Training Course on Wearable Electronics Design and Applications

Professional Development Training Course Outline

Category	Engineering	**Duration**	10 Days
Base Fee	$3,000 USD	**Delivery Mode**	Online / On-site Hybrid

Course Introduction

Introduction

Training Course on Wearable Electronics Design and Applications offers an in-depth exploration into the rapidly evolving field of smart, body-worn technologies that seamlessly integrate with our daily lives. Participants will gain a deep understanding of the unique challenges and opportunities in designing miniaturized, low-power, flexible, and comfortable electronic systems for direct human interaction. The curriculum meticulously covers core components such as biomedical sensors (PPG, ECG, IMU), microcontrollers, wireless communication modules (BLE, Wi-Fi), power management circuits, and user interface technologies (haptics, flexible displays). Attendees will acquire cutting-edge knowledge in areas like physiological signal acquisition, data processing at the edge, robust enclosure design, and ensuring user comfort and safety, essential for developing compelling and effective wearable products across diverse application domains.

The program emphasizes practical considerations and addresses trending topics in wearable technology, including e-textiles and smart fabrics, implantable devices, energy harvesting from the human body, advanced data analytics for health insights, AI at the edge for personalized feedback, and the ethical and privacy implications of continuous physiological monitoring. Participants will delve into the intricacies of power efficiency, thermal management, robust communication protocols, and validation methodologies for body-worn electronics. By the end of this course, attendees will possess the expertise to design, prototype, and evaluate innovative wearable electronic devices, driving advancements in digital health, fitness tracking, augmented reality, professional safety, and human-computer interaction. This training is indispensable for engineers, designers, and product managers seeking to lead innovation in the transformative world of wearable technology.

Programme Curriculum

Training Course on Wearable Electronics Design and Applications

Introduction

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Course Objectives

1. Understand the fundamental principles and market landscape of wearable electronics.
2. Identify and select appropriate sensors for various physiological and environmental measurements (e.g., PPG, ECG, IMU).
3. Design low-power electronic circuits for miniaturized and battery-constrained wearable devices.
4. Implement wireless communication protocols (Bluetooth Low Energy, NFC, Wi-Fi) for data transmission.
5. Develop firmware and embedded software for real-time data acquisition and processing on wearables.
6. Address power management and battery life optimization for extended usage.
7. Design for user comfort, ergonomics, and aesthetics in wearable product development.
8. Explore flexible electronics, stretchable circuits, and e-textiles for seamless integration with the body.
9. Comprehend the principles of energy harvesting from the human body for self-powered wearables.
10. Apply data analytics and machine learning techniques to extract meaningful insights from wearable data.

11. Understand regulatory considerations and electrical safety standards for body-worn devices.
12. Address biocompatibility and thermal management challenges for skin-contact electronics.
13. Explore emerging applications like augmented reality wearables, smart patches, and digital therapeutics.

Organizational Benefits

1. Accelerated R&D and product development cycles for innovative wearable solutions.
2. Creation of highly differentiated and user-centric wearable products.
3. Improved power efficiency and extended battery life of their wearable devices.
4. Enhanced capabilities in physiological monitoring and data analytics.
5. Competitive advantage in the rapidly expanding wearable technology market.
6. Development of in-house expertise in miniaturized, low-power, and flexible electronics.
7. Reduced time-to-market for new wearable product introductions.
8. Compliance with relevant industry standards and safety regulations.
9. Exploration of new revenue streams in digital health, fitness, and consumer electronics.
10. Attraction and retention of top talent in the high-demand field of wearable tech.

Target Participants

- Electrical and Electronics Engineers
- Embedded Systems Engineers
- Product Designers and Industrial Designers
- Biomedical Engineers
- Software Developers for IoT/Wearables
- Healthcare Technology Innovators
- Sports and Fitness Technology Developers
- Researchers in Human-Computer Interaction

Course Outline

Module 1: Introduction to Wearable Electronics and Market Trends

- **Definition and Evolution of Wearables:** From smartwatches to smart textiles.
- **Market Segments and Growth Drivers:** Digital health, fitness, AR/VR, professional safety.
- **Key Characteristics of Wearables:** Miniaturization, low power, comfort, connectivity.
- **Challenges in Wearable Design:** Power, size, thermal, reliability, user acceptance.
- **Case Study:** Analyzing the design philosophy and market success factors of a popular wearable device (e.g., Apple Watch or Fitbit).

Module 2: Physiological Sensors for Wearables

- **Optical Sensors (PPG):** Principles for heart rate, SpO2, blood pressure estimation.
- **Inertial Measurement Units (IMU):** Accelerometers, gyroscopes, magnetometers for activity tracking, gesture recognition.
- **Biopotential Sensors:** ECG electrodes, EMG, EDA (electrodermal activity).
- **Temperature Sensors:** Skin temperature, ambient temperature.

- **Case Study:** Selecting and integrating appropriate sensors for a multi-modal fitness tracker measuring heart rate, steps, and sleep.

Module 3: Microcontrollers and Processors for Wearables

- **Low-Power Microcontrollers:** Cortex-M series, RISC-V, power modes.
- **System-on-Chip (SoC) Solutions:** Integrated MCU, radio, memory.
- **Edge Computing:** On-device data processing, reduced cloud dependency.
- **Memory and Storage:** Flash, RAM for data logging and firmware.
- **Case Study:** Choosing an ultra-low-power microcontroller for a smart patch that needs to operate for weeks on a coin cell battery.

Module 4: Wireless Communication for Wearables

- **Bluetooth Low Energy (BLE):** Profiles (GATT), central/peripheral roles, power efficiency.
- **NFC (Near Field Communication):** Passive mode, secure transactions (payment, access).
- **Wi-Fi and Cellular (LTE-M, NB-IoT):** For higher bandwidth or wider range applications.
- **Antenna Design for Miniaturized Devices:** PCB antennas, flexible antennas.
- **Case Study:** Designing a BLE communication protocol for a smart ring to transmit heart rate data to a smartphone app.

Module 5: Power Management and Battery Technologies

- **Battery Types:** Lithium-ion, Li-Po, coin cells, solid-state batteries.
- **Power Management ICs (PMICs):** Buck/Boost converters, battery chargers, fuel gauges.
- **Low-Power Design Techniques:** Power gating, clock gating, efficient algorithms.
- **Battery Life Optimization:** Software and hardware strategies.
- **Case Study:** Calculating the battery life of a wearable device based on component power consumption and usage patterns.

Module 6: User Interface and Haptics

- **Flexible Displays:** OLED, E-ink for low power visual feedback.
- **Haptic Feedback:** Vibration motors, linear resonant actuators (LRAs) for tactile alerts.
- **Buttons, Touch Interfaces, Gestures:** Input mechanisms.
- **Audio Interfaces:** Microphones, tiny speakers for voice commands/feedback.
- **Case Study:** Designing a haptic feedback pattern for a smartwatch to differentiate between various types of notifications.

Module 7: Flexible and Stretchable Electronics

- **Flexible Substrates:** Polyimide, PET, PEN films.
- **Stretchable Materials:** Elastomers, conductive polymers.
- **Circuit Fabrication on Flexible Substrates:** Printing, laser structuring.
- **Interconnects and Packaging for Flexibility:** Strain relief.
- **Case Study:** Developing a stretchable electrode array for a wearable ECG patch to maintain contact during body movement.

Module 8: E-Textiles and Smart Fabrics

- **Conductive Yarns and Fibers:** Integrating electronics directly into fabric.
- **Sensors in Textiles:** Fabric electrodes, pressure sensors, temperature sensors.
- **Powering Smart Garments:** Flexible batteries, energy harvesting.
- **Washability and Durability:** Challenges for textile integration.

- **Case Study:** Designing a smart shirt with integrated ECG electrodes for continuous cardiac monitoring during exercise.

Module 9: Energy Harvesting for Wearables

- **Thermoelectric Generators (TEGs):** Harvesting body heat.
- **Piezoelectric Harvesters:** Converting mechanical motion to electricity.
- **Solar Cells for Wearables:** Miniaturized, flexible PV cells.
- **Hybrid Harvesting Systems:** Combining multiple sources.
- **Case Study:** Evaluating the potential power output from a TEG embedded in a smartwatch for supplementing battery power.

Module 10: Data Analytics and Machine Learning for Wearables

- **Raw Sensor Data Processing:** Filtering, artifact removal.
- **Feature Engineering:** Extracting meaningful features from time series data.
- **Machine Learning Algorithms:** Classification (activity recognition), regression (sleep stages).
- **AI at the Edge:** Running ML models directly on the wearable MCU.
- **Case Study:** Training a machine learning model to classify different types of physical activities (walking, running, cycling) using IMU data.

Module 11: Wearable Device Enclosure Design and Ergonomics

- **Materials Selection:** Biocompatibility, durability, aesthetics.
- **Ingress Protection (IP Ratings):** Water and dust resistance.
- **Thermal Management:** Dissipating heat from miniaturized electronics.
- **Ergonomics and User Comfort:** Weight, size, fit, skin contact.
- **Case Study:** Designing a waterproof and ergonomic enclosure for a swimming tracking wearable.

Module 12: Reliability, Testing, and Validation

- **Environmental Testing:** Temperature, humidity, vibration, drop tests.
- **Regulatory Compliance:** FCC, CE, Bluetooth SIG.
- **Electrical Safety:** IEC 60601 (if medical), current limits, insulation.
- **Clinical Validation:** For medical/health claims, accuracy against gold standards.
- **Case Study:** Developing a test plan to validate the accuracy of a wearable blood pressure monitor against a clinical standard.

Module 13: Cybersecurity and Data Privacy for Wearables

- **Data Encryption:** Protecting sensor data in transit and at rest.
- **Secure Authentication:** User and device authentication.
- **Firmware Security:** Secure boot, over-the-air (OTA) updates.
- **Privacy Regulations:** GDPR, HIPAA, user consent for data collection.
- **Case Study:** Identifying potential cybersecurity vulnerabilities in a cloud-connected wearable health device and proposing mitigation strategies.

Module 14: Medical Wearables and Digital Therapeutics

- **Regulatory Pathways for Medical Devices:** FDA clearance, CE Marking (MDR).
- **Clinical Grade Wearables:** High accuracy, reliability for diagnostics/monitoring.
- **Digital Therapeutics (DTx):** Software as medical device, evidence-based interventions.

- **Remote Patient Monitoring (RPM):** Using wearables for chronic disease management.
- **Case Study:** Discussing the regulatory hurdles and clinical evidence required for a wearable device to be classified as a medical device for arrhythmia detection.

Module 15: Future Trends and Emerging Applications

- **Augmented Reality (AR) Glasses:** Integrating displays, sensors, and computing.
- **Implantable Sensors:** Continuous, precise internal monitoring.
- **Bio-integrated Electronics:** Seamless fusion with biological systems.
- **Self-Healing Electronics:** Extending device lifespan.
- **Case Study:** Exploring the design challenges and potential impact of AR glasses that provide real-time health metrics overlays.

Training Methodology

This course employs a participatory and hands-on approach to ensure practical learning, including:

- Interactive lectures and presentations.
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Upcoming Scheduled Sessions

Start Date	End Date	Location	Price
23 Nov 2026	04 Dec 2026	Online	$2,000
23 Nov 2026	04 Dec 2026	Physical	$3,000
23 Nov 2026	04 Dec 2026	Physical	$6,000
23 Nov 2026	04 Dec 2026	Physical	$6,000
23 Nov 2026	04 Dec 2026	Physical	$12,000
23 Nov 2026	04 Dec 2026	Physical	$9,000
23 Nov 2026	04 Dec 2026	Physical	$12,000
23 Nov 2026	04 Dec 2026	Physical	$12,000

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