MITSUBISHI ELECTRIC

Numerical Protection Relay

MELPRO™-D Series

BIASED DIFFERENTIAL RELAY FOR TWO WINDING TRANSFORMER PROTECTION

MODEL

CAC1-A01D2

INSTRUCTION MANUAL

Request

Ensure that this Instruction Manual is delivered to the end users and the maintenance manager.

－ Safety section －

This Safety section should be read before starting any work on the relay. Be sure to read the instruction manuals and other related documents prior to commencing any work on the relay in order to maintain them in a safe condition. Be sure to be familiar with the knowledge, safety information and all caution items of the product prior to use.

CAUTION	Caution means that failure to un-observe safety information, incorrect use, or improper use may endanger personnel and equipment and cause personnel injury or physical damage.

Items as classified to the caution may become to occur more sever results according to the circumstance. Therefore, all items described in the safety section are important and to be respected without fail.

CAUTION

1. Items concerning transportation
   (1) Be sure the equipment to be kept in normal direction
   (2) Avoid the bumps, shock, and vibration, otherwise the product performance /life might be unfavorably affected.
2. Items concerning storage
   (1) Environment shall be as below, otherwise the product performance/life might be unfavorably affected.
   -Ambient temperature: -20℃～+60℃ (with no condensation nor freezing)
   -Relative humidity: 30~80% average of a day
   -Altitude: Less than 2000m
   -Avoid applying unusual shock, vibration or leaning or magnetic field
   -Not expose to harmful smoke, gas, salty air, water, vapor, dust, powder, explosive material or wind, rain.
3. Items concerning mounting/wiring work
   (1) Mounting and wiring work should be done correctly.
   Otherwise, damage, burning or erroneous operation might occur.
   (2) Screw terminal should be tightened securely.
   Otherwise, damage and burning might occur.
   (3) Grounding should be done correctly in case it is required.
   Otherwise, electric shock, damage, burning or erroneous operation might occur.
   (4) Wiring should be done without mistake especially observing the correct polarity.
   Otherwise, damage, burning or erroneous operation might occur.
   (5) Wiring should be done without mistake especially observing the phase ordering.
   Otherwise, damage, or erroneous operation might occur.
   (6) Auxiliary power source, measuring transformer and power source which have enough capacity for correct operation of product should be used.
   Otherwise, an erroneous operation might occur.
   (7) Be sure to restore the front cover, terminal cover, protection cover, etc to the original position, which have been removed during the mounting/ wiring work.
   Otherwise, electrical shock might occur at the time of checking.
   (8) Connection should be done correctly using designated and right connectors.
   Otherwise, damage or burning might occur.
   (9) Fully insert the sub unit into the case until you can hear a click while pressing the handles located on both sides of the sub unit front face.
   Otherwise, incomplete inserting the sub unit might only establish a poor contact with the terminals located on the back side of unit, which might cause erroneous operation or heating.
4. Concerning equipment operation and settings
   (1) Operational condition should be as below.
   Otherwise, the product performance/life might be unfavorably affected.
   -Deviation of auxiliary power: within +10%~-15% of rated voltage
   -Deviation of frequency: within ±5% of rated frequency
   -Ambient temperature: 0℃～+40℃ (-10℃～+50℃ is permissible during couples of hour per day, with no condensation nor freezing)
   -Relative humidity: 30~80% average of a day
   -Altitude: Less than 2000m
   -Avoid to be exposed to unusual shock, vibration, leaning or magnetic field
   -Not expose to harmful smoke, gas, salty air, water, vapor, dust, powder, explosive material, wind or rain.

(2) Qualified personnel may work on or operate this product, otherwise, the product performance/life might be unfavorably affected and/or burning or erroneous operation might occur.
(3) Be sure to read and understand the instruction manuals and other related documents prior to commencing operation and maintenance work on the product. Otherwise, electrical shock, injury, damage, or erroneous operation might occur.
(4) While energizing product, be sure not to remove any unit or parts without permissible one. Otherwise, damage, or erroneous operation might occur.
(5) While energizing product, be sure to make short circuit of current transformer secondary circuits before setting change or drawing out the sub unit. Otherwise, secondary circuit of live current transformer might be opened and damage or burning might occur due to the high level voltage.
(6) While energizing product, be sure to open trip lock terminal before setting change or drawing out the internal unit of product. Otherwise, erroneous operation might occur.
(7) Be sure to use the product within rated voltage and current.
Otherwise, damage or mal-operation might be occurred.
(8) While energizing product, be sure not to clean up the product.
Only wiping a stain on the front cover of product with a damp waste might be allowable. (Be sure to wring hardly the water out of the waste.)

5. Items concerning maintenance and checking
(1) Be sure that only qualified personnel might work on or operate this product.
Otherwise, electrical shock, injury, damage, or erroneous operation might occur.
(2) Be sure to read and understand the instruction manuals and other related documents prior to commencing operation and maintenance work on the product. Otherwise, electrical shock, injury, damage, or erroneous operation might occur.
(3) In case of replacing the parts, be sure to use the ones of same type, rating and specifications, etc.
If impossible to use above parts, be sure to contact the sales office or distributor nearest you.
Otherwise, damage or burning might occur.
(4) Testing shall be done with the following conditions.
-Ambient temperature: 20℃±10℃
-Relative humidity: Less than 90%
-Magnetic field: Less than 80A/m
-Atmospheric pressure: 86~106×10^3 Pa
-Installation angle: Normal direction±2°
-Deviation of frequency: within ±1% of nominal frequency
-Wave form(in case of AC): Distortion factor less than 2%
(Distortion factor=100%×effective value of harmonics/effective value of fundamental)
-Ripple (in case of DC): Ripple factor less than 3%
(Ripple factor=100%×(max-min)/average of DC)
-Deviation of auxiliary power: within ±2% of nominal voltage
-Be sure not to inject the voltage or current beyond the overload immunity.
Otherwise, damage or burning might occur.
-Be careful not to touch the energized parts.
Otherwise, the electric shock might occur.

6. Items concerning modification and/or repair work
Be sure to ask any modification and/ or repair work for product to the sales office or distributor nearest you.
Unless otherwise, any incidents occurred with modification or repair works (including software) done by any other entity than MITSUBIHI ELECTRIC CORPORATION shall be out of scope on warranty covered by MITSUBISHI ELECTRIC CORPORATION.

7. Items concerning disposal
Particular regulations within the country of operation shall be applied to the disposal.

- Introduction -

Thank for your purchasing MITSUBISHI ELECTRIC **MELPRO** TM – D Series Digital Protection Relay.

Please read this manual carefully to be familiar with the functions and performances enough to use the product properly.

It is necessary to forward end users this instruction manual.

For operation of the product, this manual should be used in conjunction with the following materials:

Title of document	Document No.
MELPRO – D Series Protection Relay General Operation Manual	JEP0-IL9416

When the protection relay is used together with a communication card, use the following documents too:

(For CC-Link)

Title of document	Document No.
MELPRO – D Series Protection Relay CC-COM Communication Card (CC-Link) Operation Manual (General information)	JEP0-IL9517
MELPRO – D Series Protection Relay CC-COM Communication Card (CC-Link) Operation Manual (Model-specific information)	JEP0-IL9418

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1 Features

1.1 General description

Mitsubishi Electric MELPRO-D Series is a digital protection relay product with a microprocessor for protecting high/extra-high-voltage electric power system.

With its improved functions, including operation support using the advanced communication networks, data saving at the power system faults and power system voltage/current measurement, this series of protection relay will allow stable and effective control and monitoring of electric power systems as well as provide high-reliable protection.

1.2 Features

(1) High-reliable protection

CAC1-A01D2 relay contains a 3-phase biased differential protection element and a 3-phase differential overcurrent protection element. Just this one relay is enough to protect a transformer. In addition, it also contains a 3-phase second-harmonic blocking element in order to avoid incorrect operation caused by inrush current.

(2) Communication Network (With the addition of optional communication card)

- With an open field bus system, the relays can be used to build a high-speed, high-performance network system. In addition, the relay's multi-drop serial wiring reduces the amount of labor required for communication wiring.
- Monitoring of measurement values, operation status, as well as setting changes, etc., can be performed from a remote location.
- In consideration of future network system variations and compatibility with communication networks, communication features are mounted in the relay using a replaceable card.

(3) Measurement & Recording Functions

- Real time monitor of relay input data

  The relay can measure steady state relay input values, supporting energy management.
- Fault Data Monitor

  When a fault occurs, the relay saves the past 5 effective input values, and waveform data and 2nd harmonic component ratio to assist with fault analysis.

(4) Programmable Output Configuration

The operating output contacts (DO) can be set by combining the outputs of the protection relay element using 'OR' logic, thereby simplifying sequence design.

(5) High Accurate Digital Computation

The digital computation using high-speed sampling minimizes the effect of high harmonics, etc., and results in highly accurate protection.

(6) Self-diagnosis

The relay continuously monitors electronic circuits from input to output so that it can detect internal failure before that failure causes damage on the power system, thereby improving reliability.

(7) Easy Replacement

The dimensions of the panel cutout are the same as the prior MULTICAP series. Changing from an existing relay type to this new type is easy.

(8) Easy Maintenance

The relays are adopted as draw-out unit mechanisms with automatic CT shorting at drawing, thereby making maintenance easy.

(9) Easy wiring check

It is possible to carry out forced operation of the output contacts individually. This will allow an easy wiring check.

2 Ratings and specifications

2.1 General information

<table>
<tr><td colspan="3">Type name</td><td colspan="5">CAC1-A01D2</td></tr>
<tr><td rowspan="2">Style</td><td colspan="2">Without direct communication port</td><td>302PMB</td><td>303PMB</td><td>326PMB</td><td colspan="2">327PMB</td></tr>
<tr><td colspan="2">With direct communication port</td><td>561PMB</td><td>562PMB</td><td>563PMB</td><td colspan="2">564PMB</td></tr>
<tr><td rowspan="4">Elements</td><td colspan="2" rowspan="3">Protection</td><td colspan="5">Biased differential element × 3</td></tr>
<tr><td colspan="5">2nd harmonic blocking element × 3</td></tr>
<tr><td colspan="5">Differential overcurrent element × 3</td></tr>
<tr><td colspan="2">Measurement</td><td colspan="5">Restraining current, Differential current, 2f harmonic component ratio</td></tr>
<tr><td rowspan="4">Ratings</td><td colspan="2">Frequency</td><td>50 Hz</td><td>60 Hz</td><td>50 Hz</td><td colspan="2">60 Hz</td></tr>
<tr><td colspan="2">Phase current</td><td colspan="2">5 A *20</td><td colspan="3">1 A *20</td></tr>
<tr><td rowspan="2">Auxiliary power supply *21</td><td>Voltage</td><td colspan="5">Common use for 100 ~ 220VDC / 100 ~ 220VAC</td></tr>
<tr><td>Operative range</td><td colspan="5">DC : 85 ~ 242 V (Range of 80 ~ 286VDC is allowable temporarily.)
AC : 85 ~ 242 V (Range of 80 ~ 253VAC is allowable temporarily.)</td></tr>
<tr><td rowspan="4">Display</td><td colspan="2">RUN</td><td colspan="5">Indicate the result of self-diagnosis. The lamp is lit for normal conditions and off for abnormal.</td></tr>
<tr><td colspan="2">Unit</td><td colspan="5">Indicate the unit symbol for measurements.</td></tr>
<tr><td colspan="2">Item No., Item data</td><td colspan="5">Display measurement, status, setting and option data selected with an item number.</td></tr>
<tr><td colspan="2">Communication</td><td colspan="5">With a communication card installed: the lamp is lit for normal conditions, blinking during communication and off for abnormal.
With a communication card not installed: the lamp is off.</td></tr>
<tr><td colspan="3">Self-diagnosis</td><td colspan="5">Monitor the electronic circuit and internal power supply to output signal to the RUN LED and self-diagnosis output (ALARM).</td></tr>
<tr><td rowspan="7">Output contacts</td><td rowspan="3">Configurations</td><td>For trip</td><td colspan="5">2 make contacts: X_4 and X_5 (programmable output)</td></tr>
<tr><td>For signaling</td><td colspan="5">4 make contacts: X_0 to X_3 (programmable output)</td></tr>
<tr><td>For self-diagnosis output</td><td colspan="5">1 break contact: Y (open for normal result of self-diagnosis with power on)</td></tr>
<tr><td rowspan="6">Capacity</td><td rowspan="3">For trip</td><td>Make</td><td colspan="4">110VDC, 15A, 0.5 s (L/R = 0 s)
220VDC, 10A, 0.5 s (L/R = 0 s)</td></tr>
<tr><td>Break</td><td colspan="4">110VDC, 0.3A (L/R ≤ 40 ms)
220VDC, 0.15A (L/R ≤ 40 ms)</td></tr>
<tr><td>Carry</td><td colspan="4">1.5 A , continuously</td></tr>
<tr><td rowspan="3">For signaling and self-diagnosis output</td><td>Make and break</td><td colspan="4">500 VA (cosφ= 0.4), 60W (L/R = 0.007 s)</td></tr>
<tr><td>Max. current</td><td colspan="4">5 A</td></tr>
<tr><td>Max. voltage</td><td colspan="4">380VAC, 125VDC</td></tr>
<tr><td rowspan="2">Communication</td><td colspan="2">Direct communication port</td><td colspan="5">Standard equipment (PC software for direct communication) : option</td></tr>
<tr><td colspan="2">Remote communication card</td><td colspan="5">Option for CC-Link</td></tr>
<tr><td rowspan="2">Burden</td><td colspan="2">Phase current circuit</td><td colspan="5">0.5 VA or less (with rated current)</td></tr>
<tr><td colspan="2">Auxiliary power supply circuit</td><td colspan="5">100VDC : approx. 7W (approx. 9W including communication card)
100VAC : approx. 25VA (approx. 27VA including communication card)
220VDC : approx. 9W (approx. 11W including communication card)
220VAC : approx. 30VA (approx. 32VA including communication card)</td></tr>
<tr><td colspan="3">Mass</td><td colspan="5">Net weight of relay unit : approx. 3.8 kg
Including case : approx. 5.0 kg</td></tr>
<tr><td colspan="3">Case/cover</td><td colspan="5">Size : D2 type</td></tr>
</table>

*20 Permissible continuous current value is 8.7A(for 5A rating) and 1.7A (for 1A rating).

*21 When an uninterruptible AC power source is not provided in your system for the auxiliary supply voltage, use the type B-T1 backup power supply or commercially available uninterruptible power supply (UPS).
Type B-T1 back up power supply unit can be applied for DASH series protection relay with 100V～200V auxiliary power supply voltage rating only.
In addition, the power supply duration of the type B-T1 back up power supply is confirmed about 2 seconds in combination with one MELPRO-D series relay. Therefore, in the case that the required power supply duration after power source loss exceeds 2 seconds, please use a suitable commercial uninterruptible power supply.
When the power supply back up for the control power supply of a circuit breaker is required, it is necessary to prepare the backup power supply different from the type B-T1 back up power supply.

2.2 Protection element

<table>
<tr><td rowspan="2">Style</td><td colspan="2">Without direct communication port</td><td>302PMB</td><td>303PMB</td><td>326PMB</td><td>327PMB</td></tr>
<tr><td colspan="2">With direct communication port</td><td>561PMB</td><td>562PMB</td><td>563PMB</td><td>564PMB</td></tr>
<tr><td rowspan="6">Settings</td><td rowspan="4">Biased differential protection</td><td>Matching tap 1
(I_{T1}(I_T))</td><td colspan="2">2.2 ~ 12.5A
(0.1A step)</td><td colspan="2">0.44 ~ 2.5A
(0.02A step)</td></tr>
<tr><td>Matching tap 2
(I_{T2}(I_T))</td><td colspan="2">2.2～12.5A
(0.1A step)</td><td colspan="2">0.44 ~ 2.5A
(0.02A step)</td></tr>
<tr><td>Operation current</td><td colspan="4">I_T×(LOCK—20—30—40%)</td></tr>
<tr><td>Bias
(τ=Differential current/Restraining current)</td><td colspan="4">20—30—40-%</td></tr>
<tr><td>DIF test *22</td><td colspan="4">oFF(When running)-on(When testing)</td></tr>
<tr><td>2nd harmonic blocking</td><td>2nd harmonic blocking ratio</td><td colspan="4">2nd harmonic component (If2)/ fundamental component (If1)=10~25%
(5% step)</td></tr>
<tr><td>Differential overcurrent</td><td>Operation current</td><td colspan="4">I_T×(5~12) (1 step)</td></tr>
<tr><td colspan="3">Forced operation</td><td colspan="4">Forced operation is available for any trip or signaling contacts individually.</td></tr>
<tr><td colspan="3">Operation indication</td><td colspan="4">When the relay operates, the operation indicator LED (red) will come on. And when 2nd harmonic wave is found out, the detection LED (yellow) comes on.</td></tr>
</table>

*22 When “DIF test” is set “on”, the single phase relay test can be carried out with the differential current monitor blocked.

2.3 Measurement elements

Style	Without direct communication port			302PMB	303PMB	326PMB	327PMB
	With direct communication port			561PMB	562PMB	563PMB	564PMB
Display	Restraining current	Real time	Measurement	Effective current in stationary state [multiplying factor against I_T]			
			Range *	0~9999[%]			
			Update	Approx. 200ms			
		Max. records	Measurement	Max. effective current [multiplying factor against I_T]			
			Range *	0~9999[%]			
		Fault records	Measurement	Effective current when tripping [multiplying factor against I_T]			
			Range *	0~9999[%]			
	Differential current	Real time	Measurement	Effective current at stationary state [multiplying factor against I_T]			
			Range *	0~9999[%]			
			Update	Approx. 200ms			
		Max. records	Measurement	Max. effective current [multiplying factor against I_T]			
			Range *	0~9999[%]			
		Fault records	Measurement	Effective current when tripping [multiplying factor against I_T]			
			Range *	0~9999[%]			
	2f component ratio	Real time	Measurement	If2/ If1 at stationary state			
			Range *	0~9999[%]			
			Update	Approx. 200ms			
		Fault records	Measurement	If2/ If1 when tripping			
			Range *	0~9999[%]			

* The form of display depends on value range as shown in the tables below.
When displaying value exceeds the maximum of the range, display will be blinked with the maximum value.

Display range	Display form
0~9[%]	□[%]

Display range	Display form
10~99[%]	□□[%]

Display range	Display form
100~999[%]	□□□[%]

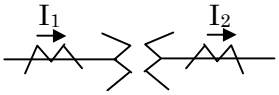
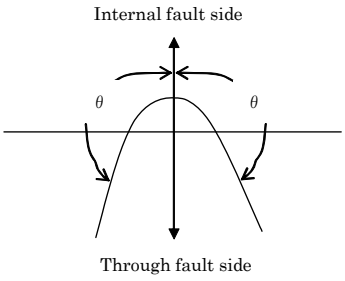
Display range	Display form
1000~9999[%]	□□□□[%]

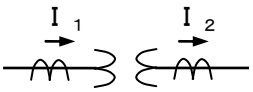
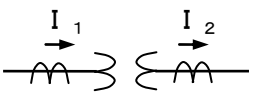
*When a communication card is connected, wave form data in the case of the power system fault can be monitored.
(See the section 4 “Function”).

3 Characteristics

Common conditions	(1) Rated frequency:±1% (2) Aux. supply voltage : Rated voltage ±2% (3) Ambient temperature: 20°C±10°C	The conditions shown on the left should be applied unless otherwise specified.

3.1 Protective elements

Items		Conditions	Guaranteed performance
Operation value	Biased differential element	Iop=I_T×Operation current (%)	Within ±5% of Iop
	Differential overcurrent element	Iop=I_T×Differential overcurrent	
Reset value	Biased differential element	Iop=I_T×Operation current (%)	Operation value×95%or more
	Differential overcurrent element	Iop= I_T×Differential overcurrent	
Operation time	Biased differential element	0[A] →Iop×300%	50ms or less
	Differential overcurrent element	0[A] → Iop×300%	40ms or less
Reset time	Biased differential element	Iop×300% →0[A]	Within 200±25ms
	Differential overcurrent element	Iop×300% →0[A]	
Biased differential characteristics		Matching tap $I_{T1} = I_{T2} = I_T$ At minimum matching tap setting $I_2 = I_T \times 200\%$ Bias $\tau = \dfrac{\lvert I_1 - I_2 \rvert}{I_1 \text{ or } I_2^*}$ (* Whichever is greater) 	When τ = 20% setting τ = 15%～25% When τ = 30% setting τ = 25%～35% When τ = 40% setting τ = 35%～45%
Phase characteristics		At minimum matching tap setting $\lvert I_1 \rvert = \lvert I_2 \rvert$ $=I_T \times 200\%$ 	Both lead and lag operation phase angle between I_1 and I_2 are shown below: Nominal bias ratio / θ 20 [%] / 168.5±5° 30 [%] / 162.7±5° 40 [%] / 156.9±5°
2nd harmonic blocking characteristics		At minimum matching tap setting $I_{DC} = I_T \times 80\%$ *Refer to the 8.2.2 characteristic test circuit	Setting value : 10% I_{AC} = 254～330% (※) Setting value : 15% I_{AC} = 137～188% (※) Setting value : 20% I_{AC} = 81～119% (※) Setting value : 25% I_{AC} = 47～77% (※) ※:Range to be possible to block
		In case of 2nd harmonic current superposing method If1=I_T×300%	2nd restraining ratio: Setting value±10%

Items		Conditions		Guaranteed performance
Auxiliary supply voltage deviation characteristic	Operation value / Reset value	(1)Rated frequency (2) Rated deviation range of Aux, supply voltage		± 5% or less of operation/resent value at rating aux, voltage.
	Operation time / Reset time	(1)Rated frequency (2)Rated deviation range of Aux, supply voltage		±5% ms or less at rating aux, voltage.
	Biased differential characteristics	(1)Rated frequency (2)Rated deviation range of Aux, supply voltage (3)At minimum matching tap and $I_2 = I_1 \times 200\%$ 		In response to the τ at rating aux, voltage, When τ = 20% τ = 15%～25% When τ = 30% τ = 25%～35% When τ = 40% τ = 35%～45%
	Phase characteristics	(1)Rated frequency (2)Rated deviation range of Aux, supply voltage (3) $\lvert I_1 \rvert = \lvert I_2 \rvert = I_T \times 200\%$		± 5% or less of phase angle at rating aux, voltage.
Frequency characteristics	Operation value / Reset value	(1)Rated aux, voltage (2)Frequency deviation ±5% of rated frequency		±5% or less of the value at the rated frequency
	Operation time / Reset time	(1) Rated aux, voltage (2)Frequency deviation ±5% of rated frequency		±5 on less of τ at the rated frequency
	Biased differential characteristics	(1)Rated aux, supply voltage (2)At minimum matching tap and $I_2 = I_T \times 200\%$ (3)Frequency deviation±5% of rated frequency		±5 on less of τ at the rated frequency
	Phase characteristics	(1)Rated aux, supply voltage (2) $\lvert I_1 \rvert = \lvert I_2 \rvert = I_T \times 200\%$ (3)Frequency deviation±5% of rated frequency		± 5% or less of phase angle at the rated frequency.
Temperature characteristics	Operation value / Reset value	(1)Rated frequency (2)Rated aux supply voltage	20℃±20℃	±5% or less of the value at 20℃
			20℃±30℃	± 10% or less of the value at 20℃
	Operation time / Reset time	(1)Rated frequency (2)Rated aux supply voltage	20℃±20℃	± 5 ms or less of the value at 20℃
			20℃±30℃	
	Biased differential characteristics	(1)Rated frequency (2)Rated aux supply voltage (3) $I_2 = I_T \times 200\%$ 	20℃±20℃	±5 or less of the value at 20℃
			20℃±30℃	±10 or less of the value at 20℃
	Phase characteristics	(1)Rated aux, supply voltage (2) $\lvert I_1 \rvert = \lvert I_2 \rvert = I_T \times 200\%$ (3)Frequency deviation±5% of rated frequency		±5 or less of the value at 20℃
				±10 or less of the value at 20℃

Items	Conditions	Guaranteed performance
Relative humidity characteristics	Temperature ：40℃ Relative humidity ： 95％RH （no condensed） Testing duration ：4 days	Operation value ±5% or less of the value at normal condition Operation time ± 10% or less of the value at normal condition Phase angle ±5° or less of the value at normal condition

*31 Mitsubishi electric corporation adopt the scheme that maximum current is applied for restrain current.
Therefore, biased differential characteristics is calculated such as the differential current divided by the maximum current.
On the other hand, biased differential characteristics calculated by outflow current base scheme is described in the following table.
（I_{DIF}：Differential current、I_{RES}：Restrain current、I_2：outflow current）

$\frac{I_{DIF}}{I_{RES}}$ Ratio	I_1 Inflow	I_2 Flow-out	I_{DIF} Differential current	$\frac{I_{DIF}}{I_2}$ Ratio
２０％	２５０％	２００％	５０％	２５％
３０％	２８６％	〃	８６％	４３％
４０％	３３３％	〃	１３３％	６６．５％

(Adopted scheme by Mitsubishi electric corporation.) (outflow current base scheme)

3.2 Common technical data

ITEM		DESCRIPTION	CONDITION	STANDARD
Environment	Ambient operating temperature	-10°C to +55°C		IEC60255-6
	Ambient storage and transport temperature	-25°C to +70°C		IEC60255-6
	Damp heat	+40°C, 95%RH, 4 days		IEC60068-2-3
Thermal withstand	VT	1.15Vn, 3h		
	CT	40In, 1s		
Dielectric test	Circuit of 60V or below	500VAC, 1min.	1) Between each circuit and the exposed conductive parts, the terminals of each independent circuit being connected together 2) Between independent circuits, the terminals of each independent circuit being connected together	IEC60255-5
	Circuit of more than 60V and 500v or below	2000VAC 1min.		
	Open contact	1000VAC, 1min.	Between open contact poles	
Impulse voltage test		5kV, 1.2μs/50μs	1) Between each circuit and the exposed conductive parts, the terminals of each independent circuit being connected together 2) Between independent circuits, the terminals of each independent circuit being connected together	IEC60255-5
High-frequency disturbance test	Common mode	2.5kV peak, 1MHz with 200Ω source impedance for 2s	Between independent circuits, and between independent circuit and earth	IEC60255-22-1 class 3
	Differential mode	1.0kV peak, 1MHz with 200Ω source impedance for 2s	Across terminals of the same circuit	
Electrostatic discharge test		8kV	Contact discharge	IEC60255-22-2 Class 4
		15kV	Air discharge	
Radiated electromagnetic field disturbance test		68 to 87Mhz 146 to 174MHz 420 to 470MHz		IEC60255-22-3 class 3
Fast transient disturbance test		2.0kV, 5ns/50ns, 1min		IEC60255-22-4
Vibration test		Refer to class 1		IEC60255-21-1 Class 1
Shock response		Refer to class 2		IEC60255-21-2 Class 2
Shock withstand		Refer to class 1		IEC60255-21-2 Class 1
Bump		Refer to class 1		IEC60255-21-2 Class 1
Enclosure protection		IP51		IEC60529

Vn: Rated voltage, In: Rated current

4 Functions

4.1 Protection

4.1.1 Protection elements

Fig. 4.1 shows internal function block diagram of “Biased differential element and differential overcurrent element”.

In this relay, a differential element with bias blocking, a 2nd harmonic blocking element (2f blocking element) and a differential overcurrent element are provided for each phase protection of 2-winding transformer. Fig. 4.2 shows the biased differential characteristic. The relay output is blocked by the operation of the 2nd harmonic blocking element which is designed to detect the exciting inrush current generated at energizing the transformer. The internal or external fault can be distinguished by differential element with bias. And the internal heavy fault can be protected quickly by differential overcurrent element with instantaneous operation characteristic.

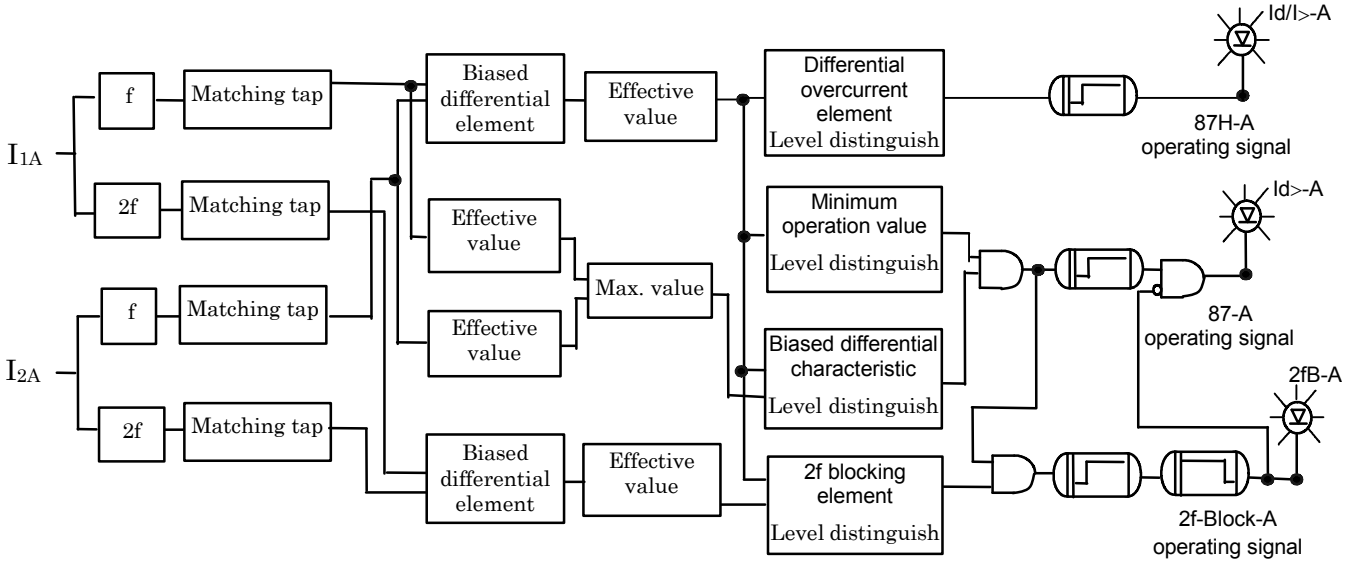


Figure 4.1 Biased differential element・Differential overcurrent element Internal function diagram (Only one phase expressed)

(1) Matching tap

The CT ratio and CT connection are designed to compensate the current difference between HV side and LV side as a consequence of the transformer ratio and winding connection so that current of HV side and LV side are become to almost same value.

To obtain perfectly same current value of HV side and LV side, matching tap installed in the relay can be applied.

The matching tap should be set according to that the current value calculated by the rated transformer operation current×rated input current of relay/setting of matching tap will be quite closer value of rated input current of relay.

(2) Biased differential

To detect the internal faults of transformer, current differential scheme can be applied in principle.

However, CT error in the condition of large current has to be considered in the actual application.

Then, biased differential scheme in which internal faults will be detected by the ratio between differential current and maximum current in circuit, is applied.

The definition of biased differential in the relay is as follows.

Biased differential = Differential current/Restraining current × 100%

Differential current: HV side current − LV side current

(The above equation is based on that generally the HV current is inflow and the LV current is outflow in the normal condition of transformer.)

Restraining current: | HV current | or | LV current | whichever is greater.

The following is the actual calculation executed in the relay.

$$\frac{(I_1 \cdot In/I_{T1} - I_2 \cdot In/I_{T2})}{(I_1 \cdot In/I_{T1} \text{ or } I_2 \cdot In/I_{T2} \text{ whichever is greater})} \geqq \frac{\tau}{100}$$

Minimum operating value

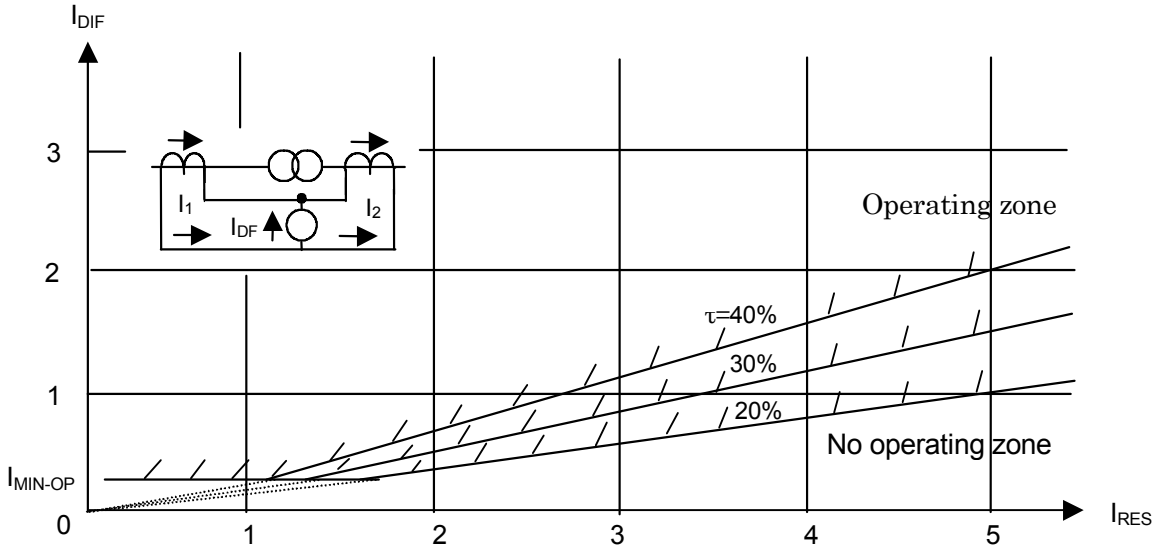
$(I_1 \cdot I_n/I_{T1} - I_2 \cdot I_n/I_{T2}) \geqq I_n \times$ (Setting value of operation current/100)

For example, minimum operating value at HV side I_{op} can be derived with I_2=0 as below.

$I_1 \geqq I_n/(I_n/I_{T1}) \times$ (setting of operation current/100) $\Rightarrow I_1 \geqq I_{T1} \times$ (setting of operation current/100)

(3) At the time of internal fault

At the time of internal fault, the differential current IDIF overcomes the restraining current IRES, so that the biased differential element operates with high-speed. Moreover, at the time of an internal fault with heavy fault current, the differential overcurrent element can operate instantaneously.



(Multiples of tap value current I_T)

I_{DIF} : *Differential current* $\left(I_1 \bullet \frac{I_n}{I_{T1}} - I_2 \bullet \frac{I_n}{I_{T2}} \right)$

I_{RES} : *Restraining current (Larger current of* $I_1 \bullet \frac{I_n}{I_{T1}}$, $I_2 \bullet \frac{I_n}{I_{T2}}$ *)*

$I_{Min.\,op}$: *Operating current (20%, 30%, 40% of matching tap value current* I_T *) (Setting value)*

τ : *Bias (20%, 30%, 40%) (Setting value)*

I_1, I_2 : *CT secondary current*

I_{T1}, I_{T2} : *Matching tap (Setting value)*

In : *Rated current*

Figure 4.2 Biased differential characteristic

(4) At the time of external fault

At the time of external fault, the relay does not operate, because no differential current is produced if Ct error is negligible. Moreover, even if CT saturation may arise due to a heavy external fault, the relay does not make any unwanted operation owing to the ratio differential characteristics.

(5) At the time of exciting inrush

In the exciting inrush current, a large quantity of 2nd harmonic component is included but in the internal fault current it is not so much included as shown on the below table. This difference is utilized and 2nd harmonic blocking principle is adopted for this relay so that unwanted operation due to the transformer inrush is prevented. Once the 2nd harmonic component is detected at the operation status of the biased differential element, the operation indication LED (yellow) comes on.

When 2nd harmonic component includes more than the setting value of 2nd blocking ratio, it operates and prevents the operation of biased differential element. So the unwanted operation caused by exciting inrush current can be prevented. There are two methods to lock the biased differential element by the operation of the 2nd harmonic blocking element; one is the All Phase OR Lock method (Once inrush is detected in any phase, all phases will be locked) and the other is the Segregated Phase Lock method (only the detected phase is locked). The two methods are switched automatically according to the following conditions:

a. The biased differential element is operating

b. The load terminal current* is nearly equal to 0

* I, or I_2 whichever smaller

Only in the case when above two conditions are met, the All Phase OR Lock method is adopted. Otherwise, the Segregated Phase Lock method is adopted. So it is possible to prevent the unwanted operation caused by exciting inrush current when power is switched on.

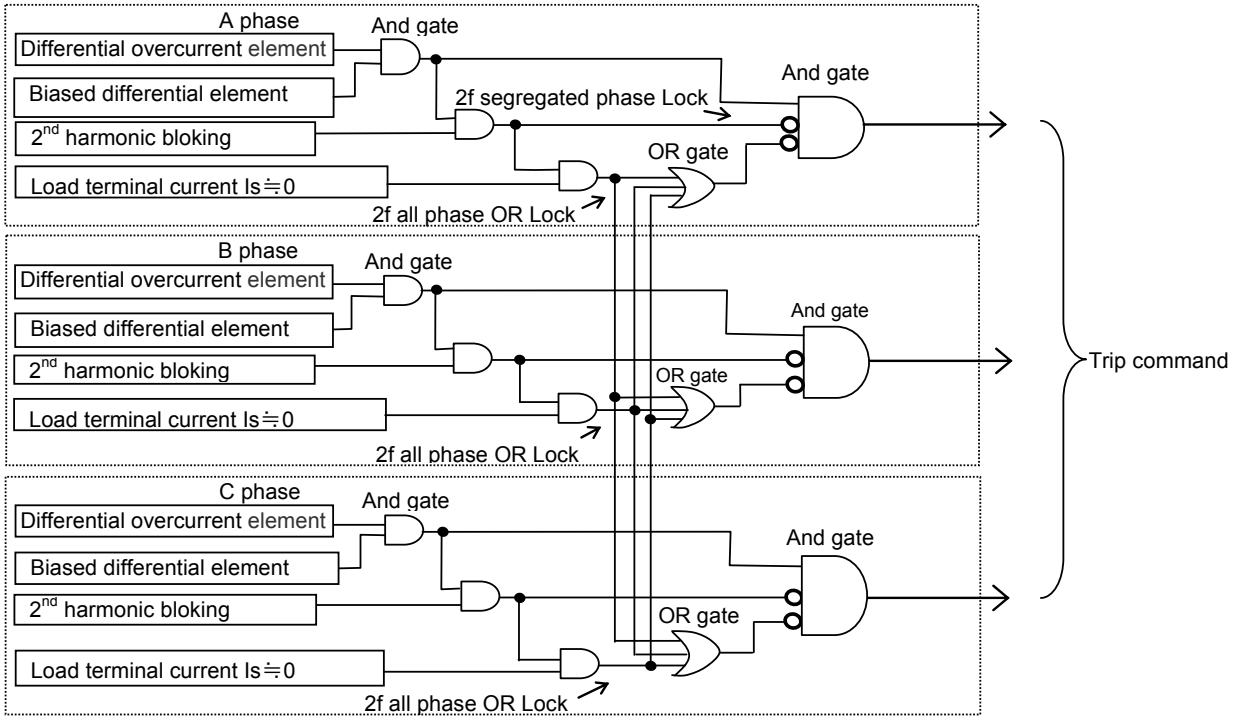


Figure4.3 Load terminal current Is＝1/2×setting value of biased differential element

Harmonic component ratio to fundamental component (%)

	Exciting inrush current			Internal fault current	
	1st cycle	2nd cycle	8th cycle	No CT saturation	CTsaturation
DC component	58	58	58	38	0
Fundamental component	100	100	100	100	100
2nd harmonic component	62	63	65	9	4
3rd harmonic component	25	28	30	4	32
4th harmonic component	4	5	7	7	9
5th harmonic component	2	3	3	4	2

4.1.2 General functions

(1) Operation indication

When operating signals come out for the biased differential element and differential overcurrent element, the corresponding operation indicator LED will come on instantaneously.

For the 2nd harmonic blocking element, when the 2nd harmonic component ratio of input current becomes more than the operation setting, the corresponding operation indicator LED will blink.

The operation indicator LED has been set to “self-hold” in the factory. This setting can be freely changed to “auto reset”.

With the “self-hold” setting, data of the latest operation indication will be stored in the internal memory even if the auxiliary power supply runs down.

The data stored will be cleared when the “indicator reset” switch is pressed.

Up to latest five phenomena can be stored and displayed as a history record. (Older data than the latest five phenomena will automatically be cleared).

Item No.	History	Sequence of recording
311	1st phenomena	Latest fault record data
312	2nd phenomena	↓
313	3rd phenomena	↓
314	4th phenomena	↓
315	5th phenomena	Oldest fault record data

(2) Output contacts

The signaling outputs X_0 to X_3 and trip outputs X_4 and X_5 are all programmable type.

The factory default setting of the arrangement of these outputs is as shown in the internal function block diagram of Figure 5.2. This setting can be freely changed by specifying outputs of the internal elements based on the OR logic.

All the output contacts have been set to “auto reset” in the factory. Any of them can be changed to “self-hold”.

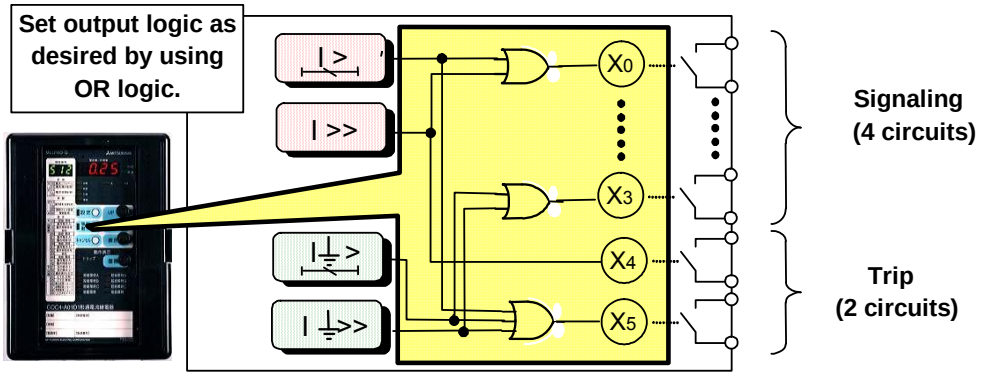


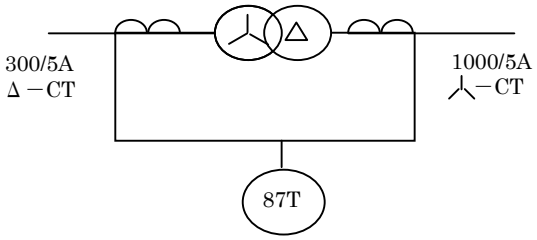
Figure 4.4 Schematic image of Programmable Outputs (example: COC4-A01D1)

(3) Forced operation

It is possible to carry out forced operation of any of the signaling outputs X_0 to X_3 and trip outputs X_4 and X_5 independently. Forced operation is useful for checking the wiring.

When forced operation is carried out, the corresponding LED lamps will come on to show the current status of the programmable outputs. Checking the lamp status will be useful not only for the wiring check but also to check the programmable outputs arrangement.

4.2 Setting



Example of transformer circuit for setting calculation

In order to set the relay correctly, please carry out the setting calculation as shown below and set the relay according to the calculation results.

4.2.1 Setting of CT ratio matching tap

(1) Required data for calculation

a. Rated capacity of the protected transformer

b. Rated voltage of transformer (High voltage side: V_H, Low voltage side: V_L)

c. Transformation ratio of CT

d. Exciting characteristic of CT (It is not always required)

e. One way conductor resistance of CT secondary (Including CT winding resistance) (R_L: value at 25°C)

f. Connecting method of CT secondary

(2) Meanings of various symbols

a. I_P = CT primary current at rated output of transformer

b. I_S = CT secondary current at rated output of transformer

c. I_R = Relay input current at rated output of transformer

I_{RH}: High voltage side, I_{RL}: Low voltage side

d. $I_{TH} = I_{T1}$ = CT matching tap value (High voltage side)

$I_{TL} = I_{T2}$= CT matching tap value (Low voltage side)

f. Z_T = CT secondary total burden

(3) Calculation method

a. Selection method of CT ratio

Select the CT ratio according to the following concepts.

- CT secondary current at the transformer rated capacity is less than 2 times rated current of relay (In).

-To keep the sensitivity, CT secondary current is more than 2.2A (when In = 5A) or more than0.44A (when In = 1A)

(Because minimum matching tap is 2.2A and 0.44A.)

b. Calculation of mismatch ratio

% mismatch = 100 × $[(I_{RH}/I_{RL})-(I_{TH}/I_{TL})]/S$

In this equation, S shows the smaller value of I_{RH}/I_{RL} and I_{TH}/I_{TL}.

In the case of transformer with tap changer, perform the setting basing on the rated value at the midpoint of the tap changer. Then, the mismatch of tap changer must be added into the above mismatch.

Thus, select the appropriate CT matching tap so that the calculated mismatch ratio is not more than 15%.

c. Examination of CT operation characteristics

For the calculation of CT error, it is required to obtain a total burden including CT winding resistance. Total burden Z_T can be determined by the following equation.

Z_T = CT secondary resistance + relay burden

= 1.13 R_L + relay burden (In the case of 人 -CT)

In the case of Δ-CT, Z_T becomes 3 times of the above value. And the above coefficient 1.13 is used to add the increased resistance of R_L due to the temperature rise during the fault continuity.

The CT ratio error (% for secondary current) at the external fault is calculated by the CT exciting current presumed from the CT exciting characteristic using the total burden voltage calculated by the total burden and the fault current,

It is the proper condition that the sum of The CT ratio error and the mismatch ratio (%) does not exceed the bias setting value of the relay (20%, 30%, 40%) throughout the external fault condition,

(4) Calculation example

【Data】

Transformer rating

High voltage side: 7500kVA 22kV

Low voltage side: 7500kVA 6.6kV

【Calculation】

Calculate according to the following procedure.

	High voltage side	Low voltage side
a. I_P	$\frac{7500\,\text{kVA}}{22\,\text{kV}\times\sqrt{3}} = 196.8\,\text{A}$	$\frac{7500\,\text{kVA}}{6.6\,\text{kV}\sqrt{3}} = 656.1\,\text{A}$

b. Set the CT ratio	300/5A = 60	1000/5A = 200
c. I_R	$I_{RH} = \frac{196.8\ A}{60} \times \sqrt{3} = 5.68\ A$	$I_{RL} = \frac{656.1\ A}{200} = 3.28\ A$
d. I_T	$I_{TH} = I_{RH} = 5.68\ A$	$I_{TL} = I_{RL} = 3.28\ A$

The relay will be set at the nearest value to the above calculation results based on the setting step.

$I_{T1} = I_{TH} = 5.7\ A$	$I_{T2} = I_{TL} = 3.3\ A$

【Note】

When the calculated I_{T1} or I_{T2} are outside the CT matching setting range (2.2～12.5A), calculate the setting value again after changing the relay rated current (In) to a value which is possible to set.

For instance, if a calculation result I_{RH} was less than 2.2A (for example I_{RH}=2A), it becomes impossible to set the relay.

In this case, the calculation should be done again like the following.

Let $I_{TH} = 2.2\ A$	Then $I_{TL} = 3.3\ A \times \frac{2.2\ A}{2\ A} = 3.63\ A$

The relay will be set at the nearest value to the above calculation results based on the setting step.

$I_{T1} = I_{TH} = 2.2\ A$	$I_{T2} = I_{TL} = 3.6\ A$

e. Calculation of mismatch ratio

$$\frac{I_{RH}}{I_{RL}} = \frac{5.68}{3.28} = 1.73$$

$$\frac{I_{TH}}{I_{TL}} = \frac{5.7}{3.3} = 1.72$$

$$\text{Mismatch ratio} = \frac{\left(I_{RH}/I_{RL}\right) - \left(I_{TH}/I_{TL}\right)}{S} = \frac{1.73 - 1.72}{1.72} = 0.58\ \%$$

4.2.2 Setting of minimum operation value “Min. op”

(1) Required data for calculation

a. Transformer tap changing error

b. CT error at normal condition (Ratio error, phase angle error)

c. Relay operation value error

d. Mismatch error

(2) Calculation example

【Data】

a. Transformer tap changing error

Max.10%

b. CT error at normal condition (in case of class 1.0)

$$\sqrt{(\text{Ratio error})^2+(\text{One degree phase angle error})^2}$$
$$=\sqrt{(0.01)^2+(\text{SIN}(1^\circ))^2}$$
$$=0.02$$
$$=2\%$$

c. Relay operation value error

Operation value ±10%

d. Mismatch error

0.58%

【Calculation】

Sum of the above error (a to d) is the differential error α at normal condition (% to CT matching tap value).

$$\alpha = 10.0\% + 2\% + 0.1 \times \text{Min.op} + 0.58\%$$
$$= 12.58\% + 0.1 \times \text{Min.op}$$

Assume, Min. op = 30%

$$\alpha = 15.58\%$$

$$\text{Accordingly, the allowance} = \frac{30\%}{15.58\%} = 1.93\,(\text{times})$$

(The standard of allowance : 1.5 ~ 2 times or more)

4.2.3 Setting of bias ratio τ

【Data】

a. Transformer tap changing error

10% at external fault (in the case of transformer with tap changer)

b. CT error

Max. 10% at external fault

c. Relay bias ratio error

Bias ratio τ ± 5%

d. Mismatch error

0.58%

【Calculation】

Sum of the above error (a to d) is the differential error β at external fault (% to through fault current).

$$\beta = 10\% + 10\% + 5\% + 0.58\%$$
$$= 25.58\%$$
$$\text{Assume, } \tau = 40\%$$
$$\text{Accordingly, the allowamce} = \frac{40\%}{25.58\%} = 1.56 \text{ (times)}$$
$$(\text{The standard of allowance} : 1.5 \sim 2 \text{ times or more})$$

4.2.4 Setting of differential overcurrent element

It is recommended to set the differential overcurrent element with a value more than the exciting inrush current.

I_T× Setting value of operation current of differential overcurrent element > Exciting inrush current

4.3 Measurement

Currents input to the relay are measured and converted into freely set CT primary currents, then indicated on the display.

(1) Real time measurement

The effective current (Restraining current and differential current) inputting into the relay under steady state is displayed for each phase.

Please confirm there is no differential current larger than the assumption.

(2) Max. record

The maximum effective current is recorded and stored for each phase.

The max. record will be all cleared when “aux. power supply OFF” or “max. record reset” operation is made.

(3) Fault record

In the event of system fault, the effective current, 2nd harmonic component ratio and waveform data that have been measured at the time when one of the protection elements operates to issue an output signal are stored. Data of up to five phenomena can be stored and displayed for each phase.

With “aux. power supply OFF”, only the wave form data will be cleared and the effective current data will remain. With “fault record reset” operation, however, both of the data items will be all cleared.

(Records older than the 5th phenomenon will automatically be cleared.)

Item No.	History	Sequence of recording
211	1st phenomena	Latest fault record data
212	2nd phenomena	↓
213	3rd phenomena	↓
214	4th phenomena	↓
215	5th phenomena	Oldest fault record data

The following fault waveform data can be collected if a communication card is installed:

The peak value of waveform data is n derived from CT secondary current with matching tap conversion.

Item	Specification
Data sampling cycle	Fixed to the electric angle of 30° of rated frequency
Data storing capacity (for a phenomenon)	224 cycles of rated frequency (Data point: 224×360°/30° = 2688 points)
Permissible setting range	224 cycles before trip ~ 224 cycles after trip
Collected data	The range for data collection can be set by cycle within the “data storing capacity” in the “permissible set range”.

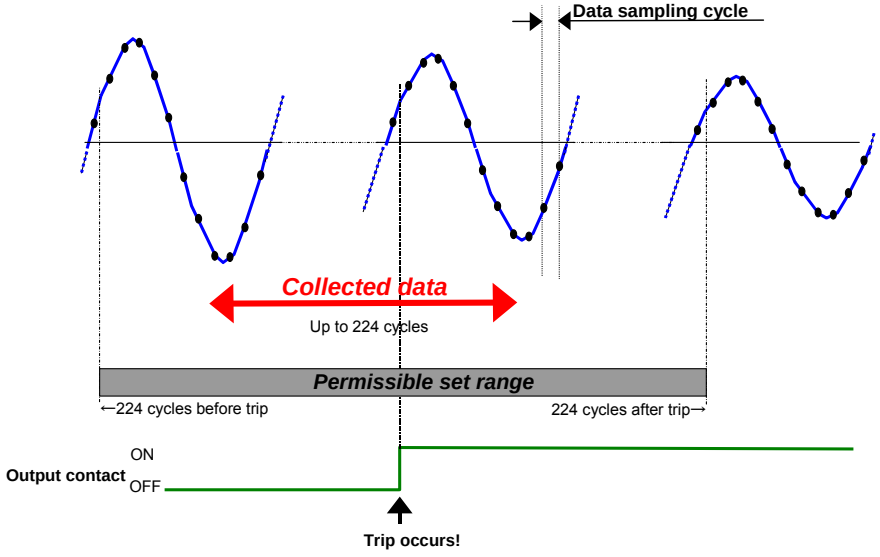


Figure 4.5 Recording concept of fault waveform

4.4 Self-diagnosis

The self-diagnosis function monitors the electronic circuit and built-in power source continuously. If an abnormal condition occurs, the protection elements will be locked for operation. Also, the RUN LED lamp will go off and self-diagnosis output contact (break contact) will be closed.

(1) Checking the defect code at failure detection

When a failure is detected, the defect code will be recorded. This defect code can be checked through self-diagnosis (ALARM) status indication .

(2) Resetting self-diagnosis output

If a failure is detected, **the failure status may be reset by turning off/on the power**.

In this case, **be sure to lock the trip circuit on the external wiring of the relay** before resetting.

(If the failure persists, an erroneous output may be caused.)

(3) Clearing the defect code

The defect code data stored at failure detection can not be cleared only by carrying out the power on/off procedure in the item (2) above. All the defect code numbers that have been detected since the previous “self-diagnosis reset” (RESET ALARM) operation was made are accumulated in the memory.

To clear the record data, carry out “self-diagnosis reset” (RESET ALARM)operation.

(4) Differential current check (Defect code 0017)

The followings are the explanation of the differential current check.

This check item monitors the differential current calculated inside of the relay and issue the alarm when the differential current is more than 80% of minimum operating value ($I_n \times$ operating current setting (20%~40%) and such condition is continued more than 20 seconds.

The differential current check monitoring is effective to prevent the relay from miss operation due to the defects of parts caused by aging.

Therefore, differential current alarm will be issued with the following cases.

① In case of one side current injection test, defect code 0017 will be issued when injection period is more than 20 seconds.

To prevent such a detection, setting item [DIF test] should be set as [ON[position during the test.

DIF test LED(yellow) will come on when DIF test set as [ON] and please pay attention that never forget to change the DIF test setting from [ON] to [OFF] after completion of the test and confirm the LED coming off.

② Occurrence of differential current due to miss setting of matching taps.

③ Occurrence of differential current due to wrong connection of cables located outside of relay.

Table 4.1 Output for protection relay failures

Status	Detected items	Output			
		Display		ALARM (break contact)	Operation output lock
		RUN	Defect code		
Normal	-	On	No display	Open	Not locked
Power circuit failure	-	Off		Closed	Locked
CPU stop	-				※45
Monitor error	ROM check		0001		Locked
	RAM check		0002		
	A/D accuracy check		0003		
	A/I check		0004		
	A/D check		0005		
	SRAM check		0006		
	D/O status check		0008		
	D/O operation check		0009		
	Analog filter check		0010		
	A/I double check		0011		
	D/I check *41		0012		
	E^2PROM check		0013		
	Computing function check		0014		
	WDT check		0015		
	Data transfer check *42		0016		
	Differential current check *43		0017		
	Communication card check *44	On	0028	Open	Not locked
	Communication card channel No. switch setting error *44		0029		
	Communication card baud rate switch setting error *44		0030		
	Communication card channel No. switch change error *44		0031		
	Communication card baud rate switch change error *44		0032		

*41 Monitored only in the models with built-in D/I function.
*42 Monitored only in the models with D2 unit.
*43 Monitored only the biased differential relay.
*44 Monitored only when communication card is installed inside the relay.
*45 No necessary to lock the output as any output would not be possible during CPU stop.

4.5 Communication (option)

Figure 4.6 shows an example of network system configuration.

For more information on the communication facilities, see the materials shown in the introduction (page 2).

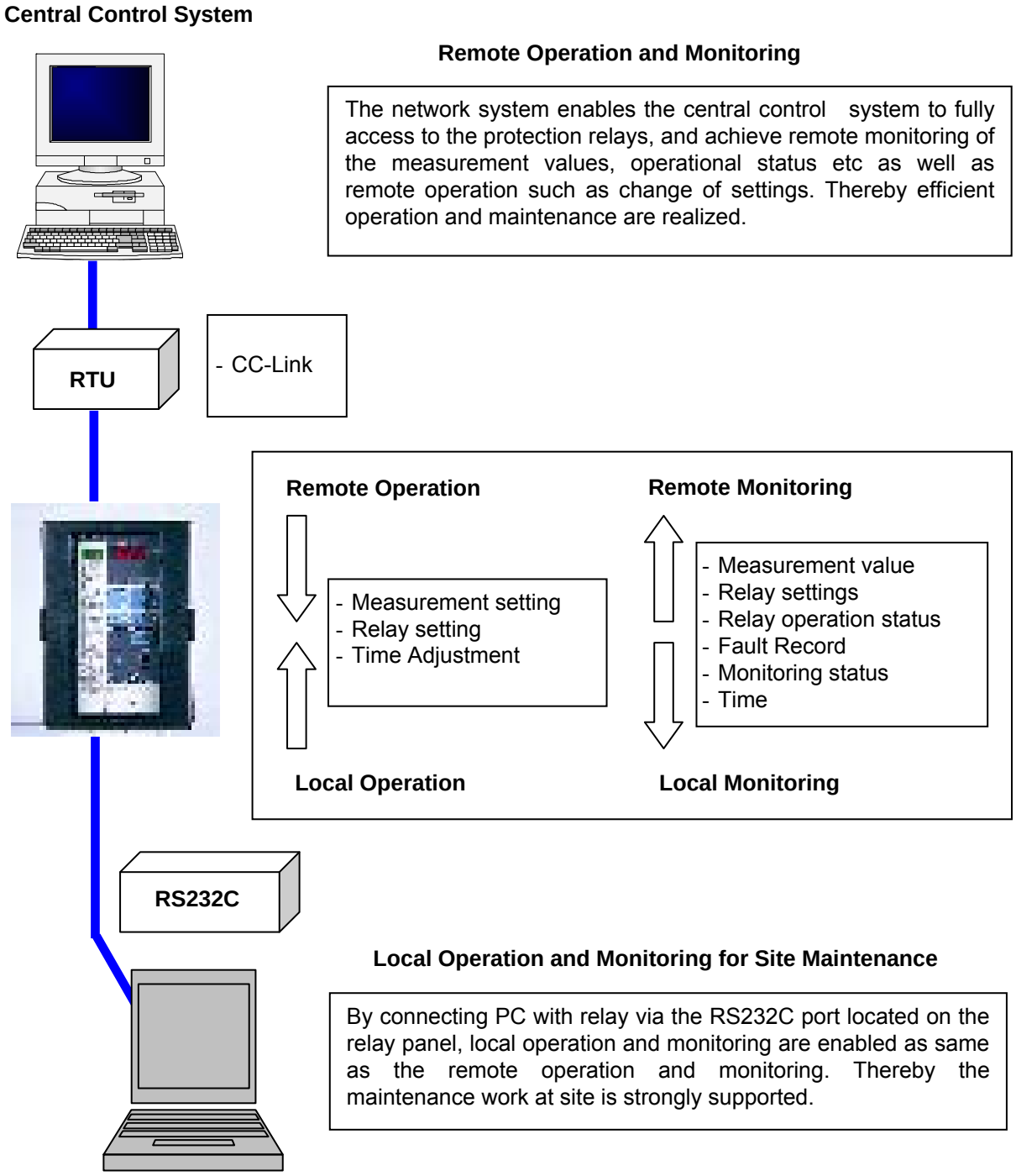


Figure 4.6 Example of communication network system configuration

By connecting PC with relay via the direct communication port (as standard equipment located on the relay front panel, local operation and monitoring are enabled as same as the remote operation and monitoring.
Please note that optional HMI software for PC is needed for local operation and monitoring.
Using the communication facilitates, it is possible to perform Remote Monitoring and Remote Operation with the various useful functions shown in Table 4.2.

Table 4.2 Outline of functions enabled by communication network

Direction of communication	Item	Description
Remote Monitoring RTU ⇐ Protection relay	Setting	Read the settings stored in the protection relay.
	Measurement	Read the measurements stored in the protection relay.
	Max. value	Read the max. values stored in the protection relay.
	Fault record	Read the measurements at the time of trip.
	Self- diagnosis (ALARM)	Read the result of self-diagnosis.
	Operation element	Read the elements that operated at the time of trip.
	Operation time	Read the time at the time of trip.
	Current time	Read the internal time of the communication card.
	Wave form record	Read the wave form at the time of trip.
Remote Operation RTU ⇒ Protection relay	Setting	Change the setting of the protection relay.
	Indicator reset	Reset the LED lamp that came on at the time of trip.
	Self-diagnosis reset (RESET ALARM)	Clear the result of self-diagnosis
	Fault record reset	Clear the fault record, operation elements and operation time data.
	Max. record reset	Clear the max. records.
	Forced operation	Carry out forced operation of output contact.
	Time	Set time of communicate card.

5 Configuration

5.1 Internal configuration

(1) I/O and CPU circuits

Fig. 5.1 shows the internal block diagram of the model CAC1-A01D2.

Current input is converted into AC signals at the electronic circuit level via the auxiliary transformer and filter circuits. These signals are retained as a form of DC signal in the sample hold circuit on each channel sharing a same time. The multiplexer selects a channel to take the signal and send it to an A/D converter. The signals are converted to digital signals sequentially in the converter to be sent to the CPU.

The setting circuit is used to input setting data into the CPU.

These inputs will be used to carry out the functions shown in Fig. 5.2 “Internal function block diagram”, then issue output signals to the display and output relay.

(2) Self-diagnosis circuit

When the self-diagnosis function detects that the electronic and power circuits are normal, the output relay will be energized to open the self-diagnosis output contact (break contact).

The self-diagnosis output contact (break contact) will be closed when a failure occurs in the circuits above or when the built-in power fuse burns.

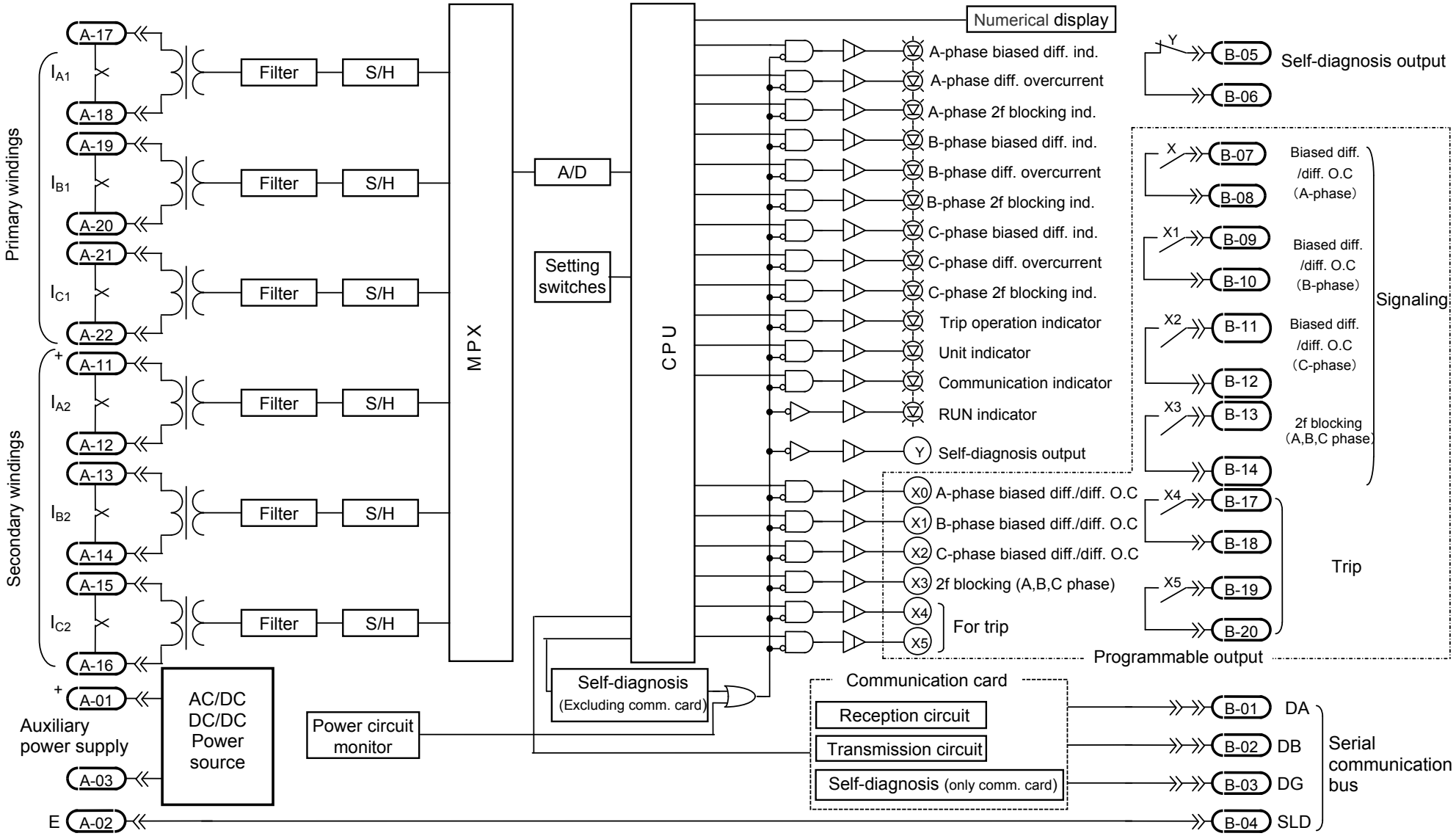


Figure 5.1 Internal block diagram of Type CAC1-A01D2 relay

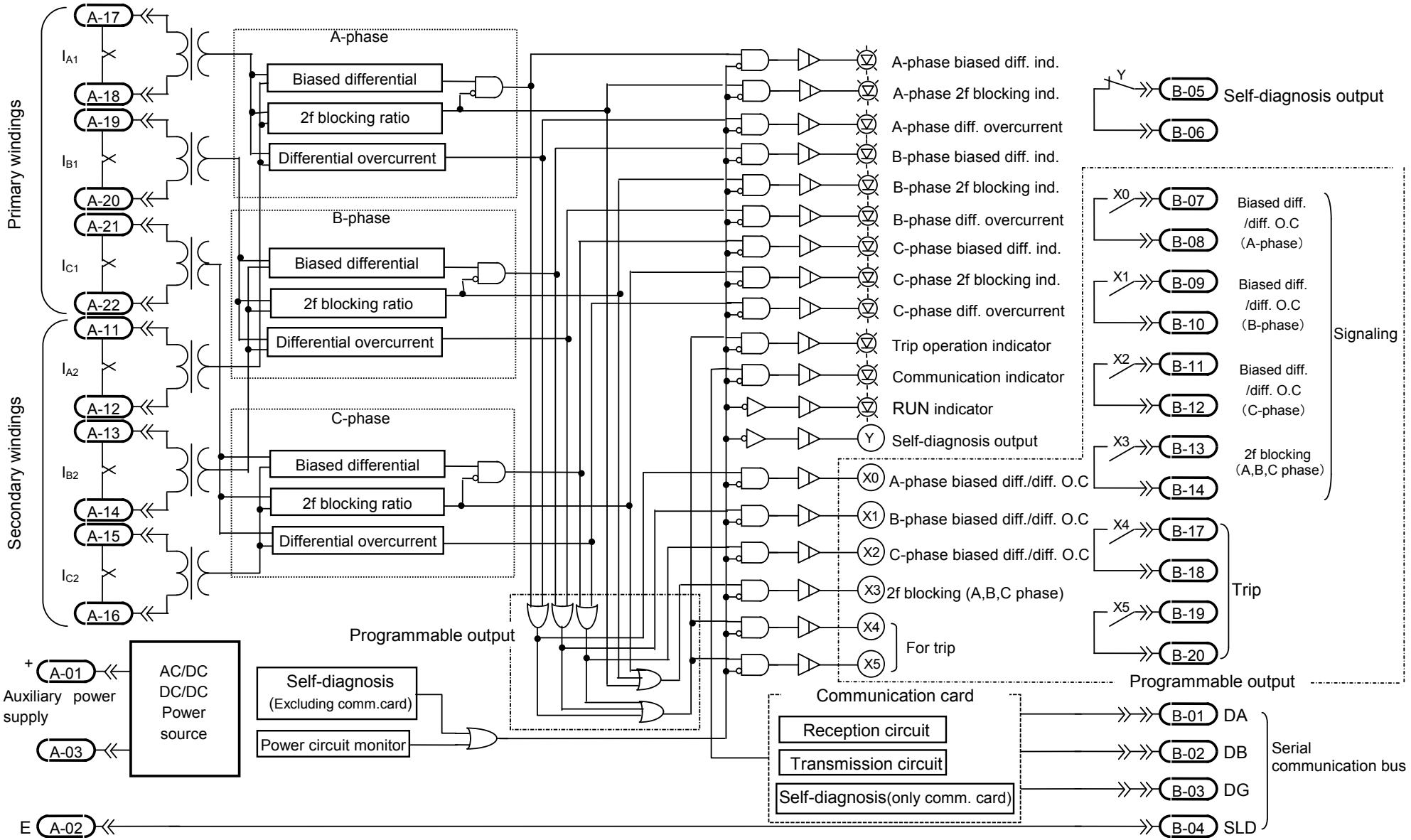


Figure 5.2 Internal function block diagram of type CAC1-A01D2

5.2 External connection

(1) Connection diagram

Figures 5.4 to 5.7 show examples of input circuit (AC circuit) connection, Figure 5.8 shows an example of control circuit (DC circuit) connection and Figure 5.9 shows the terminal arrangement.

In the terminals, M3.5 screws should be used and wires of 2 mm^2 or less are recommended using.

(2) Precautions for wiring work

a. Important facilities should be provided with the redundant system such as the fail-safe system, the dual system or the 2 out of 3 system to improve reliability of the facilities.

b. Effects of external surge

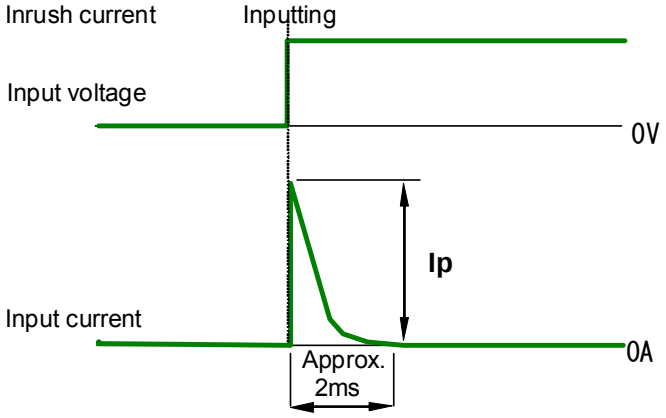
Some type of surge with a certain condition may inversely affect the relay. If so, take it into account to install MF type surge absorbers made by Mitsubishi Electric .

c. Guarantee of AC auxiliary power supply against power interruption

The AC auxiliary supply of the relay is not guaranteed against power interruption. When you do not have an uninterruptible AC power source, use the type B-T1 backup power supply manufactured by Mitsubishi Electric or uninterruptible power source (UPS) that is commercially available.

d. Inrush current of auxiliary supply

Since inrush current may flow in the relay when the auxiliary power supply is turned on as shown in the figure below, make consideration of this point when selecting the breaker for auxiliary power supply circuit.



Input voltage		Inrush current Ip
DC	110V	**Approx. 20A**
	220V	**Approx. 55A**
AC	100V	**Approx. 25A**
	220V	**Approx. 65A**

Figure 5.3 Inrush current of auxiliary power supply

e. Trip circuit

Only the contacts X_4 and X_5 can be used for the trip circuit. Please keep in mind that the contacts X_0 to X_3 cannot be used for the trip circuit. (If used, the contact may burn).

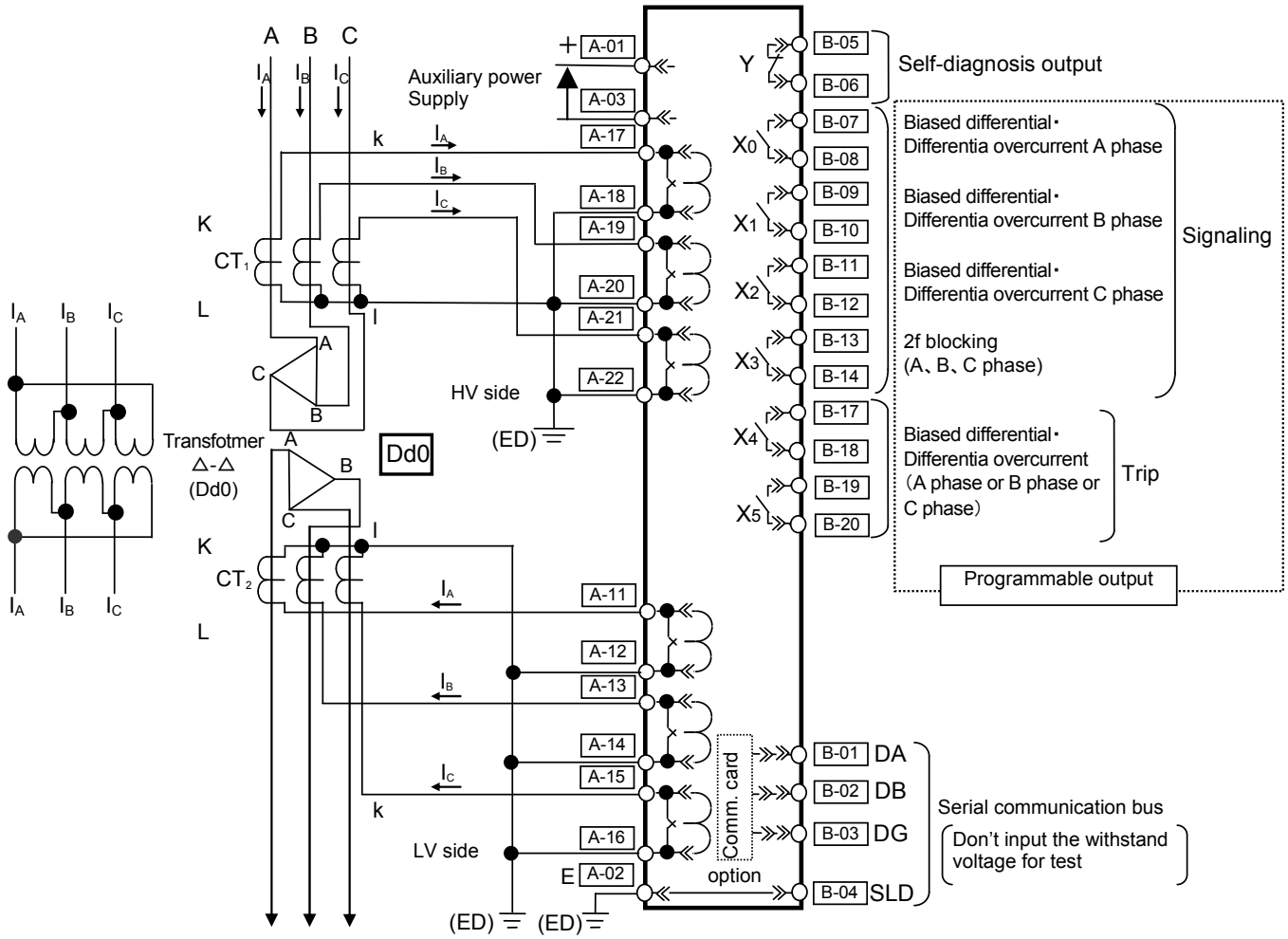
Connect the pallet contact (52a) of the circuit breaker to the trip circuit.

f. Self-diagnosis output circuit

The self-diagnosis output contact is so configured that the auxiliary relay can be energized (break contact) with normal result of monitoring, in order to be able to continue monitoring even if the built-in power fuse burns. Therefore, connect the timer to the external wiring. (See Fig. 5.8 “DC circuit connection diagram”).

g. Earth circuit

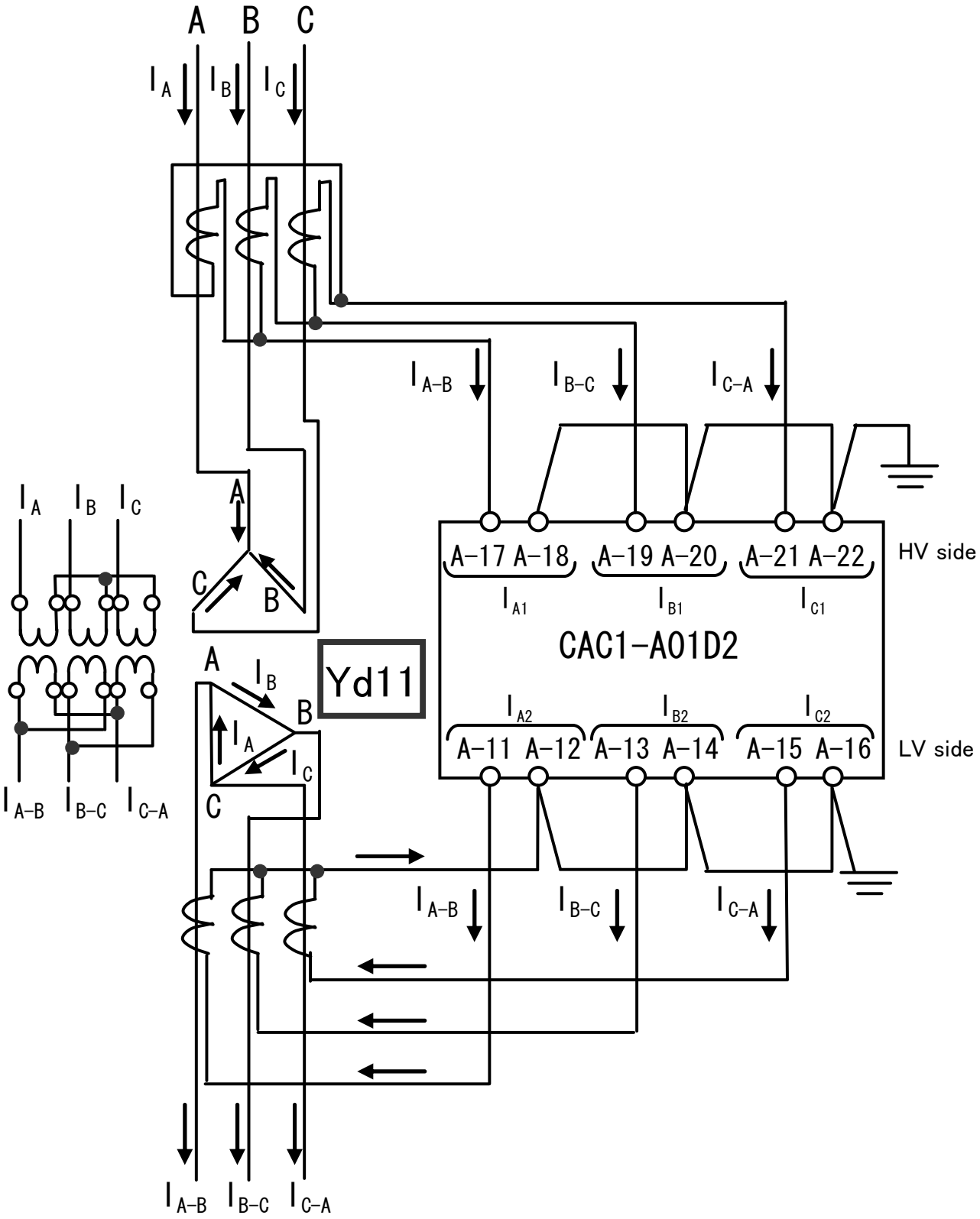
Be sure to earth the earth terminal located on the back of the relay according to the Class D earth wiring method.



CT secondary circuit should be connected so as HV side current to be inflow to the Ry terminal of HV side and LV side current to be out flow from the Ry terminal of LVside with keeping same phase angle between bothside, when flow –through current is placed.

Figure 5.4 External connection diagram (AC circuit) for CAC1-A01D2 relay

[Example 1]

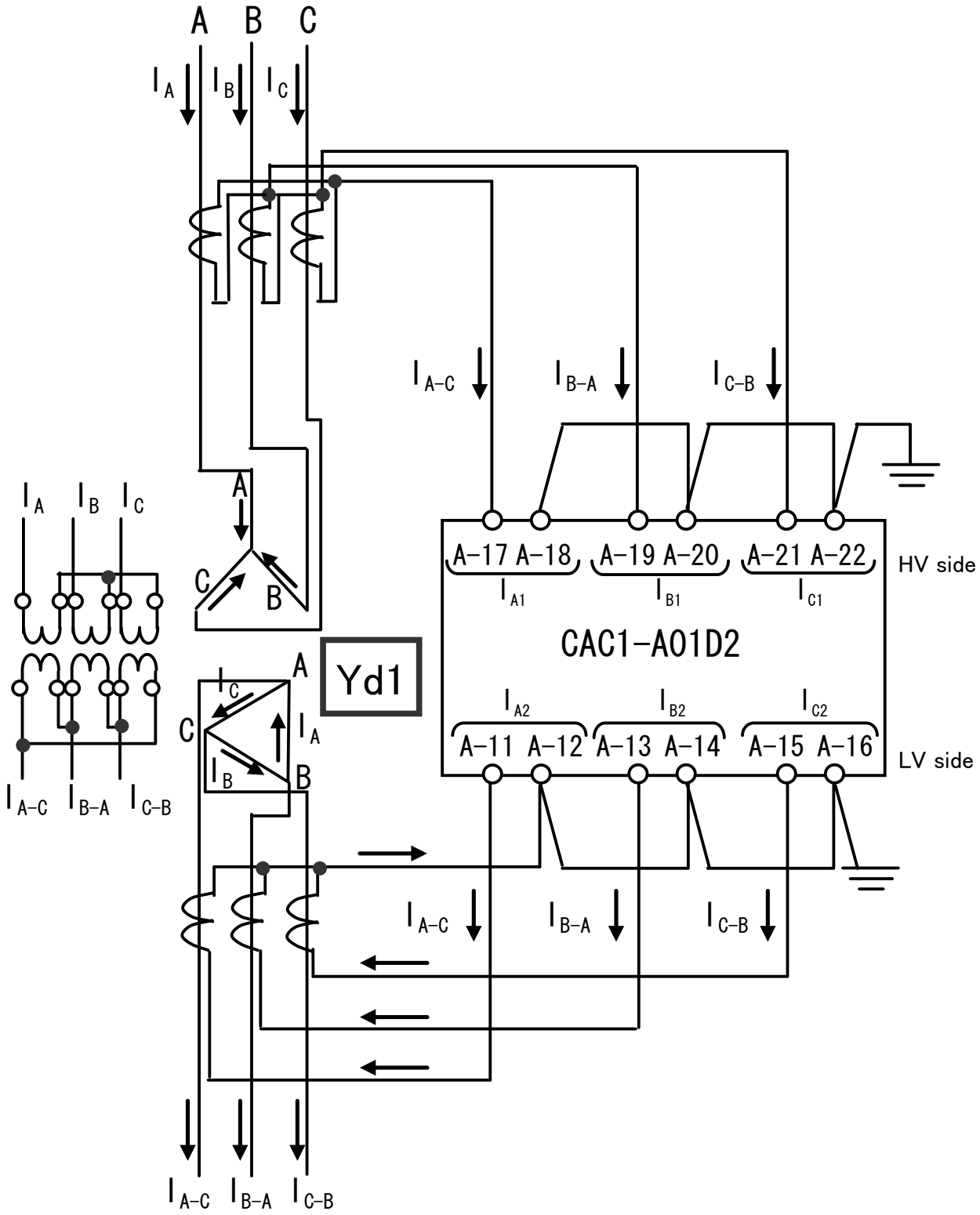


CT secondary circuit should be connected so as HV side current to be inflow to the Ry terminal of HV side and LV side current to be out flow from the Ry terminal of LVside with keeping same phase angle between bothside, when flow –through current is placed.

※Refer to the Figure 5.4 on the out circuit.

Figure 5.5 External connection diagram (AC circuit) for CAC1-A01D2 relay

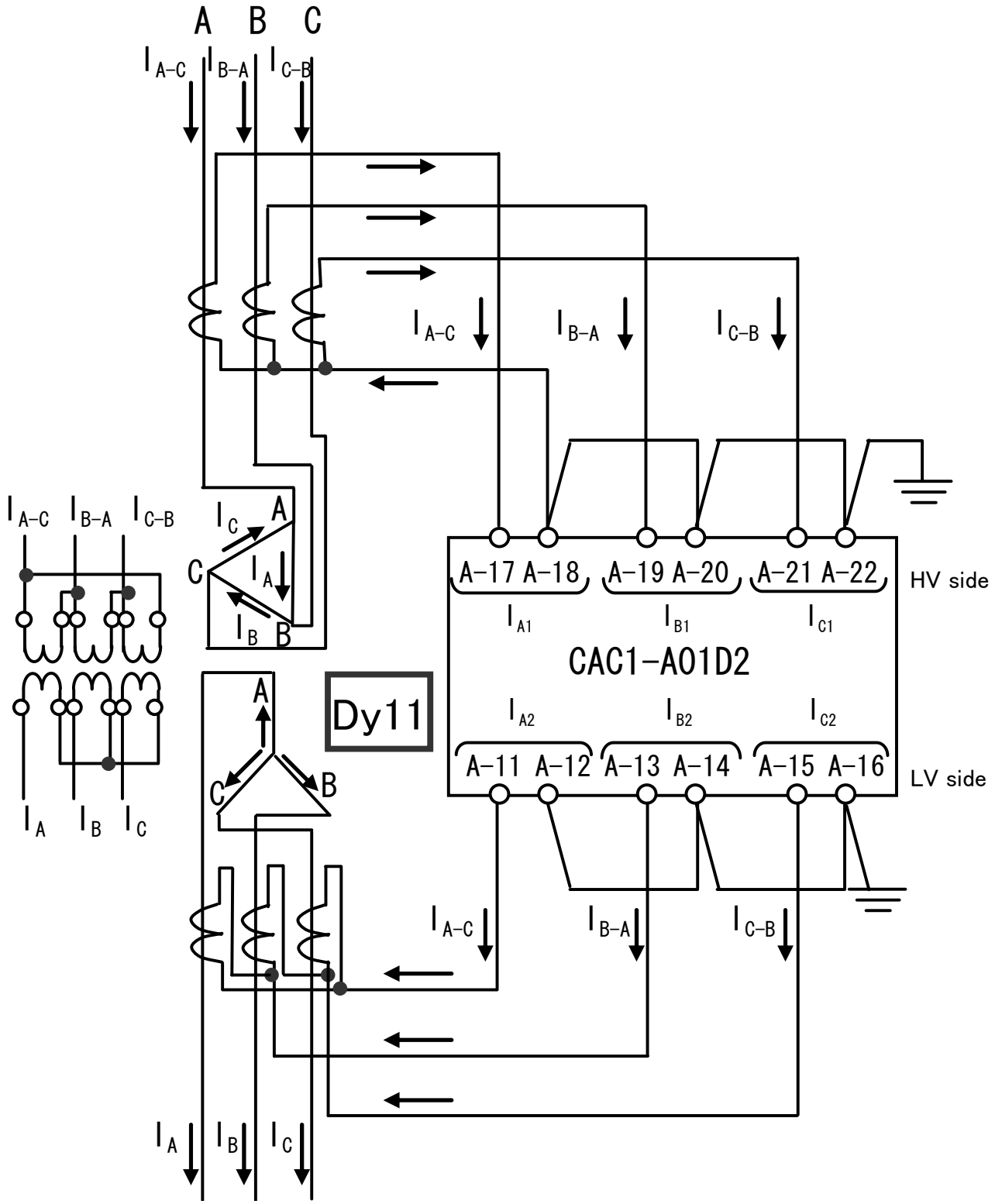
[Example 2]



CT secondary circuit should be connected so as HV side current to be inflow to the Ry terminal of HV side and LV side current to be out flow from the Ry terminal of LVside with keeping same phase angle between bothside, when flow –through current is placed.
※Refer to the Figure 5.4 on the out circuit.

Figure 5.6 External connection diagram (AC circuit) for CAC1-A01D2 relay

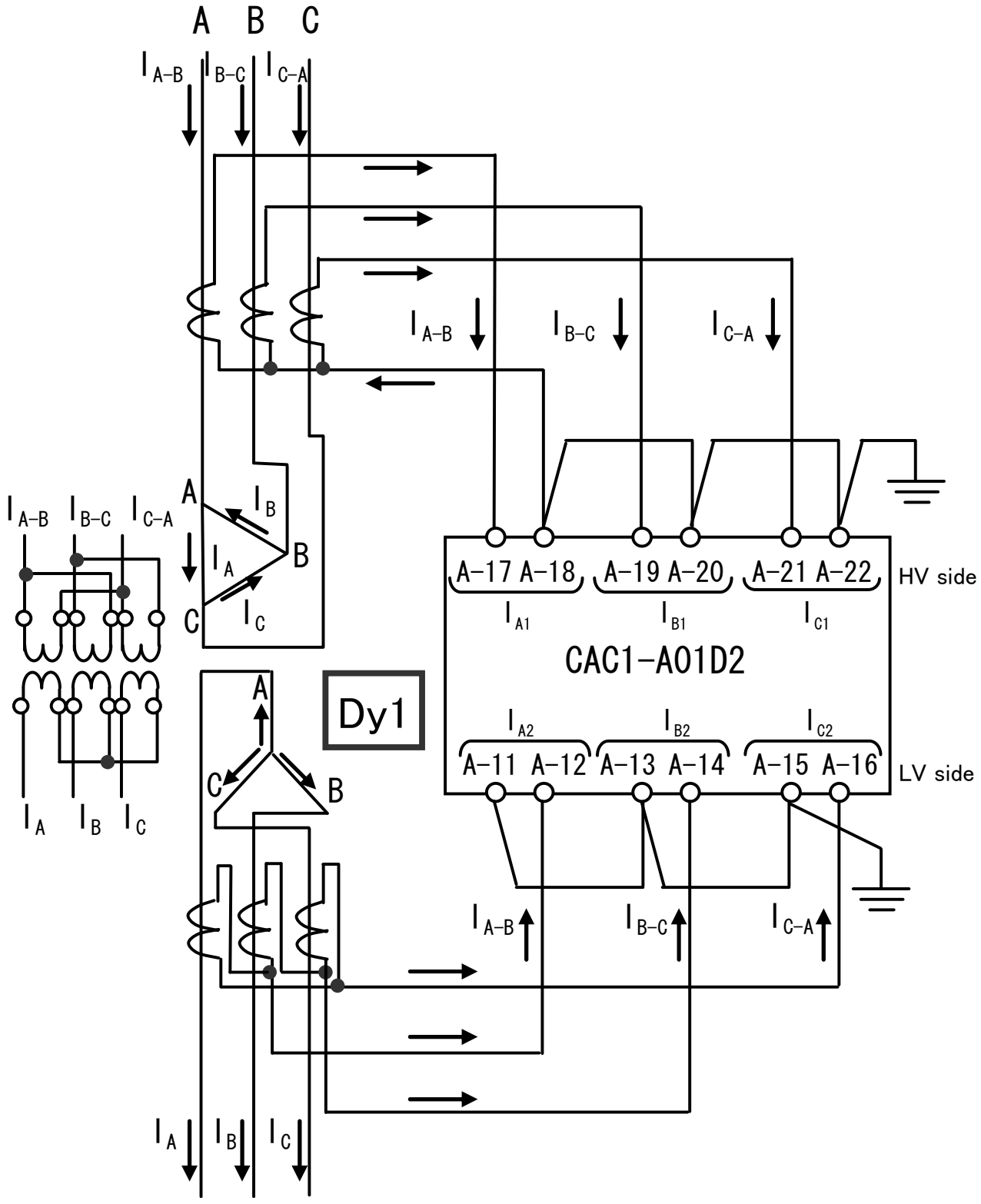
[Example 3]



CT secondary circuit should be connected so as HV side current to be inflow to the Ry terminal of HV side and LV side current to be out flow from the Ry terminal of LVside with keeping same phase angle between bothside, when flow –through current is placed.
※Refer to the Figure 5.4 on the out circuit.

Figure 5.7 External connection diagram (AC circuit) for CAC1-A01D2 relay

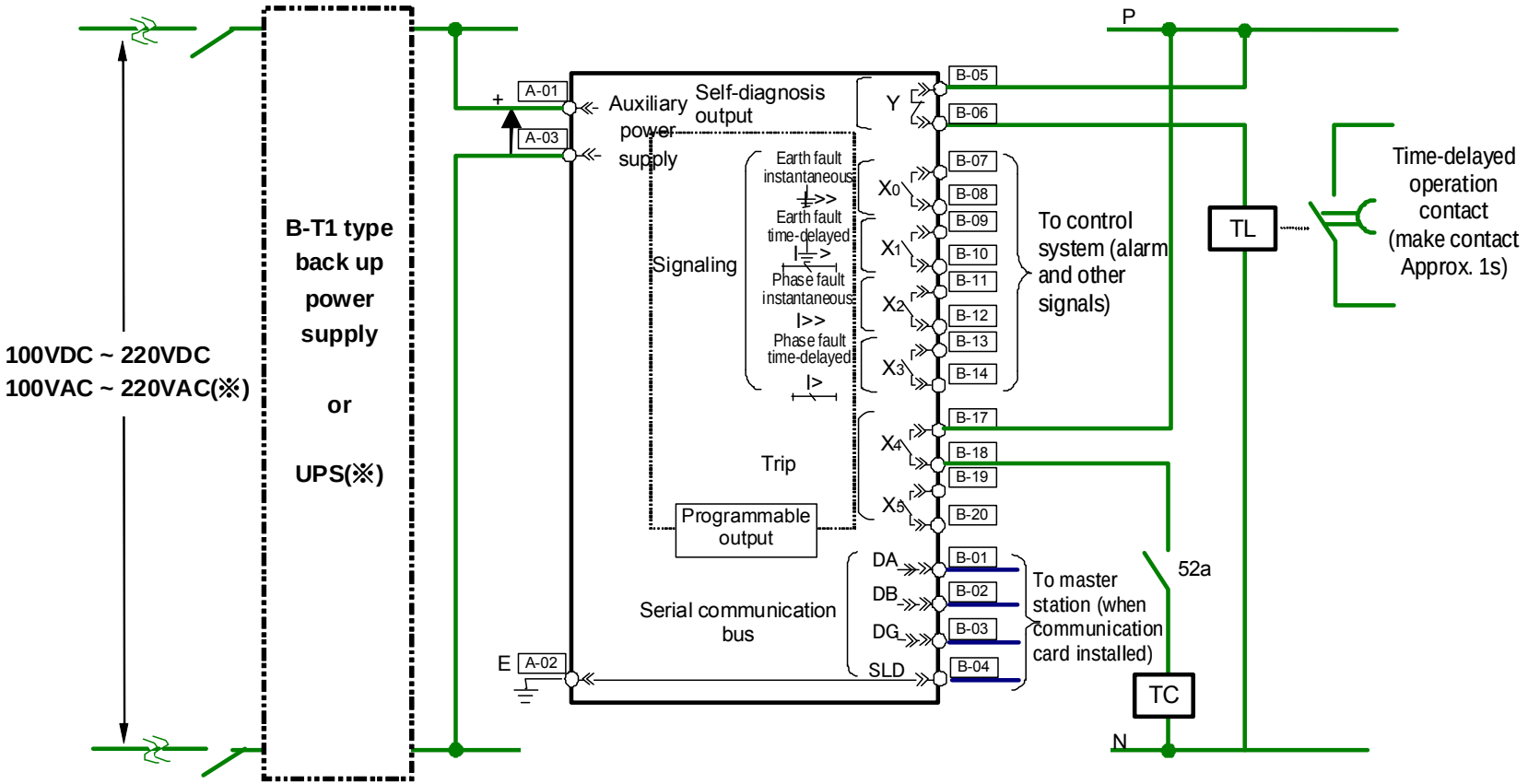
[Example 4]



CT secondary circuit should be connected so as HV side current to be inflow to the Ry terminal of HV side and LV side current to be out flow from the Ry terminal of LVside with keeping same phase angle between bothside, when flow –through current is placed.
※Refer to the Figure 5.4 on the out circuit.

Figure 5.8 External connection diagram (AC circuit) for CAC1-A01D2 relay

[Example 5]



Note 1)	The self-diagnosis output contact is so configured as below mentioned that alarm can be issued even after the built-in power fuse burns. This type of auxiliary relay circuit configured such that relay will be energized ("break contact" opened) when normal result of self-diagnosis is received. Therefore, the "break contact" is closed when the power is applied and will be opened after about 50ms. If the auxiliary power supply of the relay and the self-diagnosis output contact shares a same power source, **the "break contact" will be closed temporarily after the auxiliary power supply is turned on**. In the case where the phenomenon stated in the above would conflict with your system requirement, it is recommended that the self-diagnosis output contact should be **connected via the time-delayed timer** as shown in the left of the figure.
Note 2)	Regarding to the type B-T1 back up power supply or commercially available uninterruptible power supply (UPS), refer to the note *21 in the section 2.1 General information.

(※) Refer to the page 33, 5.2 External connection (2) Precautions for wiring work c. Guarantee of AC auxiliary power supply against power interruption.

Figure 5.9 Auxiliary power supply circuit connection example of type CAC1-A01D2 relay

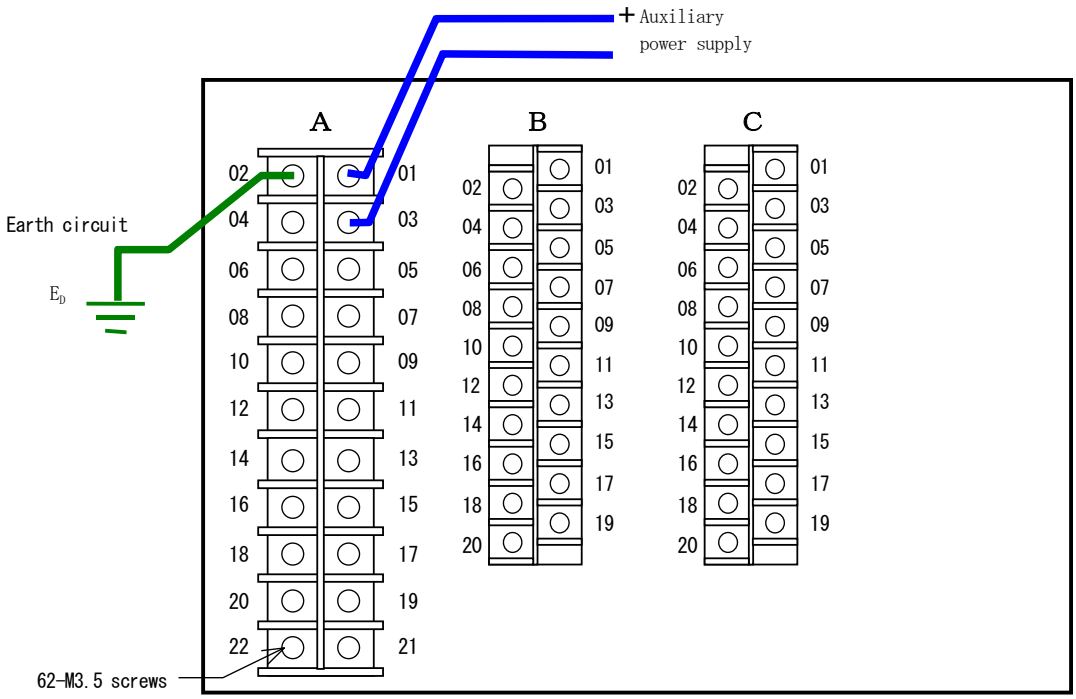


Figure 5.10 Rear view of type CAC1-A01D2 relay

6 Handling

6.1 Unpacking

Usually this relay is packed in a D2 case for transportation. However, it may occur that only the sub unit is transported independently for the convenience at repair. In such a case, fully brush off the dust, dirt, etc. adhered to the sub unit after completion of unpacking, and further visually check that the parts mounted on the front panel or built in the sub unit are not damaged.

6.2 Transportation and storage

To carry the equipment within the place of use, handle it carefully so that the parts installed on the front panel of the sub unit or built-in parts cannot be deformed or broken.

6.3 Appearance and how to pull sub unit out

The relay is so constructed that the sub unit can be drawn out, in order to facilitate inspection or test. It is possible to pull the sub unit out without disconnecting the external wiring.

Note that the sub unit should not be drawn out with the line hot. Before drawing out, be sure to take the following actions.

- Lock the tripping circuit including breakers.
- Stop the main circuit.
- Shorten and isolate the CT circuit.
- Open the auxiliary power supply circuit.

Bear in mind that careless opening of circuits may result in opening the other control circuits too to impair the protective function. Be sure to only shut off the concerned circuit.

The CT circuit is provided with an automatic short circuit mechanism. In case that you have pulled the sub unit out without isolating the CT circuit by mistake, the automatic short circuit mechanism will work to prevent the CT secondary circuit from opening.

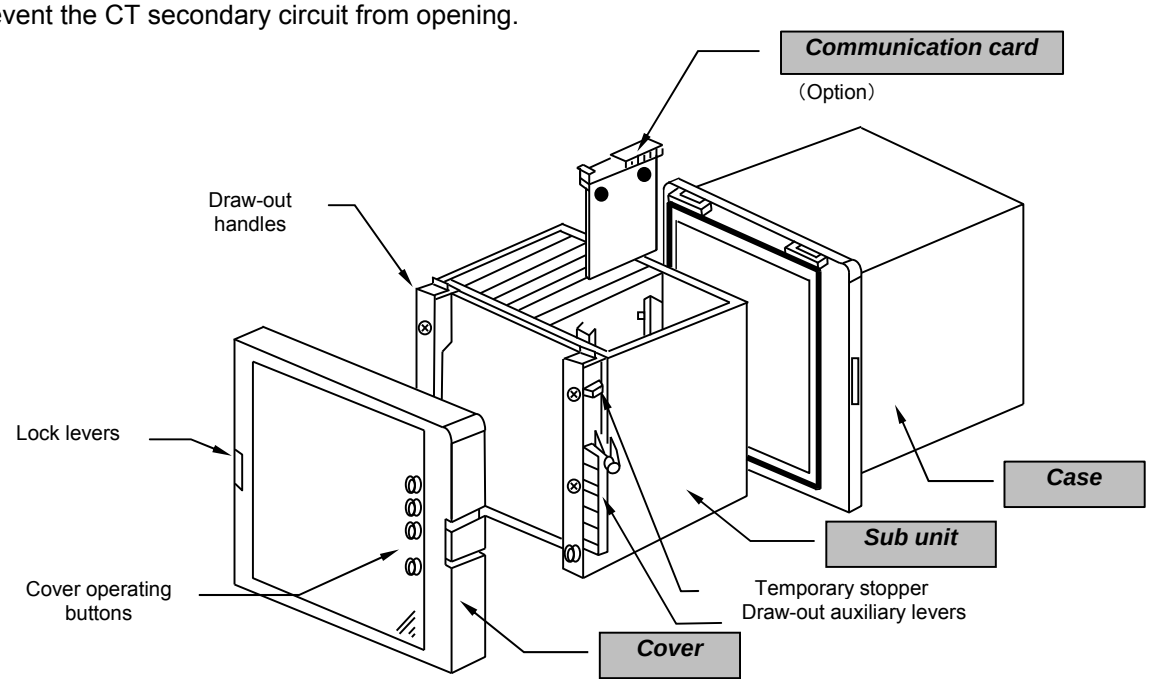
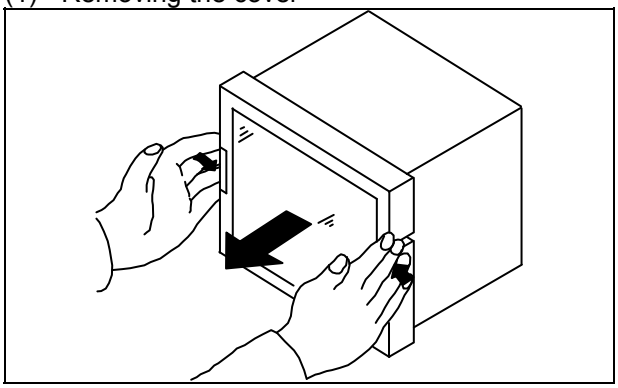


Figure 6.1 Outside view of type CAC1-A01D2 relay

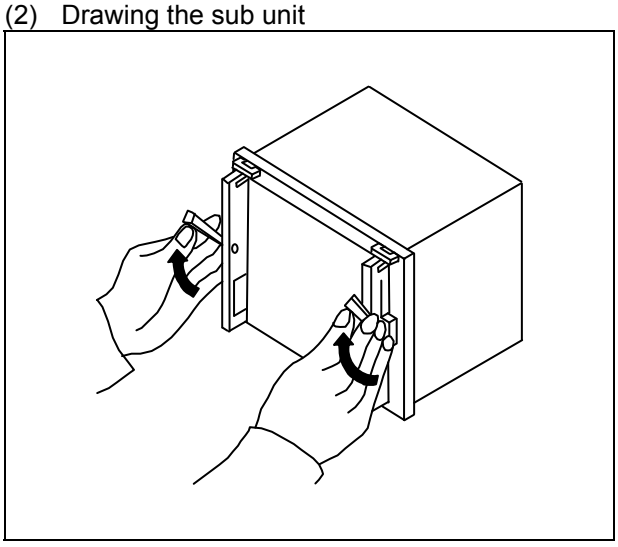
6.3.1 How to draw sub unit out

(1) Removing the cover



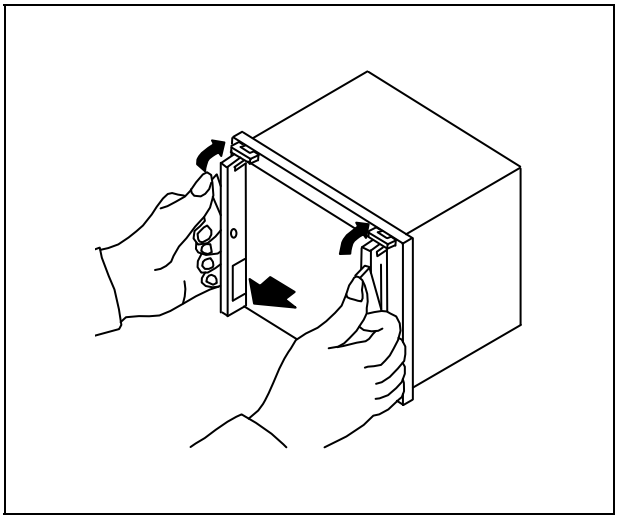
Hold the **lock levers**, which are located at both sides of the cover, on their front sections. Take off the cover **straight toward you** while pushing the levers **inwards**.

(2) Drawing the sub unit



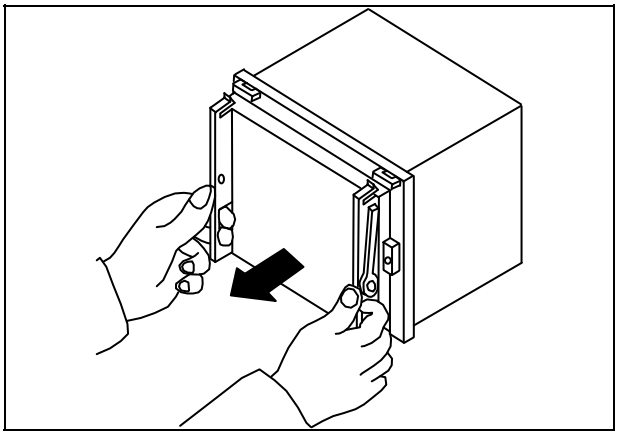
Please from under to upper direction turn round the draw-out auxiliary levers located on both sides of the front of the sub unit until the levers touch the metallic parts located on both sides of draw-out handles completely.
(Rotated angle is approx. 120°)

Note) Be careful not to put your fingers into the space between drawing-out auxiliary levers and the case.



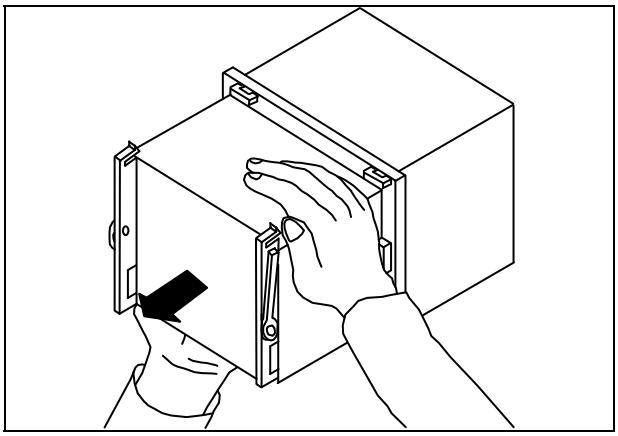
With the draw-out auxiliary levers touching the metallic parts, **exert your strength to turn round the levers** continuously, the sub unit will be drawn out a little from the case.
Then be careful not to let the draw-out auxiliary levers fall down and to **make the draw-out auxiliary levers into a locked status by the with-holders** located on the both sides upper the auxiliary levers please.
(**Rotated angle is from approx. 120°to 180°**)

Note) Be careful not to put your fingers into the space between drawing-out auxiliary levers and the case.



Grip the draw-out handles (located at both sides of the front of the sub unit), and **pull the sub unit towards you** until about a half portion of the sub unit is pulled out of the case**.**

Note) Be careful not to pull out the sub unit too much in order to prevent the sub unit falling.

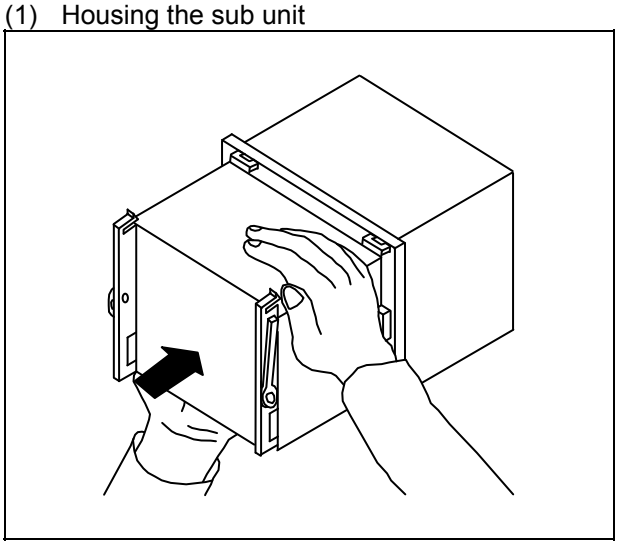


When about a half portion of the sub unit is pulled out of the case, just stop the drawing motion. Then, **hold the top and bottom of the sub unit to pull it out completely**, in order to prevent the unit from falling.

Note) Be careful not to touch the printed circuit board and parts inside the sub unit.

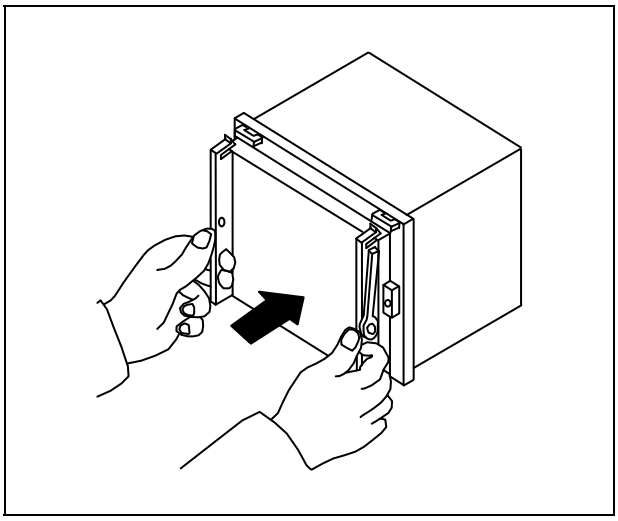
6.3.2 Housing the sub unit

(1) Housing the sub unit

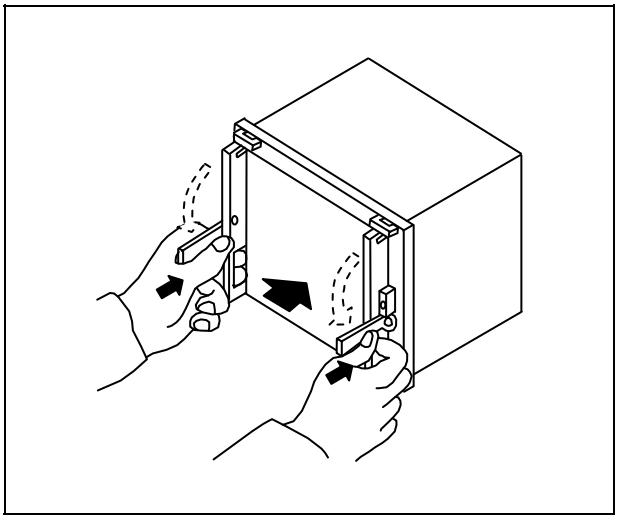


Hold the sub unit on the top and bottom to push the unit into the case approx. a half of the unit.

Note)
- Be careful not to touch the PCB and parts inside the sub unit.
- The sub unit is so constructed that it can not be housed in the case upside down.

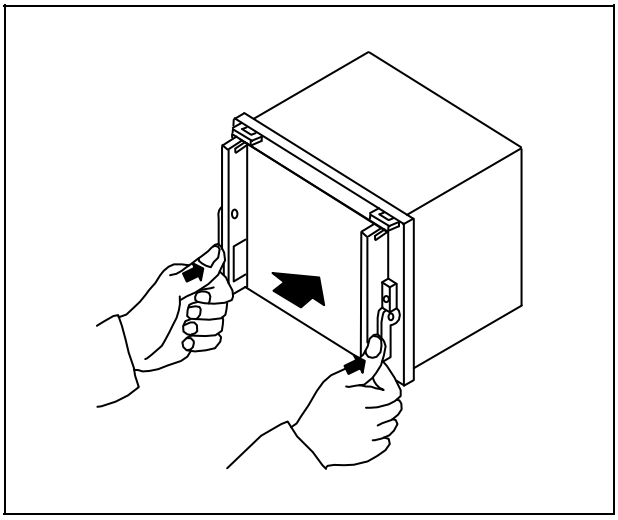


Under holding the auxiliary levers locked status by the with-holder (not to let the draw-out auxiliary levers fall down), **Insert the sub unit into the case until the auxiliary levers touch the metallic parts** while pressing the handles located on both sides of the front of the sub unit.



More fully insert the sub unit into the case until the auxiliary levers fall down automatically and catch the metal holes inside with its hooks.
(**Rotating angle is from 180° to approx. 45°**)

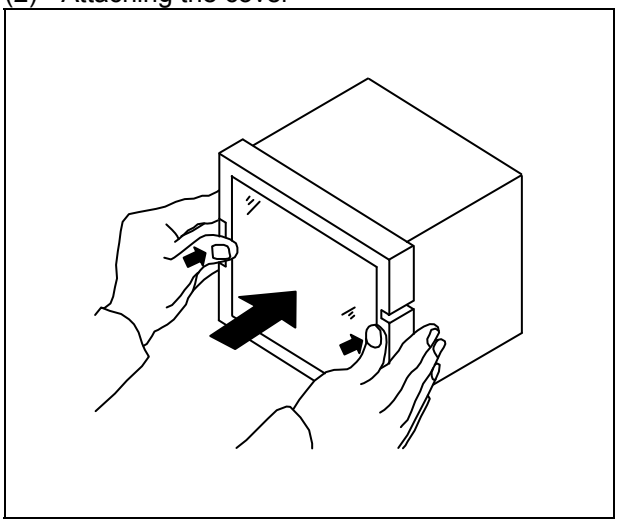
Note) If the auxiliary levers are not available to complement the wanted operation automatically, operate the auxiliary levers and make it achieve the above status please. At this time be also careful that do not injure your fingers.



Exert your strength to press the lower parts of the auxiliary levers to fully insert the sub unit into the case until you hear a click.
(**Rotated angle is from 45**° **to approx. 0°**)

Note) Please note that inserting the sub-unit incompletely may only establish a poor contact of the terminals located on the back of the unit, which may cause operational failure or heating.

(2) Attaching the cover



Fit the cover straight to the case. Hold the cover frame to **fully push the lock levers, located both side of the cover, to case side until it is clicked** and locked.

Note) After setting the cover, check if the buttons can be smoothly pressed from over the cover.

6.4 How to use front control panel

6.4.1 Front control panel layout

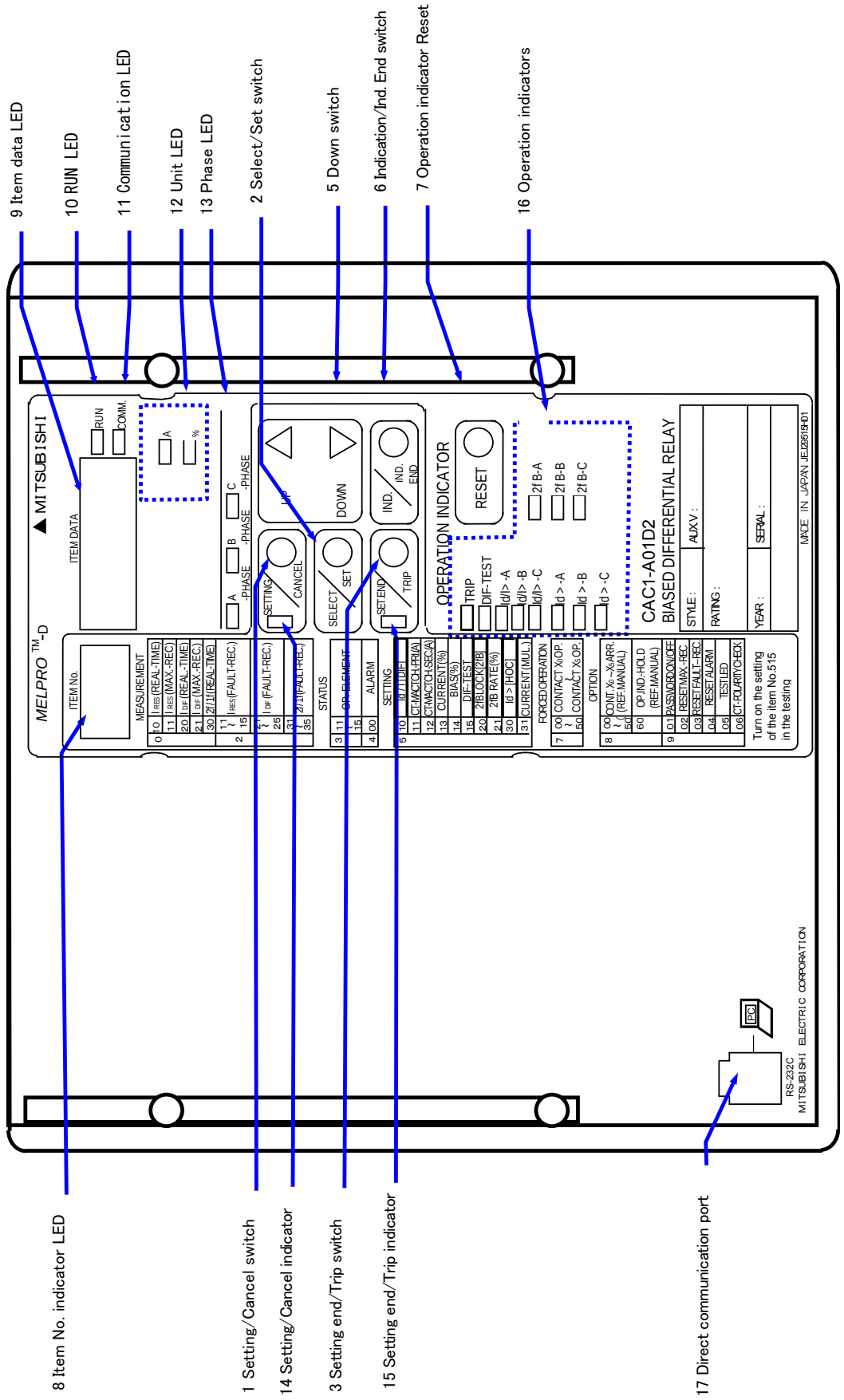
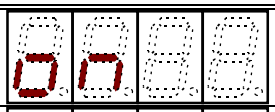
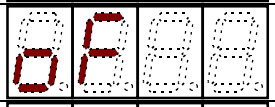
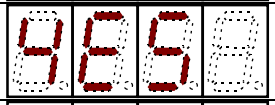
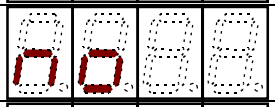
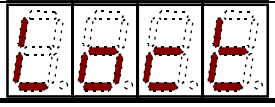


Figure 6.2 Front view of type CAC1-A01D2 relay

Table 6.1 Front control panel guide

No.	Designation			Symbol	Description
1	Operational key switches	Setting / Cancel		SETTING/CANCEL	Pressing this switch will start the procedure for setting, forced operation or option. When this switch is pressed again instead of the SET.END/TRIP switch, data that has been programmed will be all cleared to terminate the selected procedure. The SETTING/CANCEL indicator LED is lit during the procedure.
2		Select / Set		SELECT/SET	This switch is used to select an item number and to program item data during setting, forced operation or option procedure. When data is programmed to be ready for replacing the currently used setting, the SET.END/TRIP LED will blink.
3		Setting End / Trip		SET. END/TRIP	When the SET.END/TRIP switch is pressed with its LED blinking during setting, forced operation or option procedure, the currently enabled setting will be replaced by data given by programming. The new setting will be thus enabled.
4		UP select		UP	These switches are used for selecting data elements. Pressing these switches for a while will allow fast forwarding. With the cover operating buttons, you can use the switches without removing the cover.
5		DOWN select		DOWN	
6		Indication / Indication End		IND./IND.END	Pressing this switch will start or end the display of settings and measurements. With the cover operating button, you can use the switch without removing the cover.
7		Reset		RESET	Pressing this switch will reset output contacts after the relay operated and extinguish the operation indicator LEDs. With the cover operating button, you can use the switch without removing the cover.
8	Indicator LEDs	Item No.	Green	–	A number allocated to the selected setting, forced operation or option item is indicated here.
9		Item Data	Red	–	Data that corresponds to the item number selected is displayed here. For the indication of individual letters, see the Table6.2 manual specifically prepared for each model.
10		RUN	Green	–	Indicate the result of the automatic self-check. The lamp will be lit for normal results while off for abnormal.
11		Communication	Green	–	Indicate the operational status of the communication card. - With a communication card installed: the lamp will be lit for normal conditions, blinking during communication and off for abnormal conditions. - With a communication card not installed: the lamp will be off.
12		Unit	Yellow	–	Indicate the unit used for the item data.
13		Phase	Yellow	–	Indicate the phase that corresponds to the item data.
14		Setting / Cancel	Yellow	–	This lamp will be lit during setting, forced operation or option procedure.
15		Setting End / Trip	Yellow	–	This lamp will blink when new data is programmed to be ready for replacing the currently enabled setting.
16		Operation / Detection / Test	Red Yellow Yellow	– – –	Indicate the operation elements and phases. (Trip, Id/I>, Id>) Indicate the detection elements and phases. (2fB) Indicate the test mode when setting.(DIF TEST)
17	Direct communication port [current editions]			–	By connecting PC installed dedicated HMI software with relay, local operation and monitoring are enabled.

Table 6.2 Letter representation of item data indicator LEDs

Item		Display in item data box
Designation	Letters	
On	ON	
Off	OFF	
Yes	YES	
No	NO	
Operation lock	LOCK	

6.4.2 Operational procedure

For more information about the operational procedure shown below, see the MELPRO-D Series General Operation Manual (JEP0-IL9416).

6.4.2.1 Relay without RS232C communication I/F

Table 6.3 Operational procedure

Item					Description	Corresponding section of general operation manual	
No.	Designation					Indication mode	Setting/forced operation/option mode
010	Measurement	Restraining current (Real time value)			Measure and display effective input value of restraining current at real time.	A-1	
011		Restraining current (Max. records)			Display the max. effective restraining current.	A-2	
020		Differential current (Real time value)			Measure and display effective input value of differential current at real time.	A-1	
021		Differential current (Max. records)			Display the max. effective differential current.	A-2	
030		2f / 1f (Real time)			Measure and display effective input value of 2f component ratio at real time.	A-1	
211		Fault record	1st phenomena (Restraining current)		Record and display effective value of restraining current for the latest 5 phenomena of relay trip caused by system fault. The 1st phenomena is the latest trip and the 5th is the oldest one.	A-3	
212			2nd phenomena (Restraining current)				
213			3rd phenomena (Restraining current)				
214			4th phenomena (Restraining current)				
215			5th phenomena (Restraining current)				
221			1st phenomena (Differential current)		Record and display effective value of differential current for the latest 5 phenomena of relay trip caused by system fault. The 1st phenomena is the latest trip and the 5th is the oldest one.		
222			2nd phenomena (Differential current)				
223			3rd phenomena (Differential current)				
224			4th phenomena (Differential current)				
225			5th phenomena (Differential current)				
231			1st phenomena (2f / 1f)		Record and display effective value of 2f component ratio for the latest 5 phenomena of relay trip caused by system fault. The 1st phenomena is the latest trip and the 5th is the oldest one.		
232			2nd phenomena (2f / 1f)				
233			3rd phenomena (2f / 1f)				
234			4th phenomena (2f / 1f)				
235			5th phenomena (2f / 1f)				
311	Status	Operation elements	1st phenomena		Record and display the status of the operation indicator LEDs for up to five latest phenomena of relay trip caused by system fault. The 1st phenomena is the latest trip and the 5th is the oldest one.	A-4	
312			2nd phenomena				
313			3rd phenomena				
314			4th phenomena				
315			5th phenomena				
400		Self-diagnosis (ALARM)			Keep in record and display defect codes in the case where an abnormal condition is detected by the self-diagnosis.	A-6	
511	Settings	Phase fault	Biased differential elements	Matching tap primary [A]	Set and display settings.	A-7	B-1
512				Matching tap secondary [A]			
513				Operation current [%]			
514				Bias [%]			
515				DIF test			
521			2f blocking	2f blocking rate [%]			
531			Differential overcurrent	Operation current [Multiplier]			
700	Forced operation	Contact X_0 operation			Carry out forced operation of output contacts individually . The setting of programmable outputs can be checked through the operation indicator LEDs.		C-1
710		Contact X_1 operation					
720		Contact X_2 operation					
730		Contact X_3 operation					
740		Contact X_4 operation					
750		Contact X_5 operation					
800	Option	Contact arrangement	Contact X_0		Configure programmable output. Also, set and display self-hold/reset setting of programmable outputs. For the guide for setting, see the section 6.4.2.3 (1) below.	A-7	D-1
810			Contact X_1				
820			Contact X_2				
830			Contact X_3				
840			Contact X_4				

850		Contact X_5			
860	Option	Operation indicator LED hold	Set and display self-hold/auto reset setting of the operation indicator LEDs. For the guide for setting, see the section 6.4.2.3 (2) below.	A-7	D-2
901		Reset Max. record	Clear the data of the max. records.		D-4
902		Reset fault record	Clear the data of the fault records.		
903		Self-diagnosis reset (REST ALARM)	Clear data of the self-diagnosis records.		
904		Test LED lamp	Carry out forced illumination of all the LED lamps on the front of the relay unit.		D-5
905		Check CT polarity	Check the polarity of connected CT when connecting.		D-8

6.4.2.2 Relay with RS232C communication I/F

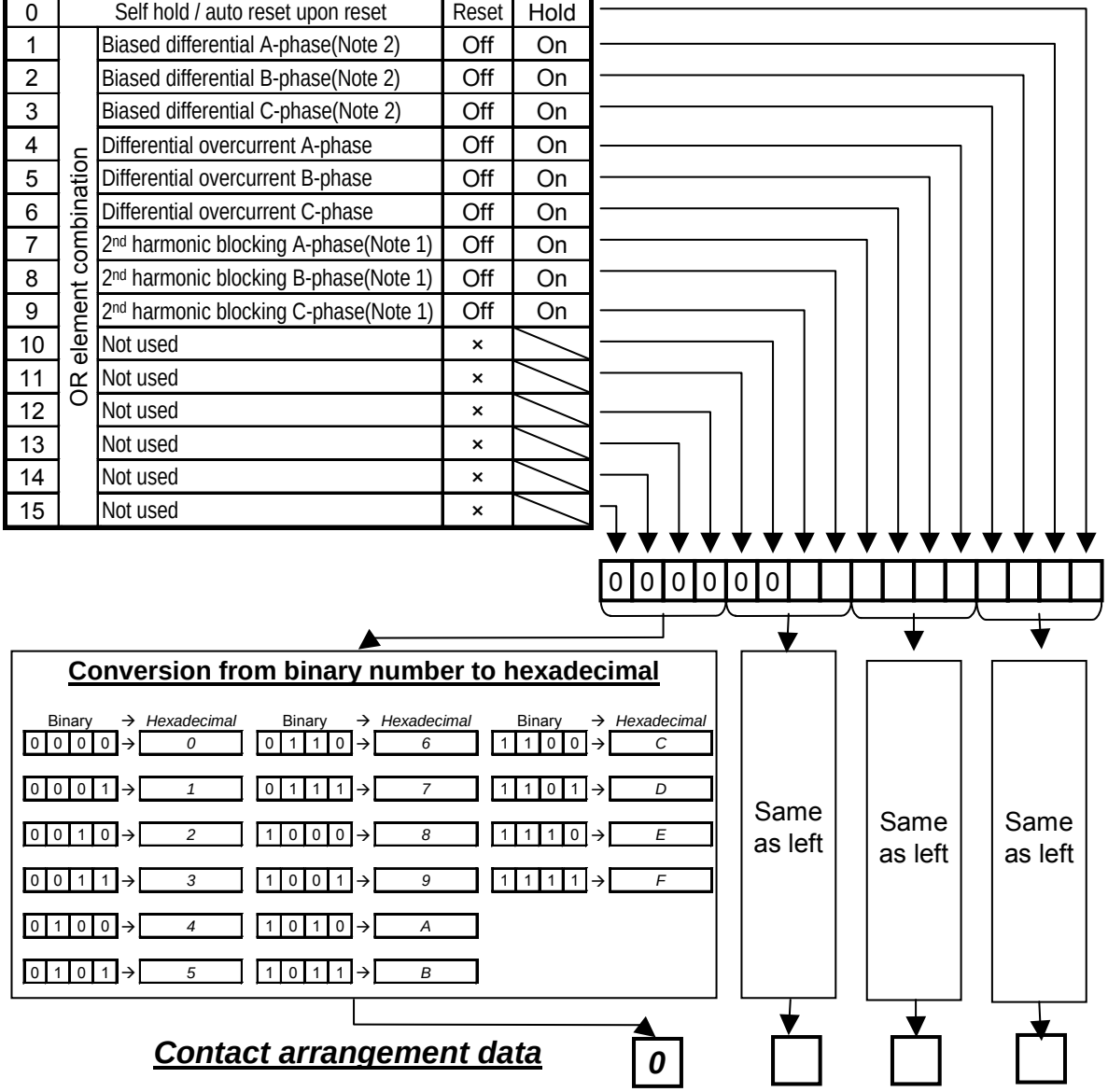
Item				Corresponding section of general operation manual	
No.		Designation	Description	Indication mode	Setting / forced operation / option mode
As the same as Table 6.3 described in item 6.4.2.1 about the No. 010～860.					
901	Option	Relay password enable/disable option	Set relay password enable or disable for setting.	A-7	D-9
902		Max. record reset	Clear data of the max. record.		D-4
903		Fault record reset	Clear data of the fault record.		
904		Self-diagnosis reset (RESET ALARM)	Clear data of the self- diagnosis record.		
905		LED lamp test	Carry out forced illumination of all the LED lamps on the front of the relay unit.		D-5
906		Check CT polarity	Check the polarity of connected CT when connecting.		D-8

6.4.2.3 Guide for option function

(1) Specifying contact arrangement data of output contacts

The table below shows the setting guide table. See the section D-1 of the general operation manual for the detailed procedure.

Digit No.	Setting item		Input 0	Input 1
0	Self hold / auto reset upon reset		Reset	Hold
1	OR element combination	Biased differential A-phase(Note 2)	Off	On
2		Biased differential B-phase(Note 2)	Off	On
3		Biased differential C-phase(Note 2)	Off	On
4		Differential overcurrent A-phase	Off	On
5		Differential overcurrent B-phase	Off	On
6		Differential overcurrent C-phase	Off	On
7		2nd harmonic blocking A-phase(Note 1)	Off	On
8		2nd harmonic blocking B-phase(Note 1)	Off	On
9		2nd harmonic blocking C-phase(Note 1)	Off	On
10		Not used	×	
11		Not used	×	
12		Not used	×	
13		Not used	×	
14		Not used	×	
15		Not used	×	



When the product is shipped from the factory, contact arrangement data are set as follows.

Contact	Item number	Contact arrangement data	Setting of the element
X0	800	0012	Biased differential/Differential overcurrent A-phase
X1	810	0024	Biased differential/Differential overcurrent B-phase
X2	820	0048	Biased differential/Differential overcurrent C-phase
X3	830	0380	2nd harmonic blocking A,B,C-phase
X4	840	007E	Biased differential/Differential overcurrent A,B,C-phase
X5	850	007E	Biased differential/Differential overcurrent A,B,C-phase

*The “Self hold/auto reset” setting are “Reset” (auto reset) for all contacts.

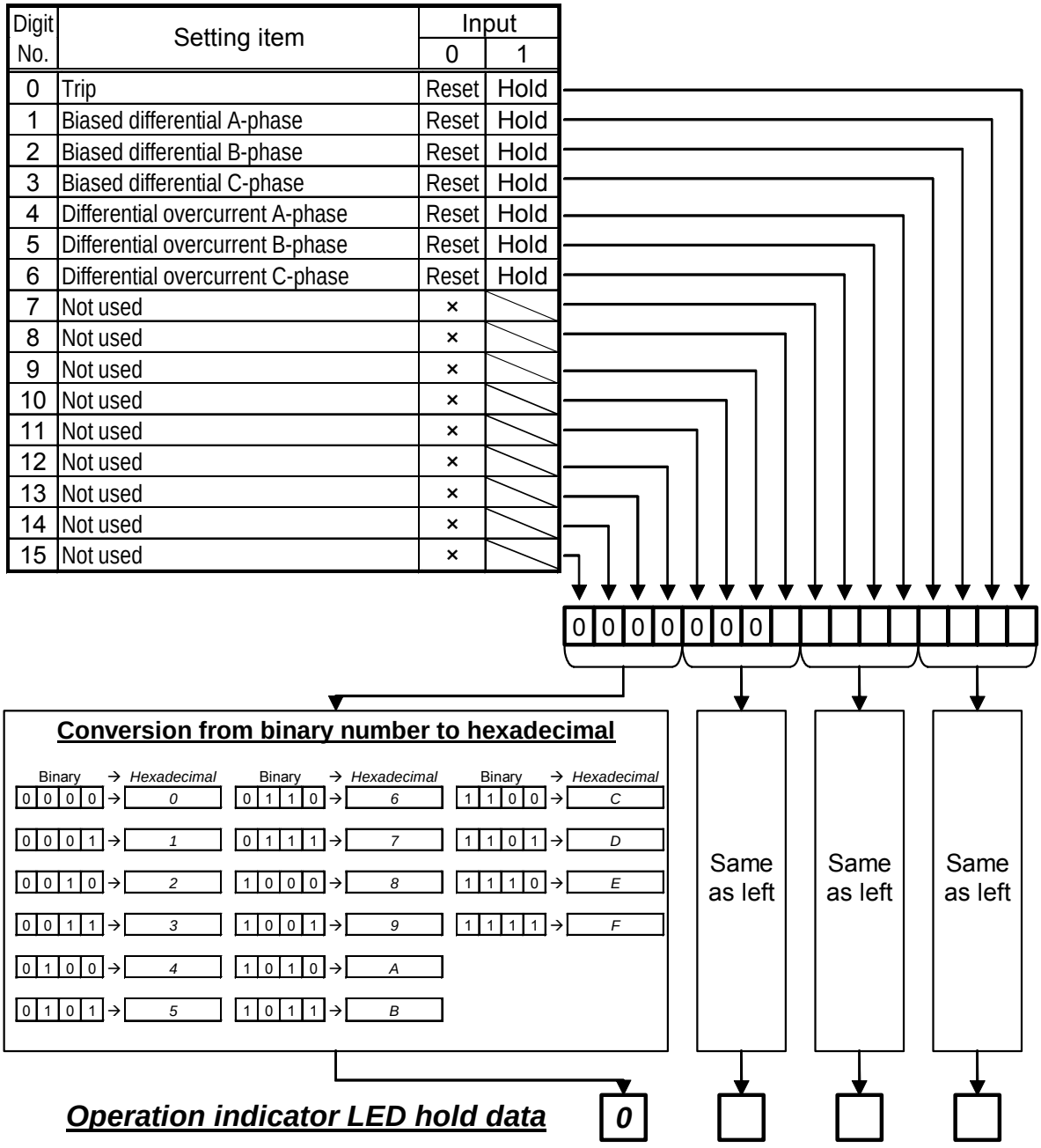
(Note 1) If the 2nd harmonic blocking elements (the digit number 7 to 9) are set to “ON” for a contact arrangement, the contact will make when the 2nd harmonic blocking element operate. Therefore, set to “OFF” for the trip contact.

(Note 2) Biased differential element for each phase has the 2nd harmonic blocking function. (Output of biased differential element for each phase is blocked by the 2nd harmonic blocking element operation signal.

(2) Specifying operation indicator LED hold data

The table below shows the setting guide table. See the section D-2 in the general operation manual for the detailed procedure.

Digit No.	Setting item	Input 0	Input 1
0	Trip	Reset	Hold
1	Biased differential A-phase	Reset	Hold
2	Biased differential B-phase	Reset	Hold
3	Biased differential C-phase	Reset	Hold
4	Differential overcurrent A-phase	Reset	Hold
5	Differential overcurrent B-phase	Reset	Hold
6	Differential overcurrent C-phase	Reset	Hold
7	Not used	×	
8	Not used	×	
9	Not used	×	
10	Not used	×	
11	Not used	×	
12	Not used	×	
13	Not used	×	
14	Not used	×	
15	Not used	×	



When the product is shipped from the factory, all LEDs are set to self-hold.

Item number	Operation indicator LED hold data
860	007F

(3) CT polarity check

This relay has a function that it can detect out the incorrect connection (polarity error or phase-sequence error) of CT connected with the primary winding and secondary winding of transformer. Be careful that it cannot detect out correctly if no current is flowing.(more than current 0.12A on the CT secondary side (relay input) is needed to detect correctly)

As the result of detection, if the code “0000” is displayed, it means that all of connection of CT is correct. Otherwise it means that the connection of CT is incorrect.

The following table 6.4 shows the indicated codes (one instance) when carrying out CT polarity check. You can reference it even for the other codes when you inform this function.

Please refer to the item D－8 of「General operation manual」in which the detailed operation is described.

Table 6.4　Codes of CT polarity check (one instance)

Primary side			Secondary side			Codes
A-phase	B-phase	C-phase	A-phase	B-phase	C-phase	
——	——	——	——	——	——	0000
Polarity	——	——	——	——	——	0001
——	Polarity	——	——	——	——	0020
——	——	Polarity	——	——	——	0400
——	——	——	Polarity	——	——	0001
——	——	——	——	Polarity	——	0020
——	——	——	——	——	Polarity	0400
Phase	Phase	——	——	——	——	0082
——	Phase	Phase	——	——	——	1040
Phase	——	Phase	——	——	——	0804
——	——	——	Phase	Phase	——	0044
——	——	——	——	Phase	Phase	0880
——	——	——	Phase	——	Phase	1002
Phase/Polarity	Phase	——	——	——	——	0090
Phase	Phase/Polarity	——	——	——	——	0102
Phase	Phase	Polarity	——	——	——	0482
Polarity	Phase	Phase	——	——	——	1041
——	Phase/Polarity	Phase	——	——	——	1200
——	Phase	Phase/Polarity	——	——	——	2040
Phase/Polarity	——	Phase	——	——	——	0808
Phase	Polarity	Phase	——	——	——	0824
Phase	——	Phase/Polarity	——	——	——	4004
——	——	——	Phase/Polarity	Phase	——	0048
——	——	——	Phase	Phase/Polarity	——	0204
——	——	——	Phase	Phase	Polarity	0444
——	——	——	Polarity	Phase	Phase	0881
——	——	——	——	Phase/Polarity	Phase	0900
——	——	——	——	Phase	Phase/Polarity	4080
——	——	——	Phase/Polarity	——	Phase	1010
——	——	——	Phase	Polarity	Phase	1022
——	——	——	Phase	——	Phase/Polarity	2002

* The meanings of symbols in this table is shown below.

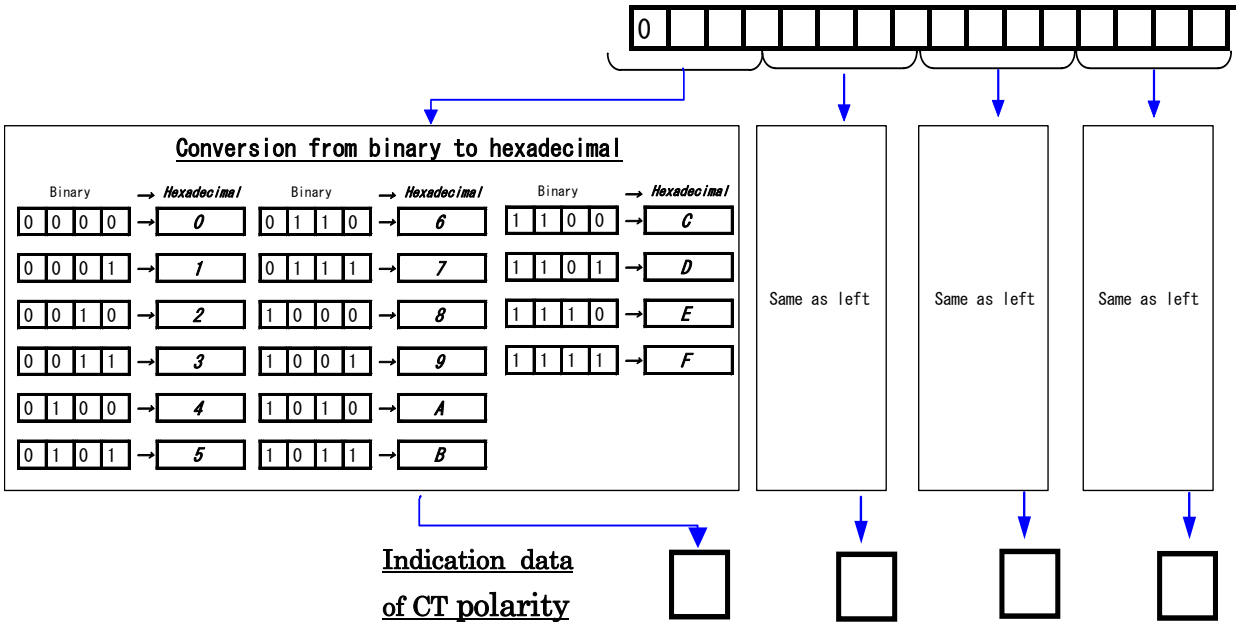
Polarity: CT polarity is incorrect.

Phase : The phase sequence is incorrect.

—　　: No abnormality

How to read and understand the CT polarity check codes

	Digit No.	Error	Output 0	Output 1
A-phase	0	Polarity error	Correct	Error
	1	Phase sequence error (A-B[Prim.],A-C[Sec.])	Correct	Error
	2	Phase sequence error (A-B[Sec.],A-C[Prim.])	Correct	Error
	3	Phase･Polarity error (A-B[Sec.],A-C[Prim.])	Correct	Error
	4	Phase･Polarity error (A-B[Prim.],A-C[Sec.])	Correct	Error
B-phase	5	Polarity error	Correct	Error
	6	Phase sequence error (A-B[Prim.],B-C[Sec.])	Correct	Error
	7	Phase sequence error (A-B[Sec.],B-C[Prim.])	Correct	Error
	8	Phase･Polarity error (A-B[Sec.],B-C[Prim.])	Correct	Error
	9	Phase･Polarity error (A-B[Prim.],B-C[Sec.])	Correct	Error
C-phase	10	Polarity error	Correct	Error
	11	Phase sequence error (A-C[Prim.],B-C[Sec.])	Correct	Error
	12	Phase sequence error (A-C[Sec.],B-C[Prim.])	Correct	Error
	13	Phase･Polarity error (A-C[Sec.],B-C[Prim.])	Correct	Error
	14	Phase･Polarity error (A-C[Prim.],B-C[Sec.])	Correct	Error
	15	Not used	0	



For instance, converse the displayed code from hexadecimal to binary,
If (Digit No.=0) = 1, A-phase polarity (CT primary or secondary) is error.
If (Digit No.=1) = 1, the phase sequence of A and B is error. (CT primary side)
or the phase sequence of A and C is error (CT secondary side).
If (Digit No.=3) = 1, the A-phase polarity of CT primary and secondary is error.
or the phase sequence of A and B is error (CT secondary side)
or the phase sequence of A and C is error (CT primary side).

7 Mounting

7.1 Mounting dimension

Mount the case to the panel according to Fig. 7.1 “Mounting dimension”.

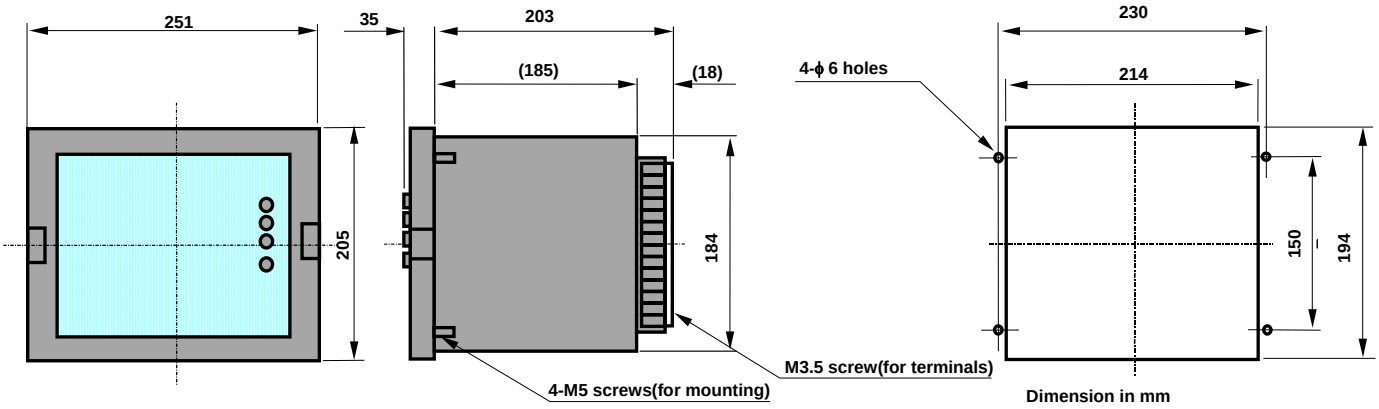


Figure 7.1 Outside dimension /drilling drawing (D2 Case)

7.2 Standard operating environment

Install the relay in the environment described in section 3.3 Common technical data. In addition, the following conditions should be kept:

- Abnormal vibration, shock, inclination or magnetic field should be avoided.
- Harmful smoke or gas, salt gas, excessive humidity, water drop or vapor, excessive dust or fine powder, rain and wind should be avoided.

8 Test

The relay has been fully tested prior to shipment. However, it is recommended to carry out a test again by referring to the following test guide before use.

8.1 Appearance inspection

Check the relay for appearance according to the following procedure:

Objects		Check points
Unit	Coil/conductor	(1) Discoloring and burning due to overheat. (2) Abnormal conditions including loosened screws.
	Printed card	(1) Discoloring of the printed card due to overheated parts. (2) Contact between the printed card and connector
	Mechanism	(1) Deformation (2) Operation of the operating key switches. (3) Damage of the draw-out lever of the sub unit. (4) Discoloring and deformation of the name plate on the front panel. (5) Damage of the terminal section.
Case/cover		(1) Damage of the cover. (2) Stain of the cover. (3) Clouding of the cover. (4) Damage of the lock lever of the cover. (5) Damage of the operating buttons of the cover. (6) Operation of the operating buttons of the cover. (7) Damage of the terminal section.
Others		Invasion of foreign matters including dust and iron chips.

8.2 Characteristic test

8.2.1 Precautions in testing

(1) Standard test conditions

Ensure the following test conditions whenever possible:

Note that carrying out a test under an environment that significantly differs from the following conditions may produce a incorrect result.

- Ambient temperature : 20°C±10°C
- Rated frequency : ±5%
- Waveform (AC) : 2% (distortion ratio)
- Auxiliary power supply voltage : rated voltage ±2%

(2) Characteristic control point

See the section 3 “Characteristics”.

The characteristic control point refers to the characteristic of a relay unit only. Note that, when a characteristic test is carried out on a relay system connected with external equipment such as CT and ZCT, the result obtained would be a combined characteristic added with the fluctuation of the external equipment.

For special control in terms of a specific control point (for instance, using the operation setting), first carry out a test at “Characteristic control point” at the time when the relay is received or put in service to determine the acceptance/rejection. Thereafter, perform another test at each control point, so that the data obtained can be used for future reference.

(3) Changing setting

Change the setting according to the section 6 “Handling”.

Please pay attention that the setting item of “DIF test (515)” should be set “ON” when you carry out characteristic test. Because this relay has continuously monitoring function of differential current, so that the monitoring abnormality (0017) will occur when current applied on. The DIF test LED (yellow) will become on when setting. And do not forget to set the DIF test (515) “OFF” after finishing the characteristic test.

(4) Operation judgment

Determine the operation currents and time and other values of the relay unit basically by turning on and off the corresponding output relay contact of each element.

(5) Determination of 2-terminal biased differential characteristic

As the determination condition, let the outflow current (I_2) be tap value (I_T) × 200%, and let the inflow current (I_1) raise slowly from tap value (I_T) × 200%, determine the operation value. Please calculate the bias τ based on the determined operation value according to the following formula.

$$\tau = \frac{I_1 - I_2}{I_1} \times 100 \ [\%]$$

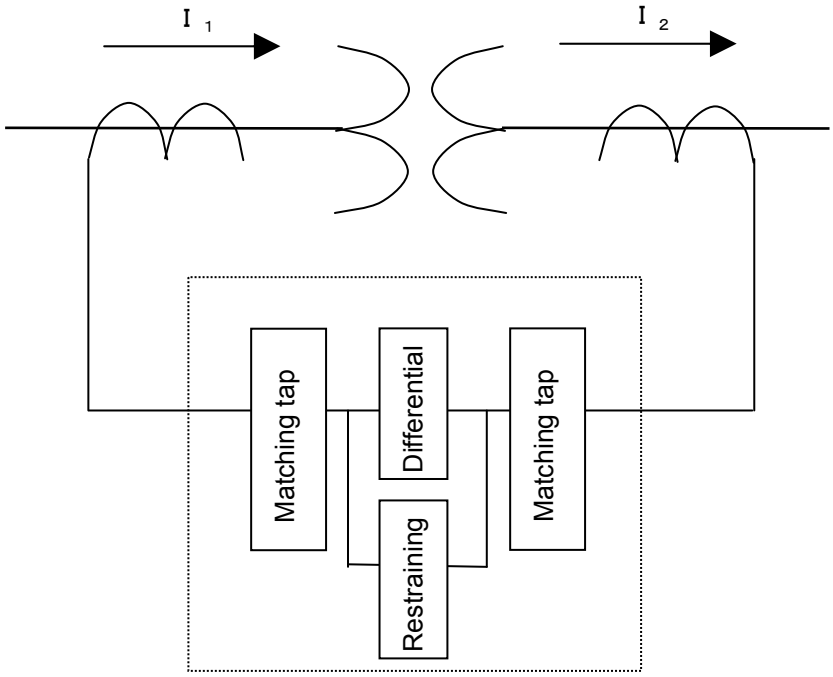
(6) Determination of differential overcurrent element operation value

When you want to determine the differential overcurrent operation value, please set the operation setting of differential element “LOCK” so that the relay will not response to the differential current. And do not forget to set the setting value with original one after finishing the determination.

(7) The calculation method of current value in case of the matching tap I_{T1} setting and I_{T2}setting is different.

As described in the item 3 [Characteristics], the testing condition is $I_{T1}=I_{T2}$ and the matching tap setting is minimum value.

However, in case of I_{T1} and I_{T2} is not equal, please calculate the current as following manner.



(Please refer to item 4.1(2) biased differential about calculation of current inside of the relay.)

The biased differential = differential current/ restraining current

$$\tau = \frac{|I_1 \cdot I_n/I_{T1} - I_2 \cdot I_n/I_{T2}|}{|I_1 \cdot I_n/I_{T1}| \text{ or } |I_2 \cdot I_n/I_{T2}| \text{ whichever is greater}}$$

(I_n: Rated current, τ : Setting value of the biased differential)

In case of $I_1>I_2$, the value of I_2 for testing should be 200% of matching tap T_1 which is the fixed value.

$$\tau = \frac{|I_1 \cdot I_n/I_{T1} - I_2 \cdot I_n/I_{T2}|}{|I_1 \cdot I_n/I_{T1}|}$$

According to the above equation, $I_1=I_2 \cdot I_{T1}/I_{T2} \cdot (1/(1-\tau))$

The criteria for evaluation for the testing results as below should be based on 2 cases in which value of τ is changed to (τ −5%) and (τ +5%).

<Example> In case of τ = 20%

① Lower limit of criteria

$I_1=I_2 \cdot I_{T1}/I_{T2} \cdot (1/(1-0.15))=2.353 \times I_{T1}$

② Upper limit of criteria

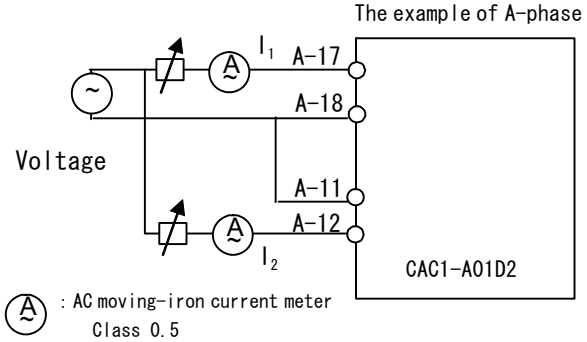
$I_1=I_2 \cdot I_{T1}/I_{T2} \cdot (1/(1-0.25))=2.667 \times I_{T1}$

8.2.2 Characteristic test

(1) Test circuit

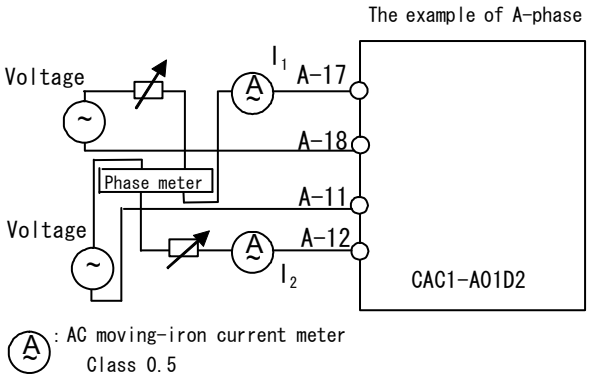
Connect the external wiring referring to the AC input circuit diagram shown below:

a. Biased differential characteristic

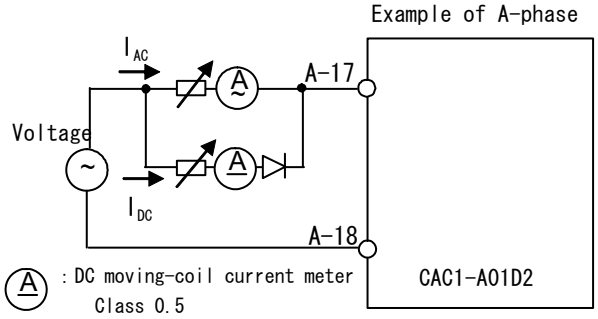


Phase	Terminals of primary windings	Terminals of secondary windings
A-phase	A-17~A-18	A-11~A-12
B-phase	A-19~A-20	A-13~A-14
C-phase	A-21~A-22	A-15~A-16

b. Phase characteristic



c. 2nd harmonic blocking characteristic



I_{AC}: SIN wave current
I_{DC}: Half wave rectifier current

$$\left(\frac{I_{f2}}{I_{f1}} = \frac{\frac{2}{3} I_{DC}}{\sqrt{2}\, I_{AC} + \frac{\pi}{2} I_{DC}} \times 100\ (\%) \right)$$

(2) Test items and characteristic control point

a. Forced operation test

See “Front control panel operational procedure” in the section 6 “Handling”.

b. Operation value test

See the item “Operation and reset values” in the section 3 “Characteristics”.

c. Operation time test

See the item “Operation time” in the section 3 “Characteristics”.

d. Reset time test

See the item “Reset time” in the section 3 “Characteristics”.

9 Maintenance

9.1 Daily inspection

Take every opportunity to carry out the following inspection:

- Check that the cover is not damaged and is attached properly.
- Check that no dust or iron chips have invaded into the unit.
- Check that the cover is not clouded notably.
- Check that abnormal noise is not generated.
- Check that the RUN LED lamp is lit.

9.2 Periodical inspection

It is recommended to carry out periodic inspections to check the relay for proper function.

For periodical inspections, perform the appearance inspection and characteristic test in accordance with the section 8 “Test”.

10 Ordering

The product and specification shown in this manual may subject to changes (including specification change and production suspend) without notice. It is advisory to inquire the nearest Mitsubishi Electric 's branch or sales office, if required, to confirm that the latest information is given in the manual, prior to placing an order.

Notify the following items when placing an order.

Item	Example of order	Remarks
Model	CAC1-A01D2	For more information, see the section 2 "Rating and specification".
Frequency	50 Hz	Select 50Hz or 60Hz.
Rating	Phase current: 5A	For more information, see the section 2 "Rating and specification".
Communication card	One of the followings can be selected: a. CC-Link communication card (Manual No.: JEP0-IL9517, JEP0-IL9418) b. No communication card	Only purchasing a communication card separately will allow customer to add the communication facilities. If customer does not need the communication facilitates at the time of introducing the system, just purchase the relay unit without communication card. Customer can add the communication facilities whenever he/she needs to introduce them. This will help decrease the initial cost and upgrade the system in stages.
Direct communication application	PC-DISW HMI software	By connecting PC with relay via the direct communication port (as standard equipment located on the relay front panel, local operation and monitoring are enabled as same as the remote operation and monitoring.

11 Guarantee

11.1 Guarantee period

The guarantee period of this product should be one year after delivery, unless otherwise specified by both parties.

11.2 Scope of guarantee

When any fault or defect is detected during the period of guarantee and such fault or defect is proved to be caused apparently at the responsibility of MITSUBISHI ELECTRIC CORPORATION, the defective unit concerned will be repaired or replaced with substitute with free of charge.

However, the fee for our engineer dispatching to site has to be covered by the user.

Also, site retesting or trial operation caused along with replacing the defect units should be out of scope of our responsibilities.

It is to be acknowledged that the following faults and defects should be out of this guarantee.

①When the faults or defects are resulted from the use of the equipment at the range exceeding the condition/environment requirements stated in the catalogue and manual.

②When the faults or defects are resulted from the reason concerning without our products.

③When the faults or defects are resulted from the modification or repair carried out by any other entity than MITSUBISHI ELECTRIC CORPORATION.

④When the faults or defects are resulted from a phenomenon which can not be predicted with the science and technology put into practical use at the time of purchase or contract

⑤In case of integrating our products into your equipment, when damages can be hedged by the proper function or structure in the possession of your equipment which should be completed according to the concept of the de fact standard of industry.

⑥In case of that the faults or defects are resulted from un-proper application being out of instruction of MITSUBISHI ELECTRIC CORPORATION.

⑦In case that the faults or defects are resulted from force majeure such a fire or abnormal voltage and as an act of God such as natural calamity or disaster.

11.3 Exclusion of loss in opportunity and secondary loss from warranty liability

Regardless of the gratis warranty term, MITSUBISHI ELECTRIC CORPORATION shall not be liable for compensation of damages caused by any cause found not be the responsibility of MITSUBISHI ELECTRIC CORPORATION, loss in opportunity, lost profits incurred to the user by failures of MITSUBISHI ELECTRIC CORPORATION products, special damages and secondary damages whether foreseeable or not, compensation for accidents, and compensation for damages to products other than MITSUBISHI ELECTRIC CORPORATION products and other tasks

11.4 Applications of products

①The user is requested to confirm the standards, the regulations and the restrictions which should be applied, in case of utilizing products described in this catalogue and another one in combination.

Also, the user is requested to confirm the suitability of our products to your applied system or equipment or apparatus by yourself.

MITSUBISHI ELECTRIC CORPORATION shall not be liable for any suitability of our products to your utilization.

②This MITSUBISHI ELECTRIC CORPORATION products described in the catalogue have been designed and manufactured for application in general industries, etc. Thus, application in which the life or an asset could be affected by special application such as medical system for life-sustaining, in nuclear power plants, power plants, aerospace, transportation devices(automobile, train, ship, etc)shall be excluded from the application. In addition to above, application in which the life or an asset could be affected by potentially chemical contamination or electrical interference and also in which the circumstances and condition are not mentioned in this catalogue shall be excluded from the application.

Note even if the user wants to use for these applications with user's responsibility, the user to be requested to approve the specification of MITSUBISHI ELECTRIC CORPORATION products and to contact to the technical section of MITSUBISHI ELECTRIC CORPORATION prior to such applications.

If the user applies MITSUBISHI ELECTRIC CORPORATION products to such applications without any contact to our technical section, MITSUBISHI ELECTRIC CORPORATION shall not be liable for any items and not be insured, independently from mentioned in this clause.

③In using MITSUBISHI ELECTRIC CORPORATION product, the working conditions shall be that the application will not lead to a major accident even if any problem or fault occur, and that backup or duplicate system built in externally which should be decided depend on the importance of facility, is recommended.

④The application examples given in this catalogue are reference only and you are requested to confirm function and precaution for equipment and apparatus and then, use our products

⑤The user is requested to understand and to respect completely all warning and caution items so that unexpected damages of the user or the third party arising out of un-correct application of our products would not be resulted.

11.5 Onerous repair term after discontinuation of product

①MITSUBISHI ELECTRIC CORPORATION shall accept onerous product repairs for 7(seven) years after production of the product is discontinued. (However, please consider the replacement of products after 15 years have been passed from ex-work of products.)

②Product supply (including repair parts) is not available after production is discontinued.

11.6 Changes in product specification

The specification given in the catalogue, manuals or technical documents are subject to change without prior to notice.

11.7 Scope of service

The technical service fee such as engineer dispatching fee is excluded in the price of our products.
Please contact to our agents if you have such a requirement.

12 Improvement of protection function

Any parts and materials applied to the protection relay have limited life time which will bring the degradation to the relay.

The degree of degradation will be variable and depend on the purpose, period in use, applied circumstance and unevenness on the performance of each part.

MITSUBISHI ELECTRIC CORPORATION design the relay so as to realize that the recommended replaced duration is more them 15 years.

However, there may be some possibilities to occur some defects before reaching 15 years due to above mentioned the degree of degradation of parts and materials being depended on the condition in use.

To prevent unwanted operation or no operation of relay due to above reasons, it is recommended to apply the relay with self-diagnosis function and/or multiplexing relay system such as dual or duplex scheme.

MITSUBISHI ELECTRIC CORPORATION

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