In [36]:

```
from math import sqrt
import tensorflow as tf

import pandas as pd
from keras import Sequential
from keras.layers import LSTM, Dense, Dropout, Conv1D, GRU
from keras.losses import mean_squared_error
from numpy.core._multiarray_umath import concatenate
from sklearn.preprocessing import MinMaxScaler
import matplotlib.pyplot as plt

# supervised监督学习函数


def series_to_supervised(data, columns, n_in=1, n_out=1, dropnan=True):
    n_vars = 1 if isinstance(data, list) else data.shape[1]
    df = pd.DataFrame(data)
    cols, names = list(), list()
    # input sequence (t-n, ... t-1)
    for i in range(n_in, 0, -1):
        cols.append(df.shift(i))
        names += [('%s%d(t-%d)' % (columns[j], j + 1, i))
                  for j in range(n_vars)]
    # forecast sequence (t, t+1, ... t+n)
    for i in range(0, n_out):
        cols.append(df.shift(-i))
        if i == 0:
            names += [('%s%d(t)' % (columns[j], j + 1)) for j in range(n_vars)]
        else:
            names += [('%s%d(t+%d)' % (columns[j], j + 1, i))
                      for j in range(n_vars)]
    # put it all together
    agg = pd.concat(cols, axis=1)
    agg.columns = names
    # drop rows with NaN values
    if dropnan:
        clean_agg = agg.dropna()
    return clean_agg
    # return agg


dataset = pd.read_csv(
    'Machine_usage_groupby.csv')

dataset_columns = dataset.columns
values = dataset.values
print(dataset)

# 归一化处理
scaler = MinMaxScaler(feature_range=(0, 1))
scaled = scaler.fit_transform(values)


# 监督学习
reframed = series_to_supervised(scaled, dataset_columns, 1, 1)
values = reframed.values

# 学习与检测数据的划分
n_train_hours = 20000
```

```
train = values[:n_train_hours, :]
test = values[n_train_hours:, :]


# 监督学习结果划分
train_x, train_y = train[:, :-1], train[:, -1]
test_x, test_y = test[:, :-1], test[:, -1]



# 为了在LSTM中应用该数据，需要将其格式转化为3D format，即[Samples, timesteps, features]
train_X = train_x.reshape((train_x.shape[0], 1, train_x.shape[1]))
test_X = test_x.reshape((test_x.shape[0], 1, test_x.shape[1]))


model = Sequential()
model.add(Conv1D(filters=32, kernel_size=5,
                 strides=1, padding="causal",
                 activation="sigmoid"))
model.add(
    GRU(
        32,
        input_shape=(
            train_X.shape[1],
            train_X.shape[2]),
        return_sequences=True))
model.add(GRU(16, input_shape=(train_X.shape[1], train_X.shape[2])))
model.add(Dense(16, activation="relu"))
model.add(Dense(8, activation="relu"))
model.add(Dropout(0.2))
model.add(Dense(1))
model.compile(loss=tf.keras.losses.Huber(),
    optimizer='adam',
    metrics=["mse"])
history = model.fit(
    train_X,
    train_y,
    epochs=300,
    batch_size=72,
    validation_data=(
        test_X,
        test_y),
verbose = 2)
```

```
          Time  cpu_util_percent  ...  net_out  disk_usage_percent
0            0              12.0  ...    26.49                31.0
1          130              13.5  ...    28.63                 2.5
2          140               5.0  ...    18.12                 1.0
3          160              13.0  ...    30.09                 3.0
4          180               5.0  ...    18.12                 1.0
...        ...               ...  ...      ...                 ...
36211   691040              28.0  ...    41.75                 3.0
36212   691060              93.0  ...    38.37                 3.0
36213   691080              31.0  ...    35.73                 3.0
36214   691110              92.0  ...    38.37                 2.0
36215   691180              18.5  ...    38.47                 3.5

[36216 rows x 6 columns]
Train on 20000 samples, validate on 16215 samples
Epoch 1/300
 - 5s - loss: 0.0032 - mse: 0.0065 - val_loss: 0.0019 - val_mse: 0.00
```

```
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Epoch 2/300
```
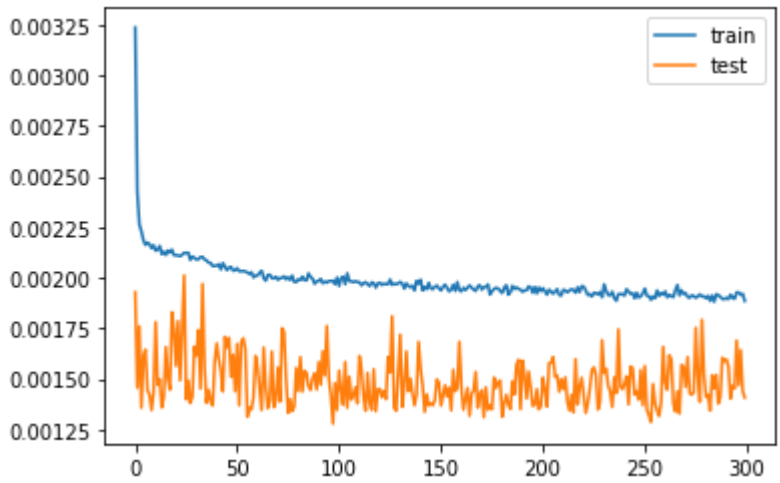

In [37]:

```
#画图
plt.plot(history.history['loss'], label='train')
plt.plot(history.history['val_loss'], label='test')
plt.legend()
plt.show()
```



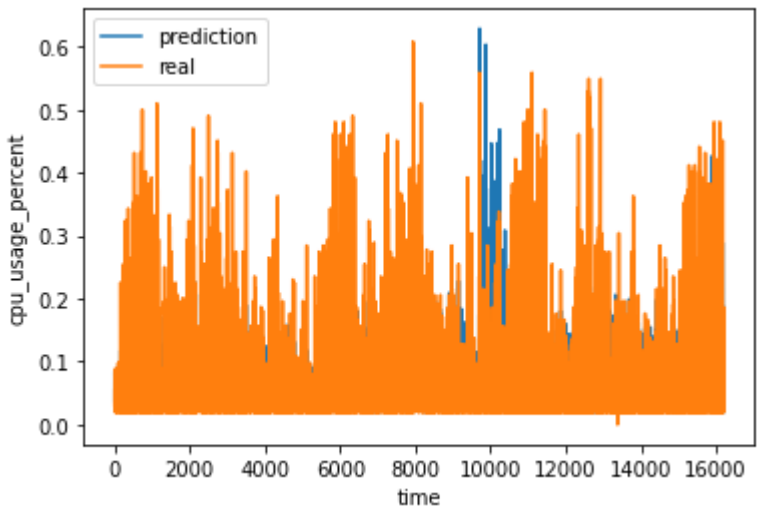
In [38]:

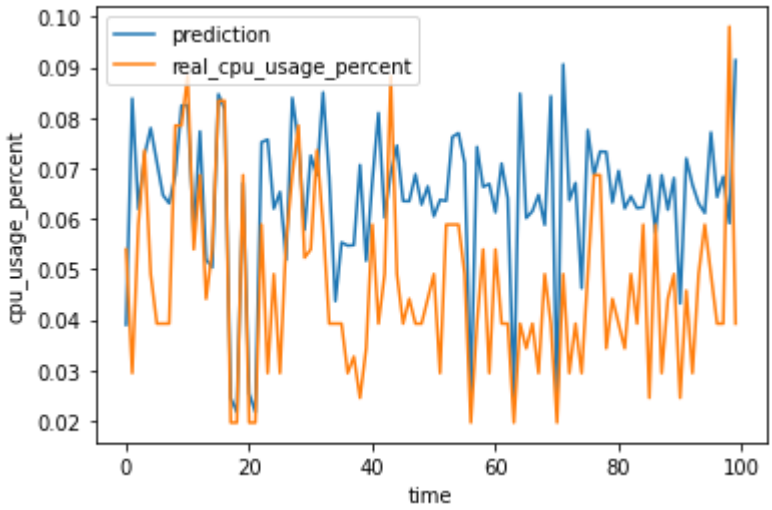
```
# make the prediction
yHat = model.predict(test_X)

inv_yHat = concatenate((yHat, test_x[:, 1:]), axis=1)    # 数组拼接
inv_yHat = inv_yHat[:, 0]

test_y = test_y.reshape((len(test_y), 1))
inv_y = concatenate((test_y, test_x[:, 1:]), axis=1)
inv_y = inv_y[:, 0]

rmse = sqrt(mean_squared_error(inv_yHat, inv_y))
print('Test RMSE: %.3f' % rmse)
mse = mean_squared_error(inv_yHat, inv_y)
print('Test MSE: %.3f' % mse)
```

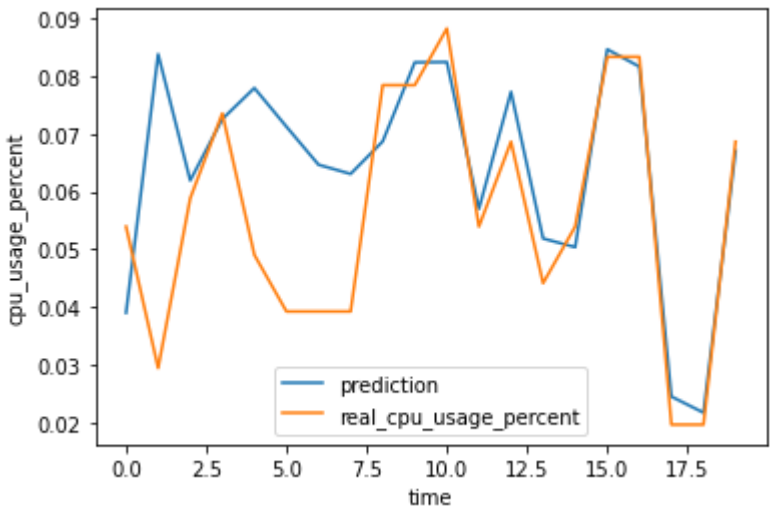
```
Test RMSE: 0.053
Test MSE: 0.003
```

In [39]:

```
yhat = model.predict(test_X)
test_X_reshaped = test_X.reshape((test_X.shape[0], test_X.shape[2]))

inv_yhat = concatenate((yhat, yhat, test_X_reshaped[:, 1:]), axis=1)
inv_yhat = inv_yhat[:, 0]
test_y = test_y.reshape((len(test_y), 1))
inv_y = concatenate((test_y, test_y, test_X_reshaped[:, 1:]), axis=1)
inv_y = inv_y[:, 0]
plt.plot(inv_yhat, label='prediction')
plt.plot(inv_y, label='real')
plt.xlabel('time')
plt.ylabel('cpu_usage_percent')
plt.legend()
plt.show()
plt.plot(inv_yhat[:100], label='prediction')
plt.plot(inv_y[:100], label='real_cpu_usage_percent')
plt.xlabel('time')
plt.ylabel('cpu_usage_percent')
plt.legend()
plt.show()
plt.plot(inv_yhat[:20], label='prediction')
plt.plot(inv_y[:20], label='real_cpu_usage_percent')
plt.xlabel('time')
plt.ylabel('cpu_usage_percent')
plt.legend()
plt.show()
```




prediction
real_cpu_usage_percent
cpu_usage_percent
time
0.10
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0
20
40
60
80
100


prediction
real_cpu_usage_percent
cpu_usage_percent
time
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.0
2.5
5.0
7.5
10.0
12.5
15.0
17.5