TECHNICAL APPLICATION GUIDE

ANSI metal-clad medium voltage digital switchgear

5, 15, 27 kV non-arc-resistant
5, 15 kV arc-resistant switchgear

Table of contents

General overview
ANSI metal-clad MV digital switchgear

Introduction
Digital switchgear (low or medium voltage) is switchgear where device status information, current and voltage measurements and commands, are reliably transferred on a common communication bus. When included, the equipment condition monitoring and diagnostic information is digitally available for advanced analysis. In the case of medium voltage switchgear, the communication is accomplished using the IEC 61850 protocol over Ethernet.

Digital switchgear utilizes the IEC 61850 communications protocol and couples it with the proven technologies of Rogowski coils for current sensing to replace current transformers and resistive voltage dividers for voltage sensing to replace voltage transformer drawout units. This simplifies engineering, improves safety and reliability, and decreases life-cycle costs. All ABB ANSI medium voltage metal-clad switchgear products are available in digital versions.

Certifications and applicable standards
All MV ANSI metal-clad digital switchgear, both arc-resistant and non-arc-resistant meets or exceeds the requirements of ANSI/IEEE C37.20.2. The SafeGear and SafeGear HD arc-resistant platforms also meet or exceed the requirements of ANSI/IEEE C37.20.7. The manufacturing locations for digital switchgear are ISO 9001 certified. All digital switchgear with voltage ratings of 5-15 kV are UL listed.

Current sensors are UL certified and designed and tested to IEC 60044-8. Voltage sensors are UL certified and designed and tested to IEC 60044-7.

Equipment ratings
All usual or normal service condition equipment ratings as defined by ANSI/IEEE C37.20.2 and all arc-resistant ratings and accessibility types found on conventional switchgear are the same for digital switchgear. Reference the related conventional switchgear technical guides for the product line's specific available ratings.

Related technical guides and sample specifications

Advance/Advance 27 Tech Guide	1VAL107003-TG
SafeGear Tech Guide	1VAL108002-TG
SafeGear HD Tech Guide	1VAL108001-TG
ReliaGear ND Tech Guide	1VAL107501-TG
Advance/Advance 27 Sample Spec	1VAL107001-SS
SafeGear/SafeGear HD Sample Spec	1VAL108002-SS
ReliaGear ND Sample Spec	1VAL107501-SS
ANSI Digital Switchgear Testing and Commissioning Guide	1VAL108401-MB

Construction
All construction characteristics of MV ANSI metal-clad digital switchgear are identical to that of conventional switchgear. See the related Technical Guides for details of the product specific construction.

Outdoor enclosures
All outdoor enclosures available for conventional MV ANSI metal-clad switchgear are available for digital switchgear.

Breakers used
All breakers used in conventional MV ANSI metal-clad switchgear are used in digital switchgear.

Protective relays
ABB Relion series of relays using Low Energy Analog (LEA) inputs are used in digital switchgear. These include the REF615, RED615, REM615 and the REX640 relays and are available in ANSI configurations with UL certifications. SSC600 can also be used in case of centralized protection and control schemes.

Accessories
Digital switchgear uses the same accessories, such as SmartRack electric racking devices, lift trucks, ground and test devices, breaker accessories and breaker racking accessories as conventional switchgear except for the FT test switches. A digital version of FT style test switch is available (FT-14D).

Testing
MV ANSI metal-clad digital switchgear is design tested per IEEE C37.20.2 and includes the following production tests:
- Point to Point wiring check
- One second dielectric test of 1800 VAC for control circuits
- Control circuit verification
- Protective relay current circuits energized by applying low current levels on the primary bus, through the sensors and into the relays. This includes proper relay functioning, ratio testing and polarity verification.
- Protective relay voltage circuits energized by applying reduced voltage levels (<1000 V) on the primary bus, through the sensors and into the relays. This includes proper relay functioning, ratio testing and polarity verification.
- Mechanical check for breaker alignment and interlock verification
- Power frequency withstand test (HI-POT) phase to phase and phase to ground
- Static circuit check
- Factory witness testing is available
- Reference the ANSI Digital Switchgear Testing and Commissioning Guide, document #1VAL108401-MB

Options
Digital switchgear is available with the same options as conventional switchgear, this includes SwitchgearMD™ asset health monitoring and all active arc mitigation systems such as REA arc detection and the Ultra-Fast Earthing Switch for incident energy level reduction.

Configuration software
Medium Voltage Pro (MVP Pro) has been developed to be a switchgear configuration tool and helps design offices in creating a switchgear lineup including front elevations and floor plans. A version of this software is available for consultants and designers. Please contact your local ABB representative for more information.

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Other reference documents

Document	Document number
ADVAC Breaker Technical Guide	1VAL050501-TG
AMVAC Breaker Technical Guide	1VAL050601-TG
Vmax/A Breaker Technical Guide	1VAL057601-TG
Plenum Technical Guide	1VAL104602-TG
Installation, Operation and Maintenance Manual for Advance	1VAL107003-MB
Installation, Operation and Maintenance Manual for SafeGear HD	1VAL108001-MB
Installation, Operation and Maintenance for SafeGear	1VAL108002-MB
Installation, Operation and Maintenance for ReliaGear ND	1VAL107501-MB
Installation, Operation and Maintenance Manual for Advance 27	1VAL107002-MB
ADVAC Breaker Installation, Operation and Maintenance Manual	1VAL050503-MB
AMVAC Breaker Installation, Operation and Maintenance Manual	1VAL050601-MB
ADVAC 63 Breaker Installation, Operation and Maintenance Manual	1VAL050502-MB
Vmax/A Breaker Installation, Operation and Maintenance Manual	1VAL057601-MB
SmartRack Installation, Operation and Maintenance Manual	1VAL104601-MB
MOG&T Installation, Operation and Maintenance Manual	1VAL064601-MB
Breaker Test Cabinet Installation, Operation and Maintenance Manual	1VAL-T0004-102427
ADVAC and AMVAC Commissioning Manual	1VAL0501-MB

Low-power passive instrument transformers
Current and voltage sensors

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01 UL Certification symbol

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02 RJ45 connector for secondary wiring connection

General
For most digital switchgear applications, conventional instrument transformers such as the SAB style current transformers and the VIZ-11 voltage transformers are replaced with electronic instrument transformers (sensors) such as the KECA style current sensors and KEVA style voltage sensors. However, it is possible to mix the conventional instrument transformers with sensors under specific conditions.

The current and voltage sensors available for the MV ANSI metal-cad switchgear product lines are shown in the chart below.

Switchgear product	Current sensor	Voltage sensor
Advance 5-15 kV	KECA 80 C184	KEVA 17.5 B21
Advance 27 kV	KECA 80 C184	KEVA 24 B21[1]
SafeGear 25-50 kA, 10-cycle/0.5 sec	KECA 80 C184	KEVA 17.5 B21
SafeGear HD	KECA 80 C184	KEVA 17.5 B21
ReliaGear ND	KECA 80 C184	KEVA 17.5 B21

[1] UL not available for this sensor

Except where noted, the current and voltage sensors above are UL certified.

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SAFETY US
E501098

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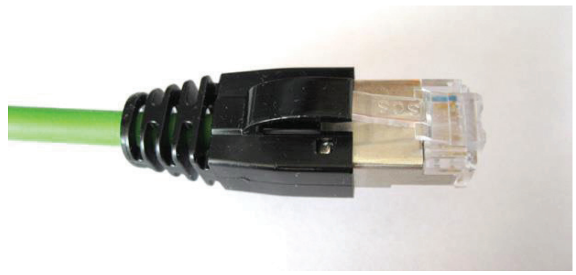
These sensors have outputs that can only be connected to relays that accept low energy analog input signals, such as the ABB REF, RED and REM 615 series and the REX640 relays. All secondary cable connections to the relays or FT style digital test switches utilize RJ45 connectors with gold plated contacts.



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Operating conditions
The sensors should be mounted in dry, indoor conditions without excess ingress of dust and/or corrosive gases. The sensors shall be protected against unusually heavy deposits of dust or similar pollution, as well as against direct sun light. Temperature ranges are as follows:

Application	Minimum Temperature	Maximum Temperature
Ambient air/operating temperature	-25°C	+80°C
Storage temperature	-40°C	+80°C

The altitude for the application should be lower than 3,280 feet (1,000 meters) above sea level. De-rating factors defined in ANSI/IEEE C37.20.2 apply to current and voltage sensors just as would be applied for current and voltage transformers. Outdoor enclosures used for digital switchgear should have the proper space heaters, controls and filtering to maintain the operating conditions described above.

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03 Illustration of the Rogowski coil principle

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04 Current sensor output performance

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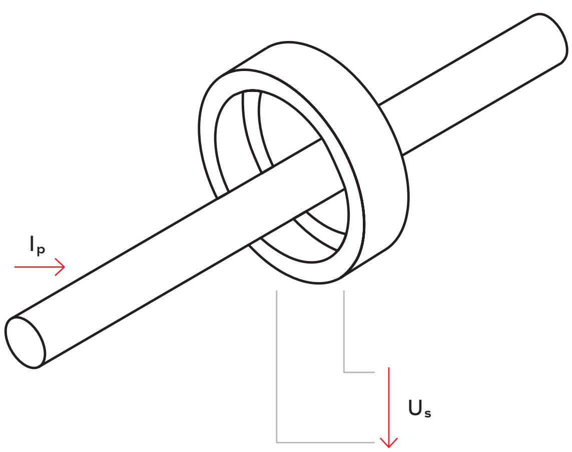
05 KECA 80 C184 dimensions

Current sensor characteristics
In all MV ANSI metal-clad digital switchgear products, current sensors are placed over the breaker bushings. There shall be one sensor per phase. Secondary wiring is made using Cat 6 cables with RJ45 connectors. Sensors are provided with pre-terminated cables, 5 meters in length. These cables are not to be cut, and any excess length is to be coiled up.

The sensor case is made of plastic, the internal parts are shielded, and the shielding is grounded. The primary conductor shall be insulated for the application voltage. The insulation of the primary conductor determines the highest permissible system voltage.

Current measurement in the KECA sensors is based on the Rogowski coil principle. A Rogowski coil is a toroidal coil placed around the primary conductor in the same way as the secondary winding in a current transformer. This results in a voltage output equal to a scaled derivative of the primary current.



$$U_s\,(t) = M\,\frac{di_p\,(t)}{dt}$$

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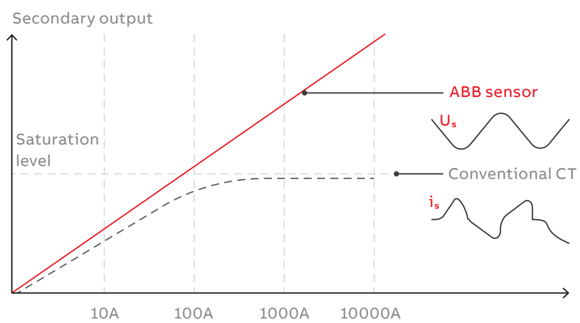
This provides a linear response over a wide dynamic range due to the lack of ferromagnetic core and due to lack of influence by the width of the hysteresis curve.

Current sensing for both metering (0.5) and protection purposes (5P) is achieved using a single secondary winding with a dual rating.

The current sensors are lightweight, easy to install and have much lower energy consumption comparted to current transformers.

Amplitude and phase errors are constant and independent from primary current and can easily be corrected by relay correction factors.



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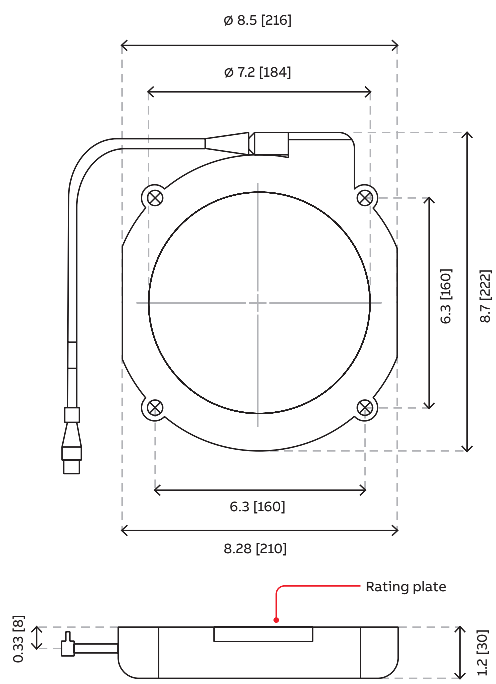
Current sensor technical details
The KECA 80 C184 current sensors are designed to fit over all breaker bushings with ratings 1200 A through 3000/4000 A continuous current. These are used in the Advance, Advance 27, SafeGear and SafeGear HD product lines.



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06 KECA 80 C184 sensors installed on breaker primary bushings

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07 KECA 80 D85 dimensions

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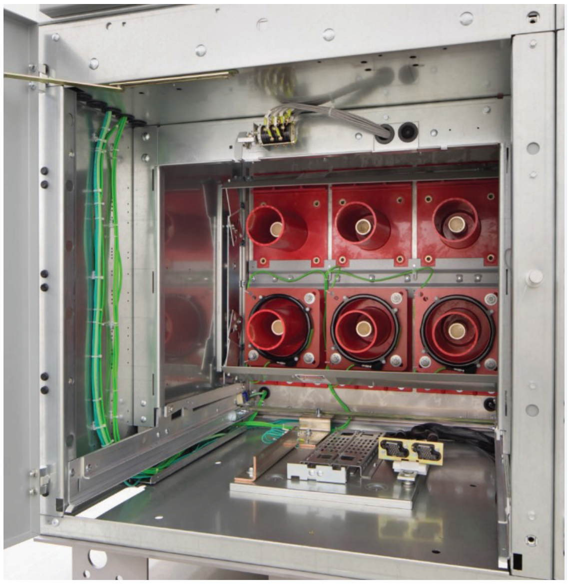
08 KECA 80 D85 sensors mounted on the bushings for ReliaGear ND



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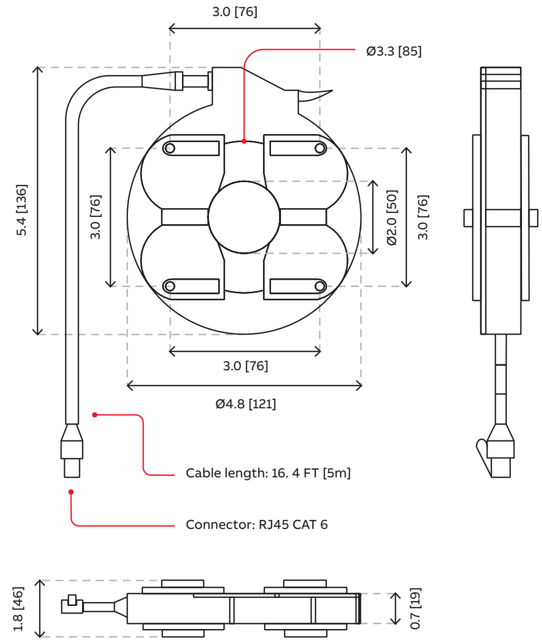

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KECA 80 C184 technical data

Characteristic	Value
Primary voltage	0.72 kV
Rated primary current	Up to 4000 A
Rated secondary output	180 mV @ 60Hz
	150 mV @ 50Hz
Rated continuous thermal current	4000 A
Rated short-time thermal current	85 kA/3s
Rated Frequency	50/60 Hz
Accuracy class	0.5/5P
Rated burden (input impedance)	10 MΩ
Weight	1.43 lbs
Operation temperature (ambient air)	-25°C/+80°C
Transport and storage	-40°C/+80°C
Style number (UL certified)	1VL5400072V0201

Reference document #1VAP500013-DB for additional technical data. Reference document #1VLM000802 for installation and maintenance instructions.

The KECA 80 D85 split core current sensors are designed to be installed over the breaker bushings for all continuous current ratings in the ReliaGear ND product only. The location for all sensors and/ or current transformers in ReliaGear ND is on the breaker primary bushings where they extend into the bus and cable compartments.

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09 Yellow ground lead on the KECA 80 D85 current sensor

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10 Typical rating label used on current sensors

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11 Testing summary

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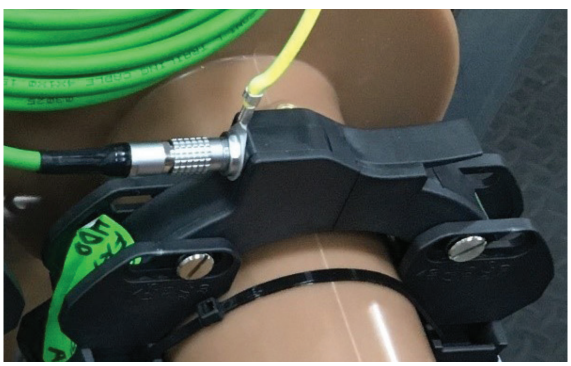
KECA 80 D85 technical data

Characteristic	Value
Primary voltage	0.72 kV
Rated primary current	Up to 4000 A
Rated secondary output	180 mV @ 60Hz
	150 mV @ 50Hz
Rated continuous thermal current	4000 A
Rated short-time thermal current	85 kA/3s
Rated Frequency	50/60 Hz
Accuracy class	0.5/5P
Rated burden (input impedance)	10 MΩ
Weight	0.55 lbs
Operation temperature (ambient air)	-25°C/+80°C
Transport and storage	-40°C/+80°C
Style number (UL certified)	1VL5400076V0201

Reference document #1VAP500012-DB for additional technical data. Reference document #1VAP500012-MB for installation and maintenance instructions.

Current sensor grounding
KECA 80 D85 current sensors have partially conductive plastic covers used as shielding and use a separate yellow/green ground wire that must be connected to ground.



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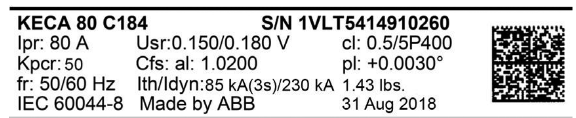
The KECA 80 C184 sensors have shielded coils inside with direct connection to the cable shielding and do not need a separate ground lead.

Correction factors and accuracy (both C184 and D85 sensors)
Technical details and values of the correction factors (Cfs) for the amplitude (al) and phase error (pl) of a current sensor for each individual current sensor are placed on the rating plate placed on the sensor surface. Values mentioned on the rating plate shall not be exceeded.

To achieve the required accuracy classes, both correction factors – amplitude correction factor and phase error correction factor – must be used.



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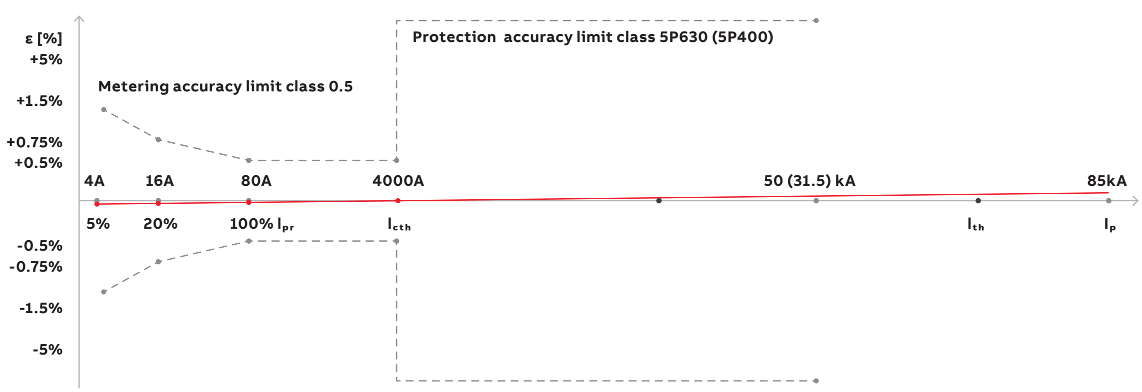
IEC 60044-8 current measurement range for KECA 80 C184 and KECA 80 D85 with accuracy class 0.5/5P
- Metering accuracy: IEC 0.5 class from 4A - 4000 A
  - IEC 0.5 class for continuous current measurement from 5% of the rated primary current (Ipr) to the rated continuous thermal current (Icth)
- Protection accuracy: IEC class 5P from 4000 A - 85 kA
  - IEC class 5P from the rated continuous thermal current (Icth) to 85 kA

Use in applications at higher currents is possible; contact your ABB sales representative for more information.



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12 Pin assignment on RJ45 connectors used for the current sensors

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13 Connectors used between the cable and the sensor

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14 AR4 Adapters

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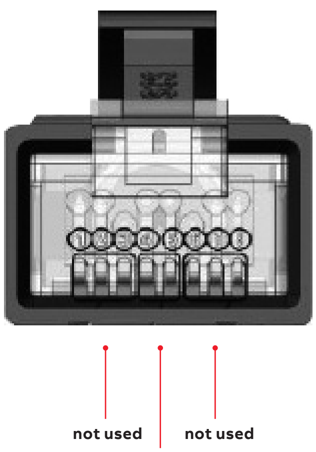
15 Pin interconnections on the AR4 adapter

Current sensor secondary cables and connections (both C184 and D85 sensors)
Cables for the secondary wiring are CAT 6 classification, which features more stringent specifications for crosstalk and system noise and are a special industrial type training cable using a polyurethane jacket that is much more durable and resistant to harsh environments that standard PVC Ethernet cables.

The sensor cable is terminated on the relay connection end by a shielded RJ45 plug connector (EIA/TIA 568A Standard) and complies with Cat 6 classification. Gold plating of the contacts are used to ensure the best performance. The connectors are screened and designed to guarantee low resistance shielding; they are particularly adapted to applications where electromagnetic compatibility (EMC) is important.

Note: The manufacturer recommends using a cable tie to fasten long cables approximately 4.0” (10cm) from the RJ45 socket.



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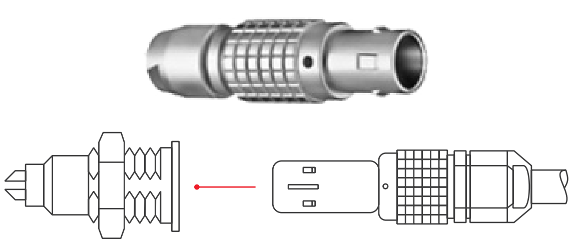
The connection between the cable and sensor is provided by LEMO/ODU push-pull type connectors. See illustration below:



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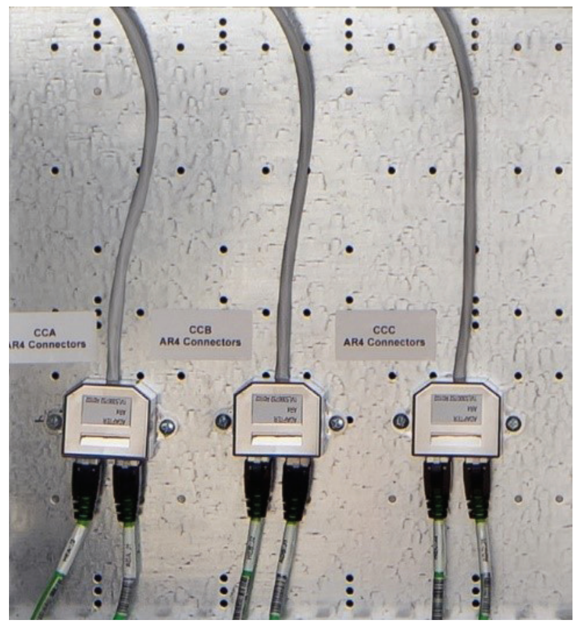
The sensor accuracy classes are verified up to the RJ45 connector and therefore consider the influence of the secondary cable and its connections. Burden calculations are not required, and no other secondary wiring is required.

Every sensor is accuracy tested when using its own cable and connectors. No other cables or connectors shall be used than those provided with the sensors.

When both current and voltage sensors are to be connected to the relay, an ABB type AR4 Adapter is used to combine the sensor inputs into one cable with RJ45 connector. See photo below.



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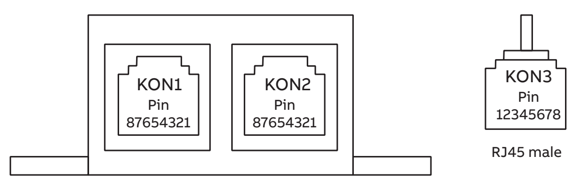
The pin interconnections for the AR4 adapters are specific to the requirements of the IEC sensor standards and the manufacturers.



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Pins interconnection

KON1 (Pin)	KON 2 (Pin)	KON 3 (Pin)
1	1	1
2	2	2
3	3	3
4	4	4
5	5	5
6	6	6
7	7	7
8	8	8

If only the current or only the voltage sensor is being connected to the relay, then it is not necessary to use the AR4 adapters. The cables can be connected from the sensor directly to the FT digital test switch and then to the relay, or directly form the sensor to the relay if there is no FT digital test switch used.

The minimum bending radius for the cable is 1.4”. The cable is not to be moved if the temperature is below 0°C. If the cable, connector or connector grommet is damaged, contact the manufacturer.

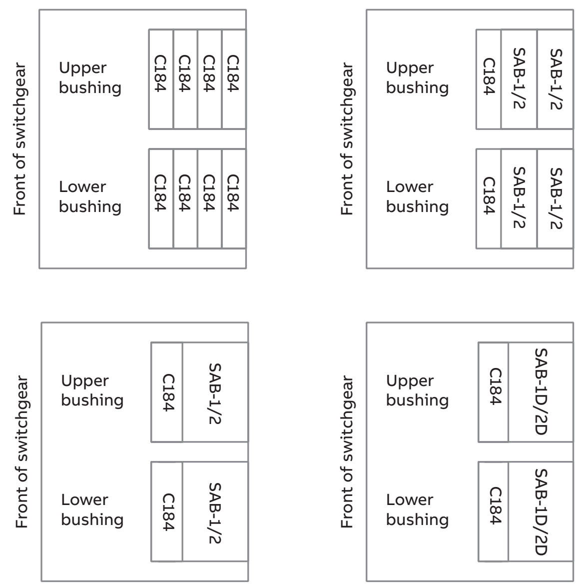
A cable not connected to the relay can be left open or short-circuited without any harm to the sensor. Even during a primary short-circuit, the voltage in the secondary circuit of the current sensor will be below 100 V. Nevertheless, it is a good safety practice to ground cables not connected to the relay.

Current sensor mounting configurations
Current sensors can be installed on the breaker bushings with or without conventional CTs. For all product lines, up to four (4) current sensors can be installed on each breaker bushings for a maximum total of eight sensors per phase.

Although it is unlikely to need this many, they can be installed during new equipment builds for future use. Although not necessary, it is recommended that the secondary cables be grounded if installed on energized equipment but not connected to the relays.

All upper and lower breaker bushings are of the same length within their respective product. Although the bushing diameters are different between the1200/2000 A and 3000/4000 A ratings, the same KECA 80 C184 sensor is used for all bushings.

The Advance, Advance 27, SafeGear and SafeGear HD product line current sensor and current transformer available configurations are shown in the illustrations below.



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16 Current sensor and current transformer available mounting configurations

For the ReliaGear ND product, the number of current sensor and CTs mixed that can be installed are dependent upon the bushing lengths used.

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17 ReliaGear ND short bushing with current sensors only

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18 ReliaGear ND long bushing with current sensors only

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19 ReliaGear ND long bushing with conventional current transformer and current sensor

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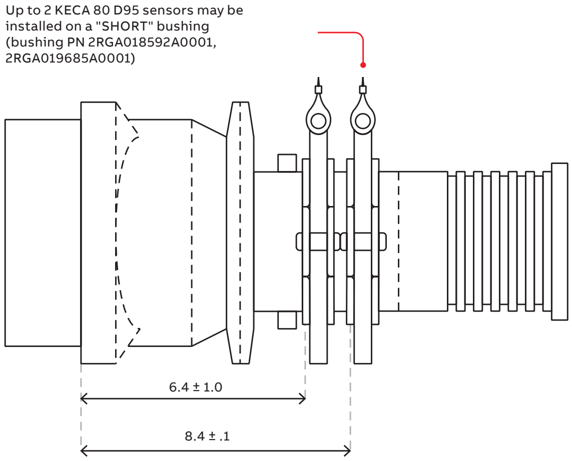
20 Fixed mounting of KECA 80 C184 current sensors



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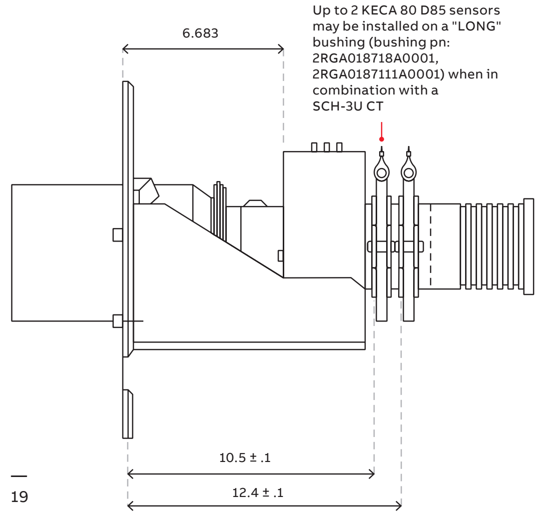

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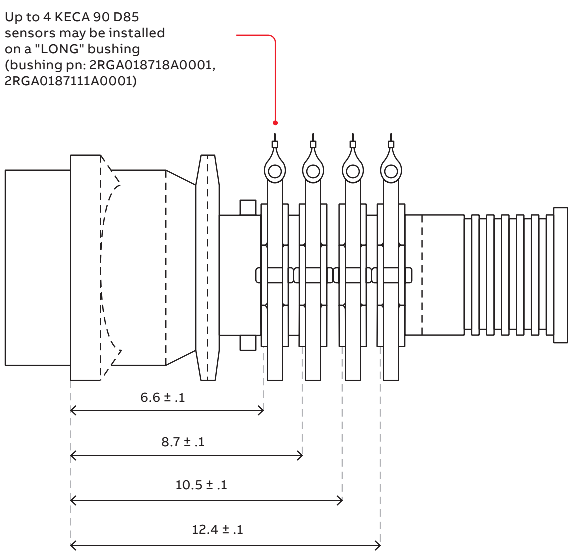

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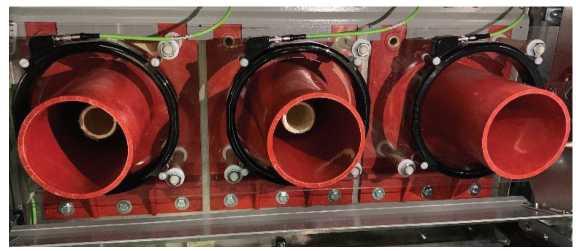
Current sensor polarity
For Advance, Advance 27, SafeGear and SafeGear HD, the KECA 80 C184 current sensors have fixed physical mounting configurations.



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Changing polarity by changing the mounting is not possible. If need be, current sensor polarity can be changed in the IED.

Group / Parameter Name	IED Value	PC Value	Unit	Min	Max
Current (3I,CT): 1					
Current (3I,CT)					
Primary current		1000,0	A	1,0	6000,0
Amplitude Corr A		1,0195		0,9000	1,1000
Amplitude Corr B		1,0229		0,9000	1,1000
Amplitude Corr C		1,0222		0,9000	1,1000
Nominal current		1000	A	39	4000
Rated secondary Val		37,500	mV/Hz	1,000	150,000
Reverse polarity		**True**			
Angle Corr A		0,0447	deg	-20,0000	20,0000
Angle Corr B		0,0380	deg	-20,0000	20,0000
Angle Corr C		0,0380	deg	-20,0000	20,0000

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21 D85 Sensor polarity indication

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22 C184 Sensor polarity indication

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23 Single line diagram showing sensor polarity options for the KECA 80 D85 sensor

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24 Single line diagram showing the sensor polarity set for the KECA 80 C184 sensor

For ReliaGear ND, the KECA 80 D85 current sensors can be mounted with polarity towards or away from the breaker. Due to the construction of the sensors, physical polarity tests are not necessary. Also, the secondary winding resistance and magnetization curve tests are not applicable to current sensors and need not be performed.

Polarity markings are physically shown on the current sensors. Polarity indication uses the designations P1 and P2 for primary polarity markings. Below are examples of polarity indications for the sensors used in MV ANSI Switchgear.

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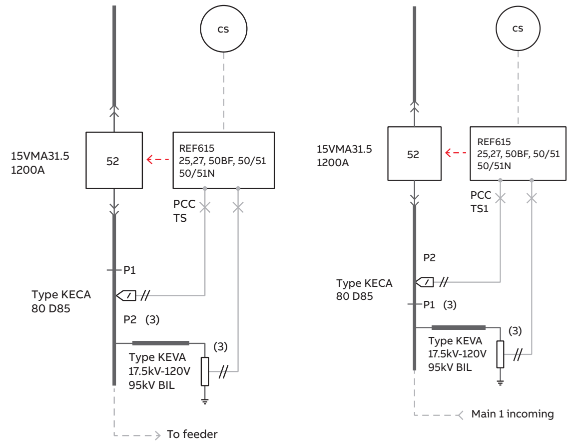
The single line diagram should show the polarity of the current sensors as they are physically oriented on the bushings they are installed on. The symbols appear as shown below. The example is for ReliaGear ND using the KECA 80 D85 sensors. (Note: Voltage sensors are also shown in this example.)



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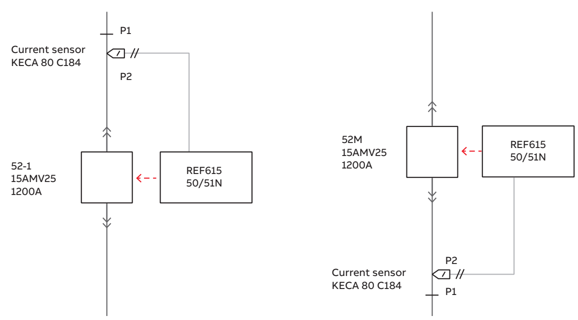
In all cases regarding the use of the KECA 80 C184 current sensor, the sensor will be physically mounted with P1 towards the bus and P2 towards the breaker. The single line diagram representation would be as shown below.



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Reference the Engineering Guide for additional details on current sensor polarity.

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25 KEVA 17.5 B21 voltage sensor

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26 Resistive voltage divider circuit

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27 KEVA 17.5 B21 voltage sensor installed in the rear cable compartment

Voltage sensor characteristics
In all MV ANSI metal-clad digital switchgear products, both the KEVA 17.5 B21 and the KEVA 24 B21 voltage sensors are installed in the primary bus and cable compartments. There shall be one sensor per phase. These are mounted as standalone units on metal mounting pan assemblies.Connection to the primary bus is made via cable or bus with removable insulating boots to ensure compliance to C37.20.2 requirements.

Secondary wiring is made using Cat 6 cables. Sensors are provided with pre-terminated cables, 5.5 meters in length. These cables are not to be cut, and any excess length is to be coiled up.

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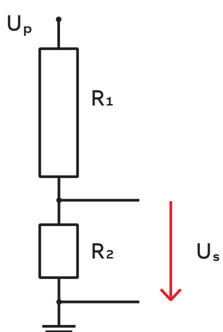
Voltage measurements in these sensors are based on the resistive voltage divider principle.



$$U_s = \frac{R_2}{R_1 + R_2} U_p$$

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The output voltage is directly proportional to the input voltage (10,000:1 transformation ratio) and reproduces the actual waveform of the primary voltage signal.

This provides a linear response over a wide dynamic range due to the lack of ferromagnetic core and influence by the width of the hysteresis curve.

The voltage sensors are lightweight, easy to install, low power, low energy consumption and are safer than conventional VTs.

Voltage sensing for both metering (0.5) and protection classes (3P) in one device.

Amplitude and phase error are constant and independent form primary voltage; can be easily corrected with IED correction factors.

Primary or secondary fusing is not required, nor recommended. This is consistent with the latest requirements of the ANSI/IEEE C37.20.2 standard.

No ferroresonance due to the device being non-inductive.

For 3-phase systems, there will be one voltage sensor per phase. Voltage transformer configurations, such as Wye-Wye and Open Delta are configured in the IED.

Voltage sensor technical details
The KEVA style voltage sensors are installed on a mounting plate assembly which is then located in the bus or cable compartment. No part of the voltage sensor can be installed in a low voltage compartment.

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Connection from the primary bus to the voltage sensor is made via Natvar copper rod (as shown in photo above), suitably rated shielded cable or bus bar, using a M16 screw. Insulating boots are included at the primary connection to meet IEEE C37.20.2 metal-clad standard requirements.

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28 Side view details of the KEVA 17.5 B21 voltage sensor

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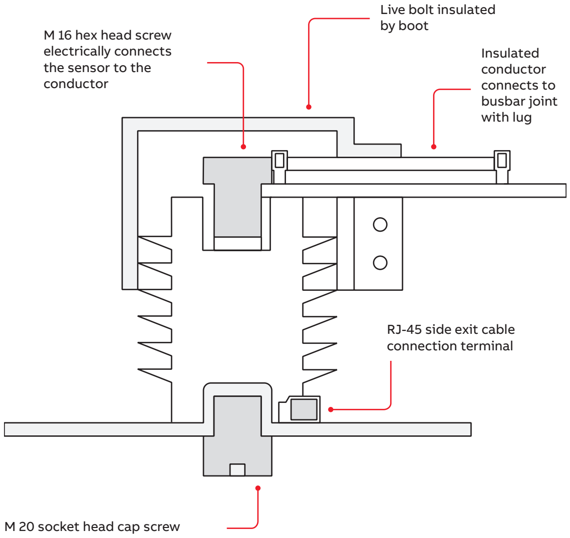
29 Voltage sensor mounting provisions



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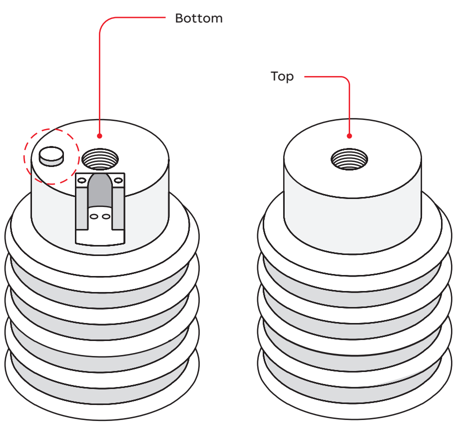
The voltage sensors are attached to the mounting plate via the M20 screw at the bottom. When voltage sensors mounted on unfinished galvanized or stainless steel have sufficient grounding for proper operation. When mounted to finished metals, or insulated materials, a minimum #6 AWG ground wire to be connected to each sensor then to ground bus. The mounting position of the sensor is determined by the protrusion at the sensor bottom side. This ensures correct sensor orientation, cable direction and rating nameplate positioning.



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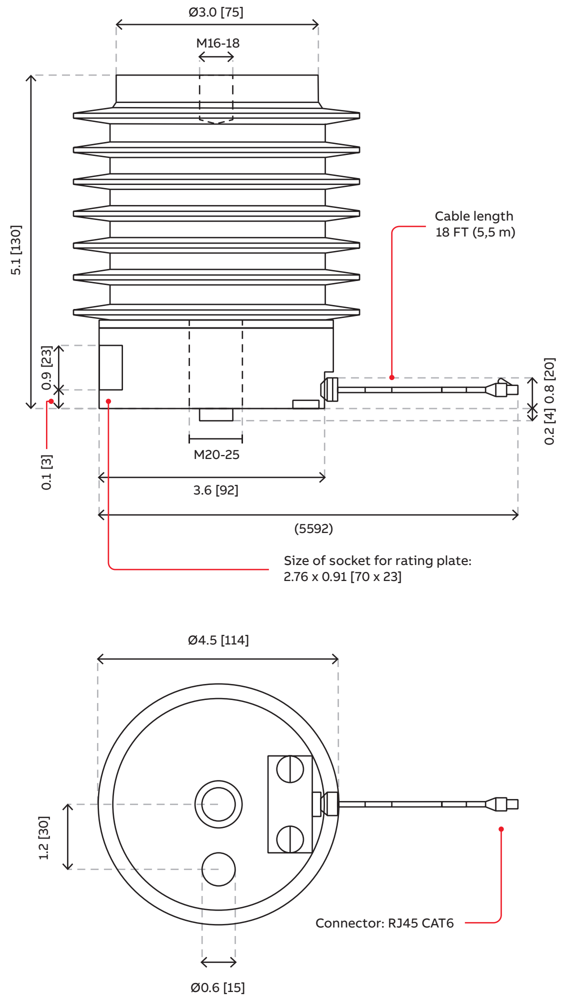
KEVA 17.5 B21 technical data

Characteristic	Value
Rated maximum operating voltage	17.5 kV
Rated primary voltage	15/√3
Rated power frequency withstand voltage	38 kV
Rated lightning impulse withstand voltage	95 kV
Rated transformation ratio	10,000:1
Accuracy Class	0.5/3P
Rated voltage factor	1.9/8h
Rated Frequency	50/60 Hz
Rated burden	10 MΩ
Operation temperature (ambient air)	-25°C/+80°C
Transport and storage	-40°C/+80°C
Style number (UL certified)	1VL5400060V0302
Weight, each	4.3 lbs

Reference document #1VAP500014-DB for additional technical data.
Reference document #1VLM000599 for installation, use and maintenance instructions.

All technical data and configurations are based on normal service conditions as defined by ANSI/IEEE C37.20.2. For unusual service conditions related to higher levels of water condensation or dust pollution, reference ABB document #1VLM000599.

KEVA 17.5 B21 Dimensional data [dimensions shown in brackets are mm]:



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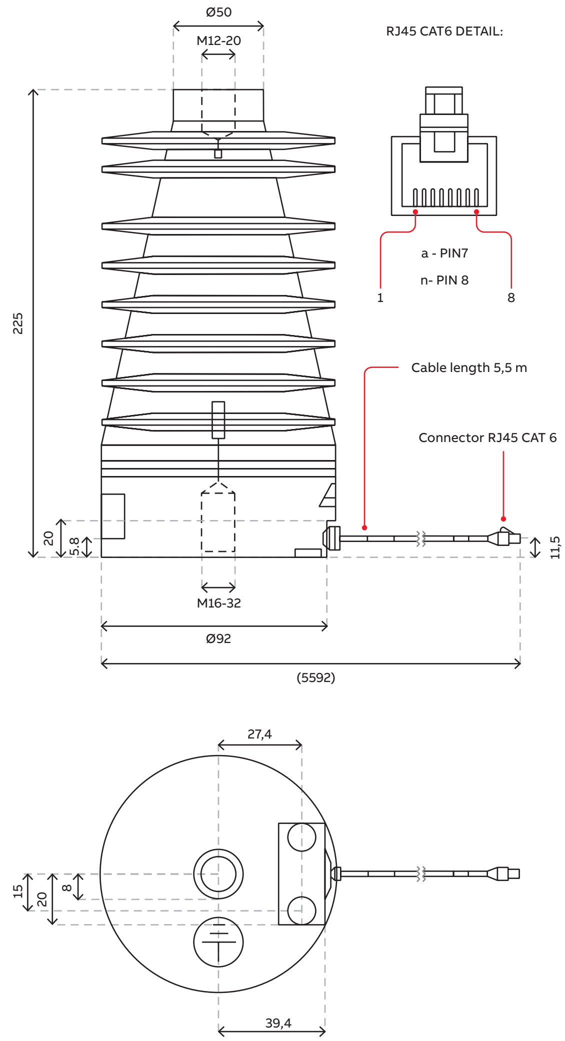
30 KEVA 17.5 B21 dimensions

Reference document #1VLC000714 for additional technical data. Reference document #1VLM000803 for installation, use and maintenance instructions.

All technical data and configurations are based on normal service conditions as defined by IEC 60044-7 and IEC KEVA 24 B21 dimensional data [shown in mm].



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31 KEVA 24 B21 dimensions

—
KEVA 24 B21 technical data

Characteristic	**Value**
Rated maximum operating voltage	24 kV
Rated primary voltage	22/√3
Rated power frequency withstand voltage	60 kV
Rated lightning impulse withstand voltage	125 kV
Rated transformation ratio	10,000:1
Accuracy Class	0.5/3P
Rated voltage factor	1.9/8h
Rated Frequency	50/60 Hz
Rated burden	10 MΩ
Operation temperature (ambient air)	-25°C/+80°C
Transport and storage	-40°C/+80°C
Style number (UL certified)	1VL5400071V1102
Weight, each	5.5 lbs

Linearity
Due to the absence of a ferromagnetic core these sensors have a linear response over a very wide primary voltage rating.

Example of voltage measurement range for metering accuracy class 0.5 and protection accuracy class 3P for both KEVA 17.5 and KEVA 24 voltage sensors. The accuracy limits are described in the following graph.

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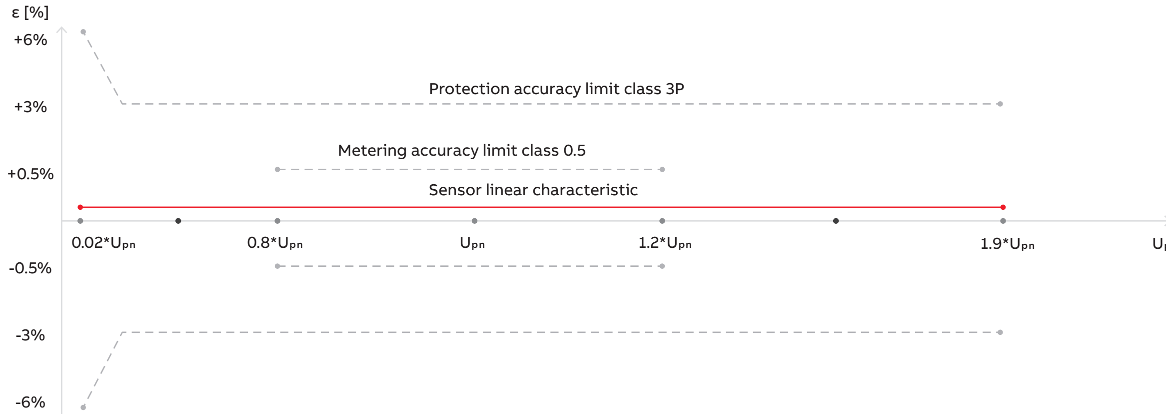
32 Voltage sensor output performance

—
33 Typical voltage sensor rating labels



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Rated parameters
Because the sensors are highly linear within a very wide range of voltages, the same single sensor can be used for the various rated voltages associated with each specific application up to the specified maximum voltage for the equipment.

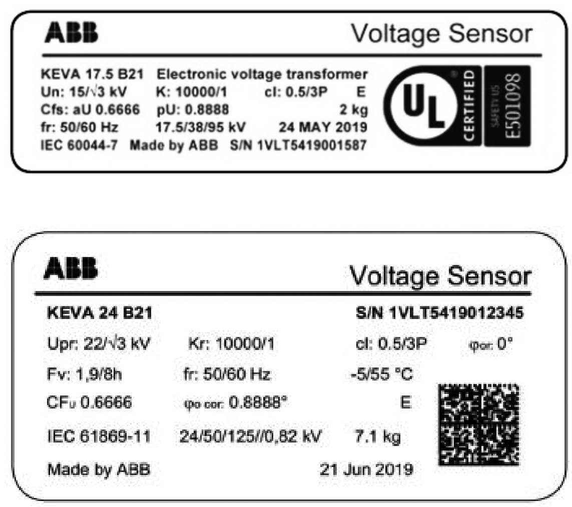
There is no need to specify other parameters such as burden, etc., since they are standard over the defined range. To achieve the correct function of the protection and control IED, the selected rated voltage as well s the rated transformation ratio, must be properly set into the IED

Correction factors and accuracy (KEVA 17.5 B21 and KEVA 24 B21 sensors)
The amplitude and phase error of a voltage sensor is, in practice, constant and independent of the primary voltage. Due to this fact it is an inherent and constant property of each sensor and it is not considered as unpredictable and influenced error.

Hence, it can be easily corrected in the IED by using appropriate correction factors, stated separately for every sensor. Values of the correction factors for the amplitude and phase error of a voltage sensor are mentioned on the sensor label (for more information please refer to Instructions for installation, use and maintenance) and should be uploaded without any modification into the IED before the sensors are put into operation (please check available correction in the IED manual).

To achieve the required accuracy classes it is necessary to use both correction factors: amplitude correction factor and phase error correction factor of a voltage sensor.

Below are examples of the labels that are included on each sensor. An additional label is also included to be placed at a convenient location for the user.



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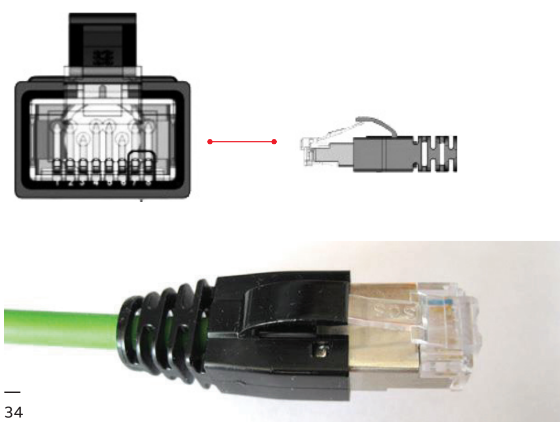
Secondary cables and connections

The secondary cable is a special shielded cable designed to give maximum EMI shielding. The secondary cable is inseparable part of each sensor and cannot be additionally extended, shortened, branched, modified, withdrawn or changed due to the guarantee of accuracy and performance of the sensor. The cable shall be connected directly (or via a connector adapter if needed) to Intelligent Electronic Device, (e.g. protection relay).

The electrical shielding of cable is connected to connector shielding and shall be earthed on IED side. The cable shall be fixed close to metal wall or inserted inside of metal cable tray far from power cables! The maximal bending radius for the cable is 7.5x cable diameter. The cable cannot to be moved if the temperature is below 0°C. If cable, connector or connector grommet is damaged please contact the manufacturer for instructions.

Connections to the IED

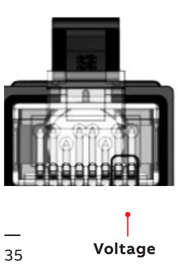
The sensor cable is terminated by shielded RJ45 plug connector that shall be connected to the inputs of the IED.



34

— 34 Typical RJ45 connector

Note: It is recommended to use a cable tie to fasten long sensor cables approximately 4 in (10 cm) from the RJ45 socket. The sensor plug connector pin's assignment is shown on in the figure below. (Front view).



Sensor wires connected acc. following assignment:

PIN 7 - a
PIN 8- ⏚

Other pins remain unused

35

— 35 Pin locations for voltage sensor wires on RJ45 connector

A cable not connected to the IED can be left open or short-circuited without any harm for the sensor. Even during a primary short-circuit the voltage in the secondary circuit of the current sensor will be below 100 V. Regardless, it is a good safety practice to ground cables not connected to the IED.

The RJ45-type connectors (EIA/TIA 568A Standard) are screened and designed to guarantee low resistance shielding; they are particularly adapted to applications where electromagnetic compatibility (EMC) is important. The connectors are robust but it is necessary to be careful during their assembly – do not use force!

Grounding Terminal

The sensor grounding terminal is located on the same side as the sensor secondary terminal part and shall be suitably grounded.

36

— 36 Ground terminal location on voltage sensor

Harsh Environment Applications

All KEVA 17.5 and 24 B2x voltage sensors are to be used under normal service conditions as defined by IEC 60044-7 and IEC 61869-1 standards. However, the voltage sensors may be used in switchgear under more severe conditions where higher levels of water condensation and dust pollution exist.

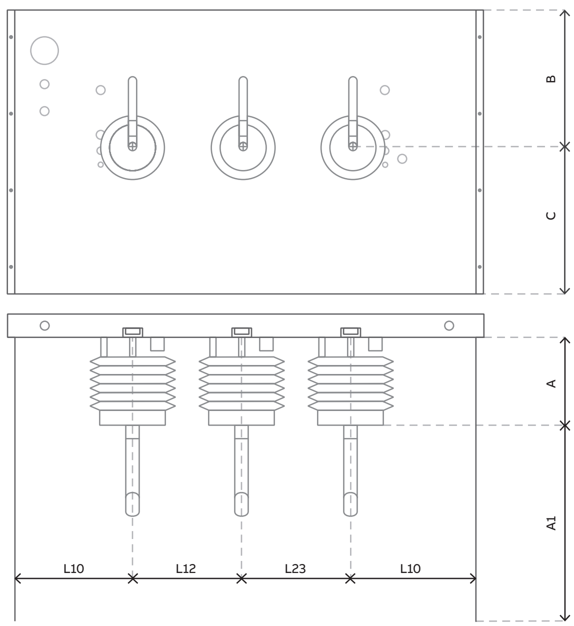
The service conditions for the installation in harsh environment are considered as Degree of severity 2, which means the level of combinations marked as “ClPh“ or “ChPl“ or “ChPh“, where:

- Cl is non-frequent condensation (not more than twice a month),
- Ch is frequent condensation (more than twice a month),
- Pl is light pollution (ambient air NOT significantly polluted by dust, smoke, gases, salt),
- Ph is heavy pollution which exceed any from Pl (does not include area with conductive dust tor smoke).

The three-phase installations of KEVA 17.5 B2x voltage sensors meet the requirements of the Design class 2, what was reliably validated by Level 2 aging tests according to IEC62271-304:2008 standard.

Following are requirements for installation in the harsh environments listed above:

- Use hot-dip zinc coated or stainless-steel screws for all connections.
- Use cables with tinned copper conductors and insulation suited for these environments.
- Maintain clearances as shown in the following illustrations and tables.



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— 37 Voltage sensor clearance requirements for harsh environments

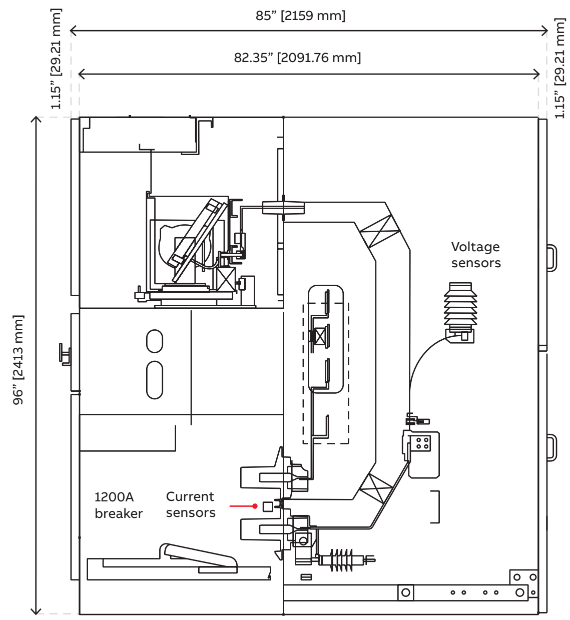
DIM ID	mm	in	Description
L10	175	6.9	Phase-to-ground
L12	150	5.9	Phase-to-phase
L23	150	5.9	Phase-to-phase
A	130	5.1	Phase-to-ground
A1	270	10.6	Phase-to-ground
B	230	9	Phase-to-ground
C	230	9	Phase-to-ground

The sensors can be installed in either horizontal or vertical positions. For unusual service conditions related to higher levels of water condensation or dust pollution, reference ABB document #1VLM000803, or contact your local ABB representative.

Mounting Configurations

Typical mounting locations will be for connection to the incoming bus, outgoing cables, main bus, tie bus and bus duct connections.

Following are a few examples of mounting locations and configurations for locating voltage sensors within the switchgear.



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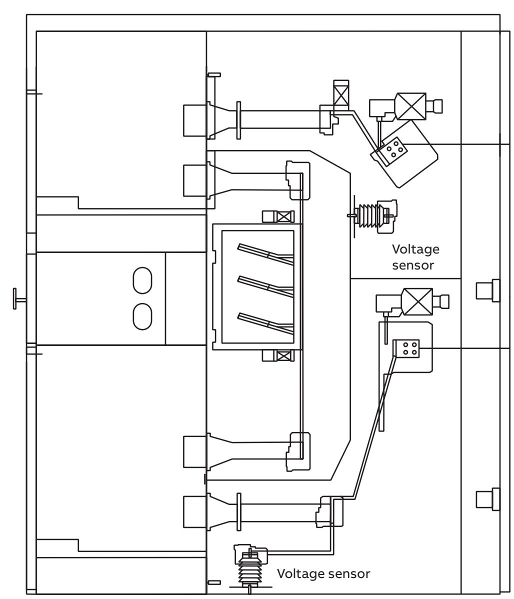
— 38 CPT/PT/Breaker Configuration in Advance indoor, including lightning arresters and ground studs. 15kV, 25kA, 1200A, incoming line connection.



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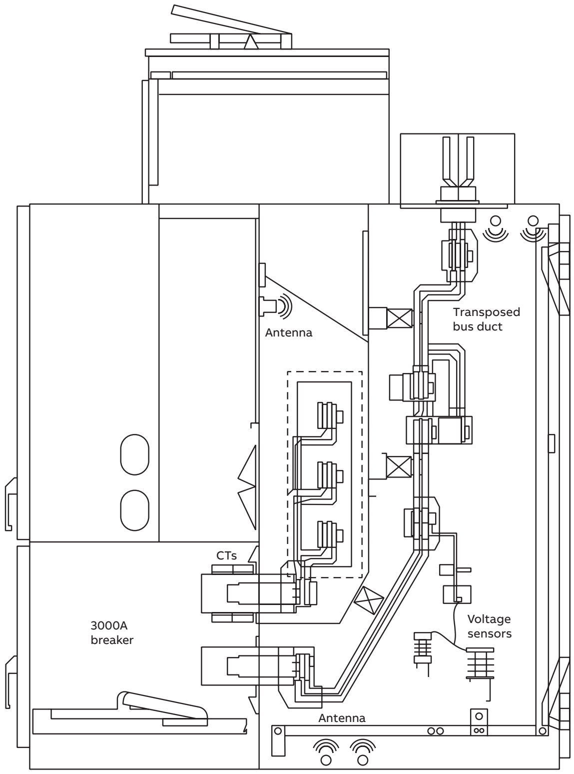
— 39 Two-high breaker configuration in ReliaGear ND. Incoming line or outgoing bus connection. 15kV, 1200 A, 31.5kA.

—
40 Sensor connection to transposed bus duct in SafeGear with lightning arresters, ground studs, SwitchgearMD and mixed with Current Transformers. 15 kV, 3000 A, 50kA.

—
41 Voltage sensors installed on main bus. SafeGear 15 kV, 3000 A, 50 kA, with SwitchgearMD and lightning arresters.

—
42 Voltage sensor in main bus compartment. Advance, incoming or feeder breaker. 15 kV, 1200 A, 50 kA.

—
43 Voltage sensors installed on main bus. SafeGear 15 kV, 3000 A, 50 kA, with SwitchgearMD and lightning arresters.



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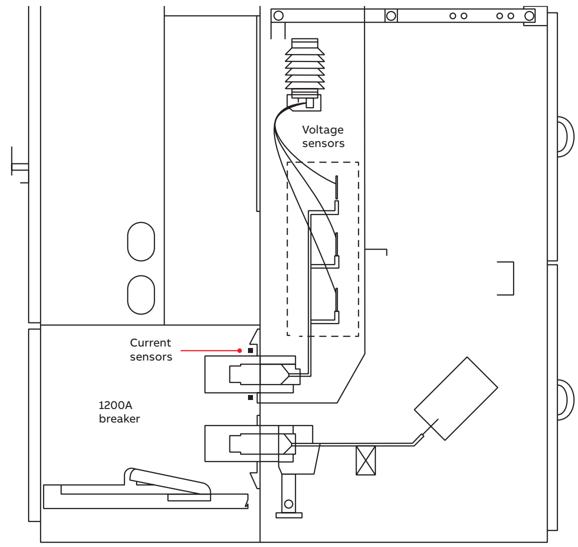

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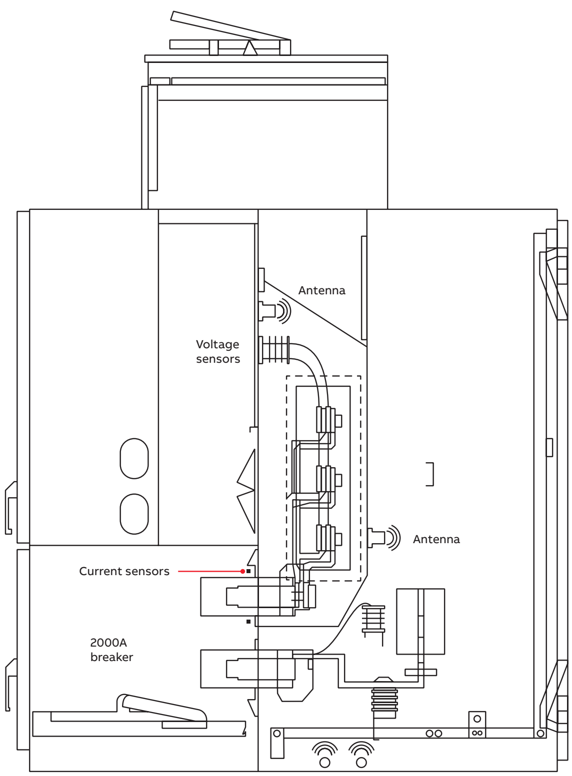

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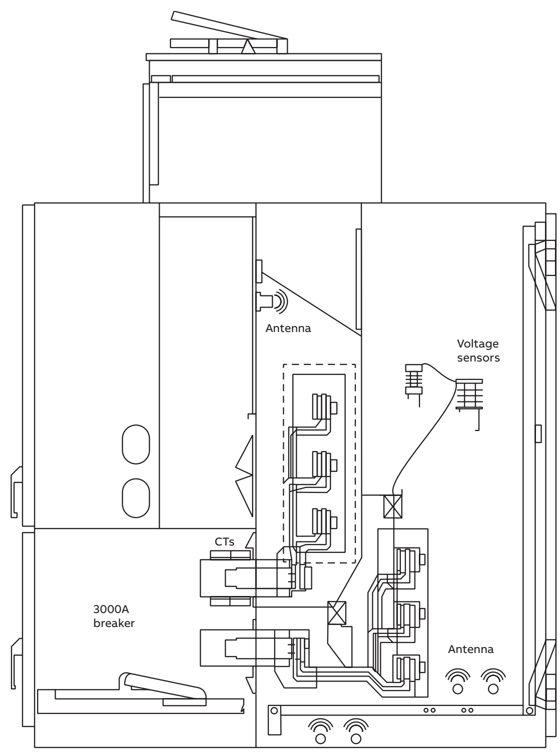

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All configurations shown above are available in all product lines and ratings.

Many configurations will require custom designs in the bus work as the there is much flexibility in the location of the voltage sensors.

There is less flexibility in locating the voltage sensors in arc-resistant switchgear due to the challenges of maintaining arc-resistant integrity, but as you can see from the location examples, most all application needs should be able to be addressed.

Maintaining electrical clearances as defined by the ABB standards is one of the most critical aspects when mounting voltage sensors. The primary cable connection must also be within the standard electrical clearances.

Due to the compartment segregation requirements of metal-clad switchgear, it may be necessary to enclose these voltage sensors within compartments. However, this would not be a concern during normal operations as there are no fuses or maintenance concerns that require accessing voltage sensors once they are installed and in service.

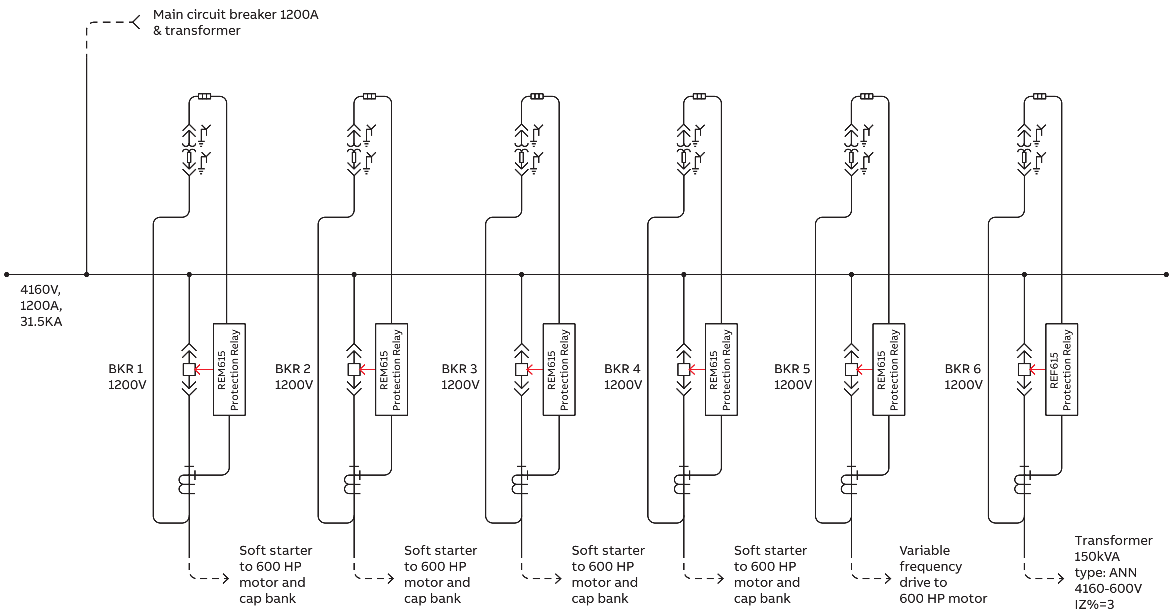
Locations of the voltage sensors should also consider the accessibility of the primary cables and should not be in location that would restrict the access to the installation of these cables wherever possible.

Contact your local ABB representative for all configuration solutions.

Application examples

Following are examples of conventional vs digital single line diagrams and corresponding front arrangement views.

—
Example 1: Conventional Single Line Diagram



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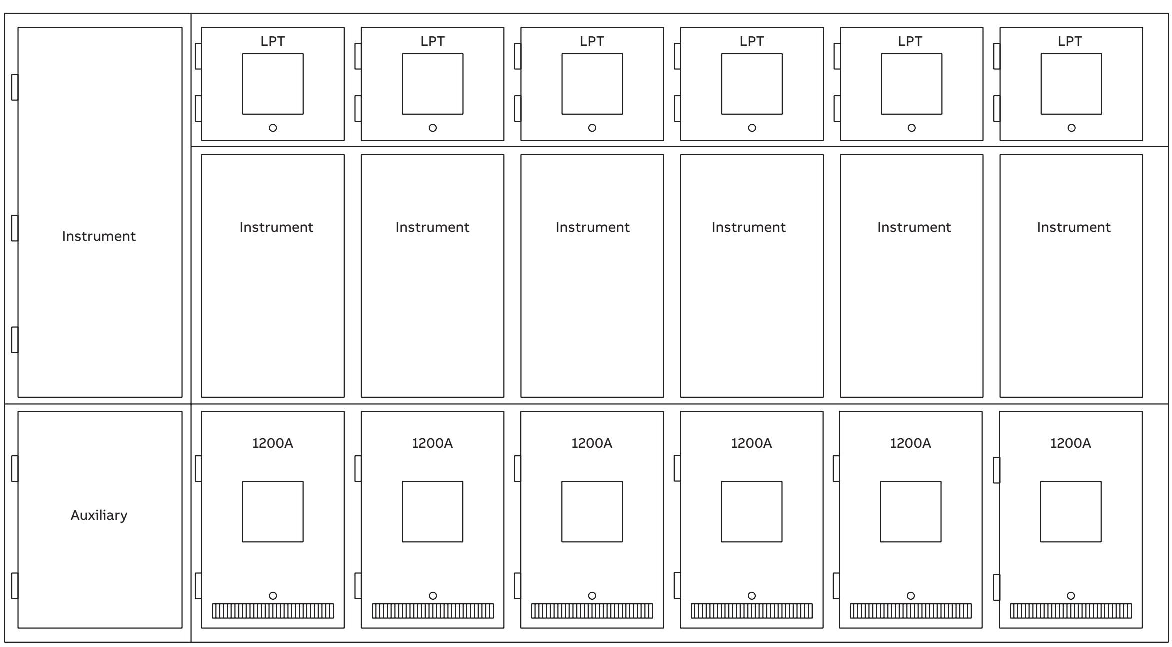
Example 2: Front View of ReliaGear ND Conventional



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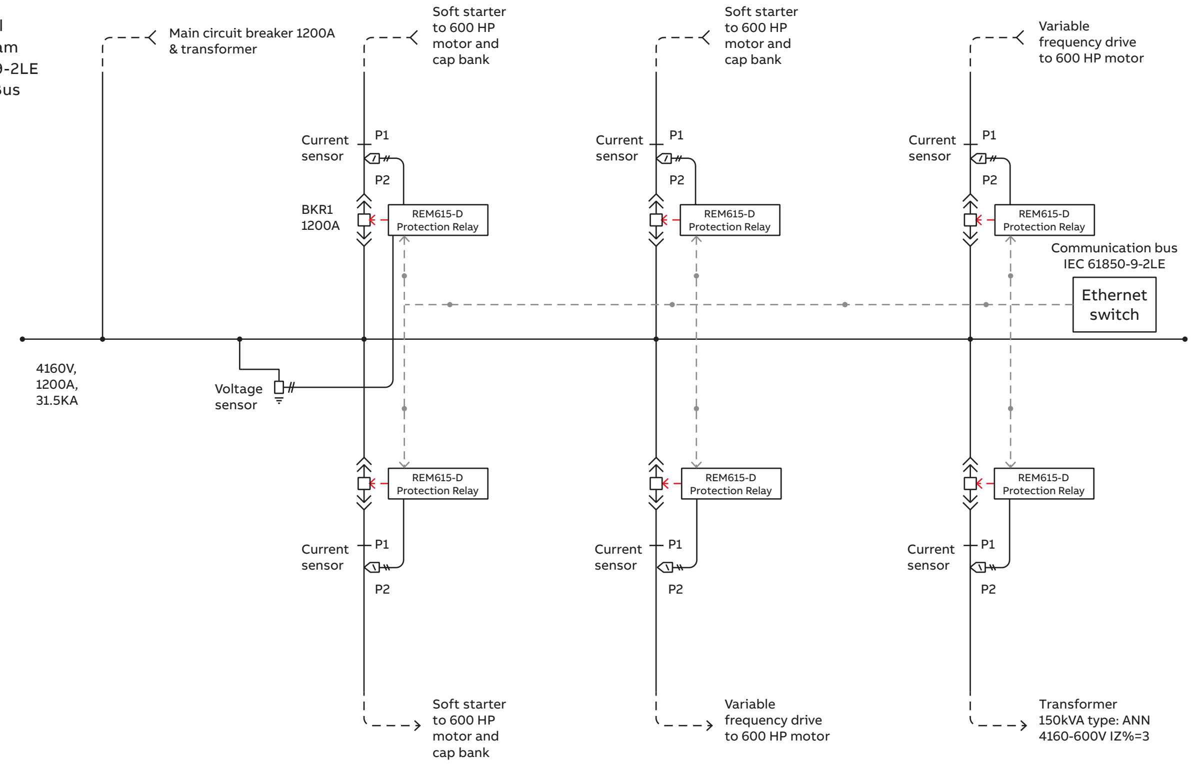
Example 3: Digital Single Line Diagram using IEC 61850-9-2LE Communication Bus



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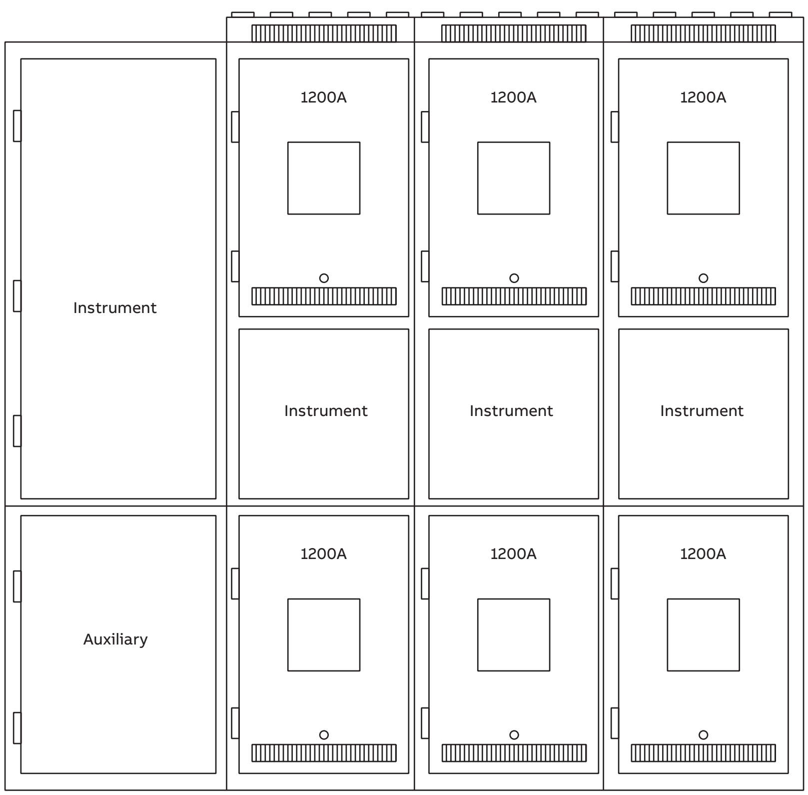
Example 4: Front View of ReliaGear ND Digital



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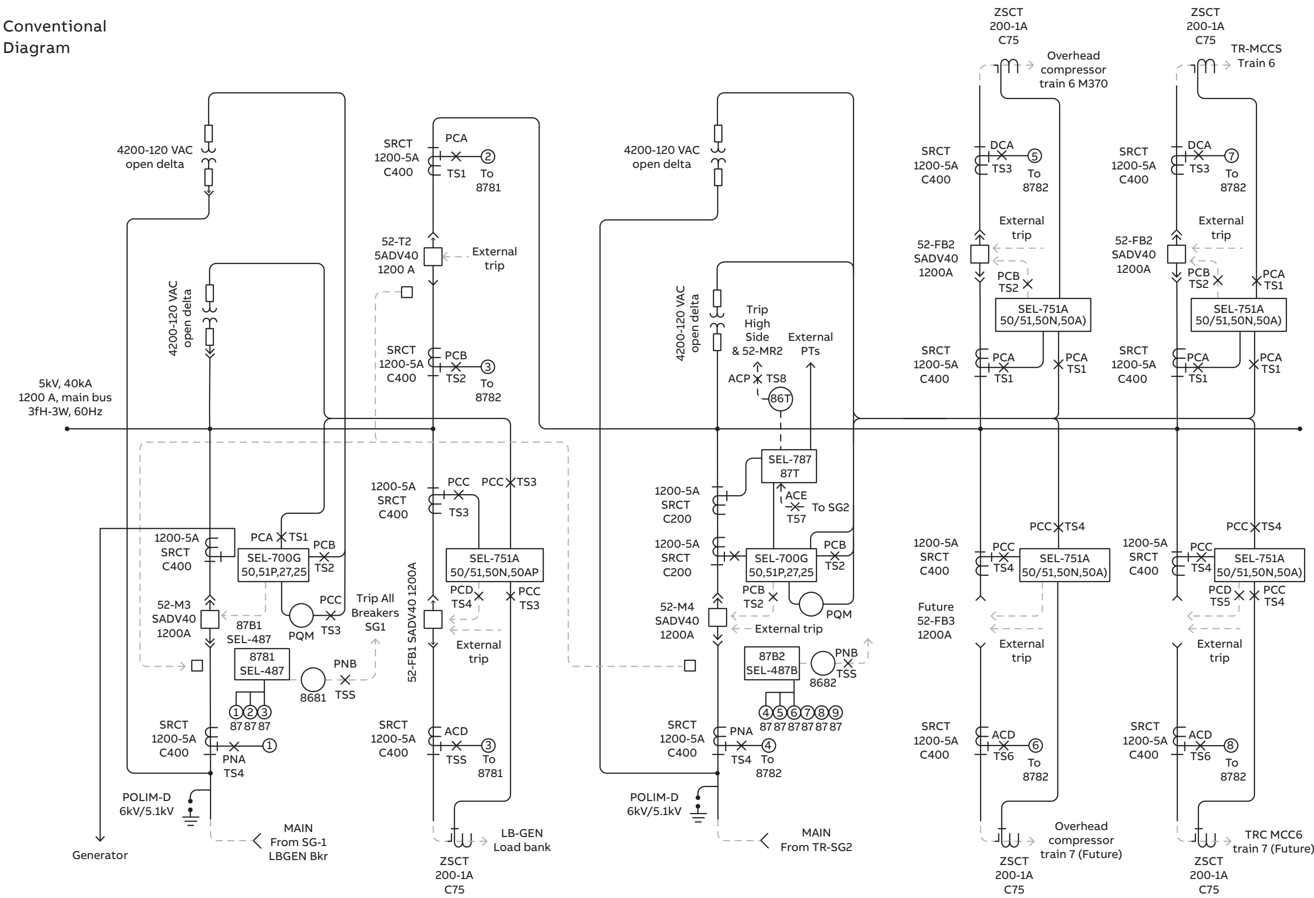
Example 5: Conventional Single Line Diagram



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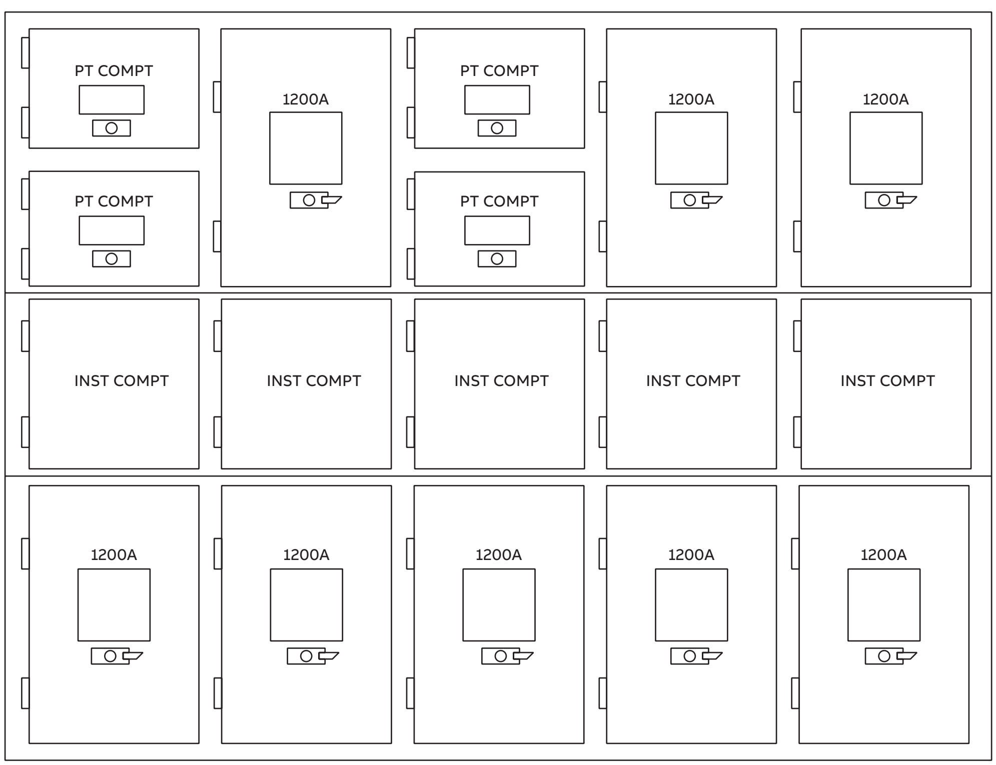
Example 6: Front View of Advance Conventional



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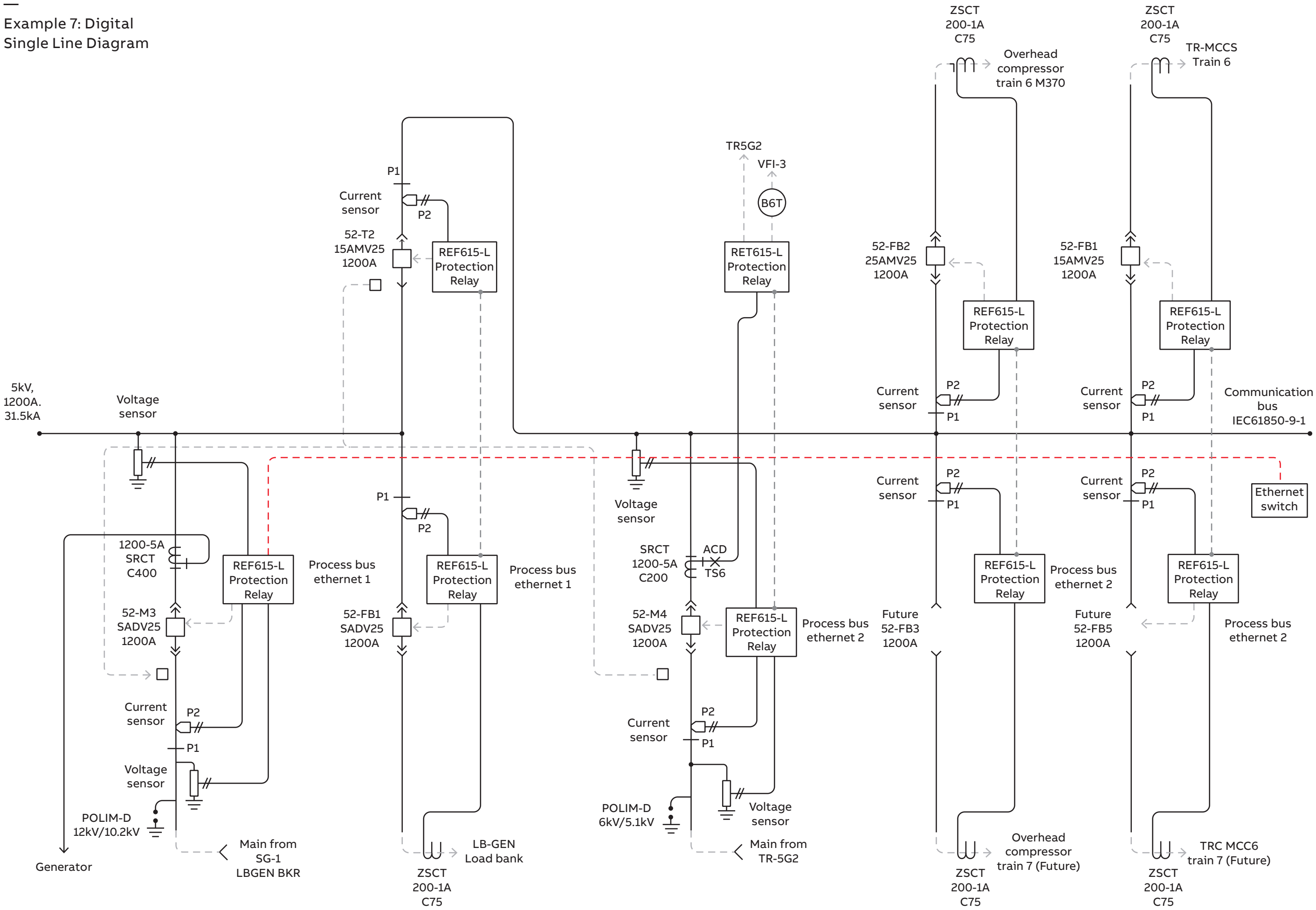
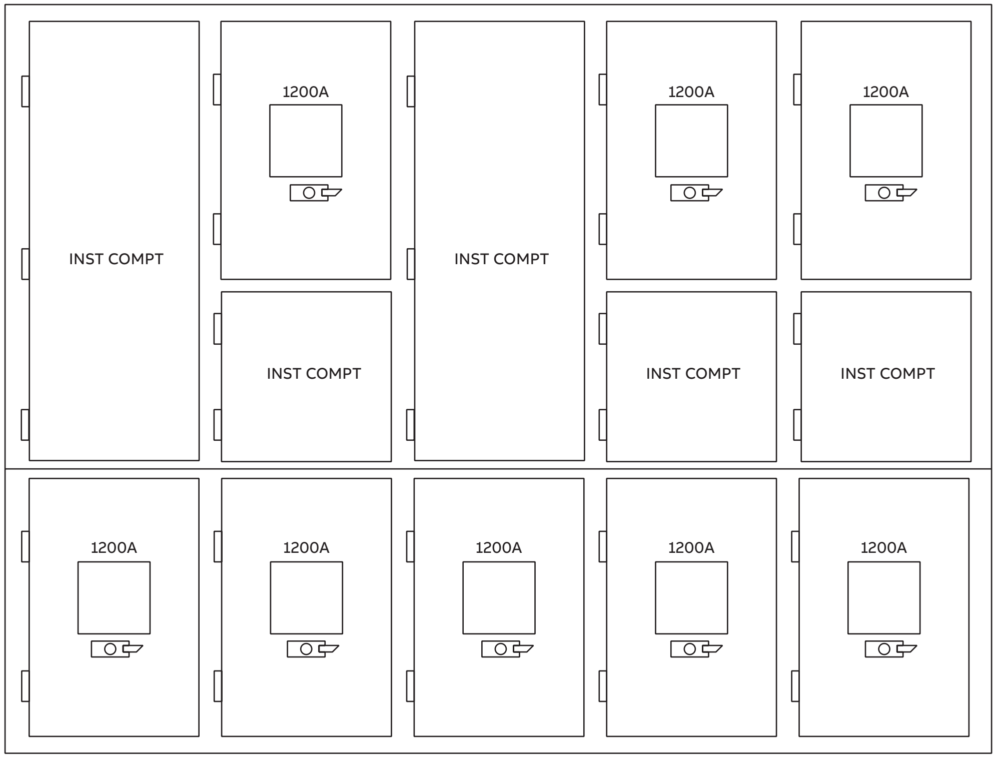
Example 7: Digital
Single Line Diagram



Note: When zero sequence ground current transformers are required, use the BYZ or BYS GCTs with 0-1A output and order the Relion relay with the 0.2/1A ground input and the Low Energy Analog (LEA) phase current inputs.

Example 8: Front View of Advance Digital



As you can see from Example 2, you may not always be able to reduce the number of frames but can always reduce the amount of wiring and increase protection and control scheme flexibility.

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