In [1]:
```
import pandas as pd
import numpy as np
import tensorflow as tf
import matplotlib.pyplot as plt
import seaborn as sns
from sklearn.model_selection import train_test_split
```

```
C:\Users\Admin\anaconda3\lib\site-packages\scipy\__init__.py:146: UserWarning: A NumPy version >=1.16.5 and <1.23.0 is required for this version of SciPy (detected version 1.26.1
  warnings.warn(f"A NumPy version >={np_minversion} and <{np_maxversion}"
```

In [2]:
```
!pip install tensorflow --user
!pip install keras
!pip install daytime
!pip install torch
```

```
Requirement already satisfied: tensorflow in c:\users\admin\anaconda3\lib\site-packag
es (2.14.0)
Requirement already satisfied: tensorflow-intel==2.14.0 in c:\users\admin\anaconda3\l
ib\site-packages (from tensorflow) (2.14.0)
Requirement already satisfied: opt-einsum>=2.3.2 in c:\users\admin\anaconda3\lib\site
-packages (from tensorflow-intel==2.14.0->tensorflow) (3.3.0)
Requirement already satisfied: numpy>=1.23.5 in c:\users\admin\anaconda3\lib\site-pac
kages (from tensorflow-intel==2.14.0->tensorflow) (1.26.1)
Requirement already satisfied: tensorboard<2.15,>=2.14 in c:\users\admin\anaconda3\li
b\site-packages (from tensorflow-intel==2.14.0->tensorflow) (2.14.1)
Requirement already satisfied: grpcio<2.0,>=1.24.3 in c:\users\admin\anaconda3\lib\si
te-packages (from tensorflow-intel==2.14.0->tensorflow) (1.59.2)
Requirement already satisfied: gast!=0.5.0,!=0.5.1,!=0.5.2,>=0.2.1 in c:\users\admin
\anaconda3\lib\site-packages (from tensorflow-intel==2.14.0->tensorflow) (0.5.4)
Requirement already satisfied: termcolor>=1.1.0 in c:\users\admin\anaconda3\lib\site-
packages (from tensorflow-intel==2.14.0->tensorflow) (2.3.0)
Requirement already satisfied: setuptools in c:\users\admin\anaconda3\lib\site-packag
es (from tensorflow-intel==2.14.0->tensorflow) (61.2.0)
Requirement already satisfied: tensorflow-io-gcs-filesystem>=0.23.1 in c:\users\admin
\anaconda3\lib\site-packages (from tensorflow-intel==2.14.0->tensorflow) (0.31.0)
Requirement already satisfied: protobuf!=4.21.0,!=4.21.1,!=4.21.2,!=4.21.3,!=4.21.4,!
=4.21.5,<5.0.0dev,>=3.20.3 in c:\users\admin\anaconda3\lib\site-packages (from tensor
flow-intel==2.14.0->tensorflow) (4.24.4)
Requirement already satisfied: astunparse>=1.6.0 in c:\users\admin\anaconda3\lib\site
-packages (from tensorflow-intel==2.14.0->tensorflow) (1.6.3)
Requirement already satisfied: absl-py>=1.0.0 in c:\users\admin\anaconda3\lib\site-pa
ckages (from tensorflow-intel==2.14.0->tensorflow) (2.0.0)
Requirement already satisfied: libclang>=13.0.0 in c:\users\admin\anaconda3\lib\site-
packages (from tensorflow-intel==2.14.0->tensorflow) (16.0.6)
Requirement already satisfied: six>=1.12.0 in c:\users\admin\anaconda3\lib\site-packa
ges (from tensorflow-intel==2.14.0->tensorflow) (1.16.0)
Requirement already satisfied: google-pasta>=0.1.1 in c:\users\admin\anaconda3\lib\si
te-packages (from tensorflow-intel==2.14.0->tensorflow) (0.2.0)
Requirement already satisfied: flatbuffers>=23.5.26 in c:\users\admin\anaconda3\lib\s
ite-packages (from tensorflow-intel==2.14.0->tensorflow) (23.5.26)
Requirement already satisfied: tensorflow-estimator<2.15,>=2.14.0 in c:\users\admin\a
naconda3\lib\site-packages (from tensorflow-intel==2.14.0->tensorflow) (2.14.0)
Requirement already satisfied: keras<2.15,>=2.14.0 in c:\users\admin\anaconda3\lib\si
te-packages (from tensorflow-intel==2.14.0->tensorflow) (2.14.0)
Requirement already satisfied: h5py>=2.9.0 in c:\users\admin\anaconda3\lib\site-packa
ges (from tensorflow-intel==2.14.0->tensorflow) (3.6.0)
Requirement already satisfied: ml-dtypes==0.2.0 in c:\users\admin\anaconda3\lib\site-
packages (from tensorflow-intel==2.14.0->tensorflow) (0.2.0)
Requirement already satisfied: wrapt<1.15,>=1.11.0 in c:\users\admin\anaconda3\lib\si
te-packages (from tensorflow-intel==2.14.0->tensorflow) (1.12.1)
Requirement already satisfied: packaging in c:\users\admin\anaconda3\lib\site-package
s (from tensorflow-intel==2.14.0->tensorflow) (21.3)
Requirement already satisfied: typing-extensions>=3.6.6 in c:\users\admin\anaconda3\l
ib\site-packages (from tensorflow-intel==2.14.0->tensorflow) (4.1.1)
Requirement already satisfied: wheel<1.0,>=0.23.0 in c:\users\admin\anaconda3\lib\sit
e-packages (from astunparse>=1.6.0->tensorflow-intel==2.14.0->tensorflow) (0.37.1)
Requirement already satisfied: markdown>=2.6.8 in c:\users\admin\anaconda3\lib\site-p
ackages (from tensorboard<2.15,>=2.14->tensorflow-intel==2.14.0->tensorflow) (3.3.4)
Requirement already satisfied: tensorboard-data-server<0.8.0,>=0.7.0 in c:\users\admi
n\anaconda3\lib\site-packages (from tensorboard<2.15,>=2.14->tensorflow-intel==2.14.0
->tensorflow) (0.7.2)
Requirement already satisfied: google-auth-oauthlib<1.1,>=0.5 in c:\users\admin\anaco
nda3\lib\site-packages (from tensorboard<2.15,>=2.14->tensorflow-intel==2.14.0->tenso
rflow) (1.0.0)
Requirement already satisfied: requests<3,>=2.21.0 in c:\users\admin\anaconda3\lib\si
```

```
te-packages (from tensorboard<2.15,>=2.14->tensorflow-intel==2.14.0->tensorflow) (2.2
7.1)
Requirement already satisfied: google-auth<3,>=1.6.3 in c:\users\admin\anaconda3\lib
\site-packages (from tensorboard<2.15,>=2.14->tensorflow-intel==2.14.0->tensorflow)
(2.23.4)
Requirement already satisfied: werkzeug>=1.0.1 in c:\users\admin\anaconda3\lib\site-p
ackages (from tensorboard<2.15,>=2.14->tensorflow-intel==2.14.0->tensorflow) (2.0.3)
Requirement already satisfied: rsa<5,>=3.1.4 in c:\users\admin\anaconda3\lib\site-pac
kages (from google-auth<3,>=1.6.3->tensorboard<2.15,>=2.14->tensorflow-intel==2.14.0-
>tensorflow) (4.7.2)
Requirement already satisfied: cachetools<6.0,>=2.0.0 in c:\users\admin\anaconda3\lib
\site-packages (from google-auth<3,>=1.6.3->tensorboard<2.15,>=2.14->tensorflow-intel
==2.14.0->tensorflow) (4.2.2)
Requirement already satisfied: pyasn1-modules>=0.2.1 in c:\users\admin\anaconda3\lib
\site-packages (from google-auth<3,>=1.6.3->tensorboard<2.15,>=2.14->tensorflow-intel
==2.14.0->tensorflow) (0.2.8)
Requirement already satisfied: requests-oauthlib>=0.7.0 in c:\users\admin\anaconda3\l
ib\site-packages (from google-auth-oauthlib<1.1,>=0.5->tensorboard<2.15,>=2.14->tenso
rflow-intel==2.14.0->tensorflow) (1.3.1)
Requirement already satisfied: pyasn1<0.5.0,>=0.4.6 in c:\users\admin\anaconda3\lib\s
ite-packages (from pyasn1-modules>=0.2.1->google-auth<3,>=1.6.3->tensorboard<2.15,>=
2.14->tensorflow-intel==2.14.0->tensorflow) (0.4.8)
Requirement already satisfied: certifi>=2017.4.17 in c:\users\admin\anaconda3\lib\sit
e-packages (from requests<3,>=2.21.0->tensorboard<2.15,>=2.14->tensorflow-intel==2.1
4.0->tensorflow) (2021.10.8)
Requirement already satisfied: idna<4,>=2.5 in c:\users\admin\anaconda3\lib\site-pack
ages (from requests<3,>=2.21.0->tensorboard<2.15,>=2.14->tensorflow-intel==2.14.0->te
nsorflow) (3.3)
Requirement already satisfied: urllib3<1.27,>=1.21.1 in c:\users\admin\anaconda3\lib
\site-packages (from requests<3,>=2.21.0->tensorboard<2.15,>=2.14->tensorflow-intel==
2.14.0->tensorflow) (1.26.9)
Requirement already satisfied: charset-normalizer~=2.0.0 in c:\users\admin\anaconda3
\lib\site-packages (from requests<3,>=2.21.0->tensorboard<2.15,>=2.14->tensorflow-int
el==2.14.0->tensorflow) (2.0.4)
Requirement already satisfied: oauthlib>=3.0.0 in c:\users\admin\anaconda3\lib\site-p
ackages (from requests-oauthlib>=0.7.0->google-auth-oauthlib<1.1,>=0.5->tensorboard<
2.15,>=2.14->tensorflow-intel==2.14.0->tensorflow) (3.2.2)
Requirement already satisfied: pyparsing!=3.0.5,>=2.0.2 in c:\users\admin\anaconda3\l
ib\site-packages (from packaging->tensorflow-intel==2.14.0->tensorflow) (3.0.4)
Requirement already satisfied: keras in c:\users\admin\anaconda3\lib\site-packages
(2.14.0)
Collecting daytime
  Downloading daytime-0.4.tar.gz (2.4 kB)
Building wheels for collected packages: daytime
  Building wheel for daytime (setup.py): started
  Building wheel for daytime (setup.py): finished with status 'done'
  Created wheel for daytime: filename=daytime-0.4-py3-none-any.whl size=2419 sha256=8
2ddde36daa2f4ed5f8c4d4ed6a512fe6068aceab3d8a42091e88bc5d1c76d93
  Stored in directory: c:\users\admin\appdata\local\pip\cache\wheels\52\d5\73\e709f43
608f7559446d32db26e22e102b1d7a23d8c06b60bc5
Successfully built daytime
Installing collected packages: daytime
Successfully installed daytime-0.4
Collecting torch
  Downloading torch-2.1.0-cp39-cp39-win_amd64.whl (192.2 MB)
Requirement already satisfied: filelock in c:\users\admin\anaconda3\lib\site-packages
(from torch) (3.6.0)
Requirement already satisfied: networkx in c:\users\admin\anaconda3\lib\site-packages
(from torch) (2.7.1)
Requirement already satisfied: fsspec in c:\users\admin\anaconda3\lib\site-packages
```

```
(from torch) (2022.2.0)
Requirement already satisfied: sympy in c:\users\admin\anaconda3\lib\site-packages (f
rom torch) (1.10.1)
Requirement already satisfied: jinja2 in c:\users\admin\anaconda3\lib\site-packages
(from torch) (2.11.3)
Requirement already satisfied: typing-extensions in c:\users\admin\anaconda3\lib\site
-packages (from torch) (4.1.1)
Requirement already satisfied: MarkupSafe>=0.23 in c:\users\admin\anaconda3\lib\site-
packages (from jinja2->torch) (2.0.1)
Requirement already satisfied: mpmath>=0.19 in c:\users\admin\anaconda3\lib\site-pack
ages (from sympy->torch) (1.2.1)
Installing collected packages: torch
Successfully installed torch-2.1.0
```

In [3]:
```
from sklearn.preprocessing import StandardScaler
from sklearn.metrics import confusion_matrix, recall_score, accuracy_score, precision_
RANDOM_SEED = 2021
TEST_PCT = 0.3
LABELS = ["Normal","Fraud"]
```

In [4]:
```
#dataset = pd.read_csv("E:\Teachning material\Deep learning BE IT 2019 course\creditca
dataset = pd.read_csv(r"C:\Users\Admin\Downloads\creditcard.csv")
#dataset.head
print(list(dataset.columns))
dataset.describe()
```

```
['Time', 'V1', 'V2', 'V3', 'V4', 'V5', 'V6', 'V7', 'V8', 'V9', 'V10', 'V11', 'V12',
'V13', 'V14', 'V15', 'V16', 'V17', 'V18', 'V19', 'V20', 'V21', 'V22', 'V23', 'V24',
'V25', 'V26', 'V27', 'V28', 'Amount', 'Class']
```

Out[4]:

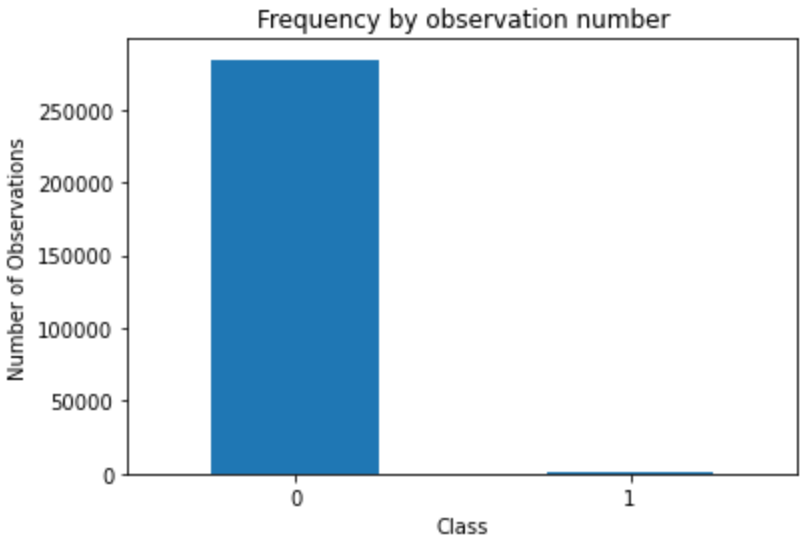
	Time	V1	V2	V3	V4	V5	
count	284807.000000	2.848070e+05	2.848070e+05	2.848070e+05	2.848070e+05	2.848070e+05	2.8
mean	94813.859575	3.918649e-15	5.682686e-16	-8.761736e-15	2.811118e-15	-1.552103e-15	2.
std	47488.145955	1.958696e+00	1.651309e+00	1.516255e+00	1.415869e+00	1.380247e+00	1.3
min	0.000000	-5.640751e+01	-7.271573e+01	-4.832559e+01	-5.683171e+00	-1.137433e+02	-2.6
25%	54201.500000	-9.203734e-01	-5.985499e-01	-8.903648e-01	-8.486401e-01	-6.915971e-01	-7.
50%	84692.000000	1.810880e-02	6.548556e-02	1.798463e-01	-1.984653e-02	-5.433583e-02	-2.
75%	139320.500000	1.315642e+00	8.037239e-01	1.027196e+00	7.433413e-01	6.119264e-01	3.
max	172792.000000	2.454930e+00	2.205773e+01	9.382558e+00	1.687534e+01	3.480167e+01	7.3

8 rows × 31 columns

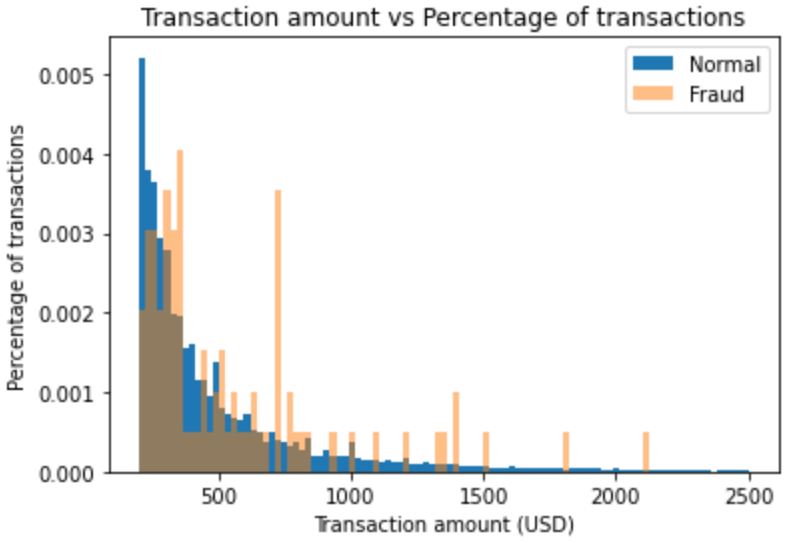
In [5]:
```
#check for any  nullvalues
print("Any nulls in the dataset ",dataset.isnull().values.any() )
print('-------')
print("No. of unique labels ", len(dataset['Class'].unique()))
print("Label values ",dataset.Class.unique())
#0 is for normal credit card transaction
#1 is for fraudulent credit card transaction
print('-------')
print("Break down of the Normal and Fraud Transactions")
print(pd.value_counts(dataset['Class'], sort = True) )
```

```
Any nulls in the dataset  False
-------
No. of unique labels  2
Label values  [0 1]
-------
Break down of the Normal and Fraud Transactions
0    284315
1       492
Name: Class, dtype: int64
```

In [6]:
```
#Visualizing the imbalanced dataset
count_classes = pd.value_counts(dataset['Class'], sort = True)
count_classes.plot(kind = 'bar', rot=0)
plt.xticks(range(len(dataset['Class'].unique())), dataset.Class.unique())
plt.title("Frequency by observation number")
plt.xlabel("Class")
plt.ylabel("Number of Observations");
```



In [7]:
```
# Save the normal and fradulent transactions in separate dataframe
normal_dataset = dataset[dataset.Class == 0]
fraud_dataset = dataset[dataset.Class == 1]
#Visualize transactionamounts for normal and fraudulent transactions
bins = np.linspace(200, 2500, 100)
plt.hist(normal_dataset.Amount, bins=bins, alpha=1, density=True, label='Normal')
plt.hist(fraud_dataset.Amount, bins=bins, alpha=0.5, density=True, label='Fraud')
plt.legend(loc='upper right')
plt.title("Transaction amount vs Percentage of transactions")
plt.xlabel("Transaction amount (USD)")
plt.ylabel("Percentage of transactions");
plt.show()
```



In [8]:
```
'''Time and Amount are the columns that are not scaled, so applying StandardScaler to
Normalizing the values between 0 and 1 did not work great for the dataset.'''
```

Out[8]:
```
'Time and Amount are the columns that are not scaled, so applying StandardScaler to o
nly Amount and Time columns.\nNormalizing the values between 0 and 1 did not work gre
at for the dataset.'
```

In [9]:
```
sc=StandardScaler()
dataset['Time'] = sc.fit_transform(dataset['Time'].values.reshape(-1, 1))
dataset['Amount'] = sc.fit_transform(dataset['Amount'].values.reshape(-1, 1))
```

In [10]:
```
'''The last column in the dataset is our target variable.'''

raw_data = dataset.values
# The last element contains if the transaction is normal which is represented by a 0 a
labels = raw_data[:, -1]
# The other data points are the electrocadriogram data
data = raw_data[:, 0:-1]
train_data, test_data, train_labels, test_labels = train_test_split(
    data, labels, test_size=0.2, random_state=2021
)
```

In [11]:
```
'''Normalize the data to have a value between 0 and 1'''

min_val = tf.reduce_min(train_data)
max_val = tf.reduce_max(train_data)
train_data = (train_data - min_val) / (max_val - min_val)
test_data = (test_data - min_val) / (max_val - min_val)
train_data = tf.cast(train_data, tf.float32)
test_data = tf.cast(test_data, tf.float32)
```

In [12]:
```
'''Use only normal transactions to train the Autoencoder.

Normal data has a value of 0 in the target variable. Using the target variable to crea

train_labels = train_labels.astype(bool)
test_labels = test_labels.astype(bool)

#creating normal and fraud datasets

normal_train_data = train_data[~train_labels]
```

```
normal_test_data = test_data[~test_labels]
fraud_train_data = train_data[train_labels]
fraud_test_data = test_data[test_labels]
print(" No. of records in Fraud Train Data=",len(fraud_train_data))
print(" No. of records in Normal Train data=",len(normal_train_data))
print(" No. of records in Fraud Test Data=",len(fraud_test_data))
print(" No. of records in Normal Test data=",len(normal_test_data))
```

```
No. of records in Fraud Train Data= 389
No. of records in Normal Train data= 227456
No. of records in Fraud Test Data= 103
No. of records in Normal Test data= 56859
```

In [13]:
```
nb_epoch = 50
batch_size = 64
input_dim = normal_train_data.shape[1] #num of columns, 30
encoding_dim = 14
hidden_dim_1 = int(encoding_dim / 2) #
hidden_dim_2=4
learning_rate = 1e-7
```

In [14]:
```
#input Layer
input_layer = tf.keras.layers.Input(shape=(input_dim, ))

#Encoder
encoder = tf.keras.layers.Dense(encoding_dim, activation="tanh",
                        activity_regularizer=tf.keras.regularizers.l2(learning_rate))(
encoder=tf.keras.layers.Dropout(0.2)(encoder)
encoder = tf.keras.layers.Dense(hidden_dim_1, activation='relu')(encoder)
encoder = tf.keras.layers.Dense(hidden_dim_2, activation=tf.nn.leaky_relu)(encoder)

# Decoder
decoder = tf.keras.layers.Dense(hidden_dim_1, activation='relu')(encoder)
decoder=tf.keras.layers.Dropout(0.2)(decoder)
decoder = tf.keras.layers.Dense(encoding_dim, activation='relu')(decoder)
decoder = tf.keras.layers.Dense(input_dim, activation='tanh')(decoder)

#Autoencoder
autoencoder = tf.keras.Model(inputs=input_layer, outputs=decoder)
autoencoder.summary()
```

```
Model: "model"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 input_1 (InputLayer)        [(None, 30)]              0

 dense (Dense)               (None, 14)                434

 dropout (Dropout)           (None, 14)                0

 dense_1 (Dense)             (None, 7)                 105

 dense_2 (Dense)             (None, 4)                 32

 dense_3 (Dense)             (None, 7)                 35

 dropout_1 (Dropout)         (None, 7)                 0

 dense_4 (Dense)             (None, 14)                112

 dense_5 (Dense)             (None, 30)                450

=================================================================
Total params: 1168 (4.56 KB)
Trainable params: 1168 (4.56 KB)
Non-trainable params: 0 (0.00 Byte)
_________________________________________________________________
```

In [15]:
```
"""Define the callbacks for checkpoints and early stopping"""

cp = tf.keras.callbacks.ModelCheckpoint(filepath="autoencoder_fraud.h5",
                                mode='min', monitor='val_loss', verbose=2, save_best_or
# define our early stopping
early_stop = tf.keras.callbacks.EarlyStopping(
    monitor='val_loss',
    min_delta=0.0001,
    patience=10,
    verbose=1,
    mode='min',
    restore_best_weights=True)
```

In [16]:
```
#Compile the Autoencoder

autoencoder.compile(metrics=['accuracy'],
                    loss='mean_squared_error',
                    optimizer='adam')
```

In [17]:
```
#Train the Autoencoder

history = autoencoder.fit(normal_train_data, normal_train_data,
                    epochs=nb_epoch,
                    batch_size=batch_size,
                    shuffle=True,
                    validation_data=(test_data, test_data),
                    verbose=1,
                    callbacks=[cp, early_stop]
                    ).history
```

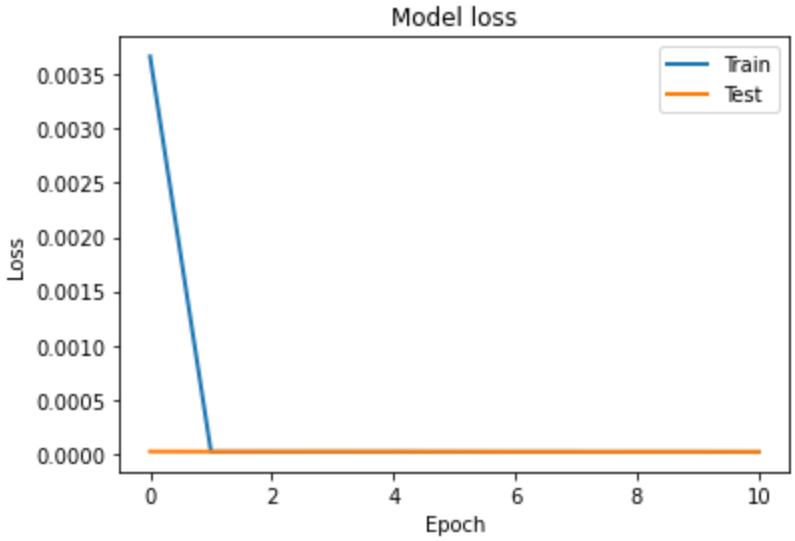
```
Epoch 1/50
3547/3554 [============================>.] - ETA: 0s - loss: 0.0037 - accuracy: 0.034
3
Epoch 1: val_loss improved from inf to 0.00002, saving model to autoencoder_fraud.h5
3554/3554 [==============================] - 29s 7ms/step - loss: 0.0037 - accuracy:
0.0344 - val_loss: 2.1230e-05 - val_accuracy: 0.0010
```

```
C:\Users\Admin\anaconda3\lib\site-packages\keras\src\engine\training.py:3079: UserWar
ning: You are saving your model as an HDF5 file via `model.save()`. This file format
is considered legacy. We recommend using instead the native Keras format, e.g. `mode
l.save('my_model.keras')`.
  saving_api.save_model(
```

```
Epoch 2/50
3551/3554 [============================>.] - ETA: 0s - loss: 1.9656e-05 - accuracy:
0.0653
Epoch 2: val_loss improved from 0.00002 to 0.00002, saving model to autoencoder_frau
d.h5
3554/3554 [==============================] - 25s 7ms/step - loss: 1.9653e-05 - accura
cy: 0.0653 - val_loss: 1.9941e-05 - val_accuracy: 0.0661
Epoch 3/50
3554/3554 [==============================] - ETA: 0s - loss: 1.9448e-05 - accuracy:
0.0628
Epoch 3: val_loss did not improve from 0.00002
3554/3554 [==============================] - 24s 7ms/step - loss: 1.9448e-05 - accura
cy: 0.0628 - val_loss: 2.0051e-05 - val_accuracy: 0.0051
Epoch 4/50
3550/3554 [============================>.] - ETA: 0s - loss: 1.9569e-05 - accuracy:
0.0607
Epoch 4: val_loss did not improve from 0.00002
3554/3554 [==============================] - 24s 7ms/step - loss: 1.9577e-05 - accura
cy: 0.0608 - val_loss: 2.0254e-05 - val_accuracy: 0.0343
Epoch 5/50
3553/3554 [============================>.] - ETA: 0s - loss: 1.9518e-05 - accuracy:
0.0632
Epoch 5: val_loss did not improve from 0.00002
3554/3554 [==============================] - 23s 7ms/step - loss: 1.9517e-05 - accura
cy: 0.0633 - val_loss: 2.0057e-05 - val_accuracy: 0.2168
Epoch 6/50
3549/3554 [============================>.] - ETA: 0s - loss: 1.9107e-05 - accuracy:
0.1521
Epoch 6: val_loss improved from 0.00002 to 0.00002, saving model to autoencoder_frau
d.h5
3554/3554 [==============================] - 24s 7ms/step - loss: 1.9111e-05 - accura
cy: 0.1523 - val_loss: 1.9341e-05 - val_accuracy: 0.1721
Epoch 7/50
3548/3554 [============================>.] - ETA: 0s - loss: 1.8519e-05 - accuracy:
0.2646
Epoch 7: val_loss improved from 0.00002 to 0.00002, saving model to autoencoder_frau
d.h5
3554/3554 [==============================] - 23s 7ms/step - loss: 1.8518e-05 - accura
cy: 0.2646 - val_loss: 1.8773e-05 - val_accuracy: 0.2996
Epoch 8/50
3553/3554 [============================>.] - ETA: 0s - loss: 1.8453e-05 - accuracy:
0.2692
Epoch 8: val_loss improved from 0.00002 to 0.00002, saving model to autoencoder_frau
d.h5
3554/3554 [==============================] - 24s 7ms/step - loss: 1.8453e-05 - accura
cy: 0.2692 - val_loss: 1.8668e-05 - val_accuracy: 0.3177
Epoch 9/50
3551/3554 [============================>.] - ETA: 0s - loss: 1.8409e-05 - accuracy:
0.2728
Epoch 9: val_loss improved from 0.00002 to 0.00002, saving model to autoencoder_frau
d.h5
3554/3554 [==============================] - 23s 7ms/step - loss: 1.8409e-05 - accura
cy: 0.2728 - val_loss: 1.8432e-05 - val_accuracy: 0.3111
Epoch 10/50
3548/3554 [============================>.] - ETA: 0s - loss: 1.8269e-05 - accuracy:
0.2770
Epoch 10: val_loss did not improve from 0.00002
3554/3554 [==============================] - 24s 7ms/step - loss: 1.8269e-05 - accura
cy: 0.2771 - val_loss: 1.8462e-05 - val_accuracy: 0.2869
Epoch 11/50
```

```
3536/3554 [============================>.] - ETA: 0s - loss: 1.7849e-05 - accuracy:
0.2786
Epoch 11: val_loss improved from 0.00002 to 0.00002, saving model to autoencoder_frau
d.h5
Restoring model weights from the end of the best epoch: 1.
3554/3554 [==============================] - 20s 6ms/step - loss: 1.7846e-05 - accura
cy: 0.2786 - val_loss: 1.7778e-05 - val_accuracy: 0.3142
Epoch 11: early stopping
```

In [18]:
```
#Plot training and test loss

plt.plot(history['loss'], linewidth=2, label='Train')
plt.plot(history['val_loss'], linewidth=2, label='Test')
plt.legend(loc='upper right')
plt.title('Model loss')
plt.ylabel('Loss')
plt.xlabel('Epoch')
#plt.ylim(ymin=0.70,ymax=1)
plt.show()
```

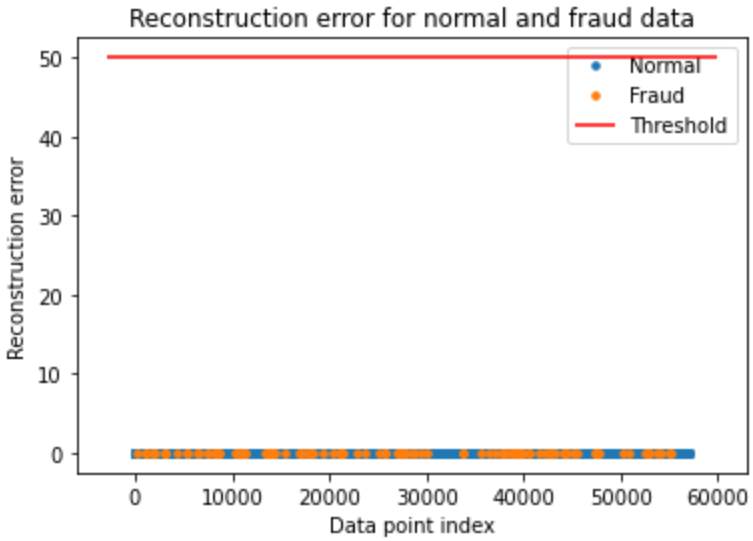


In [19]:
```
"""Detect Anomalies on test data

Anomalies are data points where the reconstruction loss is higher

To calculate the reconstruction loss on test data,
predict the test data and calculate the mean square error between the test data and th

test_x_predictions = autoencoder.predict(test_data)
mse = np.mean(np.power(test_data - test_x_predictions, 2), axis=1)
error_df = pd.DataFrame({'Reconstruction_error': mse,
                         'True_class': test_labels})
```

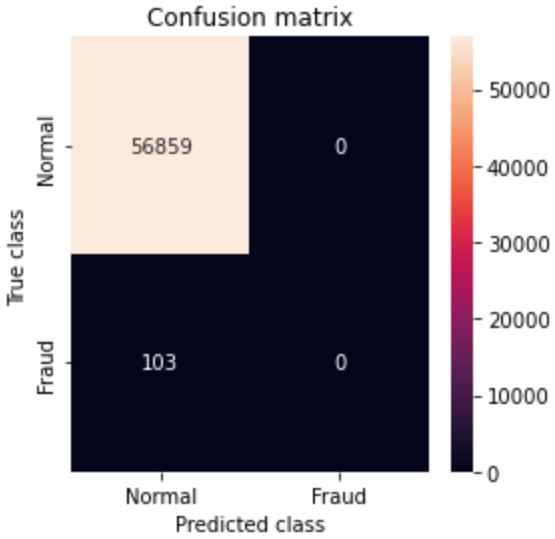
```
1781/1781 [==============================] - 3s 2ms/step
```

In [20]:
```
#Plotting the test data points and their respective reconstruction error sets a thresh
#if the threshold value needs to be adjusted.

threshold_fixed = 50
groups = error_df.groupby('True_class')
fig, ax = plt.subplots()
for name, group in groups:
    ax.plot(group.index, group.Reconstruction_error, marker='o', ms=3.5, linestyle='',
```

```
            label= "Fraud" if name == 1 else "Normal")
ax.hlines(threshold_fixed, ax.get_xlim()[0], ax.get_xlim()[1], colors="r", zorder=100,
ax.legend()
plt.title("Reconstruction error for normal and fraud data")
plt.ylabel("Reconstruction error")
plt.xlabel("Data point index")
plt.show();
```



In [21]:
```
'''Detect anomalies as points where the reconstruction loss is greater than a fixed th
Here we see that a value of 52 for the threshold will be good.

Evaluating the performance of the anomaly detection'''

threshold_fixed =52
pred_y = [1 if e > threshold_fixed else 0 for e in error_df.Reconstruction_error.value
error_df['pred'] =pred_y
conf_matrix = confusion_matrix(error_df.True_class, pred_y)
plt.figure(figsize=(4, 4))
sns.heatmap(conf_matrix, xticklabels=LABELS, yticklabels=LABELS, annot=True, fmt="d");
plt.title("Confusion matrix")
plt.ylabel('True class')
plt.xlabel('Predicted class')
plt.show()
# print Accuracy, precision and recall
print(" Accuracy: ",accuracy_score(error_df['True_class'], error_df['pred']))
print(" Recall: ",recall_score(error_df['True_class'], error_df['pred']))
print(" Precision: ",precision_score(error_df['True_class'], error_df['pred']))
```




```
Accuracy:  0.9981917769741231
Recall:  0.0
Precision:  0.0
```

```
C:\Users\Admin\anaconda3\lib\site-packages\sklearn\metrics\_classification.py:1318: U
ndefinedMetricWarning: Precision is ill-defined and being set to 0.0 due to no predic
ted samples. Use `zero_division` parameter to control this behavior.
  _warn_prf(average, modifier, msg_start, len(result))
```

In [22]:
```
'''As our dataset is highly imbalanced, we see a high accuracy but a low recall and pr

Things to further improve precision and recall would add more relevant features,
different architecture for autoencoder, different hyperparameters, or a different algo
```

Out[22]:
```
'As our dataset is highly imbalanced, we see a high accuracy but a low recall and pre
cision.\n\nThings to further improve precision and recall would add more relevant fea
tures,\ndifferent architecture for autoencoder, different hyperparameters, or a diffe
rent algorithm.'
```

In [23]:
```
history
```

Out[23]:

```
{'loss': [0.0036670698318630457,
  1.9652592527563684e-05,
  1.9448039893177338e-05,
  1.957662243512459e-05,
  1.9516715838108212e-05,
  1.9110788343823515e-05,
  1.8518483557272702e-05,
  1.845291262725368e-05,
  1.8408898540656082e-05,
  1.8269494830747135e-05,
  1.7845832189777866e-05],
 'accuracy': [0.034411050379276276,
  0.06530053913593292,
  0.06278137117624283,
  0.06083374470472336,
  0.063251793384552,
  0.15227560698986053,
  0.26456984877586365,
  0.269155353307724,
  0.27278682589530945,
  0.27706897258758545,
  0.2785945534706116],
 'val_loss': [2.1229858248261735e-05,
  1.994073136302177e-05,
  2.005093301704619e-05,
  2.0253588445484638e-05,
  2.0056804714840837e-05,
  1.934071769937873e-05,
  1.8772629118757322e-05,
  1.8667991753318347e-05,
  1.843235622800421e-05,
  1.846158193075098e-05,
  1.777845318429172e-05],
 'val_accuracy': [0.0010006671072915196,
  0.06607913970947266,
  0.005126224365085363,
  0.03430357202887535,
  0.2168463170528412,
  0.17211474478244781,
  0.2996208071708679,
  0.31765037775039673,
  0.3111197054386139,
  0.286875456571579,
  0.31415680050849915]}
```


In [ ]: