

Hardware Safety Features:

Protection Against Overvoltage and Overcurrent:

To protect the BS2 microcontroller and other sensitive components, the circuit includes voltage regulators that ensure the voltage stays within the permissible limits for the system's functioning. Furthermore, the design incorporates current-limiting resistors and fuses to restrict excessive current flow, which could lead to overheating, damage to components, or failure. These safeguards contribute to the preservation of the device's components under fluctuating power conditions.

Software Safety Features:

Predefined Shutdown Position: To ensure safe operation, the Hexa-bot is programmed to detect a predefined unsafe hand position using the flex sensors and accelerometer. If the hand is moved into a position that could result in unintended or hazardous actions—such as extreme finger bending or an abnormal hand orientation—the software triggers an emergency shutdown. This is achieved by continuously monitoring the sensor inputs, and if the inputs indicate an unsafe state, the bot will immediately stop its movements.

Invalid Input Handling and Noise Filtering: To prevent erratic behavior due to noise or invalid inputs from the sensors, the software includes a noise filtering algorithm. This algorithm checks the sensor data for excessive fluctuations that could indicate faulty or noisy readings. If the software detects too much noise or invalid data, it automatically resets the motors to a safe position—0 degrees—stopping any unintended movement and ensuring that the Hexa-bot remains in a neutral and stable state.

Motor Control Safety: The software is designed to reset the motors to 0 degrees (neutral position) if any unusual or unsafe input is detected. This reset prevents the motors from continuing to move based on erratic sensor readings, minimizing the risk of mechanical damage or dangerous robot behavior. Additionally, if the system detects no valid input or continuous invalid sensor data, the bot will enter a "safe mode," where all motors are set to their default position and no further movement is allowed until the issue is resolved.

Guidelines for Safe Operation:

Correct Finger Placement: Users should ensure that their fingers are properly positioned on the flex sensors. Proper finger placement is crucial to avoid the detection of false or extreme bending, which could trigger the shutdown mechanism. The system is calibrated to expect a specific range of finger movements, so any excessive bending should be avoided.

Avoid Rapid or Forceful Movements: To prevent noise or invalid sensor readings, users should avoid making rapid or forceful gestures while controlling the Hexa-bot. Abrupt movements can lead to erroneous inputs or stress on the sensors, potentially causing malfunction or triggering the safety shutdown.

Maintain Clear Operating Environment: Users should ensure that the Hexa-bot has a clear and unobstructed space for movement. Interference in the environment, such as physical obstructions or sudden environmental changes (e.g., vibrations), could result in incorrect sensor readings and potentially cause unsafe conditions for the device.

Regular System Calibration: To ensure continued safe operation, the Hexa-bot should be calibrated regularly, especially if sensors or components are replaced. Calibration ensures that the system can correctly interpret sensor data, minimizing the risk of invalid inputs and maintaining accuracy in the robot's movements.

Instantaneous Shutdown Procedure:

If the system detects any unsafe operation—such as invalid sensor inputs, or noise beyond acceptable levels—the predefined shutdown mechanism is activated. The flex sensors and accelerometer continuously monitor the user's gestures and hand position. If an unsafe condition is detected, the microcontroller immediately sends a command to stop all motors and reset them to 0 degrees (neutral position). This emergency stop prevents further movement, mitigating the risk of damage to the Hexa-bot or its components.

By integrating these hardware and software safety features, the Hexa-bot ensures that both the system and the user are protected from potential risks. The emergency shutdown mechanism, noise filtering, and invalid input handling all contribute to making the device safer and more reliable during operation, allowing for a secure and enjoyable user experience.