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Rockwell Automation + Schlumberger

LIFT CONTROL SYSTEMS

INSTRUCT LIFT CONTROL SYSTEMS

Power Analyzer Card for VSD Power Monitoring

MODEL: 100840440

Manual No: LCS-ENG-M0007 (InTouch ref # 7700594), Rev. 01

Publisher Notes

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REVISION HISTORY

REVISION:	DESCRIPTION OF CHANGE:	ISSUER:	APPROVER:	DATE:
01	Initial release	Tengyun CHU, Bo Siung WONG	Ahmad El-Kadri	07 Apr 2022

Table of Contents

GENERAL

WARNING!

To avoid the risk of electric shock and fire, the following safety instructions must be observed and the guidelines followed.

The specifications must not be exceeded, and the device must only be applied as described in the following.

Prior to the installation and commissioning of the unit, the installation guide must be examined carefully.

If the equipment is used in a manner not specified by the manufacturer, the protection provided by the equipment may be impaired.

GENERAL

AVERTISSEMENT!

Pour éviter tout risque de choc électrique et d'incendie, les consignes de sécurité de ce manuel doivent être observées, et les instructions suivies.

Les spécifications ne doivent pas être dépassées, et l'unité ne doit être appliquée que comme décrit dans le texte suivant.

Ce manuel doit être examiné avec soin, avant l'installation et la mise en service de l'unité.

Si l'équipement est utilisé d'une manière non spécifiée par le fabricant, la protection assurée par l'équipement peut être altérée.

INSTALLATION

WARNING!

Installation may only be carried out by electrically skilled and instructed personnel in accordance with national leg-isolation, including the relevant standards.

All technical data on the instrument is to be observed.

Changes to the design and modifications to the equipment are not permitted.

The equipment shall only be operated as intended and only in undamaged and perfect condition.

Sufficient segregation must exist between different cables and wires carrying different types of signal or power and all other circuits.

All wires must be terminated, complete with crimping lugs. Unused cores should be terminated to the earth bus bar.

INSTALLATION

AVERTISSEMENT!

L’installation ne peut être effectuée que par un électricien qualifié, conformément à la législation nationale, y compris les normes pertinentes.

Toutes les données techniques sur l'instrument doivent être observées.

Modifications de l'équipement ne sont pas autorisés.

L'équipement ne doit être utilisé comme prévu par le fabriquant et uniquement si il est en parfait état.

Une séparation suffisante doit exister entre les différents câbles et les fils transportant différents types de signaux ou de puissance et tous les autres circuits.

Tous les fils doivent être terminés, avec pattes de sertissage. Les noyaux non-utilisés doivent être terminés au jeu de barres de la terre.

Section 1: **Description**

This manual provides information about Power Analyzer Card (previously known as Switchboard Card), and instructions to setup and configure this card with an INSTRUCT ESP Intelligent Controller (previously known as Instruct Controller), for electrical power monitoring of a Variable Speed Drive (VSD) driven system.

1.1 DOCUMENT SCOPE

This document describes:

- Theory of Operation
- VSD Power Monitoring Component List
- Power Analyzer Card Wring and Setup
- Power Analyzer Card Configuration

1.2 POWER ANALYZER CARD PICTURE

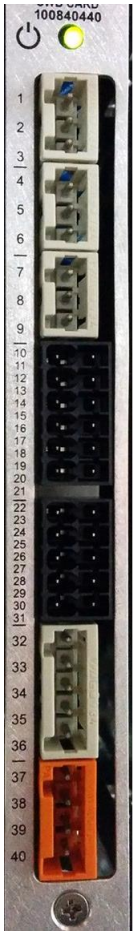
Refer to Figure 1-1, the pictures of a Power Analyzer Card.

Figure 1-1: Power Analyzer Card

Section 2: **Theory of Operations**

Support for INSTRUCT ESP Intelligent Controller dual Power Analyzer Card was added from firmware version v2.122r005. With this upgrade, two Power Analyzer Cards can be simultaneously installed into the controller, at slot A and slot B respectively. In a VSD driven system, the controller can be configured to monitor VSD input, VSD output and/or motor side electrical power. In addition to Power Analyzer Card, other components such as the external PTs, CTs, burden modules and Power Analyzer 5kV Voltage Sensor would also be required depending on the use cases.

2.1 POWER ANALYZER CARD PINOUT



	1		Contactor -NO
	2		Contactor -NC
	3		Contactor -COM
	4		Relay 1 -NO
	5		Relay 1 -NC
	6		Relay 1 - COM
	7		Relay 2 -NO
	8		Relay 2 -NC
	9		Relay 2 - COM
BSM Reset	10	11	RXTX1
RXTX2	12	13	RXTX3
No Connect	14	15	3.3V
BSM Rotation	16	17	BSM Frequency
No Connect	18	19	No Connect
GND	20	21	24V
Analog In +	22	23	Analog In -
Analog Out	24	25	Analog COM
No Connect	26	27	Digital PWR
Digital In 1	28	29	Digital In 2
Digital In 3	30	31	Digital In 4
	32		CT - A
	33		CT - B
	34		CT - C
	35		CT - Ref
	36		CT - Shield
	37		PT - A
	38		PT - B
	39		PT - C
	40		PT - N

Figure 2-1: Power Analyzer Card Pinout

2.2 VOLTAGE INPUT

The Power Analyzer Card contains three AC potential transformer (PT) voltage inputs for the purpose of measuring and monitoring 3 phase voltages. The monitored parameters are:

Table 2-1: Voltage Input Parameters

Parameter	Operation
Overvolts	Monitor condition where voltage exceeds a specified maximum value. The three phase RMS average or each individual phase RMS voltage is monitored for overload. Used to protect a system from voltage surges.

Undervolts	Monitor condition where voltage drops below a specified minimum value and apply the deviation to a six-point curve to determine the alarm duration. Used to protect a system from voltage droops and brown-outs. The alarm curve is designed to account for the voltage drop during a motor or system start
Rotation	Monitor the phase voltage sequence A-B-C. **Note** The detection of rotation change will not work if the cable phases were reversed beyond the PT or CT sensing connections. Rotation can be detected from either the current or voltage and thus appears in both the Load and Volts screens.
Unbalance	Monitor condition where voltage A-B-C magnitude are no-longer matched and apply the deviation to a six-point curve to determine the alarm duration. The three phase RMS average is compared to the individual phases to calculate unbalance. The unbalance is displayed as a percent of line voltage. The alarm curve is designed to account for the voltage unbalance during a motor or system start
Low Frequency	Monitor condition where the frequency drops below a specified minimum value. Used to protect a system from low frequency.
High Frequency	Monitor condition where the frequency exceeds a specified maximum value. Used to protect a system from high frequency.

The results of these measurements can be combined with the current inputs to determine the system power and power factor.

The potential transformer (PT) inputs are located on terminals PT-A, PT-B, PT-C and PT-N (PIN 37 - 40) and operate in a WYE “Y” configuration.

Term	Definition
PT-A, B, C	PT inputs for phase voltage A, B, C
PT-N	The neutral point connection for the three-phase voltage.

The front-end voltage divider circuitry in the Power Analyzer Card converts the 120V to small signals, and the 3-phase measuring chip on the Power Analyzer Card measured the voltage values.

The PT input voltage is limited, the maximum voltage should be 120VAC. Additional Potential Transformer should be selected in order to interface to high voltage systems as shown in Figure 2-2.

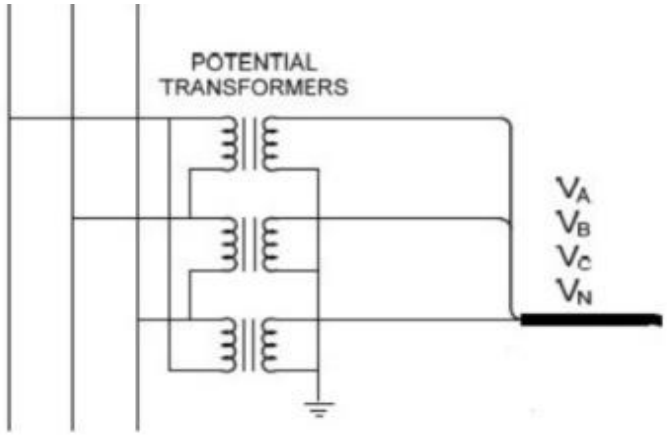


Figure 2-2: PT Connections for PA Card

The PT inputs can be scaled to match external PTs and calibrated to account for transformer tolerance.

2.3 CURRENT INPUT

The Power Analyzer Card contains three AC current transformer (CT) inputs for the purpose of measuring and monitoring 3 phase currents. A proprietary current transformer burden module is required to connect the external CT to the Power Analyzer Card. The monitored parameters are:

Table 2-2: Current Input Parameters

Parameter	Operation
Overload	Monitor condition where current exceeds a specified maximum value. The three phase RMS average or each individual phase RMS current is monitored for overload. Used to protect a system from a failing motor or motor cable while still permitting a motor start. The overload alarm has a 15 point time curve associated with it. The individual points in this curve can be edited for special applications. The set point is typically set to 15% higher than the motor running current. The alarm appears as **OVERLOAD** on the display
Underload	Monitor condition where current drops below a specified minimum value. Used to indicate a motor is not efficiently pumping fluid or has air-locked. The set point is typically set to 20% below the motor running current. The alarm appears as **UNDERLOAD** on the display.
Rotation	This feature is shared with the voltage inputs. Monitoring of rotation can be either voltage mode or current mode. **Note** When the system is stopped the current is zero and therefore rotation direction cannot be determined using the CT input. If the rotation detection source is set to CT then the rotation alarm is automatically bypassed whenever the system is stopped. The alarm appears as **ROTATION** on the display.

Unbalance	Monitor condition where current A-B-C magnitude are no-longer matched. The three phase RMS average is compared to the individual phases to calculate unbalance. The set point is typically set to 20%. The alarm appears as **C_UNBAL** on the display
Stall	Stall is a condition where the motor stops rotating. The impedance of the power cables and motor winding create a scenario where the power requirements are high but this is not a short circuit. The criteria used to define a stall condition must consider the OVERLOAD current required during a motor start. The set point must be set less than the name plate motor start amps and is typically set to three times the motor rated current. The alarm appears as **STALL** on the display.
Short Circuit	This is a condition where a short circuit occurs. This indicates a serious fault has occurred in the cable to the motor or within the motor. The criteria used to define a short circuit must consider the current used in a STALL condition. The set point is typically set to six times the motor rated current. The alarm appears as **SHORT_CCT** on the display.
Motor Amps	This is the nameplate rating of the maximum continuous motor amps. This value is used to calculate **STALL** and **SHORT_CCT**.
Power Factor	Monitor condition where the power factor drops below a specified minimum value. Used to protect a system from low power factor. **Note** Power Factor can only be determined if both PT and CT are enabled, if one or both are disabled then the Instruct automatically bypasses the PF alarm. Power Factor and Power measurement are only correct if the PT and CT wirings are correct.

The results of these measurements can be combined with the voltage inputs to determine the system power and power factor.

The CT inputs are located on terminals CT-A, CT-B, CT-C, CT-REF and CT-SHIELD (PIN 32 - 36).

Term	Definition
CT-A, B, C	CT inputs for phase current A, B, C
CT-REF	Reference signal point for the three-phase current measurement.
CT_SHIELD	A ground shield to protect the current signals from electrical noise.

Warning
Potential Severity: Serious
Potential Loss: Assets, Information
Hazard Category: Electrical

These inputs are designed for the burden module only. Do not directly connect the CT leads to the controller.

The CT inputs can be scaled to match external CTs and calibrated to account for transformer tolerances.

2.4 CT BURDEN MODULE

The CT inputs measure voltage. A burden module is required to convert the current from the CT into a voltage prior to interfacing to the controller. There exists a unique 1000:1 Burden Module (PN: 100468928, CT BURDEN MODULE). The current burden module supports only 5A nominal Input current. Appropriate xxx:5 current transformer need to be selected.

2.5 CT MODULE

This current transformer needs to be selected according to the current to be measured, three individual xxx:5 Current Transformers should be considered. Refer to Section 3:VSD Power Monitoring Components List for suggested CTs to be used.

2.6 POWER ANALYZER 5KV VOLTAGE SENSOR

2.6.1 5KV VOLTAGE SENSOR INPUTS

The Power Analyzer 5kV Voltage Sensor contains a 3-phase high voltage input for the purpose of measuring Motor side high voltages when motor is running or detecting motor rotation while the motor is not powered. The motor rotation may be the result of well characteristics continuing to flow or fluid in the pipe draining back into the formation. Depending on the requirement, the controller can be configured to not start the motor while rotation is present or start only if below a rotation threshold.

The 5kV Voltage Sensor input measures the frequency of the motor rotation and has alarm parameters associated with the frequency detection setting. There is a configurable time delay that the controller must wait before starting once the alarm has cleared. This timer will not start during a spin condition and the controller will remain in the alarm state until the rotation drops below the specified threshold, at which point the timer will start.

The 5kV Voltage Sensor Input can also detect backspin, which is designed to detect very small signals and functions with the system off. During system operation, system harmonics can create false triggers on frequency measurement.

The Power Analyzer 5kV Voltage Sensor contains a DC blocking filter. For applications where a downhole tool (DHT) is used with an electric submersible pump (ESP), the DC power for the DHT will not affect the Power Analyzer 5kV Voltage Sensor. The motor rotation signal pass through the DC blocking filter unaffected.

Warning

Potential Severity: Serious
Potential Loss: Assets, Personnel
Hazard Category: Electrical, Machinery equipment hand tools

Starting a motor which is spinning in reverse direction creates a very large current in order to stop the motor, then start the motor in the correct direction. Damage to motor winding may result.

2.6.2 LEG GROUND

The Power Analyzer Card performs leg ground measurement using the 5kV Voltage Sensor. Leg ground measures the phase-ground voltage and unbalance which indicates insulation degradation and ground fault problems. A single-phase dead short will show a 100% reading.

The measurements of frequency and voltage can determine motor rotation and line voltage.

Section 3: **VSD Power Monitoring Components List**

Depending on the use case, the required components for power monitoring are different.

3.1 VSD INPUT POWER MONITORING

For VSD input power monitoring, three xxx:120V PTs should be used to convert the VSD input voltages to 120VAC output voltages. Refer to Figure 2-2 for PT wiring diagram. Three xxx:5A CTs should be used to convert the VSD input high current to 5A output. Below is the suggested components list:

Description	Manufacturer	MPN	Quantity
Current Transformer (XXX:5)	Allen-Bradley	Option 1: 200:5 ratio: 1411-180SHT-201	3
		Option 2: 300:5 ratio: 1411-180SHT-301	
		Option 3: 400:5 ratio: 1411-180SHT-401	
		Option 4: 600:5 ratio: 1411-180SHT-601	
		Option 5: 1000:5 ratio: 1411-180SHT-102	
		Option 6: 2000:5 ratio: 1411-180SHT-202	
Voltage Transformer (480:120)	Allen-Bradley	1497A-A1-M6-1-N	3
PT fuses	Option 1: Littelfuse	0KLK.750T or 0KLK001.T	3
	Option 2: Eaton	KTK-R-3/4 or KTK-R-1	
	Option 3: Mersen	ATMR3/4 or ATMR1	
Power Analyzer Card	Sensia	100840440	1
INSTRUCT ESP Intelligent Controller	Sensia	100840400	1
CT 5A Burden Module	Sensia	100468928	1
Power Analyzer 5kV Voltage Sensor	Sensia	100840441	1 (optional)
Power Analyzer 5kV Voltage Sensor Signal Cable	Sensia	Option 1: 101947881: Power Analyzer 5kV Voltage Sensor Signal Cable, 4m	1 (optional)
		Option 2: 101947905: Power Analyzer 5kV Voltage Sensor Signal Cable, 8m	

3.2 VSD OUTPUT POWER MONITORING

To monitor the VSD output (after sinewave filter, before step-up transformer) power monitoring, the same above PT and CTs mentioned in 3.1 can be used.

Note

For VSD output power monitoring, the VSD must be equipped with Sinewave Filter.

3.3 MOTOR SIDE POWER MONITORING

Power Analyzer 5kV Voltage Sensor can be used on the Motor side for the voltage measurement. To monitor the motor side power, high voltage rating PTs and appropriate rating CTs should be selected.

Description	Manufacturer	MPN	Quantity
Current Transformer (XXX:5)	Allen-Bradley	Option 1: 50:5 ratio: 1411-180SHT-500	3
		Option 2: 100:5 ratio: 1411-180SHT-101	
		Option 3: 150:5 ratio: 1411-180SHT-151	
		Option 4: 200:5 ratio: 1411-180SHT-201	
Voltage Transformer	TBD	TBD	3
PT fuses	TBD	TBD	3
Power Analyzer Card	Sensia	100840440	1

Description	Manufacturer	MPN	Quantity
INSTRUCT ESP Intelligent Controller	Sensia	100840400	1
CT 5A Burden Module	Sensia	100468928	1
Power Analyzer 5kV Voltage Sensor	Sensia	100840441	1 (optional)
Power Analyzer 5kV Voltage Sensor Signal Cable	Sensia	Option 1: 101947881: Power Analyzer 5kV Voltage Sensor Signal Cable, 4m Option 2: 101947905: Power Analyzer 5kV Voltage Sensor Signal Cable, 8m	1 (optional)

Note

There is a known issue that the VSD output harmonics even with a sinewave filter, on the high voltage side of the step-up transformer are significant enough to cause damage to Potential Transformers. For this reason, we do not have a recommended MPNs reliable enough to suggest.

3.4 ORDERABLE KIT PART NUMBERS

Below Kit part numbers exist for easy field ordering:

Sensia PN	Description
50376080	INSTRUCT P/Analyzer Upgrade Kit -100A
50376081	INSTRUCT P/Analyzer Upgrade Kit -200A
50376082	INSTRUCT P/Analyzer Upgrade Kit -300A
50376083	INSTRUCT P/Analyzer Upgrade Kit -400A
50376084	INSTRUCT P/Analyzer Upgrade Kit -600A
50376085	INSTRUCT P/Analyzer Upgrade Kit -1000A
50376086	INSTRUCT P/Analyzer Upgrade Kit -2000A

Each kit (PN: 5037608x) contains below parts inside:

Sensia PN	Description
100840440	INSTRUCT Power Analyzer Card
100840441	INSTRUCT Power Analyzer 5kV Voltage Sens
101947905	PA 5kV Voltage Sensor Signal Cable, 8m
100468928	INSTRUCT ESP CT Burden Module
0221B00777	MOUNTING BRACKET, CT 180SHT
1411-180SHT-xxx	Current Tranformer,2.5" Inner Dia, xxxx:5

Section 4: **Power Analyzer Card Wiring and Setup**

4.1 PTS WIRING DIAGRAM

The PT outputs are connected to the Power Analyzer Card PT inputs, pin 36 through pin 40.

The voltage inputs on the Power Analyzer Card accept 120 volts AC nominal voltage levels for monitoring the three-phase supply voltages. External potential transformers (PTs) are used to provide voltage level translation from the high-voltage signals. Three individual PTs are required for full high-speed three-phase monitoring applicable with both switchboards and VSDs.

The PT secondary windings must be connected to the controller in a Wye configuration with the neutral point terminated at the instrumentation transformer secondary winding common point.

The connection to the motor cables should be a Delta configuration to allow the controller to read line-to-line voltages. Refer to the following figure for the normal 3 PT configuration wiring diagram.

The PT ratio must be correctly configured on the Instruct in order to provide the correct scaled voltage.

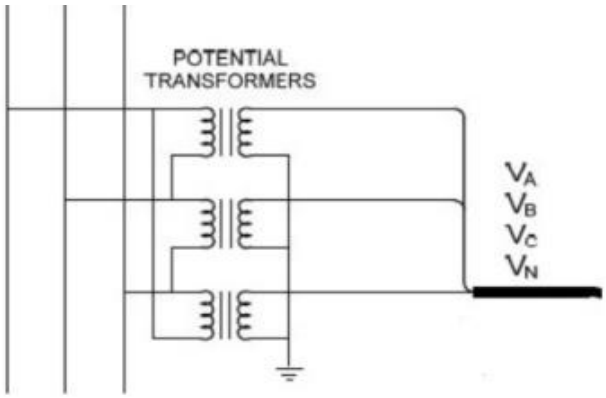


Figure 4-1: PT Wiring Diagram

4.2 CTS& BURDEN MODULE WIRING DIAGRAM

The Power Analyzer Card interfaces with conventional XXX:5 A current transformers (CTs) using the CT Burden Module. The CT outputs must be connected to the input terminals of the CT Burden Module. The measurement connection to the controller is brought back on a low-voltage signal cable. This cable must be wired to the CT input plug (pins 32-36) of the Power Analyzer Card. The CT ratio must be correctly configured for the controller readings to be valid.

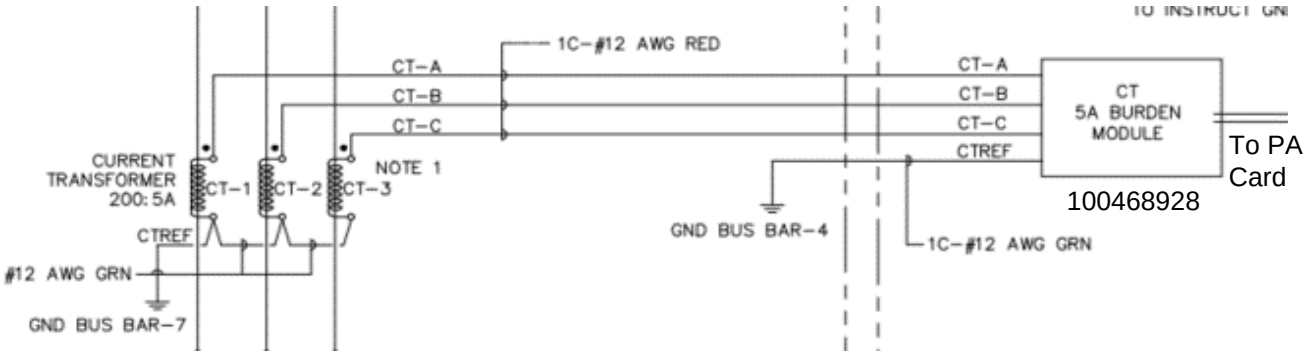


Figure 4-2: CT & Burden Module Wiring Diagram

Figure 4-3: CT burden Module

4.3 POWER ANALYZER 5KV VOLTAGE SENSOR WIRING DIAGRAM

Power Analyzer 5kV Voltage Sensor (P/N100840441, previously known as the Backspin Module) can be installed in the high-voltage compartment of a Switchboard or step-up transformer output of a VSD system. The three high voltage inputs cables are connected to the motor leads, and the ground line is connected to the 'star-point' transformer, switchboard or system ground.

The Power Analyzer 5kV Voltage Sensor is connected to the Power Analyzer Card via the PA 5kV Voltage Sensor Signal Cable. The Power Analyzer 5kV Voltage Sensor Signal Cable is available in lengths of 4 m and 8 m. The cable is NOT reversible. The end that connects to the Power Analyzer 5kV Voltage Sensor is labelled “Sensor” (previously labelled “BSM”), and the end that connects to the Power Analyzer Card (which has the cable shielding connection) is labelled “PA” (previously labelled “SWB”). Connector pins 10 to 21 of the Power Analyzer Card are for the Power Analyzer 5kV Voltage Sensor connection.

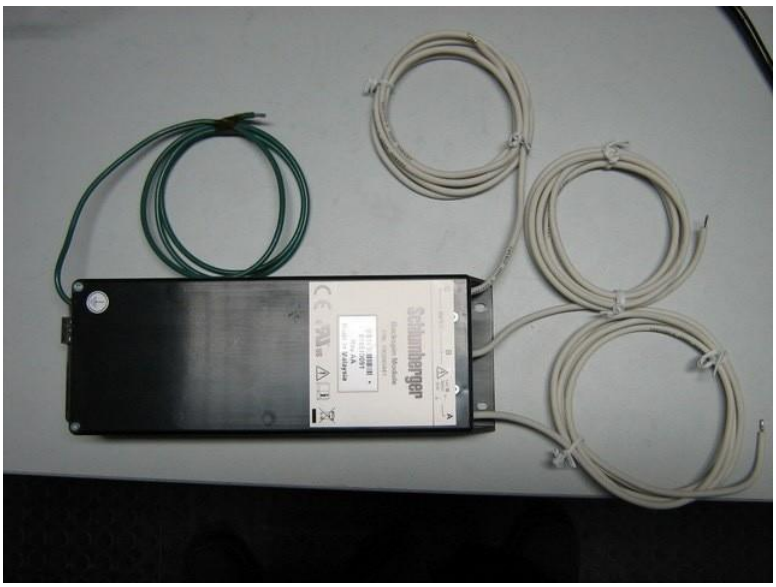


Figure 4-4: Power Analyzer 5kV Voltage Sensor

Figure 4-5: Power Analyzer 5kV Voltage Sensor Signal Cable

Section 5: **Power Analyzer Card Configuration**

5.1 POWER ANALYZER CARD MENUS

The following menus are available for VSD Power Monitoring when one or two Power Analyzer Cards are inserted into controller and its RS485 communication port or one of the slots functions is configured to VSD.

1. Summary
2. Backspin
3. Alarms
4. IO
5. Configure
6. Expert
7. Startup Chart

Note

The controller begins to support dual Power Analyzer Card from firmware version v2.122r005. Two Power Analyzer Cards can be installed to controller, at slot A and slot B respectively. The controller can then be configured for both VSD input and output power monitoring.

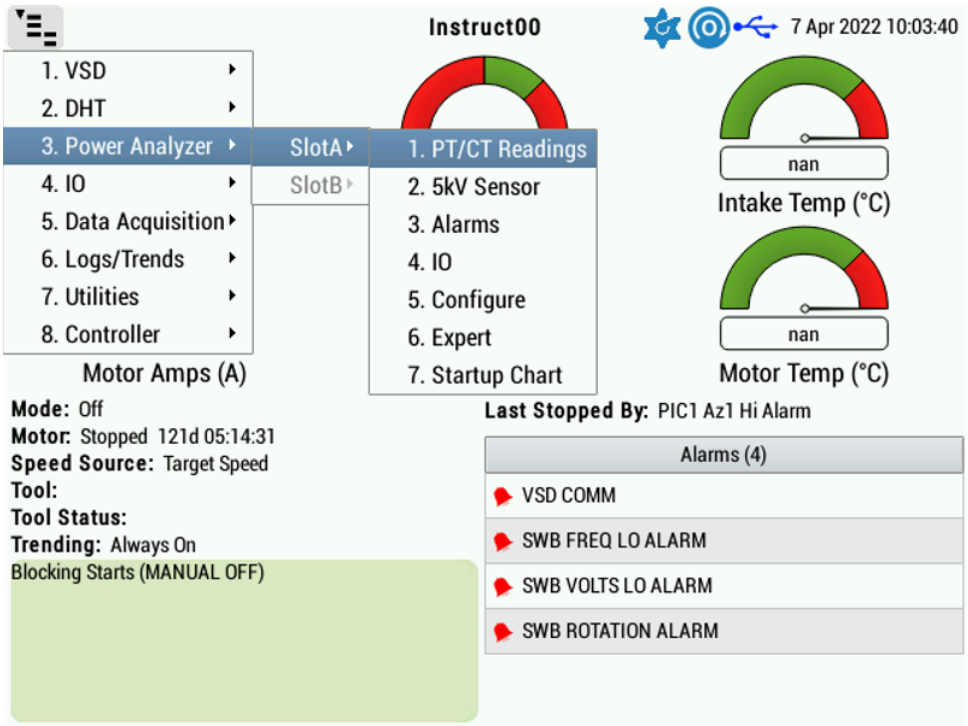


Figure 5-1: Power Analyzer menu tree

Note

If Dual Power Analyzer Cards are used, go to Menu-> Power Analyzer->SlotB for the second Power Analyzer Card readings.

5.2 SUMMARY SCREEN

The Power Analyzer Summary screen can be accessed with the navigation sequence **Power Analyzer → Slot A/B → Summary**

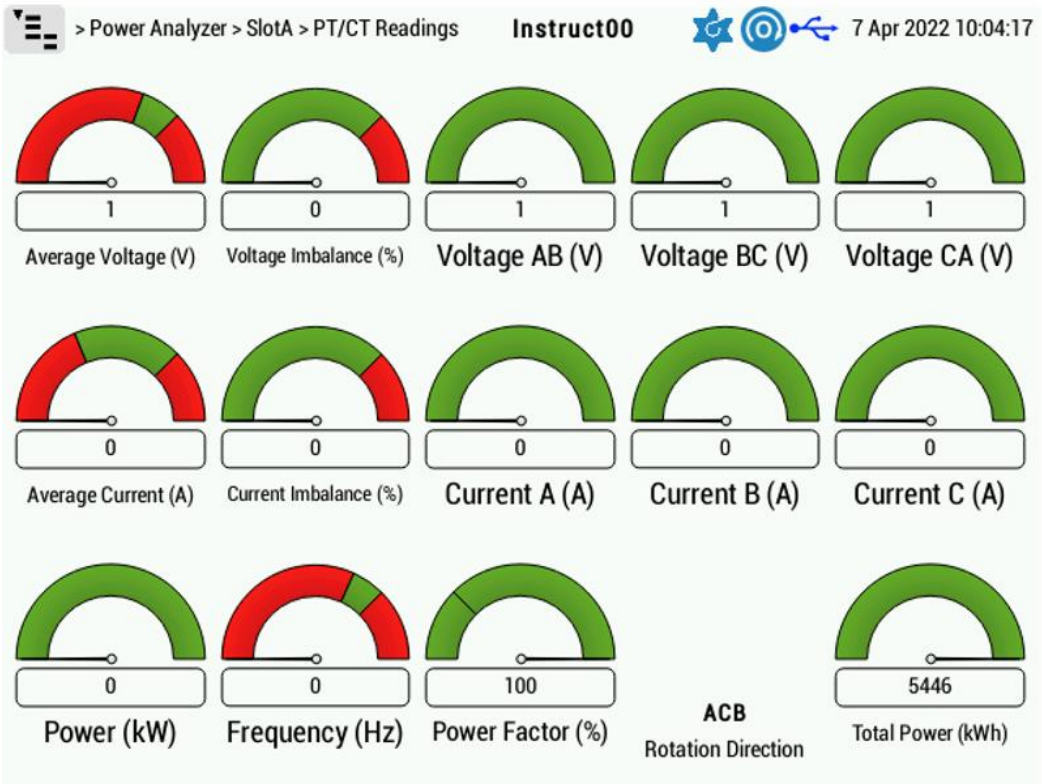


Figure 5-2: Summary Screen

5.3 5KV SENSOR SCREEN

The PA 5kV Voltage Sensor menu can be accessed with the navigation sequence **Power Analyzer → Slot A/B → 5kV Sensor**.

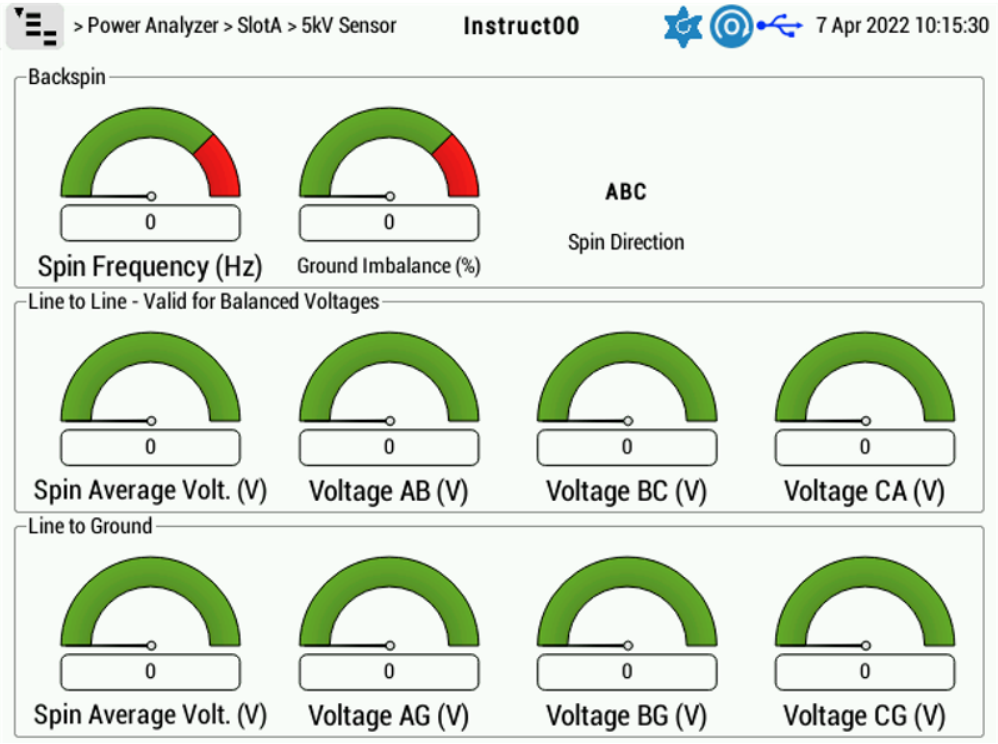


Figure 5-3: 5kV Sensor Screen

5.4 ALARMS SCREEN

The Power Analyzer alarms menu can be accessed with the navigation sequence **Power Analyzer → Slot A/B → Alarms**.

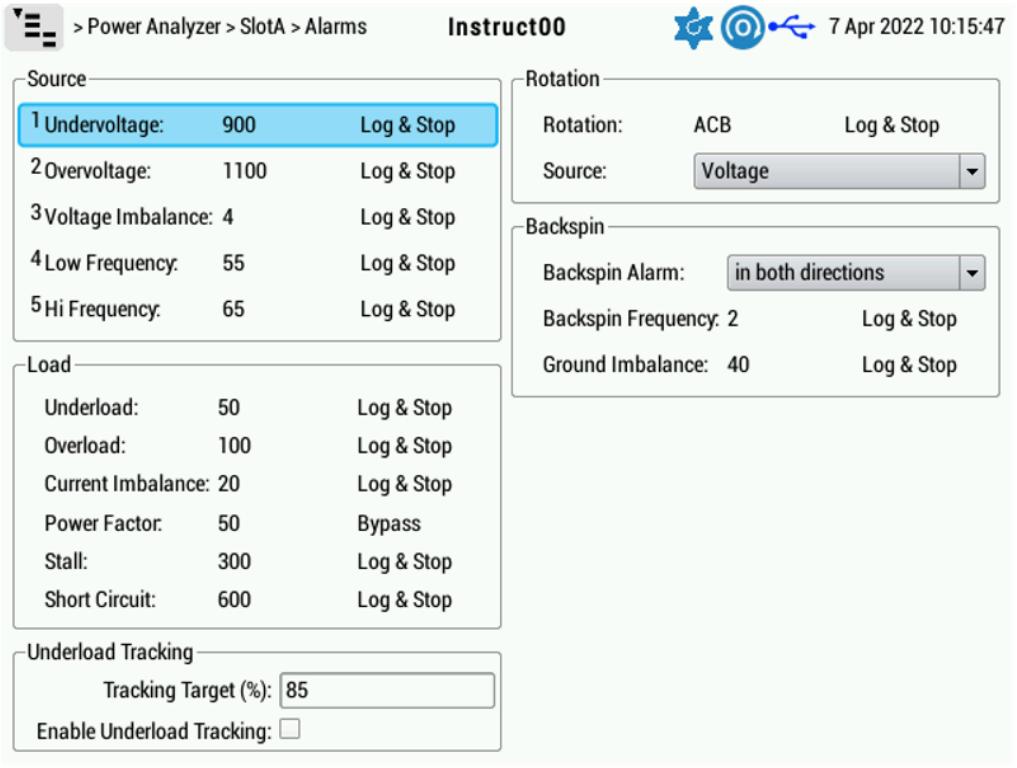


Figure 5-4: Alarms Screen

5.5 I/O SCREEN

The Power Analyzer IO menu can be accessed with the navigation sequence **Power Analyzer → Slot A/B → IO**.

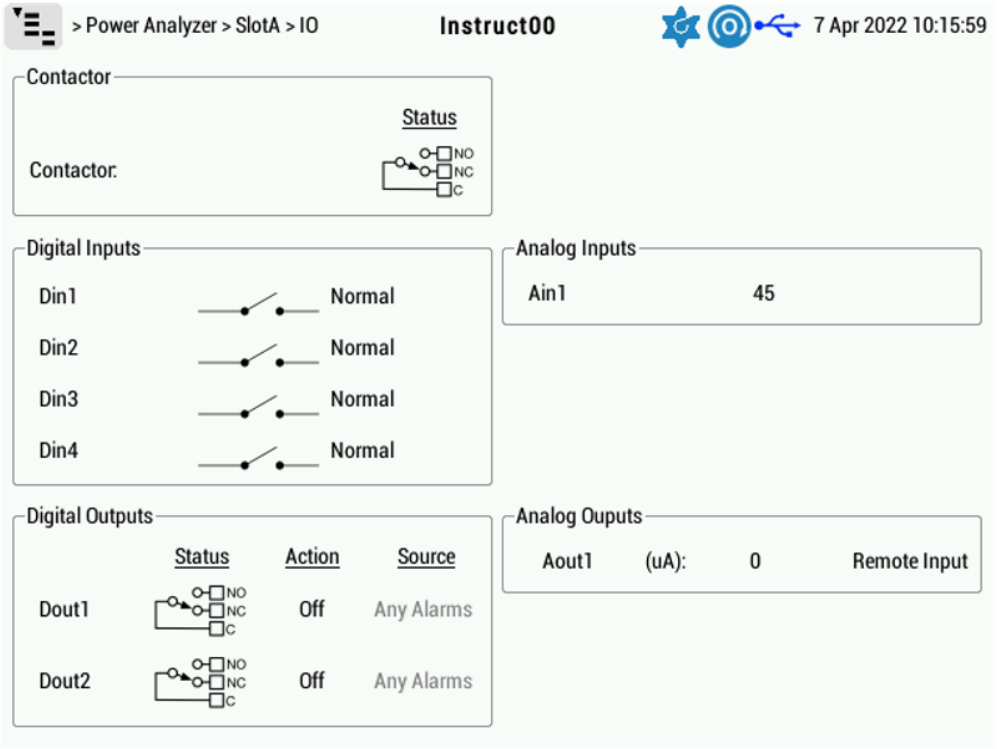


Figure 5-5: IO Screen

5.6 CONFIGURE SCREEN

The Power Analyzer configuration menu can be accessed with the navigation sequence **Power Analyzer → Slot A/B → Configure**.

The Power Analyzer Configure screen allows the user to set the PT and CT ratios and motor nameplate rating. The PT ratio and CT ratio should correspond to the CTs and PTs used in the system.

PT Module and CT module have to be set Enable to get correct power measurement. Three-PT system must be used for correct power measurement.

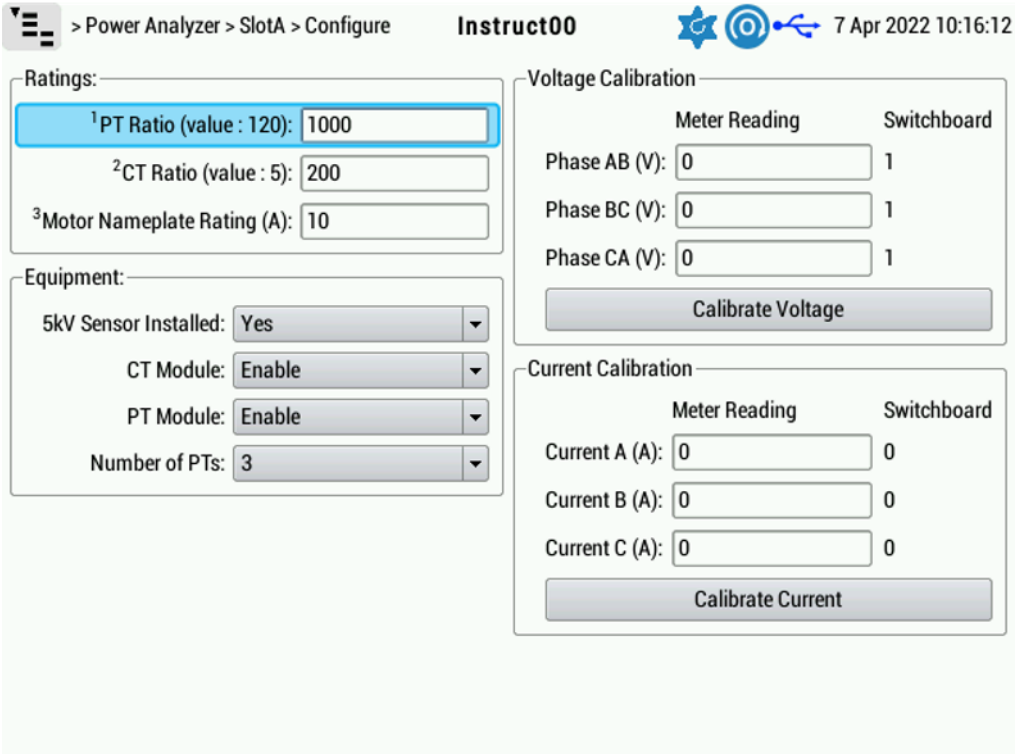


Figure 5-6: Configure Screen

The voltage and current inputs are pre-calibrated during the manufacturing process. However, the user can still recalibrate them according to their own needs to account for instrumentation tolerance.

Warning

Potential Severity: Serious
Potential Loss: Personnel
Hazard Category: Electrical

The calibration procedure involves live measurements on a high voltage system. Only to be performed by qualified personnel with the appropriate PPE.

Note: PT Calibration Procedure

1. Ensure that the PTs are correctly wired to the Power Analyzer Card and that the system voltage is stable.
2. Measure the voltage with a calibrated voltmeter. Record the values for each line-line measurement.
3. Enter the recorded values in the Meter Reading fields.
4. Press the Calibrate Voltage button.
5. Confirm that the Power Analyzer Card readings match the entered values, they are shown to the right

Note: CT Calibration Procedure

1. Ensure that the CTs are correctly wired to the CT Burden Module, and the low-voltage cable from the CT Burden Module is correctly wired to the Power Analyzer Card.
2. Ensure that the load is stable so that the current will not significantly fluctuate during the calibration process.

3. Measure the current with a calibrated clamp-on ammeter. Record the values for each phase measurement.
4. Enter the recorded values in the Meter Reading fields.
5. Press the Calibrate Current button.
6. Confirm that the Power Analyzer Card readings match the entered values, they are shown to the right.

5.7 EXPERT SCREEN

The start-up chart can be accessed with the navigation sequence **Power Analyzer → Slot A/B → Expert**.

The Power Analyzer Expert screen allows the user to set the Start Current Capture duration and the monitoring location for VSD use.

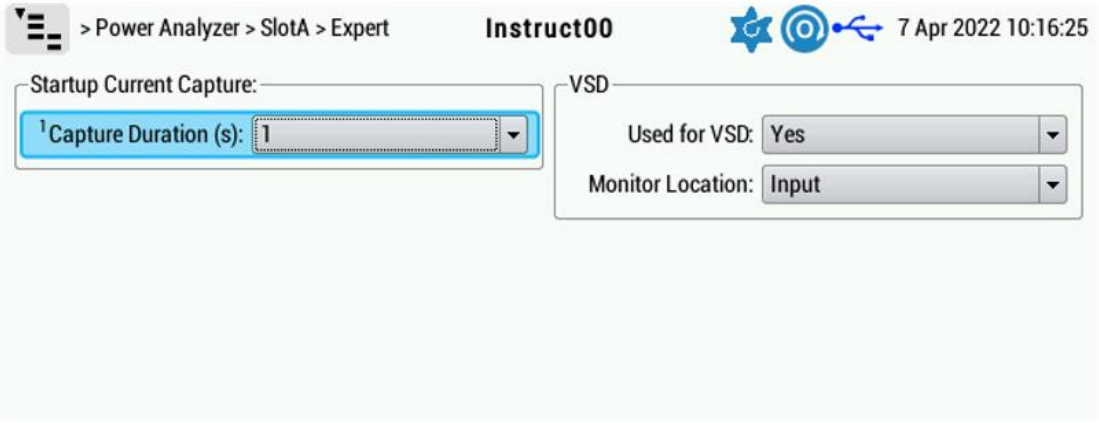


Figure 5-7: Expert Screen

5.8 STARTUP CHART SCREEN

The start-up chart can be accessed with the navigation sequence **Power Analyzer → Slot A/B → Startup Chart**.

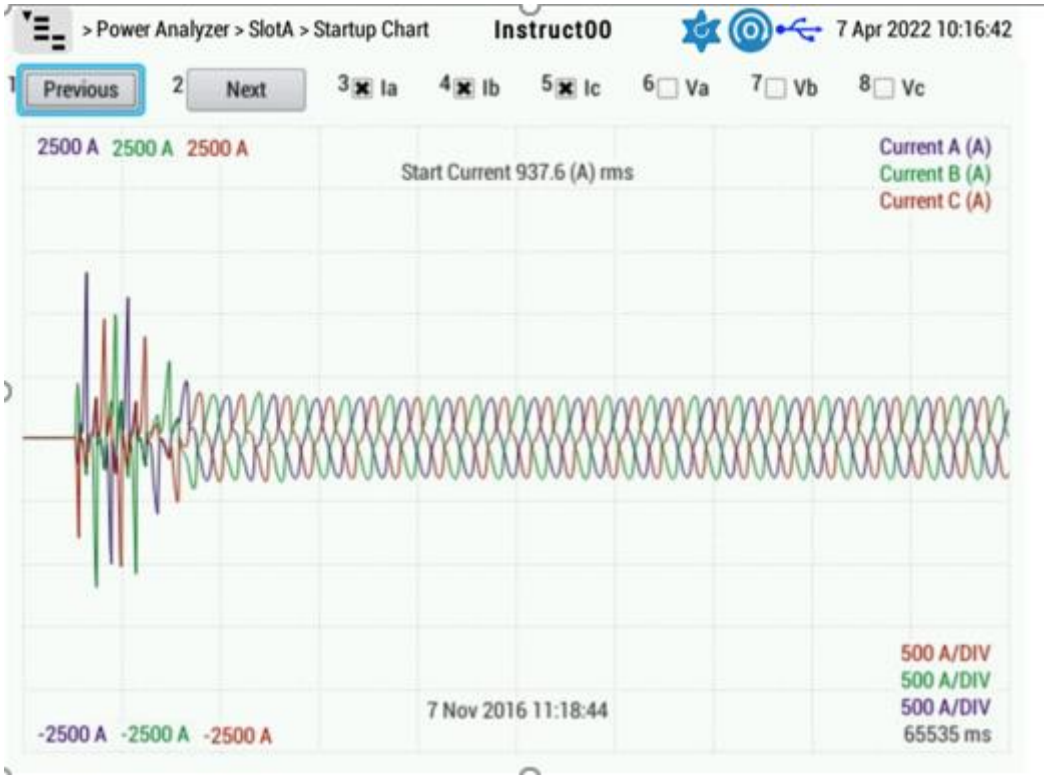


Figure 5-8: Startup Chart Screen

Startup Chart can also be viewed through Instruct Data Viewer from an exported H5 file. For details, refer to Instruct Viewer user manual embedded inside the software.

Appendix A: **Publisher Notes**

SUPPORT

For further support, contact LCSsustaining@sensiaglobal.com

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