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Flash Aid: Development and Preliminary Assessment of an Integrated Emergency Power and Alert Prototype

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Abstract. This development study presents Flash Aid, a portable prototype integrating emergency power outputs and a vibration-triggered alert. The unit combines a nominal 12.8 V, 30 Ah lithium iron phosphate battery, a battery management system, an inverter rated at 500 W, direct-current and USB outputs, and an Arduino-controlled siren. The assessment describes the assembled device, indoor functional checks, and an energy-budget analysis using explicitly stated assumptions. The battery specifications give a nominal energy capacity of 384 Wh. At an assumed inverter efficiency of 85%, calculated single-load runtimes are 36.3 hours for a 9 W lamp, 4.4 hours for a 75 W fan, and 2.2 hours for a 150 W load. These values are estimates rather than measured discharge durations. The assembled unit reportedly weighs approximately 4.1 kg, and its siren activated during a tabletop vibration demonstration. That response does not establish earthquake-detection accuracy or warning lead time. The prototype demonstrates the integration of power and alert functions in one enclosure. Its practical performance depends on usable battery capacity, conversion and standby losses, load characteristics, and operating conditions. Further work should establish load-dependent efficiency, thermal behavior, vibration discrimination, acoustic performance, electrical safety, and usability under realistic conditions before community deployment.

Keywords: emergency power; prototype development; lithium iron phosphate; vibration sensing; energy budget; disaster preparedness

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Introduction

Power interruptions create a practical need for lighting, device charging, and access to information. During emergencies, these needs may arise together while households have limited space, transport capacity, and access to replacement batteries or mains power. A portable device that combines several low-power functions could reduce the number of separate units that must be carried and maintained. However, combining functions also creates trade-offs in stored energy, heat, weight, wiring, and ease of use.

Flash Aid was developed as an integrated emergency power and alert prototype for this household context. Its main contribution is the assembly of an energy-storage module, several electrical outputs, and an audible alert within a compact enclosure. The work is a preliminary development study; the contribution lies in documenting the configuration and its engineering constraints, rather than in introducing a new battery chemistry, inverter topology, or seismic-detection algorithm.

Related work and design rationale

Battery selection and protection are central to a portable power system. Zhao et al. (2024) review lithium iron phosphate across its life cycle, including material development, applications, and recycling. That literature provides a rationale for considering this chemistry, but properties reported for the material do not establish the safety or service life of a particular assembled pack. Cell quality, connections, protection, charging, and the enclosure must be assessed at the system level.

Gabbar et al. (2021) examine battery management systems, including their monitoring, control, integration, and safety requirements. Although their review focuses on transportation and stationary energy storage, the distinction between selecting protective components and evaluating the complete system is relevant here. The inclusion of a battery management system in Flash Aid is therefore described as a design feature; it is not treated as independent proof of compliance or protection under every fault condition.

An audible alert also has to be distinguished from an effective warning system. Sadiq et al. (2023) synthesize research on public alerts and warnings, including lessons concerning the information and actions associated with warnings. A siren can attract attention, but its activation alone does not identify the hazard, establish the reliability of detection, or tell a person what protective action to take. This distinction is especially important when a local vibration sensor is described as an earthquake alarm.

Objectives and scope

The study documents the prototype configuration; describes the reported functional observations; calculates illustrative runtimes from the stated battery and load specifications; and identifies requirements for subsequent performance and safety testing. The energy calculations are separated from observations so that assumptions are not presented as experimental results. No claim is made that the prototype has been established as a medical power supply, a certified emergency warning device, or an operational earthquake early-warning system.

Methods

Development approach and artifact

The study used a prototype-development approach. Commercially available components were assembled in an acrylonitrile butadiene styrene (ABS) enclosure. The reported configuration includes a 32140 lithium iron phosphate battery pack arranged as four series-connected groups with two cells in parallel (4S2P), a nominal 12.8 V and 30 Ah rating, and a battery management system described as 4S, 60 A. The enclosure incorporates switches, a battery-capacity display, two USB ports, two 5.5 mm DC sockets, an AC outlet, and cooling fans. The inverter is rated at 500 W by its stated specification.

The alert subsystem uses an Arduino Nano, an accelerometer module, a relay, and a siren. Manual activation and a standby setting for vibration-triggered activation are described. The available account does not identify the accelerometer model, firmware, sampling rate, trigger threshold, filtering method, or timing logic. These details are necessary for reproducing the automatic detection behavior and are treated as requirements for a subsequent technical evaluation.

Table 1

Principal specifications and intended functions

Component or property	Reported specification or function
Battery pack	LiFePO4, 4S2P; nominal 12.8 V, 30 Ah
Nominal stored energy	384 Wh, calculated from voltage and capacity
Battery management system	4S, 60 A stated rating
Inverter	500 W stated rating; AC output
Auxiliary outputs	Two USB ports and two DC sockets
Alert subsystem	Arduino Nano, accelerometer, relay, and siren
Enclosure and mass	ABS enclosure; approximately 4.1 kg reported mass
Cooling and monitoring	Two DC fans and a battery-capacity display

Note. Component ratings describe the reported configuration. They do not establish continuous system output, usable battery energy, fault protection, or conformity with an electrical safety standard.

Functional checks and instrumentation

The source account describes indoor checks of the power outputs, connections, indicators, and siren, together with tabletop shaking to trigger the vibration response. It identifies a digital multimeter, watt meter, USB power tester, sound-level meter, and infrared thermometer as instruments available for assessment. Although repeated trials and instrument calibration are mentioned, trial-level observations, instrument models, calibration records, measurement distances, and uncertainty estimates are not provided. Consequently, the present report does not calculate standard deviations, confidence intervals, or statistical comparisons from those statements.

The tabletop demonstration is treated as a functional check: the sensor–controller–relay chain was reported to activate the siren when the supporting table was shaken. It does not provide a controlled vibration frequency or acceleration, a comparison with seismic intensity scales, or counts of true and false detections. No claim of seismic sensitivity, specificity, or prediction is derived from it.

Energy-budget calculations

The nominal energy estimate is calculated as $E = V \times C$, where E is energy in watt-hours, V is nominal battery voltage, and C is capacity in ampere-hours. Using 12.8 V and 30 Ah gives $E = 384$ Wh. For a constant-power load, estimated operating time is $t = E \times \eta / P$, where t is in hours, P is delivered load power in watts, and η is the assumed overall conversion efficiency for the relevant route. For the AC examples, $\eta = 0.85$ is an illustrative assumption retained from the source calculation; it is not a measured efficiency curve.

For a nominal direct-current load, E/P gives an ideal upper bound when conversion, wiring, standby, and cutoff losses are ignored. For USB loads, the same ideal bound is shown only to establish the energy scale; practical duration depends on the DC-to-USB converter and the connected device. Multiple loads share the same battery energy and cannot each be assigned the full single-load runtime simultaneously.

The relation $I = P/V$ applies to a DC load at the point where power and voltage are defined. In an AC circuit, voltage and current alone do not determine real power without accounting for power factor. Likewise, battery-side current and appliance-side current are different quantities. The analysis therefore uses specified load power and nominal battery energy consistently, rather than mixing currents and voltages measured at unspecified circuit locations.

The available numerical tables do not provide paired battery input and AC output measurements with a common time basis. They cannot establish inverter efficiency, which would require $\eta = P_{out}/P_{in}$, or the equivalent ratio of integrated output and input energy over a defined interval. Accordingly, the uniform 85% value is used only as a calculation scenario, and the originally reported efficiency percentages are not presented as experimental findings.

Ethical and reporting considerations

The work concerns a hardware artifact and reports no human or animal participants. The description separates component specifications, observations, and calculations. No user-study, clinical-use, safety-certification, or real-disaster outcome is inferred from the prototype demonstrations.

Results

Assembled prototype and functional observations

The assembled prototype combines power outlets, controls, and an alert subsystem within one enclosure. The reported mass is approximately 4.1 kg. This indicates that the unit can be transported as a single object, but ease of carrying, accessibility for older users, and suitability for evacuation have not been assessed through a user study. The report describes the output ports and indicators as operational during indoor checks.

Figure 1

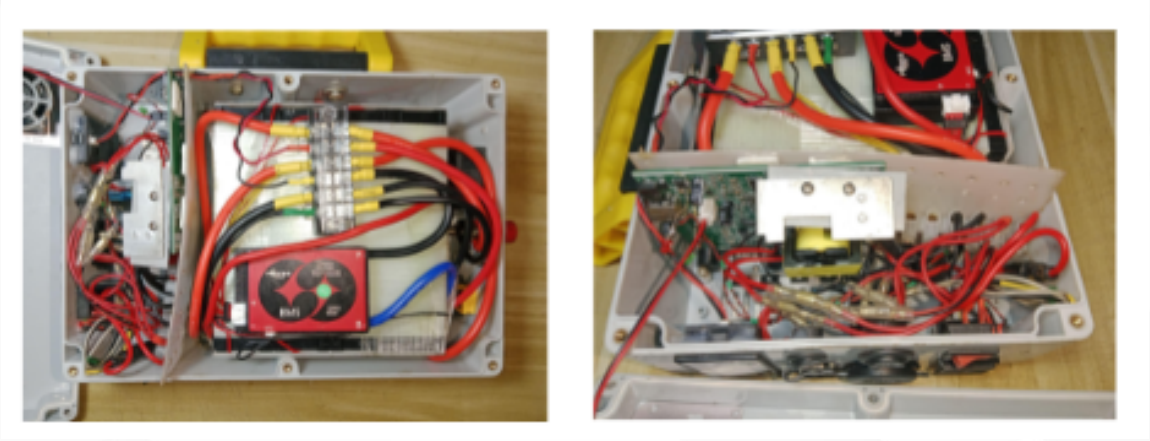
External panels of the Flash Aid prototype



Note. Photographs supplied with the manuscript show the outlet arrangement and controls.

Figure 2

Internal assembly and power modules



Note. Photographs document the assembled hardware. They do not constitute an electrical safety inspection or certification.

Calculated single-load runtimes

Table 2 presents recalculated estimates using one consistent nominal energy value. For AC loads, the 85% scenario gives 326.4 Wh of assumed delivered energy. The estimates decrease as load power increases: a 9 W lamp gives 36.3 hours, a 75 W fan 4.4 hours, and a 150 W load 2.2 hours. These are energy-budget calculations and should not be read as measured run-to-cutoff durations.

Table 2

Illustrative runtime estimates from a nominal 384 Wh battery

Illustrative load	Route	Power (W)	Time (h)	Basis
12 V LED	DC	3	128.0	Ideal bound
LED bulb	AC	9	36.3	85% scenario
Glue gun	AC	20	16.3	85% scenario
Electric fan	AC	75	4.4	85% scenario
USB device	USB	5	76.8	Ideal bound
Digital blood-pressure monitor	Unspecified	5	76.8	Ideal bound
Nebulizer	AC	150	2.2	85% scenario

Note. Each row assumes one constant-power load and full availability of the nominal energy. Ideal bounds exclude all losses; AC scenarios assume 85% conversion efficiency. The monitor's interface is unspecified, so its ideal bound does not establish a usable supply configuration. Device names identify illustrative electrical loads, not approval for medical use.

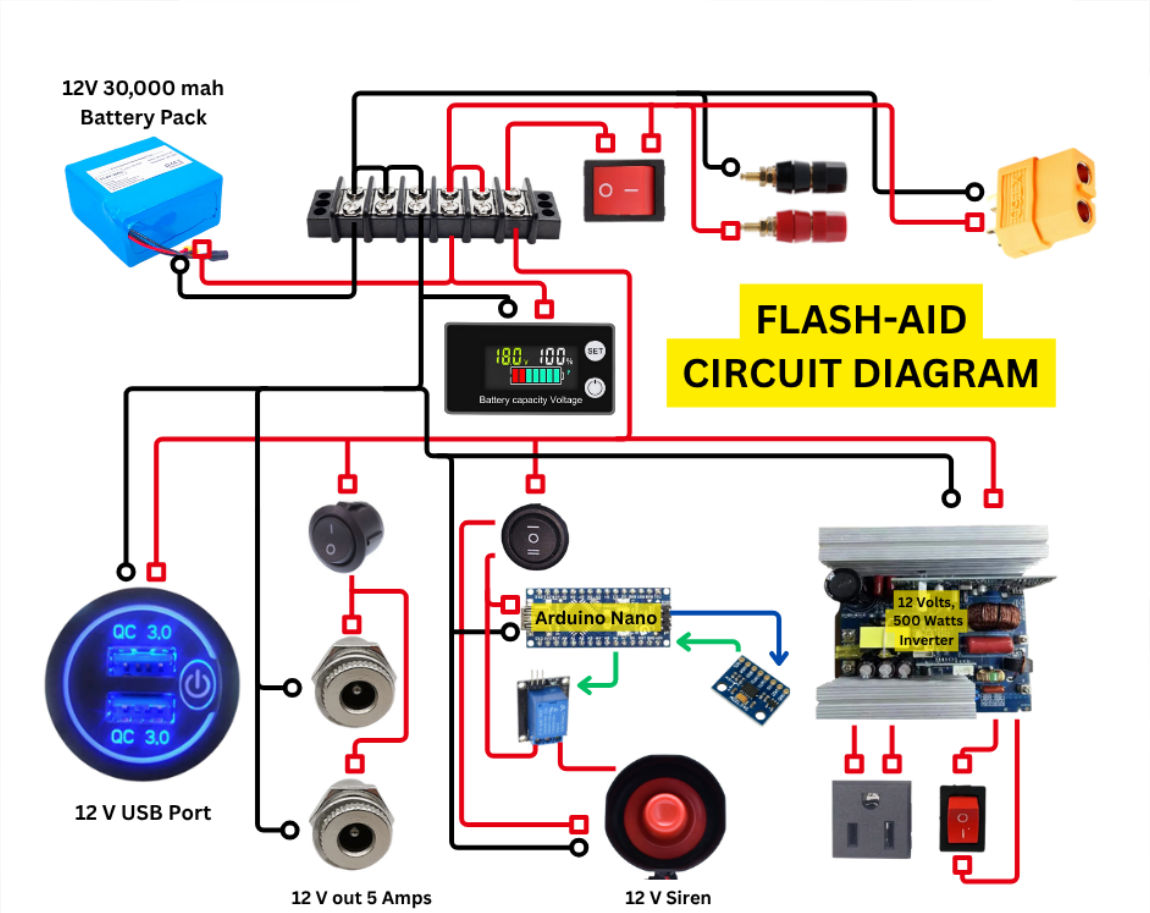
Actual duration will differ with usable depth of discharge, battery condition, cutoff settings, standby consumption, cooling-fan use, temperature, and the load's operating cycle. At low appliance power, inverter standby losses can account for a substantial part of the energy demand. Neither a fixed efficiency assumption nor nominal battery capacity is sufficient to determine an actual runtime without measured discharge data.

Alert response and design documentation

The siren reportedly activated during the tabletop vibration demonstration and could also be switched manually. The source describes a nominal 110 dB siren rating but provides inconsistent statements about whether acoustic output was measured. The value is therefore treated only as a stated device specification. No tested sound-pressure level, distance of audibility, or performance in a noisy environment is reported.

Figure 3

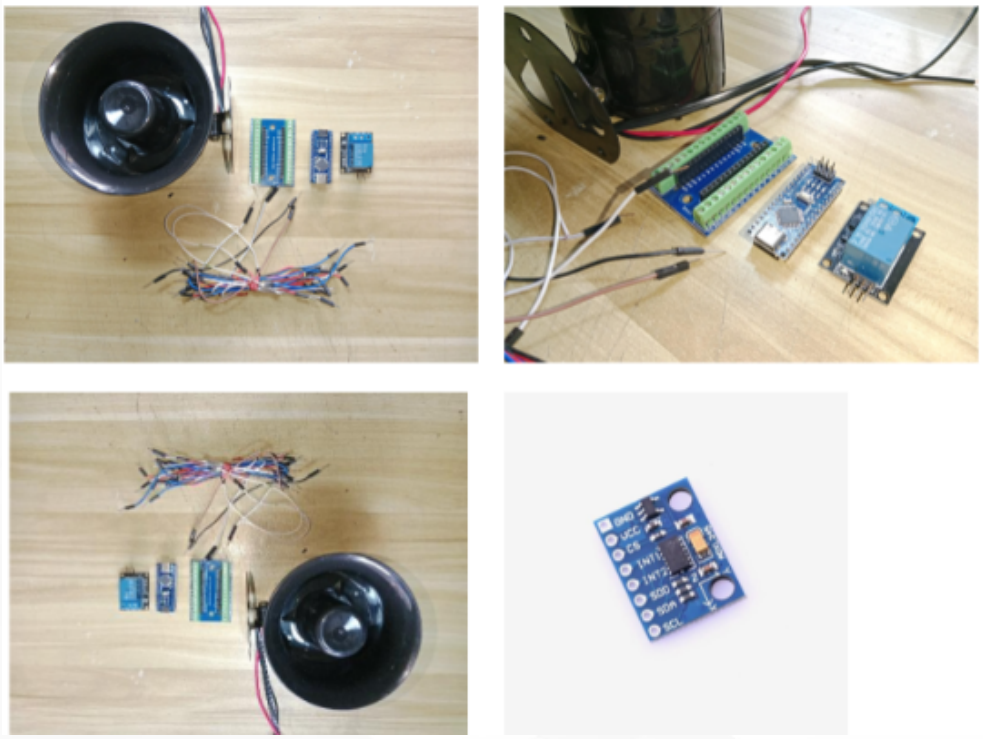
Circuit layout supplied for the prototype



Note. The diagram records the component arrangement provided by the author. Detailed protection, grounding, conductor, firmware, and test specifications are needed for reproducible engineering evaluation.

Figure 4

Components of the vibration-triggered alert subsystem



Note. The supplied photographs show the siren, controller, relay, and sensor modules.

Discussion

Energy capacity and output trade-offs

A nominal 384 Wh battery provides a finite energy budget that must be allocated across lighting, charging, signaling, and any connected appliances. The calculations demonstrate the inverse relationship between load power and operating time. They also show why a 500 W inverter rating must not be confused with stored energy: power describes the instantaneous load, whereas energy determines how long that load can be supported. The inverter rating is not evidence that the assembled prototype can sustain 500 W continuously or tolerate every motor-starting surge.

The integration of AC, DC, and USB routes gives the design flexibility, but each route introduces different losses and constraints. A DC output may avoid the inverter path for a compatible load, while a USB output requires voltage conversion. The source's electrical measurements do not identify all measurement points or account for these routes consistently. A subsequent test should measure simultaneous input and output power, record the cutoff condition, and integrate energy over a complete operating interval for each defined load.

Thermal management and protection also need evaluation at the system level. Gabbar et al. (2021) emphasize that battery-management performance involves components, operation, integration, and installation. For Flash Aid, the presence of a battery management system and cooling fans provides a basis for further testing, but temperature-rise results, protective-trip

behavior, and abnormal-load tests are not available. General advantages of lithium iron phosphate described by Zhao et al. (2024) do not remove these requirements.

Vibration detection and warning claims

The observed vibration-triggered activation demonstrates a basic functional connection between sensing and audible output. It does not show that the device can distinguish an earthquake from handling, an accidental bump, a moving vehicle, or another source of vibration. The absence of a documented algorithm and controlled reference signal prevents a reproducible assessment of sensitivity or false alarms. The term vibration-triggered alert therefore describes the demonstrated function more precisely than earthquake self-detection.

The warning literature also shows why an alert should be evaluated as part of a broader communication process (Sadiq et al., 2023). A locally triggered siren would need clear user instructions, a defined response procedure, and testing of audibility under specified conditions. It should not be equated with an authoritative earthquake warning or a guarantee of protective action. Filipino-language instructions and accessible controls are appropriate priorities for future usability work, but their effectiveness remains to be examined.

Cost, portability, and potential application

The author reports a prototype component cost of PHP 10,355. This is a record of the stated build cost, not a market-price comparison or a full life-cycle cost. Labor, testing, certification, maintenance, replacements, and end-of-life handling are not quantified. No percentage saving relative to commercial power stations is claimed because comparable specifications, prices, and performance tests were not supplied.

At approximately 4.1 kg, the prototype brings several functions into a transportable enclosure. The practical benefit of that arrangement depends on how people carry and use it, especially when other emergency supplies must also be moved. Field conditions introduce moisture, impact, temperature variation, dust, and imperfect handling that the indoor observations do not address. Solar charging is a possible extension, but solar input power, controller operation, recharge duration, and weather-dependent performance were not established in this study.

Limitations and next-stage evaluation

The evidence is limited to a prototype description, reported functional observations, and calculations based on nominal specifications. Although the original account mentions three trials, the corresponding per-trial records are unavailable; inferential statistics and uncertainty estimates cannot be reconstructed. Controlled discharge measurements, acoustic tests, calibrated vibration inputs, firmware documentation, and comparative benchmarking are needed to evaluate performance beyond the present preliminary scope.

A subsequent evaluation should first define the measurement boundary and operating conditions. Electrical tests should record battery input, delivered output, temperature, and cutoff across a range of loads. Vibration tests should include known inputs and non-seismic disturbances, with detection and false-alarm counts. Acoustic tests should specify measurement distance and background noise. A separate usability study should assess controls, carrying effort, instructions, and task completion. These are proposed evaluation tasks, not results claimed for the present prototype.

Conclusion

Flash Aid demonstrates the integration of a battery power module, multiple electrical outputs, and a vibration-triggered audible alert within one portable enclosure. A consistent calculation using the stated 12.8 V, 30 Ah battery gives 384 Wh of nominal energy. With an assumed 85% AC conversion efficiency, illustrative runtimes are 36.3 hours at 9 W, 4.4 hours at 75 W, and 2.2 hours at 150 W. These estimates describe an energy budget rather than measured endurance.

The work provides a preliminary basis for refining the prototype and planning reproducible testing. Deployment claims require measured electrical and thermal performance, documented protection and control logic, assessment of false alarms, acoustic characterization, and user evaluation. The prototype's potential value is its integration of functions; the extent of that value in actual emergencies remains a question for subsequent engineering and field assessment.

Declarations

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Conflict of interest

The author declares no conflict of interest.

Ethical statement

No human or animal participants were involved. The author reports that the work followed institutional laboratory safety procedures.

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