VFD Motor Cables — Screening, EMC and Maximum Length

cBallast Technical Sourcing · Variable frequency drive output cables and glands · issued 2026-11-09 · cballast.com/documents/vfd-motor-cable-emc-screening-length

Why a drive output cable is a different product from a supply cable: symmetrical screened construction, 360-degree screen termination, EMC categories C1–C4 under IEC 61800-3, maximum motor-cable lengths with and without output filters, dV/dt and reflected-wave stress on the motor, bearing currents, and a selection and glanding table — with armoured VFD gland kits and screened cable from the catalogue.

The short version

The cable between drive and motor carries a switched waveform, not a sine wave. PWM edges with rise times in the 0.1 microsecond class turn the cable into a transmission line and an antenna: the cable must be screened, the screen must land 360 degrees at both ends, and its length is a design parameter with a hard maximum from the drive maker.

Use a symmetrical screened motor cable. Three phase cores with the protective earth split as three symmetrically placed conductors (3+3E) or a concentric screen-as-PE keeps the sum of currents balanced and the common-mode current low; an ordinary 4-core cable with one fat PE core is the main cause of "mystery" interference on nearby instrumentation.

Maximum cable length comes from the drive data, not from voltage drop. Typical unfiltered limits sit around 50 m screened (150 m unscreened where EMC rules allow) for small IP20 drives and 100–150 m screened for larger ones; a dV/dt filter roughly doubles it and a sine-wave filter takes it to 300 m and beyond. The drive manual's table wins over every rule of thumb.

EMC category decides the filter and the cable practice. IEC 61800-3 category C1 (residential), C2 (first environment, restricted distribution), C3 (industrial), C4 (IT networks / engineered installations): a C3 drive in a building full of electronics without the screened-cable discipline is how audits fail.

Long cables punish the motor, not just the EMC lab. Reflected-wave voltage at the motor terminals reaches up to twice the DC bus on long runs — insulation stress for the motor (IEC 60034-18-41 duty) and bearing-current wear unless common-mode paths are managed (insulated bearing, shaft earthing, filters).

Glanding is half the screening. EMC glands that clamp the braid around its full circumference at the drive, the motor and every cabinet wall; pigtails of a few centimetres undo a hundred metres of good cable.

1. Why drive output cable is its own product

A drive's output is a train of DC-bus-voltage pulses at 2–16 kHz switching frequency with very fast edges. Three consequences follow. First, radiated and conducted emissions: the cable is the antenna, so it is screened with a dense copper braid (or armour acting as screen) and the screen is bonded at both ends. Second, capacitive charging current: every metre of screened cable adds capacitance the drive must charge each pulse — this, not resistance, is what sets the maximum length; exceeding it trips drives on overcurrent or derates them. Third, the reflected wave: when the cable's surge impedance mismatches the motor's, each pulse reflects and the motor terminals see up to 2x the DC bus (roughly 1,130 V peaks on a 400 V system), which is why motor insulation to IEC 60034-18-41 and minimum rise-time rules exist.

2. Construction: what to ask for

Attribute | Specification | Why |

Cores | 3 phase + 3 symmetric PE (3+3E), or 3 cores + concentric screen as PE | Balanced magnetic field, low common-mode current |

Screen | Copper braid, coverage ≥ 80–85%, often with counter-helix or foil underneath | Screen impedance at MHz frequencies; coverage is the datasheet number to check |

Insulation | XLPE or EPR, 0.6/1 kV grade even on 400 V systems | Headroom for reflected-wave peaks |

Sheath | PVC indoors; halogen-free (SHF) for marine and enclosed spaces | Fire and smoke rules — see the marine cable guide for shipboard runs |

Temperature rating | 90 °C conductor preferred | Drives run cables warm; derating margin |

Size | By motor current with the drive's duty (110% light / 150% heavy overload) on top | Size from current, as with the drive itself — see the VFD selection guide |

On ships and offshore units the same construction appears as screened halogen-free types within the IEC 60092 programme; on land, the makers' catalogue names differ but the datasheet items above are the specification. For servo axes, use the drive maker's matched cable sets — pre-assembled types such as the igus readycable servo cables carry the correct screen and connector in one part number.

3. Maximum motor cable length

Configuration | Typical screened limit | Notes |

No output filter, small drive (≤ 7.5 kW) | ≈ 50 m | Many compact drives state 50 m screened / 75–150 m unscreened |

No output filter, larger drive | ≈ 100–150 m | Check the drive's capacitive-load table; parallel runs count double |

With dV/dt (output choke) filter | ≈ 150–300 m | Slows edges; also eases motor insulation stress |

With sine-wave filter | 300 m + | Output becomes near-sinusoidal; screened cable may no longer be required for EMC — maker's rules govern |

These are planning numbers; the binding figure is the specific drive's manual, which derates by switching frequency and ambient. Two habits prevent most failures: never loop spare cable into coils behind the motor (it adds length and inductance), and count every parallel motor's cable toward the drive's total cable-charge limit on multi-motor fan walls.

4. EMC categories and the installation discipline

IEC 61800-3 defines emission categories C1–C4. A category C2 or C3 drive meets its category only with the installation its manual prescribes: screened motor cable with 360-degree terminations, separation from signal cables (a common rule is ≥ 200 mm, crossing at right angles), the internal or external RFI filter fitted and the screen landed on the drive's dedicated clamp — not on a painted panel. Signal and network cables run in their own screened types with their own one-end or both-end earthing rules. Where instrument loops misbehave near drives, the fault is almost always a pigtailed screen or a shared tray, not the instrument.

5. Glands and terminations: the 360-degree rule

The screen must be clamped around its full circumference at every entry: EMC glands with a contact spring or cone (for braided cable), or barrier/armour glands where the armour is the screen. At the motor, the same rule applies at the terminal box. Kits exist for exactly this: the VFD armoured gland kit M25 (4-core 4 mm²), M32 (10 mm²) and M40 (25 mm²) pair the gland to the cable build, and brass EMC glands such as the Jacob Perfect EMC PG16 cover panel entries. Size by the actual cable diameter against the gland size chart; an undersized seal and a floating braid are the two classic audit findings.

6. Motor-side effects: insulation and bearings

Reflected-wave peaks stress the first turns of the winding; motors for drive duty declare IEC 60034-18-41 (stress categories for converter-fed windings) and makers state a minimum rise time or require filters beyond a cable length. Common-mode current returns through the shortest path it finds — too often the motor bearings, where EDM pitting ends in a fluted raceway. The defences, in rising order of cost: correct symmetrical cable and 360-degree screening (gives the current a designed return path), insulated non-drive-end bearing on larger motors, shaft-earthing ring, common-mode chokes, sine filter. If a bearing fails grey and fluted on a drive-fed motor, the cable and screening practice is the first suspect — before the bearing brand.

7. A worked example

A 30 kW, 400 V seawater pump 85 m from its drive, on a vessel: motor FLC 56 A; heavy-duty cycle not required (centrifugal pump — light overload), so cable sized for ≈ 62 A at 45 °C ambient gives 3x25 mm² with 16 mm² earth split or concentric; construction: screened halogen-free 0.6/1 kV drive cable (shipboard: the screened types within the IEC 60092 programme); 85 m is inside the 100–150 m unfiltered class for a 30 kW drive but the maker's table is consulted; dV/dt filter added anyway for motor insulation margin on the long run; M40 EMC/armour gland kit both ends, screen on the drive's clamp plate; instrument cables for the pump's sensors rerouted to their own tray 200 mm away. The requisition lists: drive (per the VFD selection guide), cable type and length, two gland kits, dV/dt filter, and the motor's converter-duty declaration.

How buying works at cballast. We quote drive output cable by construction and length, with the matching gland kits, filters and lugs in the same quote, and we cross drive families via the VFD cross-reference when the installed maker is no longer preferred. Accounts are vetted at onboarding; first order prepaid; established accounts on credit terms with repeat discounts; public bodies invoiced against purchase order from the first order. RFQs to sales@cballast.com.

Frequently asked questions

Does a VFD always need screened motor cable?For any installation that must meet IEC 61800-3 category C1–C3 emissions, yes in practice: screened symmetrical motor cable with 360-degree terminations is the installation the drive's EMC declaration assumes. The exception is an engineered C4 installation or a drive behind a sine-wave filter where the maker explicitly releases the requirement.

What is the maximum cable length between VFD and motor?Whatever the drive's manual states for your model and switching frequency — typically about 50 m screened for compact drives and 100–150 m for larger ones without filters, roughly doubled by a dV/dt filter and extended to 300 m or more by a sine filter. The limit is capacitive charging current and reflected-wave stress, not voltage drop.

What is a symmetrical motor cable?A cable whose three phase conductors and earth are arranged so the magnetic fields cancel: either three phases with the PE split into three smaller conductors placed in the interstices (3+3E) or three phases with a concentric screen/PE. It minimises common-mode current, which is what radiates and what flows through motor bearings.

Why did the motor bearings fail on a drive-fed motor?Fluting and grey raceways point to bearing currents: common-mode current finding its return path through the bearing. Fixes in order: correct screened symmetrical cable landed 360 degrees both ends, insulated NDE bearing or shaft-earthing ring, common-mode choke or sine filter. Replacing the bearing without fixing the path repeats the failure.

C2 or C3 — which EMC category do I need?C2 for the first environment (connected to networks that also supply domestic premises) with restricted distribution; C3 for the second (industrial) environment. A C3 drive may not be used in the first environment without additional filtering; category and filter choice are stated in the drive's ordering data.

Who supplies VFD cable with the right glands in one order?cballast.com quotes screened drive cable by length with matched EMC/armour gland kits (M25–M40 held as kits), dV/dt and sine filters, and lugs in one quote, for land and shipboard installations. Write to sales@cballast.com.

References and related guides

Standards referenced: IEC 61800-3 (EMC categories for power drive systems); IEC 60034-18-41 (converter-fed winding insulation); IEC 61800-5-1 (drive safety); IEC 60092 series for shipboard constructions; drive makers' installation manuals (ABB ACS, Danfoss VLT, Siemens SINAMICS, Schneider Altivar) for binding cable-length tables.

Selecting a VFD — size by current, duty, filters, options

VFD cross-reference by kW and voltage

Danfoss VLT drive families and options

Marine cable types — RFOU, BFOU and IEC 60092

Cable gland size chart M12–M63

Questions on a cable build, a length limit or a gland kit: write to sales@cballast.com. We answer whether or not you buy from us.

Part numbers and designations are those of the original manufacturers and are given for identification. cBallast is an independent supplier. © cBallast 2026 · cballast.com