ADVANCED TECHNOLOGICAL INSTITUTE
COLOMBO 15

Higher National Diploma in Engineering

Department of Electrical and Electronic Engineering

The project proposal of

Automated Seed Planting Robot

Supervised By	**:**	**S. H. T. D. Chandrasena**
Name	**:**	**S. A. D. R. P. Samarasinghe**
Student Reg, No.	**:**	**COL/EE/2021/F/154**
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Automated Seed Planting Robot

1. Introduction

Agriculture remains one of the most vital sectors supporting national economies, especially in developing regions. However, traditional farming practices depend heavily on human labor, leading to inefficiency, high costs, and inconsistent planting results. As global food demand rises, there is a need for automation to make farming faster, more efficient, and less labor-intensive.

The Automatic Seed Planting Robot provides a low-cost automated solution for seed planting operations. It performs multiple tasks—digging, seed dropping, soil covering, and watering—without human assistance. The robot operates through an Arduino-based control system integrated with DC gear motors, servo motors, ultrasonic sensors, and a water pump.

This project contributes to smart farming innovation by demonstrating how affordable electronics and mechanical design can improve agricultural productivity. The robot aims to help small-scale farmers achieve uniform planting and efficient resource use while reducing manual workload and human error.

2. Objectives

- Main Objective:

To design and develop an autonomous robotic system capable of performing the entire seed planting process with precision, low cost, and minimal human involvement.

- Specific Objectives:

1. To construct a stable, four-wheel robotic platform capable of navigating on agricultural soil.
2. To automate seed digging, placement, and soil covering mechanisms using servo and DC gear motors.
3. To integrate an Arduino-based controller to coordinate motion, dispensing, and watering.
4. To incorporate buck converters for reliable and efficient power regulation.
5. To minimize planting time and improve accuracy and uniformity.
6. To provide a cost-effective, easy-to-operate solution suitable for small farms.
7. To evaluate prototype performance through testing and calibration on real soil surfaces.

3. Methodology

- ## Phase 1 — Requirements & Specifications

  1. **Functional requirements**
     - Robot must perform: Dig → Seed drop → Soil cover → Watering automatically.
     - Operate from 12 V battery with local buck converters for 5 V logic.
     - Use: 3 × ultrasonic sensors, 3 × servo motors, 2 × DC gear motors, motor driver(s), 1 × relay + mini water pump.
  2. **Performance targets (initial)**
     - Seed spacing accuracy: ±5 cm (configurable).
     - Digging depth: configurable 20–50 mm (via servo angle).
     - Throughput: target 200–400 seed holes per hour (depends on travel speed & cycle time).
     - Battery: operate at least 60 minutes continuous with specified load.
  3. **Non-functional**
     - Robust enough for small farm soil (muddy, uneven), easy to repair, low cost (<Rs. 40,000 target).
  4. **Deliverables from this phase**
     - Final BOM, preliminary block diagram, requirement sheet (document).

- ## Phase 2 — Detailed Design & Parts Selection

  1. **Select microcontroller** (you decided Arduino Mega recommended if many I/O; if you need Wi-Fi later, ESP32 + I/O expander). Finalize one and list pin assignments.
  2. **Select actuators & sensors** with datasheets:
     - Servos: choose metal-geared servos with torque ≥ 6–10 kg·cm.
     - DC gear motors: 12 V motors with rated stall torque adequate for chassis load.
     - Ultrasonic sensors: HC-SR04 (or equivalent).
     - Mini pump: choose one with current ≤ 2–3 A and required flow.
     - Relay: 5 V coil, contact rating ≥ 10 A , 12 V DC.

  3. **Power system sizing**

- Recalculate currents using chosen components (include stall currents & servo surge).
- Choose battery capacity (e.g., 12 V 10–20 Ah LiFePO4 or SLA).
- Choose buck converters: one or two rails (5 V servo/logic rail sized to peak servo current — e.g., 5–8 A).

4. **Mechanical design**
   - Sketch chassis, digger mount, hopper position, center-of-gravity estimates.
5. **Deliverables**
   - Final BOM with part numbers & supplier links, mechanical sketches, pin map.

- ## Phase 3— Mechanical Fabrication & Assembly

1. **Chassis fabrication**
   - Cut and assemble aluminum/acrylic base. Provide motor mounting plates and servo mounts.
   - Ensure enough clearance for soil, pump mounting, and wiring channels.
2. **Digging & covering mechanism**
   - Build servo-actuated digger arm (rotate/linear) and soil-cover arm.
   - Prototype seed release gate (you previously removed hopper from block diagram — we assume a simple servo-gate to drop one seed).
3. **Mount pump & plumbing**
   - Mount mini pump and secure hose for watering; ensure pump wiring safely routed.
4. **Mechanical checks**
   - Verify servo ranges, travel limits, torque under load.
   - Ensure mechanical stops to avoid servo over-torque.
5. **Deliverables**
   - Assembled chassis with mounted motors, servos, pump; photos.

- ## Phase 4 — Electronics Integration & Wiring

1. **Power distribution board**
   - Install fuse on battery positive (e.g., 12 A fuse for ~8–9 A estimated peak).

   - Route battery to motor driver (DC motors/pump) and to buck converters (for 5 V).
   - Add decoupling electrolytic caps near motor driver input.
2. **Motor driver wiring**
   - Connect DC gear motors to L298N or appropriate motor driver. Put heatsinks on drivers.
3. **Servo & sensor wiring**
   - Run servo power from 5 V buck rated for servo current. Keep servo power separate from MCU 5 V regulator if needed.
   - Connect ultrasonic sensors to specific digital pins; label each sensor for left/center/right.
4. **Relay & pump wiring**
   - Connect pump positive through relay COM/NO; pump negative direct to battery negative.
   - Ensure relay coil powered from 5 V (Arduino) with proper ground common.
5. **Grounding**
   - Connect common ground between battery negative, MCU GND, motor driver GND, buck converter ground.
6. **EMI & protection**
   - Put ferrite beads / twisted pair on motor leads, add snubber (RC) if needed across pump.
7. **Deliverables**
   - Wiring diagram, photos of wiring, continuity tests.

- ## Phase 5 — Software Development
- Split into modules; test each on bench.

1. **Low-level drivers**
   - Motor control functions: drive forward/backward, set speed (PWM), steer algorithm for turning.
   - Servo control functions: set digger angle, seed release gate, cover arm position.

- Ultrasonic sensor read function: measure distance (average multiple readings, filter).
- Relay control for pump on/off.

2. **State machine for planting cycle**
    - States: NAVIGATE → STOP → DIG → RELEASE_SEED → COVER → WATER → RESUME_NAV.
    - Implement non-blocking code (use mills () not delay ()) so sensors remain active.
3. **Navigation & spacing**
    - Implement timed spacing control or wheel-encoder based odometry (if no encoders, use speed × time).
    - If only time-based, calibrate speed vs distance.
4. **Safety & fault handling**
    - If ultrasonic detects obstacle < threshold → stop & wait / re-route.
    - Overcurrent detection (if possible) to stop motors on stall.
5. **Calibration routine**
    - Interactive mode: set servo angles for dig depth; set seed release duration; set watering duration.
6. **Logging & debug**
    - Serial logs for debugging. If using Mega and want later telemetry, plan for SD or Bluetooth/Wi-Fi.
7. **Deliverables**
    - Well-commented source code, test scripts, calibration instructions.

- ## Phase 6 — Bench Testing & Subsystem Validation

1. **Motor test**
    - Run motors at various PWM duty cycles and measure speed, stall behavior.
2. **Servo test**
    - Run digger and cover cycle on dry soil beds; adjust angle values.
3. **Sensor test**
    - Verify ultrasonic range and false reading filtering; mount location adjustments.

4. **Pump & relay test**
    - Turn pump on/off via relay; measure current draw during startup and normal operation.
5. **Power system test**
    - Measure current draw of whole system during a planting cycle (use clamp meter).
6. **Deliverables**
    - Test log, current draw table, adjusted calibration values.

- ## Phase 7 — Integration & Field Trials

1. **Integrated field test**
    - Run full cycle in a test plot with real soil; measure seed spacing, depth, and watering coverage.
    - Run multiple cycles (min 3 runs of 50 holes each) to collect statistical data.
2. **Data collection**
    - Record: seed spacing error (cm), depth error (mm), cycle time (sec), pump run duration, battery voltage drops, number of successful cycles.
3. **Adjust & tune**
    - Tune servo angles, timing, motor speed to meet targets: spacing ±5 cm, depth tolerance ±5 mm.
4. **Robustness checks**
    - Test in slightly wet/dry soil, sloped ground, small obstacles.
5. **Deliverables**
    - Field trial report with photos, measurements, and issues found.

- ## Phase 8— Optimization, Documentation & Final Demo

1. **Power optimization**
    - If battery life too low, reduce idle motor draw, optimize pump run time, or increase battery capacity.
2. **Mechanical fixes**
    - Strengthen mounts, add dust/water protection for electronics.

3. **Final documentation**
    - Prepare final report chapters: Introduction, Design, Implementation, Testing, Results, Conclusion, Future Work.
4. **Prepare presentation**
    - Create slides, include test photos, circuit schematic, block diagram, bill of materials, and cost summary.
5. **Final Demo**
    - Prepare demonstration script and short video of robot operation.
6. **Deliverables**
    - Final prototype, final report, final PPT, source code archive, BOM & supplier list, demo video.

4. Estimated Budget

Item	Quantity	Unit Price (LKR)	Total (LKR)
Arduino Mega Board	1	5,000	5,000
L298N Motor Driver Modules	2	1,500	3,000
DC Gear Motors	2	1,000	2,000
Servo Motors	3	1,200	3,600
Ultrasonic Sensors	3	800	2,400
Mini Water Pump	1	2,600	2,600
Relay Module	1	600	600
Buck Converters	3	900	2,700
Jumper Wires (set)	7	100	700
Battery Pack (12V)	1	3,000	3,000
Chassis & Frame Materials	1	5,000	5,000
Seed Hopper & Cover Mechanism	1	1,200	1,200
Miscellaneous (Wires, PCB, Connectors, Screws, etc.)	-	1,200	1,200

Subtotal – Components: Rs. 33,000

Other Expenses (fabrication, transport, printing, contingency): Rs. 5,000

Total Estimated Project Cost: Rs. 38,000

5. Final Outcome

At the completion of this project, a fully functional Automated Seed Planting Robot will be developed, integrating mechanical, electrical, and control systems into one efficient autonomous machine. The robot will demonstrate the successful automation of four key agricultural processes — soil digging, seed placement, soil covering, and watering — using a combination of sensors, actuators, and microcontroller-based control logic.

1. Functional Outcome

- The robot will be capable of moving across a cultivated area while performing a continuous planting sequence:

    1. Digging: Servo-driven mechanism will dig small, uniform holes at consistent intervals.

    2. Seed Dropping: The seed dispenser mechanism (servo-controlled) will release one seed per hole with accurate spacing.

    3. Soil Covering: Another servo arm will automatically push soil to cover the planted seed.

    4. Watering: A 12 V mini water pump, controlled by a relay, will supply adequate moisture to each planted seed.

- All operations will be managed by an Arduino Mega 2560 microcontroller programmed with sequential logic for autonomous field operation.

2. Technical Performance Outcome

- System Accuracy:
    - Seed spacing tolerance ≤ ±5 cm
    - Digging depth variation ≤ ±5 mm
- Operational Efficiency:
    - Continuous planting rate of 200–400 seeds/hour (depending on soil condition).
    - Field coverage capability of approximately 10–20 m^2 per battery cycle (with 12 V 10–20 Ah battery pack).

- Power System Performance:
  - Total power consumption < 100 W under normal load.
  - Run time of 1–1.5 hours per charge.
- Reliability:
  - Stable operation verified through 200+ planting cycles without major system failure.
  - Built-in fail-safe behavior when obstacle detected by ultrasonic sensors.

3. Hardware & Software Integration

- Hardware:
  - Arduino Mega 2560 (main control unit)
  - L298N motor driver modules for DC gear motor control
  - Three ultrasonic sensors for navigation and obstacle detection
  - Three servo motors for digging, dropping, and covering operations
  - One relay-controlled 12 V mini water pump for watering
  - Buck converters for regulated 5 V supply to logic and servo lines
  - 12 V rechargeable battery pack as main power source
- Software:
  - Program developed using Arduino IDE.
  - PWM control used for motor speed and servo positioning.
  - Sequential algorithm managing the four major operational stages.
  - Sensor feedback used for safe movement and obstacle avoidance.

4. Usability & Application Outcome

- The robot will reduce manual labour requirements in the planting process, offering a low-cost, portable automation tool for small to medium-scale farmers.
- Can be adapted for multiple seed types and variable spacing through simple code modification.
- Demonstrates the potential of electrical and electronic automation in the agricultural sector, bridging modern control systems with traditional farming practices.
- Serves as an educational prototype for teaching mechatronics, embedded systems, and agricultural robotics.

5. Sustainability & Future Development

- The system can be upgraded with solar charging, IoT data logging, or GPS-based path control to improve sustainability and autonomy.
- The modular electrical design allows easy replacement or scaling for multiple rows or larger farming areas.
- The project's design documentation, software, and test results will support further academic research or industrial prototyping.

6. Project Timeline (10 Weeks)

Task	October				November				December			
Research & Requirement Analysis												
Concept & System Design												
Procurement & Initial Testing												
Mechanical Fabrication												
Electrical Integration												
Software Development & Debugging												
Full System Integration												
Field Trials												
Optimization & Final Tuning												
Documentation & Presentation												

7. Conclusion

The Automatic Seed Planting Robot project successfully demonstrates the integration of mechanical automation and embedded electronics in modern agriculture. It minimizes human involvement while improving efficiency, consistency, and productivity in seed planting.

The system's design uses affordable, locally available components powered efficiently through buck converters. Its modular approach allows easy expansion into GPS or IoT-based control for precision farming.

By providing a total cost under Rs. 40,000, this prototype proves that low-budget automation can have real-world benefits for small-scale farmers and educational research, paving the way toward sustainable and intelligent agriculture.

PROJECT TITLE : Automated Seed Planting Robot

SUPERVISED BY : Eng. S.H.T.D. Chandrasena

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Date Supervisor Approval

HEAD OF DEPARTMENT : Eng. R.W.R. Jayasinghe

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Date Supervised Approval