4. Simulation and Result

4.1 Over view

This chapter covers the results obtained from the design in all mode stands, walk and sleep with the desired frequency and pulse width.

The result in this chapter division in to part :

1- Results of Sensor and transmitter part.
2- Results of Receiver and control part.

4.2 Results of Sensor and transmitter part

The FSR output is used by the means of its pressure limits concept further in the full design, when the pressure applied on the tow sensors (switch 1&switch 2 OFF), the following scenario will be resulted.

• Microcontroller receives output zero from tow sensors.
• The LCD displays the sensors states.
• Microcontroller sends one to receiver part.
• Patient in the stand state.

Figure (4.1) show the state of sensors in (TX) side.
Figure 4.1: state of sensors in (TX) side (stand) (ISIS protus)

The second case when the pressure applied on one sensor (sw1=off sw2=on), The following scenario will be resulted.

- microcontroller receives output zero from sensor 1 and one from sensor 2.
- microcontroller sends 2 to receiver part.
• Patient in the foot rise state.

Figure (4.2) state of sensors in (TX) side, foot rise.

Figure 4.2: state of sensors in (TX) side, foot rise (ISIS protus)

The third state of sensors when pressure applied on the tow sensors (switches 1&switch 2 ON)

• Microcontroller receives negative output from tow sensors.
• Microcontroller sends three to receiver part, Patient in the foot hold state. Figure 4.3: state of sensors in (TX), foot-hold.
The last state of sensor when the pressure applied on one sensor (sw1 = on & sw2 = off)

- Microcontroller receives positive output from sensor 1 and from negative sensor 2.
- Microcontroller sends 4 to receiver part.
- Patient in the foot strike state, Figure (4.4) state of sensors in (TX), foot-strike.
Figure 4.4: state of sensors in (TX), foot-strike (ISIS protues).

4.3 Results of Receiver and control part

On the side of the receiver before stimulation starts, must be selected the appropriate frequency and pulse width. There are two button to adjust frequency, (sw1) to moves between the frequency and the other (sw2) to sets selected frequency, the available frequencies are (4hz, 8hz,
16hz, 30hz, 60hz, 123hz, 244hz). The minimal stimulation frequency rates to achieve fused muscle response are generally between 12-15Hz.

There are also two switches to adjust the pulse width, switch (sw3) for the increasing pulse width (b++) and the other while switch (sw4) for decreasing pulse width (b--), figure (4.5) shows the mechanism of setting the frequency.

Figure 4.5: set frequency and (PWM) (ISIS protues).
When the received value is one

- The output of microcontroller equals zero.
- Stand mode appears on the LCD.
- PWM equals zero, Figure (4.6) show stand state in (RX) side.

![Image of circuit diagram]

Figure 4.6: stand state in (RX) side, (ISIS protus).

The High-voltage switch circuit output is zero thus Transistor in a cutoff state, Figure (4.7) show the output of stand mode in (RX)side.
Figure 4.7: output of stand mode in (RX) side, (ISIS protues).

When the received value is 2

- The microcontroller generates electrical pulse to electrode.
- Walk mode appears on the LCD with PWM value, Figure 4.8: walk mode (foot-rise) in (RX) side, Figure (4.8): show walk mode (foot-rise) in (RX) side.
Figure 4.8: walk mode (foot-rise) in (RX) side (ISIS protus).

The High-voltage switch circuit the output is high voltage around 80 V also Transistor in a connected state, Figure (4.9): show Output of walk mode in (RX).
Figure 4.9: Output of walk mode in (RX), (ISIS protus).

The figures (4.10) and (4.11) below shows different PWM values (13,223)
Figure 4.10: output of walk mode with 13 PWM (ISIS protus).

Figure 4.11: walk mode (foot-rise) with 223 PWM (ISIS protus).
While the patient is walking, the foot will lift from the ground, there is no pressure applied on the sensors in this case received value is 3

- The microcontroller continues generating an electrical pulse to electrode.
- Walk state appears on the LCD with the value of the pulse width, Figure 4.12 show output of walk mode (foot-hold).

Figure 4.12: output of walk mode (foot-hold), (ISIS protus).

When the received value is four. The following action will be happen.
• The microcontroller continues generating an electrical pulse to electrode.

• walk mode appears on the LCD with the value of the pulse width, Figure 4.13 show output of walk mode (foot-strike).

![Figure 4.13: output of walk mode (foot-strike), (ISIS protus).](image)

### 4.4 sleep mode

When the patient lifts his/her foot (Take off the boot, Sits) for more than two seconds state goes to sleep mode. Which reduces power consumption and increase the number of the work hours without charging the battery, increase the duration of the device life, Figure 4.14 shows the sleep mode from walking(hold-foot) in (RX).
Figure 4.14: sleep mode from walking (hold -foot) in (RX).

In the another hand if the patient stands for more than two seconds, the state will go to sleep mode, Figure 4.15 shows the sleep mode from stand in (RX).
Figure 4.15: sleep mode from stand in (RX).

4.5 Comparison between the proposed solutions

4.5.1 Using one microcontroller

Using one microcontroller there will be many advantages, one of the most important of speed, and reduce energy consumption, but there is a major drawback prevents the use of Micro and one is that there will be
wires connected in the patient causing the complexity of the movement and also a greater likelihood of damage to the machine.

4.5.2 Using two microcontrollers

The main advantage of this solution is that it supports the transmission via wireless so the need for two microcontroller to do this. This leads to ease of movement and handle because decreasing of conductive wires and also increase the life of device and the average rate of energy consumption is proper in this case and the delay in sending the data do not do any effect.

4.5.3 Using three microcontrollers

This solution is sterile because it uses a greater capacity of the needy to where there one microcontroller is not needed, this microcontroller is consequent increase in consumed energy, weight, size and delay responding to the device and also an increase in cost.

4.6 Discussion the design

- The circuit is working well.
- The sensor is reading the signal from patient and the microcontroller read the signals and displayed the stat of sensor.
- The microcontroller sending the sensors signals to receive side by.
- The receiver side receives signals and analyzed for state of patent.
- The result of state patent is typical and the patent can wake better.