ASLAN WEALTH CO., LTD.

กรณีวิจัยและพัฒนา (เอกสารแนบ A)

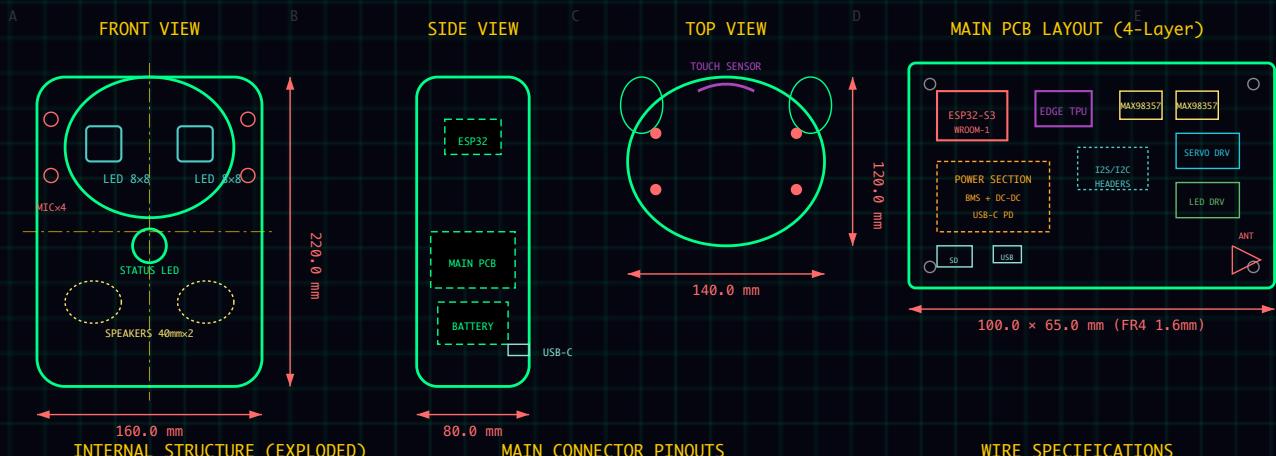# ASLAN PHYSICAL AI AGENT
Complete Hardware Engineering Specification

CAD Reference Document | BOI Category 8.2.12 Smart Electronics

DWG NO:	ASLAN-HW-001
REV:	A
SCALE:	1:2
SHEET:	1 OF 3
DATE:	2026-01-22
DRAWN:	ENGINEERING
APPROVED:	CEO

OVERALL DIMENSIONS & ASSEMBLY VIEW

FRONT VIEW
LED 8×8   LED 8×8
MIC×4
STATUS LED
SPEAKERS 40mm×2
220.0 mm
160.0 mm

SIDE VIEW
ESP32
MAIN PCB
BATTERY
USB-C
80.0 mm

TOP VIEW
TOUCH SENSOR
120.0 mm
140.0 mm

MAIN PCB LAYOUT (4-Layer)
ESP32-S3 WROOM-1
EDGE TPU
MAX98357   MAX98357
POWER SECTION
BMS + DC-DC
USB-C PD
I2S/I2C HEADERS
SERVO DRV
LED DRV
SD   USB
ANT
100.0 × 65.0 mm (FR4 1.6mm)

INTERNAL STRUCTURE (EXPLODED)
1. PLUSH FABRIC COVER
Premium Polyester | 2mm thick
2. ABS SHELL
Injection Molded | 2.5mm wall
3. MAIN PCB ASSEMBLY
4. BATTERY PACK 4×18650

MAIN CONNECTOR PINOUTS

J1: I2S AUDIO
1. BCLK (GPIO12)
2. LRCLK (GPIO11)
3. DIN (GPIO10)
4. DOUT (GPIO9)
5. GND | 6. 3V3

J2: I2C SENSORS
1. SDA (GPIO8)
2. SCL (GPIO9)
3. INT (GPIO7)
4. GND
5. 3V3

J3: SERVO MOTORS
1. SRV1 (GPIO16)
2. SRV2 (GPIO17)
3. SRV3 (GPIO18)
4. SRV4 (GPIO19)
5. GND | 6. 5V

WIRE SPECIFICATIONS
- VBAT+ : AWG18 (Red) 1.0mm²
- GND : AWG18 (Black) 1.0mm²
- 5V : AWG22 (Orange) 0.35mm²
- 3V3 : AWG24 (Yellow) 0.20mm²
- I2C : AWG26 (Green) 0.13mm²
- I2S : AWG26 (Cyan) 0.13mm²
- GPIO : AWG28 (Purple) 0.08mm²
- COAX : RG174 (Antenna) 50Ω

🪰 INTEGRATED CIRCUITS (IC) SPECIFICATIONS

Ref	IC Part Number	Package	Function	Vcc
U1	ESP32-S3-WROOM-1-N16R8	Module 25.5×18mm	Main MCU + WiFi/BT	3.3V
U2	Coral G313-06329-00	USB Module	Edge TPU ML Accelerator	5V USB
U3	MAX98357AETE+T	TQFN-16 3×3mm	I2S Audio Amplifier	2.5-5.5V
U4	MAX98357AETE+T	TQFN-16 3×3mm	I2S Audio Amplifier	2.5-5.5V
U5	W25Q128JVSIQ	SOIC-8 5.3×5.2mm	16MB SPI Flash	2.7-3.6V
U6	SHT31-DIS-B	DFN-8 2.5×2.5mm	Temp/Humidity Sensor	2.4-5.5V
U7	BH1750FVI-TR	WSOF6I 3×1.6mm	Ambient Light Sensor	2.4-3.6V
U8	INMP441ACEZ	LGA 4.7×3.8mm	MEMS Microphone I2S	1.8-3.3V
U9-11	INMP441ACEZ	LGA 4.7×3.8mm	MEMS Microphone I2S	1.8-3.3V
U12	MP1584EN-LF-Z	SOIC-8 4.9×3.9mm	DC-DC Buck 5V/3A	4.5-28V in
U13	AMS1117-3.3	SOT-223	LDO 3.3V/1A	4.5-12V in
U14	IP2721-MAX	ESOP-8	USB-C PD Trigger	5-20V PD
U15	TTP223-BA6	SOT-23-6	Touch Sensor IC (×6)	2-5.5V
U16	74HC595D	SOIC-16 10×4mm	LED Shift Register	2-6V

📐 MECHANICAL SPECIFICATIONS

Parameter	Dimension	Tolerance	Material
Overall Height	220.0 mm	±2.0mm	-
Overall Width	160.0 mm	±2.0mm	-
Overall Depth	80.0 mm	±2.0mm	-
Head Diameter	140.0 mm	±1.5mm	-
Shell Thickness	2.5 mm	±0.2mm	ABS (UL94 V-0)
Plush Thickness	2.0 mm	±0.5mm	Polyester Velboa
Main PCB Size	100×65 mm	±0.1mm	FR4 1.6mm 4-Layer
Sensor PCB Size	40×25 mm	±0.1mm	FR4 1.0mm 2-Layer
LED PCB Size (Eye)	25×25 mm	±0.1mm	FR4 0.8mm 2-Layer
Total Weight	450 g	±20g	-
Battery Weight	180 g	±5g	Li-ion 18650×4

🔌 WIRE & CABLE SPECIFICATIONS

Application	AWG	mm²	OD (mm)	Color	Type	Length/Unit	Max Current
Battery Main +	18	1.0	2.0	RED	Silicone	150mm	16A
Battery Main -	18	1.0	2.0	BLACK	Silicone	150mm	16A
5V Power Rail	22	0.35	1.4	ORANGE	PVC	200mm	7A
3.3V Power Rail	24	0.20	1.1	YELLOW	PVC	150mm	3.5A
Speaker Output	22	0.35	1.4	WHITE/BLACK	PVC Twisted	100mm	5A
I2C Bus	26	0.13	0.9	GREEN	FPC 4-pin	80mm	1A
I2S Audio	26	0.13	0.9	CYAN	FPC 6-pin	60mm	1A
GPIO/Control	28	0.08	0.7	PURPLE	Ribbon	100mm	0.5A
LED Data	26	0.13	0.9	GREEN	PVC 3-wire	120mm	1A
Servo Signal	26	0.13	0.9	ORANGE/RED/BROWN	JST-XH	80mm	1A
WiFi Antenna	-	-	2.8	BLACK	RG174 Coax 50Ω	100mm	-

⚡ ELECTRICAL SPECIFICATIONS

Parameter	Min	Typ	Max	Unit
Battery Voltage	12.0	14.8	16.8	V
Battery Capacity	-	13,600	-	mAh
5V Rail Current	-	800	3000	mA
3.3V Rail Current	-	350	1000	mA
Total Power (Active)	-	8	15	W
Total Power (Standby)	-	0.5	1	W
USB-C PD Input	5	9	20	V
Charging Current	-	2	3	A
Charging Time	-	4.5	6	hr
Active Runtime	6	8	-	hr
Standby Runtime	-	200	-	hr

🔧 PCB STACKUP & COPPER SPECIFICATIONS

Layer	Function	Copper (oz)	Thickness	Material
L1 (Top)	Signal + Components	1 oz (35μm)	0.035mm	Copper
Prepreg 1	Insulation	-	0.20mm	FR4 7628
L2 (Inner 1)	GND Plane	1 oz (35μm)	0.035mm	Copper
Core	Substrate	-	1.0mm	FR4 Core
L3 (Inner 2)	Power Plane	1 oz (35μm)	0.035mm	Copper
Prepreg 2	Insulation	-	0.20mm	FR4 7628
L4 (Bottom)	Signal + Components	1 oz (35μm)	0.035mm	Copper
Soldermask	Protection	-	20μm	Green LPI
Silkscreen	Marking	-	10μm	White Epoxy
Surface Finish	Soldering	-	3-5μm	ENIG (Au/Ni)
TOTAL THICKNESS		1.6mm ±10%		

Trace Width Specifications:

Power Traces (1A+)	0.5mm min (20mil)
Signal Traces	0.2mm min (8mil)
RF Traces (50Ω)	0.35mm (controlled impedance)
Via Size	0.3mm drill / 0.6mm pad
Clearance	0.15mm min (6mil)

📡 IoT & COMMUNICATION SPECIFICATIONS

Interface	Standard	Frequency	Data Rate
WiFi	802.11 b/g/n	2.4GHz	150 Mbps
Bluetooth	BLE 5.0 + Classic	2.4GHz	2 Mbps
Antenna	PCB Inverted-F	2.4GHz	-
Antenna Gain	2.5 dBi (Integrated)		
TX Power	+20 dBm (WiFi) / +9 dBm (BLE)		
Range (Indoor)	~30m (WiFi) / ~50m (BLE)		

Cloud API Endpoints:

Protocol	HTTPS/WSS + MQTT
API Server	api.aslan.ai (AWS AP-Southeast)
MQTT Broker	mqtt.aslan.ai:8883 (TLS)
OTA Updates	ota.aslan.ai/firmware
Telemetry	60s heartbeat interval

Security:

Encryption	TLS 1.3 / AES-256-GCM
Auth	X.509 Certificate + JWT
Secure Boot	ESP32 Secure Boot V2
Flash Encryption	AES-256-XTS

💾 EMBEDDED SOFTWARE TECHNOLOGY STACK

Layer	Technology	Version	Description
RTOS	FreeRTOS	10.4.3	Real-time Operating System (ESP-IDF bundled)
Framework	ESP-IDF	5.1.2	Espressif IoT Development Framework
ML Runtime	TensorFlow Lite Micro	2.14	On-device ML inference engine
Edge ML	Edge Impulse SDK	1.0	Wake word detection, KWS
Audio DSP	ESP-DSP	1.2	FFT, filters, AEC, noise suppression
Speech	ESP-SR	1.0	Speech recognition (wake word, commands)
LED Control	FastLED (ported)	3.6	WS2812B addressable LED driver
OTA	ESP-IDF OTA	Built-in	Secure over-the-air firmware updates
MQTT	ESP-MQTT	1.3	MQTT 3.1.1 client with TLS
HTTP	ESP-HTTP-Client	Built-in	HTTPS client for API calls
JSON	cJSON	1.7	JSON parsing and serialization
Logging	ESP-LOG	Built-in	Multi-level logging system

🌐 TUYA IoT MODULE SPECIFICATIONS (WBR3)

Module Hardware Specifications	
Module Part Number	WBR3 (BK7231N)
Dimensions	16.0 × 24.0 × 3.0 mm
Operating Voltage	3.0 - 3.6V (3.3V typ)
Operating Current	WiFi TX: 230mA, BLE: 15mA
Sleep Current	<15μA (deep sleep)
Flash Memory	2MB (internal)
Operating Temp	-40°C to +85°C
Antenna	PCB Onboard (2.4GHz)
Certification	FCC, CE, SRRC, NCC, IC

Tuya Cloud Integration	
Platform	Tuya IoT Development Platform
Protocol	MQTT over TLS 1.2/1.3
Data Center	Singapore (AP-Southeast)
Device Pairing	EZ Mode / AP Mode / BLE
OTA Update	Differential + Full image
Voice Assistant	Alexa, Google Home, Siri
SDK Version	Tuya IoT SDK 2.0.0
API Gateway	openapi.tuyaxx.com
MQTT Broker	m1.tuyaxx.com:8883

WBR3 Pinout Configuration:

Pin	Name	Function	Connected To
1	3V3	Power Supply	3.3V Rail
2	GND	Ground	GND Plane
3	TX	UART Transmit	ESP32-S3 GPIO43 (RX)
4	RX	UART Receive	ESP32-S3 GPIO44 (TX)
5	RST	Reset (Active Low)	ESP32-S3 GPIO45
6	CEN	Chip Enable	3.3V (Pull-up)
7	PWM0	Status LED	Status LED Indicator

🎯 SENSOR DETAILED SPECIFICATIONS

INMP441 MEMS Microphone (×4)

Part Number	INMP441ACEZ
Type	I2S Digital Output MEMS
Sensitivity	-26 dBFS (±1dB @ 94dB SPL)
SNR	61 dBA
Frequency Response	60Hz - 15kHz
Sample Rate	Up to 48kHz (24-bit)
Current Consumption	1.4mA (active), 5μA (sleep)
Acoustic Overload	120 dB SPL
Package	LGA 4.72 × 3.76 × 1.0 mm

MPU-6050 6-Axis IMU

Part Number	MPU-6050
Gyroscope Range	±250, ±500, ±1000, ±2000 °/s
Accelerometer Range	±2g, ±4g, ±8g, ±16g
ADC Resolution	16-bit
Interface	I2C 400kHz / SPI 1MHz
Sample Rate	Up to 8kHz (Gyro), 1kHz (Accel)
Current	3.9mA (all sensors on)
Package	QFN-24 (4×4×0.9 mm)

MPR121 Touch Controller

Part Number	MPR121QR2
Channels	12 capacitive touch inputs
Interface	I2C (up to 400kHz)
Sensitivity	Programmable (0-255)
Detection	Touch + Proximity
Interrupt	Active-low open drain
Package	QFN-20 (3×3×0.65 mm)

SHTC3 Temp/Humidity Sensor

Part Number	SHTC3-TR-10KS
Temperature Range	-40°C to +125°C
Temp Accuracy	±0.2°C (typ)
Humidity Range	0% to 100% RH
RH Accuracy	±2% RH (typ)
Interface	I2C (up to 1MHz)
Current	430μA (measuring), 0.5μA (sleep)
Package	DFN-4 (2×2×0.75 mm)

🔋 POWER MANAGEMENT SYSTEM DETAIL

Battery Pack Specifications

Cell Type	NCR18650B (Panasonic)
Configuration	4S1P (4 cells in series)
Nominal Voltage	14.8V (3.7V × 4)
Full Charge	16.8V (4.2V × 4)
Cutoff Voltage	12.0V (3.0V × 4)
Capacity	3400mAh (50.3Wh)
Max Discharge	6.8A continuous (2C)
Cycle Life	>500 cycles @ 80% capacity
Weight (4 cells)	~188g

BMS IC (BQ40Z50)

Part Number	BQ40Z50RSMT-R1
Cell Configuration	2S - 4S
Voltage Accuracy	±1mV (cell), ±8mV (pack)
Current Accuracy	±1% (coulomb counter)
Protection	OVP, UVP, OCP, SCP, OTP
Cell Balancing	Passive (internal FETs)
Communication	SMBus v1.1 / I2C
Package	VQFN-32 (5×5 mm)

USB-C PD Controller

Part Number	FUSB302BMPX
USB PD Revision	3.0 (up to 100W)
Type-C Revision	1.2
Supported PDOs	5V, 9V, 12V, 15V, 20V
Max Current	5A (with E-Marker cable)
CC Logic	Built-in (no external Rp/Rd)
Interface	I2C (up to 1MHz)
Package	MLP-14 (2.5×2.5 mm)

Power Rails Summary

Rail	Voltage	Max Current	Regulator
VBAT	14.8V	6.8A	Battery Direct
5V_MAIN	5.0V	3A	TPS562201
3V3_MAIN	3.3V	600mA	AP2112K
3V3_ANALOG	3.3V	100mA	AP2112K (separate)
VSERVO	5.0V	2A	5V_MAIN (filtered)

🔊 AUDIO SYSTEM SPECIFICATIONS

MAX98357A I2S DAC/Amplifier (×2)

Part Number	MAX98357AETE+T
Output Power	3.2W @ 4Ω, 5V (10% THD+N)
THD+N	0.015% @ 1kHz, 1W
SNR	92 dB (A-weighted)
PSRR	77 dB @ 1kHz
Sample Rates	8kHz - 96kHz
Bit Depth	16/24/32-bit
Efficiency	92% (Class D)
I2S Format	Standard, Left-justified
Gain Select	3dB, 6dB, 9dB, 12dB, 15dB
Package	TQFN-16 (3×3×0.8 mm)

Speaker Driver Specifications

Part Number	PUI AS04008PS-2-R
Type	Full Range Dynamic
Diameter	40mm
Impedance	4Ω ±15%
Power Handling	5W (RMS), 8W (Peak)
Frequency Response	300Hz - 20kHz
Sensitivity	85 dB @ 1W/1m
Magnet	Neodymium (NdFeB)
Cone Material	Paper + Cloth surround
Mounting	4× M2 screw holes
Weight	15g

Audio Signal Path

Input	ESP32-S3 I2S0 (GPIO 10,11,12)
Clock	BCLK: 3.072MHz (48kHz×64)
Word Select	LRCLK: 48kHz
Data Format	I2S Philips, 16-bit stereo
Output Filter	2nd-order LC (22μH + 1μF)

💡 LED DISPLAY SYSTEM SPECIFICATIONS

WS2812B-2020 RGB LED (Eyes)

Part Number	WS2812B-2020
Configuration	8×8 Matrix × 2 (128 LEDs total)
Package Size	2.0 × 2.0 × 0.8 mm
LED Pitch	2.5mm center-to-center
Matrix Size	20 × 20 mm per eye
Viewing Angle	120° (typical)
Luminous Intensity	R:550, G:1100, B:220 mcd
Color Depth	24-bit (8-bit per color)
Data Rate	800 Kbps (NRZ)
Current (Full White)	~12mA per LED (max)
Total Current (Eyes)	~1.5A @ full white

LED Timing Specifications

Parameter	Value	Tolerance
T0H (0 code high)	300ns	±150ns
T0L (0 code low)	900ns	±150ns
T1H (1 code high)	600ns	±150ns
T1L (1 code low)	600ns	±150ns
Reset Time	>280μs	-
Refresh Rate	~400Hz (128 LEDs)	-

Eye Animation Modes

Idle	Slow blink, breathing effect
Listening	Pulse animation (cyan)
Speaking	Wave pattern (green)
Alert	Flash pattern (orange/red)
Happy	Rainbow cycle
Sleep	Dim single pixel (blue)

🔬 QUALITY ASSURANCE & TEST SPECIFICATIONS

Functional Test Points

Test	Condition	Pass Criteria
Power On	VBAT = 14.8V	Boot in <5s
5V Rail	Load = 2A	4.9V - 5.1V
3.3V Rail	Load = 500mA	3.25V - 3.35V
WiFi RSSI	1m from AP	> -50 dBm
BLE RSSI	1m from device	> -60 dBm
Mic Sensitivity	94dB SPL @ 1kHz	-28 to -24 dBFS
Speaker Output	1kHz sine, 3W	THD < 1%
LED Test	Full white sequence	All 128 LEDs lit
Touch Response	Finger touch	<50ms latency
Servo Range	PWM sweep	0° - 180° ±2°

Environmental Test Requirements

Test	Condition	Duration
High Temp Storage	+70°C	48 hours
Low Temp Storage	-20°C	48 hours
Operating High	+45°C, active	8 hours
Operating Low	+5°C, active	8 hours
Humidity	85% RH, 40°C	96 hours
Drop Test	0.5m onto wood	6 faces × 2
Vibration	10-55Hz, 1.5mm	2 hours
ESD (contact)	±4kV	10 pulses
ESD (air)	±8kV	10 pulses

Compliance Certifications

EMC	FCC Part 15B, CE (EN 55032)
Safety	IEC 62368-1, UL Listed
Wireless	FCC ID, CE RED, NBTC
Battery	UN38.3, IEC 62133
RoHS	RoHS 3 (2015/863/EU)
REACH	Compliant

🔧 ASSEMBLY INSTRUCTIONS (REFERENCE)

Step	Operation	Tools/Equipment	Notes
1	SMT Assembly - Place components	Pick & Place Machine	Reflow Profile: Lead-free SAC305
2	Reflow Soldering	Reflow Oven	Peak: 245°C, Time above liquidus: 60-90s
3	AOI Inspection	Automated Optical Inspection	Check solder joints, polarity
4	THT Assembly (connectors)	Wave Solder / Hand Solder	USB-C, FPC connectors
5	Firmware Flash	ESP-PROG / USB	Production firmware image
6	ICT Test	In-Circuit Tester	Verify all nets, power rails
7	Functional Test	Custom Test Jig	All peripherals, sensors
8	Battery Assembly	Spot Welder (nickel strips)	4S configuration, BMS connect
9	Mechanical Assembly	Torque Screwdriver	M2×6mm screws, 0.3 N·m
10	Speaker/Mic Install	Acoustic sealant	Ensure airtight seal
11	Shell Assembly	Snap-fit + 4× screws	Check all clips engaged
12	Plush Cover Install	Manual / Zipper	Align with shell features
13	Final Test	Full Functional Test	WiFi pairing, voice test
14	QC Inspection	Visual + Checklist	Cosmetic, labeling
15	Packaging	ESD Bag + Gift Box	Include accessories, manual

📷 PROTOTYPE REFERENCE

Physical AI Agent Mascot - Production Prototype Design
Document Reference: ASLAN-HW-001 Rev.A | Scale: Not to scale

📚 REFERENCE DOCUMENTS

Document	Description	Location
ASLAN_PHYSICAL_AI_ARCHITECTURE.html	Complete Hardware & Software Architecture	02_Attachments/
TECHNICAL_WORKFLOW.html	BOI Workflow Diagrams (Mermaid)	02_Attachments/
ESP32-S3 Datasheet	Espressif ESP32-S3 Technical Reference	espressif.com
Coral Edge TPU Datasheet	Google Coral USB Accelerator	coral.ai
Tuya WBR3 Module Datasheet	Tuya WiFi+BLE Module Specification	developer.tuya.com
MAX98357A Datasheet	Maxim I2S Audio Amplifier	maximintegrated.com
INMP441 Datasheet	InvenSense MEMS Microphone	invensense.com
NCR18650B Datasheet	Panasonic Li-ion Cell Specification	panasonic.com
BQ40Z50 Datasheet	Texas Instruments BMS IC	ti.com
IPC-A-610	Acceptability of Electronic Assemblies	IPC Standard

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REV HISTORY
A - Initial Release (2026-01-22)

TOLERANCES (unless noted)
Linear: ±0.5mm | Angular: ±1°
Electrical: ±5%
APPROVALS
DESIGNED: Engineering Team
CHECKED: QA | APPROVED: CEO