



FREE GUIDE • NO. 02

7 Technologies

a Hobbyist Electronics Designer should think twice about when designing their product



A practical field guide to what these technologies really cost — in money, time, certification and risk — and what to build instead.

Introduction

Every item in this guide is a genuinely useful, legitimate engineering technology. None of them is "bad." The issue is that each one carries a specific, often underestimated cluster of cost, complexity, regulatory, or safety risk — and hobbyist and early-stage designers routinely reach for these technologies before the product actually needs them.

This guide walks through seven of the most common of these tempting-but-premature choices. Each chapter follows the same structure: confirm whether the need is real, understand what the technology actually demands beyond the headline component, look at the safer and more accessible alternative, and set out a clear recommended action and decision checklist.

Use it as a gut check before you commit a Bill of Materials, a PCB stack-up, or a certification budget to a technology your product may not actually need yet.

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CHAPTER 1

Custom Battery Packs & Chemistries

VERDICT **Fit off-the-shelf battery packs; go custom only if space demands it and testing is budgeted.**

Confirm the Need

Does the enclosure genuinely have a shape or volume that no off-the-shelf pack can fit? Do you need a chemistry other than standard Li-Po/Li-ion? For most hobbyist projects, an off-the-shelf, pre-certified pack fits fine if the enclosure is designed around it from the start.

Why It's Tempting

A custom-shaped pack can look like the cleanest way to maximise capacity in an awkward enclosure, and sourcing custom Li-Po pouch cells from overseas manufacturers is superficially easy — this apparent ease hides substantial safety and regulatory risk.

The Technical Reality

Lithium battery packs are not a benign component. Getting the design, sourcing, or handling wrong can cause thermal runaway — a self-sustaining exothermic reaction reaching several hundred degrees Celsius that can ignite surrounding materials.

Any custom pack needs protection circuitry (over-voltage, under-voltage, over-current, over-temperature) matched to the specific chemistry and configuration — not optional, not a place to improvise.

Multi-cell packs need matched cells in capacity and internal resistance, and active balancing, or individual cells can be driven outside safe limits even while the pack looks fine overall.

Batteries above certain energy thresholds require UN 38.3 testing for safe transport by air/sea; shipping without correct classification and labelling is both a safety and legal problem.

Cheap, untraceable cells from unverified suppliers are a disproportionate source of field failures — reputable manufacturers with documented QA and traceable lot numbers are a meaningfully different risk category.

Risk Check

RISK	DETAIL
Fire/explosion	Thermal runaway from cell damage, poor BMS design, or mismatched cells
Legal liability	Product safety liability is severe and personal for battery-related injuries
Transport certification	UN 38.3 required for legal shipping; non-compliance can mean seized shipments
Supplier risk	Untraceable cells are a leading cause of field battery failures
Long lead times	Custom cell tooling and safety testing both take significant time

Safer Alternatives

- Pre-certified Li-Po/Li-ion packs with an integrated BMS/PCM in standard form factors (18650, 21700, standard pouch dimensions)
- Coin cells for very low-power, low-capacity needs (RTC backup, small sensor nodes), avoiding rechargeable-lithium risk entirely
- Design the enclosure around a standard off-the-shelf pack chosen early, usually costing very little in final form factor

Recommended Action

1. Select a standard, pre-certified battery pack with integrated BMS before finalising enclosure dimensions.
2. If a custom shape is unavoidable, work with a professional pack assembly house providing BMS design, cell matching, and UN 38.3 testing — never hand-assemble custom lithium packs from individually sourced cells.
3. Always include enclosure-level mechanical protection for the battery, regardless of pack source.

Decision Checklist

- ☐ No standard pack fits the enclosure, even after redesigning around candidate packs
- ☐ I have a budget for a professional pack assembly house
- ☐ I understand or can source correct protection circuitry for the chemistry/configuration
- ☐ I have a traceable, reputable cell supplier
- ☐ I've planned for compliant shipping and product safety certification

CHAPTER 2

Fancy Displays (AMOLED, MIPI-DSI)

VERDICT Prototype with TFT LCD; reserve AMOLED/MIPI-DSI for high-volume, high-budget projects.

Confirm the Need

Does the product genuinely need smartphone-grade visuals — deep blacks, high contrast, high pixel density, fast refresh? Or does it need a functional, legible UI? A crisp, functional TFT LCD is often indistinguishable from "premium" in actual use.

Why It's Tempting

Displays are the most visible, most "wow factor" part of a product, and it's natural to want the same panel quality as the phone in your pocket. AMOLED panels are also genuinely superior on paper — true blacks, high contrast, better power efficiency for dark content.

The Technical Reality

AMOLED panels intended for embedded use are almost always driven over MIPI-DSI, a high-speed serial display interface requiring an application processor with a hardware MIPI-DSI controller — this immediately rules out most simple MCUs and pulls the whole design toward Linux-capable application processors.

This requires high-speed differential PCB routing with controlled impedance and length matching between the SoC and the display's flex connector.

A display driver IC needs correct, often panel-specific initialisation sequences that can be poorly documented outside NDA'd datasheets.

Panels are usually sold as bare modules with fragile FPC flex connectors, making mechanical design and assembly tolerances a real manufacturing risk.

AMOLED modules with MIPI-DSI commonly cost A\$21-A\$85+ per unit versus A\$4-A\$21 for a comparable TFT LCD, and consumer-grade AMOLED panels are frequently tied to specific phone models and can be discontinued with little notice.

Risk Check

RISK	DETAIL
Processor lock-in	Forces an application processor with MIPI-DSI hardware

RISK	DETAIL
PCB complexity	High-speed differential routing, impedance control
Fragile assembly	FPC flex connectors are easy to damage in hand assembly
Supply life	Tied to phone-market lifecycles; can vanish without warning
Documentation	Panel init sequences often undocumented or NDA-gated

Safer Alternatives

- **TFT LCDs with SPI or parallel RGB interfaces** — stable suppliers, mature open-source drivers (LVGL, Adafruit GFX, TFT_eSPI)
- **E-paper/E-ink displays** — excellent readability, near-zero standby power, low interface complexity
- **Character/segment LCDs** — the lowest complexity and cost option for simple status displays

Recommended Action

1. Prototype the UI on an SPI or parallel-RGB TFT LCD driven by a standard MCU.
2. Validate the actual user experience — a well-designed TFT UI usually reads as "premium enough."
3. Only move to AMOLED/MIPI-DSI once high production volume, application-processor budget, and a stable sourcing plan are confirmed.

Decision Checklist

- ☐ The product's core value proposition depends on display quality
- ☐ Forecast volume justifies an application-processor-class BOM increase
- ☐ I have (or am budgeting for) high-speed PCB design expertise
- ☐ I've confirmed a stable, long-term supply source for the exact panel
- ☐ My team can handle FPC-based mechanical assembly at scale

CHAPTER 3

Advanced USB Features

VERDICT Use USB 2.0 for data and standard power unless Power Delivery is truly required.

Confirm the Need

Does the product need to move data faster than USB 2.0's 480 Mbps? Does it need to negotiate more than standard 5V power to fast-charge a larger battery or power a higher-draw load? If not, USB 2.0 plus simple 5V charging covers the large majority of hobbyist connected-device needs.

Why It's Tempting

"USB-C" has become shorthand for modern, and it's easy to assume the connector automatically gets you USB 3.x speeds and full Power Delivery. In reality, USB-C is just the connector shape — the electrical capability behind it is a separate design decision entirely.

The Technical Reality

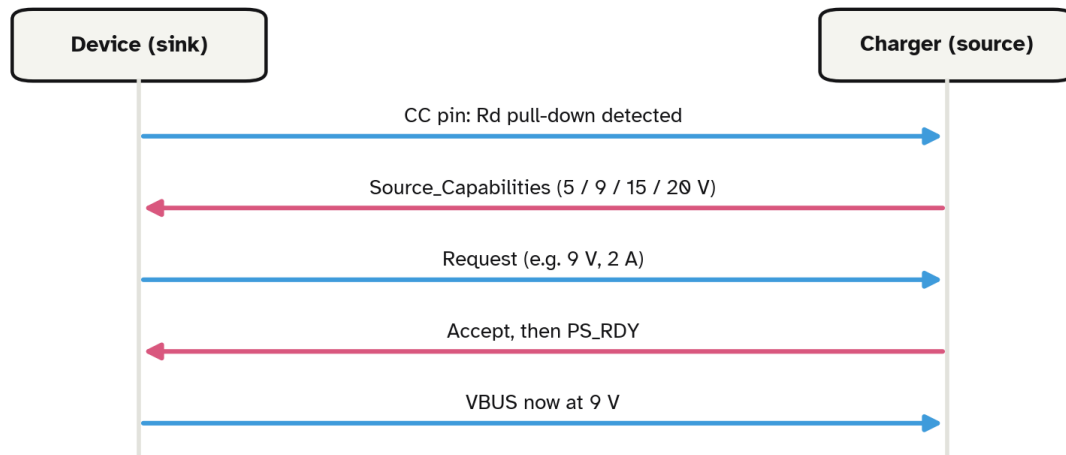
USB Power Delivery runs a full negotiation protocol over the CC pins: the device and charger exchange Source_Capabilities, Request, Accept, and PS_RDY messages before VBUS voltage actually changes.

Implementing PD requires a dedicated PD controller IC or an MCU with a native USB-PD PHY, plus firmware for the negotiation state machine; getting the CC-pin logic wrong can, at worst, damage the device or charger.

USB 3.x SuperSpeed requires high-speed differential PCB routing with controlled 90Ω impedance, length-matched pairs, and minimal stub length — a signal integrity budget that's easy to blow with one extra connector or via.

Higher-speed digital edges radiate more readily, making EMC/EMI compliance measurably harder as data rates rise.

USB Power Delivery: it's a protocol, not just a plug



Needs: a PD controller IC, negotiation firmware, correct CC logic and a robust connector

Risk Check

RISK	DETAIL
PD firmware complexity	Full negotiation state machine, not a simple voltage select
PD hardware risk	Wrong CC-pin implementation risks device or charger damage
High-speed routing	Controlled impedance, length matching for USB 3.x
EMC testing	Harder to pass at higher data rates
Component cost	PD controller ICs and USB 3.x ESD protection add BOM cost

Safer Alternatives

- **USB 2.0 (480 Mbps)** — mature, simple, well supported by every MCU with a USB peripheral
- **Simple 5V charging** — covers most hobbyist battery-charging needs without PD negotiation
- **DC barrel jack** — for higher-power devices that don't need USB-compatible charging
- **Pre-built PD "trigger" modules** — handle negotiation for a specific voltage without custom firmware

Recommended Action

1. Default to USB 2.0 for data and simple 5V USB or a barrel jack for power.
2. For higher power needs, evaluate a pre-built PD trigger module before designing custom PD hardware/firmware.
3. Only implement full custom PD negotiation or USB 3.x if a validated product requirement demands it, and budget for the added PCB and firmware complexity.

Decision Checklist

- ☐ Data transfer needs genuinely exceed 480 Mbps
 - ☐ Charging needs genuinely exceed standard 5V/1.5A
 - ☐ I've evaluated a pre-built PD trigger module and it doesn't meet the need
 - ☐ I can implement controlled-impedance routing for USB 3.x if required
 - ☐ I've budgeted for EMC testing at the higher data rate
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CHAPTER 4

Wireless Charging

VERDICT **Prototype wired first; only add wireless charging if strong customer demand exists.**

Confirm the Need

Is wireless charging a genuine, demanded feature — one customers have explicitly asked for or a clear competitive requirement? Or is it a "nice to have" that adds cost and complexity without validated demand?

Why It's Tempting

Wireless charging feels premium and modern, and removing a connector from the enclosure can simplify (or seem to simplify) waterproofing and industrial design.

The Technical Reality

Even a few millimetres of misalignment between transmitter and receiver coils can drop efficiency from ~75–85% down to below 40%, with the difference dissipated as heat in both coils.

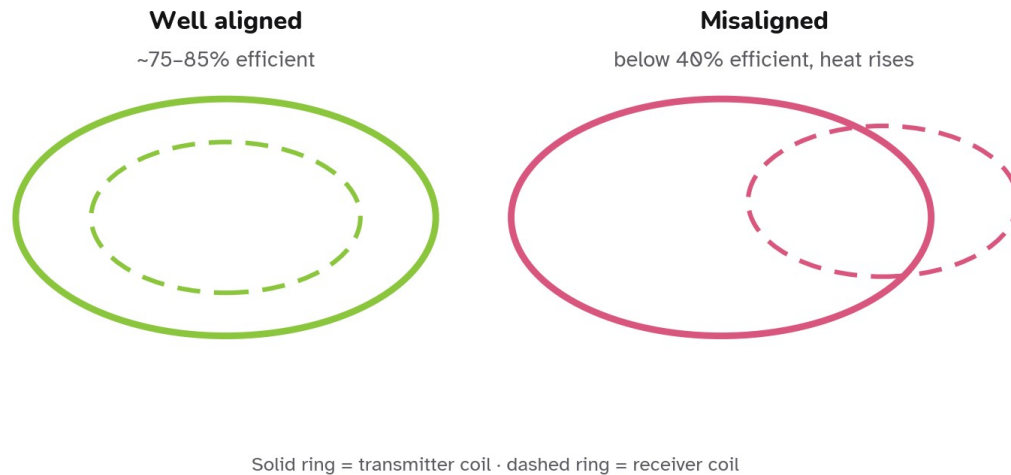
A ferrite sheet behind the receiver coil is needed to stop magnetic flux inducing eddy currents in nearby metal — get it wrong and you get localised heating right next to the battery.

The Qi standard requires Foreign Object Detection to cut power before metallic objects heat up dangerously — a real firmware and calibration exercise.

Coupling losses become heat inside a sealed enclosure, right next to a lithium battery — compounding directly with battery safety risk.

Legal use of the "Qi" branding and interoperability requires WPC (Wireless Power Consortium) certification, involving formal compliance testing and licensing fees.

Wireless charging: efficiency depends on alignment



Risk Check

RISK	DETAIL
Alignment sensitivity	Efficiency collapses quickly with misalignment
Heat near battery	Coupling losses become heat directly adjacent to lithium cells
EMI	Switching at coil frequency (commonly ~100-205kHz) can radiate/conduct interference
Certification	Qi/WPC certification needed for interoperability and branding
Complexity creep	FOD, alignment sensing, and thermal protection all need real firmware

Safer Alternatives

- **USB-C wired charging** — simple, efficient (>90%), universally compatible
- **Pogo pin charging docks** — connector-free device enclosure without inductive complexity
- **Magnetic dock connectors** — "snap it on" convenience with wired efficiency and simplicity

Recommended Action

1. Ship the first version with USB-C wired charging.
2. Validate real customer demand for wireless charging specifically.
3. If confirmed, prototype with an off-the-shelf Qi transmitter/receiver IC pair rather than designing coil driver electronics from scratch, and budget for WPC certification.

Decision Checklist

- ☐ Customers have explicitly requested or expect wireless charging
 - ☐ I've budgeted for Qi/WPC certification and testing
 - ☐ My enclosure design can accommodate ferrite shielding without excess thickness
 - ☐ Thermal design has margin for coupling losses next to the battery
 - ☐ I'm using an off-the-shelf Qi transmitter/receiver IC pair, not a custom coil driver
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CHAPTER 5

Proprietary / High-Speed Connectors

VERDICT **Stick to standard connectors; add adapters later if high-speed is genuinely needed.**

Confirm the Need

Is there a widely supported standard connector (USB-C, HDMI, SPI headers, I²C, LVDS) that would do the job? Or does the product genuinely require a proprietary interface — e.g. Apple's Lightning/MFi connector, or a very high-speed board-to-board link no standard connector supports?

Why It's Tempting

Proprietary connectors can look "more professional" or unlock specific ecosystem integrations, and high-speed proprietary connectors can seem like the only way to hit a tight form factor.

The Technical Reality

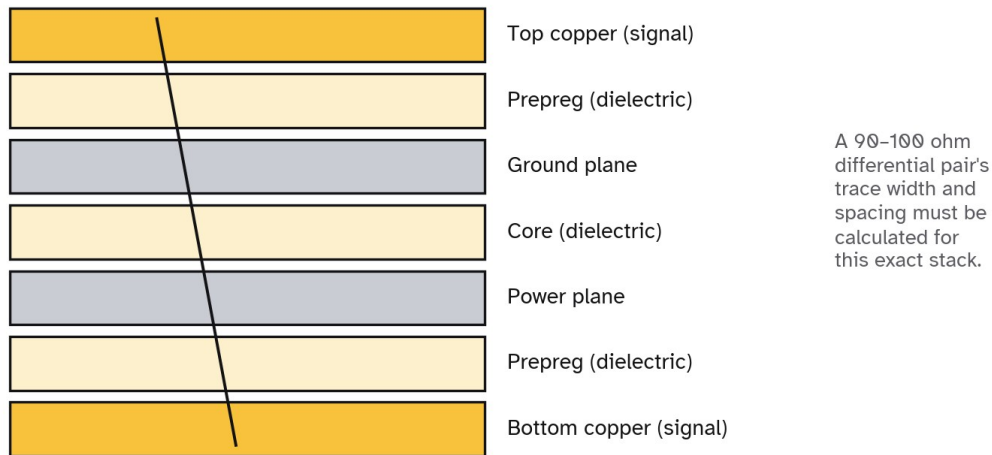
Apple's MFi programme requires a paid licence, an authentication IC in the accessory, and a formal certification process before you can legally manufacture and sell a Lightning-connector product — a business relationship, not just a part number.

Proprietary connector pinouts and specs are frequently only available under NDA, blocking the open, community-supported development hobbyists rely on.

Connectors rated for high-speed differential signalling require controlled impedance (typically 90Ω differential for USB, 100Ω for HDMI TMDS), length-matched differential pairs, and careful via/stub design.

Verifying eye diagrams, insertion loss, and return loss requires a vector network analyzer or high-bandwidth scope with TDR — well beyond typical hobbyist budgets.

Why "just add a high-speed connector" isn't simple



Risk Check

RISK	DETAIL
Licensing	MFi and similar programmes require legal agreements and certification fees
Documentation	Pinouts/specs often NDA-gated, blocking community support
PCB complexity	Controlled impedance, length matching, via stub management
Test equipment	VNA/TDR gear needed to verify signal integrity
Supply risk	Proprietary connectors often single-sourced, with MOQs and lead times

Safer Alternatives

- **USB (Type-C/Micro-B)** — universal, well documented, cheap, widely available breakout options
- **HDMI** — standard video connector with well-documented pinout
- **SPI/I²C headers** — simple board-to-board interconnects, easy to hand-solder or crimp
- **LVDS** — well-documented open standard for genuinely high-speed differential links

Recommended Action

1. Default to standard connectors (USB-C, HDMI, SPI/I²C) for every interface in the first design.
2. If ecosystem compatibility genuinely requires a proprietary connector, treat it as a budgeted business decision, not an engineering afterthought.
3. For very high bandwidth board-to-board links, consider off-the-shelf connector families (Hirose, Samtec) with published signal integrity data.

Decision Checklist

- ☐ No standard connector can meet the requirement
 - ☐ I've budgeted for licensing/certification if the connector is ecosystem-proprietary
 - ☐ I have access to signal integrity test equipment or a partner who does
 - ☐ I can manage controlled-impedance PCB design for the required data rate
 - ☐ Supply chain risk for a single-sourced connector is acceptable for my volume
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CHAPTER 6

High-End Application Processors

VERDICT **Prototype on an accessible MCU/SoC; only move to application processors with vendor support and volume.**

Confirm the Need

Does the product genuinely need smartphone-level compute and GPU-driven graphics? Or does it need to read sensors, run control loops, drive a simple display, and talk over a network — tasks a modern microcontroller handles comfortably?

Why It's Tempting

Application processors enable rich UIs, video, camera pipelines, and Linux/Android-class software — genuinely attractive for a product with ambitions beyond a simple embedded device, and the only option once you commit to MIPI-DSI displays or complex multimedia.

The Technical Reality

APs typically run a full operating system — embedded Linux or occasionally Android — requiring a bootloader, kernel configuration, and root filesystem build, a different discipline from bare-metal or RTOS firmware.

Many AP vendors gate full technical reference manuals, errata, and board support packages behind NDAs, meaning a hobbyist may not even be able to get the documentation needed without a business relationship with the vendor.

Peripheral drivers (camera ISP, GPU, display controllers, video codecs) are frequently vendor-supplied and sometimes binary-only, and can be buggy or poorly maintained outside the vendor's reference platform.

Many AP-class chips are sold through distribution with MOQs in the hundreds to thousands of units, or require a direct vendor relationship not available to individual hobbyists.

Sustained multi-core, GHz-class compute with a GPU generates real heat, and APs require multiple regulated voltage rails with specific power-up/down sequencing — getting sequencing wrong can prevent boot or damage the SoC.

Risk Check

RISK	DETAIL
Software complexity	Full OS/bootloader/kernel stack, not bare-metal firmware

RISK	DETAIL
Documentation access	Full technical reference manuals/BSPs often NDA-gated
Driver quality	Binary/closed drivers for camera, GPU, video can be buggy and hard to debug
MOQs	Distribution or vendor relationships may require volume hobbyists can't meet
Power sequencing	Multi-rail PMIC sequencing errors can prevent boot or damage the SoC
Thermal design	Real heat dissipation engineering required

Safer Alternatives

- **STM32/other Cortex-M MCUs** — bare-metal or lightweight RTOS, fully open documentation, mature free toolchains
- **ESP32** — Wi-Fi/BLE plus moderate compute, accessible SDK, enormous community knowledge base
- **Raspberry Pi Compute Module** — Linux-class compute with community-scale documentation and hobbyist-accessible purchasing
- **NXP i.MX series** — reasonable once vendor support and real volume are in place

Recommended Action

1. Prototype logic, sensing, and control on an accessible MCU/SoC, or a Raspberry Pi Compute Module if Linux-class compute/graphics is genuinely needed.
2. Validate the full product concept, including software architecture, before considering a raw vendor application processor.
3. Only move to a direct vendor AP once there's a funded plan for vendor support, documentation access, and volume that justifies MOQ commitments.

Decision Checklist

- ☐ My product genuinely needs multi-core compute and/or GPU-accelerated graphics
- ☐ A Raspberry Pi Compute Module doesn't meet the need at my target cost/power
- ☐ I have (or can establish) a vendor support relationship, including NDA-gated documentation access
- ☐ Forecast volume meets or exceeds typical distribution MOQs
- ☐ I have budget and expertise for embedded Linux bring-up, driver debugging, and thermal/power design

CHAPTER 7

High-End Analog Audio

VERDICT Avoid custom discrete analog audio unless expert-led with proper test equipment.

Confirm the Need

Does this product need to reproduce or capture audio at a level a critical listener would judge (hi-fi, music production, professional recording)? Or does it just need beeps, alerts, voice prompts, or "good enough" Bluetooth speaker quality? Most hobbyist products fall into the latter category and do not need audiophile-grade analog design.

Why It's Tempting

Audio is a domain enthusiasts have strong opinions about, and op-amp/discrete analog circuits look approachable — a handful of resistors, capacitors, and an op-amp — which hides how demanding the practical implementation actually is.

The Technical Reality

Getting the noise floor below roughly -100dB to -120dB relative to full scale requires careful attention to component noise, power supply ripple rejection, and physical layout.

Sub-0.01% Total Harmonic Distortion demands linear active devices operated well within their linear region and tight biasing.

A single ground loop or poorly placed return path introduces audible hum or high-frequency noise; star grounding and separating digital/analog ground planes are real disciplines with real failure modes.

PCB layout near switching regulators, crystal oscillators, or digital buses can couple noise straight into an analog signal chain — this is where many hobbyist designs quietly fail even with "audiophile grade" components.

Verifying noise and THD targets requires an audio analyzer or a low-noise oscilloscope with FFT — equipment most hobbyists don't own.

Risk Check

RISK	DETAIL
Invisible failure mode	Circuit "works" but has audible hum, hiss, or distortion that's hard to diagnose

RISK	DETAIL
Test equipment	Audio analyzers and low-noise scopes are expensive and specialised
Layout sensitivity	Ground loops and coupling are layout problems, not just schematic problems
Component selection	"Audiophile" parts marketing often doesn't correlate with measured performance
Time sink	Iterating on analog noise/distortion issues can consume weeks without resolution

Safer Alternatives

- **Digital audio interfaces** — USB audio class, I²S digital audio, Bluetooth A2DP — keep the signal digital until a well-characterised final DAC/amp stage
- Vendor reference designs from audio codec manufacturers (TI, Cirrus Logic, ESS, Analog Devices) that have already solved grounding/shielding
- Integrated audio codec modules for quick working audio without owning the analog design problem

Recommended Action

1. Start with a codec IC + manufacturer reference layout, or an off-the-shelf digital audio module.
2. Only pursue custom discrete/op-amp audio circuitry with specific expertise and proper measurement equipment.
3. If audiophile performance is core to the product, budget for either an analog design consultant or a long, iterative self-education process.

Decision Checklist

- ☐ Audio quality is a primary, judged product differentiator (not just "make sound")
- ☐ I have access to an audio analyzer or equivalent low-noise measurement setup
- ☐ I (or someone on the team) has prior analog audio design experience
- ☐ I've budgeted extra time for iteration on noise/grounding issues
- ☐ I understand PCB layout techniques for analog/digital separation

MORE FROM AP DESIGN LABS

Free tools for the builds this guide recommends: an ESP32 and XIAO pin planner, a LoRa repeater height planner, a winter solar sizer and battery-life calculators, plus build notes and more free guides at apdesignlabs.com.au.