

Smart Glasses for Hands-Free Datasheet Retrieval

by

Hridik Hingorani

Shiv Bahl

Preity Varanasi

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Teaching Assistant: Yushi Zhou

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Abstract

We are building a pair of camera glasses that identifies an electronic component on a workbench and pulls up its official datasheet without the user setting down the board or iron they are holding. The user centers a part, presses a button on the temple, and a custom ESP32-S3 board captures a JPEG and sends it to a laptop over local Wi-Fi. The laptop crops the center of the frame, runs OCR on the top marking, and scores the result against a catalog of known parts. It accepts a match only when the score and its margin over the runner-up clear calibrated thresholds, and otherwise asks for a new image. An accepted part number maps to exactly one verified manufacturer PDF. We target 90 percent identification accuracy, a median response under 10 seconds, 2 hours of untethered operation, and a total wearable mass under 150 g.

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1. Introduction

1.1 Problem

Identifying a component at a bench means putting down whatever you are holding, typing a top marking into a search bar, wading past resellers and scraped-PDF sites, and opening the real datasheet to check one pin. In ECE 385 and ECE 445 labs we hit this several times an hour, usually with one hand on a probe and the other holding a board steady.

The lookup is also easy to get wrong. An LM358N and an LM358D are the same die in different packages with different pinouts, and reading a specification off the wrong PDF can put a circuit outside its ratings. Existing image-to-answer tools return a confident guess with no way to tell whether the document behind it came from the manufacturer or a content farm.

What makes this a hardware problem is the image. Top markings are often under 1 mm tall, laser-etched into dark plastic with very little contrast, and lit from overhead by panels that reflect straight back into the lens. Getting a readable frame of that marking from a head-mounted camera, on a battery, at a working distance a person actually uses, is the engineering work.

1.2 Solution

We are building the camera into a pair of glasses and putting the processing on a laptop. The user centers a component and presses a capture button on the temple. A custom PCB carrying an ESP32-S3 module drives an autofocus camera, captures one JPEG, and sends it with status metadata over a local Wi-Fi network. The glasses do no recognition of their own.

The laptop crops a fixed central region, enhances it, and runs OCR. It normalizes the recognized text and scores it against a catalog of known parts, accepting a candidate only when its score clears a calibrated threshold and beats the runner-up by a set margin. Otherwise, it asks for a new image and says why.

An accepted part number resolves through a reviewed manifest to exactly one official manufacturer PDF, which the laptop caches and displays alongside the image, the OCR output, and the pages that answer the question. We are building the wearable from scratch rather than assembling development boards: the custom PCB carries the ESP32-S3 module, the camera FPC interface, USB-C input, a single-cell charger with power path, a buck-boost regulator, battery sensing, the capture button, and status LEDs.

1.3 Visual Aid

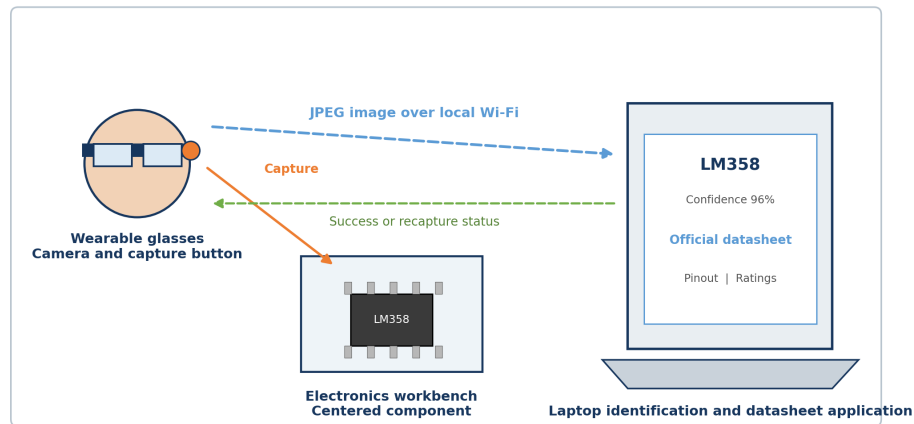


Figure 1 The user centers a component and presses capture. The glasses send one image to the laptop, which identifies the part and opens a verified datasheet.

1.4 High-Level Requirements

- Across 100 blinded trials drawn from a fixed set of at least 20 marked components, the system must return the correct part number on the first capture in at least 90 trials and must return no more than 2 confidently wrong part numbers. Every remaining trial must return a recapture request instead of a guess.
- On a local 2.4 GHz Wi-Fi network, the median time from the capture button press to the accepted part number and datasheet appearing on screen must be no more than 10 seconds, with at least 95 percent of trials finishing within 20 seconds.
- The wearable must run untethered for at least 2 hours at a workload of one capture per minute, and the complete head-worn assembly must weigh no more than 150 g.

2. Design

2.1 Block Diagram

The system splits in two. Everything in the glasses handles power, capture, and transport. Everything on the laptop handles recognition, document retrieval, and display.

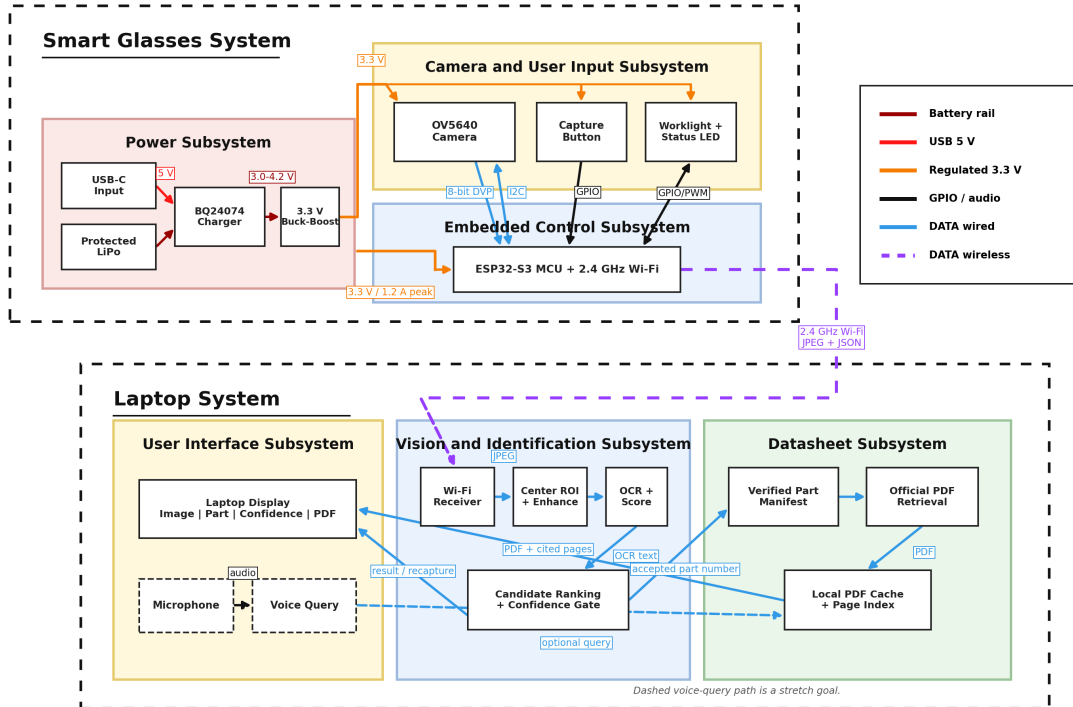


Figure 2 Block diagram. The custom PCB contains the power, embedded control, and user input blocks; recognition and datasheet handling stay on the laptop. The dashed voice path is a stretch goal.

2.2 Camera and User Input Subsystem

The camera is a 5 MP OV5640 sensor with a voice-coil autofocus module, connected to the ESP32-S3 over an 8-bit DVP bus with I2C for register and focus control. The ESP32-S3 supports a parallel camera interface of 8 to 16 bits at up to 40 MHz [2], enough to pull full-resolution frames into PSRAM.

We specify an M12 lens near 45 degrees horizontal rather than the roughly 70 degree lens most OV5640 breakouts ship with. Section 2.8.1 shows why: the wide lens puts a 0.8 mm character below the OCR floor at normal working distance.

Autofocus is not optional at that lens. A 45 degree horizontal field on a 1/4 inch sensor is about 4.35 mm of focal length, and at f/2.8 focused on 150 mm the depth of field runs roughly 137 mm to 166 mm. Our declared envelope is 100 mm to 200 mm, so a fixed-focus module would hold focus over less than a third of it. The voice-coil actuator covers the rest.

Two low-current white LEDs behind a diffuser sit beside the lens as a worklight, aimed down at the bench and switched on only during focus and exposure. A momentary button on the temple starts a capture, debounced in firmware, and an RGB LED reports ready, sending, accepted, and recapture.

2.2.1 Requirements

- The camera must deliver a JPEG of at least 2592 by 1944 pixels and must focus on a bench target anywhere from 100 mm to 200 mm within 1.5 s of the button press.
- In at least 90 percent of test images, the central 60 percent by 60 percent region of the frame must fully contain the selected package and its primary top marking.
- The capture button must produce exactly one capture event per press between 50 ms and 1 s, with a 250 ms debounce window.
- The worklight must be current limited, off outside of focus and exposure, and must not exceed 45 degrees Celsius on any touchable surface.

2.3 Embedded Control and Wireless Subsystem

We use an ESP32-S3-WROOM-1 module with 8 MB of flash and 8 MB of PSRAM. The module keeps the certified antenna and RF matching out of our layout, which is the part of a 2.4 GHz board most likely to cost a respin. The PSRAM is required: a full 2592 by 1944 frame plus its JPEG buffer does not fit in internal SRAM.

The firmware brings up the camera over I2C, runs autofocus, grabs one frame on a button press, and posts the JPEG over HTTP with a JSON header carrying a request ID, image dimensions, battery voltage, firmware version, and timestamp. The request ID lets the system discard a late response belonging to a capture the user has already abandoned. The board holds the image until the laptop acknowledges it at the application layer, retrying twice before showing failure on the LED.

The glasses join a known network in station mode and find the laptop over mDNS, with a stored IP address as fallback. The ESP32-S3 datasheet lists Wi-Fi transmit peaks as high as 340 mA [2], so the 3.3 V rail and its local decoupling are sized for that burst rather than the average.

2.3.1 Requirements

- The subsystem must operate from 3.3 V plus or minus 5 percent and must survive a 500 mA load step without the rail dropping below 3.1 V for more than 100 microseconds.
- The camera interface must carry 8 data lines, PCLK, HREF, VSYNC, XCLK, SCL, SDA, reset, and power-down at 3.3 V logic.
- The firmware must transmit a JPEG of up to 2 MB and receive an application-level acknowledgment within 5 s on the test network, retrying at most twice before reporting failure.
- The board must expose labeled test points for 5 V, VBAT, 3.3 V, GND, EN, BOOT, SCL, SDA, XCLK, and PCLK.

2.4 Power Subsystem

The wearable runs from a single protected lithium-polymer cell of about 1000 mAh. Charging goes through a BQ24074, which handles single-cell charging with dynamic power path, input current limiting, and thermal regulation, and lets the system run while the battery charges [3]. The charger is not the safety device, so the pack carries its own protection circuit for overcurrent, overvoltage, and undervoltage cutoff.

A TPS63070 buck-boost makes the 3.3 V rail. Buck-boost rather than a buck or an LDO because the cell crosses 3.3 V on its way down. The part accepts 2 V to 16 V with a 3.6 A switch current [4], leaving headroom over the roughly 700 mA capture peak.

Battery state comes from a resistor divider into an ESP32-S3 ADC input, gated by a MOSFET so the divider draws nothing when idle. A dedicated fuel gauge would give better state-of-charge estimation, but the only things that depend on this measurement are the low-battery warning and the runtime test in Appendix A, and both need voltage rather than coulomb counting. The board also carries a USB-C receptacle with the two 5.1 kilohm CC pull-downs for a sink-only port, ESD protection, and a physical power switch.

2.4.1 Requirements

- The board must accept 5.0 V plus or minus 5 percent over USB-C and must hold input current within the limit configured for the source.
- The charger must charge the cell inside the voltage, current, and temperature window in the pack datasheet, at no more than 0.5 C for the first prototypes.
- The 3.3 V rail must stay between 3.20 V and 3.40 V for loads from 20 mA to 1.2 A, including simultaneous camera capture and Wi-Fi transmission.
- Battery voltage measured at the ADC must track a reference DMM reading within 50 mV from 3.3 V to 4.2 V.
- No externally touchable surface may exceed 45 degrees Celsius over a 30-minute worst-case capture cycle at room temperature.
- The system must run for at least 2 hours at one capture per minute without discharging the cell past its protection threshold.

2.5 Vision and Identification Subsystem

The laptop validates the incoming file as a JPEG, checks its size and request ID, and crops the central 60 percent of the frame. That crop is the selection mechanism: it is how the user indicates which of several parts on the bench they mean, and the interface displays the exact crop so the behavior is visible.

The crop is converted to grayscale and run through a fixed set of enhancement variants including CLAHE, denoising, unsharp masking, and adaptive thresholding. OCR runs on the raw crop and each variant, and every recognized string is kept with its bounding box and per-token confidence rather than collapsing to one answer early.

Identification is a scoring function we write, not a language model asked to guess. The catalog stores canonical part numbers, manufacturers, known top marks, aliases, and one official datasheet URL per entry. Recognized strings are normalized and matched by exact substring and edit distance. The score combines OCR confidence, distance from the center of the crop, agreement across variants, and margin over the second candidate. The accept threshold and margin are fixed on a calibration set held out from the evaluation set.

2.5.1 Requirements

- The receiver must reject anything that is not a valid JPEG, any image over 5 MB, and any metadata payload over 16 kB.
- The OCR stage must return recognized text, bounding boxes, per-token confidence, and processing time for every trial.
- The resolver must accept a candidate only when its score exceeds threshold T and its margin over the second candidate exceeds δ , where T and δ are fixed from calibration images before evaluation begins.
- Over 100 blinded trials on at least 20 components, the subsystem must meet the accuracy requirement of Section 1.4 and must report a confusion matrix with recapture outcomes counted separately from accepted outcomes.

2.6 Datasheet Retrieval Subsystem

Each catalog entry resolves to exactly one manufacturer PDF through a version-controlled manifest holding the manufacturer, the orderable part number or explicitly supported family, the package, the official URL, a SHA-256 hash, and the retrieval date. Reviewing those entries once by hand makes retrieval deterministic and keeps an open web search off the critical path.

The laptop caches each PDF, extracts page text, and indexes page-sized chunks with their page numbers. Absolute maximum ratings and recommended operating conditions are surfaced as visibly separate sections, because confusing the two is the mistake that damages hardware. Every answer carries its page number and enough surrounding text for the user to check the conditions.

2.6.1 Requirements

- Every accepted catalog entry must resolve to exactly one reviewed manufacturer PDF, stored with its source URL, retrieval date, and SHA-256 hash.
- After the first download, the cached PDF must open with no network connection and must pass a parser validity check.
- Every retrieved specification must carry its source page number and at least one surrounding sentence or table row.
- If no manifest entry exists for a part, the subsystem must show no datasheet rather than substituting a search result.

2.7 User Interface Subsystem

The interface is a small local web app. One screen shows the captured image with the crop outlined, the accepted part with its confidence and margin, the manufacturer and datasheet link. A recapture result names a reason: low sharpness, no text in the crop, glare, or two candidates too close to separate.

2.7.1 Requirements

- The interface must move each request through received, processing, accepted, recapture, or error, preserving the request ID at every stage.
- Every accepted capture must display the full image, the crop, the OCR output, the confidence, the manufacturer, and the datasheet link.
- A recapture response must give at least one actionable reason and must not display an unverified part number as the result.
- The software must log stage timing for transfer, preprocessing, OCR, resolution, PDF retrieval, and render.

3 Design Verification

We will verify each major subsystem separately before testing the complete system. Each test has a measurable passing condition so that the results do not depend on whether the system simply appears to work.

3.1 Camera and Image Capture Verification

We will test the camera using at least 10 components with different package types, marking sizes, orientations, and surface finishes. Each component will be placed at the expected working distance under several lighting conditions. We will record autofocus time, image sharpness, glare, and whether the full component marking appears inside the central region of interest.

The subsystem passes if at least 45 of 50 captures produce a valid JPEG with the target marking visible inside the central 60 percent of the image. The laptop interface must also display the exact crop used by the OCR pipeline so the user can confirm that the correct component was selected.

3.2 Wireless Communication Verification

We will send 100 images from the ESP32-S3 to the laptop over the expected local Wi-Fi connection. Each transfer will include a request identifier, file size, and checksum so that missing or corrupted data can be detected. We will record transfer time, retries, corrupted files, and failed uploads.

The subsystem passes if at least 80 images transfer successfully on the first attempt and all 100 transfer within two retries. The ESP32-S3 must keep the image until the laptop acknowledges a valid transfer.

3.3 Power Subsystem Verification

We will test the 3.3 V rail using an oscilloscope while the camera autofocuses and the ESP32-S3 transmits over Wi-Fi. An electronic load will be used to test current steps from 20 mA to 500 mA. We will also run one capture per minute from a fully charged battery until the system reaches its controlled low-battery shutdown.

The rail must remain between 3.20 V and 3.40 V during steady operation and must not fall below 3.10 V for longer than 100 microseconds. The system must operate for at least two hours without a wired connection. During a 30-minute worst-case test, all wearer-accessible surfaces must remain below 45 degrees Celsius, and the battery, charger, converter, and ESP32-S3 must remain within their datasheet limits.

3.4 OCR and Component-Matching Verification

We will run 50 blinded identification trials using at least 10 components, with at least 3 trials per component. The user performing each capture will not see the software ranking. The OCR pipeline will record the detected text, bounding boxes, token confidence, processing time, candidate score, and margin over the second-best candidate.

The subsystem passes if at least 35 trials return the correct accepted part number, no more than two trials return an incorrect accepted result, and all remaining trials request a recapture. The acceptance threshold and required score margin will be selected using separate calibration images before the final test.

3.5 Datasheet-Retrieval Verification

For every component in the catalog, we will compare the manufacturer, full orderable part number, package, official source URL, retrieval date, and SHA-256 hash against the reviewed manifest. We will also test a component that is not included in the manifest.

The subsystem passes if every accepted component resolves to exactly one reviewed manufacturer PDF with no substitutions or silent web-search fallbacks. If no verified entry exists, the system must report that no verified datasheet is available. Any generated answer must include the correct source page, and unsupported questions must return that the requested information was not found.

3.6 Full-System Integration Verification

After the subsystems pass individually, we will run 50 end-to-end trials from the physical capture-button press to the final result displayed on the laptop. Timestamps will be recorded after image capture, wireless transfer, preprocessing, OCR, candidate selection, datasheet retrieval, and interface update.

The complete system passes if the median response time is no more than 10 seconds and at least 90 percent of trials finish within 20 seconds. Every accepted result must display the full part

number, manufacturer, confidence, datasheet source, and original PDF. Rejected results must request another image and provide a useful reason, such as glare, blur, poor centering, or an ambiguous match.

4. Cost and Schedule

4.1 Parts

Table 1 lists the parts for one wearable against a \$60 parts budget.

Table 1 Parts Costs

Part	Manufacturer	Retail Cost (\$)	Bulk Cost (\$)	Actual Cost (\$)
OV5640 autofocus camera module	OmniVision	17.50	12.00	17.50
2-layer PCB fabrication, 5 boards with shipping	JLCPCB	10.00	10.00	10.00
Protected LiPo cell, 1000 mAh with NTC	Adafruit	9.95	7.50	9.95
M12 lens, 45 degree HFOV	Generic	6.00	4.00	6.00
TPS63070RNMR buck-boost converter	Texas Instruments	3.80	2.85	3.80
ESP32-S3-WROOM-1-N8R8 module	Espressif	3.50	2.60	3.50
Power inductor and 22 uF bulk capacitors	Coilcraft, Murata	3.50	2.40	3.50
BQ24074RGTR power path charger	Texas Instruments	2.45	1.70	2.45
USB-C receptacle and ESD diode	GCT, Nexperia	1.60	1.05	1.60
24-pin 0.5 mm FPC connector	Hirose	1.20	0.80	1.20
Passives, LEDs, button, switch, connectors	Lab stock	0.00	0.00	0.00
Total		59.50	44.90	59.50

4.2 Schedule

The camera and lens must be proven on the bench before the PCB is committed, because the FPC pinout and rail voltages depend on the module selected.

Table 3 Schedule

Week	Hridik	Shiv	Preity
Sep 21	Freeze the 20-part test set, record markings and character heights	Order OV5640 modules and candidate M12 lenses	Stand up laptop receiver and image logging
Sep 28	Camera bring-up, I2C register config, autofocus sequence	Power budget, charger and converter schematic	OCR pipeline on saved images, enhancement variants
Oct 5	Capture at 100, 150, 200 mm; measure pixels per character	USB-C, protection, ADC battery sense schematic	Catalog schema and scoring function v1
Oct 12	Lock camera module and lens; write pin map	Full schematic review and 2-layer PCB layout	Datasheet manifest and PDF cache
Oct 19	Firmware capture and HTTP upload path	Submit PCB order; design enclosure and mount	Threshold calibration on held-out images
Oct 26	Retry, request ID, and status LED state machine	Board bring-up: rails from current-limited supply	Page index and grounded extraction
Nov 2	Camera on custom board, end to end capture	Charger and thermal characterization	Interface screens and stage timing
Nov 9	Integration and latency tuning	Mechanical assembly, mass and fit	Blinded trial harness and randomization
Nov 16	Full system integration and freeze firmware	Runtime and thermal verification	Freeze software, run calibration check
Nov 30	Blinded evaluation, 100 trials	Rail integrity and wearability tests	Confusion matrix and results writeup
Dec 7	Mock demo fixes	Final demo and presentation prep	Final paper

5. Conclusion

5.1 Future Work

After the core project is complete, future work could expand the system beyond the predefined component catalog and support a wider range of packages, markings, and manufacturers. The laptop processing could also be moved to a phone or more powerful wearable processor, making the system fully portable. Other improvements could include continuous video recognition, a built-in display, better voice interaction, and automatic catalog updates from verified manufacturer sources.

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Appendix A Requirement and Verification Table

Table 4 collects the subsystem requirements from Chapter 2 with the verification procedure for each. Verification status is blank because no hardware has been built at the proposal stage.

Table 4 System Requirements and Verifications		
Requirement	Verification	Verification status (Y or N)
1. Power subsystem a. 3.3 V rail stays within 3.20 V to 3.40 V for loads from 20 mA to 1.2 A b. Rail does not dip below 3.1 V for longer than 100 us during a 500 mA load step c. ADC battery reading tracks a DMM within 50 mV from 3.3 V to 4.2 V d. At least 2 hours of untethered operation at one capture per minute e. No touchable surface above 45 degrees Celsius over a 30-minute worst-case cycle	a. Sweep an electronic load from 20 mA to 1.2 A and log rail voltage at each step with a DMM b. Apply a 20 mA to 500 mA step and capture the rail on an oscilloscope in AC coupling c. Discharge the cell from full to cutoff, logging ADC readings against a bench DMM at 0.1 V intervals d. Charge fully, then run one capture per minute from the battery until controlled low-battery shutdown; log timestamps e. Run the worst-case capture cycle for 30 minutes and record charger, converter, module, LED, enclosure, and battery temperatures with a thermocouple	
2. Embedded control and wireless a. Transmits a JPEG up to 2 MB and receives an acknowledgment within 5 s b. Retries at most twice, then reports failure on the status LED c. Ignores any response whose request ID does not match the active capture	a. Run 100 uploads at normal laptop distance and log per-transfer time and success from the laptop receiver b. Drop the laptop endpoint mid-transfer and confirm two retries followed by the failure indication c. Inject a stale response with a mismatched request ID and confirm the firmware discards it	
3. Camera and user input a. Delivers a JPEG of at least 2592 by 1944 pixels b. Focuses on a bench target from 100 mm to 200 mm within 1.5 s c. Selected package and its top marking fall inside the central 60 percent crop in at least 90 percent of images d. Exactly one capture event per button press, with a 250 ms debounce	a. Inspect the JPEG header and decoded dimensions for 100 captures b. Capture a resolution target at 100, 150, and 200 mm and time the focus-complete flag over 20 trials at each distance c. Score the central crop of the 100-trial evaluation image set for full containment of the marking d. Instrument the GPIO with a logic analyzer over 200 presses of varying length and count firmware capture events	
4. Vision and identification a. Correct part returned on the first capture in at least 90 of 100 blinded trials	a and b. Run 100 randomized blinded trials across at least 20 components, at least five trials each, with the operator unable to see the ranking; tabulate accepted-correct, accepted-wrong, and recapture outcomes	

b. No more than 2 confidently wrong accepts across those 100 trials c. Accepts only when score exceeds T and margin exceeds delta	c. Replay the logged scores for all trials and confirm every accept satisfies both thresholds, with T and delta fixed from the held-out calibration set	
5. Datasheet retrieval a. Each accepted part resolves to exactly one reviewed manufacturer PDF b. Cached PDFs open with no network access c. Every returned specification carries its source page number	a. Compare manufacturer, orderable number, package, URL, and SHA-256 hash for every catalog entry against the reviewed manifest b. Disable the network interface and open every cached PDF through the parser validity check c. Ask a fixed set of pinout, absolute maximum, and recommended operating questions across at least five PDFs and confirm each answer cites a page that contains it	
6. System latency a. Median time from button press to displayed result no more than 10 s b. 95th percentile no more than 20 s	a and b. Timestamp button event, capture complete, upload complete, OCR complete, match, and UI update across the same 100 trials; compute median and 95th percentile of the end-to-end time	