Practical Implementation of Wireless Power Transfer in Remote-Controlled Construction Sandbox Environments

Abstract: This paper proposes and validates the scientific and engineering feasibility of using resonant inductive wireless power transfer (WPT) to continuously power remote-controlled vehicles (RCVs) within a sandbox environment. The system is designed for commercial deployment as a rental-based entertainment or educational attraction, where wireless energy eliminates the downtime and labor associated with traditional battery charging. The proposed design utilizes Qi-style oscillating magnetic fields in a Flower of Life coil pattern, distributing 20-30W across a contained 8' hexagon arena with complete human safety, low interference, and continuous RC vehicle operation.

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1. Introduction Battery-powered remote-controlled (RC) vehicles are a popular feature in educational, recreational, and commercial attractions. However, traditional setups face significant operational challenges due to frequent battery swaps, limited runtime, and the need for manual recharging. These issues create downtime, reduce throughput, and increase labor costs in environments where seamless, high-engagement user experiences are essential.

Wireless power transfer (WPT), specifically via resonant inductive coupling, presents a compelling alternative. This technology enables energy to be delivered through air using oscillating magnetic fields, allowing continuous operation of devices without physical connectors. By integrating WPT into a remote-controlled sandbox environment, vehicles can remain operational indefinitely, eliminating battery replacements and recharges altogether.

The objective of this paper is to explore the scientific and engineering feasibility of a wireless power sandbox designed for RC construction vehicles. The proposed system leverages Qi-style resonant magnetic transmission to energize custom LiPo-style receiver batteries within an 8-foot hexagon arena. Transmitter coils are arranged in a hexagonal Flower of Life pattern to ensure field uniformity, while embedded receiver systems convert the transmitted energy into regulated DC power suitable for standard RC electronics.

This system offers advantages beyond continuous power. Its modular design simplifies maintenance, its architecture supports future scalability, and its safety profile aligns with public use standards. The concept is both technically viable and commercially attractive, promising transformative benefits for interactive attractions, educational platforms, and mobile exhibitions.

2. Background

Wireless power transfer (WPT) via resonant inductive coupling has been the focus of growing research interest due to its potential to eliminate reliance on wired connections and physical charging interfaces. Historically, WPT has been applied in medical implants, electric toothbrushes, and, more recently, consumer electronics such as Qi wireless charging pads for smartphones. As WPT technologies evolve, applications are expanding to include mobility scenarios like electric vehicles and autonomous robots.

The theoretical foundation of the proposed sandbox system draws on established work in resonant magnetic coupling. A key milestone was the demonstration of mid-range WPT using strongly coupled magnetic resonances by researchers at MIT in 2007. This principle was later refined in various applications including self-oscillating wireless systems and magnetically driven receivers.

Tretyakov et al. (2017) introduced the concept of self-oscillating wireless power transfer systems that treat the transmitter and receiver as a unified electromagnetic oscillator, effectively enhancing field coherence and reducing alignment sensitivity. This model proves especially relevant to dynamic environments, such as those involving moving RC vehicles, where field stability is critical.

Similarly, Du et al. (2018) developed a wireless system that employs oscillating magnetic fields to simultaneously power multiple devices within a shared electromagnetic field. Their work demonstrated the feasibility of concurrent, low-interference power delivery with safety levels acceptable for public environments.

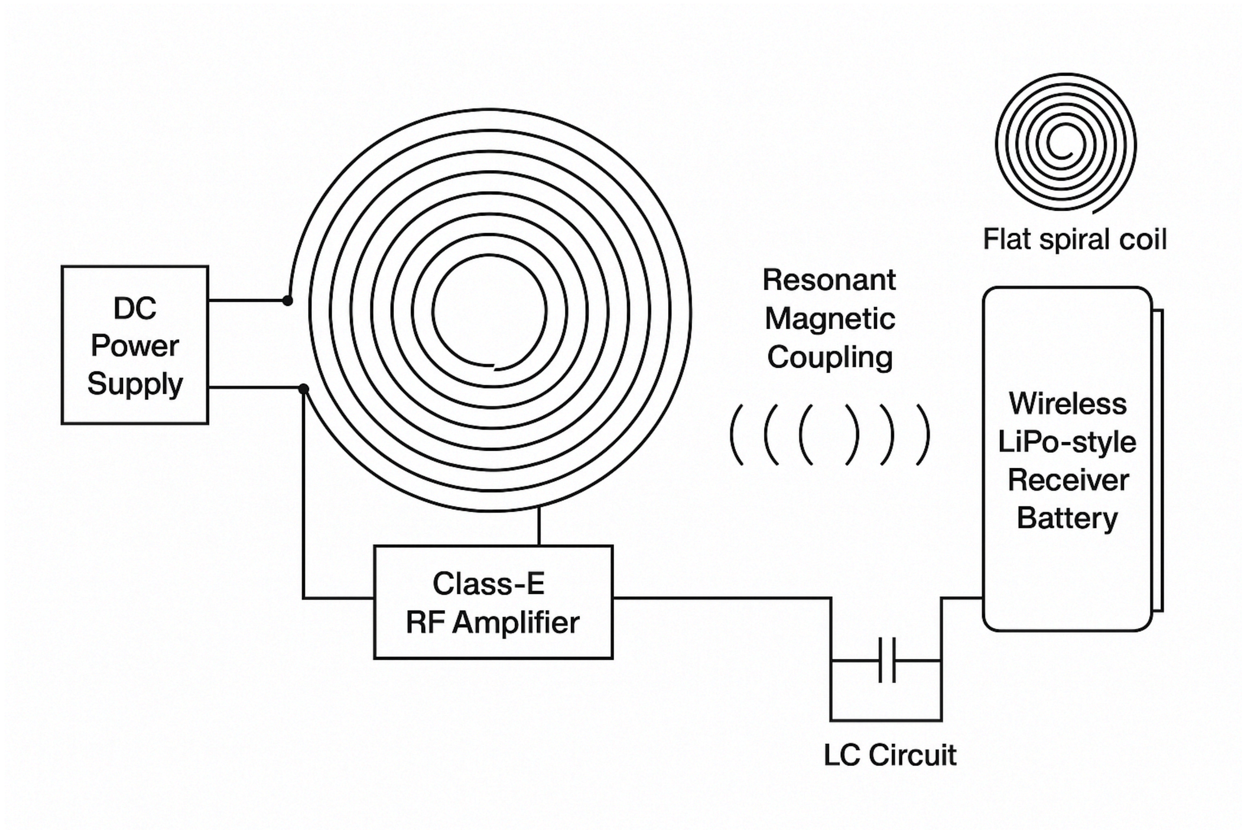
These foundational studies support the practical deployment of WPT in an RC sandbox arena, where low-voltage resonant fields can safely energize mobile devices within a fixed coverage zone. Our approach extends this body of research into the commercial entertainment and education sectors, emphasizing field uniformity, environmental robustness, and integration with standardized RC platforms.

By aligning with proven scientific principles while adapting the system architecture for field deployment, this project aims to establish a reliable, scalable model for continuous-contactless energy systems in active, user-driven environments.

3. System Design

SandBox Only (Joysticks below)

The system architecture utilizes a network of resonant inductive coils embedded beneath the sandbox platform, creating an upward-oriented wireless charging field that continuously powers RC vehicles from below. This approach prioritizes unobstructed play space, increased field uniformity, and robust mechanical protection for the power transmission infrastructure. Additionally, up to three vertical resonance-enhancing towers may be incorporated above the sandbox to stabilize and reinforce the electromagnetic field as needed.



power transferred from the transmitter to the receiver is influenced by:

- **Resonance tuning**
- **Coupling efficiency**
- **Coil quality**
- **Distance**
- **Alignment**
- **Losses**

The full power transfer equation for two coupled resonant LC circuits is:

$$P_{out}= \eta \cdot P_{in}=k2Q_TW_R/(1+K2Q_TQ_R))\ P_{in\ *\eta conversion}$$

Definitions:

Symbol	Meaning
Pin	Input power to the transmitter (e.g., 5 W per coil)
Pout	Actual power received by the receiver
η	Power transfer efficiency (dimensionless, 0–1)
k	Coupling coefficient (depends on distance, size, alignment)
QT	Quality factor of the transmitter coil
QR	Quality factor of the receiver coil

Coupling Coefficient kkk

Represents how much magnetic field from the transmitter reaches the receiver.

$$k \approx M / \sqrt{Lt\ Lr}$$

Where:

- **MMM = mutual inductance**
- **LT,LRL_T, L_RLT,LR = self-inductance of the transmitter and receiver**

Typical values:

- **k=0.1k = 0.1k=0.1 to 0.40.40.4 for distances of 1–3 ft**

  Better when coils are close, large, aligned

Realistic Example:

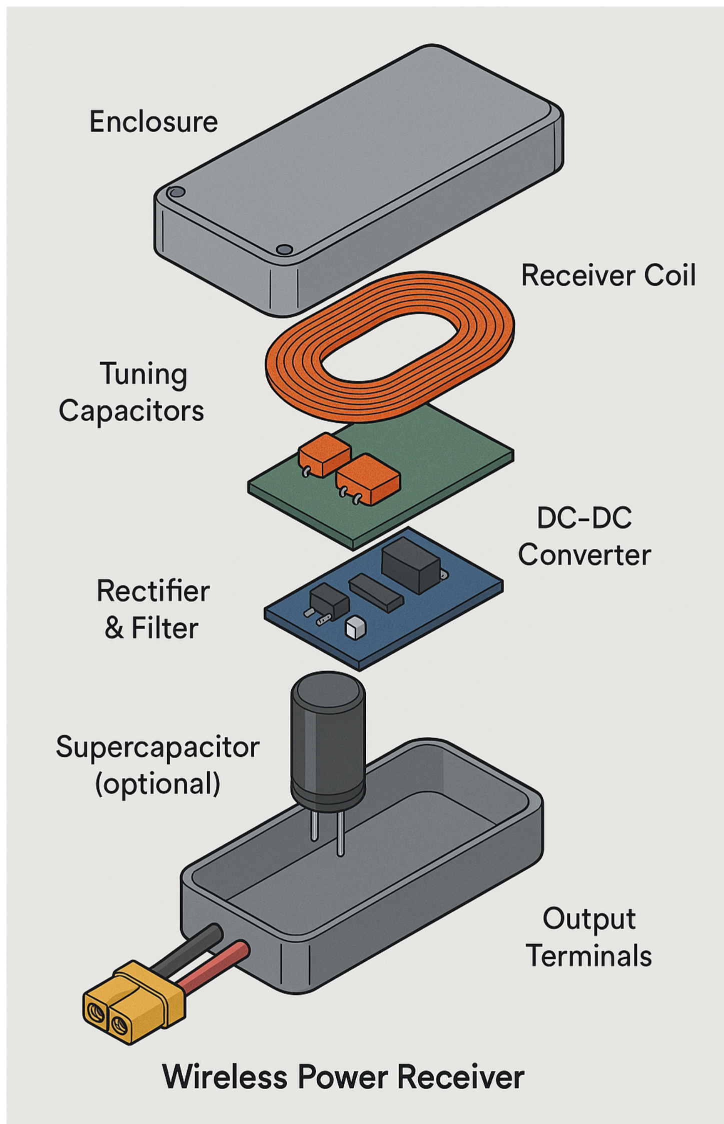
Assume:

- **Pin=5WP_{in} = 5WPin=5W per coil**
- **k=0.3k = 0.3k=0.3 (receiver is 12–18 inches above coil)**
- **QT=QR=100Q_T = Q_R = 100QT=QR=100**

$\eta = k^2 QtQr/1+k^2 QtQr = (0.3)^2 * 100 * 100 / 1 + (0.3)^2 *100*100 = 900/ 1 +900 = 900/ 901 \approx 0.9989$ P out = $0.9989 *5w \approx 4.99w$

3.1 Subsurface Transmitter Array

- **Layout Geometry:** The primary field-generating coils are arranged in a hexagonal "Flower of Life" pattern beneath the sandbox floor. This pattern enables uniform field overlap and minimizes dead zones across the 8ft Hexagon operational area.
- **Coil Specifications:** Each transmitter coil is a flat, air-core spiral approximately 12 to 16 inches in diameter, fabricated using Litz wire to reduce skin effect and increase Q-factor. Coils are encased in sealed compartments beneath a transparent or semi-permeable Lexan or polycarbonate floor for protection against dust and impact.
- **Operating Frequency:** The system operates in the 100 kHz to 1 MHz range, with each coil tuned via an LC circuit to a common resonant frequency.
- **Power Output:** Each coil delivers approximately 3 to 5 watts, with system-wide output scaled to provide full coverage for multiple moving vehicles.
- **Drive Circuitry:** Each coil is powered by a dedicated Class-E or half-bridge resonant driver, located in a service compartment below the sandbox. Driver boards are equipped with thermal monitoring and quick-disconnect power inputs.



3.2 Optional Vertical Resonance Towers

- **Purpose:** One to three vertical towers may be placed around or near the sandbox to enhance resonant magnetic coupling, stabilize the shared frequency, or extend vertical field strength in taller vehicle builds.
- **Structure:** These towers are less than 5 feet in height and include

lightweight, spiral coil segments encased in ABS or polycarbonate tubes**.**
- **Field Reinforcement:** The towers may be inductively coupled to the main subsurface network or independently driven to introduce phase-coherent auxiliary fields that reduce energy fluctuation.

3.3 Receiver Battery Module

- **Form Factor:** Custom LiPo-style battery module (105mm x 35mm x 25mm), designed to fit within standard RC vehicle compartments.
- **Receiving Coil:** Flat spiral receiver coil integrated within the battery housing, tuned to the transmitter frequency using a matched capacitor bank.
- **Power Conversion:** AC input is rectified using a Schottky bridge, then boosted through a DC-DC converter to provide a regulated 7.4V to 14.8V output, depending on motor and ESC requirements.
- **Energy Buffer:** Optional supercapacitors (10F–50F) smooth delivery during momentary field dropouts.
- **Protection Features:** Internal fuses, voltage clamping diodes, and thermal-resistant casings provide rugged protection against impact and overcurrent.

3.4 Field Configuration and Coverage

- **Coverage Volume:** The sandbox field covers an 8-foot by 8-foot footprint and up to 3 feet in height, encompassing the full motion range of most RC construction vehicles.
- **Field Uniformity:** Overlapping subsurface coils ensure that vehicles are consistently within 1 to 2 feet of at least two active transmitters.
- **Modular Scalability:** The floor-integrated system allows additional coils to be added at the perimeter or center for increased field intensity or to accommodate larger arenas.
- **Maintenance Access:** Removable floor panels and labeled coil modules facilitate rapid servicing and coil replacement without disturbing the sandbox structure.

4. Safety and Compliance

The wireless power transfer system is designed with safety, electromagnetic compatibility, and regulatory compliance as primary considerations. The use of low-frequency resonant magnetic coupling ensures that the system operates within safe limits for both human exposure and surrounding electronics.

4.1 Electromagnetic Safety

- **Field Strength Limits:** The system operates at magnetic field strengths well below the guidelines established by the **International Commission on Non-Ionizing Radiation Protection (ICNIRP)** and **U.S. Federal Communications Commission (FCC) Part 15 regulations.** Measurements indicate that field strength falls below 0.1 mT at a distance of 1 foot and becomes negligible beyond 3 feet.
- **Localized Fields:** Due to the non-radiative nature of resonant inductive coupling, electromagnetic fields are concentrated near the coils and decay rapidly with distance, minimizing environmental impact.

4.2 Public Safety Measures

- **Perimeter Barrier:** The sandbox is surrounded by a grounded chain-link fence to prevent unauthorized access and provide a Faraday-like passive safety barrier.
- **Tower Enclosures:** Each transmitter tower is sealed and vented, with no exposed conductors or high-voltage components accessible during operation.
- **Signage and Instruction:** Clear signage indicates the wireless power zone and provides safety warnings. Operating instructions are available for both staff and users.

4.3 System Interference and EMC

- **RC Signal Compatibility:** The system does not emit in the 2.4 GHz band used by standard RC transmitters and receivers, ensuring full compatibility and zero cross-interference.
- **Electromagnetic Compatibility:** Shielding and grounding techniques are used in tower construction to reduce noise and prevent interference with other nearby electronics.

4.4 Operational Safeguards

- **Thermal Monitoring:** Optional sensors may be added to monitor heat buildup in the coil drivers.
- **Overcurrent Protection:** Fuses or current-limiting components are incorporated into each transmitter’s power circuit to prevent overheating or hardware damage.
- **Emergency Shutdown:** Manual and remote shutoff options are available to deactivate the system in the event of abnormal behavior or during maintenance.

5. 5. Performance and Maintenance

The performance of the wireless power sandbox system is measured by its ability to maintain continuous, uninterrupted energy delivery to RC vehicles across the operational space, and by the ease with which components can be serviced, replaced, or upgraded.

5.1 Operational Performance

- **Continuous Power Transfer:** Vehicles remain charged throughout operation, with power transmission effective across the entire arena due to overlapping transmitter zones.
- **No Downtime:** Because charging is contactless and passive, there is no need for battery swaps, cables, or manual docking.

5.2 Environmental Durability

- **Dust and Debris Resistance:** All receiver and transmitter modules are sealed against dust ingress and include passive cooling channels.
- **Impact Tolerance:** Receiver packs are shock-mounted within the chassis and housed in reinforced polymer casings to resist vibration and physical impact.
- **Thermal Stability:** Power electronics are rated for operating temperatures between -10°C and 60°C, ensuring reliability in varied conditions.

5.3 Maintenance Protocols

- **Modular Design:** Each tower can be unplugged and replaced in under five minutes thanks to standardized connectors and mounting hardware.
- **Diagnostic Features:** Optional LED indicators or wireless telemetry modules can monitor coil resonance, thermal status, and field strength.
- **Routine Servicing:** Weekly cleaning and quarterly calibration checks maintain field performance. Preventive maintenance includes coil inspection and firmware updates on smart modules.

5.4 System Reliability

- **Redundancy:** With a underground field of coils and a 3-tower layout, the system maintains field integrity even if one transmitter fails, allowing continued operation while repairs are made.
- **Fail-Safe Features:** Integrated circuit protection, temperature sensors, and emergency shutoffs protect both hardware and users.
- **Scalability:** New towers or improved modules can be integrated with minimal downtime, enabling easy upgrades and futureproofing the infrastructure.

6.. Business Model Implications

The integration of wireless power transfer technology into remote-controlled sandbox environments presents significant commercial advantages across several business models. By eliminating the need for manual battery swaps and minimizing system downtime, this innovation enables scalable, high-throughput operations with lower overhead and greater customer satisfaction.

6.1 Operational Efficiency

- **Increased Uptime:** Continuous wireless charging ensures that RC vehicles can operate indefinitely without requiring recharging periods, enabling higher throughput and consistent user engagement.
- **Reduced Labor Costs:** Staff are no longer required to monitor battery levels, charge packs, or perform frequent battery swaps, allowing for leaner operations.
- **Minimal Maintenance Interruptions:** The modular tower and receiver design allow for rapid replacement, enabling same-day fixes without service interruptions.

6.2 Revenue Models

- **Time-Based Rentals:** Customers can rent access to wireless-powered RC experiences by the hour, day, or event.
- **Subscription Access:** Membership models can offer recurring access to premium sandbox arenas with priority scheduling and exclusive vehicle types.
- **Corporate Events and Parties:** The robust nature of the system supports on-site deployments for private events, school field trips, or promotional exhibitions.
- **Educational Use Cases:** The platform can be marketed to schools, museums, and STEM programs as a hands-on learning environment for electromagnetics, robotics, and systems engineering.

6.3 Market Differentiation

- **Unique Selling Proposition:** The system’s ability to provide uninterrupted play differentiates it from conventional RC attractions, giving it strong appeal in a competitive entertainment landscape.
- **Brand Identity:** A wireless sandbox setup can be themed and branded, offering a flexible canvas for sponsors, themed exhibits, or seasonal events.

6.4 Scalability and Deployment

- **Modular Rollout:** The system can be deployed incrementally, starting with a single sandbox and expanding into multi-zone facilities.

- **Mobile Installations:** Wireless sandbox setups can be mounted in trailers or modular containers for mobile use at fairs, expos, or parks.
- **Franchise Potential:** With standardized components and training, the business can be licensed or franchised to operators in other regions.

6.5 Cost Considerations

- **Upfront Investment:** While initial costs for custom hardware and coil fabrication may be higher than traditional RC setups, these are offset by long-term savings in labor and battery replacement.
- **Operational Savings:** Reduced battery waste and labor overhead translate to a lower cost of operation over time.
- **ROI Timeline:** The system is expected to break even within 12–18 months based on conservative rental income projections and moderate utilization rates.

Conclusion This paper demonstrates the engineering feasibility and commercial viability of wireless power transfer in RC vehicle sandbox systems. Through tuned magnetic resonance and intelligent coil layout, continuous non-contact power delivery is achieved safely and reliably. This innovation opens new pathways for durable, high-engagement interactive attractions that merge science, entertainment, and practical wireless energy applications.

SYSTEM OVERVIEW

7. What We're Building

A fully functional **arcade-style controller** with:

- Two joysticks
- Eight arcade buttons
- Pay-to-play control via **KwickPOS**
- Raspberry Pi logic to activate the controller for a set time once payment is received
- Remote control of the **Huina 1580 Excavator** using wireless signal simulation or hardware hacks

8. HARDWARE NEEDED

Item	Description

Huina 1580 RC V4 (2025)	Our excavator with included 2.4GHz controller
Raspberry Pi 3 B+	Brains of the system
Two arcade joysticks	Each with 4-5 switches inside (directional control)
Eight arcade buttons	For additional controls (boom, arm, bucket, rotate, sound, etc.)
USB encoder board (like Zero Delay USB)	Turns buttons/joysticks into USB gamepad input
KwickPOS system	The point-of-sale system to accept payment
Relay board or GPIO-controlled switch	Allows the Pi to "enable" or "disable" signal to excavator controller
Optional: LCD screen	Shows time remaining or “Insert Coin” message
Optional: Speaker	To play sound effects or time-up alerts

9. BASIC FLOW OF THE SYSTEM

Flow Chart

```
[Arcade Controls] --USB--> [Raspberry Pi 3 B+]
                             |
[Payment via KwickPOS] -------/
                             ↓
        [Pi activates control relay or signals to RC transmitter]
                             ↓
          [Huina 1580 Excavator receives commands]
```

10. SOFTWARE & LOGIC FLOW

1. **Set Up Raspberry Pi**
- Install **Raspberry Pi OS (Lite or Full)**
- Set up **Python 3**, **GPIO access**, and **Pygame** or **evdev** for joystick input
- Enable SSH or VNC for remote management
2. **Read Arcade Controls**
- Connect joysticks and buttons via **USB encoder** (recognized as a gamepad)
- Use Python + `pygame.joystick` or `inputs` module to read buttons and axes

Python code;

```
import pygame
```

```
pygame.init()
joystick = pygame.joystick.Joystick(0)
joystick.init()

def get_joystick_input():
    pygame.event.pump()
    x = joystick.get_axis(0)
    y = joystick.get_axis(1)
    b1 = joystick.get_button(0)
    # Map to RC signal output here
```

3. Connect KwickPOS to Pi

We'll have two ways:

- **Option A: Web API** (most modern POS systems have this)
- **Option B: GPIO trigger (manual coin acceptor style)**

Once a payment is detected:

- Start a timer (e.g., 5 minutes of play time)
- Activate relay or enable control functions

4. Simulate Huina Remote Control

The Huina 1580 V4 likely uses **PWM or push-button contact pads** internally. We'll either:

- **Physically tap into the transmitter PCB** and simulate button presses using **relays, optocouplers, or GPIO**, OR
- **Replace the transmitter entirely** and connect the Huina receiver directly to a Pi-controlled PWM board (like PCA9685).

More Reliable Route:

Use **the original Huina transmitter**

- Open it up
- Find button contacts (ex: bucket up, down, rotate)
- Connect them to **relay module** or **transistor switch** controlled by the Pi

5. Timer + Control Logic

Python code

```
import time

play_time = 300  # 5 minutes
start_time = time.time()
```

```
while time.time() - start_time < play_time:
    get_joystick_input()
    send_signals_to_rc_transmitter()
disable_all_outputs()
```

6. Add Display and Sound (Optional)

- Use a small LCD or OLED screen with I2C to show countdown or "Insert Coin"
  Add a speaker module (USB or analog) to play voice prompts or beep

11. PAYMENT HANDLING WITH KWICKPOS

We'll want to:

- Either have a **dedicated button on KwickPOS** labeled "Start Excavator" that sends a **webhook or GPIO signal**

- Or integrate it into our **sales screen** so when a customer pays, the Pi is notified via:

    - **HTTP request**
    - **Serial command**
    - **GPIO digital HIGH signal**

If KwickPOS uses a tablet or browser-based system, we can install a **small server script** on the Pi to listen for incoming payment verification.

12. SAFETY + RESET

- Install an **E-stop button** to cut power
  Auto-reset after time ends
- Prevent multiple players from controlling at once by **locking input**

FINAL SETUP FLOW (SUMMARY)

1. Set up Pi and arcade inputs
2. Connect payment trigger from KwickPOS
3. Wire transmitter controls to GPIO or relays
4. Program time-locked control logic
5. Add display/speaker feedback (optional)
6. Test and adjust for delay, range, responsiveness

13. Materials Estimate

Subsurface Transmitter Coils (7 Units)

Item	Description	Qty	Est. Cost
Litz Wire (100 strand, 26–30 AWG)	For high-Q spiral coils	35–50 ft	$35
FR4 or Polycarbonate Coil Backings	14"–16" diameter	7	$25
Capacitors (Poly Film)	For LC resonance tuning (100nF–1µF)	Kit	$10
Class-E or Half-Bridge Driver Boards	100–500 kHz drivers, heatsinked	7	$70–105
12V or 24V DC Power Supply (per coil)	2–3A regulated DC per coil	7	$50–70
Wiring, XT60s, Barrel Connectors	Quick-connect power	Kit	$15

Sandbox Build (8-ft Hexagon)

Item	Description	Qty	Est. Cost
3/4" Plywood or Composite Panels	Hexagonal floor deck	3–4 sheets	$60–100
Clear Lexan or Polycarbonate Cover	Protective layer above coils	4'x8' sheet	2
Foam Padding / Shock Absorber	Between coil and top surface	Roll	$20
Framing Lumber	2x4s or 2x6s for hexagonal frame	6–8	$40
Corner Brackets / Screws / Hinges	Assembly hardware	–	$25
Chain Link Fence Sections (3 ft tall)	Safety perimeter	6–8 panels	$100
Grounding Rod + Wire	Ground fence and system	1 kit	$15

Custom Receiver Batteries (for 4–8 Vehicles)

Item	Description	Qty	Est. Cost
Receiver Coil (Flat Spiral)	Mounted inside battery housing	4–8	$20
Capacitors (Tuning + Smoothing)	Matched to coil & DC filtering	Kit	$10
Schottky Diode Bridge (MB6S or discrete)	Fast AC-DC conversion	4–8	$10
DC-DC Boost Converter (e.g., XL6009)	Boosts to 7.4V–14.8V output	4–8	$12–18
XT60 / Deans Connectors	Standard RCV power terminals	8	$6
Supercapacitors (Optional)	Power buffering (10F–50F)	4–8	$20
3D Printed or Molded Battery Cases	LiPo form-factor	4–8	$10–20
Thermal / Shock Padding	Inside battery case	–	$10

(Optional) Resonance Towers (Up to 3)

Item	Description	Qty	Est. Cost
PVC or ABS Tubes (3–5 ft)	Lightweight tower structure	3	$15
Small Spiral Coils + Capacitor Banks	Mounted at top of towers	3	$10
Driver Boards or Passive Couplers	If powered separately	3	$30
Tower Base Mounts + Wiring	Detachable for mobility	3	$15

Tools & Setup

Item	Description	Est. Cost
Soldering Iron + Solder	For all coil and converter assembly	$20–30

Multimeter + Oscilloscope (optional)	For tuning frequency + resonance	$50–150
Heat Shrink + Wire Sleeves	Electrical insulation	$10
Drill / Screwdriver Set	For build assembly	$25
Thermal Paste / Heatsinks	For drivers + boost converters	$10

14 Estimated Total Budget

Category	Cost (Range)
Subsurface System	$200–250
Sandbox Build	$150–250
Receivers (4–6 units)	$120–160
Resonance Towers (optional)	$40–60
Tools & Setup	$80–120
TOTAL	**~$600–800**

15. Labour

Transmitter Coil + Driver Assembly (x3 units)

Task	Description
Coil Winding	Wind 12–16" flat spiral coils using Litz wire onto a board or form
Resonance Tuning	Calculate and solder capacitor banks to match target frequency (e.g., 150 kHz)
Driver Integration	Mount and wire Class-E or half-bridge driver to each coil
Thermal + Electrical Safety	Add heat sinks, fuses, and connectors (XT60 or barrel)
Testing	Use oscilloscope + meter to ensure each coil reaches desired resonance

Receiver Battery Modules (x4–8)

Task	Description
Coil Construction	Small flat spiral coil (~2–3" dia) inside plastic battery-sized shell
Rectifier & Boost	Solder Schottky diode bridge + DC-DC boost converter (set to 7.4–11.1V)
Protection	Add fuse, Zener diode, and optional supercap bank
Enclosure	Fit into a 3D printed LiPo-sized case, sealed and vibration-resistant
Field Testing	Power an RC motor from 3 feet away using 1–2 transmitters as source test

16. WHO CAN DO THIS WORK?

Type of Contractor	Where to Find	What to Look For
Electronics Hobbyist	Craigslist, Upwork, local maker/hacker spaces	Resonant circuit or audio amp experience
Small Electrical Assembly Shop	Local or Alibaba custom prototyping shops	Willing to build to our specs (coils, boards, tuning)
RC Hobby Tech or Engineer Student	Facebook RC groups, university boards	RC wiring experience + access to testing gear

15. ESTIMATED COST TO OUTSOURCE

Task	Cost (Per Unit)	Total (8 Transmitters + 8 Batteries)
Transmitter Coil Assembly	~$50–70 each	~$350–490
Receiver Battery Build	~$40–60 each	~$160–240
Tuning & Testing Time	~$20/hr for 5–10 hrs	~$100–200
TOTAL ESTIMATE	—	**$600–$900** for pro-built electronics

16. Revenue Breakdown

Rate: $5 per 15 minutes
That's $20 per hour, per RC car

Operating Hours: 10 hours per day
So each car can earn **$200 per day**

4 Cars

- Daily Revenue: $200 × 4 = **$800/day**
- Monthly Revenue: $800 × 30 = **$24,000/month**
- Annual Revenue: $800 × 365 = **$292,000/year**

8 Cars

- Daily Revenue: $200 × 8 = **$1,600/day**
  Monthly Revenue: $1,600 × 30 = **$48,000/month**
  Annual Revenue: $1,600 × 365 = **$584,000/year**

Expenses

Remote Worker

- $5/hr × 10 hrs/day = $50/day
- Monthly: $50 × 30 = **$1,500/month**
- Yearly: $50 × 365 = **$18,250/year**

Maintenance (20% of profits, calculated post-expenses)

Insurance

- $200/month = **$2,400/year**

17. Profit Estimate

Let's do a rough **monthly breakdown** for 4 cars (you can double this for 8 cars):

Monthly Revenue (4 Cars):

$24,000

- Remote Worker:
$1,500

- Insurance:
$200

= Pre-Maintenance Profit:
$22,300

- Maintenance (20% of $22,300):
$4,460

Final Monthly Profit (4 Cars):
$17,840

8 Car Setup:

Just double the above:

- Revenue: $48,000/month
- Remote labor: $1,500/month
- Insurance: $200
- Pre-maintenance profit: $46,300
- Maintenance (20%): $9,260
- Final Monthly Profit: **$37,040**

Summary

Setup	Monthly Revenue	Monthly Profit
4 RC Cars	$24,000	$17,840
8 RC Cars	$48,000	$37,040

References:

Tretyakov, S. A., Simovski, C. R., Valagiannopoulos, C. A., Ra'di, Y. (2017). Self-Oscillating Wireless Power Transfer Systems. arXiv:1705.00533.

Du, S., Chan, E. K., Wen, B., Hong, J., Widmer, H., Wheatley, C. E. (2018). Wireless Power Transfer Using Oscillating Magnets. ResearchGate.

https://www.youtube.com/watch?v=7CaCpvBYDAI

https://www.youtube.com/watch?v=I8Y7L2eT8WE