

# Grid feeding monitoring for generating plants connected to distribution systems

## CM-UFD.M33

The CM-UFD.M33 with Modbus RTU is a multifunctional grid feeding monitoring relay. It provides different monitoring functions to detect over- and undervoltage (10-minutes average value, voltage increase and decrease protection) as well as any changes in grid frequency (frequency increase and decrease protection).

The device is connected between the distributed generation and the public grid in order to disconnect the distributed generation in case of problems (e.g. unstable grid), faults or maintenance on the grid. Additionally, monitoring of ROCOF (rate of change of frequency) and vector shift can be configured.



2CDC2510050014

### Characteristics

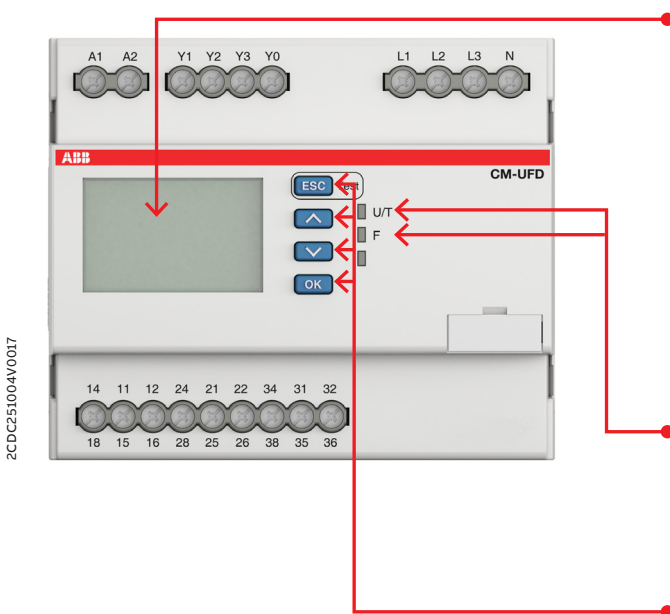
- Monitoring of voltage and frequency in single- and three-phase mains (2-wire, 3-wire or 4-wire AC systems)
- Pre-settings in accordance with G98/1 and G99/1
- Integrated management of redundancy function
- Multiline, backlit LCD display
- True RMS measuring principle
- Over- and undervoltage, 10-minutes average value as well as over- and underfrequency monitoring
- Two-level threshold settings for over-/undervoltage and over-/underfrequency
- ROCOF (rate of change of frequency) monitoring and vector shift configurable
- Interrupted neutral detection
- All threshold values and tripping delays adjustable
- Error memory for up to 99 entries (incl. cause of error, measured value, relative timestamp)
- Test function
- Password setting protection
- 3 control inputs, e.g. for feedback signal, remote trip
- 3 c/o (SPDT) contacts
- Various certifications and approvals (see overview, document no. 2CDC112249D0201)

### Ordering details

Type	Rated control supply voltage	Measuring range	Order code
CM-UFD.M33	24-240 V AC/DC	L-L: 0-550 V AC / L-N: 0-317 V AC	1SVR560730R3402

# Functions

## Operating controls



### Display

L1N:	230.0V				
L2N:	230.2V				
L3N:	229.7V				
	49.99 Hz				
R1	R2	R3	Y1	Y2	Y3

R1 R2 R3: relay status; in this case R3 is de-energized

Y1: status feedback loop Y1-Y0

Y2: status feedback loop Y2-Y0

Y3: status control input Y3-Y0,  
in this case Y3-Y0 is open

### Indication of operational states

U/T: green LED - Control supply voltage applied  
 Timing

F: red LED - Fault message

### Keypad

ESC: escape / return to previous menu

Λ: up / value increase

V: down / value decrease

OK: enter / confirm selection

## Application

The CM-UFD.M33 is a grid feeding monitoring relay, which is connected between the public grid and the distributed generation such as photovoltaic systems, wind turbines, block-type thermal power stations. It monitors the voltage and the frequency in the grid and disconnects the distributed generation whenever the measured values are not within the range of the adjusted thresholds. The fault is indicated by LED and the corresponding plain text message is shown on the display. The CM-UFD.M33 relay can be used in all low voltage plants and in medium voltage plants.

## Operating mode

The CM-UFD.M33 can be set up to monitor single- and three-phase mains (2-wire, 3-wire as well as 4-wire AC systems). The unit is configurable by front-face push-buttons. A display with the corresponding menu enables the selection of presettings as well as the precise adjustment of the different threshold values and corresponding time delays. Furthermore, the display visualizes the measured values clearly. Together with the front-face LEDs, it shows all information about operational states of output relays and control inputs.

The CM-UFD.M33 provides 3 output relays and 3 control inputs. Output relays R1 (11<sub>15</sub>-12<sub>16</sub>/14<sub>18</sub>) and R2 (21<sub>25</sub>-22<sub>26</sub>/24<sub>28</sub>) are required for disconnection of a distributed generation from the public grid. The corresponding feedback signals from the external contacts are monitored via the control inputs Y1-Y0 and Y2-Y0.

The third output relay R3 (31<sub>35</sub>-32<sub>36</sub>/34<sub>38</sub>) can be used for signalization of an event in the grid or a bus fault or the closing command of a motor drive for circuit breaker. Additionally, it can be configured to act synchronously with R1/R2 or controlled via bus.

The control inputs Y1-Y0 and Y2-Y0 monitor the corresponding feedback signals from the first and the second switching device. The third control input Y3-Y0 allows to trip the grid feeding monitoring relay (remote trip), to suppress Y1, to suppress Y2, to suppress Y1/Y2 or to suppress the vector shift detection.

## Protective functions

If control supply voltage is applied, all phases are present and the switch-on conditions for voltages and frequency are fulfilled, output relays R1 and R2 energize synchronously after the adjusted switch-on delay. The green LED U/T flashes while timing and turns steady when the switch-on delay is complete.

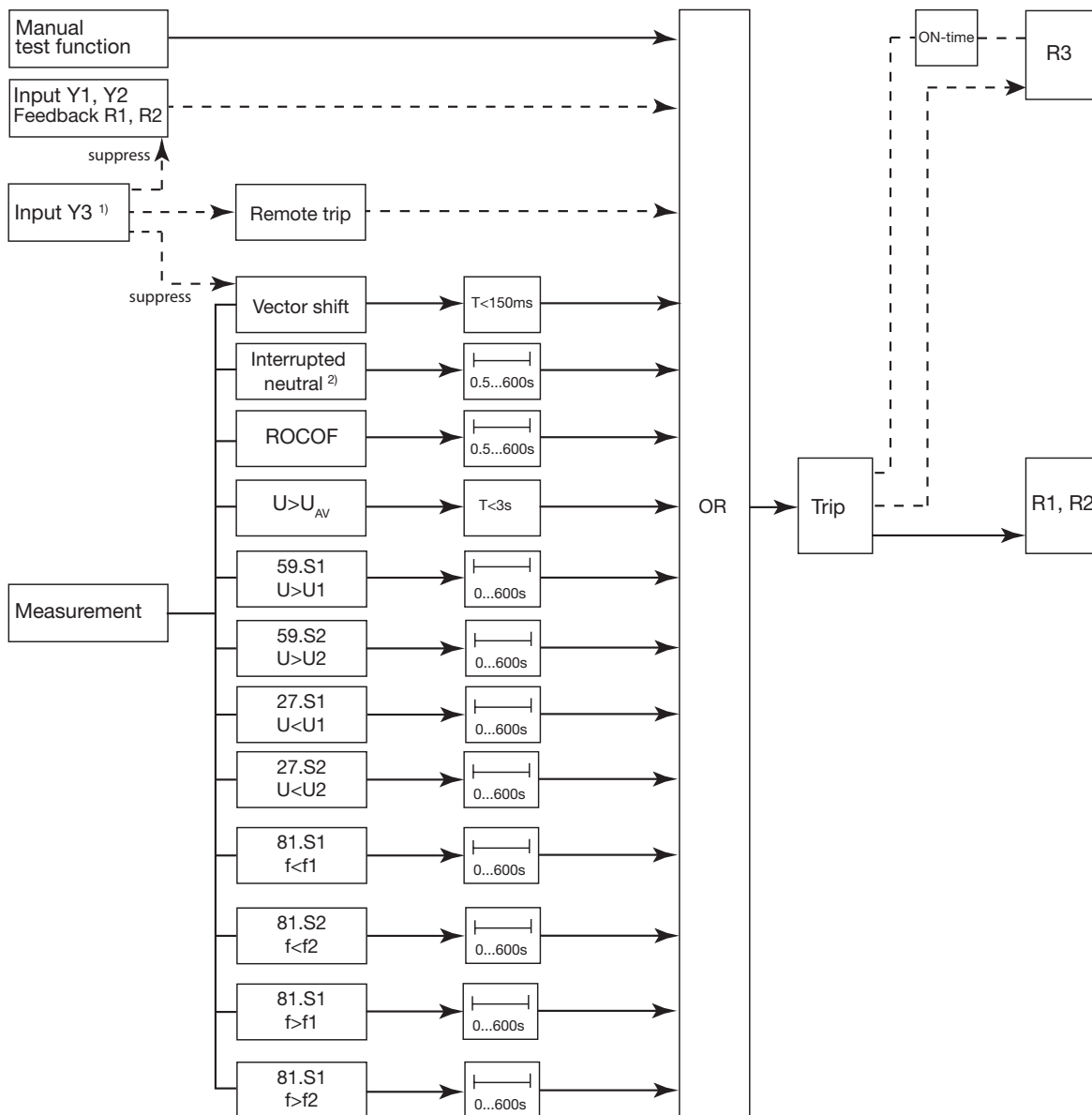
If a measured value exceeds or falls below the set threshold value (overvoltage, undervoltage, overfrequency or underfrequency), R1 and R2 de-energize after the adjusted tripping delay. As soon as the measured value returns to the tolerance range - taking into account an adjustable hysteresis – and all further switch-on conditions are fulfilled, R1 and R2 re-energize. The fault is indicated by the red LED F and the type of fault is shown on the display as a plain text message. The event that has caused tripping of the relay is recorded in the event list. The green LED U/T flashes while timing and turns steady when the delay is complete.

## Output relay R3 (31<sub>35</sub>-32<sub>36</sub>/34<sub>38</sub>)

The output relay R3 can be used for:

- Trip signalization  
R3 reacts synchronously with R1/R2. ON-time of R3 is inactive.
- Closing command of a breaker motor  
In case output relays R1 and R2 energize, the adjusted ON-delay starts. When timing is complete, output relay R3 will be activated for the duration of the ON-time or until relay R1 and R2 de-energize.
- Bus fault signalization  
In case of no bus communication during the adjusted bus timeout, the bus fault is signalized by R3 (e.g. no sign of life from the bus master)
- Additionally the control of R3 via bus or a deactivation is possible. With these configurations the settings for the ON-delay and the ON-time have no influence on the operating function.

## Operating principle / Monitoring functions



<sup>1)</sup> Function of Y3 depends on configuration

<sup>2)</sup> Active when one of the phase-neutral measuring principles is selected in the menu "Nominal voltage"

The device utilizes several separately adjustable monitoring functions for:

- Over voltage protection:  $> U_{AV}$ ,  $> U1$ ,  $> U2$
- Under voltage protection:  $< U1$ ,  $< U2$
- Over frequency protection:  $> F1$ ,  $> F2$
- Under frequency protection:  $< F1$ ,  $< F2$

Protective function  $U_{AV}$  (10-minutes average value):

The CM-UFD.M33 calculates the sliding average value of the 3 phases over a period of 10 minutes. The voltage values are updated every 3 seconds. If the 10-minutes average value exceeds the threshold value, the output relays trip.

## Control inputs Y1-Y0, Y2-Y0

Both control inputs Y1-Y0 and Y2-Y0 are used as feedback contacts for the 2 switching devices of the section switch. The current status of the switching devices is monitored by the grid feeding monitoring relay. The function of these control inputs can be configured as “disabled”, “enabled” or “tripping only”. The working principle of the control inputs can be configured as “normally closed”, “normally open” or “auto detection”. Please note that “normally” here refers to “good status” of the grid, when all the monitored voltages and the frequency stay within the set threshold values and output relays R1 and R2 are energized. A failure in the feedback loop has to be removed manually on the device.

The grid feeding standards vary from country to country. Some require that a section switch consists of 2 independent switching devices, while others require only 1 switching device working as section switch. In addition, not all standards require monitoring of the switching devices by the feedback monitoring. Therefore the monitoring functions of control inputs Y1-Y0 and Y2-Y0 are disabled by default. They can be manually enabled in the menu.

## Control input Y3-Y0

The function of control input Y3-Y0 can be configured as “remote trip”, “suppress Y1”, “suppress Y2”, “suppress Y1/Y2”, “suppress vector shift detection” or completely “disabled”. Working principle of the control input can be configured as “normally open” or “normally closed”.

Remote trip: With Y3-Y0 configured as “normally closed”, output relays R1 and R2 de-energize if Y3-Y0 is opened, and vice versa.

Suppress Y1, suppress Y2, suppress Y1/Y2: These functions can be used to suppress evaluation of the chosen feedback loop during synchronization of a generator, so that the status of the feedback signal will not be considered as a feedback error. An alternative solution is to set the release window of the corresponding feedback loop larger than the possible duration of synchronization process.

## Remote trip

The Modbus RTU and the control input Y3-Y0 allow remote tripping of the grid feeding monitoring relay. The remote trip input can be configured as normally open or normally closed. If normally closed is configured, the relay trips if Y3-Y0 is opened. If normally open is configured, the relay trips if Y3-Y0 is closed. The output relay R1 is tripped by the remote trip within less than 20 ms. When the remote trip input is deactivated, the output relay R1 energizes again.

## ROCOF (Rate of change of frequency $df/dt$ )

This function monitors the rate of change of frequency within a very short time and detects an imminent loss of mains (islanding). The ROCOF function detects zero crossings of the grid voltages. It measures the time between the zero crossings and calculates a new frequency after each zero crossing. In case the frequency changes too much since the last zero crossing, the output relay R1 trips. After the adjusted error time the relay de-energizes automatically.

The ROCOF monitoring function is deactivated per default and must be activated in the menu.

## Vector shift detection

This function is another possibility of detecting a loss of mains (islanding).

The vector shift detection is disabled by default and can be manually enabled in the menu. Through zero crossings the device detects the vector shift of mains voltage and de-energizes output relays R1 immediately if the shift exceeds the adjusted threshold value, e.g. 12°. Only after the set error time the switch-on conditions will be evaluated in order to start an auto reconnection.

## Switch-on conditions

In order to switch on the section switch after having applied control supply voltage or after a fault, the voltages as well as the frequency must stay within the set switch-on conditions during the switch-on delay. This window of voltage and frequency can be further restricted in the menu "Switch-on conditions". If one parameter leaves the window, the switch-on process is interrupted. When all parameters fulfill the switch-on conditions again, the switch-on delay restarts. When the switch-on time is complete, relays R1 and R2 re-energize automatically. If the function "Short interruption" is enabled in the menu "Switch-on conditions" -> "Switch-on delay", the switch-on delay will be reduced to 5 s in case of a short interruption of < 3 s.

## Interrupted neutral detection

Interrupted neutral detection is always active when a phase-neutral measuring principle is selected in the menu "Nominal voltage". The interruption of the neutral conductor will result in an immediate tripping of output relays R1 and R2.

## Automatic reconnecting attempts

If an error occurs at feedback loop Y1-Y0 or Y2-Y0 (e.g. undervoltage release because of a lightning strike), 0...3 automatic reconnecting attempts will be carried out, taking into account the switch-on conditions. Therefore a temporary feedback error doesn't have to be handled manually. The corresponding error in the feedback loop is stored in the error list.

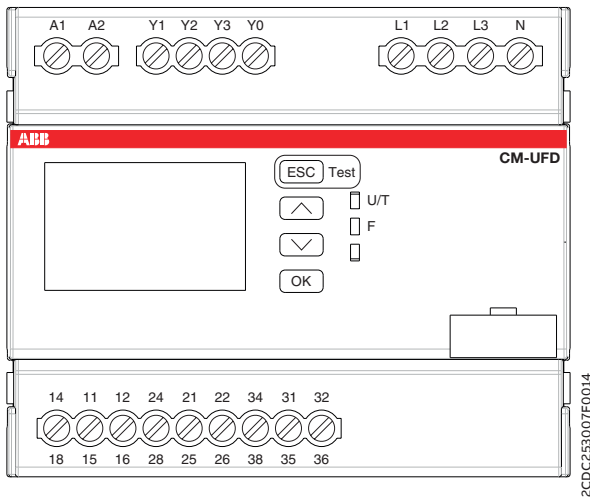
## Error memory

The CM-UFD.M33 records and logs the last 99 events that caused tripping of the grid feeding monitoring relay as well as any interruption of the control supply voltage. The type of error as well as the current value of the operation counter is recorded into the internal error list, accessible via the menu. The list is stored internally in a non-volatile memory which can be reset by the user.

## Test function

The test function can be used to simulate an error in the installation. This way, the time delays of the feedback loops can be determined. A feedback loop includes the output relay, the corresponding switching device and the feedback contact. The test function can be started by pressing the ESC button for 3 seconds. The output relays R1 and R2 de-energize immediately and the CM-UFD.M33 gets feedback signals from the section switch through control inputs Y1-Y0 and Y2-Y0 respectively. The time intervals from de-energizing both output relays to receiving both feedback signals is shown on the display. Return to the menu is realized by confirming with the OK button.

## Electrical connection



A1-A2	Control supply voltage
Y1-Y0	Control input 1, for feedback from switching device 1
Y2-Y0	Control input 2, for feedback from switching device 2
Y3-Y0	Control input 3, configurable
L1, L2, L3, N	Measuring input
11 <sub>15</sub> -12 <sub>16</sub> /14 <sub>18</sub>	Relay R1, c/o (SPDT) contact
21 <sub>25</sub> -22 <sub>26</sub> /24 <sub>28</sub>	Relay R2, c/o (SPDT) contact
31 <sub>35</sub> -32 <sub>36</sub> /34 <sub>38</sub>	Relay R3, c/o (SPDT) contact

## Configuration

The menu structure starts with the main page that shows the real time measured values. Use the arrow keys to switch between the real time voltages and the 10-minutes average voltages.

### Display menu structure, navigation and possible configurations

#### Main page

```
L1N: 230.0V
L2N: 230.2V
L3N: 229.7V
49.99 Hz
R1 R2 R3 V1 V2 V3
```



```
AUL1N: 230.0V
AUL2N: 230.2V
AUL3N: 229.7V
49.99 Hz
R1 R2 R3 V1 V2 V3
```

#### Menu navigation

- If the display is dark, press any button to light it up
- Press OK button to enter the menu
- Press arrow buttons to move between functions and parameters
- Press OK button to enter the chosen page
- Press arrow buttons to modify the values of the parameters
- Press OK button to confirm the value and proceed
- Press ESC button to return to the previous menu
- Press arrow buttons more than 1 s to scroll through the menu or password menu

Changes of parameters can be cancelled by pressing the ESC button.

### Pre-settings

The CM-UFD.M33 is delivered with 3 sets of pre-settings according to EREC (Engineering Recommendation) G98/1 and G99/1 low voltage protection and G99/1 high voltage protection, which can be loaded in the submenu "General settings" -> "Load settings".

- Pre-setting 1 (default): G99/1 LV - applies to Generating Unit(s) which are not compliant with EREC G98 requirements.
- Pre-setting 2: G99/1 HV - If the EREC G99 protection takes its voltage reference from an HV source
- Pre-setting 3: G98/1 - applies to Fully Type Tested Micro-generators (up to and including 16 A per phase) in parallel with public Low Voltage Distribution Networks

Additionally, 5 sets of self-defined pre-settings can be saved in the memory and loaded by the user.

## Global delay settings

The “Tripping delay offset” within the submenu “Global delay settings” reduces the tripping delay of every single monitoring function in order to extend the operating time of the circuit breaker.

## Password protection

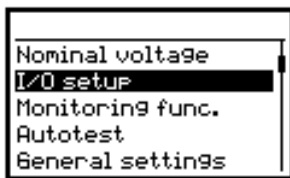
Every CM-UFD.M33 relay is delivered with the same default password [0000] for protection of its settings and local command. The installer is responsible for the verification of the parameter values and the change of the password with a personal one in order to avoid unwanted modifications.

Visualization of the parameters is always possible, modification only after having entered the password. While entering the password, the password protection is temporarily disabled until the menu is exited.

Only the parameters ‘autotest’, ‘language’, ‘display switch-off delay’ and ‘contrast’ are not password protected.

## Menu structure

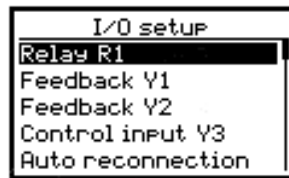
### Main menu



v down

up ^

### Submenu



v down

up ^



← ESC

Menu			Configuration possibilities	Step size	G99		G98
					G99 LV (Default)	G99 HV	G98
Nominal voltage	Measuring principle		[3L-N + 3L-L], [3L-N], [3L-L], [1L-N]		3L-N	3L-L	3L-N
	Nominal voltage		[57.7]-[240.0] V L-N / [99.9]-[415.7] V L-L	0.1 V	230 V L-N	110 V L-L	230 V L-N
I/O setup	Relay R3	Working principle	[disabled], [open-circuit], [closed-circuit], [sync. with R1/R2]		disabled	disabled	disabled
		ON-delay	[0.00]-[10.00] s	0.01 s	0 s	0 s	0 s
		ON-time	[0.05]-[10.00] s	0.01 s	0.5 s	0.5 s	0.5 s
	Feedback Y1	Monitoring	[disabled], [enabled], [tripping only]		disabled	disabled	disabled
		Working principle	[normally closed], [normally open], [auto detection]		auto detection	auto detection	auto detection
		Trip window	[0.05]-[0.50] s	0.01 s	0.1 s	0.1 s	0.1 s
		Release window	[0.5]-[6000.0] s	0.1 s	0.5 s	0.5 s	0.5 s
	Feedback Y2	Monitoring	[disabled], [enabled], [tripping only]		disabled	disabled	disabled
		Working principle	[normally closed], [normally open], [auto detection]		auto detection	auto detection	auto detection
		Trip window	[0.05]-[0.50] s	0.01 s	0.1 s	0.1 s	0.1 s
		Release window	[0.5]-[6000.0] s	0.1 s	0.5 s	0.5 s	0.5 s
	Control Input Y3	Function	[disabled], [remote trip], [suppress Y1], [suppress Y2], [suppress Y1/Y2], [suppress VS]		disabled	disabled	disabled
		Working principle	[normally closed], [normally open]		normally open	normally open	normally open
	Auto reconnection	Number of attempts	[0]-[3]	1	0	0	0



				G99		G98	
Menu			Configuration possibilities	Step size	G99 LV (Default)	G99 HV	G98
Monitoring functions	(U>) Overvoltage >UAV	Monitoring	[disabled], [enabled]		disabled	disabled	disabled
		Threshold value	[0.100]-[1.300] xU <sub>n</sub>	0.005 xU <sub>n</sub>	1.1 xU <sub>n</sub>	1.1 xU <sub>n</sub>	1.1 xU <sub>n</sub>
		Hysteresis	[0.1]-[10.0] %	0.1 %	0.1 %	0.1 %	0.1 %
	(U>>) Overvoltage >U1	Monitoring	[disabled], [enabled]		enabled	enabled	enabled
		Threshold value	[0.100]-[1.300] xU <sub>n</sub>	0.005 xU <sub>n</sub>	1.14 xU <sub>n</sub>	1.1 xU <sub>n</sub>	1.14 xU <sub>n</sub>
		Hysteresis	[0.5]-[10.0] %	0.1 %	1 %	1 %	1 %
		Tripping delay	[0.06]-[600.00] s	0.01 s	0.1 s	0.1 s	0.1 s
	Overvoltage >U2	Monitoring	[disabled], [enabled]		enabled	enabled	enabled
		Threshold value	[0.100]-[1.300] xU <sub>n</sub>	0.005 xU <sub>n</sub>	1.19 xU <sub>n</sub>	1.13 xU <sub>n</sub>	1.19 xU <sub>n</sub>
		Hysteresis	[0.5]-[10.0] %	0.1 %	1 %	1 %	1 %
		Tripping delay	[0.00]-[600.00] s	0.01 s	0.5 s	0.5 s	0.5 s
	Undervoltage <U1	Monitoring	[disabled], [enabled]		enabled	enabled	enabled
		Threshold value	[0.100]-[1.300] xU <sub>n</sub>	0,005 xU <sub>n</sub>	0.8 xU <sub>n</sub>	0.8 xU <sub>n</sub>	0.8 xU <sub>n</sub>
		Hysteresis	[0.5]-[10.0] %	0.1%	1 %	1%	1%
		Tripping delay	[0.00]-[600.00] s	0.01 s	2.5 s	2.5 s	2.5 s
	Undervoltage <U2	Monitoring	[disabled], [enabled]		disabled	disabled	disabled
Threshold value		[0.100]-[1.300] xU <sub>n</sub>	0,005 xU <sub>n</sub>	0.45 xU <sub>n</sub>	0.45 xU <sub>n</sub>	0.45 xU <sub>n</sub>	
Hysteresis		[0.5]-[10.0] %	0.1%	1%	1%	1%	
Tripping delay		[0.00]-[600.00] s	0.01 s	0.1 s	0.1 s	0.1 s	
Monitoring functions	Overfrequency >F1	Monitoring	[disabled], [enabled]		enabled	enabled	enabled
		Threshold value	[45.00]-[65.00] Hz	0.01 Hz	52.0 Hz	52.0 Hz	52.0 Hz
		Hysteresis	[0.05]-[4.00] Hz	0.01 Hz	0.1 Hz	0.1 Hz	0.1 Hz
		Tripping delay	[0.00]-[600.00] s	0.01 s	0.5 s	0.5 s	0.5 s
	Overfrequency >F2	Monitoring	[disabled], [enabled]		disabled	disabled	disabled
		Threshold value	[45.00]-[65.00] Hz	0.01 Hz	51.5 Hz	51.5 Hz	51.5 Hz
		Hysteresis	[0.05]-[4.00] Hz	0.01 Hz	0.1 Hz	0.1 Hz	0.1 Hz
		Tripping delay	[0.00]-[600.00] s	0.01 s	0.1 s	0.1 s	0.1 s
	Underfrequency <F1	Monitoring	[disabled], [enabled]		enabled	enabled	enabled
		Threshold value	[45.00]-[65.00] Hz	0.01 Hz	47.5 Hz	47.5 Hz	47.5 Hz
		Hysteresis	[0.05]-[4.00] Hz	0.01 Hz	0.1 Hz	0.1 Hz	0.1 Hz
		Tripping delay	[0.00]-[600.00] s	0.01 s	20.0 s	20.0 s	20.0 s
	Underfrequency <F2	Monitoring	[disabled], [enabled]		enabled	enabled	enabled
		Threshold value	[45.00]-[65.00] Hz	0.01 Hz	47.0 Hz	47.0 Hz	47.0 Hz
		Hysteresis	[0.05]-[4.00] Hz	0.01 Hz	0.1 Hz	0.1 Hz	0.1 Hz
		Tripping delay	[0.00]-[600.00] s	0.01 s	0.5 s	0.5 s	0.5 s
ROCOF	Monitoring	[disabled], [enabled]		enabled	enabled	enabled	
	Threshold value	[0.100]-[5.000] Hz/s	0.005 Hz/s	1 Hz/s	1 Hz/s	1 Hz/s	
	Number of cycles	[4]-[50]	1	25	25	25	
	Tripping delay	[0.00]-[600.00] s	0.01 s	0.5 s	0.5 s	0.5 s	
	Error time	[0.50]-[600.00] s	0.01 s	30 s	30 s	30 s	
Vector Shift VS	Monitoring	[disabled], [enabled]		disabled	disabled	disabled	
	Threshold value	[2.0]-[50.0] °	0.1 °	50 °	50 °	50 °	
	Error time	[0.50]-[600.00] s	0.01 s	30 s	30 s	30 s	
Global delay setting	Trip. delay offset	[000]-[100] ms	1 ms	0 ms	0 ms	0 ms	

					G99		G98
Menu			Configuration possibilities	Step size	G99 LV (Default)	G99 HV	G98
Switch-on conditions	Switch-on delay	Switch-on delay	[0.5]-[6000.0] s	0.1 s	20 s	20 s	20 s
		Short interruption	[disabled], [enabled]		disabled	disabled	disabled
	Voltage window	Monitoring	[disabled], [enabled]		disabled	disabled	disabled
		Minimum	[0.100]-[1.000] xU <sub>n</sub>	0,005 xU <sub>n</sub>	0.8 xU <sub>n</sub>	0.8 xU <sub>n</sub>	0.8 xU <sub>n</sub>
		Maximum	[1.000]-[1.300] xU <sub>n</sub>	0,005 xU <sub>n</sub>	1.14 xU <sub>n</sub>	1.1 xU <sub>n</sub>	1.14 xU <sub>n</sub>
	Frequency window	Monitoring	[disabled], [enabled]		disabled	disabled	disabled
		Minimum	[45.00]-[60.00] Hz	0.01 Hz	47.5	47.5	47.5
		Maximum	[50.00]-[65.00] Hz	0.01 Hz	52.0	52.0	52.0
	General settings	Language	Language	[English], [Deutsch]		English *)	English *)
Display		Switch-off delay	[10]-[600]s	1 s	10 s *)	10 s *)	10 s *)
		Contrast	[0]-[9]	1	5 *)	5 *)	5 *)
Password		Protection	[disabled], [enabled]		disabled *)	disabled *)	disabled *)
		Change password	[****]		0000 *)	0000 *)	0000 *)
Load settings		"Setting name"					
Save settings		"Setting name"					
Information							
Error memory	Error list						
	Error recording	Remote trip via Y3	[disabled], [enabled]		enabled *)	enabled *)	enabled *)
		Remote trip via bus	[disabled], [enabled]		enabled *)	enabled *)	enabled *)
		Power OFF	[disabled], [enabled]		enabled *)	enabled *)	enabled *)
	Reset error memory						
	Operating counter						
	Cumulated OFF-time						
	Trip counter						

\*) Device defaults, not affected by loading a setting

# Display and failure messages

```
L1N: 184.4V <U<N
L2N: 184.7V <U<N
L3N: 184.1V <U1
49.99 Hz
R1 R2 R3 Y1 Y2 V3
```

The voltage at L3 has fallen below the first undervoltage threshold. The voltages at L1 and L2 have fallen below the switch-on conditions, yet not below the undervoltage threshold.

```
L1N: 230.0V
L2N: 230.3V
L3N: 229.7V
50.61 Hz ROCOF
R1 R2 R3 Y1 Y2 V3
```

Error, ROCOF

Threshold for rate of change of frequency exceeded.

```
L1N: 260.2V >U<V
L2N: 260.3V >U<V
L3N: 260.0V >U<V
49.99 Hz
R1 R2 R3 Y1 Y2 V3
```

Error overvoltage  $U_{AV}$  in all three phases detected. If overvoltage occurs in one phase only,  $>U_{AV}$  indicates the phase with overvoltage.

```
L1N: 230.0V
L2N: 230.3V
L3N: 229.8V
49.61 Hz VS
R1 R2 R3 Y1 Y2 V3
```

Error, vector shift

Threshold for vector shift exceeded.

```
L1N: 260.2V >U1
L2N: 260.3V >U1
L3N: 260.0V >U1
49.99 Hz
R1 R2 R3 Y1 Y2 V3
```

Error overvoltage  $>U1$  in all three phases detected. If overvoltage occurs in one phase only,  $>U1$  indicates the phase with overvoltage.

```
Neutral conductor
is not connected!
R1 R2 R3 Y1 Y2 V3
```

4-wire connection

The neutral conductor is disconnected or interrupted. Please check wiring.

```
L1N: 264.6V >U2
L2N: 264.9V >U2
L3N: 264.6V >U2
49.99 Hz
R1 R2 R3 Y1 Y2 V3
```

Error overvoltage  $>U2$  in all three phases detected. If overvoltage occurs in one phase only,  $>U2$  indicates the phase with overvoltage.

```
L1N: 230.0V
L2N: 230.3V
L3N: 229.7V
49.61 Hz
Feedback Y1
R1 R2 R3 Y1 Y2 V3
```

Error in feedback loop Y1-Y0, e.g. wiring failure or welded feedback contact. Please check wiring.

```
L1N: 190.3V <U1
L2N: 190.5V <U1
L3N: 190.1V <U1
49.99 Hz
R1 R2 R3 Y1 Y2 V3
```

Error undervoltage  $<U1$  in all three phases detected. If undervoltage occurs in one phase only,  $<U1$  indicates the phase with undervoltage.

```
L1N: 230.1V
L2N: 230.3V
L3N: 229.7V
49.61 Hz
Press ESC!
R1 R2 R3 Y1 Y2 V3
```

Error in feedback loop is removed. Press ESC to reset the grid feeding monitoring relay.

```
L1N: 90.2V <U2
L2N: 90.3V <U2
L3N: 90.2V <U2
49.99 Hz
R1 R2 R3 Y1 Y2 V3
```

Error undervoltage  $<U2$  in all three phases detected. If undervoltage occurs in one phase only,  $<U2$  indicates the phase with undervoltage.

```
L1N: 229.9V
L2N: 229.2V
L3N: 229.1V
49.99 Hz
Internal error
R1 R2 R3 Y1 Y2 V3
```

Failure within the logic or hardware of the device. Remove supply and restart. If failure still occurs, there is a permanent failure in the device.

```
L1N: 230.0V
L2N: 230.2V
L3N: 229.6V
51.99 Hz >F1
R1 R2 R3 Y1 Y2 V3
```

Error overfrequency  $>F1$  detected

```
L1N: 230.2V
L2N: 230.2V
L3N: 230.3V
49.99 Hz
Remote trip via Y3
R1 R2 R3 Y1 Y2 V3
```

Remote trip via Y3

Shows that the remote trip is activated via control input Y3

\* For CM-UFD.M33M only

```
L1N: 230.3V
L2N: 230.5V
L3N: 230.1V
51.99 Hz >F2
R1 R2 R3 Y1 Y2 V3
```

Error overfrequency  $>F2$  detected

```
L1N: 230.6V
L2N: 230.7V
L3N: 230.5V
47.00 Hz <F2
R1 R2 R3 Y1 Y2 V3
```

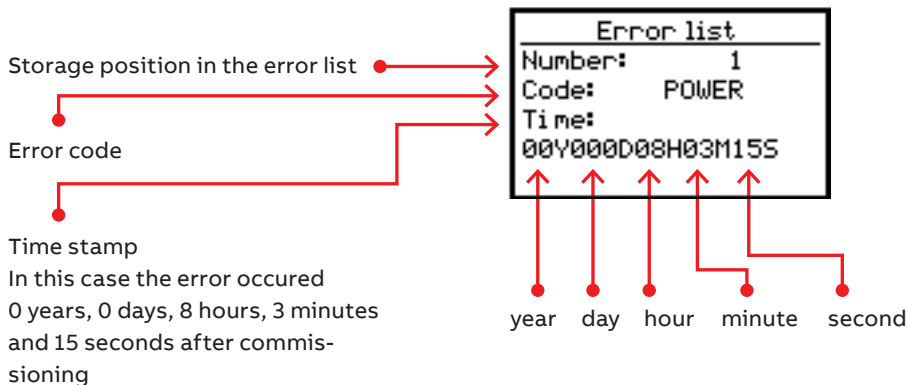
Error underfrequency  $<F2$  detected

```
L1N: 230.5V
L2N: 230.7V
L3N: 230.3V
49.00 Hz <F1
R1 R2 R3 Y1 Y2 V3
```

Error underfrequency  $<F1$  detected

## Error memory

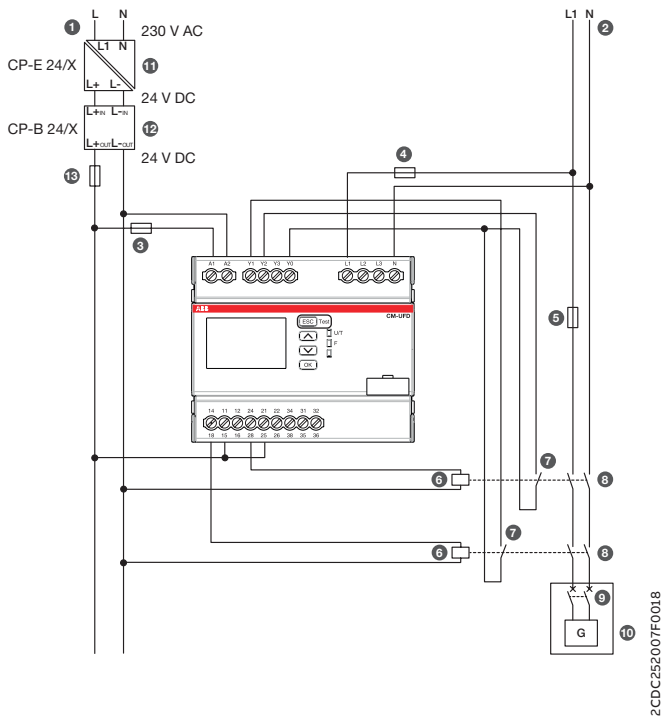
As soon as one of the above errors occurs, subsequent error codes with the corresponding time stamp will be stored in the error memory:



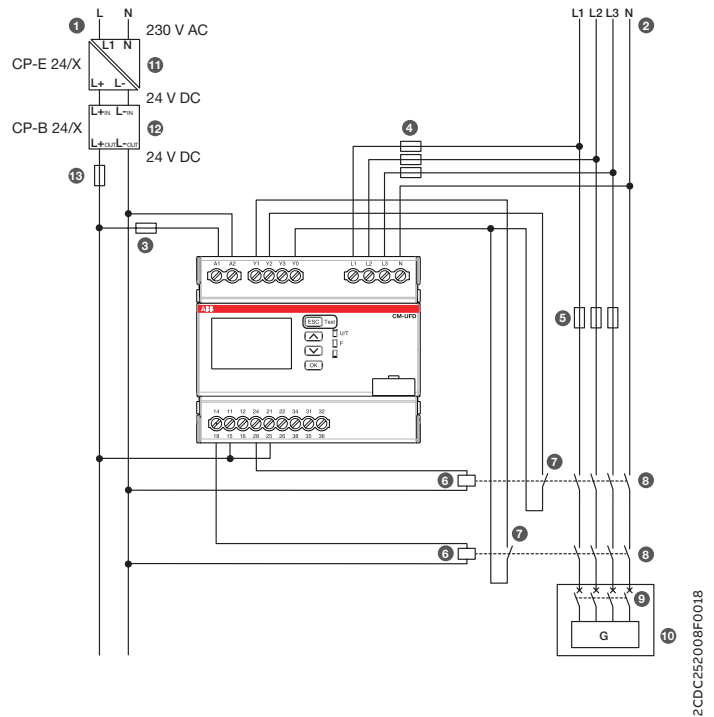
Error code	Explanation	
AVL1N>U <sub>AV</sub> or AVL2N>U <sub>AV</sub> or AVL3N>U <sub>AV</sub>	Error, Error, overvoltage U <sub>AV</sub>	10-minutes average value
AVL12>U <sub>AV</sub> or AVL23>U <sub>AV</sub> or AVL31>U <sub>AV</sub>	Error, overvoltage U <sub>AV</sub>	10-minutes average value
L1N<U1 or L2N<U1 or L3N<U1	Error, overvoltage U1	
L12>U1 or L23>U1 or L31>U1	Error, overvoltage U1	
L1N>U2 or L2N>U2 or L3N>U2	Error, overvoltage U2	
L12>U2 or L23>U2 or L31>U2	Error, overvoltage U2	
L1N<U1 or L2N<U1 or L3N<U1	Error, undervoltage U1	
L12<U1 or L23<U1 or L31<U1	Error, undervoltage U1	
L1N<U2 or L2N<U2 or L3N<U2	Error, undervoltage U2	
L12<U2 or L23<U2 or L31<U2	Error, undervoltage U2	
F>F1	Error, overfrequency F1	
F>F2	Error, overfrequency F2	
F<F1	Error, underfrequency F1	
F<F2	Error, underfrequency F2	
ROCOF	Error, ROCOF	
VECTOR	Error, Vector shift	
TEST	Error, test function	
REMOTE Y3	Error, remote trip via control input Y3	
FB1	Error, feedback of switching device 1	Malfunction of the first switching device
FB2	Error, feedback of switching device 2	Malfunction of the second switching device
POWER	Error, power	Supply voltage is disconnected or too low
NEUTRAL	Error, interrupted neutral detection	
Exxx (e.g. E123)	Internal error	Failure within the logic or hardware of the device

# Connection and wiring

## Example of single-phase application



## Example of three-phase application



## Legend

1. Control supply voltage for CM-UFD.M33
2. Public grid
3. Protection fuse for the CM-UFD.M33
4. Protection fuse for the measuring circuit of the CM-UFD.M33 (optional)
5. Short-circuit protection
6. Undervoltage release
7. Control input for feedback function
8. Switching device of the section switch
9. Switching device of the generator and/or inverter
10. Generator and/or inverter
11. Primary switch mode power supply unit CP-E (230 V AC / 24 V DC) for the buffer module CP-B
12. Ultra-capacitor based buffer module CP-B (24 V DC in/out)
13. Wire protection fuse for the output of the buffer module CP-B

# Technical data

Data at  $T_a = 25\text{ °C}$  and rated values, unless otherwise indicated

## Input circuits

Supply circuit	A1-A2	
Rated control supply voltage $U_s$	24-240 V AC/DC	
Rated control supply voltage $U_s$ tolerance	- 15...+ 10 %	
Rated frequency	DC or 50/60 Hz	
Frequency range AC	40-70 Hz	
Typical current / power consumption	24 V DC	60 mA / 1.4 W
	230 V AC	22 mA / 5.0 V A
Power failure buffering time	200 ms, acc. LVFRT (110-240 V AC)	
	10 ms, acc. IEC/EN 60255-26 (24 V AC/DC)	

Measuring circuits	L1, L2, L3, N	
Nominal voltage of the distribution system $U_n$	57.7-240.0 V AC / 99.9-415.7 V AC	
Measuring ranges	voltage: line to neutral	0-317 V AC
	voltage: line to line	0-550 V AC
	frequency	40-70 Hz
Accuracy within the temperature range	voltage	$\leq 0,5\% \pm 0,5\text{ V}$
	frequency	$\pm 20\text{ mHz}$
	delay times	$\leq 0,1\% \pm 20\text{ ms}$ (unless otherwise specified)
Monitoring functions	overvoltage 10-min average ( $> U_{AV}$ )	threshold adjustable, $1.000-1.300 \times U_n$ in $0.005 \times U_n$ steps
	overvoltage ( $> U1$ )	
	overvoltage ( $> U2$ )	
	undervoltage ( $< U1$ )	threshold adjustable, $0.100-1.000 \times U_n$ in $0.005 \times U_n$ steps
	undervoltage ( $< U2$ )	
	overfrequency ( $> F1$ )	threshold adjustable, 50.00-65.00 Hz in 0.01 Hz steps
	overfrequency ( $> F2$ )	
	underfrequency ( $< F1$ )	threshold adjustable, 45.00-60.00 Hz in 0.01 Hz steps
	underfrequency ( $< F2$ )	
		ROCOF
	vector shift	threshold adjustable, 2.0-40.0 °, in 0.1 ° steps
Hysteresis related to the threshold values	overvoltage 10-min average ( $> U_{AV}$ )	adjustable, 0.1-10.0 % in 0.1 % steps
	overvoltage ( $> U1, > U2$ )	adjustable, 0.5-10.0 % in 0.1 % steps
	undervoltage ( $< U1, < U2$ )	
	overfrequency ( $> F1, > F2$ )	adjustable, 0.05-4.00 Hz in 0.01 Hz steps
	underfrequency ( $< F1, < F2$ )	
Measuring method	true RMS	
Measuring cycle	ROCOF	adjustable between 4 and 50 periods

Control circuits	Y0, Y1, Y2, Y3	
Number of control inputs	3	
Type of triggering	volt-free triggering, signal source Y0	
Control function	Y1-Y0 control input 1	feedback switching device 1
	Y2-Y0 control input 2	feedback switching device 2
	Y3-Y0 control input 3	remote trip, suppression of Y1, Y2, Y1/Y2 or suppression of vector shift detection
Electrical isolation	from the supply voltage	yes
	from the measuring circuit	no
	from the relay outputs	yes
Maximum switching current in the control circuit	6 mA	
No-load voltage at the control inputs	typ. 24 V DC	
Minimum control pulse length	20 ms	
Maximum cable length at the control inputs	10 m	

## Timing functions

Switch-on delay (prior to first grid connection or re-connection after interruption)	adjustable, 1.00-600.00 s in 0.01 s steps	
ON-delay R3	adjustable, 0.00-10.00 s in 0.01 s steps	
ON-time R3	adjustable, 0.05-10.00 s in 0.01 s steps	
Trip window, feedback loop	adjustable, 0.05-0.50 s in 0.01 s steps	
Release window, feedback loop	adjustable, 0.5-6000.0 s in 0.1 s steps	
Tripping delay	overvoltage	
	undervoltage	
	overfrequency	adjustable, 0.06-600.00 s in 0.01 s steps; + 0 / - 50 ms
	underfrequency	
	ROCOF	
ROCOF		
vector shift		
Error time	adjustable, 0.5-600.00 s in 0.01 s steps	
Reaction time	overvoltage av.	max. 3 s
	vector shift	< 50 ms
	interrupted neutral conductor	< 150 ms

## User interface

### Indication of operational states

Control supply voltage applied / timing	U/T	LED green on / flashing
Fault message	F	LED red on
For details see the message on the display		

### Display

Backlight	on	press any button
	off	switch-off delay adjustable, 10-600 s (default 10 s)
Resolution	112 x 64 pixel	
Display size	36 x 22 mm	

### Operating controls

4 push-buttons for menu navigation, setting and entering

## Output circuits

Kind of outputs	11-12/14 (15-16/18)	relay R1, c/o (SPDT) contact, tripping relay for switching device 1
	21-22/24 (25-26/28)	relay R2, c/o (SPDT) contact, tripping relay for switching device 2
	31-32/34 (35-36/38)	relay R3, c/o (SPDT) contact, configurable
Operating principle	11-12/14	closed-circuit principle*
	21-22/24	closed-circuit principle*
	31-32/34	configurable (disabled, open-circuit, closed-circuit, sync. with R1/2, bus-controlled, bus fault)*
Contact material	AgNi alloy, Cd-free	
Minimum switching voltage / minimum switching current	24 V / 10 mA	
Maximum switching voltage / maximum switching current	see "Load limit curves"	
Rated operational voltage $U_e$ and rated operational current $I_e$	AC-12 (resistive) at 230 V	4 A
	AC-15 (inductive) at 230 V	3 A
	DC-12 (resistive) at 24 V	4 A
	DC-13 (inductive) at 24 V	2 A
AC rating (UL 508)	utilization category (Control Circuit Rating Code)	B 300
	max. rated operational voltage	300 V
	max. continuous thermal current at B 300	5 A
	max. making/breaking apparent power at B 300	3600/360 VA
Mechanical lifetime	30 x 10 <sup>6</sup> switching cycles	
Electrical lifetime	at AC-12, 230 V AC, 4 A	0.1 x 10 <sup>6</sup> switching cycles
Maximum fuse rating to achieve short-circuit protection	n/c contact	10 A fast-acting
	n/c contact	10 A fast-acting
Conventional thermal current $I_{th}$	5 A	

\* Closed-circuit principle: Output relay de-energizes if a fault is occurring  
 Open-circuit principle: Output relay energizes if a fault is occurring

### General data

MTBF	on request	
Duty cycle	100 %	
Dimensions	see "Dimensional drawing"	
Weight	net	0.312 kg (0.687 lb)
Mounting	DIN rail (IEC/EN 60715) TH 35-7.5 and TH 35-15, snap-on mounting without any tool	
Mounting position	any	
Minimum distance to other units	horizontal / vertical	not necessary
Degree of protection	housing / terminals	IP20

### Electrical connection

Connecting capacity	fine-strand with wire end ferrule	1 x 0.25-4 mm <sup>2</sup> (1 x 24-12 AWG) 2 x 0.25-0.75 mm <sup>2</sup> (2 x 24-18 AWG)
	fine-strand without wire end ferrule	1 x 0.2-4 mm <sup>2</sup> (1 x 24-12 AWG) 2 x 0.2-1.5 mm <sup>2</sup> (2 x 24-16 AWG)
	rigid	1 x 0.2-6 mm <sup>2</sup> (1 x 24-10 AWG) 2 x 0.2-1.5 mm <sup>2</sup> (2 x 24-16 AWG)
Stripping length	8 mm (0.31 in)	
Tightening torque	0.5-0.6 Nm (4.4-5.3 lb.in)	
Recommended screw driver	PH1 / Ø 4.0 mm	

### Environmental data

Ambient temperature ranges	operation	-20 °C...+60 °C (-4...+140 °F)
	storage	-20 °C...+80 °C (-4...+176 °F)
Damp heat, cyclic	IEC/EN 60068-2-30	6 x 24 h cycle, 55 °C, 95 % RH
Climatic class	IEC/EN 60721-3-3	3K5 (no condensation, no ice formation)
Vibration, sinusoidal	class 2	
Shock	class 2	

### Isolation data

Rated insulation voltage U <sub>i</sub> , overvoltage category	basic insulation	measuring (L1/L2/L3/N)	300 V, IV 600 V, III
		output 1 / output 2 / output 3	300 V, III
reinforced/doubled insulation	supply / control inputs / outputs		300 V, III
		measuring (L1/L2/L3/N) / (supply / outputs)	300 V, IV
Rated impulse withstand voltage U <sub>imp</sub>	output 1 / output 2 / output 3		4 kV; 1.2/50 µs
	supply / control inputs / outputs		6 kV; 1.2/50 µs
		measuring (L1/L2/L3/N) / (supply / outputs)	8 kV; 1.2/50 µs
Pollution degree	3		

### Standards/Directives

Standards	IEC/EN 60255-1, IEC/EN 60255-26, IEC/EN 60255-27, ENA - G98/1, G99/1
Low Voltage Directive	2014/35/EU
EMC Directive	2014/30/EU
RoHS Directive	2011/65/EU



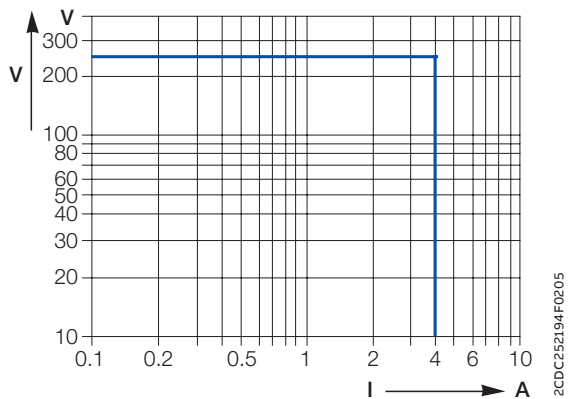
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**Electromagnetic compatibility**

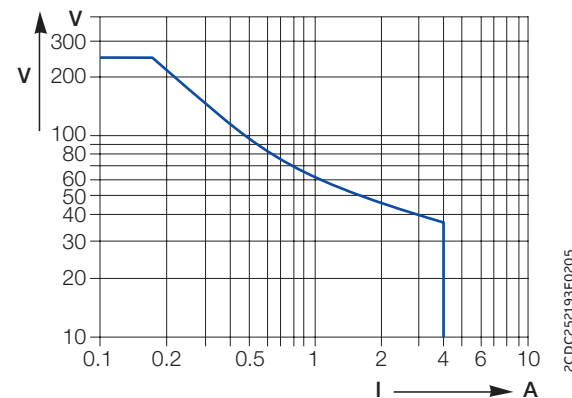
Interference immunity to		IEC/EN 60255-26
electrostatic discharge	IEC/EN 61000-4-2	level 3, 6 kV contact discharge, 8 kV air discharge
radiated, radio-frequency, electromagnetic field	IEC/EN 61000-4-3	level 3, 10 V/m; 2.7 GHz
electrical fast transient / burst	IEC/EN 61000-4-4	zone B / level 3, 2 kV / 5 kHz
surge	IEC/EN 61000-4-5	supply circuit and measuring circuit zone B / level 3; 1 kV L-L
conducted disturbances, induced by radio-frequency fields	IEC/EN 61000-4-6	level 3, 10 V
voltage dips, short interruptions and voltage variations	IEC/EN 61000-4-11	class 3
Interference emission		IEC/EN 61000-6-3
high-frequency radiated		fulfilled
high-frequency conducted		fulfilled

# Technical diagrams

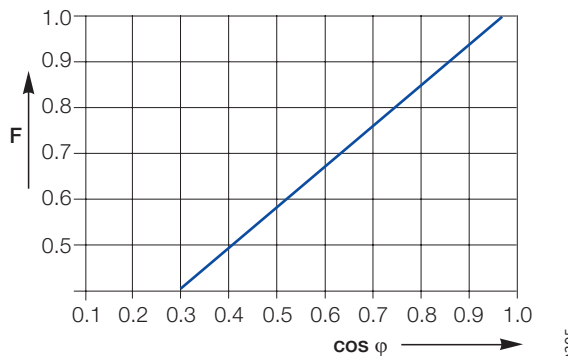
## Load limits curves



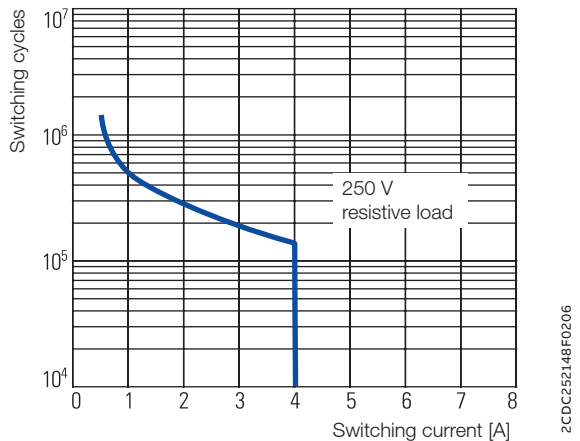
AC load (resistive)



DC load (resistive)



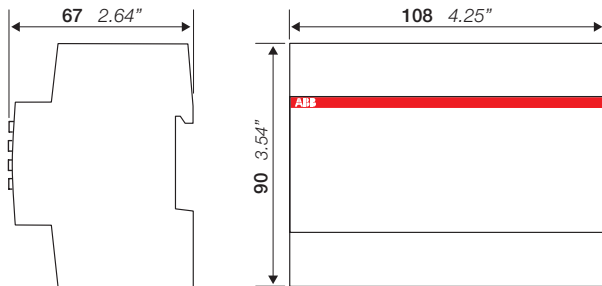
Derating factor F at inductive AC load



Contact lifetime

## Dimensional drawings

in mm and inches



2CDC252008 F0013

## Further documentation

Document title	Document type	Document number
Electronic relays and controls	Catalog	2CDC110004C02xx
CM-UFD.M33M Grid feeding monitoring relay	Instruction sheet	1SVC560516M0000
CM-UFD.M*M integration into ABB Ability EDCS	Application note	2CDC112280M0101

You can find the documentation on the internet at [www.abb.com/lowvoltage](http://www.abb.com/lowvoltage)

-> Automation, control and protection -> Electronic relays and controls -> Measuring and monitoring relays.

## CAD system files

You can find the CAD files for CAD systems at <http://abb-control-products.partcommunity.com>

-> Low Voltage Products & Systems -> Control Products -> Electronic Relays and Controls.

# Declaration of conformity

## Protection Relay Type-Test Verification Report

According to the Engineering Recommendation G99/1-3

<b>Product details</b>	Model	CM-UFD.M33
	Part Number	1SVR560730R3402
	Software Version	1.1.3
	Date	2019/05/29
	G99 Version	G99/1-3
<b>Manufactured details</b>	Name	ABB STOTZ-KONTAKT GmbH
	Address	Eppelheimer Straße 82 69123 Heidelberg Germany

## Over and Under Voltage Protection Tests LV

### Calibration and Accuracy Tests

Phase	Setting	Time Delay	Pickup Voltage				Relay Operating Time - step from 230 V to test value				
			Lower Limit	Measured Value	Upper Limit	Result	Test Value	Lower Limit	Measured Value	Upper Limit	Result
<b>Stage 1 Over Voltage</b>											
L1 - N	262.2 V 230 V system	1.0 s	258.75	261.87 V	265.65	Pass	266.2	1.0 s	1.05 s	1.1 s	Pass
L2 - N				261.81 V		Pass			1.06 s		Pass
L3 - N				261.78 V		Pass			1.06 s		Pass
<b>Stage 2 Over Voltage</b>											
L1 - N	273.7 V 230 V system	0.5 s	270.25	273.37 V	277.15	Pass	277.7	0.5 s	0.57 s	0.6 s	Pass
L2 - N				273.31 V		Pass			0.56 s		Pass
L3 - N				273.30 V		Pass			0.56 s		Pass
<b>Under Voltage</b>											
L1 - N	184.0 V 230 V system	2.5 s	180.55	183.96 V	187.45	Pass	180	2.5 s	2.56 s	2.6 s	Pass
L2 - N				183.87 V		Pass			2.56 s		Pass
L3 - N				183.93 V		Pass			2.56 s		Pass

### Stability Tests

Test Description	Setting	Time Delay	Test Condition (3-Phase Value)	Test Voltage all phases ph-n	Test Duration	Confirm No Trip	Result
Inside Normal band	-----	-----	< OV Stage 1	258.2 V	5.00 s	Pass	Pass
<b>Stage 1 Over Voltage</b>	<b>262.2 V</b>	<b>1.0 s</b>	> OV Stage 1	269.7 V	0.95 s	Pass	Pass
<b>Stage 2 Over Voltage</b>	<b>273.7 V</b>	<b>0.5 s</b>	> OV Stage 2	277.7 V	0.45 s	Pass	Pass
Inside Normal band	-----	-----	> UV	188 V	5.00 s	Pass	Pass
<b>Under Voltage</b>	<b>184.0 V</b>	<b>2.5 s</b>	< UV	180 V	2.45 s	Pass	Pass

Overvoltage test - Voltage shall be stepped from 258 V to the test voltage and held for the test duration and then stepped back to 258 V.

Undervoltage test - Voltage shall be stepped from 188 V to the test voltage and held for the test duration and then stepped back to 188 V.

## Over and Under Voltage Protection HV

Tests referenced to 110 V ph-ph VT output

### Calibration and Accuracy Tests

Phase	Setting	Time Delay	Pickup Voltage				Relay Operating Time - measured value $\pm$ 2 V				
Stage 1 Over Voltage			Lower Limit	Measured Value	Upper Limit	Result	Test Value	Lower Limit	Measured Value	Upper Limit	Result
L1 - N	121 V 110 V VT secondary	1.0 s	119.35	120.75 V	122.65	Pass	Measured value plus 2 V	1.0 s	1.06 s	1.1 s	Pass
L2 - N				121.27 V		Pass			1.06 s		Pass
L3 - N				120.82 V		Pass			1.06 s		Pass
Stage 2 Over Voltage			Lower Limit	Measured Value	Upper Limit	Result	Test Value	Lower Limit	Measured Value	Upper Limit	Result
L1 - N	124.3 V 110 V VT secondary	0.5 s	122.65	124.06 V	125.95	Pass	Measured value plus 2 V	0.5 s	0.56 s	0.6 s	Pass
L2 - N				124.12 V		Pass			0.56 s		Pass
L3 - N				124.02 V		Pass			0.56 s		Pass
Under Voltage			Lower Limit	Measured Value	Upper Limit	Result	Test Value	Lower Limit	Measured Value	Upper Limit	Results
L1 - N	88.0 V 110 V VT secondary	2.5 s	86.35	87.85 V	89.65	Pass	Measured value minus 2 V	2.5 s	2.56 s	2.6 s	Pass
L2 - N				87.91 V		Pass			2.56 s		Pass
L3 - N				87.70 V		Pass			2.56 s		Pass

### Stability Tests

Test Description	Setting	Time Delay	Test Condition (3-Phase Value)	Test Voltage all phases s ph-ph	Test Duration	Confirm No Trip	Result
Inside Normal band	-----	-----	< OV Stage 1	119 V	5.00 s	Pass	Pass
Stage 1 Over Voltage	121 V	1.0 s	> OV Stage 1	122.3 V	0.95 s	Pass	Pass
Stage 2 Over Voltage	124.3 V	0.5 s	> OV Stage 2	126.3 V	0.45 s	Pass	Pass
Inside Normal band	-----	-----	> UV	90 V	5.00 s	Pass	Pass
Under Voltage	88 V	2.5 s	< UV	86 V	2.45 s	Pass	Pass

## Over and Under Frequency Protection

### Calibration and Accuracy Tests

Setting	Time Delay	Pickup Frequency				Relay Operating Time				
Over Frequency		Lower Limit	Measured Value	Upper Limit	Result	Freq step	Lower Limit	Measured Value	Upper Limit	Result
52 Hz	0.5 s	51.90	52.00 Hz	52.10	Pass	51.7-52.3 Hz	0.50 s	0.54 s	0.60 s	Pass
Stage 1 Under Frequency		Lower Limit	Measured Value	Upper Limit	Result	Freq step	Lower Limit	Measured Value	Upper Limit	Result
47.5 Hz	20	47.40	47.51 Hz	47.60	Pass	47.8-47.2 Hz	20.0 s	20.04 s	20.2 s	Pass
Stage 2 Under Frequency		Lower Limit	Measured Value	Upper Limit	Result	Freq step	Lower Limit	Measured Value	Upper Limit	Results
47 Hz	0.5 s	46.90	47.01 Hz	47.1	Pass	47.3-46.7 Hz	0.50 s	0.54 s	0.60 s	Pass

### Stability Tests

Test Description	Setting	Time Delay	Test Condition	Test Frequency	Test Duration	Confirm No Trip	Result
Inside Normal band	-----	-----	< OF	51.8 Hz	120 s	Pass	Pass
<b>Over Frequency</b>	<b>52 Hz</b>	<b>0.5 s</b>	> OF	52.2 Hz	0.45 s	Pass	Pass
Inside Normal band	-----	-----	> UF Stage 1	47.7 Hz	30 s	Pass	Pass
<b>Stage 1 Under Frequency</b>	<b>47.5 Hz</b>	<b>20 s</b>	< UF Stage 1	47.2 Hz	19.5 s	Pass	Pass
<b>Stage 2 Under Frequency</b>	<b>47 Hz</b>	<b>0.5 s</b>	< UF Stage 2	46.8 Hz	0.45 s	Pass	Pass

Over frequency test - Frequency shall be stepped from 51.8 Hz to the test frequency and held for the test duration and then stepped back to 51.8 Hz.

Under frequency test - Frequency shall be stepped from 47.7 Hz to the test frequency and held for the test duration and then stepped back to 47.7 Hz.

## Loss-of-Mains (LOM) Protection Test

### Calibration and Accuracy Tests

Ramp in range 49.0 - 51.0 Hz	Pickup (+ / - 0.025 Hzs <sup>-1</sup> )				Relay Operating Time RoCoF = ± 0.05 / 0.10 Hzs <sup>-1</sup> above setting				
Setting = 0.5 / 1.0 Hzs <sup>-1</sup>	Lower Limit	Measured Value	Upper Limit	Result	Test Condition	Lower Limit	Measured Value	Upper Limit	Result
Increasing Frequency	0.475 0.975	0.508Hz/s 1.008Hz/s	0.525 1.025	Pass	0.55 Hzs <sup>-1</sup> 1.10 Hzs <sup>-1</sup>	> 0.5 s	0.51 s 0.52 s	< 1.0 s	Pass
Reducing Frequency	0.475 0.975	0.508Hz/s 1.008Hz/s	0.525 1.025	Pass	0.55 Hzs <sup>-1</sup> 1.10 Hzs <sup>-1</sup>	> 0.5 s	0.51 s 0.52 s	< 1.0 s	Pass

### Stability Tests

Ramp in range 49.0-51.0 Hz	Test Condition	Test frequency ramp	Test Duration	Confirm No Trip	Result
Inside Normal band	< RoCoF (increasing f)	0.45 Hzs <sup>-1</sup> 0.95 Hzs <sup>-1</sup>	4.4 s	Pass	Pass
Inside Normal band	< RoCoF (reducing f)		2.1 s	Pass	Pass

### LOM Protection - Stability Tests

	Start Frequency	Change	Confirm No trip
Positive Vector Shift	49.5 Hz	+ 50 degrees	Pass
Negative Vector Shift	50.5 Hz	- 50 degrees	Pass



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