In [1]:
```
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
import seaborn as sns
from sklearn.preprocessing import StandardScaler
from sklearn.cluster import KMeans
from sklearn.metrics import silhouette_score
from datetime import timedelta
from pandas import ExcelWriter
```

In [2]:
```
df = pd.read_excel("Online Retail.xlsx")
df.head()
```

Out[2]:

	InvoiceNo	StockCode	Description	Quantity	InvoiceDate	UnitPrice	CustomerID	Country
0	536365	85123A	WHITE HANGING HEART T-LIGHT HOLDER	6	2010-12-01 08:26:00	2.55	17850.0	United Kingdom
1	536365	71053	WHITE METAL LANTERN	6	2010-12-01 08:26:00	3.39	17850.0	United Kingdom
2	536365	84406B	CREAM CUPID HEARTS COAT HANGER	8	2010-12-01 08:26:00	2.75	17850.0	United Kingdom
3	536365	84029G	KNITTED UNION FLAG HOT WATER BOTTLE	6	2010-12-01 08:26:00	3.39	17850.0	United Kingdom
4	536365	84029E	RED WOOLLY HOTTIE WHITE HEART.	6	2010-12-01 08:26:00	3.39	17850.0	United Kingdom

In [3]:
```
df.shape
```

Out[3]:
```
(541909, 8)
```

In [4]:
```
df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 541909 entries, 0 to 541908
Data columns (total 8 columns):
 #   Column       Non-Null Count   Dtype         
---  ------       --------------   -----         
 0   InvoiceNo    541909 non-null  object        
 1   StockCode    541909 non-null  object        
 2   Description  540455 non-null  object        
 3   Quantity     541909 non-null  int64         
 4   InvoiceDate  541909 non-null  datetime64[ns]
 5   UnitPrice    541909 non-null  float64       
 6   CustomerID   406829 non-null  float64       
 7   Country      541909 non-null  object        
dtypes: datetime64[ns](1), float64(2), int64(1), object(4)
memory usage: 33.1+ MB
```

In [5]:
```
# Check missing values in dataset
df.isnull().sum()
```

Out[5]:
```
InvoiceNo          0
StockCode          0
Description     1454
Quantity           0
InvoiceDate        0
UnitPrice          0
CustomerID     135080
Country            0
dtype: int64
```

In [6]:
```
# Calculating the Missing Values % contribution in DF
df_null = round(df.isnull().sum()/len(df)*100,2)
df_null
```

Out[6]:
```
InvoiceNo       0.00
StockCode       0.00
Description     0.27
Quantity        0.00
InvoiceDate     0.00
UnitPrice       0.00
CustomerID     24.93
Country         0.00
dtype: float64
```

In [7]:
```
invoice_null_custid = set(df[df['CustomerID'].isnull()]['InvoiceNo'])
df[df['InvoiceNo'].isin(invoice_null_custid) & (~df['CustomerID'].isnull())]
```

Out[7]:

InvoiceNo	StockCode	Description	Quantity	InvoiceDate	UnitPrice	CustomerID	Country

In [8]:
```
df = df.drop('Description', axis=1)
df = df.dropna()
df.shape
```

Out[8]:
```
(406829, 7)
```

In [9]:
```
df = df.drop_duplicates()
df.shape
```

Out[9]:
```
(401602, 7)
```

In [10]:
```
df['CustomerID'] = df['CustomerID'].astype(str)
```

In [11]:
```
df.describe(include=['O'])
```

Out[11]:

	InvoiceNo	StockCode	CustomerID	Country
count	401602	401602	401602	401602
unique	22190	3684	4372	37
top	576339	85123A	17841.0	United Kingdom
freq	542	2065	7812	356726

Create month cohort of customers and analyze active customers in each cohort:

In [12]:
```
# Convert to InvoiceDate to Year-Month format
df['month_year'] = df['InvoiceDate'].dt.to_period('M')
df['month_year'].nunique()
```

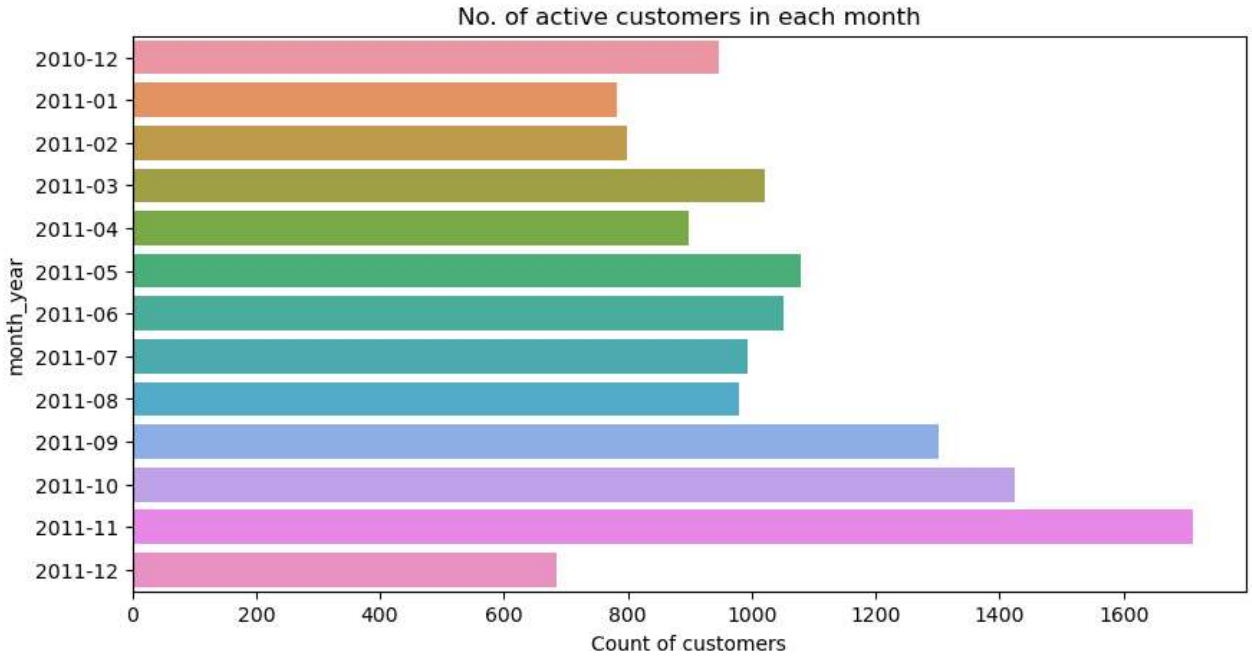
Out[12]:
```
13
```

In [13]:
```
month_cohort = df.groupby('month_year')['CustomerID'].nunique()
month_cohort
```

Out[13]:
```
month_year
2010-12     948
2011-01     783
2011-02     798
2011-03    1020
2011-04     899
2011-05    1079
2011-06    1051
2011-07     993
2011-08     980
2011-09    1302
2011-10    1425
2011-11    1711
2011-12     686
Freq: M, Name: CustomerID, dtype: int64
```

In [14]:
```
plt.figure(figsize=(10,5))
sns.barplot(y = month_cohort.index, x = month_cohort.values);
plt.xlabel("Count of customers")
plt.title("No. of active customers in each month")
```

Out[14]:
```
Text(0.5, 1.0, 'No. of active customers in each month')
```



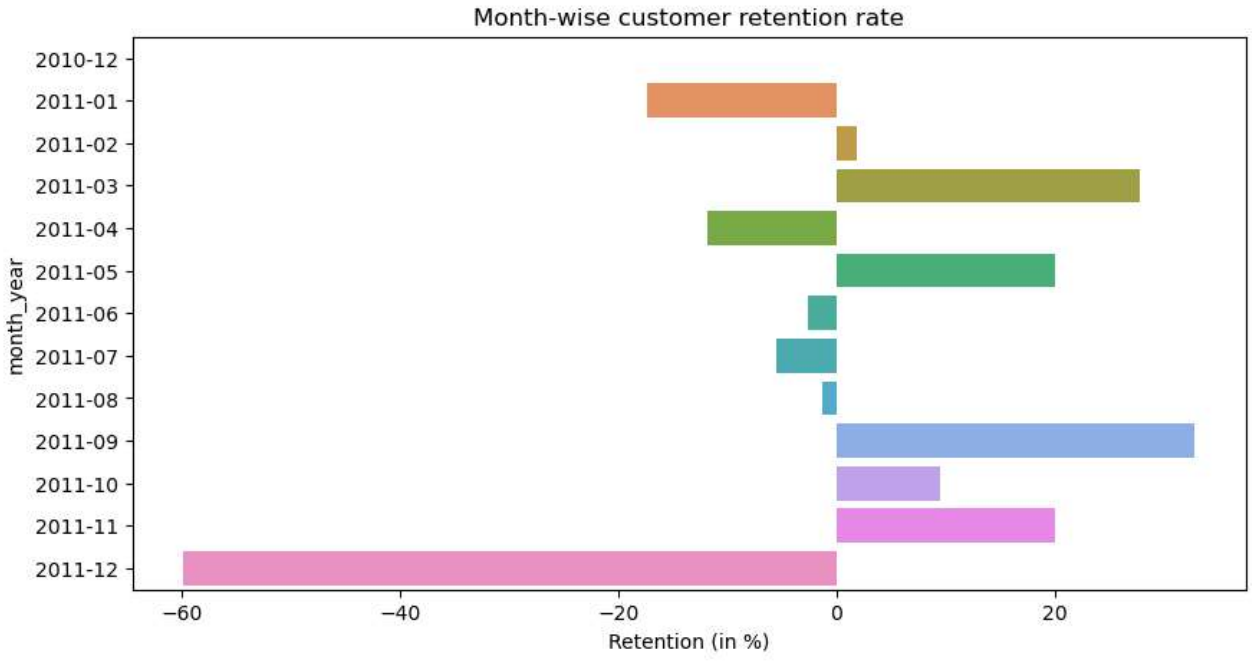
In [15]:
```
month_cohort - month_cohort.shift(1)
```

Out[15]:
```
month_year
2010-12       NaN
2011-01    -165.0
2011-02      15.0
2011-03     222.0
2011-04    -121.0
2011-05     180.0
2011-06     -28.0
2011-07     -58.0
2011-08     -13.0
2011-09     322.0
2011-10     123.0
2011-11     286.0
2011-12   -1025.0
Freq: M, Name: CustomerID, dtype: float64
```

In [16]:
```
retention_rate = round(month_cohort.pct_change(periods=1)*100,2)
retention_rate
```

Out[16]:
```
month_year
2010-12      NaN
2011-01   -17.41
2011-02     1.92
2011-03    27.82
2011-04   -11.86
2011-05    20.02
2011-06    -2.59
2011-07    -5.52
2011-08    -1.31
2011-09    32.86
2011-10     9.45
2011-11    20.07
2011-12   -59.91
Freq: M, Name: CustomerID, dtype: float64
```

In [17]:
```
plt.figure(figsize=(10,5))
sns.barplot(y = retention_rate.index, x = retention_rate.values);
plt.xlabel("Retention (in %)")
plt.title("Month-wise customer retention rate");
```



In [18]:
```
df['amount'] = df['Quantity']*df['UnitPrice']
df.head()
```

Out[18]:

	InvoiceNo	StockCode	Quantity	InvoiceDate	UnitPrice	CustomerID	Country	month_year	amount
0	536365	85123A	6	2010-12-01 08:26:00	2.55	17850.0	United Kingdom	2010-12	15.30
1	536365	71053	6	2010-12-01 08:26:00	3.39	17850.0	United Kingdom	2010-12	20.34
2	536365	84406B	8	2010-12-01 08:26:00	2.75	17850.0	United Kingdom	2010-12	22.00
3	536365	84029G	6	2010-12-01 08:26:00	3.39	17850.0	United Kingdom	2010-12	20.34
4	536365	84029E	6	2010-12-01 08:26:00	3.39	17850.0	United Kingdom	2010-12	20.34

In [19]:
```
df_monetary = df.groupby('CustomerID').sum()['amount'].reset_index()
df_monetary
```

Out[19]:

	CustomerID	amount
0	12346.0	0.00
1	12347.0	4310.00
2	12348.0	1797.24
3	12349.0	1757.55
4	12350.0	334.40
...	...	...
4367	18280.0	180.60
4368	18281.0	80.82
4369	18282.0	176.60
4370	18283.0	2045.53
4371	18287.0	1837.28

4372 rows × 2 columns

In [20]:
```
df_frequency = df.groupby('CustomerID').nunique()['InvoiceNo'].reset_index()
df_frequency
```

Out[20]:

	CustomerID	InvoiceNo
0	12346.0	2
1	12347.0	7
2	12348.0	4
3	12349.0	1
4	12350.0	1
...	...	...
4367	18280.0	1
4368	18281.0	1
4369	18282.0	3
4370	18283.0	16
4371	18287.0	3

4372 rows × 2 columns

In [21]:
```
#  calculating recenctly as last transaction day in data + 1 day
ref_day = max(df['InvoiceDate']) + timedelta(days=1)
df['days_to_last_order'] = (ref_day - df['InvoiceDate']).dt.days
df.head()
```

Out[21]:

	InvoiceNo	StockCode	Quantity	InvoiceDate	UnitPrice	CustomerID	Country	month_year	amount	days_to_last_or
0	536365	85123A	6	2010-12-01 08:26:00	2.55	17850.0	United Kingdom	2010-12	15.30	3
1	536365	71053	6	2010-12-01 08:26:00	3.39	17850.0	United Kingdom	2010-12	20.34	3
2	536365	84406B	8	2010-12-01 08:26:00	2.75	17850.0	United Kingdom	2010-12	22.00	3
3	536365	84029G	6	2010-12-01 08:26:00	3.39	17850.0	United Kingdom	2010-12	20.34	3
4	536365	84029E	6	2010-12-01 08:26:00	3.39	17850.0	United Kingdom	2010-12	20.34	3

In [22]:
```
df_recency = df.groupby('CustomerID')['days_to_last_order'].min().reset_index()
df_recency
```

Out[22]:

	CustomerID	days_to_last_order
0	12346.0	326
1	12347.0	2
2	12348.0	75
3	12349.0	19
4	12350.0	310
...	...	...
4367	18280.0	278
4368	18281.0	181
4369	18282.0	8
4370	18283.0	4
4371	18287.0	43

4372 rows × 2 columns

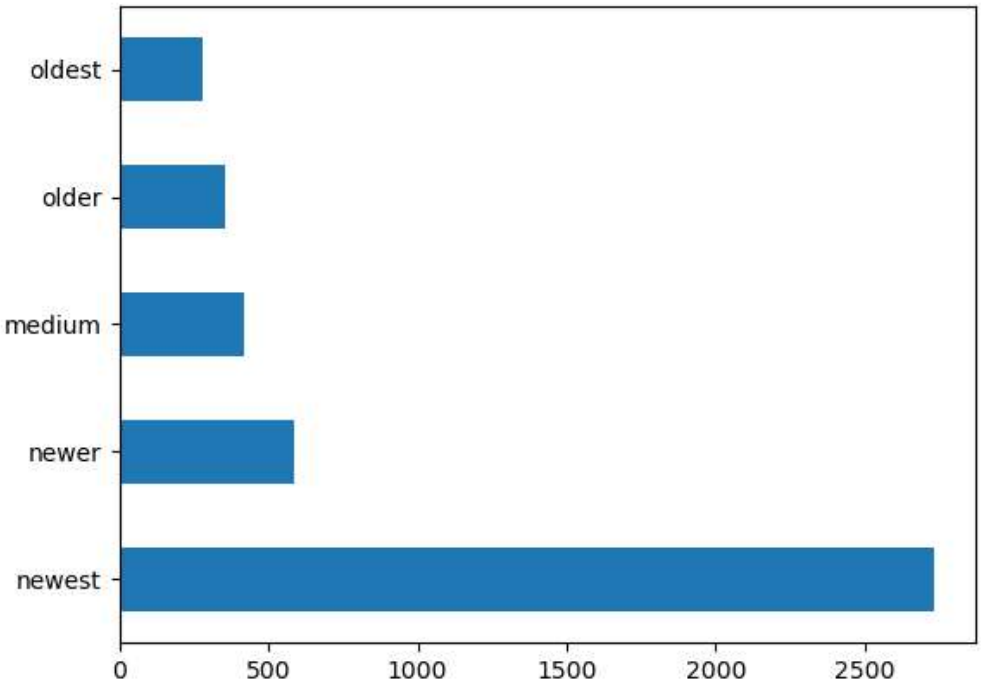
In [23]:
```
df_rf = pd.merge(df_recency, df_frequency,  on='CustomerID', how='inner')
df_rfm = pd.merge(df_rf, df_monetary, on='CustomerID', how='inner')
df_rfm.columns = ['CustomerID', 'Recency', 'Frequency', 'Monetary']
df_rfm.head()
```

Out[23]:

	CustomerID	Recency	Frequency	Monetary
0	12346.0	326	2	0.00
1	12347.0	2	7	4310.00
2	12348.0	75	4	1797.24
3	12349.0	19	1	1757.55
4	12350.0	310	1	334.40

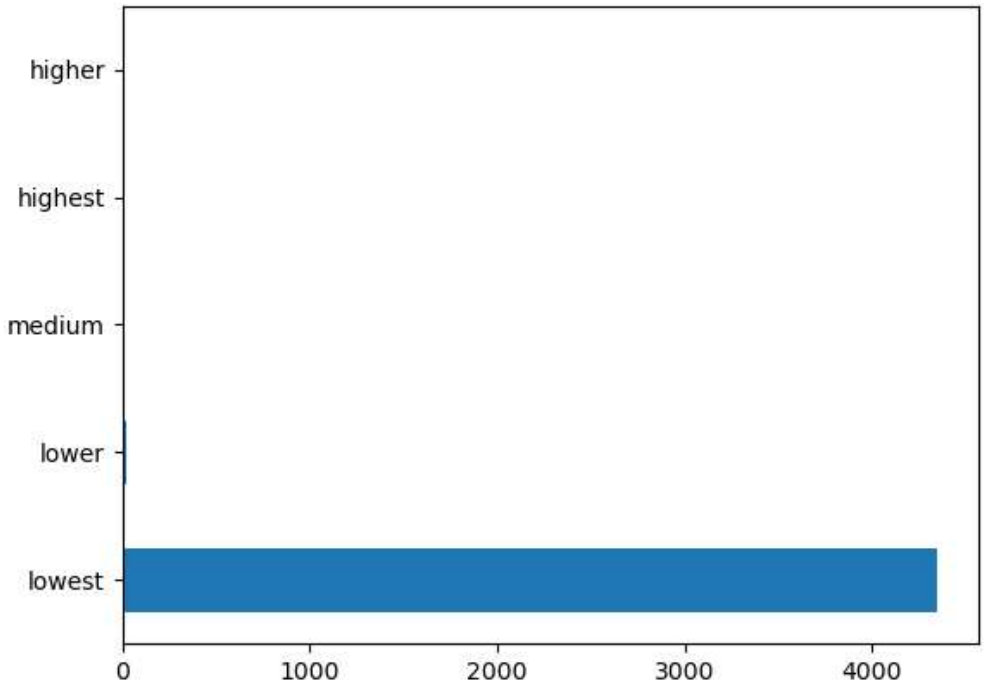
In [25]:
```
df_rfm['recency_labels'] = pd.cut(df_rfm['Recency'], bins=5,labels=['newest', 'newer', 'medium',

df_rfm['recency_labels'].value_counts().plot(kind='barh');
df_rfm['recency_labels'].value_counts()
```

Out[25]:
```
newest    2734
newer      588
medium     416
older      353
oldest     281
Name: recency_labels, dtype: int64
```



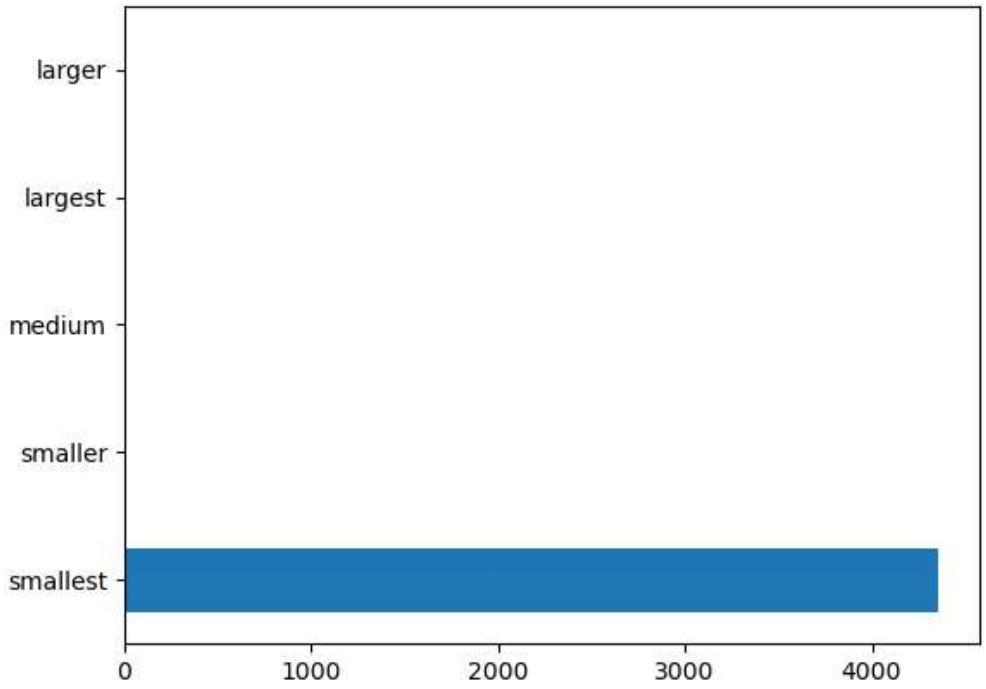
In [26]:
```
df_rfm['frequency_labels'] = pd.cut(df_rfm['Frequency'], bins=5, labels=['lowest', 'lower', 'medi
df_rfm['frequency_labels'].value_counts().plot(kind='barh');
df_rfm['frequency_labels'].value_counts()
```

Out[26]:
```
lowest     4348
lower        18
medium        3
highest       2
higher        1
Name: frequency_labels, dtype: int64
```



In [27]:
```
df_rfm['monetary_labels'] = pd.cut(df_rfm['Monetary'], bins=5, labels=['smallest', 'smaller', 'm
df_rfm['monetary_labels'].value_counts().plot(kind='barh');
df_rfm['monetary_labels'].value_counts()
```

Out[27]:
```
smallest    4357
smaller        9
medium         3
largest        2
larger         1
Name: monetary_labels, dtype: int64
```



In [28]:
```
df_rfm['rfm_segment'] = df_rfm[['recency_labels','frequency_labels','monetary_labels']].agg('-'.
df_rfm.head()
```

Out[28]:

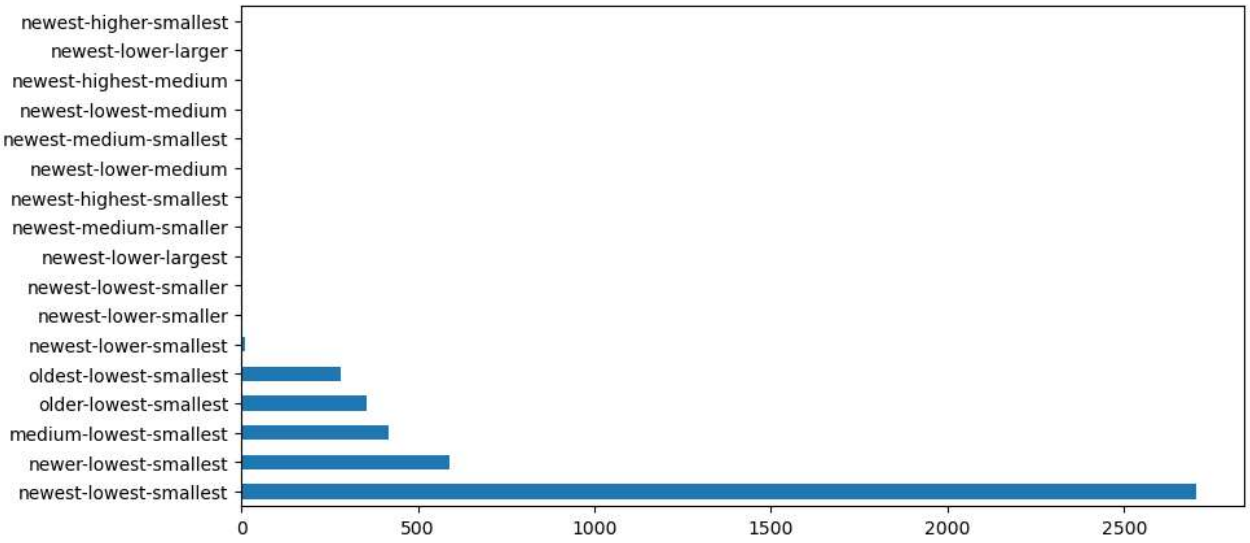
	CustomerID	Recency	Frequency	Monetary	recency_labels	frequency_labels	monetary_labels	rfm_segment
0	12346.0	326	2	0.00	oldest	lowest	smallest	oldest-lowest-smallest
1	12347.0	2	7	4310.00	newest	lowest	smallest	newest-lowest-smallest
2	12348.0	75	4	1797.24	newest	lowest	smallest	newest-lowest-smallest
3	12349.0	19	1	1757.55	newest	lowest	smallest	newest-lowest-smallest
4	12350.0	310	1	334.40	oldest	lowest	smallest	oldest-lowest-smallest

In [29]:
```
recency_dict = {'newest': 5, 'newer':4, 'medium': 3, 'older':2, 'oldest':1}
frequency_dict = {'lowest':1, 'lower':2, 'medium': 3, 'higher':4, 'highest':5}
monetary_dict = {'smallest':1, 'smaller':2, 'medium': 3, 'larger':4, 'largest':5}

df_rfm['rfm_score'] = df_rfm['recency_labels'].map(recency_dict).astype(int)+ df_rfm['frequency_
df_rfm.head(10)
```

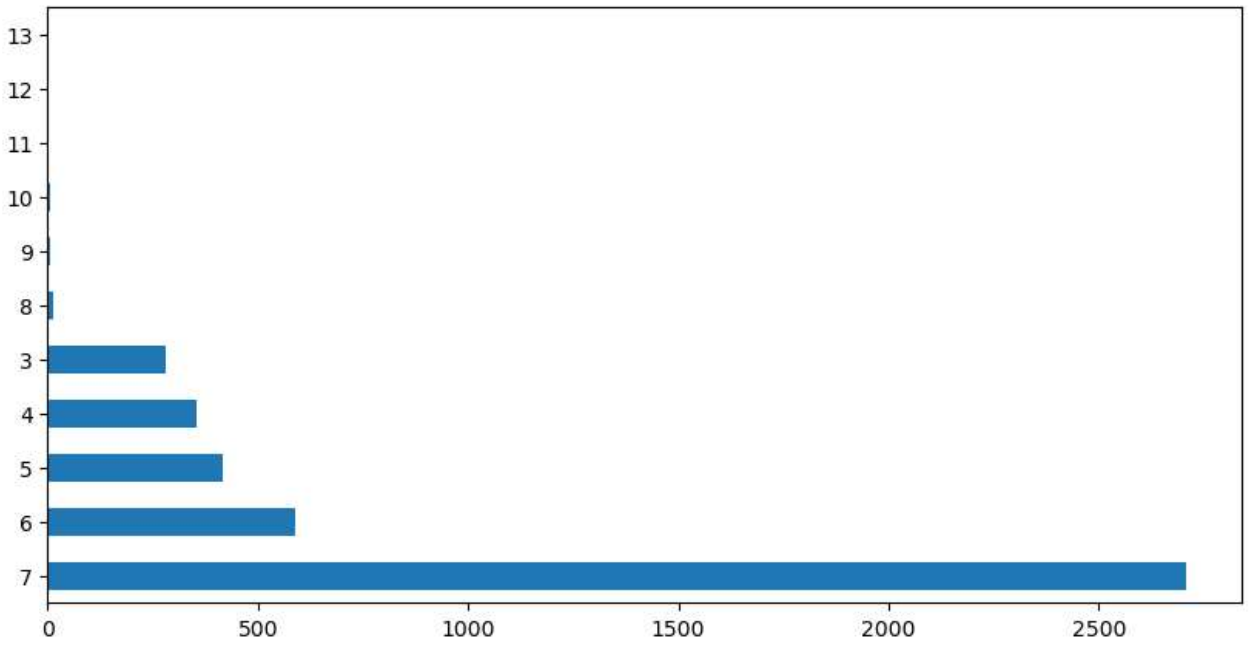
Out[29]:

	CustomerID	Recency	Frequency	Monetary	recency_labels	frequency_labels	monetary_labels	rfm_segment	rfm_sc
0	12346.0	326	2	0.00	oldest	lowest	smallest	oldest-lowest-smallest	
1	12347.0	2	7	4310.00	newest	lowest	smallest	newest-lowest-smallest	
2	12348.0	75	4	1797.24	newest	lowest	smallest	newest-lowest-smallest	
3	12349.0	19	1	1757.55	newest	lowest	smallest	newest-lowest-smallest	
4	12350.0	310	1	334.40	oldest	lowest	smallest	oldest-lowest-smallest	
5	12352.0	36	11	1545.41	newest	lowest	smallest	newest-lowest-smallest	
6	12353.0	204	1	89.00	medium	lowest	smallest	medium-lowest-smallest	
7	12354.0	232	1	1079.40	older	lowest	smallest	older-lowest-smallest	
8	12355.0	214	1	459.40	medium	lowest	smallest	medium-lowest-smallest	
9	12356.0	23	3	2811.43	newest	lowest	smallest	newest-lowest-smallest	

In [30]:
```
df_rfm['rfm_segment'].value_counts().plot(kind='barh', figsize=(10, 5));
```



In [31]:
```
df_rfm['rfm_score'].value_counts().plot(kind='barh', figsize=(10, 5));
```



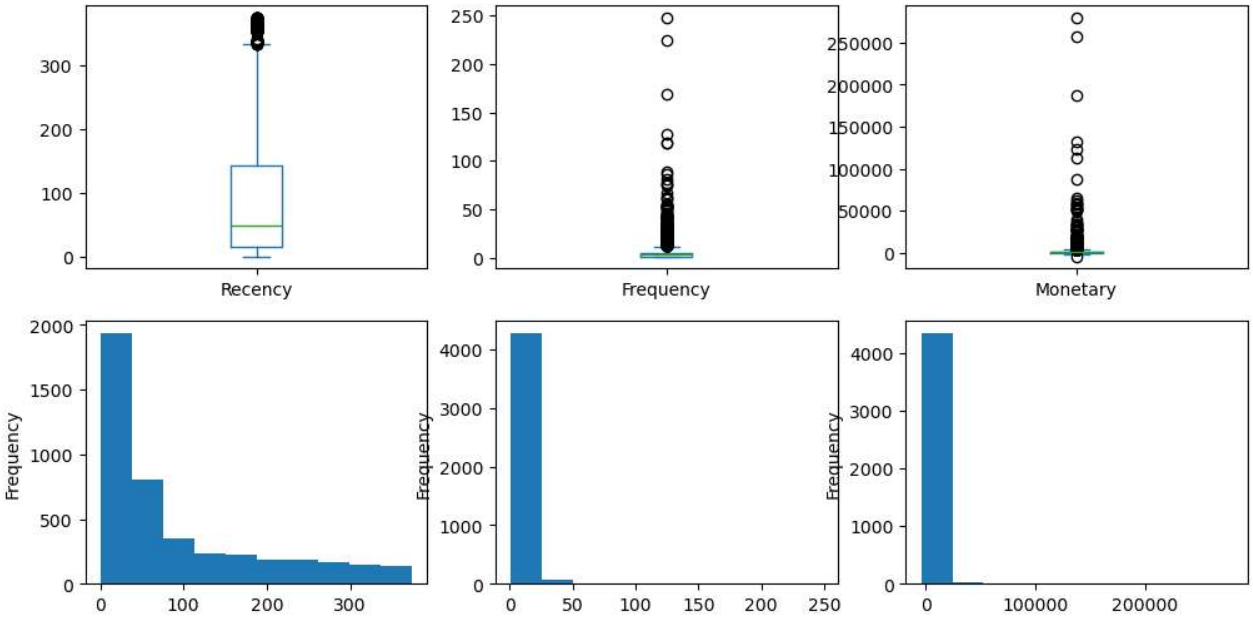
In [32]:
```
print(df_rfm.shape)
df_rfm.head()
```

```
(4372, 9)
```

Out[32]:

	CustomerID	Recency	Frequency	Monetary	recency_labels	frequency_labels	monetary_labels	rfm_segment	rfm_sc
0	12346.0	326	2	0.00	oldest	lowest	smallest	oldest-lowest-smallest	
1	12347.0	2	7	4310.00	newest	lowest	smallest	newest-lowest-smallest	
2	12348.0	75	4	1797.24	newest	lowest	smallest	newest-lowest-smallest	
3	12349.0	19	1	1757.55	newest	lowest	smallest	newest-lowest-smallest	
4	12350.0	310	1	334.40	oldest	lowest	smallest	oldest-lowest-smallest	

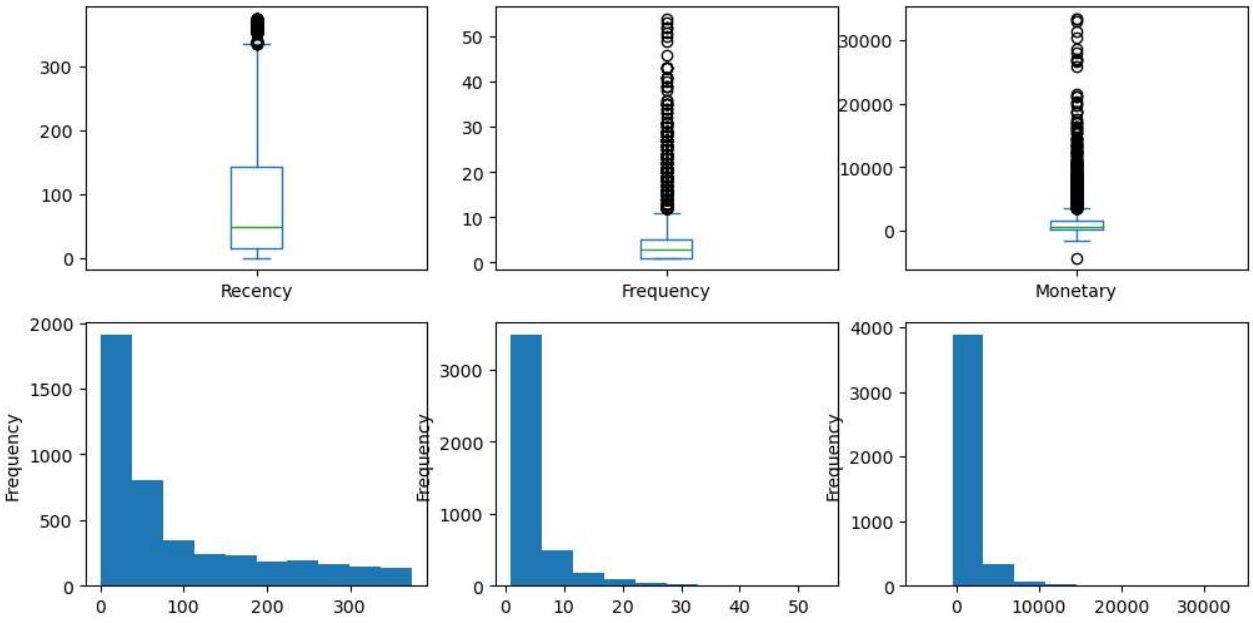
In [33]:
```
plt.figure(figsize=(12,6))

for i, feature in enumerate(['Recency', 'Frequency', 'Monetary']):
    plt.subplot(2,3,i+1)
    df_rfm[feature].plot(kind='box')
    plt.subplot(2,3,i+1+3)
    df_rfm[feature].plot(kind='hist')
```



In [34]:
```
df_rfm = df_rfm[(df_rfm['Frequency']<60) & (df_rfm['Monetary']<40000)]
df_rfm.shape
```

Out[34]: (4346, 9)

In [35]:
```
plt.figure(figsize=(12,6))

for i, feature in enumerate(['Recency', 'Frequency', 'Monetary']):
    plt.subplot(2,3,i+1)
    df_rfm[feature].plot(kind='box')
    plt.subplot(2,3,i+1+3)
    df_rfm[feature].plot(kind='hist')
```



In [ ]:
```
#Log Transformation:
```

In [36]:
```
df_rfm_log_trans = pd.DataFrame()
df_rfm_log_trans['Recency'] = np.log(df_rfm['Recency'])
df_rfm_log_trans['Frequency'] = np.log(df_rfm['Frequency'])
df_rfm_log_trans['Monetary'] = np.log(df_rfm['Monetary']-df_rfm['Monetary'].min()+1)
```

In [ ]:
```
#Standard Scalar Transformation:
```

In [37]:
```
scaler = StandardScaler()

df_rfm_scaled = scaler.fit_transform(df_rfm_log_trans[['Recency', 'Frequency', 'Monetary']])
df_rfm_scaled

df_rfm_scaled = pd.DataFrame(df_rfm_scaled)
df_rfm_scaled.columns = ['Recency', 'Frequency', 'Monetary']
```

In [38]:
```
df_rfm_scaled.head()
```

Out[38]:

	Recency	Frequency	Monetary
0	1.402988	-0.388507	-0.770922
1	-2.100874	0.967301	1.485132
2	0.392218	0.361655	0.364190
3	-0.552268	-1.138669	0.342970
4	1.368370	-1.138669	-0.527416

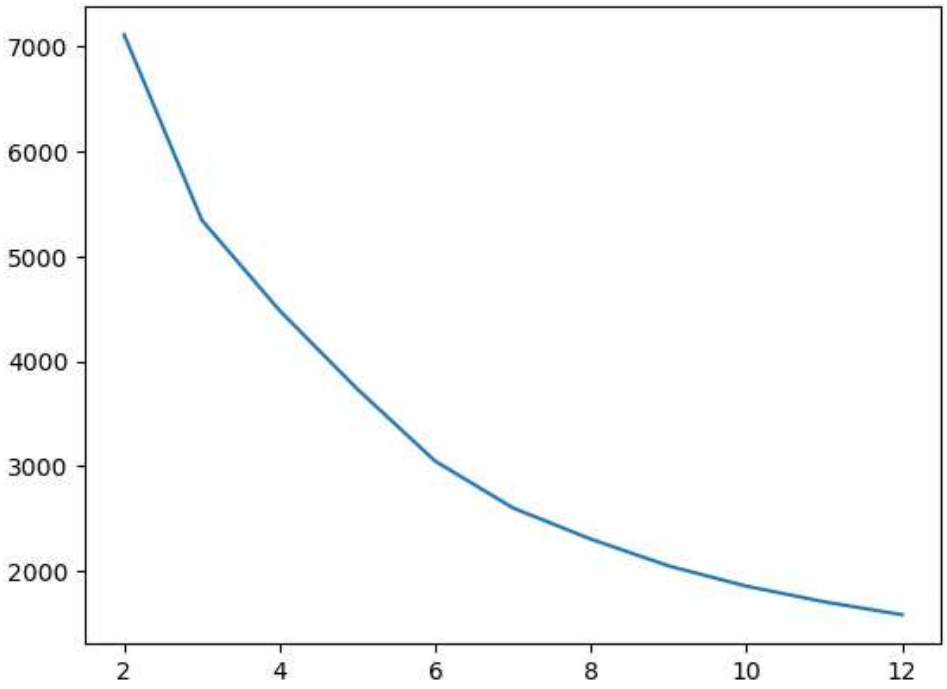
In [39]:
```
# k-means with some arbitrary k
kmeans = KMeans(n_clusters=3, max_iter=50)
kmeans.fit(df_rfm_scaled)
```

Out[39]:
```
KMeans(max_iter=50, n_clusters=3)
```

In [40]:
```
kmeans.labels_
```

Out[40]:
```
array([1, 2, 0, ..., 0, 2, 0])
```

In [41]:
```
ssd = []
range_n_clusters = [2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12]
for num_clusters in range_n_clusters:
    kmeans = KMeans(n_clusters=num_clusters, max_iter=100)
    kmeans.fit(df_rfm_scaled)

    ssd.append(kmeans.inertia_)

# plot the SSDs for each n_clusters
plt.plot(range_n_clusters,ssd);
```



In [42]:
```
# Creating dataframe for exporting to create visualization in tableau later
df_inertia = pd.DataFrame(list(zip(range_n_clusters, ssd)), columns=['clusters', 'intertia'])
df_inertia
```

Out[42]:

	clusters	intertia
0	2	7113.109513
1	3	5343.136928
2	4	4480.966244
3	5	3730.690486
4	6	3044.999774
5	7	2598.665907
6	8	2301.542620
7	9	2046.156974
8	10	1853.011464
9	11	1704.000984
10	12	1580.762814

In [43]:
```
# Finding the Optimal Number of Clusters with the help of Silhouette Analysis
range_n_clusters = [2, 3, 4, 5, 6, 7, 8, 9, 10]

for num_clusters in range_n_clusters:
    kmeans = KMeans(n_clusters=num_clusters, max_iter=50)
    kmeans.fit(df_rfm_scaled)

    cluster_labels = kmeans.labels_

    silhouette_avg = silhouette_score(df_rfm_scaled, cluster_labels)
    print("For n_clusters={0}, the silhouette score is {1}".format(num_clusters, silhouette_avg))
```

```
For n_clusters=2, the silhouette score is 0.44132753537785846
For n_clusters=3, the silhouette score is 0.3777355515144021
For n_clusters=4, the silhouette score is 0.3624139517202161
For n_clusters=5, the silhouette score is 0.36419107385871785
For n_clusters=6, the silhouette score is 0.3447566670598209
For n_clusters=7, the silhouette score is 0.34295615020953824
For n_clusters=8, the silhouette score is 0.3395626912561983
For n_clusters=9, the silhouette score is 0.3463314430741466
For n_clusters=10, the silhouette score is 0.35612016121427464
```

In [44]:
```
# Final model with k=3
kmeans = KMeans(n_clusters=3, max_iter=50)
kmeans.fit(df_rfm_scaled)
```

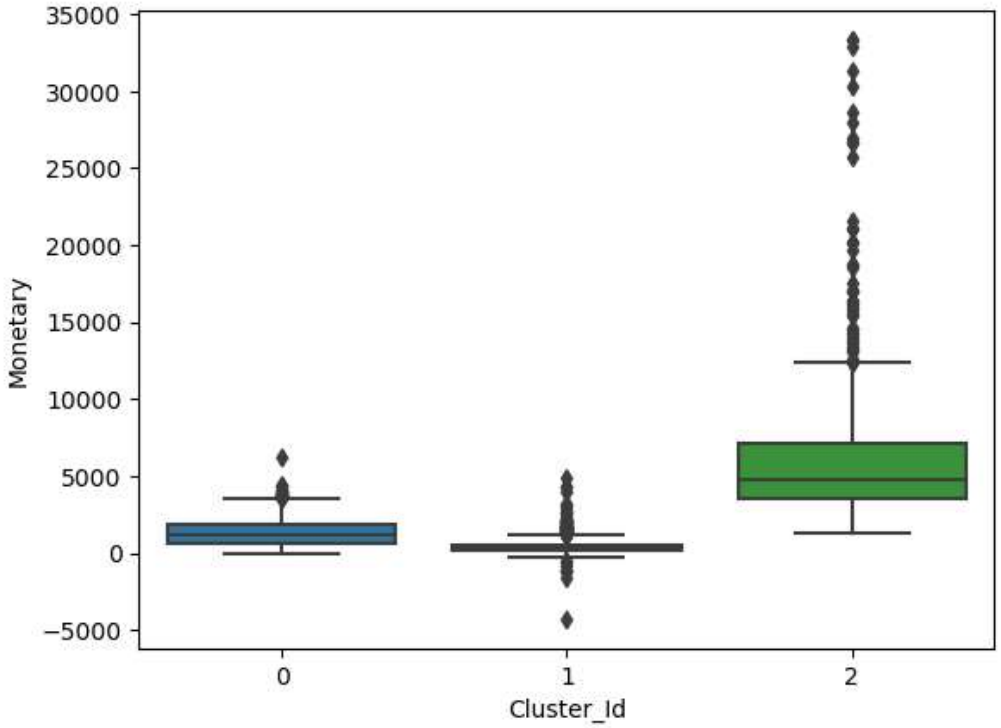
Out[44]:
```
KMeans(max_iter=50, n_clusters=3)
```

In [45]:
```
# assign the label
df_rfm['Cluster_Id'] = kmeans.labels_
df_rfm.head()
```

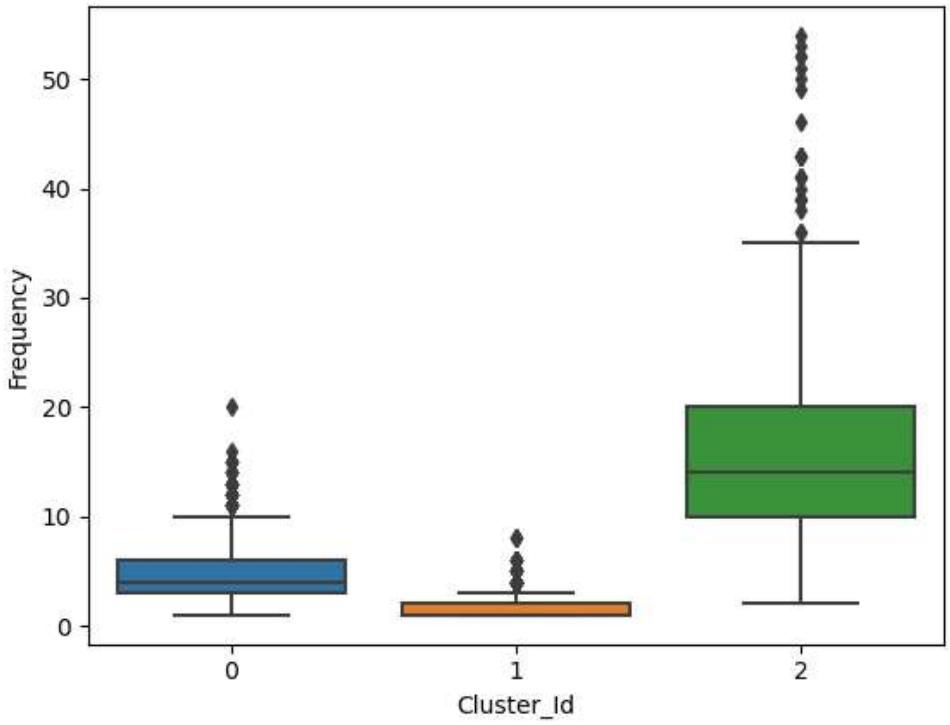
Out[45]:

	CustomerID	Recency	Frequency	Monetary	recency_labels	frequency_labels	monetary_labels	rfm_segment	rfm_sc
0	12346.0	326	2	0.00	oldest	lowest	smallest	oldest-lowest-smallest	
1	12347.0	2	7	4310.00	newest	lowest	smallest	newest-lowest-smallest	
2	12348.0	75	4	1797.24	newest	lowest	smallest	newest-lowest-smallest	
3	12349.0	19	1	1757.55	newest	lowest	smallest	newest-lowest-smallest	
4	12350.0	310	1	334.40	oldest	lowest	smallest	oldest-lowest-smallest	

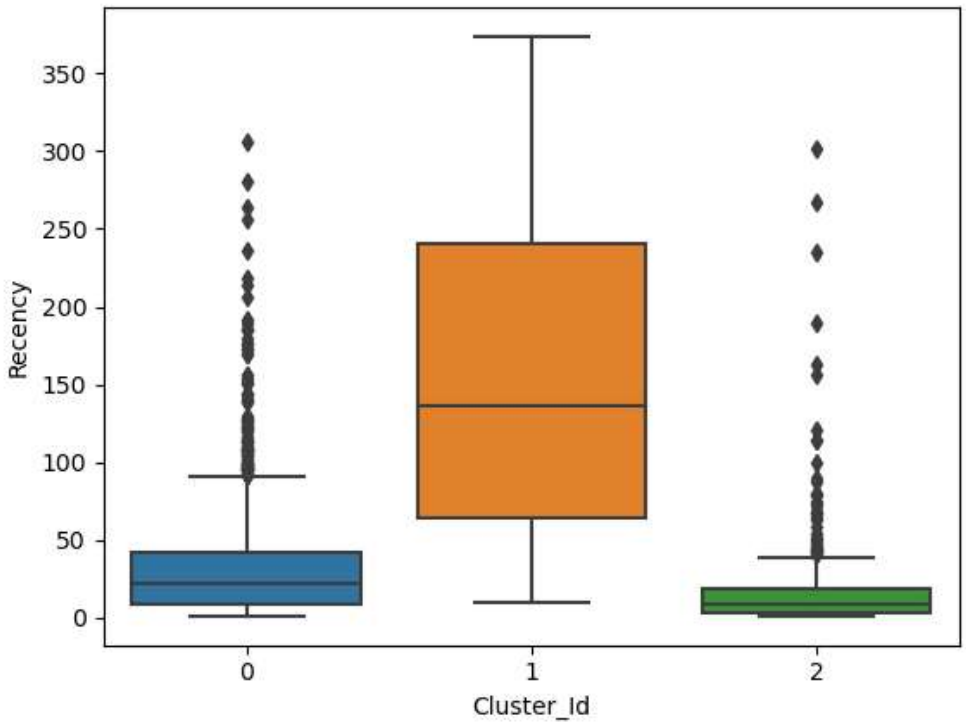
In [46]:
```
# Box plot to visualize Cluster Id vs Monetary
sns.boxplot(x='Cluster_Id', y='Monetary', data=df_rfm);
```



In [47]:
```
# Box plot to visualize Cluster Id vs Frequency
sns.boxplot(x='Cluster_Id', y='Frequency', data=df_rfm);
```



In [48]:
```
# Box plot to visualize Cluster Id vs Recency
sns.boxplot(x='Cluster_Id', y='Recency', data=df_rfm);
```



In [ ]:
```

```