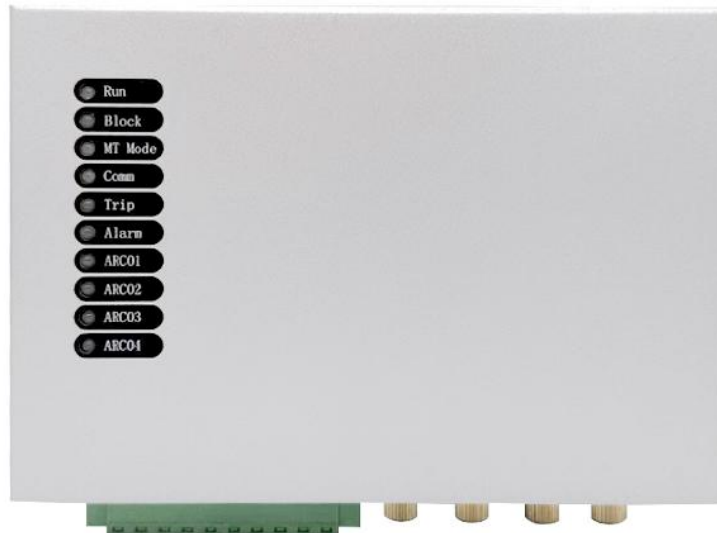


AFR-4

Arc Flash Protection Relay

User Manual



Version: 1.10

Revision: 2024.10

Read me

When you use AFR-4, be sure to read this user manual carefully, and be able to fully understand the implications, the correct guidance of operations in accordance with user manual, which will help you make better use of arc protection device, and help to solve the various problems at the scene.

1. This product must be earthed reliably.
2. Do not drop this product during installation to avoid damage to this product.
3. The terminal blocks must be connected firmly to avoid serious consequences caused by dropping.
4. Please do not plug or unplug the circuit board during the normal operation of this product; otherwise, the data of this product will be lost and the product may not operate normally.
5. The rated value is not changed randomly and it can be only changed by relevant professionals.
6. When installing, please install this product according to the terminal definition, and do not wire randomly.
7. After installation and energizing, do not touch the exposed terminals and the bare parts of the power supply and do not place this product in a damp area to avoid leakage and short circuit at the terminals.



- **Please read this user manual carefully**
- **Please save this document**

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1.- SUMMARIZE

AFR-4 is a versatile and independently operating device for bay based protection. It supports 4-channels arc signal detection and can configuration multiple arc tripping modes, ensuring accurate and fast fault isolation. With a fast relay output speed up to 5ms, AFR-4 can minimize or completely eliminate arc flash damage, improving system safety and reliability. It can be used in various arc protection applications in low or medium voltage power distribution system.

AFR-4 also provides flash warning and dual criteria tripping mechanism (arc detection + current), providing a comprehensive solution for arc flash protection. Integrated RS485/Modbus communication enables seamless remote monitoring and control, which is ideal for modern power systems.

FEATURES

- ≤5ms fast relay tripping;
- Regional arc light detection
- Multiple combined tripping modes;
- Circuit breaker failure protection;
- 4 channels of arc light signals detection;
- Dual criteria for arc detection and overcurrent detection;
- Integrated /RS485 MODBUS communication protocol;
- Support ST visible light and ST ultraviolet sensor access.

APPLICATIONS

- Power substations;
- Box-type substations;
- Water conservancy projects;
- Electrical switchgear for thermal power plants;
- Switchgear for wind farms and photovoltaic stations;
- Large-scale municipal engineering projects.

2.- DIP SWITCH FUNCTION DESCRIPTION

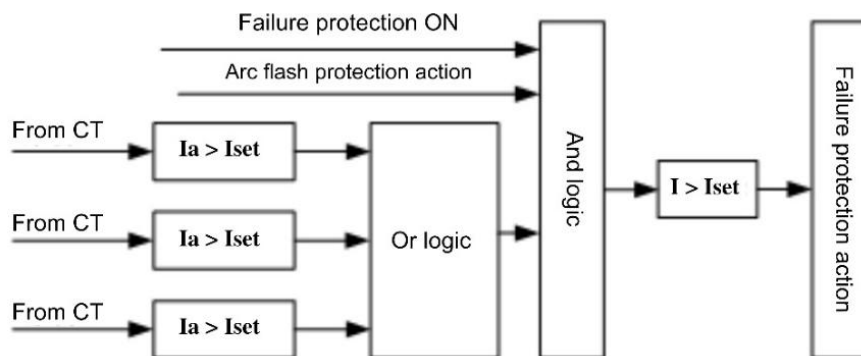
2.1.- Arc flash protection mode setting

Arc protection function can be set by the ON/OFF DIP switch. It can be set to Mode 1, Mode 2, or MT mode. Detail see followings:

SW01	Mode	0-M1/1-M2
SW02	MT Mode	0-OFF/1-ON
SW03	Alarm	0-OFF/1-ON
SW04	$I > I_{set}$	0-OFF/1-ON
SW05	ARC01	0-OFF/1-ON
SW06	ARC02	0-OFF/1-ON
SW07	ARC03	0-OFF/1-ON
SW08	ARC04	0-OFF/1-ON

2.1.1.- Mode 1: Linkage mode - ON/OFF by SW01

Applied to single switchgear protection. When any channel arc sensor detects arc signal, arc protection device quickly trips FT, Trip1, Trip2. When the current criterion is turn on and the arc protection is activated, if there is still exist current in any phase, after a delay time (the circuit breaker is damaged and cannot trip), then trip Trip3.Trip4. Current default value is 1A, and default delay time is 300ms. Users can adjust according to needs.



2.1.2.- Mode 2: Independent mode - ON/OFF by SW01

Applied to multiple switchgear protection. the arc sensor corresponds to the trip output one by one. When ARC01 sensor detects arc signal, then trips Trip1. When ARC02 sensor detects arc signal, then trips Trip2. when ARC03 sensor detects arc signal, then trips Trip3. when ARC04 sensor detects arc signal, then trips Trip4.

2.1.3.- MT (master trip) mode - ON/OFF by SW02

Applied to regional logic control of entire busbar section. each switchgear in a busbar section needs to be installed with an arc protection device.

ARC01: Installed in Busbar room

ARC02: Installed in CB room 1

ARC03: Installed in CB room 2

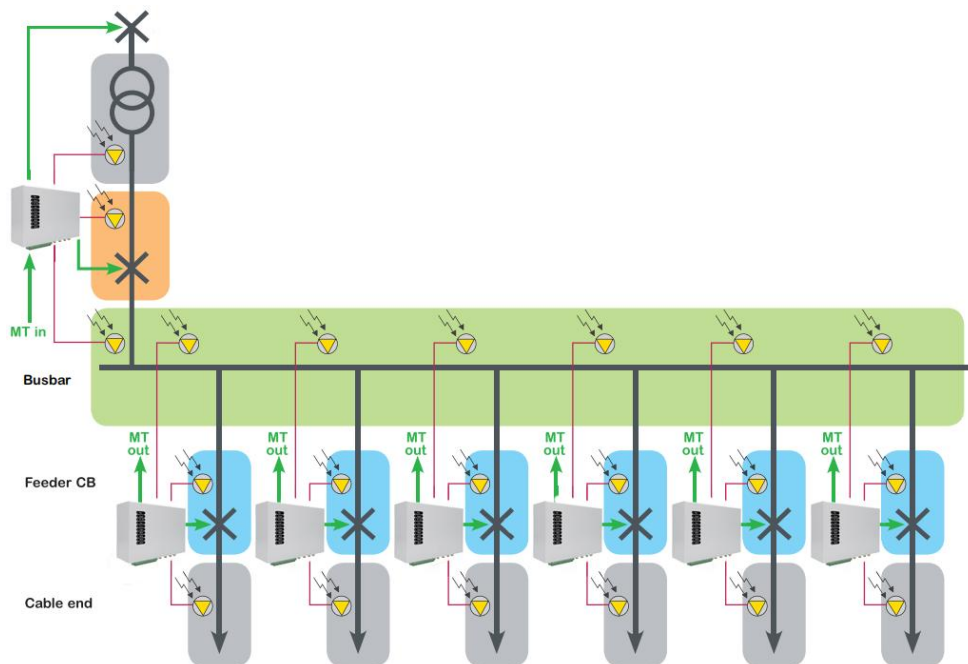
ARC04: Installed in Cable room

When any of ARC01 or ARC02 detects arc signal, then trips MT out, Trip3, Trip4.

When any of ARC03 or ARC04 detects arc signal, then trips FT, Trip1, Trip2.

MT out can be connected to MT in. And MT comm can collect slave data in real time. The devices are connected through shielded cables, and a maximum of 32 devices can be connected.

The zone tripping function can be completed through the mutual cooperation between the host and the slave devices. Users can choose the action mode and system networking according to needs.



Note: When MT mode is enabled, both mode 1 and mode are invalid.

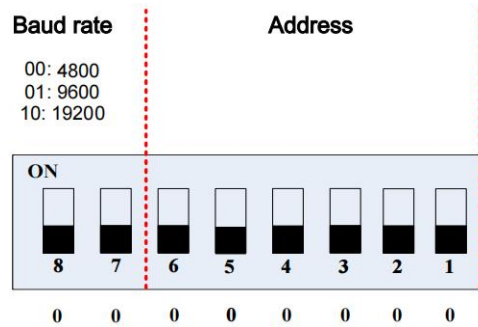
2.2.- ARC Alarm function setting

SW-03 switch can turn on/off arc alarm function. When the function enabled, the arc signal occurs or the current exceeds the set value, then trip the alarm signal output.

2.3.- ADD setting

Used to set communication:

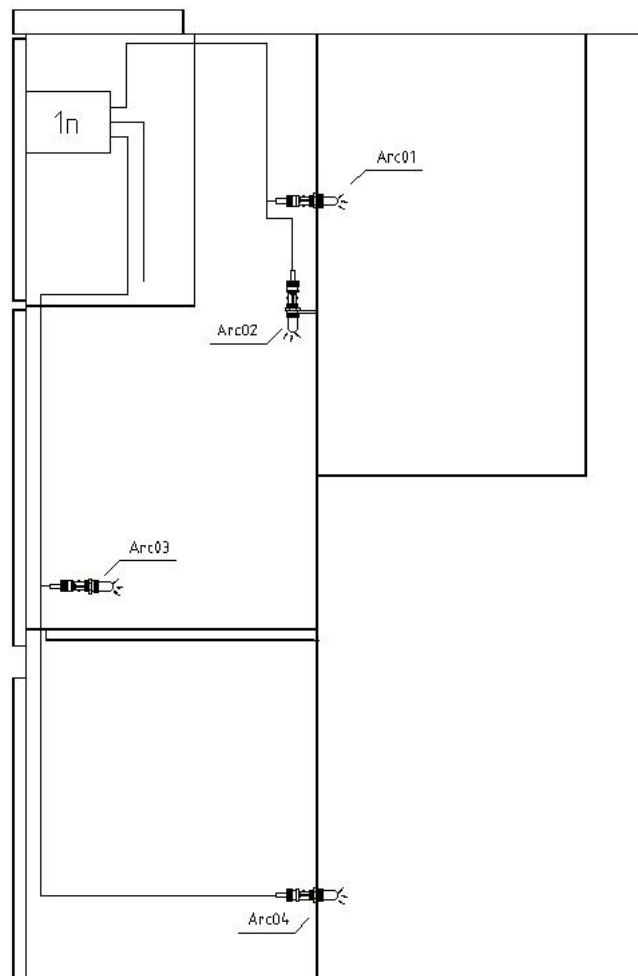
- 1-2 bits used to set the baud rate
- 3-8 bits used to set communication address
- ON direction means set to "1".



2.4.- Arc sensor introduction

Arc sensors are light sensing elements that detect arcs. When no arc fault occurs, the light intensity increases greatly, and the arc sensor converts the optical signal into an electrical signal and sends it to the arc protection or arc extension unit. Arc sensor wiring has no polarity.

Arc sensors are installed in relevant parts of the switchgear, such as the busbar compartment in the switchgear, CT and PT components in the lower part of the switchgear, circuit breaker contacts, cable connectors, etc.



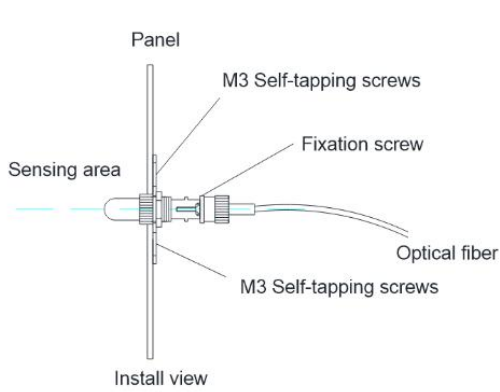
At present, there are three main types of arc light probes in the market: arc light probes, white light arc light sensing probes and ultraviolet arc light sensing probes. Among them, the ultraviolet arc light sensor has the strongest photosensitive ability, and is also the most effective in sensing arc ultraviolet light inside the switchgear. No interference and influence on visible light.

The ultraviolet arc light sensor is designed for arc light spectral characteristics, using special optical materials, polymer blending and doping technology, and optical lens technology. It can filter out the arc light detection sensor probe that interferes with visible light. The ultraviolet arc light probe can quickly detect the arc light that occurs within a range of more than 240 degrees, and

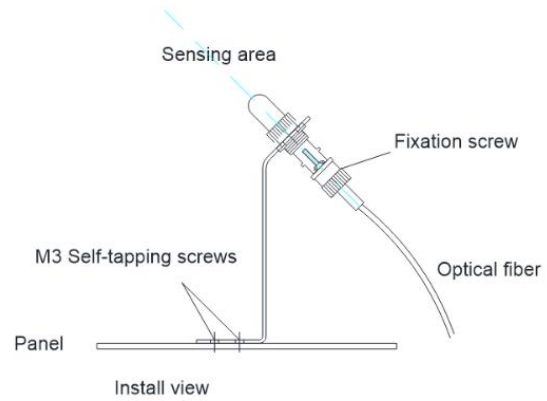
transmit it to the control equipment through the optical fiber, so as to quickly cut off the fault at the millisecond level and avoid serious consequences.



Arc light sensor external shape and hole size (Unit: mm)

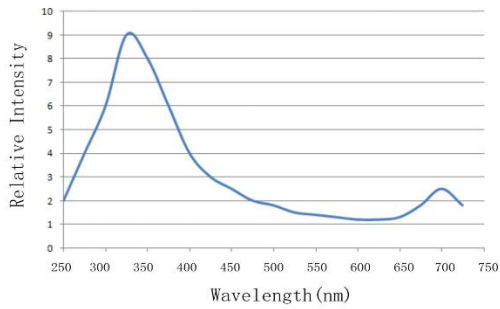


Notes: Suggest open hole 2.8mm diameter on switchgear panel for M3 screw

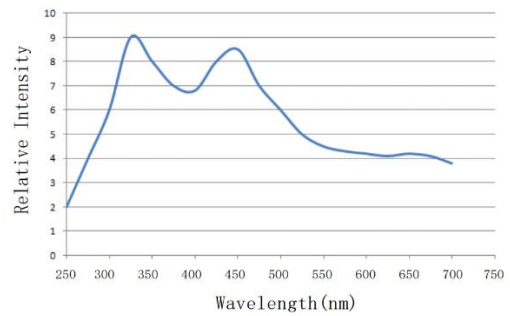


Notes: Suggest open hole 2.8mm diameter on switchgear panel for M3 screw

Sensor installation diagram



UV spectral response curve



Visible light spectrum response curve

Arc sensor parameter comparison:

Sensor type	Visible light sensor	UV light sensor
Sensitivity type	Full spectrum	UV spectrum
Spectral response bandwidth	250nm ~ 550nm	280nm ~ 400nm
Monitoring angle	-120°~ 120°	-120°~ 120°
Angle decay rate	≤20%	≤10%
Operating temperature	-30~70°C	-40~85°C
Interface type	ST fiber optic/screw fixing	ST optical fiber
Optical fiber length	5/10/15 meters	5/10/15 meters

3.- SPECIFICATION

Working power supply

Power supply	AC/DC 85~265V
Power consumption	≤8W

Current input

Rated current value	5A/1A
Measuring range	Protection current: 0.6~6In
Error	≤4%

Arc signal input

Number of channels	4 channels
Sensor type	ST optical fiber type
Detection light type	Visible/ UV optional
Spectrum	280-550nm
Optical threshold	8000 lux (±20%)
Optical fiber	5m/10m/15m

Action time

Fast relay output	≤5ms
Pure arc trip	≤8ms
Current+ arc trip	≤15ms

Relay output

Quantity	6 trip output
Operating Voltage	AC250V/5A
Input	Passive contact, photoelectric isolation, isolation voltage 2500V
Mechanical life	≥10000 times

Communication Interface

Communication Interface	1 Channel, photoelectric isolation, with lightning protection
Baud rate	4800, 9600bps (default 9600), 19200
Communication protocol	Modbus RTU

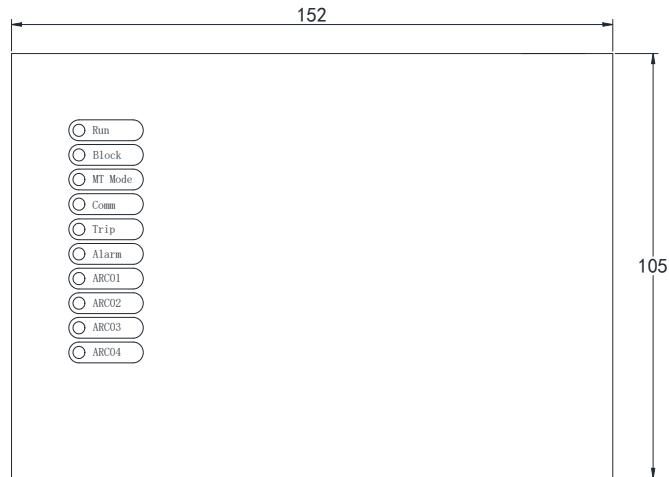
Environment

Working temperature	-10 ~ +55°C
Storage temperature	-25 ~ +70°C
Humidity	5~95%RH
Atmospheric pressure	60kPa~106kPa

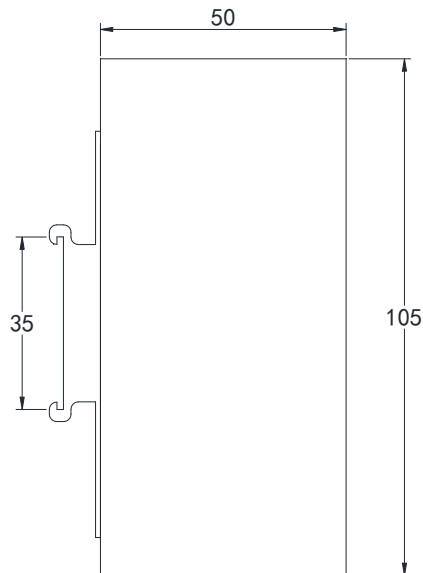
4.- INSTALLATION

4.1.- Dimension:

W*H*D: 152*105*50mm, Din-rail mount: 35mm

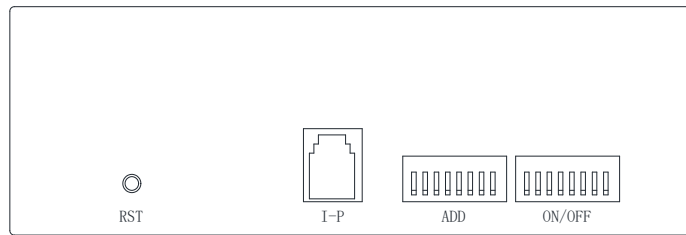


Front view

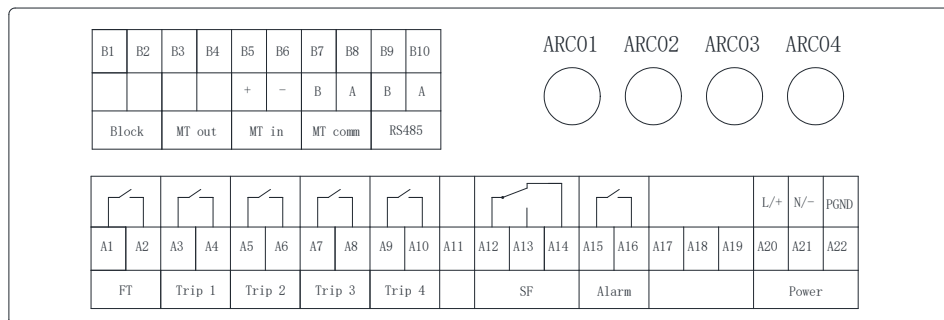


Side view

4.2.- Terminal definition



Marked	Notes
RST	Reset the device
I-P	Current measuring interface
ADD	Communication setting
ON/OFF	Arc protection function setting



No.	Marked	Notes
B1-B2	Block	External block input , for device maintenance
B3-B4	MT out	Master trip output
B5-B6	MT in	External master trip input
B7-B8	MT comm	Master trip communication
B9-B10	RS485 A,B	Device communication interface
ARC 01-04	ARC 01-04	Arc sensor channel 01-04
A1-A2	FT	Fast trip relay (HSO type)
A3-A4 A5-A6 A7-A8 A9-A10	Trip 1-4	Arc trip relay 1-4
A11	Reserve	
A12-A14	SF	Device self-test
A15-A16	Alarm	Arc alarm output
A17-A19	Reserve	
A20-A22	Power	Power supply +/-, ground wire

4.3.- Indicator description

<input type="radio"/> Run	Device running normally, and flashes once per second.
<input type="radio"/> Block	External block input, the arc protection function is turned off.
<input type="radio"/> MT Mode	Device is in MT (master trip) mode.
<input type="radio"/> Comm	Device is communicating.
<input type="radio"/> Trip	Arc trip relay action.
<input type="radio"/> Alarm	Device self-test abnormality/ Arc alarm action.
<input type="radio"/> ARC01	Arc sensor 1 connection.
<input type="radio"/> ARC02	Arc sensor 2 connection.
<input type="radio"/> ARC03	Arc sensor 3 connection.
<input type="radio"/> ARC04	Arc sensor 4 connection.

Notes:

- **“Run”** indicator flashes once per second. If the light is constantly on, means that the program is stuck during the operation. user can try shutting down and restarting.
- **“Alarm”** indicator stays on for the first time, it means that the device has a self-test abnormality. user can through host computer to inquiry the reason for abnormality. If the device set arc alarm output, the indicator light will also light up. user can press the reset button to reset.
- **“Trip”** indicator light is constantly on, means that the arc protection output a trip signal, and an arc action has occurred. After the action occurs, it is necessary to inspect the switchgear to determine whether there is combustion or damage. After confirming that there are no abnormalities, press reset button to reset the device. After resetting, can close circuit breaker again.

5.- COMMUNICATION INTERFACE

5.1.- MODBUS © Protocol

Modbus RTU Frame Format:

Address code	1 BYTE	Slave device address 1-255
Function code	1 BYTE	Indicates function codes like read coils / inputs
Data code	4 BYTE	Starting address, high byte Starting address, low byte Number of registers, high byte Number of registers, low byte
Error Check code	2 BYTE	Cyclical Redundancy Check (CRC)

Modbus Functions:

Code	Meaning	Description
FUNCTION 02	Read discrete inputs	Read the digital input status of device bit by bit
FUNCTION 03	Read input registers	Read the analog quantity of the device
FUNCTION 04	Read input registers	Read parameters and settings value of device
FUNCTION 05	Write single coil	Control CB ON/OFF and function selection
FUNCTION 06	Write single register	Writes a value into a single holding register.
FUNCTION 10	Write multiple register	Modify parameters and set values
FUNCTION 13	Write single register	Restore factory settings

Notes:

- The transmission mode of the device is RTU (remote terminal unit) mode, and the information transmission is asynchronous.
- Communication method: support RS485 communication method.
- Baud rate: 4800/9600. Default is 9600.
- Start bit=1, data bit=8, stop bit=1, parity bit=none.
- This protocol adopts the standard calculation method of MODBUS RTU CRC16, and the verification sequence is (low-high).
- Physical address setting range: 1~255.

5.2.- Register Map

5.2.1.- Read DI signal, Read only, “02H” code to read

Addr.	Bit	Data
00 00	0	General act signal
	1	General alarm signal
	2	Maintain arc
	3	MT out
	4	MT in
	5	ARC 01
	6	ARC 02
	7	ARC 03
00 01	0	ARC 04
	1	HSO output(Fast relay output)
	2	Trip 1
	3	Trip 2
	4	Trip 3
	5	Trip 4
	6	Self-test abnormality
	7	Arc alarm output
00 02	0	Communication status
	1	Overcurrent alarm
	2	
	3	
	4	
	5	
	6	
	7	
00 03	0	Mode 1/ mode 2
	1	MT mode
	2	Arc alarm ON
	3	Current criterion
	4	ARC 01 ON
	5	ARC 02 ON
	6	ARC 03 ON
	7	ARC 04 ON

- Command format:

Host inquiry:

Data Format	Data	Description
Address	01H	Device address: 1-99
Function code	02H	Read DI signal
Starting register H	00H	Starting register high byte
Starting register L	00H	Starting register low byte
DI signal quantity	00H XXH	DI signal quantity
CRC L	XXH	CRC check code high byte
CRC H	XXH	CRC check code low byte

Slave response:

Data Format	Data	Description
Address	01H	Device address:1-99
Function code	02H	Read DI signal
Data length	N	Total data length
Data range	-	-
CRC_L	XXH	CRC check code low byte
CRC_H	XXH	CRC check code high byte

Note: $N = \text{input quantity}/8$, if the remainder is not equal to 0, then $N = N + 1$

- Command example

1. Read DI Signal

Host inquiry:

01 02 00 00 00 40 79 FA

Slave response:

01 02 08 00 00 02 01 03 00 00 00 F8 74

5.2.2.- Parameter query, Read only, “03H” code to read

Parameter list:

Addr.	Type	Byte	Description
01 00	INT	2	Device communication address, Default:1
01 01	INT	2	Communication serial port 1 baud rate setting: 4800,9600, Default:9600
01 02	INT	2	Communication serial port 2 baud rate setting: 4800,9600, Default:9600
01 03	INT	2	Arc judgment delay, range: 0.001-0.05s, Default:0.01s
01 04	INT	2	Protection current setting value: 0.05A-40.00A, Default:10A
01 05	INT	2	Circuit breaker failure protection current value: 0.05A-40.00A, Default:1A
01 06	INT	2	Circuit breaker failure protection delay time setting value: 0.01s-10.00s, Default:0.30S

-. Command format:

Host inquiry:

Data Format	Data	Description
Address	01H	Device address: 1-99
Function code	03H	Read input registers
Starting register H	01H	Starting register high byte
Starting register L	00H	Starting register low byte
Data length	N	Inquiry length high byte
CRC_L	XXH	CRC check code low byte
CRC_H	XXH	CRC check code high byte

Slave response:

Data Format	Data	Description
Address	01H	Device address
Function code	03H	Read input registers
Data length	N	Total data length
Data range	N*2	Data range
CRC_L	XXH	CRC check code low byte
CRC_H	XXH	CRC check code high byte

Note: “N” represents register numbers, and the communication address supports FF inquiry.

- Command example

1. Read parameters

Host inquiry:

01 03 01 00 00 07 05 F4

Slave response:

01 03 0E 00 01 25 80 25 80 00 01 01 2C 00 64 00 1E F8 59

2. Read device address

Host inquiry:

FF 03 01 00 00 01 90 28

Slave response:

FF 03 02 00 02 10 51

5.2.3.- Basic parameter, Read only, “04H” code to read

Addr.	Data	Type	Byte	Description
00 00	Ia	INT	2	Protection current secondary value, unit: 0.01A
00 01	Ib	INT	2	Protection current secondary value, unit: 0.01A
00 02	Ic	INT	2	Protection current secondary value, unit: 0.01A

-. Command format:

Host inquiry:

Data Format	Data	Description
Address	01H	Device address: 1-99
Function code	04H	Read input registers
Starting register H	00H	Starting register high byte
Starting register L	00H	Starting register low byte
Data length	N	Data length
CRC_L	XXH	CRC check code low byte
CRC_H	XXH	CRC check code high byte

Slave response:

Data Format	Data	Description
Address	01H	Device address
Function code	04H	Read input registers
Data length	2*N	Total data length
Byte length	N*2	Number of bytes
CRC_L	XXH	CRC check code low byte
CRC_H	XXH	CRC check code high byte

Note: "N" represents the number of registers

-. Command example:

1. Integer type

Host inquiry:

01 04 00 80 00 03 B1 E3

Slave response:

01 04 06 01 2C 01 2C 01 2C 30 FC

5.2.4.- DO control, write only, “05H” code to write**-. Command example****1. DO 1 action: MT out**

Host inquiry: 01 05 00 01 FF 00 DD FA

Slave response: 01 05 00 01 FF 00 DD FA

2. DO 2 action: HSO Fast trip output

Host inquiry: 01 05 00 02 FF 00 2D FA

Slave response: 01 05 00 02 FF 00 2D FA

3. DO 3 action: Trip 1

Host inquiry: 01 05 01 01 FF 00 DC 06

Slave response: 01 05 01 01 FF 00 DC 06

4. DO 4 action: Trip 2

Host inquiry: 01 05 01 02 FF 00 2C 06

Slave response: 01 05 01 02 FF 00 2C 06

5. DO 5 action: Trip 3

Host inquiry: 01 05 02 01 FF 00 DC 42

Slave response: 01 05 02 01 FF 00 DC 42

6. DO 6 action: Trip 4

Host inquiry: 01 05 02 02 FF 00 2C 42

Slave response: 01 05 02 02 FF 00 2C 42

7. DO 7 action: Self-test output

Host inquiry: 01 05 03 01 FF 00 DD BE

Slave response: 01 05 03 01 FF 00 DD BE

8. DO 7 action: Arc alarm output

Host inquiry: 01 05 03 02 FF 00 2D BE

Slave response: 01 05 03 02 FF 00 2D BE

5.2.5.- DI signal reset, write only, “06H” code to write

- Command format:

Host inquiry:

Data Format	Data	Description
Address	01H	Device address: 1-99
Function code	06H	DI signal reset
Starting register H	00H	Starting register high byte
Starting register L	00H	Starting register low byte
Data length H	00H	Data length high byte
Data length L	00H	Data length low byte
CRC_L	XXH	CRC check code low byte
CRC_H	XXH	CRC check code high byte

Slave response:

Data Format	Data	Description
Address	01H	Device address: 1-99
Function code	06H	DI signal reset
Starting register H	00H	Starting register high byte
Starting register L	00H	Starting register low byte
Data length H	00H	Data length high byte
Data length L	00H	Data length low byte
CRC_L	XXH	CRC check code low byte
CRC_H	XXH	CRC check code high byte

- Command example

1. Device reset

Host inquiry:

01 06 00 00 00 00 89 CA

Slave response:

01 06 00 00 00 00 89 CA

5.2.6.- Parameter modification, Write only, “10H” code to write

Parameter list:

Addr.	Type	Byte	Description
01 00	INT	2	Device communication address, Default:1
01 01	INT	2	Communication serial port 1 baud rate setting: 4800,9600, Default:9600
01 02	INT	2	Communication serial port 2 baud rate setting: 4800,9600, Default:9600
01 03	INT	2	Arc judgment delay, range: 0.001-0.05s, Default:0.01s
01 04	INT	2	Protection current setting value: 0.05A-40.00A, Default:10A
01 05	INT	2	Circuit breaker failure protection current value: 0.05A-40.00A, Default:1A
01 06	INT	2	Circuit breaker failure protection delay time setting value: 0.01s-10.00s, Default:0.30S

-. Command format:

Host inquiry:

Data Format	Data	Description
Address	01H	Device address: 1-99
Function code	10H	Write multiple register
Starting register H	00H	Starting register high byte
Starting register L	00H	Starting register low byte
Data length H	00H	Data length high byte
Data length L	06H	Data length low byte
Total length	2*N	Total length
Byte length	N*2	Number of bytes
CRC_L	XXH	CRC check code low byte
CRC_H	XXH	CRC check code high byte

Slave response:

Data Format	Data	Description
Address	01H	Device address:1-99
Function code	10H	Write multiple register
Starting register H	00H	Starting register high byte
Starting register L	00H	Starting register low byte
Data length H	00H	Data length high byte
Data length L	06H	Data length low byte
CRC_L	XXH	CRC check code low byte
CRC_H	XXH	CRC check code high byte

-. Command example

1. Modify parameters

Host inquiry:

01 10 01 00 00 05 0A 00 01 00 00 25 80 25 80 00 05 01 64

Slave response:

01 10 01 00 00 05 01 F6

5.2.7.- Restore factory settings, Write only, “13H” code to write

-. Command format:

Host inquiry:

Data Format	Data	Description
Address	01H	Device address
Function code	13H	Device time synchronization
Starting register H	00H	Starting register H
Starting register L	00H	Starting register L
Data length H	00H	Data length H
Data length L	00H	Data length L
CRC_L	XXH	CRC check code low byte
CRC_H	XXH	CRC check code high byte

No slave response

-. Command example

Host inquiry:

01 13 00 00 00 00 84 09

No slave response:

After restoring the factory settings, the device restarts and the indicator lights light up alternately.

6.- SAFETY CONSIDERATIONS



All installation specification described at the previous chapters named:
INSTALLATION AND STARTUP, INSTALLATION MODES and SPECIFICATIONS.

Please note that with the instrument powered on, the terminals could be dangerous to touching and cover opening actions or elements removal may allow accessing dangerous parts. This instrument is factory-shipped at proper operation condition.

- ◆ The device must have a professional installation and maintenance.
- ◆ Any operation of the device, you must cut off the input signal and power.

7.- MAINTENANCE

The AFR-4 does not require any special maintenance. No adjustment, maintenance or repairing action should be done when the instrument is open and powered on, should those actions are essential, high-qualified operators must perform them.

Before any adjustment, replacement, maintenance or repairing operation is carried out, the instrument must be disconnected from any power supply source.

When any protection failure is suspected to exist, the instrument must be immediately put out of service. The instrument's design allows a quick replacement in case of any failure.

For any inquiry about the instrument performance or any failure,
contact to Blue Jay's technical service.

Blue Jay - After-sales service

E-mail: tech@cqbluejay.com