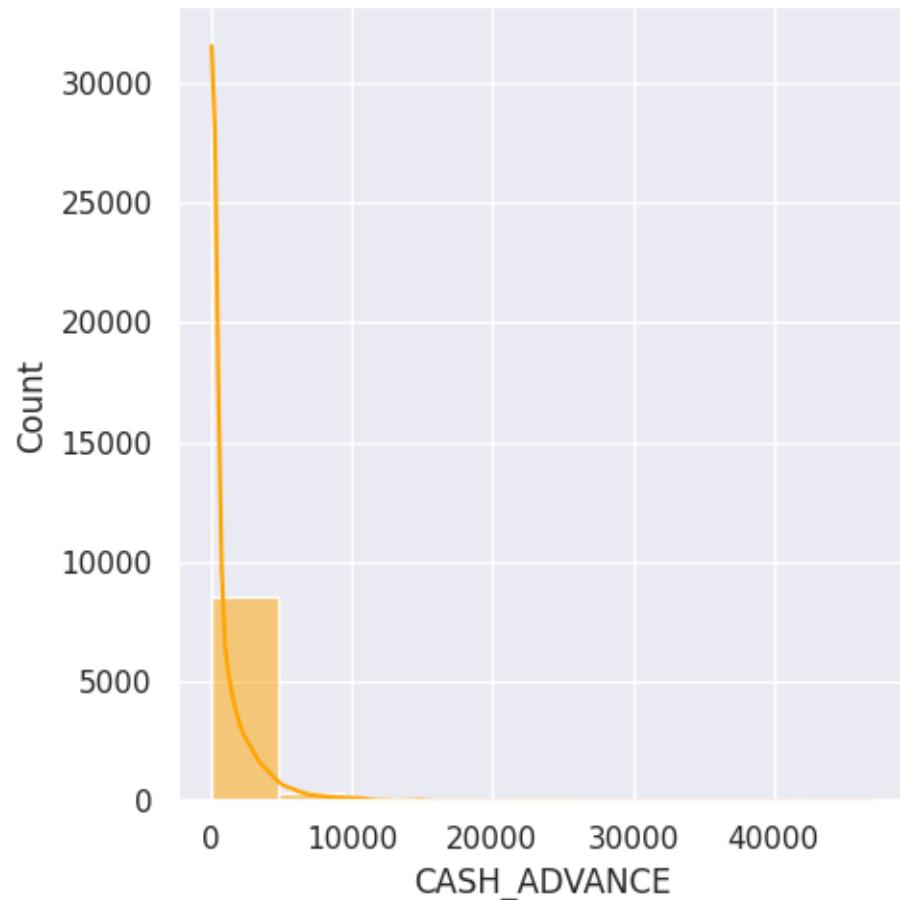


```
[23]: df["INSTALLMENTS_PURCHASES"].value_counts()
```

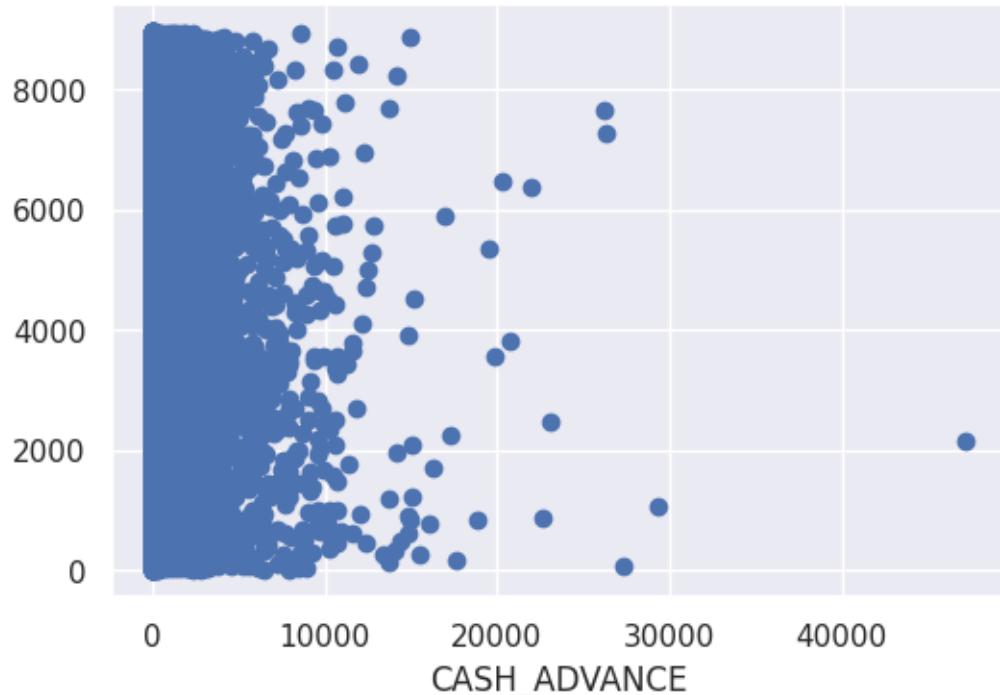
```
[23]: 0.00      3916
 300.00      14
 200.00      14
 100.00      14
 150.00      12
 ...
 276.62      1
 590.76      1
 945.46      1
 414.48      1
 144.40      1
Name: INSTALLMENTS_PURCHASES, Length: 4452, dtype: int64
```

```
[24]: sns.set(rc={"figure.figsize":(6,4)})
sns.displot(df["CASH_ADVANCE"], kde=True, color="orange", bins=10)
```

```
[24]: <seaborn.axisgrid.FacetGrid at 0x78f29c41a320>
```



```
[25]: plt.figure(figsize=(6,4))
plt.scatter(x=df['CASH_ADVANCE'], y=df.index)
plt.xlabel("CASH_ADVANCE")
plt.show()
```



```
[26]: df["CASH_ADVANCE"].value_counts()
```

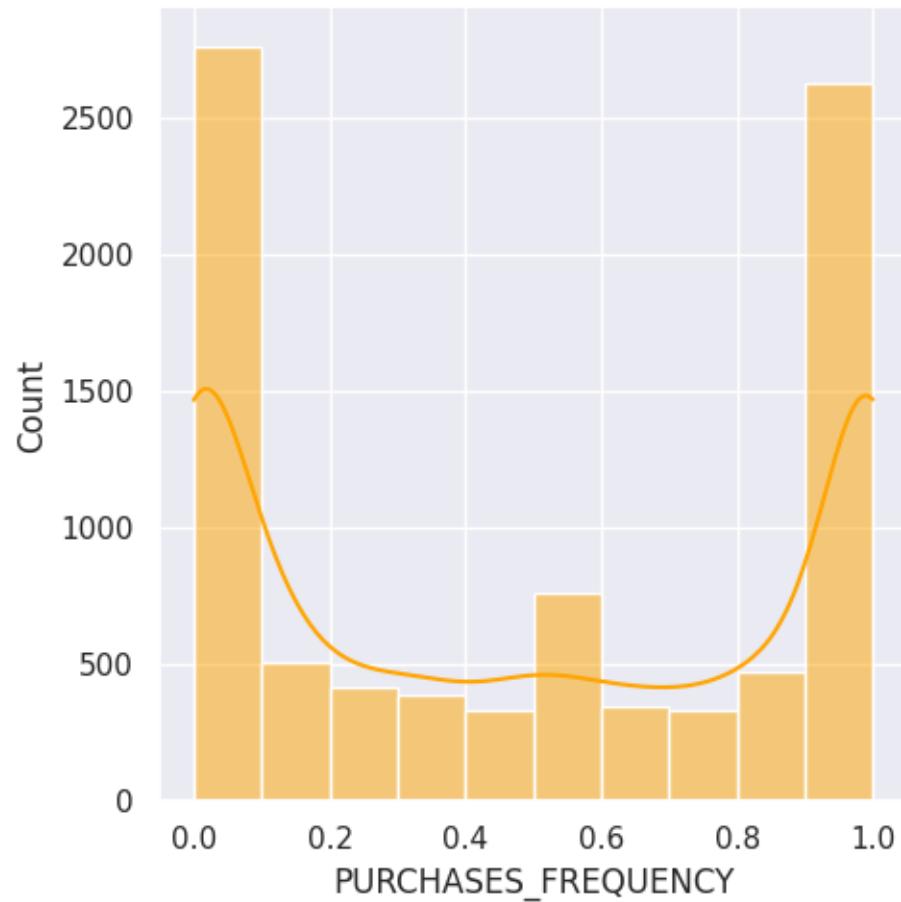
```
[26]:
```

0.000000	4628
495.425832	1
1486.243293	1
855.232779	1
3767.104707	1
..	
5187.029833	1
137.757459	1
124.941315	1
272.559361	1
127.040008	1

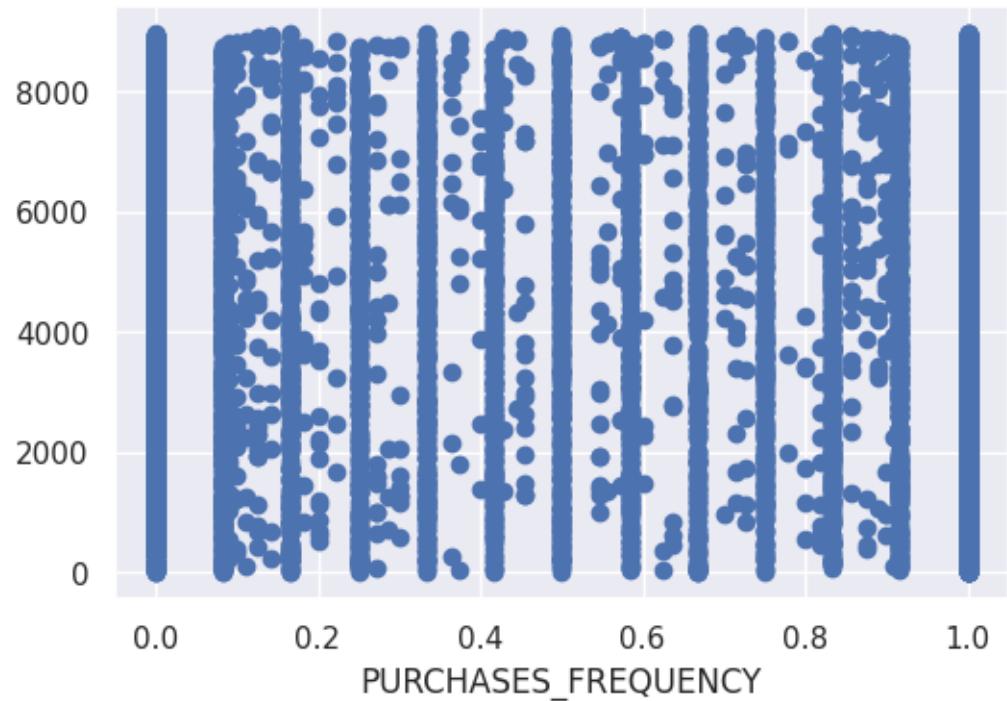
Name: CASH\_ADVANCE, Length: 4323, dtype: int64

```
[27]: sns.set(rc={"figure.figsize":(6,4)})  
sns.displot(df["PURCHASES_FREQUENCY"], kde=True, color="orange", bins=10)
```

```
[27]: <seaborn.axisgrid.FacetGrid at 0x78f29c2abfd0>
```

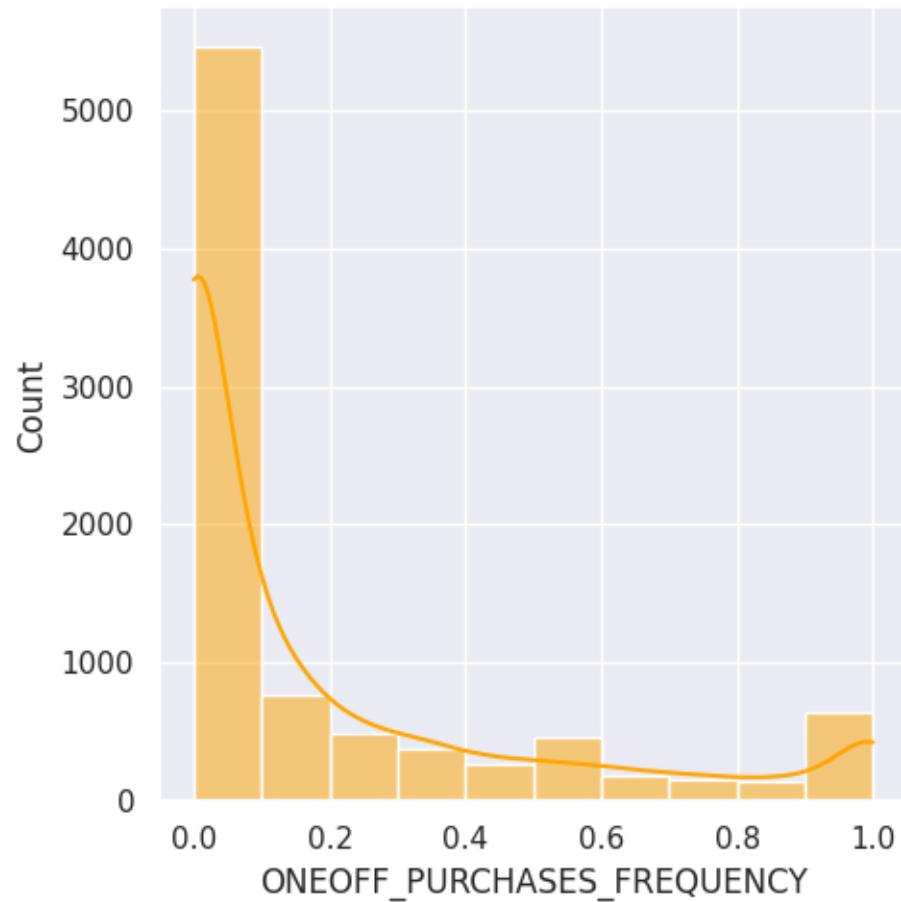


```
[28]: plt.figure(figsize=(6,4))
plt.scatter(x=df['PURCHASES_FREQUENCY'], y=df.index)
plt.xlabel("PURCHASES_FREQUENCY")
plt.show()
```

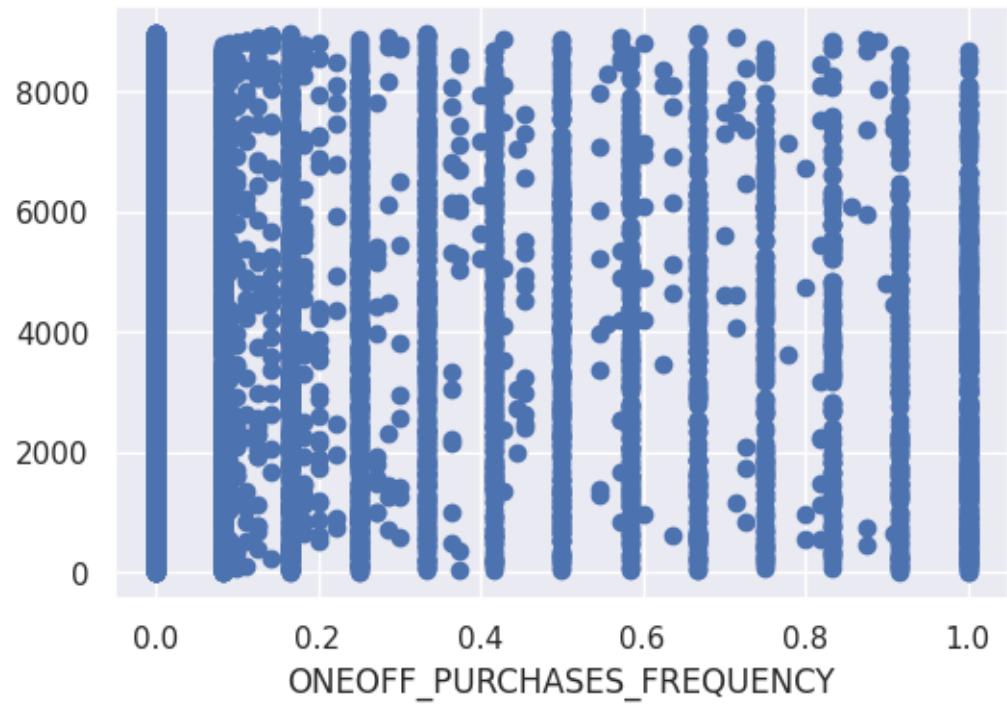


```
[29]: sns.set(rc={"figure.figsize":(6,4)})  
sns.displot(df["ONEOFF_PURCHASES_FREQUENCY"], kde=True, color="orange", bins=10)
```

```
[29]: <seaborn.axisgrid.FacetGrid at 0x78f29c36bbe0>
```

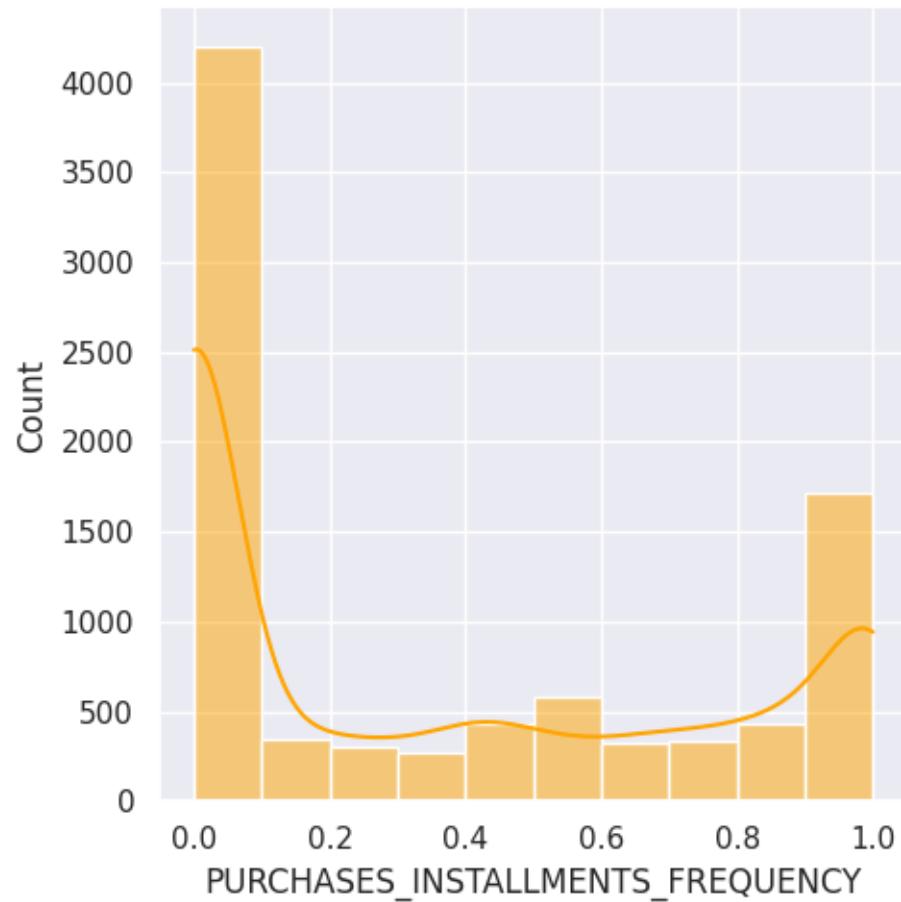


```
[30]: plt.figure(figsize=(6,4))
plt.scatter(x=df['ONEOFF_PURCHASES_FREQUENCY'], y=df.index)
plt.xlabel("ONEOFF_PURCHASES_FREQUENCY")
plt.show()
```

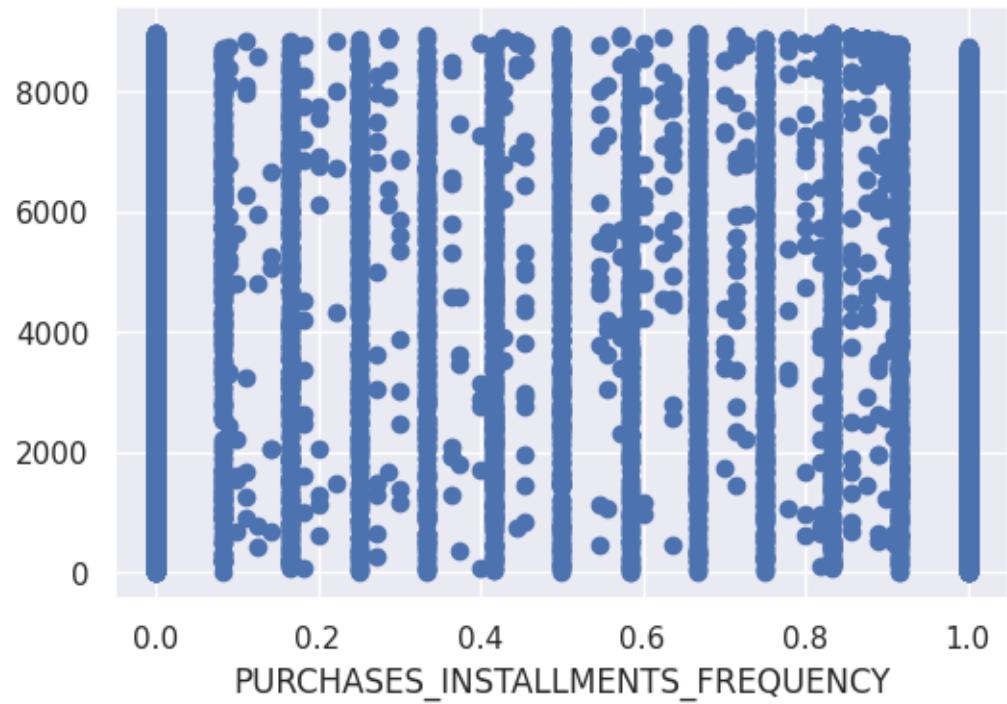


```
[31]: sns.set(rc={"figure.figsize":(6,4)})  
sns.displot(df["PURCHASES_INSTALLMENTS_FREQUENCY"], kde=True, color="orange",  
           bins=10)
```

```
[31]: <seaborn.axisgrid.FacetGrid at 0x78f2a1851210>
```

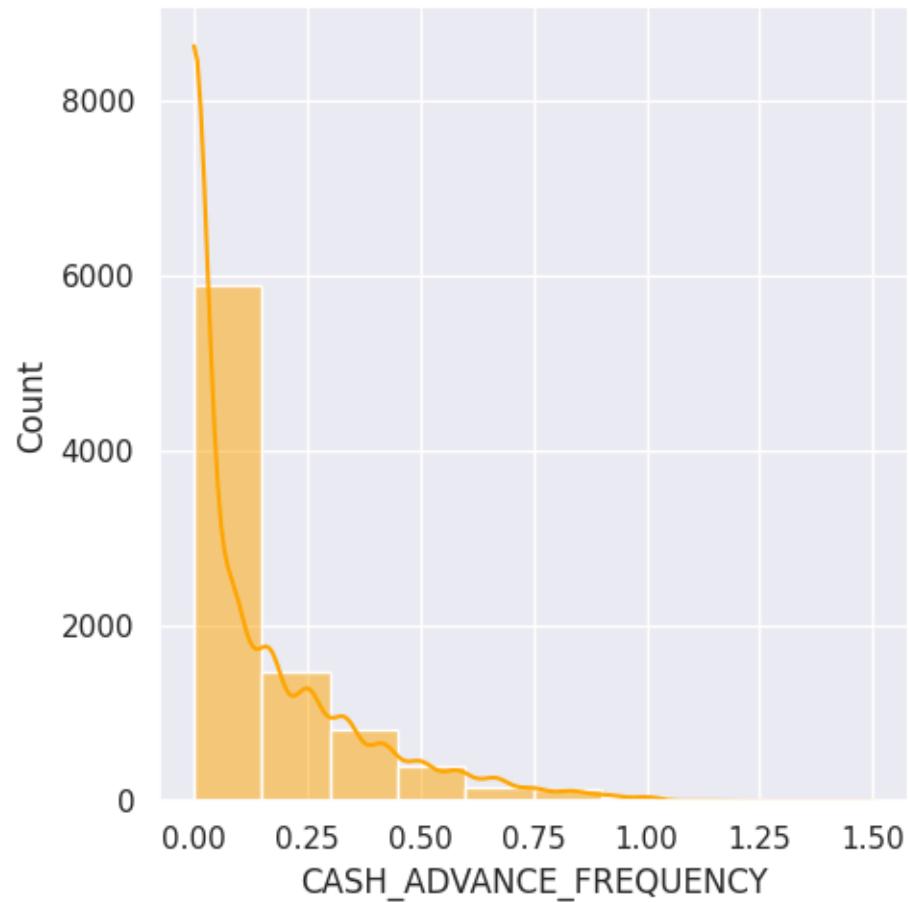


```
[32]: plt.figure(figsize=(6,4))
plt.scatter(x=df['PURCHASES_INSTALLMENTS_FREQUENCY'], y=df.index)
plt.xlabel("PURCHASES_INSTALLMENTS_FREQUENCY")
plt.show()
```

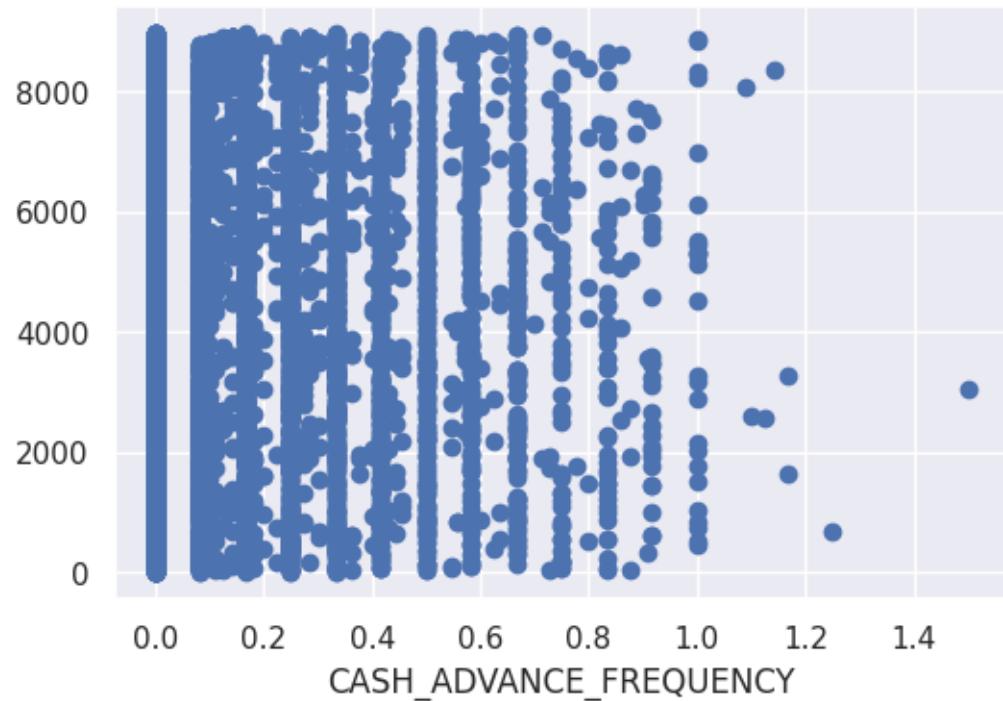


```
[33]: sns.set(rc={"figure.figsize":(6,4)})  
sns.displot(df["CASH_ADVANCE_FREQUENCY"], kde=True, color="orange", bins=10)
```

```
[33]: <seaborn.axisgrid.FacetGrid at 0x78f29cee6290>
```

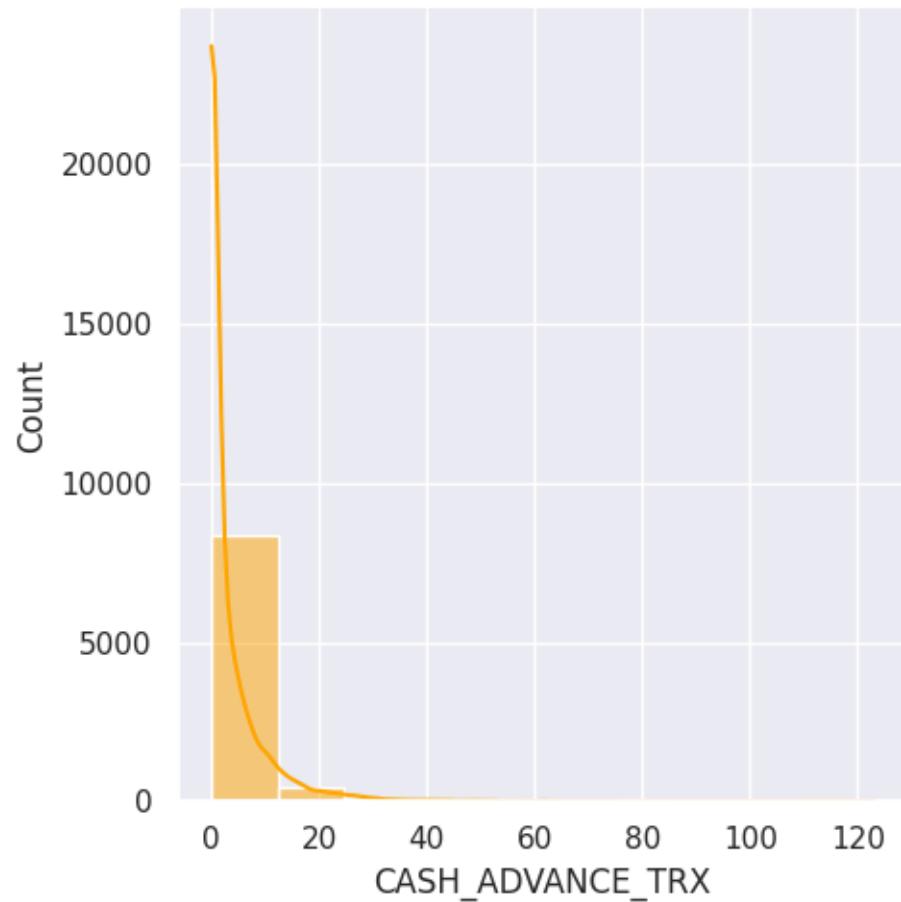


```
[34]: plt.figure(figsize=(6,4))
plt.scatter(x=df['CASH_ADVANCE_FREQUENCY'], y=df.index)
plt.xlabel("CASH_ADVANCE_FREQUENCY")
plt.show()
```

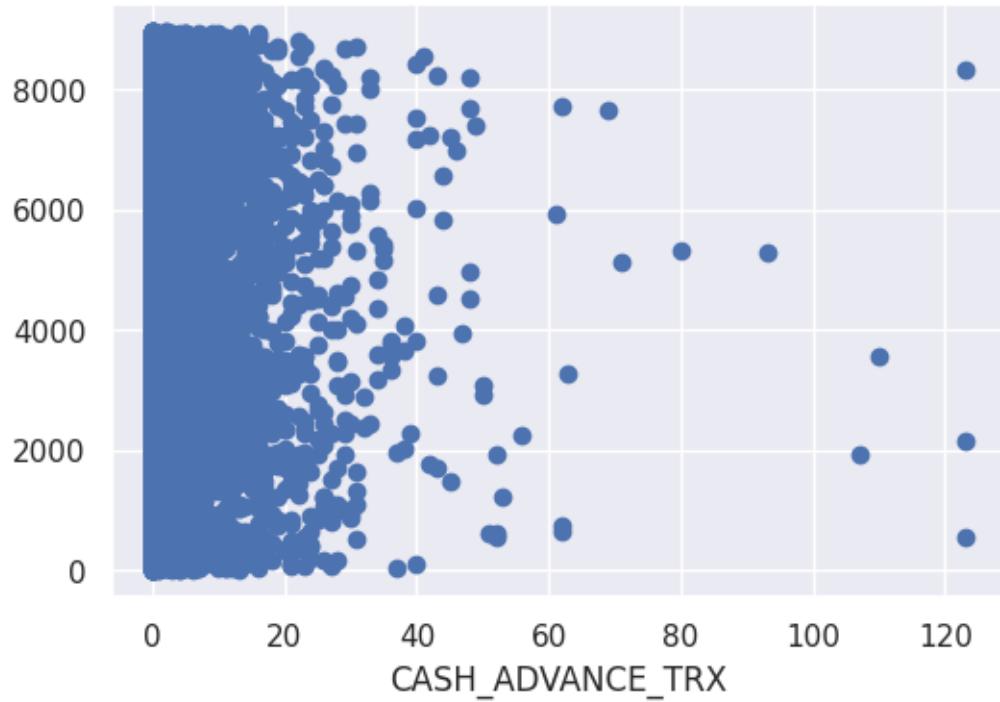


```
[35]: sns.set(rc={"figure.figsize":(6,4)})  
sns.displot(df["CASH_ADVANCE_TRX"], kde=True, color="orange", bins=10)
```

```
[35]: <seaborn.axisgrid.FacetGrid at 0x78f29c127370>
```



```
[36]: plt.figure(figsize=(6,4))
plt.scatter(x=df['CASH_ADVANCE_TRX'], y=df.index)
plt.xlabel("CASH_ADVANCE_TRX")
plt.show()
```

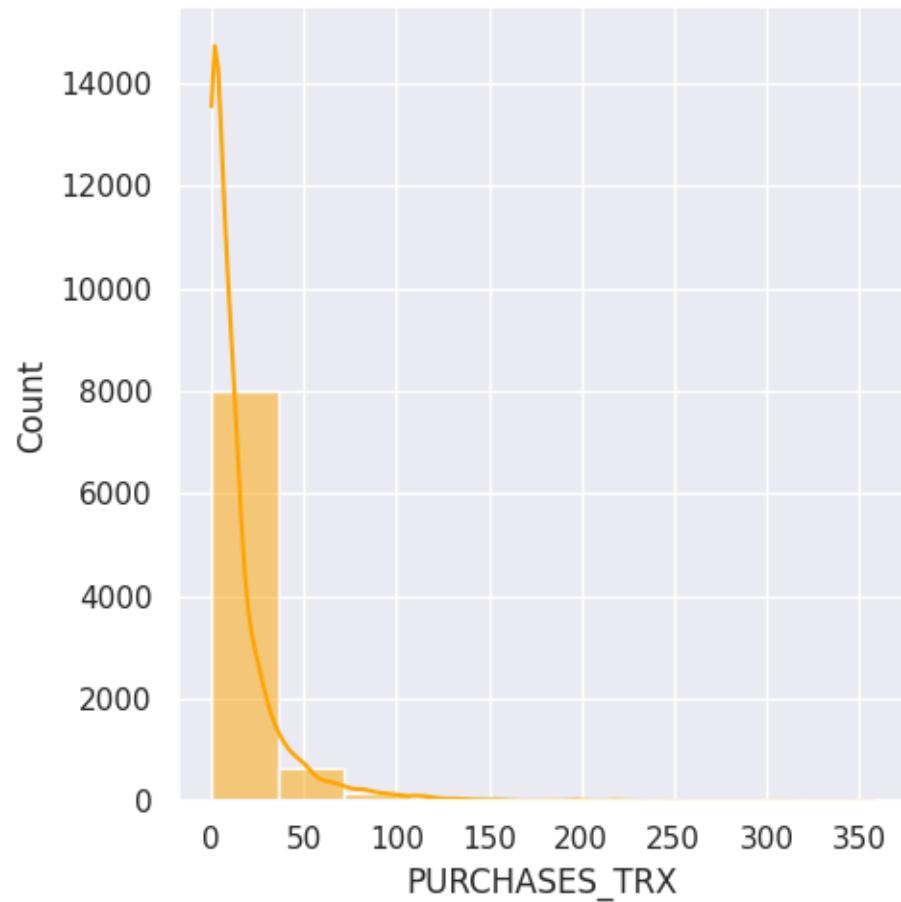


```
[37]: df["CASH_ADVANCE_TRX"].value_counts()
```

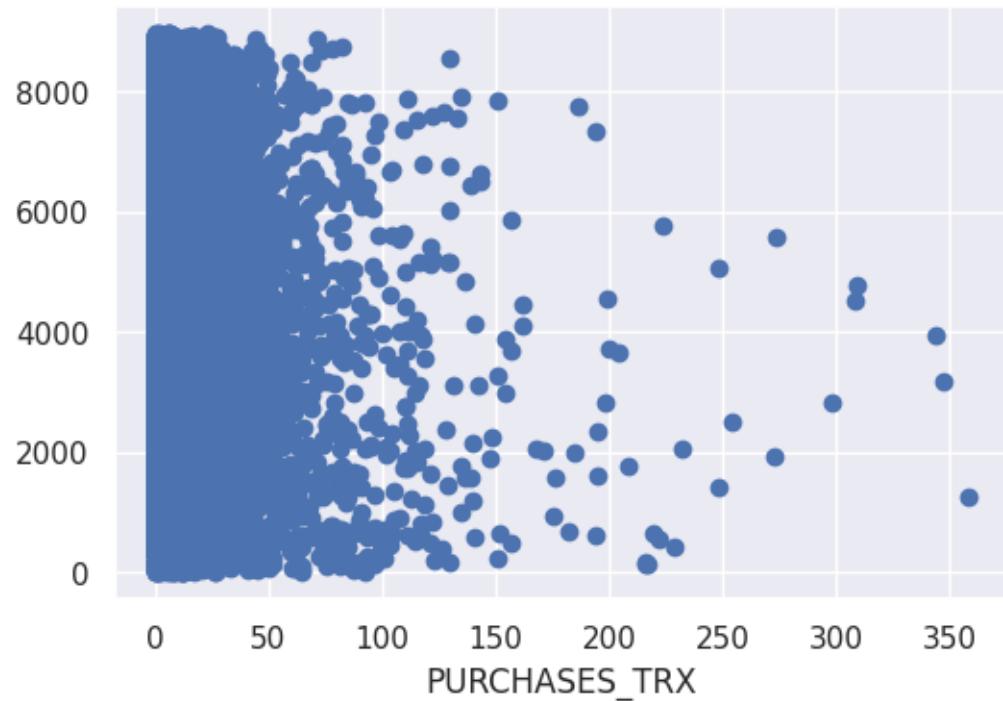
```
[37]: 0      4628
1      887
2      620
3      436
4      384
...
39      1
56      1
107     1
53      1
41      1
Name: CASH_ADVANCE_TRX, Length: 65, dtype: int64
```

```
[38]: sns.set(rc={"figure.figsize":(6,4)})
sns.displot(df["PURCHASES_TRX"], kde=True, color="orange", bins=10)
```

```
[38]: <seaborn.axisgrid.FacetGrid at 0x78f296fdece0>
```

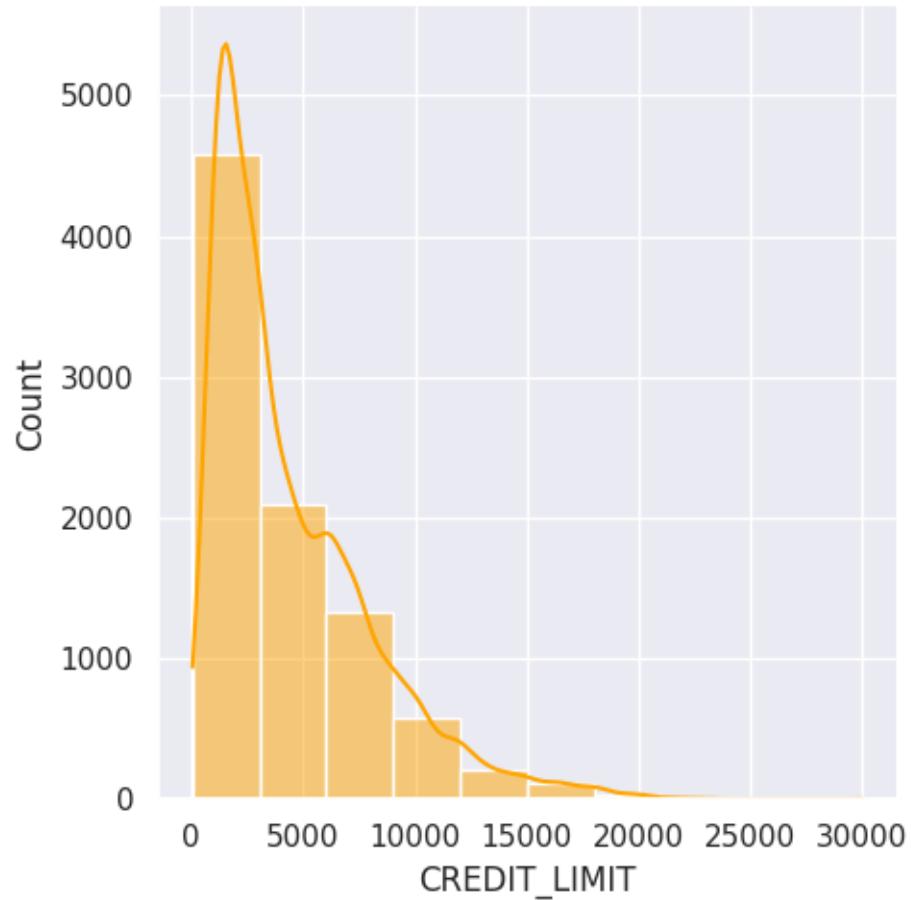


```
[39]: plt.figure(figsize=(6,4))
plt.scatter(x=df['PURCHASES_TRX'], y=df.index)
plt.xlabel("PURCHASES_TRX")
plt.show()
```

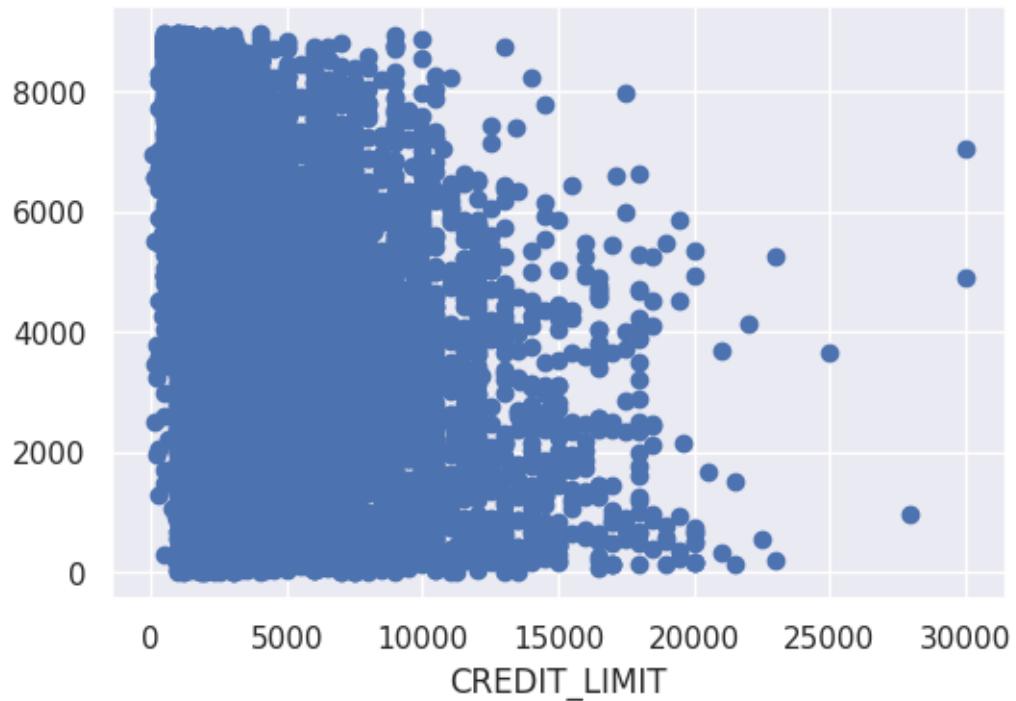


```
[40]: sns.set(rc={"figure.figsize":(6,4)})  
sns.displot(df["CREDIT_LIMIT"], kde=True, color="orange", bins=10)
```

```
[40]: <seaborn.axisgrid.FacetGrid at 0x78f296ee3a90>
```

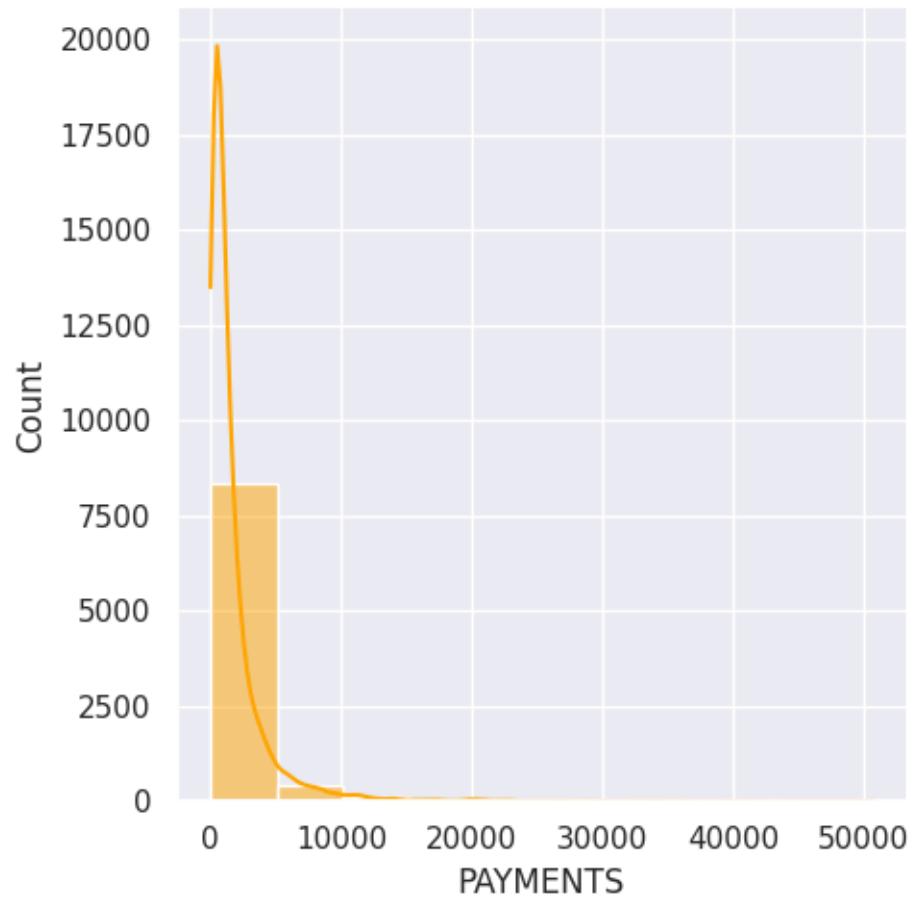


```
[41]: plt.figure(figsize=(6,4))
plt.scatter(x=df['CREDIT_LIMIT'], y=df.index)
plt.xlabel("CREDIT_LIMIT")
plt.show()
```

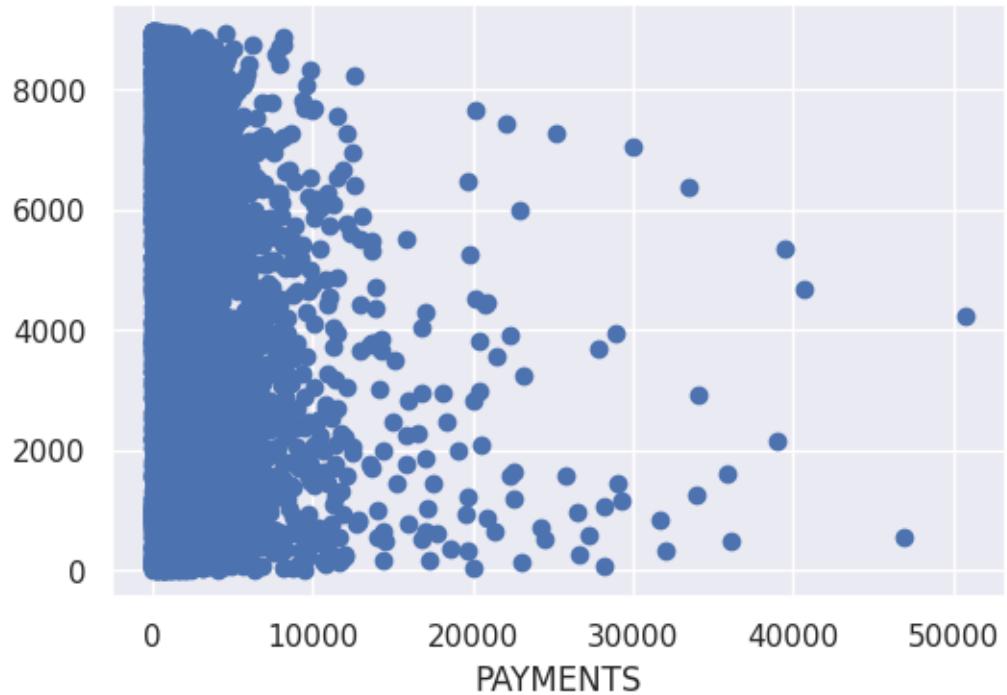


```
[42]: sns.set(rc={"figure.figsize":(6,4)})  
sns.displot(df["PAYMENTS"], kde=True, color="orange", bins=10)
```

```
[42]: <seaborn.axisgrid.FacetGrid at 0x78f296d62710>
```



```
[43]: plt.figure(figsize=(6,4))
plt.scatter(x=df['PAYMENTS'], y=df.index)
plt.xlabel("PAYMENTS")
plt.show()
```



```
[44]: df["PAYMENTS"].value_counts()
```

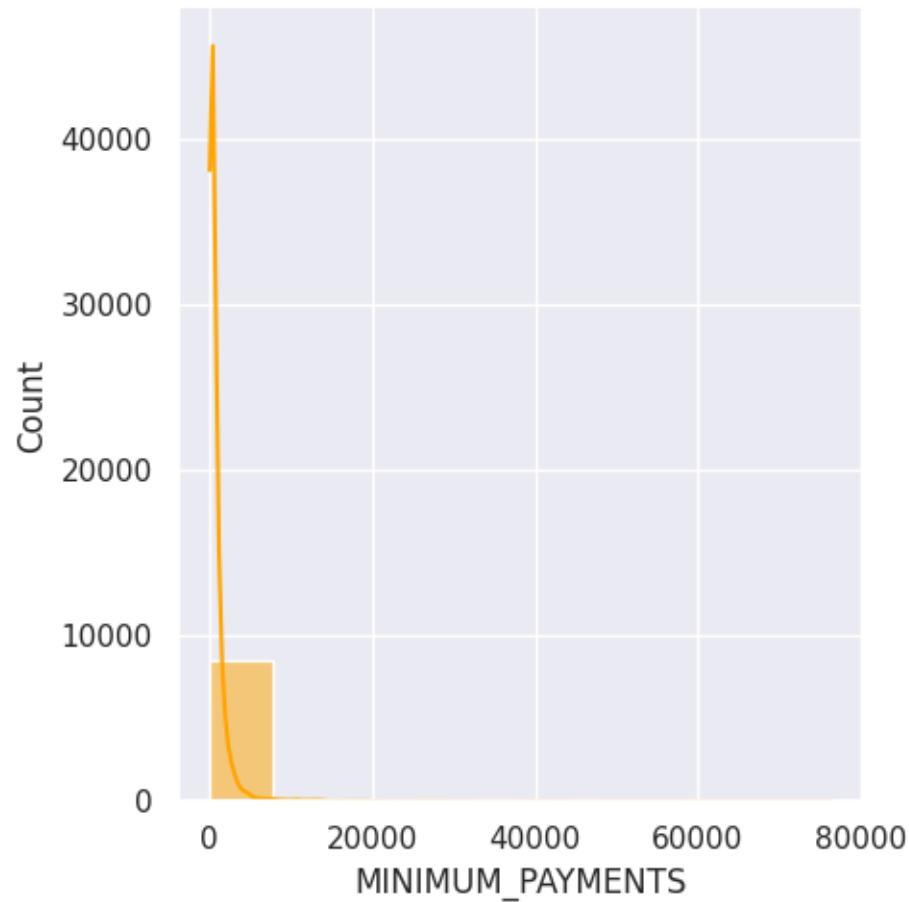
```
[44]:
```

0.000000	240
201.802084	1
398.316441	1
826.036748	1
2571.573214	1
...	
14176.748670	1
6200.550587	1
1877.023036	1
372.093413	1
63.165404	1

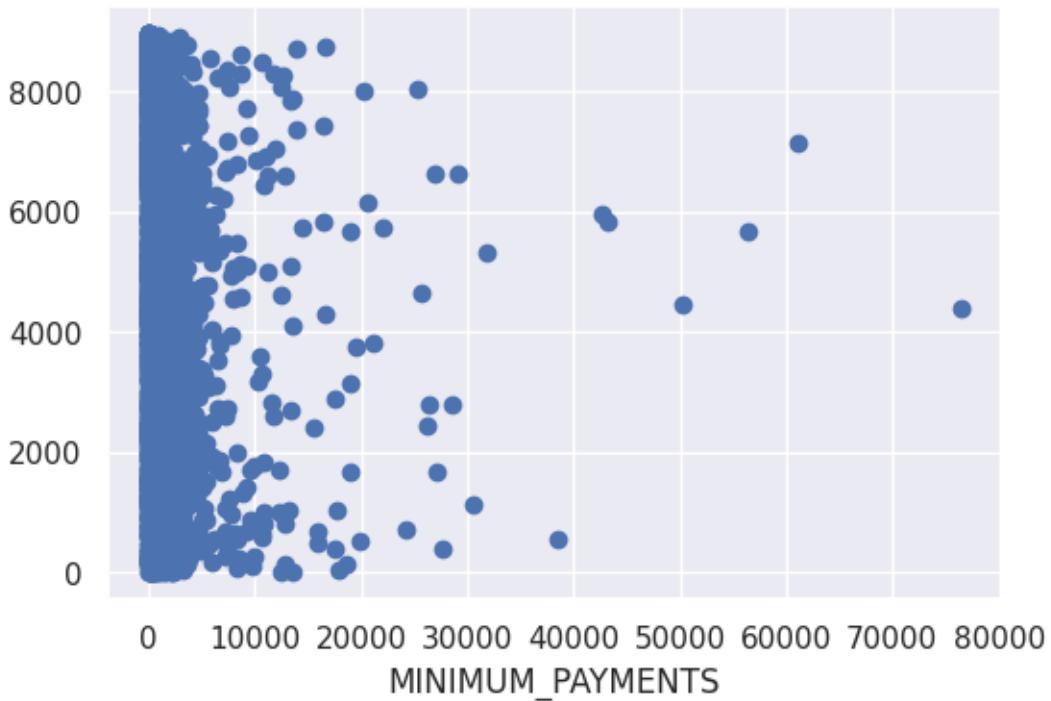
Name: PAYMENTS, Length: 8711, dtype: int64

```
[45]: sns.set(rc={"figure.figsize":(6,4)})  
sns.displot(df["MINIMUM_PAYMENTS"], kde=True, color="orange", bins=10)
```

```
[45]: <seaborn.axisgrid.FacetGrid at 0x78f296c5a4d0>
```



```
[46]: plt.figure(figsize=(6,4))
plt.scatter(x=df['MINIMUM_PAYMENTS'], y=df.index)
plt.xlabel("MINIMUM_PAYMENTS")
plt.show()
```



```
[47]: df["MINIMUM_PAYMENTS"].value_counts()
```

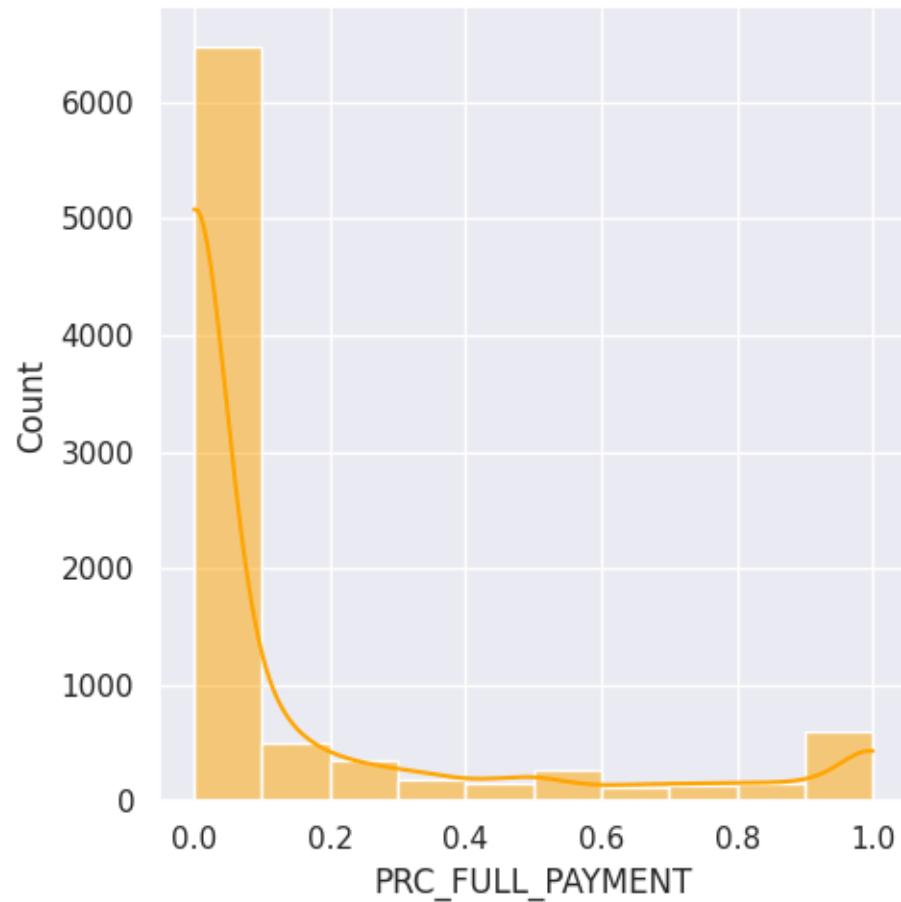
```
[47]:
```

299.351881	2
342.286490	1
184.464721	1
276.486072	1
309.140865	1
..	
181.773223	1
711.894455	1
256.522546	1
127.799107	1
88.288956	1

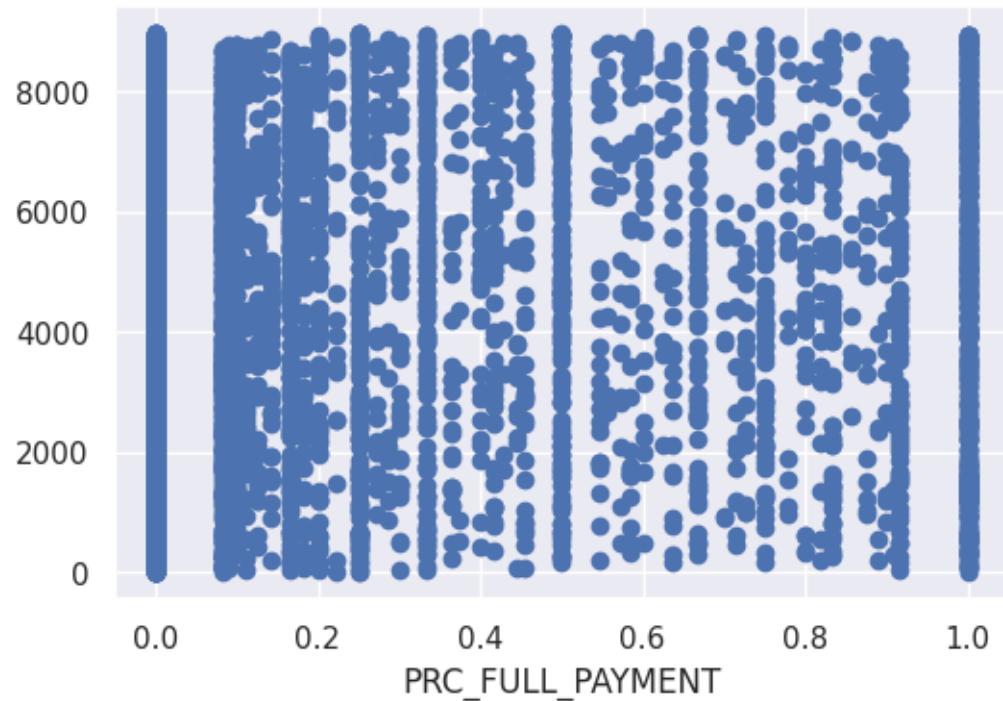
```
Name: MINIMUM_PAYMENTS, Length: 8636, dtype: int64
```

```
[48]: sns.set(rc={"figure.figsize":(6,4)})  
sns.displot(df["PRC_FULL_PAYMENT"], kde=True, color="orange", bins=10)
```

```
[48]: <seaborn.axisgrid.FacetGrid at 0x78f296b5a9e0>
```

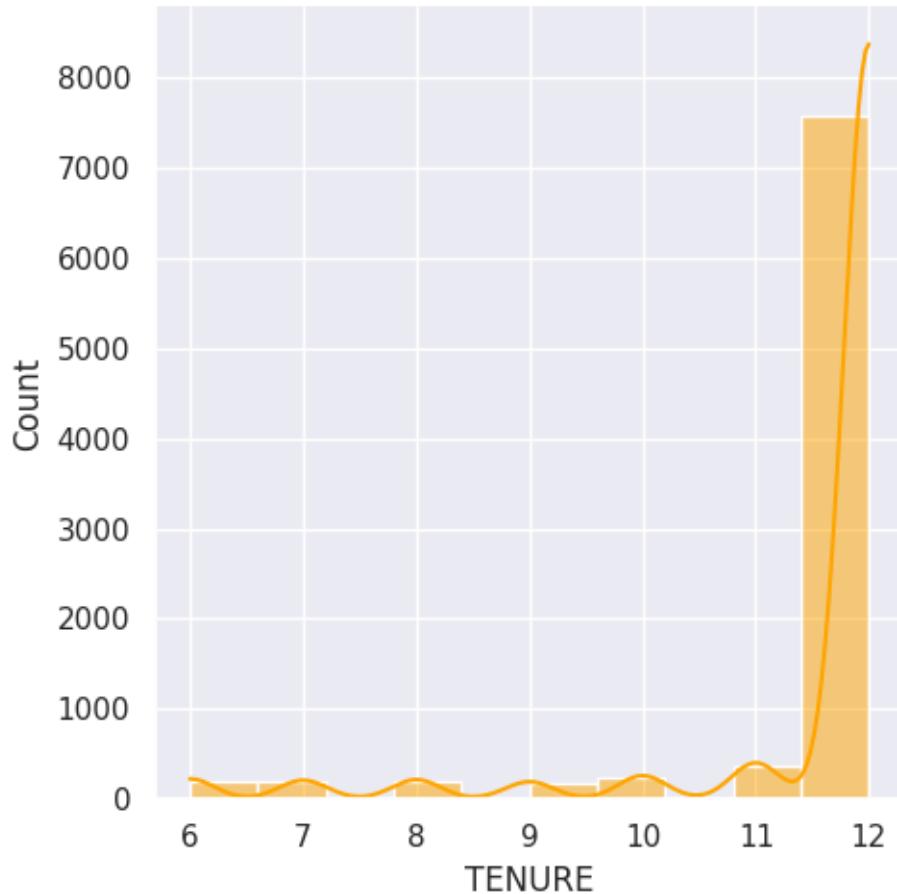


```
[49]: plt.figure(figsize=(6,4))
plt.scatter(x=df['PRC_FULL_PAYMENT'], y=df.index)
plt.xlabel("PRC_FULL_PAYMENT")
plt.show()
```

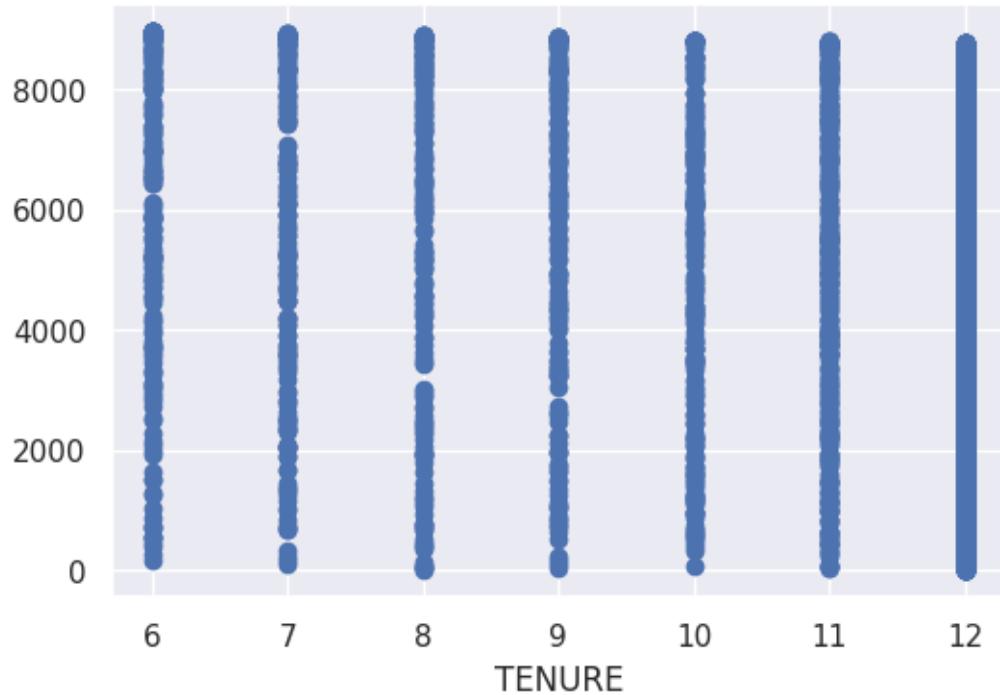


```
[50]: sns.set(rc={"figure.figsize":(6,4)})  
sns.displot(df["TENURE"], kde=True, color="orange", bins=10)
```

```
[50]: <seaborn.axisgrid.FacetGrid at 0x78f296b92680>
```



```
[51]: plt.figure(figsize=(6,4))
plt.scatter(x=df['TENURE'], y=df.index)
plt.xlabel("TENURE")
plt.show()
```



## 6 EDA (Exploratory Data Analysis)

### Remove Duplicate

```
[52]: duplicate = df.duplicated()  
print(duplicate.sum())
```

0

### Check And Remove NaN Values

```
[53]: df.isnull().sum()
```

```
[53]: CUST_ID                      0  
BALANCE                       0  
BALANCE_FREQUENCY              0  
PURCHASES                      0  
ONEOFF_PURCHASES               0  
INSTALLMENTS_PURCHASES         0  
CASH_ADVANCE                   0  
PURCHASES_FREQUENCY             0  
ONEOFF_PURCHASES_FREQUENCY     0  
PURCHASES_INSTALLMENTS_FREQUENCY 0  
CASH_ADVANCE_FREQUENCY          0  
CASH_ADVANCE_TRX                0
```

```
PURCHASES_TRX          0  
CREDIT_LIMIT           1  
PAYMENTS               0  
MINIMUM_PAYMENTS      313  
PRC_FULL_PAYMENT       0  
TENURE                 0  
dtype: int64
```

```
[54]: df["CREDIT_LIMIT"].value_counts()
```

```
3000.000000    784  
1500.000000    722  
1200.000000    621  
1000.000000    614  
2500.000000    612  
...  
9200.000000     1  
13550.000000    1  
7227.272727     1  
11250.000000    1  
1833.333333     1  
Name: CREDIT_LIMIT, Length: 205, dtype: int64
```

```
[55]: df["CREDIT_LIMIT"] = df["CREDIT_LIMIT"].fillna(df["CREDIT_LIMIT"].mean())
```

```
[56]: df.isnull().sum()
```

```
CUST_ID                  0  
BALANCE                  0  
BALANCE_FREQUENCY         0  
PURCHASES                0  
ONEOFF_PURCHASES         0  
INSTALLMENTS_PURCHASES   0  
CASH_ADVANCE              0  
PURCHASES_FREQUENCY       0  
ONEOFF_PURCHASES_FREQUENCY 0  
PURCHASES_INSTALLMENTS_FREQUENCY 0  
CASH_ADVANCE_FREQUENCY    0  
CASH_ADVANCE_TRX          0  
PURCHASES_TRX             0  
CREDIT_LIMIT               0  
PAYMENTS                 0  
MINIMUM_PAYMENTS          313  
PRC_FULL_PAYMENT          0  
TENURE                   0  
dtype: int64
```

```
[57]: df["MINIMUM_PAYMENTS"].value_counts()
```

```
[57]: 299.351881      2  
342.286490      1  
184.464721      1  
276.486072      1  
309.140865      1  
..  
181.773223      1  
711.894455      1  
256.522546      1  
127.799107      1  
88.288956      1  
Name: MINIMUM_PAYMENTS, Length: 8636, dtype: int64
```

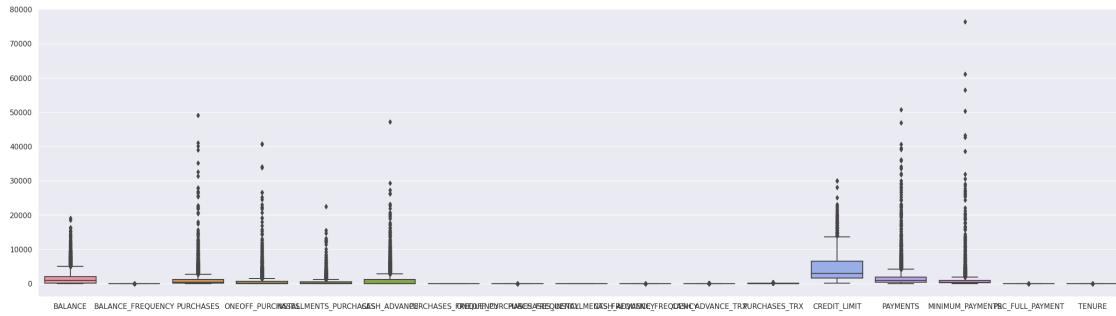
```
[58]: df["MINIMUM_PAYMENTS"] = df["MINIMUM_PAYMENTS"].fillna(df["MINIMUM_PAYMENTS"].  
                           .mean())
```

```
[59]: df.isnull().sum()
```

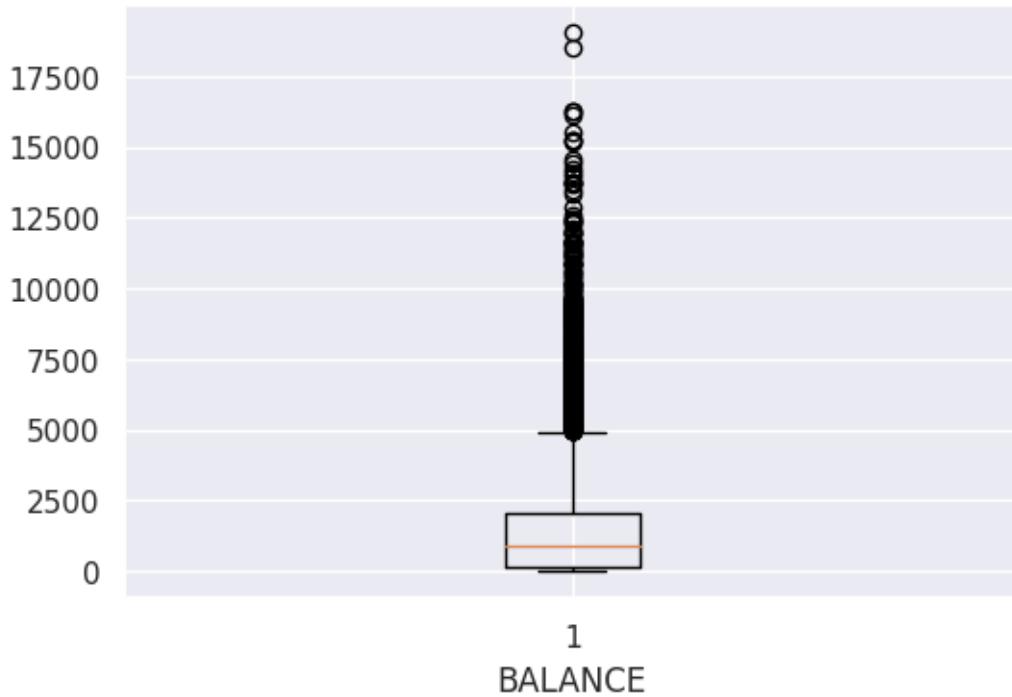
```
[59]: CUST_ID                  0  
BALANCE                   0  
BALANCE_FREQUENCY          0  
PURCHASES                 0  
ONEOFF_PURCHASES          0  
INSTALLMENTS_PURCHASES    0  
CASH_ADVANCE               0  
PURCHASES_FREQUENCY        0  
ONEOFF_PURCHASES_FREQUENCY 0  
PURCHASES_INSTALLMENTS_FREQUENCY 0  
CASH_ADVANCE_FREQUENCY     0  
CASH_ADVANCE_TRX           0  
PURCHASES_TRX              0  
CREDIT_LIMIT                0  
PAYMENTS                   0  
MINIMUM_PAYMENTS           0  
PRC_FULL_PAYMENT           0  
TENURE                     0  
dtype: int64
```

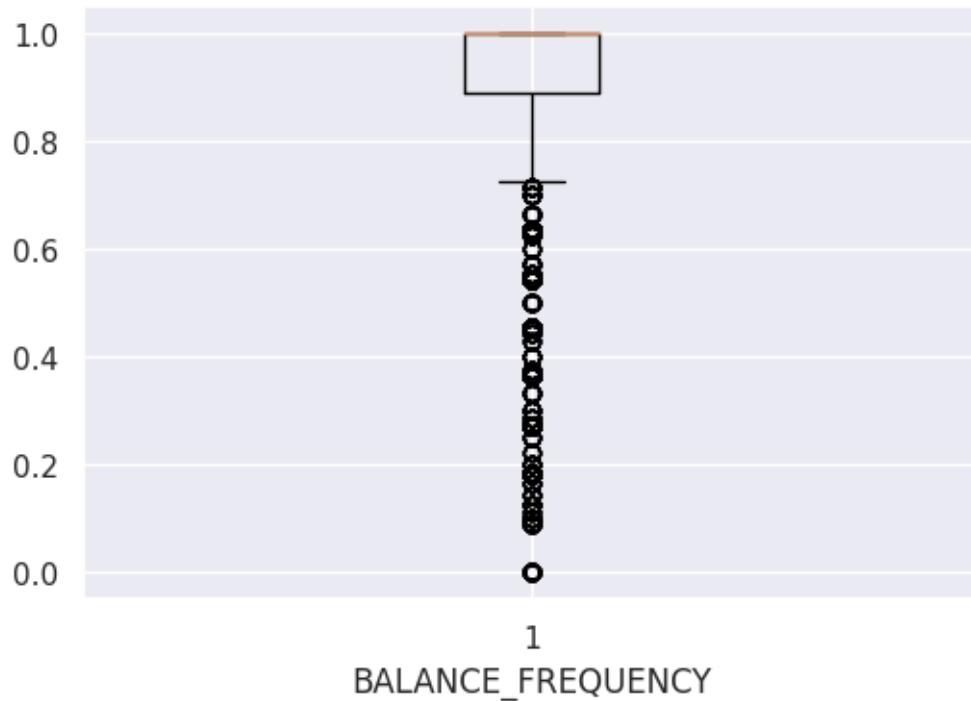
### Remove Outlier

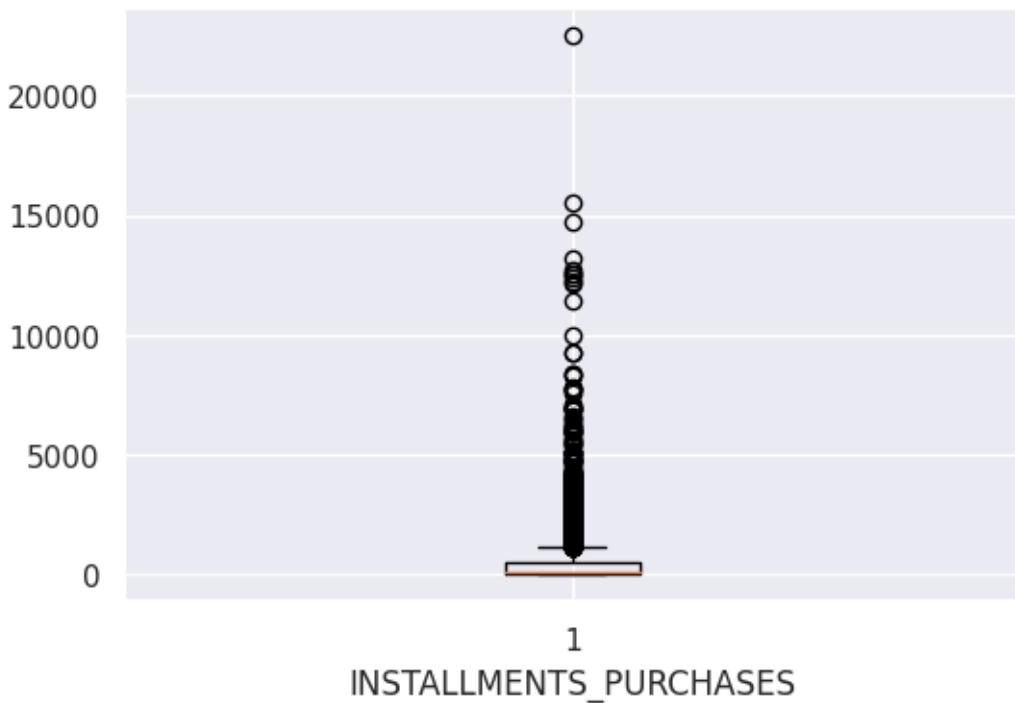
```
[60]: plt.figure(figsize=(30,8))  
sns.boxplot(data=df)  
plt.show()
```

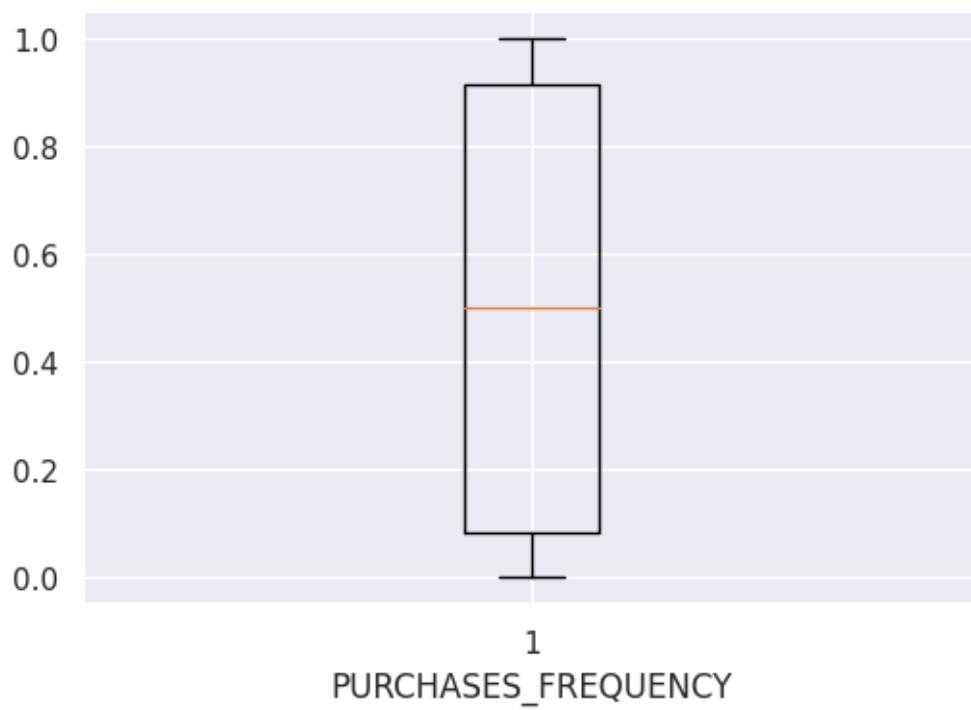
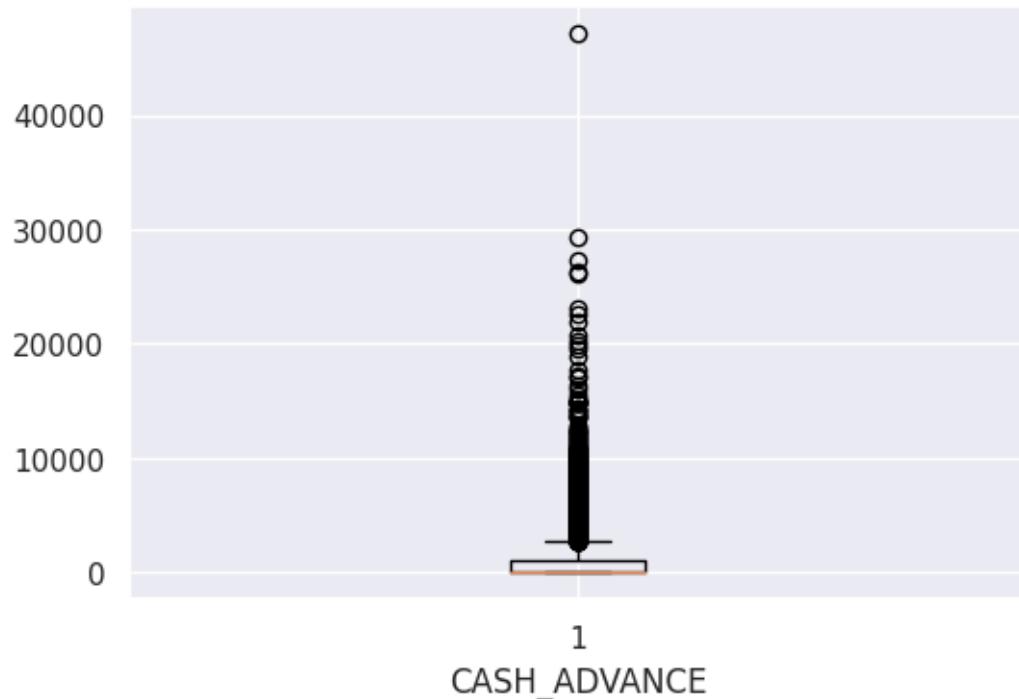


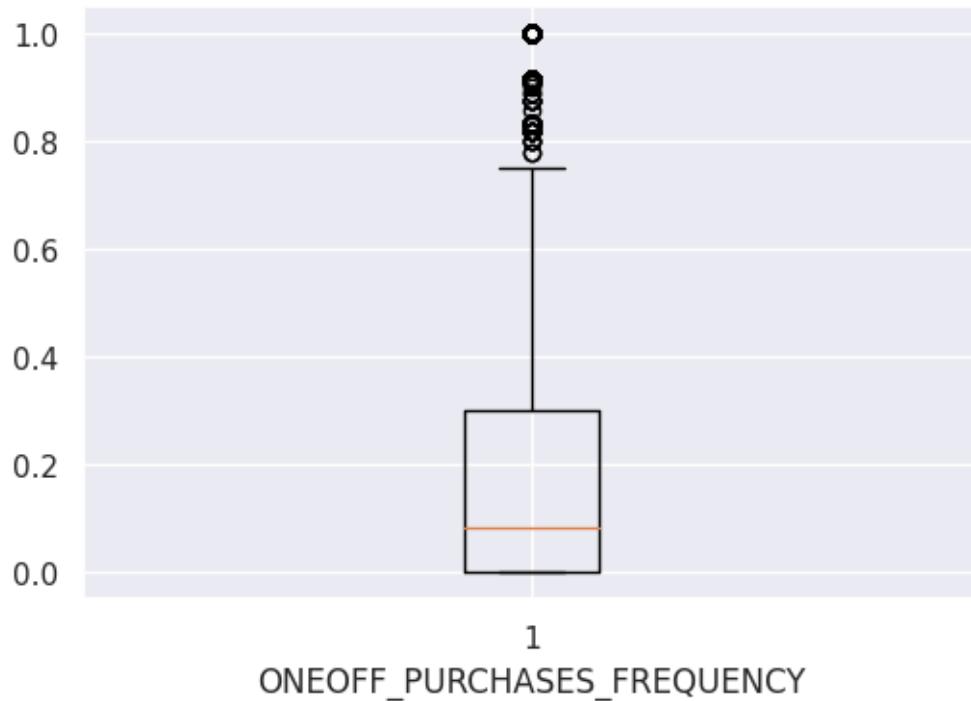
```
[61]: num_col = df.select_dtypes(["float64","int64"])
for i in num_col.columns:
    plt.boxplot(df[i])
    plt.xlabel(i)
    plt.show()
```

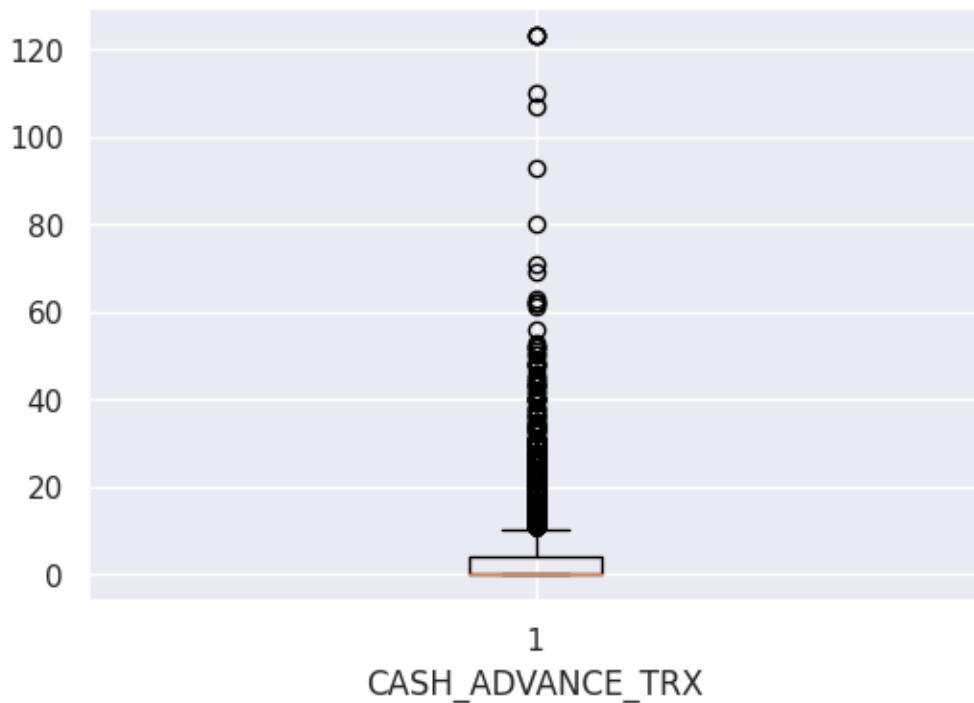
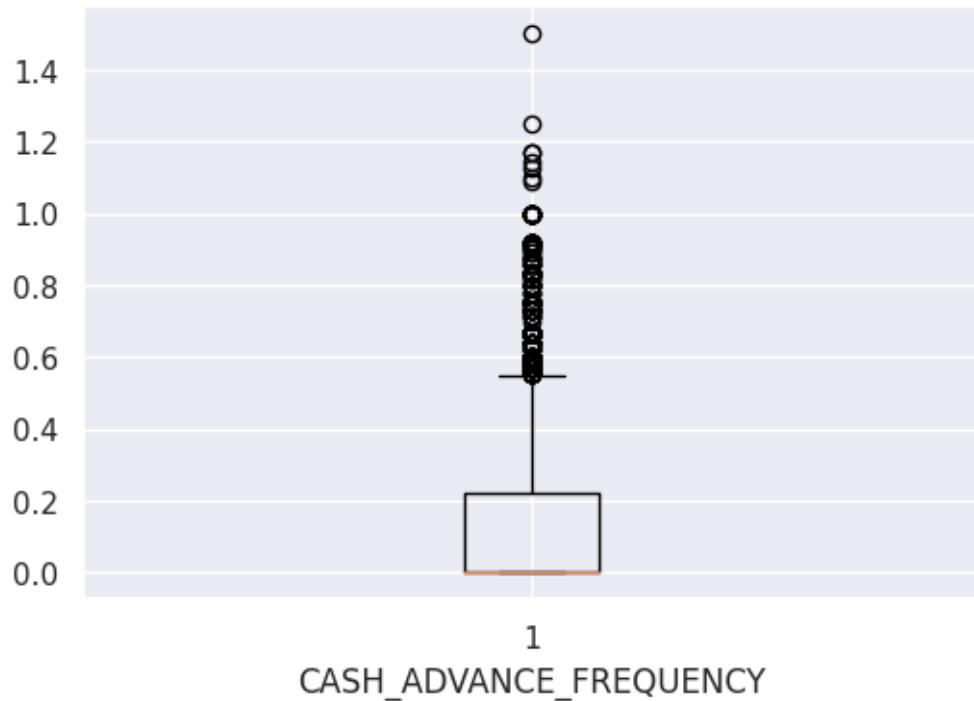


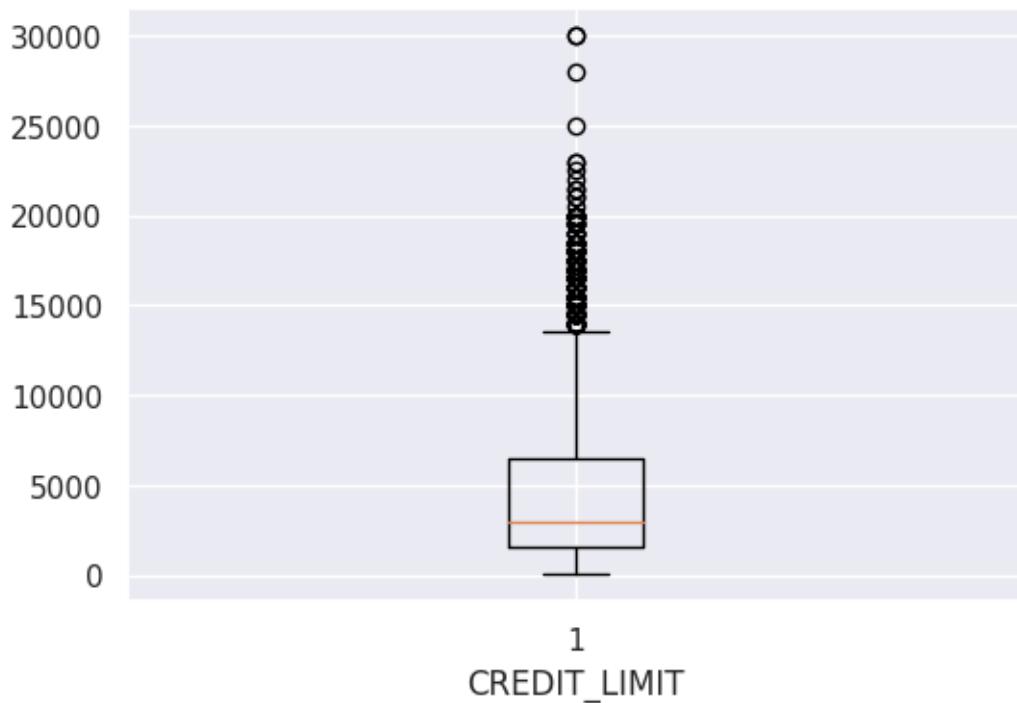




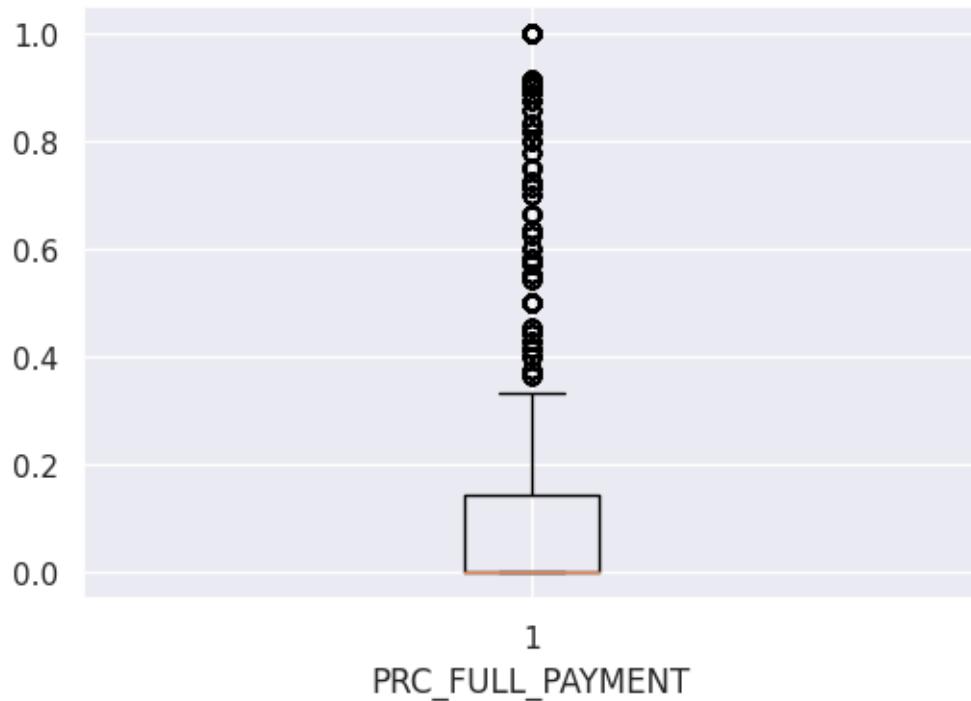












```
[62]: df["TENURE"].value_counts()
```

```
[62]: 12    7584
      11    365
      10    236
      6    204
      8    196
      7    190
      9    175
Name: TENURE, dtype: int64
```

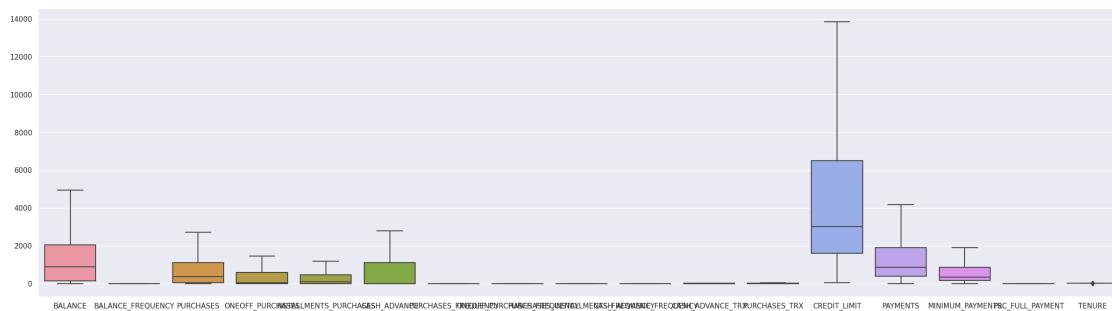
```
[63]: print(df.columns.get_loc('TENURE'))
```

17

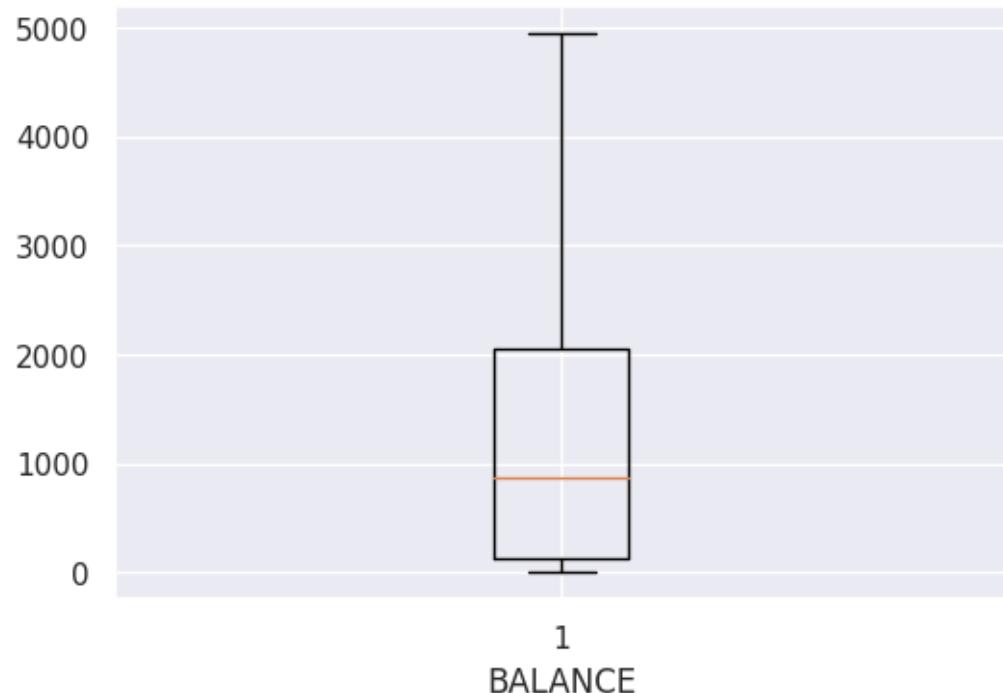
```
[64]: def remove_outlier(col):
        sorted(col)
        Q1,Q3 = col.quantile([0.25,0.75])
        IQR = Q3 - Q1
        lower_range = Q1 - (1.5 * IQR)
        upper_range = Q3 + (1.5 * IQR)
        return lower_range,upper_range
```

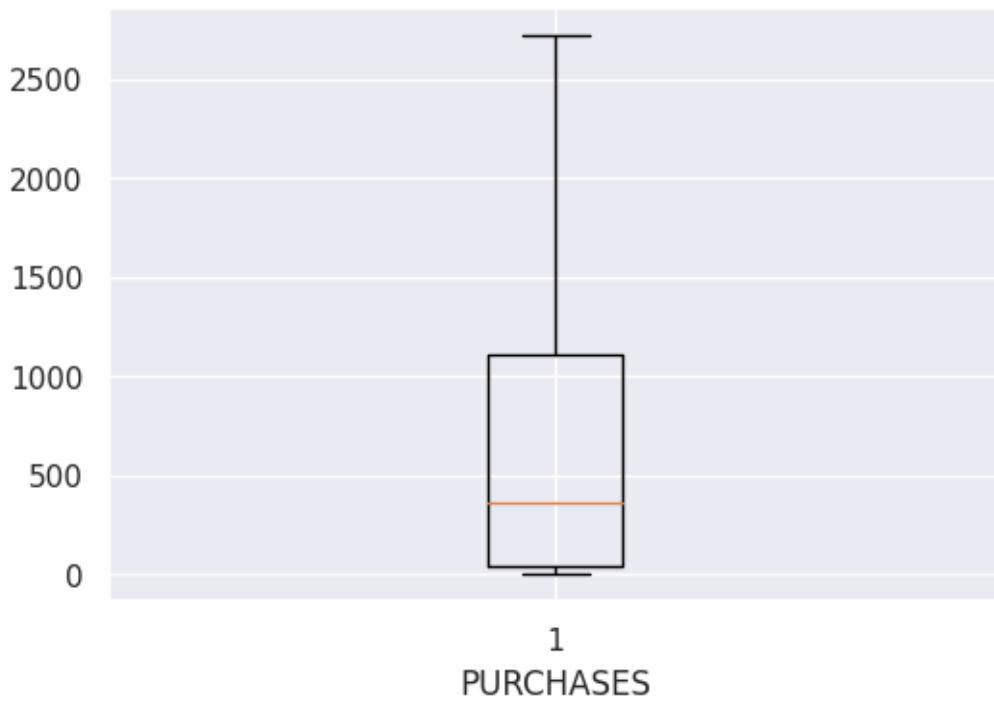
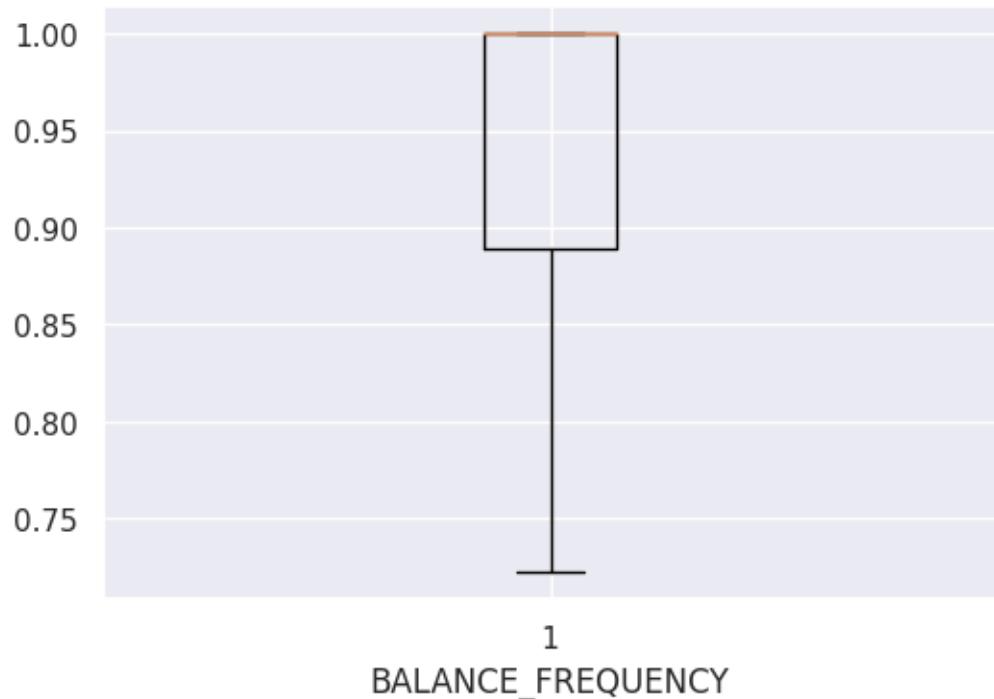
```
[65]: num_col = df.select_dtypes(["float64","int64"])
for i in num_col.columns:
    if df.columns.get_loc(i) == 17:
        pass
    else:
        lower_range,upper_range = remove_outlier(df[i])
        df[i] = np.where(df[i] > upper_range, upper_range, df[i])
        df[i] = np.where(df[i] < lower_range, lower_range, df[i])
```

```
[66]: plt.figure(figsize=(30,8))
sns.boxplot(data=df)
plt.show()
```

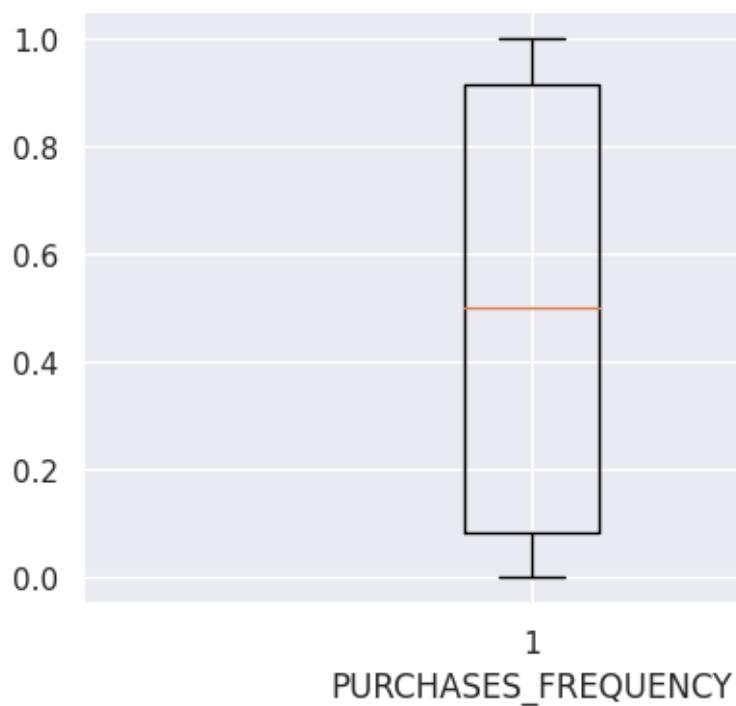
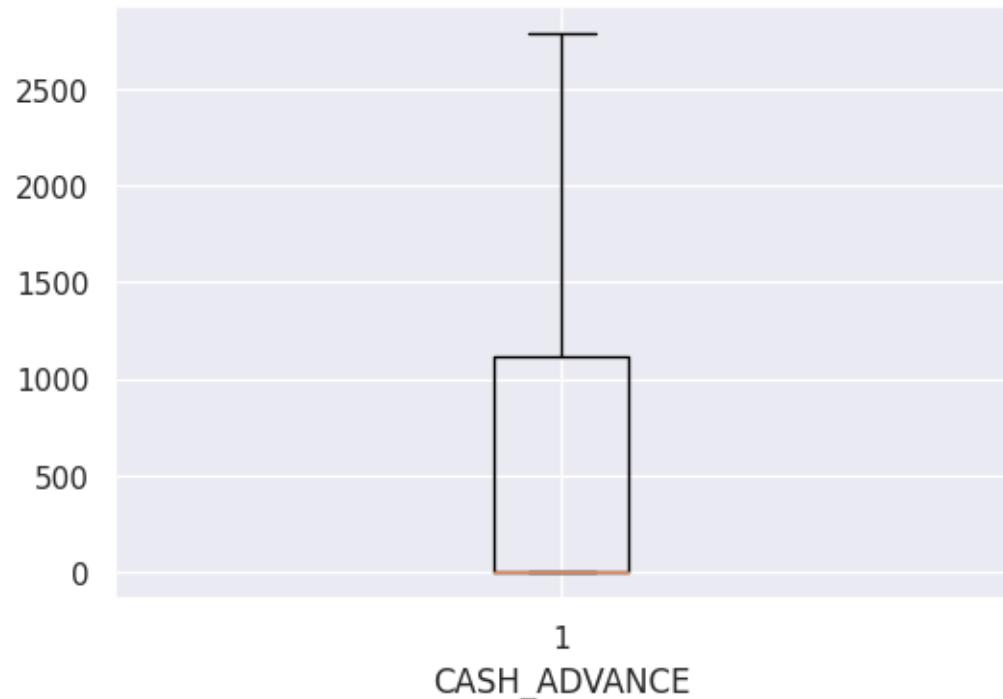


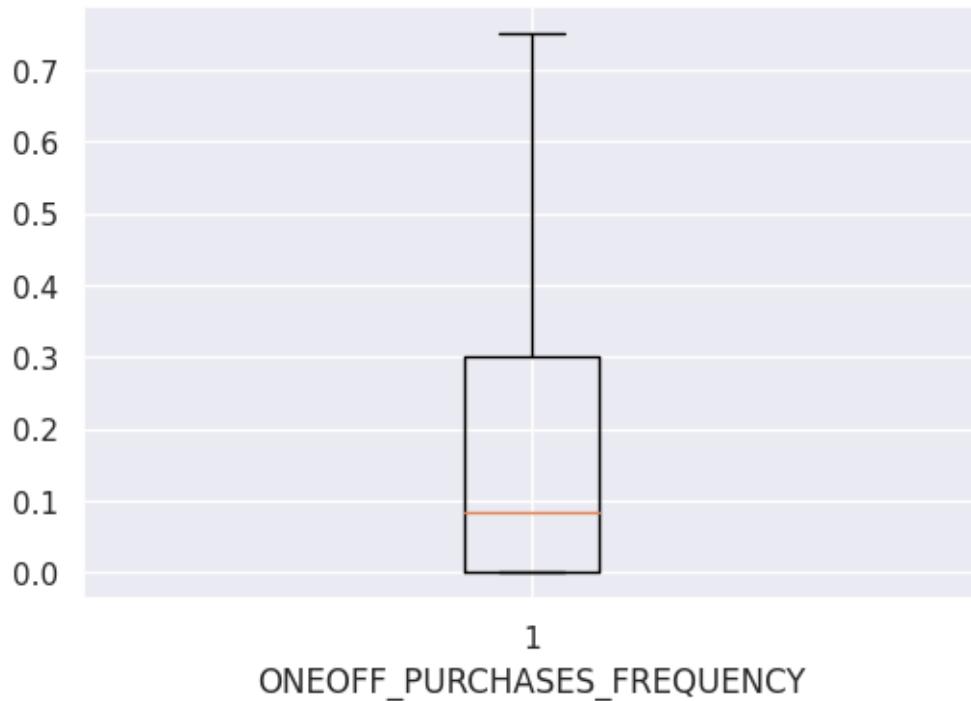
```
[67]: num_col = df.select_dtypes(["float64","int64"])
for i in num_col.columns:
    plt.boxplot(df[i])
    plt.xlabel(i)
    plt.show()
```

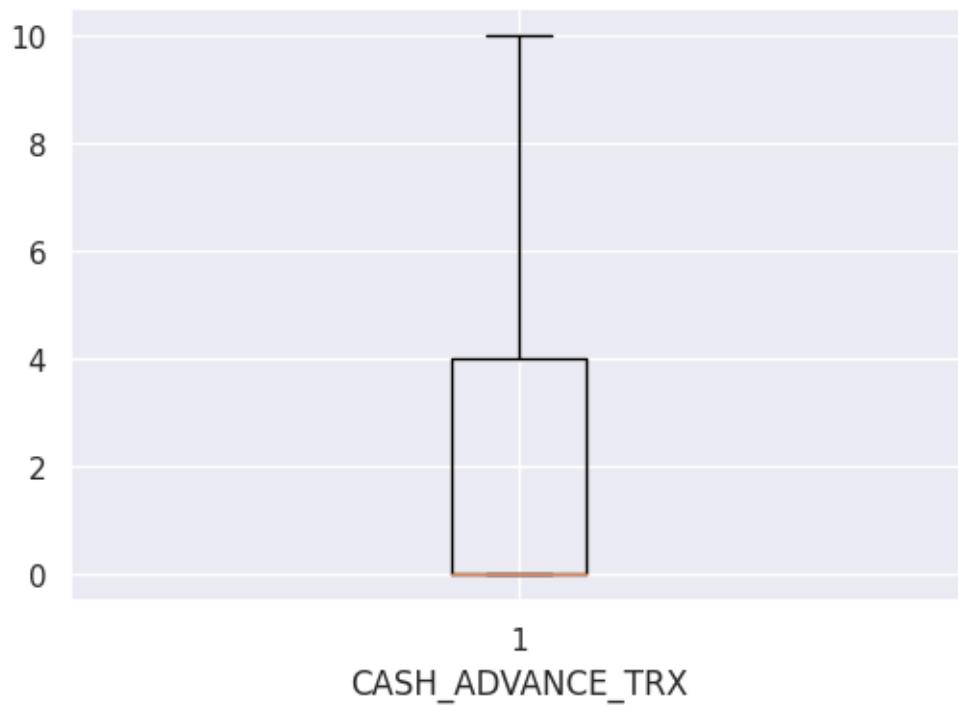
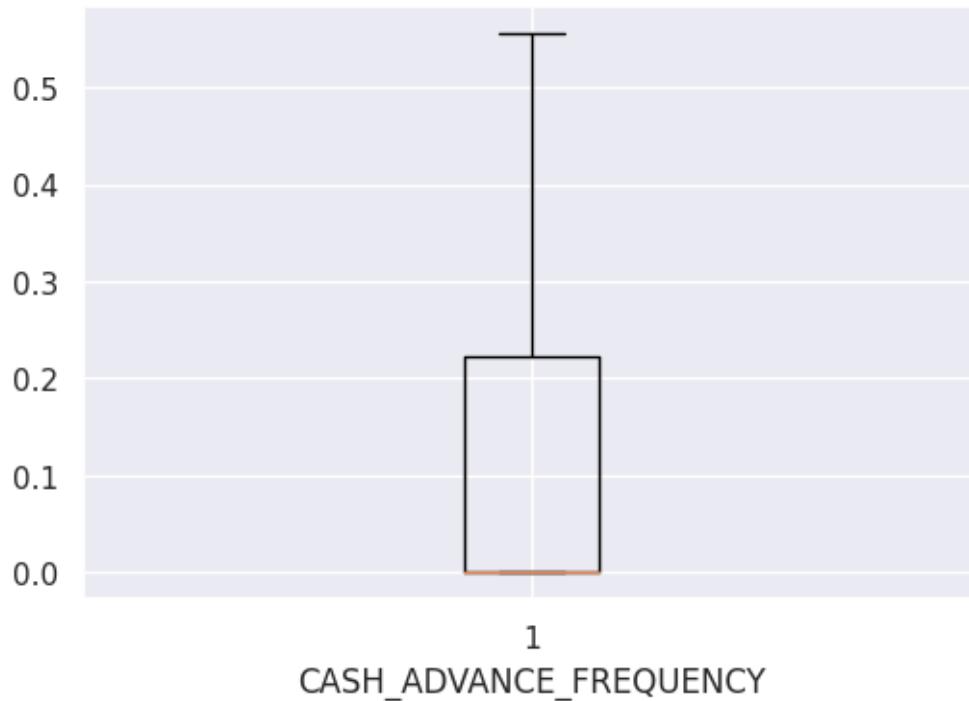






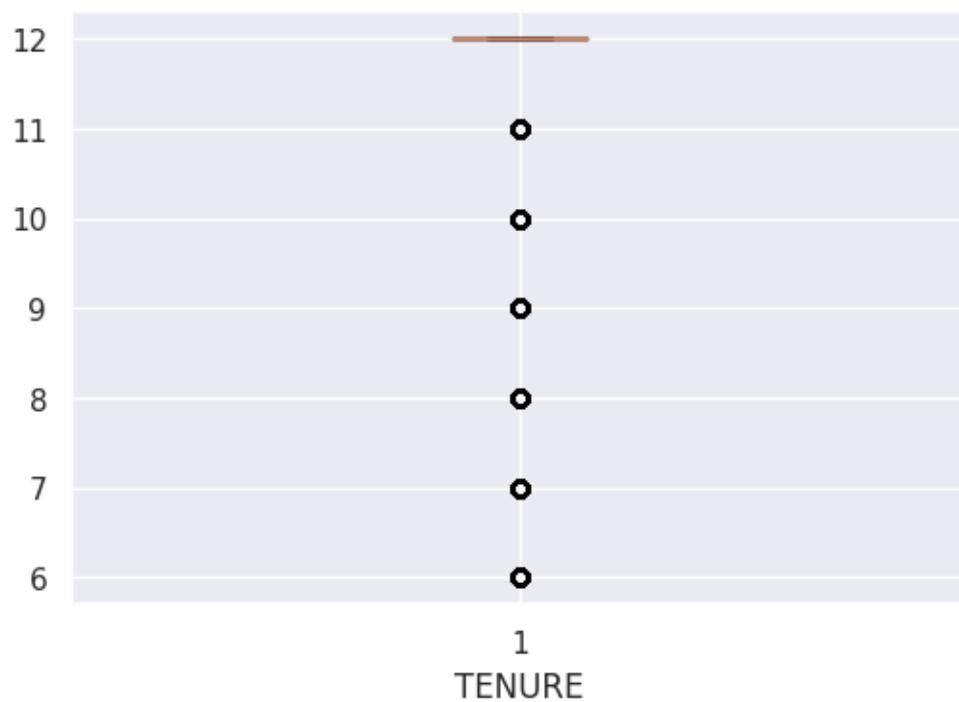
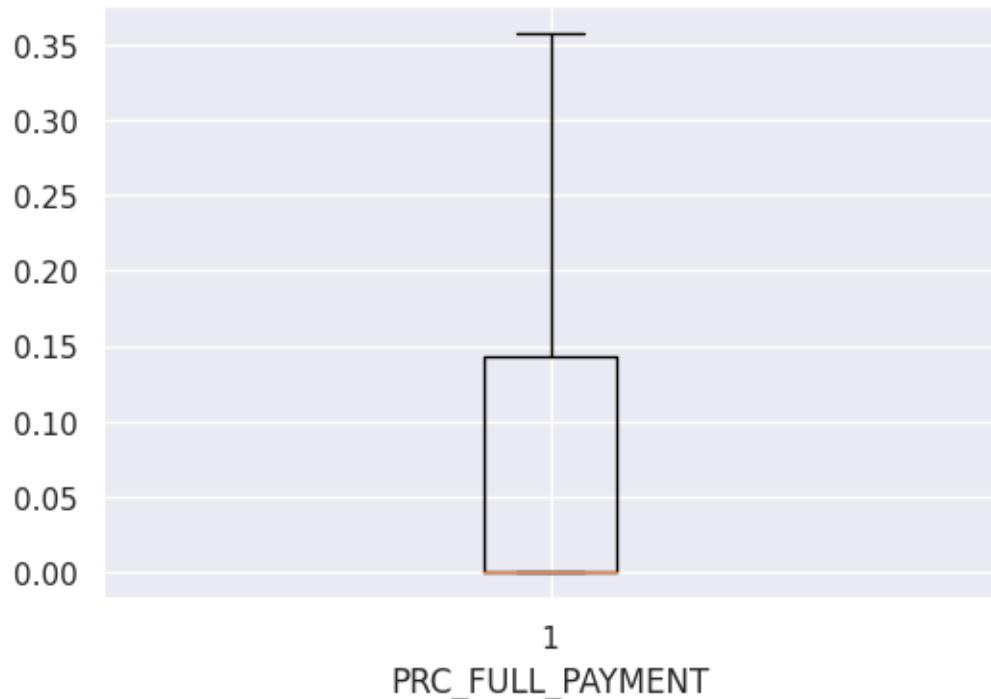










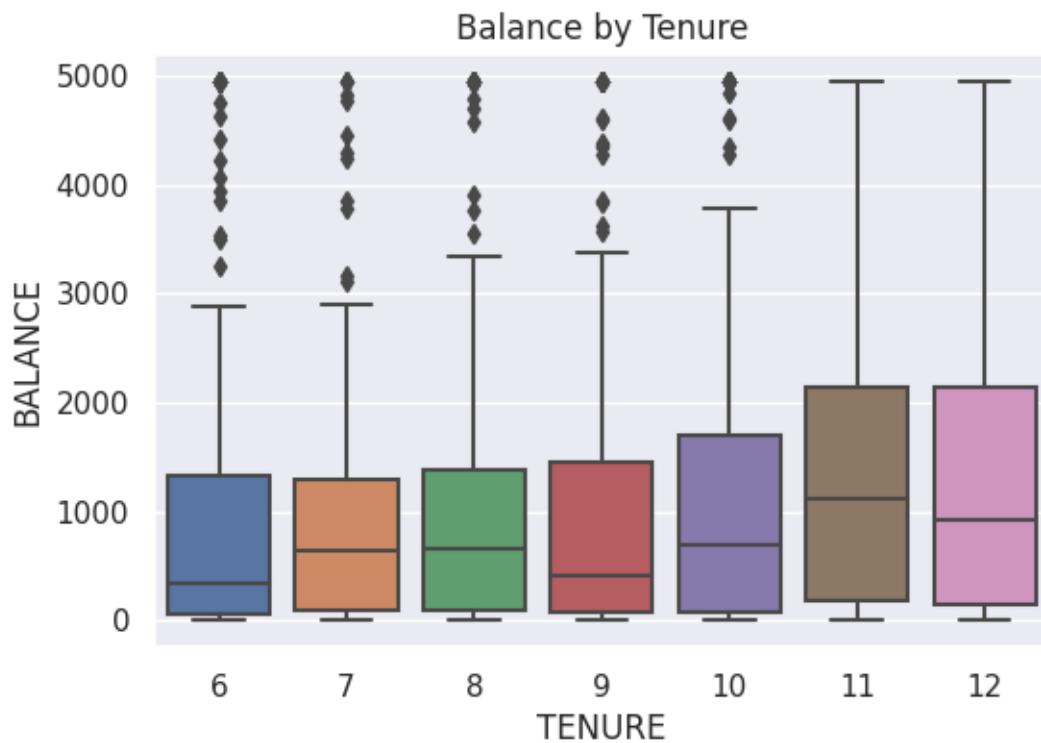


## Bivariate Analysis

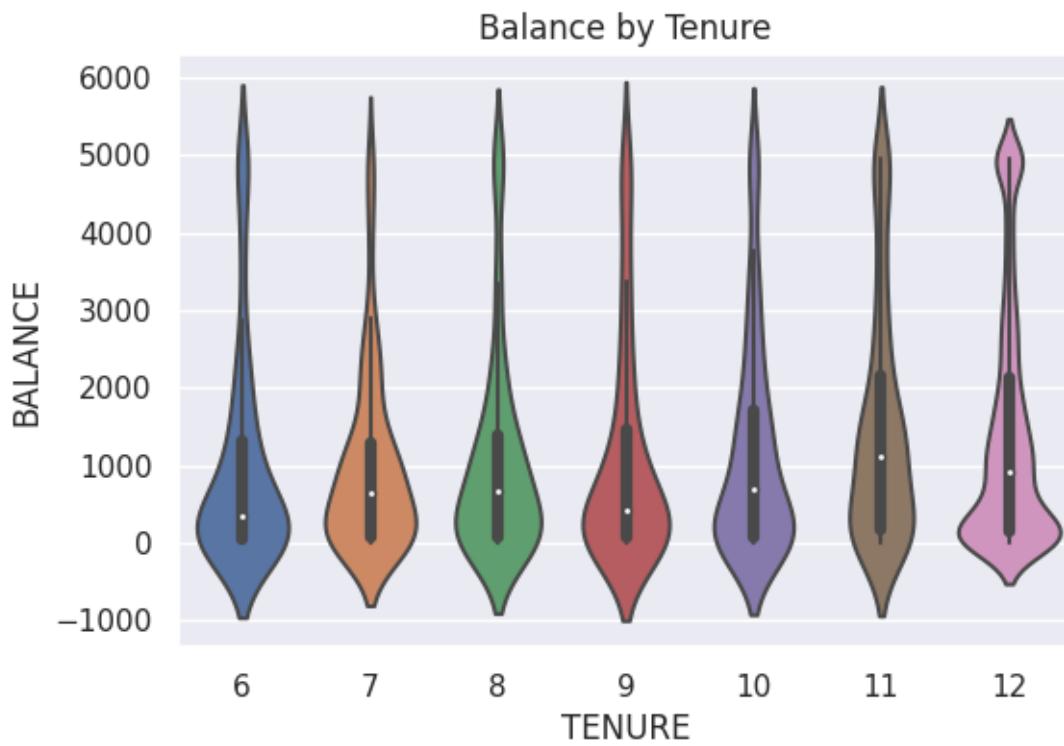
```
[68]: df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 8950 entries, 0 to 8949
Data columns (total 18 columns):
 #   Column           Non-Null Count  Dtype  
--- 
 0   CUST_ID          8950 non-null    object  
 1   BALANCE          8950 non-null    float64 
 2   BALANCE_FREQUENCY 8950 non-null    float64 
 3   PURCHASES        8950 non-null    float64 
 4   ONEOFF_PURCHASES 8950 non-null    float64 
 5   INSTALLMENTS_PURCHASES 8950 non-null    float64 
 6   CASH_ADVANCE     8950 non-null    float64 
 7   PURCHASES_FREQUENCY 8950 non-null    float64 
 8   ONEOFF_PURCHASES_FREQUENCY 8950 non-null    float64 
 9   PURCHASES_INSTALLMENTS_FREQUENCY 8950 non-null    float64 
 10  CASH_ADVANCE_FREQUENCY 8950 non-null    float64 
 11  CASH_ADVANCE_TRX 8950 non-null    float64 
 12  PURCHASES_TRX   8950 non-null    float64 
 13  CREDIT_LIMIT    8950 non-null    float64 
 14  PAYMENTS        8950 non-null    float64 
 15  MINIMUM_PAYMENTS 8950 non-null    float64 
 16  PRC_FULL_PAYMENT 8950 non-null    float64 
 17  TENURE          8950 non-null    int64  
dtypes: float64(16), int64(1), object(1)
memory usage: 1.2+ MB
```

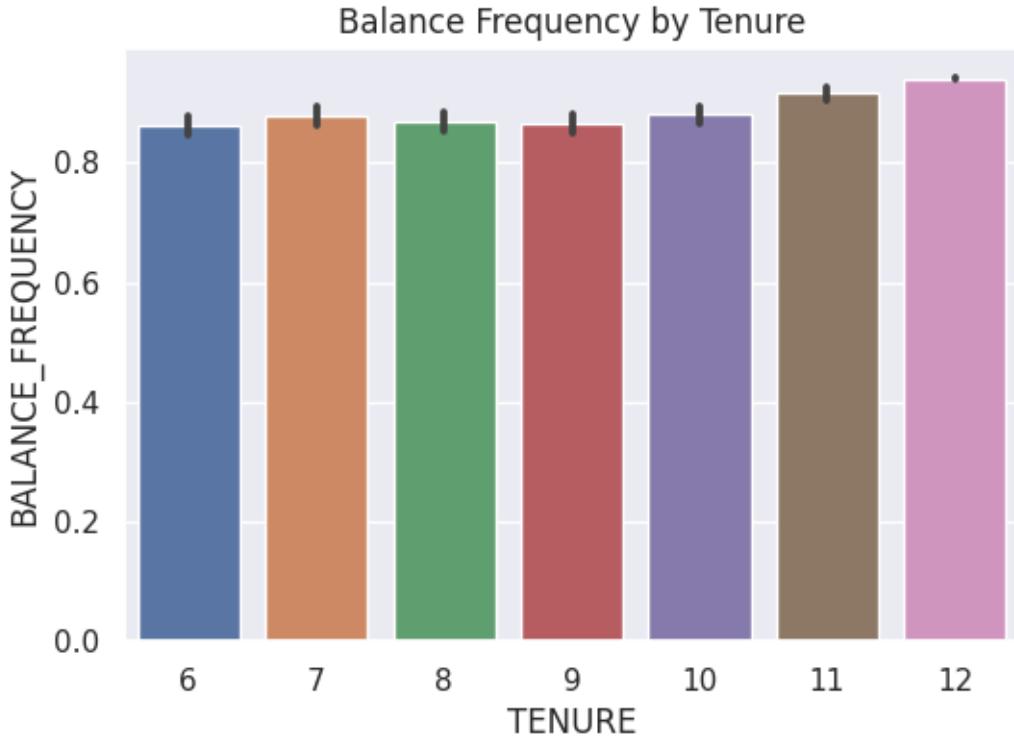
```
[69]: sns.boxplot(x='TENURE', y='BALANCE', data=df)
plt.title('Balance by Tenure')
plt.xlabel("TENURE")
plt.ylabel("BALANCE")
plt.show()
```



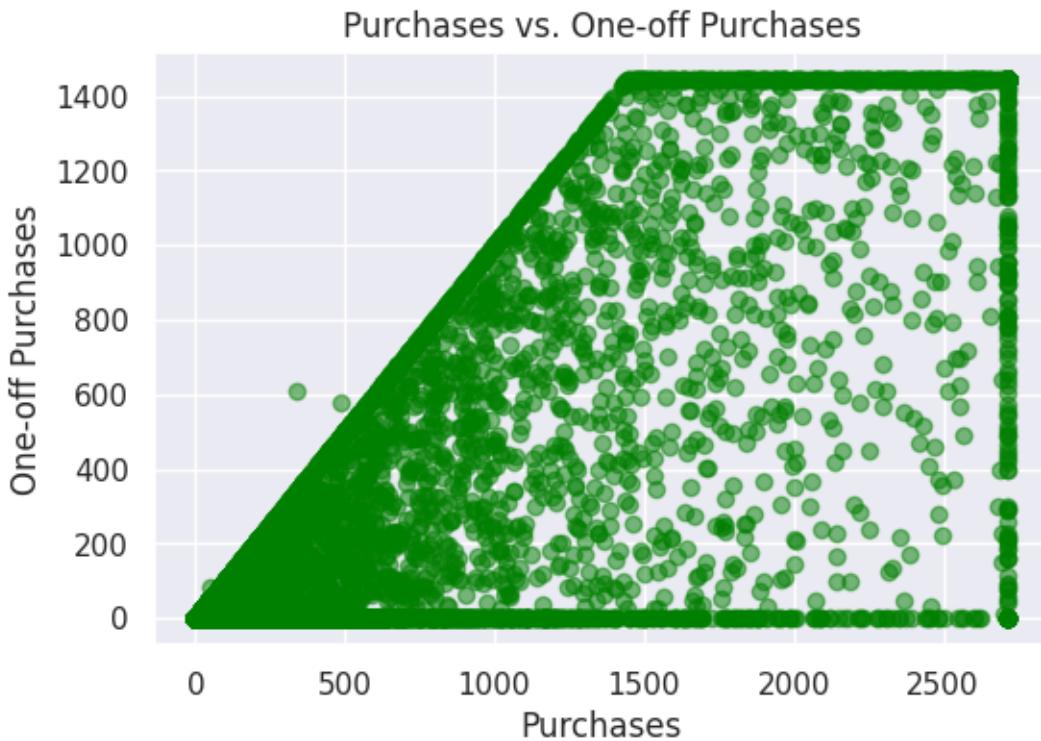
```
[70]: sns.violinplot(x='TENURE', y='BALANCE', data=df)
plt.title('Balance by Tenure')
plt.show()
```



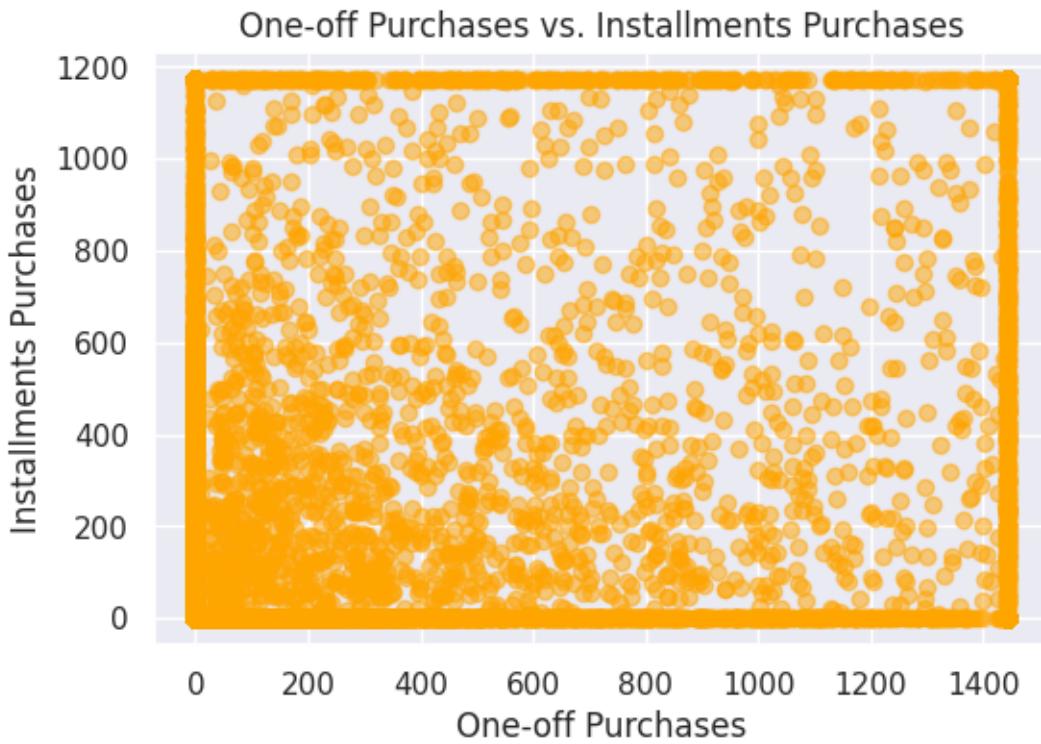
```
[71]: sns.barplot(x='TENURE', y='BALANCE_FREQUENCY', data=df)
plt.title('Balance Frequency by Tenure')
plt.show()
```



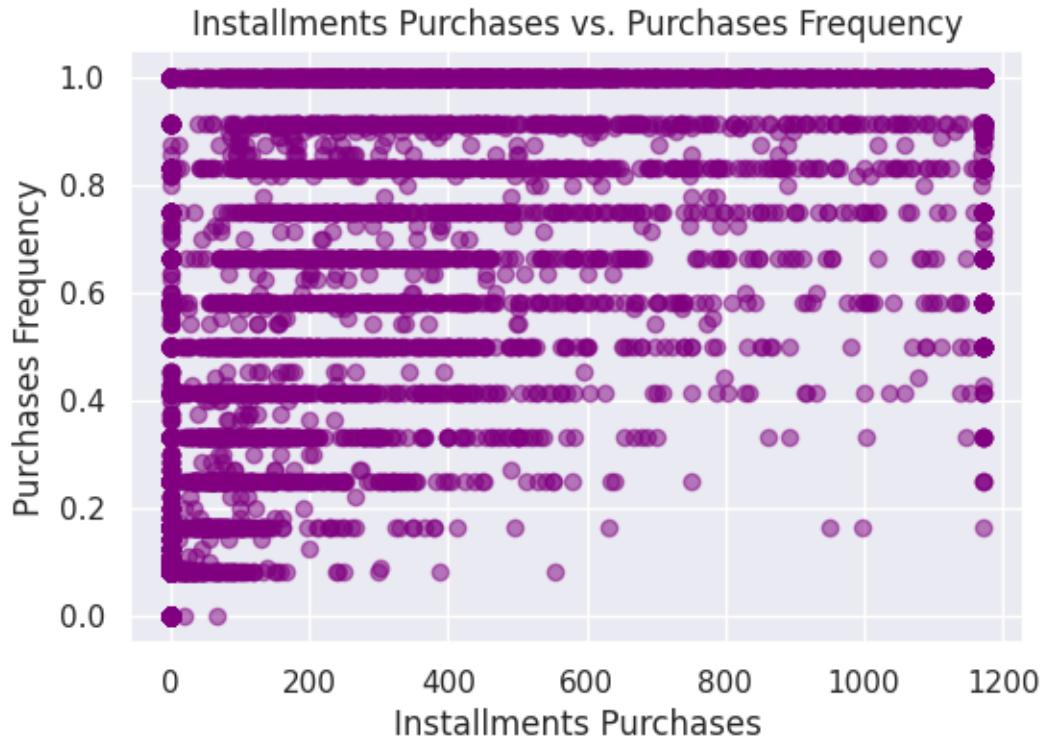
```
[72]: plt.scatter(df['PURCHASES'], df['ONEOFF_PURCHASES'], alpha=0.5, color='green')
plt.xlabel('Purchases')
plt.ylabel('One-off Purchases')
plt.title('Purchases vs. One-off Purchases')
plt.show()
```



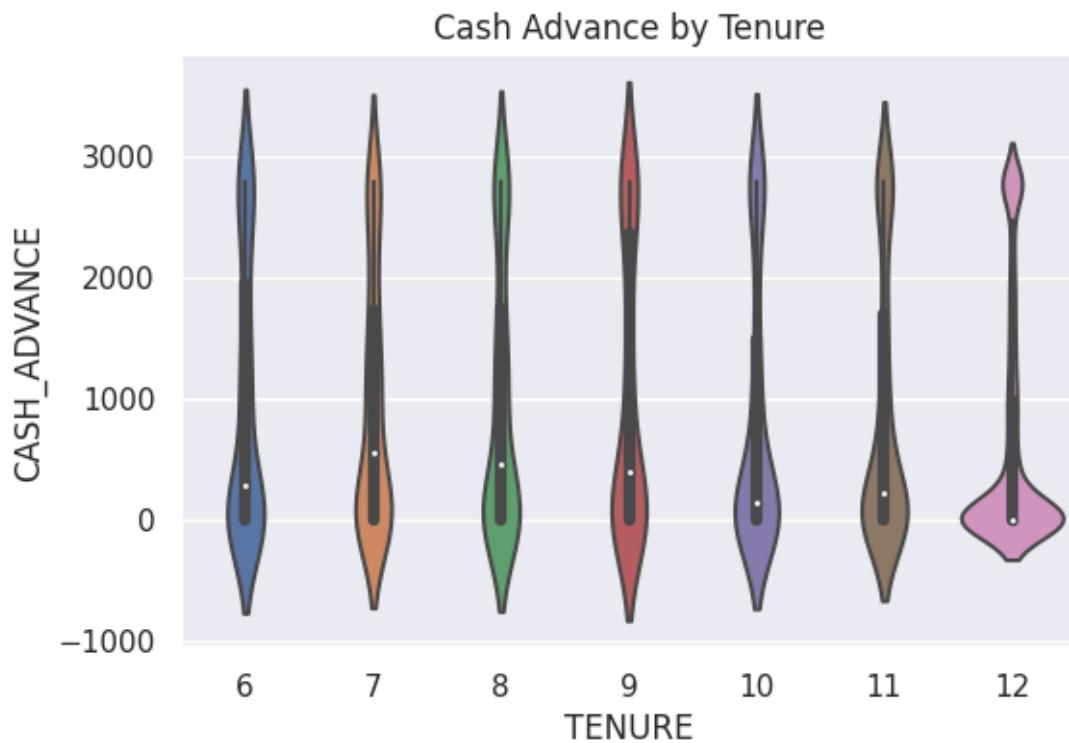
```
[73]: plt.scatter(df['ONEOFF_PURCHASES'], df['INSTALLMENTS_PURCHASES'], alpha=0.5, color='orange')
plt.xlabel('One-off Purchases')
plt.ylabel('Installments Purchases')
plt.title('One-off Purchases vs. Installments Purchases')
plt.show()
```



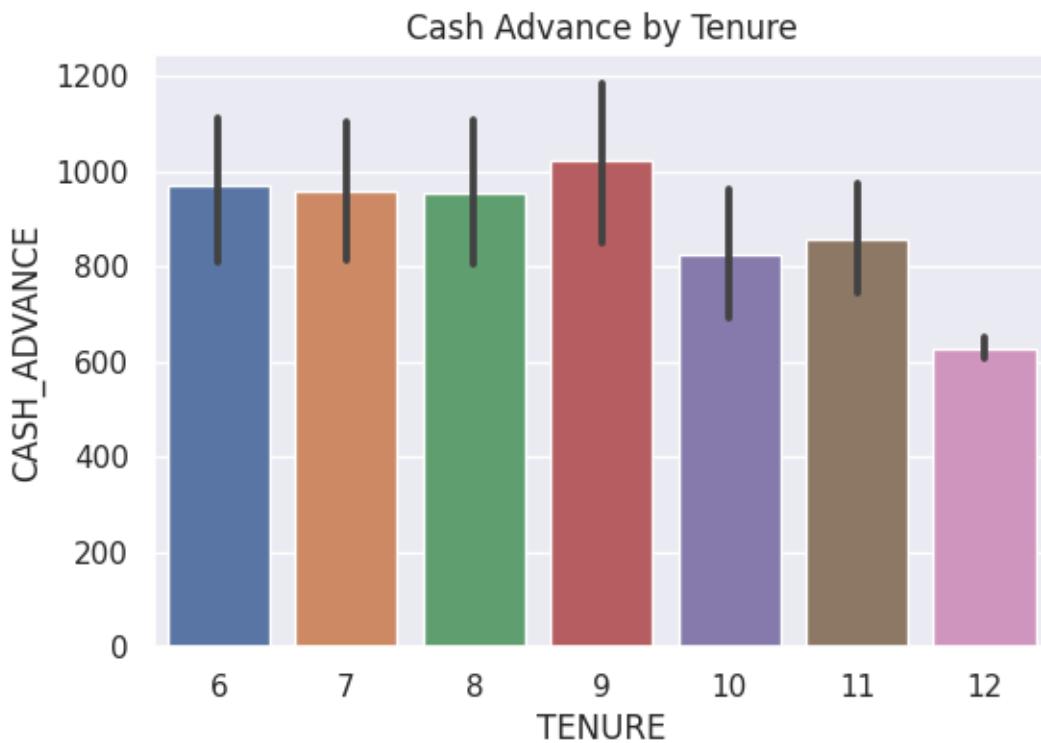
```
[74]: plt.scatter(df['INSTALLMENTS_PURCHASES'], df['PURCHASES_FREQUENCY'], alpha=0.5,  
                 color='purple')  
plt.xlabel('Installments Purchases')  
plt.ylabel('Purchases Frequency')  
plt.title('Installments Purchases vs. Purchases Frequency')  
plt.show()
```



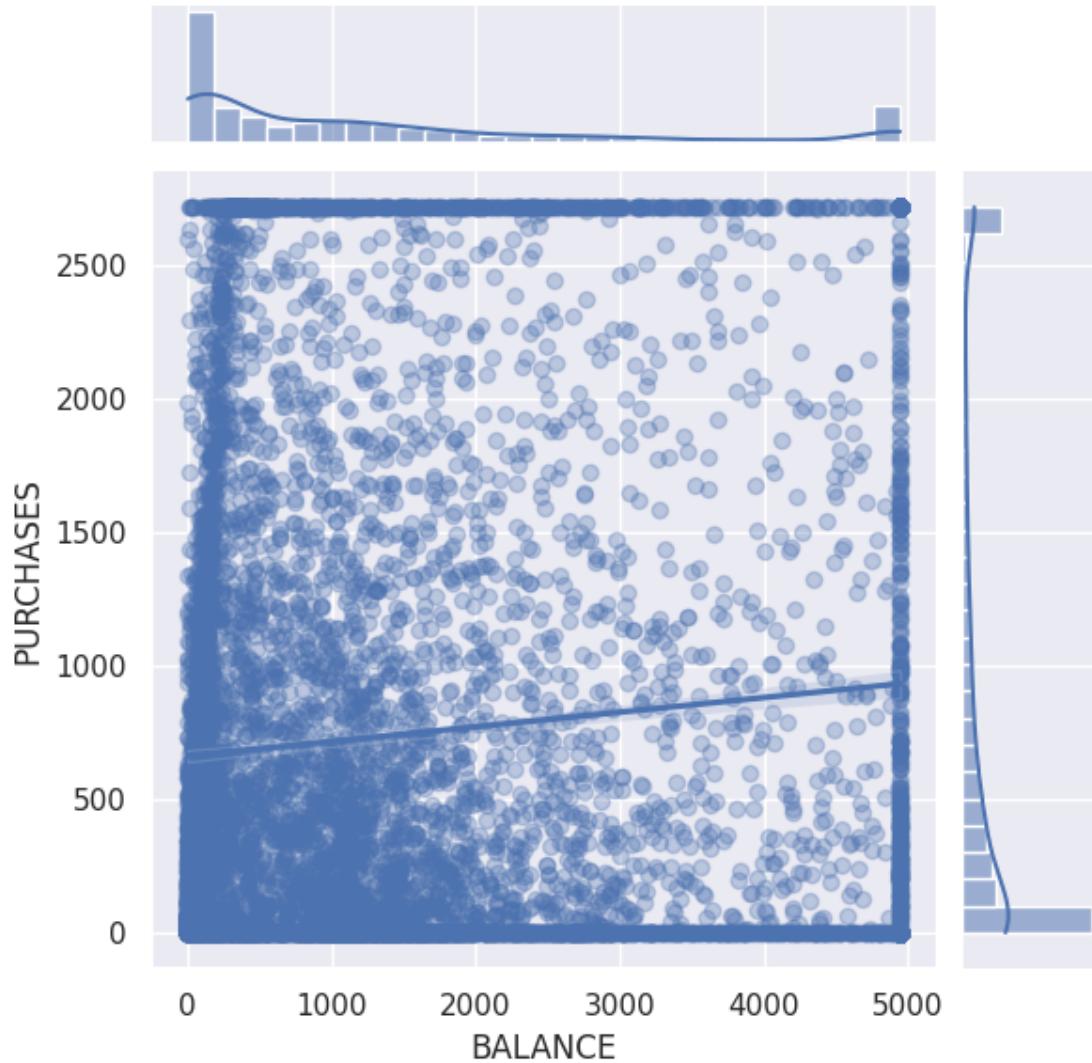
```
[75]: sns.violinplot(x='TENURE', y='CASH_ADVANCE', data=df)
plt.title('Cash Advance by Tenure')
plt.show()
```



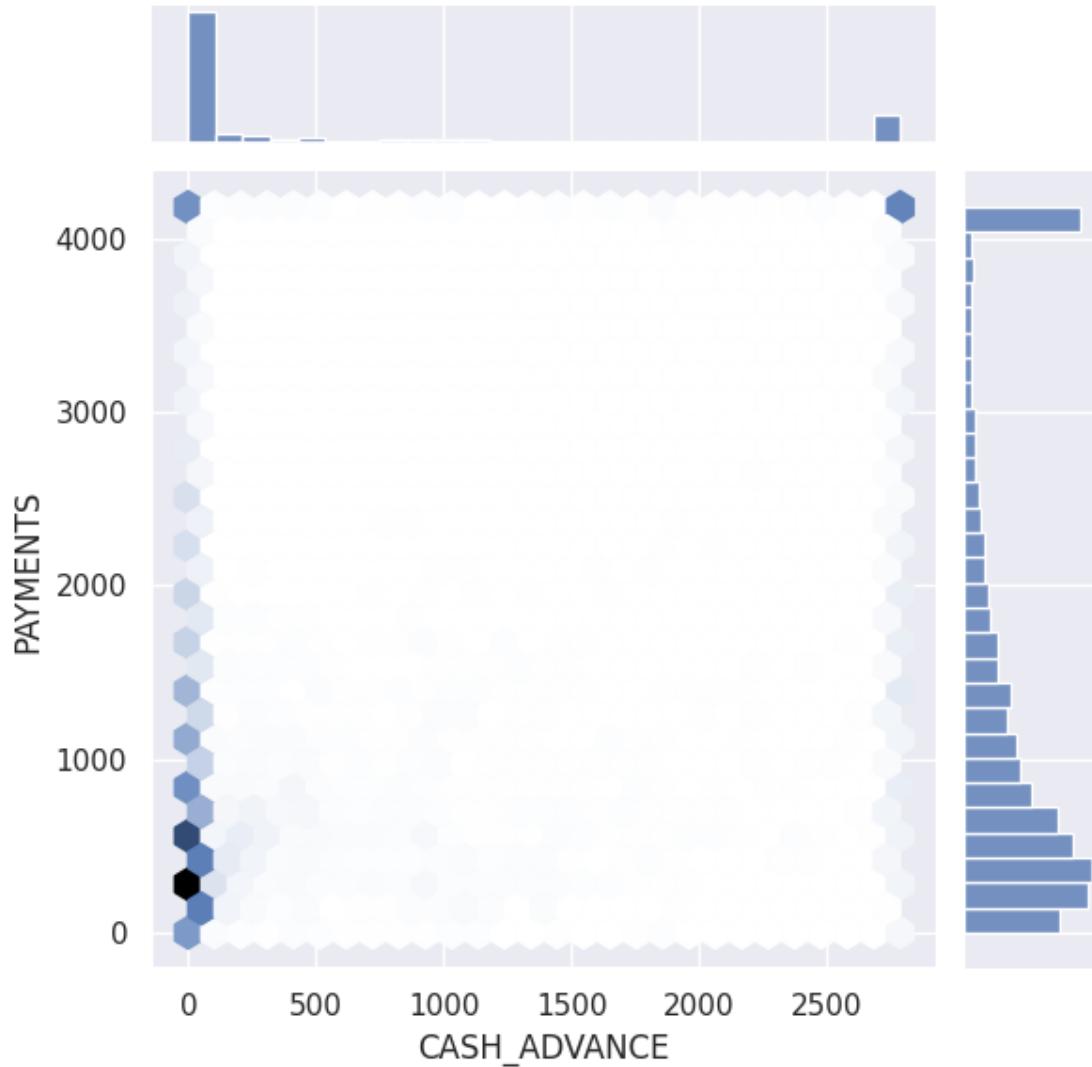
```
[76]: sns.barplot(x='TENURE', y='CASH_ADVANCE', data=df)
plt.title('Cash Advance by Tenure')
plt.show()
```



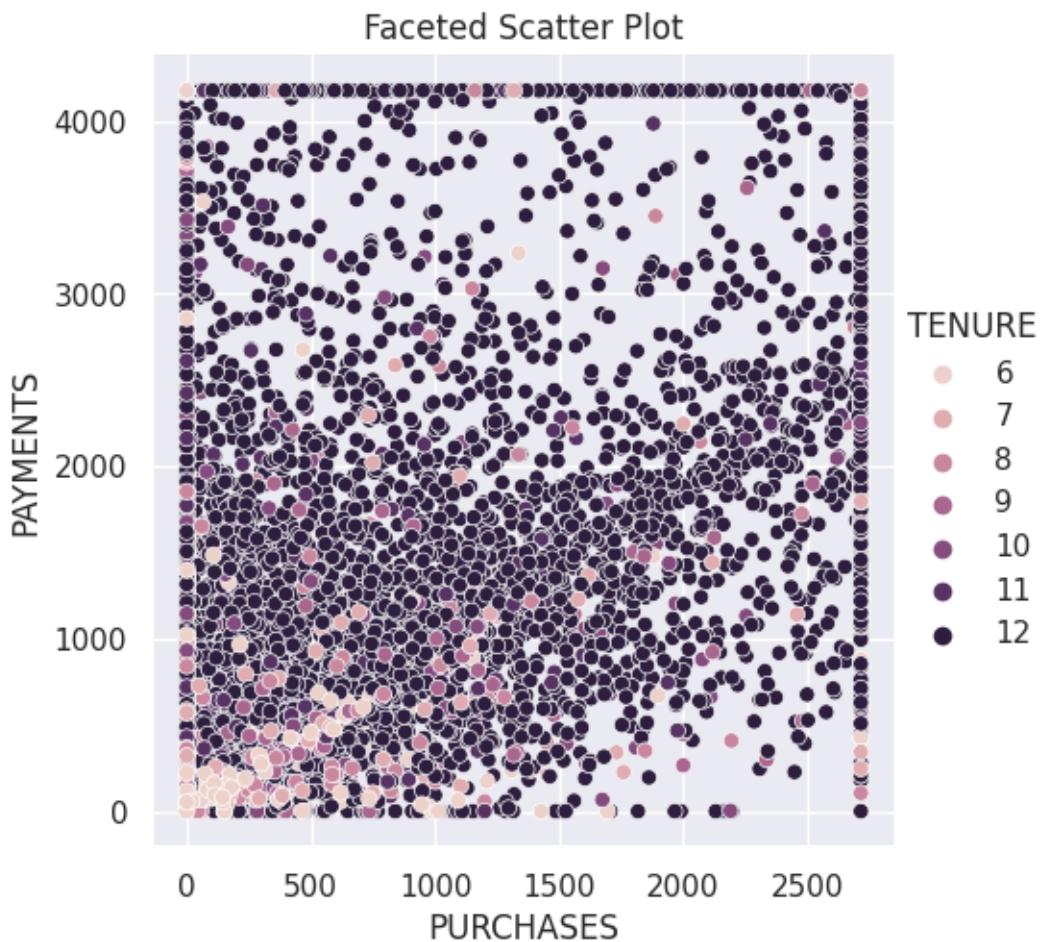
```
[77]: sns.jointplot(x='BALANCE', y='PURCHASES', data=df, kind='reg',  
                   scatter_kws={'alpha':0.3})  
plt.show()
```



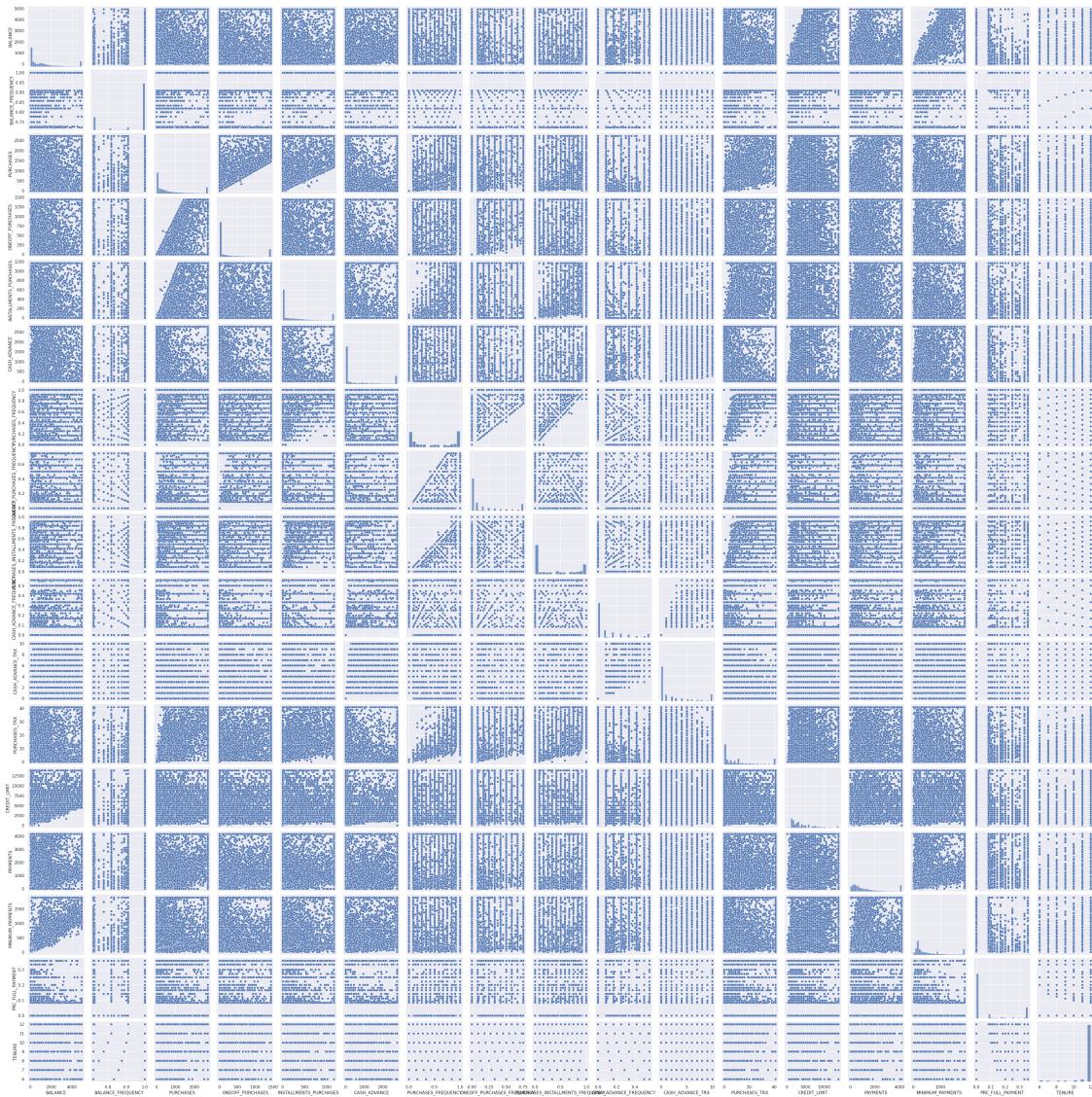
```
[78]: sns.jointplot(x='CASH_ADVANCE', y='PAYMENTS', data=df, kind='hex')
plt.show()
```



```
[79]: sns.relplot(x='PURCHASES', y='PAYMENTS', hue='TENURE', data=df)
plt.title('Faceted Scatter Plot')
plt.show()
```



```
[80]: sns.pairplot(df)
plt.show()
```

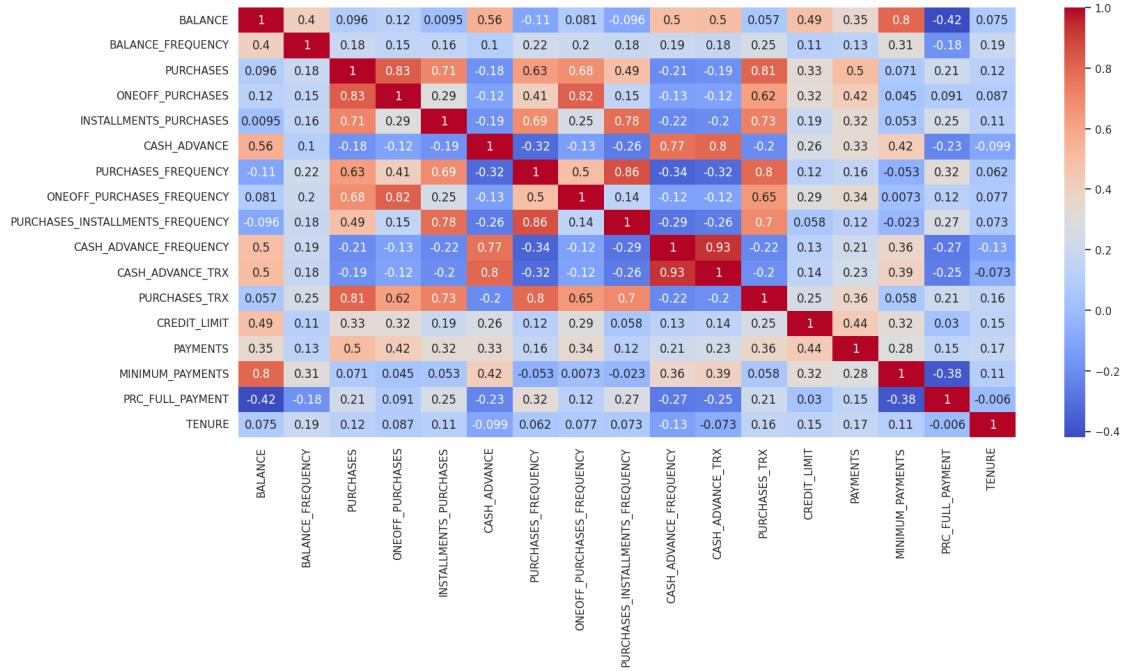


```
[81]: fig, ax = plt.subplots(figsize=(18, 8))
sns.heatmap(df.corr(), annot=True, cmap='coolwarm')
```

```
<ipython-input-81-f7122f16c753>:2: FutureWarning: The default value of  
numeric_only in DataFrame.corr is deprecated. In a future version, it will  
default to False. Select only valid columns or specify the value of numeric_only  
to silence this warning.
```

```
sns.heatmap(df.corr(), annot=True, cmap='coolwarm')
```

[81]: <Axes: >



```
[82]: num_cols = df.select_dtypes(include=["int64", "float64"])

def plots(num_cols, variable):
    plt.figure(figsize=(15,6))
    plt.subplot(1, 2, 1)
    #num_cols[variable].hist()
    sns.distplot(num_cols[variable], kde=True, bins=10)
    plt.title(variable)
    plt.subplot(1, 2, 2)
    stats.probplot(num_cols[variable], dist="norm", plot=pylab)
    plt.title(variable)
    plt.show()

for i in num_cols.columns:
    plots(num_cols, i)
```

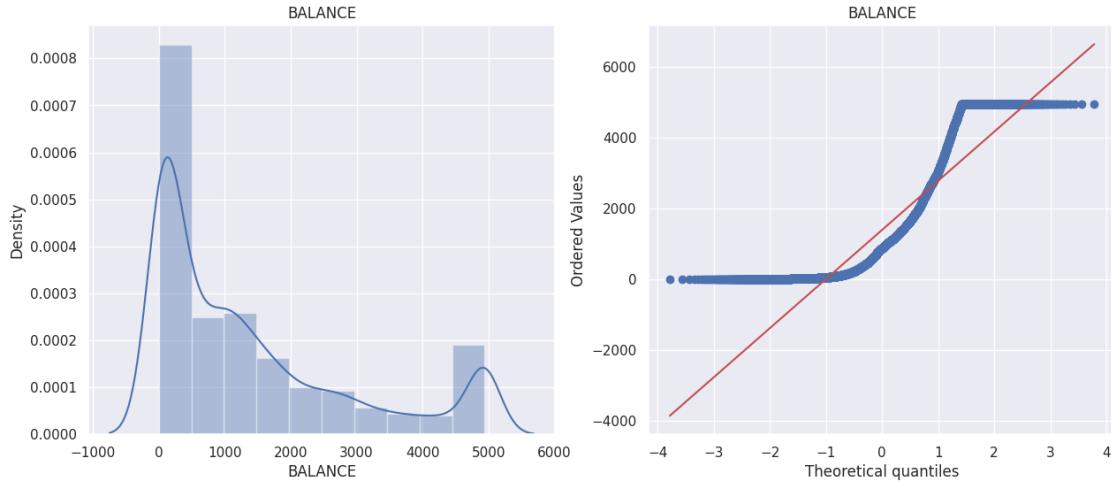
<ipython-input-82-7af58d2ef5aa>:6: UserWarning:

`distplot` is a deprecated function and will be removed in seaborn v0.14.0.

Please adapt your code to use either `displot` (a figure-level function with similar flexibility) or `histplot` (an axes-level function for histograms).

For a guide to updating your code to use the new functions, please see <https://gist.github.com/mwaskom/de44147ed2974457ad6372750bbe5751>

`sns.distplot(num_cols[variable], kde=True, bins=10)`



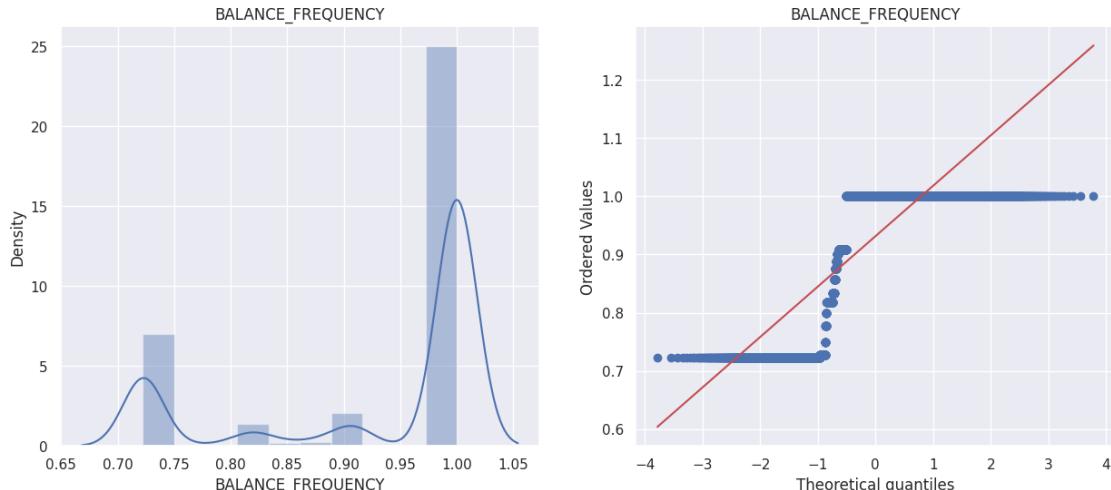
<ipython-input-82-7af58d2ef5aa>:6: UserWarning:

`distplot` is a deprecated function and will be removed in seaborn v0.14.0.

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```
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```



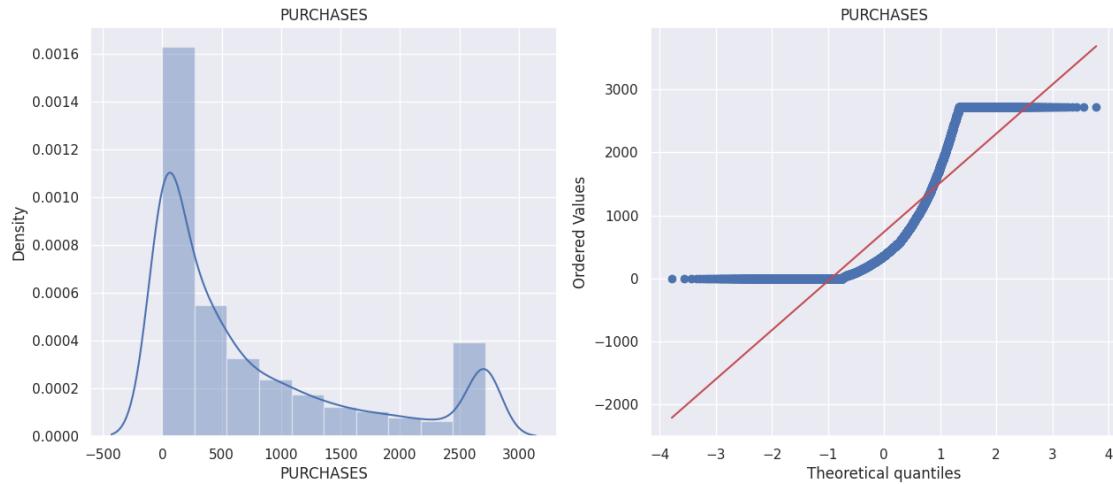
<ipython-input-82-7af58d2ef5aa>:6: UserWarning:

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```
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```



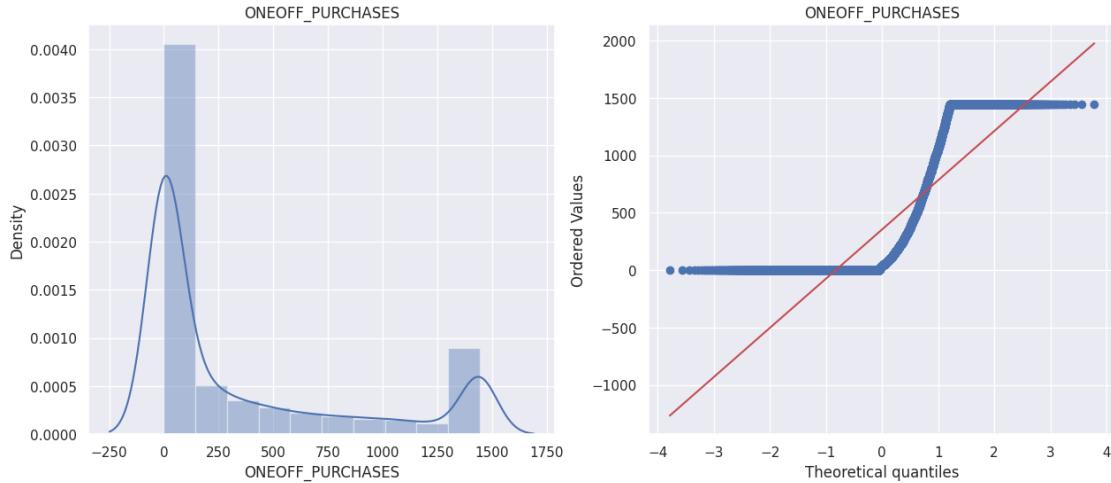
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```
sns.distplot(num_cols[variable], kde=True, bins=10)
```



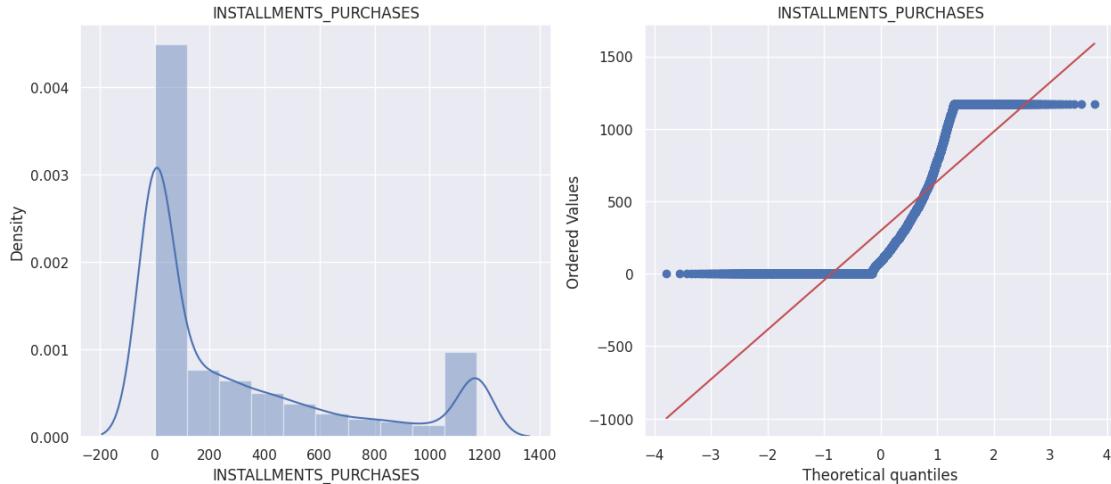
<ipython-input-82-7af58d2ef5aa>:6: UserWarning:

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```
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```



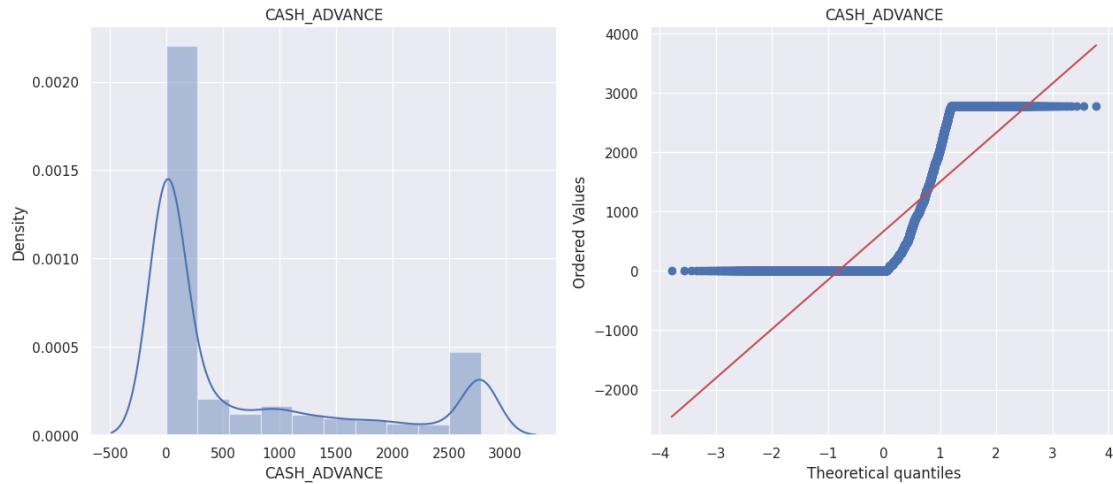
<ipython-input-82-7af58d2ef5aa>:6: UserWarning:

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```
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```



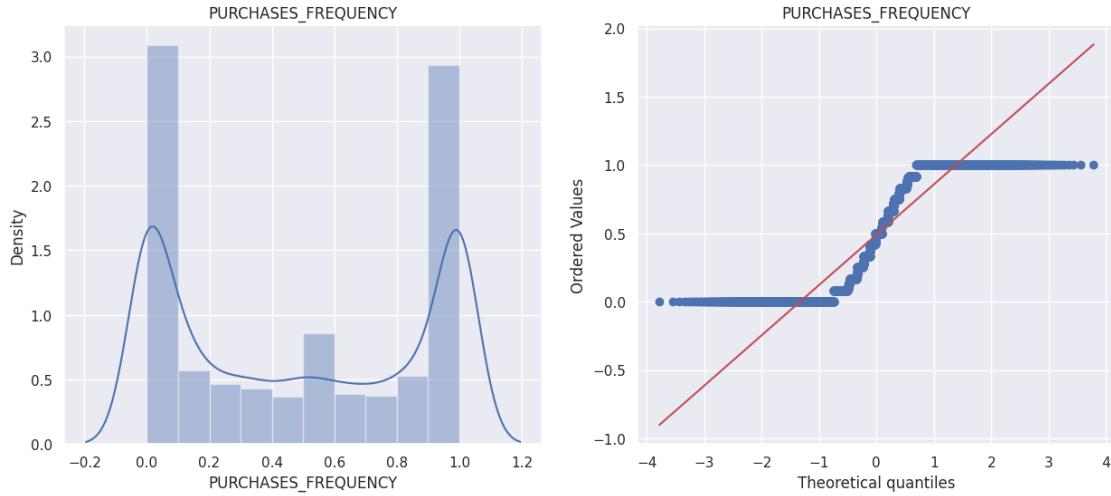
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```
sns.distplot(num_cols[variable], kde=True, bins=10)
```



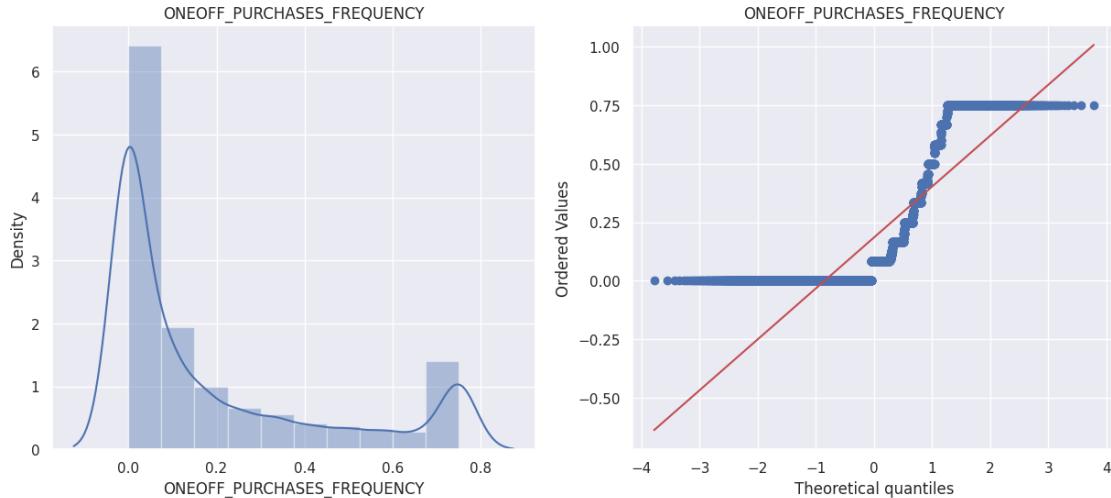
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```
sns.distplot(num_cols[variable], kde=True, bins=10)
```



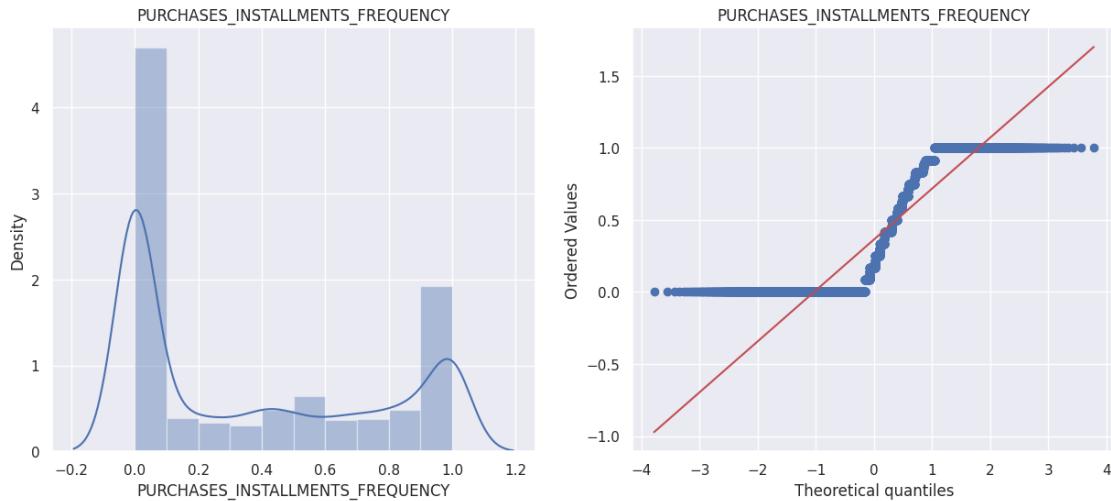
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```
sns.distplot(num_cols[variable], kde=True, bins=10)
```



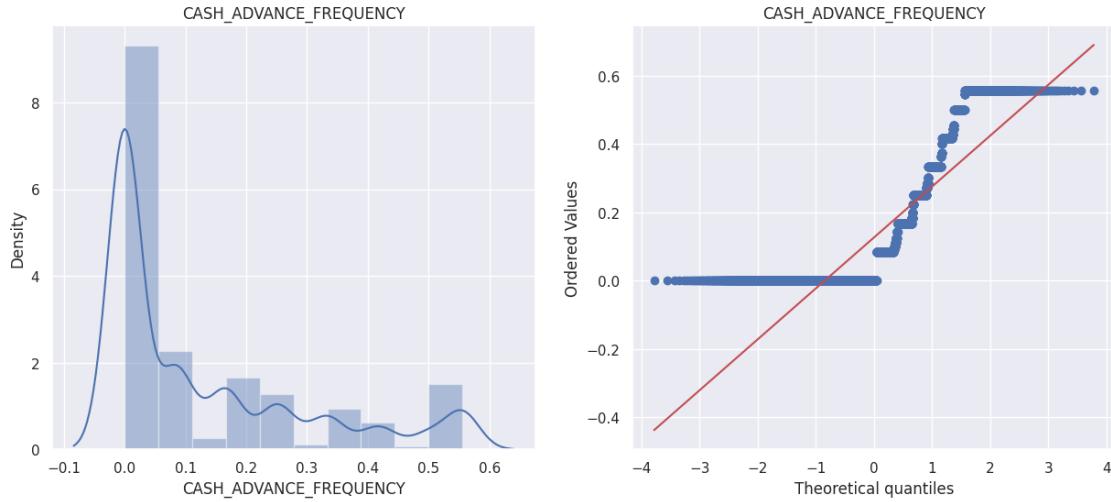
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```



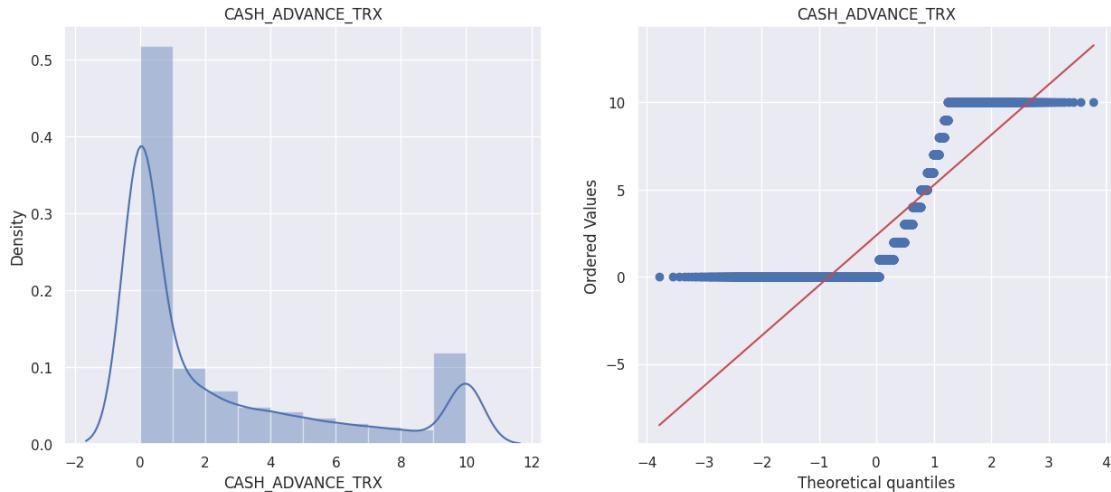
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```



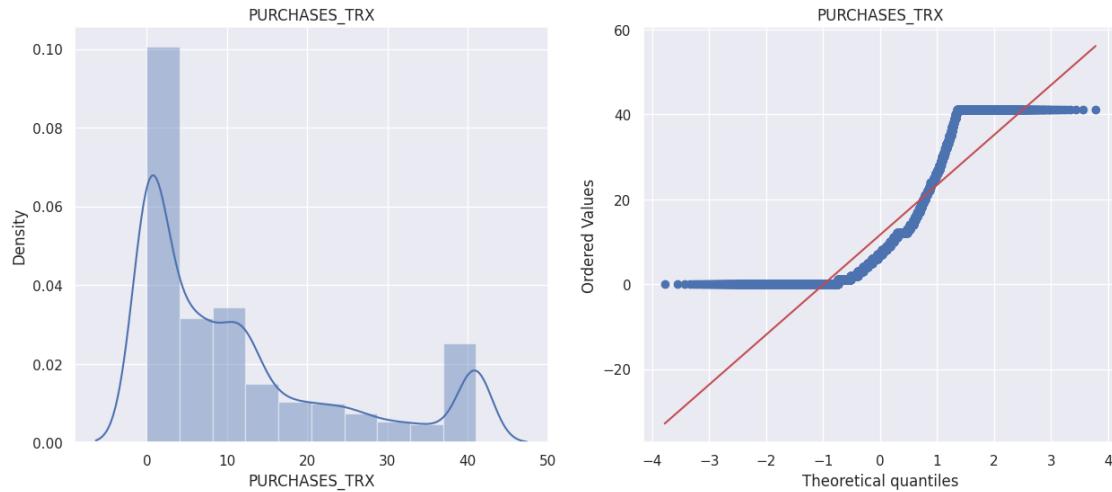
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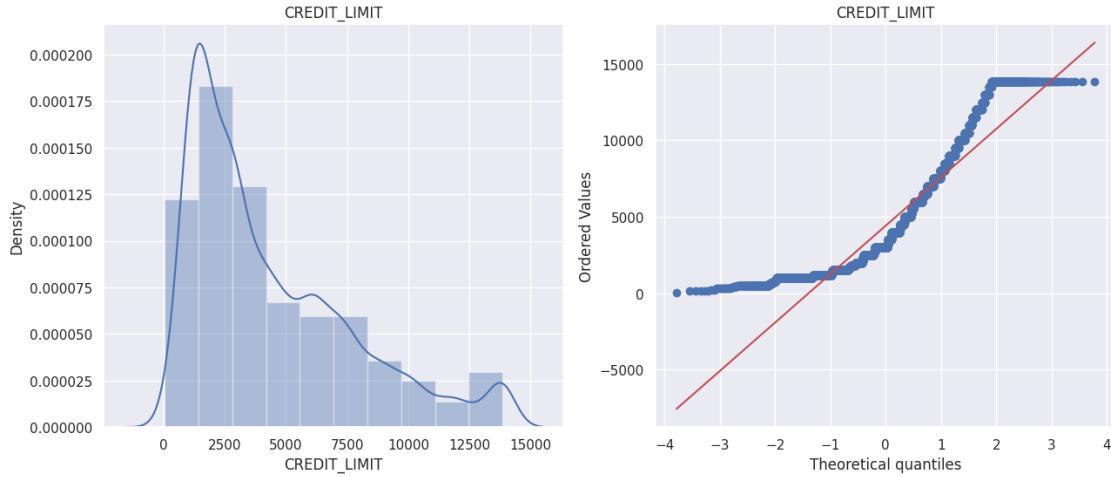
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```
sns.distplot(num_cols[variable], kde=True, bins=10)
```



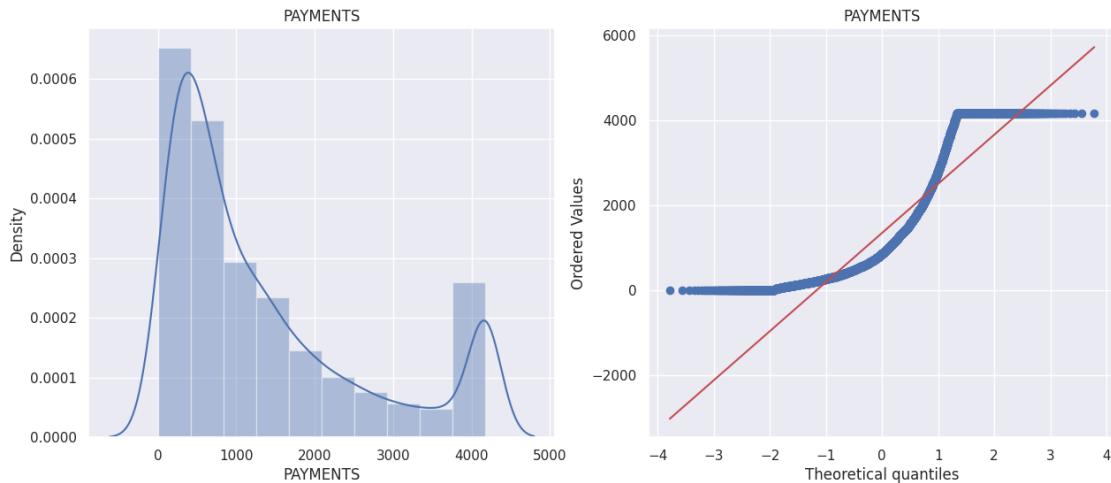
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```
sns.distplot(num_cols[variable], kde=True, bins=10)
```



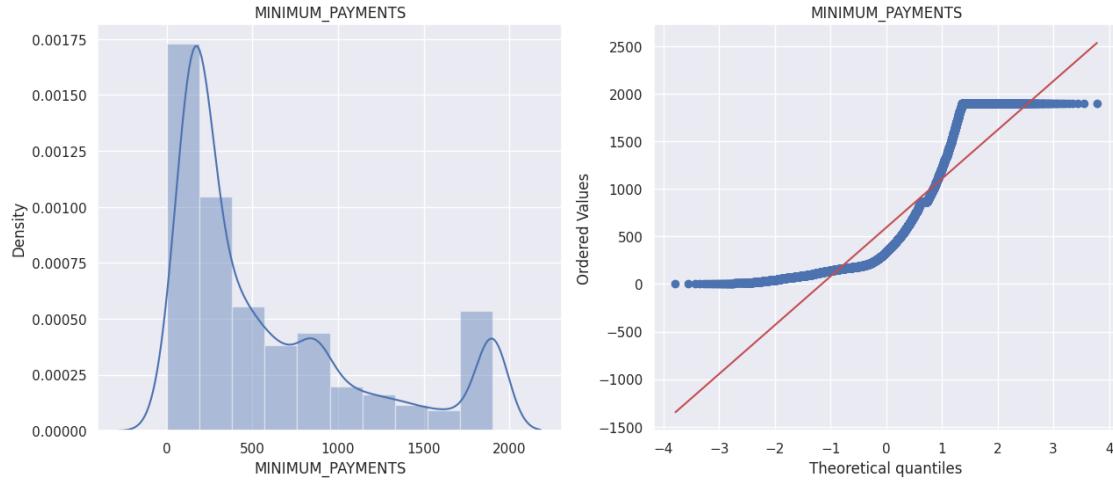
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```
sns.distplot(num_cols[variable], kde=True, bins=10)
```



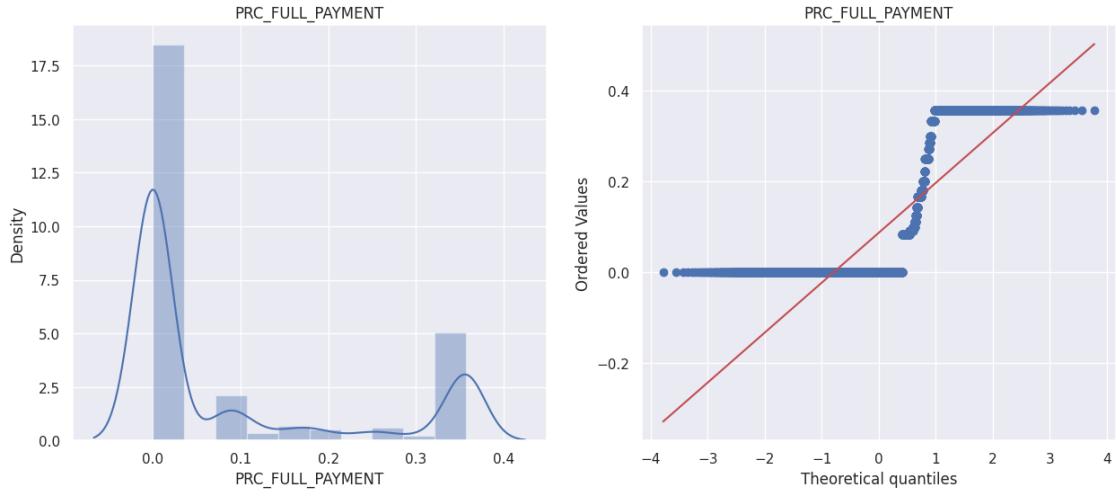
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```
sns.distplot(num_cols[variable], kde=True, bins=10)
```



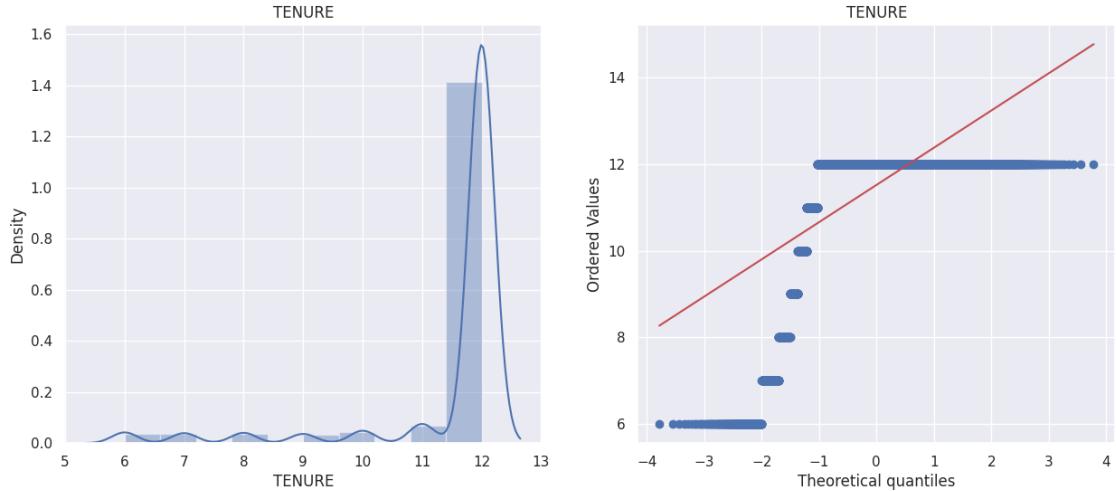
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```
sns.distplot(num_cols[variable], kde=True, bins=10)
```



## 7 Feature Engineering

```
[83]: X = df.iloc[:,1:]
```

```
[84]: X.head()
```

```
[84]:      BALANCE  BALANCE_FREQUENCY  PURCHASES  ONEOFF_PURCHASES \
0    40.900749          0.818182     95.40        0.0000
1   3202.467416          0.909091      0.00        0.0000
2   2495.148862          1.000000    773.17      773.1700
3   1666.670542          0.722223   1499.00     1443.5125
4    817.714335          1.000000     16.00      16.0000

      INSTALLMENTS_PURCHASES  CASH_ADVANCE  PURCHASES_FREQUENCY \
0                  95.4       0.000000        0.166667
1                  0.0      2784.552848        0.000000
2                  0.0       0.000000        1.000000
3                  0.0      205.788017        0.083333
4                  0.0       0.000000        0.083333

      ONEOFF_PURCHASES_FREQUENCY  PURCHASES_INSTALLMENTS_FREQUENCY \
0            0.000000           0.083333
1            0.000000           0.000000
2            0.750000           0.000000
3            0.083333           0.000000
4            0.083333           0.000000

      CASH_ADVANCE_FREQUENCY  CASH_ADVANCE_TRX  PURCHASES_TRX  CREDIT_LIMIT \
0            0.000000           0.0           2.0       1000.0
1            0.250000           4.0           0.0       7000.0
2            0.000000           0.0          12.0       7500.0
3            0.083333           1.0           1.0       7500.0
4            0.000000           0.0           1.0       1200.0

      PAYMENTS  MINIMUM_PAYMENTS  PRC_FULL_PAYMENT  TENURE
0   201.802084         139.509787        0.000000     12
1  4103.032597        1072.340217        0.222222     12
2   622.066742         627.284787        0.000000     12
3    0.000000         864.206542        0.000000     12
4   678.334763         244.791237        0.000000     12
```

### Normalizing Data

```
[85]: sc = StandardScaler()
X = sc.fit_transform(X)
```

```
[86]: X
```

```
[86]: array([[-0.87782104, -1.02187519, -0.72968709, ..., -0.79404745,
       -0.62927738,  0.36067954],
       [ 1.1785459 , -0.2027079 , -0.83815959, ...,  0.83675109,
        0.9739614 ,  0.36067954],
       [ 0.71848713,  0.61645939,  0.04095652, ...,  0.05869355,
       -0.62927738,  0.36067954],
       ...,
       [-0.88920486, -0.88535181, -0.67397271, ..., -0.89385616,
        1.17436805, -4.12276757],
       [-0.89567082, -0.88535181, -0.83815959, ..., -0.94046866,
        1.17436805, -4.12276757],
       [-0.66200474, -1.88655177,  0.40489651, ..., -0.88359305,
       -0.62927738, -4.12276757]])
```

## PCA

```
[87]: pca = PCA(n_components=2)
X_principle = pca.fit_transform(X)
X_principle = pd.DataFrame(X_principle,columns=["P1","P2"])
X_principle.head()
```

```
[87]:      P1      P2
0 -1.624789 -2.381615
1 -2.158390  2.289496
2  1.198983  0.280710
3 -0.495849 -0.185932
4 -1.632622 -1.597279
```

```
[88]: explained_variance = pca.explained_variance_ratio_
print("Explained Variance Ratios:", explained_variance)
```

Explained Variance Ratios: [0.31561234 0.23665552]

## 8 Model

### KMean Model

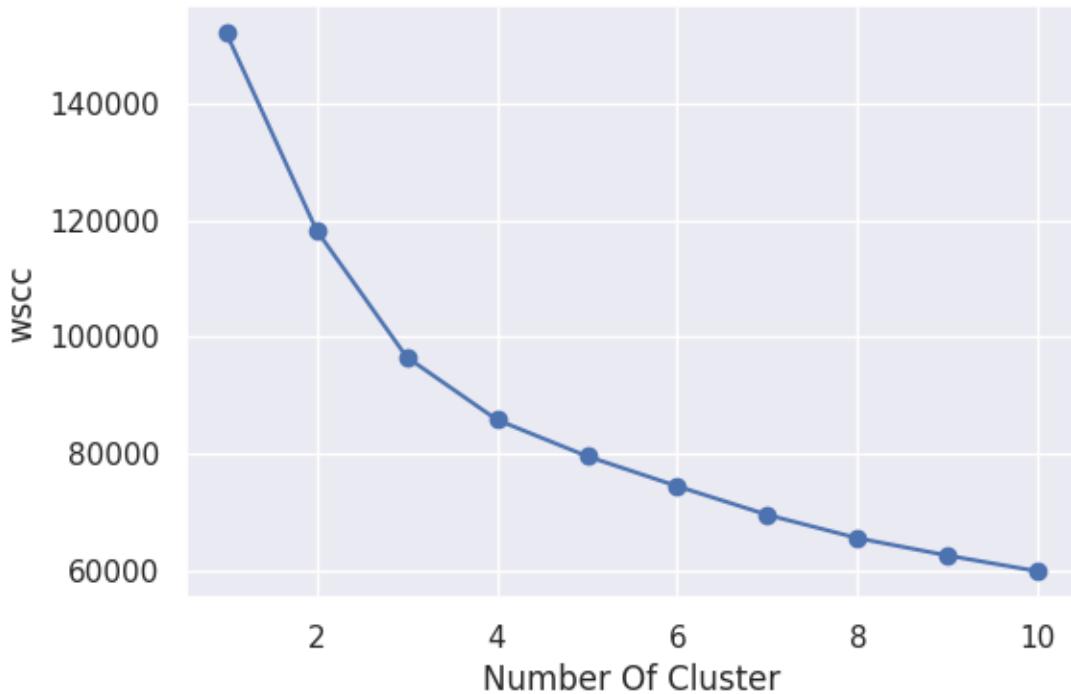
```
[89]: wscc = []
```

```
[90]: for i in range(1,11):
    model_kmean = KMeans(n_clusters=i,init="k-means++",random_state=0)
    model_kmean.fit(X)
    wscc.append(model_kmean.inertia_)
```

```
/usr/local/lib/python3.10/dist-packages/sklearn/cluster/_kmeans.py:870:
FutureWarning: The default value of `n_init` will change from 10 to 'auto' in
1.4. Set the value of `n_init` explicitly to suppress the warning
    warnings.warn(
/usr/local/lib/python3.10/dist-packages/sklearn/cluster/_kmeans.py:870:
```

```
[91]: plt.plot(range(1,11),wscc, marker = 'o')
plt.title("The Elbow Method")
plt.xlabel("Number Of Cluster")
plt.ylabel("wscc")
plt.show()
```

### The Elbow Method



```
[92]: model_kmean = KMeans(n_clusters=3,random_state=0).fit(X_principle)
```

```
/usr/local/lib/python3.10/dist-packages/sklearn/cluster/_kmeans.py:870:  
FutureWarning: The default value of `n_init` will change from 10 to 'auto' in  
1.4. Set the value of `n_init` explicitly to suppress the warning  
warnings.warn(
```

```
[93]: y_cluster = model_kmean.predict(X_principle)
```

```
[94]: y_cluster
```

```
[94]: array([0, 2, 1, ..., 0, 0, 0], dtype=int32)
```

```
[95]: silhouette_score(X_principle, y_cluster)
```

```
[95]: 0.43085099690525414
```

```
[96]: X_principle
```

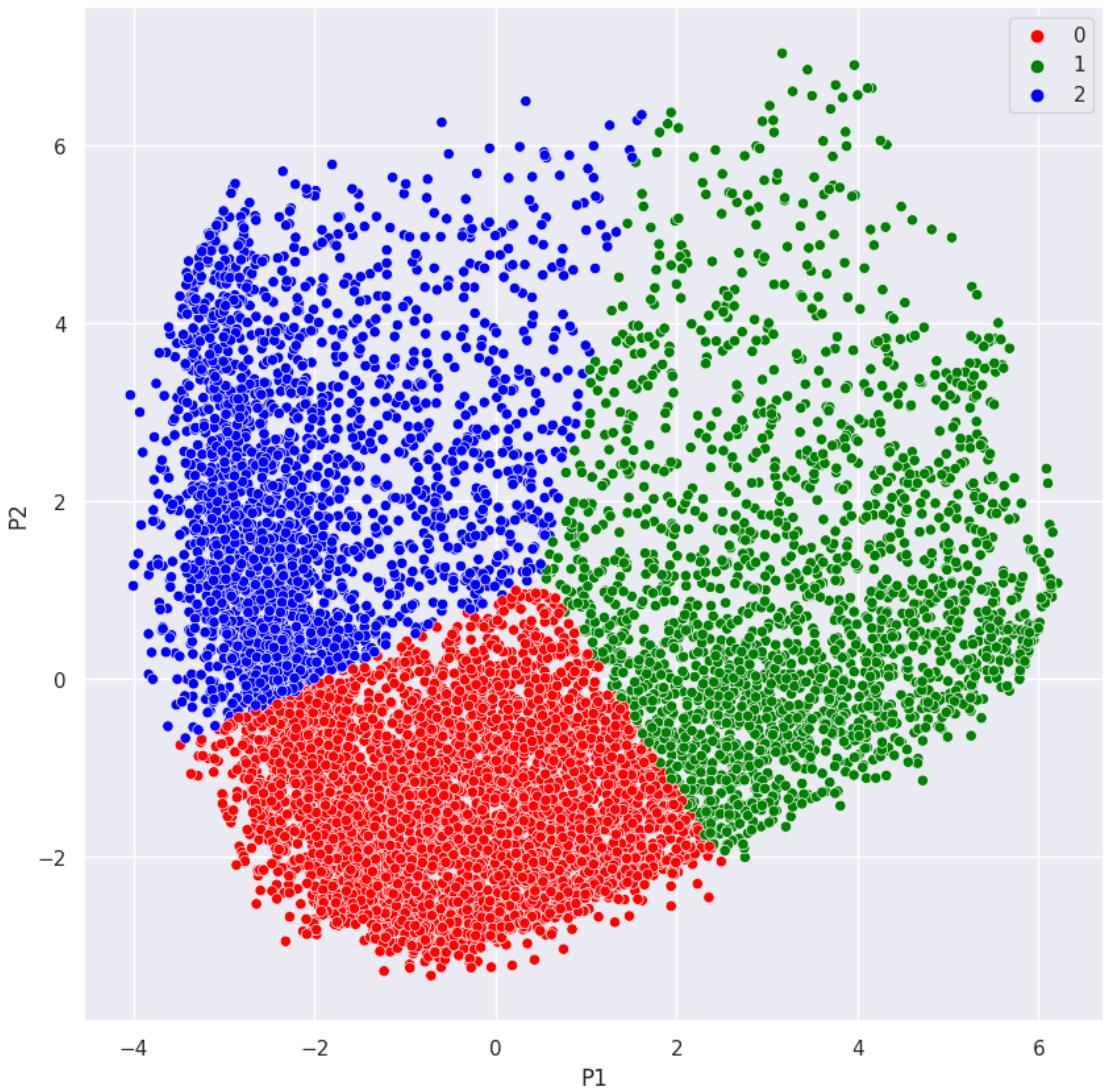
```
[96]:          P1          P2  
0    -1.624789 -2.381615  
1    -2.158390  2.289496  
2     1.198983  0.280710
```

```
3      -0.495849 -0.185932
4     -1.632622 -1.597279
...
8945   0.320141 -2.739866
8946  -0.131128 -1.803644
8947  -0.463207 -2.990444
8948  -2.418519 -2.466634
8949   0.180087 -0.908287
```

[8950 rows x 2 columns]

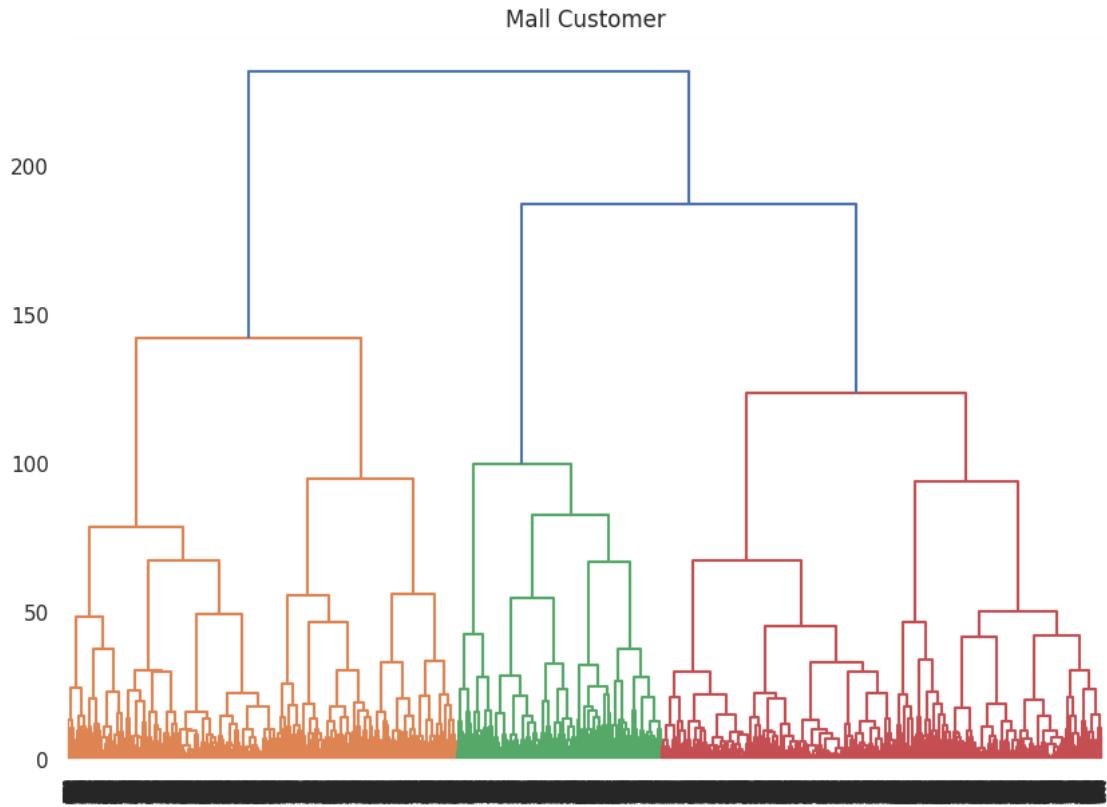
```
[97]: df_y_cluster = pd.concat([X_principle,pd.DataFrame({'cluster':y_cluster})],  
    axis = 1)
```

```
[98]: plt.figure(figsize=(10,10))  
ax = sns.scatterplot(x="P1", y="P2", hue = y_cluster, data = X_principle,  
    palette=['red','green','blue'])  
plt.show()
```



```
[99]: # Another Way To Used Linkage Metrics
from scipy.cluster.hierarchy import dendrogram, linkage
import matplotlib.pyplot as plt

plt.figure(figsize=(10,7))
plt.title("Mall Customer")
dend = dendrogram(linkage(X,method="ward"))
```



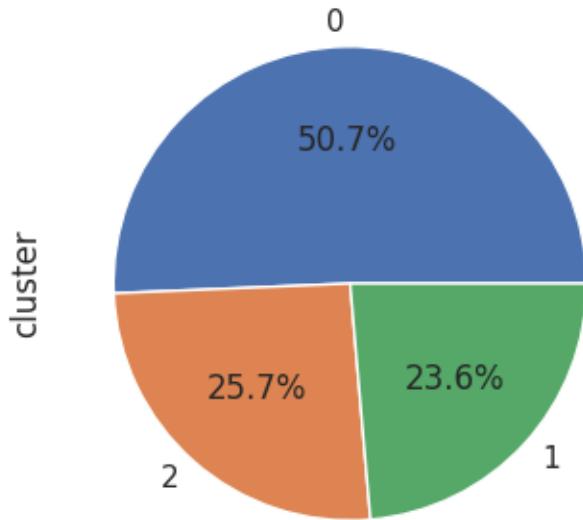
```
[100]: X_principle
```

```
[100]:          P1          P2
0    -1.624789 -2.381615
1    -2.158390  2.289496
2     1.198983  0.280710
3    -0.495849 -0.185932
4    -1.632622 -1.597279
...
8945   ...      ...
8946  0.320141 -2.739866
8946 -0.131128 -1.803644
8947 -0.463207 -2.990444
8948 -2.418519 -2.466634
8949  0.180087 -0.908287
```

[8950 rows x 2 columns]

```
[101]: df_y_cluster["cluster"].value_counts().plot.pie(autopct= '%.1f%%')
```

```
[101]: <Axes: ylabel='cluster'>
```



### Agglomerative Clustering

```
[102]: model_agg = AgglomerativeClustering(n_clusters=3).fit(X_principle)
```

```
[103]: y_pred = model_agg.labels_
y_pred
```

```
[103]: array([0, 2, 0, ..., 0, 0, 0])
```

```
[104]: silhouette_score(X_principle, y_pred)
```

```
[104]: 0.40260454393255907
```

```
[105]: df_y_cluster
```

```
[105]:      P1      P2  cluster
0    -1.624789 -2.381615      0
1    -2.158390  2.289496      2
2     1.198983  0.280710      1
3    -0.495849 -0.185932      0
4    -1.632622 -1.597279      0
...
8945   ...     ...     ...
8946  0.320141 -2.739866      0
8946 -0.131128 -1.803644      0
8947 -0.463207 -2.990444      0
8948 -2.418519 -2.466634      0
8949  0.180087 -0.908287      0
```

```
[8950 rows x 3 columns]
```

```
[106]: df_y_cluster = pd.concat([df_y_cluster,pd.DataFrame({'label':y_pred})], axis = 1)
```

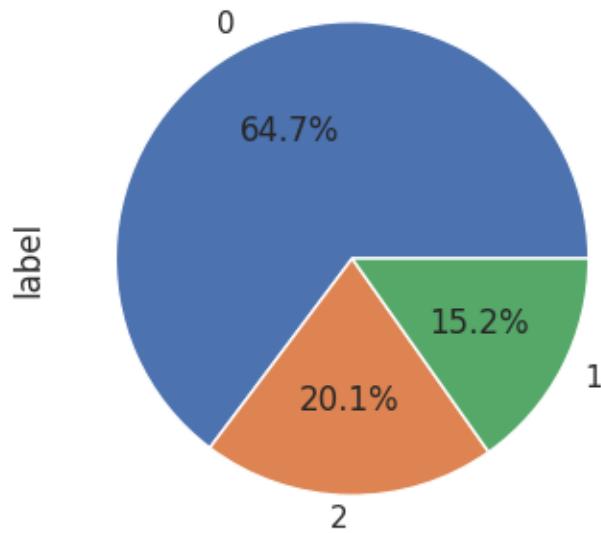
```
[107]: df_y_cluster
```

```
[107]:      P1      P2  cluster  label
0    -1.624789 -2.381615      0      0
1    -2.158390  2.289496      2      2
2     1.198983  0.280710      1      0
3    -0.495849 -0.185932      0      0
4    -1.632622 -1.597279      0      0
...
8945   0.320141 -2.739866      0      0
8946  -0.131128 -1.803644      0      0
8947  -0.463207 -2.990444      0      0
8948  -2.418519 -2.466634      0      0
8949   0.180087 -0.908287      0      0
```

```
[8950 rows x 4 columns]
```

```
[108]: df_y_cluster["label"].value_counts().plot.pie(autopct= '%.1f%%')
```

```
[108]: <Axes: ylabel='label'>
```



```
[109]: plt.figure(figsize=(10,10))
ax = sns.scatterplot(x="P1", y="P2", hue = y_pred, data = X_principle, palette='viridis')
plt.show()
```



```
[116]:
```