FC SOLUTIONS

Fabiano Oliveira

Electrical Engineer · Control Panel Design & Estimating

> Control panels designed, quoted and documented: from a 2 × 3,200 A hospital switchboard to PLC-controlled mooring winches.



172
feeders on a 3,200 A, 80 kA hospital switchboard I designed

~50%
less assembly time per panel on repeat models

330
panels I inspected personally before shipping

1,400+
quote requests the company has logged on the estimating standard I built

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About me

Electrical engineer (UTFPR, Brazil) with an electrical technician diploma. At a control panel shop in Brazil I went from the assembly floor to Operations Manager in three years, leading a team of up to 15. I designed the panels, prepared every quote and built the standards the shop still runs on.

After moving to the U.S., I rebuilt my career through construction: solar, pool automation, smart home and low voltage, and most recently Assistant PM and Estimator at a foundations contractor. Now I am back to my field: panel design, estimating and documentation.

What I offer

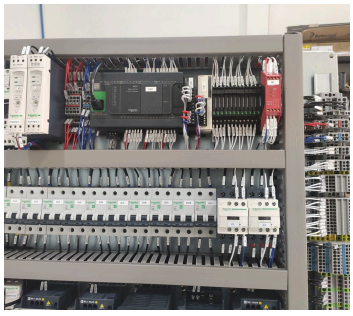
For panel builders, fabricators, machine builders and integrators:

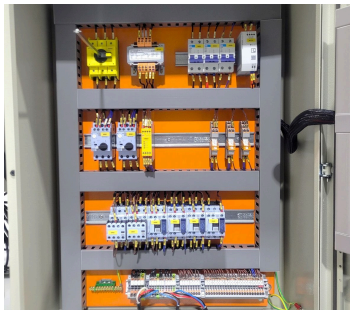
- Electrical schematics, panel layouts, BOMs, wire and terminal lists
- Estimating and quoting support
- PDF and markup to CAD, as-builts, technical documentation
- Shop organization: SOPs, test checklists, process improvement

The projects

#	PROJECT	CLIENT	WHAT IT SHOWS	PAGE
01	**OEM machine panels and production system**	Industrial bakery equipment OEM	PLC, VFD and servo networks, shop process	3
02	**Quality control and factory testing**	Utilities, solar, global switchgear maker	ITPs, megger and hipot, traceability	4
03	**Wastewater treatment panels**	State water utility	Design to a utility's standard	5
04	**Repeat solar EPC client**	Solar EPC	Proposals, control and network panels	6
05	**Substation AC/DC panels**	Substation contractor	Station service, drawings	7
06	**Crane VFD control panels**	Crane builder	VFDs, safety relays, radio control	8
07	**Hospital main switchboard**	Engineering firm / university hospital	80 kA bus, commissioning	9
08	**Solar CCTV and power panel families**	Solar EPC	Standardization, estimating	10
09	**Mooring winch PLC and motor control**	Equipment maker / port terminal	S7-1200, Modbus RTU, Profinet	11
10	**Design and estimating standard**	The panel shop itself	Templates, cost sheet, quote log	12
11	**100 kW load bank retrofit**	Shop client (engineering capstone)	Electrical design, Modbus, panel build	13

About these projects. Cases 01 to 10 were designed at a control panel shop in Brazil. Case 11 is my engineering capstone, on a shop client's load bank. Client names are withheld; photos and drawings are shown with the shop's permission, with client data blurred. Drawing sheets appear as originally issued, in Portuguese. Full drawing packages for Cases 03 to 09 and 11 are available on request.



CASE 01 OEM MACHINE PANELS

OEM Machine Panels and the Production System Behind Them

Standardized 40 machine panel models and built the shop system around them, cutting assembly time per panel by about half.

CLIENT An industrial bakery equipment OEM **MY ROLE** Electrical designer and operations manager

40
panel models standardized: about 20 designs, each in 220 V and 380 V

12.8 h → 6.35 h
assembly time per panel, same model and connection count

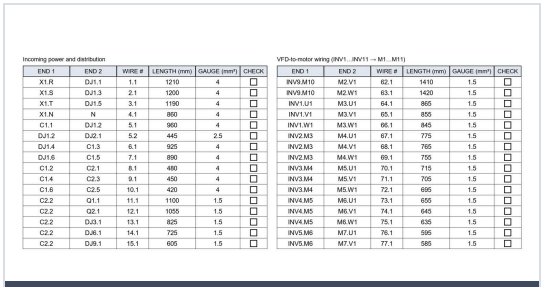
330
panels inspected, 220 of them logged by serial number



Panel built into the machine: servo drive, VFDs and PLC, with the HMI above



Feeder panel: 11 VFDs on Modbus and a Modicon M241 PLC



Incoming power and distribution

END 1	END 2	WIRE #	LENGTH (mm)	GAUGE (mm²)	CHECK
X1.R	DJ1.1	1.1	1210	4	☐
X1.S	DJ1.3	2.1	1200	4	☐
X1.T	DJ1.5	3.1	1190	4	☐
X1.N	N	4.1	860	4	☐
C1.1	DJ1.2	5.1	960	4	☐
DJ1.2	DJ2.1	5.2	445	2.5	☐
DJ1.4	C1.3	6.1	925	4	☐
DJ1.6	C1.5	7.1	890	4	☐
C1.2	C2.1	8.1	480	4	☐
C1.4	C2.3	9.1	450	4	☐
C1.6	C2.5	10.1	420	4	☐
C2.2	Q1.1	11.1	1100	1.5	☐
C2.2	Q2.1	12.1	1055	1.5	☐
C2.2	DJ3.1	13.1	825	1.5	☐
C2.2	DJ6.1	14.1	725	1.5	☐
C2.2	DJ9.1	15.1	605	1.5	☐

VFD-to-motor wiring (INV1 ... INV11 → M1 ... M11)

END 1	END 2	WIRE #	LENGTH (mm)	GAUGE (mm²)	CHECK
INV9.M10	M2.V1	62.1	1410	1.5	☐
INV9.M10	M2.W1	63.1	1420	1.5	☐
INV1.U1	M3.U1	64.1	865	1.5	☐
INV1.V1	M3.V1	65.1	855	1.5	☐
INV1.W1	M3.W1	66.1	845	1.5	☐
INV2.M3	M4.U1	67.1	775	1.5	☐
INV2.M3	M4.V1	68.1	765	1.5	☐
INV2.M3	M4.W1	69.1	755	1.5	☐
INV3.M4	M5.U1	70.1	715	1.5	☐
INV3.M4	M5.V1	71.1	705	1.5	☐
INV3.M4	M5.W1	72.1	695	1.5	☐
INV4.M5	M6.U1	73.1	655	1.5	☐
INV4.M5	M6.V1	74.1	645	1.5	☐
INV4.M5	M6.W1	75.1	635	1.5	☐
INV5.M6	M7.U1	76.1	595	1.5	☐
INV5.M6	M7.V1	77.1	585	1.5	☐

Wire cut list generated from the from-to wire list (recreated in English)

THE CHALLENGE

- The shop's main client had about 20 panel designs, each in a 220 V and a 380 V version (40 panel models), ordered in repeat batches. When I joined, the shop had about three months of late orders and no assemblers.
- PLCs, Modbus and CANopen networks, up to 11 VFDs, servo drives and safety circuits were built with no written standard. Each batch depended on the assembler's memory, and errors showed up at the client.

WHAT I DID

- **Standardized all 40 models:** a BOM and a from-to wire list for each, over 100 spreadsheets. Modicon M241 PLCs tied to the machine HMI, up to 11 VFDs on Modbus, Lexium 32 servo drives on CANopen and Cat. 4 / PL e safety relays.
- **Wrote the build procedure** in four stages: mechanical prep (templates, DIN rail, wire duct, drilling), mounting, wiring against a reference panel, and a signed-off final inspection.
- **Timed every operation** and built a time calculator comparing model, batch size, time per panel and connection count.
- **Built a serial-numbered inspection system** (Google Forms + Sheets) with photo and inspector on every panel.
- **Error-proofed the wire labels:** the wire list set each marker's print orientation, so labels came off the card already facing the right way.

RESULT

- Assembly time per panel cut by about half on repeat models: A40 from 12.8 h to 6.35 h (same 136 connections), M500 from 8.0 h to 3.6 h (same 86 connections).
- 330 panels inspected, 220 of them logged by serial number. 85 of those had at least one issue fixed before shipping.
- About 10 assemblers worked to the same standard. A new batch no longer depended on who built it.

CASE 02 QUALITY CONTROL AND TESTING

Quality Control, from the Bench to the Client Witness Test

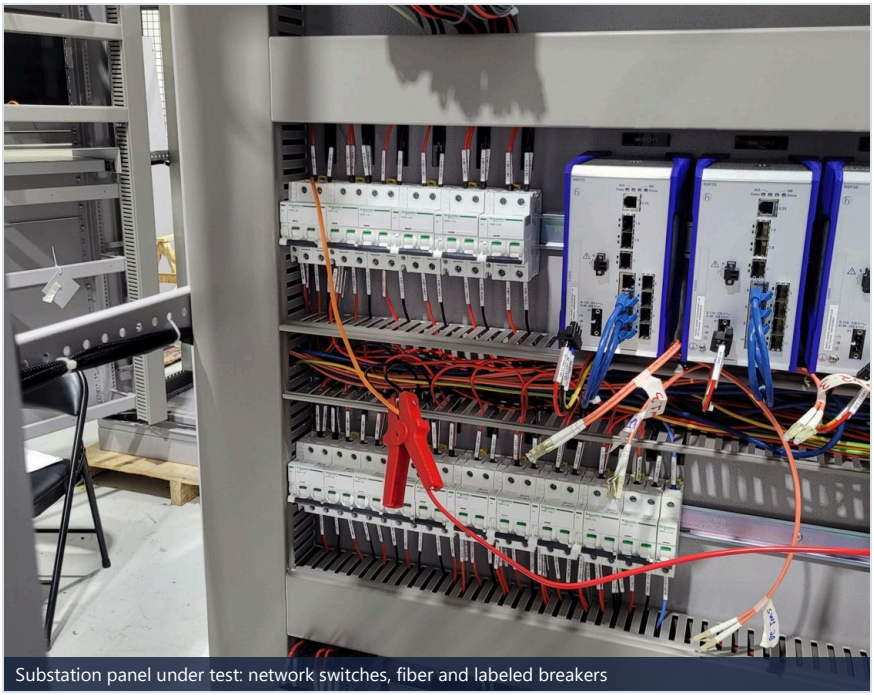
Built the QA system of a panel shop: serial-numbered inspection on every panel, plus test plans, megger and hipot tests and signed reports.

CLIENT Utilities, solar plants and a global switchgear manufacturer **MY ROLE** QA lead and test engineer

330
panels I inspected personally

85 of 220
logged panels caught with an issue before shipping

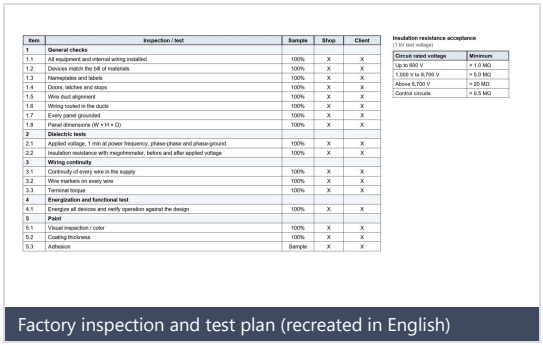
17
design and assembly issues logged and resolved for a global switchgear maker



Substation panel under test: network switches, fiber and labeled breakers



Insulation resistance: 19.63 GΩ on the megger



Item	Inspection / test	Sample	Shop	Client
1	**General checks**			
1.1	All equipment and internal wiring installed	100%	X	X
1.2	Devices match the bill of materials	100%	X	X
1.3	Nameplates and labels	100%	X	X
1.4	Doors, latches and stops	100%	X	X
1.5	Wire duct alignment	100%	X	X
1.6	Wiring routed in the ducts	100%	X	X
1.7	Every panel grounded	100%	X	X
1.8	Panel dimensions (W × H × D)	100%	X	X
2	**Dielectric tests**			
2.1	Applied voltage, 1 min at power frequency, phase-phase and phase-ground	100%	X	X
2.2	Insulation resistance with megohmmeter, before and after applied voltage	100%	X	X
3	**Wiring continuity**			
3.1	Continuity of every wire in the supply	100%	X	X
3.2	Wire markers on every wire	100%	X	X
3.3	Terminal torque	100%	X	X
4	**Energization and functional test**			
4.1	Energize all devices and verify operation against the design	100%	X	X
5	**Paint**			
5.1	Visual inspection / color	100%	X	X
5.2	Coating thickness	100%	X	X
5.3	Adhesion	Sample	X	X

Insulation resistance acceptance (1 kV test voltage)

Circuit rated voltage	Minimum
Up to 600 V	> 1.0 MΩ
1,000 V to 8,700 V	> 5.0 MΩ
Above 8,700 V	> 20 MΩ
Control circuits	> 0.5 MΩ

Factory inspection and test plan (recreated in English)

THE CHALLENGE

- Panels shipped with no record of what had been checked or who built them. When an error showed up at the client, there was no way to trace it.
- Utility and solar clients require an inspection and test plan, megger and hipot tests, signed reports and often a witnessed test.
- A global switchgear manufacturer started outsourcing assemblies to the shop, with its own follow-up forms and tight deadlines.

WHAT I DID

- **In-process inspection:** a serial number per panel, with checks for components, wiring, terminal position and torque, labels, layout, photo and inspector.
- **Inspection and test plan (ITP)** for witnessed tests: 5 groups and 17 checks (1-minute hipot test, insulation resistance before and after, continuity, functional test, paint), with an acceptance table (> 1 MΩ up to 600 V) per NBR IEC 60439-1.
- **Factory test reports** for substation panels, issued and signed by me as Projects Supervisor.
- **Production follow-up reports** for the switchgear manufacturer: 4 projects and 20 panels, with 17 design and assembly issues logged with their fix and 6 design improvements sent back to the client.

RESULT

- 330 panels inspected by me. Of the 220 logged by serial number, 85 were corrected before leaving the shop.
- Utility panels shipped with ITP, test report and recorded readings, such as 19.63 GΩ against a 1 MΩ minimum and a 1,500 V hipot test passed.
- The manufacturer's next projects already included the improvements I suggested.

CASE 03 WATER AND WASTEWATER

Wastewater Treatment Panels Built to a Utility's Design Manual

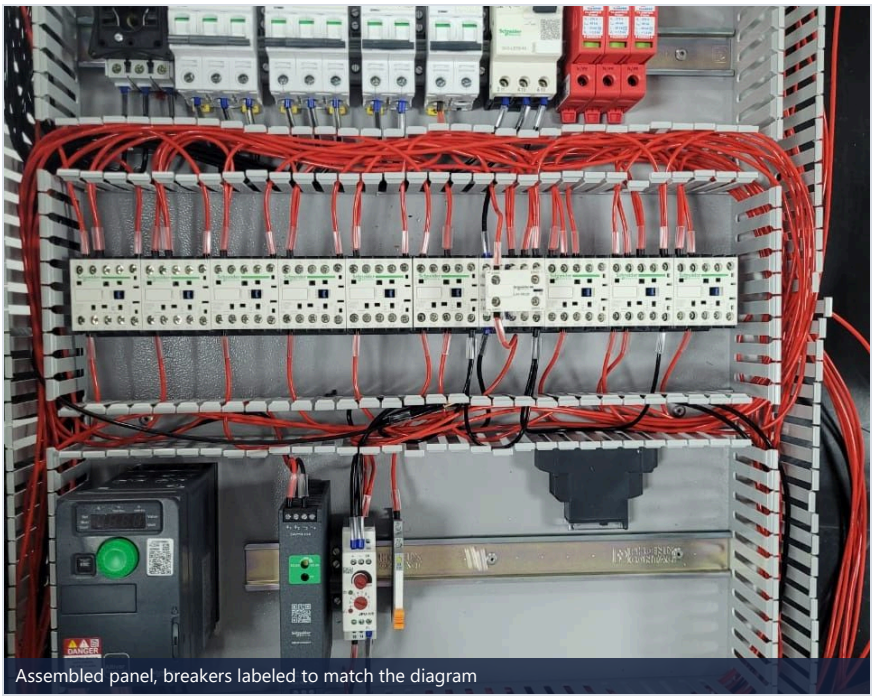
Designed wastewater-plant control panels to a state utility's own design manual and turned its review comments around in under a week.

CLIENT A state water utility, through its contractor and equipment supplier **MY ROLE** Electrical designer

4
control panels designed, built and shipped

11 sheets
per panel, in the utility's format

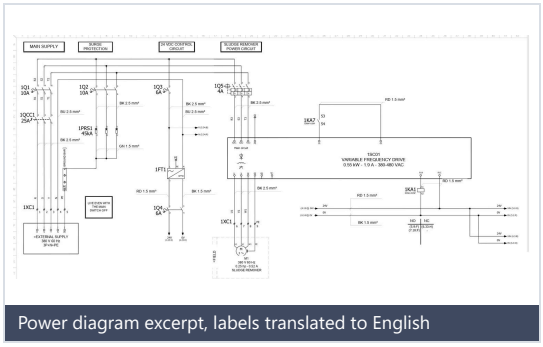
6 days
to reissue the package after the utility review



Assembled panel, breakers labeled to match the diagram



VFD, surge protection, contactors and 24 VDC supply



Power diagram excerpt, labels translated to English

THE CHALLENGE

- Expansion of a city wastewater treatment plant: two trickling-filter rotary distributors and two sludge collectors.
- The utility only approves supply if the design follows its own manual: cover, index, symbols, specs, three-line and control diagrams, A3 mechanical drawing, BOM and nameplate list.
- The first review came back with corrections: supply voltage, missing manufacturers and part numbers, and a mechanical drawing that did not match the diagrams.

WHAT I DID

- **Set up the utility's standard inside the shop:** a CAD template with title block, layers, pen weights, symbols, nameplates and BOM format.
- **Designed the 4 panels:** 380 V, 60 Hz, 3-phase + neutral + ground, a VFD for the motor, 45 kA surge protection, 24 VDC control and an inductive proximity sensor.
- **Delivered an 11-sheet package per panel:** index, symbols, datasheet, three-line diagram, 3 control schematic sheets, terminal strip, BOM with part numbers, nameplate list and mechanical drawing.
- **Reissued the package 6 days after the review,** with 380/220 V supply and a complete BOM.

RESULT

- 4 panels designed to the utility's standard, built in-house and shipped to site.
- The CAD template became the base for the shop's next water and wastewater jobs, now one of its three largest sectors (125 quote requests, company volume).

Full drawing package available on request.

CASE 04 SOLAR EPC, REPEAT CLIENT

Repeat Solar EPC Client: Proposal, Design and Test

Ran the full cycle for a repeat solar EPC client: proposals, panel design, test plans and stainless outdoor enclosures shipped with documentation.

CLIENT A solar EPC building PV plants and their substations **MY ROLE** Estimator and electrical designer

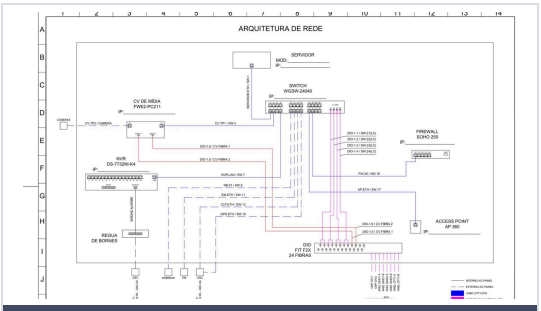
11
orders from the same client in about a year

32
proposals and revisions, some with priced options

5
panel types designed for two plants



Stainless AC and DC distribution boxes for outdoor use



Network architecture of the SCADA rack (original sheet)



Crated for shipping with the printed drawings

THE CHALLENGE

- The EPC needed many panel types for its plants and substations: metering boxes, AC and DC distribution boxes for the 34.5 kV and 13.8 kV sectors, distribution and UPS panels, and SCADA and control panels.
- Outdoor installation: the boxes had to withstand the weather.
- Each plant brought scope changes, so proposals had to be revised fast, sometimes with price options.

WHAT I DID

- **Proposals for all 11 orders:** 32 documents and revisions, with BOM per panel, manufacturers, supply terms and planned tests (functional, insulation, continuity and hipot per NBR IEC 60439).
- **Designed 5 panel types for two plants:** a SCADA and control panel with PLC analog and digital I/O; a 19" network rack (managed switch, firewall, NVR, media converter, fiber patch panel) with network architecture and connection table; low-voltage distribution, UPS and main breaker panels.
- **Stainless distribution boxes** for 127/220 VAC and 125 VDC, with thermostat and enclosure dehumidifier.
- **Factory test plan** for the SCADA panel, and crated shipping with the drawings.

RESULT

- 11 orders from the same client in about a year.
- Every order shipped with its proposal, design and tests documented, from quote to crate.

Full drawing package available on request.

CASE 05 SUBSTATIONS

Substation Control Building: AC/DC Station Service Panels

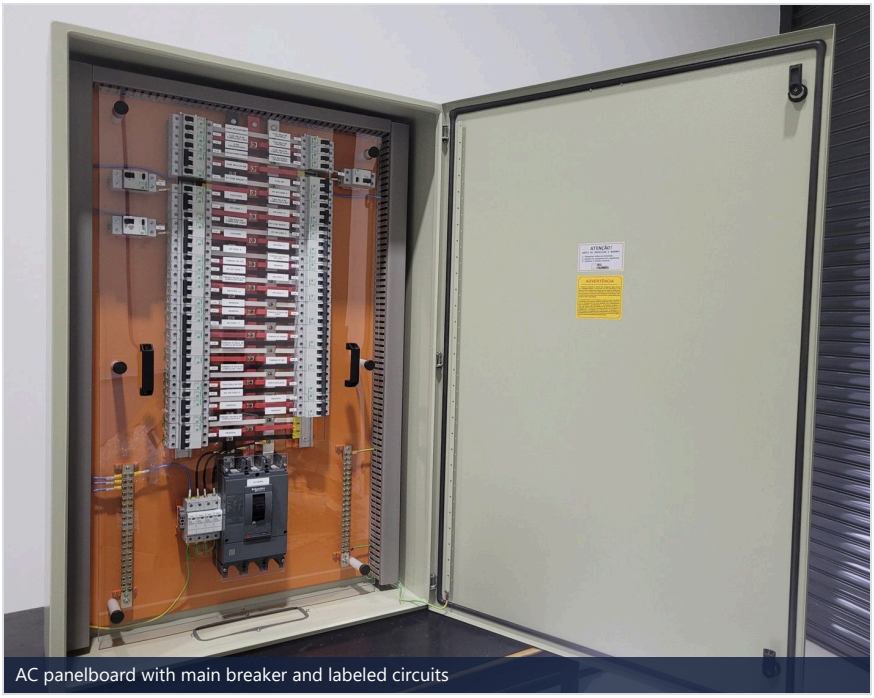
Quoted and designed the AC/DC station service panels for a utility substation control building, with a full drawing package per panel.

CLIENT A substation contractor (utility substation) **MY ROLE** Estimator and electrical designer

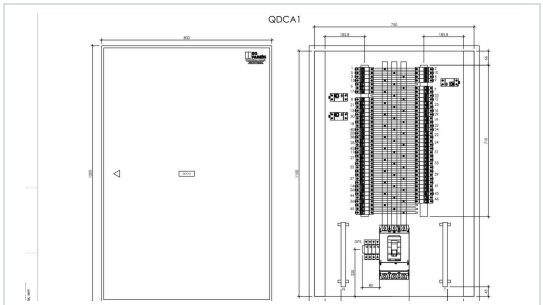
~12
orders from the same contractor

4 panels
plus field junction boxes

15 sheets
in the drawing package of AC panelboard 1



AC panelboard with main breaker and labeled circuits



Panel layout from the drawing package (original sheet)



AC and DC panelboards side by side

THE CHALLENGE

- A new substation: the control building needs AC and DC station service, outdoor lighting and field interconnection.
- A demanding utility: factory inspection, an approved test plan and witnessed tests.
- Back-to-back orders from the same client, each built from its reference drawings.

WHAT I DID

- **Commercial proposals** from the client's reference drawings, revised from R00 to R02.
- **Designed the control building package:** two 220 VAC panelboards, a 125 VDC panelboard, an outdoor lighting panel and field junction boxes. I issued the layouts; my design assistant drew the final drawing packages under my supervision.
- **A drawing package per panel** in the shop standard: datasheet, three-line diagrams (7 sheets on AC panelboard 1), layout, BOM and a panel schedule with loads, breakers and wire sizes.
- **Factory test plan for another substation** (2 CT/PT boxes and 4 loss-metering panels), revised after the utility's comments.

RESULT

- About 12 orders from the same contractor.
- Panels finished and photographed one day after the final drawing packages were issued.
- The test plan was approved on the revision that followed the utility's comments.

Full drawing package available on request.

CASE 06 MATERIAL HANDLING

Overhead and Gantry Crane VFD Control Panels

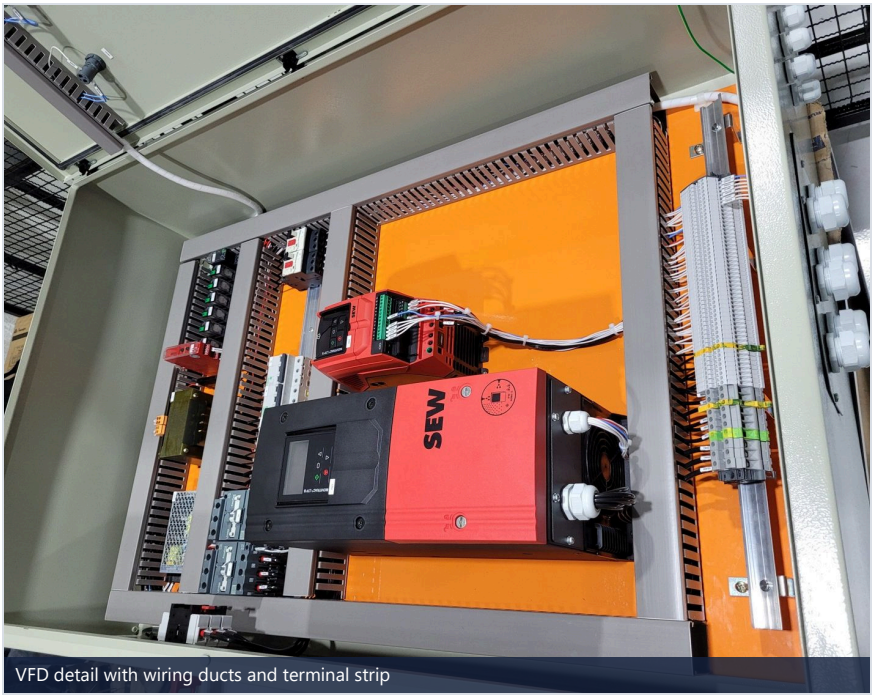
Designed the VFD control panels for three cranes, from 4 t to 30 t, and took one order from first drawing to finished panels in two weeks.

CLIENT A crane builder **MY ROLE** Electrical designer and production planner

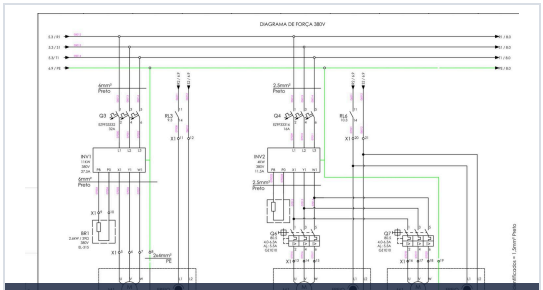
3 cranes
4 t to 30 t, in 220 V and 380 V

1 VFD
per motion: hoist, trolley and travel

14 days
from first drawing issued to finished panels



VFD detail with wiring ducts and terminal strip


Power diagram: VFDs, braking resistor and motors (original sheet)


4 t overhead crane panel: three VFDs

THE CHALLENGE

- Cranes lift loads over people: the emergency stop must be fail-safe, with pendant and radio remote control.
- Three motions per crane, each with its own motor, brake and limit switches, and smooth starts so the load does not swing.
- The same client had cranes from 4 t to 30 t, in 220 V and 380 V. The design needed a base that could repeat without redoing everything.

WHAT I DID

- **A repeatable architecture:** one VFD per motion, brake control per motor, main contactors, phase-loss relay, 24 VDC supply and door pilot lights (power, running, motion with buzzer, fault per VFD).
- **5 t gantry:** 3 SEW VFDs (11 kW hoist with braking resistor and blower-cooled motor, 4 kW travel, 1.5 kW trolley), a Cat. 4 safety relay on the e-stop chain (pendant, radio, limit switch) and a load limiter interface. 22-sheet drawing package.
- **30 t double-girder gantry at 220 V:** 18.5 kW hoist with braking resistor, 175 A main breaker and a 6-button two-speed radio; 4 versions of a 20-sheet drawing package. Also an 8 t electric hoist and a 4 t overhead crane with load limiter and anti-collision sensor.
- **Planned the shop build:** mechanical prep, power wiring, control wiring and final check, with time per operation and per assembler.

RESULT

- Three cranes from the same client, all on the same design base.
- One order went from the first drawing issued to two finished panels in 14 days.
- The 4 t crane panel was finished the same day its final drawing revision was issued.

Full drawing package available on request.

CASE 07 POWER DISTRIBUTION

Hospital Main Switchboard: 3,200 A Bus Braced for 80 kA

Designed an 11-section main switchboard for a university hospital to an 80 kA spec, from the 3,200 A bus to all 172 feeder breakers, and supervised installation and commissioning on site.

CLIENT An engineering firm, for a university hospital **MY ROLE** Electrical designer and commissioning supervisor

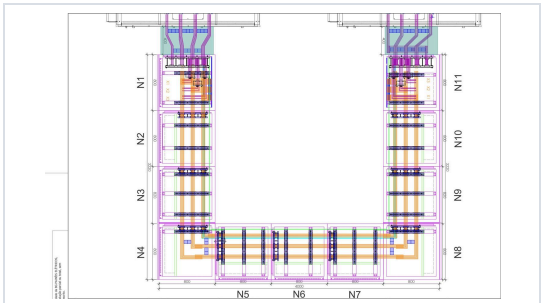
11
freestanding sections in a U-shaped layout

3,200 A
main bus I designed, braced for 80 kA

172
feeder breakers I selected for 80 kAIC, each mapped to its circuit



The 11 sections assembled in a U at the shop, before shipping



Top view: U-shaped layout, a transformer at each end



Sections N8 to N11, with the power meter on N11

THE CHALLENGE

- A hospital cannot stop: the switchboard feeds ICUs, operating rooms, the blood bank, sterilization, elevators and the chiller.
- An electrical upgrade with a new electrical room: all 170+ existing circuits had to move to the new switchboard, with none left behind.
- The spec called for 80 kA at 3,200 A: the bus, its supports and all 172 feeder breakers had to withstand a fault that size.

WHAT I DID

- **Mapped every circuit to its new section** by crossing the design list (breaker, rating, destination) with the field survey (current destination, existing cable), tracking the total rating per section.
- **Arranged 11 sections** (2,000 × 800 × 800 mm) in a U forced by the room, each end fed by a transformer through a 3,200 A main breaker, with power meter, 4,000/5 A CTs and 8 SPDs.
- **Designed the bus for 3,200 A, braced for 80 kA:** 3 bars per phase on the main bus, 2 per phase on each section's vertical bus, phase and support spacing, and copper vs. copper-clad aluminum (CCA).
- **Selected all 172 molded-case feeder breakers** (25 A to 500 A) for 80 kAIC, sized each breaker's wire and lug, and detailed every bus bar for the shop.
- **25-sheet drawing package:** layouts, one-line, 11 three-line sheets and BOM, revised from R00 to R02.
- **Supervised installation and commissioning** on site.

RESULT

- A 2 × 3,200 A, 172-feeder switchboard designed, built, installed and commissioned, with me on site.
- The bus and all 172 breakers met the client's 80 kA requirement.
- The full cycle with one person, from bus design to energization.
- Every circuit had its section, breaker and cable defined on paper before the shop drilled the first bar.

Full drawing package available on request.

CASE 08 SOLAR PV PLANTS

Standardized CCTV and Power Panel Families for Solar Plants

Standardized a solar EPC's CCTV panels into six reusable types and quoted its plants site by site.

CLIENT A solar EPC building PV plants across Brazil **MY ROLE** Electrical designer and estimator

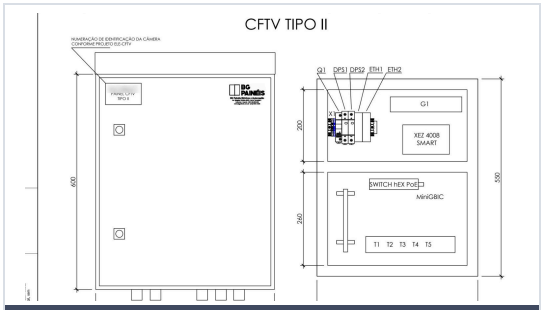
6
standard CCTV panel types (I to VI)

25
site-by-site quote requests in six months

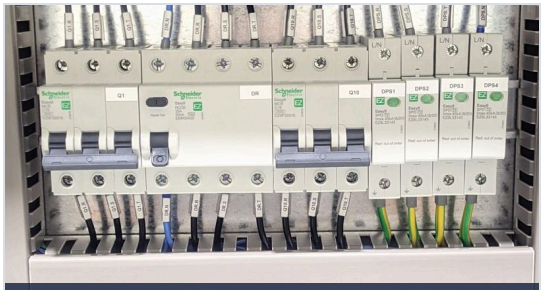
37
panels ordered, built in batches of up to 15



A batch of CCTV panels in assembly



CCTV panel Type II layout (original sheet)



Distribution panel: breakers, ground-fault breaker, four surge protectors and labeled wiring

THE CHALLENGE

- Every plant is a new order, with a short deadline and the client quoting competitors.
- The same panel types repeat from plant to plant, with variations in camera count, network ports and power.
- Outdoor field panels: an IP66 enclosure with surge protection and network electronics (PoE switch, fiber module, power supplies) inside.

WHAT I DID

- **Standardized the CCTV panels into six types,** each with its own drawing package. Type II, for example: 9 sheets with datasheet (220 V, IP66, 600 × 500 enclosure), wiring diagrams for power, network and cameras, terminal strip, layout and a BOM with breaker, surge and network protectors, power supply, PoE switch and fiber module.
- **Reused the same drawings across plants:** the engineering notes on later quotes call for panels identical to the earlier project. One plant took 15 CCTV panels; two sister plants took 7 each, grouped in 3 types.
- **Other panels for the same client:** AC combiner panels, auxiliary power panels and skid automation panels.
- **Quoted plant by plant:** 25 quote requests in six months, logged with panel type and quantity per plant.

RESULT

- 5 purchase orders and 37 panels in six months alone, on top of earlier orders.
- Designed once, reused many times: the six CCTV types served different plants without redrawing.
- Batch production of up to 15 identical panels per order.

Full drawing package available on request.

CASE 09 INDUSTRIAL AUTOMATION

Mooring Winch PLC and Motor Control Panels

Designed the PLC and motor control for three mooring winches at a port terminal, plus compact reversing starters, for an equipment maker.

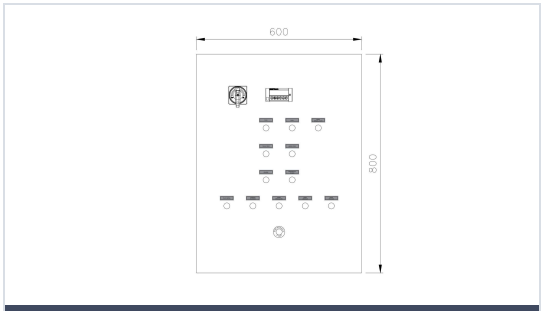
CLIENT An industrial equipment manufacturer, for a port terminal **MY ROLE** Electrical designer and estimator

S7-1200
PLC as Modbus RTU master of 3 VFDs and 3 load-cell indicators

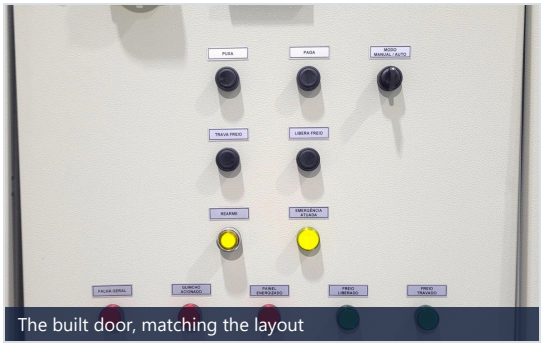
54 sheets
power and PLC package, in the client's standard

11 days
from door layout to assembled batch on the test benches


Control panels powered up on the test benches



Door layout of the control panel


The built door, matching the layout

THE CHALLENGE

- A mooring winch holds a ship. Each one has a braked motor, a hydraulic lock pump, a load cell and local and remote control; a control failure on the dock puts people and the vessel at risk.
- Three winches on a floating pier, with a power panel on deck and an operator station at each winch, linked by network.
- A large package on a short deadline: 4 panel models in the quote, built from the client's documents.

WHAT I DID

- **Estimated the package:** materials, assembly and engineering hours per model (power, operator station, control desk and control panels).
- **Power and PLC panel (54 sheets):** 440 V / 60 Hz; per winch a 5.5 kW braked motor and a 2.2 kW hydraulic pump; Siemens S7-1200 (CPU 1214C) with RS-485 and 3 I/O modules.
- **Networks:** Modbus RTU with the PLC as master of 3 VFDs and 3 load-cell indicators, shielded cable from deck to hold; Profinet with an Ethernet switch.
- **Safety:** master and per-winch e-stop relays, a safety contactor per winch and electromagnetic brakes. PLC I/O sheet by sheet, layouts, label list and BOM.
- **Local operator station** (load indicator, haul/slack, lock, pilot lights, local/remote, e-stop) and a **compact reversing starter** in 220 V and 380 V with interlocked contactors and 24 VAC control.

RESULT

- From door layout to assembled batch in 11 days. The built door matches the drawing.
- A complete winch automation design (power, PLC, two networks and safety) delivered in the client's drawing standard.
- Two orders closed with the same client.

Full drawing package available on request.

CASE 10 HOW I WORK

The Design and Estimating Standard the Company Still Runs On

Built the design and estimating standard a panel builder still runs on, and I still coach the team remotely.

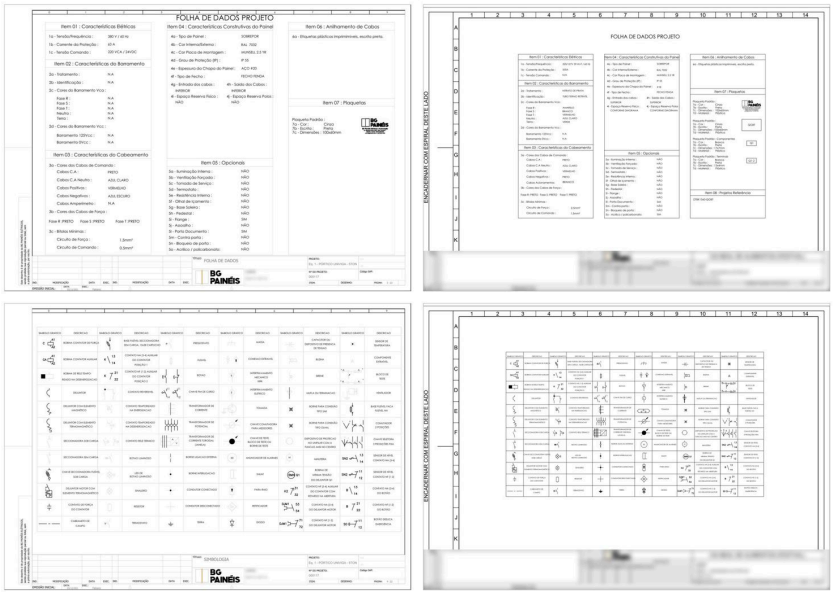
CLIENT The panel shop itself, across all sectors **MY ROLE** Creator of the standard, estimator and remote coach

1,400+
quote requests logged by the company on this toolkit

380+
clients in 10 sectors (company volume)

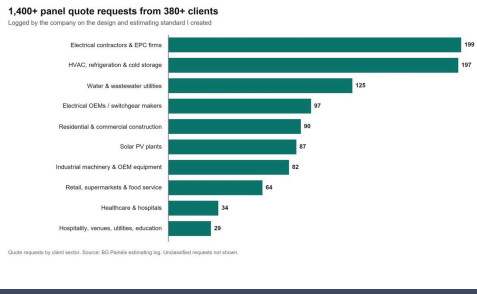
100 RFQs
and 787 panels quoted by me in my last six months

Databook template I created **A recent databook by the BG team**

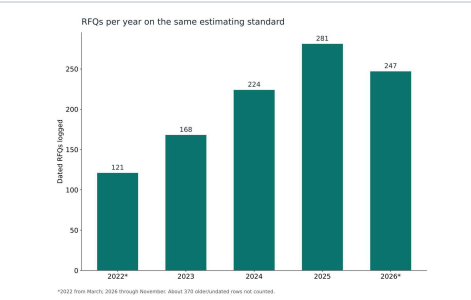


Same panel datasheet (top) and symbol legend (bottom), still used on every new project. Client names and title blocks blurred.

Left: my datasheet and symbol legend. Right: the same sheets in a recent drawing package by the team



Quote requests by client sector



Quote requests per year on the same standard

THE CHALLENGE

- A small panel builder with no method: every project came out in a different format, and each quote depended on who made it.
- Many quote requests for few people. Answers had to be fast and priced right, with the taxes of each item (credits and debits) built in.
- The standard had to keep working without me after I moved to the U.S.

WHAT I DID

- **Drawing package template:** the same sheet sequence on every project (cover, index, datasheet, symbols, diagrams, layout, BOM), with title block and design library. It is the format of the drawing packages in Cases 03 to 08.
- **Shop SOPs:** build procedure, inspection and assembly tools (Cases 01 and 02).
- **Cost sheet per order:** part number, supplier, lead time, unit price, tax credits and debits, markup, final cost, price and gross margin per line.
- **Quote log:** every request with proposal number, status, client, job, panel count, engineering takeoff dates, panel types, client feedback and delivery date. The company still uses it.
- **Proposal templates** (technical and commercial): scope, lead times, inspection, freight, payment, warranty, tests per NBR IEC 60439 and documentation.
- **Prepared every quote myself** until I left, trained the designer who runs the standard today, and still coach the team remotely.

RESULT

- Still in use: a drawing package issued now by the team follows the same datasheet and symbols I created.
- Company volume on this toolkit: 1,400+ quote requests from 380+ clients in 10 sectors, growing year after year.
- My last six months: 100 quote requests, 787 panels and 47 clients, all quoted by me.

CASE 11 TEST EQUIPMENT RETROFIT

100 kW Load Bank Retrofit: From Breakers to PLC Control

Took an out-of-service 100 kW load bank to automatic fixed, timed and ramp tests: I designed the electrical package and Modbus network and built the panel.

CLIENT A client of the panel shop (engineering capstone, with a classmate) **MY ROLE** Electrical designer and panel builder

100 kW
resistive load bank, 8 stages from 1 kW to 40 kW, at 380 V

1 kW
steps in automatic ramp tests, up or down

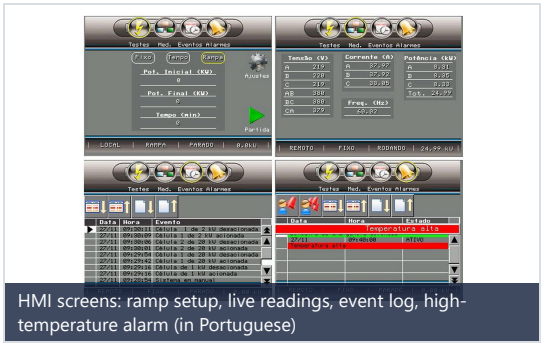
10 sheets
electrical package I drew in AutoCAD



After: touchscreen HMI, power meter, temperature controller, e-stop and one selector per stage



Before: manual control by breakers and failed seven-segment displays



HMI screens: ramp setup, live readings, event log, high-temperature alarm (in Portuguese)

THE CHALLENGE

- A 100 kW load bank, used to test generators, UPS systems and batteries, was out of service, but the resistors were fine: replacing it made no sense.
- It ran only by hand, one breaker per resistor stage. No load ramps, which some equipment tests require.
- Failed meter and displays, undersized breakers, and controls on the same supply as the load under test.

WHAT I DID

- **Electrical design:** 380 V circuits sized to code (6 A to 63 A per stage), contactors chosen by current and electrical life (28,800 operations for 8 years), and a separate control supply.
- **Selected the hardware:** PLC, touchscreen HMI, Modbus power meter with 200/5 A CTs, and a stand-alone temperature controller so cooling works even if the PLC fails.
- **Drew the 10-sheet AutoCAD package:** 6 schematic sheets (power, metering, PLC I/O, Modbus), panel and door layouts, and BOM.
- **Set up the Modbus RTU network** (PLC, HMI, power meter) and **built the panel**: new door, back panel and installation.
- **My classmate programmed the PLC and HMI:** fixed, timed and ramp modes, 10 alarms and event log.

RESULT

- The load bank ran again, now automatic, with manual mode kept as a backup.
- Automatic ramp tests in 1 kW steps, not possible before.
- 25 kW set, 24.99 kW measured; 43 kW set, 42.92 kW measured.
- Contactor failure alarms, e-stop and high-temperature trip tested one by one under load.

Full drawing package available on request.

Let's work together

HOW TO WORK WITH ME

Directly with FC Solutions (registered in Massachusetts, own EIN): fixed-price or hourly contracts, invoiced by the company. No payroll and no employment paperwork on your side. **Or through Upwork**, if you prefer a platform, with payment protection for both sides.

Let's start with a **small, fixed-scope pilot (10 to 20 hours)**: one panel package, one estimate, or one set of drawings to clean up. You see the work before committing to more.

FC SOLUTIONS

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