

Understanding AC and DC Distribution

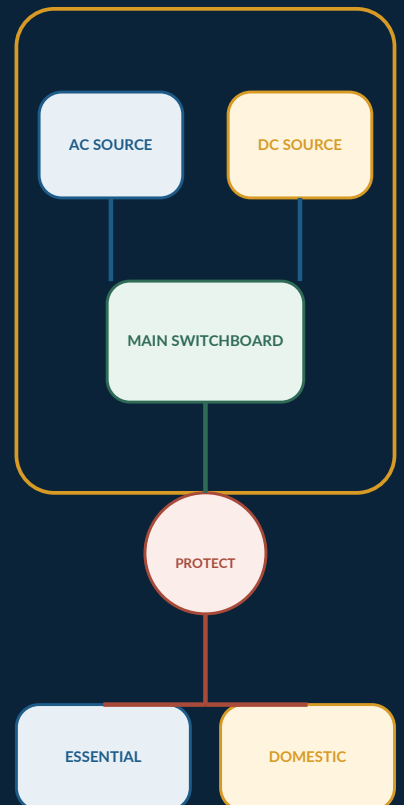
An owner's guide to switchboards, protection, cabling, isolation and electrical resilience

Distribution determines where power goes, what protects it and what remains after a fault.

A small connection or labelling defect can remove several apparently separate systems.

Absolute Marine

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GUIDE OVERVIEW

What AC and DC distribution is designed to do

Distribution systems route electrical power from shore, generators, inverters and batteries to individual loads through switching, protection, isolation and monitoring.

SCOPE	This guide provides owner-level understanding of common low-voltage AC and DC arrangements on cruising yachts. Actual fault levels, cable sizes, earthing methods and protective-device settings are vessel-specific and should be assessed from current drawings and competent electrical testing.
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By the end of this guide, you should be able to:

- Trace the principal AC and DC routes from source to switchboard, branch circuit and load.
- Identify main switchboards, sub-panels, busbars, breakers, fuses, RCDs, isolators and essential buses.
- Recognise overload, short circuit, loose connections, voltage drop, leakage current, water ingress and undocumented modification.
- Understand why protective-earth, neutral, DC negative and bonding paths serve different purposes.
- Ask better questions during purchase, survey, refit, maintenance and offshore preparation.

CORE PRINCIPLE	Distribution reliability depends on selectivity: a fault should be isolated by the correct protective device without unnecessarily removing healthy essential circuits.
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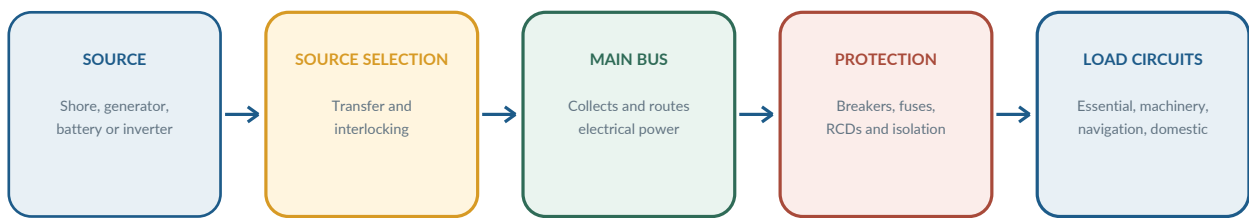
Safety

AC and high-current DC equipment can remain dangerous after a source is switched off. Inverters, capacitors, automatic source transfer and battery banks may keep parts energised. Do not open live panels or defeat interlocks unless the work and isolation procedure are appropriate.

SYSTEM ARCHITECTURE

How sources, buses and load circuits fit together

A useful single-line diagram shows each source, transfer device, main bus, bus-tie, protective device, sub-distribution board, essential supply and the controlled point where neutral, earth or DC return paths connect.



Meters, alarms, emergency supplies and load shedding provide supervision and recovery across the complete route.

The practical hierarchy

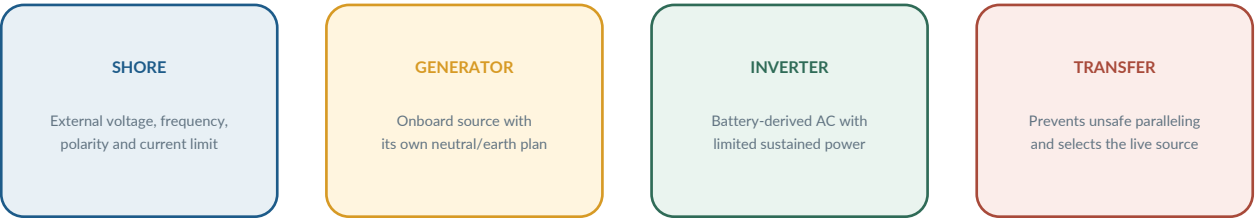
- Sources: Shore, generators, inverter outputs, batteries, chargers and emergency supplies.
- Source selection: Manual or automatic transfer prevents incompatible sources from being connected together.
- Main distribution: Switchboards and busbars divide power into protected feeders and major loads.
- Sub-distribution: Local panels reduce cable runs and group machinery, accommodation or navigation circuits.
- Protection: Breakers, fuses and leakage devices should clear faults before cables or people are endangered.
- Essential and emergency supplies: Preserve selected loads after a source or normal bus is lost.

ONE DIAGRAM SHOULD MATCH THE YACHT	A neat drawing from build may no longer reflect later solar, inverter, lithium, generator or domestic upgrades. Physical verification and controlled drawing updates are part of reliability.
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AC SOURCES AND TRANSFER

Shore power, generators, inverters and bus selection

AC sources can differ in voltage, frequency, available current, phase arrangement and neutral-to-earth treatment. The transfer system must select the correct source without unsafe paralleling.



The switchboard must know which source is connected because neutral, earth and protection behaviour may change.

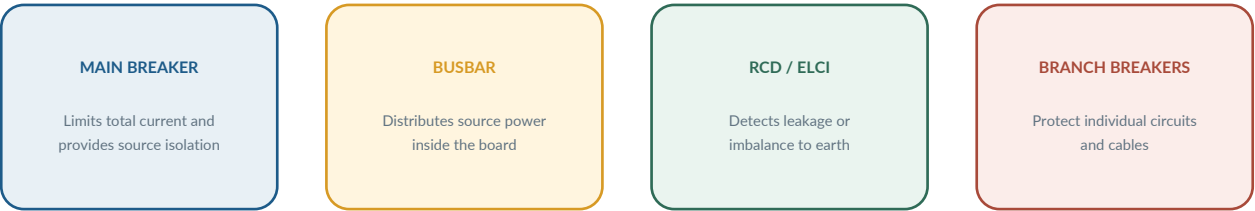
Area	What can go wrong	Owner focus
Shore source	Incorrect voltage/frequency, poor polarity, low current limit, damaged connection or unstable supply.	Verify indication before connection, manage available load and inspect cable/inlet condition.
Generator source	Low/high voltage, frequency change, phase imbalance or breaker/neutral fault.	Loaded readings, warm-up/cool-down, protection and what feeds essential circuits.
Inverter source	Overload, low battery, waveform incompatibility or transfer relay failure.	Continuous/surge rating, priority loads and automatic bypass behaviour.
Transfer switch	Both sources connected, no source selected, one pole fails or position feedback is wrong.	Mechanical/electrical interlocks, delay, manual fallback and neutral switching where required.
Bus tie or parallel operation	Incorrect synchronising or tie closure joins incompatible buses.	Understand whether paralleling is permitted and who is competent to operate it.
Source priority logic	Automatic system repeatedly changes source or reconnects heavy loads too quickly.	Set points, delays, load shedding and behaviour after blackout or shore restoration.

SOURCE INDICATION IS NOT SOURCE QUALITY	A green 'shore' or 'generator' light may confirm switch position without proving voltage, frequency, neutral or available current are acceptable under load.
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AC SWITCHBOARDS AND PROTECTION

Main breakers, branch circuits and leakage protection

The AC switchboard should isolate sources, distribute current and clear overload, short-circuit and earth-leakage faults in a controlled way.



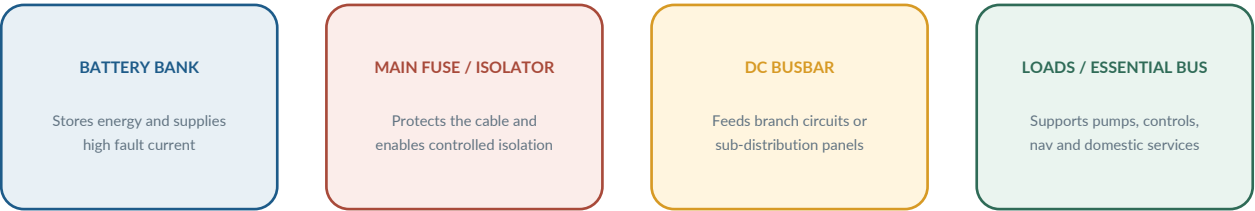
Component	Purpose	Owner focus
Main source breaker	Limits total source current and provides a defined isolation point.	Correct rating, number of switched poles, condition, labels and trip history.
Branch breaker / RCBO	Protects a branch cable and may also provide leakage protection.	Cable/load match, test method, nuisance trips and no casual uprating.
RCD / ELCI	Detects current imbalance indicating leakage outside the intended path.	Test as instructed, investigate recurring operation and understand which circuits it removes.
Busbars and links	Carry current between source, tie and feeder sections.	Heat, discolouration, corrosion, secure covers and thermal inspection under load.
Meters and phase indication	Display voltage, current, frequency, power and phase loading.	Normal ranges, sensor accuracy and no reliance on one failed meter.
Panel enclosure	Protects live parts from contact, water and loose conductive objects.	Seals, drains, ventilation, access, intact dead-fronts and no storage inside/against panels.

A LARGER BREAKER IS NOT A REPAIR	Increasing breaker or fuse rating to stop repeated trips can leave the cable unprotected. The load, cable, device and fault history must be assessed together.
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DC DISTRIBUTION

Battery feeds, busbars, essential loads and isolation

DC systems often operate at lower voltage but can deliver very high current. Voltage drop, fuse location, cable length and secure terminations are central to safe operation.



Area	Common weakness	Owner focus
Battery feed and main fuse	Unfused cable length, wrong interrupt rating, poor mounting or bypassed protection.	Protection close to source, correct rating and safe replacement strategy.
Main isolator / contactor	Seized, overheated, underrated or dependent on control power.	Normal state, emergency isolation, local override and consequences of opening under load.
Positive busbar	Loose links, exposed live metal, corrosion or too many added circuits.	Covers, spacing, current rating, connection quality and updated circuit schedule.
Negative return bus	Shared or bypassed path defeats shunts, protection or expected separation.	Trace returns, inspect high-current joints and confirm monitoring placement.
Essential DC panel	Critical loads share one feed, breaker, converter or low-voltage disconnect.	Navigation, communications, bilge, alarms and control-system endurance after one failure.
Remote sub-panels	Hidden feeder fuse, water ingress, poor labels or undersized return cable.	Accessible isolation, feeder protection, voltage at load and dry installation.

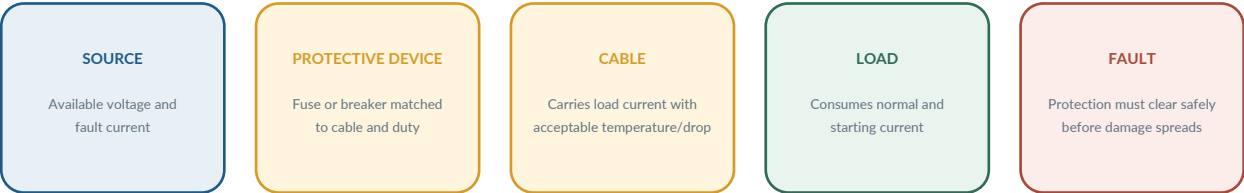
LOW VOLTAGE DOES NOT MEAN LOW RISK

A 24 V battery bank can supply enough current to melt tools, ignite cables or sustain an arc. Treat high-current DC distribution with the same discipline as AC.

CIRCUIT PROTECTION AND CABLE SIZING

Matching fault protection to the conductor and load

A protective device should carry normal demand, tolerate legitimate starting current and interrupt a fault before the conductor or equipment is damaged.



Factor	Why it matters	Owner focus
Cable ampacity	Conductor size, insulation, bundling, ambient heat and routing determine safe current.	Do not judge size by appearance alone; verify design and later modifications.
Voltage drop	Long or undersized cables reduce voltage and increase heat, especially on DC circuits.	Measure at the load under realistic current, not only at the bus.
Breaker/fuse rating	Must protect the cable while accommodating normal and starting demand.	Correct type, curve, poles, interrupt rating and no repeated replacement without diagnosis.
Fault current / interrupt capacity	Battery and generator faults may exceed what a small device can safely open.	Use equipment rated for the available source and installation standard.
Selectivity / discrimination	Downstream device should usually clear a local fault before the main source trips.	Investigate faults that black out large sections from one small appliance.
Conductor protection at source	A cable can be unprotected between source and remote device.	Confirm fuse/breaker location and permissible unprotected length.

STARTING CURRENT MUST BE UNDERSTOOD	Motors, pumps, compressors and transformers can draw several times their running current. Persistent trips may reflect a genuine mechanical or electrical fault rather than a poorly chosen breaker.
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PANELS, BUSBARS AND CONNECTIONS

Heat, access, labelling and hidden deterioration

Many distribution failures begin at a joint rather than in the cable itself. Connection pressure, corrosion, vibration and repeated heating can turn a small defect into a switchboard fire.

CORRECT CONTACT

Clean, tight, supported and appropriately torqued

HIGH RESISTANCE

Loose, corroded or damaged joint creates heat

VOLTAGE DROP

Load receives less voltage and may behave erratically

THERMAL DAMAGE

Insulation, breaker or busbar condition deteriorates

Area	What can go wrong	Owner focus
Busbar joint or link	Loose fastener, oxidation, incompatible metals or poor contact area.	Manufacturer torque procedure, witness marks, thermal trend and no live tightening.
Breaker terminal	Damaged conductor, loose clamp, heat cycling or incorrect ferrule/lug.	Discolouration, smell, softened insulation and loaded temperature.
Crimped cable lug	Wrong die, poor crimp, water ingress or unsupported cable weight.	Correct tooling evidence, sealed support and no movement at the stud.
Panel ventilation	Blocked grille or hot compartment raises breaker and electronics temperature.	Clean airflow, no stored items, fan operation and ambient temperature.
Labelling and circuit schedule	Labels are vague, duplicated or no longer match modifications.	Clear source, feeder, breaker and destination identity including emergency circuits.
Dead-fronts and covers	Missing screws, open spaces or exposed terminals permit accidental contact.	Complete barriers, correct blanks and safe access to operating handles only.

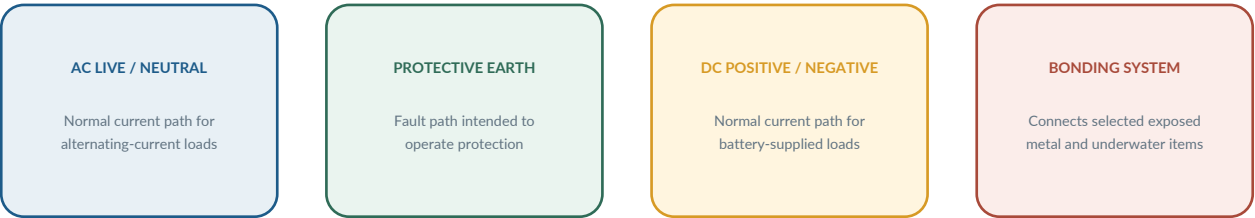
THERMAL IMAGING NEEDS LOAD

A scan is most useful when circuits carry representative current and results are compared with similar phases, poles or connections. Cold equipment can hide a high-resistance defect.

NEUTRAL, EARTH, DC RETURN AND BONDING

Understanding current paths without treating them as interchangeable

Electrical safety depends on controlled current paths. Incorrect neutral-to-earth links, broken protective conductors or improvised DC/bonding connections can create shock, corrosion and protection faults.



These paths may be connected at controlled points, but they are not interchangeable and should not be improvised.

Path	Normal purpose	Owner focus
AC neutral	Carries normal return current from AC loads to the active source.	Switching/bonding may change with shore, generator or inverter source; follow the designed arrangement.
Protective earth	Provides a low-impedance fault path so protective devices can operate.	Continuity, secure connections, no use as normal current return and correct shore interface.
DC negative	Carries normal return current from DC loads to the battery/source.	High-current joints, shunt bypass, bank separation and no undocumented hull return.
Bonding network	Connects selected exposed conductive and underwater components for safety/corrosion strategy.	Condition, design intent, galvanic protection and no casual additions or removals.
Isolation transformer / galvanic isolator	Addresses shore-earth interface and galvanic-current pathways in different ways.	Correct installation, monitoring/test records and understanding that neither repairs onboard leakage faults.
Insulation monitoring or earth-leakage detection	Warns of insulation breakdown or current escaping the intended path.	Alarm set points, test method and investigation rather than automatic repeated reset.

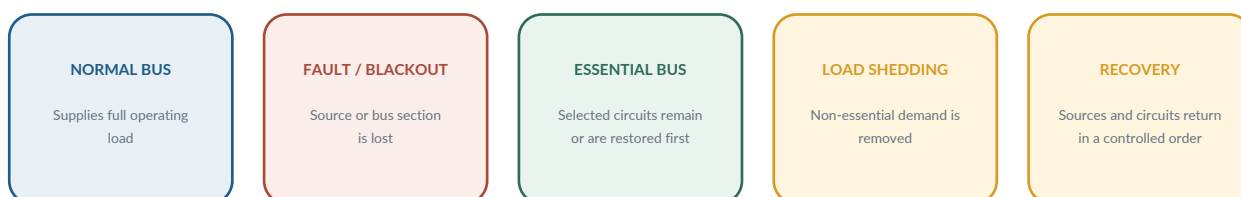
DO NOT ADD A NEUTRAL-EARTH LINK CASUALLY

The correct bond depends on the active source and installation design. An extra link can create circulating current, nuisance trips, corrosion risk or an unsafe shore connection.

ESSENTIAL LOADS AND ELECTRICAL RESILIENCE

What should remain after a source or bus is lost

Offshore readiness is less about keeping every domestic load available and more about preserving control, navigation, communications, flooding response and a route back to stable generation.



Area	Questions to resolve	Owner focus
Essential AC loads	Which pumps, chargers, fans or navigation equipment require AC to continue operating?	Alternative supply, restart order and sustained generator/inverter capacity.
Essential DC loads	Which controls, alarms, bilge pumps, radios and navigation devices remain after one DC section fails?	Independent feeds, converters, batteries and actual endurance.
Emergency lighting / communications	Are designated circuits independent of the normal switchboard and charger?	Functional tests and battery condition rather than labels alone.
Bus tie or alternate feeder	Can a healthy source safely feed the failed side without spreading the fault?	Interlocks, loading limit, clear procedure and competent operation.
Load shedding	Which circuits drop automatically or manually when power is limited?	Preserve essential services and avoid unexpected loss of a hidden control dependency.
Blackout recovery	What powers generator starting, ventilation, fuel transfer, controls and the first switchboard restoration?	Practice the sequence and confirm circuits do not all restart simultaneously.

REDUNDANCY CAN FAIL THROUGH THE BOARD

Two pumps or two navigation displays are not electrically redundant if one breaker, converter, bus section, negative return or control supply can remove both.

MONITORING AND NORMAL VALUES

Learning what healthy distribution looks like

Meters and alarms are most useful when the crew knows the expected values for each source and loading condition. Trends often reveal deterioration before a breaker trips.

VOLTAGE
Reveals source condition and drop under load

CURRENT
Shows loading, imbalance and unexpected consumption

FREQUENCY / PHASE
Confirms AC source quality and phase loading

TEMPERATURE / ALARMS
Identifies heat, leakage, trip and source-change events

Observation	Possible interpretation	Owner response
Voltage falls as load rises	Source limit, cable drop, weak connection, battery weakness or generator regulation issue.	Compare at source, bus and load; inspect heat and current before increasing load.
One AC phase carries more current	Poor load distribution, failed phase or equipment connected unevenly.	Rebalance only with design understanding; compare voltage and neutral current.
Frequency changes with load	Generator governor/load issue or unstable external supply.	Reduce load and protect frequency-sensitive equipment.
Unexpected DC current	Hidden load, failed relay, charger/inverter operation or measurement path error.	Isolate logically, check shunt placement and avoid removing essential circuits blindly.
Recurring earth-leakage trip	Moisture, cable damage, appliance fault, incorrect neutral bond or cumulative leakage.	Identify the faulty branch; do not defeat protection or repeatedly reset under load.
Panel or connection runs hot	High load, poor ventilation, loose joint, wrong device or phase imbalance.	Reduce demand and refer for safe inspection before heat damage progresses.

RECORD CONDITIONS WITH THE READING

Voltage or temperature without source, load, location and time is difficult to interpret. Repeatable records turn isolated observations into useful trends.

FAILURE AWARENESS

Common weaknesses, warning signs and hidden modifications

Distribution defects often begin with an occasional trip, hot smell, flickering load, damp panel or circuit that no longer matches its label.

OVERLOAD / SHORT

Protection trips or a cable heats rapidly

LOOSE CONNECTION

Intermittent power, smell, heat or discolouration

WATER / CORROSION

Leakage current, tracking and unreliable contacts

UNDOCUMENTED CHANGE

Labels, ratings and drawings no longer match reality

Evidence or failure	Possible cause	Why it matters
One branch trips repeatedly	Overload, starting fault, damaged cable/appliance, leakage or incorrect device.	Repeated resetting can worsen heat or fire damage and may remove other loads.
Main source trips from a small fault	Poor selectivity, wrong breaker rating or upstream leakage device operating first.	A local defect can black out propulsion support, charging or essential services.
Warm smell, buzzing or crackling	Loose connection, arcing contactor, overloaded transformer or failing breaker.	Can progress rapidly to smoke, fire and bus damage.
Water marks or green corrosion	Leak, condensation, salt ingress or failed enclosure drainage.	Creates tracking, leakage current and unreliable isolation.
Circuit works only with another breaker on	Backfeed, shared neutral/return, incorrect modification or labelling error.	Unexpected energisation can defeat isolation and create shock risk.
Drawing and panel do not agree	Later equipment added, circuits moved, protection changed or temporary repair made permanent.	Fault finding and emergency isolation become slower and less reliable.

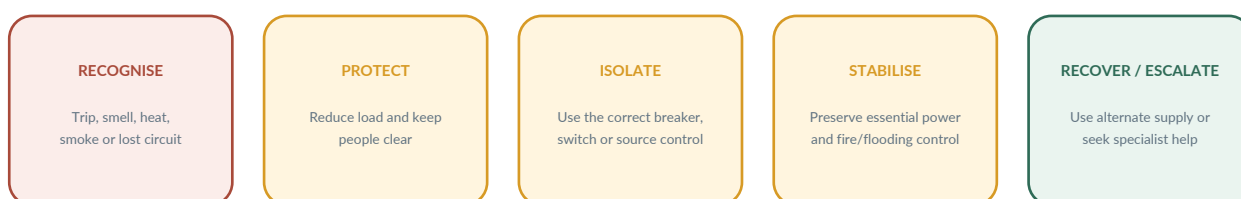
DO NOT NORMALISE IT

A breaker that 'sometimes needs two tries', a warm cable, flickering light, repeated shore trip or handwritten label over an old one deserves explanation.

FAILURE RESPONSE

Protecting people, essential systems and recovery options

Electrical faults may involve shock, fire, loss of propulsion support, loss of bilge pumping or an unexpected source remaining live. The first response should reduce exposure and prevent escalation.



Situation	Immediate thinking	Avoid
Smoke, arcing or electrical fire	Raise alarm, isolate the correct source if safe, control ventilation/fuel as applicable and use the vessel's fire plan.	Opening an energised panel or applying an unsuitable extinguishing medium.
Person receives electric shock	Do not touch until the source is safely isolated; call for emergency/medical help and provide first aid within competence.	Entering a wet or live area without confirming isolation.
AC bus lost	Confirm source, transfer switch and main breaker; preserve DC control and start an alternate source in the planned order.	Repeatedly re-closing a breaker without identifying the fault.
DC essential bus low or lost	Reduce load, preserve communications/bilge/control power and confirm battery, fuse, isolator and charger state.	Paralleling banks casually if the failed bank may have a short or overheating fault.
Leakage device trips	Treat as possible insulation or neutral/earth fault; isolate branches to identify the cause.	Bypassing RCD/ELCI protection to restore comfort loads.
Hot connection or cable	Reduce current and isolate if safe; keep combustibles clear and obtain competent inspection.	Tightening or touching a hot energised connection.

PROVE DEAD BEFORE WORK

A switched-off circuit can remain energised from an inverter, generator, charger, backfeed or automatic transfer path. Safe electrical work requires the correct isolation and verification procedure.

After a fault

Document the source, load, protection that operated, smell/heat, weather or water exposure and any temporary configuration. Restore normal labels, covers and interlocks before considering the system returned to service.

MAINTENANCE STRATEGY

Inspection, testing, records and realistic spares

Electrical maintenance should preserve protection, connection integrity, environmental sealing, accurate diagrams and the ability to isolate and restore circuits safely.

Area	Good maintenance evidence	Why it matters
Switchboards and panels	Dry, clean, complete covers, ventilation clear and no discolouration or loose hardware.	Reduces contact, tracking, heat and fire risk.
Connections and busbars	Qualified inspection, correct torque method, thermal comparison and voltage-drop checks.	Finds high resistance before visible failure.
Breakers, fuses and leakage devices	Correct type/rating, function tests where specified and investigated trip history.	Confirms fault protection and avoids unsafe substitutions.
Cabling and penetrations	Support, chafe protection, gland/seal condition, segregation and no water path.	Preserves insulation and fire/flooding boundaries.
Meters, alarms and transfer logic	Source-change, low/high voltage, frequency, leakage and bus alarms functionally tested.	Provides warning and controlled recovery rather than silent failure.
Drawings and circuit schedules	Updates reflect every approved modification, feeder, breaker, cable and essential circuit.	Supports safe isolation, fault finding and future ownership.

Useful spares and tools

- Exact replacement fuses and selected breakers, relays or contactors where owner replacement is realistic and approved.
- Correct lamps, labels, terminal covers and small control fuses rather than improvised substitutes.
- Portable meter and clamp meter used only within ratings and competence, plus insulated hand tools.
- Moisture-control and inspection equipment without spraying unsuitable products into live panels.
- Current single-line drawings, circuit schedules, protection settings, blackout procedure and specialist contacts.

WORK TO REFER	Live switchboard work, insulation-resistance testing, breaker coordination, cable design, neutral/earth modification, busbar repair and persistent leakage or fire faults require competent marine electrical specialists.
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OFFSHORE READINESS

Buyer questions and readiness checklist

An offshore-ready distribution system has current drawings, selective protection, sound connections, tested source transfer and a clear essential-power strategy after one source or bus section is lost.

Area	Questions for purchase or survey
Architecture	Can every source, main bus, tie, sub-panel, essential feed and emergency supply be traced on a current single-line diagram?
Protection	Do breaker/fuse ratings, RCD/ELCI devices and cable sizes appear coordinated and supported by records?
Condition	Are panels dry, covers complete and connections free from heat, corrosion, arcing or improvised repair?
Source transfer	Do shore, generator and inverter changeovers work correctly without unsafe paralleling or ambiguous indication?
Neutral, earth and returns	Are controlled bonds, protective-earth continuity, DC returns and bonding arrangements documented and tested?
Essential loads	Which navigation, communications, bilge, alarm and control circuits remain after one bus/source failure?
History and support	Are trips, overheating, water damage, modifications, obsolete devices and spare availability fully understood?

Quick readiness check

	Readiness statement
☐	I can trace the main AC and DC sources, buses, feeders, sub-panels and essential circuits.
☐	Current single-line diagrams and panel schedules match the installation.
☐	Breakers, fuses and leakage devices are correctly identified and have no unresolved trip history.
☐	Panels, busbars, cables and connections are dry, covered and free from abnormal heat or corrosion.
☐	Source transfer, bus ties and alternate feeds have been functionally tested under a controlled procedure.
☐	Neutral, protective-earth, DC return and bonding arrangements are understood and documented.
☐	A reduced-load and blackout-recovery plan preserves navigation, communications, bilge and control functions.
☐	More than one person knows how to isolate an electrical fault without removing every recovery option.

KEY TAKEAWAY

Dependable AC and DC distribution combines clear architecture, correctly coordinated protection, sound connections, controlled earthing and return paths, accurate documentation and a tested essential-power recovery plan.

Guidance to consult

Use current vessel electrical drawings and the installed generator, inverter, charger, switchboard and protective-device manufacturers' instructions, together with applicable flag-state, coding, class, insurance and yard requirements.

Understanding Yacht Systems

Practical guides for owners, buyers
and offshore cruising crews.

AMTG-023

Understanding AC and DC Distribution

RELATED GUIDES

AMTG-003 Understanding Marine Electrical Systems

AMTG-004 Understanding Electrical Redundancy

AMTG-005 Understanding Generators and Load Management

AMTG-021 Understanding Battery Banks and Charging Systems

AMTG-022 Understanding Inverters and Shore Power

AMTG-025 Understanding Load Shedding and Blackout Recovery

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