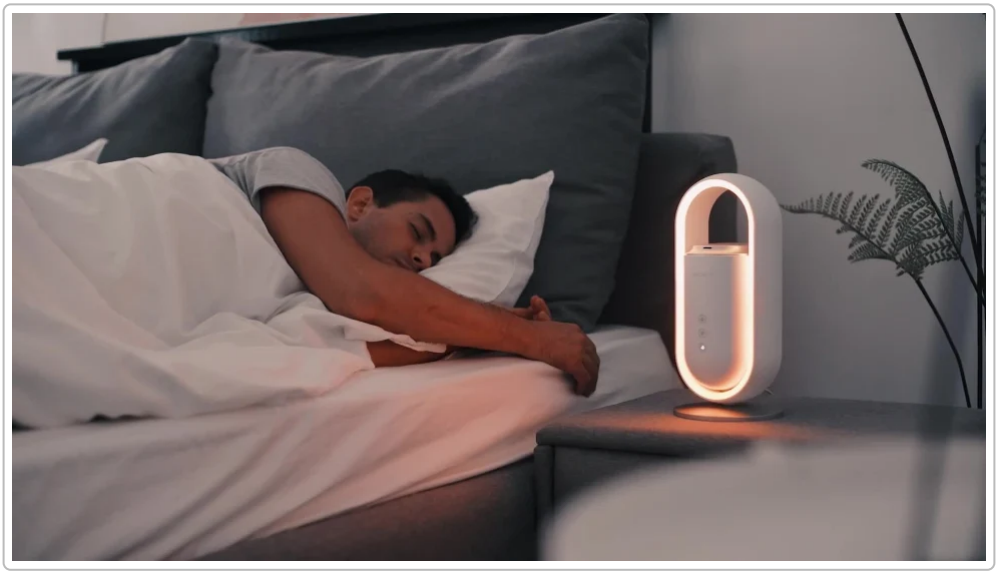
ChatGPT

Materials & Fabrication for Ritual Atmospherics

Overview: Designing a ritual ambiance device ("Herb SM" system) involves creating safe, controllable outputs that engage multiple senses. We focus on primary outputs of **light** and **sound**, with an optional **scent diffusion** module, all suitable for home use or small installations (with potential to scale up). A Bluetooth/Wi-Fi-enabled microcontroller will coordinate these elements, allowing central control via the Herb SM system, while also supporting a fail-safe stand-alone mode. The following sections survey programmable lighting rigs, sound and scent devices, recommend a modular hardware stack, and outline safety-first guidelines.



Example of a multi-sensory ambient device (Aromeo Sense) using soft light and essential oils for a calming ritual environment [1] [2] .

Programmable Light and Sound Systems

Lighting: Modern programmable lighting offers dynamic control over color, intensity, and patterns to set the desired atmosphere. For a compact home ritual device, **LED-based systems** are ideal – for instance, addressable RGB LED strips or smart LED modules that can produce a spectrum of colors and gentle fades. These can mimic candlelight, sunrise/sunset cycles, or other ritualistic lighting effects without the hazards of open flames. A microcontroller can drive such LEDs either directly (for low-power strips) or via driver circuits. Care must be taken to avoid strobe effects in the sensitive 5–30 Hz range, as flashing lights in that frequency can trigger discomfort or even seizures in photosensitive individuals [3] . Instead, transitions should be smooth and slow. Using warm-toned lighting in evening or meditative modes is recommended (e.g. dim amber or orange hues for relaxation, as used in the Aromeo Sense's sleep mode) while cooler tones can energize during focus sessions [4] . Ensure the LEDs are diffused (through frosted covers or lampshades) to create an ambient glow rather than harsh direct light. Additionally, LED systems run cool

but if many high-brightness LEDs are used, provide ventilation to dissipate heat and avoid enclosure hot-spots.

Sound: Soundscapes are a core part of immersive rituals – think of chanting, bells, or ambient music. A built-in **sound module** can play guided meditations, nature sounds, or soft music to complement the lighting. The Herb SM-controlled device can include a small speaker or audio transducer, driven either by the microcontroller (some microcontrollers can output audio via DAC/I^2S to an amplifier) or by pairing with an external smart speaker. Key is to maintain **safe volume levels**: prolonged sound should stay around conversational levels (≈60–70 dB) which are considered safe for long-term listening [5]. Providing volume control and a reasonable upper limit protects users' hearing and keeps the experience comfortable. For example, start sound at a low default volume – loud enough to set the mood but not so loud that one must shout over it (sounds above ~70 dB can cause hearing damage over time [5]). In a small room, even a 3–5 W mini speaker can suffice for gentle ambient audio. The system can also incorporate **sound-responsive effects** (e.g. lights that gently pulse with the music), but again any synchronization should avoid rapid flashes. By combining controlled lighting and soothing audio, the device can transform a space's mood at the press of a button or on a schedule (e.g. a morning alarm routine with a simulated sunrise and soft chimes).

Programmable Scent Diffusion (Optional Add-On)

Scent can powerfully enhance a ritual or atmosphere, but it introduces unique design and safety considerations. **Electronic scent diffusers** provide a controllable way to release fragrances or essential oils without open flames (avoiding traditional incense or candles for safety). Several approaches exist:

- **Ultrasonic Diffusers:** These are common home devices that use ultrasonic vibrations to evaporate water mixed with essential oil into a cool mist. They often include built-in LEDs and timers. A microcontroller can interface with such a diffuser by simulating button presses or switching its power. For example, one DIY IoT project used an optocoupler to trigger a standard diffuser's power button via an ESP8266 module [6]. This non-invasive method preserves the diffuser's internal safety features (like auto shut-off when water is low) while allowing external control. Ultrasonic diffusers are water-based, so **regular cleaning** is important – stagnant water left inside can breed mold or bacteria [7]. Users should empty and wipe the reservoir after use.

- **Fan-Based or "Nebulizer" Diffusers:** These methods forego water by either using a fan to blow air over an absorbent pad infused with oil, or by nebulizing pure oils into fine droplets. They allow stronger aroma output and avoid any heating. For a prototype, a simple implementation is a **mini fan module** that can be dipped in or placed over a scent pad or a vial – when the fan runs, it disperses the fragrance. This can be easier to control (just on/off the fan) and has no water to refill. Commercial devices like the Moodo "scent DJ" even use multiple scent cartridges with fans and let you blend them via an app [8] [9], though a DIY approach can start with a single scent at a time for simplicity.

- **Heating Elements:** *These are generally not recommended for safety reasons.* While one could use a resistive heating element to gently heat oils (simulating how a tealight oil burner works), **essential oils are highly flammable and should be kept away from open flames or high heat sources** [10]. Heat-based diffusion also risks degrading the oil or causing burns. It's safer to stick with cool-mist or fan methods. If heat is ever used, it must be very low-grade (just enough to volatilize the oil) and

equipped with temperature controls and auto-shutoff. However, given the safety-first goal, it's best to avoid active heating altogether in a unattended device [11].

When adding scent to the system, **dose and exposure must be carefully controlled**. Unlike light or sound which stop instantly when turned off, scents linger in the air. We should follow an intermittent diffusion schedule rather than continuous output [12]. For example, run the diffuser for 15–30 minutes at a time, then allow a rest period so the aroma doesn't become overpowering or cause sensitization. The Tisserand Institute notes that 30–60 minutes on, then equal time off, is both more effective and safer than constant diffusion [12] – the nervous system stops registering (habituates) after a while, and overexposure can even become stressful to the body with no added benefit [13]. Therefore, the Herb SM controller could automatically enforce such cycles (e.g. one could schedule a "ritual mode" where scent diffuses on a timer). Also ensure the space is **well-ventilated** when diffusing [14]. Good airflow prevents heavy buildup of VOCs from essential oils, which in high concentrations can irritate the respiratory system [15] [16]. Each user's sensitivity varies; some people (or pets) might find certain scents overwhelming or may have allergies, so providing an easy way to disable or swap out the scent component is wise.

Scent material considerations: Use only **pure, high-quality essential oils or aroma blends** intended for diffuser use. Synthetic or impure oils can leave residue or produce unwanted fumes when diffused. The device components that contact oils (reservoirs, tubing, pads) should be made of oil-resistant materials (many essential oils can dissolve common plastics). Typically, medical-grade polypropylene or glass are used for containers. If using a commercial diffuser, this is taken care of by the manufacturer; for a DIY build, choose components accordingly. Finally, store any refill oils safely – away from heat and out of reach of children.

Modular Hardware Components for Prototyping

To build this system, we recommend a **modular hardware stack** – each function (control, light, sound, scent) is a separate module that can be developed and tested independently, then integrated. Below is a list of core components and modules, emphasizing ease of prototyping and safety:

- **Microcontroller & Connectivity:** *Brain of the system.* Use a Wi-Fi/Bluetooth capable microcontroller board to receive commands and orchestrate outputs. An ESP32-based board (or similar IoT dev kit) is a strong choice – it provides 2.4 GHz Wi-Fi for cloud or local network control and Bluetooth for direct Herb SM pairing, all in a small, affordable package [17]. It has plenty of GPIO pins for sensors/actuators and can run standalone routines when not connected. Alternative boards could be Arduino models with added Wi-Fi (e.g. Arduino MKR WiFi 1010) or a Raspberry Pi if more heavy processing is needed, but a microcontroller is typically sufficient for controlling lights/sound and is real-time reliable. Ensure the board can be powered from a stable source (most dev boards accept 5V via USB or VIN pin and have onboard regulators). In code, implement a **fallback mode** that activates if the network connection is lost – for instance, the device can revert to a default lighting scene and soft music on loop so it remains functional on its own. Including some onboard input (buttons) for manual control of modes is also useful. (The Aromeo Sense, for example, has physical buttons to toggle between preset "focus/relax/sleep" modes without needing a phone [2].)

- **Lighting Module:** *High-output LEDs with driver circuitry.* For prototype simplicity, addressable RGB(W) LED strips (like Neopixels/WS2812 or APA102 types) are ideal – they run on 5V, can display arbitrary colors, and are easily programmed via libraries. These strips can produce dynamic patterns (fading,

pulsing, color shifts) and are modular (cut to length). If using only single-color or white light, a dimmable LED or LED bulb could be used instead. **Important:** Do not drive high-power LEDs directly from microcontroller pins – use a proper transistor or MOSFET driver for each channel [18]. For instance, if using a 12V LED strip or a common-anode RGB LED, you'd place an N-channel MOSFET for each color channel, controlled by a PWM-capable GPIO pin. This allows the microcontroller's 3.3V/5V logic to switch the higher voltage safely (preventing the "magic smoke" release from overstressing the microcontroller) [19]. Driver modules and logic level shifters can be bought off-the-shelf to simplify this interfacing. Additionally, plan the power budget for LEDs – a full-length LED strip at high brightness can draw significant current (each WS2812 LED can draw ~60 mA at full RGB white). Use shorter strips or limit brightness in code to keep current in check, or provide a dedicated 5V supply line for the LEDs. For larger installations, consider DMX-controlled LED fixtures or smart bulbs which come with built-in drivers (the microcontroller can output DMX or send wireless commands), but for home scale, low-voltage LED strips are sufficient and safe.

- **Sound Module:** *Audio playback and speaker.* The simplest route for prototyping is to use a small powered speaker (like a USB or battery-powered speaker) and feed it audio from the microcontroller or an attached audio player module. For example, one can use a DFPlayer Mini MP3 module or similar, which reads audio files from an SD card and outputs analog audio – the microcontroller sends it commands to play tracks. Alternatively, the microcontroller can output synthesized tones or simple audio by itself; an ESP32 can even stream moderate-quality audio data thanks to its DAC. For better audio quality or flexibility (like streaming from a library of sounds), one could integrate a single-board computer or use Bluetooth to trigger audio on a separate device. Initially, a **single-channel (mono) speaker of 3W–5W** is enough for ambient sound. Mount the speaker in the device enclosure with proper cut-outs or a grille for sound. Provide a means of volume adjustment – either via a physical knob (potentiometer) or software control – and set conservative default volumes. Since sound is a primary output, treat the speaker as an integral module that can be swapped (for a bigger speaker or a stereo setup) if scaling up. If the device is likely to be used at night, consider a headphone jack output as well, so a user could use it silently (though for rituals this may be less relevant).

- **Scent Diffuser Module (optional):** *Interchangeable scent unit.* This could be a modified off-the-shelf diffuser or a custom mechanism as discussed. For prototyping, using a ready-made **mini diffuser** is convenient: for example, a USB-powered diffuser or aroma humidifier can be obtained cheaply – you can then hack it by wiring its power through a MOSFET or relay controlled by the microcontroller, or by simulating the button press [6]. The microcontroller would effectively turn the diffuser on/off per the desired schedule. Ensure the control method does not bypass built-in safety (e.g., if the diffuser has a timer or water sensor, it's best to trigger it normally so it will still auto-stop when empty). If building a custom scent dispenser with a fan, treat that fan like any other motor load – possibly use a transistor or a small motor driver to switch it on/off (many fans are 5V DC and can run directly, but a driver avoids back-EMF issues). Also include a way to **contain the oils** (a cartridge or absorbent pad) to avoid spills inside the device. This module should be easily removable for refilling or cleaning. Eventually, one could imagine having **multiple scent cartridges** for different moods (like "energizing" vs "calming" scents) that the system selects between, but to start, a single scent output is simpler and avoids mixing concerns.

- **Power Supply and Regulation:** All modules need to be powered from a common supply. A home-based device can plug into the wall via an AC/DC adapter (choose a quality adapter that meets the

voltage and current requirements with some headroom). For instance, a 5V 3A adapter could run a small system (sufficient for a microcontroller, a short LED strip, and a small diffuser). If using 12V LED strips or certain diffusers, you might opt for a 12V supply and then use a DC-DC converter (buck regulator) to step down to 5V or 3.3V for the logic and other parts. Keep power rails and ground connections robust to handle peak currents (e.g., LED surge when all turn on). It's good practice to put a fuse or resettable polyfuse on the main input for safety – this prevents overload or short conditions from causing fires or damage. Also, ensure separation of high-voltage sections if any (for example, if a component runs directly off mains, which ideally none should in a low-voltage design). Since this is for a ritual device, **portability** might be considered – if battery operation is needed for an installation without outlets, one could use a rechargeable battery pack, but that adds complexity (battery management, shorter runtime). For initial prototyping, stick to plug-in power for reliability.

- **Enclosure & Assembly:** Finally, plan for a **modular enclosure** that houses these components safely. A prototype might use a 3D-printed or laser-cut enclosure with compartments for each module (light, sound, scent, electronics). Keep the electronics section insulated and away from any liquid (oil/water) sections – for example, mount the diffuser at the top with a seal, and electronics at the bottom. Provide ventilation slots especially near any component that can get warm (LED drivers, voltage regulators, or the diffuser's ultrasonic transducer if it warms up). Use fire-retardant materials if available (some plastics like ABS are flammable, whereas polycarbonate or certain resins are more heat resistant). All user-accessible parts (buttons, refillable oil container) should be easily reachable without exposing wiring. A **base or stand** is important for stability – the device should not tip over if placed on an altar or shelf. For scaling up to an installation, the enclosure design might change (e.g., mounting lights around a room and having a centralized controller), but the modular approach ensures each piece can be handled appropriately.

Safety Checklist for Materials & Exposure

When building and operating a multi-sensory ritual device, safety must remain the top priority. Below is a checklist of safety considerations covering electrical, thermal, chemical, and user safety:

- **Electrical Safety:** All electrical connections should be secure and insulated. Use proper wire gauges for LED strips and power lines to handle the expected current. Avoid overloading the microcontroller pins – use transistors, relays or driver modules for controlling anything beyond low-power LEDs or sensors [18]. Include a fuse on the primary input. Double-check polarity and voltage levels when connecting components (e.g., ensure 5V to the 5V pin, not to a 3.3V pin). If the device plugs into mains power, the AC/DC adapter must be certified (look for UL/CE markings) to prevent shock or fire hazards. Grounding is important: common ground all modules to avoid floating potentials, and ground the enclosure if it's metal.

- **Heat & Fire Safety:** Design the device so that no part gets excessively hot during normal use. High-power LEDs and voltage regulators can heat up – use heatsinks or limit their output. Never enclose a heat source without ventilation. **Do not use open flames** in the device; replicate candlelight with LEDs. Remember that many essential oils and their vapors are flammable – keep them away from any ignition source [10]. Even a heating element, if used, should be well below the flash point of the oils. All materials near lights or diffuser should have a high melting point or flame resistance. If using a plastic enclosure, ensure the internal temperatures stay far below its deformation temperature. It's wise to add an **auto-off timer** or thermal cutoff: for instance, if the device runs a

long session, have it automatically power down after a certain number of hours to cool off and prevent any unattended overheating.

- **Chemical & Scent Safety: Ventilation** is crucial when diffusing scents [14]. Operate in a room with some airflow (or periodically air it out) – this prevents the buildup of VOCs and keeps oxygen levels normal. Use only diffuser-approved oils; some oils can produce irritants (or even toxic compounds) when overheated or used in excess. Avoid diffusing allergenic oils or at least warn users to choose oils they know are safe for them. Adhere to **intermittent diffusion** guidelines (don't run the scent continuously for hours on end) [12]. A good rule is no more than 60 minutes of diffusion per hour, often less. Overexposure can cause headaches, nausea or respiratory irritation in sensitive individuals, even if the scent is pleasant. The system should ideally enforce reasonable limits (for example, the software can turn off the diffuser after 30 minutes automatically). If the device is used in a public or group setting, always get consent for diffusing oils and be prepared to turn it off if anyone feels uncomfortable. Also, **keep oils out of reach** – store refill bottles safely and design the device so that if it's knocked over, oil won't easily spill onto electronics or surfaces. In case of a spill, unplug the device before cleaning.

- **Light Safety:** The visual output should be calming, not harmful. Avoid pointing bright LEDs directly at eye level; indirect or diffused light is preferable. If using any high-intensity LEDs or laser elements for special effects (likely not needed here), follow appropriate eye-safety standards (most importantly, no class 3B/4 lasers or powerful UV lights in a consumer device). For LEDs, the main hazard is flicker and brightness. As noted, **avoid rapid flashing** especially in the 5–30 Hz range [3] to not trigger photosensitive epilepsy or simply discomfort. Keep any dynamic lighting slow and "breath-like." If strobe effects are desired for some reason, users should be warned and ideally a manual override provided. In terms of brightness, in a dark room even a 1W LED can feel blinding – so use diffusers and lower brightness levels for LEDs when used in small or intimate spaces. One can also incorporate an ambient light sensor to auto-dim the LEDs in very dark environments. Always test the lighting on yourself in a dark room first: if it feels too harsh or causes eye strain, adjust the design (e.g., add a diffuser or reduce LED count).

- **Sound Safety:** We've addressed volume – keep it moderate. Also consider the frequency content: extremely bass-heavy or shrill sounds might be uncomfortable even at lower dB. Use high-quality sound files to avoid harsh noise. If using looping soundscapes, ensure the loop is smooth to not jolt the listener. The device should power on at a low volume by default, as sudden loud noise can startle. If headphones can be used, implement a volume limiting circuit or follow the standard that ~50% volume on personal devices is a safe level [20]. For public installations, if amplifying sound, monitor the levels with a decibel meter initially to set a safe maximum. Also be mindful of **noise pollution** – if used at home, the sounds should not inadvertently disturb others in the vicinity (e.g., avoid sub-bass that could vibrate through walls).

- **Mechanical & User Safety:** Physically, the device should be stable and robust. All heavy components (like a water reservoir in a diffuser) should be secured so the unit isn't top-heavy. If the device is floor-standing for a larger ritual space, ensure it has a wide base or mounting to prevent tip-over. Edges of the enclosure should be smooth or rounded to prevent cuts or snags. **Child/Pet Safety:** If there's any chance children could access it, avoid small detachable parts that could be choking hazards. Use child-resistant design for any openings that lead to the oils. Pets can be sensitive to oils (cats especially lack enzymes to metabolize certain compounds) [21] [22], so ensure the device is

placed where pets can't directly ingest the oil or lick the diffuser. From a user interaction perspective, clearly label any manual controls and provide instructions – e.g., an indicator light for when the diffuser is active (so users know when scent is being emitted), and perhaps a warning if the device's oil is low. As a final check, perform a **fault scenario test**: consider what happens if a component fails (e.g., if the fan in the diffuser gets stuck, does the unit safely shut off to prevent overheating? [23]). Incorporating fail-safes like thermal fuses or software watchdogs that turn off components if they aren't responding as expected can add an extra layer of safety.

- **Scaling Up Precautions:** For larger ritual environments (e.g., multiple devices in a hall), remember that risks scale as well. More devices mean more combined heat and more scent in the air – plan for **distributed deployment** (don't cluster diffusers all in one corner, spread them out and perhaps use a central controller to synchronize them). Ensure the electrical infrastructure can handle multiple units (each drawing power). If using radio communication, ensure signals remain reliable in the bigger space (might need mesh networking or repeaters). Always comply with venue regulations – e.g., some venues have strict rules about fog/scent machines due to fire alarm concerns, so verify that gentle diffusers won't set off alarms (they normally shouldn't, but dense theatrical foggers could). Use flame-retardant cable casings and secure any cabling to avoid trip hazards in an installation. In essence, treat a scaled installation with the same caution as any public interactive art piece – do a risk assessment and have contingency plans (like easily accessible power cut-off switches, and personnel monitoring during use).

Prototype Implementation Plan

Building the prototype can be tackled in stages, verifying each function before combining them. Below is a step-by-step plan to prototype the Herb SM ritual device:

1. **Controller Setup:** Begin by configuring the microcontroller with basic firmware. Program it to connect to your control interface (e.g., pair with the Herb SM app or listen on Wi-Fi for commands). Also implement a simple standalone loop – for instance, a routine where it cycles through a default light color pattern and plays a gentle sound periodically. This will be the fallback if no external control is present. Test the connectivity (e.g., send a command from a phone or computer to blink an onboard LED or print a message). Ensuring reliable communication early on is key.

2. **Integrate and Test Outputs One by One:**
   a. *Lighting:* Connect a small section of the LED strip to the microcontroller (through a level shifter or driver as needed). Write a test code to set the strip to various colors and brightness. Power this from a bench supply or the intended adapter and verify the colors mix correctly and the strip doesn't flicker or brown-out (if it does, you may need to inject power at both ends of the strip or use a larger gauge power wire). Try out a simple animation (e.g., a slow pulse or color transition) to confirm smooth control. Adjust code for any timing issues (some LED libraries require specific CPU timing, especially on Wi-Fi chips, so you may need to disable Wi-Fi while updating LEDs or use dual-core features of ESP32).
   b. *Sound:* Hook up the audio module or speaker. If using a DFPlayer or similar, load a couple of ambient sound files (e.g., a short music loop or nature sounds) on the SD card. Use the microcontroller to send a play command. If using the ESP32 DAC, you might generate a test tone or simple waveform first. Gradually work up to playing an actual audio clip – you may need to integrate an audio library or stream from memory. Ensure the volume is initially low – play the sound and

manually listen or measure if possible. Check there's no excessive noise or distortion. If the sound quality is poor, consider if it's the file encoding or if you need an amplifier. Resolve those issues (perhaps by using an external small amplifier board if driving a loudspeaker directly is insufficient).
c. *Scent:* If you have a commercial diffuser to integrate, open it up or use its manual controls to understand how it toggles. For a unit with a simple on/off button, one approach is to control its power line with a relay module – wire the relay in series with the diffuser's power input (or USB cable) so the microcontroller can cut power on or off. Test this by toggling a microcontroller pin controlling the relay: does the diffuser start/stop as expected? (Make sure the diffuser is left in the "on" switch position if it has a manual switch). If using an optocoupler across the button contacts as in some hacks [24] [25], test that the optocoupler indeed triggers the on/off. This might require some soldering onto the diffuser's PCB – ensure those connections are solid and won't short anything. For a DIY fan-based diffuser, connect the small fan to a transistor output and test turning it on for a few seconds (you should feel airflow). In any case, once the control is working, add a few drops of a chosen essential oil to the diffuser and run it briefly in a ventilated area – verify you can smell it and that the amount is reasonable. This will help in calibrating how long it needs to run to scent a small room without being overpowering.

3. **Module Integration:** Now combine the modules and get them working together. Mount the LED strip, speaker, and diffuser in the provisional enclosure or on a test bench in their relative positions. Update the microcontroller code to handle simultaneous tasks – e.g., it should be able to fade lights while playing sound and also cycle the diffuser on a timer. This may involve using non-blocking code or an RTOS if using ESP32 (or simply careful scheduling of tasks). Implement the logic for mode changes: for example, define a "Meditation Mode" where lights are dim and flicker like candles, soft music plays, and the diffuser emits a calming scent intermittently. Also define an "Energize Mode" where lights are brighter or dynamic, uplifting sound plays, and perhaps a different scent. The Herb SM system could send a command to switch modes, or the user could press a local button. Test each mode end-to-end. Make sure transitions between modes turn off the previous settings (e.g., if you switch off a mode, the diffuser and sound from the previous mode stop). This is a good time to incorporate safety checks in software: for instance, a counter for diffuser runtime so that even if a mode is left on, the scent will cycle off after 30 minutes automatically [12]. Also handle error states – if the diffuser was to run out of water (some have an indicator or will simply stop misting – you might detect it via a current draw drop or a sensor if advanced, but at least ensure the system can handle the diffuser turning off on its own without getting out of sync).

4. **Safety and Stress Testing:** With everything running, do a series of test runs to simulate actual use. **Thermal test:** run the device for an extended period (say a couple of hours in a safe observed setting) with lights at medium-high brightness and some sound playing. Periodically check temperatures of key parts (the microcontroller, LED drivers, power supply, diffuser body). Nothing should be more than warm to the touch. If something is hot, address it (improve cooling or reduce load). **Continuous operation test:** especially for the diffuser, ensure it doesn't malfunction if left on. Most ultrasonic diffusers have auto-shutoff when water is low – test that this still works under microcontroller control (i.e., let it run out of water; it should stop misting and not burn out). Verify the microcontroller can reconnect to the Herb SM system after losing and regaining connection (simulate by turning your router or Bluetooth off and on). Also test the **stand-alone mode:** turn off the controlling app and see that the device still cycles through some default behavior (this ensures rituals aren't interrupted by connectivity issues). **User testing:** if possible, have a few people experience the device in a small room as a mock ritual. Pay attention to feedback – e.g., does anyone

find the scent too strong, the light too dim, or the sound annoying? Use this to fine-tune the settings (maybe the diffuser only needs to run 5 minutes every 15 in a small space, or the light could be even more diffused).

5. **Iteration and Scaling:** Incorporate the findings from testing into the next prototype revision. This could mean using a larger enclosure to space components out for cooling, adding an extra feature like an LCD status display (to show mode or timers), or simply adjusting software parameters. Once the design works well for one unit, consider how it scales. For a **larger installation**, you might network multiple units – for example, having one master controller send synchronized commands to several identical devices placed around a room. In that case, ensure each device has a unique address or identifier so they don't interfere with each other's signals. If lighting a large space, you might replace the small LED strip with, say, a DMX-controlled stage light; the microcontroller could output DMX signals or you might use an intermediate controller. For sound in a big space, you'd likely tie into a PA system rather than tiny speakers – but the prototype's sound module logic can instead send its audio to a mixer or trigger playback on a more powerful system. Similarly, for scent in a large venue, multiple diffusers (or a commercial HVAC scenting unit) would be used – but each would follow the same safety timing and dose principles as the small one. The modular prototype you built can serve as a **blueprint**: each module can be "scaled up" (e.g., replace a 1 m LED strip with a 5 m strip or a spotlight, use a bigger amplifier for sound, multiple diffusers for scent). By keeping the control logic flexible, the Herb SM system can address each output module no matter its size. Document all the component specs and settings clearly in a manual or README for the project. This will help others (or future you) replicate and maintain the system, and it ensures that safety considerations (like recommended run times, volumes, etc.) are communicated. Before deploying in a public setting, do a final safety audit against the checklist above and local regulations.

With a robust hardware stack, safety measures in place, and iterative testing, the resulting device will be a **reliable, safe, and immersive ritual companion**. It can transform environments with light, sound, and fragrance in a controlled way – enhancing mood and focus while prioritizing the well-being of users. By starting with home-scale prototypes and modular design, we also ensure the concept can grow organically into larger experiential installations without compromising on safety or controllability.

Sources:

1. Brian Nadel. *"IOT Essential Oil Diffuser."* Instructables – showing how to hack a simple diffuser with an ESP8266 for wireless control [26] [6].

2. *"LED Controller."* Instructables – project using an ESP32 and transistors to drive LED strips (includes discussion on voltage and transistor switching for safe LED control) [17] [18].

3. Lindsey Vickers. *"The bedside device that's a light, sound machine, and oil diffuser all in one."* Reviewed.com (Apr 15, 2024) – describes the Aromeo Sense device with integrated modes (focus/relax/sleep) and its multi-sensory outputs [1] [2].

4. AromaTech. *"Are Electric Oil Diffusers Safe?"* (Oct 28, 2020) – explains safety concerns of diffusers, advising to avoid cheap units and any that use heat or flame, and to keep units clean to prevent bacteria [11] [7].

5. American Lung Association – *Essential Oils: More Harmful Than Helpful?* (Jan 8, 2024). Blog post highlighting that essential oil VOCs can irritate lungs, and recommending to use diffusers with ventilation and not to overexpose (cites issues with >1 hour/day use) [16] [14] .

6. Tisserand Institute – *"Safety guidelines for diffusion."* – Quote from Robert Tisserand advising intermittent diffusion (30–60 minutes on, then off) as safer than continuous; notes that continuous diffusion can stress the body without added benefits [12] .

7. Epilepsy Foundation – *"Photosensitivity and Seizures."* – States that flashing lights between ~5–30 Hz are most likely to trigger seizures in sensitive individuals (small percentage of people) [3] , informing our guideline to avoid such flashing frequencies.

8. Hearing Health Foundation – *"What Are Safe Decibels?"* – Defines that sounds at or below 70 dB are considered safe for prolonged exposure, whereas higher levels can cause hearing damage over time [5] . This supports keeping device audio in a safe volume range for relaxation.

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[1] [2] [4] Aromeo Sense: the new bedside device to help you sleep better - Reviewed
https://www.reviewed.com/sleep/features/aromeo-essential-oil-sound-light-bedside-device

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[7] [11] [21] [22] [23] Are Electric Oil Diffusers Safe?
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