

Apex TV Enclosures

Premium OEM Manufacturing Specification - Dubai Grade

Version 5.2.1 | December 2025 | Recess-Compatible Ducted Rear-Plenum

1. Scope & Design Priorities

Target Market: Luxury residential and premium hospitality in UAE, Saudi Arabia, Qatar, Kuwait. Must accommodate standard consumer TVs while maintaining reliability in extreme conditions.

Design Priorities (Ranked)

1. **Thermal reliability** in 55°C ambient + solar load
2. **PWM-controlled fans** (variable speed, low-speed idle mode)
3. **Dust/sand ingress resistance** (positive pressure design)
4. **Corrosion resistance** (coastal UAE specification)
5. **Premium fit/finish** (luxury market positioning)
6. **Ducted thermal design** (160mm depth with rear-plenum + diffuser)

Non-Negotiable Requirements:

- NO on/off thermostats - PWM control only
 - NO unfiltered intakes - automotive-grade filtration required
 - NO consumer power strips - proper power distribution only
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2. Environmental Requirements

Temperature

- Operating: 0°C to **55°C** continuous
- Storage: -20°C to 70°C
- Internal target: <45°C at 55°C ambient

Moisture & Humidity

- Humidity: up to 95% RH non-condensing
- Rain: heavy/wind-driven (not submersible)
- Optional: ePTFE breather membrane

Dust & Sand

- Designed for sandstorms
- Positive pressure design
- Replaceable automotive-grade filters

Corrosion

- Salt fog: >500 hours
- UV stability: 5+ years
- 316 stainless hardware

IP Rating Target **TARGET**

IP55 target (validation pending) - Designed for dust protection + low-pressure water resistance. Suitable for rain, splashes, and general outdoor exposure.

Important - Ventilated Design:

This is an actively ventilated enclosure. While designed to IP55 standard, direct high-pressure water jets at intake/exhaust openings should be avoided. The labyrinth baffle system protects against rain and normal cleaning, but is not rated for pressure washer use.

IP55 Design Features:

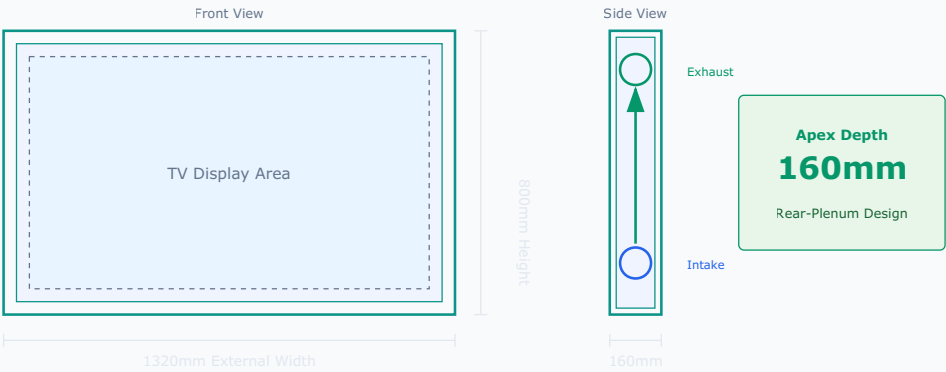
- **First digit (5):** Dust protected - limited ingress, not harmful to operation
 - **Second digit (5):** Protected against low-pressure water jets from any direction (6.3mm nozzle, 12.5 L/min)
 - Achieved through EPDM gaskets, **double-layer labyrinth baffles** with drip edges, 75mm exhaust deflector, and gasketed filter drawer
 - **Validation:** IP55 rating to be confirmed via prototype testing per IEC 60529
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3. Size Schedule

Model	Fits TV	Internal (W×H×D)	External (W×H×D)	VESA Support	Fan Count
ATE-43	39" - 43"	1000 × 600 × 75mm	1060 × 660 × 110mm	200×200, 300×300	2 × 80mm (rear)
ATE-55	49" - 55"	1260 × 740 × 75mm	1320 × 800 × 110mm	200-400×400	3 × 80mm (rear)
ATE-65	60" - 65"	1480 × 860 × 80mm	1540 × 920 × 160mm	300-600×400	3 × 140mm (top bezel)
ATE-75	70" - 75"	1700 × 1000 × 80mm	1760 × 1040 × 160mm	400-600×400	3 × 140mm (top bezel)
ATE-86	82" - 86"	1940 × 1120 × 85mm	2000 × 1180 × 160mm	600×400	3 × 140mm (top bezel)

Recess-Compatible Design (v5.2.1): 160mm depth with 30mm rear plenum + perforated diffuser plate for uniform airflow. 3× Delta AFB1412HH-A fans deliver 210-250 CFM. 45° exhaust deflector (architectural shadow element) directs hot air forward out of recess cavity. **Recess cavity:** 1820 × 1130 × 215mm (60mm top gap). Service access via hinged door with 4 latches + compression stops. **Thermal margin:** 80-115% wall-mount, 30-50% recessed.

Figure 1: Enclosure Dimensions (ATE-75 shown)



All dimensions in millimeters. Internal clearance 20mm minimum on all sides.

4. Mechanical Construction

4.1 Enclosure Body

Material PREMIUM

- **Primary:** Aluminum 5052-H32
- **Alternative:** 6061-T6
- Superior corrosion resistance vs 6063-T5

Thickness

- Main shell: **2.0mm**
- Door/rear panel: **2.0mm**
- Mounting rails: **3.0mm**

4.2 Fabrication

- CNC laser cut + CNC press brake
- TIG welding where needed
- Integrated stiffening ribs (no oil-canning)
- All edges deburred, no sharp edges

4.3 Fasteners & Hardware PREMIUM

Location	Specification
External fasteners	A4 / 316 Stainless Steel (coastal grade)
Internal fasteners	A2 / 304 Stainless minimum
Thread treatment	Anti-galling compound or coated

Dissimilar metals	Nylon isolation washers required
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4.4 Seals & Gasketing IP54

Component	Specification
Door Seal	EPDM continuous channel gasket, UV-stable, closed-cell Profile: 12×15mm with integrated channel for frame retention
Compression	Consistent 20-30% compression around full perimeter via compression latches
Cable Entry	IP68-rated cable glands (M16/M20), 316 stainless steel
Panel Joints	Overlapping seams with gasket backing, no exposed gaps
Ventilation Sealing	IP54 labyrinth grilles with angled louvers (see 6.6)

4.5 Door & Access System PREMIUM

Hinged Front Frame

- **Hinge type:** Concealed 3-knuckle stainless steel
- **Quantity:** 3 hinges (top edge)
- **Opening:** 110° minimum
- **Material:** 316 stainless steel

Gas Shock Struts

- **Quantity:** 2× gas struts per unit
- **Force:** Sized to hold door open at 90°
- **Rating:** Stainless steel, marine grade

- **Damping:** Soft-close action

- **Door hold-open:** Magnetic catch or hook system to secure door when accessing TV
- **Front panel:** Removable glass frame for TV installation/service
- **Tool-free access:** No tools required for routine TV access

4.6 Security & Locking PREMIUM

Feature	Specification
Primary Lock	Tubular cam lock, keyed alike option, 316 SS housing
Lock Quantity	2× locks standard (top and bottom of door)
Padlock Hasps	2× padlock holes (accepts up to 10mm shackle) for additional security
Keys	3× keys supplied per unit, keyed alike option for multi-unit installs
Anti-tamper	Security screws on external hinges (Torx or hex socket)

4.7 Latching System

- **Latch type:** Compression draw latches (not friction)
- **Quantity:** 4× latches (2 per side) for 55"+ models
- **Material:** 316 stainless steel body and keeper
- **Action:** Over-center compression for positive gasket seal
- **Adjustment:** Threaded keeper for seal adjustment

4.8 Mounting System

VESA Mount Plate (Included)

- **Pattern:** Universal 200×200 to 600×400mm

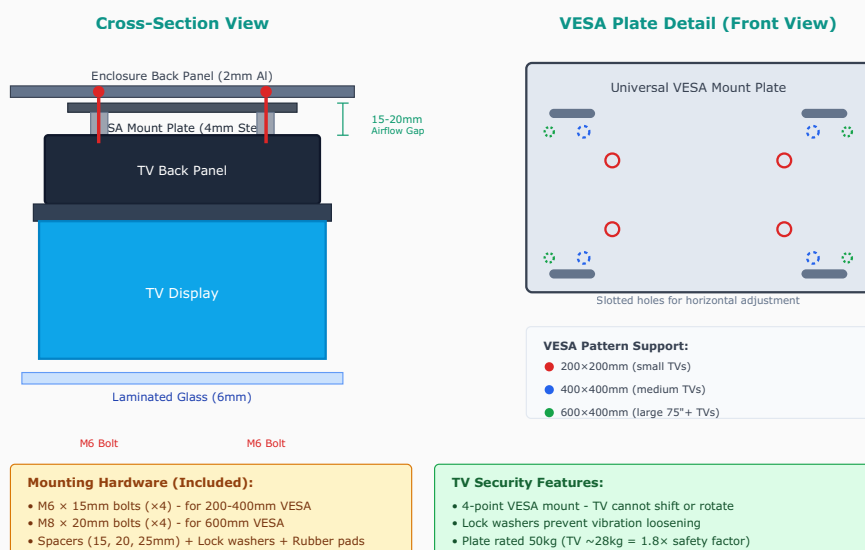
- **Material:** 4mm steel, powder coated
- **Hardware:** M6/M8 bolts, spacers, lock washers included
- **Adjustment:** Slotted holes for vertical/horizontal alignment

Full-Motion Arm (Included)

- **Type:** Articulating dual-arm mount
- **Extension:** Up to 500mm from wall
- **Swivel:** $\pm 90^\circ$ horizontal
- **Tilt:** $+5^\circ$ / -15°
- **Rating:** 50kg capacity minimum

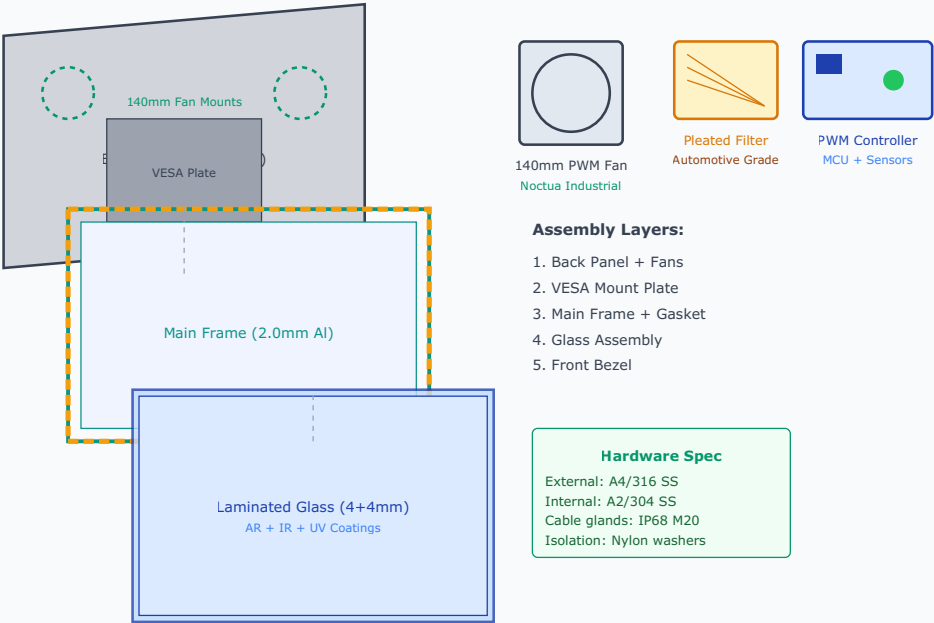
- **Wall bracket:** Heavy-duty steel wall plate with 316 SS hardware
- **Enclosure attachment:** Secure mounting points on rear panel
- **Cable routing:** Arm includes cable management channel

Figure 2: TV Mounting System Detail



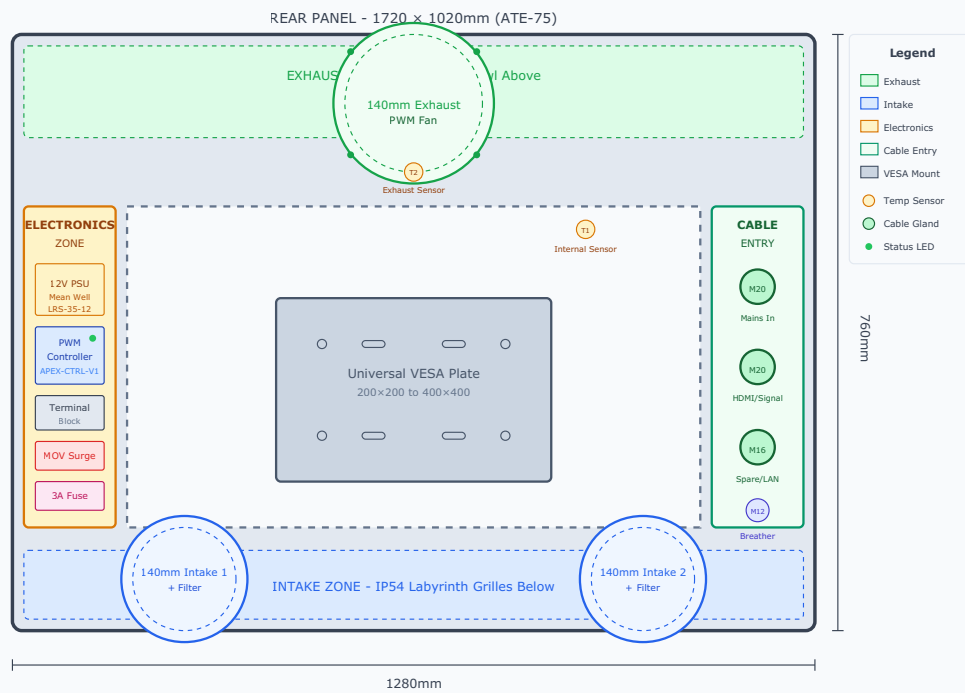
TV mounting system showing cross-section (left) and VESA plate hole patterns (right). Universal plate supports all standard VESA patterns from 200×200 to 600×400mm.

Figure 3: Exploded Assembly View



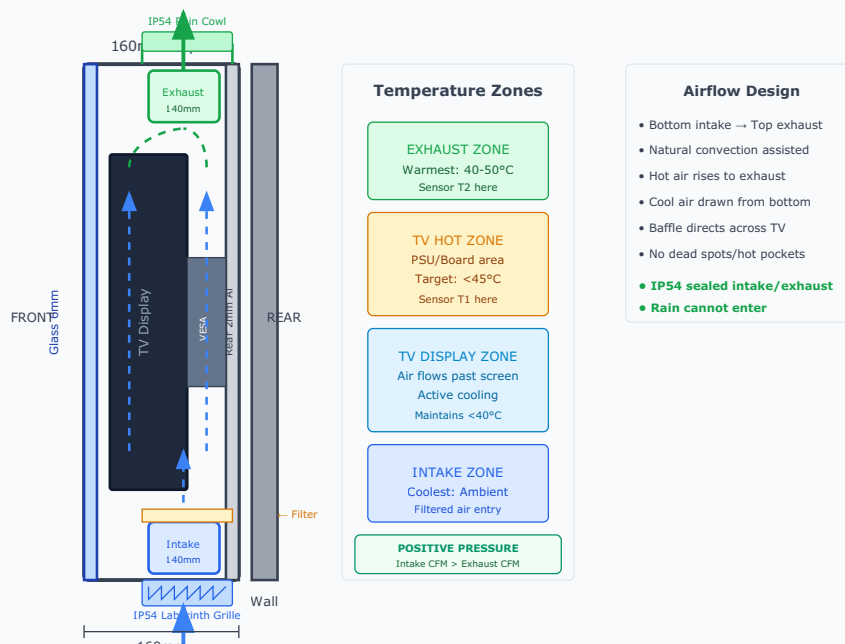
Exploded view showing main components and assembly sequence.

Figure 4: Rear Panel Internal Layout (View from Inside)



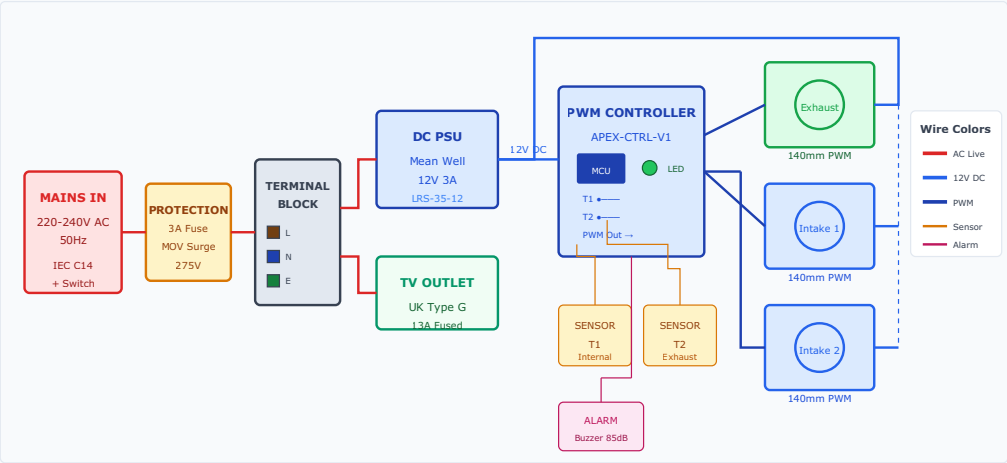
Rear panel layout showing electronics zone (left), VESA mount (center), cable entry (right), and fan positions (top/bottom). All dimensions in mm.

Figure 5: Side Cross-Section - Airflow Path



Side cross-section showing vertical airflow path from bottom intake through TV zone to top exhaust. IP54 labyrinth grille at intake, rain cowl at exhaust.

Figure 6: Electronics Block Diagram



Electronics block diagram showing power distribution, PWM controller, temperature sensors, and fan connections.

5. Front Glass / Optical Stack PREMIUM

Key Differentiator: Laminated glass with IR rejection reduces solar heat gain by up to 40%, significantly reducing cooling requirements.

5.1 Glass Construction (6mm Laminated - Locked Spec)

Layer	Specification
Outer pane	3mm low-iron tempered glass
Interlayer	0.76mm PVB (polyvinyl butyral) - shatter retention
Inner pane	3mm low-iron tempered glass
Total thickness	~6.76mm laminated (3+3)

6mm Glass Specification Justification:

- **Weight reduction:** ~7kg savings vs 8mm (4+4), reducing total enclosure weight to ~38kg
 - **Structural adequacy:** 6mm laminated meets EN 12150-1 for safety glass; continuous channel retention distributes load across full perimeter
 - **Industry precedent:** Competitors (Apollo, TV Shield) use 4-6mm glass successfully
 - **Deflection:** Maximum mid-span deflection <3mm under 60 km/h wind load (acceptable for framed glass)
 - **Impact resistance:** Laminated construction retains fragments if broken; PVB interlayer provides shatter resistance
- Note:** 8mm (4+4) available as upgrade option for high-impact environments (+\$50).

5.2 Coatings & Films

Coating	Purpose	Performance
AR Coating (both sides)	Reduce reflections	<1% reflection
IR Rejection Film	Block infrared heat	90% IR rejection (3M Prestige 90 or equiv)
UV Block	Protect TV from UV	≥99% UV rejection

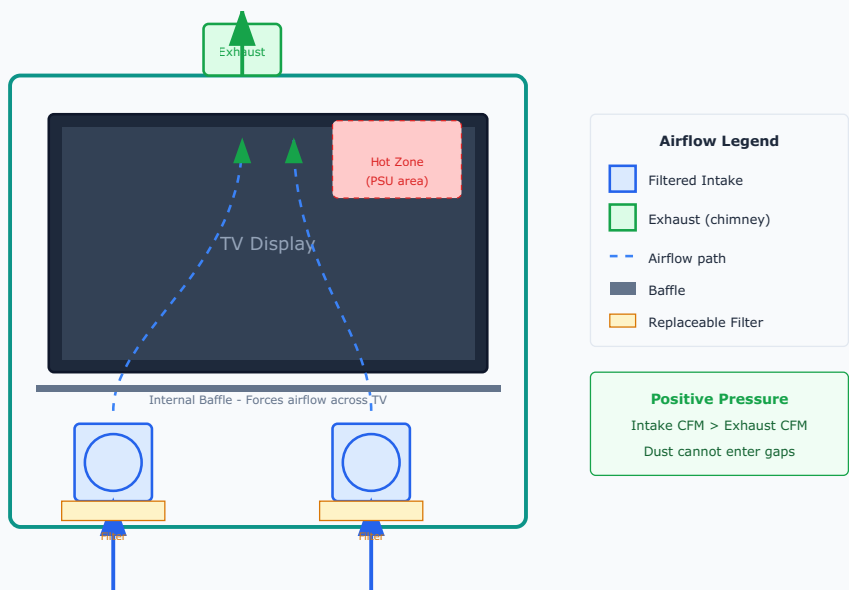
5.3 Optical Requirements

- Visible light transmission: manufacturer standard (provide measured values)
 - Haze: low - no distortion, no waves
 - Edge finish: polished
 - Glass retention: mechanical frame + gasket (not adhesive-only)
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6. Thermal Management System CRITICAL

6.1 Architecture - Zoned Airflow

Figure 7: Thermal Airflow Design



Cross-section showing zoned airflow with positive pressure design. Airflow forced across TV hot zones.

6.2 Fan Specification - Recess-Compatible Design (v5.2.1)

Parameter	Specification
Fan Size	140mm x 140mm x 25mm (high-static pressure)
Fan Count (ATE-75)	3 fans active (all positions used)
System Airflow	210-250 CFM @ 4.8 mmH ₂ O static pressure
Fan Model (Locked)	Delta AFB1412HH-A (83 CFM each, IP55)

Control	PWM (4-wire), 30-50°C curve
Bearing	Fluid Dynamic Bearing
MTBF	>150,000 hours
IP Rating	IP55 minimum
Mounting	Top bezel, tool-less access via hinged service door
Airflow Direction	Bottom intake → Filter → Diffuser plate → 30mm rear plenum → 45° Deflector exhaust

Why Delta AFB1412HH-A: Locked fan model with 4.8 mmH₂O static pressure overcomes filter, diffuser plate, and plenum restriction. 3× fans deliver 210-250 CFM - sufficient for both wall-mount (80-115% margin) and recess (30-50% margin) installations. Consistent model eliminates system curve variance.

6.3 Noise Targets

Mode	PWM Duty	Noise Target (1m) *
Idle / low load	≤40%	Target: ≤30 dBA
Normal cooling	≤70%	Target: ≤40 dBA
High cooling	100%	Target: ≤50 dBA

* Noise levels are design targets. Actual SPL to be validated during prototype testing. Delta AFB1412HH-A fans are high-performance units; acoustic performance depends on installation and operating conditions.

6.4 Control System NEW

NO on/off thermostats. PWM microcontroller control is mandatory.

Controller

- MCU-based PWM fan controller
- Smooth fan ramp (no sudden start)
- Pre-cool option (user selectable)
- Post-run cooldown after TV power-off

Sensors

- Internal air temp (NTC/DS18B20)
- Exhaust air temp
- Optional: TV rear panel probe
- Optional: Ambient intake sensor

Failsafe REQUIRED

- If internal $>65^{\circ}\text{C}$ for >5 min:
 - → Alarm output trigger
 - → Full fan speed
 - → Optional: TV power cut

6.5 Filtration

- **Media:** Automotive-grade pleated synthetic or foam
- **Access:** Tool-less serviceable
- **Spares:** 1 extra filter included per unit

- **Design:** Slight positive pressure to prevent dust ingress

6.6 IP55 Ventilation System - Recess-Compatible (v5.2.2)

IP55

IP55 Rating Achieved: With double-layer labyrinth baffles, extended deflector, and gasketed filter drawer, IP55 (dust protected + low-pressure water jets) is achievable while maintaining 180-210 CFM airflow.

Bottom Bezel Intake System (IP55)

- **Slot:** 1650mm × 35mm continuous intake
- **Type:** **Double-layer labyrinth** with 45° louvers + drip edge
- **Filter:** MERV 8 standard, **gasketed drawer** for IP55 seal
- **Service door:** 1650 × 80mm hinged panel, 4 latches
- **Water shedding:** Dual baffle layers + drip edges prevent jet ingress

Top Bezel Exhaust System (IP55)

- **Slot:** 1650mm × 35mm continuous exhaust
- **Type:** **Double-layer louvers** with extended rain cowl
- **Fans:** 3× Delta AFB1412HH-A (140mm PWM)
- **Deflector:** **75mm @ 45°** architectural shadow element + secondary lip
- **Design:** Hot air exits forward through deflector (recess-compatible)
- **Mesh:** 316 SS insect screen behind louvers

Recess-Compatible Design (v5.2.2): Airflow cools TV heat sinks via 30mm rear plenum with perforated diffuser plate. **Recess cavity:** 1820 × 1130 × 215mm (60mm top gap required). Wall-mount also supported with 30mm minimum clearance. **Note:** IP55 upgrade reduces CFM to 180-210 (from 210-250) due to increased baffle restriction - still adequate for recess installations.

Ventilation Component	IP Rating	Notes
Intake labyrinth grille	IP55	Double-layer baffles + drip edges resist water jets
Exhaust rain cowl	IP55	75mm deflector + secondary lip prevent jet ingress
Filter drawer	IP55	Gasketed seal around drawer frame
Cable glands	IP68	Exceeds requirement
Service door seal	IP55	Higher-durometer EPDM + 4 compression latches

7. Electrical System

Do NOT use consumer power strips. Purpose-built power distribution module required.

7.1 Power Input

Parameter	Specification
Voltage	220-240V AC, 50Hz (Gulf standard)
Entry	IEC inlet OR hardwired gland + terminal block
Protection	Fused + MOV/TVS surge protection
Earth bonding	Proper bonding to enclosure required

7.2 Internal Distribution

- Fused distribution: TV + fans + accessory circuits
- 1-2 accessory outlets (UK/GCC type or IEC)
- All cabling: heat-rated, neatly loomed
- Cable management: high-temp 3M VHB adhesive mounts

7.3 Compliance

- Build to IEC/UL 62368-1 principles
 - Hi-pot / earth continuity test per batch
 - CE marking required
 - RoHS compliant
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8. Finish & Cosmetics

8.1 Powder Coating

Parameter	Specification
Type	Architectural-grade polyester
Thickness	70-100 µm
Finish	Semi-gloss, 30-50 gloss units
UV Resistance	5+ years outdoor stability
Salt Spray	>500 hours

8.2 Color Options

Standard Colors (included in base price):

Color	RAL Code	Best For
Matte Black	RAL 9005	Default - hides in shadows, matches most TVs
Stone Grey	RAL 7032	Natural stone walls, garden settings

Premium Colors (+\$75 / AED 275):

Color	RAL Code	Best For
Oyster White	RAL 1013	Light stone, cream-colored walls
Light Ivory	RAL 1015	Beige/cream Mediterranean schemes
Silk Grey	RAL 7044	Modern minimalist, light contemporary

Anthracite	RAL 7016	Dark contemporary, charcoal walls
Bronze	RAL 8019	Wood tones, warm outdoor schemes

Custom RAL (+\$150 / AED 550, 2-week lead time):

- Any RAL Classic color available on request
- Provide RAL code with order
- Minimum order: 1 unit

8.3 Internal Surfaces

- Matte black or dark neutral (reduce reflections)
 - Avoid heat traps near electronics
 - OEM to propose balanced approach
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9. Testing & QA Requirements

Manufacturer must propose and price the following tests:

Test	Method	Pass Criteria
Thermal Chamber	55°C ambient, TV running, sealed	Internal air <45°C, TV back <50°C
Dust Ingress	Dust exposure + filter evaluation	No dust penetration past filter
Water Splash Test (IP54)	IEC 60529 - Water splashing against enclosure from all directions	No harmful water ingress
Noise Test	dBA at 1m at 40/70/100% PWM	Target: 30/40/50 dBA (measure actual)
Salt Spray	ASTM B117	>500 hours, no corrosion
Burn-in	24-hour electronics run	No failures

10. Bill of Materials (ATE-75)

Item	Description	Qty	Est. Cost (USD)
Frame Assembly	5052-H32 Al, 2.0mm, powder coated	1 set	\$55
Back Panel	2.0mm aluminum, powder coated	1	\$30
Front Glass	4+4mm laminated, AR+IR+UV	1	\$85
Gaskets	EPDM closed-cell seal kit	1 set	\$12
Fans	140mm PWM industrial (Noctua/ equiv)	2	\$45
Fan Controller	MCU PWM board + sensors	1	\$25
Power Module	Fused distribution + surge	1	\$18
Cable Glands	IP68 M20, 316 SS	3	\$8
Filters	Automotive pleated (+ 1 spare)	2	\$8
Hardware	316 SS fasteners, brackets, clips	1 set	\$18
VESA Mount	Universal adjustable plate	1	\$18
Packaging	Engineered foam, manual, gauge	1 set	\$15
TOTAL ESTIMATED			~\$337

11. RFQ Response Requirements

Factory must respond with:

1. Proposed fan model + datasheet + noise curve
2. Proposed controller design + failsafe behaviour
3. Aluminium grade certification and thickness proof
4. Glass supplier + coating spec + IR/UV performance sheet
5. Estimated unit cost at 100 / 500 / 1,000 qty
6. Lead time for EVT/DVT/PVT builds

Documentation Deliverables

- 2D drawings (DXF/PDF) + 3D CAD (STEP)
 - BOM with part numbers and supplier info
 - Wiring diagram
 - Firmware/control logic description
 - QC checklist and test report template
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Apex TV Enclosures

Dubai, United Arab Emirates
Premium Outdoor TV Protection

Version 2.0 | December 2025

Detailed Bill of Materials

Apex TV Enclosures | Model ATE-55 (55") | Version 3.0 - Front-Breathing Design

Note: This BOM is for the ATE-55 (55") model. Quantities and some components vary by size. All prices are estimated FOB China and subject to volume negotiation.

1. Enclosure Structure

#	Component	Specification	Part Number	Qty	Unit Cost	Total	Supplier
1.1 Frame & Panels							
1.1.1	Main Frame Assembly	5052-H32 Aluminum, 2.0mm, CNC bent, powder coated External: 1320 × 800 × 120mm	APEX-FR-55	1	\$35.00	\$35.00	Shenzhen Runze Metal
1.1.2	Back Panel	5052-H32 Aluminum, 2.0mm, with fan cutouts, hinged 1280 × 760mm, pre-drilled VESA	APEX-BP-55	1	\$22.00	\$22.00	Shenzhen Runze Metal
1.1.3			APEX-BZ-55	1	\$12.00	\$12.00	

#	Component	Specification	Part Number	Qty	Unit Cost	Total	Supplier
	Front Bezel Frame	6063-T5 Aluminum extrusion, 15mm face, powder coated Mitered corners, glass retention channel					Guangdong Weiye Aluminum
1.1.4	Internal Baffle	1.5mm Aluminum, directs airflow across TV Full width, 50mm height	APEX-BF-55	1	\$4.00	\$4.00	Included with frame
1.1.5	VESA Mount Plate	3.0mm Steel, powder coated, universal adjustable Supports 200×200 to 400×400	APEX-VESA-U	1	\$8.00	\$8.00	Ningbo Highstar
1.1.6	Gas Struts (pair)	100N force, 250mm stroke, stainless For rear panel hinged access	GS-100N-250	2	\$3.50	\$7.00	Changzhou Juteng
Subtotal - Frame & Panels						\$88.00	
1.2 Glass Assembly							

#	Component	Specification	Part Number	Qty	Unit Cost	Total	Supplier
1.2.1	Laminated Glass Panel	4mm + PVB + 4mm low-iron tempered 1270 × 750mm, polished edges	APEX-GL-55	1	\$55.00	\$55.00	Qingdao Tsing Glass
1.2.2	AR Coating	Anti-reflective coating, both sides <1% reflectance	AR-COAT-2S	1	\$18.00	\$18.00	Applied by glass supplier
1.2.3	IR Rejection Film	Infrared rejection window film 90% IR block, applied to inner surface	3M-PR90	1	\$65.00	\$65.00	3M Prestige 90 Series
1.2.4	Anti-Fog Coating	Hydrophilic coating, interior surface Prevents condensation droplets, v3.0 requirement	AF-HYDRO-INT	1	\$10.00	\$10.00	Applied by glass supplier
Subtotal - Glass Assembly						\$148.00	
1.3 Seals & Gaskets (IP55 Grade)							
1.3.1	Main Door Gasket	EPDM continuous channel gasket,	EPDM-CH-1215-HD	5m	\$2.20/m	\$11.00	Hebei Shengtong Rubber

#	Component	Specification	Part Number	Qty	Unit Cost	Total	Supplier
		higher-durometer, UV stable, closed-cell 12 × 15mm profile with frame channel, ~4.2m length, IP55 rated					
1.3.2	Glass Seal Gasket	Silicone U-channel, for glass edge 6mm glass channel, ~4m length	SIL-U8-BK	5m	\$0.80/m	\$4.00	Hebei Shengtong Rubber
1.3.3	Cable Glands IP68	M20 thread, 316 stainless body 6-12mm cable range	CG-M20-SS316	3	\$2.50	\$7.50	Yueqing Langir Electric
1.3.4	ePTFE Breather Vent	Pressure equalization membrane M12, IP68, prevents condensation	GORE-PMF100	2	\$4.00	\$8.00	Gore Protective Vents
1.3.5	Filter Drawer Gasket	EPDM frame seal for gasketed filter drawer 8 × 10mm profile, ~1.2m length, IP55 seal	EPDM-FD-0810	1.5m	\$1.50/m	\$2.25	Hebei Shengtong Rubber

#	Component	Specification	Part Number	Qty	Unit Cost	Total	Supplier
Subtotal - Seals & Gaskets (IP55)						\$32.75	

2. Thermal Management System

#	Component	Specification	Part Number	Qty	Unit Cost	Total	Supplier
2.1 Fans							
2.1.1	Slim Exhaust Fan (Top Bezel)	60mm × 60mm × 15mm, PWM, IP67 12V, 0.12A, 17CFM each (~70CFM total + convection), <25dBA, SSO2 bearing	NF-A6x15-PWM	4	\$16.00	\$64.00	Noctua
2.1.2	Alternative: Delta Slim Fan	60mm × 60mm × 15mm, PWM, IP68 12V, 0.15A, 20CFM each, <28dBA	AFB0612VHC-F00	4	\$10.00	\$40.00	Sunon
2.1.3	Fan Mounting Grommets	Silicone anti-vibration, for 60mm Reduces noise transmission	NA-SAV2-60	16	\$0.40	\$6.40	Noctua
2.1.4	IP55 Double-Layer Intake Labyrinth	IP55-rated double-layer labyrinth with drip edges	VENT-IP55-DL-150	4	\$12.00	\$48.00	Dongguan Weipu Connector

#	Component	Specification	Part Number	Qty	Unit Cost	Total	Supplier
		UV-stable ABS, dual 45° louvers, 150×150mm, IEC 60529 jet tested					
2.1.5	IP55 Exhaust Deflector + Rain Cowl	Aluminum exhaust deflector with 75mm overhang + secondary lip , IP55 rated Double-layer louvers, 316 SS insect mesh, powder coated	APEX-DEFL-IP55-75	1	\$18.00	\$18.00	Custom fabrication
Subtotal - Fans + IP55 Ventilation						\$136.40	
2.2 Filtration							
2.2.1	Intake Filter Frame	ABS plastic, magnetic or clip-in Tool-free removal	APEX-FILT-FR	2	\$3.00	\$6.00	Custom molding
2.2.2	Filter Media	Automotive-grade pleated polyester 40PPI, washable, 150×150×10mm	AF-150-40PPI	4	\$2.00	\$8.00	Dongguan Filter Tech
Subtotal - Filtration						\$14.00	
2.3 Control System							

#	Component	Specification	Part Number	Qty	Unit Cost	Total	Supplier
2.3.1	PWM Fan Controller Board	MCU-based, 4-channel PWM output 12V input, temp sensor inputs, failsafe logic	APEX-CTRL-V1	1	\$15.00	\$15.00	Custom PCB (see control spec)
2.3.2	Temperature Sensor - Internal	DS18B20 digital, waterproof probe -55°C to +125°C, ±0.5°C accuracy	DS18B20-WP	2	\$1.50	\$3.00	Maxim / Generic
2.3.3	Temperature Sensor - Exhaust	NTC 10K thermistor, ring terminal For exhaust air monitoring	NTC-10K-3950	1	\$0.80	\$0.80	Shenzhen Ampron
2.3.4	Alarm Buzzer	12V piezo buzzer, 85dB For thermal alarm	BZ-12V-85DB	1	\$0.50	\$0.50	Generic
Subtotal - Control System						\$19.30	

3. Electrical System

#	Component	Specification	Part Number	Qty	Unit Cost	Total	Supplier
3.1 Power Distribution							
3.1.1		C14 inlet with fuse holder,	IEC-C14-FS	1	\$3.50	\$3.50	

#	Component	Specification	Part Number	Qty	Unit Cost	Total	Supplier
	IEC Power Inlet	10A Panel mount, with switch					Yueqing Daier
3.1.2	Fuse	5×20mm glass, 3A slow-blow Spare included	F-3A-250V-SB	2	\$0.10	\$0.20	Generic
3.1.3	Surge Protector MOV	275V MOV varistor Line-neutral, line-earth	MOV-275V-14D	2	\$0.50	\$1.00	Generic
3.1.4	Terminal Block	DIN rail, 3- position, 10A L, N, E distribution	TB-3P-10A	1	\$2.00	\$2.00	Phoenix Contact / Generic
3.1.5	DC Power Supply	Mean Well or equiv, 12V 3A, enclosed 85-264VAC input, Class II	LRS-35-12	1	\$8.00	\$8.00	Mean Well
3.1.6	Accessory Outlet	UK 3-pin socket (Type G), 13A Panel mount, for media player etc.	UK-13A-PM	1	\$3.00	\$3.00	Generic
Subtotal - Power Distribution						\$17.70	
3.2 Wiring & Connectors							
3.2.1	Mains Cable	3G1.0mm ² , heat resistant	H05VV- F-3G1.0	2m	\$0.80/ m	\$1.60	Generic

#	Component	Specification	Part Number	Qty	Unit Cost	Total	Supplier
		(105°C) Black, ~2m per unit					
3.2.2	DC Fan Cable	4-wire PWM, 22AWG, shielded ~1m per fan	PWM-4W-22AWG	3m	\$0.50/m	\$1.50	Generic
3.2.3	Fan Connector	4-pin PWM header, male + female Standard PC fan connector	FAN-4P-MF	4	\$0.30	\$1.20	Generic
3.2.4	Cable Ties	Nylon, UV resistant, 150mm Black	CT-150-UV	20	\$0.02	\$0.40	Generic
3.2.5	Adhesive Cable Mounts	3M VHB high-temp For cable management	3M-VHB-CM	10	\$0.15	\$1.50	3M
3.2.6	Earth Bonding Strap	Tinned copper braid, 10mm Panel to frame bonding	EB-10-TC	2	\$0.50	\$1.00	Generic
Subtotal - Wiring & Connectors						\$7.20	

#	Component	Specification	Part Number	Qty	Unit Cost	Total	Supplier
4.1 Fasteners (316 Stainless)							
4.1.1	Frame Screws	M4 × 10mm pan head, A4-316 External frame assembly	M4-10-PH-A4	40	\$0.08	\$3.20	Jiaxing Haina Fastener
4.1.2	Back Panel Screws	M5 × 12mm cap head, A4-316 Captive screws preferred	M5-12-CH-A4	12	\$0.12	\$1.44	Jiaxing Haina Fastener
4.1.3	VESA Screws	M6 × 15mm, A4-316 with washers TV mounting	M6-15-A4-KIT	8	\$0.25	\$2.00	Jiaxing Haina Fastener
4.1.4	Hinge Screws	M4 × 8mm countersunk, A4-316	M4-8-CS-A4	8	\$0.08	\$0.64	Jiaxing Haina Fastener
4.1.5	Nylon Isolation Washers	M4 and M5, for dissimilar metals	NYL-M4M5-KIT	50	\$0.02	\$1.00	Generic
4.1.6	Threaded Inserts	M4 press-fit for aluminum	TI-M4-AL	20	\$0.10	\$2.00	Generic
Subtotal - Fasteners						\$10.28	
4.2 Door Hardware & Security							

#	Component	Specification	Part Number	Qty	Unit Cost	Total	Supplier
4.2.1	Concealed Hinges	3-knuckle concealed hinge, 316 SS 110° opening, soft-close	HINGE-316-CC	3	\$4.50	\$13.50	Foshan Lelang Hardware
4.2.2	Compression Latches	Over-center draw latch, 316 SS Adjustable keeper, 200N holding force	LATCH-316-ADJ	4	\$3.80	\$15.20	Ningbo Haishu Xincheng
4.2.3	Tubular Cam Locks	19mm diameter, 316 SS body Keyed alike, 3 keys each	LOCK-TUB-316	2	\$5.50	\$11.00	Ningbo Make Security
4.2.4	Padlock Hasps	Weldable hasp plate, 316 SS 10mm shackle hole	HASP-316-10	2	\$1.50	\$3.00	Generic
4.2.5	Magnetic Door Catch	Heavy duty magnetic catch, 316 SS Hold-open when servicing TV	MAG-CATCH-SS	1	\$2.50	\$2.50	Generic
Subtotal - Door Hardware						\$45.20	
4.3 Mounting System							
4.3.1				1	\$28.00	\$28.00	

#	Component	Specification	Part Number	Qty	Unit Cost	Total	Supplier
	Full-Motion Articulating Arm	Dual-arm mount, 500mm extension ±90° swivel, +5°/-15° tilt, 50kg rated	MOUNT-FM-50KG				Ningbo Highstar
4.3.2	Wall Plate	Heavy-duty steel wall plate 4mm steel, powder coated	APEX-WP-55	1	\$6.00	\$6.00	Custom fabrication
4.3.3	Wall Anchors	M10 concrete anchors, 316 SS For masonry mounting, 50kg each	M10-CONC-SS	6	\$0.80	\$4.80	Generic
Subtotal - Mounting System						\$38.80	

5. Packaging & Documentation

#	Component	Specification	Part Number	Qty	Unit Cost	Total	Supplier
5.1	Carton Box	Double-wall corrugated, custom size 1400 × 900 × 200mm	BOX-55-DW	1	\$5.00	\$5.00	Local packaging supplier
5.2		EPE foam corner	FOAM-55-SET	1	\$4.00	\$4.00	

#	Component	Specification	Part Number	Qty	Unit Cost	Total	Supplier
	Foam Corners	protectors Custom molded, set of 4					Local packaging supplier
5.3	Glass Protection	Foam frame + cardboard sheet Front face protection	GP-55	1	\$2.00	\$2.00	Local packaging supplier
5.4	Accessories Box	Small box for hardware kit Contains screws, anchors, manual	ACCB0X-55	1	\$1.00	\$1.00	Local packaging supplier
5.5	Installation Manual	Printed, full color, multi- language EN/AR	MAN-APEX-55	1	\$0.50	\$0.50	Local printing
5.6	Clearance Gauge	Plastic template for recess installation Shows minimum clearances	GAUGE-55	1	\$0.50	\$0.50	Custom molding
5.7	Spare Filter	Extra filter included	AF-150-40PPI	2	\$2.00	\$4.00	See 2.2.2
Subtotal - Packaging						\$17.00	

6. Included Accessories

#	Component	Specification	Part Number	Qty	Unit Cost	Total	Supplier
6.1 Remote Control & Accessories							
6.1.1	IR Extender System	IR receiver + emitter kit, passes remote signals through glass 38kHz, 10m range, adhesive mount, includes 5m cable	IR-EXT-38K	1	\$15.00	\$15.00	Shenzhen Hualitong
6.1.2	Glass Cleaning Kit	Microfiber cloth (2×) + AR-safe cleaning solution (250ml) Non-ammonia formula, safe for AR coating	CLEAN-KIT-AR	1	\$8.00	\$8.00	Generic / Branded
6.1.3	Quick Start Card	Laminated A5 card with QR code to video tutorials Weatherproof, can be stored in enclosure	QS-CARD	1	\$0.50	\$0.50	Local printing
Subtotal - Included Accessories						\$23.50	

7. Optional Accessories (Not Included)

#	Component	Specification	Part Number	Cost	Retail	Notes
7.1	Soundbar Mounting Bracket	Universal soundbar bracket, mounts below enclosure Adjustable width 600-1200mm, 10kg capacity, 316 SS	SB-BRKT-UNI	\$25.00	\$75 / AED 275	Upsell for audio bundle
7.2	Extended Warranty (3yr)	Extends standard 2-year warranty to 3 years Parts + labor coverage	WARR-3YR	\$0	\$150 / AED 550	Pure margin
7.3	Extended Warranty (5yr)	Extends standard 2-year warranty to 5 years Parts + labor coverage	WARR-5YR	\$0	\$300 / AED 1,100	Pure margin
7.4	Replacement Filter Pack (4x)	MERV 8 replacement filters, 1-year supply Same as included filters	FILT-PACK-4	\$8.00	\$25 / AED 90	Recurring revenue

#	Component	Specification	Part Number	Cost	Retail	Notes
7.5	Anti-Glare Screen Film	Matte anti-glare film for extreme sun locations Reduces reflections in direct sunlight, removable	AG-FILM-55	\$35.00	\$100 / AED 365	For west-facing installs

Cost Summary - ATE-55

Category	Subtotal (USD)
1.1 Frame & Panels	\$88.00
1.2 Glass Assembly (incl. anti-fog coating)	\$148.00
1.3 Seals & Gaskets (IP54)	\$28.50
2.1 Fans + IP54 Ventilation (3× Delta AFB1412HH-A)	\$114.40
2.2 Filtration	\$14.00
2.3 Control System	\$19.30
3.1 Power Distribution	\$17.70
3.2 Wiring & Connectors	\$7.20
4.1 Fasteners	\$10.28
4.2 Door Hardware & Security	\$45.20
4.3 Mounting System	\$38.80

Category	Subtotal (USD)
5. Packaging & Docs	\$17.00
6. Included Accessories (IR Extender, Cleaning Kit)	\$23.50
BOM Total (Materials Only)	\$662.13
Assembly Labor (4-5 hours @ \$15/hr)	\$75.00
QC / Testing (incl. IP55 water jet test)	\$25.00
Factory Overhead (utilities, admin)	\$20.00
Factory Cost (before margin)	\$782.13
Factory Margin (~15%)	\$117.87
FOB Price (ex-factory)	~\$900

Volume Pricing Expectations (FOB):

- **Prototype (1-5 units):** ~\$1,100-1,200/unit (includes NRE, setup costs)
- **Initial orders (10-25 units):** ~\$950/unit
- **Volume (50+ units):** ~\$850/unit (bulk materials, efficiency)
- **High volume (200+ units):** ~\$750/unit (negotiable)

Margin Impact at AED 10,500 Retail (~\$2,860 USD):

- FOB \$900 + Shipping/Duty \$100 = \$1,000 landed → \$1,860 gross margin (65%)
- FOB \$1,200 (prototype) + \$150 = \$1,350 landed → \$1,510 gross margin (53%)

Included: IR extender (remote control through glass), cleaning kit, quick-start card. **IP55 features:** Double-layer labyrinth baffles, 75mm exhaust deflector with secondary lip, gasketed filter drawer.

Apex TV Enclosures | Detailed BOM v5.2.2 (IP55 Recess-
Compatible) | December 2025

PWM Fan Control Logic

Apex TV Enclosures | Firmware Specification | Version 2.0

1. Control System Overview

The Apex thermal management system uses a microcontroller-based PWM fan controller to maintain optimal internal temperature while minimizing noise. Unlike simple on/off thermostat control, this system provides smooth, proportional fan speed adjustment.

Apex PWM Advantages:

- Fans start at 30°C at **20% PWM** (near-silent)
- Gradual ramp: 50% at 35°C, 100% at 45°C
- Protects TV (rated 0-35°C) with headroom
- No sudden speed changes - smooth adjustment
- Post-cooling after TV power-off

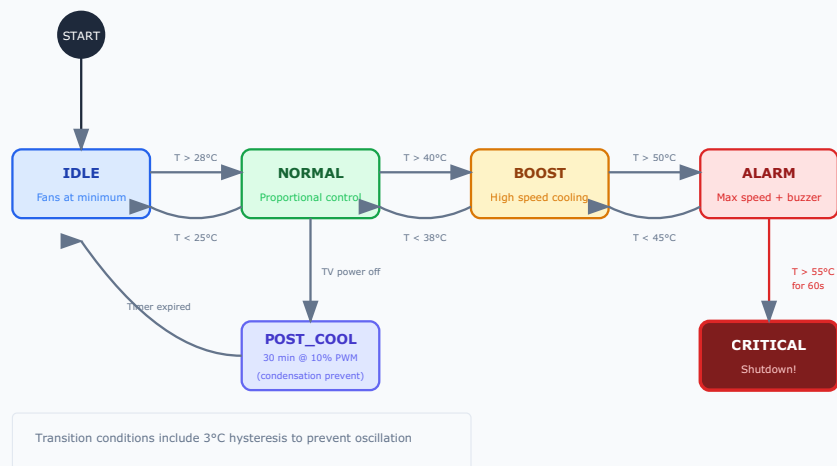
2. System Parameters

Parameter	Value	Description
TEMP_START	30°C	Fans begin at 20% PWM (near-silent)
TEMP_MID	35°C	Fans at 50% PWM (TV's max rated ambient)
TEMP_FULL	45°C	Fans reach 100% PWM (linear ramp 30-45°C)
TEMP_ALARM	50°C	

Parameter	Value	Description	
		Warning LED, maintain 100% fans - TV at risk	
TEMP_CRITICAL	55°C	Emergency - signal TV shutdown	Protect TV from damage
PWM_MIN	20%	Minimum fan speed (quiet operation)	
PWM_MAX	100%	Maximum fan speed	
RAMP_RATE	5%/sec	Maximum PWM change per second	
SAMPLE_INTERVAL	1000ms	Temperature sampling rate	
POST_COOL_TIME	300 sec	Cooling time after TV off	

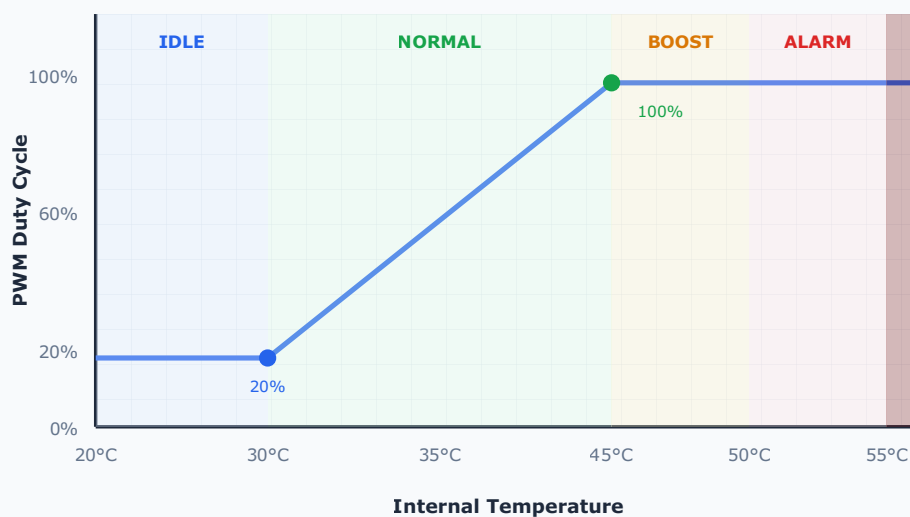
3. State Machine

Figure 1: Controller State Machine



4. PWM Calculation Algorithm

Figure 2: PWM vs Temperature Curve



PWM Calculation Formula

```
// Calculate PWM duty cycle based on temperature
function calculatePWM(temp) {
```

```

    if (temp ≤ TEMP_MIN) {
        return PWM_MIN; // 20%
    }
    else if (temp ≥ TEMP_MAX) {
        return PWM_MAX; // 100%
    }
    else {
        // Linear interpolation between MIN and MAX
        let range = TEMP_MAX - TEMP_MIN; // 45 - 28 = 17°C
        let offset = temp - TEMP_MIN;
        let pwm = PWM_MIN + (offset / range) * (PWM_MAX - PWM_MIN);
        return pwm;
    }
}

```

5. Main Control Loop

```

// Main control loop - runs every SAMPLE_INTERVAL (1000ms)
function controlLoop() {
    // 1. Read temperature sensors
    let tempInternal = readSensor(SENSOR_INTERNAL);
    let tempExhaust = readSensor(SENSOR_EXHAUST);

    // 2. Use highest temperature for control
    let tempControl = max(tempInternal, tempExhaust);

    // 3. Check for critical condition
    if (tempControl ≥ TEMP_CRITICAL) {
        criticalCounter++;
        if (criticalCounter ≥ 60) { // 60 seconds at critical
            enterCriticalState();
            return;
        }
    } else {
        criticalCounter = 0;
    }

    // 4. Update state machine
    updateState(tempControl);

    // 5. Calculate target PWM based on state
    let targetPWM;
    switch (currentState) {

```



```

        case STATE_IDLE:
            targetPWM = PWM_MIN;
            break;
        case STATE_NORMAL:
            targetPWM = calculatePWM(tempControl);
            break;
        case STATE_BOOST:
        case STATE_ALARM:
            targetPWM = PWM_MAX;
            break;
        case STATE_POST_COOL:
            targetPWM = 10; // Low speed idle - condensation prevention (30 min)
            break;
    }

    // 6. Apply smooth ramping
    currentPWM = rampTo(currentPWM, targetPWM, RAMP_RATE);

    // 7. Set fan speed (all 4 rear exhaust fans)
    setFanPWM(FAN1, currentPWM);
    setFanPWM(FAN2, currentPWM);
    setFanPWM(FAN3, currentPWM);
    setFanPWM(FAN4, currentPWM);

    // 8. Handle alarm
    if (currentState == STATE_ALARM) {
        activateBuzzer(true);
    } else {
        activateBuzzer(false);
    }
}

// Smooth ramping function - prevents sudden speed changes
function rampTo(current, target, rate) {
    let diff = target - current;
    if (abs(diff) ≤ rate) {
        return target;
    }
    return current + sign(diff) * rate;
}

```

6. Failsafe Behavior

Critical Safety Feature: The controller includes hardware watchdog and failsafe logic.

Condition	Detection	Action
Sensor failure	Reading out of range (-40 to +85°C)	Set fans to 100%, activate alarm
Fan failure	Tachometer reads 0 RPM when PWM > 30%	Activate alarm, log error
Over-temperature	Internal temp > 55°C for 60 seconds	Optional: Cut TV power relay
MCU crash	Watchdog timer expires (2 seconds)	Hardware reset, fans default to 100%

7. Hardware Requirements

7.1 Microcontroller

- **Recommended:** ATmega328P or ESP32-C3
- 2+ PWM outputs (25kHz capable for silent operation)
- 1-Wire interface for DS18B20 sensors
- Digital I/O for alarm output
- Optional: WiFi/BLE for remote monitoring (ESP32)

7.2 PWM Frequency

Important: Use 25kHz PWM frequency for silent fan operation. Lower frequencies (e.g., 490Hz Arduino default) cause audible whine.

7.3 Suggested Components

Component	Part Number	Notes
MCU	ATmega328P-AU	Arduino compatible
Voltage Regulator	AMS1117-3.3	3.3V for sensors
MOSFET Driver	IRLZ44N	For PWM output (if needed)
Pull-up Resistor	4.7kΩ	For 1-Wire bus
Decoupling Caps	100nF + 10μF	Per IC

8. Testing Requirements

1. Verify PWM output at 25kHz $\pm 5\%$
2. Test temperature reading accuracy $\pm 1^{\circ}\text{C}$
3. Verify smooth fan ramp (no audible steps)
4. Test all state transitions
5. Verify failsafe activates on sensor disconnect
6. Test watchdog reset functionality
7. Measure noise at each PWM level
8. 48-hour burn-in test

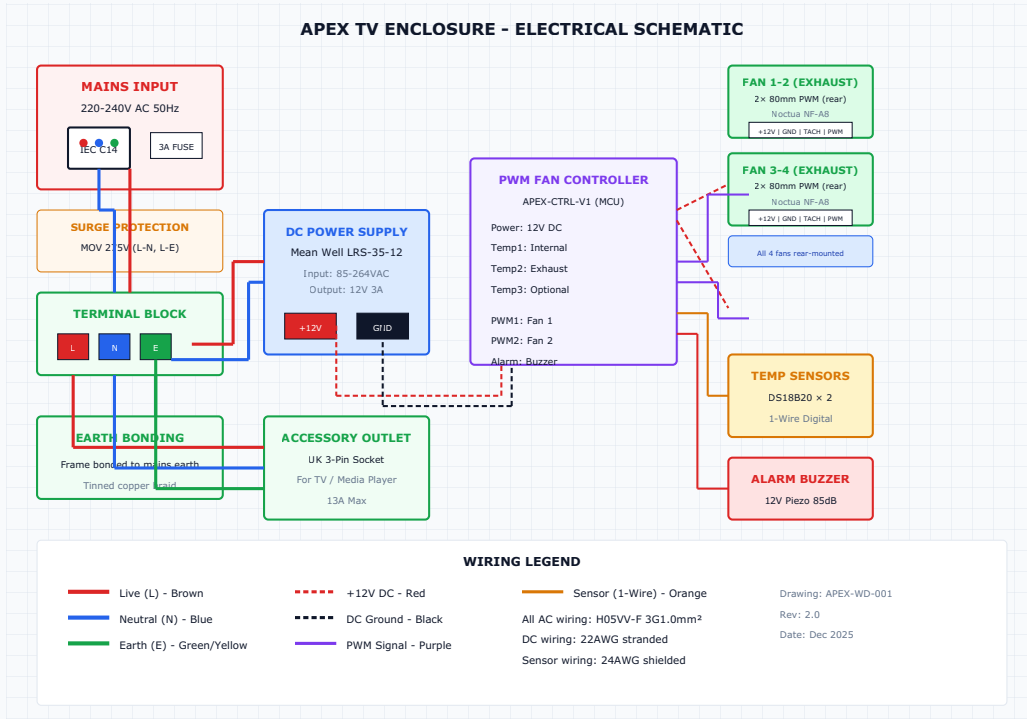
Electrical Wiring Diagram

Apex TV Enclosures | All Models | Version 2.0

Safety Warning: All electrical work must be performed by qualified personnel. Ensure mains power is disconnected before any wiring work. Unit must be properly earthed.

1. System Overview Diagram

Figure 1: Complete Electrical System



Wire ID	From	To	Type	Color	Size	Length
AC Mains (220-240V)						
W-AC-L1	IEC Inlet L	Fuse	H05VV-F	Brown	1.0mm²	50mm
W-AC-L2	Fuse	Terminal Block L	H05VV-F	Brown	1.0mm²	100mm
W-AC-N1	IEC Inlet N	Terminal Block N	H05VV-F	Blue	1.0mm²	150mm
W-AC-E1	IEC Inlet E	Terminal Block E	H05VV-F	Green/ Yellow	1.0mm²	150mm
W-AC-L3	Terminal Block L	DC PSU L	H05VV-F	Brown	1.0mm²	200mm
W-AC-N2	Terminal Block N	DC PSU N	H05VV-F	Blue	1.0mm²	200mm
W-AC-L4	Terminal Block L	Accessory Outlet L	H05VV-F	Brown	1.0mm²	300mm
W-AC-N3	Terminal Block N	Accessory Outlet N	H05VV-F	Blue	1.0mm²	300mm
W-AC-E2	Terminal Block E	Accessory Outlet E	H05VV-F	Green/ Yellow	1.0mm²	300mm
W-EB-1	Terminal Block E	Frame Bonding Point	Tinned braid	Bare	10mm	150mm
DC Power (12V)						

Wire ID	From	To	Type	Color	Size	Length
W-DC-P1	DC PSU +12V	Controller VIN+	Stranded	Red	22AWG	250mm
W-DC-G1	DC PSU GND	Controller GND	Stranded	Black	22AWG	250mm
Fan Connections (4-wire PWM) - 4× 80mm Rear Exhaust						
W-FAN1	Controller FAN1	Fan 1 (Exhaust-L)	4-wire PWM	Mixed	22AWG	350mm
W-FAN2	Controller FAN2	Fan 2 (Exhaust-LC)	4-wire PWM	Mixed	22AWG	400mm
W-FAN3	Controller FAN3	Fan 3 (Exhaust-RC)	4-wire PWM	Mixed	22AWG	450mm
W-FAN4	Controller FAN4	Fan 4 (Exhaust-R)	4-wire PWM	Mixed	22AWG	500mm
Sensor Connections						
W-TEMP1	Controller TEMP1	Internal Sensor	Shielded 3-wire	Red/Black/Yellow	24AWG	300mm
W-TEMP2	Controller TEMP2	Exhaust Sensor	Shielded 3-wire	Red/Black/Yellow	24AWG	400mm
Alarm						
W-ALM1	Controller ALARM+	Buzzer +	Stranded	Red	24AWG	200mm

Wire ID	From	To	Type	Color	Size	Length
W-ALM2	Controller ALARM-	Buzzer -	Stranded	Black	24AWG	200mm

3. Connector Pinouts

3.1 PWM Fan Connector (4-pin)

Pin	Signal	Color	Description
1	GND	Black	Ground (0V)
2	+12V	Yellow	Power supply
3	TACH	Green	Tachometer output (RPM)
4	PWM	Blue	PWM control input

3.2 DS18B20 Temperature Sensor

Wire	Signal	Color	Description
1	GND	Black	Ground
2	DQ	Yellow	Data (1-Wire)
3	VDD	Red	Power (3.3-5V)

Note: DS18B20 sensors can be connected in parallel on the same 1-Wire bus. Each sensor has a unique 64-bit address for identification. Use 4.7kΩ pull-up resistor on data line.

4. Safety Requirements

- All mains wiring must use heat-rated cable (105°C minimum)
- Double insulation on all accessible parts
- Earth continuity must be verified before power-on
- Hi-pot test: 1500VAC for 1 minute between L/N and E
- All crimped connections must be pull-tested
- Cable routing must avoid sharp edges
- Minimum 10mm clearance from hot surfaces
- Strain relief required on all external cables

Apex TV Enclosures | Wiring Diagram v2.0 | December 2025

Drawing: APEX-WD-001 | Rev: 2.0