RW ENERGY

PRODUCT MANUAL

http://www.rw-relay.com

RWK-65

6kV,⋯.40.5kV Automatic Recloser controller

High reliability

Precise time control

Multiple reclosing methods

Comply with IEC / CEI /GB/JB/DL standards
Provided customized manufacture
Whole solutions for design, assembly, test...
Accountable solution for safety and reliability
Wide range offering, easy business and convenient installation

Foreword

Please read this chapter carefully before using this product!

This chapter introduces the safety precautions before using this product. Please make sure the content of this chapter is fully read and understood before installation and usage. Our company will not undertake any responsibilities for any damage or injury caused by improper operations because of ignoring relevant warning in this operation instruction.

Before operating this device, relevant professional personnel shall read this instruction carefully and well understand the content.

Operation instructions and warnings:

The following standard definitions will be adopted in this operation instruction.

Danger! Ignoring of safety precautions may cause personal death, serious personal injury or serious equipment damage.

Warning! Ignoring of safety precautions may cause personal death, serious personal injury or serious equipment damage.

Caution! Ignoring of safety precautions may cause a slight personal injury or equipment damage, especially the damage of device or the equipment protected by the device.

- **Danger!**

When the primary system is live working, secondary open circuit for the current transformer connected to the device is absolutely forbidden, and the open of this circuit may cause extremely dangerous high voltage.

- **Warning!**

Some parts of the device may have high voltage when the electrical device is running. Improper operation may cause serious personal injury or equipment damage.

Only qualified professional personnel are allowed to operate the device or work nearby the device. The operators professional shall well understand the precautions, working flows and safety regulations mentioned in this instruction.

- **Caution!**

Grounding terminals of the device shall be firmly grounded.

The device is only permitted to run in atmospheric environment that specified in the technical specifications, and abnormal vibrations shall be avoided in its running environment.

When connect the AC voltage current circuit or power circuit, please make sure they conform to the rated parameters of the device.

When the output terminals of the device are connected to external circuit, please check carefully the voltage of external power to prevent overheating of the circuit.

Carefully check the cable connected to the device, preventing applying too much external force on it.

- **Note!**

Every care has been taken in preparation of this manual. However, please note that not all the details or variations in the equipment or process being described can be covered. Neither is it expected to address all contingencies associated with the installation and operation of this equipment. If you need more information, please contact the manufacturer.

The fixed value in the picture is only for demonstration, not for actual configuration.

Contents

Chapter 1: Overview

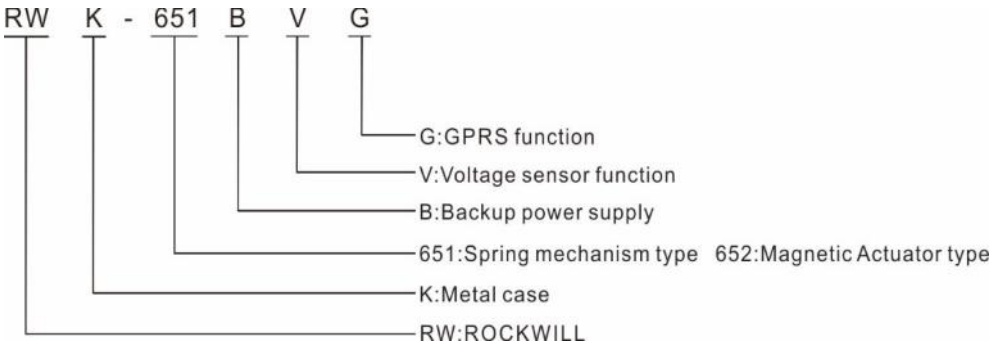
1.1 Description

RWK-65 overhead line protection switch intelligent controller is medium voltage overhead line grid monitoring unit, it can be equipped with RCW(RVB) type vacuum circuit breaker for achieve of automatic monitoring, fault analysis and event records.

It's given to us a safety power grid for cutting line fault and automatic recovery operation and power automation.
RWK-65 series is suitable for up to 35kV outdoor switchgear using, include: vacuum circuit breakers, oil circuit breakers and gas circuit breakers.
RWK-65 intelligent controller is gathering with line protection, control, measurement and monitoring of voltage and current signals integrated automation and control devices outdoors.

RWK is an automatic management unit for single way/multi ways/ring network/two power sourcing, provided with all voltage and current signals and all functions.
RWK-65 column switch intelligent controller supports:
Wireless (GSM/GPRS/CDMA), Ethernet mode, WIFI, optical fiber, power line carrier, RS232/485, RJ45 and other forms of communication, and can access other station premises equipment (such as TTU, FTU, DTU, etc.).

1.2 Product mode definition



1.3 Protection

Well designed protection elements for identification of particular fault types:

For radial line configuration:

· Short circuit fault (phase-to-phase and three-phase short circuits, single-phase and double-phase earth faults)

· Bolted Fault

· Sensitive Earth Fault

· Upstream broke wire

· Downstream broken wire

· Low System voltage

· Low System frequency

In addition for ring line configuration:

· Loss of Supply

· Automatic Backfeed Restoration

· Unique Source detector capable of source side identification under static and dynamic conditions such as motor start/stop and reverse reactive power flow

· Separate Bolted Fault detector which works independently of over-current elements and thus provides high flexibility in settings of overcurrent protection elements

· Real auto-reclosing elements for under-voltage and under-frequency resilient to nuisance tripping

· Automatic Group Transfer of settings according to date/season

· Flexible Time Current Characteristics (TCC) providing user-friendly configuration of inverse curves and automatic configuration of upstream TCC for configured downstream TCC (Auto coordination, Auto correction)

1.4 Supervision

74T/CCS Trip & Close Circuit Supervision

1.5 Control

86 Lockout

CB Control

1.6 Features

Password Protection – 2 levels.

50Hz/60Hz systems and two phase/three phase wiring method are available, so that the use scope of device is extended.

Protection configuration is complete, and all protection functions can be switched on and off flexibly.

9-way intellectual switching value input.

Large capacity flash memory can record at least 2400 times of historical events, and no data will loss even the power is off.

Circuits operating loop can be used both the direct or alternating current, self-adaptation open/close brake function, which can co-work with various of breakers, and the operation is simple and reliable.

The device has complete self-inspection function to in-service monitor the working conditions of various parts of the device, ensuring the reliability of the device.

1.7 Monitoring Functions

Primary Phases and Earth Currents

Direction

Primary Line and Phase Voltages

Apparent Power and Power Factor

Real and Reactive Power

Zero Phase Sequence Voltage

Frequency

Energy

Binary Input/Output status

Trip circuit healthy/failure

Time and date

Counters

Event records

1.8 Hardware

4 CT 1 VT 6 Voltage sensor 9 Binary Inputs 2 Binary Outputs

1.9 Data Storage and Communication

RS485/USB or RS485/RS232 port and Ethernet/RJ45

Protocols –IEC60870-5-101, IEC60870-5-104, DNP3.0 or Modbus RTU

Event Records

Fault Records

Measurands

Commands

Time Synchronism

Viewing and Changing Settings

Chapter 2: Technical Performance Index

2.1 Inputs and Outputs

Phase Current Inputs

Quantity	3
Rated Current In	1A
Measuring Range	20 x In
Instrumentation≥ 0.1xIn	±1% In
Frequency	50/60Hz
Thermal Withstand: Continuous 10 Second 1 Second	 5 x In 10 x In 40 x In
Burden @ In	≤0.2VA (5A Phase element)

Sensitive Earth Current Inputs

Quantity	1
Rated Current In	1A
Measuring Range	2 x In
Instrumentation≥ 0.1xIn	±1% In
Frequency	50/60Hz
Thermal Withstand: Continuous 10 Second 1 Second	 5 x In 10 x In 40 x In
Burden @ In	≤0.02VA (1A Earth element)

Voltage Inputs

Quantity	1 PT voltage
Nominal	40…120 Vrms
Operating Range	0...200 Vrms
Instrumentation≥0.8xVn	±1% Vn
Burden @ 110V	0.06 VA
Overvoltage Withstand	240 Vrms

Voltage sensor Inputs

Quantity	6 x Voltage sensor
Nominal	0…60 Vrms

Auxiliary Supply

DC Voltage	220V Range 200 to 320V
AC Voltage	220 V AC 50/60Hz Range 175 to 285Vrms AC 50/60Hz ±5%
Power consumption	≤100W/300W

Binary Inputs

Number	9
Operating Voltage	24V DC
Maximum dc current for operation	2mA

Binary Outputs

Number	5
Operating Voltage	220V DC (2) Passive(3)
Operating Mode	User selectable - Self or Hand/Electrical Reset or pulsed
Operating Time from Energizing Binary Input	<20ms

2.2 Unit Design

Indication	16 Character 4 line Display 41 LEDs
User Interface	21 Navigation Keys
Weight	32kg

2.3 Serial Interface

Communication Port	RS485/RS232/RJ45
Protocols	IEC60870-5-101 IEC60870-5-104 DNP3.0 MODBUS RTU

2.4 Data Storage

Events	1200 times(Totally)

2.5 Mechanical Tests

Vibration (Sinusoidal) --- IEC 60255-21-1 Class I

Type	Level	Variation
Vibration response	0.5gn	≤5%
Vibration withstand	1.0gn	≤5%

Shock and Bump --- IEC 60255-21-2 Class I

Type	Level	Variation
Shock response	0.5gn, 11ms	≤5%
Shock withstand	15gn, 11ms	≤5%
Bump test	10gn,16ms	≤5%

Shock and Bump --- IEC 60255-21- 3 Class I

Type	Level	Variation
Seismic response	X-plane-3.5mm Displacement below crossover freq (8-9Hz) 1gn and above Y-plane-1.5mm Displacement below crossover freq (8-9Hz) 0.5gn above	≤5%

Mechanical Classification

Durability	>106 operations

2.6 Electrical Tests

Insulation --- IEC 60255-5

Type	Level
Between any terminal and earth	2.0 kV AC RMS for 1 min
Between independent circuits	2.0 kV AC RMS for 1 min
Across normally open contacts	kV AC RMS for 1 min

High Frequency Disturbance --- IEC 60255-22-1 Class Ⅲ

Type	Level	Variation
Common (longitudinal) mode	2.5 kV	≤5%
Series (transverse) mode	1.0 kV	≤5%

High Frequency Disturbance --- IEC 60255-22-2 Class Ⅳ

Type	Level	Variation
Contact discharge	8.0 kV	≤5%

Fast Transients --- IEC 60255-22-4 Class A (2002)

Type	Level	Variation
5/50 ns 2.5 kHz repetitive	4 KV	≤5%

Surge Immunity --- IEC 60255-22-5

Type	Level	Variation
Analog Inputs: Line to Earth	4.0 kV	≤10%
Case, Aux Power & I/O: Line to Earth	2.0 kV	≤10%
RS485 Comms port: Line to Earth	1.0 kV	No Data Loss
Analog Inputs: Line to Line	1.0 kV	≤10%
Case, Aux Power & I/O: Line to Line	1.0 kV*	≤10%

* Note 45ms DTL pick-up delay applied to binary inputs

Conducted Radio Frequency Interference --- IEC 60255-22-6

Type	Level	Variation
0.15 to 80 MHz	10 V	≤5%

Radiated Radio Frequency --- IEC 60255-25

Type	Limits at 10 m, Quasi-peak
30 to 230 MHz	40 dB(μV)
230 to 10000 MHz	47 dB(μV)

Conducted Radio Frequency

Type	Limits	
	Quasi-peak	Average
0.15 to 0.5 MHZ	79 dB(μV)	66 dB(μV)
0.5 to 30 MHZ	73 dB(μV)	60 dB(μV)

Radiated Immunity --- IEC 60255-22-3 Class Ⅲ

Type	Level
80 MHz to 1000 MHz Sweep	10 V/m
1.4GHz to 2.7GHz Sweep	10 V/m
80,160,380,450,900,1850,2150 MHz Spot	10 V/m

2.7 Climatic Tests

Temperature --- IEC 60068-2-1/2

Operating Range	-10°C to +55°
Storage range	-25°C to +70°

Humidity --- IEC 60068-2-78

Operational test	56 days at 40°C and 93% relative humidity

Chapter 3: Protection Functionality

3.1 Function Description

Protection

The protection functionality supports the following key applications:

· Radial line recloser
· Ring line recloser

Radial line configuration covers the following types of faults:

· short circuit (phase-to-phase and three-phase short circuits, single-phase and double-phase earth faults)
· bolted fault (caused by human error)
· sensitive earth fault
· upstream broken wire
· downstream broken wire
· low system voltage
· low system frequency

In addition to the above-mentioned functions Ring line configuration provides Loss of Supply and Automatic Backfeed Restoration functionality in normally open ring lines. Ring line configuration supersedes the Radial line one and has two sets of protection element settings depending on at which side of the recloser the source has been found.

Protection elements against short circuit, sensitive earth fault, low system voltage and low system frequency faults are provided with independent reclosing elements.

All protection elements are controlled by a source detector element, which detects the presence of the power supply source on the designated side of each recloser. The protection elements are blocked if the power supply source cannot be found.

The reclosing elements as well as the Automatic Backfeed Restoration are controlled by the Voltage Reclosing element, which looks at the compliance of global reclosing conditions: the presence of high power supply quality.

Diagram 1 illustrates structural tree of the protection element if recloser type=Radial.

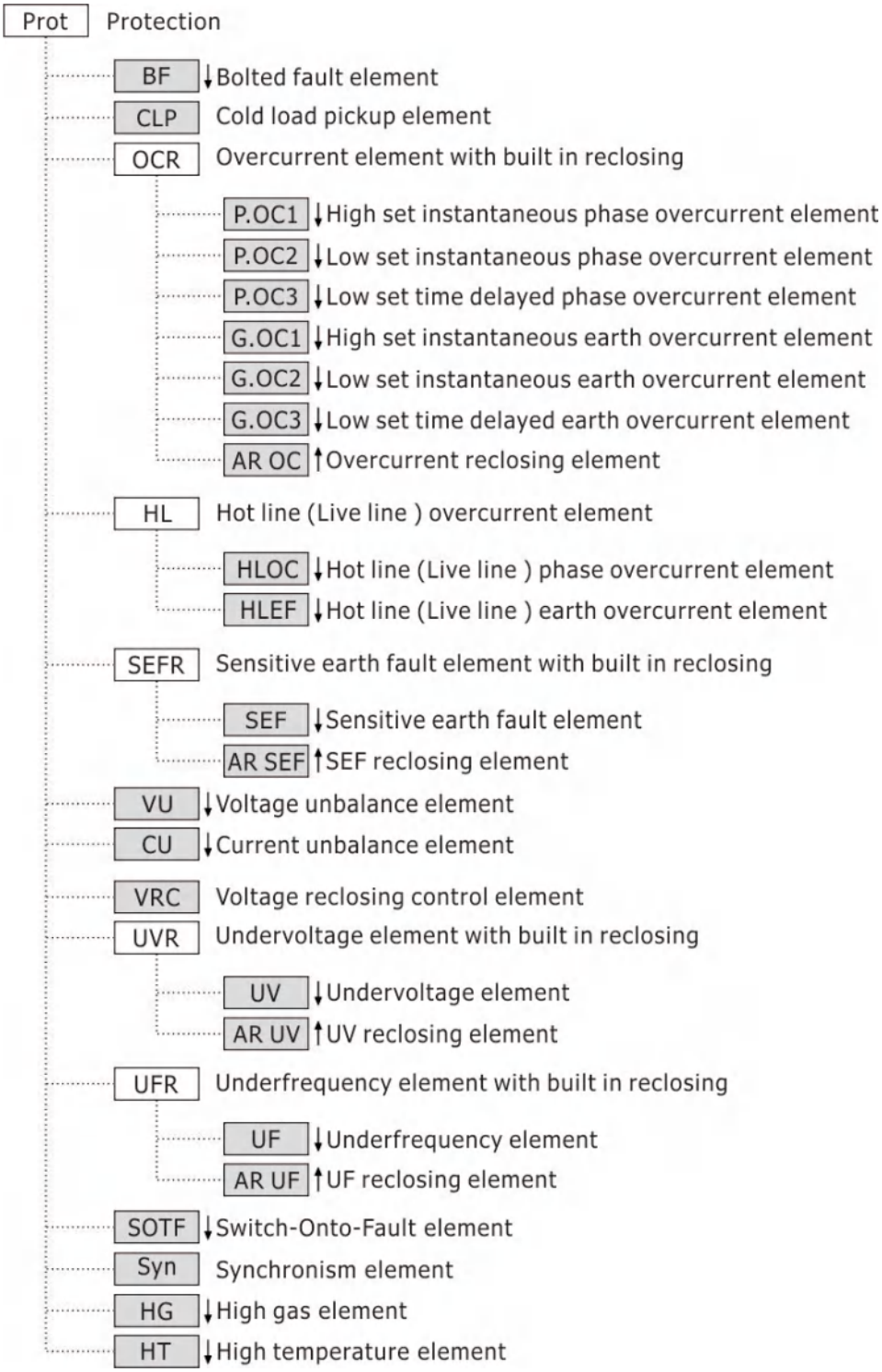
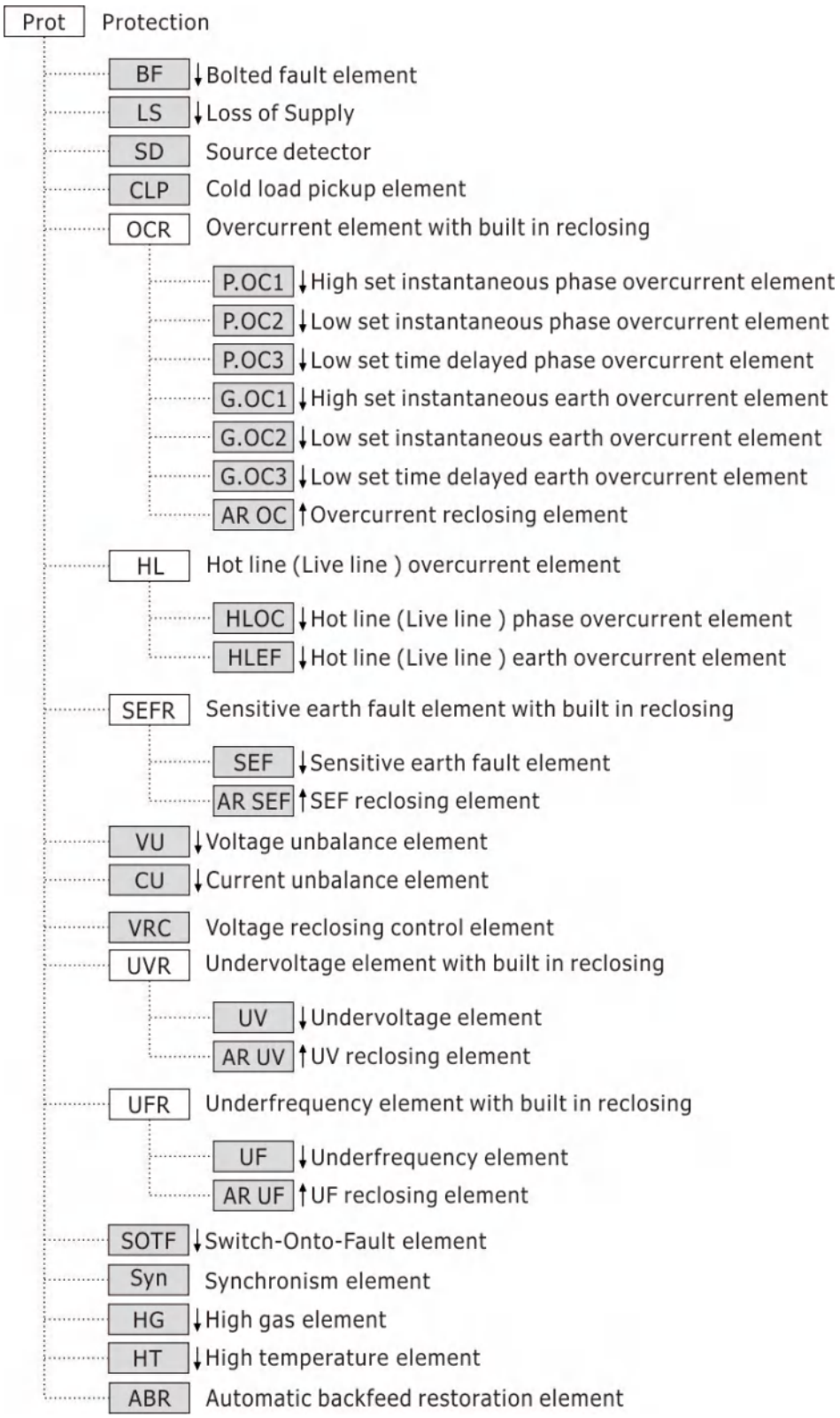


Diagram 2 illustrates structural tree of the protection element if recloser type=Ring.



Individual protection elements are colored with grey. Sets of elements are not colored. Furthermore elements providing closing or tripping are marked with upward (↑)and downward (↓)arrows correspondingly. Auxiliary elements and sets of elements are not marked with arrows.

For the above protection elements, four groups of protection settings are available. Group 1 is the default group setting. Preset groups of protection settings can for example be used to facilitate adaptation to different local conditions, which depend on the weekday or season. An active group may be changed automatically or by communications commands.

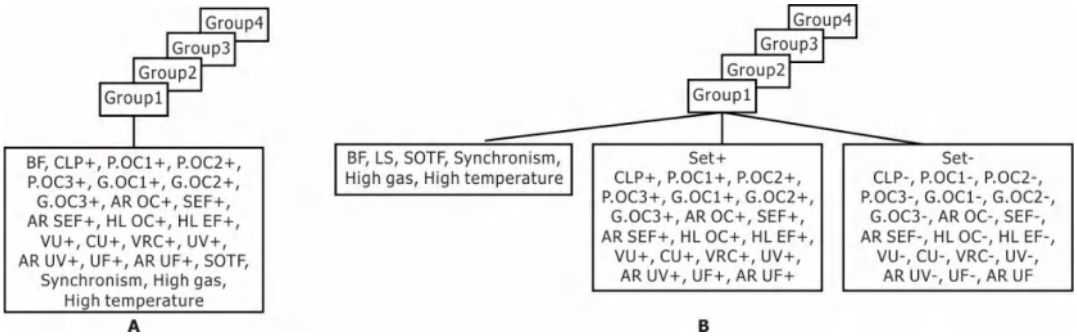


Diagram 3
Protection settings structure:
A - for Recloser type=Radial; B - for Recloser type=Ring

At it is seen from Diagram 3, B some elements have two identical settings sets in each group if Recloser type=Ring. The active set depends on the state of SD element. Thus, for example, the "Pickup current" setting of SEF element is determined with one only setting in each group if Recloser type=Radial. For Recloser type=Ring there are two settings in each group – the first one in Set+ and the second one in Set-.

See description of SD element for details.

Protection Elements

Source detector (SD)

For ring lines it detects the presence of a source on the positive or negative side for both closed and open recloser states. The operation of the protection elements OCR, LL, SEFR, VU, CU, UVR, UFR and ABR depend on the source side identified. If source found at the Source+ side or no source those elements use the settings "Set+". If source found at the Source- side those elements use settings "Set-".

The element includes an algorithm, which provides correct operation for various transient conditions including motor start/stop when connected to the line. It responds correctly even during fault conditions where the motor acts as generator feeding power into the network. The same it true for reactive power flow in reverse direction.

This element does not have selectable settings.

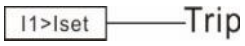
Bolted fault element (BF)

This element provides instantaneous tripping when bolted fault conditions are detected. The element will respond to a fault if the positive sequence current I1 exceeds the pickup current Iset.

BF element settings:

Description		Setting range	Step length
Bolted fault	Pickup current	1～6000A	1A

Action Logic diagram:



I1—Positive sequence current Iset—Pickup current

The element is blocked when the following communication signal is activated:
· Protection Disable

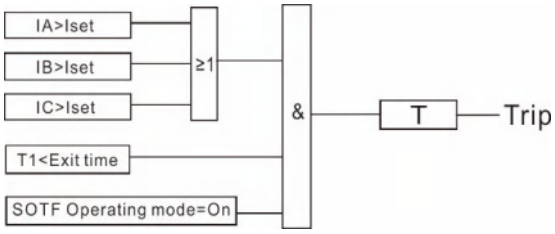
TRSOTF Switch-Onto-Fault (SOTF)

When switching on manual closing acceleration, if accidents happened in the exit time after operated the close, the phase over current protection will accelerate the operation. The exit time of acceleration can be adjusted.

SOTF element settings:

Description		Setting range	Step length
SOTF	Operating mode	0: Off, 1: On	
	Exit time	0.1～9.99S	0.01S
	Pickup current	1～6000A	1A
	Delay time	0～9.99S	0.01S

Action Logic diagram:



IA IB IC—Measured current Iset—Pickup current T—Delay time
T1— The time after manual close

The element is blocked when the following communication signal is activated:
· Protection Disable
· Hotline enabled

51c Cold Load Pickup (CLP)

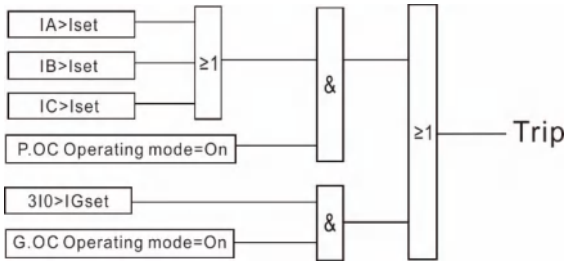
If a circuit breaker is closed onto a "cold" load, i.e.one that has not been powered for a prolonged period, this can impose a higher than normal load-current demand on the system which could exceed normal settings. These conditions can exist for an extended period and must not be interpreted as a fault. To allow optimum setting levels to be applied for normal operation, the cold load pickup feature will apply alternative current settings for a limited period. The feature resets when either the circuit breaker has been closed for a settable period, or if the current has reduced beneath a set level for a user set period.

When the time of the line lost current longer than the "Loss-load time", the load of the line be cold. Next time the line have current, "Cold load" protection start, the protection you set (phase fault/earth fault/sensitive earth fault)is invalid, the recloser just trip when the current satisfy the logic diagram below. After the" Restore time", "Cold load" protection end the protection you set is available.

Cold load element settings:

Description		Setting range	Step length
Cold load	Operating mode	0: Off, 1: On	
	Pickup-Phase+	1～6000A	1A
	Pickup-Ground+	1～6000A	1A
	Pickup-Phase-	1～6000A	1A
	Pickup-Ground-	1～6000A	1A
	Loss-load time	0.1～99.99S	0.01S
	Restore time	0.1～99.99S	0.01S

Action Logic diagram:



IA IB IC—Measure current Iset—Pickup-Phase current

3I0—Measure Ground current IGset—Pickup-Ground current

This protection cannot be used alone, but must be used together with P.OC2, P.OC3, G.OC2 and G.OC3, and the protection needs to be opened.

Loss of supply element (LS)

The Loss of Supply element detects loss of voltage on all six bushings and loss of current on all three phases. This element provides tripping resulted from loss of supply. This functionality is applicable for sectionalizing recloser in order to support automatic backfeed restoration.

The operation of the element can be described as follows: It is passive as long as SD reports a source present. It starts timing up the user set Tripping time Tt when the SD cannot find the source. When this time expires and the source is still not found, LS initiates a trip request to the driver to open the recloser. If the source is found whilst element is timing up its tripping time, this element becomes passive again and the timer is reset.

LS element settings:

Description		Setting range	Step length
Loss of supply	Operating mode	0: Off, 1: On	
	Delay time	0.1～99.99S	0.01S

The element is blocked when the following communication signal is activated:
· Protection Disable

Voltage reclosing control element (VRC)

This element monitors the presence high power supply quality. It provides reclosing blocking of ABR element when voltage and frequency do not meet user set values.

VRC element settings for Recloser type = Radial:

Description		Setting range	Step length
Voltage control	Pickup voltage+	1 ~ 42KV	0.1KV
	Pickup freq.+	45 ~ 60Hz	0.01Hz
	Phase	1 ~ 3	1

VRC element settings for Recloser type = Ring:

Description		Setting range	Step length
Voltage control	Pickup voltage+	1 ~ 42KV	0.1KV
	Pickup freq.+	45 ~ 60Hz	0.01Hz
	Pickup voltage-	1 ~ 42KV	0.1KV
	Pickup freq.-	45 ~ 60Hz	0.01Hz
	Phase	1 ~ 3	1

The operation of the element (radial feeder) can be described as follows: It becomes active (power failure) when either the positive sequence voltage measured from source+ side (U1+) is less than the pickup voltage (Up) or when the frequency measured from source+ side (F+) is less than the pickup frequency Fp. It becomes passive (power OK) as soon as both U1+ and F+ exceed the above requirements.

Phase is the frequency selective phase. **Phase** is also applicable to synchronism check element.

Automatic backfeed restoration element (ABR)

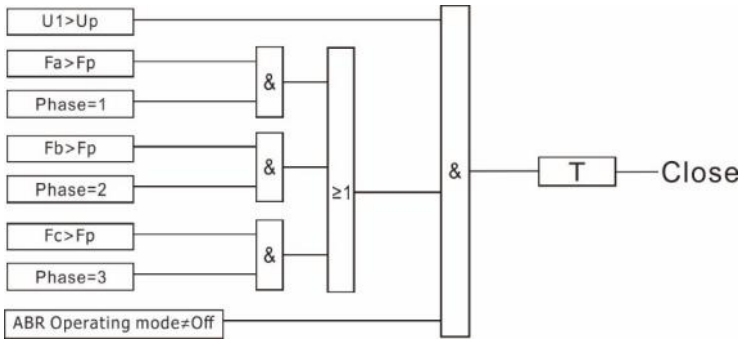
Automatic backfeed restauration if used to automatically close a normally open recloser if it detects a source (via SD element) on the alternative source side. This allows the recloser to be used as a tie point in an automation system. This element is only applicable for ring line recloser type and provides automatic backfeed restoration when relevant conditions are met.

ABR element settings:

Description		Setting range	Step length
Auto backfeed	Operating mode	0-Off, 1-Both, 2-Only, 3-Only	
	Reclose time+	0.1 ~ 180S	0.01S
	Reclose time-	0.1 ~ 180S	0.01S

Operating mode means:
Off: Disable
Both: No matter which side has voltage, it can be closed, but only one side has voltage
Only+: Switch on only when there is voltage on the source+ side (ABC side)
Only-: Switch on only when there is voltage on the source- side (RST side)

Action Logic diagram:



U1—Positive sequence voltage Up—Pickup voltage T—Delay time

Fa—Frequency of phase A voltage Fb—Frequency of phase B voltage

Fc—Frequency of phase C voltage Fp—Pickup frequency

Up, Fp and Phase are set in VRC, T is set in ABR.

The element is blocked when the following Communication signals are activated:
· Protection Disable
· Hotline Enabled
· Backfeed Restoration Disable
It is also blocked by the SD and VRC protection elements.

Synchronism Check Element

The two synchronism check elements are single-phase elements, with single phase voltage inputs VP and VS used for both elements:
VP is the source side phase input voltage (UA, UB, or UC), designated by setting **Phase** (if **Phase**=1, then VP=UA; if **Phase**=2, then VP=UB; if **Phase**=3, then VP=UC).
VS is the load side phase input voltage (UR, US, or UT), designated by setting **Phase** (if **Phase**=1, then VS=UR; if **Phase**=2, then VS=US; if **Phase**=3, then VS=UT).

Synchronism check is only needed when the circuit breaker is open. System frequencies determined from Voltages VP and VS. Single-phase voltage inputs VP and VS are compared to a voltage window, to verify that the voltages are "healthy" and lie within settable voltage limits **Low voltage** and **High voltage**. The two synchronism check elements use the same voltage window (to ensure healthy voltage), slip frequency settings and max angle settings.

Synchronism check elements settings as shown in the following table:

Setting	Definition
Low voltage	low voltage threshold for "healthy voltage" window
High voltage	high voltage threshold for "healthy voltage" window
Phase	synchronizing phase
Max angle	synchronism check element maximum angle
Slip frequency	maximum slip frequency
Close time	breaker close time for angle compensation
Max time	maximum synchronization time

Slip Frequency Calculator:

Slip Frequency = fP – fS (in units of Hz = slip cycles/second)

fP = frequency of voltage VP (in units of Hz = cycles/second)

fS = frequency of voltage VS (in units of Hz = cycles/second)

A complete slip cycle is one single 360-degree revolution of one voltage (e.g., VS) by another voltage (e.g., VP). Both voltages are thought of as revolving phasor-wise, so the "slipping" of VS past VP is the *relative* revolving of VS past VP. For example, if voltage VP has a frequency of 59.95 Hz and voltage VS has a frequency of 60.05 Hz, the difference between them is the slip frequency:

Slip Frequency = 59.95 Hz – 60.05 Hz = –0.10 Hz = –0.10 slip cycles/second

The slip frequency in this example is negative, indicating that voltage VS is not "slipping" *behind* voltage VP, but in fact "slipping" *ahead* of voltage VP. In a time period of one second, the angular distance between voltage VP and voltage VS changes by 0.10 slip cycles, which translates into:

0.10 slip cycles/second • (360°/slip cycle) • 1 second = 36°

Thus, in a time period of one second, the angular distance between voltage VP and voltage VS changes by 36 degrees.

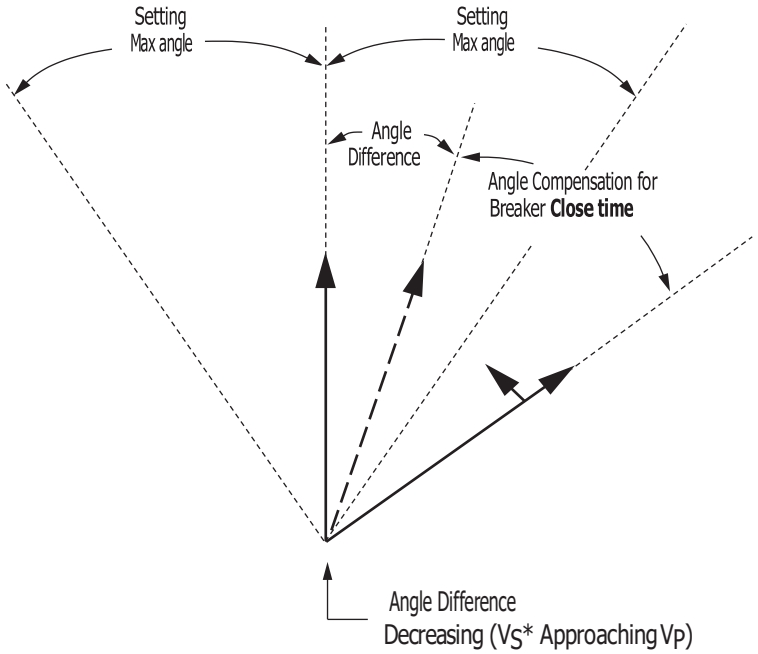
Angle Difference Calculator

The synchronism check element Angle Difference Calculator runs if the slip frequency is less than the maximum **Slip frequency** setting.

If the slip frequency is less than or equal to 0.005 Hz, the Angle Difference Calculator does not take into account breaker close time—it presumes voltages VP and VS are "static" (not "slipping" with respect to one another).This would usually be the case for an open breaker with voltages VP and VS that are paralleled via some other electric path in the power system. The Angle Difference Calculator calculates the angle difference between voltages VP and VS:

Angle Difference = |(∠VP –∠VS)|

Also, if breaker **Close time** setting = 0.000S, the Angle Difference Calculator does not take into account breaker close time, even if the voltages VP and VS are "slipping" with respect to one another.



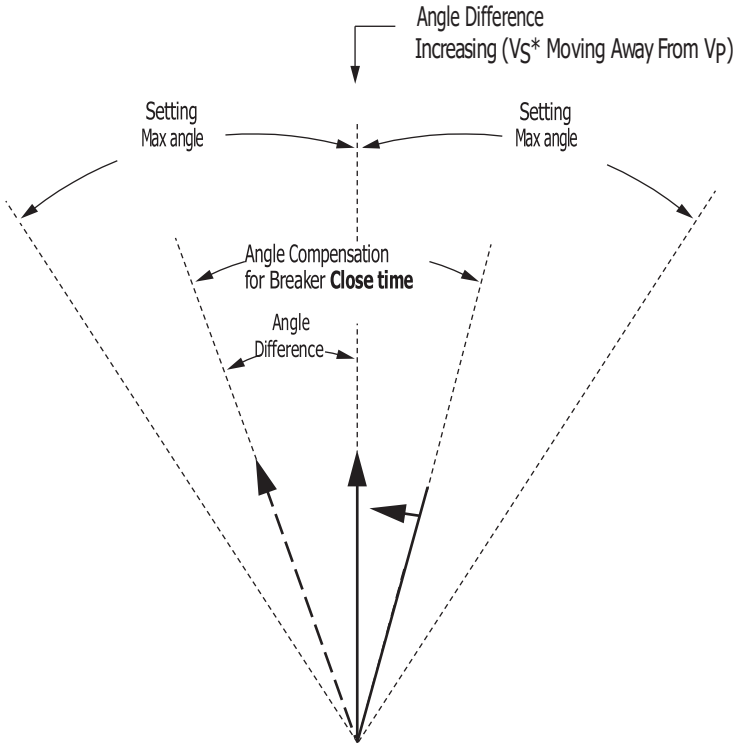


Figure 1 Angle Difference Between VP and VS Compensated by Breaker Close Time (fP < fS; VP Shown as Reference in This Example)

If the slip frequency is greater than 0.005 Hz and breaker **Close time** $\neq 0$, the Angle Difference Calculator takes the breaker close time into account with breaker close time setting. The Angle Difference Calculator calculates the Angle Difference between voltages VP and VS, compensated with the breaker close time:

Angle Difference = |(∠VP – ∠VS) + [(fP – fS) • **Close time** • 360°]|

Angle Difference Example (Voltages Vp and Vs Are "Slipping"). For example, if the breaker **Close time** is 0.167s. Presume the slip frequency is the example slip frequency calculated previously. The Angle Difference Calculator calculates the angle difference between voltages VP and VS, compensated with the breaker close time:

Angle Difference = |(∠VP – ∠VS) + [(fP – fS) • **Close time** • 360°]|

Intermediate calculations:

(fP – fS) = (59.95 Hz – 60.05 Hz) = –0.10 Hz = –0.10 slip cycles/second

Close time = 0.167second

Resulting in:

Angle Difference = |(∠VP – ∠VS) + [(fP – fS) • **Close time** • 360°]|
= |(∠VP – ∠VS) + [–0.10 • 0.167 • 360°]|
= |(∠VP – ∠VS) – 6°|

During the breaker **Close time**, the voltage angle difference between voltages VP and VS changes by 6 degrees. This 6-degree angle compensation is applied to voltage VS, resulting in derived voltage VS*, as shown in *Figure 1.*

The top of *Figure 1* shows the Angle Difference *decreasing*—VS* is approaching VP. Ideally, circuit breaker closing is initiated when VS* is in-phase with VP (Angle Difference = 0°). Then when the circuit breaker main contacts finally close, VS is in-phase with VP, minimizing system shock.

The bottom of *Figure 1* shows the Angle Difference *increasing*—VS* is moving away from VP. Ideally, circuit breaker closing is initiated when VS* is in-phase with VP (Angle Difference = 0°). Then when the circuit breaker main contacts finally close, VS is in-phase with VP. But in this case, VS* has already moved past VP, it will be

switched on immediately.

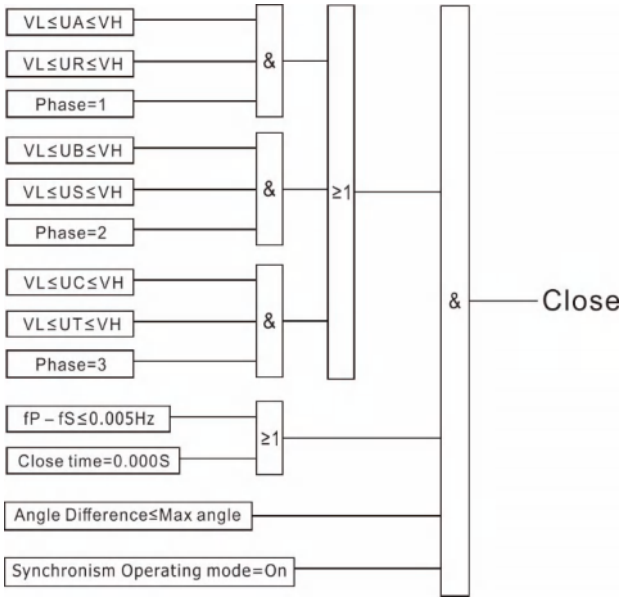
Synchronism Check Element Outputs. Synchronism check element outputs assert to logical 1 for the conditions explained in the following text.
Voltages VP and VS are "Static" or setting **Close time** = 0.000S. If VP and VS are "static" (not "slipping" with respect to one another), the Angle Difference between them remains constant—it is not possible to close the circuit breaker at an ideal zero degree phase angle difference. Thus, synchronism check elements assert to logical 1 if the Angle Difference is less than corresponding maximum angle setting **Max angle**. Also, if breaker **Close time** setting = 0.000S, the Angle Difference Calculator does not take into account breaker close time, even if the voltages VP and VS are "slipping" with respect to one another. Thus, synchronism check elements assert to logical 1 if the Angle Difference is less than corresponding maximum angle setting **Max angle**.
Voltages VP and VS are "Slipping" and setting **Close time** ≠ 0.000S. If VP and VS are "slipping" with respect to one another and breaker close time setting **Close time** ≠ 0.000S, the Angle Difference (compensated by breaker **Close time**) changes through time. Synchronism check element asserts to logical 1 for any one of the following two scenarios.

1. The top of *Figure 1* shows the Angle Difference *decreasing*—VS* is approaching VP. When VS* is in-phase with VP (Angle Difference = 0°), synchronism check elements assert to logical 1.
2. The bottom of *Figure 1* shows the Angle Difference *increasing*—VS* is moving away from VP. VS* was in-phase with VP (Angle Difference = 0°), but has now moved past VP. If the Angle Difference is *increasing*, but the Angle Difference is still less than maximum angle settings **Max angle**, then corresponding synchronism check elements assert to logical 1.
In this scenario of the Angle Difference increasing, but still being less than maximum angle settings **Max angle**, the operation of corresponding synchronism check elements becomes *less restrictive*. Synchronism check breaker closing does not have to wait for voltage VS* to slip around again in-phase with VP (Angle Difference = 0°). There might not be enough time to wait for this to happen. Thus, the "Angle Difference = 0°" restriction is eased for this scenario.

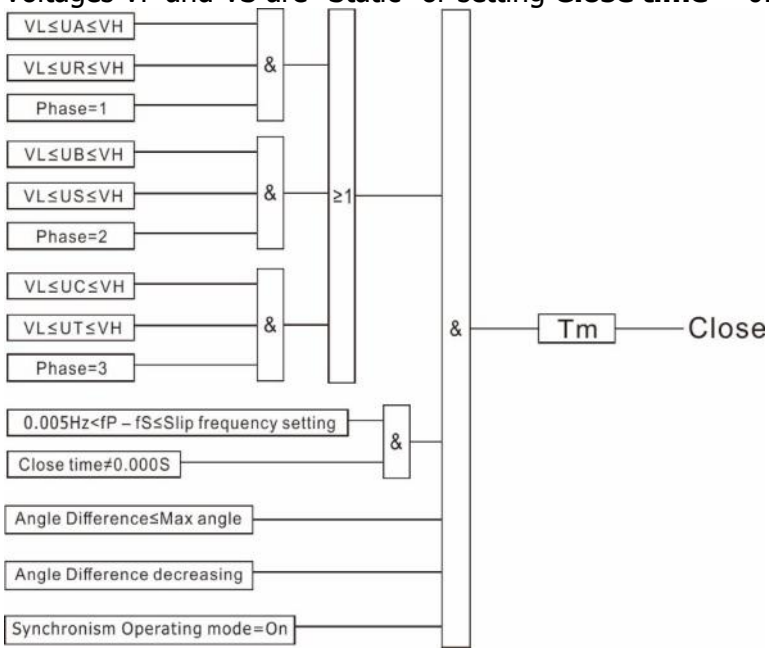
Synchronism check element settings:

Description		Setting range	Step length
Synchronism	Operating mode	0: Off, 1: On	
	Low voltage	1 ~ 42KV	0.1KV
	High voltage	1 ~ 42KV	0.1KV
	Max angle	0.1 ~ 60°	0.1°
	Slip frequency	0．01 ~ 1 Hz	0.01 Hz
	Close time	0 ~ 9.999 S	0.001 S
	Max time	0 ~ 60 S	0.1 S

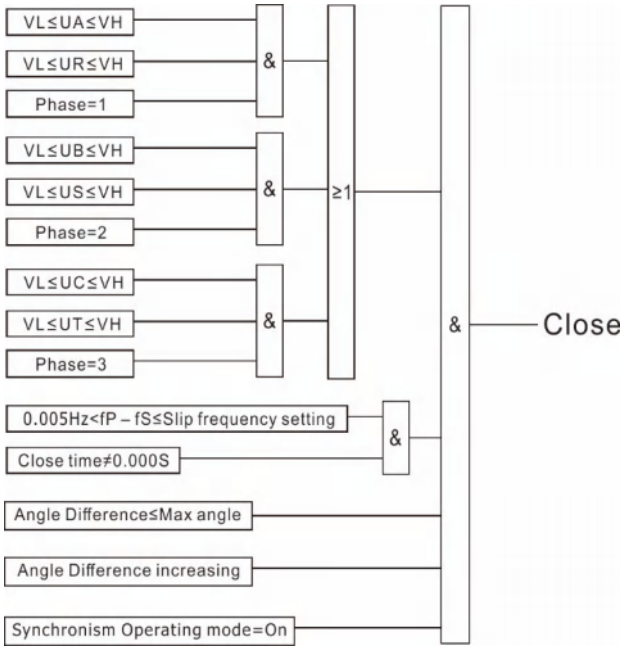
Action Logic diagram:



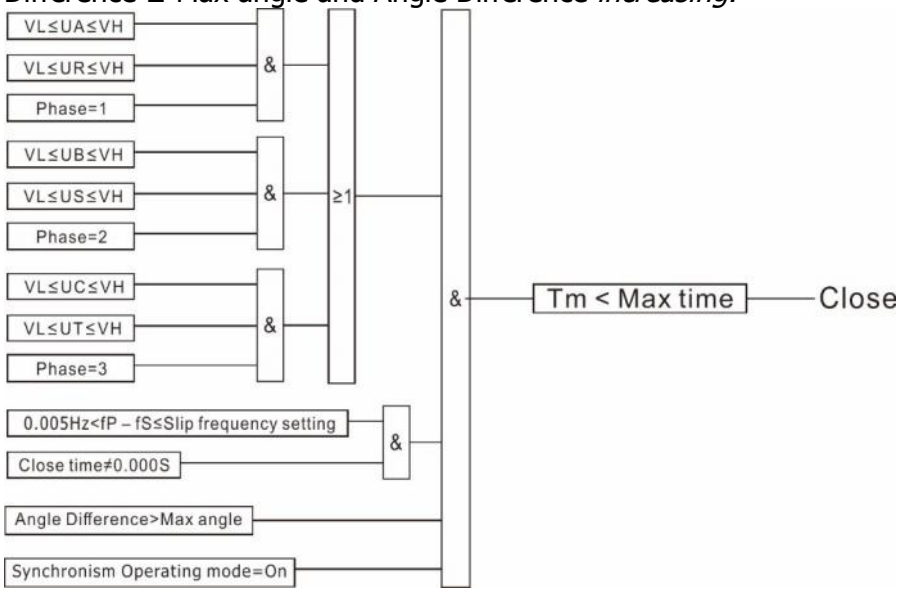
Voltages VP and VS are "Static" or setting **Close time** = 0.000S.



Voltages VP and VS are "Slipping" and setting **Close time** ≠ 0.000S. The Angle Difference ≤ Max angle and Angle Difference *decreasing.*



Voltages VP and VS are "Slipping" and setting **Close time** ≠ 0.000S. The Angle Difference ≤ Max angle and Angle Difference *increasing.*



Voltages VP and VS are "Slipping" and setting **Close time** ≠ 0.000S. The Angle Difference > Max angle.

VL—Low voltage VH—High voltage Tm—Time from VS * approaching VP to VS* is in-phase with VP (Angle Difference = 0°) fP – fS—Slip frequency

UA, UB, UC—The source side phase voltage

UR, US, UT—The load side phase voltage

Phase is set in VRC.

Note: In the check synchronization logic, the auto reclosing is the same as the closing.

The element is blocked when the following communication signal is activated:

· Protection Disable

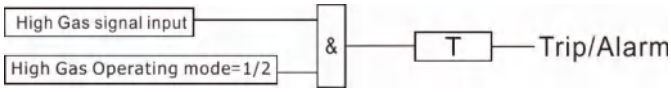
· Hotline Enabled

Heavy gas protection (High Gas)

High gas element settings:

Description		Setting range	Step length
High gas	Operating mode	0: Disable, 1:Trip, 2:Alarm	
	Delay time	0～99.99S	0.01S

Action Logic diagram:



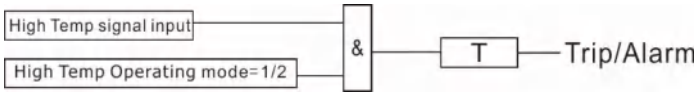
The element is blocked when the following communication signal is activated:
· Protection Disable
· Hotline Enabled

High temperature protection (High Temp)

High temp element settings:

Description		Setting range	Step length
High temp	Operating mode	0: Disable, 1:Trip, 2:Alarm	
	Delay time	0～99.99S	0.01S

Action Logic diagram:



The element is blocked when the following communication signal is activated:
· Protection Disable
· Hotline Enabled

Overcurrent element with built in reclosing (OCR)

Phase overcurrent protection P.OC

This element provides protection against phase-to-phase and three phase short circuits.

OC protection consists of six (6) individual overcurrent elements providing three stages of protection for both Source + and Source- side: P.OC1+, P.OC1-, P.OC2+, P.OC2-, P.OC3+, P.OC3-.

P.OC1 Phase fault high set instantaneous element provides protection against phase high current faults with the reduced number of trips to lockout. If there is no intention to reduce the number of trips to lockout at high current faults enabling of this element is not

recommended. TCC applied for P.OC2 and P.OC3 allows reduction of tripping time to any desired value at high currents.

High set element is not effected by CLP.

The operation of the high set element P.OC1 (radial feeder) can be described as follows: It starts timing up the user set tripping time T when the phase current exceeds the pickup current value Iset. When this time expires and the phase current still exceeds the pickup current value Iset, P.OC1 initiates a trip request to the driver to open the recloser.

P.OC1 is blocked when the following communication signals are activated:

· Protection Disable

· Hotline Enabled

P.OC2 Phase overcurrent low set element P.OC2 is designated to provide instantaneous trips. If sequence step in overcurrent reclosing element is set "D" (Delayed) P.OC2 element is disabled. If sequence step in overcurrent reclosing element is set "I" (Instanteneous) P.OC2 element is enabled.

P.OC3 Phase overcurrent low set element P.OC3 is designated to provide time delayed trips. It is enabled in any selected sequence in Overcurrent Reclosing element (Instanteneous I; Delayed D).

The operation of the low set elements P.OC2 and P.OC3 (radial feeder) can be described as follows: It starts timing up the Tripping time T defined by the time current characteristic TCC curves, when the phase current exceeds the pickup current value Iset. When this time expires and the phase current still exceeds a pickup current value, the low set overcurrent element initiates a trip request to the driver to open the recloser. If the phase current is lower than the pickup current value whilst the timer is active, then the element becomes passive again (refer to description of Time-Overcurrent Curves for details).

P.OC2 and P.OC3 are blocked when the following communication signals are activated:

· Protection Disable

· Hotline Enabled

P.OC2 can also be blocked by the AR OC element if it is executing a delayed (D) trip sequence step.

P.OC1 element settings:

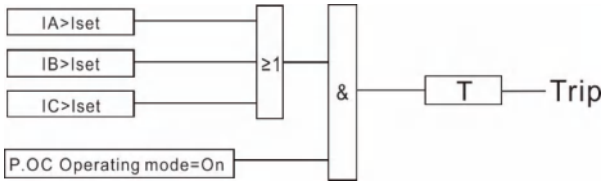
Description		Setting range	Step length
P.OC1	Operating mode	0: Off, 1: On	
	Pickup current	1 ~ 6000A	1A
	Delay time	0 ~ 9.99S	0.01S

P.OC2 and P.OC3 elements settings:

Description		Setting range	Step length
P.OC2	Operating mode	0: Off, 1: On	
	Curve type	0: No curve, 1: IEC-SI, 2: IEC-VI, 3: IEC-EI, 4: IEC-LT, 5: IEC-ST, 6: U.S-MI, 7: U.S-I, 8: U.S-VI, 9: U.S-EI, 10: U.S-ST, 11: PB-80, 12: PB-81, 13: USER-1, 14: USER-2, 15: USER-3, 16: USER-4	
	Pickup current	1～6000A	1A
	Time dial	0～99.99S	0.01S
	Time adder	0～99.99S	0.01S
	Minimum response	0～99.99S	0.01S
P.OC3	Operating mode	0: Off, 1: On	
	Curve type	0: No curve, 1: IEC-SI, 2: IEC-VI, 3: IEC-EI, 4: IEC-LT, 5: IEC-ST, 6: U.S-MI, 7: U.S-I, 8: U.S-VI, 9: U.S-EI, 10: U.S-ST, 11: PB-80, 12: PB-81, 13: USER-1, 14: USER-2, 15: USER-3, 16: USER-4	
	Pickup current	1～6000A	1A
	Time dial	0～99.99S	0.01S
	Time adder	0～99.99S	0.01S
	Minimum response	0～99.99S	0.01S

Note: When the curve type is no curve, it is normal overcurrent. Time dial is the delay time. USER1..USER4 is a user-defined curve, which is defined in RWK651Tool.

Action Logic diagram:



IA IB IC—Measured current Iset—Pickup current T—Delay time

Earth Fault G.OC

This element provides protection against single phase and double phase earth faults.

G.OC protection consist of six (6) individual overcurrent protection elements providing three stages of protection for both Source+ and Source- side: G.OC1+, G.OC1-, G.OC2+, G.OC2-, G.OC3+, G.OC3-.

G.OC1 Phase fault high set instantaneous element provides protection against phase high current faults with the reduced number of trips to lockout. If there is no intention to reduce the number of trips to lockout at high current faults enabling of this element is not

recommended. TCC applied for G.OC2 and G.OC3 allows reduction of tripping time to any desired value at high currents. Like P.OC1 this element is also generally not applied for downstream recloser and for systems with resistively earthed neutral.

High set element is not effected by CLP.

The operation of the high set element G.OC1 can be described as follows: It starts timing up the user set Tripping time T, when the residual current 3I0 exceeds the pickup current value Iset. When this time expires and the residual current still exceeds the pickup current value, G.OC1 initiates a trip request to the driver to open the recloser.

G.OC1 is blocked when the following communication signals are activated:

· Protection Disable

· Ground Disable

· Hotline Enabled

G.OC2 Phase overcurrent low set element G.OC2 is designated to provide instantaneous trips. If sequence step in overcurrent reclosing element is set "D" (Delayed) G.OC2 element is disabled. If sequence step in overcurrent reclosing element is set "I" (Instanteneous) G.OC2 element is enabled.

G.OC3 Phase overcurrent low set element G.OC3 is designated to provide time delayed trips. It is enabled in any selected sequence in overcurrent reclosing element (Instanteneous I; Delayed D).

The operation of the low set elements G.OC2 and G.OC3 (radial feeder) can be described as follows: It starts timing up the tripping time T defined by the time current characteristic TCC curves, when the residual current 3I0 exceeds the pickup current value Iset. When this time expires and the residual current still exceeds the pickup current value, low set element initiates a trip request to the driver to open the recloser. If the residual current is lower than the pickup current value whilst the timer is active, then the element becomes passive again.

G.OC2 and G.OC3 are blocked when the following local and remote communication signals are activated:

· Protection Disable

· Ground Disable

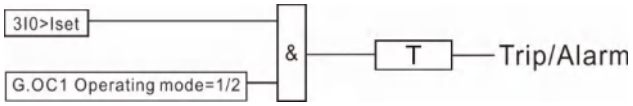
· Hotline Enabled

G.OC2 can also be blocked by the AR OC element if the latter is executing a delayed (D) trip sequence step.

G.OC1 element settings:

Description		Setting range	Step length
G.OC1	Operating mode	0: Off, 1: Trip, 2: Alarm	
	Pickup current	1～6000A	1A
	Delay time	0～9.99S	0.01S

Action Logic diagram:



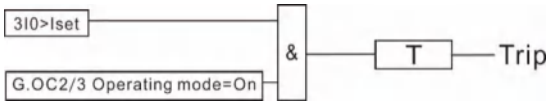
3I0—Earth current Iset—Pickup current T—Delay time

G.OC2 and G.OC3 elements settings:

Description		Setting range	Step length
G.OC2	Operating mode	0: Off, 1: On	
	Curve type	0: No curve, 1: IEC-SI, 2: IEC-VI, 3: IEC-EI, 4: IEC-LT, 5: IEC-ST, 6: U.S-MI, 7: U.S-I, 8: U.S-VI, 9: U.S-EI, 10: U.S-ST, 11: PB-80, 12: PB-81, 13: USER-1, 14: USER-2, 15: USER-3, 16: USER-4	
	Pickup current	1～6000A	1A
	Time dial	0～99.99S	0.01S
	Time adder	0～99.99S	0.01S
	Minimum response	0～99.99S	0.01S
G.OC3	Operating mode	0: Off, 1: On	
	Curve type	0: No curve, 1: IEC-SI, 2: IEC-VI, 3: IEC-EI, 4: IEC-LT, 5: IEC-ST, 6: U.S-MI, 7: U.S-I, 8: U.S-VI, 9: U.S-EI, 10: U.S-ST, 11: PB-80, 12: PB-81, 13: USER-1, 14: USER-2, 15: USER-3, 16: USER-4	
	Pickup current	1～6000A	1A
	Time dial	0～99.99S	0.01S
	Time adder	0～99.99S	0.01S
	Minimum response	0～99.99S	0.01S

Note: When the curve type is no curve, it is normal overcurrent. Time dial is the delay time. USER1..USER4 is a user-defined curve, which is defined in RWK651Tool.

Action Logic diagram:



3I0—Earth current Iset—Pickup current T—Delay time

Phase and Earth Overcurrent Reclosing Element (AR OC)

The AR OC element provides reclosing initiated by tripping of one of P.OC1, P.OC2, G.OC1, G.OC2, P.OC3 or G.OC3 elements. The user set delay between trip and reclose is called reclose time (T) and can be set differently for each trip in a sequence. If the fault still exists the recloser will trip again under protection. This will happen a number of times until the fault is cleared or the AR OC element reaches the end of the user defined reclose sequence. At this point the recloser remains open and will not reclose automatically anymore. This is known as lockout and the recloser can only be closed by local or remote operator command, which clears the lockout condition.

To control the number of trips to lockout in a reclosing sequence, the number has to be set. It can be selected individually for low set (Trip count) and high set (High Trip count) protection elements, while High Trip count cannot exceed Trip count. If the high set elements (P.OC1, G.OC1) are enabled they can initiate trip during the whole reclosing sequence defined by Trip count. But only for trips 1..High Trip count -1 it could be the trip to reclose.

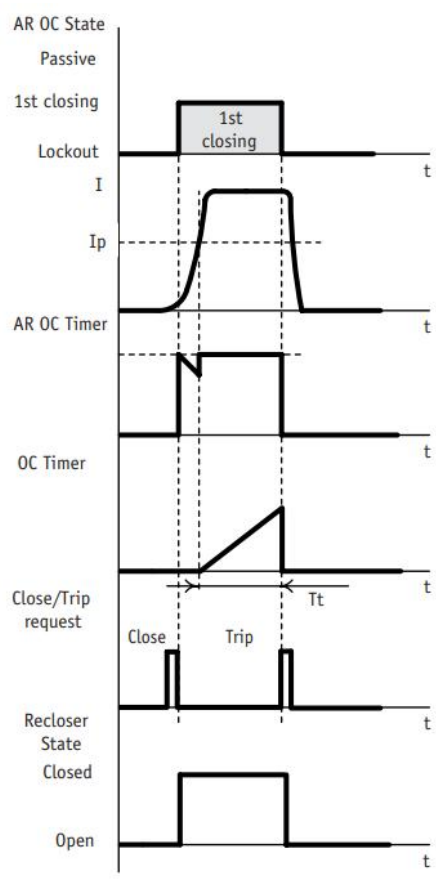
Finally the reclosing sequence (Seq) has to be selected. The Seq setting consists of i=1..Trip count characters. Seq[i]="I" means that the corresponding trip in sequence is set instantaneous, Seq[i]="D" means that it is set to delayed. Each character enables or disables the operation of instantaneous (P.OC2, G.OC2) elements on the corresponding step in sequence (counting characters from the left to the right).

AR OC element settings:

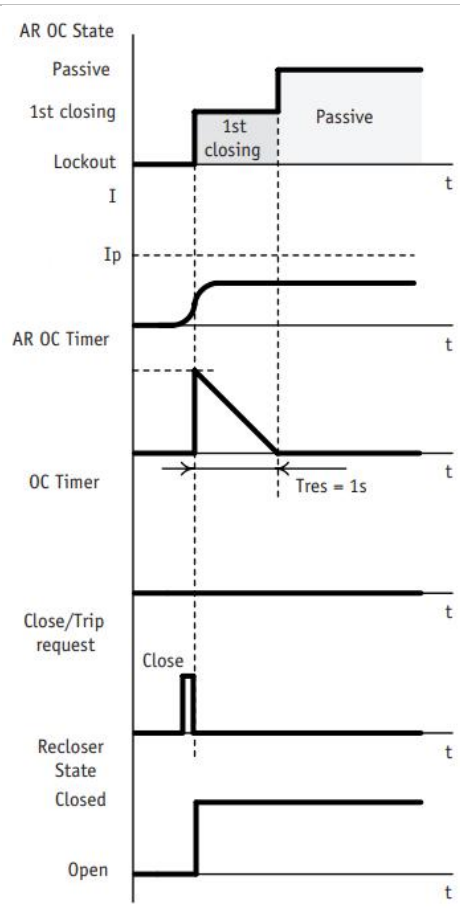
Description		Setting range	Step length
Reclose	Trip count	1: One, 2:Two, 3:Three, 4:Four	
	High Trip count	1: One, 2:Two, 3:Three, 4:Four	
	Sequence	For 4 trips to lockout: IIII/IIID/IIDD/IDDD/DDDD/ DDDI/DDII/DIII/IIDI/IDII/IDDI For 3 trips to lockout: III/IID/IDD/DDD/DDI/DII/IDI For 2 trips to lockout: II/ID/DD/DI For 1 trip to lockout: I/D	
	1st delay time	0 ~ 60S	0.01S
	2nd delay time	0 ~ 60S	0.01S
	3rd delay time	0 ~ 60S	0.01S
	Sequence Coord.	0: Disable, 1:Enabled	

Single shot to lockout algorithm is supported by the AR OC element.

The operation of the element for single shot can be described as follows: After first time closing the AR OC element starts timing up the reset time (1 second). If a fault occurred before this time expires, corresponding overcurrent element starts timing up its tripping time and prevents the timer of AR OC from counting the reset time. If the fault is still present after tripping time expires, a trip request is sent to the driver to make a single shot to lockout independent of which number of trips to lockout is set (see the diagram Single shot to lockout). If no fault was sensed or the fault disappeared during the reset time, the element gets passive after this time expires and can perform set auto-reclosing sequence (see diagram Successful first closing).



Single-shot to lockout



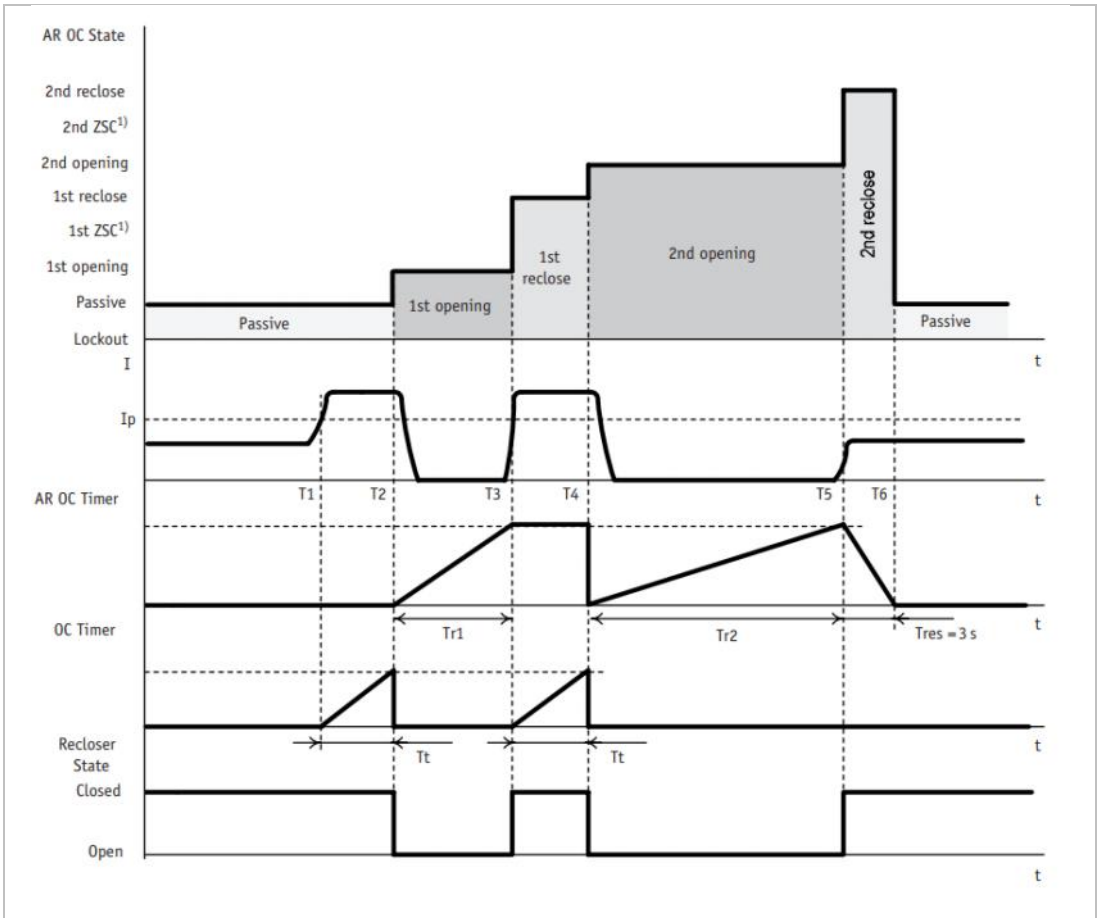
Successful first closing

The functionality of the element is described below for several particular scenarios.

Scenario 1: Appearance of a transient fault

A sequence of events could occur when a transient short circuit fault appears. Here it is assumed that the number of trips to lockout is set 4 and the second reclosing cleared the fault.

Initially the AR OC element is passive and can perform the user set reclosing sequence. The fault is sensed by overcurrent or earth fault elements (P.OC1, P.OC2, P.OC3, G.OC1, G.OC2, G.OC3) at time T1 (see the diagram below). After tripping time of corresponding protection element expires it trips the recloser (time T2). AR OC element proceeds to trip to reclose (first opening) and starts timing up first reclose time. After this time expires AR OC closes the recloser (time T3, first reclosure). As the fault is still present, the corresponding protection element starts timing up its tripping time, thus preventing AR OC from resetting. After the protection element initiated trip (time T4, third opening), the AR element starts timing up the second reclose time. After this time expires, the AR OC closes the recloser to the healthy line (time T5, second reclosure). As no fault is sensed by the protection elements, the AR OC starts timing up the reset time (3 second). After expiration of the reset time (time T6) the AR OC becomes passive and the recloser is ready to provide the user set reclosing sequence again.



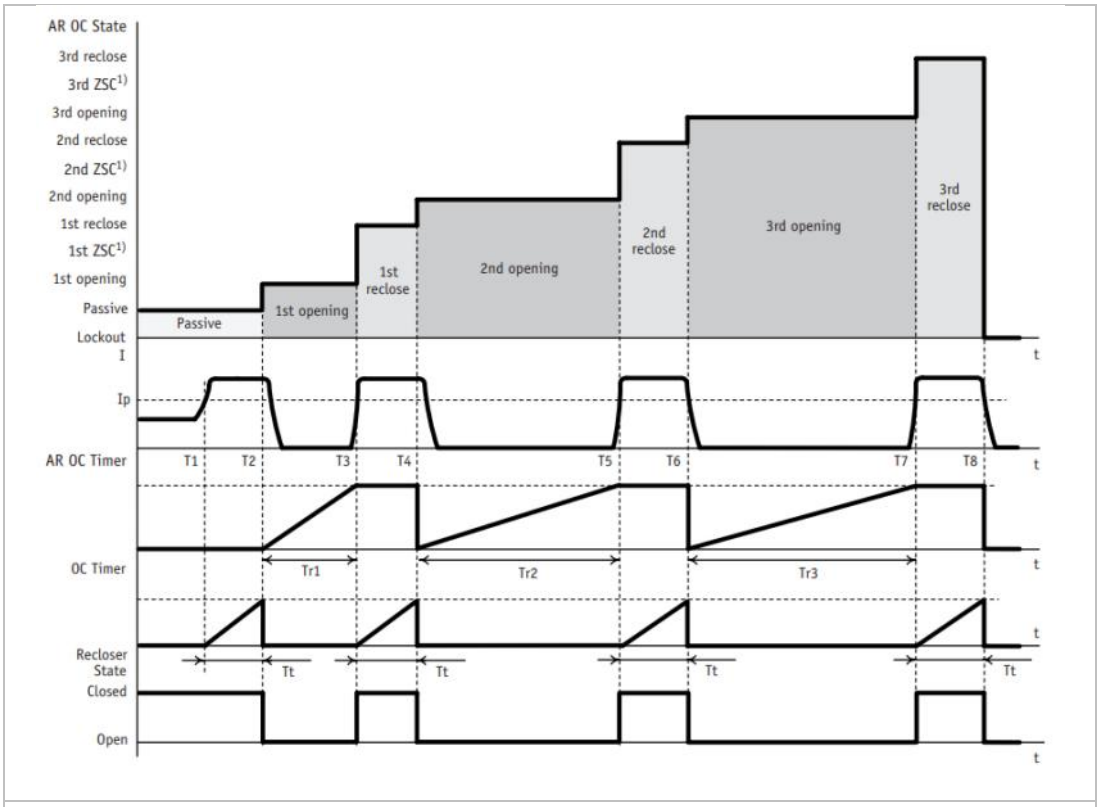
Successful reclosing

1)ZSC = Zone Sequence Coordination; Please refer to the corresponding chapter on page 36

Scenario 2: Appearance of a permanent fault

It is assumed that the settings are the same as for Scenario 1: the number of trips to lockout is set 4. In this case the permanent fault appears in the line.

When the permanent fault appears, corresponding elements of the recloser act the same way as in Scenario 1 up to the moment T5 (see diagram Unsuccessful reclosing). Since after the second reclosing the fault is still present, the corresponding overcurrent element will trip the recloser after tripping time of this element expires (time T6, third opening). The AR OC starts timing up the third reclose time and after the timer expires it closes the recloser (time T7, forth closing). Since the fault is still present, the recloser will trip to lockout (open to lockout) after tripping time of corresponding overcurrent element expires (time T8).



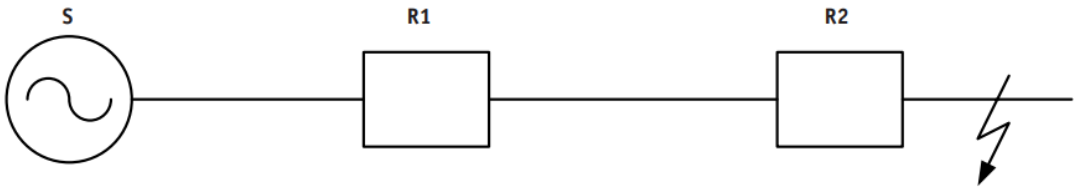
Unsuccessful reclosing

Scenario 3: Zone sequence coordination

The AR OC also provides Zone sequence coordination (ZSC). ZSC causes the AR OC element to step to the next count in the reclose sequence on reset of all protection elements if it detects a downstream protection device has operated.

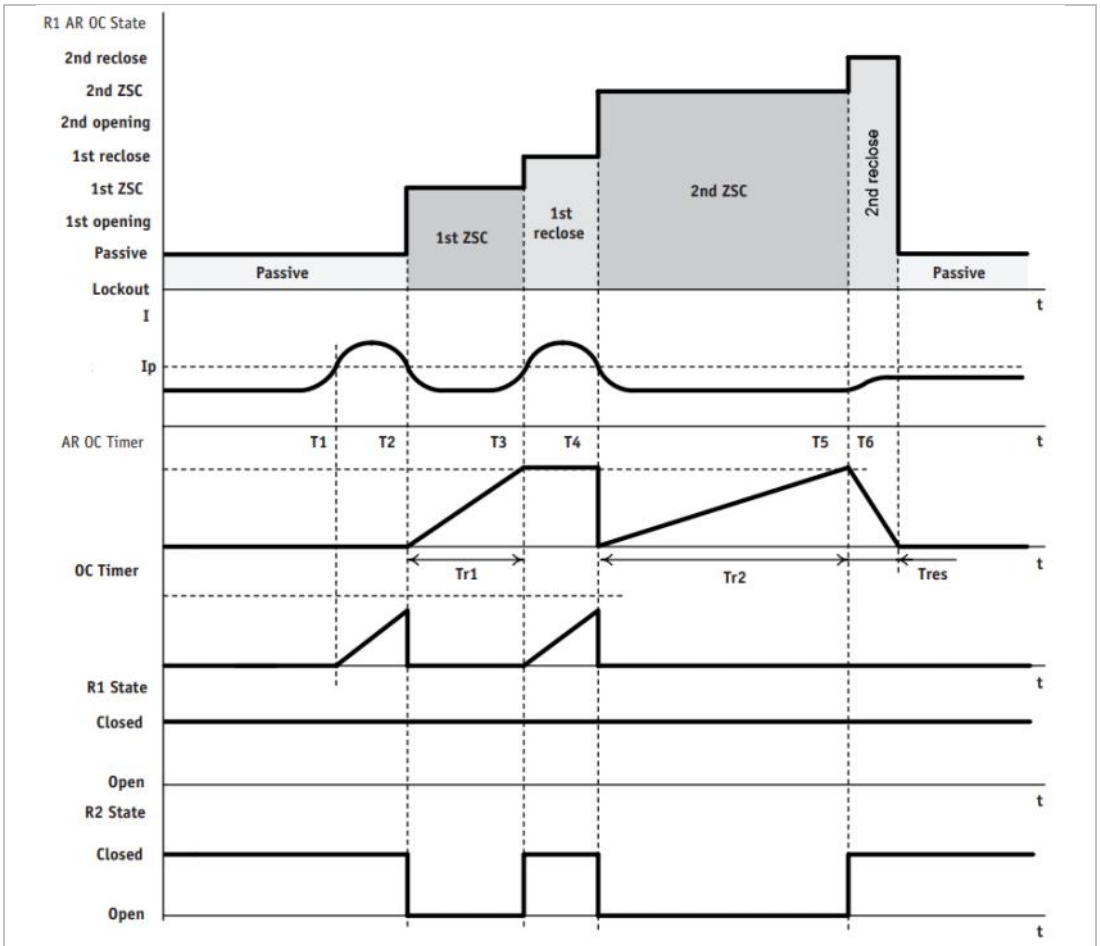
A simple radial line sectionalized with two recloser is presented in the figure below. ZSC is applied for the upstream recloser R1 and is not applicable for the downstream recloser R2.

It is assumed that:
· A transient short circuit fault appears below the downstream recloser
· The number of trips to lockout is set to 4 for both recloser
· The second reclosure of downstream device cleared the fault.



In this case the operation of the downstream recloser R2 is similar to the one given in Scenario 1. The operation of R1 with applied ZSC algorithm can be described as follows:

Initially the AR OC elements of both reclosers are passive. The fault is sensed by both reclosers at time T1 (see the diagram below). After tripping time of the corresponding protection element of R2 expires it trips the recloser (time T2). At this moment R1 initiates the dropout event because the current and/or time grade is used to coordinate the recloser. The AR OC element of R1 initiates the first zone sequence coordination and (simultaneously with R2) starts timing up the first reclose time, as if it made trip to reclose. After this time expires, R2 closes the recloser (time T3, first reclosure). At the same time AR OC of R1 attempts to count the reset time (as its first reclose time expires), as if it made first reclosure. As the fault is still present, corresponding protection elements of R1 and R2 start timing up their tripping time, thus preventing AR OC elements (of both R1 and R2) from resetting. After this time expires the protection element of R2 initiates the trip (time T4, second opening). At the same time AR OC element of R1 initiates a second zone sequence coordination due to the dropout event and starts timing up the second reclose time simultaneously with R2. After this time expires, R2 closes to the healthy line (time T5, second reclosure). At the same time AR OC of R1 behaves as if it made second reclosure. Because no fault is sensed by both reclosers, their AR OC elements start timing up the reset time (3 second). After expiration of the reset time (time T6) the AR OC elements of both recloser become passive.



Zone Sequence Coordination

Note: ZSC is always enabled.

The element is blocked when the following communication signals are activated:
· Reclose Disable
· Hotline Enabled
· Protection Disable
· Ground Disable (Only for EF)

Sensitive earth fault element with built in reclosing (SEFR)

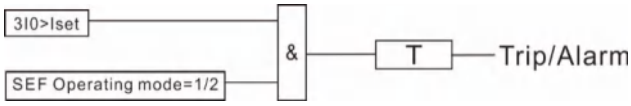
This element provides protection against resistive earth faults.

Sensitive earth fault element (SEF)

SEF element settings:

Description		Setting range	Step length
SEF	Operating mode	0: Off, 1: Trip, 2: Alarm	
	Pickup current	1～80A	1A
	Delay time	0～9.99S	0.01S

Action Logic diagram:



3I0—Earth current Iset—Pickup current T—Delay time

The operation of the element (radial feeder) can be described as follows: It starts timing up the user set tripping time T when the residual current exceeds the pickup current value Iset. When this time expires and the residual current still exceeds the Pickup current value, SEF initiates a trip request to the driver to open the recloser.

The element is blocked when the following communication signals are activated:
· Hotline Enabled
· Protection Disable
· Ground Disable
· SEF Disable

Sensitive earth fault reclosing element (AR SEF)

This element provides reclosing initiated by SEF element. It also supports single shot to lockout and logical reset functionality.

AR SEF element settings:

Description		Setting range	Step length
SEF Reclose	Trip count	1: One, 2:Two, 3:Three, 4:Four	
	1st delay time	0 ~ 60S	0.01S
	2nd delay time	0 ~ 60S	0.01S
	3rd delay time	0 ~ 60S	0.01S

The operation of AR SEF is similar to that of AR OC element including Scenarios 1 and 2. ZSC is not applicable for AR SEF.

The element is blocked when the following communication signals are activated:
· Hotline Enabled
· Protection Disable
· Reclose Disable
· Ground Disable
· SEF Disable

Undervoltage element with built in reclosing (UVR)

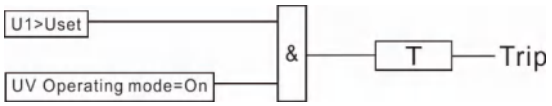
This element provides protection against low source voltage.

Undervoltage element (UV)

UV element settings:

Description		Setting range	Step length
UV	Operating mode	0: Off, 1: On	
	Pickup voltage	1～42KV	0.1KV
	Delay time	0～99.99S	0.01S

Action Logic diagram:



U1—Positive sequence voltage Uset—Pickup voltage T—Delay time

The operation of the element (radial feeder) can be described as follows: It starts timing up the user set tripping time T, when the positive sequence voltage measured from source+ side (U1+) is less than the pickup voltage value (Uset). When this time expires and U1+ still exceeds the pickup voltage value, UV initiates a trip request to the driver to open the recloser.

The element is blocked when the following communication signals are activated:
· Protection Disable
· Hotline Enabled

Undervoltage reclosing element (AR UV)

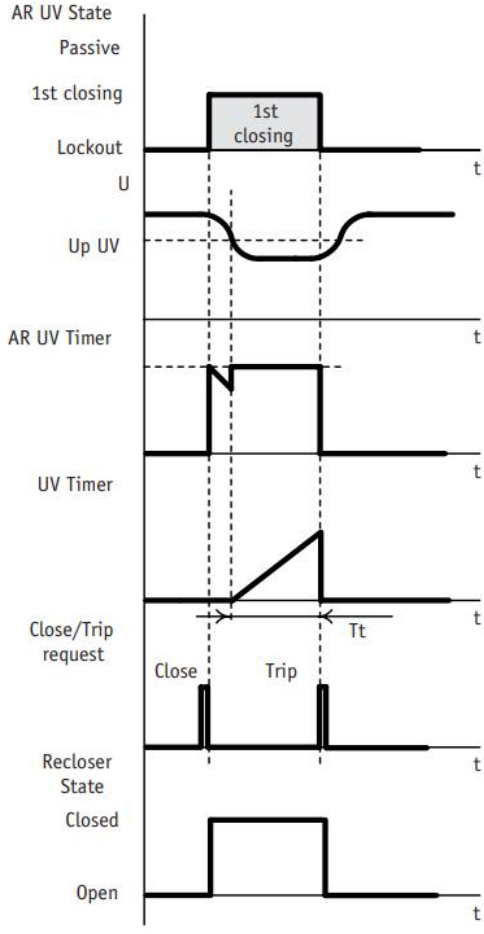
This element provides reclosing initiated by UV element. It also provides single shot to lockout functionality to avoid multiple reclosing in case of incorrect coordination of pickup or settings of UV element.

AR UV element settings:

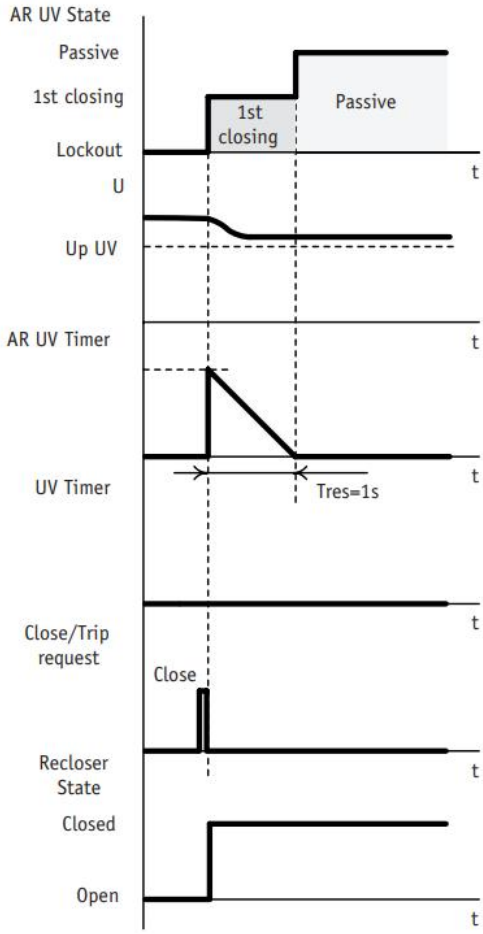
Description		Setting range	Step length
UV Reclose	Trip count	1: One, 2:Two	
	delay time	0～60S	0.01S

Single shot to lockout algorithm is supported by AR UV element.

The operation of this algorithm can be described as follows: After initial closing the AR UV element goes to state "1st closing" and starts timing up the reset time (1 second). If the system voltage dropped below the pickup level of UV element before this time expires, UV element starts timing up its tripping time and prevents the timer of AR UV from counting the reset time. If the low system voltage is still present after tripping time expires, the recloser will make a single shot to lockout even if the number of trips to lockout is set 2 (see the diagram Single shot to lockout). If low system voltage was sensed during the reset time, the AR UV element becomes Passive after this time expires and can make reclosing (see diagram Successful first closing).



AR UV Single-shot to lockout

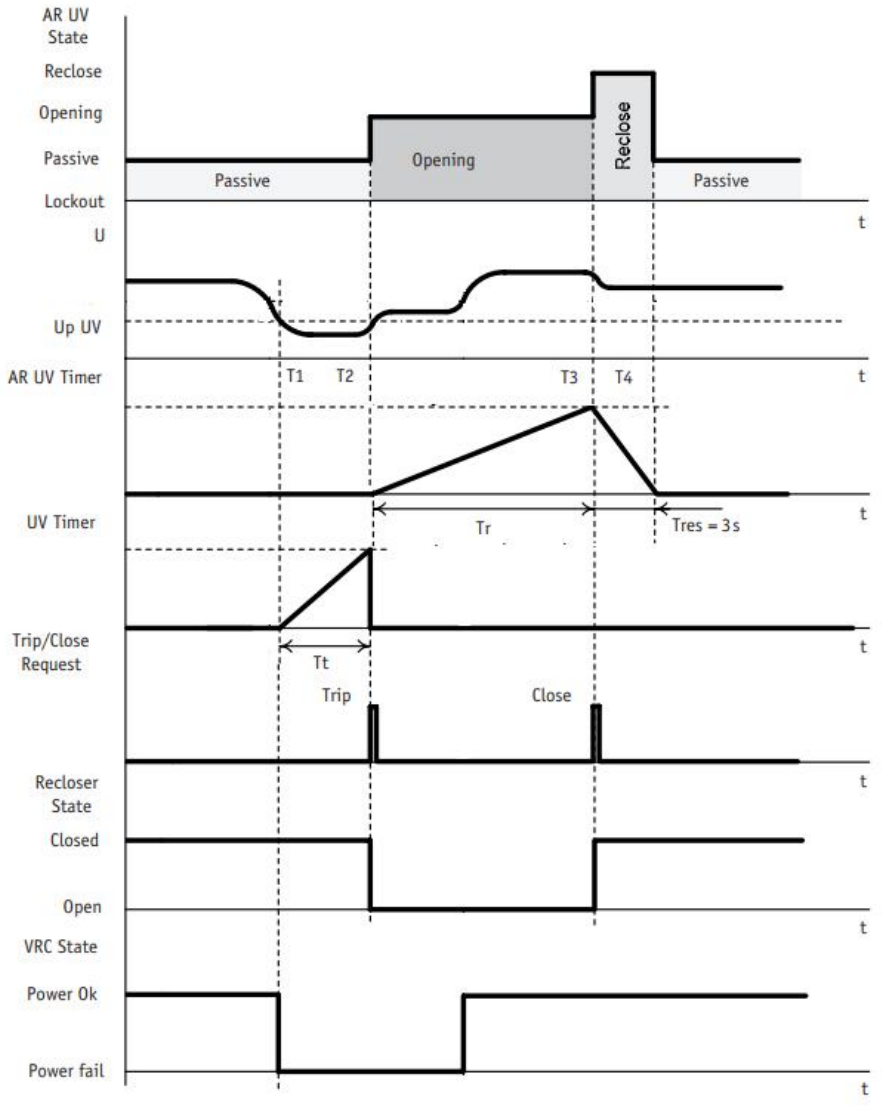


AR UV Successful first closing

Scenario 1. Successful AR UV reclosing.

It is assumed that the number of trips to lockout is set 2 and the reclosing does not lead to system voltage drop below the pickup level of UV element.

Originally AR UV element is passive and can provide the complete user set autoreclosing sequence. The system voltage drops below the UV pickup level (Up UV) at the time T1 (see the diagram below). After the tripping time of the UV element expires it trips the recloser (time T2, first opening), AR UV starts timing up the delay time Tr. After this time expires AR UV closes the recloser (time T3, reclosure). As the system voltage after closing exceeds the pickup level of UV element, AR UV starts timing up the reset time (3 second). When this time expires and system voltage still exceeds Up of UV, the AR UV becomes passive (time T4) and is ready to provide the complete autoreclosing sequence again.

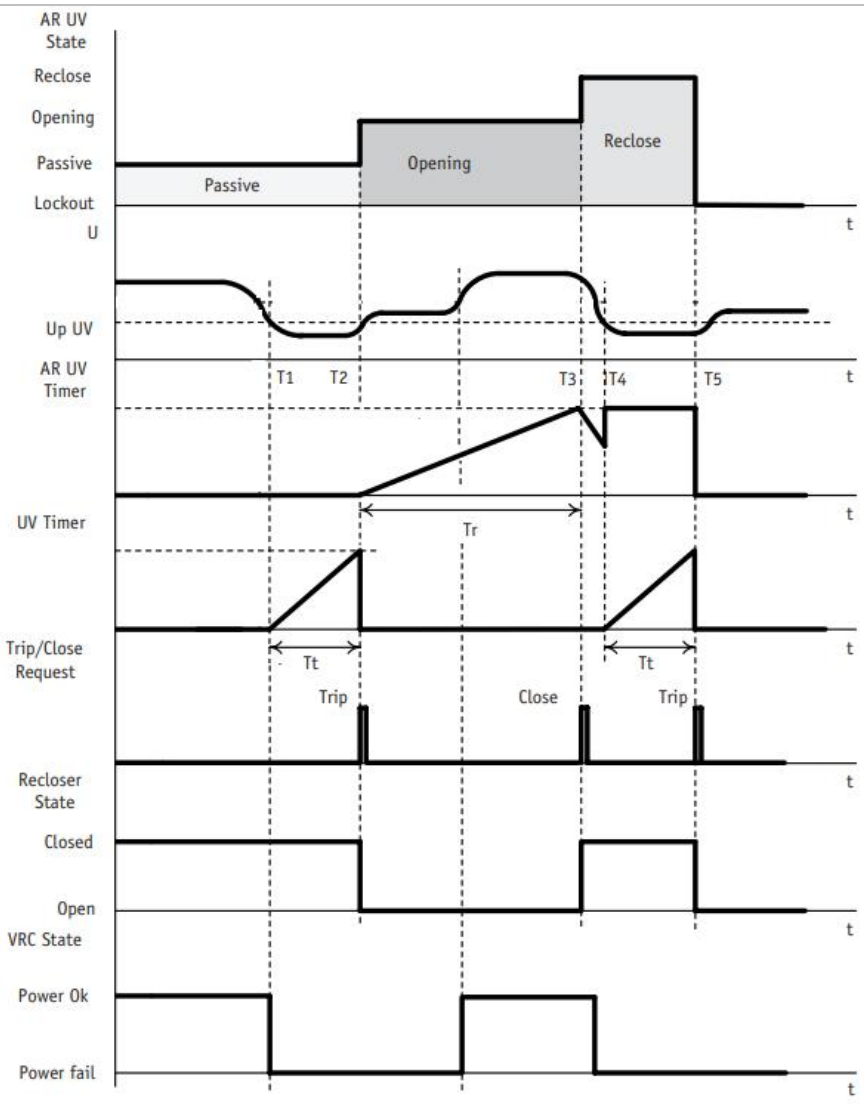


AR UV Unsuccessful reclosing

Scenario 2. Unsuccessful AR UV reclosing.

It is supposed that the number of trips to lockout is set 2 and the reclosing results in system voltage drop below the pickup level of UV element.

In this case UV and UV AR elements act the same way as in Scenario 1 up to the moment T3 (see diagram AR UV unsuccessful reclosing). Because after reclosing the system voltage drops below the pickup level of UV element, this element starts timing up tripping time (time T4) and prevents AR UV from resetting. When this time expires and the system voltage is still below the pickup level of UV element, the recloser trips to lockout (time T5).



AR UV Unsuccessful reclosing

The element also proceeds to open to lockout when the following communication signals are activated:

· Protection Disable
· Reclose Disable
· Hotline Enabled

Underfrequency element with built in reclosing (UFR)

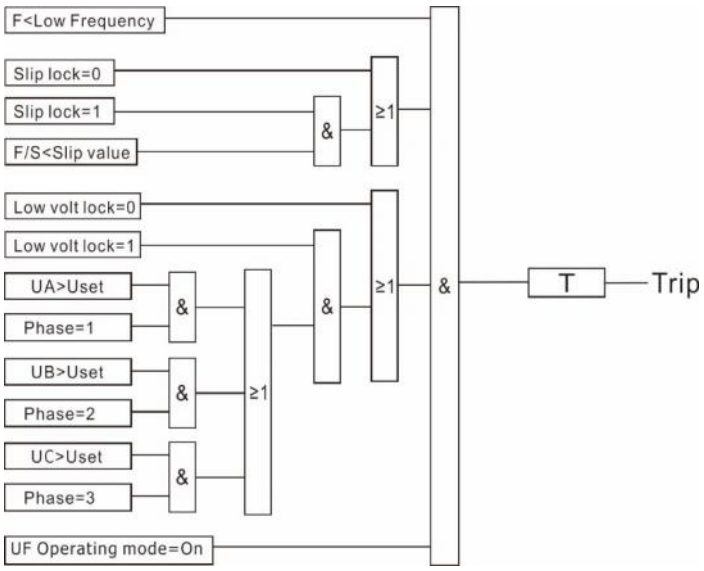
This element provides protection against low system frequency. It is generally applied for under-frequency shedding.

Underfrequency element (UF)

UF element settings:

Description		Setting range	Step length
UF	Operating mode	0: Off, 1: On	
	Low frequency	40 ~ 60Hz	0.1Hz
	Delay time	0.2 ~ 20S	0.1S
	Slip lock	0 ~ 1	1
	Slip value	0.3 ~ 40	0.1
	Low volt.lock	0 ~ 1	1
	Low volt.value	1 ~ 42KV	0.1KV

Action Logic diagram:



F—Frequency fo power PT F/S—The rate of frequency (HZ) and seconds (S)
UA UB UC—Measured voltage T—Delay time Uset—Low voltage value
Phase is set in VRC, frequency comes from PT voltage.

The operation of the element (radial feeder) can be described as follows: It starts timing up the user set tripping time T when the frequency measured from source+ side (F+) is less than the low frequency. When this time expires and F+ still exceeds the low frequency, UF initiates a trip request to the driver to open the recloser.

The element is blocked when the following communication signals are activated:
· Protection Off

Underfrequency reclosing element (AR UF)

This element provides reclosing initiated by UF element. It also provides single shot to lockout functionality to avoid multiple reclosing in case of incorrect coordination of voltage pickup, settings of UF elements.

AR UF element settings:

Description		Setting range	Step length
UF Reclose	Trip count	1: One, 2:Two	
	delay time	0～60S	0.01S

The basic operation of the element can be described as follows: A Trip Request is received from the UF element and subsequently the recloser opens and the driver signals that it has opened. If the number of trips to lockout Trip count=1, then the recloser is in open to lockout. If Trip count=2, a timer is activated for the duration of the delay time Tr. When this time expires, the recloser will close and a timer is activated for three second. In the majority of cases, the fault will have been cleared. The AR UF element then becomes passive. If the fault is still present, then the AR UF proceeds to open to lockout.

First closing for recloser:
This is the initial closed position of the recloser. It remains in this condition whilst a timer is activated for one second and then proceeds to passive. If the recloser is tripped due to a fault or due to a communication signal, the AR UF will proceed to open to lockout.

The element also proceeds to Open to Lockout when the following communication signals are activated:
· Protection Disable
· Reclose Disable
· Hotline Enabled

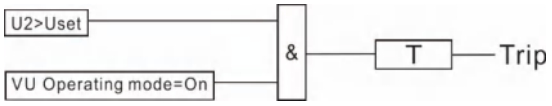
Voltage unbalance element (VU)

This element provides protection of sensitive load against upstream broken wire. It is generally applied when the upstream device cannot provide relevant protection. Otherwise it is generally disabled.

VU element settings:

Description		Setting range	Step length
VU	Operating mode	0: Off, 1: On	
	Pickup voltage	1～42KV	0.1KV
	Delay time	0～99.99S	0.01S

Action Logic diagram:



U2—Negative sequence voltage Uset—Pickup voltage T—Delay time

The operation of the element (radial feeder) can be described as follows: It starts timing up the user set tripping time T when the negative sequence Voltage measured from source+ side (U2+) exceeds the pickup voltage value. When this time expires and U2+ still exceeds the pickup voltage value, VU initiates a trip request to the driver to open the recloser.

The element is blocked when the following communication signals are activated:
· Protection Disable
· Hotline Enabled

It is also blocked by the OCR, CU and SEFR protection elements.

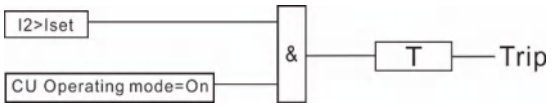
Current unbalance element (CU)

This element provides protection against downstream broken wire. It is generally applied for protection of three phase loads sensitive to current unbalance, for example, electrical motors.

CU element settings:

Description		Setting range	Step length
CU	Operating mode	0: Off, 1: On	
	Pickup current	1 ~ 6000A	1A
	Delay time	0 ~ 99.99S	0.01S

Action Logic diagram:



I2—Negative sequence current Iset—Pickup current T—Delay time

The operation of the element (radial feeder) can be described as follows: It starts timing up the user set tripping time T when the negative sequence current I2 exceeds the pickup current value. When this time expires and the negative sequence current still exceeds the pickup current value, CU initiates a trip request to the driver to open the recloser.

The element is blocked when the following communication signals are activated:
· Protection Disable
· Hotline Enabled

Hotline element (HL)

When the line is in the repair, you can turn on the feature of hotline, and we can not make any closing operation for safety. Press the "Hotline" pushbutton the feature of hotline is turned on. Press the "Hotline" pushbutton again, the feature of hotline is turned off.

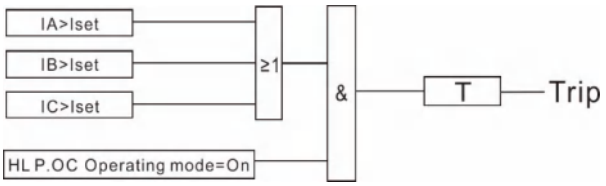
This element consists of two sub-elements, which provide protection against short circuit faults during live line maintenance. It generally has more sensitive settings than corresponding OCR settings and it has no reclosing functions.

HL consists of two non-directional overcurrent elements, one for phase overcurrent (HL P.OC) and one for earth fault (HL G.OC). Operation of either element results in a trip to lockout. An independent definite time can be selected for each. Enabling the HL element automatically disables any automatic reclosing from any source.

HL P.OC element settings:

Description		Setting range	Step length
Hotline P.OC	Operating mode	0: Off, 1: On	
	Pickup current	1～6000A	1A
	Delay time	0～99.99S	0.01S

Action Logic diagram:



IA IB IC—Measured current Iset—Pickup current T—Delay time

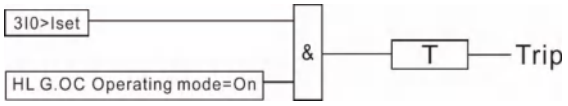
The operation of HL P.OC (radial feeder) can be described as follows: It starts timing up the user set tripping time T, when the phase current exceeds the pickup current value Iset. When this time expires and the phase current still exceeds the pickup current value, HL P.OC initiates a trip request to the driver to open the recloser.

The element is blocked when the following communication signals are activated:
· Protection Disable
· Hotline Disable

HL G.OC element settings:

Description		Setting range	Step length
Hotline G.OC	Operating mode	0: Off, 1: On	
	Pickup current	1～6000A	1A
	Delay time	0～99.99S	0.01S

Action Logic diagram:



3I0—Earth current Iset—Pickup current T—Delay time

The operation of HL G.OC (radial feeder) can be described as follows: It starts timing up the user set tripping time T, when the residual current 3I0 exceeds the pickup current value Iset. When this time expires and the residual current still exceeds the pickup current value, HL G.OC initiates a trip request to the driver to open the recloser.

The element is blocked when the following communication signals are activated:
· Protection Disable
· Ground Disable
· Hotline Disable

Control circuit breaking alarm
In normal situation, the switch on and switch off signals are in different status, and when these two signals are in the same status for 10s, the device will send control circuit breaking alarming signal.

3.2 Time-Overcurrent Curves

The following information describes the curve timing for the curve and time dial settings made for the time-overcurrent elements. The time-overcurrent relay curves conform to IEEE C37.112-1996 IEEE Standard Inverse-Time Characteristic Equations for Overcurrent Relays.

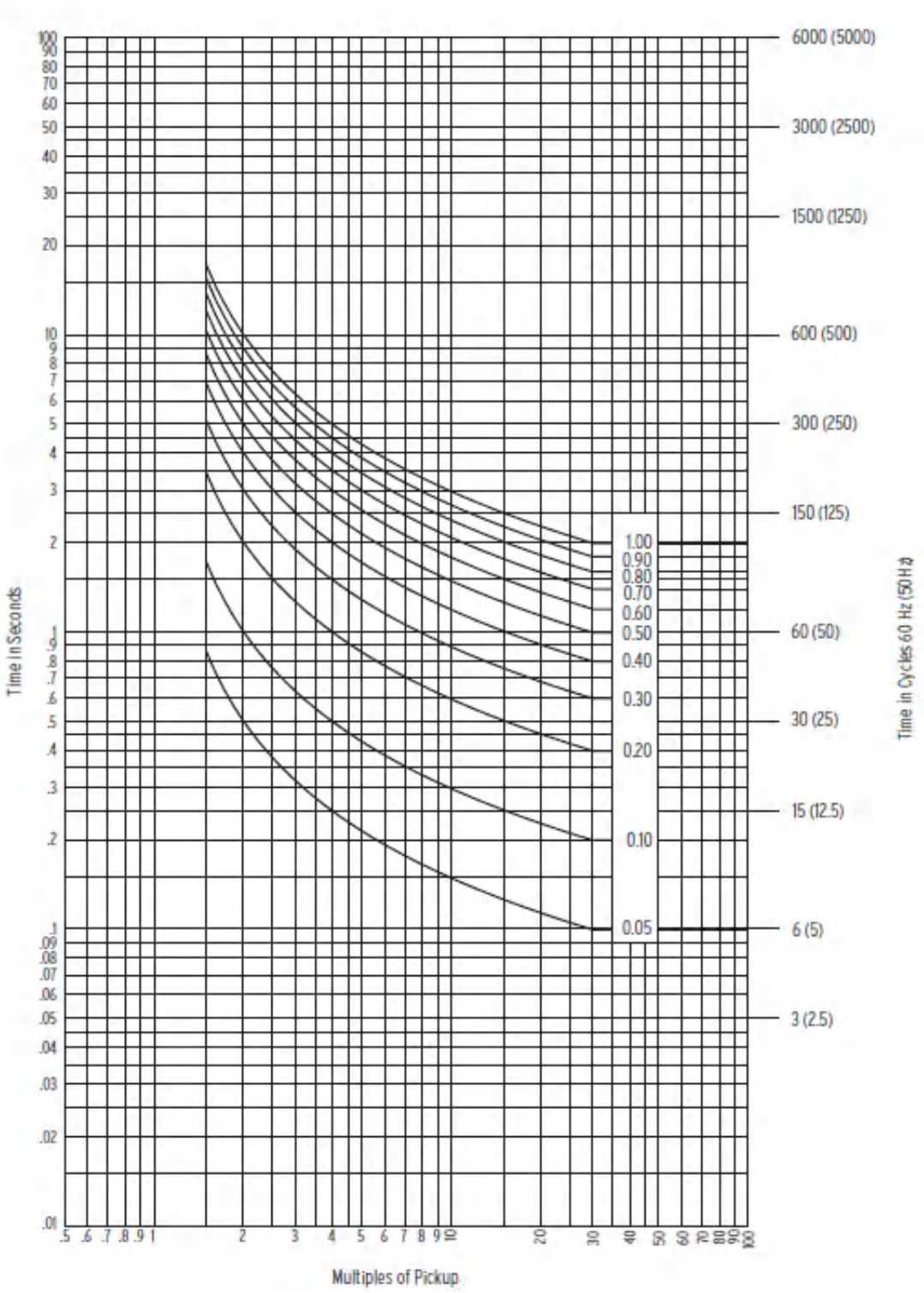
T_p = Operating time in seconds
TD = Time-dial setting
M = Applied multiples of pickup current

Equations Associated With IEC Curves

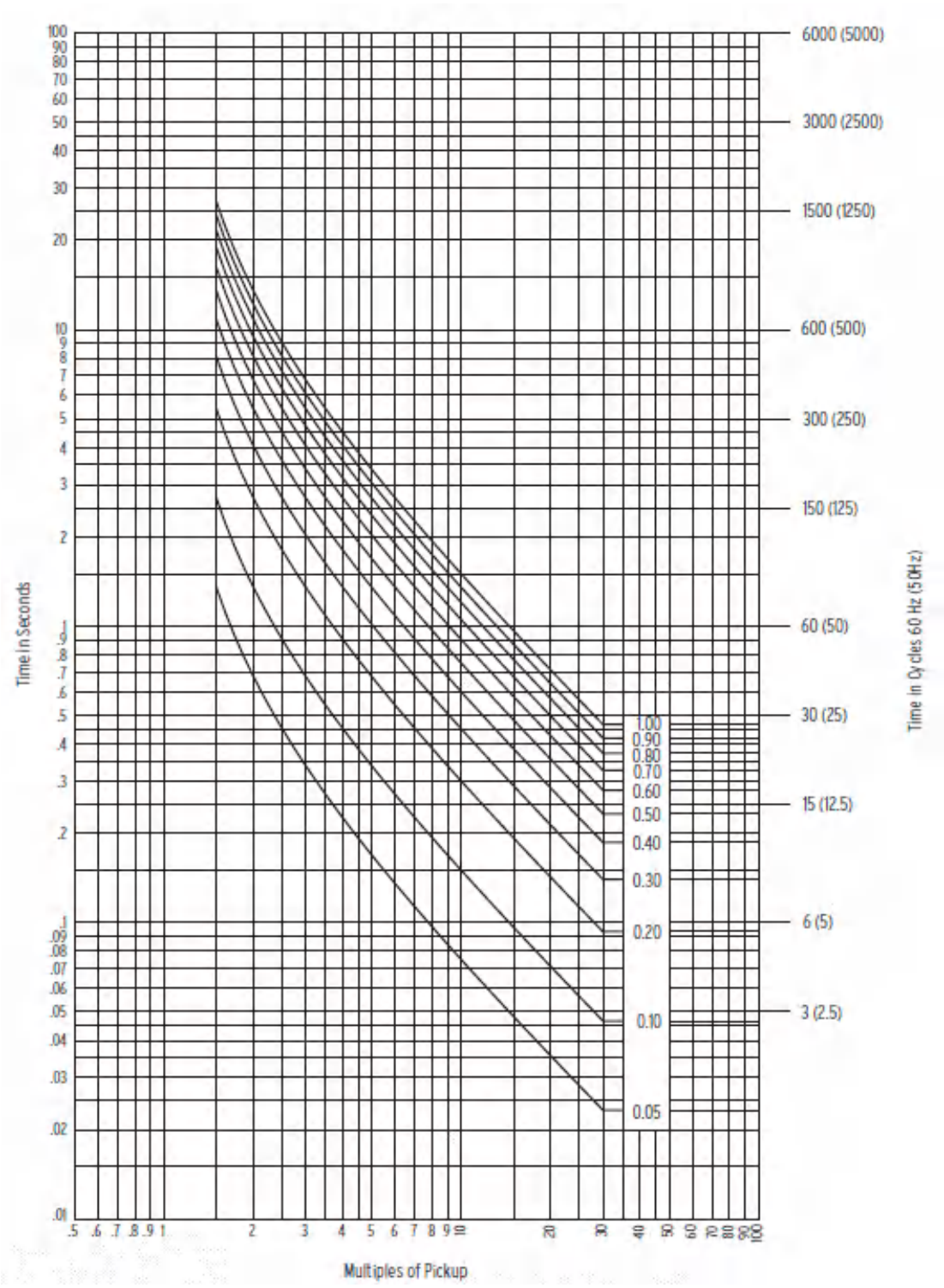
No	Curve Type	Operating time
1	C1 (Standard Inverse)	$T_p = TD \bullet \left(\frac{0.14}{(M^{0.02} - 1)} \right)$
2	C2 (Very Inverse)	$T_p = TD \bullet \left(\frac{13.5}{(M - 1)} \right)$
3	C3 (Extremely Inverse)	$T_p = TD \bullet \left(\frac{80}{(M^2 - 1)} \right)$
4	C4 (Long-Time Inverse)	$T_p = TD \bullet \left(\frac{120}{(M - 1)} \right)$
5	C5 (Short-Time Inverse)	$T_p = TD \bullet \left(\frac{0.05}{(M^{0.04} - 1)} \right)$

Equations Associated With U.S.Curves

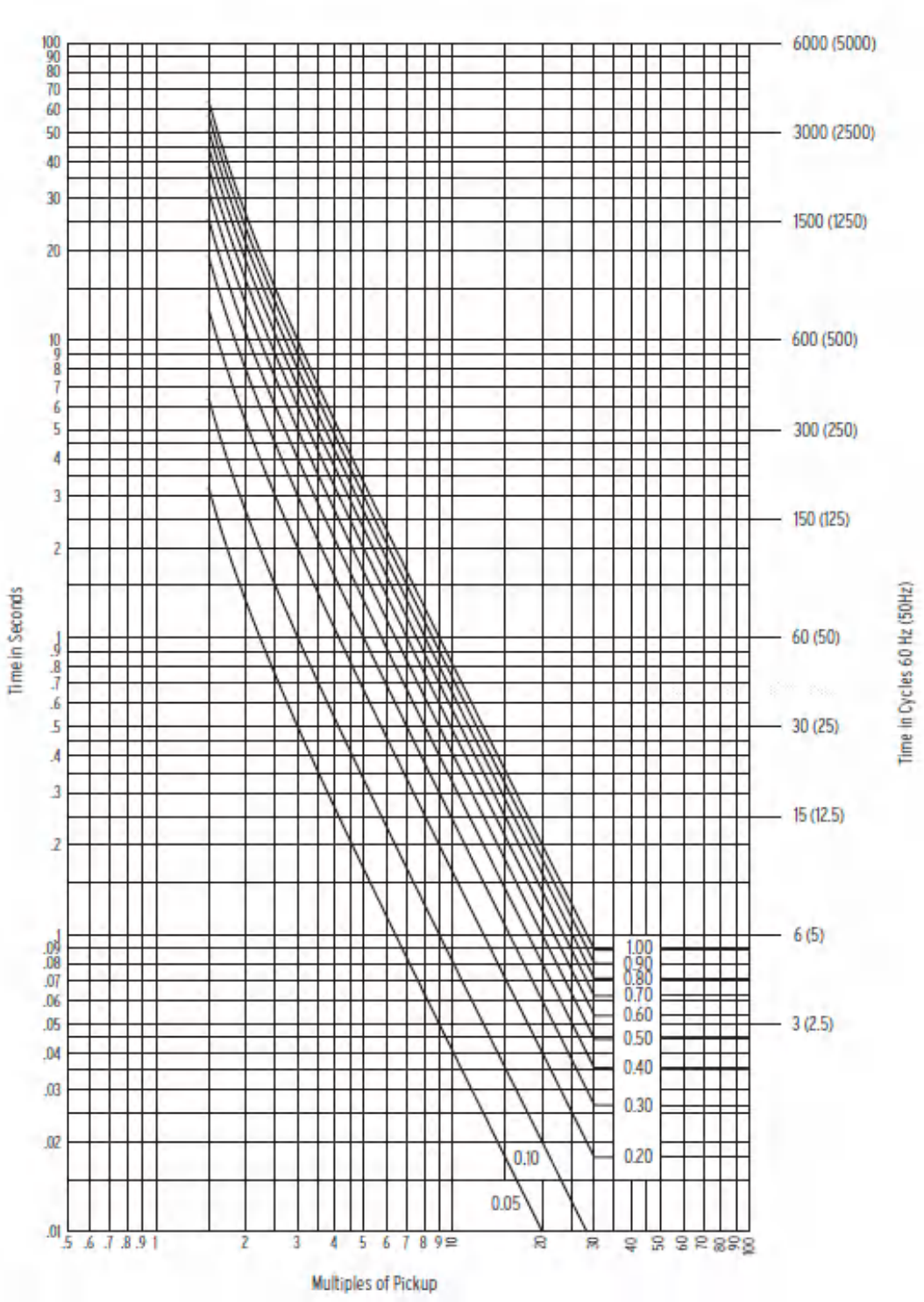
No	Curve Type	Operating time
6	U1 (Moderately Inverse)	$T_p = TD \bullet \left(0.0226 + \frac{0.0104}{(M^{0.02} - 1)} \right)$
7	U2 (Inverse)	$T_p = TD \bullet \left(0.180 + \frac{5.95}{(M^2 - 1)} \right)$
8	U3 (Very Inverse)	$T_p = TD \bullet \left(0.0963 + \frac{3.88}{(M^2 - 1)} \right)$
9	U4 (Extremely Inverse)	$T_p = TD \bullet \left(0.0352 + \frac{5.67}{(M^2 - 1)} \right)$
10	U5 (Short-Time Inverse)	$T_p = TD \bullet \left(0.00262 + \frac{0.00342}{(M^{0.02} - 1)} \right)$



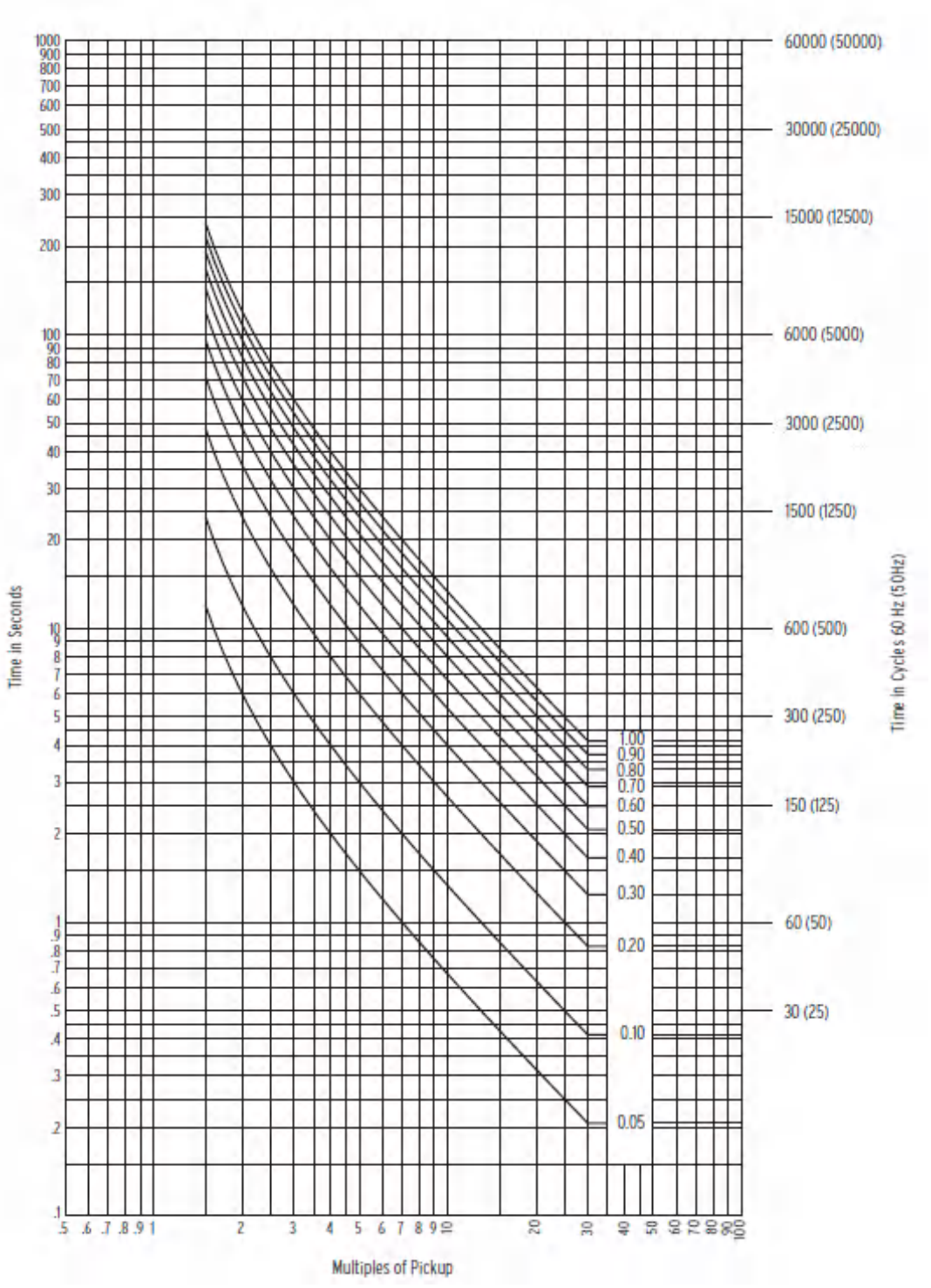
IEC Class A Curve (Standard Inverse): C1



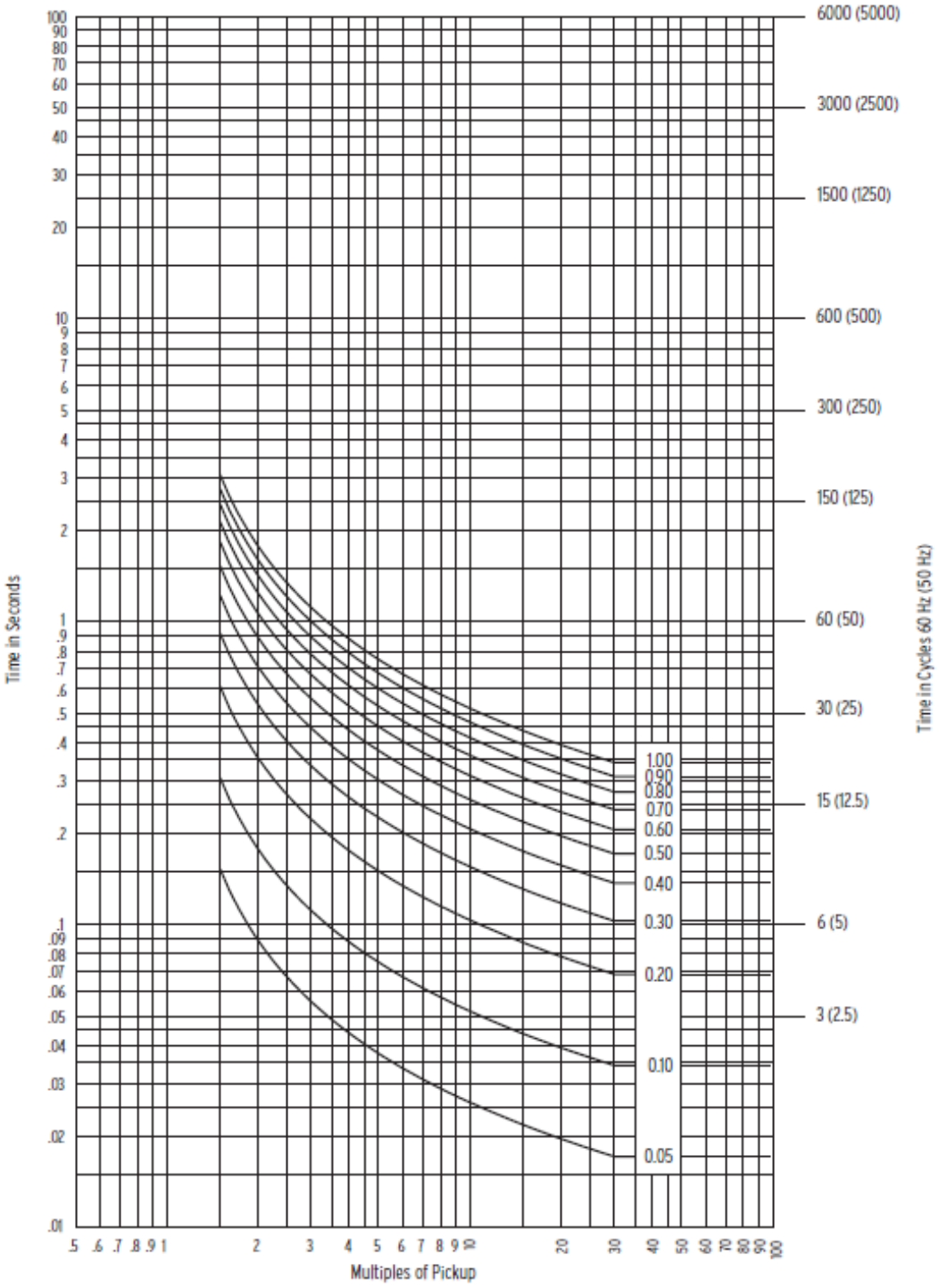
IEC Class B Curve (Very Inverse): C2



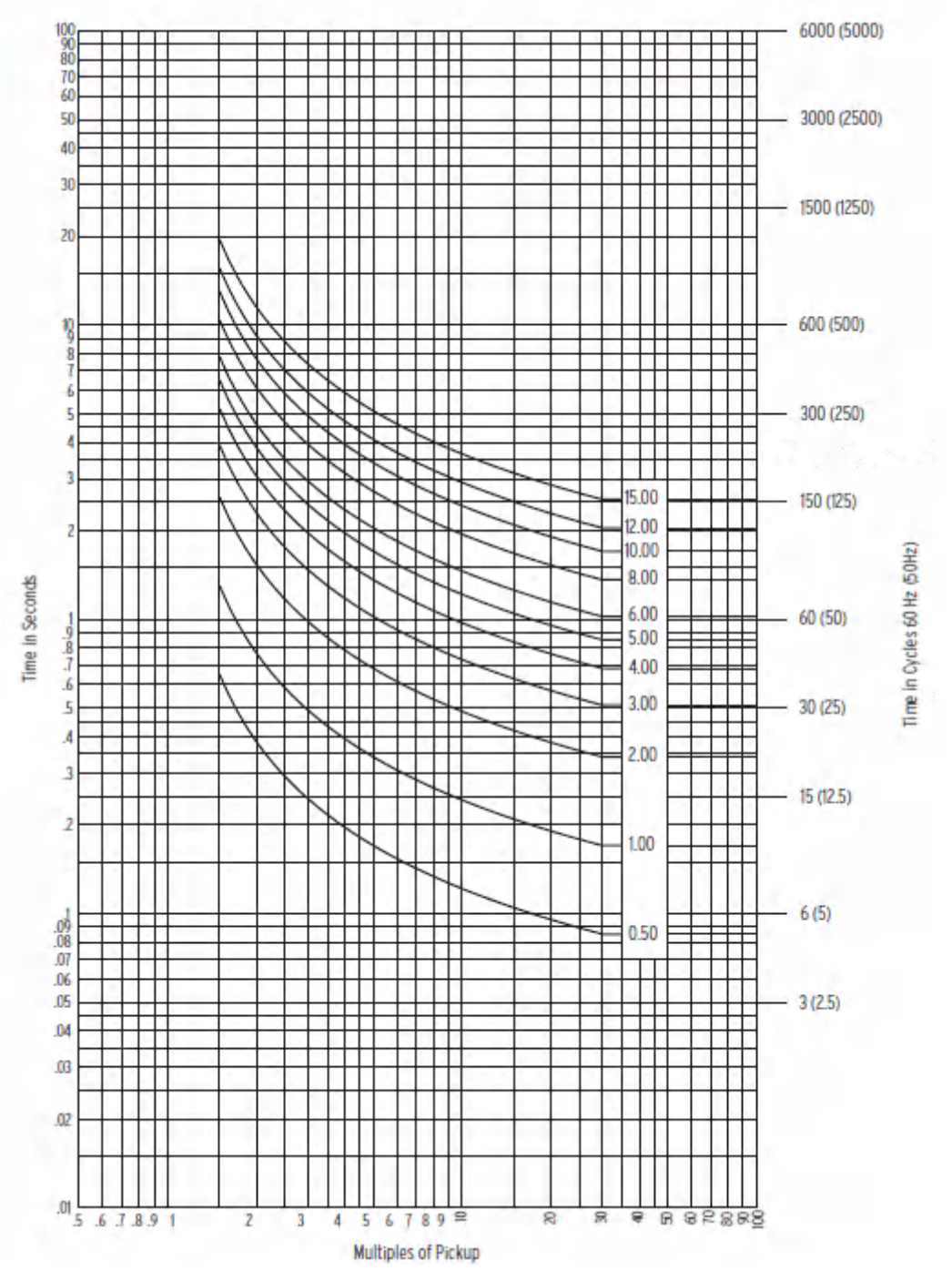
IEC Class C Curve (Extremely Inverse): C3



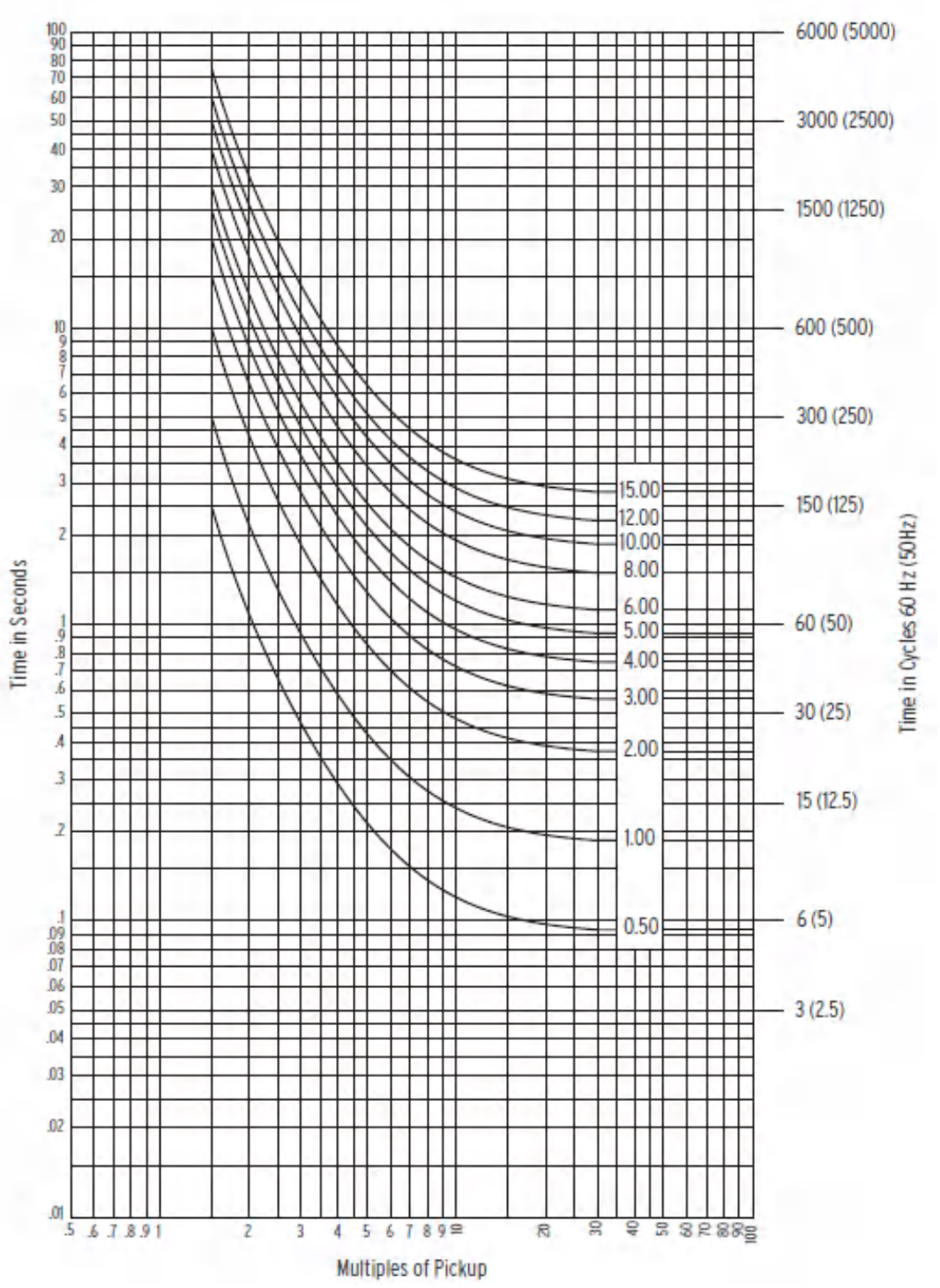
IEC Long-Time Inverse Curve: C4



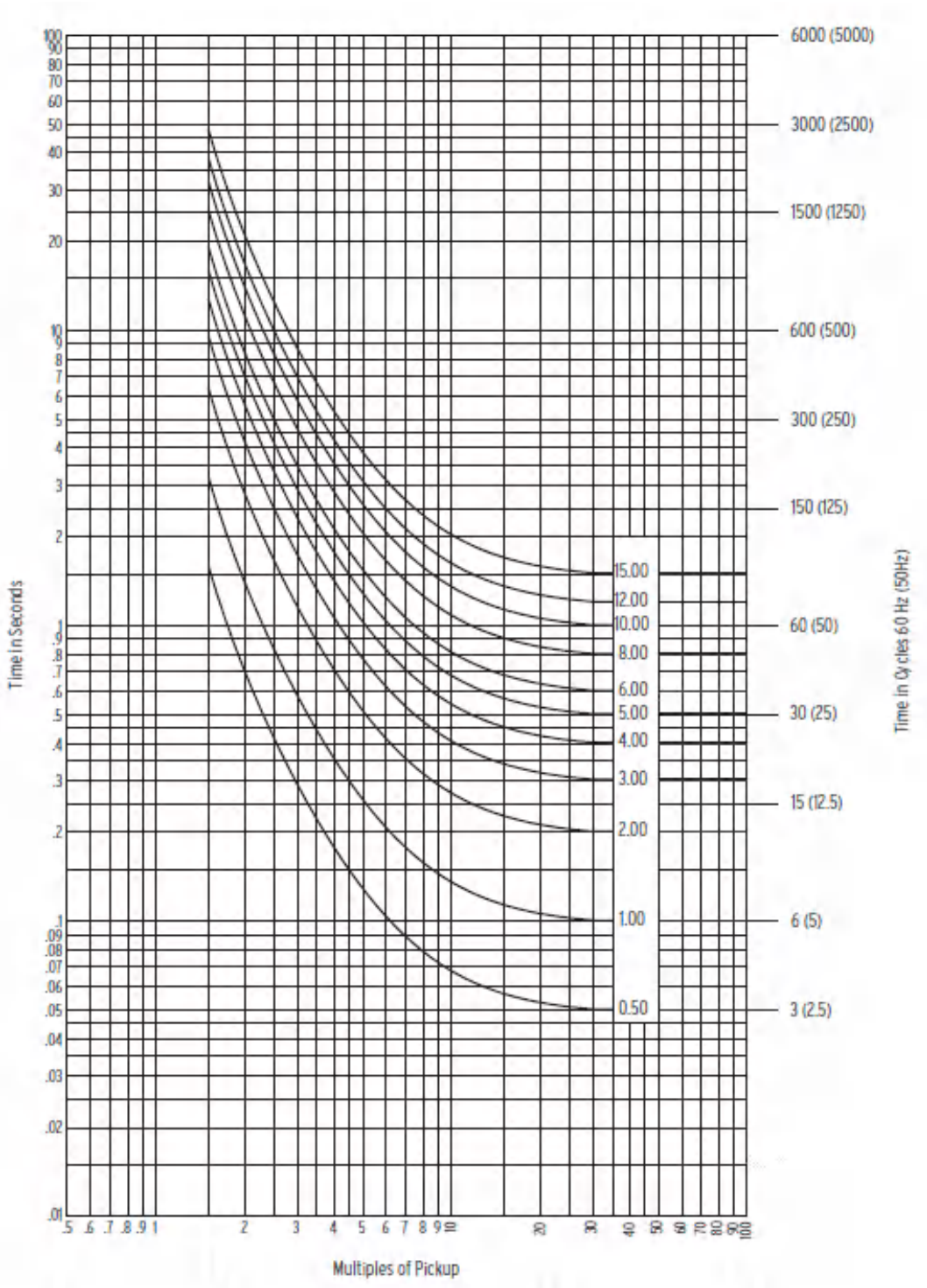
IEC Short-Time Inverse Curve: C5



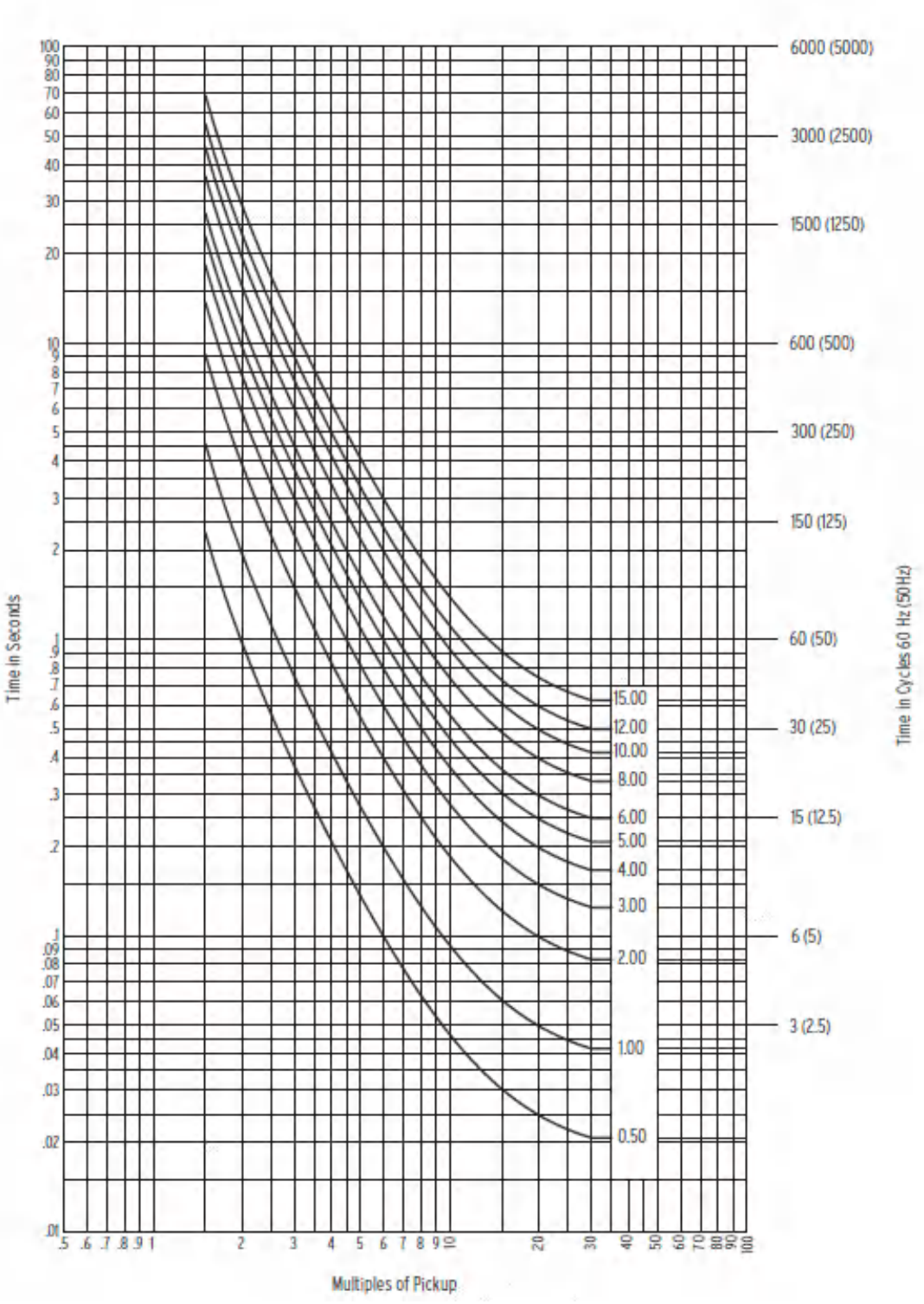
U.S. Moderately Inverse Curve: U1



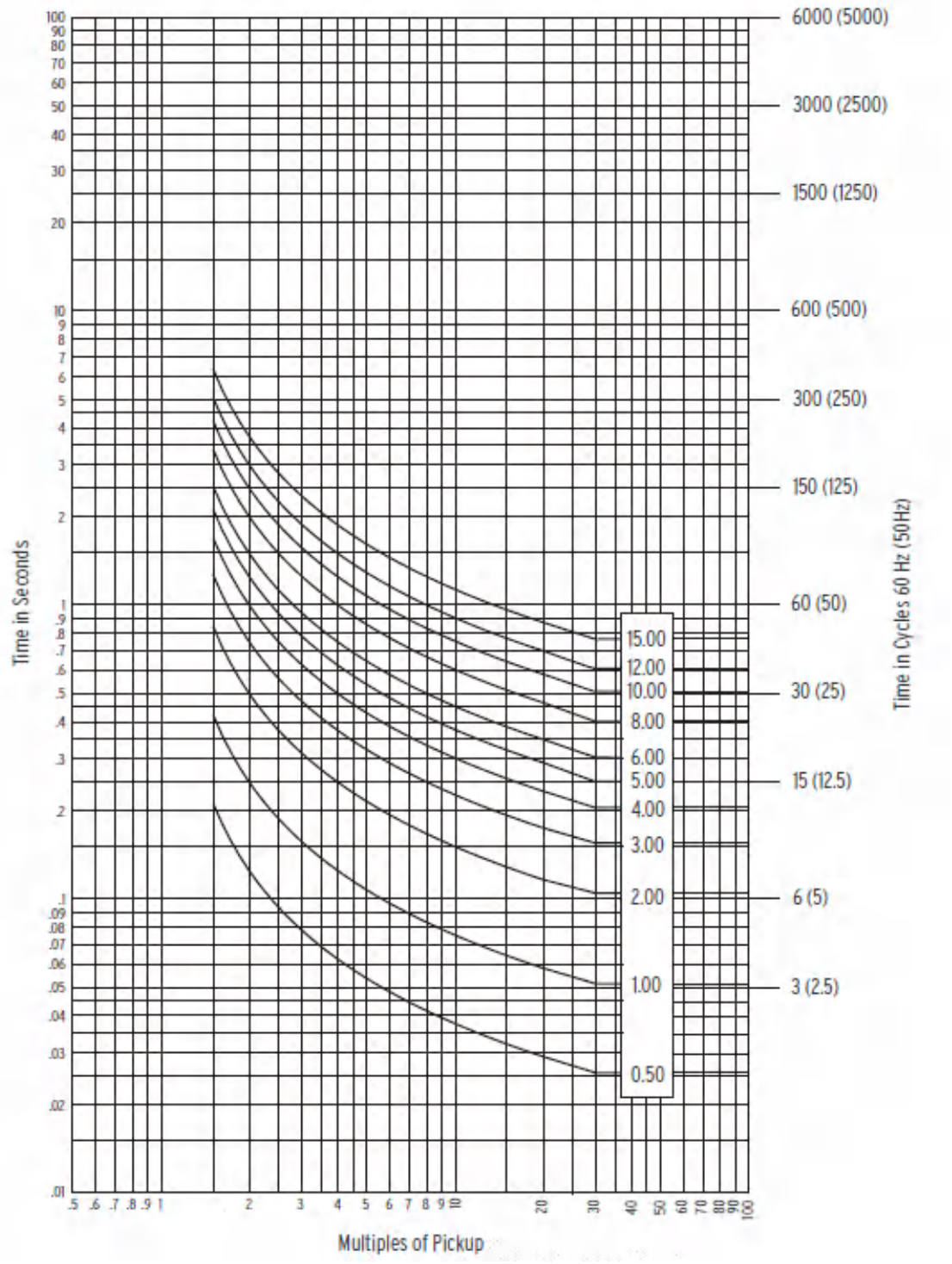
U.S. Inverse Curve: U2



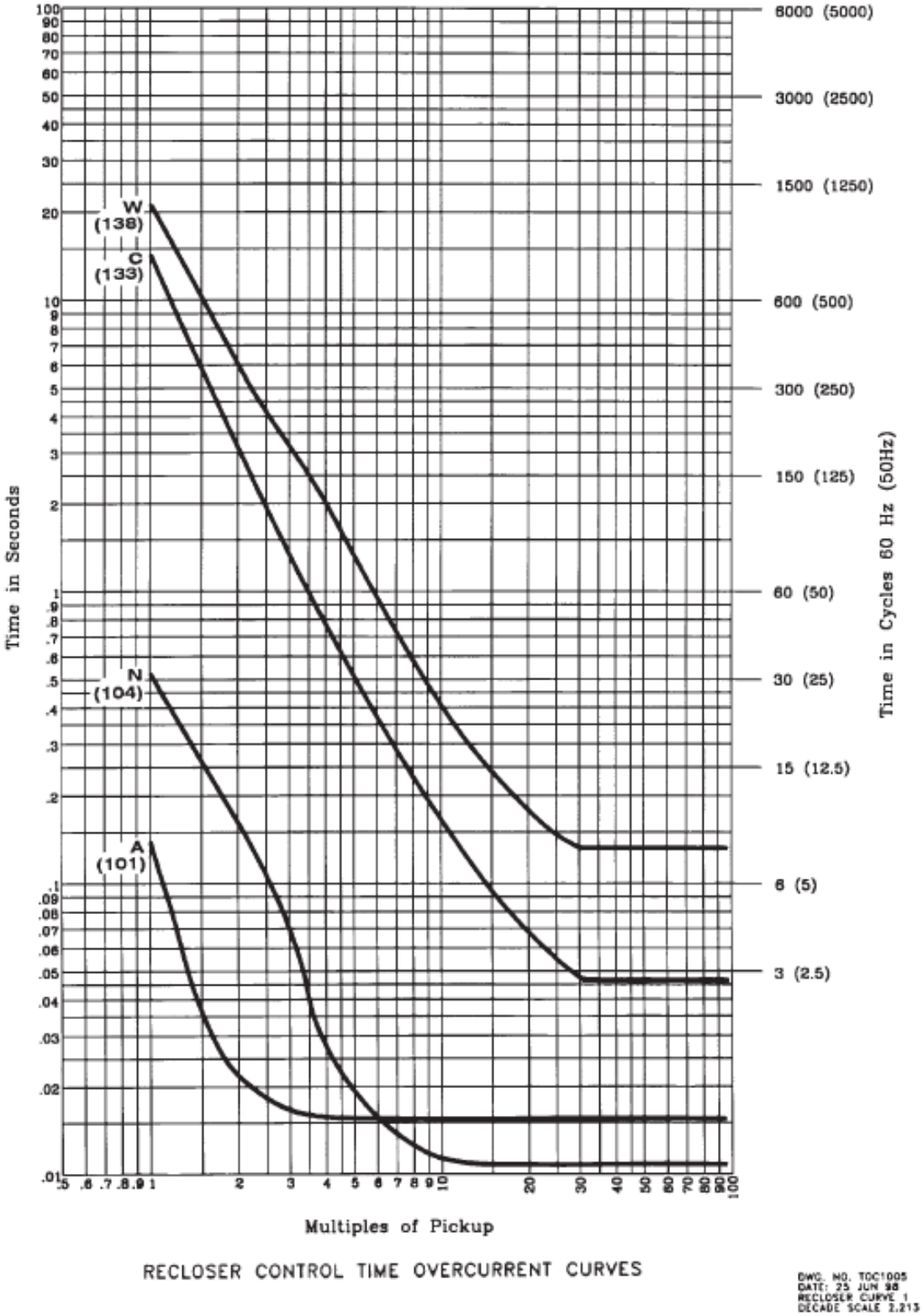
U.S. Very Inverse Curve: U3



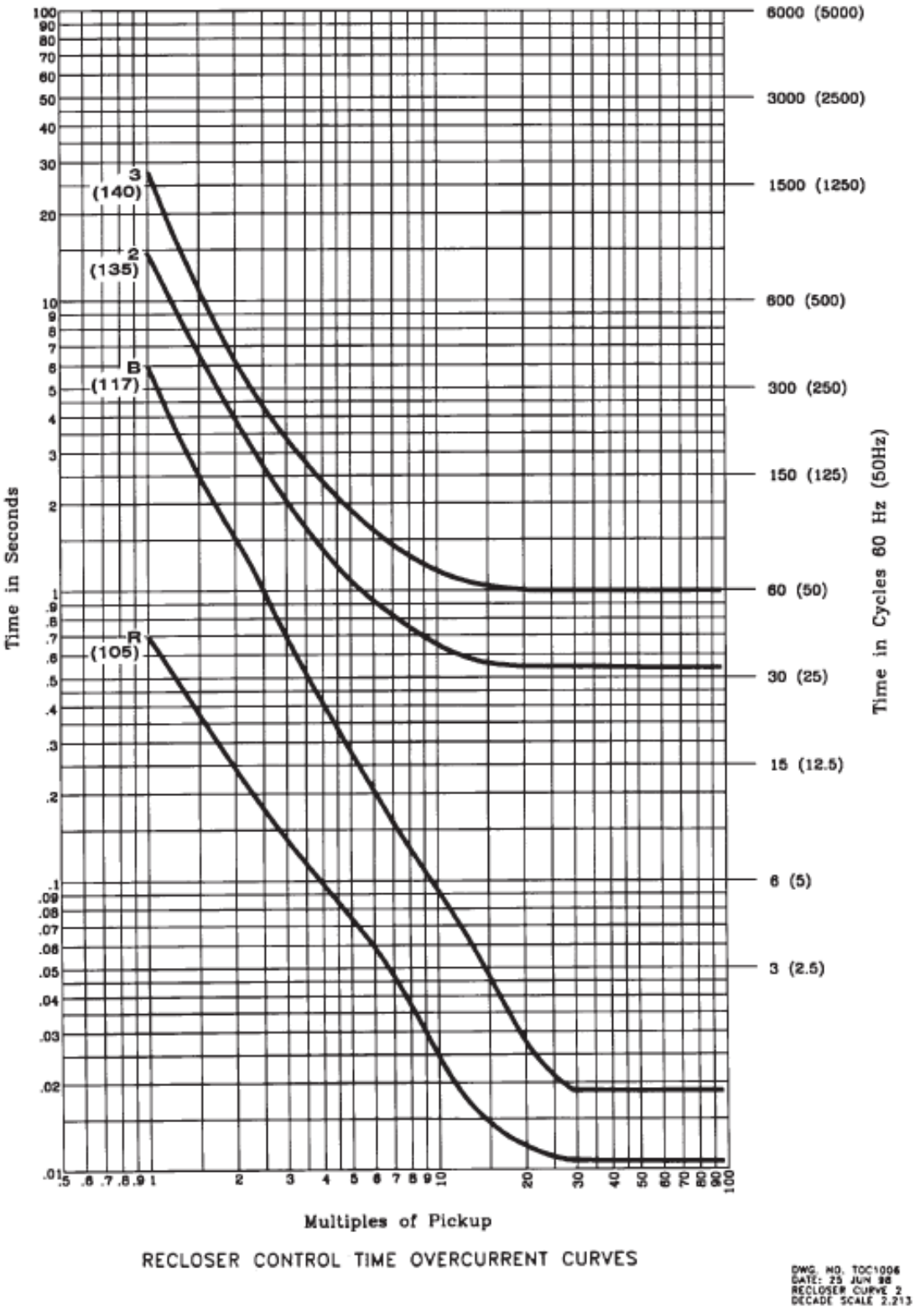
U.S. Extremely Inverse Curve: U4



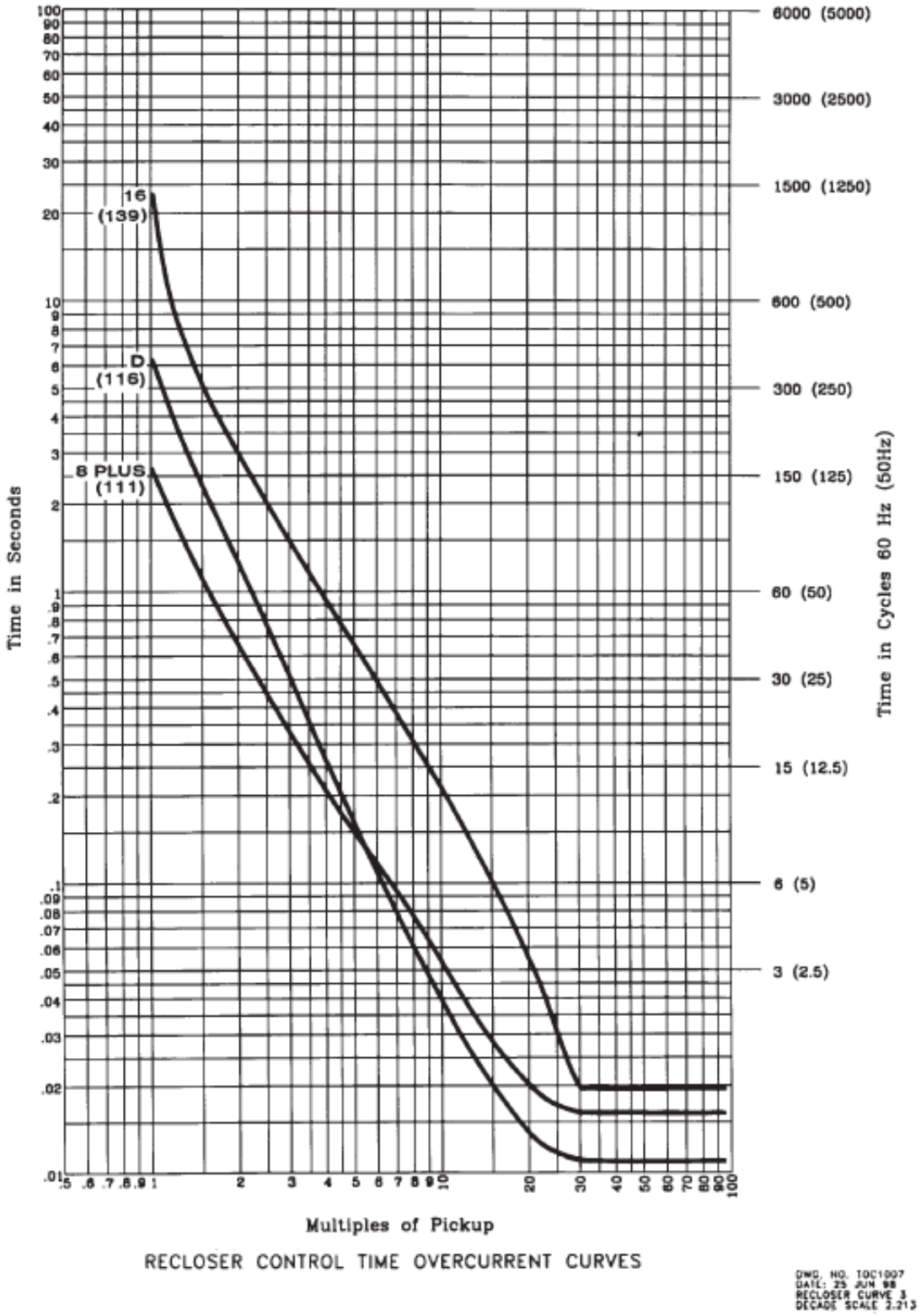
U.S. Short-Time Inverse Curve: U5



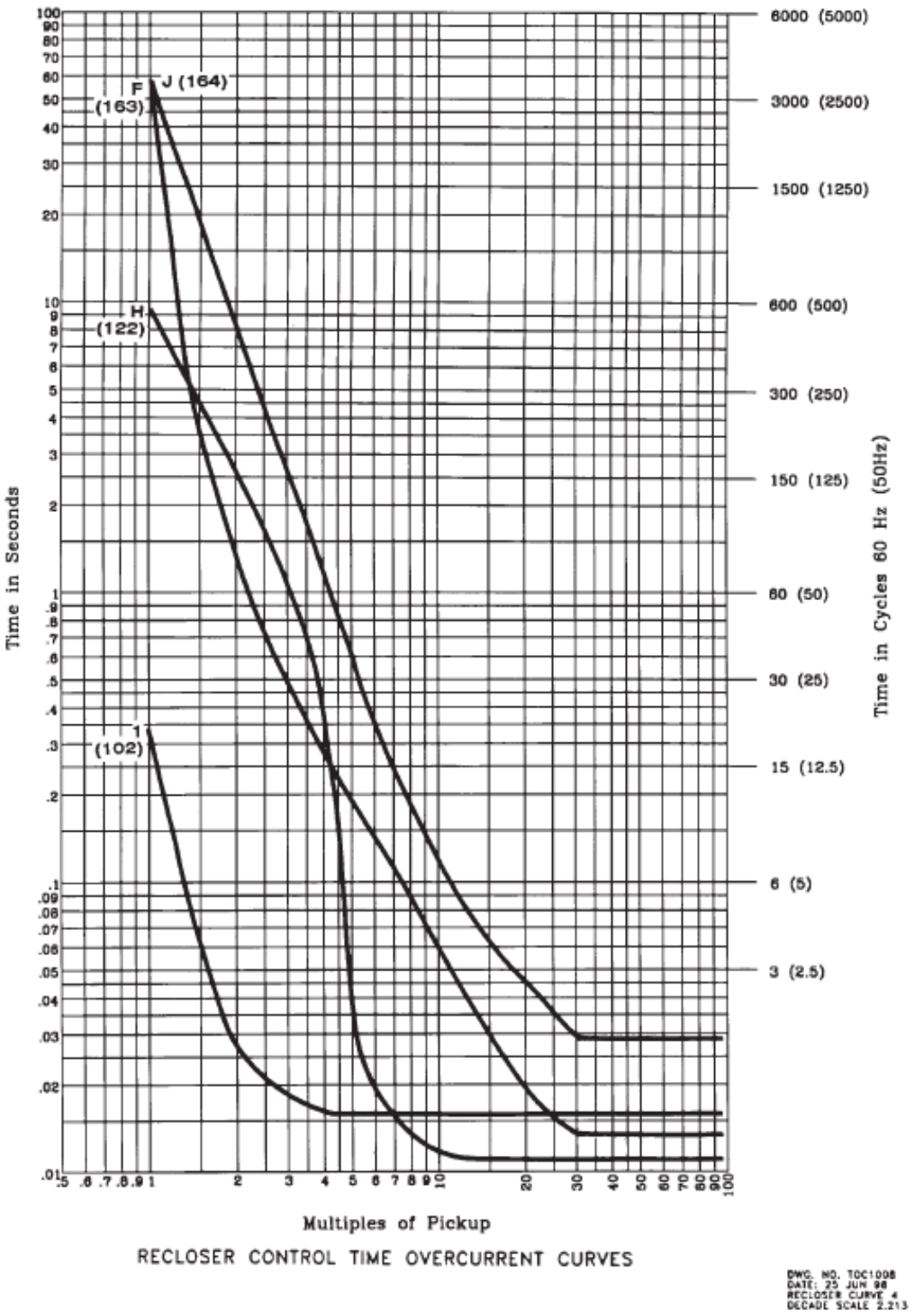
Recloser Control Response Curves A, C, N, and W



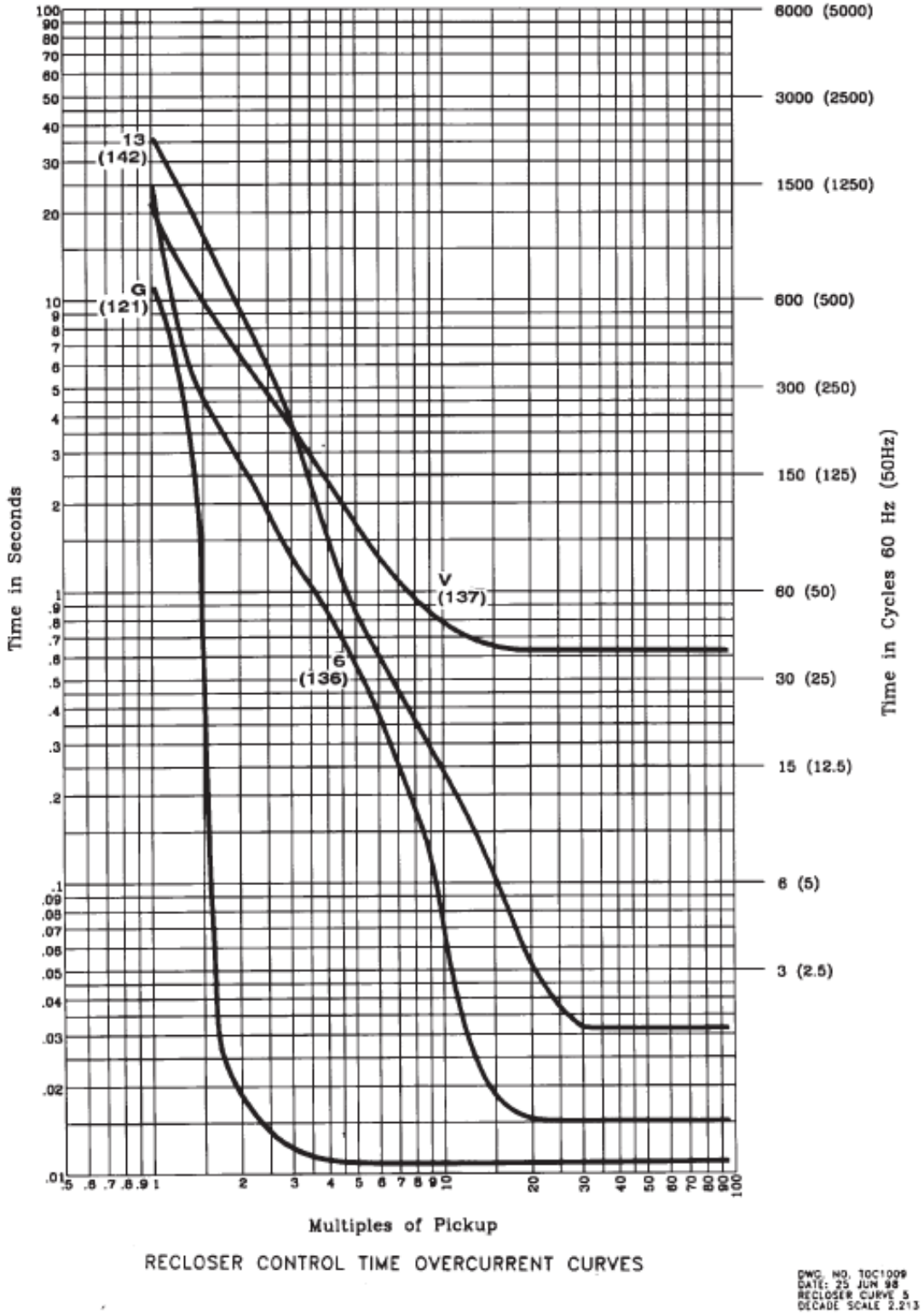
Recloser Control Response Curves B, R, 2, and 3



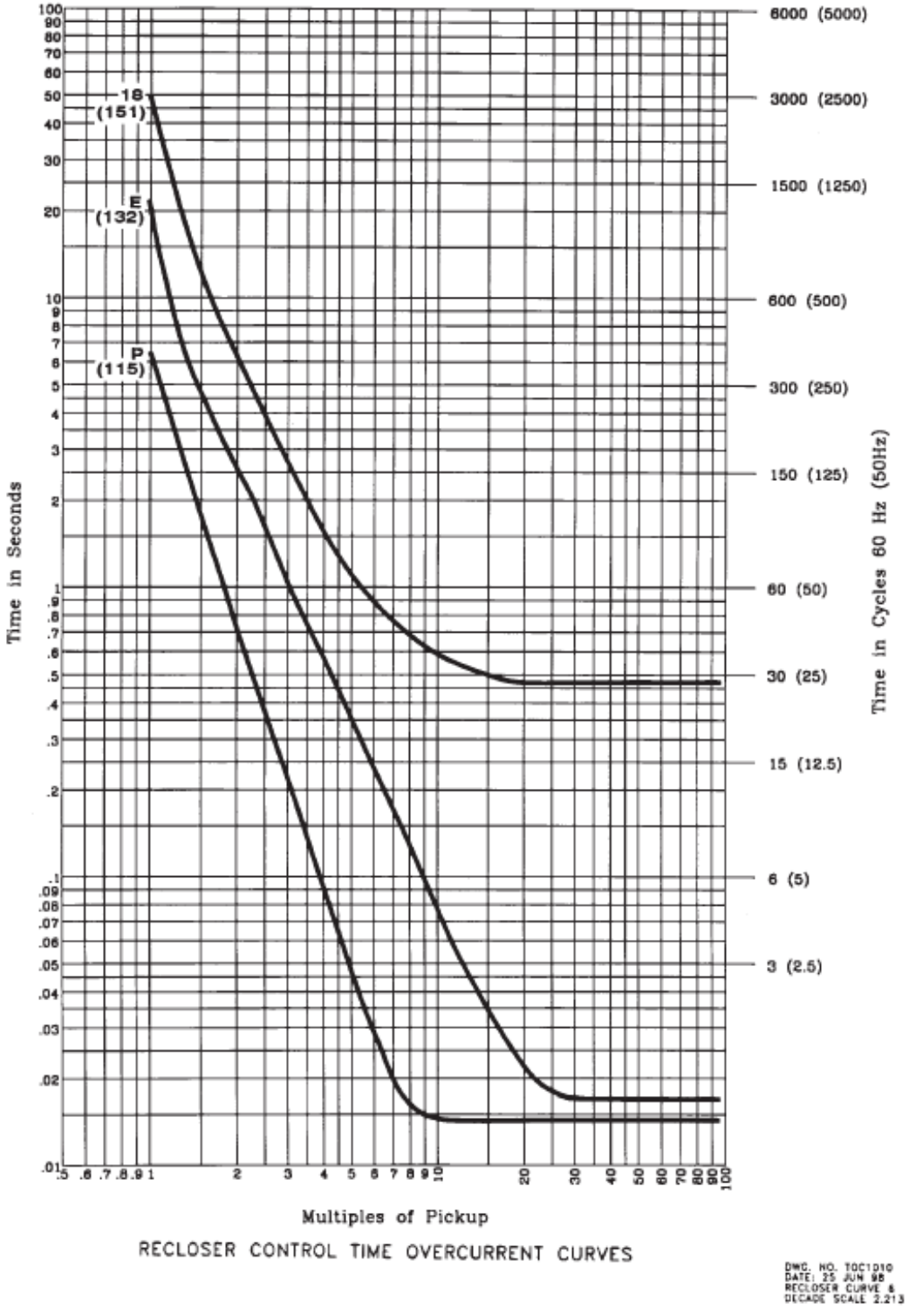
Recloser Control Response Curves D, 8PLUS, and 16



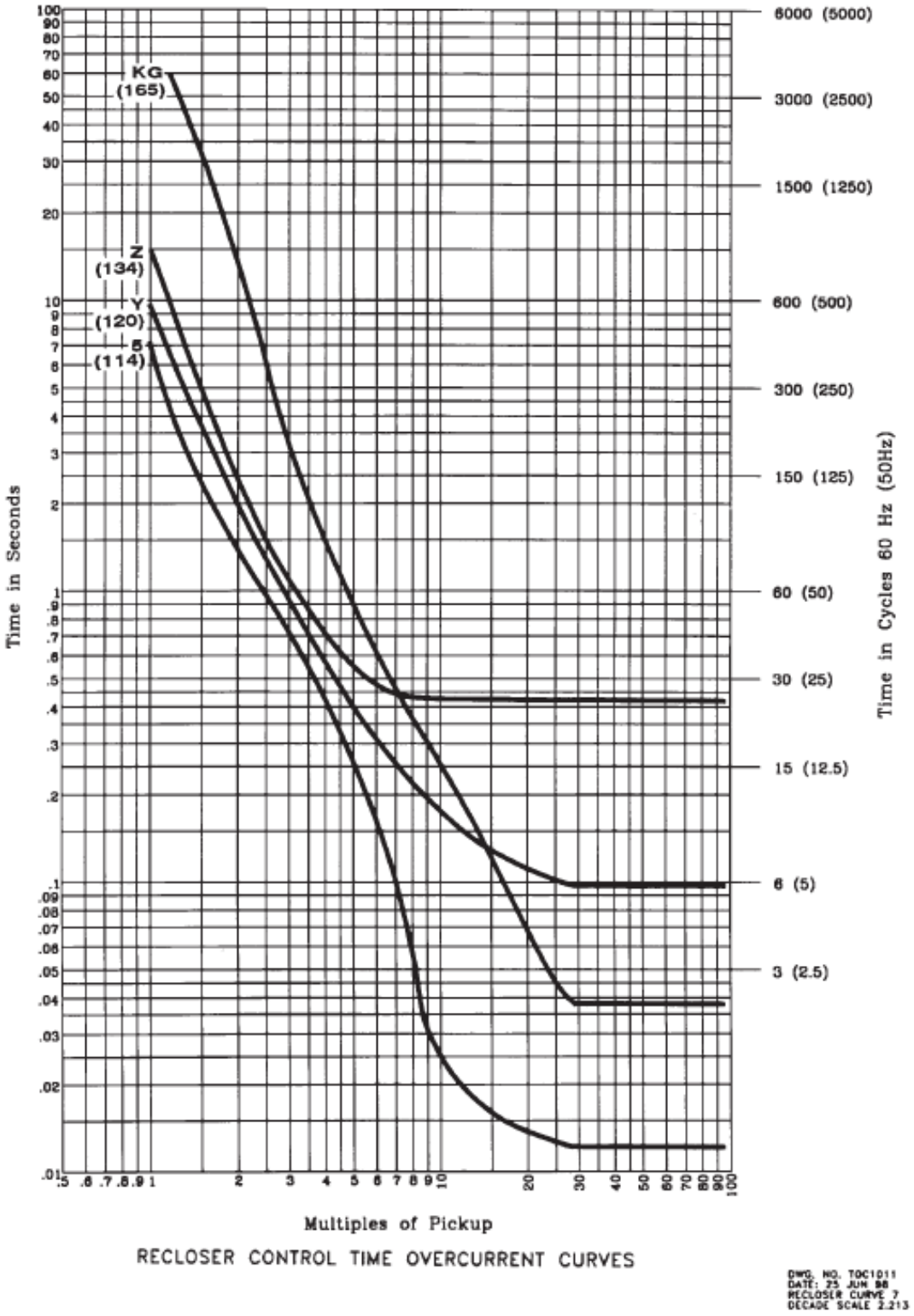
Recloser Control Response Curves F, H, J, and 1



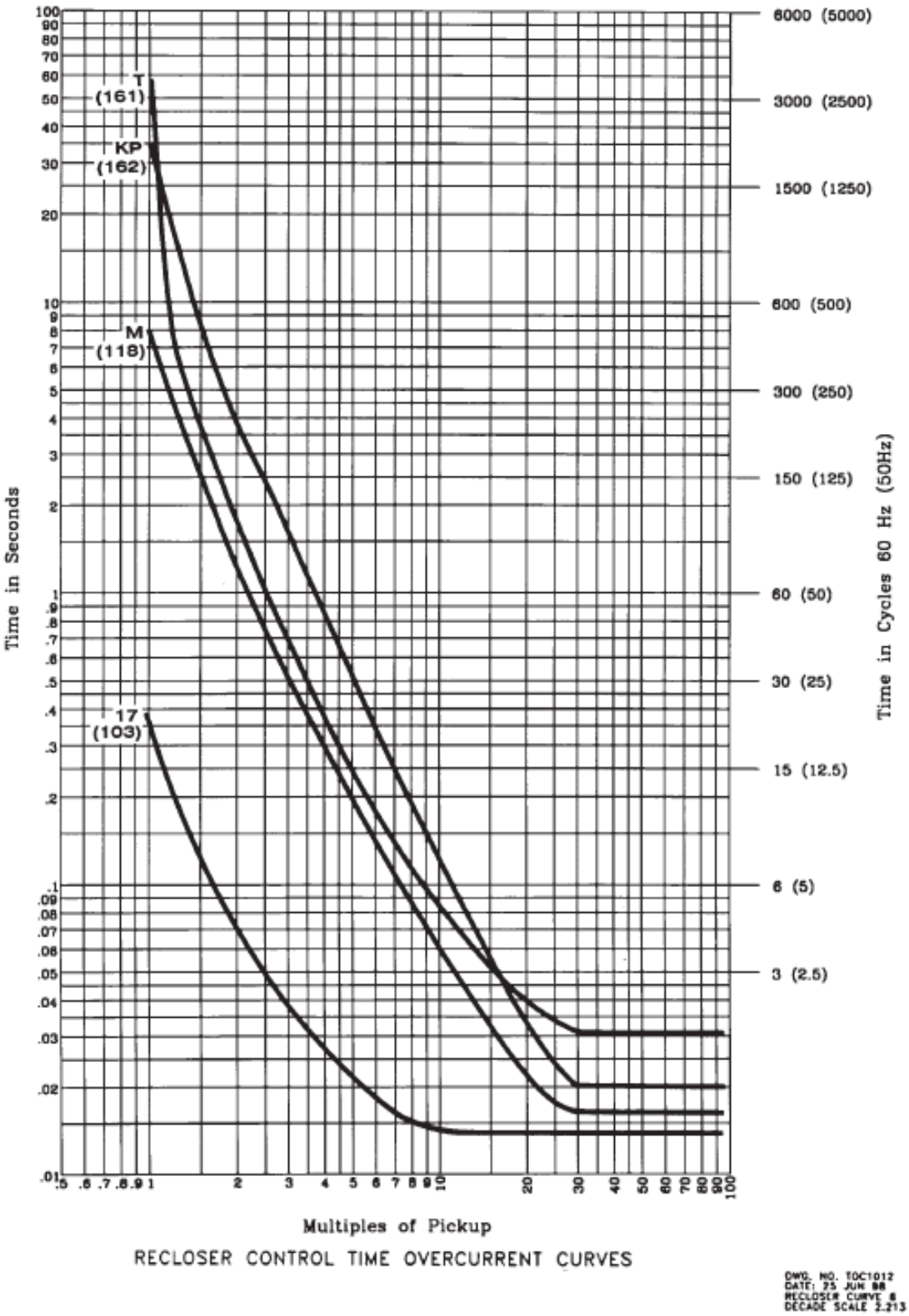
Recloser Control Response Curves G, V, 6, and 13



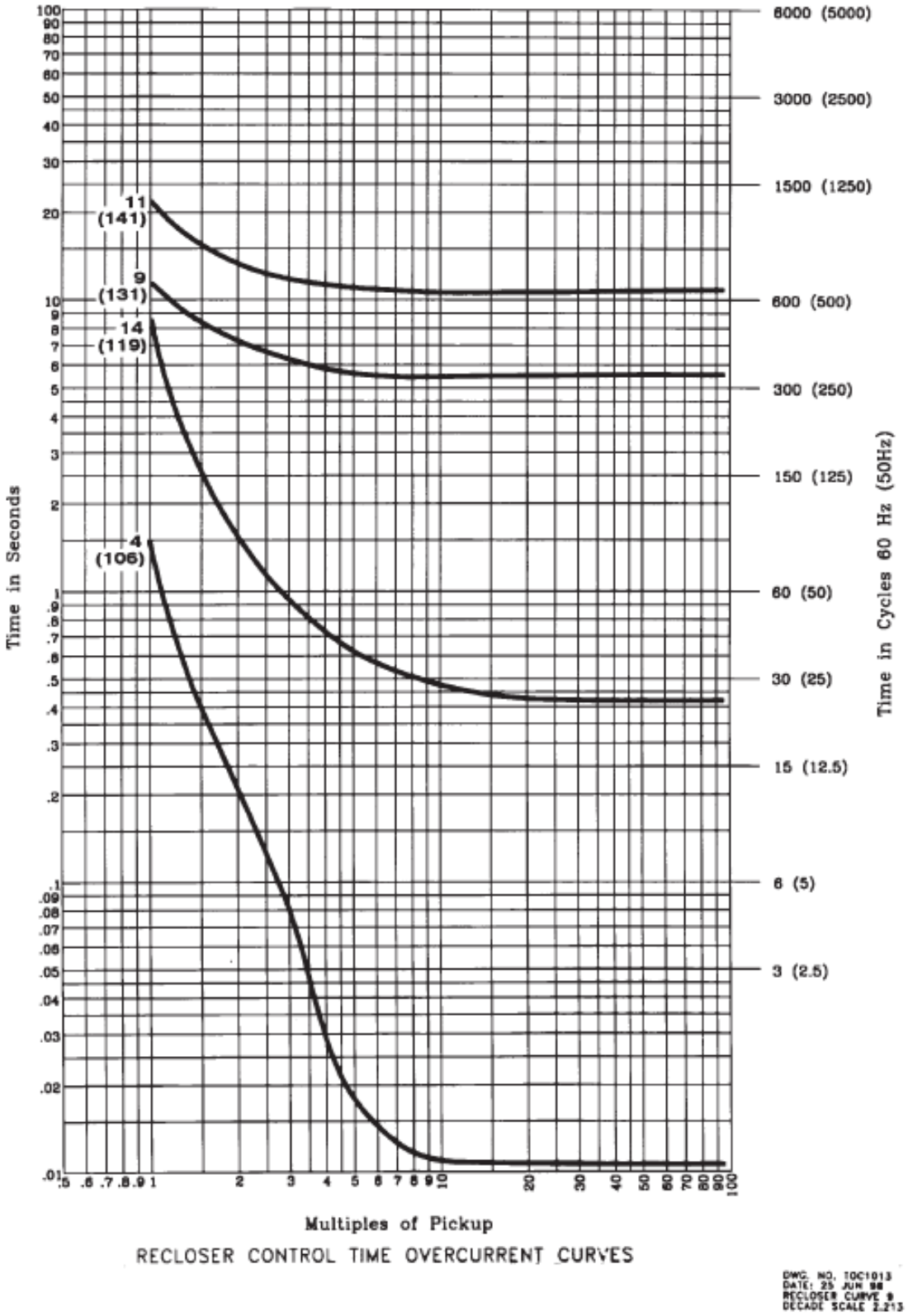
Recloser Control Response Curves E, P, and 18



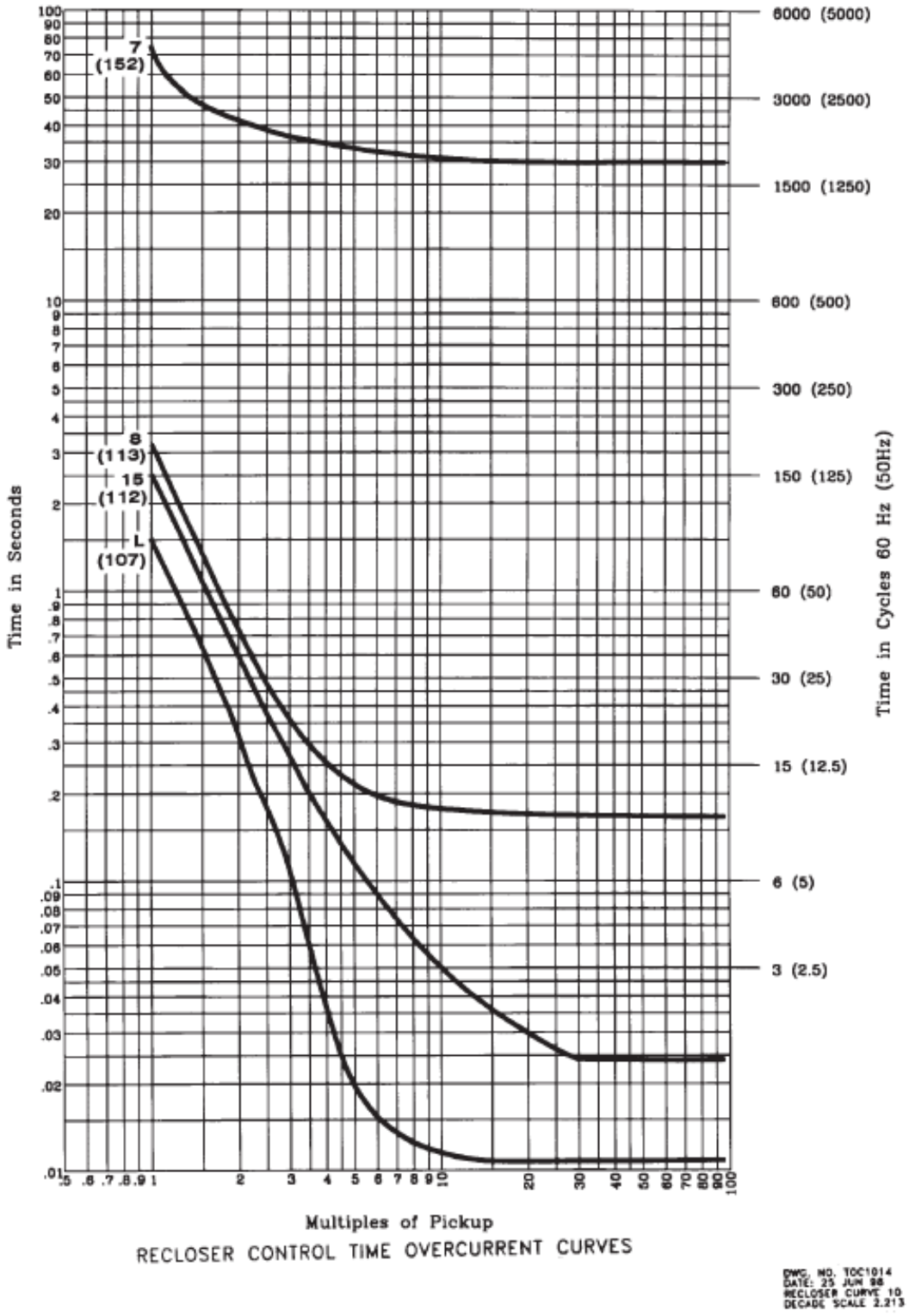
Recloser Control Response Curves KG, Y, Z, and 5



Recloser Control Response Curves KP, M, T, and 17



Recloser Control Response Curves 4, 9, 11, and 14



Recloser Control Response Curves L, 7, 8, and 15

3.3 Data Storage

Data records are backed up in non-volatile memory and are permanently stored even in the event of loss of auxiliary supply voltage. Data storage includes functions of energy, trip count and event records. These records can be reset clear.

Energy

Press the **VIEW** → **Energy**, enter to the energy menu. This includes forward active energy, forward reactive energy, forward one quadrant reactive energy, forward four quadrant reactive energy, reverse active energy, reverse reactive energy, reverse two quadrant reactive energy, reverse three quadrant reactive energy, forward total energy, reverse total energy and total energy.

Counters

Press the **VIEW** → **Counters**, enter to the counters menu. There are opening counting and closing counting.

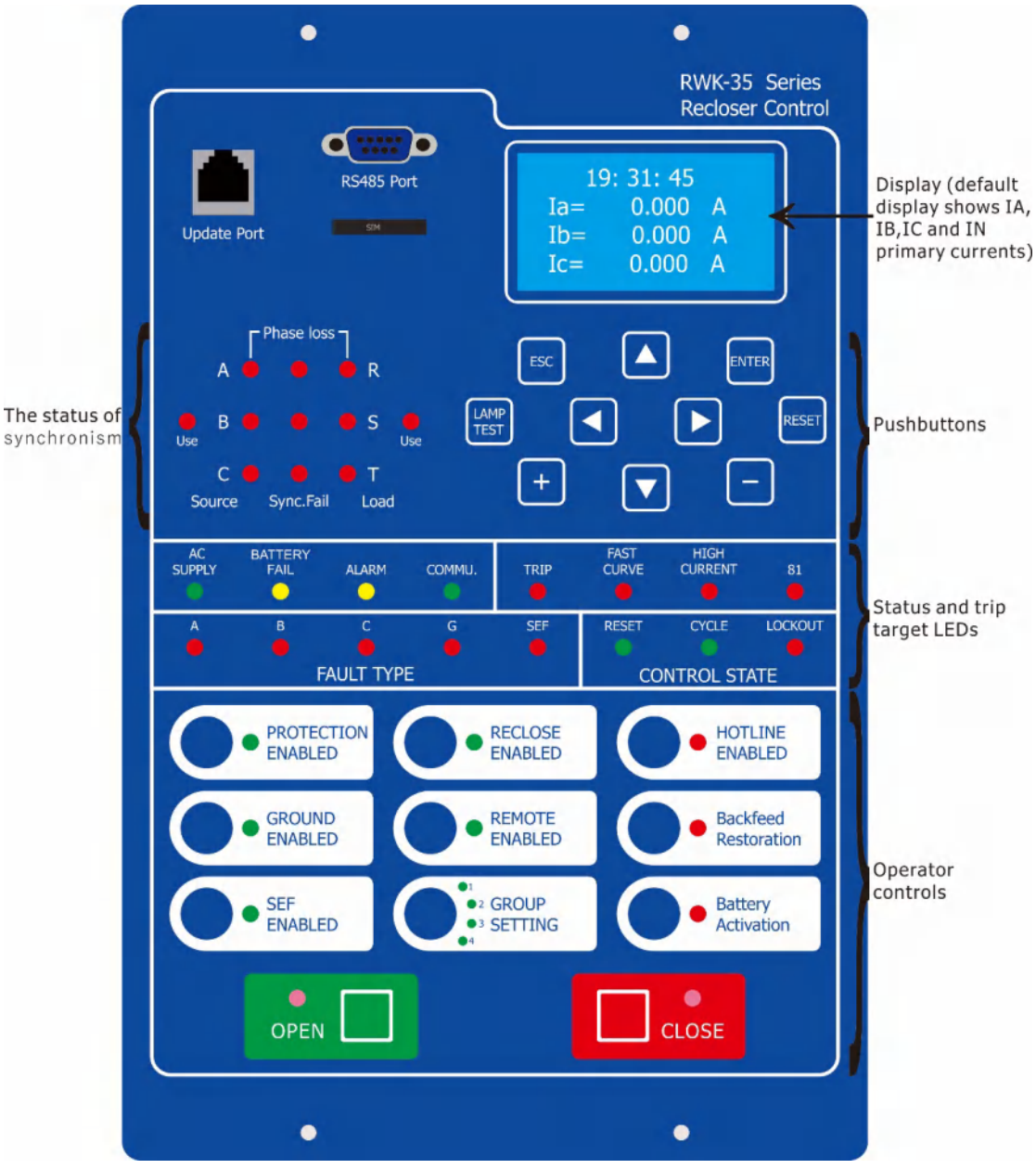
OC(O): Increments on phase overcurrent trip command issued.
EF(O): Increments on earth fault trip command issued.
SEF(O): Increments on sensitive earth fault trip command issued.
BF(O): Increments on bolted fault t trip command issued.
UV(O): Increments on phase under voltage trip command issued.
UF(O): Increments on under frequency trip command issued.
VU(O): Increments on voltage unbalance trip command issued.
CU(O): Increments on current unbalance trip command issued.
LS(O): Increments on loss of supply trip command issued.
Manual(O): Increments on manual trip command issued.
Remote(O): Increments on remote trip command issued.
ALL(O): Increments on each trip command issued.
AR OC(C): Increments on phase overcurrent or earth fault reclose command issued.
AR SEF(C): Increments on sensitive earth fault reclose command issued.
AR UV(C): Increments on phase under voltage reclose command issued.
AR UF(C): Increments on phase under frequency reclose command issued.
ARB(C): Increments on automatic backfeed close command issued.
Manual(C): Increments on manual close command issued.
Remote(C): Increments on remote close command issued.
ALL(C): Increments on each close command issued.

Event Records

Select the **CTRL** submenu, press "Enter" key to enter the **CTRL** submenu. Event records include tripping records, alarm records and SOE records. The event recorder feature allows the time tagging of any change of state (Event) in the relay. As an event occurs, the actual event condition is logged as a record along with a time and date stamp to a resolution of 1ms. There is capacity for a maximum of 2400 event records (1000 trip records, 400 alarm records and 1000 SOE records) that can be stored in the relay and when the event buffer is full any new record will over-write the oldest. The following events are logged:

- Change of state of Binary outputs
- Change of state of Binary inputs
- Protection element operation

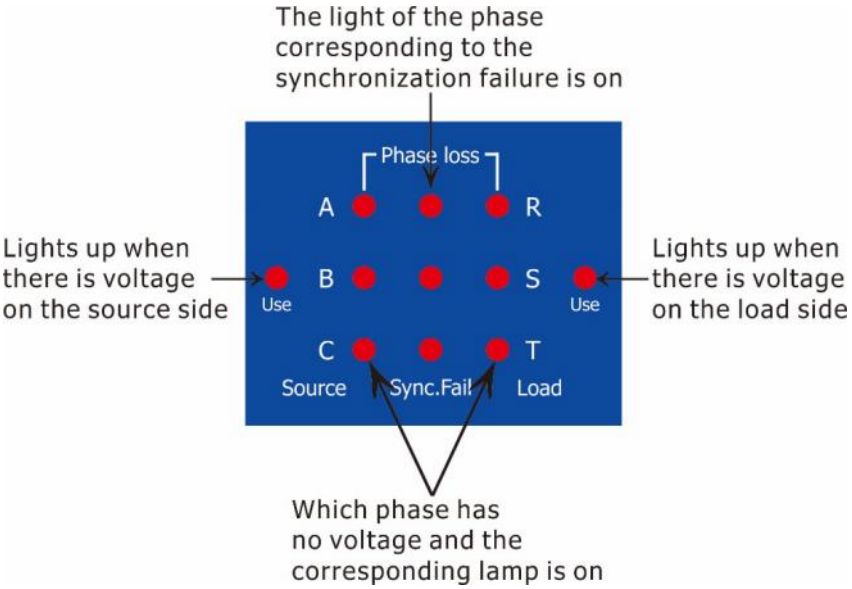
Chapter 4: User Interface

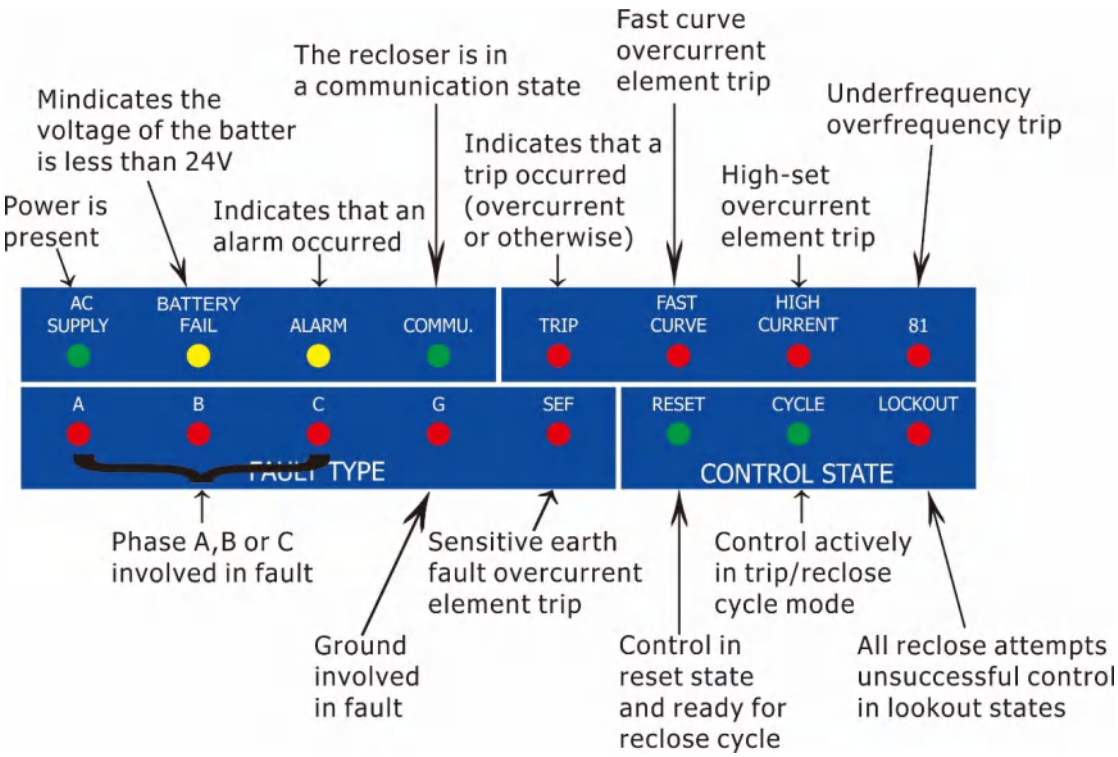


The operator interface is designed to provide a user friendly method of controlling, viewing menus, entering settings and retrieving data from the relay. Eight buttons are provided for navigation around the menu structure.

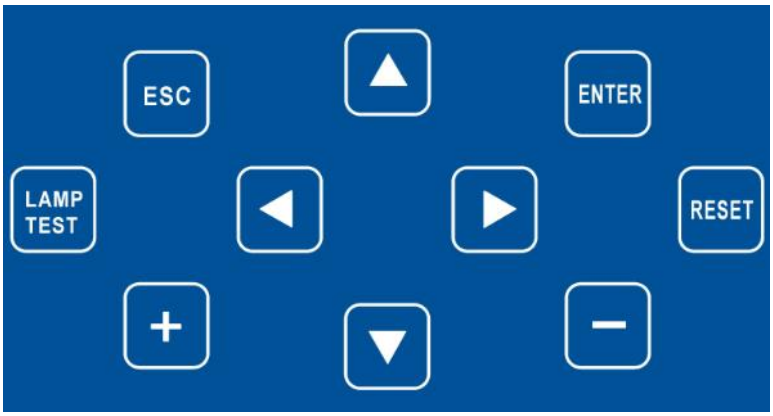
4.1 Status and Trip Target LEDs

Most of the status and Trip Target LEDs and Operator Controls can change function (if desired by the user)by programming at a higher logic level. This subsection discusses each function as shipped from the factory and inscribed on the front panel.



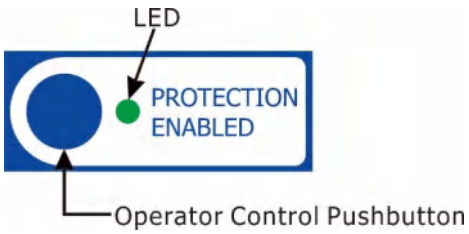


4.2 Pushbuttons



Button	Function
LAMP TEST	Illuminate all front-panel LEDs for 1 second.
RESET	Clear trip-latched targets TRIP, FAST CURVE, HIGH CURRENT, 81, A,B, C, G, and SEF.
ENTER	Select displayed option or setting.
ESC	Cancel command edit or escape to upper command level.
▲	Scroll up on display.
▼	Scroll down on display.
◀	Scroll left on display.
▶	Scroll right on display.
+	increment value.
−	decrement value.

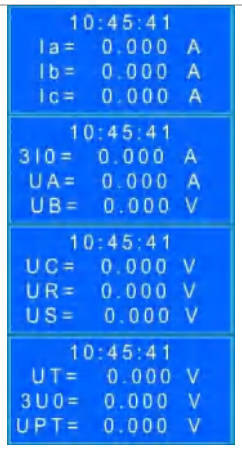
4.3 Operator Controls

All the following operator control pushbuttons should be pressed momentarily to execute their function.	
Press the **PROTECTION ENABLED** to enable/disable the protection tripping. Corresponding LED illuminates to indicate the enabled state.	
Press the **GROUND ENABLED** to enable/disable the ground overcurrent and sensitive earth fault(SEF) element tripping. Corresponding LED illuminates to indicate the enabled state.	
Press the **SEF ENABLED** to enable/disable sensitive earth fault(SEF) element tripping. Corresponding LED illuminates to indicate the enabled state.	
Press the **RECLOSE ENABLED** to enable/disable auto reclosing. Corresponding LED illuminates to indicate the enabled state.	
Press the **REMOTE ENABLED** to enable/disable remote control. Corresponding LED illuminates to indicate the enabled state.	
Press the **GROUP SETTING** to switch setting group. There are four groups in the set value group. Each time you press, add one to the group, and the corresponding light will be on.	
Press the **HOTLINE ENABLED** to enable/disable hotline. Corresponding LED illuminates to indicate the enabled state. **NOTE**: When the reclose is in a status of hotline, the **CLOSE** pushbutton is invalid.	
Press the **Backfeed Restoration** to enable/disable the automatic backfeed closing. Corresponding LED illuminates to indicate the enabled state.	
Press the **Battery Activation** to activate the battery activation function. The corresponding LED lights up to indicate that the battery is active.	

Press the **CLOSE** operator control pushbutton to close the recloser. Corresponding LED illuminates to indicate the reclose is closed. The CLOSE operator control pushbutton does not have to be continually pressed to allow for cold load pickup (i.e., disable fast curves, and desensitize delay curves and SEF element). There is automatic allowance for cold load pickup. See the Cold Load Pickup settings in Chapter 3.1: Function Description.	
Press the **Trip** operator control pushbutton to trip the recloser(and take the control to the lockout state). Corresponding LED illuminates to indicate the reclose is Open.	

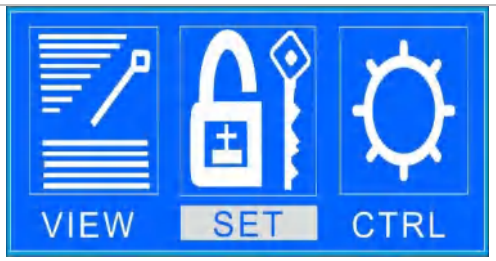
4.4 Default Display

The LCD default display shows IA,IB,IC,3I0,UA,UB,UC,UR,US,UT,3U0,UPT.
Note: The light of the LCD will turn off after five minutes, if you do not operator the reclosing.



4.5 The Main Menu

Press "Enter" when on the main screen, as shown below, including "EDIT" and "VIEW" menu item. Select the corresponding menu item with the [←] key, [→] and press "ENTER" button to enter the corresponding sub-menu, press the "ESC" key to return to the previous screen.

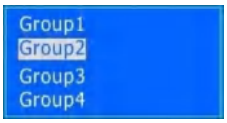


Primacy Menu

4.6 Submenu

SET submenu

Choose the **SET** options, the screen will enter the submenu of the **SET** menu, as shown below, the submenu includes "Protection", "System", "Communication", "Time", "Auto Group", "Measure Adjust", "Factory".

Submenu of SET	
Protection 	Enter "Protection" submenu, you can select the corresponding group to enter and view each protection feature and set up the parameters.
System	Enter "System" submenu, you can modify or view other parameters. Like Recloser type, CT rate, PT rate, PTS rate, Telesignal time, Close pulse time, Trip pulse time, Lock reset time, Action interval, Close input type, Enable Mech-Lock, Mech-Lock time.
Communication	Enter "Communication" submenu, you can modify or view communication parameters.
Time	Enter the "Time" submenu will modify or check the time.
Auto Group	Automatic switchover can be set in the group, which can be switched to summer workday group, summer rest day group, winter workday group and winter rest day group. You can also set the start and end time of summer and the start and end time of rest days. Automatic group switching is based on time.
Measure Adjust	Enter "Measure Adjust" submenu, current and voltage values can be corrected, press the function key "ENTER" to be modified.
Factory	Enter "Factory" Sub-menu, modify and view the factory settings.

VIEW submenu

Choose the **VIEW** options, the screen will enter the submenu of the **VIEW** menu, as shown below, the sub-menu includes "Measurement", "Energy", "Events", "Counters", "Input", "Version".

VIEW submenu	
Measurement	Enter "Measurement" submenu, you can view the primary side measurement data include: Phase current, Ground current, PT voltage, Phase voltage, Line voltage, Battery voltage, Zero sequence voltage, Active power, Reactive power, Apparent power, Power factor and Frequency.
Energy	Enter "Energy" submenu, you can view the energy data include: Forward active energy, Forward reactive energy, Forward one quadrant reactive energy, Forward four quadrant reactive energy, Reverse active energy, Reverse reactive energy, Reverse two quadrant reactive energy, Reverse three quadrant reactive energy, Forward total energy, Reverse total energy and Total energy.
Events	Enter "Events" submenu, you can view the trip report, alarm report, SOE report.
Counters	Enter "Counters" submenu, you can view the opening times and closing times.
Input	Enter the "Input" submenu, you can view the input signal. The input signal includes: Power fault, Active battery, Heavy gas, High temperature, Breaker open, Breaker close, Remote open, Remote close, Door open, Lockout in, Remote enable.
Version	Enter "Version" submenu, you can view the device type, version, date of manufacture and device ID.

CTRL submenu

Choose the **CTRL** options, the screen will enter the submenu of the **CTRL** menu, as shown below, the sub-menu includes "Clear Events", "Clear Counters", "Clear Energy", "Password", "Test".

CTRL submenu	
Clear Events	Enter "Clear Events" submenu, you can clear out the trip report, alarm report, SOE report.
Clear Counters	Enter "Clear Energy" submenu, you can clear out the opening and closing times.
Clear Energy	Enter "Clear Energy" submenu, you can clear out the energy.
Password	Enter "Password" submenu, there are two passwords in the menu, one is the system password and the other is the protection password. The system password can be used in all occasions, and the protection password can only be used to set protection settings.
Test	Enter "Test" submenu， you can set the trip and close counts and time interval to test circuit breaker.

4.7 Entering the password interface

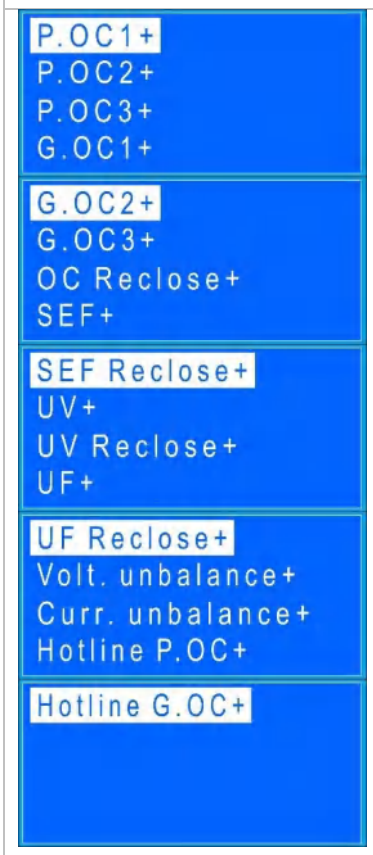
According to the above operation, before entering some item will first enter a password input interface to prevent professional staff misuse. The device original password is "0099", as shown below, press [←] and [→] keys to switch, press the [+] and [-] keys to increase and decrease the number of line with the correct password press "Enter" button to enter.

	Password interface

4.8 Protection setting

Select "Protection" in the edit submenu, press the function key "Enter" to enter, select the corresponding group, press the function key "Enter" to enter the "Protection" submenu, as shown below, each item has a check box.

There are three protection settings: Set+, Set-, Common. SET+ and SET- are identical settings. For Recloser type=Radial, use the protection in Set+ and Common; for Recloser type=Ring, use the protection in Set+, Set-and Common



1、Bolted fault element (BF)
2、Switch-Onto-Fault (SOTF)
3、51c Cold Load Pickup (CLP)
4、Loss of supply element (LS)
5、Automatic backfeed restoration element (ABR)
6、Voltage reclosing control element (VRC)
7、Synchronism check element
8、High Gas
9、High Temp
10、Phase overcurrent element (P.OC1)
11、Phase time-Overcurrent element (P.OC2/P.OC3)
12、Ground overcurrent element (G.OC1)
13、Ground time-Overcurrent element (G.OC2/G.OC3)

14、Phase and Earth Overcurrent Reclosing Element (AR OC) 15、Sensitive earth fault element (SEF) 16、Sensitive earth fault reclosing element (AR SEF) 17、Undervoltage element (UV) 18、Undervoltage reclosing element (AR UV) 19、Underfrequency element (UF) 20、Underfrequency reclosing element (AR UF) 21、Voltage unbalance element (VU) 22、Current unbalance element (CU) 23、Hotline P.OC 24、Hotline G.OC

Bolted fault element (BF)

Select **Bolted fault** in "Common" menu press "Enter" key to enter, operational processes as shown below:

	Step 1: Setting the bolted fault protection current value, the current value can be between 0.01A ~ 20A. Note: Press the [+] and [-] keys to modify the corresponding value.
The operational processes of bolted fault protection setting	

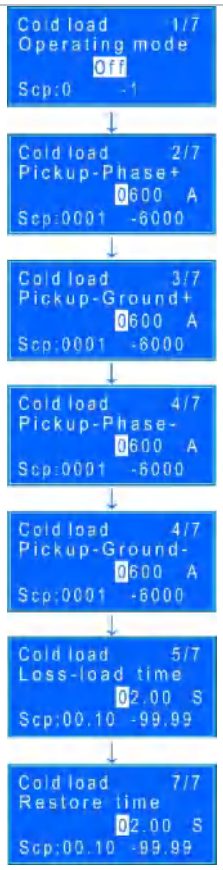
Switch-Onto-Fault (SOTF)

Select SOTF in the "Common" menu, press "Enter" key to enter, operational processes as shown below:

	Step 1: Setting the SOTF operating mode (0: Off, 1:On). Step 2: Setting the SOTF exit time, the exit time can be between 0.1S~9.99S. Step 3: Setting the SOTF protection current value, the current value can be between 1A ~ 6000A. Step 4: Setting the delay time, the delay time can be between 0S ~ 9.99S. Note: Press [↓] key to switch to next screen, press the [+] and [-] keys to modify the corresponding value.
The operational processes of manual closing acceleration protection setting	

51c Cold Load Pickup (CLP)

Select **Cold load** in the "Common" menu, press "Enter" key to enter, operational processes as shown below:



Step 1: Setting the cold load operating mode (0: Off, 1:On).

Step 2: Setting the cold load protection phase current value, the current value can be between 1A ~ 6000A.

Step 3: Setting the cold load protection ground current value, the current value can be between 1A ~ 6000A.

Step 4: Setting the loss-load time, the time can be between 0.1S ~ 99.99S.

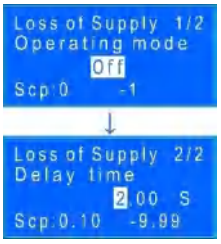
Step 5: Setting the restore time, the time can be between 0.1S ~ 99.99S.

Note: Press [↓] key to switch to next screen, press the [+] and [-] keys to modify the corresponding value.

The operational processes of cold load protection setting

Loss of supply element (LS)

Select **Loss of Supply** in the "Common" menu, press "Enter" key to enter, operational processes as shown below:



Step 1: Setting the cold load operating mode (0: Off, 1:On).

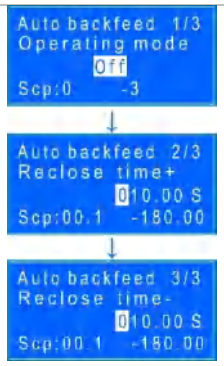
Step 2: Setting the delay time, the delay time can be between 0S ~ 9.99S.

Note: Press [↓] key to switch to next screen, press the [+] and [-] keys to modify the corresponding value.

The operational processes of loss of supply protection setting

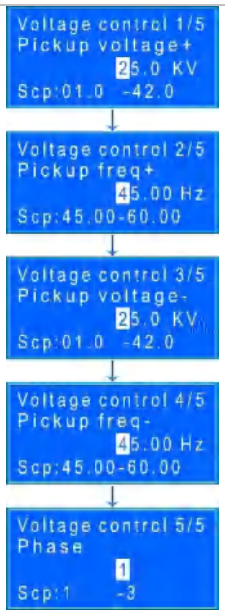
Automatic backfeed restoration element (ABR)

Select **Auto backfeed** in the "Common" menu, press "Enter" key to enter, operational processes as shown below:

	Step 1: Setting the auto backfeed operating mode (0: Off, 1:Both, 2: Only+, 3: Only-). Step 2: Setting the reclose time, the delay time can be between 0.1S ~ 180S. Note: Press [↓] key to switch to next screen, press the [+] and [-] keys to modify the corresponding value.
The operational processes of auto backfeed protection setting	

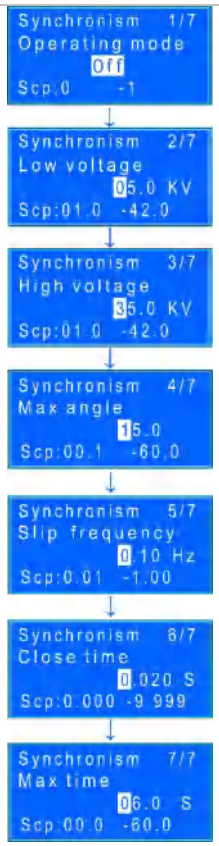
Voltage reclosing control element (VRC)

Select **Voltage control** in the "Common" menu, press "Enter" key to enter, operational processes as shown below:

	Step 1: Setting the pickup voltage value, the pickup voltage value can be between 1KV ~ 42KV. Step 2: Setting the pickup frequency, the pickup frequency can be between 40Hz~60Hz. Step 3: Setting the phase from which the frequency originates, the phase can be between 1 ~ 3 (1: A phase, 2: B phase, 3: C phase). Note: Press [↓] key to switch to next screen, press the [+] and [-] keys to modify the corresponding value.
The operational processes of voltage control protection setting	

Synchronism

Select **Synchronism** in the "Common" menu, press "Enter" key to enter, operational processes as shown below:



Step 1: Setting the synchronism operating mode (0: Off, 1:On).

Step 2: Setting the low voltage value, the low voltage value can be between 1KV ~ 42KV.

Step 3: Setting the high voltage value, the high voltage value can be between 1KV ~ 42KV.

Step 4: Setting the max angle, the max angle can be between 0.1° ~60°.

Step 5: Setting the slip frequency, the slip frequency can be between 0.01 Hz ~1Hz.

Step 6: Setting the close time, the close time can be between 0S ~9.999S.

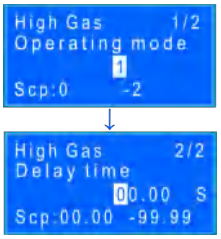
Step 7: Setting the max time, the max time can be between 0S~60S.

Note: Press [↓] key to switch to next screen, press the [+] and [-] keys to modify the corresponding value.

The operational processes of synchronism protection setting

Heavy gas protection (High Gas)

Select **High Gas** in the "Common" menu press "Enter" key to enter, operational processes as shown below:



Step 1: Choose the operating mode (0: Off, 1: Trip 2: Alarm).

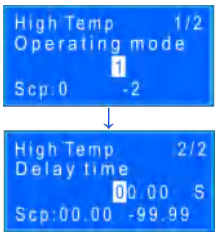
Step 2: Setting the delay time, the delay time can be between 0S ~ 99.99S.

Note: Press [↓] key to switch to next screen, press the [+] and [-] keys to modify the corresponding value.

The operational processes of heavy gas protection setting

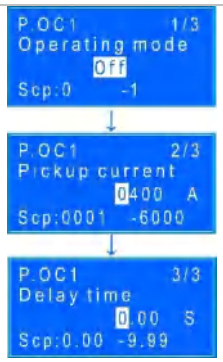
High temperature protection (High Temp)

Optional **High Temp** in the "Common" menu, press "Enter" key to enter, operational processes as shown below:

	Step 1: Choose the operating mode (0: Off, 1: Trip 2: Alarm). Step 2: Setting the delay time, the delay time can be between 0S ~ 99.99S. Note: Press [↓] key to switch to next screen, press the [+] and [-] keys to modify the corresponding value.
The operational processes of high temperature protection setting	

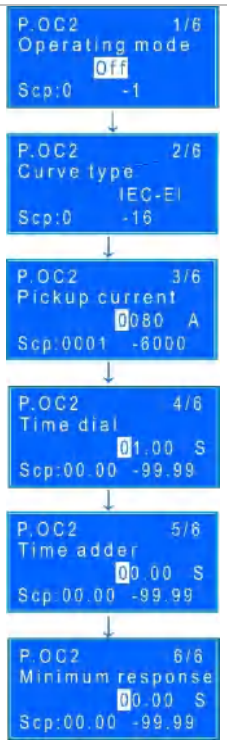
Phase overcurrent element (P.OC1)

Select **P.OC1** in "Set+/Set-" menu, press "Enter" key to enter, operational processes as shown below:

	Step 1: Setting the P.OC1 operating mode (0: Off, 1: On). Step 2: Setting the P.OC1 protection current value, the current value can be between 1A ~ 6000A. Step 3: Setting the P.OC1 delay time, the delay time can be between 0S ~ 9.99S. Note: Press [↓] key to switch to next screen, press the [+] and [-] keys to modify the corresponding value.
The operational processes of P.OC1 protection setting	

Phase time-Overcurrent element (P.OC2/P.OC3)

Select **P.OC2/P.OC3** in "Set+/Set-" menu, press "Enter" key to enter, operational processes as shown below:



Step 1: Setting the P.OC2/P.OC3 operating mode (0: Off, 1: On).

Step 2: Choose the Curve type of Inverse-time overcurrent.

Step 2: Setting the P.OC2/P.OC3 protection current value, the current value can be between 1A ~ 6000A.

Step 3: Setting the Time dial of time-overcurrent curve.

Step 4: Setting the Time adder of time-overcurrent curve (the delay time to trip after "Tp").

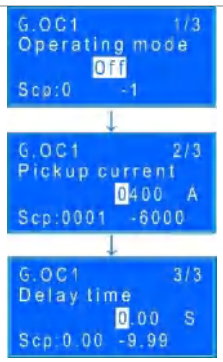
Step 5: Setting the Minimum response of time-overcurrent curve (If the "Tp" less than it, the recloser will trip after this time).

Note: Press [↓] key to switch to next screen, press the [+] and [-] keys to modify the corresponding value.

The operational processes of P.OC2/P.OC3 protection setting

Ground overcurrent element (G.OC1)

Select **G.OC1** in "Set+/Set-" menu, press "Enter" key to enter, operational processes as shown below:



Step 1: Setting the G.OC1 operating mode (0: Off, 1: On).

Step 2: Setting the G.OC1 protection current value, the current value can be between 1A ~ 6000A.

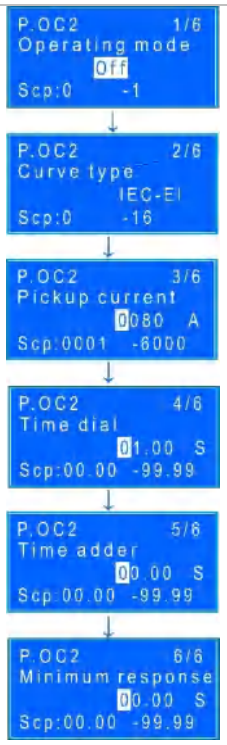
Step 3: Setting the G.OC1 delay time, the delay time can be between 0S ~ 9.99S.

Note: Press [↓] key to switch to next screen, press the [+] and [-] keys to modify the corresponding value.

The operational processes of G.OC1 protection setting

Ground time-Overcurrent element (G.OC2/G.OC3)

Select **G.OC2/G.OC3** in "Set+/Set-" menu, press "Enter" key to enter, operational processes as shown below:



Step 1: Setting the G.OC2/G.OC3 operating mode (0: Off, 1: On).

Step 2: Choose the Curve type of Inverse-time overcurrent.

Step 3: Setting the G.OC2/G.OC3 protection current value, the current value can be between 1A ~ 6000A.

Step 4: Setting the Time dial of time-overcurrent curve.

Step 5: Setting the Time adder of time-overcurrent curve (the delay time to trip after "Tp").

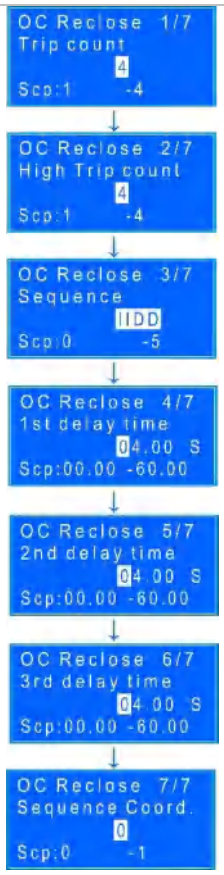
Step 6: Setting the Minimum response of time-overcurrent curve (If the "Tp" less than it, the recloser will trip after this time).

Note: Press [↓] key to switch to next screen, press the [+] and [-] keys to modify the corresponding value.

The operational processes of G.OC2/G.OC3 protection setting

Phase and Earth Overcurrent Reclosing Element (AR OC)

Select **OC Reclose** in "Set+/Set-" menu press "Enter" key to enter, operational processes as shown below:



Step 1: Setting the low set trip count (1: One, 2: Two, 3: Three, 4: Four).

Step 2: Setting the high set trip count (1: One, 2: Two, 3: Three, 4: Four).

Step 3: Setting the sequence.

Step 4: Setting the 1st delay time, the delay time can be between 0S ~ 60S.

Step 5: Setting the 2nd delay time, the delay time can be between 0S ~ 60S.

Step 6: Setting the 3rd delay time, the delay time can be between 0S ~ 60S.

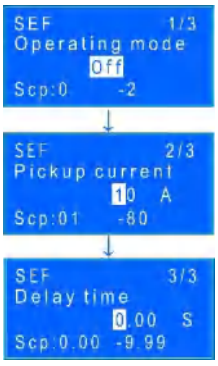
Step 7: Setting the sequence coordination (0: Disable, 1: Enable).

Note: Press [↓] key to switch to next screen, press the [+] and [-] keys to modify the corresponding value.

The operational processes of OC reclose setting

Sensitive earth fault element (SEF)

Select **SEF** in "Set+/Set-" menu, press "Enter" key to enter, operational processes as shown below:



Step 1: Setting the SEF operating mode (0: Off, 1: Trip, 2: Alarm).

Step 2: Setting the SEF protection current value, the current value can be between 1A ~ 80A.

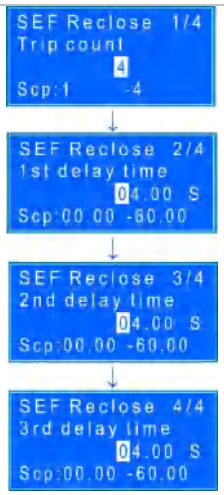
Step 3: Setting the SEF delay time, the delay time can be between 0S ~ 9.99S.

Note: Press [↓] key to switch to next screen, press the [+] and [-] keys to modify the corresponding value.

The operational processes of SEF protection setting

Sensitive earth fault reclosing element (AR SEF)

Select **SEF Reclose** in "Set+/Set-" menu press "Enter" key to enter, operational processes as shown below:



Step 1: Setting the trip count (1: One, 2: Two, 3: Three, 4: Four).

Step 2: Setting the 1st delay time, the delay time can be between 0S ~ 60S.

Step 3: Setting the 2nd delay time, the delay time can be between 0S ~ 60S.

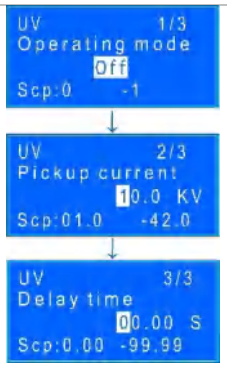
Step 4: Setting the 3rd delay time, the delay time can be between 0S ~ 60S.

Note: Press [↓] key to switch to next screen, press the [+] and [-] keys to modify the corresponding value.

The operational processes of SEF reclose setting

Undervoltage element (UV)

Select **UV** in "Set+/Set-" menu press "Enter" key to enter, operational processes as shown below:



Step 1: Setting the UV operating mode (0: Off, 1: On).

Step 2: Setting the UV protection pickup voltage value, the pickup voltage value can be between 1KV ~ 42KV.

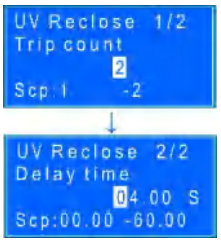
Step 3: Setting the UV delay time, the delay time can be between 0S ~ 99.99S.

Note: Press [↓] key to switch to next screen, press the [+] and [-] keys to modify the corresponding value.

The operational processes of undervoltage element setting

Undervoltage reclosing element (AR UV)

Select **UV Reclose** in "Set+/Set-" menu press "Enter" key to enter, operational processes as shown below:

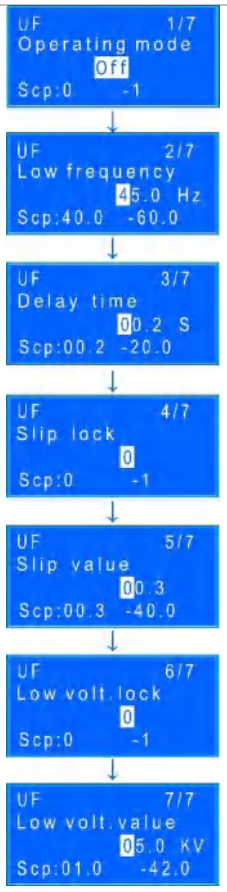
<table>
<tr>
<td> 
</td>
<td>Step 1: Setting the trip count (1: One, 2: Two).

Step 2: Setting the delay time, the delay time can be between 0S ~ 60S.

Note: Press [↓] key to switch to next screen, press the [+] and [-] keys to modify the corresponding value.</td>
</tr>
<tr>
<td colspan="2">The operational processes of UV reclose setting</td>
</tr>
</table>

Underfrequency element (UF)

Select **UF** in "Set+/Set-" menu press "Enter" key to enter, operational processes as shown below:

<table>
<tr>
<td> 
</td>
<td>Step 1: Setting the UF operating mode (0: Off, 1: On).

Step 1: Setting the low frequency, the low frequency can be between 40Hz~60Hz.

Step 3: Setting the delay time, the delay time can be between 0.2S ~ 20S.

Step 4: Setting the slip lock, the slip lock can be between 0 ~1 (0: Disable, 1: Enable).

Step 5: Setting the slip value, the slip value can be between 0.3 ~40.

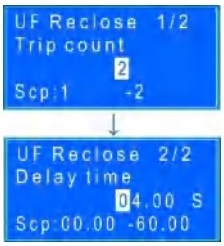
Step 6: Setting the low voltage lock value, low voltage lock value can be between 0 ~1 (0: Disable, 1: Enable).

Step 7: Setting the low voltage value, low voltage value can be between 1KV~42KV.

Note: Press [↓] key to switch to next screen, press the [+] and [-] keys to modify the corresponding value.</td>
</tr>
<tr>
<td colspan="2">The operational processes of underfrequency protection setting</td>
</tr>
</table>

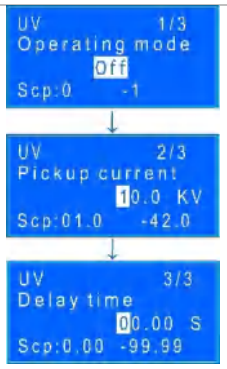
Underfrequency reclosing element (AR UF)

Select **UF Reclose** in "Set+/Set-" menu press "Enter" key to enter, operational processes as shown below:

	Step 1: Setting the trip count (1: One, 2: Two). Step 2: Setting the delay time, the delay time can be between 0S ~ 60S. Note: Press [↓] key to switch to next screen, press the [+] and [-] keys to modify the corresponding value.
The operational processes of UF reclose setting	

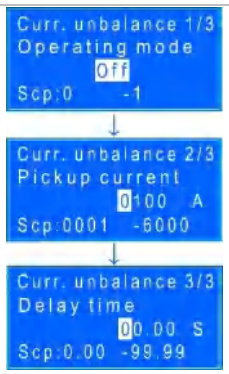
Voltage unbalance element (VU)

Select **Volt. unbalance** in "Set+/Set-" menu press "Enter" key to enter, operational processes as shown below:

	Step 1: Setting the VU operating mode (0: Off, 1: On). Step 2: Setting the VU protection pickup voltage value, the pickup voltage value can be between 1KV ~ 42KV. Step 3: Setting the UV delay time, the delay time can be between 0S ~ 99.99S. Note: Press [↓] key to switch to next screen, press the [+] and [-] keys to modify the corresponding value.
The operational processes of voltage unbalance element setting	

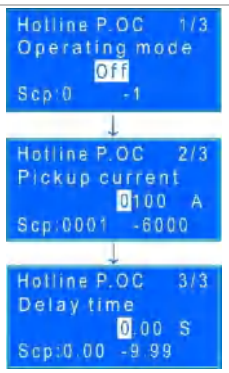
Current unbalance element (CU)

Select **Curr. unbalance** in "Set+/Set-" menu, press "Enter" key to enter, operational processes as shown below:

	Step 1: Setting the CU operating mode (0: Off, 1: Trip, 2: Alarm). Step 2: Setting the CU protection current value, the current value can be between 1A ~ 6000A. Step 3: Setting the CU delay time, the delay time can be between 0S ~ 99.99S. Note: Press [↓] key to switch to next screen, press the [+] and [-] keys to modify the corresponding value.
The operational processes of current unbalance protection setting	

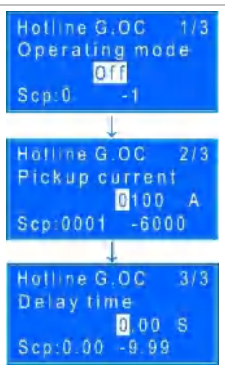
Hotline P.OC

Select **Hotline P.OC** in "Set+/Set-" menu, press "Enter" key to enter, operational processes as shown below:

	Step 1: Setting the hotline P.OC operating mode (0: Off, 1: Trip, 2: Alarm). Step 2: Setting the hotline P.OC protection current value, the current value can be between 1A ~ 6000A. Step 3: Setting the hotline P.OC delay time, the delay time can be between 0S ~ 9.99S. Note: Press [↓] key to switch to next screen, press the [+] and [-] keys to modify the corresponding value.
The operational processes of hotline P.OC protection setting	

Hotline G.OC

Select **Hotline G.OC** in "Set+/Set-" menu, press "Enter" key to enter, operational processes as shown below:

	Step 1: Setting the hotline G.OC operating mode (0: Off, 1: Trip, 2: Alarm). Step 2: Setting the hotline G.OC protection current value, the current value can be between 1A ~ 6000A. Step 3: Setting the hotline G.OC delay time, the delay time can be between 0S ~ 9.99S. Note: Press [↓] key to switch to next screen, press the [+] and [-] keys to modify the corresponding value.
The operational processes of hotline G.OC protection setting	

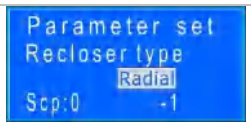
4.9 Save parameter

	After setting, press "ESC" key to exit, if modified below figure will show. If you need to save press "Enter" key and input password, otherwise press "ESC" key.
	If you want to save, press the "Enter" key, and you need to enter the correct password to save.
	This interface appears, indicating that the saving is successful.
	If the password is error, this interface will appear.

4.10 System set

Press the **SET → System**, enter the "parameter set". **If it is not necessary, all parameters in the para menu cannot be changed.**

Recloser type

	0: Radial 1: Ring

CT, PT and PTS rate set

	CT rate is the measuring three phase current rate. The value of CT ratio is equal to the primary side current value divided by the secondary side current value.
	PT rate is the measuring voltage rate. The value of PT ratio is equal to the primary side voltage value divided by the secondary side voltage value.
	PTS rate is the power voltage rate. The value of PTS ratio is equal to the primary side voltage value divided by the secondary side voltage value.

Note:
1 Different current transformer, CT ratio becomes different.
2 Different voltage transformer, PT ratio becomes different.
3 Different PT power voltage transformer, PTS ratio becomes different.

Close and trip pulse time set

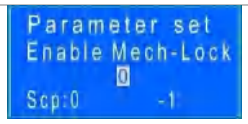
	"Close pulse time" is the discharge time for close coil.
	"Trip pulse time" is the discharge time for trip coil.

Note: Please do not modify the trip and close pulse time, if in doubt, please contact supplier.

Reclose lock reset time

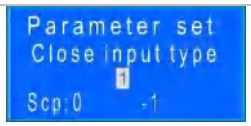
	Locking time after the first closing.

Mechanical locking

	Enabling mechanical locking requires corresponding binary input. The circuit breaker is used for manual interlocking.
	Mechanical locking time, beyond which it will be locked.

Note: Please do not modify these values, if in doubt, please contact supplier.

Other parameters

	Identification time of binary input. Please do not modify this time, if in doubt, please contact supplier.
	The waiting time after pressing the opening or closing button on the panel. When the time is up, the opening or closing will occur.
	This is used when the switch position signal is connected reversely.

4.11 Communication

Press the **SET** → **Communication**, enter to the communication set menu.

<table>
<tr>
<td> 
</td>
<td>There are 3 communication channels in total here. Enter the corresponding channels and set the corresponding settings. The channel settings are as follows. There is also a common setting.

Note: Press [↓] key to choose the port which you need to set, press the[Enter] to Enter the menu, press [+] and [-] keys to modified communication value.</td>
</tr>
<tr>
<td> 
</td>
<td>Step 1: Enable this channel
0: Close this channel
1: Open this channel

Step 2: Set the baud rate of this channel (Default 9600).

Step 3: Select the communication protocol for this channel
1: IEC60870-5-101
2: IEC60870-5-104
3: DNP3.0
4: MODBUS

Step 4: Choose whether IEC60870-5-101 protocol is balanced.
0: Unbalanced
1: Balance

Step 5: Set up device address or source address.

Step 6: Set up destination address (DNP3.0 needs to be set).

Step 7: Enable active upload (For 101 and 104 protocols).
0: Do not upload actively
1: Active upload

Step 8: Enable the active upload of signaling (For 101 and 104 protocols).

Step 9: How often is the signal uploaded.

Step 10: Enable the active upload of meter (For 101 and 104 protocols).

Step 11: How often is the meter uploaded.

Note: The settings of the three channels are the same.</td>
</tr>
</table>

Communication common settings are as follows:

Name	Setting range	Step length	Description
Signal type	1 ~ 2	1	1: Single point 2: Double point
Control type	1 ~ 2	1	1: Single point 2: Double point
Meter type	1 ~ 4	1	1: Normalized telemetry 2: Normalized telemetry without quality 3: Standardized telemetry 4: Short floating point telemetry
Address len	1 ~ 2	1	Address length 1: 1 byte 2: 2 byte
COT len	1 ~ 2	1	COT length 1: 1 byte 2: 2 byte
I factor	0.01 ~ 100	0.01	Phase current multiplier
I deadband	0.1 ~ 1000	0.1	Phase current dead zone
I0 factor	0.01 ~ 100	0.01	Zero sequence current multiplier
I0 deadband	0.1 ~ 1000	0.1	Zero sequence current dead zone
U factor	0.01 ~ 100	0.01	Line voltage multiplier
U deadband	0.1 ~ 1000	0.1	Line voltage dead zone
U0 factor	0.01 ~ 100	0.01	Zero sequence voltage multiplier
U0 deadband	0.1 ~ 1000	0.1	Zero sequence voltage dead zone
P factor	0.01 ~ 100	0.01	Power multiplier
P deadband	1 ~ 10000	1	Power dead zone
COS factor	0.01 ~ 100	0.01	COS multiplier
COS deadband	0.01 ~ 1	0.01	COS dead zone
OTH factor	0.01 ~ 100	0.01	Other multiplier
OTH deadband	0.01 ~ 1	0.01	Other dead zone
CLASSA	0 ~ 3	1	Class for analog event data
CLASSB	0 ~ 3	1	Class for digital event data
Select Timeout	0 ~ 30	0.1	Select/operate time-out
Confirm Link	0 ~ 1	1	Enable confirm data link (For 101 and 104 protocols)
Link Retry Times	0 ~ 15	1	Data link retries times
Link Timeout	0 ~ 50	0.1	Seconds to data link time-out
Upload Confirm	0 ~ 1	1	Enable upload confirmation (For DNP3.0 protocols)
Upload Timeout	0 ~ 50	0.1	Seconds to upload time-out
Upload Retry Times	2 ~ 10	1	Upload retries times
Auto Refresh	0 ~ 1	1	Enable automatic reset of events
Refresh time	0 ~ 65535	1	Seconds to automatic reset event

4.12 Auto switch group

Press the **SET** → **Auto Group**, enter to the auto switch group set menu. Automatic switchover can be set in this menu, which can be switched to summer workday group, summer rest day group, winter workday group and winter rest day group. You can also set the start and end time of summer and the start and end time of rest days. Automatic group switching is based on time.

4.13 Measure Adjust

Select the **SET** → **Measure Adjust**, press "Enter" key to enter the "Measure Adjust" submenu, press the [+] and [-] keys to correct the value of current and voltage.

Note: All voltage and current values in the factory have been corrected before. Please do not change the parameter values which, if in doubt, please contact supplier.

4.14 Clear

Select the **CTRL** submenu, press "Enter" key to enter the **CTRL** submenu. The stored data can be cleared here. The contents include event records, energy, and counters.

Press "↑" and "↓" keys to switch, select the option to be cleared and press the "Enter" key to enter the correct password.

4.15 Password set

Select the **CTRL**→ **Password**, press "Enter" key to enter the **Password** submenu.

	The system initial password is "0099", the password for the user to modify from the "0000" ~ "9999", when revised press "Enter" key to confirm, enter the password before the modification. The system password can be used in all occasions.
	The protection initial password is "0099", the password for the user to modify from the "0000" ~ "9999", when revised press "Enter" key to confirm, enter the system password. The protection password can only be used to set protection settings.

4.16 View input signal

Enter the main menu select the "VIEW" option press "Enter" key to enter, and then select the "Input" option press "Enter" key to enter the "Input" submenu, you can view the state of input signal.

The input signal includes: Power fault, Active battery, Heavy gas, High temperature, Breaker open, Breaker close, Remote open, Remote close, Door open, Lockout in, Remote enable. 0 to 1 represents binary input.

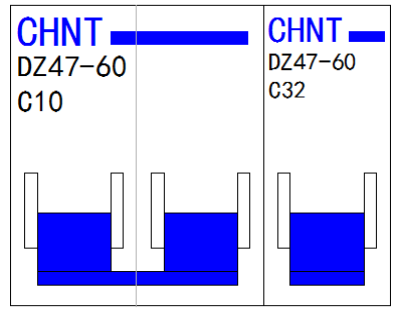
Chapter 5: Peripheral Accessories

5.1 RF remote controller

	Function of each key A:Close B:Trip C:Unlock D:Reset

Note:
1. In order to prevent misuse, press the unlock button for 3 seconds, before execution of the closing operation.
2. The effective distance of RF remote controller is 30 meters.

5.2 Features and the use of external sockets and switches



PT power switch Backup switch

Note1: Before using the controller, ensure the battery charge enough for 24 hours.

Note2: About using these switches

- Turn on the backup switch when using battery power, turn on the PT power switch when using external PT power (PT voltage depends on the standard at the time of order).

NOTE: If the controller is not used temporarily, be sure to turn off the two switches. When charging is needed, connect the power from the outside and turn on the two switches at the same time.

5.3 The main secondary component parts

	
Cable plug, connect the controller and circuit breakers	Surge protector

Note: For security norms, Surge protector has to be grounded (green line) to the earth.

5.4 Capacitor (Used by permanent recloser)

	1 Temperature range: -25°C~+105°C. 2 Rated voltage: DC250V. 3 Capacity: Choose according to demand . 4 Rated ripple current: 34.7Arms.

Note: The following operation will cause self-heating of the capacitor that can result in leaking electrolyte outside the seal area. worst of all, perhaps there will be burst or spark that can lead the capacitor to spontaneous combustion.

1. Inverse voltage.

2. Overvoltage (over rated voltage).

3. Exceeding the rated ripple current.

4. Violently charge/discharge.

5.5 Battery

- RWK-65 stand-by battery adopts two 9AH lead-acid free of maintenance batteries, the average battery life exceeds 3 years.
- **If the controller is idle, be sure to charge it every two months. Turn on the power switch and battery switch when charging!**

Chapter 6: Installation and Maintenance

Danger: The dangerous voltage with the device maybe result in the permanent damage of equipment or personnel casualty during installing RWK-35. These voltages mainly distributes at terminal bar of device and circuits of AC current input, AC voltage input, digital input, IGBT output and operation power supply., etc. This device's installation, debugging and maintenance can only be operated by technical staff who has been authorized and trained strictly.

6.1 Installation

☆ See the Quick Reference Guide for details!

6.2 Maintenance

- If the device is not used, it should be kept in dry and ventilated places indoors, and charged **once every three months**, the charging time should be more than 24 hours. Before the device is used, the charging time should not be less than 24 hours. Replace the storage battery each three years.

- This device has storage battery management module, which will automatically cut off the storage battery output circuit when the storage battery voltage is on the low side. You should check the storage battery each year, please replace the storage battery immediately when single storage battery voltage id lower than DC12V.

- About "para" menu, before leaving the factory, CT / PT / close pulse time / open pulse time have already been set. Under normal circumstances, do not modify them without authorization. PTs is the transformation ratio of voltage transformer, please modify it according to the actual situation, such as 10kV / 0.22kv voltage transformer, PTs shall be set to 45.

- Please firstly make sure the first system is power off before the device is maintained, forbid inserting or pulling out aeronautical connector under power, thus avoid CT short circuit happening.

Chapter 7: Others

7.1 Decommission

Shut-down Power Supply

Shut-down Device Power Supply: Turn off external power supply switch of the device.

Disconnect All Power Cables

Disconnect all power cables connected to the device.

Danger: Before disconnecting all power cables connected to the device power module, it must confirm that the external power switch is turned off to avoid danger.

Danger: Disconnecting all power cables connected to the device alternating current module, it must confirm that the equipment corresponding to input alternating component has stopped operation to avoid danger.

Dismantle from Display Cabinet

When the above steps are completed, loosen the fix screws and dismantle the device from the display cabinet.

Danger: When neighboring equipment is in operation, it must strictly confirm the safety distance between the dismantled device and other device in operation and unskilled professional shall take particular caution.

7.2 Disposal

When dispose decommissioned device, please follow relevant regulations of the country where the product is used for the disposal of scrapped electronic products.

Caution: It must strictly adhere to relevant regulations of the country where the product is used for the disposal of scrapped electronic products.

7.3 Parts Attached with the Device

Name	Quantity	Collocation	Usage or Description
User Manual	1	Standard	Please read it carefully before use the device
Software manual	1	Standard	Special introduction to the use of operating software
Quick Reference Guide	1	Standard	For users to quickly understand the product
Hand-held telecontroller	1	Selectable	Telecontrol the close and trip of switch within 30 meters
USB drive	1	Standard	Testing debugging software
Control Cable	According to function	Standard	