

```
In [1]: import sys
        sys.path.append('../')
```

```
In [2]: import matplotlib.pyplot as plt
        from neuro_models.neuro_ode_models import Iz_Simple
        from neuro_models.utils import plot_voltage
```

```
In [3]: param1 = {
        "Vth": 30,
        "a": 0.02,
        "b": -0.1,
        "c": -55,
        "d": 6,
        "Ix": 0
        }

        iz_simple1 = Iz_Simple(param1)
```

```
In [4]: # fp1_case1 = (-40, 4) # Unstable (saddle)
        fp2_case1 = (-87.5, 8.75) # Stable node

        t0 = 0.0
        tn = 11
        dt = 0.001

        injected_current_duration = 0.2

        injected_current_1 = 266
        injected_current_2 = 267

        Vth = 30 # threshold voltage for spiking
```

```
In [5]: # Run the Euler method for case 1
        # Only run for stable fixed point

        t_case1_fp2_266, y_case1_fp2_266 = iz_simple1.euler_method_spiking(
            V0=fp2_case1[0],
            n0=fp2_case1[1],
            t0=t0,
            tn=tn,
            dt=dt,
            Vth=Vth,
            injected_current_duration=injected_current_duration,
            injected_current=injected_current_1
        )

        t_case1_fp2_267, y_case1_fp2_267 = iz_simple1.euler_method_spiking(
            V0=fp2_case1[0],
            n0=fp2_case1[1],
            t0=t0,
            tn=tn,
            dt=dt,
            Vth=Vth,
```

```

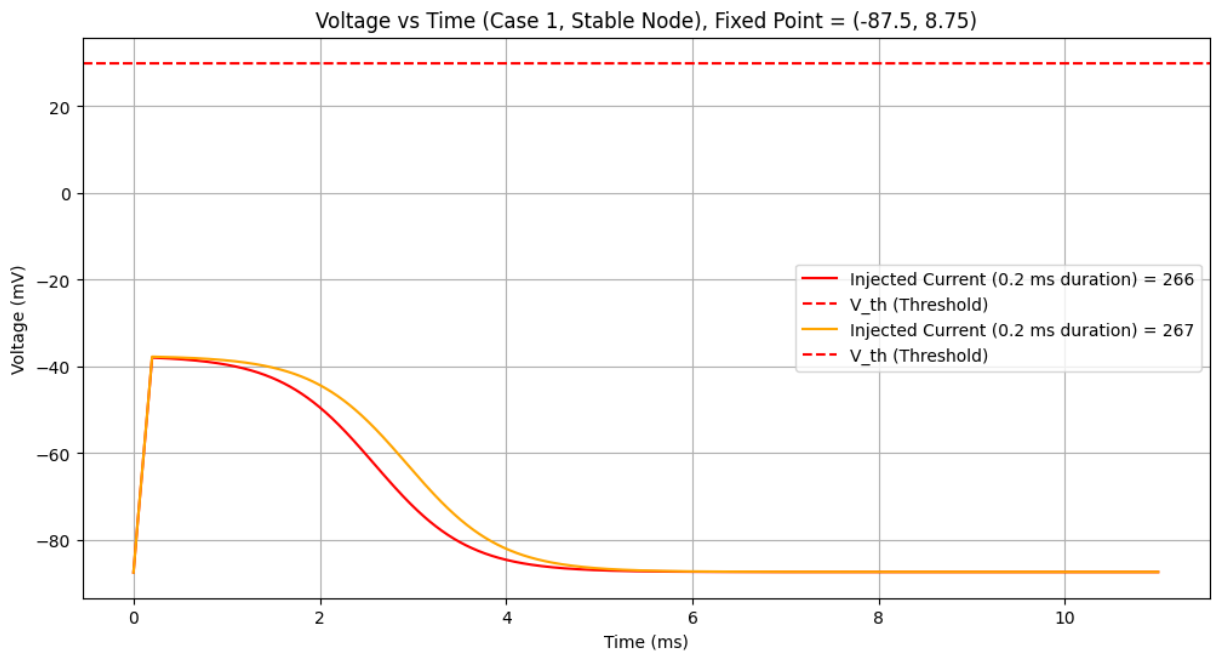
    injected_current_duration=injected_current_duration,
    injected_current=injected_current_2
)

```

```

In [6]: plt.figure(figsize=(12, 6))
plot_voltage(t_case1_fp2_266, V_values=y_case1_fp2_266[0,:], Ix=266, yth=30, yr=None,
            label_name="Injected Current (0.2 ms duration)")
plot_voltage(t_case1_fp2_267, V_values=y_case1_fp2_267[0,:], Ix=267, yth=30, yr=None,
            title=f"Voltage vs Time (Case 1, Stable Node), Fixed Point = {fp2_case1}

```



```

In [7]: param2 = {
    "Vth": 30,
    "a": 0.1,
    "b": 0.26,
    "c": -60,
    "d": -1,
    "Ix": 0
}

iz_simple2 = Iz_Simple(param2)

```

```

In [31]: # fp1_case2 = (-56, -14.56) # Unstable (saddle)
fp2_case2 = (-62.5, -16.25) # Stable node

t0 = 0.0
tn = 5000
dt = 0.001

injected_current_duration = 0.2

injected_current_1 = 12
injected_current_2 = 13

```

```

In [32]: # Run the Euler method for case 1
# Only run for stable fixed point

```

```

t_case2_fp2_12, y_case2_fp2_12 = iz_simple2.euler_method_spiking(
    V0=fp2_case2[0],
    n0=fp2_case2[1],
    t0=t0,
    tn=tn,
    dt=dt,
    Vth=Vth,
    injected_current_duration=injected_current_duration,
    injected_current=injected_current_1
)

t_case2_fp2_13, y_case2_fp2_13 = iz_simple2.euler_method_spiking(
    V0=fp2_case2[0],
    n0=fp2_case2[1],
    t0=t0,
    tn=tn,
    dt=dt,
    Vth=Vth,
    injected_current_duration=injected_current_duration,
    injected_current=injected_current_2
)

```

```

In [33]: plt.figure(figsize=(12, 6))
plot_voltage(t_case2_fp2_12, V_values=y_case2_fp2_12[0,:], Ix=12, yth=30, yr=None,
             label_name="Injected Current (0.2 ms duration)")
plot_voltage(t_case2_fp2_13, V_values=y_case2_fp2_13[0,:], Ix=13, yth=30, yr=None,
             title=f"Voltage vs Time (Case 2, Stable Spiral), Fixed Point = {fp2_cas

```

```

c:\Users\Teddy\anaconda3\envs\comp_neuro\Lib\site-packages\IPython\core\events.py:8
2: UserWarning: Creating legend with loc="best" can be slow with large amounts of da
ta.

```

```

    func(*args, **kwargs)

```

```

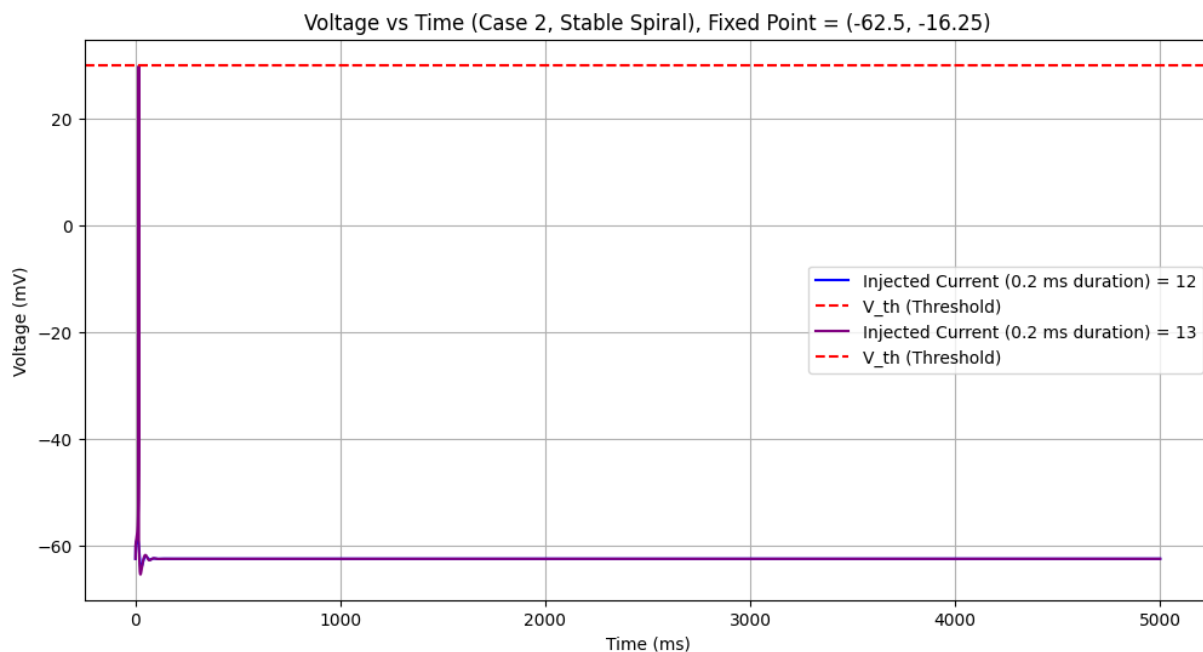
c:\Users\Teddy\anaconda3\envs\comp_neuro\Lib\site-packages\IPython\core\pylabtools.p
y:170: UserWarning: Creating legend with loc="best" can be slow with large amounts o
f data.

```

```

    fig.canvas.print_figure(bytes_io, **kw)

```



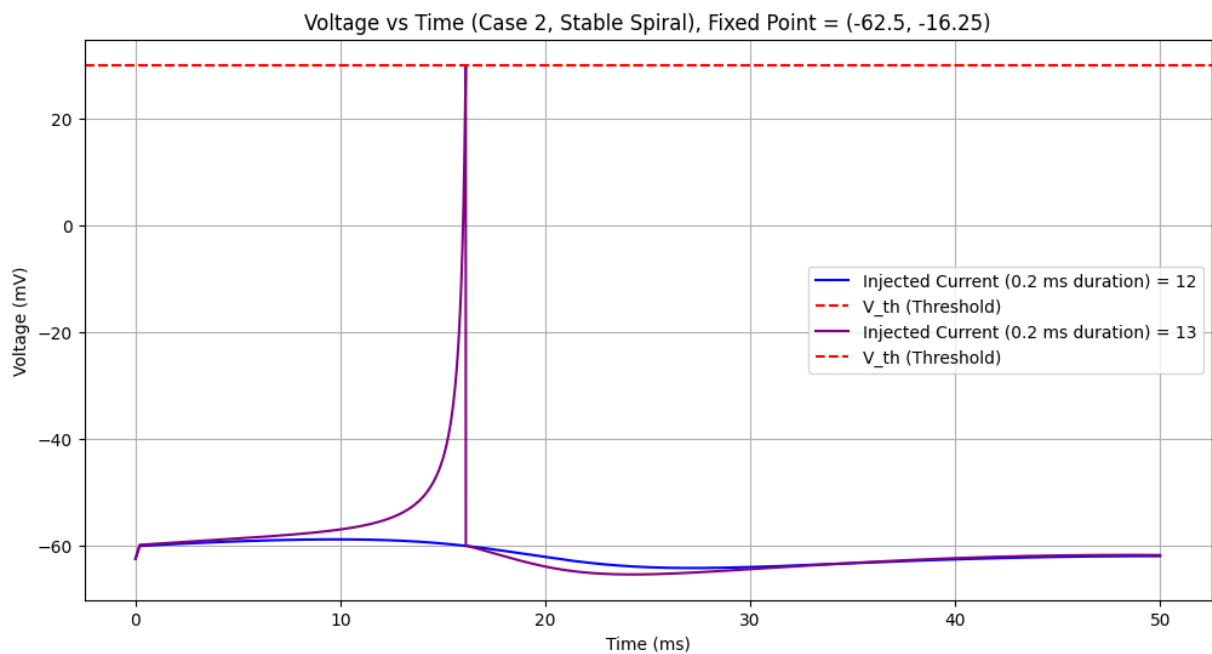
In [34]: `tn = 50`

```
# Run the Euler method for case 1
# Only run for stable fixed point
```

```
t_case2_fp2_12, y_case2_fp2_12 = iz_simple2.euler_method_spiking(
    V0=fp2_case2[0],
    n0=fp2_case2[1],
    t0=t0,
    tn=tn,
    dt=dt,
    Vth=Vth,
    injected_current_duration=injected_current_duration,
    injected_current=injected_current_1
)
```

```
t_case2_fp2_13, y_case2_fp2_13 = iz_simple2.euler_method_spiking(
    V0=fp2_case2[0],
    n0=fp2_case2[1],
    t0=t0,
    tn=tn,
    dt=dt,
    Vth=Vth,
    injected_current_duration=injected_current_duration,
    injected_current=injected_current_2
)
```

```
plt.figure(figsize=(12, 6))
plot_voltage(t_case2_fp2_12, V_values=y_case2_fp2_12[0,:], Ix=12, yth=30, yr=None,
             label_name="Injected Current (0.2 ms duration)")
plot_voltage(t_case2_fp2_13, V_values=y_case2_fp2_13[0,:], Ix=13, yth=30, yr=None,
             title=f"Voltage vs Time (Case 2, Stable Spiral), Fixed Point = {fp2_cas
```



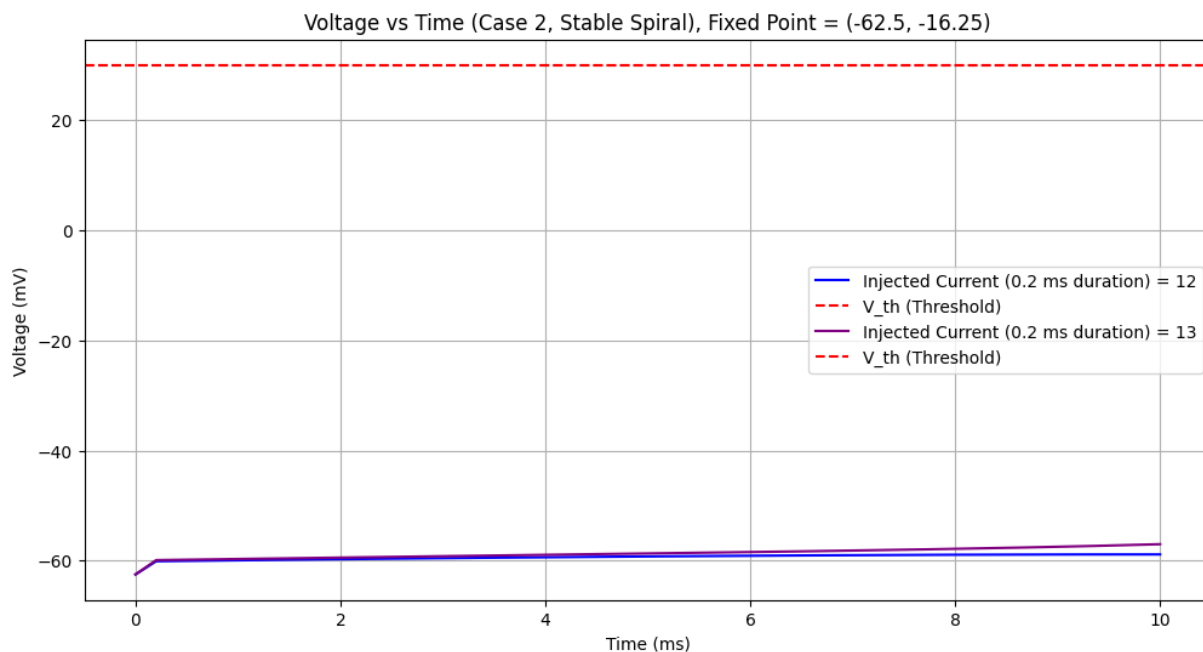
```
In [27]: tn = 10

# Run the Euler method for case 1
# Only run for stable fixed point

t_case2_fp2_12, y_case2_fp2_12 = iz_simple2.euler_method_spiking(
    V0=fp2_case2[0],
    n0=fp2_case2[1],
    t0=t0,
    tn=tn,
    dt=dt,
    Vth=Vth,
    injected_current_duration=injected_current_duration,
    injected_current=injected_current_1
)

t_case2_fp2_13, y_case2_fp2_13 = iz_simple2.euler_method_spiking(
    V0=fp2_case2[0],
    n0=fp2_case2[1],
    t0=t0,
    tn=tn,
    dt=dt,
    Vth=Vth,
    injected_current_duration=injected_current_duration,
    injected_current=injected_current_2
)

plt.figure(figsize=(12, 6))
plot_voltage(t_case2_fp2_12, V_values=y_case2_fp2_12[0,:], Ix=12, yth=30, yr=None,
             label_name="Injected Current (0.2 ms duration)")
plot_voltage(t_case2_fp2_13, V_values=y_case2_fp2_13[0,:], Ix=13, yth=30, yr=None,
             title=f"Voltage vs Time (Case 2, Stable Spiral), Fixed Point = {fp2_cas
```



In [28]: `tn = 1`

```
# Run the Euler method for case 1
# Only run for stable fixed point
```

```
t_case2_fp2_12, y_case2_fp2_12 = iz_simple2.euler_method_spiking(
    V0=fp2_case2[0],
    n0=fp2_case2[1],
    t0=t0,
    tn=tn,
    dt=dt,
    Vth=Vth,
    injected_current_duration=injected_current_duration,
    injected_current=injected_current_1
)
```

```
t_case2_fp2_13, y_case2_fp2_13 = iz_simple2.euler_method_spiking(
    V0=fp2_case2[0],
    n0=fp2_case2[1],
    t0=t0,
    tn=tn,
    dt=dt,
    Vth=Vth,
    injected_current_duration=injected_current_duration,
    injected_current=injected_current_2
)
```

```
plt.figure(figsize=(12, 6))
plot_voltage(t_case2_fp2_12, V_values=y_case2_fp2_12[0,:], Ix=12, yth=30, yr=None,
             label_name="Injected Current (0.2 ms duration)")
plot_voltage(t_case2_fp2_13, V_values=y_case2_fp2_13[0,:], Ix=13, yth=30, yr=None,
             title=f"Voltage vs Time (Case 2, Stable Spiral), Fixed Point = {fp2_cas
```

