COMPLETE GPC SOLUTION SET · BATTERY FORMATION

BATTERY FORMATION LABS

Gigafactory formation lines · R&D labs · Cell manufacturers · Universities

Every electrochemical cell is formed exactly once. The interface that forms in the first cycles — the SEI — determines ionic conductivity, impedance growth, and degradation for the entire life of the cell. It cannot be re-formed later. Yet industrial CC/CV protocols are chosen for cost and predictability, not interface quality. Generated Pattern Current (GPC) formation — Dynamic Defined Pattern Charging (DDPC) under PCT/TR2025/051176 — makes the pattern itself the control variable: targeting SEI nucleation density, layer uniformity, and growth rate directly, at every point in the formation cycle.

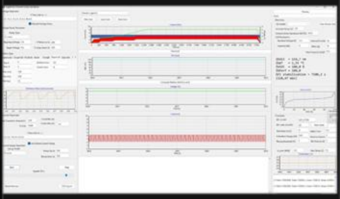
ONE ECOSYSTEM — FROM CHEMISTRY TO PRODUCTION NODE

1 · SYNTHESIZE

GP ChemPat

Chemistry-native GPC pattern derivation → .gpchem / 1024-pt LUT

2 · SIMULATE



GP Sim — Formation

Physics-based SEI simulation before a single cell is touched

3 · VALIDATE

GP Lab R&D

4-ch physical validation + full data recording, in your lab

4 · DEPLOY

GP Module

Validated pattern on licensed firmware, per power source

THE GPC FORMATION PROTOCOL — THREE PHASES, FEEDBACK-

PHASE 1
NUCLEATION

OBJECTIVE

A high-density, spatially uniform field of field of SEI nucleation sites across the the anode, at the lowest workable current density.

PATTERN

Low-amplitude ramped-square; S-curve ramps suppress inductive spikes that localize nucleation.

FEEDBACK

HF impedance (real part) · surface ΔT ΔT gradient · dV/dt slope.

EXIT CRITERION

HF resistance stabilizes in tolerance band band → uniform coverage confirmed. confirmed.

PHASE 2
CONSOLIDATION

OBJECTIVE

Grow the SEI to target thickness and composition — anode (SEI) and cathode (CEI) managed simultaneously.

PATTERN

Mid-amplitude phase-delayed composite; the delay alternates anode/cathode emphasis, encoded per chemistry in .gpchem.

FEEDBACK

OCV relaxation constant · mid-freq impedance arc · live S_form index.

EXIT CRITERION

S_form under chemistry threshold; OCV OCV relaxation diffusion-limited.

PHASE 3
STABILIZATION

OBJECTIVE

Complete the first full charge, terminate residual electrolyte decomposition, set the CE baseline.

PATTERN

Full-capacity cycle on the chemistry-specific template — for calibrated cells, a ChemPat-synthesized GPC.

FEEDBACK

Coulombic efficiency · capacity delta · gas proxy via dV/dt anomaly.

EXIT CRITERION

CE above target; ψGP_wear plateaus → → SEI stabilized.

Phase boundaries are not time-based — they are feedback-gated. A phase ends when the cell's measured state confirms the state confirms the objective is met. Cells whose interfaces form quickly are not held to the slowest cell's schedule: at scale, schedule: at scale, this reduces average formation time and the variance in cell quality leaving the line — the two numbers the two numbers that drive gigafactory formation economics.

BATTERY FORMATION

GP CHEMPAT

CHEMISTRY-NATIVE PATTERN DESIGNER · UNIVERSAL SYNTHESIS PLATFORM

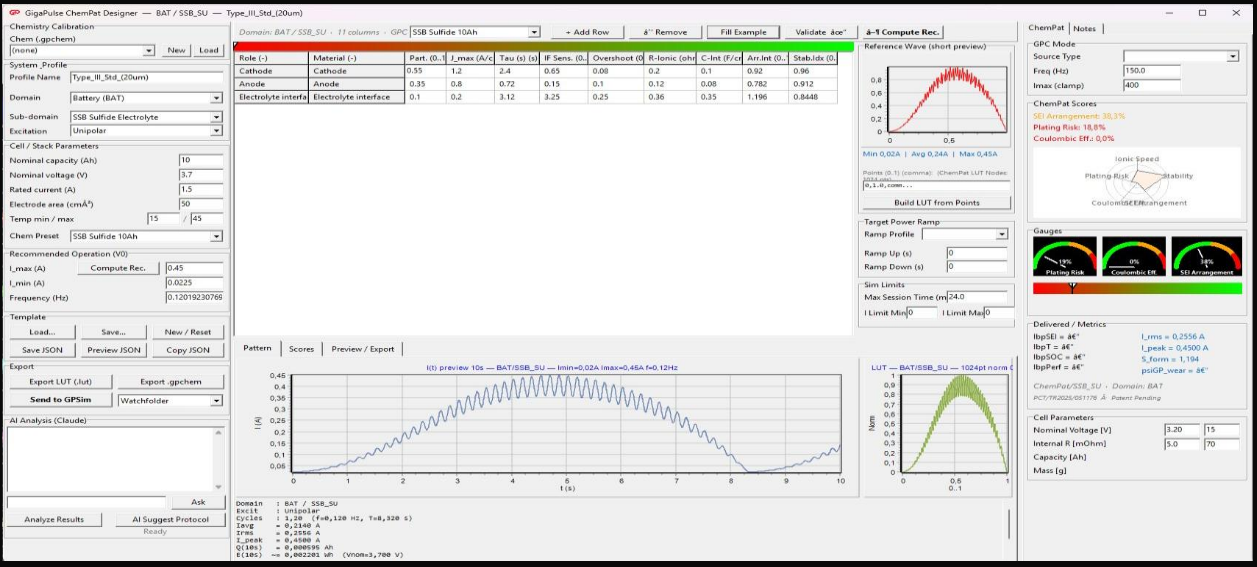
Not a template library — a derivation engine. GP ChemPat is scientific software in its own right: a universal electrochemical pattern synthesis platform that designs physics-derived GPC waveforms across 17 electrochemical domains, from battery formation to electrolysis, plating, and water treatment. Input your electrode kinetics, mass transport, and thermal response — ChemPat derives the minimum-stress pattern for that exact system.

20+
MAIN DOMAINS

95+
SUBDOMAIN PRESETS

101+
CHEMISTRY PRESETS

1024,...
POINT GPC LUT



GigaPulse ChemPat Designer — BAT / SSB_SU — Type_III_Std_(20um)

Chemistry Calibration
Chem (.gpchem): (none)

System _Profile
Profile Name: Type_III_Std_(20um)
Domain: Battery (BAT)
Sub-domain: SSB Sulfide Electrolyte
Excitation: Unipolar

Cell / Stack Parameters
Nominal capacity (Ah): 10
Nominal voltage (V): 3.7
Rated current (A): 1.5
Electrode area (cmÅ²): 50
Temp min / max: 15 / 45
Chem Preset: SSB Sulfide 10Ah

Recommended Operation (V0)
I_max (A): 0.45
I_min (A): 0.0225
Frequency (Hz): 0.12019230769

Domain: BAT / SSB_SU · 11 columns · GPC SSB Sulfide 10Ah

Role (-)	Material (-)	Part. (0..1	J_max (A/c	Tau (s) (s)	IF Sens. (0..	Overshoot (0	R-Ionic (ohr	C-Int (F/cr	Arr.Int (0..	Stab.Idx (0.
Cathode	Cathode	0.55	1.2	2.4	0.65	0.08	0.2	0.1	0.92	0.96
Anode	Anode	0.35	0.8	0.72	0.15	0.1	0.12	0.08	0.782	0.912
Electrolyte interfa	Electrolyte interface	0.1	0.2	3.12	3.25	0.25	0.36	0.35	1.196	0.8448

Reference Wave (short preview)
Min 0,02A | Avg 0,24A | Max 0,45A
Points (0..1) (comma): (ChemPat LUT Nodes: 1024 pts)
0,1.0,comm...

Target Power Ramp
Ramp Up (s): 0
Ramp Down (s): 0

Sim Limits
Max Session Time (m: 24.0
I Limit Min: 0
I Limit Max: 0

GPC Mode
Freq (Hz): 150.0
Imax (clamp): 400

ChemPat Scores
SEI Arrangement: 38,3%
Plating Risk: 18,8%
Coulombic Eff.: 0,0%

Delivered / Metrics
IbpSEI = â€"
IbpT = â€"
IbpSOC = â€"
IbpPerf = â€"
I_rms = 0,2556 A
I_peak = 0,4500 A
S_form = 1,194
psiGP_wear = â€"
ChemPat/SSB_SU · Domain: BAT
PCT/TR2025/051176 Â· Patent Pending

Cell Parameters
Nominal Voltage [V]: 3.20 | 15
Internal R [mOhm]: 5.0 | 70

```
Domain   : BAT / SSB_SU
Excit    : Unipolar
Cycles   : 1,20  (f=0,120 Hz, T=8,320 s)
Iavg     = 0,2140 A
Irms     = 0,2556 A
I_peak   = 0,4500 A
Q(10s)   = 0,000595 Ah
E(10s)   ~= 0,002201 Wh  (Vnom=3,700 V)
```

New
Load
Ramp Profile
Source Type
Capacity [Ah]
Mass [g]
Template
Load...
Save...
New / Reset
Save JSON
Preview JSON
Copy JSON
Export
Export LUT (.lut)
Export .gpchem
Send to GPSim
Watchfolder
AI Analysis (Claude)
Ask
Analyze Results
AI Suggest Protocol
Ready
+ Add Row
â'' Remove
Fill Example
Validate âœ"
â–¶ Compute Rec.
Build LUT from Points
ChemPat
Notes
Ionic Speed
Stability
Plating Risk
Coulombic Eff.
SEI Arrangement
Gauges
19%
0%
38%
Pattern
Scores
Preview / Export
I(t) preview 10s — BAT/SSB_SU — Imin=0,02A Imax=0,45A f=0,12Hz
I (A)
t (s)
LUT — BAT/SSB_SU — 1024pt norm
Norm
0..1

THE SCIENCE INSIDE

Physics-based waveform synthesis

Every chemistry has a distinct electrochemical fingerprint: LFP a fingerprint: LFP a flat plateau, LTO square, NMC811 sigmoid with sigmoid with harmonic damping, solid-state an ultra-slow S-slow S-curve. The LUT is computed per chemistry — never a never a generic Gaussian.

The Jensen inequality principle

In nonlinear electrochemical systems, f(I-bar) ≠ (1/T)∫f(I(t))dt. (1/T)∫f(I(t))dt. GPC exploits this gap: at the same average current average current — same line throughput — pattern shape alone shape alone delivers better SEI quality and lower Li-plating risk. plating risk.

20+ battery chemistries built in

Incl. Solid Power (Si EV, Li-Metal, Conversion) and Maxwell dry-Maxwell dry-electrode presets: LFP · NMC811 · NMC622 · · NMC532 · NCA · LCO · LTO · LMO · Na-ion · Li-Metal · SSB Oxide · SSB Oxide · SSB Sulfide · LMR · LNMO · LFMP · High-Si · Graphite Graphite

Five-metric domain scoring

Radar scoring with domain-specific physics. For formation: Ionic formation: Ionic Speed · Cycle Stability · SEI Arrangement · Arrangement · Coulombic Efficiency · Plating Risk. Every protocol protocol is graded before it ever touches hardware.

INTEGRATED AI — ON EVERY

AI ANALYZE — protocol assessment

Analyzes the current parameter set, interprets scores, raises physics-grounded warnings (LFP plateau behavior, NMC811 Ni reactivity, SSB dendrite risk...) and proposes concrete improvements.

AI SUGGEST PROTOCOL — full grid proposal

From chemistry and cell parameters, generates the complete protocol grid — every row, I_min / I_max / f values — and writes it in. A physics-based starting point in one click.

AI ASK — free-form domain questions

"Why is plating risk high in this chemistry?" — answered with domain physics knowledge, inside the tool. New engineers become productive without years of formation experience.

WORKFLOW

Select domain → Enter chemistry parameters → Compute Recommendation → Preview GPC pattern → AI analysis & refinement → Export to GP Sim

EXPORT & INTEGRATION

Direct hand-off to GP Sim: all physics parameters, SEI model, thermal block, and cell limits in a single file.
.gpjson — GP Sim pattern · .gpchem — ChemPat template · .lut — binary LUT · .csv — tabular · .pdf — ChemPat report

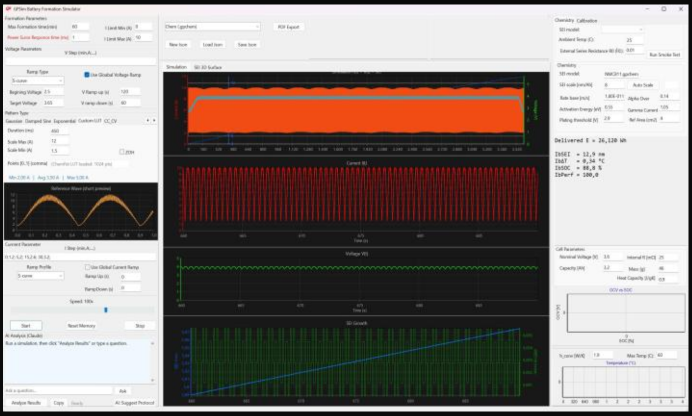
$$I(t) = I_{min} + (I_{max} - I_{min}) \times S(t)$$

Average current preserved — only the shape changes. I_min, I_max, ƒ adapt live from I/V feedback; frequency lives in the control loop, unlike PWM.

GP SIM — BATTERY FORMATION

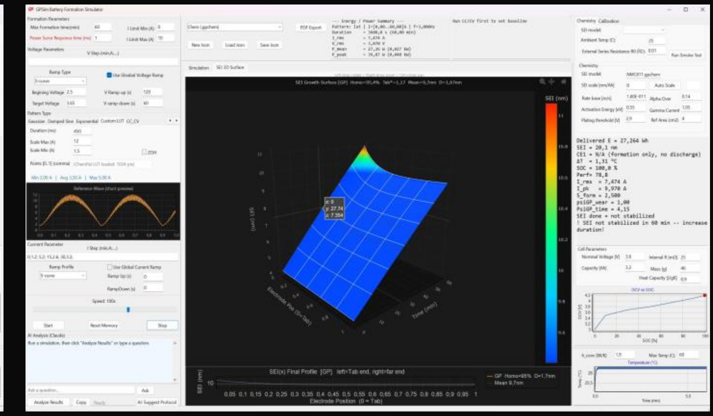
FORMATION PROTOCOL SIMULATOR · A PHYSICS PLATFORM, NOT A CHARGER DEMO

GP Sim is a scientific simulation platform without an equivalent on the market: it simulates formation under any electrical form electrical form — not only GPC. Conventional CC/CV is built in as the benchmark reference, so every claim can be tested against be tested against the industry standard on identical physics. Simulate SEI nucleation, growth, and stabilization before a single before a single cell is touched — with results that are real-time and scientifically defensible.



```
Delivered E = 26,120 Wh

IbSEI  = 12,9 nm
IbΔT   = 0,34 °C
IbSOC  = 88,8 %
IbPerf = 100,0
```



```
Delivered E = 27,264 Wh
SEI = 20,1 nm
CE1 = N/A (formation only, no discharge)
ΔT  = 1,31 °C
SOC = 100,0 %
Perf= 78,8
I_rms  = 7,474 A
I_pk   = 9,970 A
S_form = 2,500
psiGP_wear = 1,00
PsiGP_time = 4,15
SEI done = not stabilized
! SEI not stabilized in 60 min -- increase
duration!
```

THE SEI ENGINE

Live, nm-resolution SEI simulation

SEI thickness computed live against time; stabilization detected detected automatically via the dSEI/dt → 0 criterion. Growth Growth constant kSEI0 is chemistry-specific; Arrhenius activation activation energy (Ea, eV) captures temperature dependence; dependence; alpha-over / gamma-current sensitivity; plating plating threshold guards against lithium deposition.

3D spatial SEI map

SEI thickness across the full formation run as an interactive 3D interactive 3D surface — homogeneity analysis along the the electrode, not just one averaged number.

Every electrical form, one engine

All patterns with I-Step and V-Step support: Gaussian · Sinusoidal · Damped Sine · Exponential · Trapezoid · Ramped Ramped Square · Superpulse · Bezier · Custom LUT (1024-pt) · (1024-pt) · CC/CV — benchmark reference

Multi-chemistry, one .gpchem file

LFP, NMC622/811, NCA, LCO, LTO and graphite-family anodes. anodes. Load a .gpchem file and SEI kinetics, thermal properties, properties, voltage limits and recommended formation currents currents are assigned automatically. Real-PSU calibration keeps calibration keeps simulation accuracy honest.

AI PROTOCOL DESIGNER

Selects the optimal pattern for the chemistry profile; proposes I_min, I_max, V_max, V0; estimates formation duration from SEI stabilization analysis; raises critical warnings (plating risk, thermal limits, ramp-up) — and states the rationale: why this pattern, this frequency, this current band.

EVERY RUN, FULLY MEASURED

ENERGY / POWER

I_rms · I_peak · V_rms · P_mean · P_peak
Apparent power (kVA) · power factor
Delivered energy (Wh) · ohmic loss (Wh)
End-to-end efficiency (%)

CHEMISTRY / SEI

SEI thickness (nm) vs target
SEI done time (min) — stabilization instant
Delivered Q (Ah) · SOC (%) · ΔT (°C)
CE1 — first-cycle Coulombic efficiency
OCV-vs-SOC tracking · thermal profile

GPC QUALITY METRICS

S_form — formation quality score
ψGP_wear — cell wear index (1.0 = minimal stress)
ψGP_time — time-efficiency score
Perf — overall performance index

REPORTING & FILES

One-click PDF report

Every metric, every graph, and the AI analysis in a single document your team can archive, compare, and defend. File File system: .gpsim · .gppat · .gpchem · .gpcal · PDF / CSV CSV

GP Sim takes battery formation out of the realm of "black art" and turns it into a measurable, repeatable, optimizable repeatable, optimizable engineering process. Chemistry changes? Load one file. New engineer? AI carries the domain carries the domain knowledge. Black box? Every metric is transparent and reportable.

GP LAB R&D

4-CHANNEL ADAPTIVE GPC CONTROL PLATFORM · TEST & DATA-LOGGING INSTRUMENT

CONTROL

Transforms any standard power supply into a synchronized, synchronized, high-precision adaptive GPC control system — no system — no hardware change. Four independent channels, full channels, full pattern library, real-time waveform generation generation and behavioral analysis. The physical validation validation platform for GP Sim outputs.

RECORD & REPORT

GP Lab is far more than a GPC application tool — it is a precision precision measurement and data-logging instrument. It samples samples current and voltage at sub-millisecond resolution resolution through the entire run and derives the complete complete picture from the raw stream — capacity (C), internal internal resistance, Coulombic efficiency, thermal response — response — delivered as a full report. CC/CV runs included; full included; full CSV export.

GigaPulse® 4ch Lab Dev
USPTO 19/298,223
PCT/TR2025/051176
GP Lab Control
CH1
CH2
CH3
CH4

ADAPTIVE CONTROL ENGINE

Real-time I/V/T measurement
Dynamic impedance (Rdyn)
Capacity & Coulombic eff.
Thermal response analysis
dV/dt · dI/dt tracking
Current offset adaptation

Frequency & duty control
Saturation time mgmt.
A/B channel comparison
FIFO deterministic timing
JSON recipe load
24V industrial I/O · rack

MEASURED

Current (0-10V)
Voltage (0-10V)
Temperature (ext. sensor)
8× digital inputs

CONTROLLED

I_CTRL waveform output
V_OUT limit signal
8× digital outputs
4-channel synchronization

Stabilization alert — the invisible error, made visible

In fixed-duration formation, declaring a cell "formed" before its before its SEI has actually plateaued is a systematic error no one no one sees. GP Lab computes S_form and ψGP_wear in real real time and explicitly flags any cell whose interface has not not stabilized within the formation window.

VALIDATE IT IN YOUR LAB — NOW

GPC patterns are derived from your chemistry — so the only only validation that matters is the one you run on your own own cells. A 4-channel GP Lab unit and a cell of interest is is everything needed: full pattern library, real-time S_form / S_form / ψGP_wear / ψGP_time, .gpchem support for any cell any cell type, CC/CV side-by-side on the A/B channels, and and complete data export. Don't take our word for it — measure it on your chemistry, on your bench, with your data. data.

EIS sweep	1st-cycle CE	Retention	SEI estimate	S_form / ψGP
100kHz-10mHz, cyc 10/100	Q_dis / Q_chg cycle 1	vs nominal cyc 10-500	model fit to EIS	GP Lab real-time

Your chemistry · your data · your IP

All GP software runs locally — nothing leaves your facility. Your GPC protocol is as proprietary as your electrode formulation; only formulation; only optional AI features touch the internet.

FROM YOUR BENCH TO THE GIGAFACTORY

THE FULL HORIZON — WHAT THE GP LAB KIT UNLOCKS

The GP Lab kit is not a lab-instrument purchase — it is the entry point of a production trajectory. Every pattern you validate on four channels is, unchanged, the pattern that will run your formation lines. This is exactly where that investment leads.

THE SCALING PATH — ONE PATTERN, THREE STAGES

TODAY — VALIDATE

GP LAB R&D

4 channels on your bench. Validate GPC GPC on your chemistry, build your proprietary .gppat library, capture a full full per-cell measurement record from from day one.

NEXT — PILOT

GP CORE

Industrial cabinet scaling 4 → 40 channels channels in 4-channel increments. High-High-throughput validation, certification certification labs, OEM lines, limited pilot pilot production.

THEN — PRODUCE

GP MODULE FLEET

One module per power source. A single single gigafactory formation line typically typically runs 50–500+ GP Modules — — your validated patterns on licensed licensed firmware, at line scale.

GP MODULE — THE FIELD EXECUTION LAYER

"From Pattern to Power — Deterministic Control for Electrochemical Systems."

Standalone and deterministic: Pattern Pattern Storage → Playback Engine → Feedback Processing → → Control Layer → I/O. I/O. The pattern executes at hardware level — no PC dependency, no OS jitter. DIN-rail mount, licensed firmware, one one node per power source. Real-time I/V/T I/V/T feedback, closed-closed-loop optimization, Rdyn, I_ref modulation, thermal correlation.

GP
PWR
STAT
RST ETH
ETH
IN
OUT
GP
R MODULE
Industrial Edge Control
Powered by GigaPulse TECHNOLOGY

An Ethernet-controlled fleet, not a box count

Patterns upload to every node over the network. GP Module Writer is the licensing gateway: every deployed pattern passes through it — a traceable, auditable IP chain from simulation to production node. GP Module Control orchestrates the facility: multi-line synchronization, per-node monitoring, pattern distribution, and a factory-level analytics dashboard.

One download, instant switchover

Chemistry tweak? New product? A single download to the GP the GP Modules switches the entire system instantly — every every node on the line picks up the new pattern. No line rebuild, rebuild, no re-engineering, no commissioning cycle. Product Product changeover becomes a network event, not a project. project.

THE PAYOFF AT SCALE

THE 1 GWH/YEAR FACTORY EFFECT MODEL-DERIVED SCENARIO

Formation time

135 min vs 280 min CC/CV — per formation cycle

Rack throughput

up to ~2× cells per rack · same footprint, same power feed

Energy per cell ↓

shorter cycle · lower ohmic loss across the run

CE1 ↑

less Li inventory lost in cycle 1 → more sellable GWh per line

Variance ↓

feedback-gated exit · fewer out-of-spec cells after formation

Changeover ≈ 0

one Ethernet download · the whole line switches

Scenario-based simulation results. The path to these numbers runs through GP Lab validation — measure them on your own chemistry first.

What you will have gained

A proprietary .gppat pattern library as defensible as your your electrode formulation. A per-cell quality record from every from every formation run. Formation rack capacity effectively effectively doubled in the model scenario. A line that changes changes products with a download. And a formation process process your team understands, measures, and owns — instead instead of inherits.

It all starts with a 4-channel kit on a bench

The GP Lab kit is the smallest possible step onto this trajectory — and the only one that requires no production commitment. commitment. Validate first. Scale when your own data says so.

START YOUR VALIDATION

Feasibility report · lab kit · NDA package

contact@gigapulse.energy