

Analysis_of_results

March 28, 2021

This notebook includes the analysis of the results of the paper “On the use of a multimodal optimizer for fitting neuron models. Application to the cerebellar granule cell”, M. Marín et al.(2021), Front. in Neuroinformatics.

1 Base imports

```
In [3]: import pprint
        pp = pprint.PrettyPrinter(indent=4)
        ##matplotlib notebook
        #import seaborn as sns
        #sns.set(style="darkgrid")

        import matplotlib.pyplot as plt
        import nest
        import numpy
        import pdb
        import sys
        import os
```

2 Utility functions

```
In [9]: # Files used to calculate each feature and score in the fitness function
        sys.path.insert(1, '/home/mmarin/gitHubRepositories/Multimodal-optimization-')
        import SpikingSimulation.CurrentSimulation as CurrentSimulation
        import SpikingSimulation.Features.MeanFrequency as MeanFrequency
        import SpikingSimulation.Features.Latency as Latency
        import SpikingSimulation.Features.BF_sd as BF_sd

        # Some utility functions for simulating and analyzing the resulting neuron
        import functions

        # Configuration file that only contains the default values for some internal
        config_file = './EANeuronModel_raw_basic_wo_seed.cfg'
```

3 UEGO RESULTS: POPULATION OF NEURONS ANALYZED IN THE PAPER

```
In [13]: sys.path.insert(1, '/home/mmarin/gitHubRepositories/Multimodal-optimization')
import results_UEGO_60k as uego60k
# Extraction of the candidate configurations and their total scores generated
dict_total_ind, dict_total_fit = uego60k.getResultUEGO_60k_E2()
for i in range(0, len(dict_total_ind)):
    dict_total_ind[i].append(0.001) # Adding the default value of the parameters
#pp.pprint(dict_total_ind) # Print the population of neuron configurations
#pp.pprint(dict_total_fit) # Print the total score of each neuron configuration
print 'Population of neurons = ', len(dict_total_ind)
```

Population of neurons = 25

4 SCORE ANALYSIS AND REPRESENTATION OF EACH NEURON

4.0.1 The next cell represents each of the neuron configuration of the resulting population from the workflow. In this analysis, firstly the neuron configuration is printed, then the feature scores, and finally some plots are represented: the spiking resonance, bursts plots and finally I-F and first-spike latency plots.

```
In [14]: show=True #True for plotting the graphics, False for not plotting them in the notebook
savefig=False # True for saving the plot, False for not saving it.
```

```
In [15]: for cont in range(0, len(dict_total_ind)): #For analysing the whole population
    neuron_config = dict_total_ind[cont] #Select one neuron from the population
    identifier = 'NEURON {}'.format(cont+1) #Identify the neuron
    print '\n \n', identifier

    # Create a dictionary that will accumulate all the information of the neuron
    dict_individual = functions.create_dict_case('{}'.format(identifier))

    # This step transforms the unit values of the parameters from the International System
    parameters_id = ['a', 'espike', 'eth', 'b', 'cm', 'erest', 'grest', 'delta_tau', 'tau', 'tau_ref', 'tau_reset', 'tau_th', 'tau_tref', 'tau_vreset', 'tau_vth', 'tau_vtref', 'tau_vreset_th', 'tau_vreset_tref', 'tau_vreset_th_tref', 'tau_vreset_tref_th', 'tau_vreset_tref_th_tref', 'tau_vreset_th_tref_th_tref']
    IS_params_list = dict(zip(parameters_id, neuron_config))
    IS_params_list = [IS_params_list]
    to_nest_params_list = []
    for i in range(len(IS_params_list)):
        param_dict = {
            'g_L': IS_params_list[i]['grest']*1.e9,
            'E_L': IS_params_list[i]['erest']*1.e3,
            'V_reset': IS_params_list[i]['vreset']*1.e3,
            'V_th': IS_params_list[i]['eth']*1.e3,
            't_ref': IS_params_list[i]['tref']*1.e3,
            'C_m': IS_params_list[i]['cm']*1.e12,
            'V_peak': IS_params_list[i]['espike']*1.e3,
```

```

        'tau_w':IS_params_list[i]['tw']*1.e3,
        'Delta_T':IS_params_list[i]['delta_t']*1.e3,
        'a':IS_params_list[i]['a']*1.e9,
        'b':IS_params_list[i]['b']*1.e9 }
    to_nest_params_list.append(param_dict)
    dict_individual['param_configuration'] = IS_params_list[0] #Save t
    dict_individual['scores']['total_score_obtained_in_UEGO'] = dict_t
    #pp.pprint(to_nest_parameter_list)

# Simulation of the neuron and calculation of the spiking resonance fe
functions.score_calculation(dict_individual,config_file,simulation_tin
print '\t Parameter configuration:'
pp.pprint(dict_individual['param_configuration'])
print '\n \t Feature and total score:'
pp.pprint(dict_individual['scores'])

#Representation of the features
functions.score_representation(dict_individual, config_file, simulation

```

NEURON 1

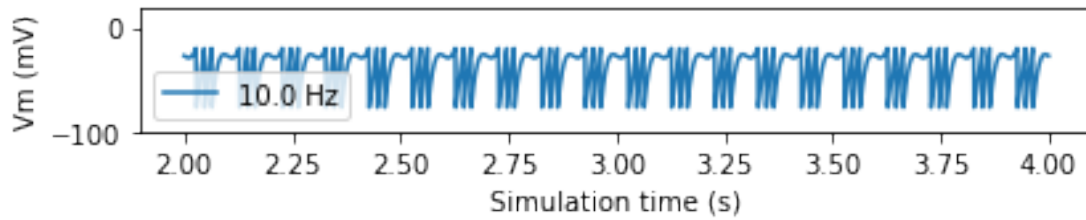
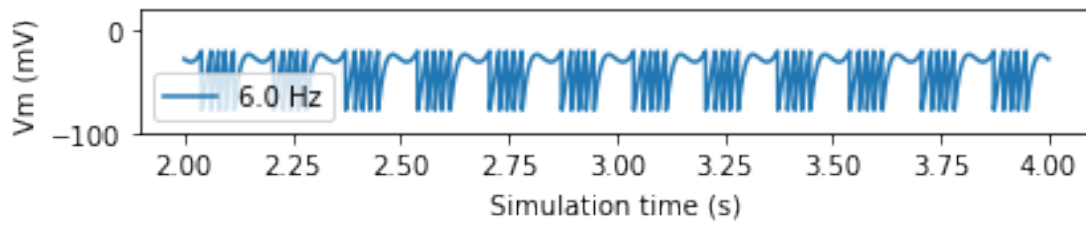
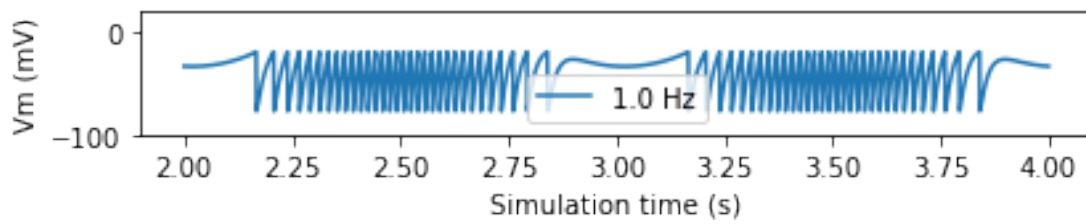
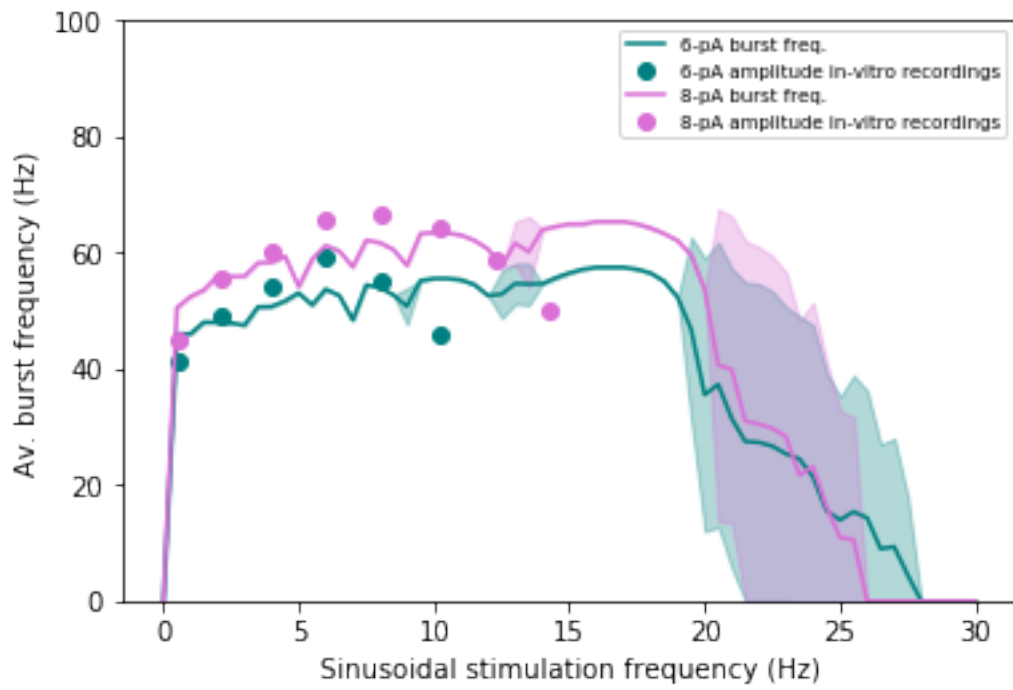
```

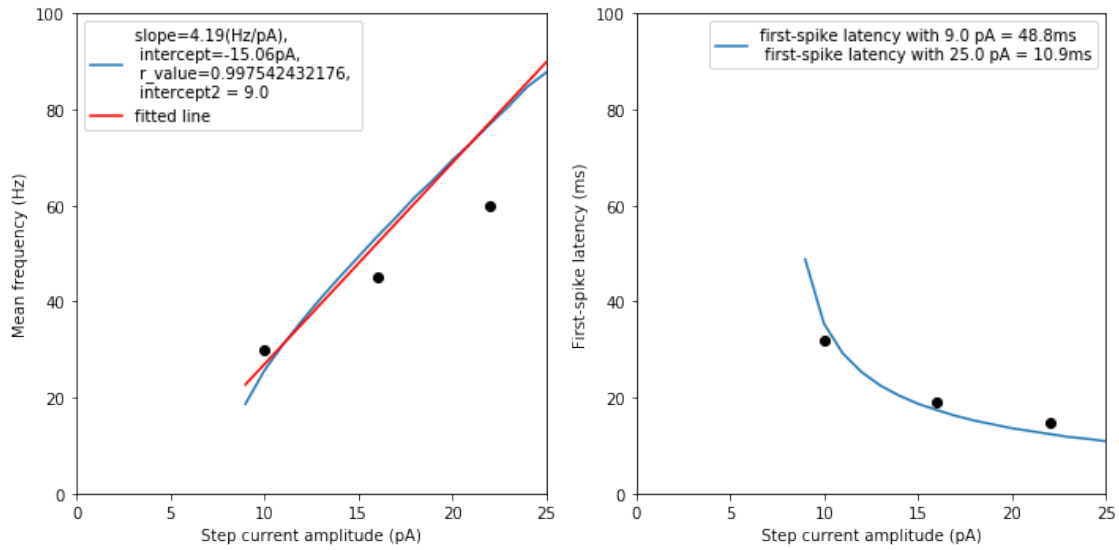
        Parameter configuration:
{   'a': 1.2305945282694373e-10,
    'b': -9.998472663833964e-10,
    'cm': 4.225802172929736e-12,
    'delta_t': 0.05588139497076256,
    'erest': -0.07922524278167772,
    'espike': -0.019981145683855703,
    'eth': -0.020446012905153542,
    'grest': 3.3328556400509713e-10,
    'tref': 0.001,
    'tw': 0.007137508729479229,
    'vreset': -0.07663839785499513}

        Feature and total score:
{   'feature_Burst_Frequency': 57.64183204583235,
    'feature_Latency': 7.35,
    'feature_Mean_Frequency': 29.0,
    'total_score_obtained_in_UEGO': 93.991832}

```

NEURON 1





NEURON 2

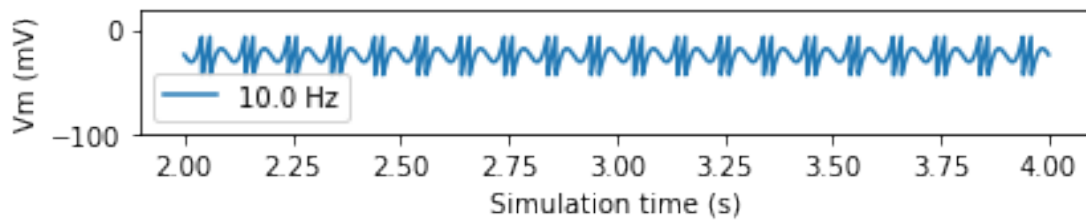
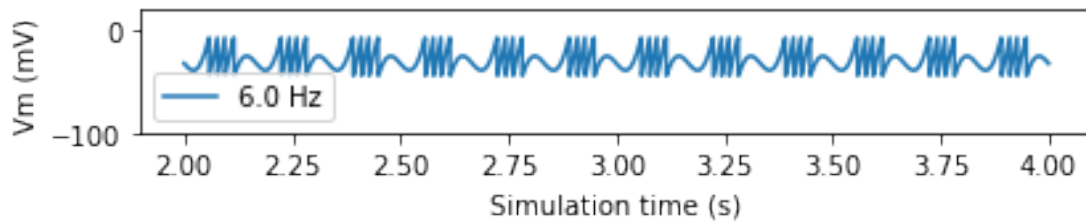
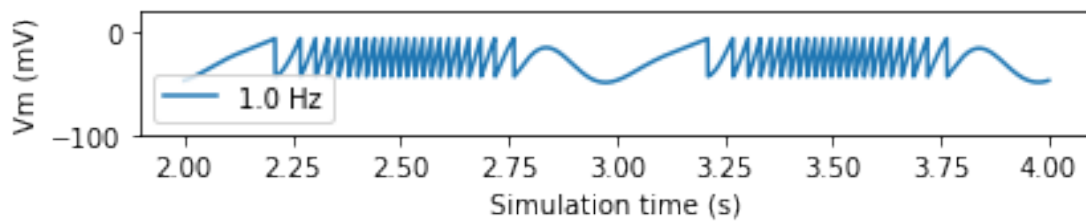
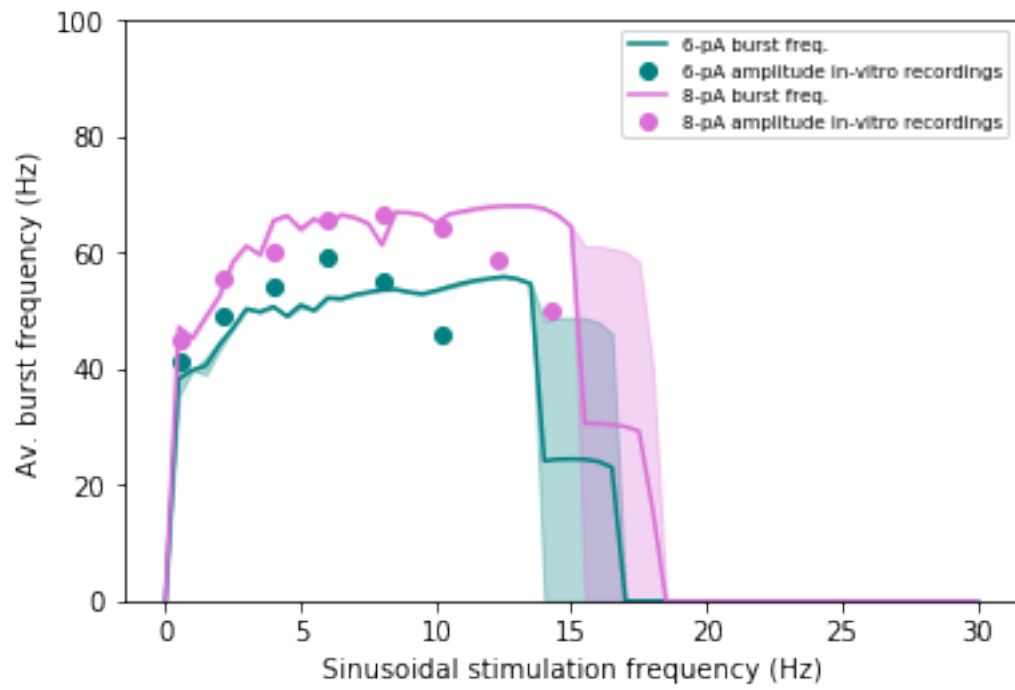
Parameter configuration:

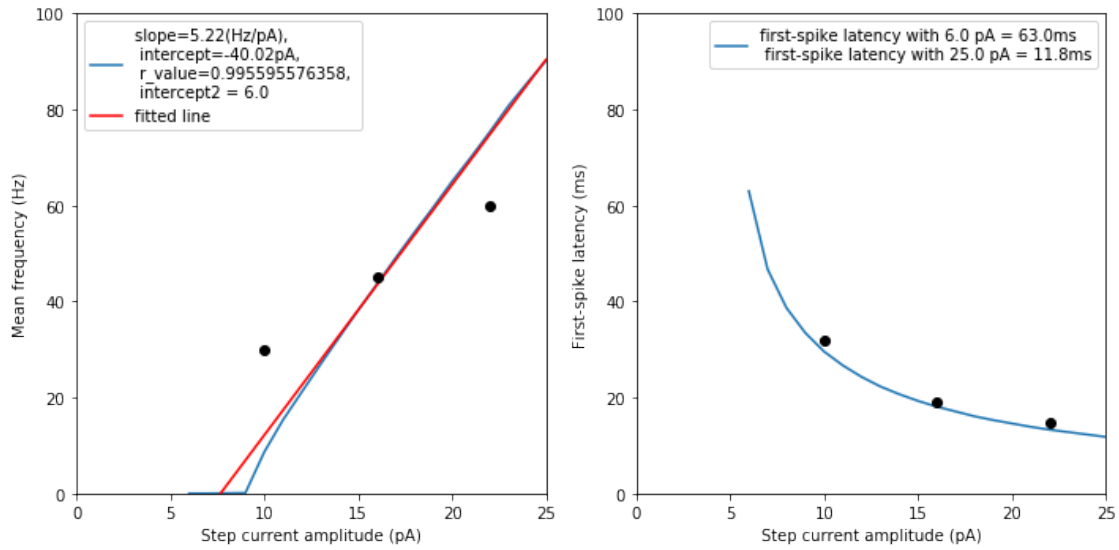
```
{
  'a': 2.0211942863984134e-10,
  'b': 1.398492155753093e-10,
  'cm': 4.399792533964841e-12,
  'delta_t': 0.054382051404931006,
  'erest': -0.06719423686022967,
  'espike': -0.007077809882505752,
  'eth': -0.03814939864478801,
  'grest': 1.5509457844399663e-12,
  'tref': 0.001,
  'tw': 0.07344149740582574,
  'vreset': -0.043458127030672165}
```

Feature and total score:

```
{
  'feature_Burst_Frequency': 61.35617198256388,
  'feature_Latency': 4.5499999999999994,
  'feature_Mean_Frequency': 37.0,
  'total_score_obtained_in_UEGO': 102.906172}
```

NEURON 2





NEURON 3

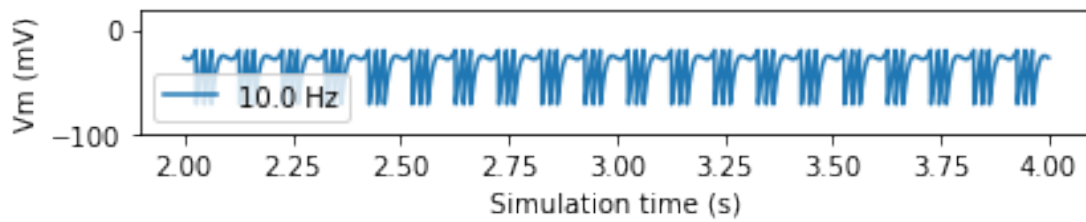
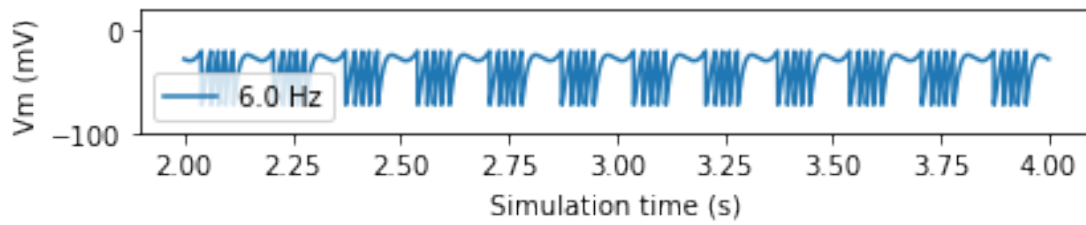
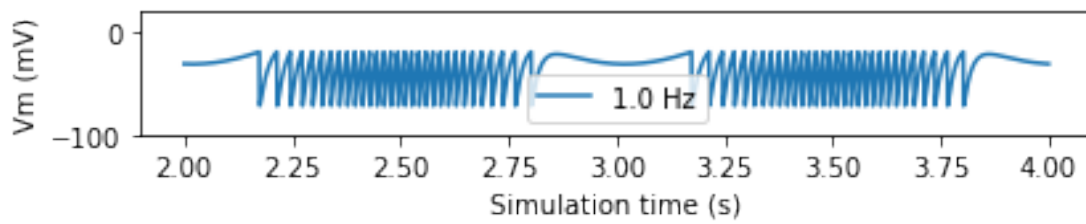
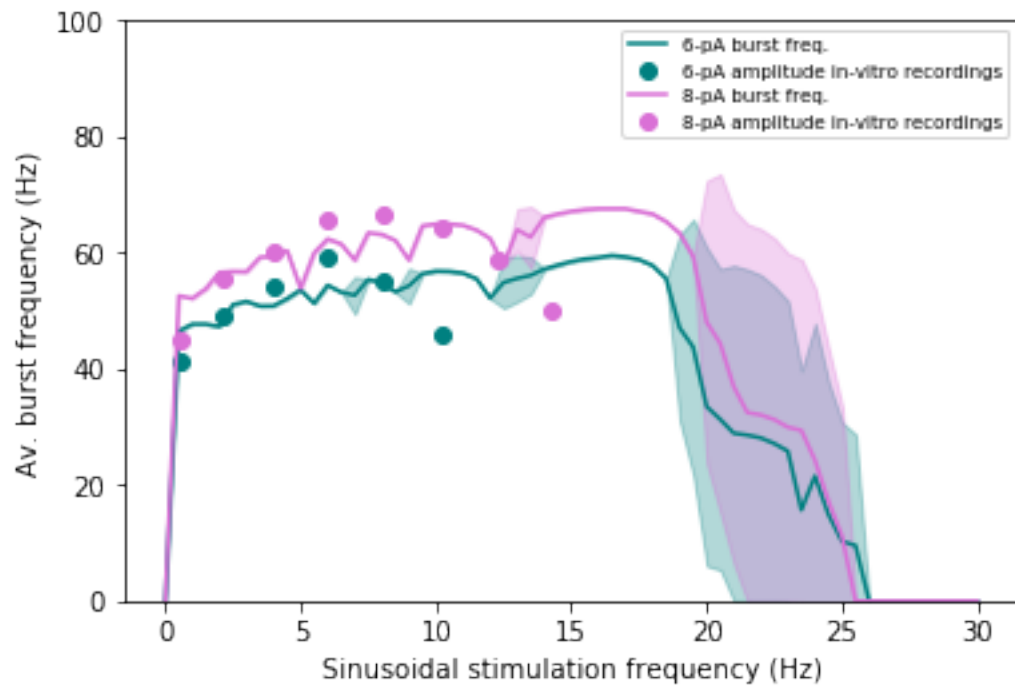
Parameter configuration:

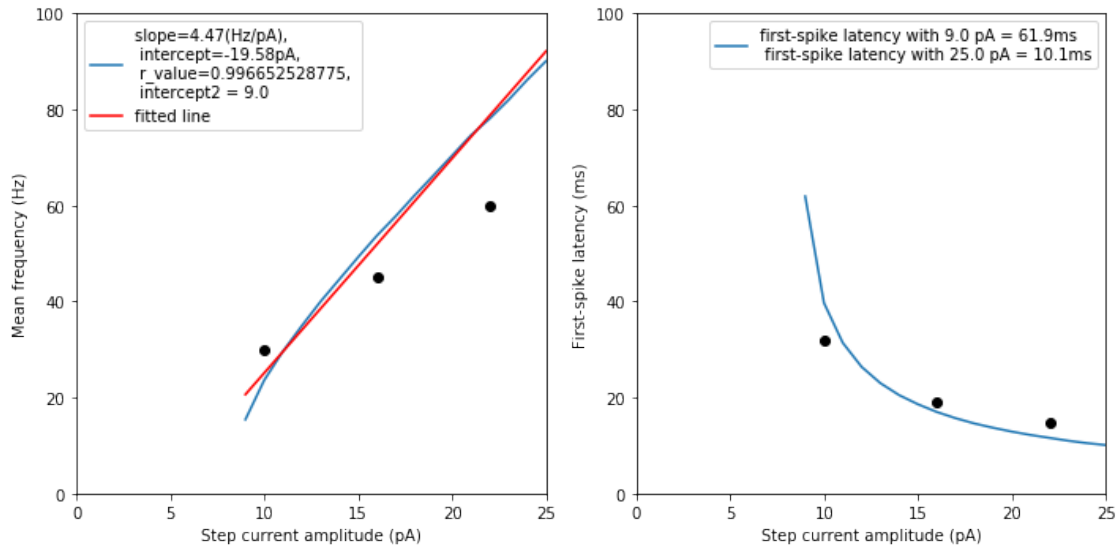
```
{
  'a': 2.2300779903436193e-10,
  'b': -4.289259972856559e-10,
  'cm': 4.408481833247137e-12,
  'delta_t': 0.6534684559666518,
  'erest': -0.06652681591466889,
  'espike': -0.01998396136387164,
  'eth': -0.05452662864108663,
  'grest': 2.7091080756679072e-12,
  'tref': 0.001,
  'tw': 0.0017003848612645778,
  'vreset': -0.07156802699763551}
```

Feature and total score:

```
{
  'feature_Burst_Frequency': 60.6724793083487,
  'feature_Latency': 12.850000000000009,
  'feature_Mean_Frequency': 33.0,
  'total_score_obtained_in_UEGO': 106.522479}
```

NEURON 3





NEURON 4

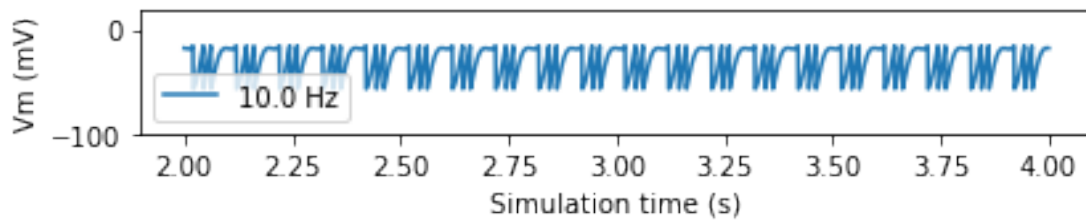
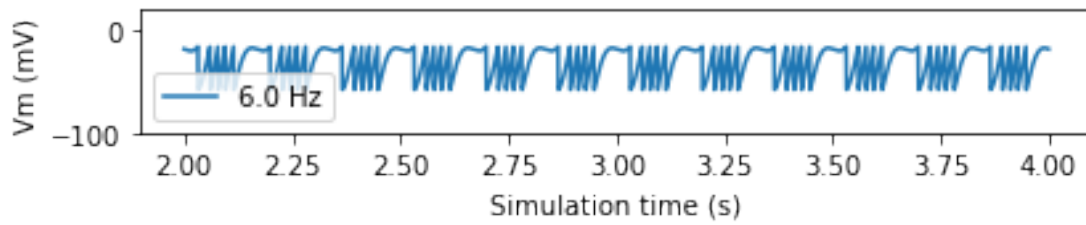
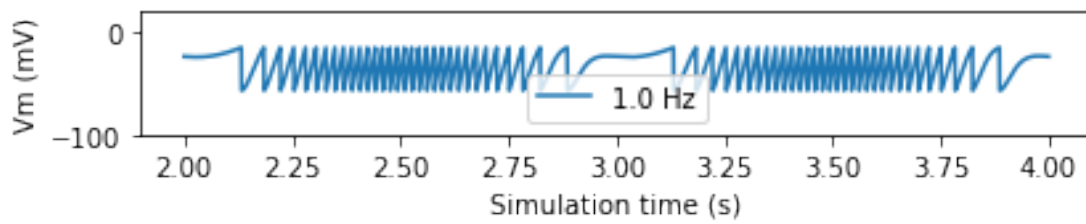
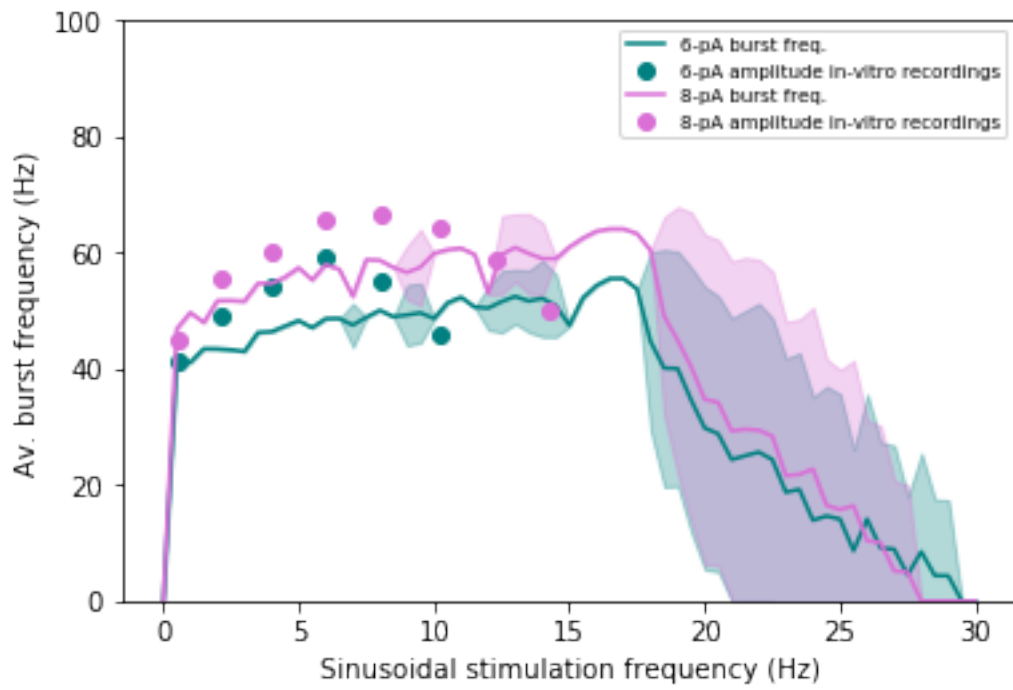
Parameter configuration:

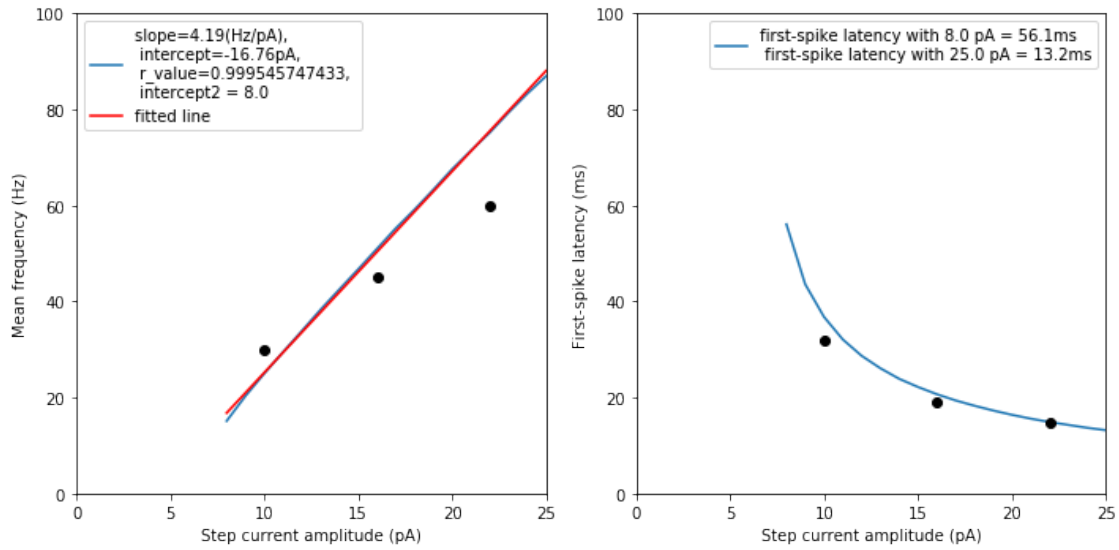
```
{
  'a': 1.3859070019095325e-10,
  'b': 1e-09,
  'cm': 4.9975653657435176e-12,
  'delta_t': 0.792296004536065,
  'erest': -0.07603747544251435,
  'espike': -0.01573128607724861,
  'eth': -0.020000002680840881,
  'grest': 1.3773146178928825e-12,
  'tref': 0.001,
  'tw': 0.012717111443994827,
  'vreset': -0.056917090301078506}
```

Feature and total score:

```
{
  'feature_Burst_Frequency': 75.85821855793246,
  'feature_Latency': 6.85000000000000085,
  'feature_Mean_Frequency': 26.0,
  'total_score_obtained_in_UEGO': 108.708219}
```

NEURON 4





NEURON 5

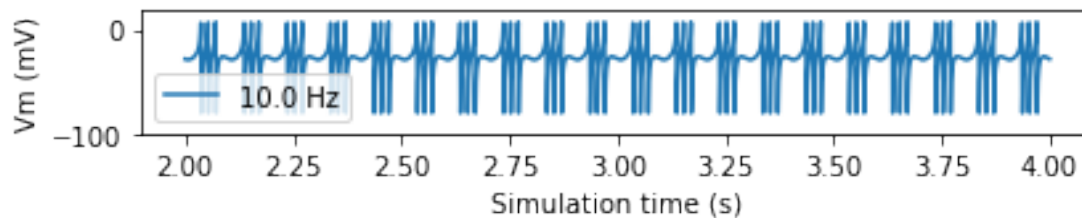
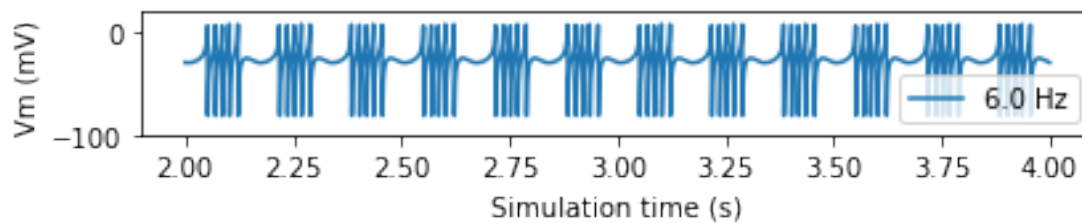
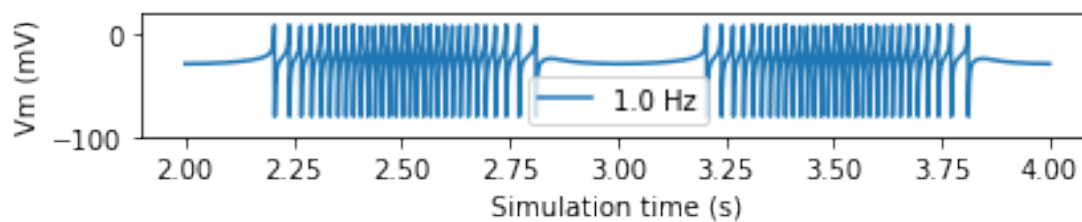
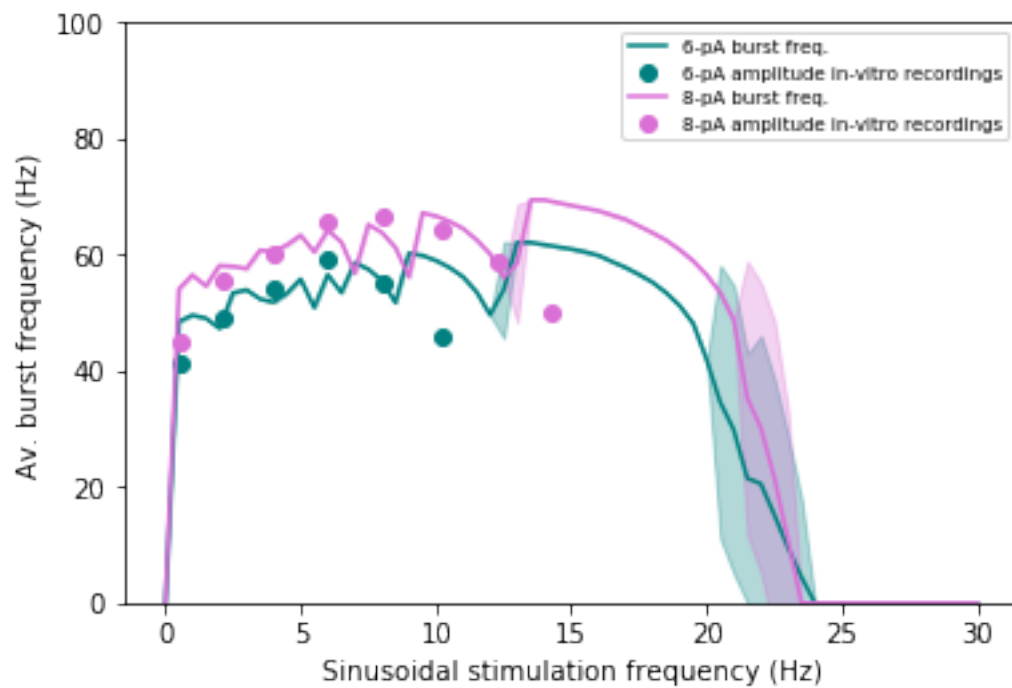
Parameter configuration:

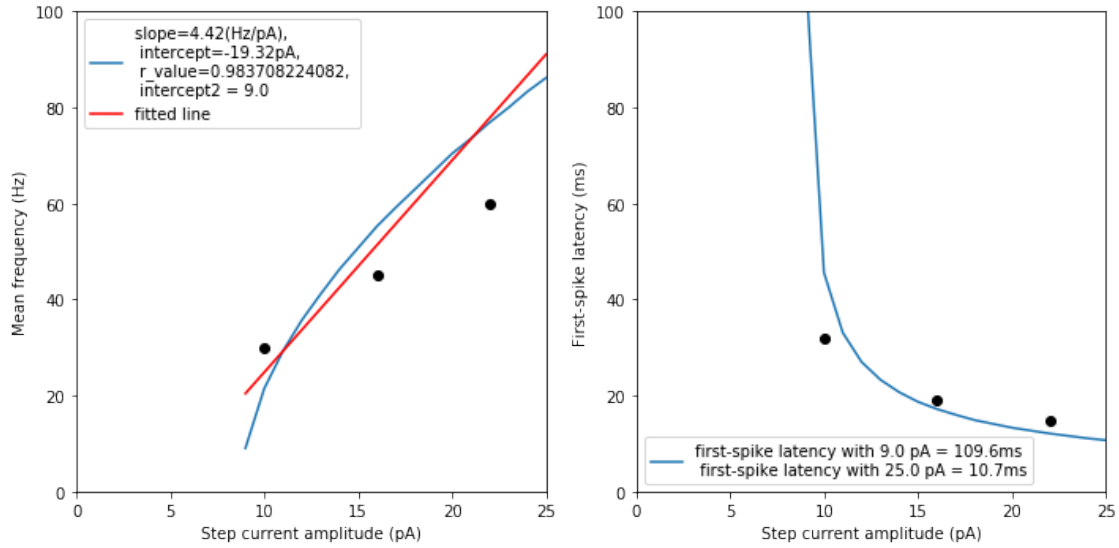
```
{
  'a': 2.4433872894101664e-10,
  'b': -9.459366492336183e-10,
  'cm': 4.7413904766902e-12,
  'delta_t': 0.055820071594513486,
  'erest': -0.07998482434075026,
  'espike': 0.00784092367010342,
  'eth': -0.024829410099130818,
  'grest': 7.413447740172787e-09,
  'tref': 0.001,
  'tw': 0.001039409317304495,
  'vreset': -0.0799723603807997}
```

Feature and total score:

```
{
  'feature_Burst_Frequency': 63.602205655682894,
  'feature_Latency': 18.050000000000004,
  'feature_Mean_Frequency': 35.0,
  'total_score_obtained_in_UEGO': 116.652206}
```

NEURON 5





NEURON 6

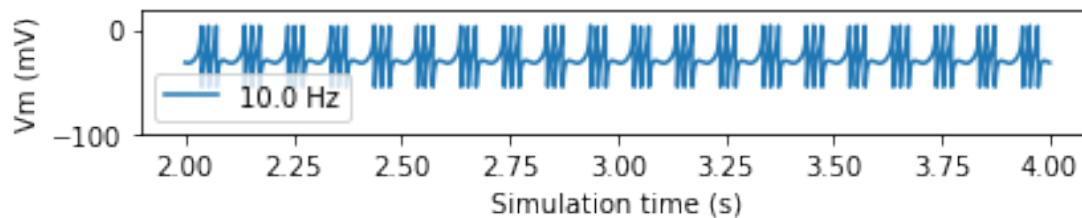
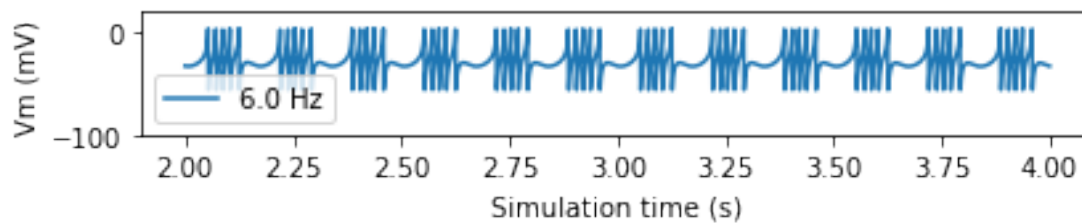
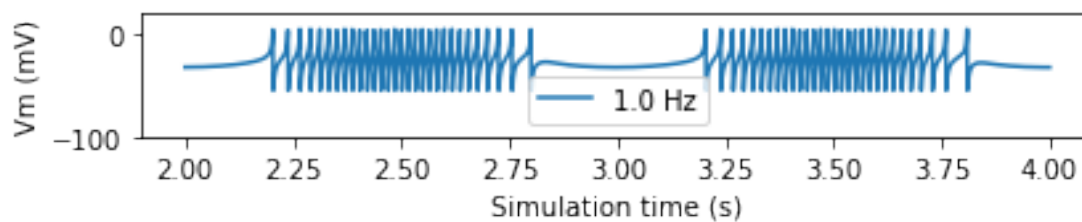
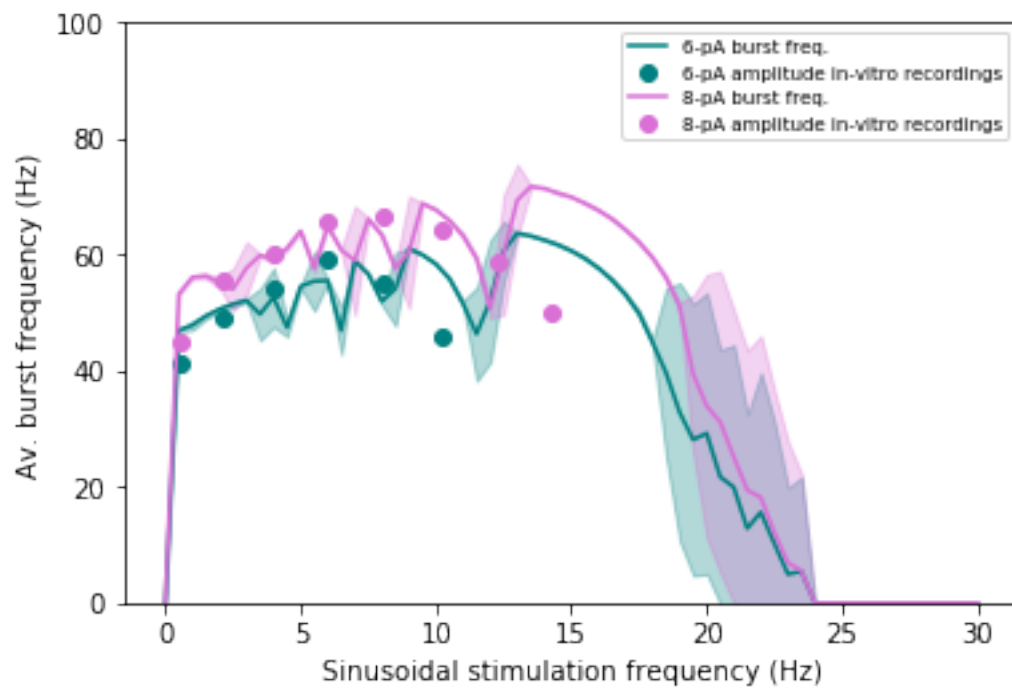
Parameter configuration:

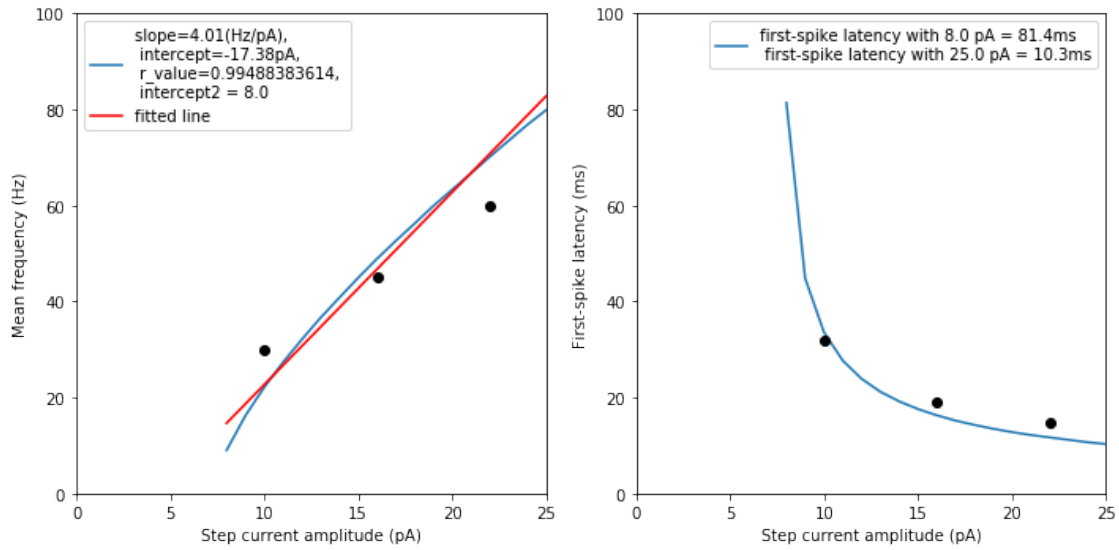
```
{
  'a': -9.687240098694335e-12,
  'b': 8.056999338699485e-11,
  'cm': 4.32405576712212e-12,
  'delta_t': 0.03648022626145565,
  'erest': -0.0634209521754019,
  'espike': 0.003858772102261949,
  'eth': -0.024928756735631503,
  'grest': 3.742332226097707e-09,
  'tref': 0.001,
  'tw': 0.790811153829154,
  'vreset': -0.05506866959670498}
```

Feature and total score:

```
{
  'feature_Burst_Frequency': 80.81899089715667,
  'feature_Latency': 7.350000000000003,
  'feature_Mean_Frequency': 33.0,
  'total_score_obtained_in_UEGO': 121.168991}
```

NEURON 6





NEURON 7

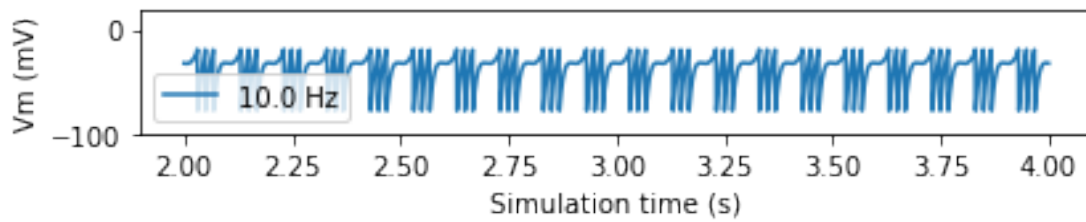
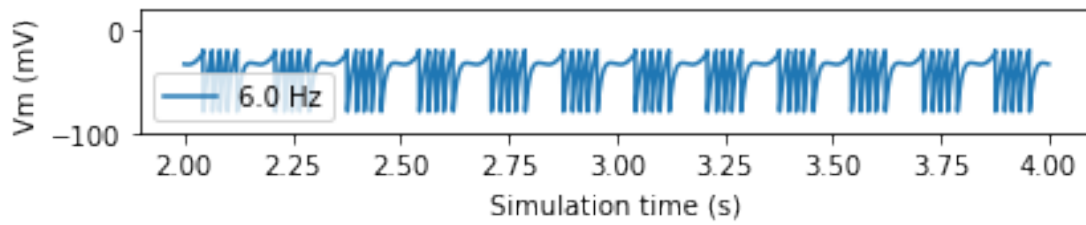
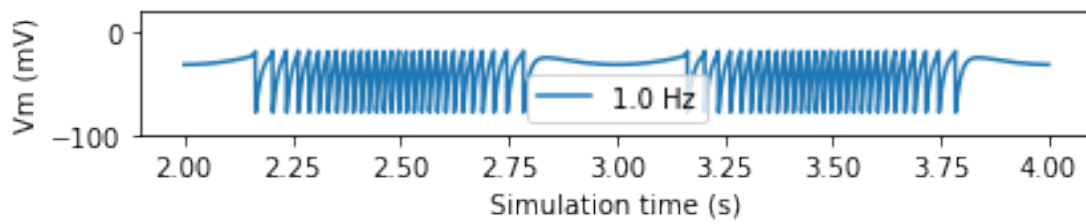
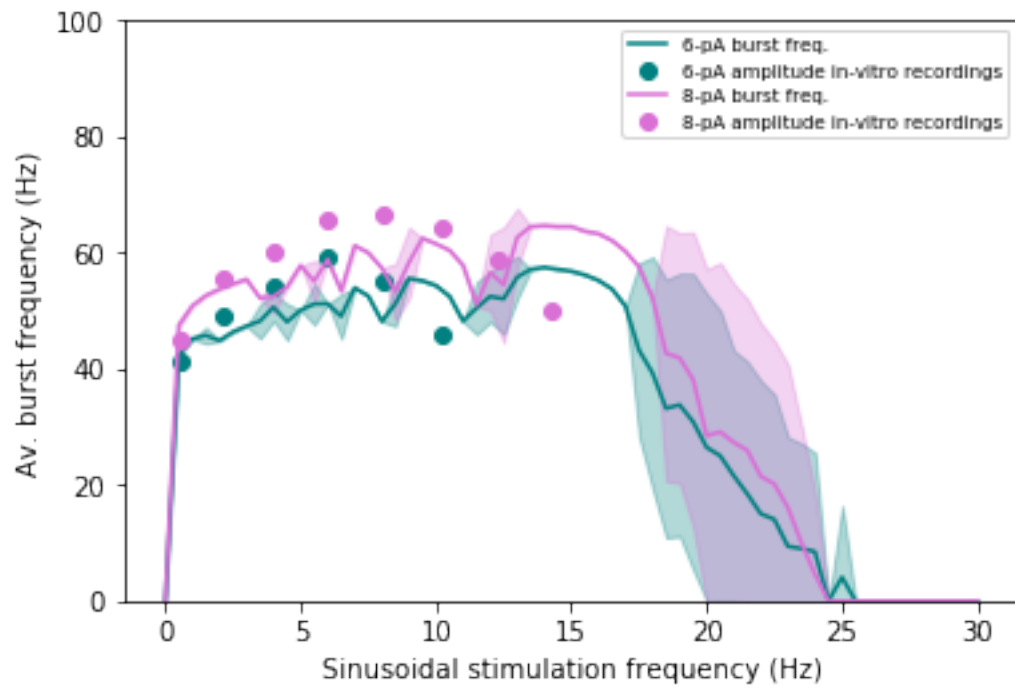
Parameter configuration:

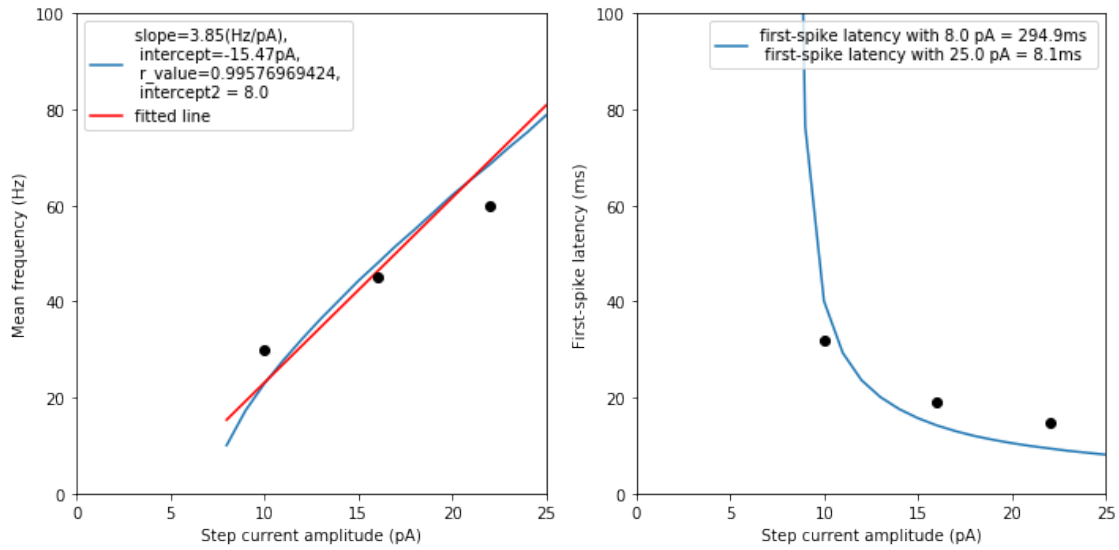
```
{
  'a': -6.909919486766509e-11,
  'b': 8.906583764925223e-11,
  'cm': 4.302705373090603e-12,
  'delta_t': 0.0011164871471789476,
  'erest': -0.05150075703049911,
  'espike': -0.018914485817725722,
  'eth': -0.024208343803528216,
  'grest': 3.415215620227131e-10,
  'tref': 0.001,
  'tw': 0.27324300085752906,
  'vreset': -0.07787189204219844}
```

Feature and total score:

```
{
  'feature_Burst_Frequency': 87.3595176603957,
  'feature_Latency': 18.250000000000004,
  'feature_Mean_Frequency': 21.0,
  'total_score_obtained_in_UEGO': 126.609518}
```

NEURON 7





NEURON 8

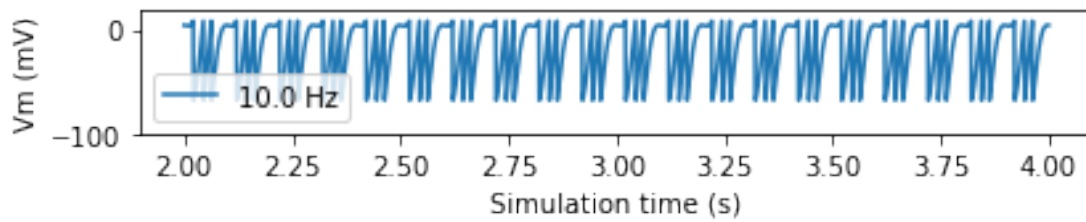
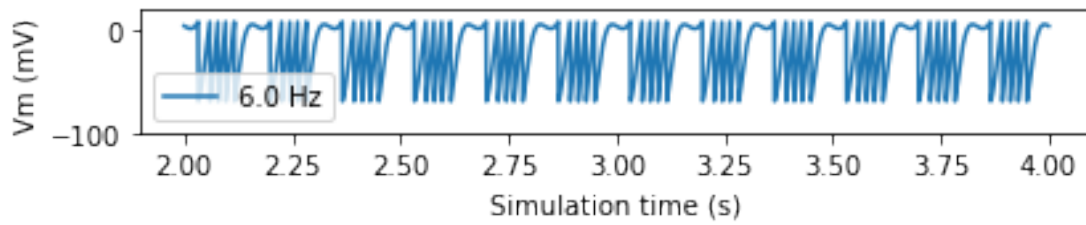
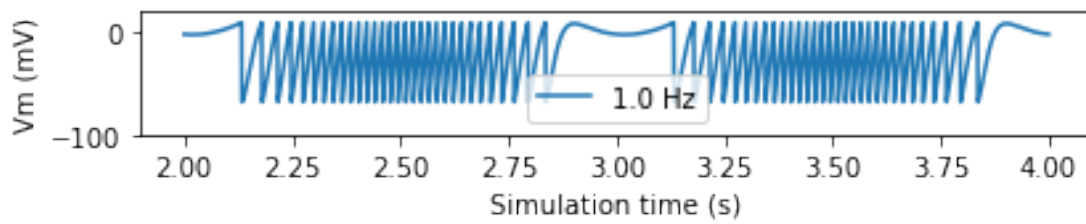
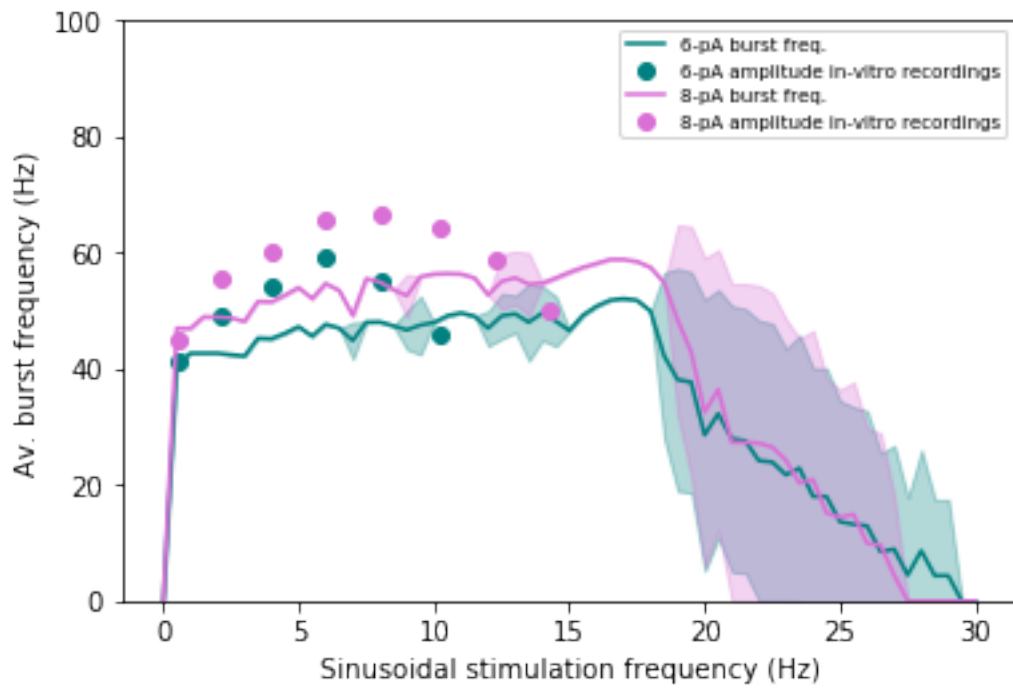
Parameter configuration:

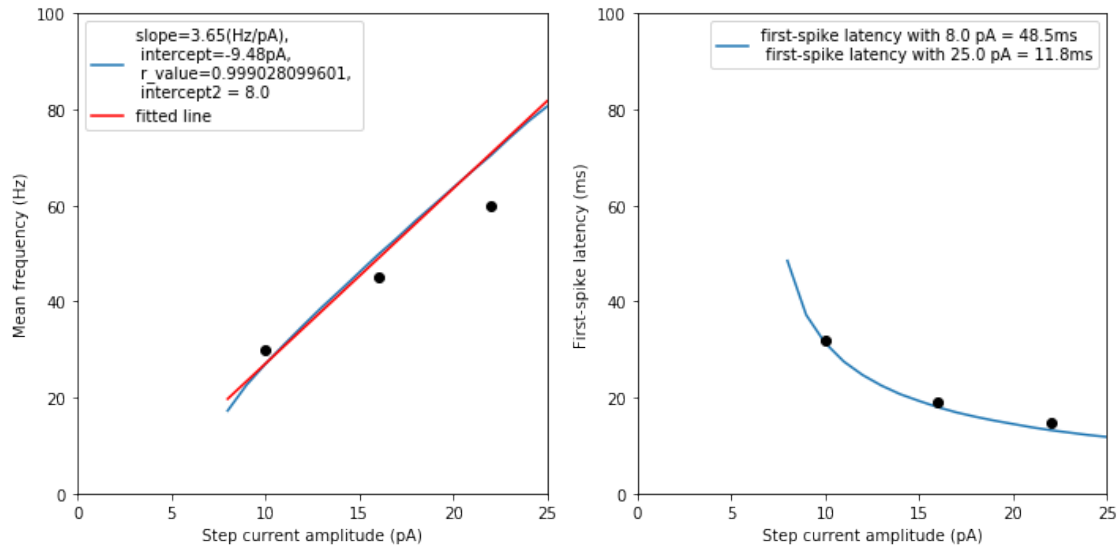
```
{
  'a': 1.2620253474580043e-10,
  'b': -2.6718925642620473e-10,
  'cm': 3.4234811847810425e-12,
  'delta_t': 0.6313090984685393,
  'erest': -0.07398095462090382,
  'espike': 0.008171070247206251,
  'eth': -0.025613192248793736,
  'grest': 4.949136429284093e-12,
  'tref': 0.001,
  'tw': 0.008874564254189216,
  'vreset': -0.06797266757962256}
```

Feature and total score:

```
{
  'feature_Burst_Frequency': 110.35260055101442,
  'feature_Latency': 2.9499999999999999,
  'feature_Mean_Frequency': 17.0,
  'total_score_obtained_in_UEGO': 130.302601}
```

NEURON 8





NEURON 9

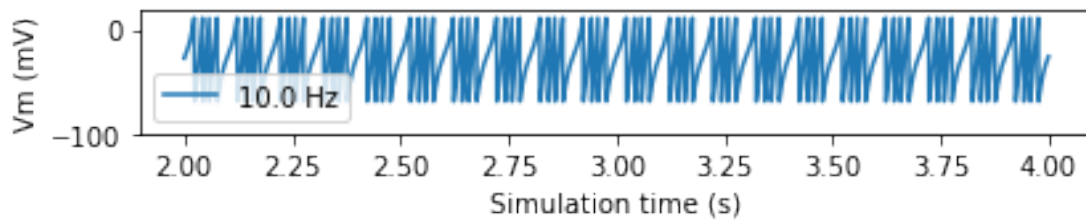
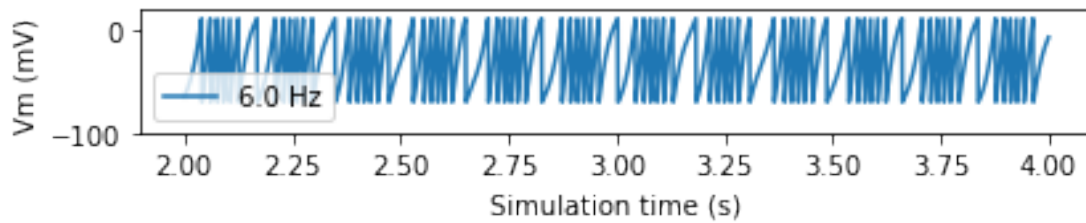
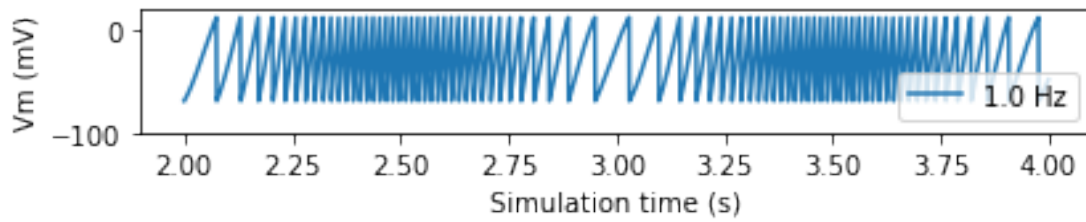
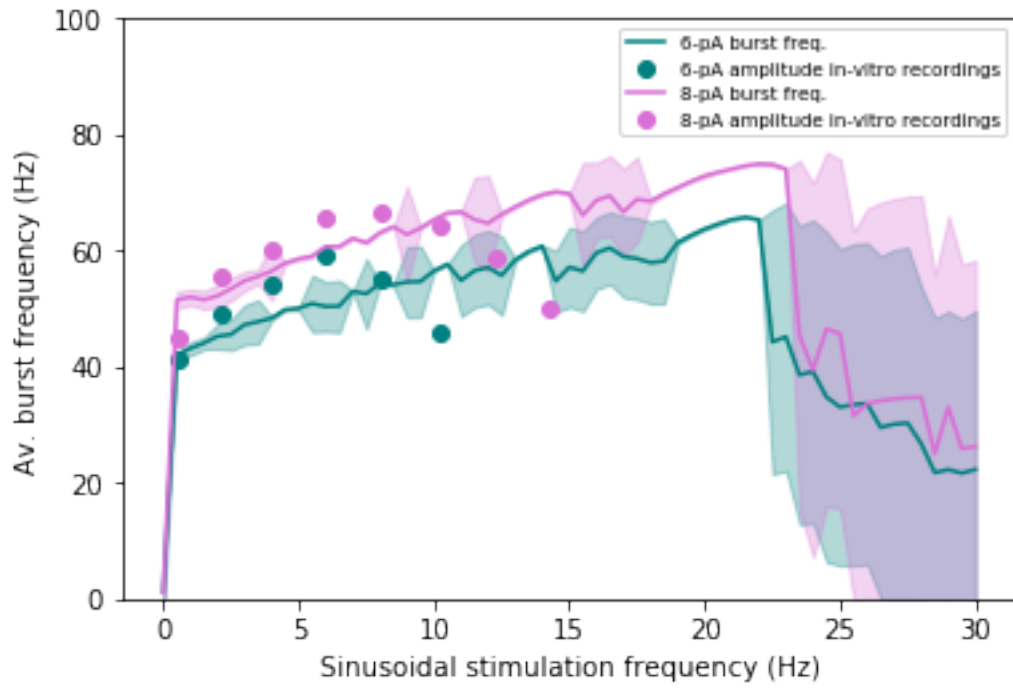
Parameter configuration:

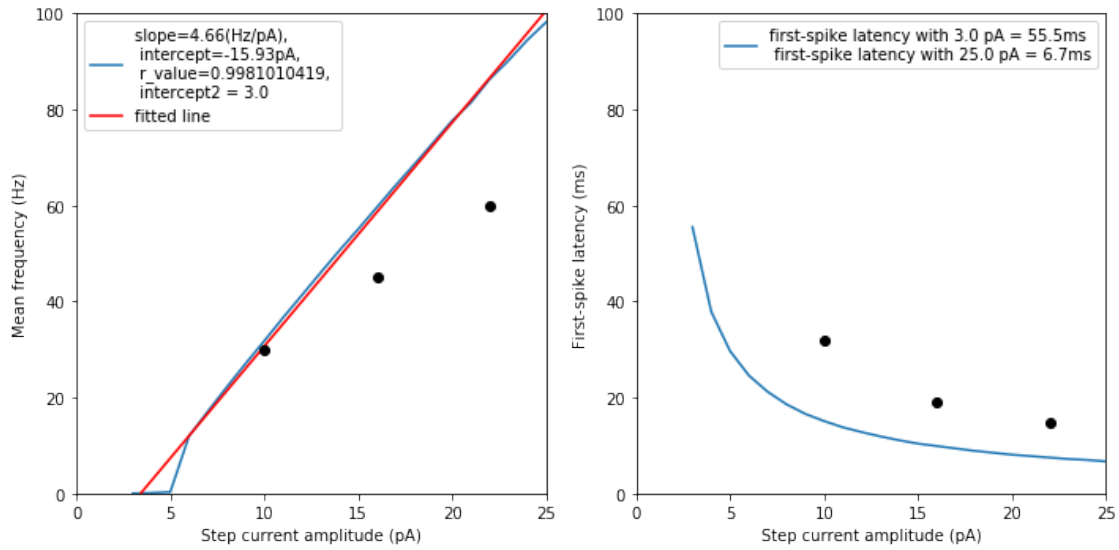
```
{
  'a': 2.286294709055454e-10,
  'b': 2.8297736070846036e-11,
  'cm': 2.4734156327620315e-12,
  'delta_t': 0.25270319667846924,
  'erest': -0.045792008114262685,
  'espike': 0.011269129282705608,
  'eth': -0.05212278231180796,
  'grest': 1e-12,
  'tref': 0.001,
  'tw': 0.19322118706587108,
  'vreset': -0.06886109958207905}
```

Feature and total score:

```
{
  'feature_Burst_Frequency': 95.00408155966856,
  'feature_Latency': 33.05,
  'feature_Mean_Frequency': 50.0,
  'total_score_obtained_in_UEGO': 178.054082}
```

NEURON 9





NEURON 10

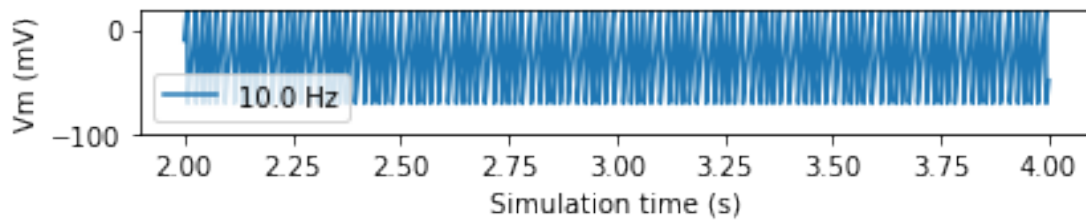
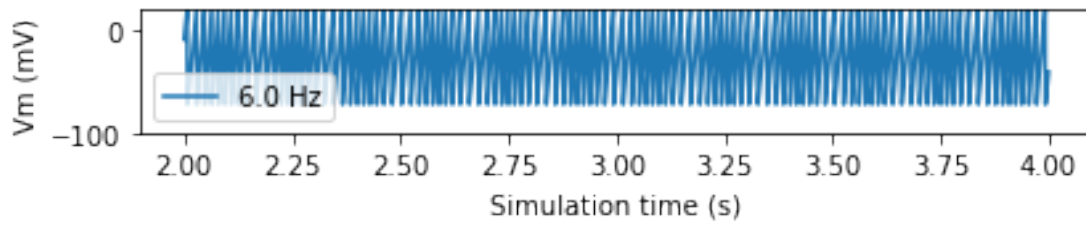
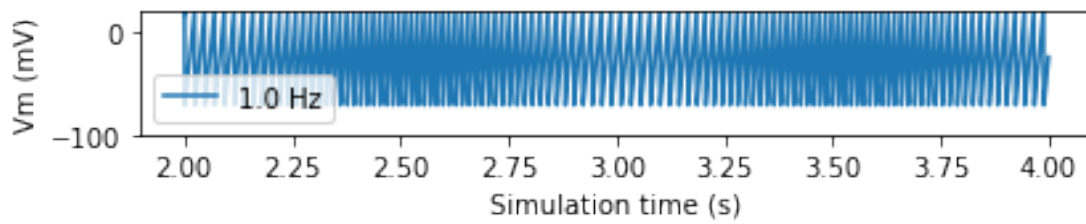
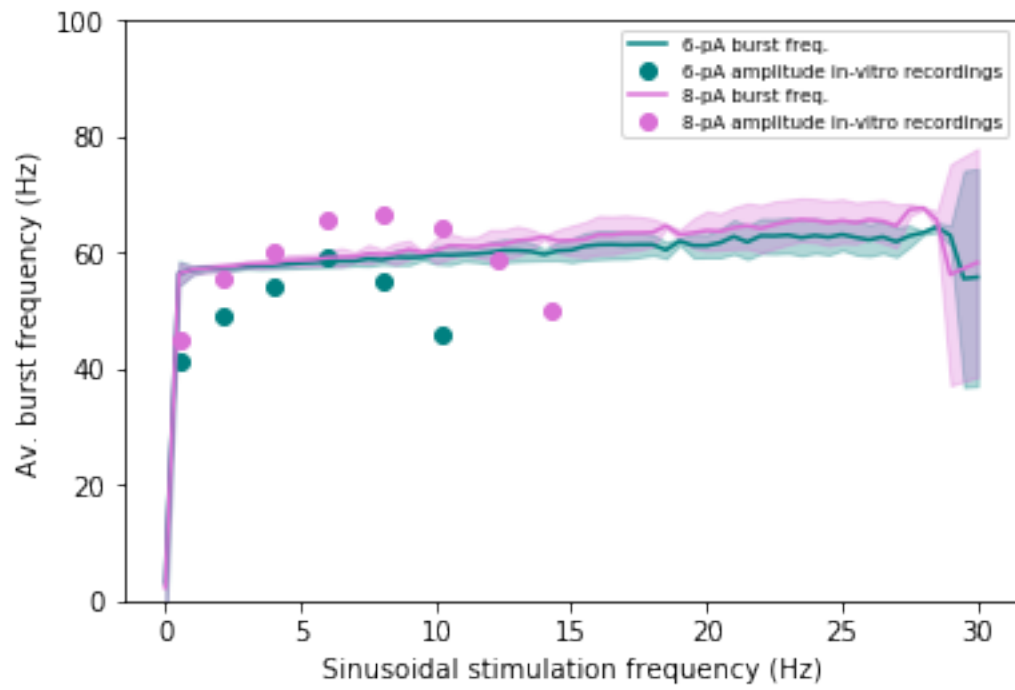
Parameter configuration:

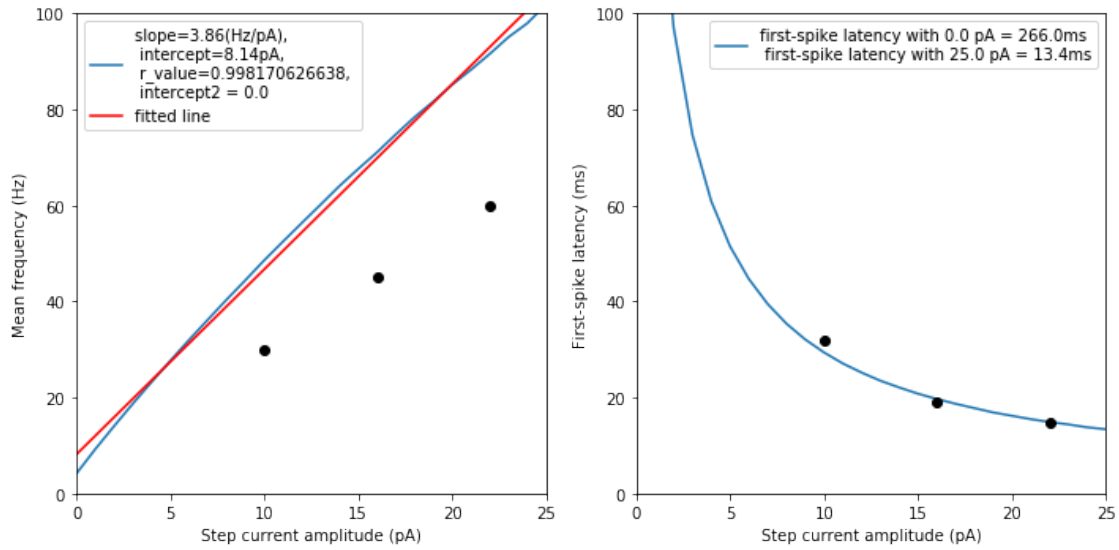
```
{
  'a': 2.733550126016111e-11,
  'b': -8.501225127216428e-10,
  'cm': 4.989126126907265e-12,
  'delta_t': 0.9994545038989721,
  'erest': -0.045028035528713185,
  'espike': 0.01999246222696729,
  'eth': -0.06,
  'grest': 1.4357556456822754e-12,
  'tref': 0.001,
  'tw': 0.3019474484425327,
  'vreset': -0.0709971558442862}
```

Feature and total score:

```
{
  'feature_Burst_Frequency': 156.96826962596717,
  'feature_Latency': 3.4499999999999995,
  'feature_Mean_Frequency': 29.0,
  'total_score_obtained_in_UEGO': 189.41827}
```

NEURON 10





NEURON 11

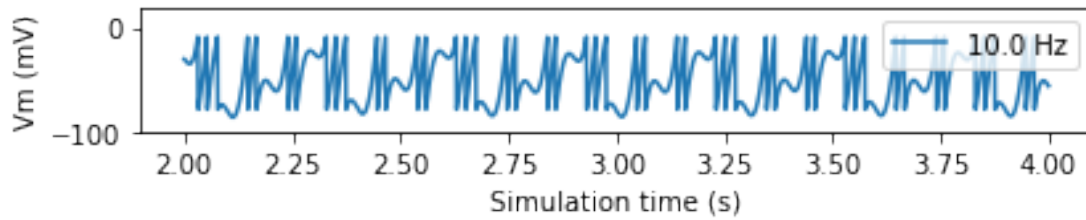
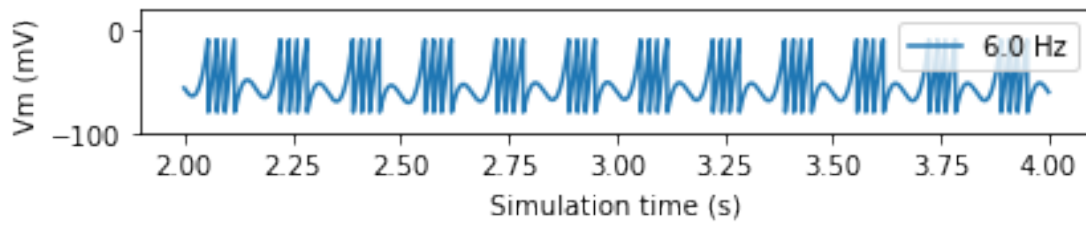
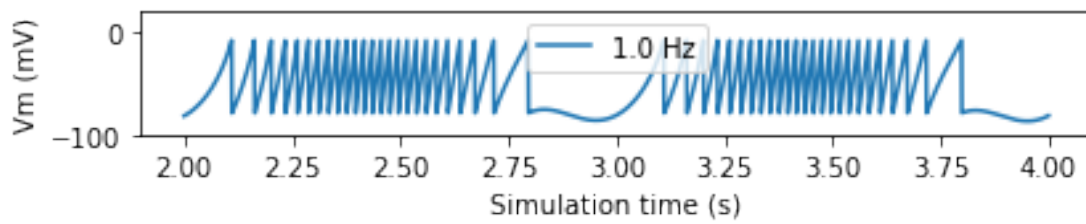
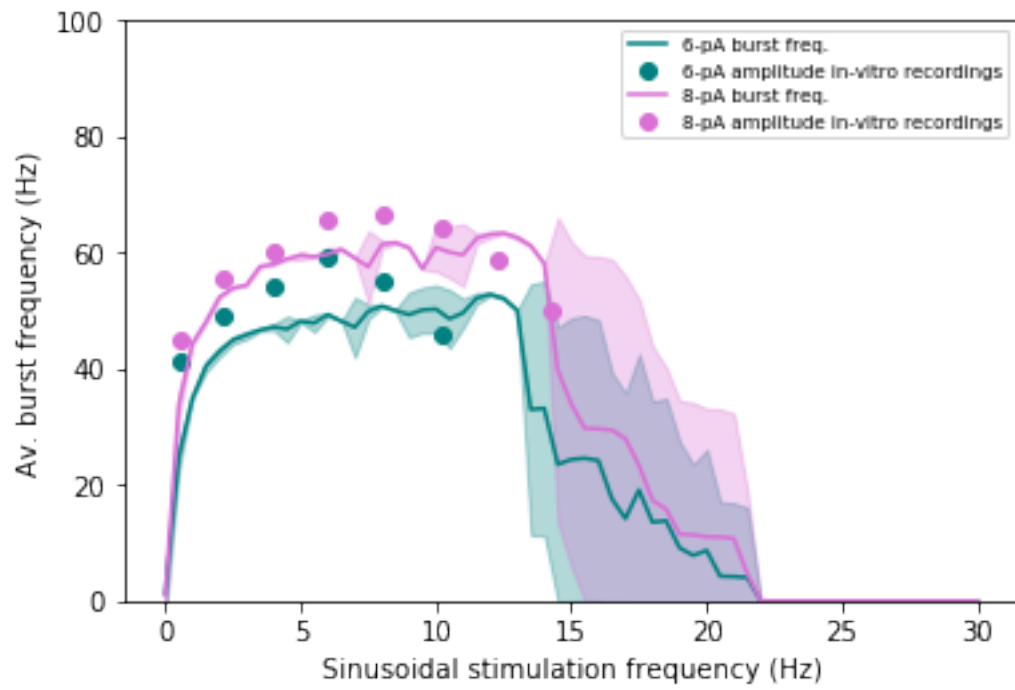
Parameter configuration:

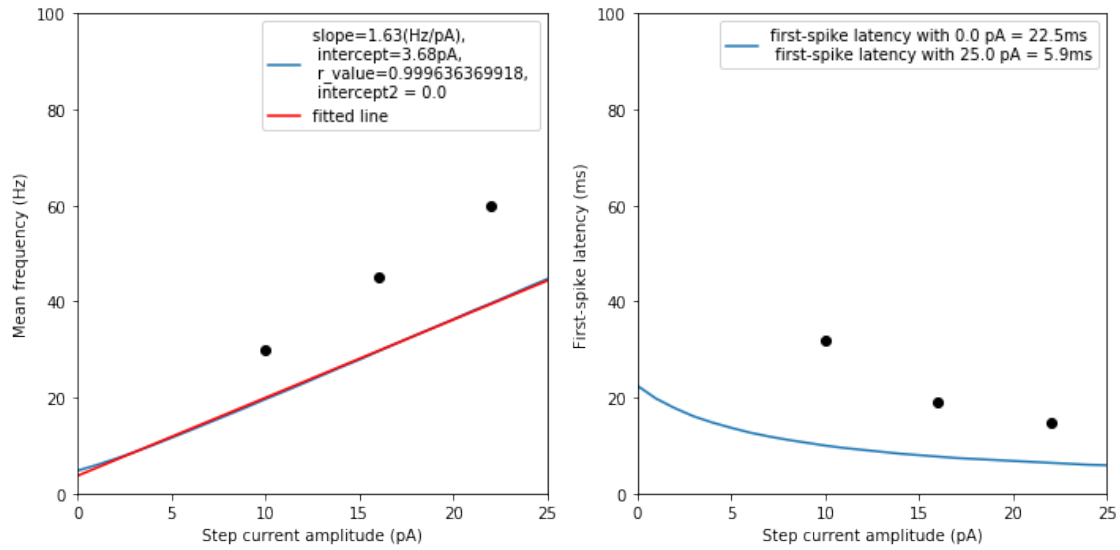
```
{
  'a': 2.4517075524883583e-10,
  'b': 5.127337412566659e-10,
  'cm': 2.5976580157771746e-12,
  'delta_t': 0.09102797871780305,
  'erest': -0.07048794787027418,
  'espike': -0.008854035065416628,
  'eth': -0.05626761539675543,
  'grest': 8.969590965007617e-11,
  'tref': 0.001,
  'tw': 0.8123256135991225,
  'vreset': -0.07854148669950141}
```

Feature and total score:

```
{
  'feature_Burst_Frequency': 133.2679368833888,
  'feature_Latency': 41.449999999999996,
  'feature_Mean_Frequency': 18.0,
  'total_score_obtained_in_UEGO': 192.717937}
```

NEURON 11





NEURON 12

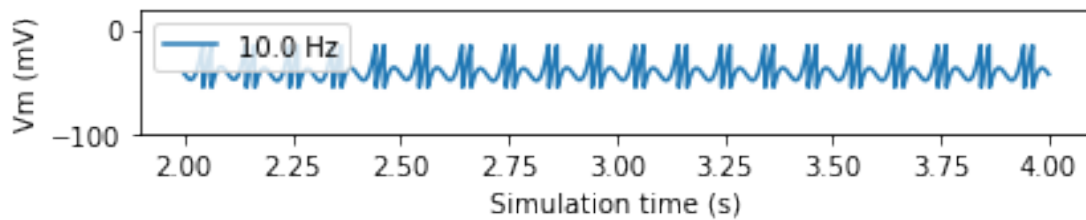
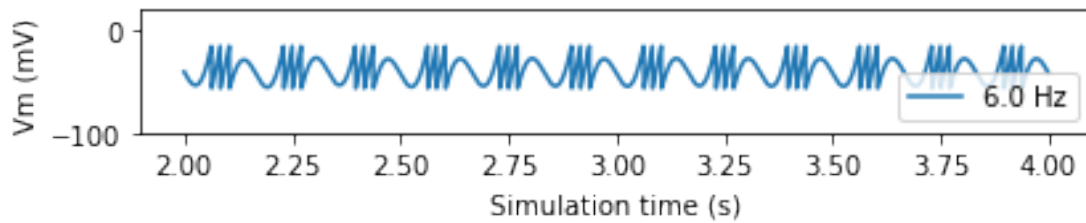
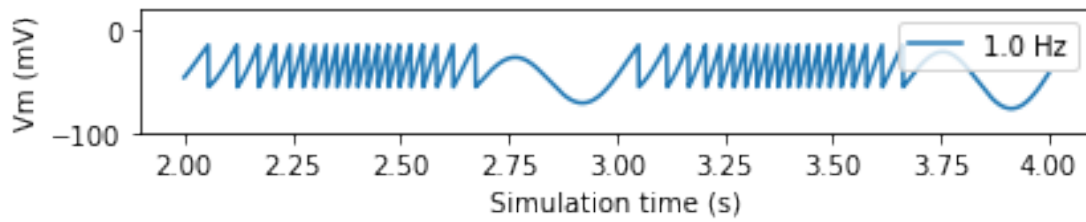
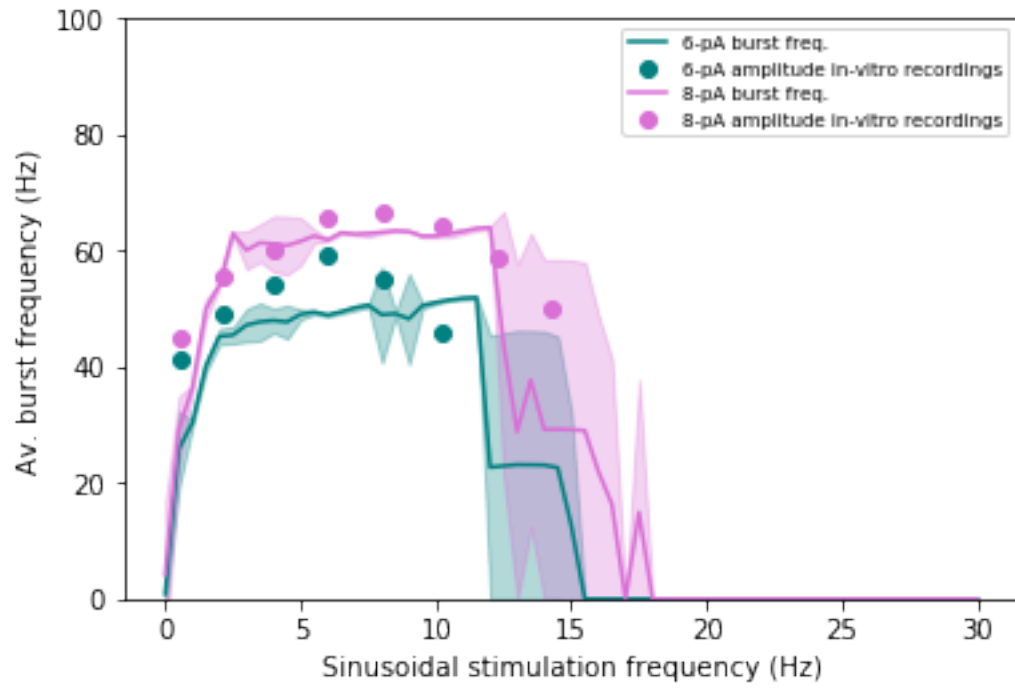
Parameter configuration:

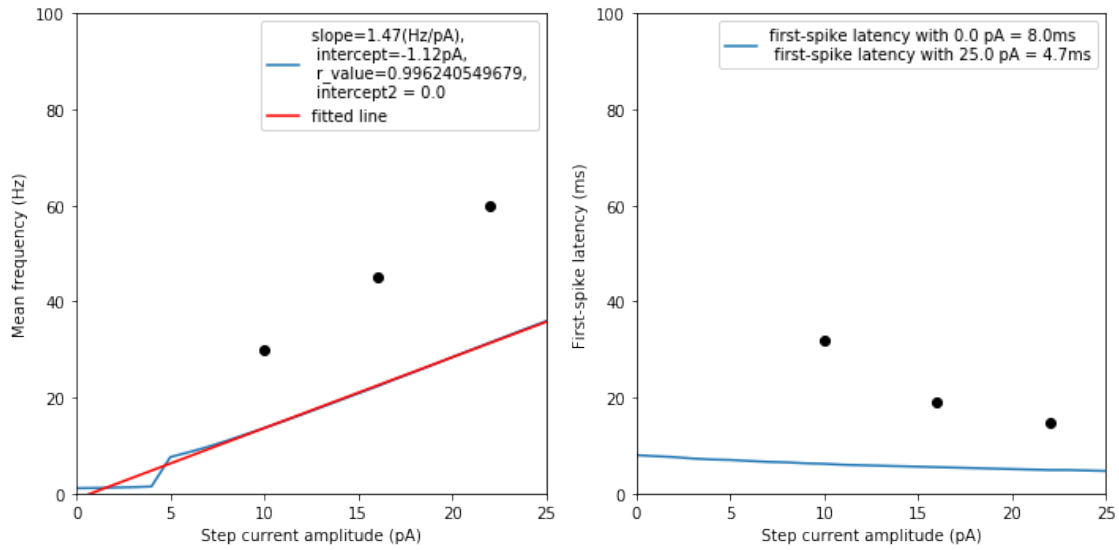
```
{
  'a': 9.812224056206048e-10,
  'b': 7.255410677251826e-10,
  'cm': 4.22420187642868e-12,
  'delta_t': 0.37001015651526387,
  'erest': -0.06646609510591613,
  'espike': -0.015273236427083574,
  'eth': -0.037669612932198844,
  'grest': 7.959738398683855e-11,
  'tref': 0.001,
  'tw': 0.6786891172024856,
  'vreset': -0.0554783132547836}
```

Feature and total score:

```
{
  'feature_Burst_Frequency': 133.50467670548284,
  'feature_Latency': 48.949999999999996,
  'feature_Mean_Frequency': 45.0,
  'total_score_obtained_in_UEGO': 227.454677}
```

NEURON 12





NEURON 13

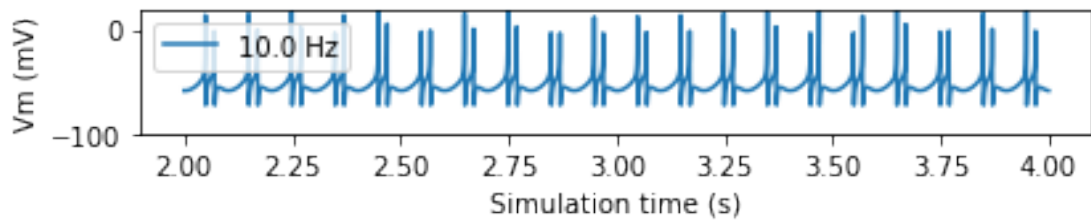
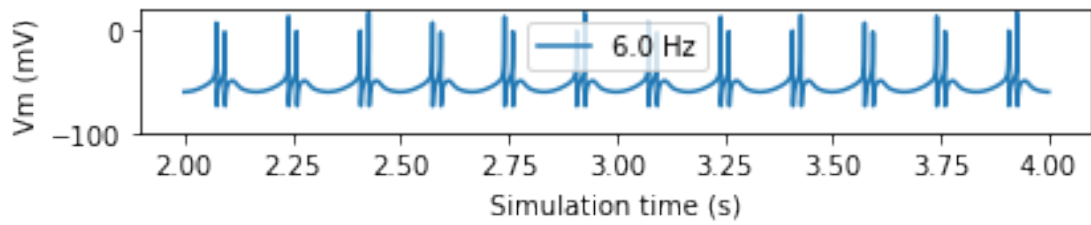
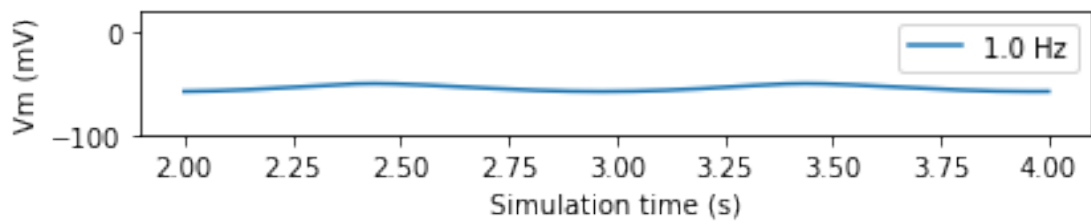
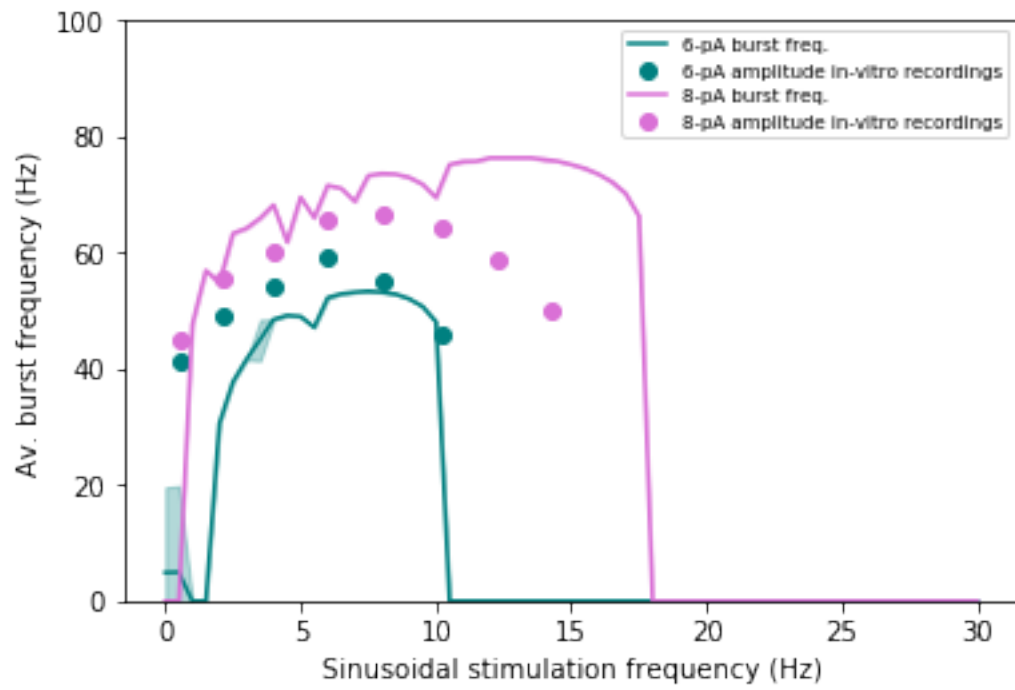
Parameter configuration:

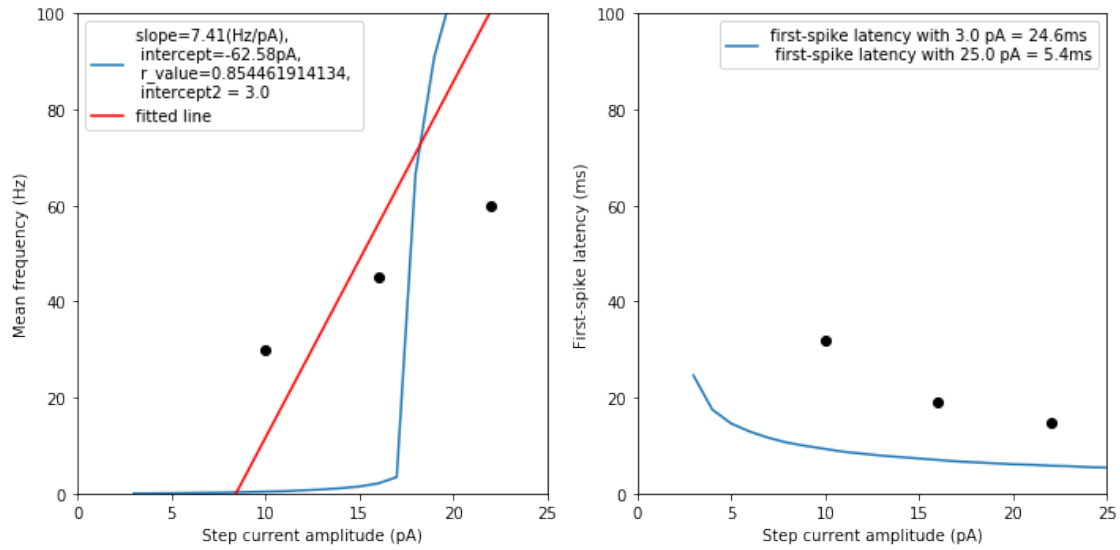
```
{
  'a': 9.889688743691697e-10,
  'b': -8.49723375315887e-10,
  'cm': 3.547954455744094e-12,
  'delta_t': 0.02169950481491026,
  'erest': -0.07049273829775649,
  'espike': 0.019949282308608794,
  'eth': -0.048882541535440895,
  'grest': 4.132581341066913e-09,
  'tref': 0.001,
  'tw': 0.11592427598971587,
  'vreset': -0.07251377172246015}
```

Feature and total score:

```
{
  'feature_Burst_Frequency': 192.8458924485085,
  'feature_Latency': 43.449999999999996,
  'feature_Mean_Frequency': 96.0,
  'total_score_obtained_in_UEGO': 332.295892}
```

NEURON 13





NEURON 14

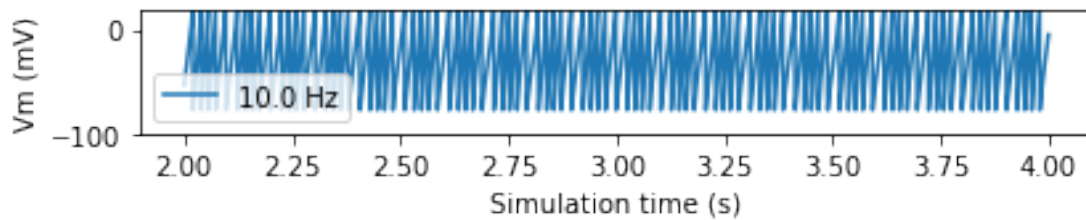
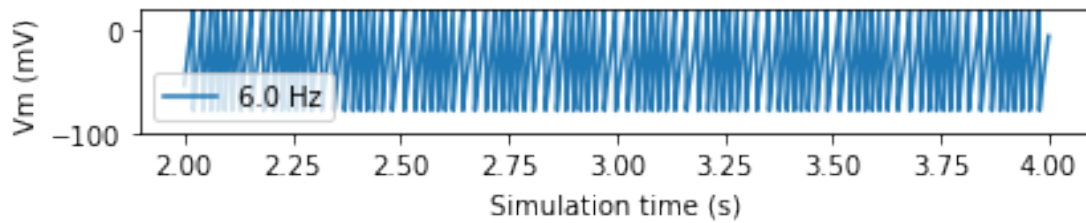
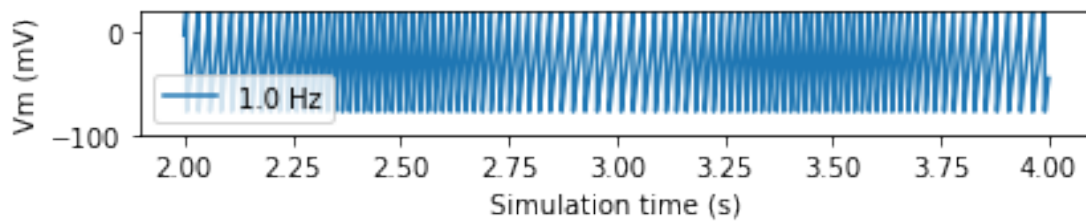
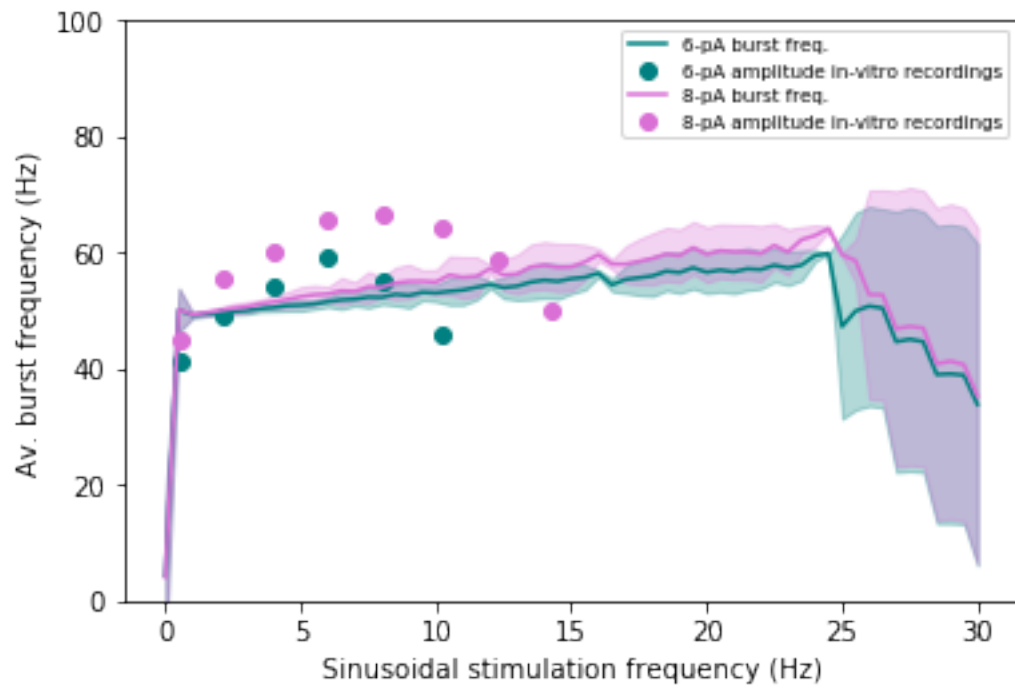
Parameter configuration:

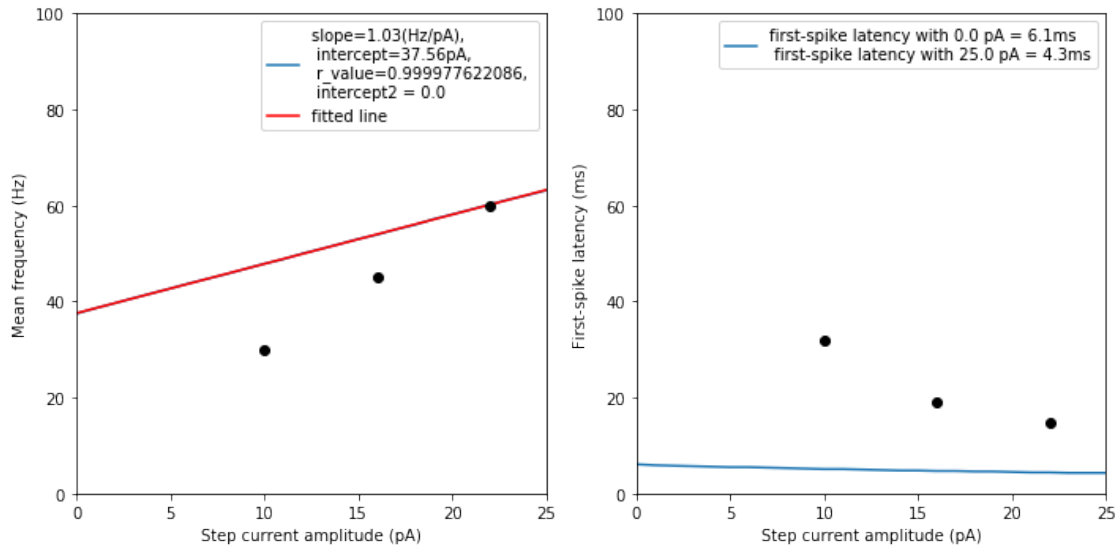
```
{
  'a': 5.595716316833177e-10,
  'b': 7.530436496105926e-10,
  'cm': 4.0202880544766265e-12,
  'delta_t': 0.08501811048329797,
  'erest': -0.04381950271502837,
  'espike': 0.019999937608638853,
  'eth': -0.02996383659692586,
  'grest': 5.677049777311429e-10,
  'tref': 0.001,
  'tw': 0.7660048292381835,
  'vreset': -0.07714398784789002}
```

Feature and total score:

```
{
  'feature_Burst_Frequency': 193.34978886170722,
  'feature_Latency': 51.349999999999994,
  'feature_Mean_Frequency': 102.0,
  'total_score_obtained_in_UEGO': 346.699789}
```

NEURON 14





NEURON 15

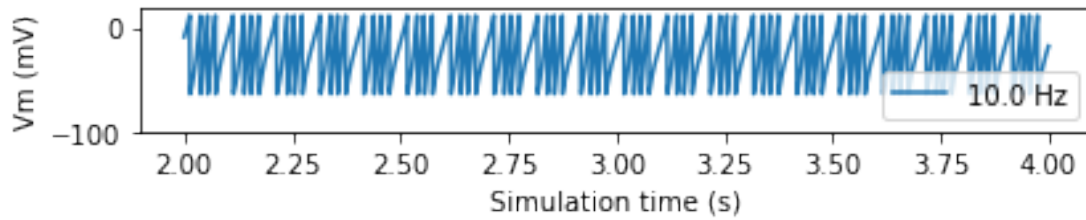
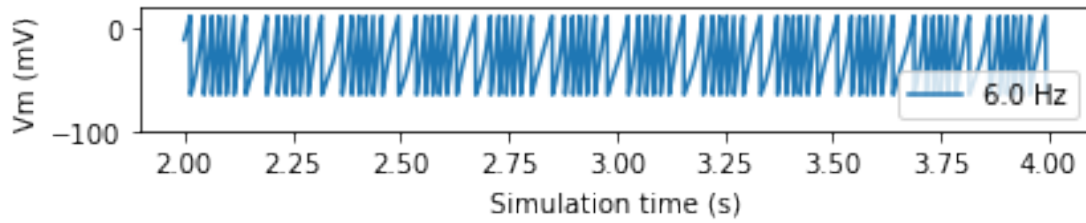
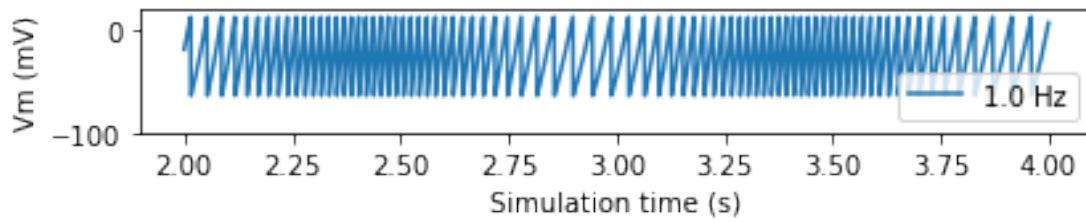
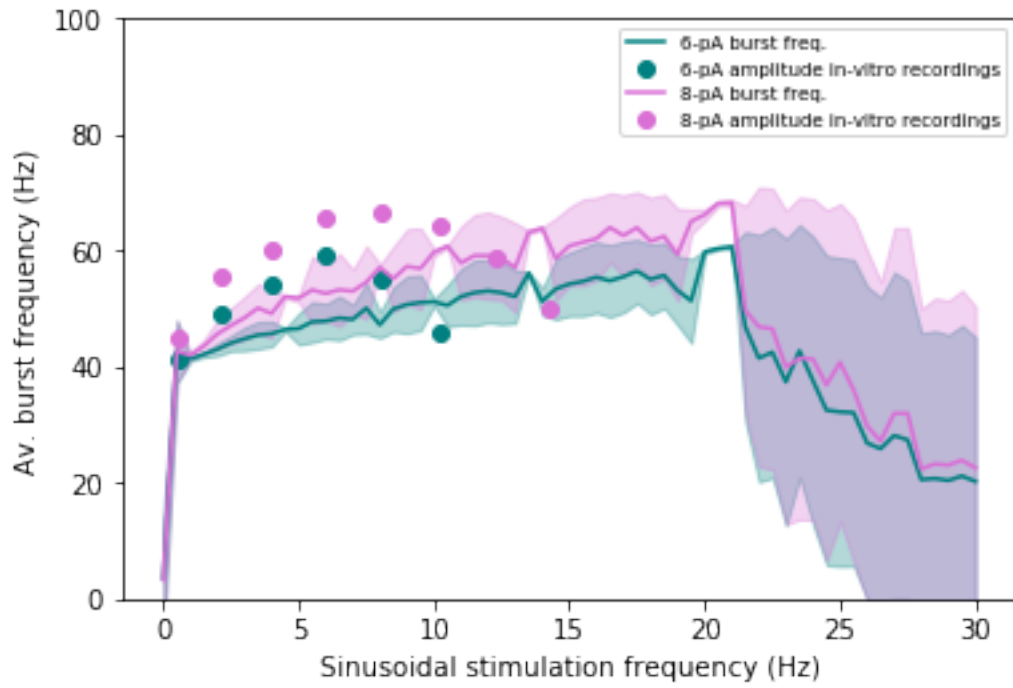
Parameter configuration:

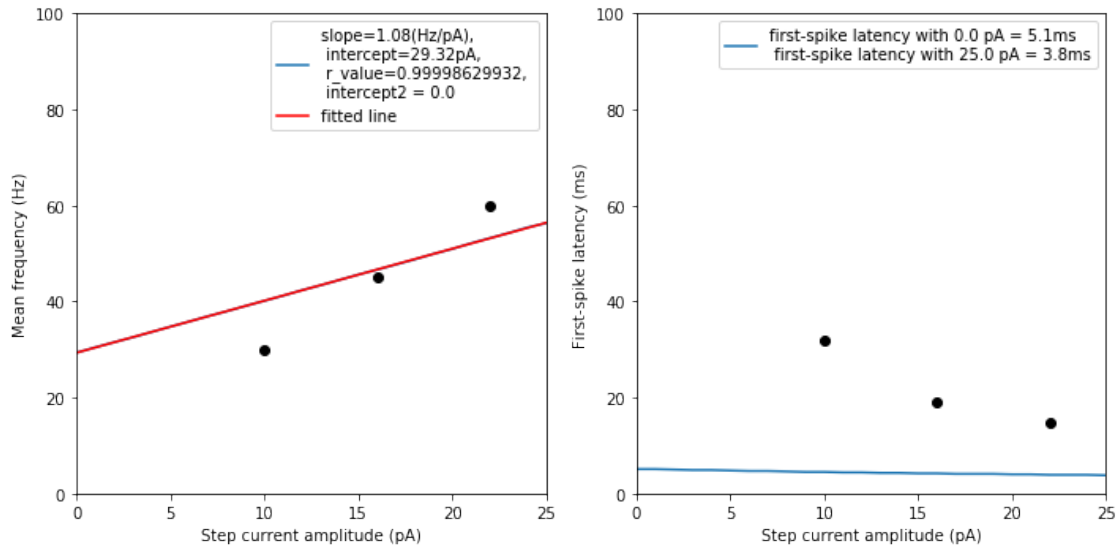
```
{
  'a': 5.878940062986193e-10,
  'b': 9.94684545373047e-10,
  'cm': 3.1241268027322132e-12,
  'delta_t': 0.3960309043804251,
  'erest': -0.07132677304337474,
  'espike': 0.01171975787007554,
  'eth': -0.05999985936707369,
  'grest': 1.319462796672471e-10,
  'tref': 0.001,
  'tw': 0.6909744127065662,
  'vreset': -0.06372876184439545}
```

Feature and total score:

```
{
  'feature_Burst_Frequency': 185.5614013032503,
  'feature_Latency': 52.949999999999996,
  'feature_Mean_Frequency': 119.0,
  'total_score_obtained_in_UEGO': 357.511401}
```

NEURON 15





NEURON 16

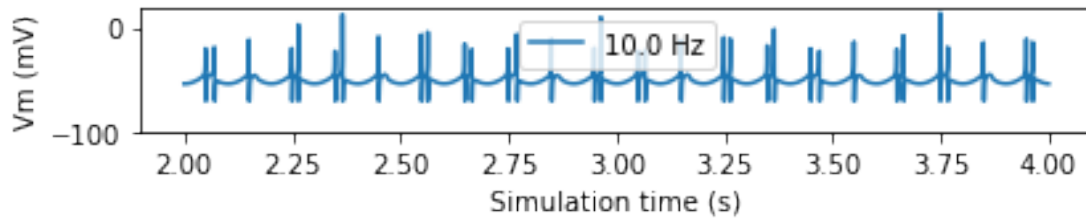
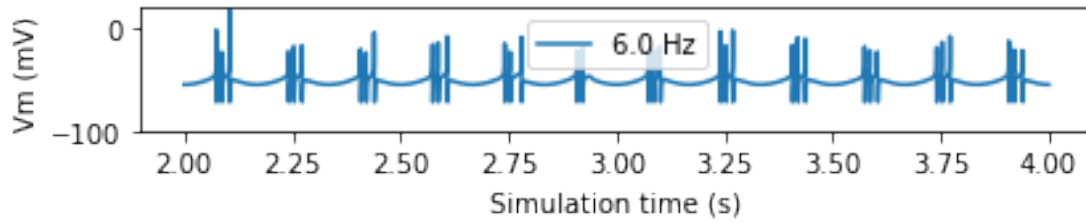
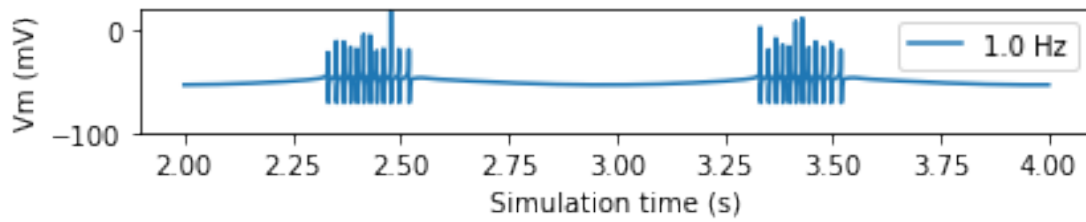
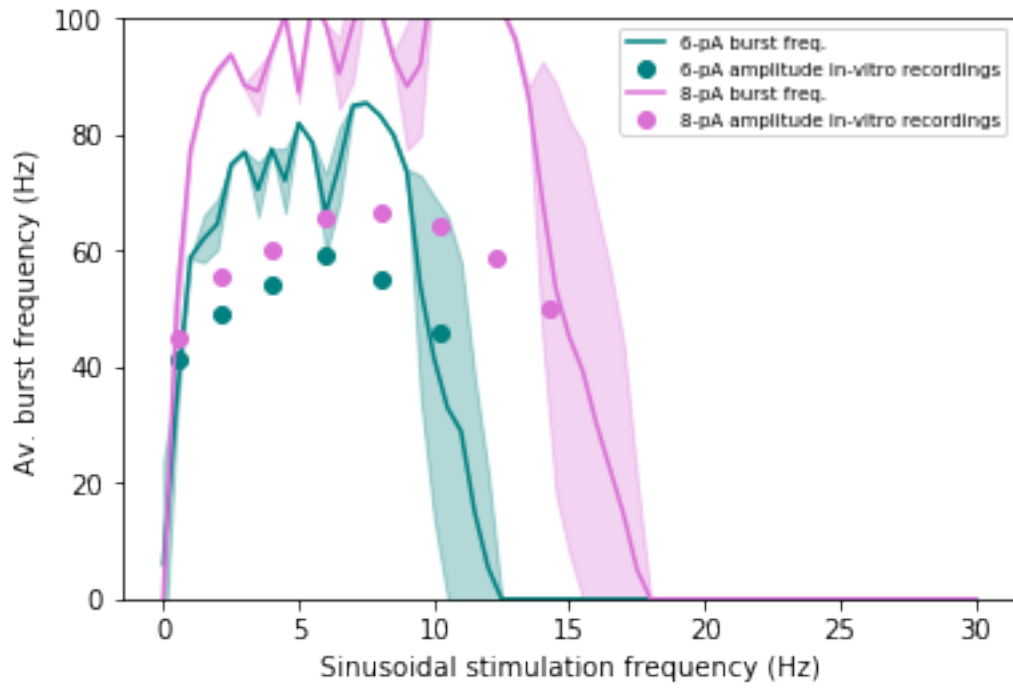
Parameter configuration:

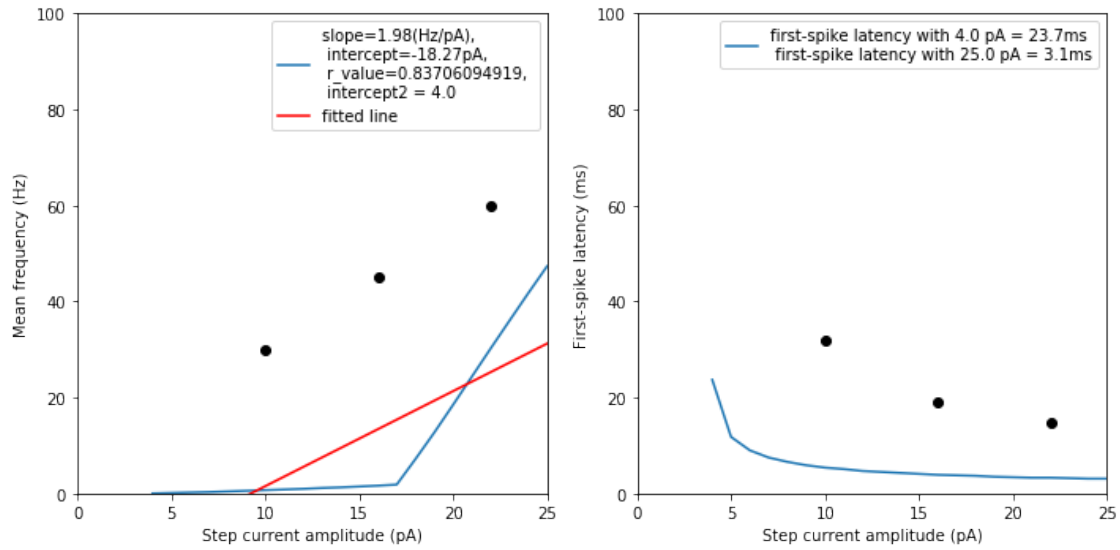
```
{
  'a': 9.860355688113379e-10,
  'b': 3.0336712773149645e-10,
  'cm': 2.3339168870062802e-12,
  'delta_t': 0.013871998788304047,
  'erest': -0.061014192859422986,
  'espike': 0.01942086476492474,
  'eth': -0.04659754742293269,
  'grest': 6.199650975879663e-09,
  'tref': 0.001,
  'tw': 0.6201436168158879,
  'vreset': -0.07059046343534763}
```

Feature and total score:

```
{
  'feature_Burst_Frequency': 511.9034821234357,
  'feature_Latency': 52.949999999999996,
  'feature_Mean_Frequency': 43.0,
  'total_score_obtained_in_UEGO': 607.853482}
```

NEURON 16





NEURON 17

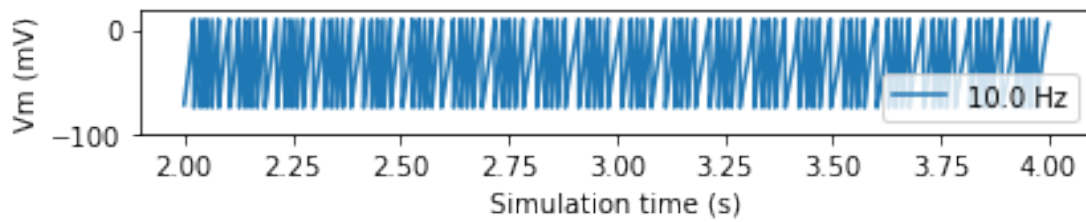
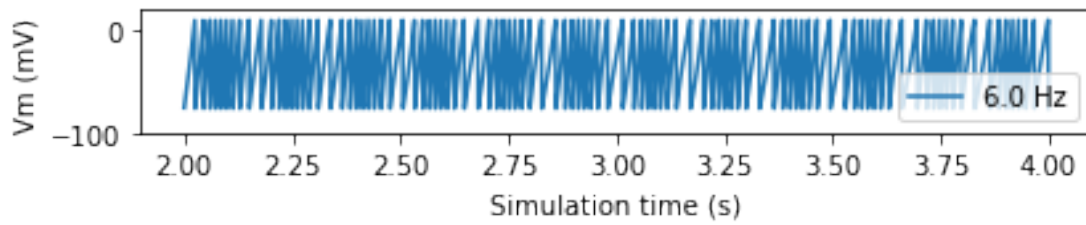
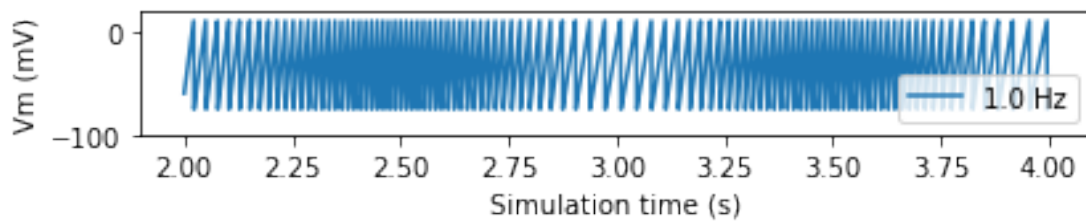
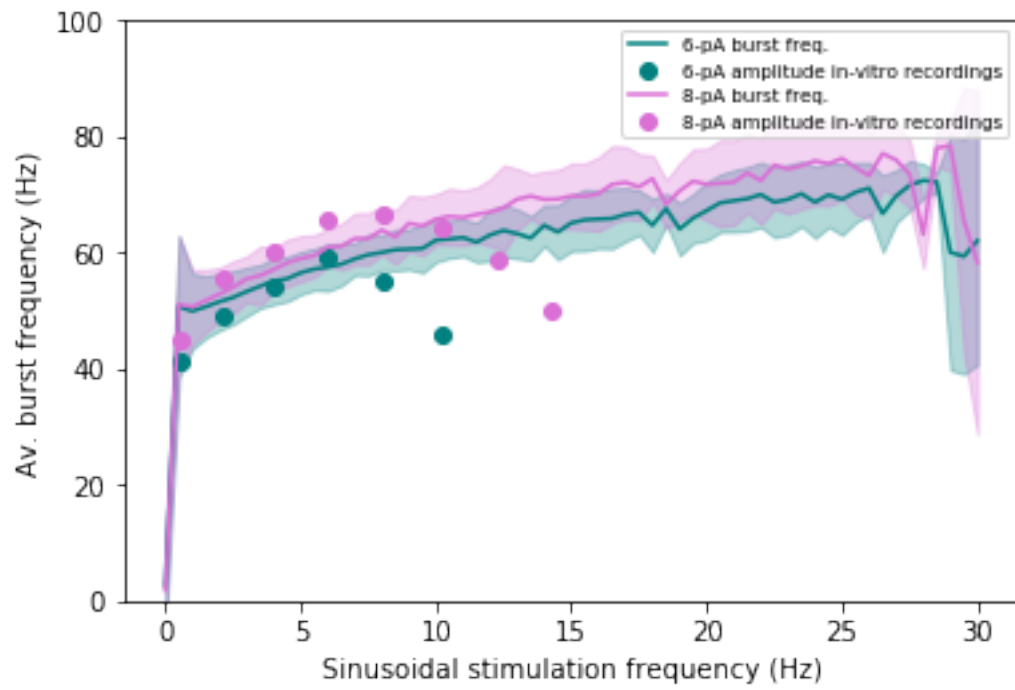
Parameter configuration:

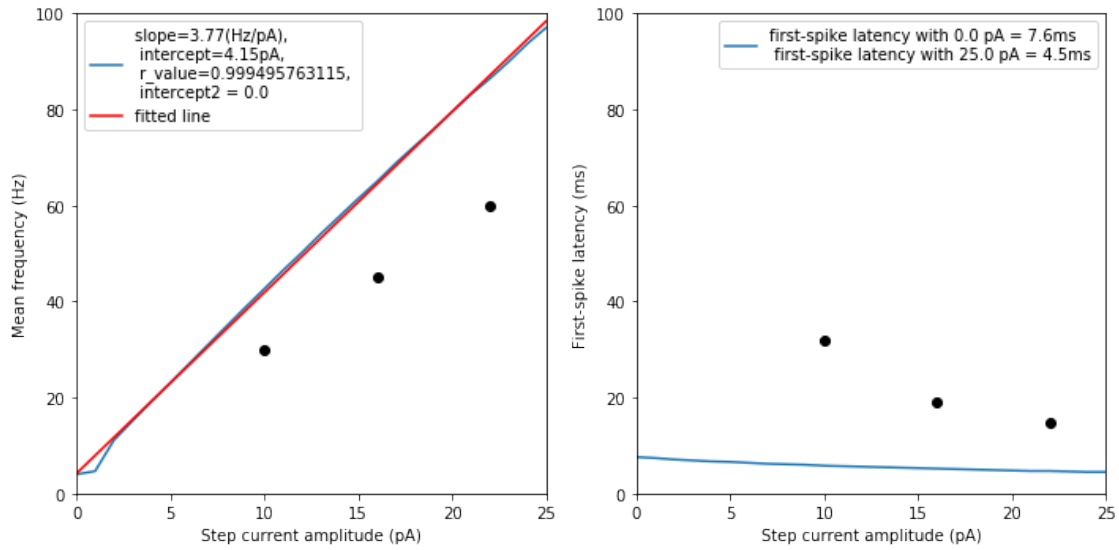
```
{
  'a': 9.505751807053072e-10,
  'b': 3.971891857487626e-11,
  'cm': 2.8075370896596384e-12,
  'delta_t': 0.5629660662093825,
  'erest': -0.06101563163581637,
  'espike': 0.009851227657297845,
  'eth': -0.04115166536536517,
  'grest': 4.867271269730346e-11,
  'tref': 0.001,
  'tw': 0.971471731551307,
  'vreset': -0.07499062669227913}
```

Feature and total score:

```
{
  'feature_Burst_Frequency': 341.9484031586796,
  'feature_Latency': 49.85,
  'feature_Mean_Frequency': 218.0,
  'total_score_obtained_in_UEGO': 609.798403}
```

NEURON 17





NEURON 18

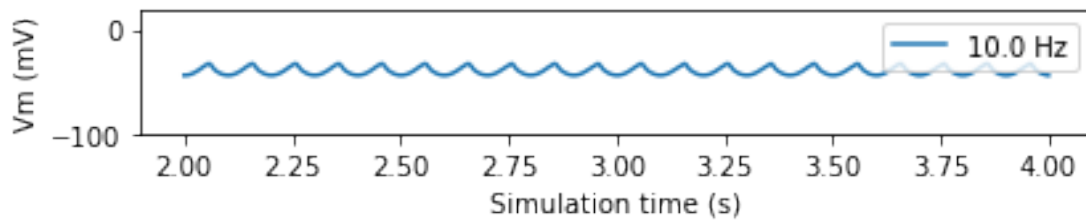
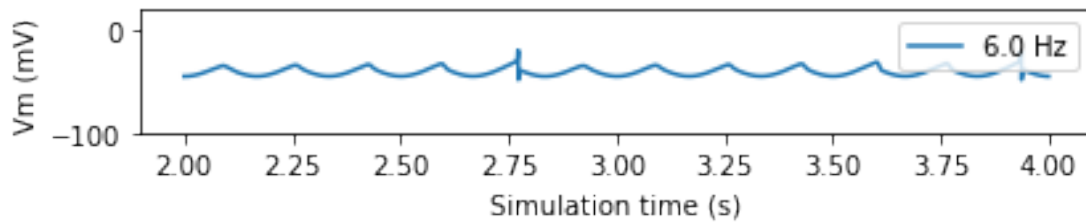
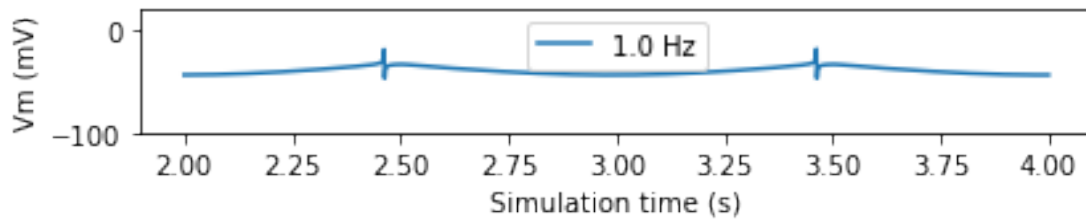
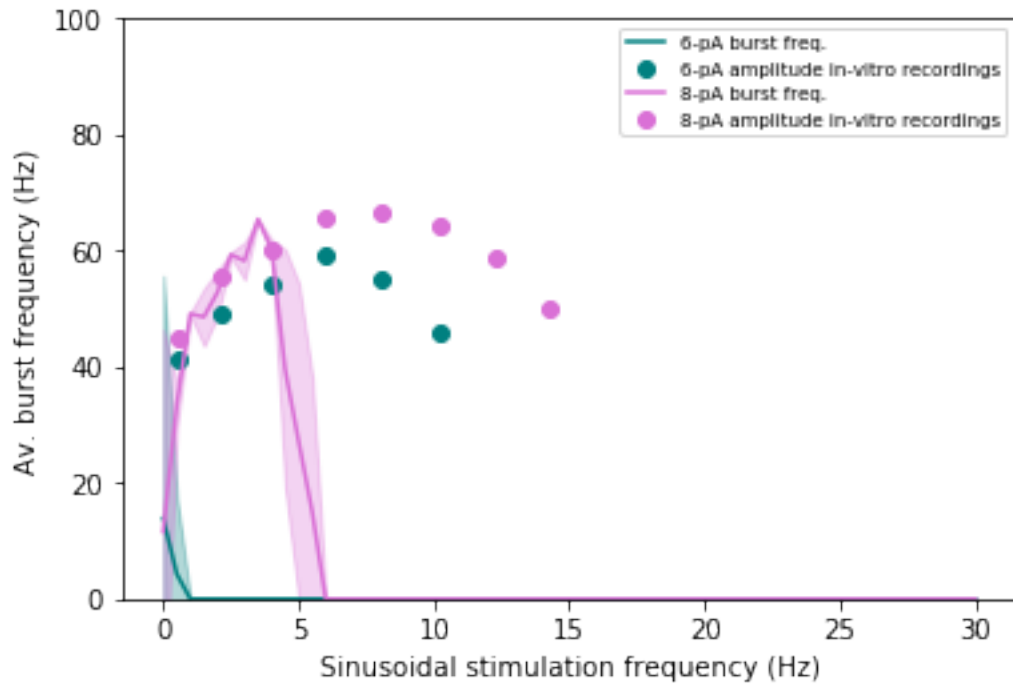
Parameter configuration:

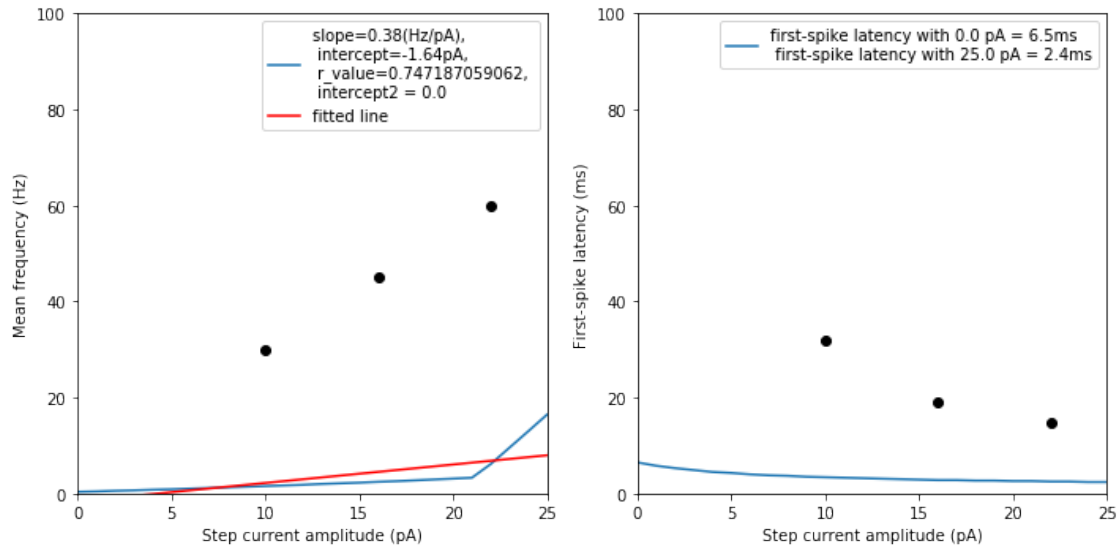
```
{  'a': 6.713584456324034e-10,
    'b': 3.0480561419704576e-10,
    'cm': 1.74375010030707e-12,
    'delta_t': 0.039643009073479944,
    'erest': -0.07265284731514911,
    'espike': -0.018540426235013507,
    'eth': -0.033507278800319035,
    'grest': 9.061634481017134e-09,
    'tref': 0.001,
    'tw': 0.9240245639354042,
    'vreset': -0.047297986876928516}
```

Feature and total score:

```
{  'feature_Burst_Frequency': 624.8169131896159,
    'feature_Latency': 56.849999999999994,
    'feature_Mean_Frequency': 34.0,
    'total_score_obtained_in_UEGO': 715.666913}
```

NEURON 18





NEURON 19

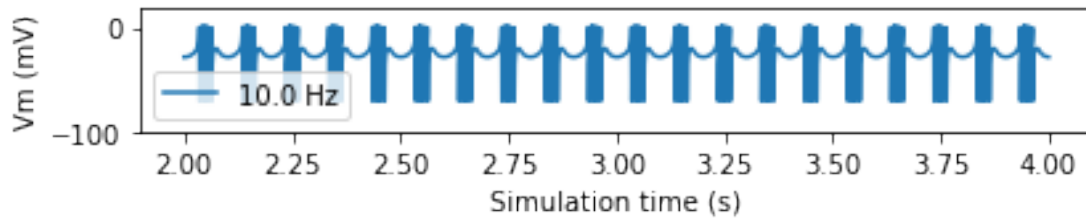
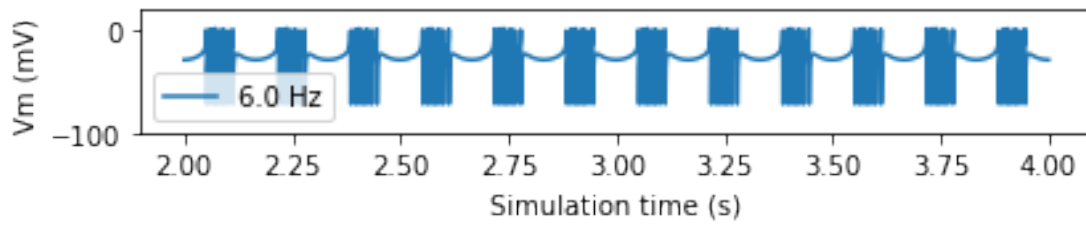
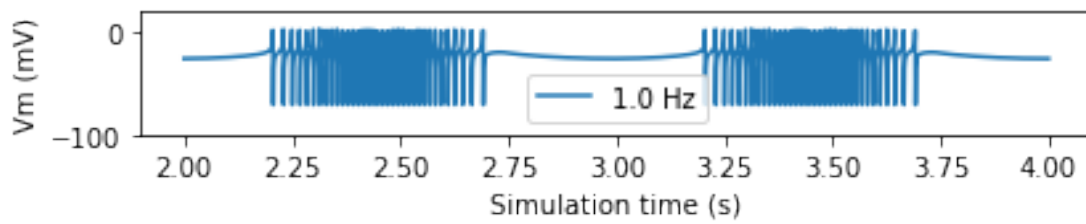
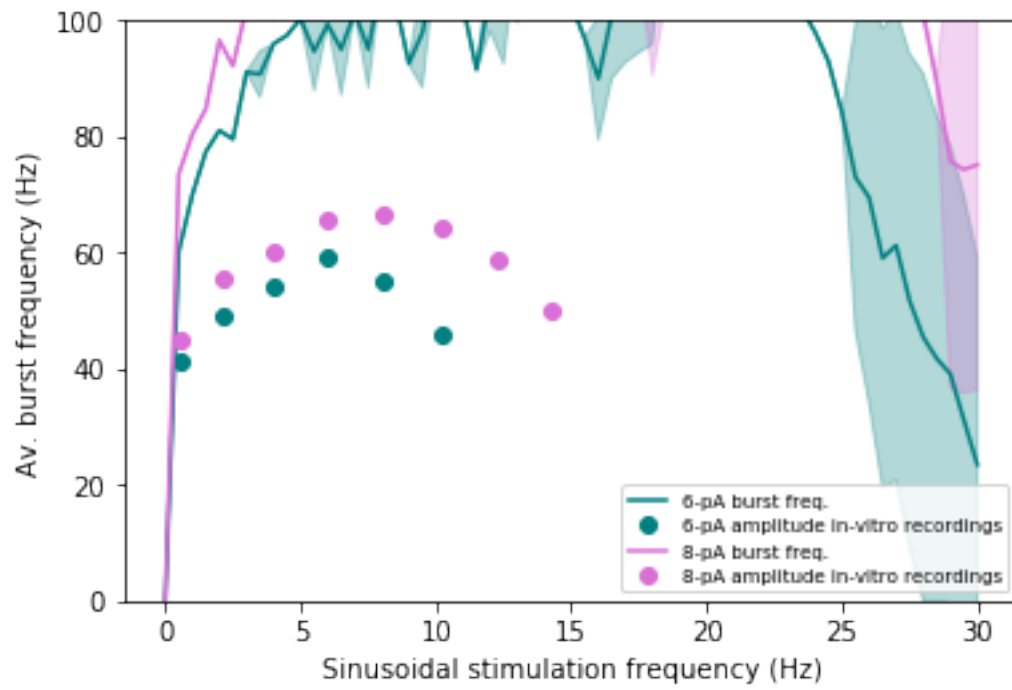
Parameter configuration:

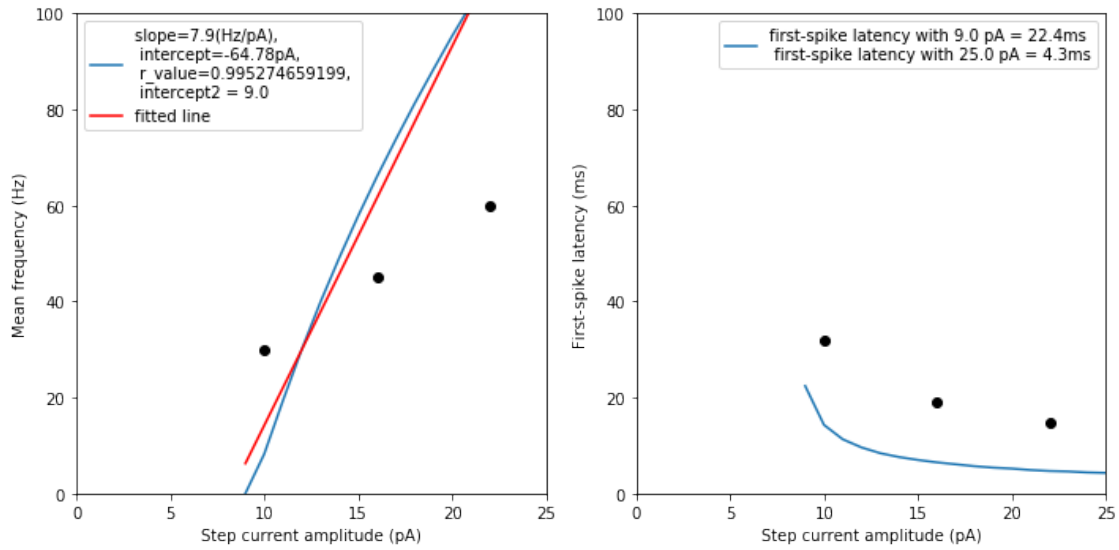
```
{  'a': 2.960400903259269e-11,
    'b': 6.804184815124409e-10,
    'cm': 2.0126803093305832e-12,
    'delta_t': 0.04733263323262459,
    'erest': -0.06826857122416598,
    'espike': 0.0021434279956355287,
    'eth': -0.020021268702600417,
    'grest': 8.851979848712472e-09,
    'tref': 0.001,
    'tw': 0.10895237092613652,
    'vreset': -0.07069401821995801}
```

Feature and total score:

```
{  'feature_Burst_Frequency': 660.4720936512716,
    'feature_Latency': 40.05,
    'feature_Mean_Frequency': 98.0,
    'total_score_obtained_in_UEGO': 798.522094}
```

NEURON 19





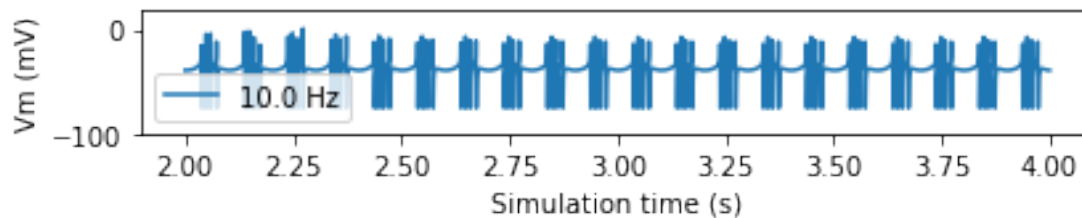
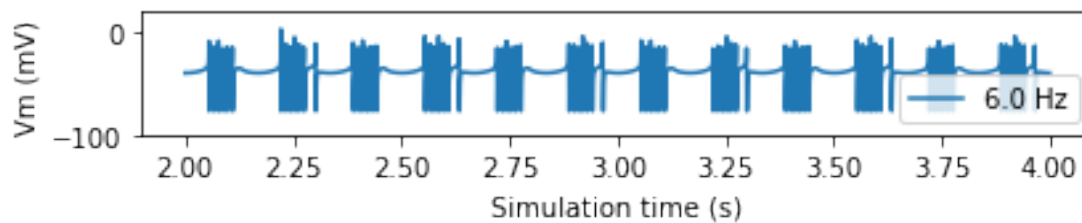
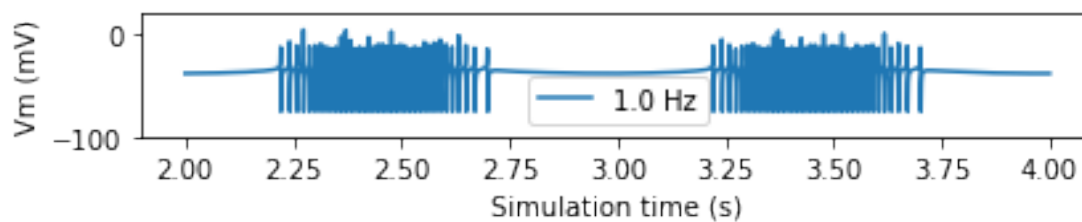
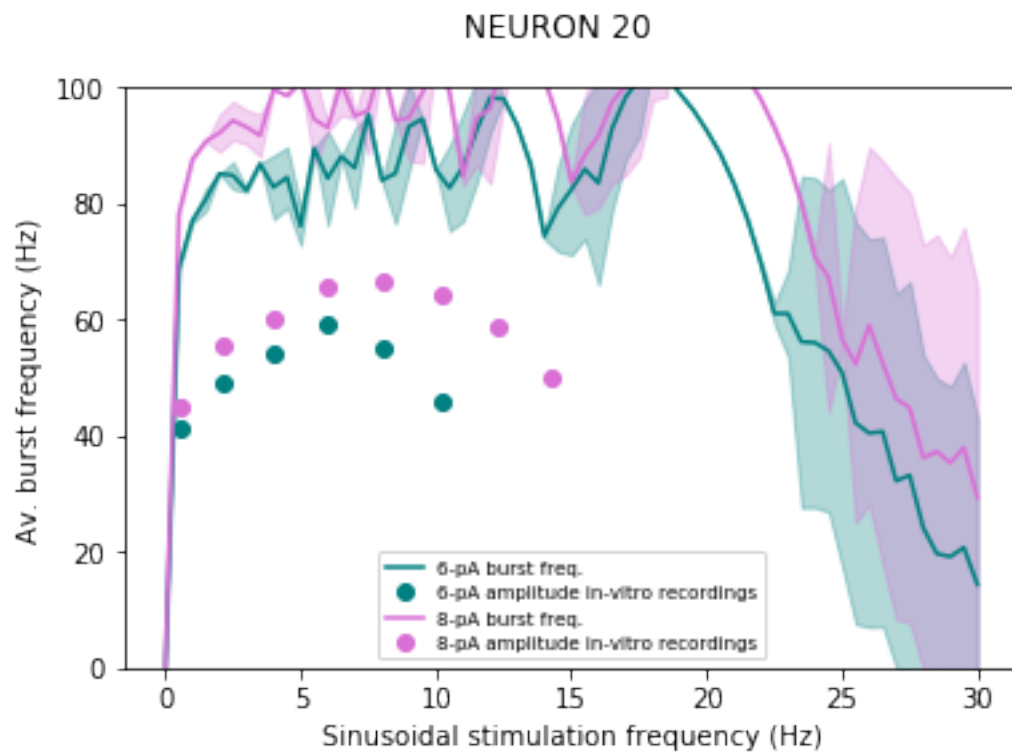
NEURON 20

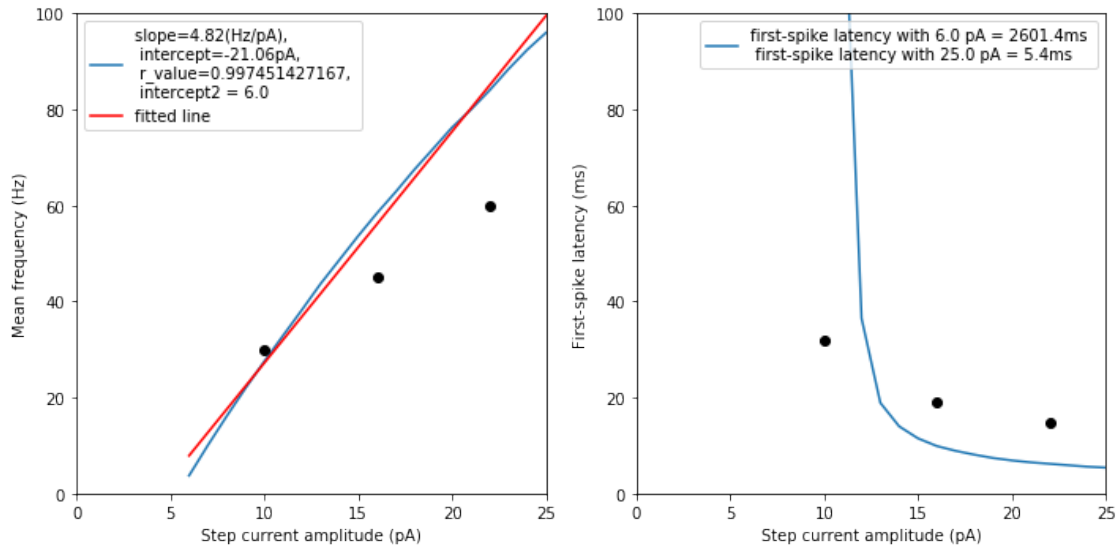
Parameter configuration:

```
{
  'a': -5.85614360229604e-10,
  'b': 1.8484057486651986e-10,
  'cm': 4.378754234065261e-12,
  'delta_t': 0.00964210498279568,
  'erest': -0.04602544097397198,
  'espike': 0.003970587853158493,
  'eth': -0.034747813310158165,
  'grest': 7.222435391086991e-09,
  'tref': 0.001,
  'tw': 0.6149407916714055,
  'vreset': -0.0753700003069744}
```

Feature and total score:

```
{
  'feature_Burst_Frequency': 1269.446279207915,
  'feature_Latency': 264.15000000000003,
  'feature_Mean_Frequency': 66.0,
  'total_score_obtained_in_UEGO': 1599.596279}
```





NEURON 21

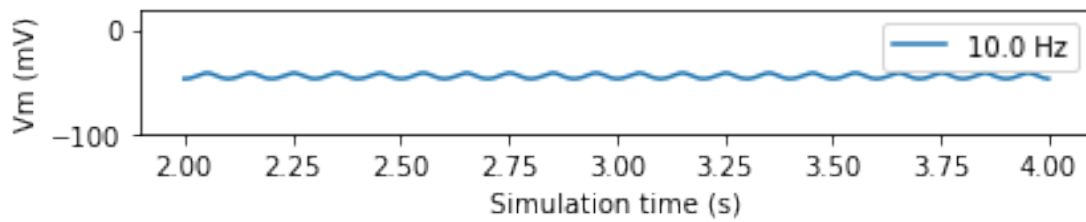
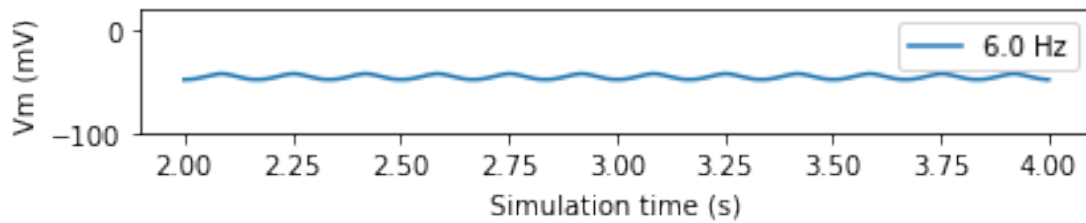
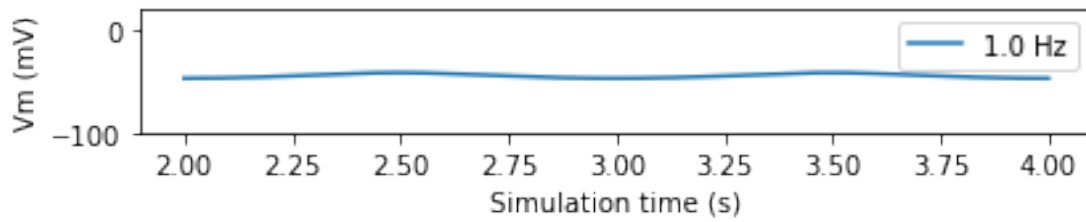
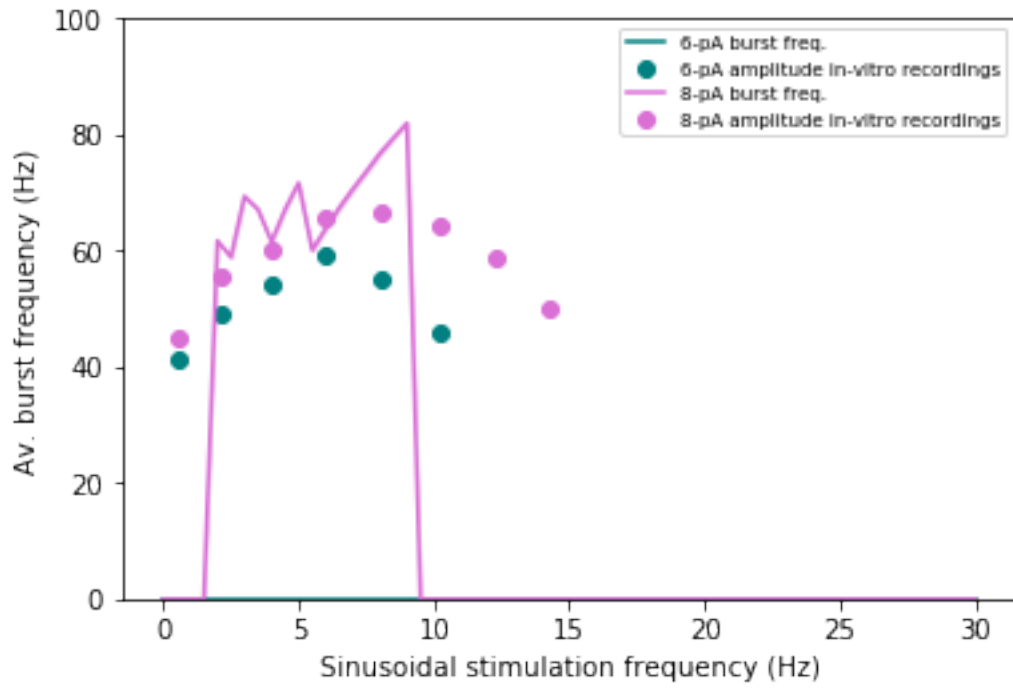
Parameter configuration:

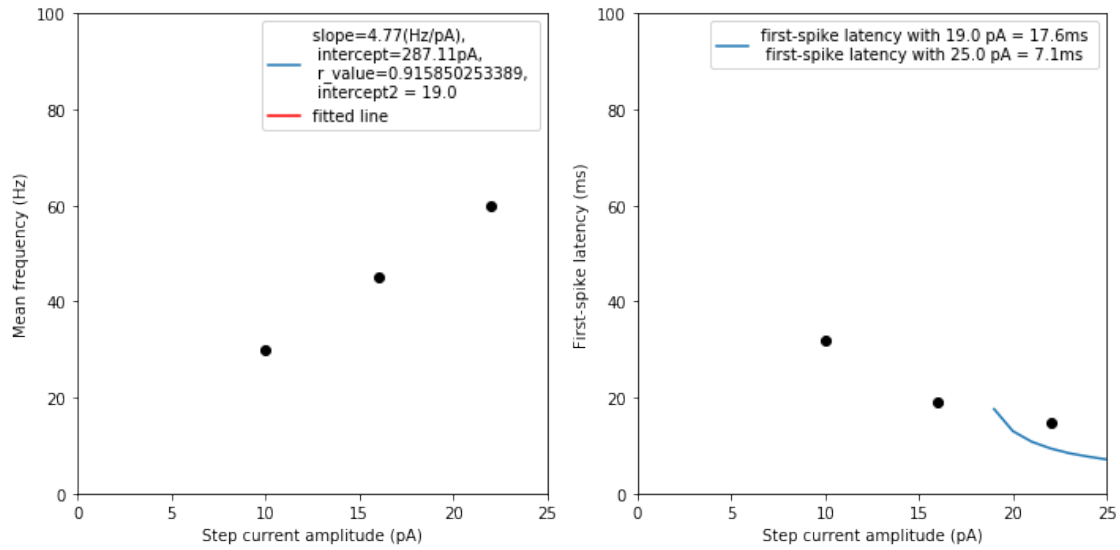
```
{  'a': 2.1683424223041087e-10,
  'b': -7.07969251466221e-10,
  'cm': 3.1064107343183466e-12,
  'delta_t': 0.015101391431213803,
  'erest': -0.05626285237579564,
  'espike': -0.005904643735903966,
  'eth': -0.038468750937949096,
  'grest': 6.531375716592925e-09,
  'tref': 0.001,
  'tw': 0.28196827790206413,
  'vreset': -0.0670494412016734}
```

Feature and total score:

```
{  'feature_Burst_Frequency': 537.2011166436093,
  'feature_Latency': 1954.35,
  'feature_Mean_Frequency': 292.0,
  'total_score_obtained_in_UEGO': 2783.551117}
```

NEURON 21





NEURON 22

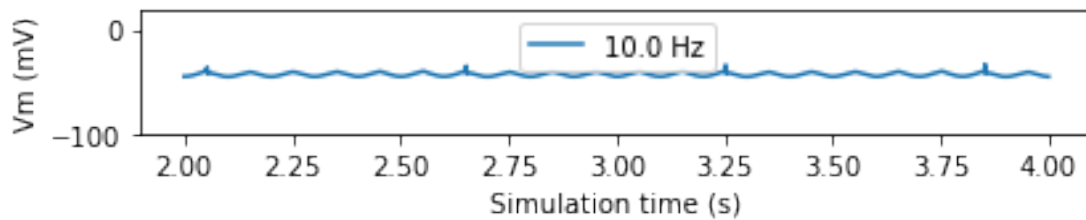
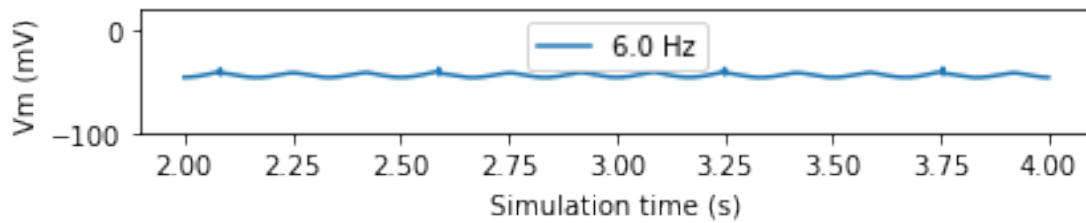
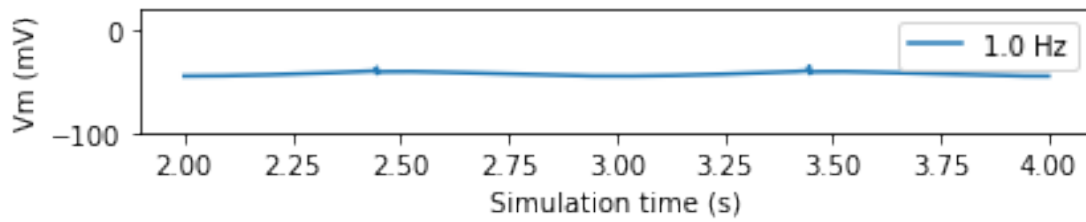
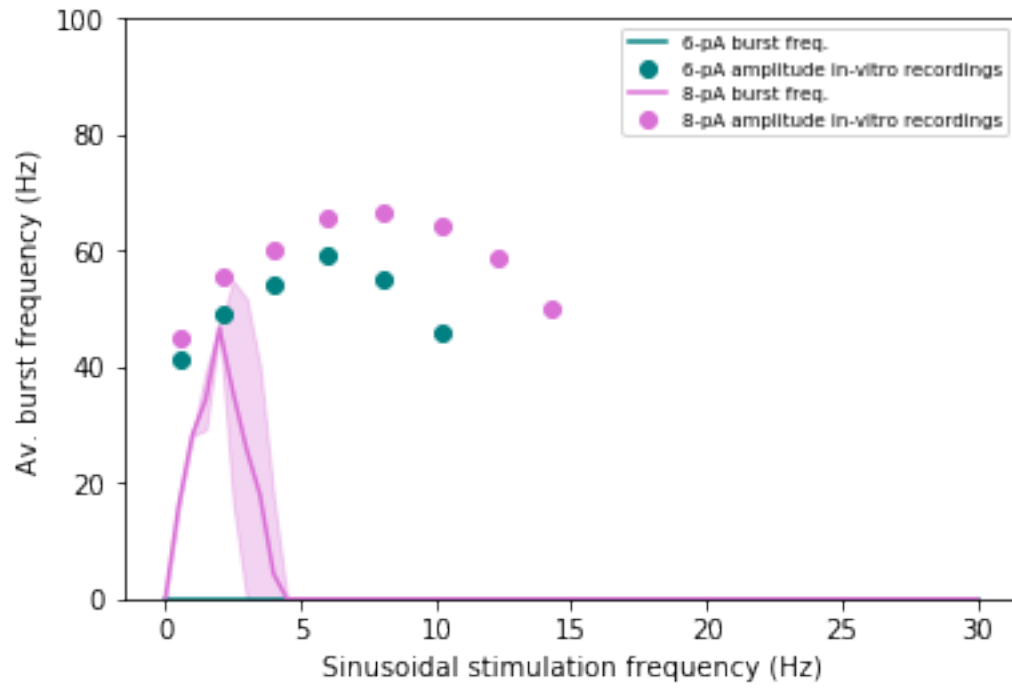
Parameter configuration:

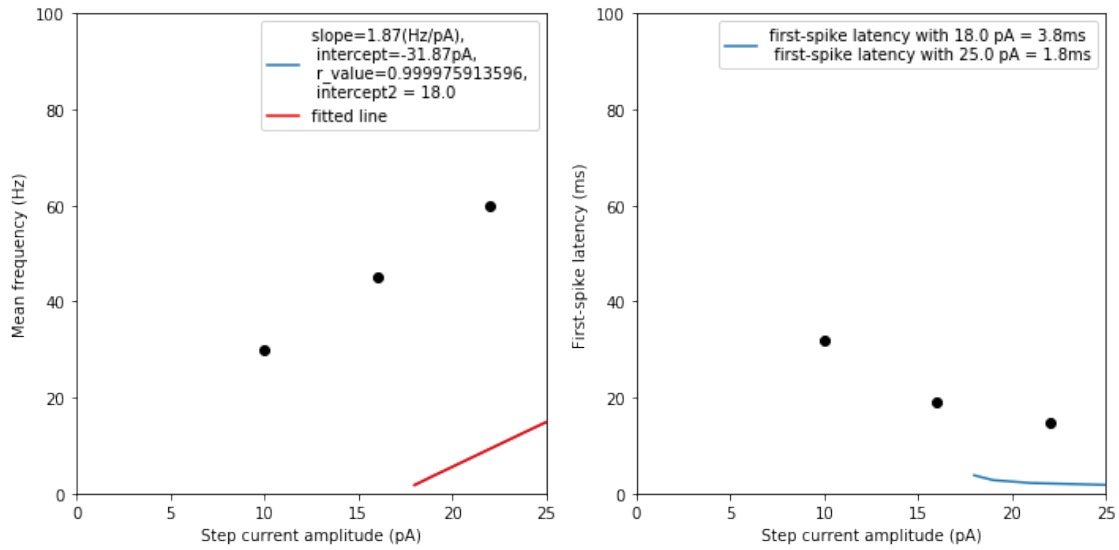
```
{
  'a': 4.9046612393234875e-11,
  'b': 9.513460392844031e-10,
  'cm': 7.798556320837359e-13,
  'delta_t': 0.0022117037703909756,
  'erest': -0.04668960119304483,
  'espike': -0.006619982497055841,
  'eth': -0.04004789787858831,
  'grest': 3.872986401566292e-09,
  'tref': 0.001,
  'tw': 0.5734796538404362,
  'vreset': -0.04257677748924182}
```

Feature and total score:

```
{
  'feature_Burst_Frequency': 710.1189637945221,
  'feature_Latency': 1961.6499999999999,
  'feature_Mean_Frequency': 121.0,
  'total_score_obtained_in_UEGO': 2792.768964}
```

NEURON 22





NEURON 23

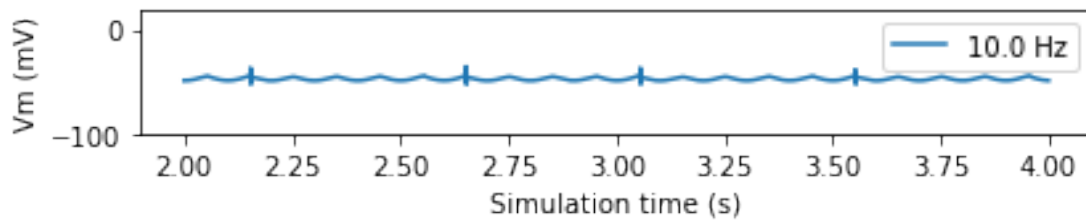
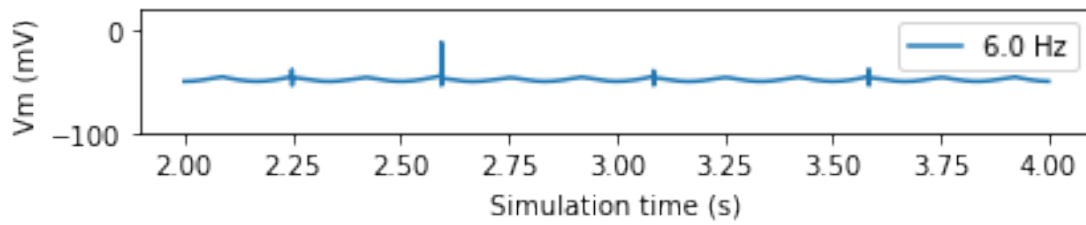
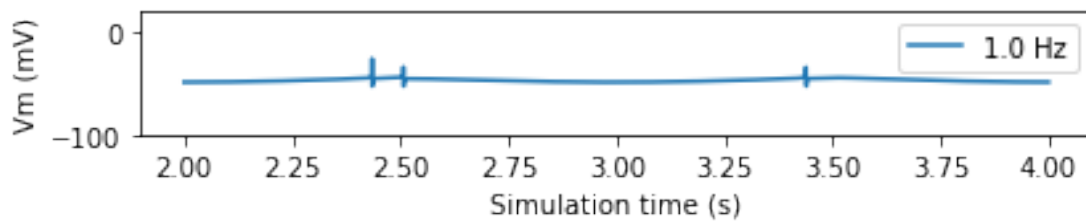
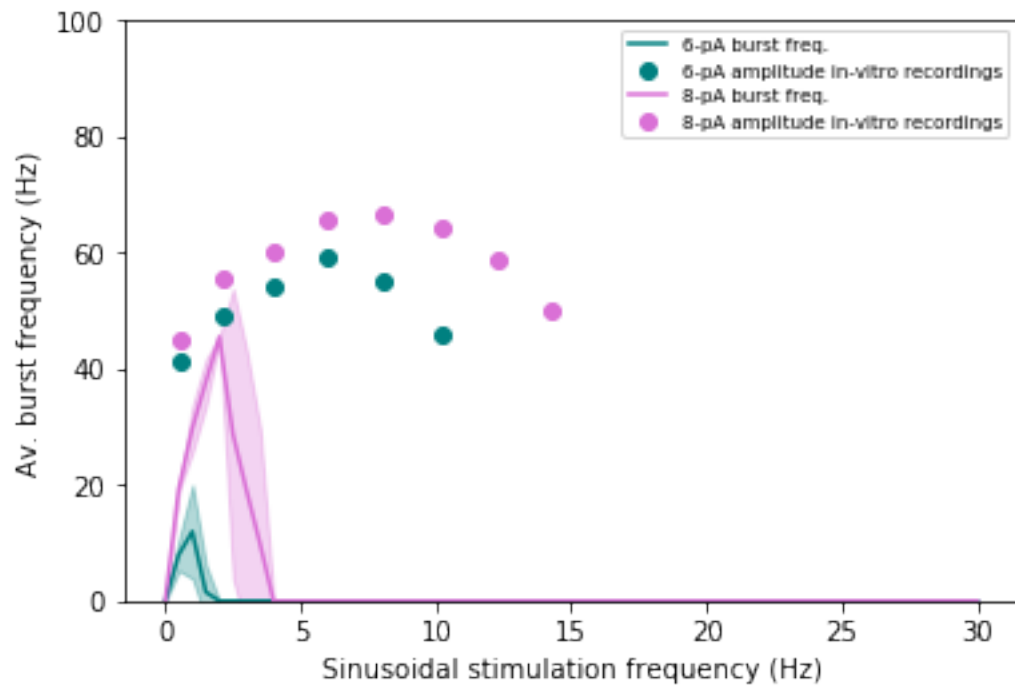
Parameter configuration:

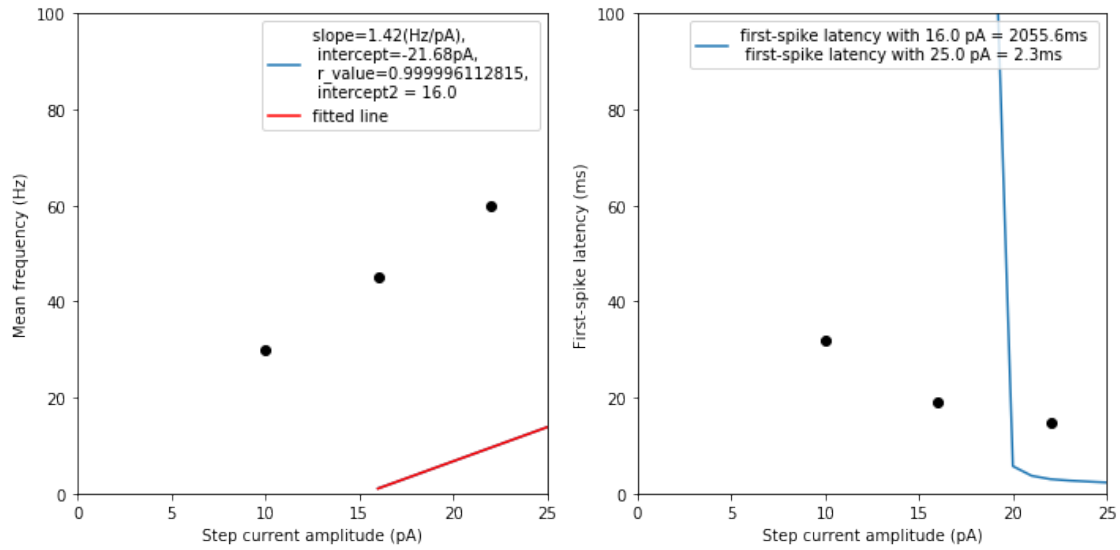
```
{
  'a': -5.069561839431242e-10,
  'b': 8.467243651967009e-10,
  'cm': 9.878558073208283e-13,
  'delta_t': 0.006499343822483023,
  'erest': -0.05309826614469508,
  'espike': 0.01868003525419652,
  'eth': -0.04464965999460547,
  'grest': 9.994592124769459e-09,
  'tref': 0.001,
  'tw': 0.8528247719086086,
  'vreset': -0.05268694156229488}
```

Feature and total score:

```
{
  'feature_Burst_Frequency': 723.1150217163542,
  'feature_Latency': 1960.75,
  'feature_Mean_Frequency': 122.0,
  'total_score_obtained_in_UEGO': 2805.865022}
```

NEURON 23





NEURON 24

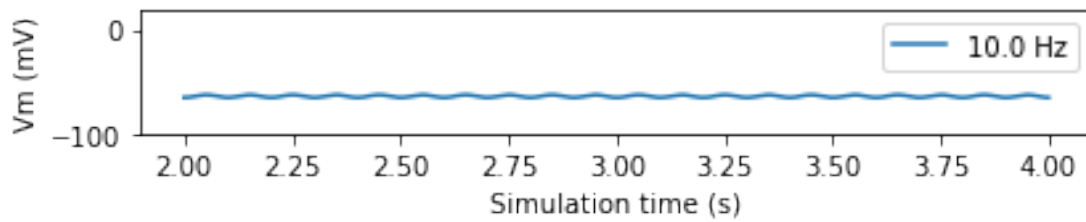
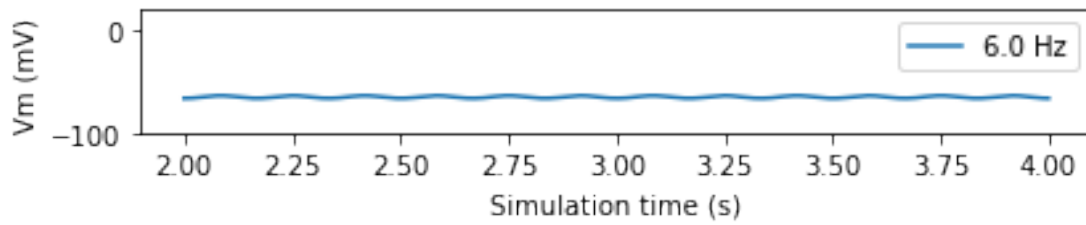
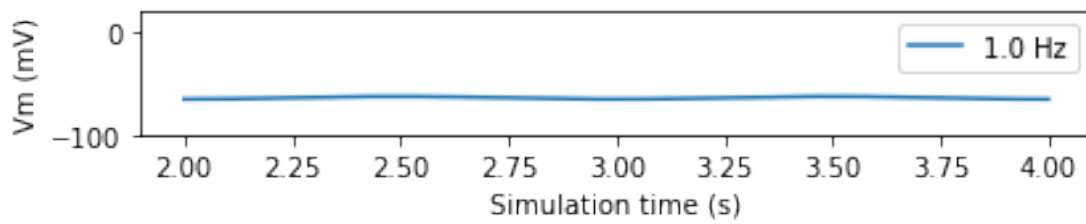
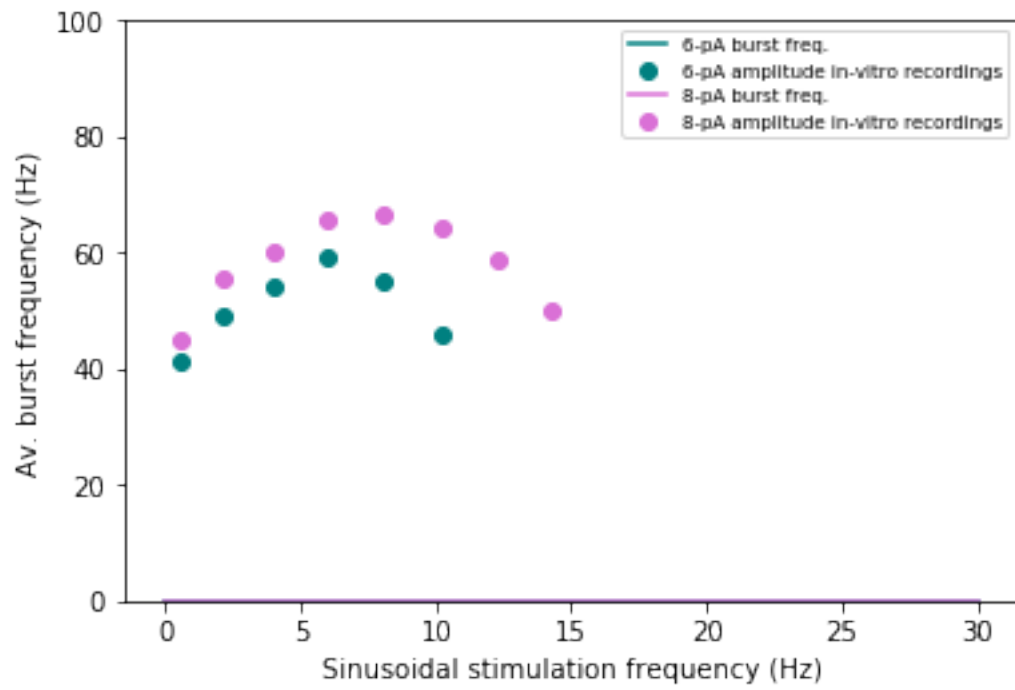
Parameter configuration:

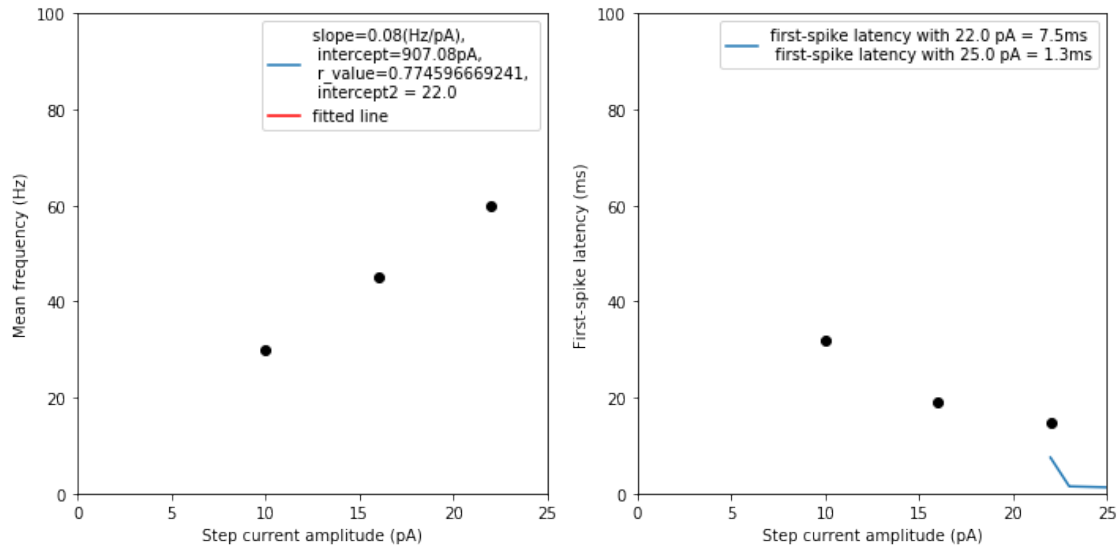
```
{
  'a': 8.885888305533453e-10,
  'b': -9.877017450489092e-10,
  'cm': 1.3306214228976113e-13,
  'delta_t': 0.0024958406234318175,
  'erest': -0.0663265017272475,
  'espike': -0.011841426312105888,
  'eth': -0.05999152989317109,
  'grest': 5.72336366454014e-09,
  'tref': 0.001,
  'tw': 0.5506061985207004,
  'vreset': -0.05970566749924521}
```

Feature and total score:

```
{
  'feature_Burst_Frequency': 770.43,
  'feature_Latency': 1956.25,
  'feature_Mean_Frequency': 918.0,
  'total_score_obtained_in_UEGO': 3644.68}
```

NEURON 24





NEURON 25

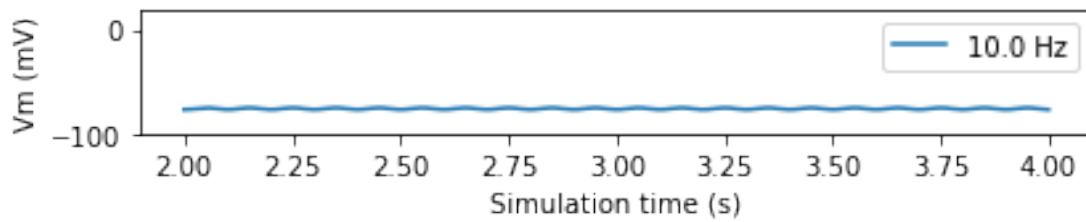
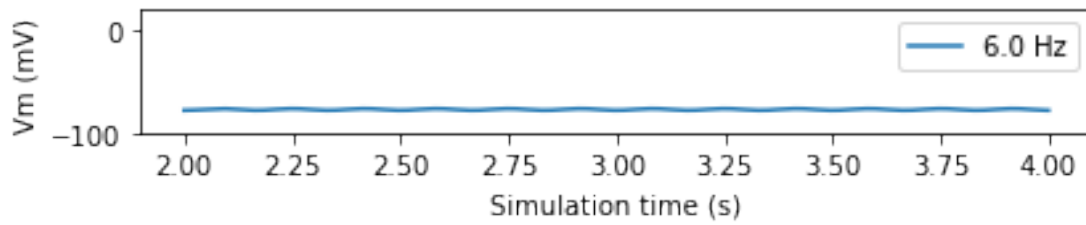
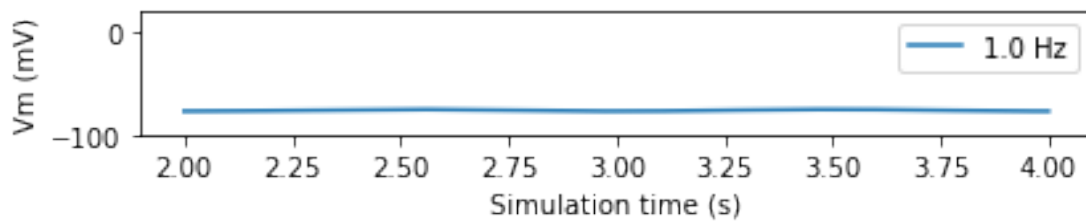
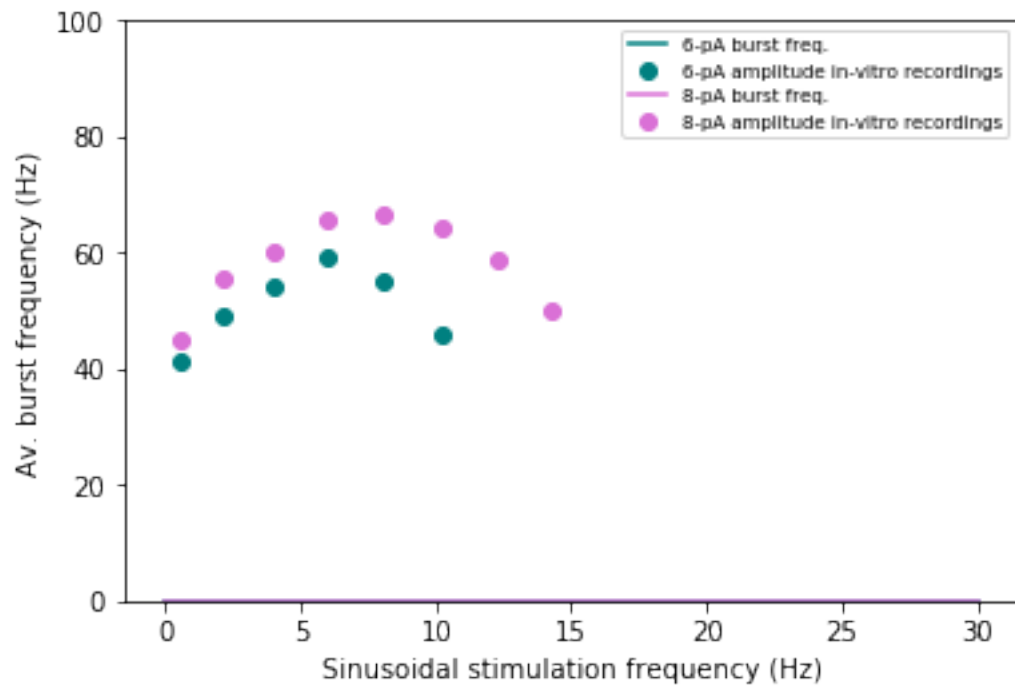
Parameter configuration:

```
{
  'a': -4.0165184543749986e-10,
  'b': -6.839824060613925e-11,
  'cm': 6.985333664088788e-13,
  'delta_t': 0.001,
  'erest': -0.07778234787504298,
  'espike': -0.0004304292241678158,
  'eth': -0.029018746530720414,
  'grest': 7.270087787186214e-09,
  'tref': 0.001,
  'tw': 0.41060061967312633,
  'vreset': -0.04823380506724272}
```

Feature and total score:

```
{
  'feature_Burst_Frequency': 770.43,
  'feature_Latency': 2934.45,
  'feature_Mean_Frequency': 135.0,
  'total_score_obtained_in_UEGO': 3839.88}
```

NEURON 25



There is no spike generated to calculate the I-F slope

In []: