In [1]:
```
import numpy as np
import matplotlib.pyplot as plt
```

Unipolar sigmoid function = f(x): $\frac{1}{1+e^{-x}}$

In [2]:
```
def unipolar_sigmoid(x):
    return 1/ (1+np.exp(-x))
```

Bipolar sigmoid function = f(x): $\frac{1-e^{-x}}{1+e^{-x}}$ = $\frac{2}{1+e^{-x}} - 1$

In [3]:
```
def bipolar_sigmoid(x):
    return 2*unipolar_sigmoid(x) -1
```

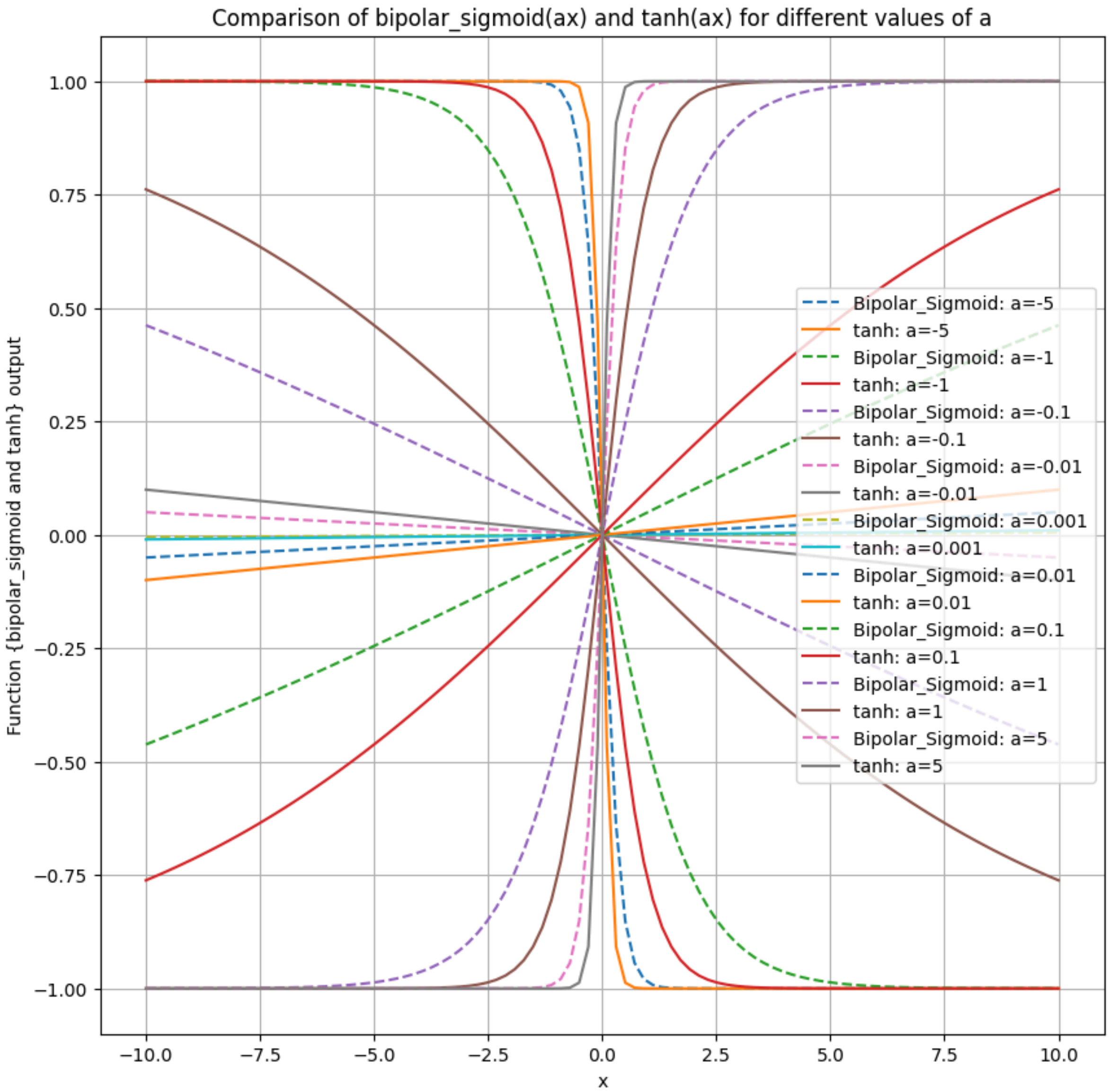
tanh = f(x): $\frac{e^{x}-e^{-x}}{e^{x}+e^{-x}}$

In [4]:
```
def tanh(x):
    return np.tanh(x)
```

In [5]:
```
a = [-5, -1, -.1, -.01, .001, .01, .1, 1, 5]
x = np.linspace(-10,10,100)
```

In [6]:

```
plt.figure(figsize=(10,10))
for i in a:
    plt.plot(x,bipolar_sigmoid(i*x),'--',label=f"Bipolar_Sigmoid: a={i}")
    plt.plot(x,tanh(i*x),label=f"tanh: a={i}")
plt.title('Comparison of bipolar_sigmoid(ax) and tanh(ax) for different va
plt.grid(True)
plt.xlabel('x')
plt.ylabel('Function {bipolar_sigmoid and tanh} output')
plt.legend()
plt.show()
```



In [7]:

```
# Linear range of X: The range of values of x for which the function behav
```

In [20]:

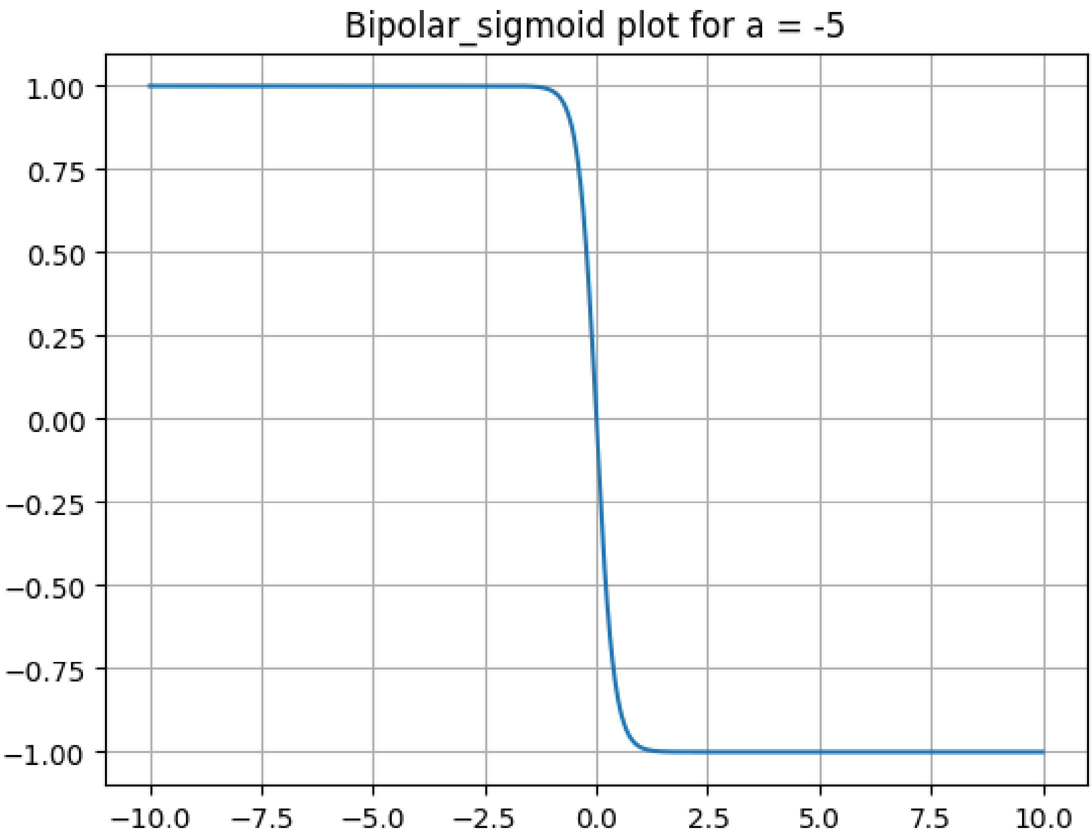
```
a = [-5, -1, -.1, -.01, .001, .01, .1, 1, 5]
x = np.linspace(-10,10,1000)

def linear_approx(i,x):
    return i*x

```

In [21]:
```
X_linear = []
for i in a:
    y_bipolar_sigmoid = bipolar_sigmoid(i*x)
    y_linear = linear_approx(i,x)
    diff = np.abs(y_bipolar_sigmoid - y_linear)
    index = np.where(diff<0.1)[0] # Looking for points within 10% deviatio
    linear_range = round(x[index[0]],2), round(x[index[-1]],2)
    X_linear.append(linear_range)

```

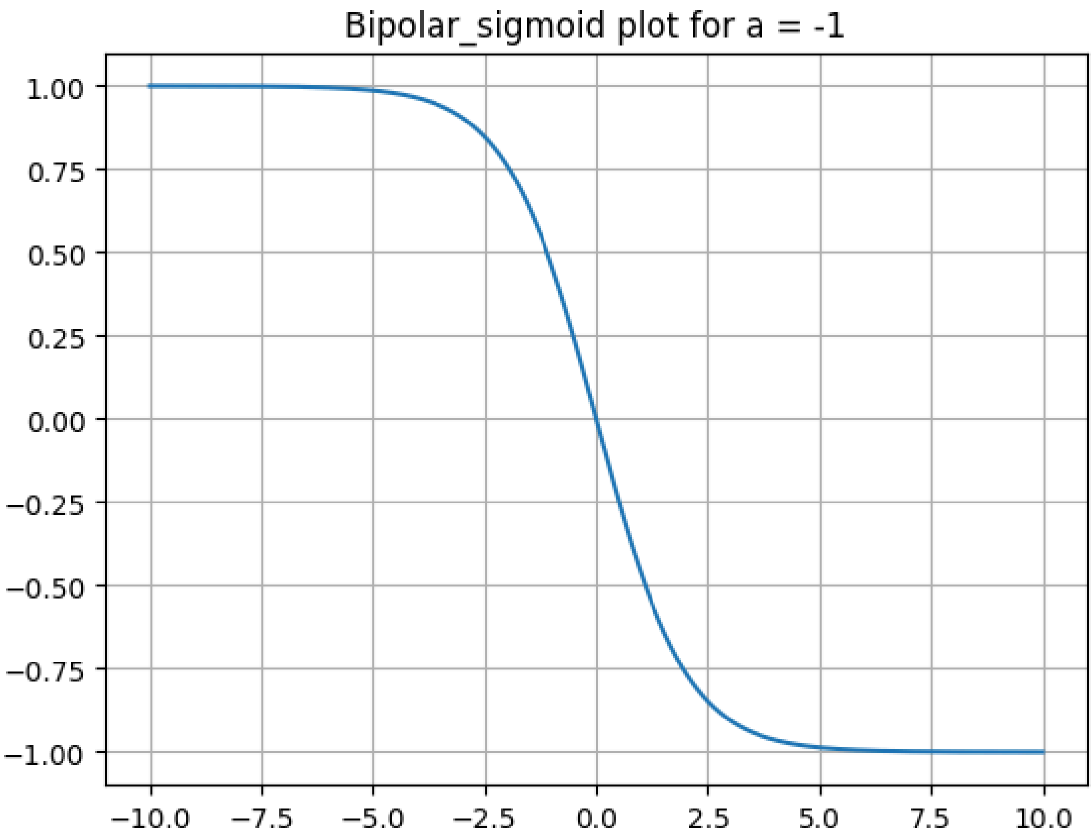
In [22]:
```
for i in range(len(a)):
    print(f"Linear range of X for a= {a[i]}: ",X_linear[i])
    print()
```

```
Linear range of X for a= -5:  (-0.03, 0.03)

Linear range of X for a= -1:  (-0.19, 0.19)

Linear range of X for a= -0.1:  (-1.99, 1.99)

Linear range of X for a= -0.01:  (-10.0, 10.0)

Linear range of X for a= 0.001:  (-10.0, 10.0)

Linear range of X for a= 0.01:  (-10.0, 10.0)

Linear range of X for a= 0.1:  (-1.99, 1.99)

Linear range of X for a= 1:  (-0.19, 0.19)

Linear range of X for a= 5:  (-0.03, 0.03)
```

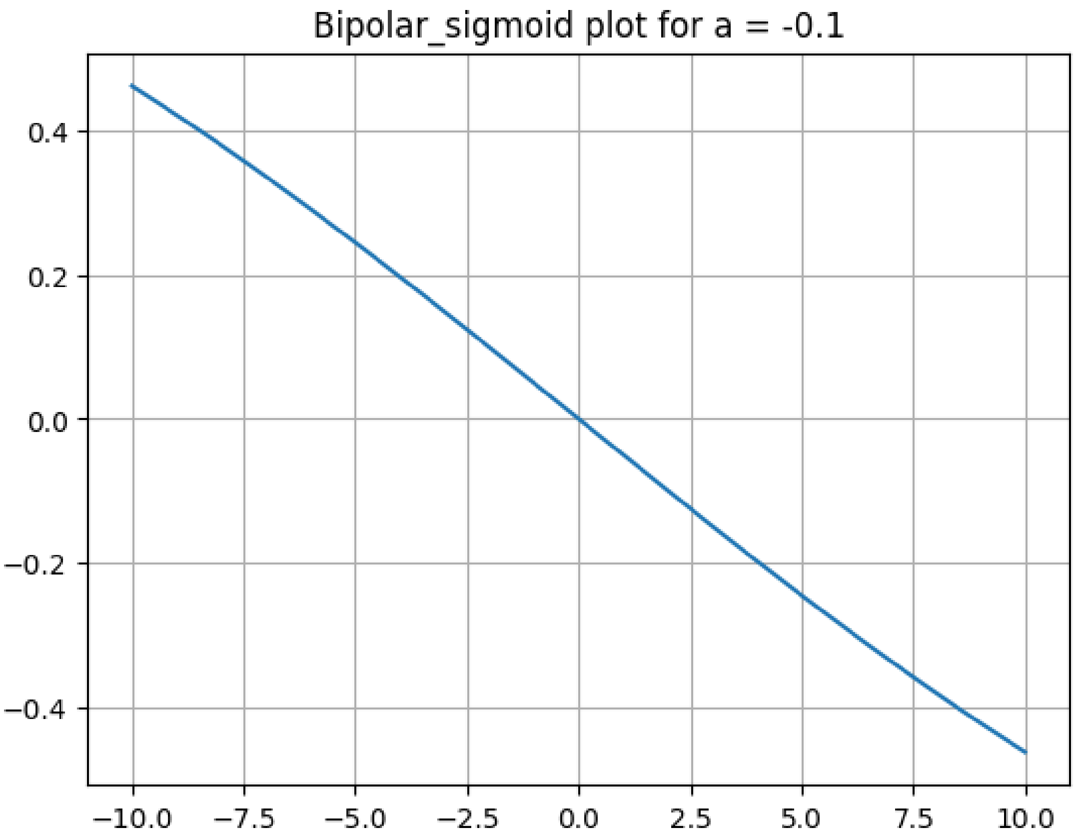
In [24]:
```
plt.figure()
plt.title(f"Bipolar_sigmoid plot for a = {-5}")
plt.plot(x,bipolar_sigmoid(-5*x))
plt.grid(True)
plt.show()
```



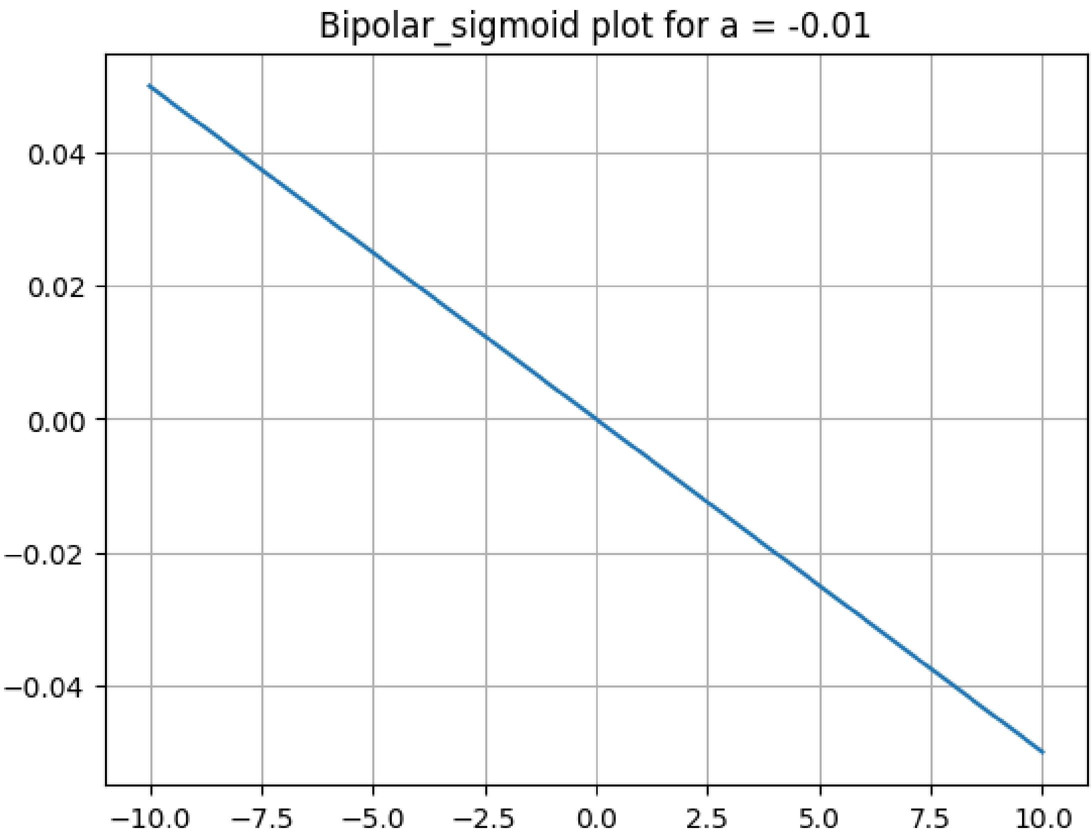
In [27]:
```
plt.figure()
plt.title(f"Bipolar_sigmoid plot for a = {-1}")
plt.plot(x,bipolar_sigmoid(-1*x))
plt.grid(True)
plt.show()
```



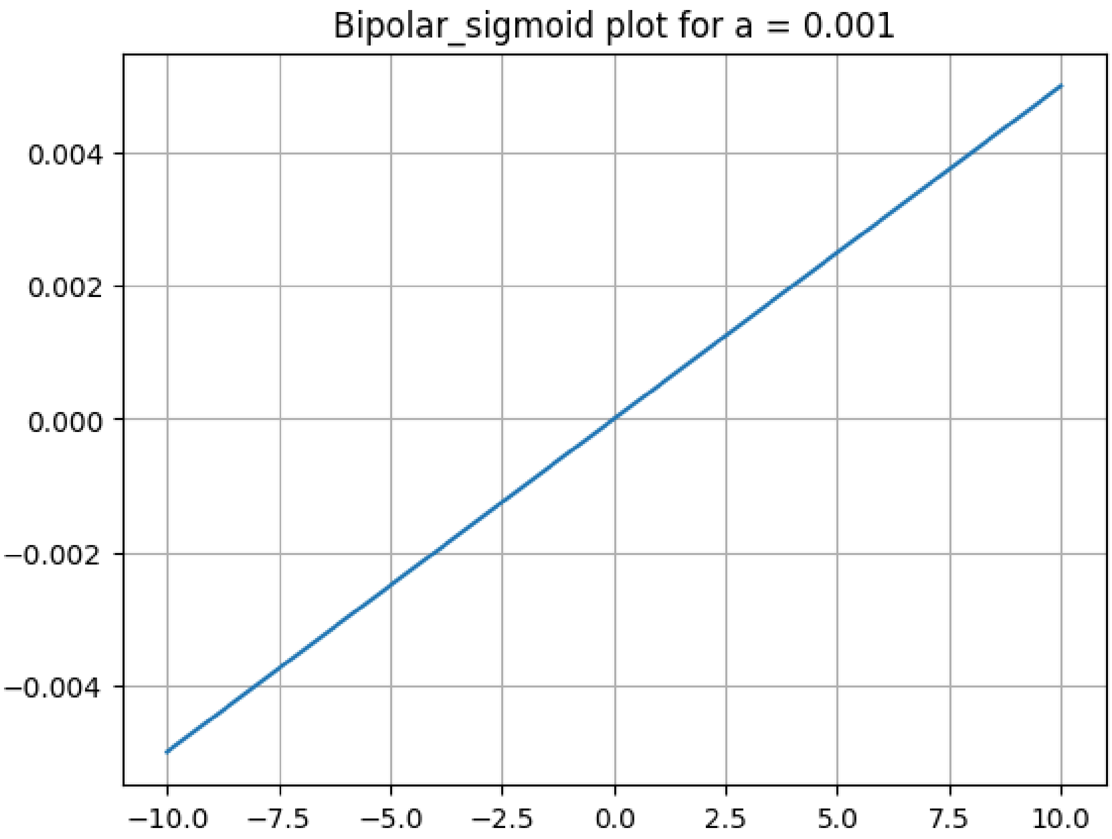
In [28]:
```
plt.figure()
plt.title(f"Bipolar_sigmoid plot for a = {-.1}")
plt.plot(x,bipolar_sigmoid(-.1*x))
plt.grid(True)
plt.show()
```



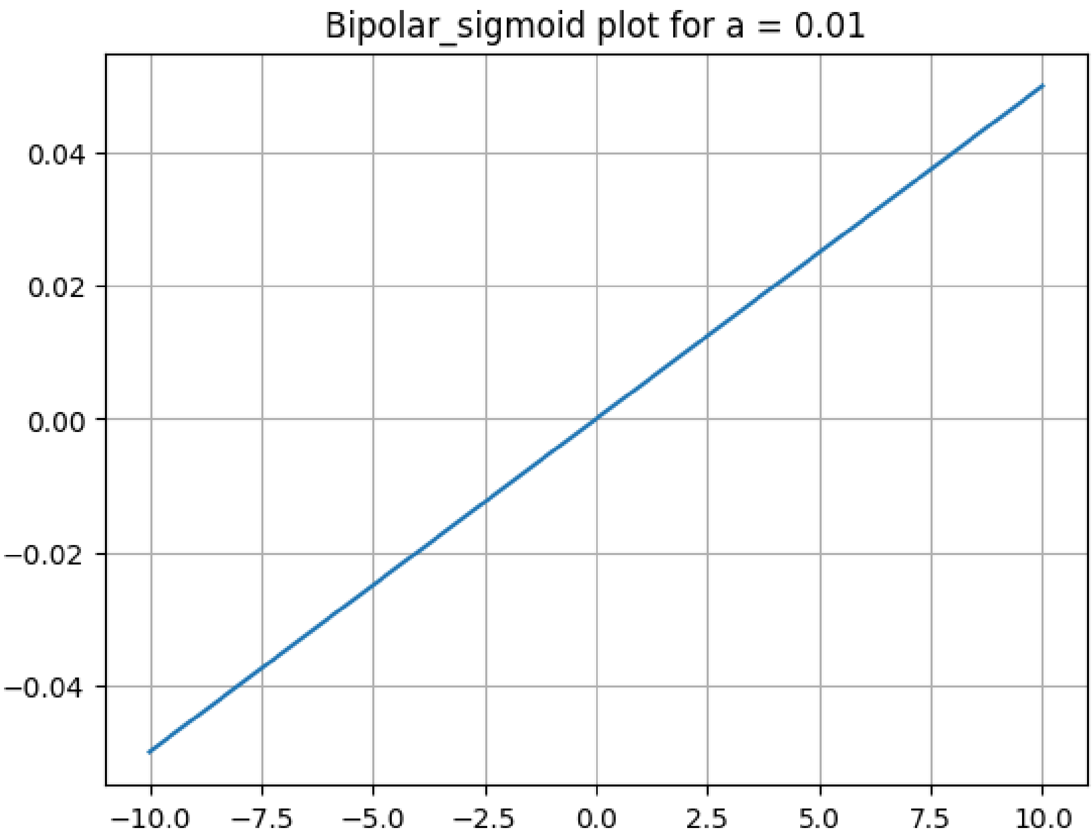
In [29]:
```
plt.figure()
plt.title(f"Bipolar_sigmoid plot for a = {-0.01}")
plt.plot(x,bipolar_sigmoid(-0.01*x))
plt.grid(True)
plt.show()
```



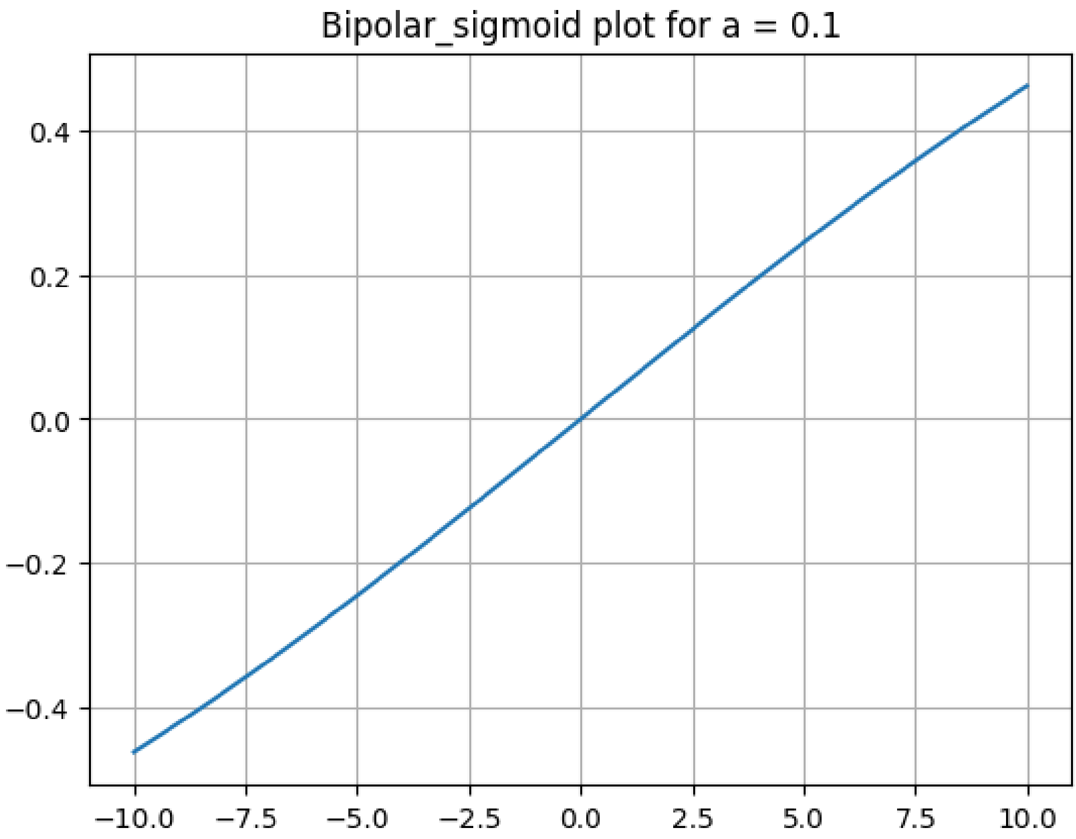
In [30]:
```
plt.figure()
plt.title(f"Bipolar_sigmoid plot for a = {0.001}")
plt.plot(x,bipolar_sigmoid(0.001*x))
plt.grid(True)
plt.show()
```



In [31]:
```
plt.figure()
plt.title(f"Bipolar_sigmoid plot for a = {0.01}")
plt.plot(x,bipolar_sigmoid(0.01*x))
plt.grid(True)
plt.show()
```

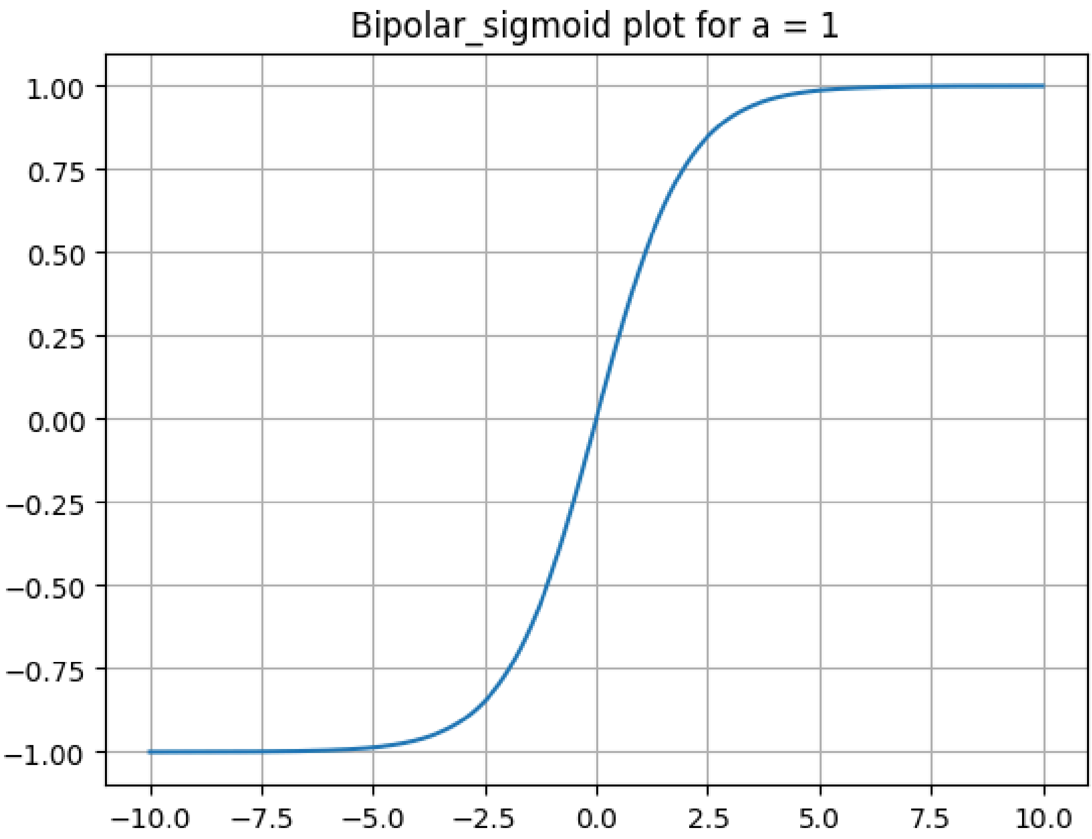


In [32]:
```
plt.figure()
plt.title(f"Bipolar_sigmoid plot for a = {0.1}")
plt.plot(x,bipolar_sigmoid(0.1*x))
plt.grid(True)
plt.show()
```



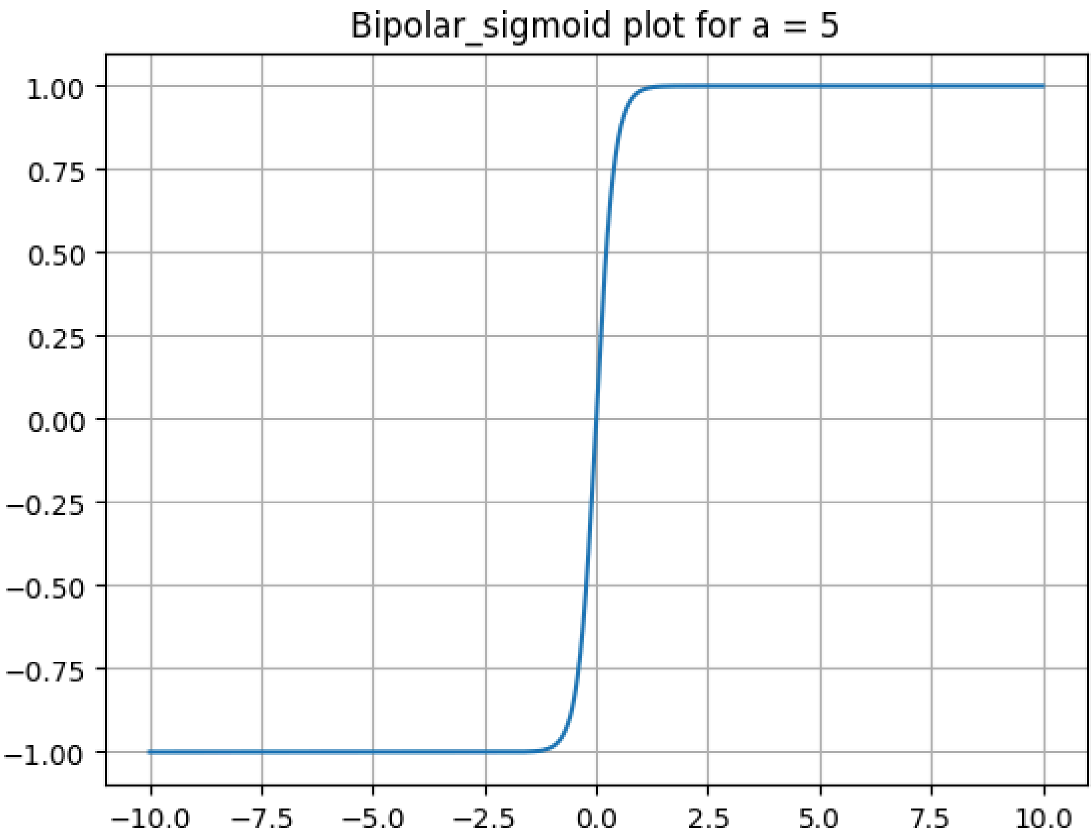
In [33]:

```
plt.figure()
plt.title(f"Bipolar_sigmoid plot for a = {1}")
plt.plot(x,bipolar_sigmoid(1*x))
plt.grid(True)
plt.show()
```



In [34]:

```
plt.figure()
plt.title(f"Bipolar_sigmoid plot for a = {5}")
plt.plot(x,bipolar_sigmoid(5*x))
plt.grid(True)
plt.show()
```



In [ ]:

```

```