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November 12th, 2024

Advanced Battery Ground Monitoring System (ABGMS)

Modernizing Battery Ground Monitoring for the Utility of the Future

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Agenda

- Current State & Theory
- ABGMS Schematic Design
- ABGMS Relay Settings
- ABGMS SCADA Integration
- ABGMS Results and Future State

Importance of DC Battery Ground Monitoring

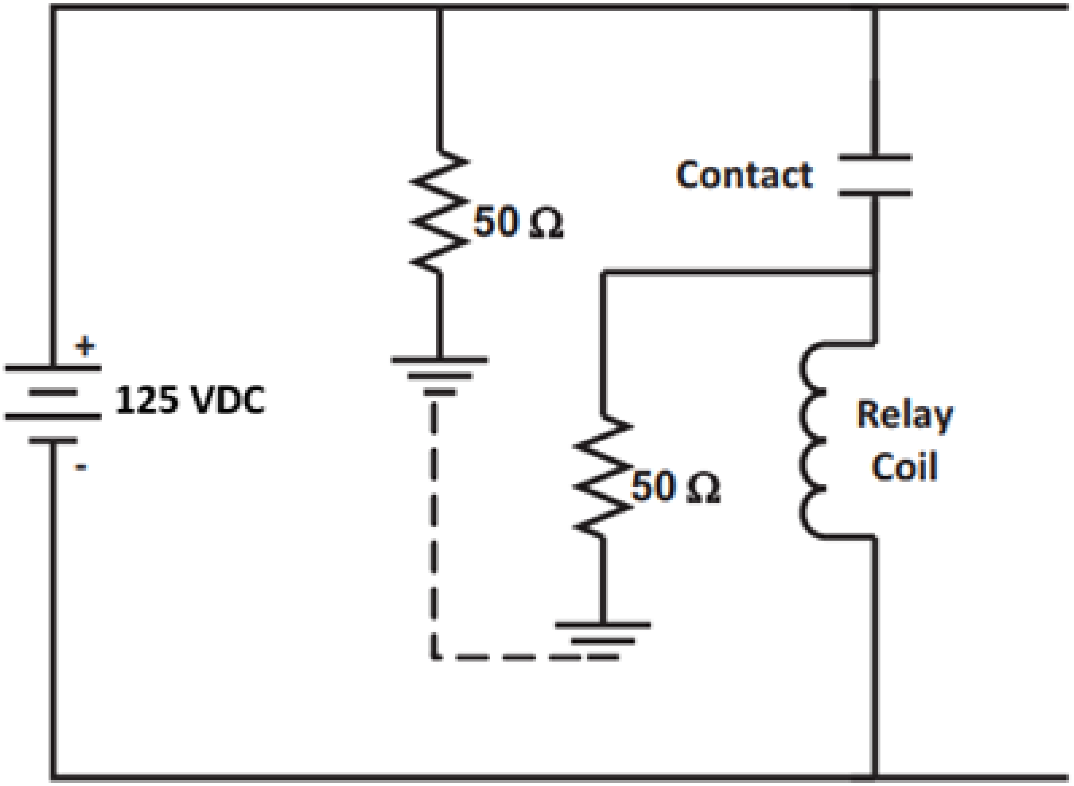


Figure 2 -- Two Battery Grounds (Misoperation)

- **Importance of Utility DC Battery Systems**
  - Powers critical equipment
    - Protection, Monitoring, Equipment operation
  - Backbone of the system in event of auxiliary power loss
- **DC Battery Grounds**
  - Caused by degraded wiring, faulty equipment, environmental impact, wildlife, etc.
  - Several DC ground-related equipment mis-operations over the years
  - Opportunity to remove battery ground source before it becomes problematic

Current Practices at ComEd

Initial Check for DC Battery Ground

Check is performed upon entering a substation

Identification is made at DC Battery Charger

Needle deflection over 60% of nominal DC voltage

Manual FBGRMS (Kugler) Method testing required

Challenges with Current Practices

Personnel required on site

No real-time monitoring

No historical data/trends

Floating Battery Ground Resistance Measurement System (FBGRMS)

$$Rpg = Test\ Resistor\ \frac{(Vpn - Vpg)}{Vng} - Test\ Resistor$$

$$Rng = Test\ Resistor\ \frac{(Vpn - Vng)}{Vpg} - Test\ Resistor$$

- **FBGRMS developed at ComEd by James Kugler**
  - Known as the Kugler Method
  - Manual method for measuring DC battery ground resistance values
- **Requires 3 measurements & test resistor**
  - Vpn = Voltage Positive to Negative
  - Vpg = Voltage Positive to Ground w/ 200kOhm resistor in parallel
  - Vng = Voltage Negative to Ground w/ 200kOhm resistor in parallel

Critical Ground Resistance Values (CGRV)

R_{PG} OR R_{NG} (KILO-OHMS)	PRIORITY LEVEL	RESPONSE TYPE
Less than or equal to 10	10	Immediate
Less than or equal to 20, but above 10	20	Next business day or within two weeks
Above 20 up to and including 40	40	Next scheduled outage
Above 40	None	No response

- Importance of Electrical Response
  - Understanding DC pickup and drop-out threshold characteristics
  - Essential for determining CGRV's
- Establishing Critical Ground Resistance Values (CGRV)
  - Based on study of existing ComEd equipment and historical learnings
- CGRV determines response to battery grounds

Need for Automation

Opportunity for Modernization

- Identified need to update methodology for detecting DC battery grounds
- Need for real-time notification & data trending

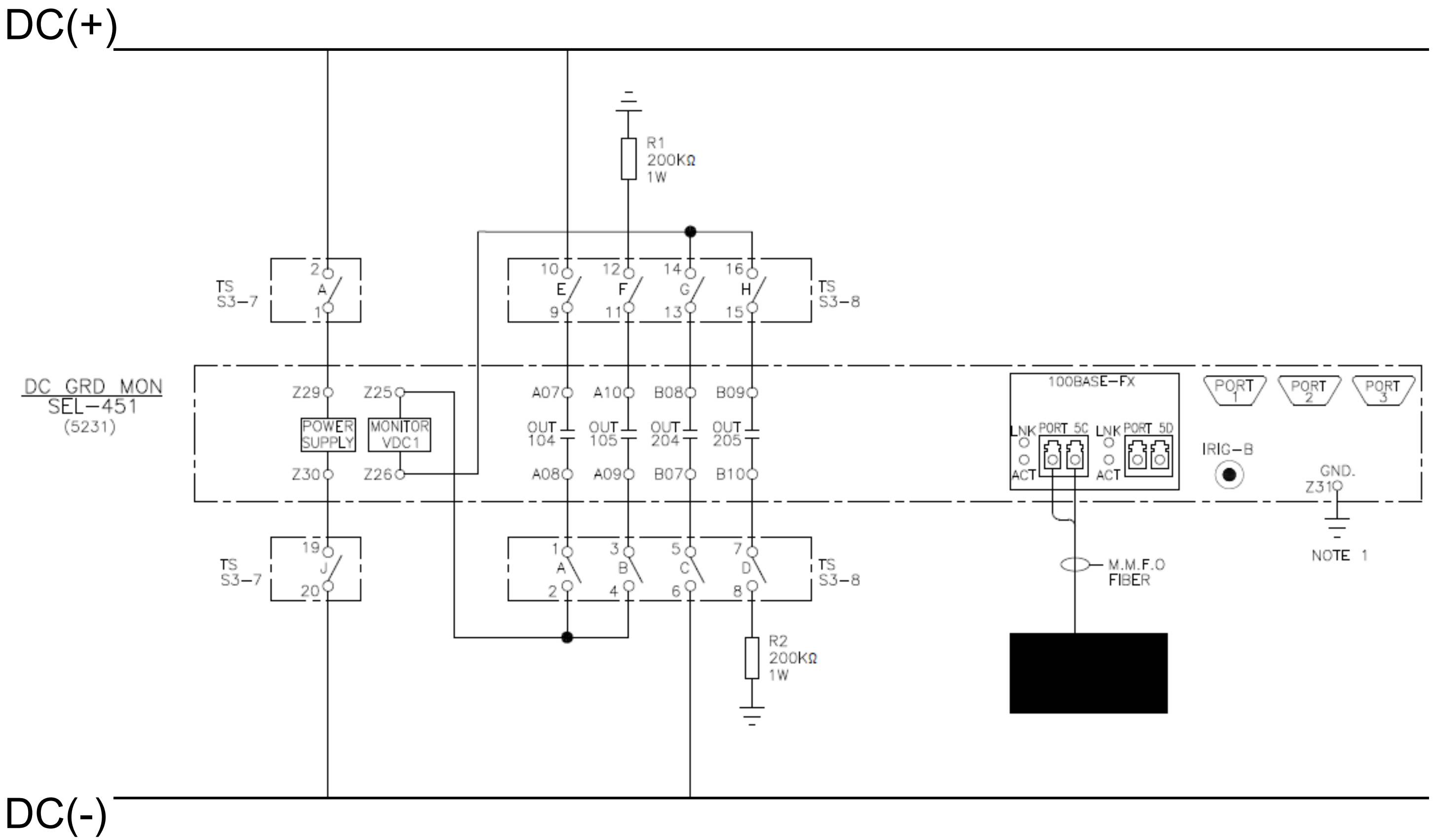
Existing Solutions

- Commercially available options
- Voltage & Current Based Approaches, limited data provided

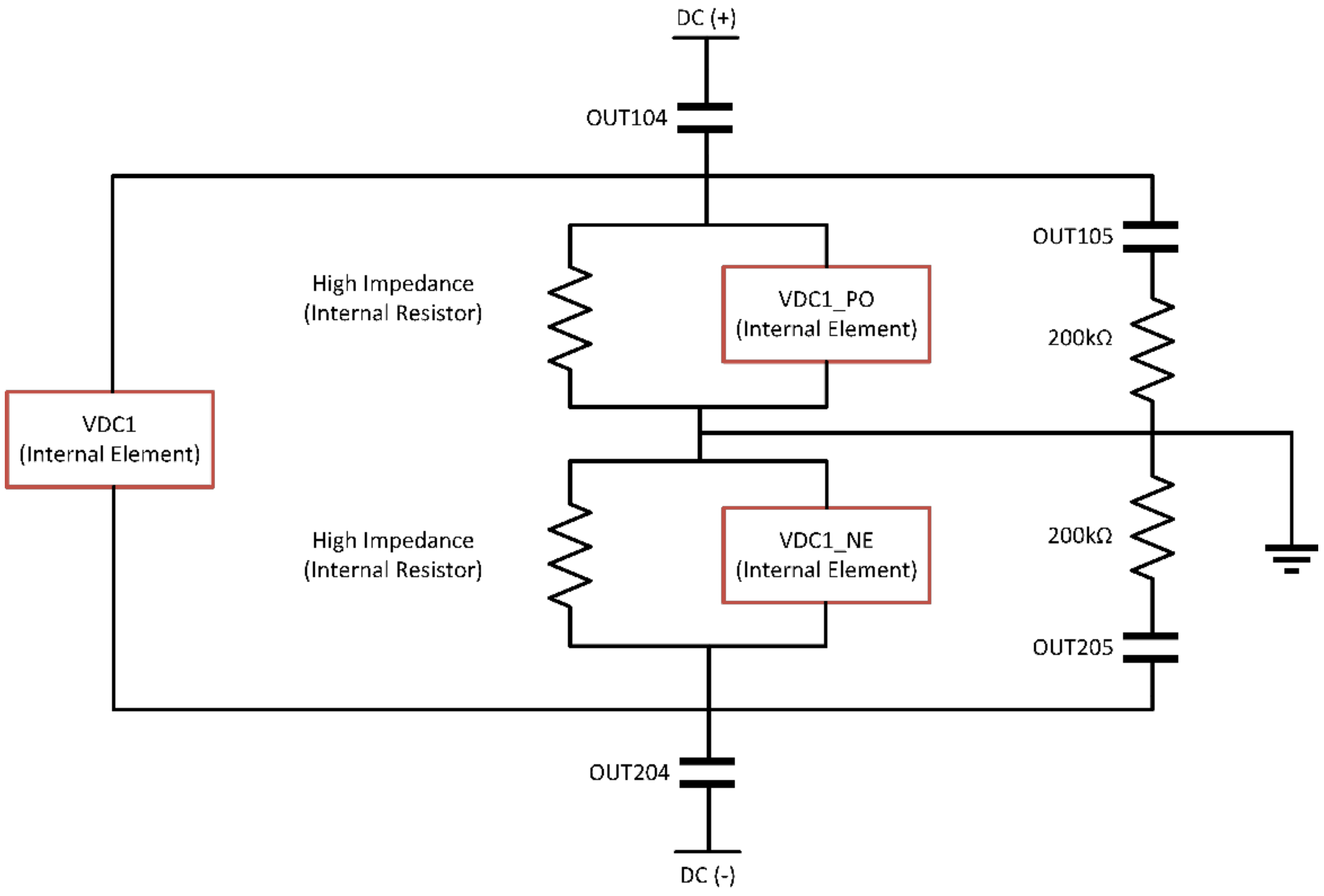
- **ComEds Criteria for Automated Solutions**
  - Accurately measure the DC to ground ohmic resistance values
  - Store the measurements for later analysis
  - Correctly alarm for specific conditions with minimal nuisance alarms
  - Ability to retrofit into any of our stations, regardless of DC battery voltage

Overview of ABGMS

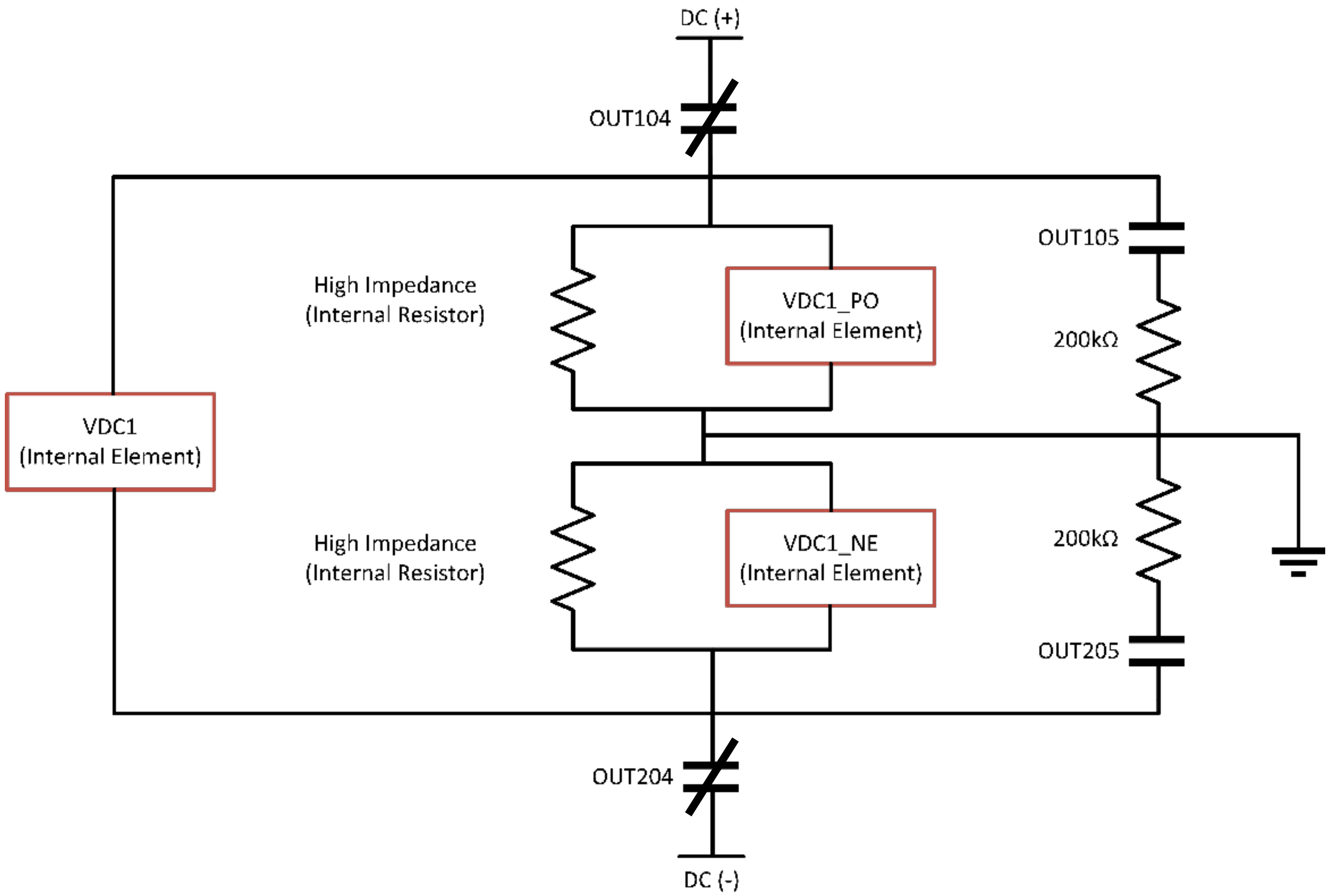
- **Introduction of ABGMS**
  - Automates detection using the Kugler Method hourly
  - Utilizes Schweitzer SEL-451 relay and SEL-3350 RTU
  - Provides immediate local indication and remote alarms through SCADA
- **Data Management and Analysis**
  - Stores historical ohmic values in a centralized database (PI Processbook)
  - Enables trend analysis and correlation with external factors like weather, maintenance activities, etc.



ABGMS Circuit



ABGMS Circuit Evolution



Stage 1 (V_PN)

Output Contacts

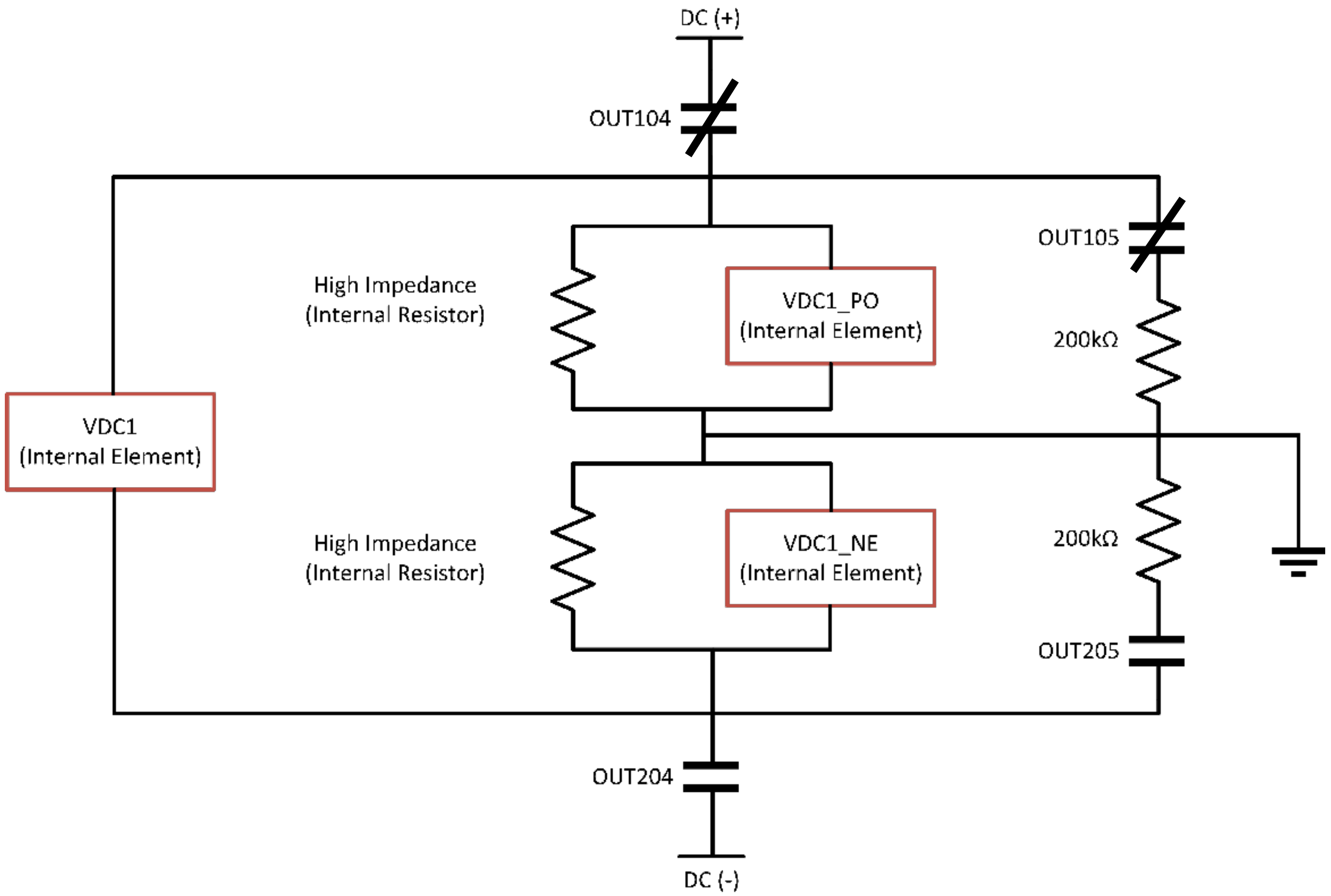
CLOSED: OUT104, OUT204

OPENED: OUT105, OUT205

DC Voltage Input

VDC1 Element measures voltage

ABGMS Circuit Evolution

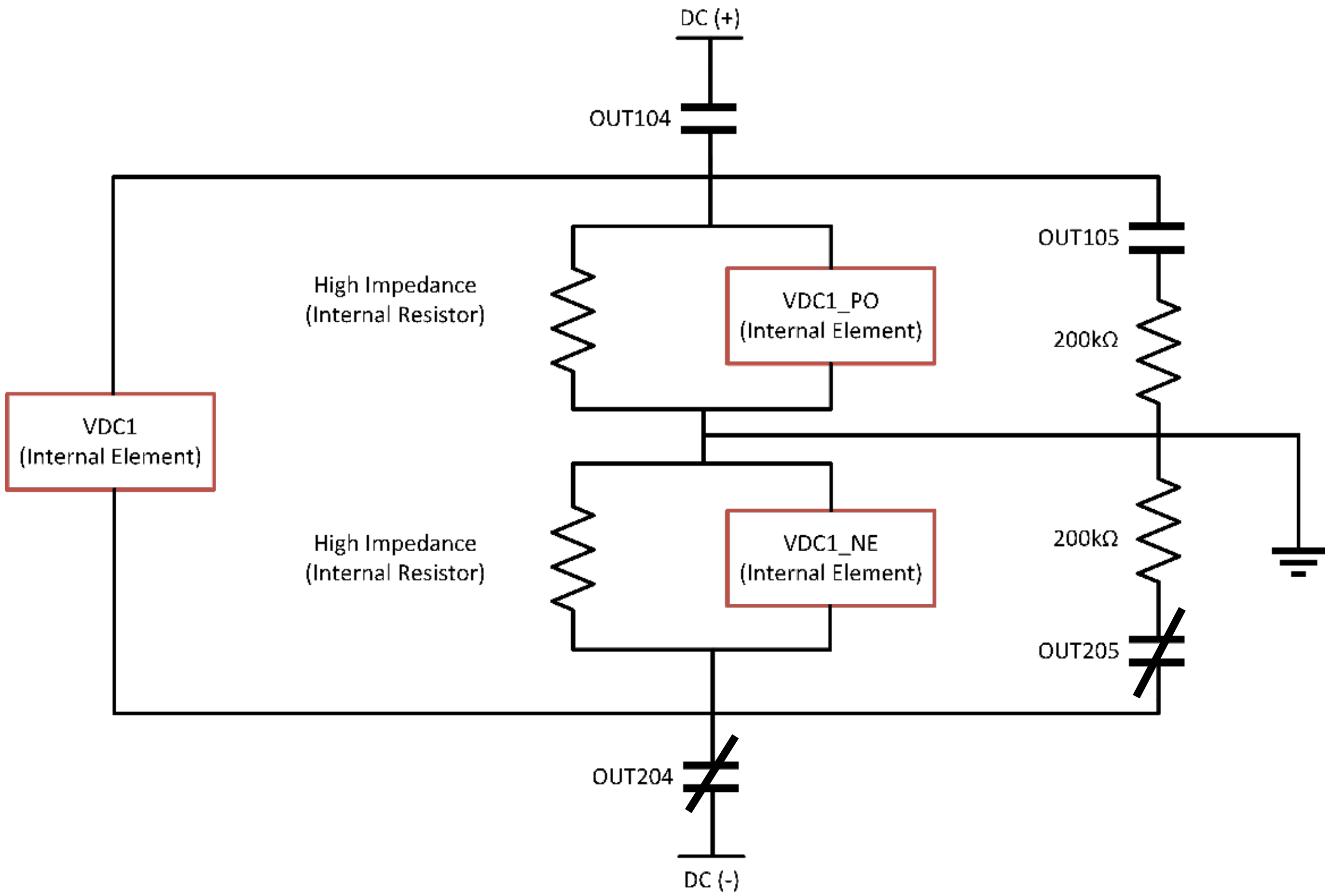


Stage 2 (V_PG)

Output Contacts
- *CLOSED:* OUT104, OUT105
- *OPENED:* OUT204, OUT205

DC Voltage Input
- VDC1_PO measures voltage

ABGMS Circuit Evolution



Stage 3 (V_NG)

Output Contacts

CLOSED: OUT204, OUT205

OPENED: OUT104, OUT105

DC Voltage Input

VDC1_NE Element measures voltage

Data Processing, Alarms, & SCADA Integration

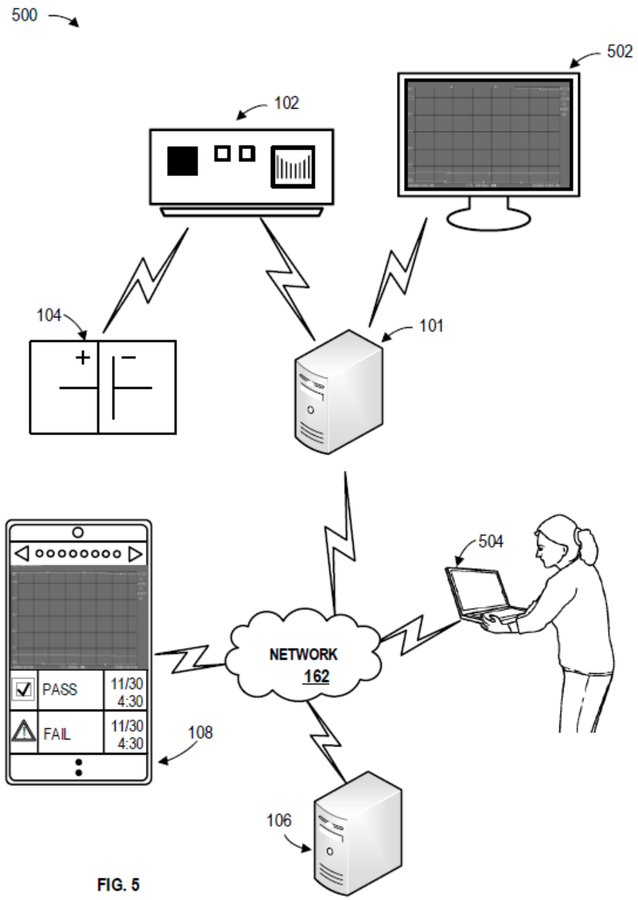


FIG. 5

Binary Input Flag for Phase Indication

- Sent to SEL-3350 RTAC RTU
- Determines start and end of each phase

DC Voltage Analog Input Measurement

- Averaged and stored by RTU
- Three readings stored in RTU

Resistance to Ground Calculation

- RTU calculates ohmic values
- Determines battery ground alarms
- Values and alarms sent to SEL-451 relay

Alarming to SCADA

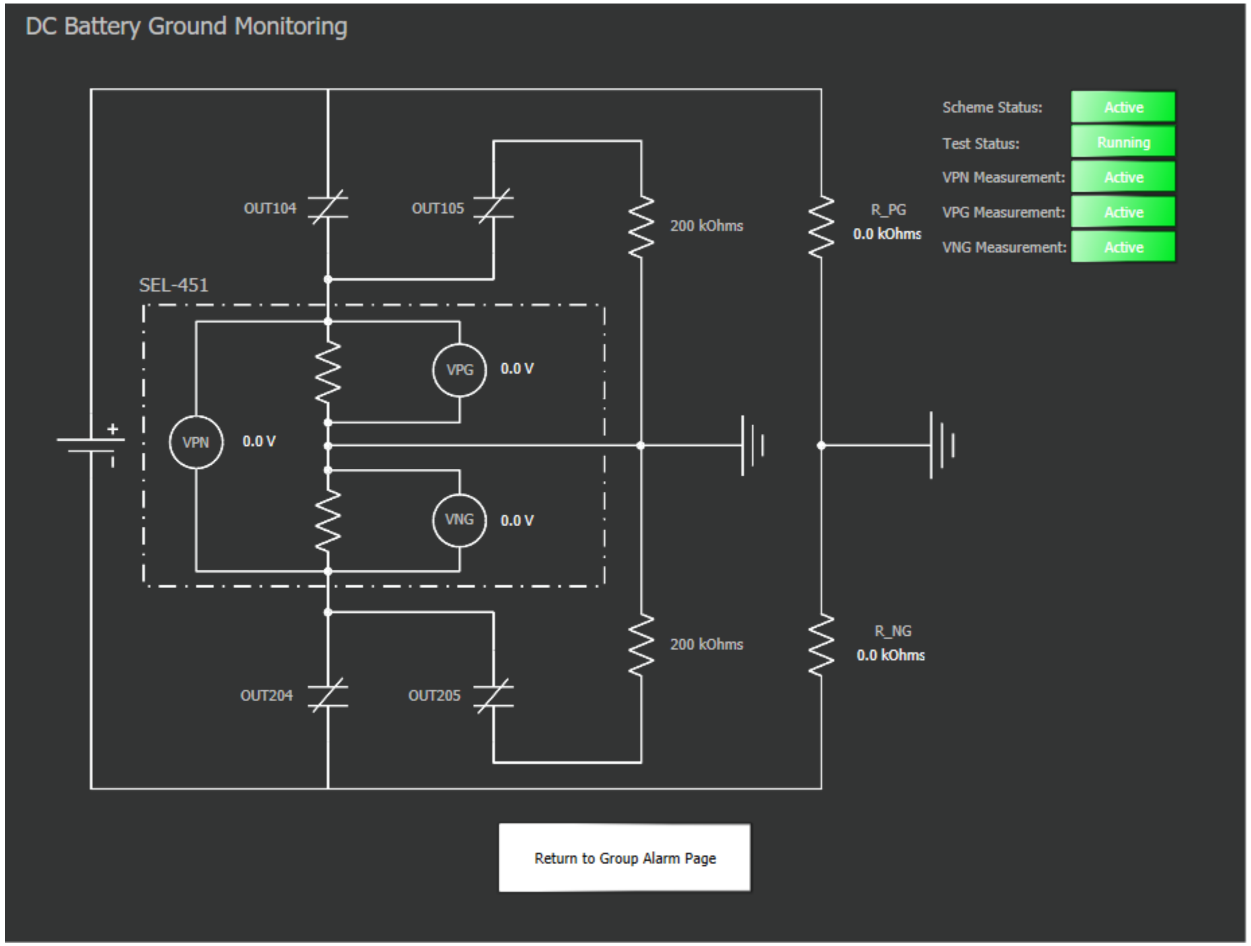
- Results within alarm threshold are verified upon next test
- Two consecutive alarm conditions result in SCADA alarm

Automated and Manual Testing

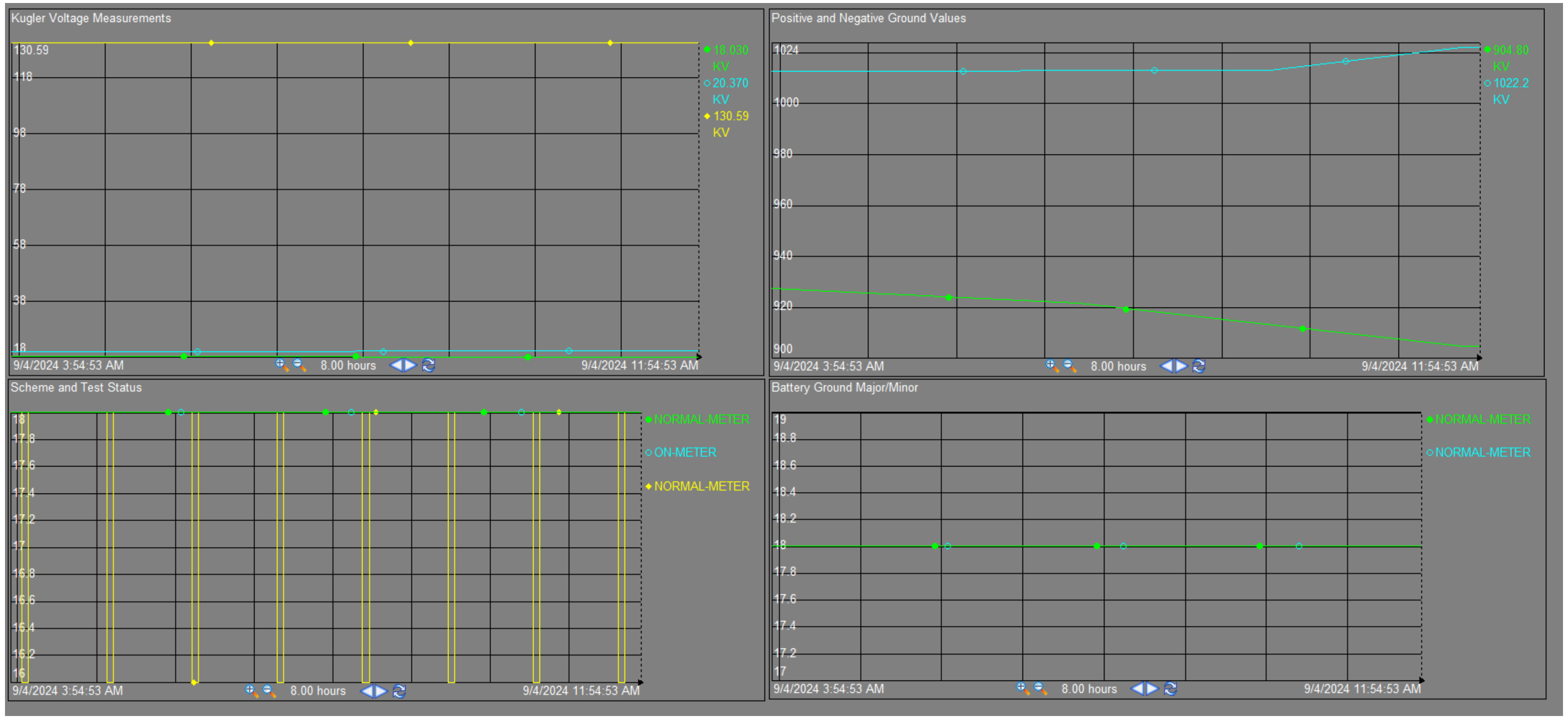
- Measurements collected hourly
- Manual measurement available

ABGMS HMI Display

- **Data Provision to Local HMI**
  - SEL-3350 RTU sends data to SEL-3555 RTAC HMI
- **Real-Time Monitoring for On-Site Personnel**
  - HMI display allows real-time observation of tests
  - Useful for personnel without access to main RTU

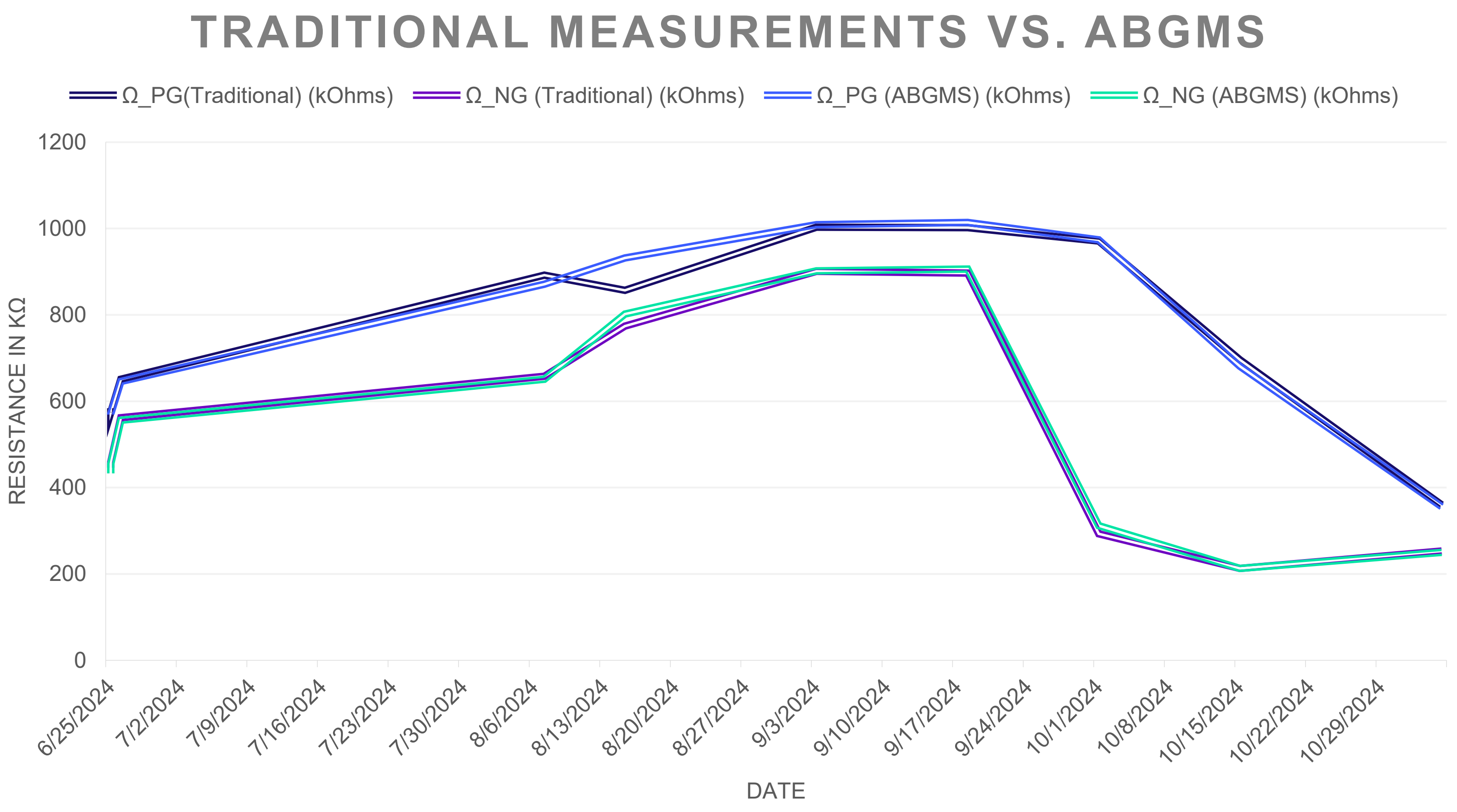


Overview of SCADA Integration



- **SEL-3350 RTAC RTU**
  - Receives binary and analog input data from SEL 400 series relay
  - Analog and Binary data published to PI Processbook
- **PI Processbook Dashboard**
  - Trends all key values
  - Correlate battery grounds to local events at stations

Pilot Installation



- First Pilot Installation
  - Executed in June 2024
- Results
  - Field personnel to taking bi-weekly measurements
  - Delta of ~1.93% between Manual & ABGMS results
    - 2.03% delta on R_PG
    - 1.83% delta on R_NG
    - 10 data points thus far

Future Plans for our Utility of the Future

Data Collection

- Ongoing through the end of 2024
- Capture lessons learned from engineering & field personnel

Standardization

- Creation of construction specification, general design diagram (GDD), & Relay/RTU Setting Template
- Rollout to additional stations

Patent

- Design/methodology currently patent pending

Thank you for your time!

Questions?